Volume 32 Supplement 3 September 2016 ISSN: 1120-1797

ELSEVIER

aifm ASSOCIAZIONE ITALIANA DI FISICA MEDICA

EFOMP

IAPM

sfpm

Physica Medica

European Journal of Medical Physics

The official journal of the
Associazione italiana di Fisica Medica,
European Federation of Organizations for Medical Physics,
Irish Association of Physicists in Medicine and
Société Française de Physique Médicale

Abstracts from the 1st European Congress of Medical Physics

September 1–4, 2016
Eugenides Foundation, Athens, Greece

JOURNAL CITATION REPORTS, SCIENCE EDITION 2013
LATEST IMPACT FACTOR 2.403
THOMSON REUTERS

Physica Medica
European Journal of Medical Physics

Aims and Scope

• *Medical Imaging*
Physics in medical imaging
Image processing
Medical acoustics and ultrasound

• *Radiation Therapy*
Physics in radiation oncology
Radiation dosimetry
Laser applications in medicine

• *Radiation Protection*
Ionising and non-ionising radiation protection
Biological effects of ionising and non-ionising radiation

• *Measuring Systems and Signal Processing*
Study and measurements of physiological parameters
Biomedical instrumentation
Physics of biological systems
Biosignal processing
Modelling and simulations
Information technology in medicine

• *Education and training in Medical Physics*

Contributions on other topics related to Applications of Physics to Biology and Medicine and in particular related to new emerging fields such as Molecular Imaging, Hadrontherapy, System biology, Nanoparticles and Nanotechnologies, etc. are strongly encouraged.

Available online at www.sciencedirect.com

ScienceDirect

Physica Medica:
European Journal of Medical Physics
Volume 32, Supplement 3

Abstracts from the 1st European Congress of Medical Physics
September 1–4, 2016
Eugenides Foundation, Athens, Greece

CONTENTS

Invited Lectures

Abstracts from the 1st European Congress of Medical Physics: Invited Lectures
Eugenides Foundation|Main Auditorium (Hall A) - September 1st, 2016 169

Abstracts from the 1st European Congress of Medical Physics: Invited Lectures
Metropolitan Hotel|Aegean Sea Ballroom (Hall B) - September 1st, 2016 171

Abstracts from the 1st European Congress of Medical Physics: Invited Lectures
Eugenides Foundation|Main Auditorium (Hall A) - September 2nd, 2016 175

Abstracts from the 1st European Congress of Medical Physics: Invited Lectures
Metropolitan Hotel|Aegean Sea Ballroom (Hall B) - September 2nd, 2016 179

Abstracts from the 1st European Congress of Medical Physics: Invited Lectures
Eugenides Foundation|Main Auditorium (Hall A) - September 3rd, 2016 184

Abstracts from the 1st European Congress of Medical Physics: Invited Lectures
Metropolitan Hotel|Aegean Sea Ballroom (Hall B) - September 3rd, 2016 188

Abstracts from the 1st European Congress of Medical Physics: Invited Lectures
Eugenides Foundation|Main Auditorium (Hall A) - September 4th, 2016 192

Abstracts from the 1st European Congress of Medical Physics: Invited Lectures
Metropolitan Hotel|Aegean Sea Ballroom (Hall B) - September 4th, 2016 194

Oral Presentations

Abstracts from the 1st European Congress of Medical Physics: Oral Papers|September 1st, 2016 196

Abstracts from the 1st European Congress of Medical Physics: Oral Papers|September 2nd, 2016 222

Abstracts from the 1st European Congress of Medical Physics: Oral Papers|September 3rd, 2016 251

Abstracts from the 1st European Congress of Medical Physics: Oral Papers|September 4th, 2016 274

E-Posters

Abstracts from the 1st European Congress of Medical Physics: E-Posters 284

Abstracts from the 1st European Congress of Medical Physics

September 1–4, 2016
Eugenides Foundation, Athens, Greece

Organized by

EFOMP

Hosted by

1969
THE HELLENIC ASSOCIATION OF MEDICAL PHYSICISTS (HAMP)

Physica Medica 32 (2016) 169–170

Contents lists available at ScienceDirect

Physica Medica

journal homepage: http://www.physicamedica.com

Abstracts from the 1st European Congress of Medical Physics: Invited Lectures Eugenides Foundation|Main Auditorium (Hall A) - September 1st, 2016

SMALL SCALE RADIOPHARMACEUTICAL DOSIMETRY

Manuel Bardiès. *INSERM – Centre de Recherches en Cancérologie de Toulouse, France*

Nuclear medicine uses radiations with highly variable ranges: for photons emissions, the range to be studied is that of the whole body. Electrons/beta have a range of some mm or less, alpha have usually a range inferior to 100 μm. Low energy Auger electrons deposit their energy within some nm.

The relationship between particle range and the scale of the biologic structure of interest conditions the type of dosimetric study to implement. In a context of therapeutic nuclear medicine, radiopharmaceutical dosimetry is implemented at various scales for different reasons:

- At the cellular scale, the objective is to understand the radiobiology of ionizing radiations and to document the absorbed dose – effect relationship.
- Small animal dosimetry is usually performed during preclinical experiments to test the potential of new radiopharmaceuticals.
- Clinical dosimetry is implemented to document and optimize molecular radiotherapy.

We will present various preclinical dosimetric approaches (cell/small animals) implemented in a context of molecular radiotherapy.

http://dx.doi.org/10.1016/j.ejmp.2016.07.262

THE INDIVIDUALIZATION IN RADIOTHERAPY: WHERE ARE WE NOW, AND WHERE ARE WE GOING?

Paweł Kukołowicz. *Maria Sklodowska-Curie Memorial Cancer Center and Institute of Oncology, Warsaw, Poland*

The synonym of the best treatment method is individualization of the treatment. Based on a description of the characteristics of the patient, his or her disease, treatment volume, etc., the best method of irradiation is proposed. The individualization could be considered in terms of the individual dose distribution and individual fractionation. However, the dose distribution and the fractionation are usually treated separately. Currently the individualization of dose distribution, thanks to development of technology, is very advanced. Several methods of Intensity Modulation Radiotherapy allowed to conform the dose distribution to the actual anatomy. Dose-painting becomes a common method of treatment. Nevertheless, due to inherent characteristic of radiation used in radiotherapy, the ideal dose distribution can't be obtained. Proton therapy does offer improved dose conformity, compared to IMRT. Another limitation in individualisation of the dose distribution is the lack of precise (description) delineation of the tumour. Several new imaging methods (positron-emission tomography and magnetic resonance) are very promising. According to Bentzen, we are able not only to conform the dose distribution to the individual anatomy but also to deliver some additional dose to tumour subvolumes with a potential resistance. To describe this type of treatment he coined a term of dose-painting by numbers. Another area for individualization is a time pattern of the dose delivery. Several randomized trials proved the importance of overall treatment time shortening to avoid rapid tumour cell proliferation. Patient-specific fractionation schedule optimization can improve the therapeutic index at least for some patients. The new imaging and molecular data and more reliable models of tumour dynamics may help in making radiotherapy more personalized.

http://dx.doi.org/10.1016/j.ejmp.2016.07.263

THE INDIVIDUALIZED DOSIMETRY IN THE RADIOEMBOLIZATION OF HEPATOCARCINOMA WITH 90Y-MICROSPHERES

Carlo Chiesa. *Nuclear Medicine of Foundation IRCCS Istituto Nazionale Tumori, Milan, Italy*

The individualized dosimetry in the radioembolization of hepatocarcinoma with 90Y glass microspheres was introduced in my institution to plan patient treatment as in external beam radiotherapy. We started with a retrospective analysis of 99mTc-MAA simulation SPECT images of strictly selected patients treated with standard 120 Gy to liver lobe. We determined dose-toxicity and dose response correlation and NTCP and TCP. A decompensation risk of 15% was considered acceptable, corresponding to $NTCP_{15}$ = 75 Gy, averaged on the whole non tumoral organ volume. A TCP(50%) was found at about 500 Gy, but strongly dependent upon lesion size. Such planning paradigm was then prospectically applied to 116 less selected patients. With respect to the 120 Gy to lobe indication, administered activity was, on the average, doubled in half of patients, reduced of 50% in a quarter of patients. The decompensation incidence was maintained below 15% as planned. TCP of the second cohort was compatible with the first one, while NTCP was shifted to a lower $NTCP_{15}$ = 60 Gy. After stratification of patients with (PVT) vs without Portal Vein Thrombosis (NO PVT), in the first PVT subgroups, where lesion had the same size distribution, treatment planning improved median survival from 8 to 12 months, close to significance with Mantel Cox test (p = 0.067). In the NO PVT subgroups, the median survival was 17 vs 15 months (n.s.) i.e. maintained despite the larger tumor size.

Such encouraging results were obtained despite methodological limits: absence of SPECT scatter correction, and observed mismatch between simulation and 90Y PET therapy biodistribution.

http://dx.doi.org/10.1016/j.ejmp.2016.07.264

BONE METASTASES DOSIMETRY FOR ^{223}RA-DICHLORIDE: AN ITALIAN MULTICENTER STUDY

Massimiliano Pacilio, Bartolomeo Cassano. *Azienda Ospedaliera San Camillo Forlanini, Circonvallazione Gianicolense 87, 00152 Rome, Italy; Risk Management and Technology Assessment, Medical Physics Unit, Bambino Gesù Children's Hospital, IRCCS, P.zza S. Onofrio 4, 00165 Rome, Italy*

Purpose. In-vivo macrodosimetry of bone lesions in ^{223}Ra-dichloride therapy is feasible, but the possibility of personalised treatments requires further research. Multicenter studies are powerful tools to investigate the role of dosimetry, but the standardization of dosimetric procedures should be guaranteed, to assure data comparability. Recently, a multicenter study in this context was proposed in Italy, and calibration protocol of gamma cameras, criteria for patients' eligibility, and dosimetric methodologies are currently under investigation.

Methods. The sensitivity of some gamma cameras (3/8-inch crystal, MEGP collimators) for ^{223}Ra was measured in air, varying activity, source-detector distance, and source diameter. Transmission curves were measured for attenuation/scatter correction with the pseudo-extrapolation number method, varying the experimental setup. The lesions visibility on ^{223}Ra images was studied by univariate ROC analysis (25 patients, 69 lesions), considering visible/non visible lesions as true positive/true negative group, and using as score value the lesion/soft tissue contrast ratio (CR) derived from ^{99m}Tc-MDP WB scan.

Results. Sensitivity was nearly constant varying activity and distance, and for object area $\geqslant 960\,mm^2$. Transmission curves are affected by experimental setup and source size, leading to activity quantification errors up to 20%. The ROC analysis yielded an AUC of 0.972 and an optimal threshold of CR of 10, corresponding to an accuracy of 92%.

Conclusion. The minimum calibration protocol requires sensitivity and transmission curves measurements varying the object size. Lesions with ^{99m}Tc-MDP CR higher than 10, not overlapping the GI tract, are generally visible on $_{223}$Ra images at 24 h, and thus eligible for dosimetric studies.

http://dx.doi.org/10.1016/j.ejmp.2016.07.265

THE ADVANTAGE OF COMBINED TREATMENTS: ALPHA-EMITTERS RADIOPHARMACEUTICAL AND EXTERNAL BEAM RADIO-THERAPY

Lidia Strigari. *IRE-IFO, Rome, Italy*

Prostate cancer (PC) is the most commonly diagnosed solid organ malignancy. More than 90% of patients with metastatic castration-resistant PC (mCRPC) develop bone metastases with a median overall survival (OS) of about 2 year and significant comorbidities. Radium-223 chloride ($^{223}RaCl_2$) is a novel first-in-class radiopharmaceutical, recently approved by FDA for relief of bone pain, emitting α-particles able to increase biologic efficacy and cell killing, theoretically limiting cellular damage to areas of normal bone marrow (BM).

To improve the OS of patients with mCRPC, combined treatments using both radionuclide and external beams have been proposed. Given the question of optimal activity and schedule duration of $^{223}RaCl_2$treatment has not been yet definitively addressed, the estimated biological efficacy of combined treatments has been calculated using radiobiological models. In particular, given the limited follow-up of the registration trial, the degree of BM toxicity may be under-reported. To investigate the link between the delivered dose and biodosimetric assays (i.e. increment of number of dicentrics and micronuclei from lymphocytes), preliminary results from a prospective trial enrolling PC patients with bone metastasis undergoing $^{223}RaCl_2$ therapy at IRE-IFO have been used as input data. The expected dose-effect results in terms of OS and toxicity are presented.

http://dx.doi.org/10.1016/j.ejmp.2016.07.266

Physica Medica 32 (2016) 171–174

Contents lists available at ScienceDirect

Physica Medica

journal homepage: http://www.physicamedica.com

Abstracts from the 1st European Congress of Medical Physics: Invited Lectures Metropolitan Hotel|Aegean Sea Ballroom (Hall B) - September 1st, 2016

BASIC QUALITY CONTROL IN ROUTINE MRI

Thomas G. Maris. *Department of Medical Physics, University of Crete, Greece*

Aim. Magnetic Resonance Imaging (MRI) has evolved a valid clinical tool in everyday practice. Its unique capabilities of imaging soft tissue human anatomy and physiology with excellent spatial, temporal and contrast resolution explain its outstanding role in clinical imaging. The aim of this lecture is to present the rationale of Quality Control (QC) and Quality Assurance (QA) in MRI and to briefly present a set of basic QC tests that can ensure MRI system's performance and help on maintain diagnostic quality in routine clinical MRI examinations.

Learning objectives.

- Understand the general rationale of QC and QA in MRI.
- Presentation of the AAPM 100 protocol. Basic procedures and methodologies.
- Presentation of accredited phantoms and tools used for basic QC and QA in MRI.
- Presentation of a set of basic QC tests for assessing MRI system's performance based solely on simple imaging post-processing methods. This will include assessments of the following system's parameters:
  - H_0 static field homogeneity
  - Signal to Noise (SNR) and Contrast to Noise (CNR) measurements
  - Spatial Uniformity of SNR
  - Chosting Ratio and MR image uniformity
  - Geometric Distortion and Spatial Linearity
  - Slice thickness
  - High Contrast Spatial Resolution
  - Low Contrast Object Detectability

http://dx.doi.org/10.1016/j.ejmp.2016.07.268

HIGH FIELD MRI: WHAT ARE THE SPECIAL SAFETY RISKS AT HIGHER FIELDS?

Paul W. de Bruin. *Radiology Department, Leiden University Medical Center, Leiden, The Netherlands*

In the last 10 years the use of MR-scanners with a magnetic field stronger than 3 Tesla (''Ultra-high field MRI", i.e. UHF-MRI, defined as 7–9.4 Tesla in this presentation) has increased sharply, mainly driven by the fact that the three main manufacturers decided to develop 7 Tesla MRI scanners for research purposes. More recently, also human 9.4 Tesla research MRI scanners are offered commercially. Over the last 10 years, important improvements in hardware and imaging sequences at 7 Tesla have led to a quality of fMRI, anatomical neuroimaging, cerebral angiography and spectroscopy clearly surpassing the quality routinely obtained at 3 Tesla. This improved performance has resulted in the use of UHF-MRI not only in normal, young volunteers but also for clinical research in patients. When using UHF-MRI scanners in patient populations the amount of subjects having implants or a history of surgery increases sharply, resulting in a more urgent need of safety testing of common implants as well as a strong local implementation of safety procedures. In this presentation the safety aspects of UHF-MRI, regarding normal volunteers, patients and workers, will be discussed.

http://dx.doi.org/10.1016/j.ejmp.2016.07.269

QUALITY ASSURANCE IN QUANTITATIVE MRI

Ioannis Seimenis. *Medical Physics Laboratory, School of Medicine, Democritus University of Thrace, Alexandroupolis, Greece*

There is a continuously evolving paradigm shift in MRI, that of quantitative MRI (qMRI). Therefore, a gradual transition exists from a simplified, phenomenological and descriptive procedure to a quantitative measurement used for early diagnosis, disease evaluation and monitoring, as well as for therapeutic guidance. There is a plethora of parameters that can be used as quantitative markers in MRI, ranging from relaxation times to indices related to complex mechanisms such as diffusion and perfusion. The advent of qMRI has introduced new concepts in clinical MRI practice such as sensitivity, accuracy and specificity. The measurement precision and accuracy can be determined through a carefully designed program of quality control employing both phantoms and healthy volunteers. The need for high specificity lies in choosing the optimal parameter to be measured and monitored. The main requirement for increasing the measurement's sensitivity and accuracy and for achieving high sensitivity is to fully understand the underlying q-MRI mechanism. With regard to the various sources of error and inaccuracy involved, q-MRI can be divided into two subprocesses: data collection and data analysis. A quality assurance program has to address issues related to both sub-processes. The second one refers to post-processing and, thus, it is a repeatable process which can adopt suitable measures for mitigating pertinent inaccuracies. The former refers to scanning. Spatial distortions and signal inaccuracies stem from many factors related to the measurement conditions. It is essential, therefore, to characterize, reduce and correct these distortions and inaccuracies, so as not to adversely affect quantitative results.

http://dx.doi.org/10.1016/j.ejmp.2016.07.270

QUALITY ASSURANCE IN MRI FOR RADIOTHERAPY PLANNING

Niko Papanikolaou, Daniel Saenz. *University of Texas Health Sciences Center San Antonio, United States*

MRI has played an important complimentary role with more universal imaging techniques (e.g. CT) in radiotherapy. As its role continues to evolve with novel MRI techniques and further integration with the radiation oncology clinic, an understanding of the capabilities and limitations of MRI is vital to appreciate. The implications and quality assurance of MRI in radiotherapy treatment planning were investigated through a comprehensive literature search. The historical and present role of MRI in radiation therapy is first summarized. MRI as a radiation therapy simulator is first introduced, including a presentation of the advantages and disadvantages for a clinic. The impact of geometrical distortions (of various magnitudes depending on scanner, pulse sequence, bandwidth, etc.) is discussed in the context of various anatomical sites. Methods to reduce the magnitude of these distortions are summarized. Distortion correction algorithms should be subjected to regular quality assurance. Other workflow issues including the creation of DRRs, the fusion with CT for electron density information, and other artifacts such as motion are discussed. A site-by-site overview of clinical applications of MR in radiation therapy is presented. Finally, the quality assurance is described specific to the type of MR application (for planning as the sole imaging modality, in conjunction with CT, if used as a simulator, etc.).

http://dx.doi.org/10.1016/j.ejmp.2016.07.271

RISKS RELATED TO STATIC MAGNETIC FIELDS

Lars G. Hanson. *DRCMR, Copenhagen University Hospital Hvidovre, and DTU Elektro, Technical University of Denmark, Denmark*

Magnetic Resonance Imaging (MRI) is considered a safe non-invasive scanning method. This is only true, however, if necessary precautions are taken to avoid risks associated with the strong static and time-varying fields that are essential for MRI. The most widely known of these, is the strong static polarizing field B_0 ranging up to approximately 10 Tesla for human use. The risks associated with this field are numerous: considerable energy is stored in the field that may be released during a quench. Of more importance are the magnetic forces acting on ferromagnetic material, and which can turn common objects into deadly projectiles. The field will also affect many implants and equipment. Finally, physiological effects are of concern and need to be considered. These risks associated with the static field are reviewed in the presentation along with limits and recommendations pertaining to the use of high magnetic field for MRI.

http://dx.doi.org/10.1016/j.ejmp.2016.07.272

RISKS RELATED TO GRADIENT FIELDS

Ioannis Tsougos. *Medical Physics Department, Medical School, University of Thessaly, Greece*

Magnetic Resonance Imaging (including advanced techniques such as spectroscopy, fMRI DTI etc.) has been in use for almost two decades now. It is considered a safe medical procedure; nevertheless there exist some acceptable and well controlled associated risks, medical practitioners should be aware of these risks, especially the ones related to MR gradient fields may occur rapidly and many concerns regarding the safety of certain applications remain unanswered. This lecture aims to analyse the main safety risks associated with MR gradient fields, from a medical physics perspective and the potential clinical oriented impact advanced MRI may have on safety considerations. The practical implications of these safety issues will also be evaluated. Finally, the mitigating strategies to reduce the aforementioned effects will be proposed.

http://dx.doi.org/10.1016/j.ejmp.2016.07.273

RISKS RELATED TO RF FIELDS

Andrew Webb. *Leiden University Medical Center, Netherlands*

One of the main safety concerns in MRI is the interaction between the electric field produced by the RF coil and conductive tissue and any implants within the patient. This results in power deposition and potential heating. International safety guidelines are formulated in terms of specific absorption rate (SAR) rather than rises in temperature, although there are strong indications that future regulations will concentrate on direct thermal effects. The effects of implants can be studied via electromagnetic simulations and phantom experiments. As MRI static magnetic fields increase local and global SAR values also become higher, and asymmetry in their spatial distribution also increases. This talk will concentrate on methods to simulate and measure RF heating, both using MRI and MRI-compatible optical techniques, and suggest some methods for potentially reducing heating using targeted RF fields.

http://dx.doi.org/10.1016/j.ejmp.2016.07.274

EUROPEAN LEGAL FRAMEWORK FOR SAFETY AND QUALITY ASSURANCE IN MRI

Alberto Torresin. *Medical Physics Dep., ASST Grande Ospedale Metropolitano, Milano, Italy*

European Parliament Council Directive 2013/35/EU covers all known direct biophysical effects and other indirect effects caused by electromagnetic fields. The purpose was to regulate physical agents which define exposure limits to electromagnetic fields in the workplace. This must be transposed into national law by 1st July 2016.

Article 10 contains important derogations informing that exposure may exceed the ELVs if it is related to the installation, testing, use, development, maintenance of magnetic resonance imaging. The derogation allows exposures to exceed the ELVs providing certain conditions are satisfied. The electromagnetic field exposures of patients and volunteers within the scanner fall outside the scope of the Directive. A consultation with relevant stakeholders defined practical guidance to employers on achieving compliance with the conditions of the derogation taking into account the CENELEC publications.

The MR-community is preparing a high degree of self-regulation, to develop effective training program for workers in the field.

An inter-society working group on MR-safety has been established where the EFOMP, EFRS, ESMRMB, ISMRM, and ESR are represented with an approved consensus document. It explains the organization able to support the control of possible ELFs excess. The MR medical/research director (MRMD/MRRD) is the operational responsible for the facility; MR safety officer (MRSO) is closely involved with the scanning and the MR safety expert (MRSE) can advise, regarding all matters and issues related to MR safety.

The role of MRSE requires a higher level of KSC. MRSE is responsible for the safety of staff, and for a MRI quality control program.

http://dx.doi.org/10.1016/j.ejmp.2016.07.275

DOSE OPTIMIZATION IN CARDIAC CT

Mannudeep K. Kalra. *Massachusetts General Hospital and Harvard Medical School, Boston, MA, USA*

Modern multidetector-row CT scanners offer a unique opportunity to perform cardiac CT scanning for non-invasive evaluation of coronary arteries in appropriate clinical settings. Several technologic innovations have helped reduce radiation dose for cardiac CT procedures including automatic exposure control with ECG based and organ based modulations of tube current, automatic kV selection technique, greater detector efficiency, as well as dynamic X-ray beam collimation. Prospectively triggered ECG based scanning in sequential scanning mode has emerged as an important technique for reducing radiation dose. Certain scanners allow use of high beam pitch (>1.5:1) for obtaining cardiac CT at lower radiation doses. Availability of iterative reconstruction techniques also help modify scan parameters to accomplish dose reduction without sacrificing image quality. Orchestration of perfect scanning technique for cardiac CT depends on several factors such as patient size, baseline heart rate, and clinical indication for cardiac CT. The presentation will touch upon use of best scanning practices for cardiac CT examinations in order to optimize radiation dose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.276

AN OVERVIEW OF ESR EXPERIENCE, WITH A FOCUS ON EUROSAFE IMAGING

Guy Frija. *Chair, EuroSafe Imaging Steering Committee, L'Université Paris Descartes, France*

The ESR launched EuroSafe Imaging, an ambitious radiation protection initiative, at ECR 2014 as a driver for improved quality and safety in medical imaging in Europe. The EuroSafe Imaging activities are led by a Steering Committee composed of stakeholder representatives, including EFOMP.

The 'EuroSafe Imaging Call for Action' issued in September 2014 comprises 12 action items with concrete projects and specific goals to achieve EuroSafe Imaging's objectives of promoting appropriateness in radiological imaging, maintaining radiation doses within diagnostic reference levels, using the ALARA principle and promoting the use of up-to-date equipment, empowering patients, and joining forces with various stakeholders.

The ESR and EFOMP are collaborating in many activities under the umbrella of EuroSafe Imaging, including the projects "European Diagnostic Reference Levels for Paediatric Imaging" (PiDRL) and "BSS Transposition in the Medical Sector". Other activities of EuroSafe Imaging focus on imaging referral guidelines embedded in clinical decision support (ESR iGuide), data collection ('Is your Imaging EuroSafe?'), clinical audit, as well as appropriate image quality, clinical DRLs and a European CT repository. A network of institutions committed to best practice in radiation protection is created through the 'EuroSafe Imaging Stars' initiative. In addition, research in medical radiation protection is fostered.

This variety of actions and the range of different stakeholders involved in EuroSafe Imaging reflect the ESR's inclusive and holistic approach to medical radiation protection. EuroSafe Imaging serves as role model for medical radiation protection campaigns in other continents, such as Latin America Safe, Afro Safe and Canada Safe, and embraces a collaborative approach with these campaigns.

http://dx.doi.org/10.1016/j.ejmp.2016.07.277

AN OVERVIEW OF EFOMP EXPERIENCE, WITH A FOCUS ON EUROSAFE IMAGING

John Damilakis. *University of Crete, Greece*

The European Society of Radiology has launched the EuroSafe Imaging Campaign to support and strengthen medical radiation protection across Europe following a holistic, inclusive approach. The European Federation of Organisations for Medical Physics (EFOMP) has supported this campaign since its launch. Medical Physics Experts (MPEs) are involved in medical imaging departments to estimate patient and staff radiation doses, monitor doses using dose tracking methods, establish and review diagnostic reference levels, maintain patient doses within diagnostic reference levels, reduce patient doses while maintaining the image quality needed for diagnosis, develop appropriate examination protocols and train staff in medical radiation protection. These activities are of great importance for CT and interventional radiology, where radiation doses are high. Undoubtedly, MPEs can play a major role in radiation protection in the context of EuroSafe Imaging campaign. Activities where MPEs could be provided valuable expertise include the introduction of decision support tools for the implementation of referral guidelines, the use of dose tracking systems, the development and application of tools for patient exposure records, the development of tools for patient dose reduction, the development of methods for accurate organ dose estimation and risk assessment, the development of methods for accurate conceptus dose estimation, the introduction of innovative education and training platforms and the development and application of tools for accurate and prompt measurement of occupational exposure.

http://dx.doi.org/10.1016/j.ejmp.2016.07.278

EURAMED – THE EUROPEAN ALLIANCE FOR MEDICAL RADIATION PROTECTION RESEARCH

Lluís Donoso Bach. *Past President, European Society of Radiology (ESR), Hospital Clínic de Barcelona, Spain*

The European Alliance for Medical Radiation Protection Research (EURAMED) represents a consortium of associations involved in the application of ionising radiation in medicine, namely the European Association of Nuclear Medicine (EANM), the European Federation of Organisations for Medical Physics (EFOMP), the European Federation of Radiographer Societies (EFRS), the European Society of Radiology (ESR) and the European Society for Radiotherapy and Oncology (ESTRO) with the goal of jointly improving medical care and its radiation protection issues through sustainable research efforts.

For the first time the medical societies joined forces and agreed on a collaboration to improving the application of ionising radiation in medical care by developing and exploring common research strategies and by actively promoting the translation of results into clinical practice. The first major step to overcome the fragmentation and lacking visibility of radiation protection the medical field was the development of a first edition of a strategic research agenda (SRA) for medical radiation protection, approved by the boards of the five societies in November 2015.

EURAMED complements existing established European platforms in several other fields of radiation protection and will thus create visibility for the medical field.

Mission:

- To jointly improve medical care through sustainable research efforts in medical radiation protection
- Identification of common research areas defined in a common strategic research agenda
- To serve as a platform for medical radiation protection research, linking researchers and clinicians, adopting a harmonised approach to lobbying at European level to impact the European research funding landscape
- To develop an aligned approach and response to European research calls

http://dx.doi.org/10.1016/j.ejmp.2016.07.279

STRUCTURED DOSE REPORTING

Peter Mildenberger. *Radiologist and Head of Imaging IT, Dept. Radiology, University Medicine Mainz, Germany*

For a long time, radiation dose documentation has been done manually. In the late Nineties, DICOM has introduced MPPS (Modality Performed Procedure Step), which has been the first general solution for digital communication of dose measurements. In parallel, OCR has been used to analyse the "images" keeping dose information, which are part of most CT studies.

Both of these efforts have some advantages and also a lot of disadvantages, e.g. MPPS is a message based communication, which could fail and OCR could produce errors.

Therefore, some years ago DICOM has started to develop new objects for documentation of dose information as "DICOM Dose Structured Reports". These objects are full DICOM objects, which can be communicated, stored and displayed like any other DICOM object. Such Dose SRs are available for many different imaging modalities, meanwhile also a Dose SR for nuclear medicine is available (Supplement 159, 2013). Actually, the second generation of Dose SR on Radiotherapy (Suppl. 177) and a "Patient Radiation Dose Reporting" (Suppl. 191) are in discussion in DICOM.

The real world application is "prescribed" with the IHE profile on "Radiation Exposure Monitoring". Based on this profile, different roles for creating, archiving and analysing dose information have been defined and described.

This model allows building local, regional or even international dose registers from real life examinations. Such information is optimal for benchmarking or creation of DRLs.

Using structured dose information, there are new opportunities for research. Also, in principle there patient-oriented dose-profiles could be created in future.

http://dx.doi.org/10.1016/j.ejmp.2016.07.280

TOWARDS BENCHMARKING PAEDIATRIC CRANIAL CT PROTOCOLS USING A DOSE TRACKING SOFTWARE SYSTEM: A MULTICENTRE STUDY

Timo De Bondt. *Antwerp University Hospital, Belgium*

Objectives: To benchmark and standardize regional practice for paediatric cranial CT procedures, in terms of radiation dose and acquisition parameters.

Methods: Paediatric cranial CT data were retrospectively collected during 1-year, in 3 hospitals of the same country. A dose tracking system was used to automatically gather information. Radiation dose (CTDI and DLP) were stratified by age and clinical indication. Scan length, amount of retakes and demographic data were acquired; appropriate use of child specific protocols was assessed.

Results: In total, 296 paediatric cranial CT procedures were collected. Although the median dose of each hospital was below the national and international diagnostic reference level (DRL) for all age categories, statistically significant (p-value <0,001) differences among hospitals were observed. The hospital with lowest dose levels showed smallest dose variability and used age-stratified protocols for standardizing paediatric head exams. Erroneous selection of adult protocols for children still occurred, mostly in the oldest age-group.

Conclusion: Even though all hospitals complied with national and international DRLs, dose tracking and benchmarking showed that further dose optimization and standardization is possible by using age-stratified protocols for paediatric cranial CT. Moreover, having a dose tracking system revealed that adult protocols are still applied for paediatric CT, a practice that must be avoided.

http://dx.doi.org/10.1016/j.ejmp.2016.07.281

Physica Medica 32 (2016) 175–178

Contents lists available at ScienceDirect

Physica Medica

journal homepage: http://www.physicamedica.com

Abstracts from the 1st European Congress of Medical Physics: Invited Lectures Eugenides Foundation|Main Auditorium (Hall A) - September 2nd, 2016

BASIC MRI PHYSICS FOR RADIOTHERAPY PHYSICISTS

David J. Lurie. *University of Aberdeen, Scotland, United Kingdom*

CT has long been the modality of choice for radiotherapy treatment planning, because of its inherent lack of spatial distortion and its natural ability to provide electron-density information about tissues, directly feeding in to dose calculations. Nevertheless, MRI offers much better soft-tissue contrast than CT, with the added benefit of zero radiation dose. Advances in MRI technology have improved its geometric accuracy, while image segmentation allows dose-related parameters to be inferred, making MRI a viable option for radiotherapy planning. In MRI-guided radiotherapy, MR images are used to delineate tumour boundaries and guide the radiation distribution in real time.

MRI uses signals generated by nuclear magnetic resonance (NMR) of magnetic hydrogen nuclei (protons). The frequency of the signal depends on the strength of the magnetic field, typically 1.5 tesla giving an NMR frequency of 64 MHz. Spatial information is obtained by magnetic field gradients, which alter the local magnetic field (and hence the resonant frequency) as a function of position; analysis of the frequency and phase of the measured NMR signals allows images to be produced in 2- or 3-dimensions. The geometric accuracy of the images is crucial to MR-based treatment planning, and depends on the homogeneity of the main magnetic field and the linearity and homogeneity of the magnetic field gradients. A plethora of MRI pulse sequences exist, which can be optimised to improve the results of image segmentation for dose calculations.

This presentation will cover MRI concepts and how they impact on MR-based treatment-planning and on MR-guided therapy.

http://dx.doi.org/10.1016/j.ejmp.2016.07.283

MR-GUIDED RADIATION THERAPY

Uulke A. van der Heide. *Department of Radiation Oncology, The Netherlands Cancer Institute, Amsterdam, The Netherlands*

Image guided radiotherapy currently relies on cone-beam CT for imaging the patient prior to irradiation. With integrated MRI accelerator systems, it becomes feasible to use the superior soft-tissue contrast of MRI and image the patient not only prior to, but also during irradiation. To integrate a MRI with an accelerator, challenges needed to be overcome: active shielding of the magnet is modified so that critical components of the accelerator can be placed in a zero magnetic field environment, close to the scanner. To avoid interference of the radiofrequency systems of the scanner and the accelerator, the accelerator is positioned outside the scanners' RF cage. Monte-Carlo dose calculation considers the impact of the magnetic field on the scatter electrons.

We participate in the MR Linac Consortium to introduce the system developed by Elekta in cooperation with UMC Utrecht and Philips in the clinic. A key application is the treatment of rectal cancer. As the target volume shows considerable movement, currently generous margins are applied to ensure target coverage. To exploit the potential of MR-guided radiotherapy, we investigated adaptation strategies as well as techniques for contour propagation. We investigated the impact of rectal gas on the dose distribution caused by the electron return effect. With these methods, we expect to be able to reduce treatment margins, resulting in a reduction in toxicity. Also local dose escalation to the tumour will be feasible so as to improve the probability of achieving complete remission. This may expedite organ sparing treatment strategies.

Support for this research provided, in part, by Elekta AB, Stockholm Sweden

http://dx.doi.org/10.1016/j.ejmp.2016.07.284

RAISING AWARENESS OF MEDICAL PHYSICS: THE VIEW OF INTERNATIONAL ORGANIZATION FOR MEDICAL PHYSICS (IOMP)

Slavik Tabakov. *King's College London, UK*; *International Organization for Medical Physics, UK*

One of the main aims of the International Organization for Medical Physics (IOMP) is raising awareness of medical physics. IOMP has built throughout the years many links with other international organisations, as IAEA, IUPAP, WHO, ILO. The latter link (developed over years-long discussions) resulted in the inclusion of the occupation "medical physicist" in the International Standard Classification of Occupations (ISCO-08). As part of IUPESM we became members of the International Council of Scientific Unions (ICSU), what is another high professional visibility.

At a local level IOMP has helped the establishment of tens medical physics societies and currently we have 82 National Member Societies with 22,000 members. To further increase the internal collaboration of these societies IOMP has created Regional Organisations (RO) on geographical basis, which have good internal understanding of regional requirements. During 2015 IOMP created Regional Coordination Board to further strengthen the links of IOMP with its RO (EFOMP, AFOMP, ALFIM, SEAFOMP, MEFOMP, FAMPO).

Future plans to raise the awareness of medical physics with all means and at all levels, include:

- at local level through short seminars focussing on various new medical devices; links with Hospital management, etc;
- at national/regional level through links with the media to publicise similar subjects and our involvement in hospital/patient safety, etc;
- at international level through further collaboration with institutions related to medicine/sciences/education/safety, etc.

Increasing the visibility of our profession is one of the objectives during the current IOMP office and we all have to make this a standing priority.

http://dx.doi.org/10.1016/j.ejmp.2016.07.285

RAISING AWARENESS OF MEDICAL PHYSICS: THE ICTP PROGRAMME

Renato Padovani. *International Centre for Theoretical Physics (ICTP), Trieste, Italy*

The Abdus Salam International Centre for Theoretical Physics (ICTP), a UNESCO institute, following its mission " *... develop high-level scientific programmes keeping in mind the needs of developing countries* ...", has developed a medical physics programme addressed to developing countries with pillars the Master of advanced studies in MP, the College of MP, the Radiotherapy school and the Joint IAEA/ICTP advanced courses.

The Master: ICTP and the Trieste University in 2014 initiated the Master, a two-years training programme designated to provide young graduates in physics, mainly from developing countries, with a post-graduated theoretical and clinical training suitable to be recognised as Clinical Medical Physicist in their countries. The programme is following the IAEA and IOMP relevant recommendations. Presently, the 3 editions have seen 49 participants from 33 Countries: Africa (19), Asia (11), Central and South America (14), and Europe (5), selected from more than 300 applicants per year. The programme is supported by scholarships awarded to candidates from developing countries by IAEA, TWAS, KFAS, IOMP, EFOMP and ICTP.

The MP College and the Radiation Oncology School are 2–3 weeks biennial course, aiming to give basic knowledge in these fields to young medical physicists. The School of radiation oncology, at the 3rd edition next 2017, is receiving a substantial support from IOMP, EFOMP and AAPM.

ICTP is seeing these initiatives as an answer to the growing demand of high education from developing Countries and is representing an important International and European contribution to the development of medical physics in the developing world.

http://dx.doi.org/10.1016/j.ejmp.2016.07.286

RAISING AWARENESS OF MEDICAL PHYSICS: THE VIEW OF INTERNATIONAL ATOMIC ENERGY AGENCY (IAEA)

H. Delis, G.L. Poli, B. Healy, K. Christaki, G. Loreti, A. Meghzifene. *Dosimetry and Medical Radiation Physics Section, Division of Human Health, IAEA, Austria*

The International Basic Safety Standards, published in 2014, recognizes the need for multidisciplinary approach to ensure Quality and Safety in Radiation Medicine. Specifically regarding the Medical Physics support, it is highlighted that corresponding requirements for calibration, dosimetry and quality assurance, including the acceptance and commissioning of medical radiological equipment, are fulfilled by or under the supervision of a medical physicist. The IAEA has been working to increase awareness on the need of comprehensive quality systems and accurate dosimetry practices in radiation medicine; these elements require the involvement of highly competent professionals, such as the medical physicists.

Although the role of medical physicists in Radiation Therapy was been relatively well established for many years, corresponding involvement of medical physicists in imaging is still very weak, almost throughout the world. Historically, this can be partially justified by the large number of diagnostic departments and the perception of low complexity and doses in the field of medical imaging. However, the last few years, (i) the importance of accurate diagnosis to the patient management, (ii) the increasing complexity of diagnostic equipment and procedures, and (iii) the possibility of relatively high doses resulted from imaging procedures, have led to an increasing demand for medical physics support also in medical imaging.

Supporting the Member States to establish medical physics capacities, the IAEA develops guidelines to harmonize the roles and the education and training requirements of medical physicist. In addition provides structured training to medical physics professionals, through individual fellowships, national, regional and interregional courses and workshops.

http://dx.doi.org/10.1016/j.ejmp.2016.07.287

THE IMPACT OF EXTERNAL DOSIMETRY VERIFICATION IN RADIOTHERAPY

Catharine Clark. *Royal Surrey County Hospital and National Physical Laboratory, UK*

The value of independent dosimetry audit is now better recognised and has become well documented. From the excellent work of the IAEA and national standards labs in reference dosimetry audit through to end-to-end measurements which follow the commissioning of a new advanced radiotherapy technique, there is no doubt that the quality of radiotherapy has improved over recent decades, and that audit has played a role in this. These independent audits increase the confidence in delivery as well as creating the data which allow centres to benchmark themselves against others and thus know whether they have got the best out of a system. This process also improves standards by identifying outliers and providing support to help them improve.

However the impact of dosimetry audit also extends further. A survey in the UK on quality assurance procedures for IMRT, suggested that audit increases confidence and therefore helps to support the reduction of measurement based QA which is done on a per patient basis. There is also increasing evidence that dosimetry audit has an impact on improving clinical outcomes. Additionally the robust approach of external beam audit has been taken up in brachytherapy and an increasing number of dosimetry audits are now taking place for source based therapy. Furthermore the experience in therapy audit is helping to guide the development of quality assurance in pre-clinical work, thus ensuring true end to end dosimetry verification from the laboratory to the clinic.

http://dx.doi.org/10.1016/j.ejmp.2016.07.288

REDUCING TOTAL EDUCATION AND TRAINING TIME WITHOUT LOSS OF QUALITY: THE EDUCATION AND TRAINING MODEL IN MALTA

Carmel J. Caruana. *Medical Physics Department, Faculty of Health Sciences, University of Malta, Malta*

The number of Medical Physicists in Malta was until recently much lower than that recommended by the European Guidelines on the Medical Physics Expert. This was impacting the extent,

effectiveness, safety and efficiency of clinical services. The Maltese Ministry of Health and University of Malta together partnered a project the objective of which was to produce an Education and Training scheme for the Clinically Qualified Medical Physicist which followed the recommendations of the 'European Guidelines on the Medical Physics Expert' project, EFOMP Policy Statement 12.1 and IAEA Training Course Series 37, 47 and 50 whilst optimizing costs and ensuring future-proofing. We present the innovative scheme as a model of academic and public administration cooperation in the service of patients. The project was part financed by the European Social Fund. It is hoped that the model will help other countries in Europe where Medical Physics Education and Training is not yet developed to set up similar cost-effective schemes.

http://dx.doi.org/10.1016/j.ejmp.2016.07.289

TECHNICAL DEVELOPMENTS IN HIGH PRECISION RADIOTHERAPY

Carlo Cavedon. *Medical Physics Unit, University Hospital of Verona, Italy*

Introduction. Modern Radiotherapy techniques demand high spatial accuracy and precision in order to guarantee the necessary quality and safety of high-dose, often hypo-fractionated treatments. This need prompted the development of refined in-room imaging and tracking techniques that allow correction of patient position and even real-time compensation of organ motion to be performed. In this presentation, some examples of technological solutions and related methods are analysed with the aim of providing an overview of the evolving field of image-guided and signal-guided Radiotherapy techniques.

Technology and methods. High precision techniques in Radiotherapy can be categorized in image-guided methods, non-conventional system architectures, signal-guidance by means of non-imaging techniques used to track a surrogate signal in real time, and combinations of these approaches. The theory and technology underlying these techniques come both from the imaging and therapy realms, with interesting examples that will be presented in this talk.

From the standpoint of a Medical Physicist, a strong need of reference guidance is generally felt as specialised systems show peculiarities that make standard protocols often non-applicable. Furthermore, the increasing sensibility to the organized approach to quality and safety in Radiation Oncology asks for more standardization.

Final considerations. The Medical Physicist has the opportunity to play an important role in the management of safety and quality of precision techniques in Radiotherapy, especially in view of the inherent multi-disciplinarity of Medical Physics that benefits from competences acquired in the diverse fields that embrace our profession. It will be the task of our scientific societies to provide members with sufficient resources – education and scientific support, above all – so that this opportunity is fully understood.

http://dx.doi.org/10.1016/j.ejmp.2016.07.290

SMALL BEAM DOSIMETRY: A MULTI-CENTER MULTI-DETECTOR ITALIAN PROJECT

C. Talamonti, S. Russo, Tonghi L. Barone, G. Benecchi, G. Borzi, S. Bresciani, E Cagni, C. Carbonino, M. Casale, S. Clemente, R. Consorti, V. D'Alessio, E. Dicastro, G. Donofrio, M.D. Falco, D. Fedele, C. Fiandra, C. Frassanito, C. Gasperi, F.R. Giglioli, C. Iervolino, E. Infusino, S. Linsalata, G. Loi, E. Lorenzini, C. Marino, S. Martinotti, L. Masi, E. Menghi, R. Miceli, E. Moretti, B. Nardiello, R. Nigro, G. Pastore, M.C. Pressello, M. Pimpinella, G. Raza, F. Rosica, R. Ruggeri, L. Spiazzi, M. Stasi, L. Strigari, V. Tremolada, A. Vaiano, S. Vigorito, E. Villaggi, F. Vittorini, P. Mancosu. *Università di Firenze, AOU Careggi, Firenze, Italy*; *Azienda USL Toscana Centro, Firenze, Italy* ; *Policlinico San Donato, S. Donato M.se (MI), Italy*; *A.R.N.A.S. Garibaldi di Catania, Italy*; *AO Parma, Italy*; *Centro REM Radioterapia Catania, Italy* ; *IRCCS Candiolo Torino, Italy* ; *Arcispedale S.Maria Nuova –IRCCS Reggio Emilia, Italy* ; *A.O. Ospedale Niguarda, Milano, Italy*; *AO "Santa Maria" Terni, Italy*; *IRCCS CROB Potenza, Italy* ; *AO San Filippo Neri, Roma, Italy* ; *Malzoni Radiosurgery Center – Agropoli SA, Italy* ; *Umberto I – Policlinico di Roma, Italy*; *AUSL Pescara, Italy*; *Policlinico SS. Annunziata, Chieti, Italy*; *Casa di Cura S.Rossore, Pisa, Italy* ; *Molinette, Torino, Italy*; *Centro Cyberknife di Bari, Italy*; *Istituto Besta di Milano, Italy*; *Usl8 Arezzo, Italy*; *Molinette, Torino, Italy*; *A.0 "S.G.MOSCATI" Avellino, Italy*; *Università Campus Bio-Medico, Roma, Italy*; *USL 2 Lucca, Italy*; *AOU Maggiore delle Carità Novara, Italy*; *Asl 1 Carrara, Italy*; *Humanitas Catania, Italy*; *CDI Milano, Italy*; *IFCA Firenze, Italy*; *I.R.S.T., Meldola (FC), Italy* ; *AOU TorVergata, Roma, Italy* ; *AOU "Santa Maria della Misericordia" Udine, Italy* ; *UPMC San Pietro FBF, Roma, Italy*; *O.G. P. S.Camillo de Lellis, Rieti, Italy*; *Ecomedica Empoli, Italy*; *AO San Camillo Forlanini, Roma, Italy* ; *ENEA, Italy*; *Ospedale San Pietro Fatebenefratelli, Roma, Italy* ; *ASL di Teramo, Italy* ; *Ospedale sacro Cuore don Calabria, Negra, Italy* ; *Spedali Civili, Brescia, Italy*; *A.O. Ordine Mauriziano di Torino, Italy* ; *IFO, Roma, Italy*; *Spedali Civili, Brescia, Italy*; *USL 3 Pistoia, Italy*; *Istituto Europeo Oncologia Milano, Italy*; *AUSL Piacenza, Italy*; *L'Aquila, Italy*; *Humanitas Milano, Italy*

A project dedicated to stereotactic body radiotherapy (SBRT) dosimetric aspects started in the framework of the Italian Association of Medical Physics (AIFM) SBRT working group. Its main objectives are manifold but sharing the knowledge between different clinics is the one of the most important. More than 30 centres, equipped with Varian, Elekta, Siemens or CyberKnife linac were enrolled. The project was divided in several work-packages, the first one evaluated the relative measurements with detectors routinely used by individual centers and in the following different detectors run in various centre. Each centre in the same work-package performed dose profile of field size ranging from $0.6 \times 0.6\ cm^2$ to $5.0 \times 5.0\ cm^2$, and relative output factors (ROF) measurements with a diamond or silicon diode or scintillator detector. In workpackage-1 ROF values measured in the first phase were compared with the ones measured with a microdiamond showing a higher inter-center consistency with this dosimeter compared to routine detectors. In workpackage-2 a silicon diode of new generation was used also to develop a mathematical relation from multicentric experimental data, which describes and predicts the ROF as a function of effective field size for TrueBeam Varian and Elekta linacs. Workpackage-3 used a plastic scintillator for TPR20, 10 and ROF; the latter showed

a greater variability. Workpackage-4 used diamond and plastic scintillator with Cyberknife beams, to evaluate if microDiamond could be a suitable alternative to silicon diodes for OF determination and to validate the feasibility of using the scintillator as a reference detector in consideration of the ČerenkovLightRatio and experimental uncertainties. The results of the study for all the detectors emphasized the usefulness of a multi-center validation over a single center approach.

http://dx.doi.org/10.1016/j.ejmp.2016.07.291

MULTIINSTITUTIONAL NATIONAL STUDY FOR PLANNING COMPARISON ON DIFFERENT ANATOMICAL SITES

Carmelo Marino[a], Elisa Bonanno[a], Giuseppina R. Borzì[b], Laura Bottalico[c], Elisabetta Cagni[d], Claudia Carbonini[e], Michelina Casale[f], Marta Casati[g], Stefania Clemente[h], Rita Consorti[i], Valentina D'Alesio[c], Marco Esposito[j], Maria D. Falco[k], David Fedele[l], Christian Fiandra[m], Maria C. Frassanito[n], Randa E. Gawhary[o], Francesca R. Giglioli[p], Isidora Ielo[q], Valeria Landoni[g], Gianfranco Loi[r], Elena Lorenzini[s], Giulia Maggi[t], Tiziana Malatesta[o], Maria R. Malisan[u], Anna Martinotti[v], Enrico Menghi[w], Barbara Nardiello[x], Roberta Nigro[y], Caterina Oliviero[h], Gabriella Pastore[z], Mariagrazia Quattrocchi[aa], Riccardo Ragona[m], Irene Redaelli[ab], Giacomo Reggiori[t], Ruggero Ruggieri[ac], Serenella Russo[j], Michele Stasi[ad], Lidia Strigari[g], Elena Villaggi[ae], Pietro Mancosu[t]. [a]*Humanitas C.C.O., Catania, Italy* ; [b]*REM Radioterapia, Catania, Italy* ; [c]*Malzoni Radiosurgery Center Salerno, Agropoli, Italy*; [d]*IRCCS – Arcispedale Santa Maria Nuova, Reggio Emilia, Italy* ; [e]*ASST "Grande Ospedale Metropolitano Niguarda", Milano, Italy* ; [f]*Azienda Ospedaliera Santa Maria Terni, Terni, Italy*; [g]*Regina Elena Cancer Center IFO, Roma, Italy*; [h]*Azienda Ospedaliera Universitaria Federico II Napoli, Italy* ; [i]*ACO San Filippo Neri, Roma, Italy*; [j]*Azienda Sanitaria Firenze, Italy*; [k]*Fondazione Policlinico Tor Vergata, Roma, Italy*; [l]*Casa di Cura Privata San Rossore, Pisa, Italy*; [m]*Università di Torino, Torino, Italy*; [n]*Mater Dei Hospital, C.B. H. Città di Bari Hospital, Bari, Italy*; [o]*O.San Pietro Fatebenefratelli, Roma, Italy*; [p]*A.O.U. Città della Salute e della Scienza di Torino, Torino, Italy* [q]*A. O.U. Policlinico G. Martino, Messina, Italy*; [r]*A.O.U. Maggiore della Carità di Novara, Italy* ; [s]*Azienda USL 1 Massa e Carrara, Italy* ; [t]*Humanitas Clinical and Research Hospital, Rozzano (MI), Italy* ; [u]*A.O.U. di Udine, Udine, Italy*; [v]*Centro Diagnostico Italiano, Milano, Italy*; [w]*IRCCS–IRST, Istituto S.Romagnolo per lo Studio e la Cura dei Tumori, Meldola, Italy*; [x]*UPMC San Pietro FBF, Roma, Italy*; [y]*Ospedale S.Camillo de Lellis, Rieti, Italy*; [z]*Ecomedica Empoli, Italy*; [aa]*USL 2 Lucca, Italy*; [ab]*A.O. San Gerardo di Monza, Italy* ; [ac]*Ospedale Sacro Cuore – don Calabria, Negrar (VR), Italy*, [ad]*A.O. Ordine Mauriziano di Torino, Torino, Italy*; [ae]*AUSL Piacenza, Italy*

Purpose. The SBRT working group of Italian Association of Medical Physics (AIFM) performed 4 multicenter planning studies on patients who were candidates for SBRT in the treatments of prostate, liver, lung and spine cancer with the aim of evaluating the dosimetric consistency among the different hospitals.

Methods and materials. Plans were performed following the dose prescription of 35 Gy in five fractions for the planning target volume (PTV) on prostate, 54 Gy in 3 fractions for liver, 75 Gy in 3 fractions for lung and 3 fractions of 10 Gy for spine. Different techniques were used (3D-CRT, fixed-Field IMRT, VMAT, TomoTherapy, CyberKnife) and plans were compared in terms of dose-volume histogram (DVH) parameters.

Results. For prostate, important differences were found in terms of the HI. Doses to OARs were heterogeneous. For Liver, no significant correlations between technological factors and DVH for target and OARs were observed; the optimisation strategies selected by the planners played a key role in the planning procedure. For lung, significant correlations for PTV-gEUD2 versus PTV-HI, and MLD2 versus PTV-GI, were observed.

Conclusions. Important dosimetric differences with possible clinical implications, in particular related to OARs, were found. Multicenter clinical trials on SBRT should require a preplanning study to standardize the optimization procedure. The differences both in terms of target coverage and OAR sparing suggest intercomparison of DVH could be a useful tool to standardize treatment planning of stereotactic treatments before starting multicentric clinical trial.

http://dx.doi.org/10.1016/j.ejmp.2016.07.292

Physica Medica 32 (2016) 179–183

Contents lists available at ScienceDirect

Physica Medica

journal homepage: http://www.physicamedica.com

Abstracts from the 1st European Congress of Medical Physics: Invited Lectures Metropolitan Hotel|Aegean Sea Ballroom (Hall B) - September 2nd, 2016

PERFORMANCE EVALUATION OF HARDWARE AND SOFTWARE FOR SPECT CARDIAC IMAGING

Marco Brambilla. *University Hospital of Novara, Italy*

Myocardial perfusion SPECT is used in the non invasive assessment of coronary artery disease. This talk describes the design of new iterative reconstruction algorithms (IRR) and of heart-dedicated solid-state SPECT cameras for Myocardial Perfusion Imaging and discuss how these devices improve image quality while reducing study time and/or radiation dose to the patient.

Methods. The relative performances of IRR and gammacameras were studies over a wide range of acquisition count statistics, also in respect to conventional reconstruction software (OSEM and FBP), using an anthropomorphic phantom and selected physical figures of merit for image evaluation.

Results and discussion. IRR always determined significant improvements in all indices in comparison to FBP or OSEM. Their performances depend on the combined application of scatter and/or attenuation corrections that take full advantage of the capability of such algorithms. The impact of count statistics on the performances of IRR can be neglected down to a quarter of the reference study count statistics.

As for the new solid state gammacameras D-SPECT showed a lower LV wall thickness and an inferior sharpness than D530c. No significant differences were found in terms of contrast or CNR. The regional normalized tracer uptake is maintained across all count densities up to a quarter of a standard study count statistic with conventional cameras and half with advanced systems. To compare data from the analysis of polar maps across different systems will require the adoption of specific normality databases, developed for each system coupled with the reconstruction method employed.

http://dx.doi.org/10.1016/j.ejmp.2016.07.294

INTRODUCING THE EFRS AND TRANSLATING RESEARCH INTO CLINICAL PRACTICE

Graciano Paulo. *IPC – Escola Superior de Tecnologia da Saúde de Coimbra, Portugal*

The European Federation of Radiographer Societies (EFRS) was founded in 2008 by 27 professional societies of radiographers. Before that many European radiographer societies had been meeting and cooperating already since the nineteen fifties under the umbrella of the ISRRT.

Now in 2015 already 38 radiographer societies from 32 countries in the geographical region of Europe are registered as full member, 55 educational institutions from 25 countries joined as affiliate members and are cooperating in the EFRS educational wing.

Through its member organisations the EFRS represents more than 100.000 radiographers and 8000 radiography students in Europe.

Research in Radiography is essential for the development of the body of knowledge of medical imaging & radiotherapy and to contribute for the radiographer professional role development and advance practice.

Translating research evidence into clinical practice is essential to assure the development of the quality of the healthcare delivered to the patients. The EFRS Radiography Research Network (www.efrs-rrn.eu) is a powerful tool to promote and share the research that is being developed by Radiographers, to exchange experiences, to discuss new professional practices, with the objective to meet the patients' needs and expectations.

It is known that the translation of new knowledge into practice occurs through 3 stages: (a) awareness; (b) acceptance; (c) adoption.

The major challenge for the next decade is to build solid bridges between clinical and academic environments, with the objective to develop the Radiographers field of knowledge through evidenced based research.

Nothing to Disclose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.295

ESTABLISHING AND MONITORING DRLS

John Damilakis. *University of Crete, Greece*

Diagnostic Reference Levels (DRLs) have proven to be an effective tool for dose optimisation of protection in medical imaging. The 'Euratom Basic Safety Standards' states that *'Member States shall ensure the establishment, regular review and use of diagnostic reference levels for radiodiagnostic examinations, having regard to the recommended European diagnostic reference levels where available, and when appropriate, for interventional radiology procedures, and the availability of guidance for this purpose*'. The 'European DRLs for Paediatric Imaging' project (abbreviation: PiDRL) has very recently developed European Guidelines on how to establish and how to use paediatric DRLs.

DRLs should be established primarily for examinations that significantly contribute to the collective effective dose of the patient population. DRLs should be based on appropriate patient dose surveys. In general, it is recommended that from each institution a representative sample of at least 10 patients per procedure type and per patient group is needed for non-complex examinations such as radiography and CT and at least 20 patients per procedure type for complex procedures such as fluoroscopy and fluoroscopically guided procedures. For all body examinations, weight should be used as a parameter for patient grouping. Patient dose data should be col-

lected from a representative sample of various types of equipment and practices in the geographical area concerned. Dose management solutions can play a very important role in the establishment and use of DRLs.

http://dx.doi.org/10.1016/j.ejmp.2016.07.296

DOSE OPTIMIZATION IN PAEDIATRIC PATIENTS

Syrgiamiotis Vasilis. *General Children's Hospital of Athens Agia Sophia, CT- MRI Department, Greece*

Computer Tomography (CT) is under scrutiny because it has become the largest contributor to manmade radiation exposure. According to latest literature the radiation dose level is (today) in the same range as the annual natural background radiation of 3.1 mSv. The same patterns of utilization are observed in all industrialized countries and it is expected others to follow. Computer tomography is of great importance for imaging paediatric patients but due to the limitations that occur the right optimized exposure is imposed. As a consequence, the ALARA principle is of particular importance. In order to right dose we aim to invest in knowledge of basic principles, in innovative technologies providing CT examinations with low dose, in establishing PiDRLs in National level and in Dose management programs that can definitely optimize the applied scan doses and can control the daily clinical routine.

http://dx.doi.org/10.1016/j.ejmp.2016.07.297

PATIENT DOSE OPTIMIZATION IN FLUOROSCOPICALLY-GUIDED PROCEDURES

E.P. Efstathopoulos. *2nd Department of Radiology, University General Hospital 'Attikon', School of Medicine, National and Kapodistrian University of Athens, Athens, Greece*

The advances in digital imaging and the development of new interventional tools and devices resulted in a significant increase of about 80% in fluoroscopically-guided procedures the last two decades. Moreover, many fluoroscopically-guided procedures deliver high doses to the patients that might cause radiation-induced deterministic effects on patients, such as skin injuries and increase risk for stochastic effects. Therefore, there is an immediate need for patient dose optimization to minimize risks associated with fluorosco pically-guided procedures.

The goal of dose optimization is to reduce radiation dose without affecting diagnostic quality or therapeutic outcome. In general, a dose optimization process includes: gradual modification of the parameters that affect radiation dose, evaluation of image quality for different dose levels and determination of a threshold of diagnostic acceptable image quality for the specific clinical task. The efficacy of optimization must be verified and the process must be repeated for all clinical protocols. The optimization of patient dose requires continuous education and training of staff on radiation protection issues, quality assurance programs and effective communication of all stakeholders. Monitoring and recording of patients' radiation dose, evaluation of image quality and patients' follow-up are essential tools for the optimization procedure.

The aim of this presentation is to highlight the need for patient dose management, present the most common dose saving techniques and discuss the impact and the challenges of patient dose optimization in fluoroscopically-guided procedures.

http://dx.doi.org/10.1016/j.ejmp.2016.07.298

WHAT THE CLINICAL STAFF KNOW AND UNDERSTAND

Jonathan L Portelli. *University of Malta, Malta*

By February 2018 each Member State is required to transpose Council Directive 2013/59/EURATOM into national legislation, so as to lay down updated safety standards for the protection against dangers arising from exposure to ionising radiation. Professionals contributing to medical radiation exposures, particularly those recognised as referrers or practitioners will have several key responsibilities to fulfil, such as committing their involvement in the justification and/or optimisation processes of each individual exposure. Additionally referrers and/or practitioners will have the responsibility to provide each patient with adequate information relating to the benefits and risks associated with the radiation dose to be received.

In light of these key responsibilities, it stands to reason that apart from having a sound understanding of radiation protection principles, referrers and practitioners need to be knowledgeable of the radiation doses and risks associated with medical imaging examinations they refer or perform. Unfortunately however, research evidence suggests that this is not always the case, with numerous studies similarly reporting poor radiation knowledge amongst referrers and/or practitioners. Questions therefore arise as to what effect this lack of knowledge may have in the justification and optimisation of medical exposures. Furthermore, if referrers and/or practitioners are not aware of the radiation doses and risks of medical examinations, how can they communicate adequate information to patients?

In this context, this talk will highlight how research investigating referrers' and practitioners' radiation knowledge and practice of communicating benefit-risk information, can help identify knowledge gaps and misconceptions amongst different professions; encourage self-reflection; and offer motivation for professionals to engage in team efforts so as to enhance the radiation protection culture within their work environment.

http://dx.doi.org/10.1016/j.ejmp.2016.07.299

MOVING BEYOND QUALITY CONTROL IN DIAGNOSTIC RADIOLOGY

H. Delis, A. Meghzifene. *Dosimetry and Medical Radiation Physics Section, Division of Human Health, IAEA, Austria*

Quality control (QC), according to ISO definitions, represents the most basic level of quality. It is considered to be the snapshot of the performance or the characteristics of a product or service, in order to verify that it complies with the requirements.

Although it is usually believed that "the role of medical physicists in Diagnostic Radiology is QC", this, not only limits the contribution of medical physicists, but is also no longer adequate to meet the needs of Diagnostic Radiology in terms of Quality.

In order to assure quality practices more organized activities and efforts are required in the modern era of diagnostic radiology. The complete system of QC is just one element of a comprehensive quality assurance (QA) program that aims at ensuring that the requirements of quality of a product or service will consistently be fulfilled. A comprehensive QA system, starts even before the procurement of any equipment, as the need analysis and the development of specifications are important components under the QA framework.

Further expanding this framework of QA, a comprehensive Quality Management System can provide additional benefits to a Diagnostic Radiology service. Harmonized policy and procedures and elements such as mission statement or job descriptions can provide clarity and consistency in the services provided, enhancing the outcome and representing a solid platform for quality improvement.

The IAEA promotes this comprehensive quality approach in diagnostic imaging and especially supports the field of comprehensive clinical audits as a tool for quality improvement.

http://dx.doi.org/10.1016/j.ejmp.2016.07.300

THE ROLE OF COMPREHENSIVE CLINICAL AUDITS IN QUALITY IMPROVEMENT IN DIAGNOSTIC RADIOLOGY

Keith Faulkner. *Consultant Medical Physicist, United Kingdom*

There is much interest in QA processes and quality improvement in diagnostic radiology, driven by a number of factors. These include the high cost of radiological equipment, the ever increasing complexity of examination equipment and examination procedures due to technical advances, an acknowledgement of the possibility of increasing doses to patients, and the importance of radiological diagnosis to patient management within the health care. The importance of these matters has been acknowledged within Europe through a European Council directive and by the International Atomic Energy Agency through the development of the QUAADRIL audit process.

Clinical audit involves evaluation of data, documents and resources to check performance against standards. It is essentially a process of fact finding and interpretation and, as such, provides an efficient tool for improvement of quality. The purpose of a multidisciplinary clinical audit can be generally summarized as to improve the quality of patient care; promote the effective use of resources; enhancing the provision and organization of clinical services; and to further professional education and training

The principles and criteria for good practice of the medical physics aspects of radiology involve the available facility infrastructure, radiation protection and safety, imaging equipment QA processes, optimization in clinical practice, dosimetry, and instrumentation and calibration. All policies and procedures should be documented and regularly updated, and be available to staff at all times.

This presentation will describe the QUAADRIL clinical audit process and summarise some of the key findings from the application of the audit tool in various centres worldwide.

http://dx.doi.org/10.1016/j.ejmp.2016.07.301

ACQUISITION PROTOCOLS FOR 18F-FDG WHOLE BODY PET/CT: OPTIMIZING SCAN DURATION VERSUS ADMINISTERED DOSE

Søren Holm. *Dept. of Clinical Physiology, Nuclear Medicine and PET, Rigshospitalet, University Hospital Copenhagen, Denmark*

The stochastic nature of radionuclide decay is a limiting factor for all NM imaging, including PET-examinations with 18-F FDG. Signal to noise ratio (SNR) depends on integrated #counts C that for given object ideally scale by activity-time product A*t. A determines radiation dose to the patient, while examination time t is important for department efficiency. Many factors affect the real function C(A,t); A and t cannot be chosen freely, and SNR cannot be expressed in a closed form as a function of A,t and patient size (height h, weight w).

In PET, true coincidences (T) are counted together with Random (R) and scattered coincidences (S) that must be corrected for, resulting in Noise Equivalent Counts (NEC) being considerably lower than T. While T and S (neglecting dead time) scale with A, R scales with A^2. For any object and time, the function NEC(A) will deviate from linearity and reach a maximum (A_m), NEC_m before declining. NEC (A) is often a very flat curve, so even a significant, dose-saving reduction in A below A_m will not affect NEC much.

T decreases exponentially with patientsize (−10%/cm). The ratio R/T as well as the scatter fraction S/(T + S) increases. Thus, for given A and t, NEC(w) decreases.

It is common to scale A in proportion to weight w. A quadratic relation has been proposed and validated but is feasible only up to a certain A_{max}. Other schemes determining (A,t) (h,w) from tables will be shown. For larger w, increase in t is the only viable possibility.

http://dx.doi.org/10.1016/j.ejmp.2016.07.302

RADIATION DOSE FROM DUAL ENERGY CT APPLICATIONS

Mannudeep K. Kalra, MD. *Massachusetts General Hospital and Harvard Medical School, Boston, MA, USA*

Dual energy CT has emerged as a topical scanning technique with advances in MDCT technologies which enable near simultaneous acquisition of scan data at two separate kV or energy levels. Major applications in kidney stone characterization, pulmonary CT angiography, gout evaluation and differentiation of blood and contrast media have been reported. Due to differences in acquisition techniques for dual energy CT between different vendor offerings, it is important to keep in mind that these variations have important implications on associated radiation doses. While recent publications suggest that radiation doses with dual energy CT are similar to single kV scanning techniques, these data should not be generalized without appropriate analysis of local practices and thorough rationale for clinical applications. In this presentation, we will review radiation dose aspects of dual energy CT using different acquisition techniques.

http://dx.doi.org/10.1016/j.ejmp.2016.07.303

RADIATION PROTECTION OF CHILDREN – FROM STANDARDS TO PRACTICE

Jenia Vassileva. *International Atomic Energy Agency, Austria*

The new International Basic Safety Standards on Radiation Protection and Safety of Radiation Sources (the BSS), published in 2014, identifies two particular groups of patients for special consideration with respect to justification and optimization: patients who are pregnant or are children. Owing to the higher radiosensitivity of the embryo or fetus, knowledge about the pregnancy status of a female patient is useful before a diagnostic or therapeutic radiological procedure is performed. Similarly, as children are at greater risk of incurring radiation-induced stochastic effects, paediatric examinations or procedures necessitate special consideration in the justification process. Once judged appropriate, the procedure should be optimized to manage the radiation dose to the patient commensurate with the medical purpose. For medical radiological equipment used for performing radiological procedures on children, there should be additional design features that both facilitate successful radiological procedures on patients who may be uncooperative and suit the imaging of very small patients. Special attention should be given to developing protocols for children adapted to body size and age, from neonates to teenagers. As a tool for optimization of patient protection, the BSS requires that diagnostic reference levels (DRLs) for paediatric patients are established and used. IAEA is supporting countries/regions in their effort to implement the international requirements, by providing information, guidelines and practical tools. The current projects under the Technical Cooperation (TC) program also include actions to support Member states in strengthening their actions on radiation protection of children.

http://dx.doi.org/10.1016/j.ejmp.2016.07.304

UNBORN CHILDREN: RADIATION PROTECTION IN PREGNANCY

John Damilakis. *University of Crete, Greece*

A diagnostic or interventional X-ray examination of a pregnant patient is sometimes considered to be necessary. In these cases, conceptus dose estimation is needed to assess radiogenic risks to the unborn child. During extra-abdominal examinations, the unborn child is exposed to scattered radiation and in most cases its dose is lower than 1 mGy. A detailed embryo/fetus dose evaluation is not needed for these examinations. Abdominal and/or pelvis X-ray examinations may deliver higher radiation doses to the conceptus. An abdominal CT examination performed on the mother is associated with an embryo/fetus dose of about 10–25 mGy. However, this is only a typical range of dose values. The actual dose depends on factors such as exposure parameters, x-ray tube filtration and use of dose reduction tools such as automatic exposure control. Doses to the unborn child below 100 mGy should not lead to therapeutic abortion. The risk to the embryo/fetus for stochastic effects is assessed on the basis of radiation dose using appropriate conversion coefficients provided by international organizations. Several methods have been developed to estimate doses to unborn children from X-ray examinations. CODE (COnceptus Dose Estimation) is a free web-based software tool (uploaded on embryodose.med.uoc.gr) developed for the estimation of conceptus radiation dose and risks in case of: a) pregnant patients subjected to radiological examinations and b) pregnant employees exposed during fluroscopically guided interventional procedures.

http://dx.doi.org/10.1016/j.ejmp.2016.07.305

OPTIMIZATION OF PAEDIATRIC CT

Mannudeep K. Kalra. *Massachusetts General Hospital and Harvard Medical School, Boston, MA, USA*

Children have a special place in the hearts of their parents and the same should be true for CT practices too! They have longer life expectancy, more dividing cells which have greater risk potential from radiation exposure. Plus, they can range from less than a kilogram to more than 100 kg with childhood obesity. Younger children also provide additional challenges when they cannot or do not cooperate during CT scanning, which can result in motion artifacts and suboptimal interpretations. These issues demand special attention to details during paediatric CT. The best way to optimize dose for children is to rationalize clinical indications for CT in children. Whenever possible and appropriate, non-ionizing radiation based imaging techniques should be used in children. When CT is appropriately indicated, careful attention must be given to patient positioning and counselling. Several scan techniques can help optimize radiation doses, and these must be liberally employed. Each paediatric CT should be tailored to personalize scan technique, image reconstruction and radiation doses to specific clinical indication, body region, and patient size. In this presentation, we will review strategies to optimize paediatric CT.

http://dx.doi.org/10.1016/j.ejmp.2016.07.306

SIZE SPECIFIC DOSE ESTIMATES IN PEDIATRIC CHEST, ABDOMEN AND PELVIS CT EXAMINATIONS

Aysegul Yurt [a], Ismail Ozsoykal [a], Kadir Akgungor K. [b]. a*Dokuz Eylul University, Department of Medical Physics, Turkey*

[b] *Dokuz Eylul University, Department of Physics, Turkey*

Introduction. Volume computed tomography dose index (CTDIvol) does not contain any dose information regarding the patient size. Size specific dose estimates (SSDE) give more reliable results accounting for the patient size as well. This parameter uses CTDIvol and size dependent conversion factors (fDw) which are calculated by means of water equivalent diameter (Dw) of the patient cross section in every slice of image.

Purpose. To develop software to automatically calculate SSDE and to assess the impact of variations in Dw along the z axis on SSDE for CT examinations of the torso in pediatric patients.

Materials and methods. 55 consecutive CT exams of the combined chest, abdomen and pelvis (CAP) have been examined. SSDE has been calculated for 6 hypothetical scan ranges: chest alone, abdomen alone, pelvis alone, chest and abdomen, abdomen and pelvis, and CAP. Two methods were used in mean SSDE approach: (1) mean SSDE over each scan range; (2) SSDE value at the middle of the scan range.

Results. For scan ranges 1 to 6, the average of the difference in maximal and minimal Dw accross patients was 3.7, 3.8, 2.6, 4.1, 4.4 and 4.5 cm. The mean SSDE values calculated using methods (1) and (2) were highly compatible, with root mean square differences of 0.4, 0.5, 0.3, 1.0, 1.5 and 0.7 mGy or 3%, 4%, 2%, 7%, 10%, 5%.

Conclusion. Using the mean CTDIvol and the water equivalent diameter at the middle of the scan range provides a reasonable estimation of patient dose in pediatric exams.

http://dx.doi.org/10.1016/j.ejmp.2016.07.307

THE ESTABLISHMENT OF LOCAL DIAGNOSTIC REFERENCE LEVELS FOR PEDIATRIC CT

Birute Griciene [a,b], Milda Petkelyte [a,b], Arijanda Neverauskiene [a,c], Linas Petkevicius [d,a]. a*Vilnius University, Faculty of Medicine, Lithuania*

[b] *Department of Clinical Radiation Surveillance, Vilnius University Hospital Santariskiu Klinikos, Lithuania*

[c] *Centre of Radiology, Children's Hospital, Affiliate of Vilnius University Hospital Santariskiu Klinikos, Lithuania*

[d] *Vilnius University, Faculty of Mathematics and Informatics, Lithuania*

Introduction. Computed tomography (CT delivers more than a half of collective effective dose received at medical diagnostic procedures. It is recommended that routine procedures have diagnostic reference levels (DRLs) set and kept up-to-date, especially for pediatric examinations.

Purpose. The main objective of this study is to analyse dose trends in 2010–2014, identify future optimisation targets and set local DRLs for most common pediatric CT examinations.

Materials and methods. A retrospective study of pediatric (<18 y) patients that underwent CT examinations in 2010, 2012 and 2014 was done. Effective dose was calculated. The mean DLP, CTDIvol values were estimated for age groups, body area scanned and compared to national and European DRLs.

Results. 2042 examinations were analysed, most of them (57.9%) head CT scans. Head dose decreased in all age groups from 2,9 to 1,6 mSv. In 2014 the mean DLP for head was 267, 293, 313 and 371 mGy* cm for patients aged 0–1, 1–5, 5–10 and 10–18 years respectively; the mean DLP for chest was 74, 199 and 303 mGy* cm for patients aged 1–5, 5–10 and 10–18 years; the mean DLP for pelvis was 69, 91, 159 and 284 mGy* cm for patients aged 0–1, 1–5, 5–10 and 10–18 years. The local DRLs for head, chest and pelvis CT were set.

Conclusion. For CT procedures the comparison between local DRLs and the national DRLs shows that doses don't exceed the recommended levels. While CT dose decreases, it is important to ensure that examinations are performed at optimised state.

Disclosure. None.

http://dx.doi.org/10.1016/j.ejmp.2016.07.308

ESTIMATING PATIENT DOSE AND RADIOLOGY PRACTICE FROM INTERVENTIONAL CARDIOLOGY PROCEDURES IN THE PAEDIATRIC CARDIOLOGY DEPARTMENT IN BULGARIA

Kostova-Lefterova. *National Cardiology Hospital, Bulgaria*

Introduction. The radiation dose from interventional cardiology procedures is essential when treating children because of their greater radiosensitivity compared with adults.

Purpose. The purpose of the present study was to estimate patient dose and radiology practice from interventional procedures in the only paediatric cardiology department in Bulgaria. The dedicated angiographic equipment is used for both adult and paediatric procedures.

Materials and methods. Data for 54 paediatric patients was collected over a five month period. Two most common procedures were included: coronary angiography (CA) (42 patients) and percutaneous coronary intervention (CA + PCI) (12 patients). For each patient the following information was collected: sex, age, weight, and height, frame rate, total fluoroscopy time (FT), number of acquired series/images, dose area product (DAP) and kerma at IRP. Body mass index for each patient was calculated.

Results. Data were analyzed by grouping the patients in age and weight groups, and comparison will be presented. For children who underwent CA procedures a weak correlation was found between the DAP and weight values ($r_2 = 0.627$). Large variation of the dose parameters were found within the groups. For better statistics age groups are presented. The average DAP values for CA procedures were 137.6 (range 54.9–285.04) cGy.cm^2 for age group (0–12 months), 269.8 (48.4–830.2) cGy.cm^2 for (1–4 years), 275.8 (54.5–751.0) cGy.cm^2 for (5–9 years) and 878.7 (313.6–1766.4) cGy.cm^2 for (10–15 years). Data for CA + PCI procedures was analyzed for groups (1–4 years) and (10–15 years). The average DAP values were 457.8 (177.2 –1037.2) cGy.cm^2 and 948.2 (703.9–1318.4) cGy.cm^2 respectively. The average FT for CA was: (0–12 m)–12.0 (6.7–26.6) min; (1–4 y)–15.7 (1.7–40.6) min; (5–9 y)–10.1 (0.9–30.3) min; (10–15 y)–11.6 (2.9–31.0) min. The average kerma at IRP values for CA were: 16.0 (7.6–41.52) mGy for (0–12 m); 18.5 (4.2–54.2) mGy for (1–4 y); 17.2 (2.6–45.7) mGy for (5–9 y) and 51.0 (15.1–126.3) mGy for (10–15 y). The average FT for CA + PCI was: 25.8 (4.8–65.7) min for (1–4 y) and 17.5 (7.6–27.1) min for (10–15 y). The average kerma at IRP values for CA + PCI were: 37.1 (15.1–77.7) mGy for (1–4 y) and 50.2 (39.2–77.1) mGy for (10–15 y).

Conclusion. The dose values are lower than the typical doses for adult patients but higher than reported from other studies which shows the potential for optimization of the radiology practice.

http://dx.doi.org/10.1016/j.ejmp.2016.07.309

Physica Medica 32 (2016) 184–187

Contents lists available at ScienceDirect

Physica Medica

journal homepage: http://www.physicamedica.com

Abstracts from the 1st European Congress of Medical Physics: Invited Lectures Eugenides Foundation|Main Auditorium (Hall A) - September 3rd, 2016

TOLERANCE LEVELS AND METHODOLOGIES FOR IMRT VERIFICATION QA

Dimitris Mihailidis [a], Niko Papanikolaou [b]. [a]*University of Pennsylvania, United States*; [b]*University of Texas Health Sciences Center San Antonio, United States*

Purpose. Patient-specific IMRT QA measurement is a process designed to identify discrepancies between calculated and delivered doses. Error tolerance limits are not well-defined or consistently applied across centers. To improve the understanding and consistency of this process, the AAPM TG-218 report provides recommendations for tolerance limits and methodologies in patient-specific IMRT QA.

Methods. The performance of the dose difference/distance-to-agr eement (DTA) and gamma verification metrics are investigated. Measurement methods are reviewed and followed by a discussion of the pros and cons of each. Methodologies for absolute dose verification are discussed and new IMRT QA verification tools are presented. Literature on the expected or achievable agreement between measurements and calculations for different types of planning and delivery systems was reviewed and analyzed. Different vendor implementations of verification algorithms were tested using benchmark cases.

Results. Operational shortcomings that can reduce the tool effectiveness and accuracy for IMRT QA are described. Practical considerations including spatial resolution, normalization, dose threshold, and data interpretation are discussed. Published data on IMRT QA and the clinical experience of the group members were used to develop guidelines and recommendations on tolerance and action limits for IMRT QA.

Conclusion. Recommendations on delivery methods, data interpretation, normalization, the use of gamma analysis routines and choice of tolerance limits for IMRT QA are made. The focus is on detecting differences between calculated and measured doses using robust analysis methods and an in-depth understanding of IMRT verification metrics. The recommendations are intended to improve the IMRT QA process and establish consistent and comparable criteria among institutions for IMRT QA.

http://dx.doi.org/10.1016/j.ejmp.2016.07.312

GENERAL OVERVIEW ON CHARGED PARTICLE THERAPY: CURRENT STATUS AND FUTURE CHALLENGES

Mario Ciocca. *Fondazione CNAO, Medical Physics Unit, Pavia, Italy*

Ion beam radiotherapy is rapidly growing worldwide: 15 centers are currently operative in Europe (3 for carbon ions also), while other 15 are under construction or in planning stage. The main advantage of charged particles over photons is represented by significantly lower energy deposition in the patient (i.e. similar clinical target coverage combined to reduced dose to the normal tissues). Cyclotrons and synchrotrons are mostly used to accelerate ion beams, while pencil beam scanning modality is replacing passive scattering. Fully rotating isocentric and fixed beam lines can be nowadays be considered as a standard choice for protons and carbon ions, respectively, only two existing facilities (HIT and NIRS) being equipped with a very heavy gantry for carbon ions. Dedicated devices and phantoms for accurate dosimetry, commissioning and fast QA in particle therapy are available, including 2-D scintillators, Bragg Peak and multi-layer ion chambers. In-patient ion range and RBE determination represent the two main specific sources of uncertainty, while organ motion management is still highly challenging. The main research activities include microdosimetry, by means of mini-TEPCs, ultra-thin silicon detectors or synthetic microdiamonds, adaptive radiotherapy using in-room volumetric imaging devices, robust optimization, in vivo range verification (PET, prompt gamma and secondaries, proton radiography). Besides protons and carbon ions, the interest is increasing for fast helium ions, expected as beneficial for paediatric patients, for example, thanks to lower fragmentation tail and RBE than carbon ions, while less lateral beam scattering compared to protons.

http://dx.doi.org/10.1016/j.ejmp.2016.07.313

EXPECTED CLINICAL BENEFITS AND CHALLENGES OF PARTICLE THERAPY FOR PAEDIATRIC TUMOURS

Solveig Schulz [a], Felicitas Guntrum [a], Christian Bäumer [b], Beate Timmermann [a]. [a]*Clinic for Particle Therapy at West German Proton Therapy Centre, University Hospital Essen, Germany* ; [b]*West German Proton Therapy Centre, Germany*

Proton therapy for non-ocular tumours in children is a relatively new development in Europe. Main arguments for proton therapy are the reduced risk for secondary cancers as well as a more precise sparing of organs at risk (OAR).

Due to interdisciplinary advances more children survive their childhood cancer and have to deal with late effects of their primary cancer treatment.

Children are by about a factor of ten more sensitive to radiation-induced malignancies than adults. Due to a smaller body volume, the scattering is more significant than in the (larger) body of an adult. At the West German Proton Therapy Centre (WPE) 276 children were treated between 06/2013 and 05/2016. 190 patients were 0–10 years, 86 were 11–18 years old. 154 patients needed anaesthesia.

The most frequent malignancies treated were CNS tumours (145) and sarcomas (107). Very precise radiation volumes can be achieved e.g. in retroperitoneal malignancies, cranio-spinal axes, ENT and CNS tumours. Sparing of OAR, such as brain stem, hippocampus, pituitary gland, cochlea, chiasma, lacrimal and salivary glands is very important to reduce late side-effects and preserve quality of life.

A main challenge of proton therapy remains the prolonged time for treatment planning. Metal or breathing movements in the irradiated volume pose additional challenges and sometimes develop into a pitfall during treatment planning. Similar problems occur, if density changes happen (e.g. growing or shrinking of cysts in the PTV, air inclusions). An adhoc adaption of the treatment plan is not simply arranged, but takes time.

http://dx.doi.org/10.1016/j.ejmp.2016.07.314

THE FUTURE ROLE OF PARTICLE BEAMS IN THE TREATMENT OF PEDIATRIC TUMOURS, BY A MEDICAL PHYSICS POINT OF VIEW

A. Bolsi, T. Lomax, D.C. Weber. *Centre for Proton Therapy, Paul Scherrer Institute (CH), Switzerland*

Proton therapy, as compared to standard photon radiotherapy, presents the advantage of sparing non-target tissue. This is especially important for treatments of paediatric patients, where the reduction of integral dose and dose to organs at risk can significantly improve children's quality of life, while reducing the risk for late toxicity, not limited but including secondary malignancies.

Cranio-spinal irradiation with protons represents a good example of reduced integral dose, as the dose to all anatomical structures anterior to the spinal cord (such as kidneys, heart, liver) are reduced when compared to photon treatments.

Those advantages are increased by the use of proton beam scanning technique (PBS) as compared with passive scattering, due to more accurate proximal dose conformity and to the use of Intensity Modulated Proton therapy (IMPT) for OARs sparing in vicinity of the target. From medical physic's perspective, the efforts are focused in further exploiting those advantages in different areas, such as: (i) evaluation of optimal fields' number, as a compromise between dose conformality and plan robustness; (ii) plan evaluation considering radiobiological effects (i.e. LET) (iii) dose sparing for sensitive functional structures; (iv) reduction and optimisation of PTV margins; (v) improvement in image guidance for positioning, in order both to reduce dose and to increase positioning accuracy. This could be obtained by extensive use of MRI for daily positioning (no extra dose, high soft tissue contrast).

Paediatrics proton treatments already present several advantages if compared to standard photon treatments; the medical physics role is to exploit them even further.

http://dx.doi.org/10.1016/j.ejmp.2016.07.315

SUCCESSES AND CHALLENGES OF E-LEARNING PRACTICAL INTRODUCTION IN MEDICAL PHYSICS EDUCATION AND TRAINING

Slavik Tabakov. *King's College London, UK*; *International Organization for Medical Physics, UK*

Introduction. The presentation is based on over 15 years everyday use of e-learning in the teaching process. It incorporates the findings of several feedback collections and assessments (by students and teachers).

Purpose. The successes of practical introduction of e-learning in medical physics, as well as the challenges faced in this process, will be useful to a wide audience of educators.

Methods. The presentation describes the methods used for development of e-learning materials; the paradigm and the process of practical use; the testing and assessment of e-learning. Statistics from the use of these materials and their web sites will be used to support the findings.

Results. The results include the implementation of c.250 e-learning practical tasks. The paradigm plus quick dissemination was found essential for their success. Similarly, the flexibility built into the e-learning materials, allowed potential modification and easy implementation. The uncomplicated e-platform led to increased longevity of the materials, also allowing updates. The international implementation of the e-learning materials (c.70 countries) was supported by the introduction of Multilingual Dictionary of Medical Physics Terms. The greatest challenge was associated with the constantly changing e-learning software format, this being the main reason for the short life of most e-learning materials. Interactive teaching materials are specially affected by this issue.

Conclusion. The presentation underlines the need of e-learning in medical physics and shows the link between its application and the growth of medical physicists globally. e-Learning is presented as essential for education/training, especially when it is blended with classical learning.

http://dx.doi.org/10.1016/j.ejmp.2016.07.316

THE SOCIAL WEB: A NEW COMMUNICATION MEDIUM AND SCIENTIFIC EVALUATION TOOL

Gaspar Sánchez Merino. *Araba University Hospital, Spain*

The term Web 2.0 describes World Wide Web sites that emphasize user-generated content, usability, and interoperability. It was popularized by Tim O'Reilly and Dale Dougherty at the O'Reilly Media Web 2.0 Conference in late 2004, though it was coined by Darcy DiNucci in 1999. An important part of Web 2.0 is the Social web, consisting of a number of online tools and platforms where people share their perspectives, opinions, thoughts and experiences.

Nowadays, the Social Web is highly accepted in the general population, and it can be regarded as an imperative communication tool; yet scientific community remains reluctant to exploit its potential. A recent study showed that the adoption of the social Web by 1517 highly cited scientist is very low, being LinkedIn the most popular. In a survey conducted by Nature in 2014 with 3509 respondents, more than 88% of scientists and engineers said that they were aware of Google+ and Twitter with little difference between countries, but still only 15% visited those sites regularly.

In this work, we present the main Web 2.0 tools in the context of communication medical physics and scientific research. Furthermore, we analyze its potential value as a scientific evaluation tool by introducing the concept of altmetrics.

http://dx.doi.org/10.1016/j.ejmp.2016.07.317

TRUTH OR DARE: ACHIEVING LOWER RADIATION DOSES IN CT

Euthimios M. Agadakos. *Panhellenic Society of Radiological Technologists, General Hospital of Athens LAIKO, Greece*

The continuous evolution of computed tomography (CT) technology has allowed for wider clinical CT utilization. However the increased radiation doses associated with CT have raised concerns about the risk of carcinogenesis among Radiation Protection Authorities, health professionals and patients. Although the benefit of a justified CT examination by and large outweighs the risk, optimization of the procedure is essential to further this risk. Moreover CT

manufacturers have developed several dose reduction tools and dose alert platforms to modulate and record the radiation doses administered to patients.

The scope of this presentation is to outline the significance of optimization in CT, to describe CT parameters, scanner dose output indices and the methodology to reduce dose without compromising diagnostic quality.

Learning Outcomes: Following the presentation, participants will be able to:

1. Demonstrate the difference between CT scanner output and effective dose.
2. Fine-tune dose reduction parameters ensuring ALARA and according to clinical requirements (i.e. mAs and kV modulation, section collimation, detector array selection, pitch).
3. Distinguish between noise reduction iterative reconstruction algorithms and dose.
4. Correlate CT dose indices to national DRLs.
5. Participate in CT protocol design and continuous quality improvement programs.
6. Promote Radiation Protection Campaigns (i.e. Image Wisely, Image Gently, Eurosafe Imaging, RPOP).

No disclosures.

http://dx.doi.org/10.1016/j.ejmp.2016.07.318

ANGIOGRAPHY – NEUROINTERVENTIONAL LABORATORY PROCEDURAL SAFETY ISSUES

Konstantinos Thanassoulas. *Department of Medical Imaging, Korgialeneio – Benakeio Hospital Athens, Greece*

Interventional Radiology is a rapidly evolving field since its founding. Consecutively, the constant growth of Angiography as a tool for endovascular diagnosis and treatment has further enhanced the need for expertise. Furthermore the introduction of Neuroradiology, a novel specialty revealed additional safety issues which had to be dealt with by Interventional Radiographers.

In the past, the responsibilities of a radiographer within the Interventional Imaging team were somewhat limited. However, recent technological advances in diagnostic and therapeutic applications mandate for Radiographer involvement.

Interventional procedures such as Angioplasty, Central Nervous System Embolisms have encouraged Radiographers in communicating radiation protection policy and practical tips to other members of the Angiography Team. The collaboration with other medical specialties has also extended the Radiographer's role, as one often assumes that of the tutor for health professionals unaware or with little knowledge of ionizing radiation safety issues.

Finally the growth in the areas of mechanical and software engineering (Biplane Angiographic systems, 3D angiography, Rotational angiography etc.) necessitate for Radiographers to get intensely involved with crucial matters relating to the safe completion of the procedure, such as image manipulation and equipment handling.

Radiographers in the angiography suite are an ever changing and involving specialty within Radiology. New procedures and technological breakthroughs initiate for radiographer role expansion in order to adapt to innovation and hence to achieve the optimal outcome safely and timely for both, the patient and staff.

Nothing to disclose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.319

THE IMPACT OF MEDICAL INFORMATICS ON SAFETY AND QUALITY ASSURANCE

Nikolaos Delikanakis. *Department of Medical Imaging, Korgialeneio – Benakeio Hospital, Athens, Greece*

Health Informatics have radically changed the way medical imaging and radiotherapy services are delivered and they continue to evolve rapidly. Apart from the modality-specific post-processing techniques that have improved the clinical outcomes of the procedures and led to the development of novel techniques, medical networks has also played an important role in improving the quality and safety during the delivery of those services.

Widespread use of networks has allowed for more efficient sharing of important information about the patient, his medical history and the requirements of the requested procedures. This can improve the workflow, lead to more appropriate planning of the procedures and radically decrease the possible hazards and adverse effects on the patient. Besides, the availability of exam data and meta-data can provide valuable information which can be used to assess the established practices and point out possible shortcomings or opportunities for possible improvement.

Medical imaging networks operate according to established standards that ensure the exchange of data between the components of the network and the modalities but allow certain flexibility in their implementation in order to be applicable in all different modalities and facilities. So, it is important responsibility of all the professionals involved in all steps of the work routine to refine the use of network data according to the needs of the facility and develop consistent and efficient ways of handling all possible challenges.

http://dx.doi.org/10.1016/j.ejmp.2016.07.320

IMAGE GUIDED RADIATION THERAPY: A SAFETY PRACTICE

Anastasia Sarchosoglou Radiotherapy Radiographer, MSc. *General Oncological Hospital of Kifissia "Agii Anargiri", Greece*

The aim of this presentation is to provide an understanding of the role of Image Guided Radiation Therapy (IGRT), the factors and activities that required for its safe and effective implementation.

The goal of radiation therapy is to deliver high dose to target volume while minimizing the dose to surrounding healthy tissues. Sophisticated radiotherapy techniques could achieve this goal but require accuracy and high precision as during treatment delivery many uncertainties and errors may arise that could result in higher toxicity and poor local control.

Image Guided Radiation Therapy is the process that images are taken prior and during a course of radiation treatment, to assess the accuracy of the radiation field placement and improve it if necessary. Various IGRT technologies are now widely available with all major imaging modalities represented.

To ensure safe and accurate radiation therapy IGRT has to be carefully implemented developing comprehensive quality assurance programs and protocols for image acquisition and interpretation. Consideration should be given to factors that may influence the efficiency of the process such as effective communication of radiotherapy team, continuous education and training.

Image guidance plays a vital role in radiation therapy providing tools for safe and precise treatments leading to improved therapy outcomes.

http://dx.doi.org/10.1016/j.ejmp.2016.07.321

FETAL DOSE FROM RADIATION THERAPY

Michalis Mazonakis. *Department of Medical Physics, University of Crete, Heraklion, Greece*

The diagnosis of cancer during pregnancy is relatively rare with an incidence up to 0.1%. External-beam radiotherapy may be the treatment of choice for several pregnant patients with malignancies outside the abdominopelvic region. However, radiotherapy at any site above the diaphragm unavoidably exposes the fetus to head leakage radiation and to scattered radiation generated from the therapy machine or within the patient's body. This fetal radiation exposure may increase the probability for the induction of deterministic and/or stochastic effects.

The decision to proceed to radiotherapy can be made only if the fetal dose and the relevant risks are estimated before patient's irradiation and considered as acceptable. This presentation will describe the procedure of fetal dose determination which is usually performed with thermoluminescent dosimeters placed on physical phantoms simulating the full-scatter geometry of a pregnant patient. Computational methods, based on Monte Carlo simulations on mathematical humanoid phantoms, have also been carried out for estimating the conceptus dose. The possibility of fetal dose reduction with special shielding devices will be discussed. The dependence of the conceptus dose upon the shielding dimensions and the shielding location in respect to the treatment volume or patient's abdomen will be defined. Practical guidelines will be provided for the protection of the fetus during the treatment planning process. Fetal dose measurements/calculations from radiation therapy for brain, head-neck and breast cancer will be presented. The variation of the fetal dose and risks with the gestational age during treatment and the irradiation parameters will also be determined.

http://dx.doi.org/10.1016/j.ejmp.2016.07.322

ADVANCES IN HADRONTHERAPY DOSIMETRY

L. Raffaele. *Laboratori Nazionali del Sud, INFN, Catania, Italy*

This paper investigates suitability of two new commercial solid-state detectors as alternative to reference detectors for dosimetry of proton and carbon ion beams, as for scattered and scanned beams.

Investigated detectors are PTW microDiamond and PTW PR 60020 diode that have very small measuring volume with extremely reduced thickness of active detector layer (1 μm for diamond, 20 μm for diode).

Both detectors were tested in 62 MeV ocular proton therapy beam (INFN-LNS), PTW microdiamond was tested in clinical scanned carbon ion beams up to 400 MeV/u (CNAO), PTW PR 60020 Dosimetry was tested in scanned proton beams up to 250 MeV (CNAO).

As for scattered and scanned proton and carbon ion beams, both detectors showed excellent *short-term precision* (<0.5%), a good linear behavior with dose ($R^2 = 1$) and dose rate independence ($\leqslant 1\%$) in the investigated irradiation conditions.

Negligible differences were observed in depth-dose distributions measured by investigated detectors and reference plane-parallel Markus chamber, as for unmodulated and modulated beams, both for scattered and scanned fields.

Values of Peak-to-Plateau ratios for unmodulated beams measured by tested detectors and Markus Chamber agree to $\pm 2\%$ as for protons and carbon ions, indicating that investigated solid-state detectors are not affected by the LET values.

Moreover microDiamond and diode measure with great accuracy basic parameters of modulated clinical proton beams: (i) range (d'90) (ii) SOBP length (m'90) (iii) distal-dose falloff (80–20%).

Diode "edge-on" arrangement of PTW diode provides lateral beam profiles with a spatial resolution comparable to EBT3 film also for narrow proton beams of ocular proton therapy.

Furthermore, PTW diode is suitable for determining OFs of narrow proton beams in ocular protontherapy up to collimator 5 mm in diameter, as resulted by an intercomparison with radiochromic EBT3 films.

http://dx.doi.org/10.1016/j.ejmp.2016.07.323

ORGAN MOTION MANAGEMENT IN SCANNING ION BEAMS

Mario Ciocca. *Fondazione CNAO, Medical Physics Unit, Pavia, Italy*

The treatment of moving organs is still even more critical in ion beam radiotherapy than in IMRT, due to the finite range of charged particles, and particularly for pencil beam scanning modality (compared to passive scattering). The interplay effect (interference between moving tissues and scanning beams), together with in-patient ion range uncertainty, can strongly deteriorate the actually delivered dose distribution. Several strategies have been proposed to mitigate the dosimetric effects of organ motion, including breath-old, abdominal compression, gated delivery, layered or volumetric rescanning, 4-D optimization, beam tracking. At CNAO, 4-D treatments started in September 2014 and 31 patients have been treated so far, mainly for liver and pancreas tumours and using scanning carbon ion beams, rather than protons. The organ motion management strategy included the combination of patient abdominal compression using custom thermoplastic masks, multi-field planning approach, multiple fractionations, gating (end-exhale respiratory phase) and layered repainting dose delivery. Custom optical tracking system based on multiple surface marker detection or the Anzai commercial system based on a pressure sensor is used to provide the respiratory signal for gated delivery. The commissioning of the 4-D delivery system included measurements performed using EBT3 radiochromic films and a PinPoint ion chamber, as well as the Anzai respiratory and ExacTrac gating phantoms. Comparisons between protons and carbon ions showed that larger spot sizes represent a more favorable condition to minimize motion effect.

http://dx.doi.org/10.1016/j.ejmp.2016.07.324

Physica Medica 32 (2016) 188–191

Contents lists available at ScienceDirect

Physica Medica

journal homepage: http://www.physicamedica.com

Abstracts from the 1st European Congress of Medical Physics: Invited Lectures Metropolitan Hotel|Aegean Sea Ballroom (Hall B) - September 3rd, 2016

DICOM STANDARDS FOR PATIENT DOSIMETRY

Annalisa Trianni. *Udine University Hospital, Italy*

Data related to patient radiation exposure during radiologic procedures can be stored and communicated using the *non-image information object definitions* (non IOD) DICOM objects.

More specifically, there are three DICOM objects in the standard that can be used to transport exposure information: the DICOM header, the DICOM Modality Performed Procedure Step (MPPS) and the DICOM Radiation Dose Structured Report (RDSR). All these objects have several advantages and some limitations. All the mentioned objects are carrying information about equipment output and do not provide any information on patient dose.

The most complete of the three objects previously mentioned is the DICOM RDSR, which was added to the Standard in 2005. This object transports the information related to the equipment output along with information about the patient and the procedure that could be used to estimate the exposure to the patient. Although unfortunately this information is not complete.

Moreover some new modalities (e.g: CBCT) need specific attributes to be stored and communicated and the present RDSR structure needs to be enhanced to allow it.

Furthermore none of this DICOM object includes a template for patient-specific dose data to be recorded after estimation. For this reason a new DICOM object, the Patient Radiation Dose Structured Report (P-RDSR) has being developed. The new P-RDSR will provide the archival tool to record the results of the estimations and the methodology used to achieve this estimate.

http://dx.doi.org/10.1016/j.ejmp.2016.07.326

INSTRUMENTATION/OPTIMIZATION/QC OF IMAGING FOR NUCLEAR MEDICINE DIAGNOSTIC DOSIMETRY

Søren Holm. *Dept. of Clinical Physiology, Nuclear Medicine and PET, Rigshospitalet, University Hospital Copenhagen, Denmark*

In diagnostic nuclear medicine (NM), images are often used qualitatively or "semi-quantitatively" reporting SUV. In dosimetry, absolute values of activity (concentration) are needed at organ, lesion, or even voxel level. This requires a strict QC of the whole quantitative chain from activity meter (dose calibrator) over imaging device and acquisition protocols to the processes of reconstructing images and extracting values from VOIs.

Imaging for dosimetry comprises two different situations: estimating individual dose for radionuclide therapy and establishing an average value for a diagnostic method. In both cases, imaging must (ideally) be applied over time periods covering the dynamics of the radioactivity to avoid unsupported extrapolations. In general diagnostics, time constraints exclude the feasibility of performing true dosimetric measurements on individuals. For reference, activity is used as a surrogate, converting to dose using values of Sv/Bq obtained from groups of patients in more demanding imaging setups.

Historically, PET was recognized as the quantitative NM technique, but recent advances in SPECT(/CT) ensure that this modality has the potential as well. In all cases, corrections for dead time, attenuation and scatter must be considered. In reconstruction with iterative methods the level of convergence is important and Partial Volume Effects must be considered.

For diagnostic purposes, radiopharmaceuticals have often been developed to accommodate ideal nuclides for imaging, e.g., Tc-99m for SPECT or F-18 for PET. When imaging for dosimetry, less ideal nuclides are often encountered with greater demands on corrections from e.g., down-scattered photons (in SPECT) or prompt gamma corrections (in PET).

http://dx.doi.org/10.1016/j.ejmp.2016.07.327

DOSIMETRY METHODOLOGY FOR DIAGNOSTIC NUCLEAR MEDICINE

Uta Eberlein.
Department of Nuclear Medicine, University of Würzburg, Germany

For diagnostic dosimetry in nuclear medicine, quantitative imaging and activity measurements of blood and urine samples are essential. This is followed by the calculation of the absorbed organ doses and the effective dose. To achieve this, a correct temporal sampling and the use of adequate procedures to integrate the time-activity curves to obtain the total number of decays in the source organs (the time-integrated activity coefficients, TIACs) are prerequisites.

If the TIACs are known, a calculation of the absorbed doses is performed by applying the "MIRD formalism": $D = TIAC \cdot A_0 \cdot S$

D: the mean absorbed dose to a target from a source region.
A_0: administered activity
S: mean absorbed dose per unit cumulated activity in the target region.

The S-values used for diagnostics are still based on mathematical phantoms. Although, the ICRP in its publication 103 requires the use of a set of gender-specific realistic voxel phantoms, the S-values for isotopes, however, are not yet made publicly available.

For diagnostics the effective dose is the main protection quantity. It is calculated using the tissue weighting factors established by the ICRP in the publications ICRP60 and ICRP103. The effective dose, however, is only intended to calculate the risk for an age-independent reference person, not the individual risk. It is a protection quantity and is related to the probability of health detriment to an adult reference person due to stochastic effects from exposure to *low* doses of ionizing radiation.

http://dx.doi.org/10.1016/j.ejmp.2016.07.328

DOSIMETRY BASED OPTIMISATION IN MOLECULAR RADIOTHERAPY

Mark Konijnenberg. *Radiology & Nuclear Medicine Dept. Erasmus MC, Rotterdam, The Netherlands*

Retrospective dosimetry assessments on therapies showed several evidences for clear dose-effect relations in normal organ toxicity. Late radiation induced toxicity to the kidneys by ^{90}Y-labelled peptides showed a clear doses-effect curve following the Linear Quadratic model for the lower dose rate by this high-energy β-emitter (E_{mean} = 0.93 MeV). Lower energy β-emitters, however, do not show evidence for the same dose constraint, most probably due to more inhomogeneous dose distributions. Radiobiology of the sub-lethal damage repair mechanism plays an important role during the dose delivery.

Heterogeneous dose distributions are the sine-qua-non for molecular radiotherapies based on α-particle emitters. This makes the targeting properties of the drug-vector, the radionuclide and its radioactive progeny extremely demanding. The quality of quantitative imaging of most α-emitters needs to be improved to establish reliable dosimetry. The relative biologic effect of all molecular radiotherapies is strongly influenced by the dose distribution inhomogeneity and functional sub-unit targeting.

Most absorbed doses needed for cure of the tumour and its metastatic spread are much higher (typically >150 Gy) than needed with external beam radiotherapy. Low dose rates and inhomogeneous dose distributions cause this difference. Molecular radiotherapy is evolving as a promising type of radiotherapy treatment for various types of metastasized cancers, especially when given according to a good treatment planning protocol.

http://dx.doi.org/10.1016/j.ejmp.2016.07.329

PATIENT-SPECIFIC DOSIMETRY IN CT

Georgia Solomou. *University of Crete, Department of Medical Physics, Greece*

Radiation originated from CT examinations has been identified as the major contributor of radiation dose to patient population from medical purposes in the United States. Therefore, there is a great concern regarding the risk associated with radiation exposure from these examinations in both children and adults. Although effective dose has been the most commonly used dose metric when reporting the risk related to a given type of procedure, it has been recently suggested that the radiation dose delivered to specific radiosensitive organs should be determined. Physical anthropomorphic phantoms and mathematical models have been widely used for this purpose. However, the variability of human anatomy may be significant, especially for pediatric patients. In addition, modern CT scanners are equipped with automatic tube current modulation systems (TCM), which allow for images at reduced patient radiation dose. These systems modulate the tube current depending on the patient body size. Consequently, the dose reduction due to the activation of the TCM will considerably vary for patients with different body habitus. Methods based on voxelized patient models have been developed to individualize patient radiation dose. Size-specific, scanner-independent '$CTDI_{vol}$ to organ' dose conversion factors have been produced to estimate organ doses from various CT examinations. Patient's sex, body status and TCM settings should be taken into account in patient specific CT-dosimetry. In this presentation methods developed to determine individual-specific organ doses from CT examinations, based on patient specific models, will be reviewed.

http://dx.doi.org/10.1016/j.ejmp.2016.07.330

CT DOSE OPTIMIZATION

Antonios E. Papadakis. *Medical Physics Department, University Hospital of Heraklion, Crete, Greece*

The advances in computed tomography (CT) technology have expanded the clinical applications of CT imaging. As a result the use of CT has been markedly increased over the recent years raising concerns about the stochastic risks of radiation and consequently safety in patient's care. To comply with the "as low as reasonably achievable" principle, there is need to develop appropriate strategies to optimize CT examinations. CT manufacturers strive to develop techniques to reduce radiation dose while delivering tomographic images of diagnostic quality. Automatic exposure control systems and iterative reconstruction algorithms constitute the state of the art techniques for radiation dose optimization in CT. However, technological advancements have led to the introduction of new parameters that complicate CT examination protocols. Parameters that affect radiation dose and image quality in CT include quality reference tube current, quality reference image noise, tube voltage, quality reference contrast to noise ratio, beam width, pitch, length of z-overscan, reconstruction kernel, weight of blending between filtered back projection and iterative reconstruction algorithms. To optimize CT examination protocols, a basic understanding of CT scan parameters and their effect on image quality is required. CT radiation dose optimization is an important issue that needs to be addressed first by CT vendors and consequently by radiologists, medical physicists and radiologic technologists. In this presentation the basic principles of CT radiation exposure and the strategies followed for CT radiation dose optimization from the medical physicist's perspective are reviewed.

http://dx.doi.org/10.1016/j.ejmp.2016.07.331

CERN BREAKTHROUGH TECHNOLOGIES FOR NON-INVASIVE, IN VIVO, IMAGE-GUIDED DIAGNOSIS

Evangelia Dimovasili. *CERN and University of Cyprus, Cyprus*

CERN, the largest laboratory for particle physics worldwide is at the forefront of detector technology development for many different applications. Over recent decades, many important medical diagnostic and therapeutic techniques have been developed from CERN's fundamental research results or from technological progresses in these areas. A short description of these technologies and their application to medicine will be given. Focus will be made on new, higher performance imaging tools with multimodal capabilities including PET. These tools introduce breakthrough technologies for novel endoscopic procedures in diagnostic and therapeutic endoscopy and in surgical oncology aiming at diagnosing more patients with earlier tumour stages and improving patient outcome and therapy, as well as reducing health costs. Technical objectives include: a very high sensitivity allowed by the endoscopic approach and the proximity of the target. A spatial resolution of 1 mm to delineate early

tumours. A time resolution of 200 ps corresponding to a spatial resolution of 3 cm along the Line of Response (LOR) in a dual-head system, allowing a direct (and therefore fast) 3-dimensional reconstruction through a limited number of angular projections only, and an efficient rejection of background coming from outside of the few cubic centimetres region of interest (ROI). The presentation will also emphasize on the number of challenges that have been addressed, both technically and clinically, which have led to the development and introduction of cutting edge technologies in three technological areas: scintillator performances and production methods, light transport and photo-detectors.

http://dx.doi.org/10.1016/j.ejmp.2016.07.332

FAST-FIELD CYCLING MRI: A NEW TOOL FOR ENHANCED DIAGNOSIS

Lionel Broche. *University of Aberdeen, United Kingdom*

Fast Field-Cycling MRI (FFC MRI) is a major shift in MRI technology. It aims to explore how relaxation rates change with the magnetic field strength, an idea that has been successfully exploited in NMR for more than half a century and which is known to provide unique structural information on materials, non-invasively.

Scaling up FFC NMR to whole-body MRI systems is a difficult technical challenge that has maintained a lock on this area of research for many years. Our research group has successfully lifted this lock and developed two whole-body FFC MRI scanners: one with a field range of 0.1 mT to 59 mT that has been used in clinical trials for several years and the other with a range of 20 uT to 0.2 T still under development.

Our pilot studies, which use both FFC MRI and FFC NMR, have discovered new biomarkers in a range of diseases such as osteoarthritis, breast carcinoma, musculoskeletal sarcoma, obesity, liver fibrosis, thrombosis and others. These FFC MRI biomarkers can differentiate tissues that appear similar on conventional MRI devices thanks, in part, to the greater endogenous contrast present at lower magnetic fields but also due to patterns that emerge from the overall relaxation dispersion curves of these tissues. The latter provides unique insight into the structure of materials and is, we believe, a promising tool to characterise tissue remodelling.

This presentation will focus on FFC MRI technology, how it differs from conventional MRI and the results obtained so far from our pilot studies.

http://dx.doi.org/10.1016/j.ejmp.2016.07.333

RADIATION-INDUCED CATARACTS IN STAFF ENGAGED IN INTERVENTIONAL PROCEDURES

Madan M. Rehani. *Harvard Medical School, Massachusetts General Hospital, Boston and Duke University, Durham, USA*

Among the radiation effects currently of concern, cataract is the main possibility among interventionalists. Radiation induced eye lens opacities have been found in 1/3rd to half of the operators in interventional suites primarily among interventional cardiologists (ICs) but this may apply to interventional radiologists, electrophysiologists and vascular surgeons as well, who perform similar magnitude of work as ICs. Further, nurses in interventional suites who stay inside for most of the time when radiation beam is ON have been shown to have lens opacities. Data among other category of medical professionals like orthopaedic surgeons, urologists, gastroenterologists and anaesthetists is awaited but lack of use of protective means that is common, tends to indicate that they too may have significant risk. A recent study indicates higher doses to eye lens among urologists, even more than ICs. Most studies so far have shown lens opacities rather than frank cataract, but data from A Bomb survivors indicates that lens opacities have the potential to lead to cataract after several years of latent period. International Commission on Radiological Protection (ICRP) has reduced dose limits for occupational exposure for the eyes from 150 mSv/year to 20 mSv/year and this has been adopted by the European Commission in its BSS and also by the international BSS of IAEA. There is great momentum currently in large part of the world in this area. While the risk is real, the avoidance is also a real possibility.

http://dx.doi.org/10.1016/j.ejmp.2016.07.334

USING GATE FOR IMAGING APPLICATIONS

George Loudos. *Technological Educational Institute of Athens, Greece*

GATE has been well validated by many groups over the past decade for several imaging applications, with particular emphasis in nuclear medicine (SPECT and PET), as well as X-ray and CT imaging. Although the initial focus of published studies was to demonstrate that GATE can accurately reproduce experimental results, the robustness of the toolkit allowed its application in different imaging studies such as: (a) optimization of detector geometry and components selection to design dedicated systems for particular applications; (b) production of imaging data to optimize reconstruction algorithms and correction techniques by separating penetrating, scattered and random events; (c) optimization of imaging protocols by allowing the in silico evaluation of alternative acquisition schemes; (d) exploitation of computational anthropomorphic phantoms to allow reproduction of clinical exams and study of alternative imaging protocols and (e) validation of motion and respiratory techniques by using anthropomorphic phantoms in combination with animal models. The current challenge is to now use GATE in order to provide answers to specific diseases and focused imaging problems, where the performance of imaging systems must be pushed to the limits. Taking into account the current shift of detector technology towards patient personalization, GATE and realistic human phantoms provide a valuable tool that overcomes several practical limitations (including cost) for the assessment of novel imaging systems and technologies. Several examples from recent EC projects show that GATE is a well validated tool, which is exploited in a continuously increasing number of imaging applications.

http://dx.doi.org/10.1016/j.ejmp.2016.07.335

USING GATE FOR RADIATION THERAPY APPLICATIONS

Panagiotis Papadimitroulas. *BET Solutions, Athens, Greece*

Monte Carlo (MC) simulations is a standard method for studying physical processes in medical physics, worldwide. GATE is an open-source platform for simulating imaging, radiotherapy (RT) and dosimetry applications in a user-friendly environment. In RT applications, during the treatment planning, it is essential to accurately assess the deposited energy and the absorbed dose per tissue or organ of interest, as well as the local statistical uncertainty. Several types of realistic dosimetric applications are described including: molecular radiotherapy, radio-immunotherapy, brachytherapy, particle and external beam therapy.

GATE is a MC toolkit which is well validated and is widely accepted by the scientific community. More specifically, it has been efficiently used in several applications, such as Dose Point Kernels, S-values, Brachytherapy parameters (anisotropy and radial dose function), and compared against a variety of MC codes which are considered as standard tools for decades. Furthermore, comparison studies

reported reliable modelling of electron, photon and proton beams comparing experimental with simulated data.

Personalization of medical protocols can be achieved by combining GATE MC simulations with anthropomorphic computational models and clinical anatomical data. High statistics obtained by speeding up these computationally demanding simulations (GPU, Grids, Variance Reduction Techniques, Phase-Space), can lead to accurate dosimetric assessment in clinical applications. In the present study, examples of validated RT applications are presented, describing the structure of such simulations and examples of recently funded H2020 projects (i.e. ERROR) are given.

http://dx.doi.org/10.1016/j.ejmp.2016.07.336

Physica Medica 32 (2016) 192–193

Contents lists available at ScienceDirect

Physica Medica

journal homepage: http://www.physicamedica.com

Abstracts from the 1st European Congress of Medical Physics: Invited Lectures Eugenides Foundation|Main Auditorium (Hall A) - September 4th, 2016

BASIC PHYSICS AND TECHNOLOGY OF MEDICAL LASERS

Ayyakkannu Manivannan. *Crosshouse Hospital, NHS Ayrshire & Arran, Scotland, United Kingdom*

Theodore Maiman created the first ruby laser in 1960. In 1962 Dr. Goldman, a dermatologist used a ruby laser to remove a tattoo. Medical lasers are now a multi-billion dollar industry. They are now commonly used in ophthalmology, dermatology, gynaecology and urology. Recent advances in very short pulse lasers are pushing their use in orthopaedics, dentistry and neurosurgery. The optical radiation emitted by lasers has the potential to damage the eyes and skin of patients and healthcare workers. There is also a risk of fires or explosions from lasers igniting flammable gases and the problem of inhalation of smoke with surgical lasers. The EU directive 2006/25/EC "Control of Artificial Optical Radiation at work Regulations" aims to detect adverse health effects and protect workers from the risk stated above by limiting the exposure levels to both eye and skin. Radiation Protection sections of Medical Physics departments in most hospitals are responsible for implementing the safety control mechanisms, training staff on laser safety and investigating any adverse events when either patient or staff are injured. This talk will cover the basic physics and technology of medical lasers. How different types of optical radiation are produced with different types of active media is explained. Further delivery methods to treat both soft and hard tissues are demonstrated. Delegates will be able to understand the characteristics of optical radiation emitted from different types of equipment and their effect on tissue. Delegates are advised to attend the next talk on quality and safety management.

http://dx.doi.org/10.1016/j.ejmp.2016.07.339

QUALITY AND SAFETY MANAGEMENT

Ayyakkannu Manivannan. *Crosshouse Hospital, NHS Ayrshire & Arran, Scotland, United Kingdom*

The optical radiation emitted by lasers has the potential to damage the eyes and skin of patients and healthcare workers such as nurses, clinicians and medical technicians. Laser related accidents resulting in blindness and deaths have been reported. The EU directive 2006/25/EC "Control of Artificial Optical Radiation at work Regulations" aims to protect workers from the risk stated above by limiting the exposure levels to both eye and skin. Medical Physics departments in most hospitals are responsible for managing the safe use of lasers. A Laser Protection Advisor (similar to Radiation Protection Advisor) is responsible for implementing the safety control mechanisms, training staff on laser safety and investigating any adverse events when either patient or staff are injured. This talk will cover the quality and safety management of laser use. Delegates are advised to attend the topic on "Basic Physics and Technology of Medical Lasers" as a prerequisite. Basic principles of risk assessment, maximum permissible exposure (MPE) levels and laser classification are explained. Methods to keep exposure of unprotected skin and eyes below the MPE levels are demonstrated. Hazard control procedures such as controlled area access, written safe operating procedures, warning signs and lights, authorised use of equipment and the use of personal protection are explained. Principles and requirements of equipment quality assurance processes and procedures to maintain the quality of safety are demonstrated. Relevant legislations and standards are covered in this talk.

http://dx.doi.org/10.1016/j.ejmp.2016.07.338

ISSUES IN ACCURATE PET FOR TARGET DELINEATION IN RADIOTHERAPY

Roberta Matheoud. *Medical Physics Dept., AOU Maggiore della Carità, Novara, Italy*

Tumor delineation in PET imaging has been one of the main concerns for treatment planning in radiation oncology.

However, a standardized way of converting PET signals into target volumes is not yet available.

The majority of the literature on delineation methods deals with 18FDG-PET imaging.

In this context, semiautomatic and automatic segmentation methods have been developed implying gradient, region growing, clustering, statistical methods, but the majority of these new algorithms are not widely and readily available.

Adaptive thresholding methods based on contrast-oriented contouring algorithms have been developed by many groups and validated in patient data for different anatomical regions. Among their strong points easiness of use and low cost must be accounted for, while among the drawbacks heterogeneity in lesion uptake and lesion motion are still open questions.

Moreover, quantification and delineation issues become even more troublesome when partial volume effect is considered and corrected for by applying resolution modeling techniques.

Literature shows lack of evidence ensuring that resolution modeling algorithms can provide accurate and reproducible data, suggesting that resolution modeling reconstruction algorithms in quantitative 18FDG-PET imaging need to be accurately validated before introduction in clinical routine.

Other issues in tumor delineation are concerned with PET imaging performed with radiotracers different from 18FDG, for example 11C-choline and 11C-methionine for prostate and brain tumors imaging, for which the conclusions drawn for 18FDG imaging delineation may not apply and different techniques and strategies must be looked for.

http://dx.doi.org/10.1016/j.ejmp.2016.07.340

PATIENT-SPECIFIC DOSIMETRY IN MOLECULAR RADIOTHERAPY: WHY AND HOW?

Manuel Bardiès. *INSERM – Centre de Recherches en Cancérologie de Toulouse, France*

According to Euratom Directive 2013/59: "For all medical exposure of patients for radiotherapeutic purposes, exposures of target volumes shall be individually planned and their delivery appropriately verified taking into account that doses to non-target volumes and tissues shall be as low as reasonably achievable and consistent with the intended radiotherapeutic purpose of the exposure"

The Directive further defines "radiotherapeutic means pertaining to radiotherapy, including nuclear medicine for therapeutic purposes".

Interestingly, this paragraph belongs to the "optimisation" part of the Directive.

This obviously has consequences for radiopharmaceutical dosimetry implementation in nuclear medicine. The fact is that there is not a unique approach to patient-specific dosimetry. If the objective is to optimise the practice, then several possibilities must be considered: dosimetry can be implemented to assess efficacy or toxicity. This will lead to different dosimetric protocols.

We will review various situations of molecular radiotherapy and associated dosimetric approaches.

http://dx.doi.org/10.1016/j.ejmp.2016.07.341

NANOPARTICLES FOR RADIATION THERAPY ENHANCEMENT

Kiki Theodorou. *Medical Physics Dept., Medical School, University of Thessaly, Greece*

Nanoparticles (NPs) have been used for drug delivery, for *in vitro* diagnosis and for *in vivo* imaging. During the last decades, efforts have been made for the use of nanoparticles as therapeutic agents. Given that radiation therapy is not a selective antitumor treatment, the main challenge is to increase its therapeutic efficacy and thus to increase the differential radiation effect between healthy and cancer cells by the combined use of NPs.

In the many research projects that have been contacted the last years, different nanoparticle designs and materials have been employed but the main idea is the use of high-Z NPs for radiosensitization. In this context, these NPs can intensify the production of secondary electrons and ROS that in turn enhance radiation therapy effects. The enhancement of radiotherapy efficiency could be evaluated by the determination of the Nanoparticle-mediated Enhancement Ratio (NER) after a single radiation dose, the determination of the Dose Modifying Factor (DMF) based on survival curves and the variation of the ROS production upon irradiation.

This review will focused on the different approaches followed on the use of nanoparticles, the dosimetric studies available, the radiobiological issues and the target selectivity. Discussion will be made on the efficiency and the prospective of the use of NPs in current radiotherapy practice.

http://dx.doi.org/10.1016/j.ejmp.2016.07.342

AUTOMATED ANALYSIS OF OPHTHALMOLOGICAL IMAGES FOR EARLY SIGNS OF DIABETIC RETINOPATHY

P.F. Sharp. *Medical Physics, University of Aberdeen, UK*

Diabetic eye disease is the leading cause of blindness in the working age population. Early detection is important so a Scottish national screening service was set up ensuring that every person with diabetes has an annual retinal imaging. As this requires a person to examine every image it is time consuming and expensive. So we were asked to develop software to automatically detect early signs of eye disease from retinal images.

Software was developed to assess the quality of retinal images and, if quality was sufficient, to identify the presence of diabetic eye disease, namely microaneurysms, exudates and haemorrhages. The software was evaluated on a series of 33,535 consecutive patients imaged at two Scottish screening centres. The results were compared with those given by manual screeners. The costs of implementing the software into the national screening programme were evaluated.

It showed a detection rate of 99.8% for observable retinopathy, an early stage of disease which requires the person to undergo frequent monitoring, and 98.2% for referable retinopathy, where the person needs to be seen by an ophthalmologist. No cases of proliferative retinopathy, advanced disease, were missed. 12,185 patients would not have required seeing by manual screeners as they had no retinopathy. A health economics analysis showed that cost savings were in excess of £200,000 per annum.

The software was shown to provide a cost-effective way of reducing the number of retinal images needing examination by a trained screener and is now routinely used by the screening service.

http://dx.doi.org/10.1016/j.ejmp.2016.07.343

Physica Medica 32 (2016) 194–195

Contents lists available at ScienceDirect

Physica Medica

journal homepage: http://www.physicamedica.com

Abstracts from the 1st European Congress of Medical Physics: Invited Lectures Metropolitan Hotel|Aegean Sea Ballroom (Hall B) - September 4th, 2016

QUALITY CONTROL PROGRAM OF X-RAY MAMMOGRAPHY

Nabil Iqeilan, Huda M. Al-Naemi. *Hamad Medical Corporation, P.O. Box: 3050, Doha, Qatar*

To maintain high quality in mammography, a routine quality control program is necessary to detect drifting or degradation of system performance overtime and it is becoming more important especially when the machine is used for population screening, a large number of asymptomatic women will receive a large amount of dose. Therefore, the importance of optimization of image quality and minimization of radiation dose is essential to accomplish the goals of mammography screening, and this require to have and make sure that the Mammography X-ray machine working properly and stable.

Due to advances in technology, the regulation and testing of digital mammography systems has become complicated. Not only does each mammographic X-ray unit model have its own test protocol, peripheral equipment must also be tested according to manufacturer specifications. And this program must be followed in detail by both physicists testing the device and other clinical users performing routine QC functions on a daily basis.

In this lecture the Mammography QC testing program will be discussed and recent advances in the automation of QC measurements by some manufacturers will be highlighted.

http://dx.doi.org/10.1016/j.ejmp.2016.07.345

QUALITY CONTROL IN COMPUTED TOMOGRAPHY

Virginia Tsapaki. *Konstantopoulio General Hospital, Athens, Greece*

Computed Tomography (CT) is considered as one of the most important imaging techniques of modern times. The introduction of multi-detector CT (MDCT) with sub second acquisition and CT fluoroscopy have further advanced CT applications by enabling interventional radiological (IR) procedures which were traditionally performed using C-arm machines. CT use is extended to CT fluoroscopy, angiography, cardiac CT, screening, multi-phase dynamic CT, urography and other applications. Due to the shorter MDCT scanning times, increasing number of patients receive repeat CT examinations especially in the oncology and emergency departments of hospitals. The development of hybrid systems such as PET/CT, SPECT/CT, CT simulators in radiotherapy and its incorporation in CT planning and dose delivery systems, progressed CT from the domain of diagnostic radiology to other specialities. Although vendors have invested time and exhausting efforts in development of radiation dose optimization techniques, contribution of CT to patient radiation dose continues to increase. Furthermore, growing number of adverse events related to excessive CT radiation exposure, as well as its relation to elevated risk of radiation induced cancer are reported in the media. All these clearly point to the critical need for ongoing quality control (QC) and cautious relation of radiation dose and image quality. An extensive review of the latest routine QC tests will be presented, based on the most recent publications, starting from more simple tests that can be easily performed by a radiation technologist to the more complex ones that must be executed and analysed by a medical physicist.

http://dx.doi.org/10.1016/j.ejmp.2016.07.346

RADIATION INCIDENTS AND ACCIDENTS IN DIAGNOSTIC RADIOLOGY. WHAT TO DO NEXT IN CT

Mahadevappa Mahesh. *Professor of Radiology and Cardiology, Johns Hopkins University School of Medicine, Baltimore, MD 21287, USA*

Radiation incidents in diagnostic radiology are rare and may not be as life threatening as in radiation oncology, yet it is equally important to devise plans of action to address radiation incidents in diagnostic radiology. This talk will discuss various measures medical physicists can do to address such situations with focus on CT studies.

Radiation incidents can lead to deterministic effects such as hair-loss or skin erythema, which are rare but possible due to prolonged fluoroscopy procedures or CT scans (CT perfusion studies) due to incorrect settings. When radiation incidents occur, a physicist can do the following.

First, physicist should record details of scan settings that have led to the radiation incident. Next, assess and make necessary changes to avoid future incidents. This should be followed by detail assessment of radiation exposure to patients (skin dose and organ dose) and work with the radiologists and other physicians to address the radiation events.

Further, medical physicists can take precautions to avoid such incidents in future. Recently introduced 'CT Dose Alert' can be customized for each CT protocol such that incorrect settings that could lead to unintended high radiation exposure can be flagged prior to CT scan. This presentation will discuss in detail about the CT dose alert and CT dose notifications, which are key to avoid unintended radiation exposure to patients undergoing CT studies.

http://dx.doi.org/10.1016/j.ejmp.2016.07.347

RADIATION INCIDENTS AND ACCIDENTS IN DIAGNOSTIC AND INTERVENTIONAL RADIOLOGY. WHAT TO DO NEXT IN INTERVENTIONAL RADIOLOGY

Virginia Tsapaki. *Konstantopoulio General Hospital, Athens, Greece*

The International Commission on Radiological Protection (ICRP) defines interventional Radiology (IR) procedures as the techniques that encompass guided diagnostic and therapeutic interventions either by percutaneous or other access under local anaesthesia and/or sedation. Fluoroscopic imaging is applied to best localise the lesion or the treatment site as well as to continuously monitor and record the procedure. Whereas diagnostic radiology is generally safe for patients and staff, these techniques involve high risk of skin injuries of patients and occupational overexposure of staff involved. IR skin injuries are termed as fluoroscopy-induced radiation dermatitis. They usually appear within 7–14 days of exposure and may be acute or chronic. A certain threshold is required, reached either at once or in cumulative radiation doses. It causes inflammation of the skin, presenting as erythema, pain, and pruritus that may later transform into ulceration, atrophy, telangiectasia, sclerosis, discoloration, and malignancy, such as invasive basal cell or squamous cell carcinoma. A number of cases are reported in the literature in order to emphasize the importance of recognizing fluoroscopy as a cause of radiation dermatitis among other skin injuries. Interventionalists are often unaware of the high radiation doses to which a patient's skin may be subjected, even with the use of modern, state of the art equipment. This paper will consider the knowledge, techniques and possible regulatory requirements necessary to prevent radiological incidents and accidents and provide recommendations in the case such events occur.

http://dx.doi.org/10.1016/j.ejmp.2016.07.348

RADIATION INCIDENTS AND ACCIDENTS IN DIAGNOSTIC AND INTERVENTIONAL RADIOLOGY. WHAT TO DO NEXT IN PREGNANT PATIENTS

John Damilakis. *University of Crete, Greece*

Despite precautions, pregnant patients occasionally are exposed accidentally to X-rays. Accidental irradiation of pregnant patients occurs during the first postconception weeks. During the first 2 weeks postconception, the embryo will either recover completely or not survive. This is known as 'all or nothing effect'. From the 3rd to 8th week postconception, malformation of body organs is the most possible form of damage. Therefore, after accidental examination of pregnant patients, the gestational age should be known. Accurate estimation of embryo/fetus radiation dose is needed when the mother is after the 2nd week of gestation and the embryo has been exposed primarily to X-ray beam. CODE (COnceptus Dose Estimation) is a free web-based software tool (uploaded on embryodose.med.uoc.gr) that can be used for estimation of embryo dose from radiography, diagnostic fluoroscopy, CT and fluoroscopically-guided procedures.

It is important to avoid accidental irradiation during pregnancy. Careful screening is needed to identify pregnant patients before X-ray examinations. According to ICRP publication 84, 'investigation of the reproductive status of a female of childbearing age prior to X-ray imaging' is needed. Also, 'it is prudent to consider as pregnant any woman of reproductive age presenting herself for an X-ray examination at a time when a menstrual period is overdue, or missed, unless there is information that precludes a pregnancy'. X-ray departments must have posters in the waiting area asking female patients to inform the radiographer or radiologist about a possible pregnancy.

http://dx.doi.org/10.1016/j.ejmp.2016.07.349

X-RAY COMPUTED TOMOGRAPHY DEDICATED TO THE BREAST

Paolo Russo. *University of Naples Federico II, Dept. of Physics "Ettore Pancini" & INFN Sect. of Naples, Naples, Italy*

Planar digital mammography is the gold standard for breast cancer screening; also available in conjunction with mammography is Digital Breast Tomosynthesis, as a pseudo-tomographic imaging modality of the compressed breast in clinical diagnosis. However, fully 3D X-ray computed tomography of the uncompressed pendant breast is now available both experimentally and commercially, using cone-beam dedicated scanners. They provide excellent-contrast views of the 3D anatomy of the breast, based on X-ray attenuation in breast tissues. Significant advancements are expected from different phase contrast techniques, now being explored experimentally for both 2D and 3D X-ray imaging of the breast, for their potential to provide improved visibility of soft masses. Both laboratory setups using X-ray tubes, and synchrotron radiation based CT setups will be described.

http://dx.doi.org/10.1016/j.ejmp.2016.07.350

DUAL ENERGY CT: PHYSICS AND APPLICATIONS

Kostas Perisinakis. *University of Crete, Medical School, Greece*

Despite material differentiation through CT scans acquired with X-ray beams of different spectra had been conceived soon after the emergence of single energy CT in early 70 s, the clinical endorsement of the method and its widespread application was only initiated after the introduction of the first dual source CT systems in 2006. Ever since dual energy CT (DECT) technology has rapidly progressed and several clinical applications have emerged.

Apart from enhancing image quality through artifact suppression, DECT imaging was found to provide unique data on tissue composition and function, and therefore it was enthusiastically welcomed by clinicians. Nowadays, most modern commercially available CT scanners provide the ability for dual energy CT imaging. Although the underlying basic principles of dual-energy CT are the same regardless of scanner type, there are different technical implementation approaches adopted by different vendors. Currently, there are four different DECT imaging methods available i.e. the dual CT scan, the dual source, the fast kV switching and the two-layer detector approach with considerable differences regarding both image data acquisition and processing. Understanding of these differences may help optimization of DECT imaging protocols and identify pros and cons for each technical implementation of DECT imaging.

Renal stone differentiation, pulmonary perfusion and metallic implant imaging are well established clinical applications of DECT imaging, while there are several promising applications under investigation in musculoskeletal, liver, genitourinary and heart imaging.

http://dx.doi.org/10.1016/j.ejmp.2016.07.351

Physica Medica 32 (2016) 196–221

Contents lists available at ScienceDirect

Physica Medica

journal homepage: http://www.physicamedica.com

Abstracts from the 1st European Congress of Medical Physics: Oral Papers|September 1st, 2016

MAXIMA – A HORIZON2020 PROJECT FOR INCREASING THE RESEARCH AND INNOVATION CAPACITY OF EU UNIVERSITIES IN THE FIELD OF BREAST CANCER MODELLING

Kristina Bliznakova [a,*], Hilde Bosmans [b], Giovanni Mettivier [c], Paolo Russo [c]

[a] *Technical University of Varna, Varna, Bulgaria*
[b] *Katholieke Universiteit Leuven, Leuven, Belgium*
[c] *University of Naples - Federico II, Naples, Italy*
* Corresponding author.

Introduction. In X-ray breast imaging, the availability of realistic three-dimensional computational and physical models of breast tumours and normal tissue structures (and corresponding histological evidences) would be a powerful tool in the hands of engineers, physicians and physicists for the development of new technologies and to validate computer tools for precise definition of the breast shapes, glandular tissue anatomical distribution, shape and type of breast cancer masses. Authorities may accept the results of computations as an alternative to tedious clinical studies.

Aim. In the frame of the EU Horizon2020 TWINN project three networking universities will cooperate towards an increase in the research and innovation capacity in breast modelling. The planned networking events should also contribute to education and training.

Method. Collaborative research will result in the development of more advanced computer-based breast cancer models. Together, the 3 partners have and allow access to several simulation platforms, phase contrast imaging, phase contrast tomosynthesis and state-of-the-art digital mammography. Proper validation and use of breast and lesion models for breast tomosynthesis and breast phase-contrast imaging is aimed for.

Results. During the kick-off meeting of the project, plans for educational workshops were made. Available tools and technologies have been listed and cooperation plans were made. The Ph.D. plans for the first 3 students have been discussed.

Conclusion. The created network will allow integration of the results of the ongoing research in the groups and will facilitate the research activities of all partners through a joint and mutually fruitful collaboration.

http://dx.doi.org/10.1016/j.ejmp.2016.07.667

PATIENT DAILY TREATMENT VERIFICATION USING MLC LOG FILES

D. Defoor, N. Papanikolaou, S. Stathakis *

University of Texas Health Science Center San Antonio, San Antonio, TX, USA
* Corresponding author.

Purpose. To investigate the viability of patient specific IMRT QA method which uses MLC log files to recreate a delivered fluence and compare to the planned fluence.

Materials and methods. A Varian Novalis Tx equipped with a HD120 MLC was used in this study. A total of 40 patients of both VMAT and step and shoot of various sites were used. Error containing plans were generated for 5 of the 40 patients. The errors introduced were MLC shifts, gantry angle errors and collimator errors. The treatment plans were delivered in air and the MLC log files recorded. An in-house MatLab program was used to recreate the planned fluence from the dicomRT file for reference and recreate the delivered fluence using data from the MLC log files. The resulting beam fluence maps and composite fluence maps were then compared using the gamma index. Gamma passing percentages were then compared to the results of the original IMRT QA (performed using the Delta^4 to establish a correlation and compare error detection capabilities.

Results. The overall mean gamma values for the Delta^{4}and the fluence comparisons were similar. Gamma passing percentages for the Delta^4 were 96.9% while the fluence comparisons resulted in averages of 99.7% and 98.8% for 3%/3 mm and 2%/2 mm respectively. The error detection capabilities of the fluence comparison method was on par with that of the Delta^4.

Conclusion. Using fluences created from MLC log files for patient specific IMRT QA is a valid alternative to traditional methods. The ease of use and efficiency of the fluence method makes it an attractive option for routine patient specific IMRT QA.

http://dx.doi.org/10.1016/j.ejmp.2016.07.668

EVALUATION OF TWO DETECTOR ARRAYS FOR VMAT PRE-TREATMENT QUALITY ASSURANCE

S. Russo [a,*], A. Bruschi [b], M. Esposito [a], S. Pini [a], A. Ghirelli [a] S. Mazzocchi [a], P. Bastiani [c], G. Zatelli [a]

[a] *Azienda USLToscana Centro, Medical Physics Unit, Florence, Italy*
[b] *University of Florence, Florence, Italy*
[c] *Azienda USLToscana Centro, Radiotherapy Unit, Florence, Italy*
* Corresponding author.

Introduction. Patient-specific pre-treatment quality assurance (QA) is a necessary prerequisite to VMAT treatment. 2D detector arrays have become the standard device for verification of intensity modulated dose distributions.

Purpose. Aim of this work is to verify the suitability of two ionization chamber 2D arrays (PTW Octavius4D 1500 and PTW Octavius4D 729) for pre-treatment VMAT plan verification and to compare the results achieved by the two systems.

Materials and methods. Measurements were performed by Octavius4D 1500 and Octavius4D 729 in the Octavius4D phantom. Forty VMAT plans elaborated by TPS Elekta Monaco® 5.0 and delivered by Elekta Synergy® Linac (6, 10 MV) have been used in this study (10 head and neck, 10 breast, 10 prostate and 10 pelvic treatments). 3D gamma metric at 3% L/3 mm has been used to compare measured and computed maps.

Results. Mean gamma pass rate for the Octavius4D 1500 was 93.9% (s.d. 3.5%) for HN plans, 95.6% (s.d. 2.4%) for breast treatments, 98.9% (s.d. 1.7%) for prostate and 95.6% (s.d. 2.2%) for pelvic plans. Mean gamma pass rate for the Octavius4D 729 was 92.4% (s.d. 4.9%) for HN plans, 80.7% (s.d. 11.9%) for breast treatments, 97.8% (s.d. 5.1%) for prostate and 87.6% (s.d. 4.3%) for pelvic plans.

Improve measurement resolution by merging two longitudinally shifted measurements resulted in a better agreement between measured and computed maps for both dosimetric devices.

Conclusion. Both investigated systems resulted suitable for VMAT pre-treatment QA, but Octavius 4D 1500 outperformed its predecessor Octavius4D 729 because of the higher spatial resolution of the dosimeters.

http://dx.doi.org/10.1016/j.ejmp.2016.07.669

DIBH TECHNIQUE GUIDED BY AN OPTICAL SYSTEM IN LEFT BREAST IRRADIATION

S. Russo *, F. Rossi, L. Paoletti, R. Barca, S. Fondelli, P. Alpi, B. Grilli, M. Esposito, S. Pini, A. Ghirelli, L. Cunti, L. Isgrò, P. Bastiani

Azienda USLToscana Centro, Florence, Italy
* Corresponding author.

Introduction. Optical systems provide both patient setup verification and intrafraction motion detection and enable respiratory gating treatment procedure.

Purpose. Aim of this work is the evaluation of a deep inspiration breath-hold (DIBH) technique guided by an advanced optical system in terms of dosimetric benefits and positional accuracy.

Materials and methods. The CatalystTM (C-RAD Sweden) can manage respiratory gated treatments by enabling visualization of the respiratory pattern and direct beam control. Forty left side adjuvant radiotherapy patients were included in this study. Standard 3D conformal radiotherapy technique with tangential beams and 50 Gy dose prescription were used. For each patient a free breathing (FB) and a DIBH treatment plans were elaborated and dose volume histograms were compared. Treatments were performed in DIBH. Inter-fraction and intra-fraction variability were quantified in mean and SD translations and rotations displacements over all the treatment fractions.

Results. A significant dose reduction in Heart Mean Dose (1,3 Gy FB vs 0,4 Gy BH), and LAD mean dose (10,7 Gy FB vs 2,0 Gy BH) was achieved by DIBH technique. DIBH plans provided a better PTV coverage (V 95% 88,9% FB vs 92,6% BH) and no difference in Lung V10, V20 and Dmean.

Inter-fraction variability after setup correction was lower than 1 mm and 1° for translations and rotations respectively. Intra-fraction variability was <2.1 mm in translations and $<1°$ in rotations.

Conclusion. Significant reduction of hearth and LAD mean dose and a limited inter-fraction and intra-fraction variability were obtained by DIBH treatments guided by an optical system.

http://dx.doi.org/10.1016/j.ejmp.2016.07.670

DEPENDENCE OF TISSUE INHOMOGENEITY CORRECTION FACTORS ON NOMINAL PHOTON BEAM ENERGY

M. Akhtaruzzaman [a,b,*], P. Kukolowicz [b]

[a] *Faculty of Physics, University of Warsaw, Warsaw, Poland*
[b] *Department of Medical Physics, Maria Skłodowska-Curie Memorial Cancer Centre and Institute of Oncology, Warsaw, Poland*
* Corresponding author.

Introduction. Before the first clinical use of the treatment planning system commissioning of dose calculation algorithms must be performed. One of the most difficult tasks is to check the accuracy of calculations in the inhomogeneous absorber. Several results of so called inhomogeneity correction factors were published but it is not clear, if they might be used for the user beam due to differences in beam energies.

Purpose. The aim of the study was to check how much the correction factors depend on the energy of the beam.

Materials and methods. The Batho correction method, which is the ratio of powers of Tissue Air Ratios (TARs), was used for calculation of the set of correction factors for lung. The TAR factors for wide range of energies were calculated using depth doses with the Gerbi's formula (Gerbi, Med. Phys.18(4), 724, 1991) and peak scatter factors with the Li's formula (Allen Li, Med. Phys. 26(6), 962, 1999). The correction factors were calculated for lung of 0.25 g/cm^3 density for several beam sizes and points lying at several depths inside of and below lung.

Results. The linear dependence of the correction factors on the energy were obtained. For nominal energies of 6 MV (TPR20/20 = 0.670) and 15 MV (TPR20/20 = 0.750), the 1% difference in energy lead to changes of CF of 0.7% and 0.8% respectively inside of lung. The maximum differences for points below lung were 1%.

Conclusion. For two photon beams of energies differed no more than 1%, the correction factors differ of less than 0.8%.

http://dx.doi.org/10.1016/j.ejmp.2016.07.671

WEIGHT LOSS INFLUENCE IN HEAD AND NECK VMAT TREATMENTS

V. Puchades-Puchades, A. Serna-Berná *, J.F. Mata-Colodro, D. Ramos-Amores

Department of Radiation Protection and Medical Physics, Hospital General Universitario Santa Lucia, C/ Mezquita S/N. Paraje los Arcos, Cartagena, Spain
* Corresponding author.

Introduction. Cancer patients often suffer weight loss along their treatment, which might affect the result of the planned treatment.

Purpose. To investigate the effect of patient weight loss on the Head and Neck (H&N) radiation treatments with Volumetric Art Therapy (VMAT) technique.

Materials and methods. Patient body contour shrinkage was used as a surrogate of patient weight loss. Variations of 4 mm and 8 mm in the patient body diameter were studied.

The dosimetric indexes studied were: PTVs Mean Dose (PTVs D_{mean}, Homogeneity Index (HI), Dose maximum to 0,01 cm^3 of PRV spinal cord (D_{mean} and Parotid Glands Mean Dose.

We adapted the different PTVs according to the shrinkage of the patient body contour, always requiring a minimum distance of 3 mm to the contour body; no variations for Organs at Risk (OARS) were considered.

Results. PTVs D_{mean} increased around 5% and HI worsened as patient body contour decrease.

D_{mean} PRV spinal cord has small variations less than 3%.

D_{mean} of parotid glands decreased (till 10%) as the patient body contour shrugged.

Conclusion. Patient weight lose do not affect critically to OARs (spinal cord and parotid glands. Nevertheless, for PTVs there is a worsening of the HI and an increase of D_{mean} as the patient body contour decrease.

In our center, daily Cone Beam CT is performed, triggering a resimulation process when diameter variation us higher than 4 mm.

Disclosure. There is no disclosure.

http://dx.doi.org/10.1016/j.ejmp.2016.07.672

DVH COMPARISON BEWEEN FORWARD IMRT, INVERSE IMRT & RAPIDARC® FOR PATIENTS WITH LEFT SIDED BREAST CANCER AFTER LUMPECTOMY

Panagiotis Zaverdinos [a], Aikaterini Konidari [a], Stefanos Diamantopoulos [a], Ioannis Kantemiris [a,*], J.C.A. Dimopoulos [b]

[a] *Medical Physics Department, Radiation Oncology Division, Metropolitan Hospital, Athens, Greece*
[b] *Radiation Oncology Department, Metropolitan Hospital, Athens, Greece*
* Corresponding author.

Introduction. When patients with left sided breast cancer are treated with adjuvant radiotherapy after lumpectomy, a significant volume of the heart and the left descending coronary artery (LDCA) receive enough radiation to result in serious late cardiac morbidity. This study dosimetrically compares the following three delivery techniques: forward intensity-modulated therapy (F-IMRT), inverse intensity-modulated therapy (I-IMRT), and volumetric-modulated arc therapy (RapidArc® in terms avoiding the heart and the LDCA. Other DVH parameters were also studied.

Purpose. The primary aim of this study is a feasibility check for the use of RapidArc®technique for breast radiotherapy to our department, as well as the identification of the potential advantages of RapidArc®into clinical routine. A secondary aim is a non inferiority check of RapidArc® versus conventional IMRT.

Materials and methods. Twenty patients with T1-2N0M0 breast cancer of the left breast who were treated with I-IMRT after lumpectomy were re-planned with F-IMRT and RapidArc® using Eclipse™ Treatment Planning System form Varian medical systems. Comparative endpoints were consider to be the doses to the surrounding structures, Conformity Index (CI), Homogeneity Index (HI), number of monitor units (MUs) and treatment delivery time. Statistical program SPSS was used in order to investigate the null hypothesis of this study: "No difference exists in distribution of various dosimetric scores between the three techniques".

Results. RapidArc® significantly reduced the dose received from the 50% volume of the LDCA compared with I-IMRT and F-IMRT. RapidArc® and I-IMRT had better CI compared with F-IMRT but F-IMRT achieved better HI compared with I-IMRT and RapidArc®. RapidArc® reduced the number of MUs by 47% and the treatment time by 70% compared with I-IMRT.

Conclusion. RapidArc® achived better sparing of LDCA, with fewer MUs and shorter delivery time than F-IMRT and I-IMRT. Conformity significantly higher with RapidArc® and I-IMRT compared to F-IMRT.

Disclosure. No conflict of interest, financial or other, exists.

http://dx.doi.org/10.1016/j.ejmp.2016.07.673

TIME-DEPENDENT DOSE-RESPONSE RELATION FOR ABSENCE OF VAGINAL ELASTICITY AFTER GYNECOLOGICAL RADIATION THERAPY

Eleftheria Alevronta [a,e,*], Elisabeth Åvall-Lundqvist [a,d], Massoud al-Abany [a,c], Tommy Nyberg [a], Helena Lind [a], Ann-Charlotte Waldenström [e,f], Caroline Olsson [e,g], Gail Dunberger [a,h], Karin Bergmark [a,e,f], Gunnar Steineck [a,e], Bengt K. Lind [b]

[a] *Department of Oncology-Pathology, Division of Clinical Cancer Epidemiology, Karolinska Institutet, Stockholm, Sweden*
[b] *Department of Oncology-Pathology, Division of Medical Radiation Physics, Karolinska Institutet, Sweden*
[c] *Department of Hospital Physics, Karolinska University Hospital, Stockholm, Sweden*
[d] *Department of Oncology and Department of Clinical and Experimental Medicine, Linköping University, Sweden*
[e] *Department of Oncology, Institute of Clinical Sciences, Division of Clinical Cancer Epidemiology, Sahlgrenska Academy, Gothenburg, Sweden*
[f] *Department of Oncology, Sahlgrenska University Hospital, Gothenburg, Sweden*
[g] *Department of Radiation Physics, Institute of Clinical Sciences, Sahlgrenska Academy at University of Gothenburg, Gothenburg, Sweden*
[h] *Ersta Sköndal University College, Department of Health Care Sciences, Stockholm, Sweden*
* Corresponding author.

Background and purpose. To investigate the dose-response relation between the dose to the vagina and the patient-reported symptom *'absence of vaginal elasticity'* and how time to follow-up influences this relation.

Materials and methods. The study included 78 long-term gynecological cancer survivors treated between 1991 and 2003 with external beam radiation therapy. Of those, 24 experienced absence of vaginal elasticity. A normal tissue complication model is introduced that takes into account the influence of time to follow-up on the dose-response relation and the patient's age. The best estimates of the dose-response parameters were calculated using Probit, Probit-Relative Seriality (RS) and Probit-time models. Log likelihood (LL) values and the Akaike Information Criterion (AIC) were used to evaluate the model fit.

Results. The dose-response parameters for 'absence of vaginal elasticity' according to the Probit and Probit-time models with the 68% Confidence Intervals (CI) were: LL=−39.8, D_{50} = 49.7 (47.2–52.4) Gy, γ_{50} = 1.40 (1.12–1.70) and LL = −37.4, D_{50} = 46.9 (43.5–50.9) Gy, γ_{50} = 1.81(1.17–2.51) respectively.

Conclusions. The proposed model, which describes the influence of time to follow-up on the dose-response relation, fits our data best. Our data indicate that the steepness of the dose-response curve of the dose to the vagina and the symptom 'absence of vaginal elasticity' increases with time to follow-up, while D_{50}decreases.

- Alevronta E, Avall-Lundqvist E, Al-Abany M, et al. Time-dependent dose-response relation for absence of vaginal elasticity after gynecological radiation therapy. Radiother Oncol 2016. http://dx.doi.org/10.1016/j.radonc.2016.02.013.

http://dx.doi.org/10.1016/j.ejmp.2016.07.674

DOSIMETRIC CHARACTERIZATION OF A COMMERCIAL 2-D SCINTILLATION DETECTOR FOR QUALITY ASSURANCE TESTS IN SCANNED PROTON AND CARBON ION BEAMS

S. Russo [a], D. Boi [b,*], A. Mirandola [a], S. Molinelli [a], A. Mairani [a], E. Mastella [a], G. Magro [a], S. Giordanengo [c], M. Ciocca [a]

[a] *Centro Nazionale di Adroterapia Oncologica (CNAO), Pavia, Italy*
[b] *Department of Physics, Università degli Studi di Cagliari, Cagliari, Italy*
[c] *Università degli Studi di Torino, Italy*
* Corresponding author.

Introduction. Pencil beam scanning technique used at CNAO requires beam characteristics to be carefully and periodically checked to guarantee patient safety. Radiochromic films are used within daily QA checks.

Purpose. This study aimed at characterizing the Lynx PT system (IBA Dosimetry) and assessing its suitability for QA tests, for proton and carbon ion beams.

Materials and methods. The Lynx PT is a 2D high-resolution dosimetry system consisting of a scintillating screen coupled with a CCD camera, in a compact light-tight box. A dedicated software is used for image acquisition, raw data correction and fast data analysis. Lynx was characterized in terms of short-term stability, image geometrical distortion, uniformity, signal proportionality, response dependence on IRIS and on particle intensity, particle energy and type. Irradiations were performed at the Centro Nazionale di Adroterapia Oncologica (CNAO) for both protons and carbon ions. Measurements with Lynx were compared to those made with EBT3 reference films. The detector response dependence on radiation LET was also investigated.

Results. Lynx basic characterization results have shown a proportional behavior with delivered number of particles. Strong dependence of the acquired signal on beam energy and particle type was found. No significant differences in the investigated beam parameters measured with Lynx and EBT3 film were observed. The detector also showed good performances in term of image uniformity and geometrical distortion.

Conclusion. The Lynx PT system appears as a promising tool for measurements for both single pencil beam and scanned beam, enabling fast QA and beam optics optimization checks.

http://dx.doi.org/10.1016/j.ejmp.2016.07.675

DECISSION OF TREATMENT WITH IODINE-131 OF ONE PATIENT PREVIOUSLY IRRADIATED WITH RADIOTHERAPY

Jose Miguel Jimenez *, Rocio Garcia, Alvaro Seguro, Gema Ruiz

Medical Physics Department, Hospital Universitario Rey Juan Carlos, c/ Gladiolo s/n, 28933 Móstoles, Madrid, Spain
* Corresponding author.

Introduction. With the purpose of starting a treatment with Iodine-131 it's necessary to evaluate the remanent organ doses of previous treatments with other radioactive sources.

Purpose. To make sure that a new treatment with radiation will not increase the dose above a threshold value that could result in a deterministic effect.

Materials and methods. Once diagnosed the hyperthyrodism in a patient of our hospital, the evaluation of the treatment with Iodine-131 should be evaluated analyzing other factors in addition to the pathology, uptake rate and hormonal indicators.

The patient was irradiated eight years ago on the right mandibular region in the treatment of a LNH (Lymphoma No Hodgdkin).

To evaluate the glandular doses that can uptake high radiation doses in the treatment with the Iodine-131, it's necessary to calculate the remanent dose, especially in salivary glands. For that purpose it's recovered the plan of the radiotherapy treatment.

Results. In this case the remanent dose in salivary glands calculated biologically after eight years and added to the average doses with Iodine-131 doesn't overcome threshold values. Nevertheless in some publications are indicated maximum doses in salivary glands that should be taken into account when previous treatments with radiation have been made.

Conclusion. With the treatment with Iodine-131 in patients previosly irradiated, the salivary glands should be considered to prevent some effects as the xerostomy. It's essential to promote after the administration of Iodine-131 some rules not to uptake the radiopharmaceuticals in some critical organs as the salivary glands.

http://dx.doi.org/10.1016/j.ejmp.2016.07.676

PREVISIONAL DOSIMETRY IN ^{99M}TC-MAA SPECT-TC IMAGES FOR LIVER RADIOEMBOLIZATION WITH ^{90}Y MICROSPHERES: INFLUENCE OF ITERATIVE AND FBP RECONSTRUCTION ALGORITHMS ON DOSE CALCULATION

E. Richetta [a,*], L. Radici [a], M. Pasquino [a], C. Cutaia [a], S. Valzano [a], M. Menga [b], R.E. Pellerito [b], M. Stasi [a]

[a] *Medical Physics Department, Mauriziano Hospital, Turin, Italy*
[b] *Nuclear Medicine Department, Mauriziano Hospital, Turin, Italy*
* Corresponding author.

Introduction. ^{90}Y radioembolization is preceded by a ^{99m}Tc-MAA simulation to calculate tumour (T) and normal liver (NL) doses with MIRD, supposing a uniform distribution, or with voxel-dosimetry taking into account for the inhomogeneities.

Purpose. To evaluate differences between iterative and FBP algorithms.

Materials and methods. 18 patients SPECT-TC ^{99m}Tc-MAA were acquired (SiemensIntevo) and reconstructed with iterative (Flash3D, attenuation-scatter corrected) and with FBP (no corrections). A physician countored VOIs on both series: mean doses to T and NL were obtained with MIRD. All series were processed with an home-made voxel code: mean doses and DVHs were evaluated (NL and T: $D_{2\%}D_{20\%}$ $D_{95\%}$ $D_{100\%}$ and $V_{30\ Gy}$ $V_{40\ Gy}$ $V_{50\ Gy}$ and $V_{120\ Gy}$ for T). Wilcoxon paired-test compared volumes and doses. Acquisition on a phantom 1.25 MBq/ml (spheres 1 ÷11 ml) and cylinder (130 ml) was also performed.

Results. FBP T volumes were smaller than IT ones in 15/18 patient images (median −18%), no statistical difference was found for NL. T mean doses were higher for FBP both with MIRD (17/18 patients, +10%) and voxel method (15/18 patients, +5%); NL mean doses were higher for FBP with MIRD only (14/18 patients, +25%). DVH analysis showed no statistical difference in D_x and V_x but with an extended range of variability. In phantom opposite results were found: mean doses and DVHs were lower in FBP than IT (spheres −22%, cylinder −53%).

Conclusion. FBP and Iterative algorithms can affect volumes and mean-dose calculations probably due to not appropriate homogeneity hypothesis. At voxel level lower discrepancies were found on patients but not in phantom.

Disclosure. The authors disclose any relationship that may bias their presentation.

http://dx.doi.org/10.1016/j.ejmp.2016.07.677

DOSIMETRY OF LESIONS IN RADIOIODINE THERAPY OF METASTATIC THROID CANCER: SPECT-TC CALIBRATION, VERIFICATION AND PRELIMINARY PATIENT RESULTS

E. Richetta [a], L. Radici [a,*], C. Cutaia [a], S. Valzano [a], G. Lo Moro [a] M. Pasquino [a], R.E. Pellerito [b], M. Stasi [a]

[a] *Medical Physics Department, Mauriziano Hospital, Turin, Italy*
[b] *Nuclear Medicine Department, Mauriziano Hospital, Turin, Italy*
* Corresponding author.

Introduction. ^{131}I is used in treatment of metastatic thyroid cancer. Higher activity seems to improve the outcome compared to multiple lower treatments. Patient-specific dosimetry avoids adverse effects and allows appropriate metastasis irradiation. SPECT-TC is more accurate to estimate activity than planar methods.

Purpose. To define quantitative SPECT-TC lesion dosimetry protocol.

Materials and methods. Three hollow spheres (11.5, 5.6 and 1.1 ml) and a cylinder (130 ml), filled with liquid ^{131}I (13 MBq/ml) and placed into a water phantom, were acquired (SPECT-TC SiemensIntevo, 64views, 20s/view, circular-orbit, 128 × 128 and 256 × 256) on successive days (dead time 26÷0.5%). Images were Iterative (Flash3D) scatter-attenuation corrected. Detectors counts-rates and dead-time were noted. Counts/activity were evaluated on volumes segmented with TC and threshold-method. Partial volume effects, radius dependence (25-33cm) and dead-time were evaluated; calibration's verification and a first patient dosimetry was also reported.

Results. Calibration factors (cylinder:25.4, smallest sphere:1.4 kcts/MBq) confirmed partial volume effects. Volume recovery coefficients (130 ml–100%, 11 ml–75%, 5.5ml-58%, 1.1 ml–6%) showed radius dependence (within 4.5 % for cylinder; up to 43% for the smallest sphere). The dead-time versus cts/MBq showed a linear dependence ($r^2 = 0.99$) that allowed the relative correction. According to literature (MIRD24), calibration's verification showed an accuracy within ±11 % (except for the smallest volume up to 36 %). Similar results were found for all segmentation methods but the CT-based was the most accurate one. This calibration was applied to a patient lung lesion (56 Gy).

Conclusion. SPECT-TC represents the more reliable system for lesion dosimetry, allowing accurate volumes and dead-time correction.

http://dx.doi.org/10.1016/j.ejmp.2016.07.678

OPTIMIZATION OF ACTIVITY AND ABSORBED DOSES CALCULATION TO TARGET/TUMOR AND NORMAL LIVER VOLUMES IN PATIENTS SUBMITTED TO YTTRIUM-90 RADIOEMBOLIZATION WITH GLASS MICROSPHERES

Paulo Ferreira [a,*], Rui Parafita [a], Ana Canudo [a], Carla Oliveira [a], Luís Rosa [a], Pedro Girão [b], Durval C. Costa [a]

[a] *Champalimaud Centre for the Unknown, Fundação Champalimaud, Lisbon, Portugal*
[b] *Instituto Superior Técnico/Universidade de Lisboa, Lisbon, Portugal*
* Corresponding author.

Introduction. The model provided by manufacturers of the Y-90 microspheres does not consider dose restrictions to tumor and to normal liver volumes, but simply calculates activity to be administered based on a prescribed dose of 120 Gy corrected for liver volumes and hepato-pulmonary shunt. It is paramount to analyze data post Y-90 injection, creating dose volume histograms (DVH), to calculate the real absorbed dose distribution in liver segments with and without tumor.

Purpose. To investigate new algorithms to calculate activities during Y-90 glass microspheres liver radioembolization and optimizing absorbed doses to tumor/target and normal liver volumes.

Materials and methods. This is a retrospective study of eleven patients with multiple colorectal liver metastases submitted to liver radioembolization with Y-90 glass microspheres (Therasphere™). CT and Y-90 PET images were used together with Stratos™ software to obtain values for absorbed doses (based on distribution of Y-90) throughout the entire liver volume. Dose volume histograms (DVH) were created to stratify absorbed dose as percentage of total irradiated volume.

Results. Our results reveal that only 7% of the liver volume received twice and/or trice the intended prescribed dose of 120 Gy. 25% and 68% of the liver volume received respectively 120 and less than 50 Gy. All patients receiving less than 80 Gy in more than 50% of the liver volume are alive and well.

Conclusion. Our data suggest a relationship between patient clinical outcome and absorbed doses in liver volumes. Work to optimize administered activities according to tumor/target and normal liver volumes is underway.

Disclosure. None.

http://dx.doi.org/10.1016/j.ejmp.2016.07.679

SKIN DOSE EVALUATION FOR 3DCRT AND VMAT BREAST CANCER TECHNIQUES

A.G. Dias [a,b,*], D. Pinto [c], F. Borges [a], J. Lencart [a,b]

[a] *Medical Physics Department, Portuguese Institute of Oncology, Porto, Portugal*
[b] *Medical Physics, Radiobiology and Radiation Protection Group, Research Centre, Portuguese Institute of Oncology, Porto, Portugal*
[c] *Radiotherapy Department, Portuguese Institute of Oncology, Porto, Portugal*
* Corresponding author.

Introduction. Skin dose is a concern both in breast conservative and post-mastectomy irradiation. Although in most cases the skin is considered an organ at risk, in some there is the need to irradiate it with therapeutic doses. When Volumetric Modulated Arc Therapy (VMAT) technique is used for the treatments, because the Three-Dimensional Conformal Radiation Therapy (3DCRT) dose distribution is not clinically satisfactory, the issue about the skin dose arises.

Purpose. The purpose of this work is to evaluate the surface dose when each of these techniques is used, to compare the measured doses with the doses calculated by the Treatment Planning System (TPS) and to assess the need of using bolus during part or all the treatment fractions

Materials and methods. A MOSFET-based system was used. A complete characterization of the system performance was previously made. The skin dose was measured at two points tattooed on the skin, equally distanced from the breast/thoracic wall midline. Measurements were performed for 6MV 3DCRT and 6MV VMAT and compared with the dose values predicted by the TPS.

Results. The mean measured dose is higher for the 6MV 3DCRT technique than for VMAT (both without bolus). The surface dose difference between the two techniques is lower when bolus is used.

The same differences were obtained for the mean calculated dose in both conditions.

Conclusion. Despite some discordant results in literature, one found from the present results, that skin sparing effect is better achieved with VMAT technique.

Disclosure. The authors have no relevant financial or non-financial relationships to disclose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.680

PROSTATE SBRT: THE USE OF ERB AND MOSFET IN VIVO DOSIMETRY FEASIBILITY

A.G. Dias [a,b,*], L.T. Cunha [a,b], A. Oliveira [c], J.A.M. Santos [a,b], J. Lencart [a,b]

[a] *Medical Physics Department, Portuguese Institute of Oncology, Porto, Portugal*
[b] *Medical Physics, Radiobiology and Radiation Protection Group, Research Centre, Portuguese Institute of Oncology, Porto, Portugal*
[c] *Radiotherapy Department, Portuguese Institute of Oncology, Porto, Portugal*
* Corresponding author.

Introduction. Hypofractionated treatment regimens are indicated for some stages of prostate cancer. In order to provide the reproducibility of the relative position between rectum and prostate and to allow that only a small volume of the rectal wall remains close to the prostate, an endorectal balloon (ERB) may be used.

Purpose. This work aims to assess the dose on the rectal wall in the presence of the ERB filled with water or air and evaluate the deviation between the measured and calculated doses using two different algorithms (Eclipse AAA and iPlan PencilBeam)

Materials and methods. Two CT scans were obtained for a modified Rando phantom where an ERB (filled with water or air) with three MOSFET detectors was inserted. A simple 4 field in box plan and an IMRT (6MV beam) clinical plan were calculated in both CT sets, using two different algorithms. The treatment plans were delivered to the phantom using a Varian Novalis linac. Four sets of measurements were obtained and the results were compared with the calculated values.

Results. The difference between the calculated and measured doses around the ERB is lower when it is filled with water for both algorithms. The maximum relative differences when the ERB is filled with air are 1.8% for Eclipse and 5.5% for iPlan.

Conclusion. Both algorithms show a better a performance in the presence of water. Water filled ERB seems to be a suitable option. MOSFET dosimetry in association with ERBs for real-time in vivo during hypofractionated treatment of the prostate is a practical and reliable procedure.

Disclosure. The authors have no relevant financial or non-financial relationships to disclose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.681

CHARACTERIZATION OF THE EXRADIN A26 MICROCHAMBER FOR SMALL FIELD DOSIMETRY

M. Pasquino, C. Cutaia, L. Radici, E. Gino, M. Stasi *

Medical Physics Department, AO Mauriziano, Torino, Italy
* Corresponding author.

Introduction. In modern radiation therapy accurate dosimetry within small photon fields is a challenge. The aim of the study is to investigate the main dosimetric characteristics of a new small field detector.

Material and methods. An Exradin A26 microionization chamber was tested. Short term stability, dose linearity, polarity effect, angular dependence and energy dependence were evaluated for field sizes up to $10 \times 10\ cm^2$. Results were compared with those obtained with an Exradin A1SL IC. PDD curves, OAR profiles and OF values were measured for different field sizes. The results were compared with those obtained with an IC and an EDGE diode.

Results. A26 IC readings showed a 0.2% and 0.1% relative standard deviation for 3×3 and $10 \times 10\ cm^2$ fields, respectively. Dose response was linear to within 0.5%. The microchamber showed the maximum variation from the reference condition at the lowest dose rate. The polarity effect is within 0.5% for field size greater than $2 \times 2\ cm^2$; for field size less than $2 \times 2\ cm^2$ the effect increases, still remaining within 1%. No energy and angular dependence were observed. A26 IC PDD measurements agreed with those obtained with the EDGE diode. FWHM values show a better agreement with the EDGE diode values than A1SL. The penumbra values were greater than those obtained with the EDGE diode. Of values showed a good agreement with EDGE diode ones.

Conclusions. The study confirms A26 IC as a reference detector for PDD and OAR measurements.

http://dx.doi.org/10.1016/j.ejmp.2016.07.682

CORRELATION BETWEEN BLADDER VOLUME AND BOWEL RADIATION DOSE FOR RECTUM CANCER PATIENTS

Lina Andersson [a,b,*], Claus F. Behrens [b], David Sjöström [b]

[a] *Department of Medical Radiation Physics, Lund University, 221 85 Lund, Sweden*
[b] *Radiotherapy Research Unit, Department of Oncology, Herlev Hospital, University of Copenhagen, Herlev Ringvej 75, DK-2730 Herlev, Denmark*
* Corresponding author.

Introduction. For rectum cancer patients, the bladder volume varies during the course of treatment. This results in a delivered dose distribution different than planned.

Purpose. To study the effect of bladder filling on dose distributions of bowel for rectum cancer patients.

Materials and methods. Twenty-eight rectal cancer patients treated with preoperative radiotherapy in the period February 2015 to January 2016 were included in the study. Each patient had a planning CT scan and weekly CBCT were acquired the first three, four, five and six weeks for 23, 1, 1 and 3 patients, respectively. Bladder and bowel was delineated on the CBCT images and the delineations were transferred to the CT image.

Results. Out of the 28 patients, 6 patients had bladders that were larger on all CBCTs than on the CT. For 13 patients, the bladder on all the CBCTs was smaller than on the CT. For 9 patients, the relationship between the bladder volume on the CT and CBCT images varied. The bladder volumes on the CBCTs ranged from 0.1 to 3.5 times the bladder volume on the corresponding CT, with the majority (81/96) in the range between 0.3 and 2. The change in bladder filling did not result in a violation of the constraint $V_{45Gy} < 195$ cc for any patient.

Conclusion. There is a correlation between bladder volume and bowel radiation dose, however, the dose constraint for the small bowel was not violated for any of the patients in this study.

http://dx.doi.org/10.1016/j.ejmp.2016.07.683

A NEW ROBUST STATISTICAL METHOD FOR TREATMENT PLANNING SYSTEMS VALIDATION USING EXPERIMENTAL DESIGNS

S. Dufreneix [a,*], K. Briand [b], C. Di Bartolo [a], C. Legrand [a], M. Bremaud [a], J. Mesgouez [a], T. Tiplica [b], D. Autret [a]

[a] *Department of Medical Physics, ICO – Paul Papin, Angers, France*
[b] *ISTIA, Angers University, Angers, France*
* Corresponding author.

Introduction. Dose computation verification is an important part of acceptance testing. The IAEA Tecdoc 1540 and 1583 suggest comparing computed dose to measurements for several beam configurations. However, this process is time-consuming and results out of tolerance are often left unexplained.

Purpose. To validate a treatment planning system using experimental designs which allow evaluating several parameters in a few tests selected by a robust statistical method.

Materials and methods. The Taguchi table L36 ($2^{11} \times 3^{12}$) was used to determine the 72 beams needed to test the 7 parameters chosen: energy, MLC, depth, jaw field size in X, Y_1 and Y_2 directions and wedge. Measurements were conducted in water using a CC04 (IBA) on a TrueBeam STx, a TrueBeam Tx, a Trilogy and a C-serie clinac (Varian). Dose was computed using the AAA algorithm (Eclipse, version 11). The same raw data was used for all accelerators during the algorithm configuration.

Results. The mean difference between computed and measured doses was $0.1 \pm 0.5\%$ for all tested beams and all linacs with a maximum difference of 2.4% (under the 3% tolerance level). For all beams, the measured doses were within 0.6% for all linacs. No studied parameter led to statistically significant deviation between computed and measured doses.

Conclusion. Experimental design is a robust statistical method to validate an algorithm. Only 2 h of measurements were needed to evaluate 7 parameters. Furthermore, the commissioned accelerators were found dosimetrically equivalent even though the linac characteristics differ.

Disclosure. No disclosure.

http://dx.doi.org/10.1016/j.ejmp.2016.07.684

CARBON AND OXIGEN MINIBEAM RADIATION THERAPY: A MONTE CARLO DOSIMETRY STUDY

W. González *, C. Peucelle, Y. Prezado

IMNC-UMR 8165, CNRS, Paris 11 Universities, 91406 Orsay Cedex, France
* Corresponding author.

Introduction. Minibeam radiation therapy (MBRT) is a promising RT approach born at synchrotrons that combines the use of a spatial fractionation of the dose with the utilization of submillimetric field sizes (500–700 μm). Contrary to conventional RT, the dose profiles in MBRT consist in peaks and valleys, making the peak-to-valley-dose ratio a very important dosimetric parameter, since in order to spare the normal tissues, high PVDR and low valley doses are required. MBRT has been shown to further increase the normal tissue resistance compared to standard RT.

Purpose. The aim of this work was to perform an in depth dosimetric evaluation of carbon and oxygen minibeam radiation therapy.

Materials and methods. The dose distributions of rectangular minibeams of 600 μm × 2 cm of C and O ions impinged in a water phantom with the Monte Carlo simulation code GATE v6.2 (Geant4.9.5).

Results. PVDR and valley doses were assessed for different irradiation configurations. In particular, a detailed evaluation of the role of secondary particle contamination of the valley doses, which is one of the more critical aspects of MBRT, has been carried out.

Conclusion. The favourable dose distributions obtained indicate that these novel RT approaches might allow reducing the side effects in normal tissues. It should also make charged particle therapy more amenable to administration in either a single dose fraction.

http://dx.doi.org/10.1016/j.ejmp.2016.07.685

COMPARATIVE PATIENT ORGAN DOSE LEVELS FOR MAXILLOFACIAL EXAMINATIONS PERFORMED WITH DIFFERENT RADIOLOGICAL FACILITIES

Marta Sans-Merce [a,b,*], Jérôme Damet [a,c], Minerva Becker [b]

[a] *Institute of Radiation Physics, Lausanne University Hospital, Switzerland*
[b] *Department of Medical Imaging and Information Sciences, University Hospitals of Geneva, Switzerland*
[c] *Department of Radiology, University of Otago, Christchurch, New Zealand*
* Corrresponding author.

Introduction. Maxillofacial radiologic examinations often result in irradiation of the thyroid gland, parotid glands and lens due to primary exposure or scatter radiation. Organ exposure depends on imaging modalities and protocols.

Purpose. The purpose of this investigation was to evaluate radiation doses to the above-mentioned organs for CT, cone beam CT (CBCT) and panoramic radiographs (orthopantomography, OPT).

Materials and methods. The absorbed dose was measured on the surface of a head phantom with thermoluminescence dosimeters. The phantom was imaged with CT, CBCT and OPT using standardized protocols employed in clinical routine. The areas examined included the paranasal sinuses, the entire head and the mandible depending on the protocol used. Dose measurements were performed individually for each modality and each protocol.

Results. Doses to the thyroid gland when located outside the area of interest were lowest for all modalities (range: 0.01–1.22 mGy; measurement uncertainty: 10% at $k = 2$). Depending on the examination protocol, doses to the eye lens (due to primary beam or scattered radiation) showed wide variability (range: 0.02–26.22 mGy). The parotid glands were the only organs systematically placed in the primary beam for all modalities and protocols. Values ranged from 1.40–29.11 mGy with the highest values for CT examinations. For OPT, doses to the parotid glands were strongly inhomogeneous due to its operating mode.

Conclusion. CT was the most irradiating modality. The mean doses to the parotid glands were similar for CBCT and OPT, while doses to organs in the scattered field were systematically higher for CBCT than OPT.

Disclosure. The authors declare that they have no relevant material or financial interests that relate to the research described in this study.

http://dx.doi.org/10.1016/j.ejmp.2016.07.686

WHAT DOSE DISTRIBUTION METRICS IN THE PTV IS CLOSE TO THE GENERALIZED EQUIVALENT UNIFORM DOSE?

Marzena Mrozowska [a], Paweł Kukołowicz [b,*]

[a] *Subcarpathian Oncology Center, Brzozow, Poland*
[b] *Center of Oncology, Warsaw, Poland*
* Corresponding author.

Introduction. Several mathematical approaches to find a direct link between the dose distribution and the treatment outcome were proposed. Brahme introduced the so called effective dose, Niemierko described the concept of the general Equivalent Uniform Dose (gEUD). The ICRU Report 83 proposed to prescribe the dose to the median dose to the PTV.

Purpose. The aim of the study was to compare the mean dose, median dose, the effective dose and the gEUD.

Materials and methods. The study was performed for three groups of patients with breast, lung and prostate cancer treated radically with external beams in Brzozow. There were 10 patients in each group. In the treatment planning the differences between the maximum and minimum doses to PTV were minimized.

Results. There was a very good correlation between the gEUD and the median dose in the PTV ($R^2 = 0.954$). The discrepancy between these two values for the same patient was never larger than 1%. Such good correlation was not obtained for the gEUD and the effective dose. There was also poor correlation between the mean dose delivered to the PTV and the gEUD ($R^2 = 0.183$).

Conclusion. These findings prove that the proposal published in the ICRU 83 Report form a very good and comprehensive system of dose prescription which can be used as a link between the ICRU 50, the NACP recommendations and the gEUD.

Disclosure. There is any relationship that may bias our presentation.

http://dx.doi.org/10.1016/j.ejmp.2016.07.687

A NEW OPTICAL SYSTEM FOR QUALITY CONTROL AND PATIENTS POSITIONING IN RADIATION THERAPY

Paweł Kukołowicz [a,*], Agnieszka Walewska [a], Arkadiusz Smigielski [b], Michal Dyrek [b]

[a] *Centrum Onkologii-Instytut im. Marii Skłodowskiej Curie, Poland*
[b] *OptiNav Company, Poland*
* Corresponding author.

Introduction. Measurements of distances with relation to user defined coordinate system (UCS) is one of the main task in quality control of radiotherapy.

Purpose. Introducing a new optical system for quality control, especially for all mechanical tests where position or distance is measured and for positioning of patients is presented.

Materials and methods. The standard version of the system consists of two optical cameras, a data collecting computer, specialized software and a set of markers. The system allows for the measurement of the 3D position of the marker center (X,Y,Z) and three vectors representing the position of the center with respect to UCS. The UCS is defined with a set of three markers. The uncertainty of the standard system with 0.8 megapixels cameras, 2 cm × 2 cm marker size, and the FOV of about 50 cm × 50 cm is ~0.2 mm (1 SD). The position of the marker is defined thanks to mathematical operations on the pattern of the marker. This mathematical procedure and the pattern of the marker are waiting for patent. In general unlimited number of different markers might be printed, so the positions of many points may be measured in the same time. The marker may be printed on any material. The results of the quality control test performed to check the rotational precision of two IsoAligne will be presented.

Results. Both IsoAligne rotated very well around their centers; however we found some differences between them. For some rotational position there was a deflection from the ideal position of about 0.4 mm.

Conclusion. The system is a very promising tool for all quality control tests in which distance (position) has to be measured.

Disclosure. There is any relationship that may bias our presentation.

http://dx.doi.org/10.1016/j.ejmp.2016.07.688

NEW VARIANCE REDUCTION TECHNIQUES FOR MCNP6 FOR EXTERNAL RADIATION THERAPY CALCULATIONS

Ildikó Papp [a,*], Gábor Stelczer [b], Csilla Pesznyák [c], Máté Szieberth [a], Szabolcs Czifrus [a]

[a] *Institute of Nuclear Techniques, Budapest University of Technology and Economics, Czech Republic*
[b] *National Institute of Oncology, Czech Republic*
[c] *Institute of Nuclear Techniques, Budapest University of Technology and Economics, National Institute of Oncology, Czech Republic*
* Corresponding author.

Introduction. Over the last years, Monte Carlo methods have taken an important role in radiation therapy. One of the main disadvantages of these methods is their huge computational demand.

Purpose. The goal of the current work is to describe and develop new variance reduction methods relevant to external radiation therapy in the MCNP6 source code.

Materials and methods. In this study a new filter-technique and filtered azimuthal particle redistribution (fAPR) method were developed. To test the efficiency of these methods a modified FOM value was introduced.

Results. The modified FOM value of the fAPR technique has been found to be approximately 5 times higher in the case of percentage depth dose curves than the modified FOM value of the filter technique. At the same time when simulating dose profiles this ratio has been found to be 5.5 in advance for the fAPR technique as well. Calculated data was compared to measured values and good agreement was found in the case of the filtered and fAPR results.

Conclusion. Computational time can be significantly reduced by using the new methods which have been tested to give unbiased results. Results show that the filtered technique combined with azimuthal particle redistribution is a beneficial method in radiation therapy.

http://dx.doi.org/10.1016/j.ejmp.2016.07.689

THE REPEATABILITY OF THE SCANNER IN RADIOCHROMIC FILM DOSIMETRY

Mendez Ignasi *, Sljivic Zeljko, Hudej Rihard, Jenko Aljasa, Casar Bozidar

Institute of Oncology, Ljubljana, Slovenia
* Corresponding author.

Purpose. The repeatability of the scanner EPSON 10000 XL in radiochromic film dosimetry was studied. Several patterns were observed and analyzed.

Methods. The dispersion of the measures of the scanner as a function of the pixel position was calculated for resolutions 50, 72, 96 and 150 dpi. The distance between the position of the same pixel

in different scanners, as well as the dependency of this distance with the position in the axis perpendicular to the scanner lamp, was examined. Inter-scan and intra-scan variability of the scanner response was studied.

Results. The scanner noise is not independent of the pixel position; its variance follows periodical patterns in both axes, which causes grid patterns. The initial positioning and the speed of the scanner lamp varies between scans. Consequently, average pixel values from different scans have more uncertainty at the end of the scanning reading than at the beginning. The scanner response varies not only inter-scan, but also intra-scan. This is caused by deviations of the individual CCD detectors from their reference state.

Conclusions. Three new perturbations which affect radiochromic film dosimetry with flatbed scanners were discovered and analyzed: grid patterns, scanning reading repeatability and intra-scan variations. A novel correction method which reduces inter- and intra-scan variations was proposed.

http://dx.doi.org/10.1016/j.ejmp.2016.07.690

DOSIMETRY FOR LOW ENERGY PROTONS WITH IONIZATION CHAMBERS AND EBT3 FILMS IN THE BRAGG PEAK REGION

M.C. Battaglia [a,b,*], D. Schardt [c], J. Espino [a,b], M. Gallardo [a], M.A. Cortés-Giraldo [a], J.M. Quesada [a], A.M. Lallena [d], H. Miras [e], D. Guirado [f]

[a] *Departamento de Física Atómica, Molecular y Nuclear, Universidad de Sevilla, 41013 Seville, Spain*
[b] *Centro Nacional de Aceleradores (CNA) de la Universidad de Sevilla, Junta de Andalucia y CSIC, 41092 Seville, Spain*
[c] *GSI Helmholtz Centre for Heavy Ions Research, 61291 Darmstadt, Germany*
[d] *Departamento de Física Atómica, Molecular y Nuclear, Universidad de Granada, E-18071 Granada, Spain*
[e] *Hospital Universitario Virgen Macarena (HUVM), 41071 Seville, Spain*
[f] *Hospital Universitario San Cecilio, E-18012 Granada, Spain*
* Corresponding author.

Introduction. Protons beams are largely used for tumor therapy thanks to their property of delivering dose in a small localized area (Bragg peak). The 3 MV Tandem accelerator at CNA allows to perform measurements with low energy protons. By degrading passively the beam energy, we can study the dosimetry at the end of the range in tissue of therapeutic proton beams.

Purpose. Study of dosimetry in the Bragg peak region, in order to establish a dosimetry protocol in such region.

Materials and methods. A special device was used to degrade passively the energy of the beam. It mainly consists of a precise positioning system and a holder designed to house a ionization chamber (IC) and radiochromic films, which allowed to perform dosimetry studies at different distances in air.

Results. We present an experimental study of the Bragg peak in air using two ICs, the dosimetry with radiochromic films in the Bragg peak region and the comparison of data with Geant4 Monte Carlo simulations. Moreover, we expect to give a characterization of the radiochromic film dosimetry for the Bragg peak region where effects of saturation are occurring comparing Geant4 simulations with experimental data.

Conclusion. Few studies have been conducted until now to quantify the dose deposition in the Bragg peak, and by means of such measurements we are trying to establish a dosimetry protocol in such region, using Monte Carlo simulations and measurements with ICs and radiochromic films.

Disclosure. The authors have no conflicts of interest.

http://dx.doi.org/10.1016/j.ejmp.2016.07.691

A SIMPLE PMMA PHANTOM FOR DAILY QA ENERGY CHECKS IN PROTON THERAPY

N. Bizzocchi *, F. Fracchiolla, M. Schwarz

Azienda Provinciale per i Servizi Sanitari (APSS) Protontherapy Department, Trento, Italy
* Corresponding author.

Introduction. Beam energy measurements are one of the most important data that every radiotherapy facility has to collect periodically as constancy check. In proton therapy, due to the energy selection system and to the shape of the Bragg peak, this check has to be performed daily.

Purpose. To demonstrate that reliable daily proton energy verification is achievable using a 2D array of ionization chambers (IC) combined with our PMMA phantom.

Material and methods. The PMMA phantom is provided with three couples of wedges: thanks to these, Bragg peak is sampled at different depths and the image becomes a transposition on the transverse plane of the depth dose. Coupled wedges are necessary to compensate for set-up errors. Three wedges of different slopes (the first and lowest one is for energy from 70 to 100 MeV, the middle one from 100 to 140 MeV and the third and highest one from 140 to 226 MeV) are used to spread the depth dose of every single checked energy in a way that the distal penumbra can be properly detected by an adequate number of IC in the 2D Array device.

Results. A sensitivity test showed that the phantom is able to detect range variations greater than the threshold (2 mm).

Conclusions. We designed and built a reliable phantom for the range verification. Moreover, the costs of this phantom are very low compared to other commercial solutions used for range verification in proton therapy.

http://dx.doi.org/10.1016/j.ejmp.2016.07.692

EVOLUTION OF FREEBREATHING USING THE SDX SYSTEM IN 4D-CT WITH THE SIEMENS SOMATOM SCANNER FOR STEREOTAXIC LUNG TREATMENT WITH VMAT SBRT (X6 FFF)

Daniel Julian [a,*], Paul-Alexandre Daviau [b]

[a] *CCGM Clementville, Montpellier, France*
[b] *CCGM Clementville, University Blaise Pascal in M2-PTR-IPM Formation, Clermont-Ferrand, France*
* Corresponding author.

Introduction. Study on the improvement in scanner precision associated with the use of the SDX System in 4D-CT.

Purpose. As part of lung stereotactic protocol development in free breathing, the company Dyn'R partnered for the first time with Siemens. Dyn'R has a specific spirometer system allowing the measurement of the patients internal respiratory volume; up until now the SDX System has been used uniquely in voluntary Breath Hold thoracic treatments.

Innovation has come from free-breathing synchronization between the SDX System and the Siemens Somatom using the 4D-CT retrospective mode. The aim of this study was to establish the primary imaging phase of an END to END protocol on the stereotaxic lung treatment with VMAT SBRT 6MV FFF in association with free breathing.

Materials and methods. Volunteers created human respiratory cycles for importation into the Quazar Phantom (MODUS) to provide real respiratory motion to the SDX System & simulation of systemic position error within the scanner Siemens Somatom Scope.

Results. Overall control of the imaging phase using both simulated & volunteer free breathing respiratory data for the acquisition

process gives satisfactory results concerning the synchronization between the two systems.

Conclusion. The precision of 4D-CT using the SDX System and the Siemens Somatom will allow for an improved lung stereotactic VMAT 4D treatment, sparing healthy tissues whilst making the process simpler and faster for the patient.

http://dx.doi.org/10.1016/j.ejmp.2016.07.693

PRELIMINARY INVESTIGATIONS ON THE USE OF MRI FOR DECISION MAKING IN ADAPTIVE PROTON RADIOTHERAPY FOR HEAD AND NECK CANCER

Florence Giesen *, Luiza Bondar, Benoit Macq

IMAGX-R, Université Catholique de Louvain, Louvain-La-Neuve B1348, Belgium

* Corresponding author.

Introduction. For proton therapy of head and neck (H&N) virtual CT-scans (VCTs) generated from CBCTs can aid decision making for treatment adaptation.

Purpose. The aim was to investigate the accuracy of VCTs generated from daily MRIs. This work is relevant for proton centers without CBCT, but equipped with an out-of-room MRI scanner.

Materials and methods. For 5 H&N tomotherapy patients, 4 weekly CT-scans and MRIs were used. To allow comparison, CBCTs were generated from CTs using an in-house algorithm and for each pair of weekly CT and MRI pose changes were minimized by non-rigid registration. VCTs were generated by non-rigidly deforming the planning CT into the anatomy of the MRIs (VCT_MRIs) and CBCTs (VCT_CBCTs). The geometric accuracy of VCTs was evaluated by the Dice's coefficient (DSC) between structures on VCTs and on weekly CTs. Water equivalent thickness (WET) maps at the surface of structures were calculated from stopping power maps for projections at 90° and 270° angles. Differences in WET maps between weekly CTs and VCTs were analyzed using a gamma index of 1mm/1mm.

Results. The average DSCs for VCT_MRI and for VCT_CBCT were respectively, 0.96 ± 0.01 and 0.98 ± 0.01 (external), 0.78 ± 0.09 and 0.86 ± 0.04 (parotids), 0.88 ± 0.04 and 0.91 ± 0.02 (brainstem), and 0.55 ± 0.21 and 0.62 ± 0.22 (GTV). The percentage of pixels that passed the gamma index criterion was significantly higher for VCT_CBCT ($75.30 \pm 13.07\%$ versus $45.84 \pm 21.27\%$).

Conclusion. Geometrically accurate VCTs could be generated from daily MRIs and CBCTs. Full dosimetric calculations will provide further insight on the use of MRIs for decision making in proton radiotherapy.

Disclosure. This work was supported by the Fonds de la Recherche Scientifique - FNRS under Grant(s) n° 7463215F.

http://dx.doi.org/10.1016/j.ejmp.2016.07.694

PRIMO SOFTWARE AS A TOOL FOR MONTE CARLO SIMULATIONS OF INTENSITY MODULATED RADIOTHERAPY: A FEASIBILITY STUDY

Alessandro Esposito [a,c,*], Sofia Silva [a,b], Luis T. Cunha [a,b], Anabela Gregório Dias [a,b], Diana Pimparel [b], Silvia Gutierrez [b], Susana Dias [a,c], Joana Lencart [a,b], João A.M. Santos [a,b]

[a] *Medical Physics, Radiobiology and Radiation Protection Group, Research Centre, Portuguese Institute of Oncology, Porto, Portugal*

[b] *Medical Physics Department, Portuguese Institute of Oncology, Porto, Portugal*

[c] *Departamento de Física e Astronomia, Faculdade de Ciências, Universidade do Porto, Porto, Portugal*

* Corresponding author.

Introduction. Intensity Modulated Radiation Therapy (IMRT) allows creating complex dose distributions. The Monte Carlo (MC) is considered the gold standard method to perform dose calculations. A recent new MC user-friendly interface named PRIMO was developed targeting External Radiotherapy environment. Nevertheless, advanced features such as IMRT are not yet introduced.

Purpose. To assess the capability of PRIMO to simulate IMRT procedures.

Materials and methods. Two Radiotherapy units, both using Varian 2300CD LINAC head were simulated. While one uses Millennium120, the other has 120HD as Multi Leaf Collimator (MLC). Static simulations were performed to validate LINAC heads and MLC models. Homemade software was developed to configure PRIMO to reproduce MLC modulation as planned by the Treatment Planning System and create dose distribution images at specific planes from PRIMO output files.

For each unit, a dynamic MLC delivery was split into a number of static segments and simulated on solid water phantom. Gafchromic films were used to measure the actual dose and make comparisons with the simulations. Assessments were performed using the 2D Gamma analysis.

Results. More than 95% of Gamma points <1 was found in static simulations of both Radiotherapy units. Simulation of dynamic procedures resulted in 93.5% and 95.2% of Gamma points <1 using respectively the Millennium120 and 120HD MLC unit.

Conclusion. A workflow was found to drive PRIMO to simulate IMRT procedures. The results of simulations agree with the experimental measurements, indicating PRIMO software as a potential tool for clinical implementation of MC simulations of IMRT technique.

Disclosure. The author has no relevant financial or nonfinancial relationships to disclose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.695

IN VIVO DOSIMETRY FOR HEAD CT EXAMINATIONS IN PAEDIATRIC PATIENTS

Ioannis Stathopoulos [a,*], Agapi Ploussi [a], Vasileios Syrgiamiotis [b], Triantafillia Makri [b], Christiana Hatzigiorgi [b], Eleftheria Carinou [c], George Sakellaropoulos [d], George S. Panayiotakis [d], Efstathios P. Efstathopoulos [a]

[a] *2nd Department of Radiology, University General Hospital 'Attikon', School of Medicine, National and Kapodistrian University of Athens, Athens, Greece*

[b] *Children's Hospital Agia Sophia, CT-MRI Department, Greece*

[c] *Greek Atomic Energy Commission (GAEC), Agia Paraskevi, Attiki, Greece*

[d] *Department of Medical Physics, Faculty of Medicine, University of Patras, Patras, Greece*

* Corresponding author.

Introduction. Serious concerns about children exposure to ionizing radiation have been raised due to the widespread use of computed tomography (CT) in paediatrics. The increased radiosensitivity of children and the radiation-associated cancer risk call for immediate action in the field of patient-specific dosimetry and optimization of existing CT protocols.

Purpose. The main objective of our study is to present in vivo radiation dose measurements during paediatric head CT examinations using thermoluminescent dosimeters (TLDs). To our knowledge, there are limited literature data concerning in vivo dosimetry in paediatric patients.

Materials and methods. The ongoing study includes paediatric patients ranging from neonates to 15 years old who underwent head CT examinations on a 16-slice CT scanner in ''Agia Sofia'' Children's

Hospital in Athens using iterative reconstruction algorithm. LiF:Cu,P TLDs, properly calibrated, were placed in eyes, forehead, behind ears and thyroid glands. Surface doses to the lens of the eye, the brain and the thyroid were calculated for each patient.

Results. For patients $\leqslant$5 years old, surface doses in eye lens, brain and thyroids were 38.45 ± 5 mGy, 33.69 ± 14.05 mGy and 1.84 ± 0.48 mGy respectively, while for patients >5 years old, the surface doses were 35.56 ± 11.16 mGy, 40.04 ± 7.67 mGy and 2.05 ± 0.32 mGy respectively.

Conclusion. Although there are many challenges, patient-specific dosimetry is of great importance in paediatric patients. In vivo dosimetry is a powerful tool which provides an accurate and effective method for skin dose measurements. Furthermore, since the eyes and the thyroid are superficial organs, the calculated surface dose can give a good estimation of the organ dose to ocular lens and thyroid gland.

Disclosure. None.

http://dx.doi.org/10.1016/j.ejmp.2016.07.696

EVALUATION OF MODEL BASED ITERATIVE RECONSTRUCTION IMR IN COMPUTED TOMOGRAPHY

N. Paruccini [b], C. Pasquali [b], R. Villa [a,b,*], C. Spadavecchia [a,b], A. Baglivi [a,b], A. Radice [b], A. Crespi [b]

[a] *Postgraduated School of Medical Physics, University of Milan, Italy*
[b] *Medical Physics Department, San Gerardo Hospital, ASST Monza, Italy*
* Corresponding author.

Introduction. In the last decades the population dose increase is mainly due to CT. Recently iterative reconstruction algorithms were introduced to obtain dose reduction without compromising the diagnostic performance.

Purpose. To investigate the effect of the model-based IMR algorithm in terms of image quality and patient dose.

Materials and methods. CATPHAN phantom was scanned varying CTDIvol values from 0.8 to 31.8mGy., FBP and IMR algorithms were used to reconstruct the images. Different IMR reconstruction curves were analysed: Routine, Soft and SharpPlus.

The homogeneous insert was used to analyse noise in terms of standard deviation and NPS; Low Contrast Detectability with statistical method was investigated too. MTF was evaluated using a tungsten bead, TTF with a homemade phantom. Patient dose indexes have been collected and analysed.

Results. The averaged noise reduction for IMR routine and soft images is 45% and 66% respectively; IMR noise reduction works better for highly noisy images. LCD curve are better with IMR especially for small inserts and low doses. An averaged improvement of 35%–45% of contrast detectability with different curves has observed for 5 mm detail; these results are compatible with a reduction of 50% of CTDIvol on patient scans.

IMR significantly improved MTF: MTF 50 increases by 12%, 24%, 64% with Soft, Routine and SharpPlus algorithm respectively; TTF curves confirm this trend.

Dose reduction of 25% in cerebral exams and 50% in thorax-abdominal scans is confirmed by median values of CTDIvol from patient data.

Conclusion. IMR reduces noise, improves low contrast detectability and reduces dose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.697

PAEDIATRIC MULTI DETECTOR COMPUTED TOMOGRAPHY RADIATION DOSES IN A DEDICATED PAEDIATRIC HOSPITAL IN GREECE

D. Akrividou [a,*], G. Douskas [a], A. Stratigopoulou [b], N. Evlogias [b], V. Tsapaki [c]

[a] *Medical Physics Dpt., Sotiria General Hospital, Athens, Greece*
[b] *Radiology Dpt., General Hospital Paidon Pedelis, Athens, Greece*
[c] *Radiology Dpt., Konstantopoulio General Hospital, Athens, Greece*
* Corresponding author.

Introduction. Multi detector CT (MDCT) X-ray systems provide high quality paediatric imaging. However, the last years, concern has been expressed on radiation exposure to children. Very few surveys depicting paediatric exposure from MDCT s are available.

Purpose. To shape the status of radiation dose in children from MDCT practice in a dedicated paediatric hospital in Greece.

Materials and methods. This was a retrospective study in a 160 bed paediatric hospital equipped with a Philips Brilliance 16 CT scanner installed in 2010. Patient data and acquisition parameters were recorded for CT studies of head, abdomen, chest and spine and were divided in three age groups (1–5 years, 5–10 years, 10–15 years). The dosimetric results were reported in terms of volumetric CT dose index (CTDIvol) (mGy), dose length product (DLP) (mGycm), and total DLP for multiphase studies. The results were compared with adult national DRLs and paediatric European published data.

Results. Data were collected from 97 MDCT examinations and included 39 head CTs, 12 abdomen CTs, 20 chest CTs and 26 spine CTs. Acquisition parameters used were according to age for head CTs and weight-dependent for the other scans. Spiral or axial scan depended on anatomic area and on the radiologist on duty. Multiphase studies accounted for 10% of patient sample, 80% of these in the abdomen region. For the three age groups, CTDIvol, DLP and total DLP average values were significantly lower than adult national DRLs, although they increased with age, and were in accordance with published paediatric European data.

Conclusion. Initial data showed that use of protocols tailored to patient's age or weight results in significant dose reduction. Use of standardized CT protocols should be encouraged.

http://dx.doi.org/10.1016/j.ejmp.2016.07.698

INTRA-VOXEL HETEROGENEITY AND ITS EFFECT ON 3D BRACHYTHERAPY DOSE DISTRIBUTIONS

G. Yegin *, I. Kalp

Celal Bayar University, Faculty of Science and Letters, Physics Dept, Manisa, Turkey
* Corresponding author.

Introduction. CT based images are used to reconstruct a voxelized dose calculation geometry in 3d brachytherapy treatment planning.

Purpose. To investigate dose uncertainties due to intra-voxel inhomogeneities of CT based phantoms for brachytherapy sources.

Materials and methods. In this study, an HDR ^{192}Ir source is placed in a water phantom. A target volume with the dimensions of either $1.0 \times 1.0 \times 1.0\ mm^3$ or $2.0 \times 2.0 \times 2.0\ mm^3$ is located at 1 cm away from the source center and divided into a grid of $10 \times 10 \times 10$ cubic sub-voxels. Heterogeneous media within the target volume is obtained by filling each sub-voxel with one of 5 materials; water, adipose, air, lung and bone. In another comparison study, the target volume is filled with only one medium, a kind of material which has an average elemental composition and mass density over sub-voxels at the other simulation geometry. Brachy-Dose Monte Carlo code is used in all dose calculations.

Results. $r^2D(r)$ values were evaluated to eliminate inverse square dependence. Our results showed that intra-voxel heterogeneities

may result in up to 3% or 5% dose difference on the brachytherapy dose distributions for either $1.0 \times 1.0 \times 1.0\ mm^3$ or $2.0 \times 2.0 \times 2.0\ mm^3$ target volumes, respectively.

Conclusion. Our conclusion is that the influence of intra-voxel inhomogeneities on brachytherapy dose distributions are significant and they should be taken into account in treatment planning systems.

Disclosure. This study is partly supported by TUBITAK under project number: 213E028.

http://dx.doi.org/10.1016/j.ejmp.2016.07.699

CLINICAL APPLICATION OF MO*SKIN* DOSIMETERS TO RECTAL WALL IN VIVO DOISMETRY IN GYNECOLOGICAL AND PROSTATE HDR BRACHYTHERAPY

M. Carrara [a,*], D. Mazzeo [b], A. Romanyukha [c], C. Tenconi [a], A. Cerrotta [d], M. Borroni [a], D. Cutajar [c], M. Petasecca [c], M. Lerch [c], J. Bucci [e], C. Fallai [d], G. Gambarini [b], A. Rosenfeld [c], E. Pignoli [a]

[a] *Medical Physics Unit, Fondazione IRCCS Istituto Nazionale Tumori, Milan, Italy*
[b] *Department of Physics, Università degli Studi di Milano, and INFN, Milan, Italy*
[c] *Centre for Medical Radiation Physics, University of Wollongong, Wollongong, NSW, Australia*
[d] *Radiation Therapy Unit 2, Fondazione IRCCS Istituto Nazionale Tumori, Milan, Italy*
[e] *St George Cancer Care Center, Kogarah, NSW, Australia*
* Corresponding author.

Introduction. MO*Skins* are MOSFET dosimeters designed and developed at the Centre for Medical Radiation Physics (University of Wollongong, Australia), optimized to measure the dose in steep dose gradients. In this work, their clinical application to rectal wall in vivo dosimetry (IVD) during gynecological and prostate high dose rate brachytherapy (HDR-BT) was studied.

Purpose. To evaluate the discrepancies between planned and measured doses to the rectal wall and to investigate the impact of the duration of the treatment planning procedure on these discrepancies.

Materials and methods. In gynecological HDR-BT, three MO*Skins* were assembled over a semi-flexible rectal probe and 51 IVD measurements were performed. In prostate HDR-BT, two MO*Skins* were assembled on the trans-rectal ultrasound probe and 36 IVD measurements were performed.

The absolute differences ΔD between measured and calculated doses in the estimated dosimeters positions were quantified and a possible correlation with the treatment planning time was investigated.

Results. Grouping ΔD according to the time elapsed between imaging and treatment (i.e., group 1: $\leqslant$90 min; group 2: >90 min), average ΔD for groups 1 and 2 were $5.1 \pm 3.0\%$ and $8.3 \pm 6.2\%$ for prostate and $3.8 \pm 3.5\%$ and $6.5 \pm 4.3\%$ for gynecology HDR-BT, respectively. Average ΔD were in both cases lower for group 1, demonstrating higher uncertainties of the calculated dose with higher treatment planning times (i.e., probability of morphological changes increases with time).

Conclusion. MO*Skin* dosimeters coupled to rectal probes may be used for rectal IVD during gynecological/prostate HDR-BT. Planning time should be kept as low as possible to reduce uncertainties in calculated doses.

Disclosure. none

http://dx.doi.org/10.1016/j.ejmp.2016.07.700

ON THE DOSIMETRIC EFFECT OF HETEROGENEITIES AND FINITE PATIENT DIMENSIONS ON ^{60}CO HDR BRACHYTHERAPY

K. Zourari [a,*], I. Fotina [b], E. Pantelis [a], P. Papagiannis [a]

[a] *Medical Physics Laboratory, Medical School, National and Kapodistrian University of Athens, Greece*
[b] *Eckert & Ziegler BEBIG GmbH, Germany*
* Corresponding author.

Introduction. Model based dose calculation algorithms (MBDCAs) for ^{192}Ir HDR brachytherapy have become clinically available to account for effects disregarded by TG-43 dosimetry (tissue heterogeneity and patient specific scatter conditions).

Purpose. To assess the relative benefit from introducing MBDCAs in Co-60 and Ir-192 HDR brachytherapy.

Materials and methods. Dual plans were prepared for 15 cases (gynaecological, esophagus, breast) using the Ir2.A85-2 and the Co0.A86 HDR sources with a TG-43 based TPS (SagiPlan®, Eckert&Ziegler BEBIG, Germany). Monte Carlo (MC) simulation dosimetry was performed for all plans using the MCNP6 code with input files prepared using the BrachyGuide software tool to parse information from DICOM RT exported plans. Differences between patient-specific (MC) and TG-43 dosimetry were compared in the form of 3D distributions and clinical plan indices and checked for statistical and clinical significance. Results were compared between Co-60 and Ir-192.

Results. Patient-specific dose distributions are clinically equivalent for the two isotopes. The effect of tissue heterogeneities and patient specific scatter conditions is less for Co-60 HDR treatments. A lower dose to critical organs close to the target and a small increase in the overdose volume were observed for Co-60. The choice of isotope was not found to have an impact on the prescribed dose.

Conclusion. Co-60 is equivalent to Ir-192 HDR brachytherapy, with similar target coverage. Besides logistical advantages owing to its longer half-life, Co-60 demonstrates reduced effects of tissue heterogeneities and patient dimensions that obviate the need for using MBDCAs.

Disclosure. Research supported in part by Eckert & Ziegler BEBIG.

http://dx.doi.org/10.1016/j.ejmp.2016.07.701

ON THE USE OF TIME RESOLVED DOSE RATE DISTRIBUTIONS IN BRACHYTHERAPY

Vasiliki Peppa *, Eleftherios Pappas, Pantelis Karaiskos, Panagiotis Papagiannis

Medical Physics Laboratory, Medical School, University of Athens, Athens, Greece
* Corresponding author.

Introduction. Time-resolved dose rate distributions (TR-DRD) are not used in brachytherapy although this is information easily retrieved from treatment planning. An example is the evaluation of pulsed-dose-rate (PDR) and high-dose-rate (HDR) biological equivalence, where analytical expressions for biological effective dose (BED) are based upon constant intra-fraction dose rates neglecting time-resolved effects of repair during irradiation.

Purpose. To study the effect of accounting for TR-DRD in brachytherapy.

Materials and methods. PDR plans were prepared from a head and neck (mobile tongue) HDR boost case using variable doses/pulse (0.3–0.7 Gy), repair half-times (0.3–2 h), pulse duration (10–40 min), and total doses (15–24 Gy). The TR-DRD of each plan was calculated using a Monte Carlo generated single source dose rate matrix with data parsed from plan dicom RT information. BED calculation was based on the linear–quadratic model and Dale's formula for PDR

relative effectiveness considering either a constant dose rate per pulse or the TR-DRD. Corresponding Tumor Control Probabilities (TCP) were calculated and compared.

Results. TR-DRD-based TCP is greater than TCP based on constant dose rate, with differences ranging between 0.06% and 26.6%. Differences increase with dose/pulse and pulse duration, and decrease with repair half-time and total dose.

Conclusion. TR-DRD data should be taken into account for PDR biological effectiveness estimations and, especially, the derivation of equivalent HDR schemes. TR-DRD data are also useful for in-vivo dosimetry as reference data or input for response dose-rate dependency correction.

Disclosure. VP is supported by IKY fellowship of excellence for postgraduate studies in Greece-Siemens Program.

http://dx.doi.org/10.1016/j.ejmp.2016.07.702

TESTING MBDCA PERFORMANCE IN ^{192} IR HDR BRACHYTHERAPY FOR LIP CARCINOMA

Vasiliki Peppa [a,*], Evaggelos Pantelis [a], Tibor Major [b], Ioanna Skampardoni [a], Panagiotis Papagiannis [a]

[a] *Medical Physics Laboratory, Medical School, University of Athens, Athens, Greece*
[b] *National Institute of Oncology, Budapest, Hungary*
* Corresponding author.

Introduction. Model-based dose calculation algorithms (MBDCAs) for ^{192}Ir HDR brachytherapy have become clinically available to account for effects disregarded by TG-43 dosimetry. International committees recommend the preparation of clinical test cases for their benchmarking.

Purpose. To evaluate the dosimetric accuracy of a MBDCA in clinical scatter conditions departing from TG-43 assumptions (homogeneity, isotropic scatter).

Materials and methods. Treatment planning dosimetry was performed for three clinical cases using the Advanced Collapsed Cone Engine (ACE) of the OncentraBrachy v4.5 treatment planning system. Corresponding Monte Carlo (MC) simulation reference data were obtained using MCNP6 with input files prepared from parsing dicom RT data with the BrachyGuide software tool. ACE and MC were compared in terms of percentage dose differences, Dose-Volume Histograms (DVHs) and indices of clinical interest for the Planning Target Volume (PTV) and Organs-At-Risk.

Results. ACE and MC-based DVH indices were in excellent agreement for the PTV except for an ACE underestimation of the high dose volume (5% for V150 and V200). While an excellent agreement was also observed in the high dose regions of the mandible, ACE overestimated D30, D50 and Dmean by up to 6.3%. ACE and MC results agreed within 0.6% for the skin and normal tissue surrounding the PTV.

Conclusion. ACE improves dosimetric accuracy relative to TG-43. The clinical importance of observed discrepancies from MC should be evaluated taking radiobiological analysis into account. A corresponding test case is available online (www.rdl.gr).

Disclosure. VP is supported by IKY fellowship of excellence for postgraduate studies in Greece-Siemens Program.

http://dx.doi.org/10.1016/j.ejmp.2016.07.703

STATISTICAL BAYESIAN ANALYSIS OF THE BRACHYTHERAPY SOURCE POSITION

A. Serna [a,*], P. Parrado [b]

[a] *Medical Physics Department, Hospital General Universitario Santa Lucia, Cartagena, Spain*
[b] *Physics Faculty, Universidad de Murcia, Spain*
* Corresponding author.

Purpose. Accurate knowledge of the source position (SP) in brachytherapy treatments is of paramount importance due to the high dose gradient around the source.

The purpose of this work is to present our own developed Bayesian statistical formalism to determine the SP.

Material and methods. The differential factor of the Bayesian analysis rely on the determination of the probability density function (PDF) of the magnitude of interest, in this case the source position, hence this magnitude is no longer a constant but a variable that follows a certain PDF. The full knowledge of the magnitude is contained in its PDF. According to the Bayes' Theorem we can obtain this PDF from measured data and an appropriate prior function.

Radiochromic EBT-3 films were exposed with a Varisource Ir-192, 5 mm length, and digitized using a film scanner EPSON-1000XL. A code was written in Matlab to numerically generate the PDF of the SP.

Results. The PDF showed higher variance in the longitudinal compared with the transversal direction, 0.004 mm and 0.002 mm respectively. This might be due to the AAPM-TG 43 is much less accurate along the source than in the transversal direction. Anyway, the accuracy of the method is higher than normally used methods to determine the SP, which are around 0.5 mm.

This procedure can be applied to any type of source, provided reliable dosimetric data are available.

Conclusion. Bayesian analysis provides an extremely accurate method for brachytherapy source position determination.

Disclosure. None.

http://dx.doi.org/10.1016/j.ejmp.2016.07.704

DEVELOPMENT OF A THREE DIMENSIONAL PRINTED MRI COMPATIBLE TEMPLATE FOR HIGH DOSE RATE PROSTATE BRACHYTHERAPY IMPLANTS

Stefanos Diamantopoulos *, Panagiotis Zaverdinos

Medical Physics Department, Radiation Oncology Division, Metropolitan Hospital, Athens, Greece
* Corresponding author.

Introduction. The significance of the delineation of prostate gland and its main surrounding organs in contemporary HDR prostate brachytherapy requires the use of highly sophisticated imaging techniques, such as MRI. Therefore, implant related equipment should meet MRI compatibility standards.

Purpose. This work presents the construction and testing of an inexpensive MR-compatible prostate-template for HDR brachytherapy which took place in Metropolitan hospital, Greece

Materials and methods. A free CAD designer and a 3D printer system were utilised for template production. The template was tested under clinical conditions, using the imaging, operating and sterilization equipment of our department along with a home-made prostate phantom.

Results. The template was printed according to the original design and fitted well in the equipment currently in use. MRI field does not interfere with the item, while the needle arrangement is consistent in several depths in the phantom. Among the contemporary commercially available templates for HDR interstitial prostate

brachytherapy, the 3D printed template constructed in our clinic offers a reusable, cost-effective solution.

Conclusion. The functionality of the presented prototype template exploits the possibilities of employing 3D printing technology in clinical practice of brachytherapy which will allow the configuration of patient-specific equipment.

Disclosure. No conflict of interest, financial or other, exists.

http://dx.doi.org/10.1016/j.ejmp.2016.07.705

COST-EFFECT AND ETHICAL REASONING IN RADIONUCLIDE THERAPY DOSIMETRY UNDER THE NEW EU BSS

J.A.M. Santos [a,b,c]

[a] *Instituto Português de Oncologia do Porto Francisco Gentil, EPE (IPOPFG E.P.E.), Serviço de Física Médica, Rua Dr. António Bernardino de Almeida, 4200-072 Porto, Portugal*
[b] *IPOPFG E.P.E., Centro de Investigação, Porto, Portugal*
[c] *Instituto de Ciências Biomédicas Abel Salazar da Universidade do Porto, Rua J Viterbo Ferreira 228, 4050-313 Porto, Portugal*

Introduction. Radionuclide therapy (RT) dosimetry is wide-ranging, sometimes complex, and always needs resource allocation. From Iodine-131 (e.g. hyperthyroidism) to Lutetium-177 (e.g. neuroendocrine cancers) or Itrium-90 (e.g. radioembolization), there is a broad range of radionuclides and activities for therapeutic use. Since each patient is unique, a personalized dosimetry approach can therefore be recommended.

Purpose. New developments in the field, and the new EU BSS Directive, are approaching dosimetry in RT to dosimetry in External Radiotherapy. However, there is a price to attain this goal and it needs to be justified.

Materials and methods. Beauchamp and Childress beneficence principle is evoked to justify dosimetry in almost every patient subjected to RT, although the cost of such procedures can be onerous for the majority of the already overloaded health care systems. This fact, together with necessarily limited available funding, can conflict with the principle of justice, stated by these authors, when allocating resources, leading to the need of rationing and ethical reasoning.

Results. Dosimetry implementation according to the EU BSS Directive must be carefully considered for each particular patient and pathology. The same Directive also strongly reinforces the medical physics expert (MPE) as part of the therapeutic team for RT. This implies that MPE are fundamental elements in the process of decision whether dosimetry should or not be performed in each particular circumstance.

Conclusion. MPE should be aware of the vast range of ethical values and reasoning behind clinical decision making, and a formal education in Bioethics should be pursued by these professionals.

Disclosure. The author has no relevant financial or nonfinancial relationships to disclose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.706

RADIOIODINE THERAPY AFTER RECOMBINANT HUMAN TSH ADMINISTRATION OR HORMONE WITHDRAWAL: IS THERE A DIFFERENCE IN I-131 EFFECTIVE HALF-LIFE?

Kostas Perisinakis [a,*], Christos Donas [a], Dimitraki Anastasia [b], John Damilakis [a]

[a] *University of Crete, Medical School, Medical Physics Department, Greece*
[b] *University of Crete, Physics Department, Greece*
* Corresponding author.

Introduction. The release of thyroidectomized patients treated with radioactive iodine I-131 from the treating facility is predominantly judged on the basis of the residual I-131 activity which is dictated by the effective half-life of I-131.

Purpose. To determine the effective half-life of I-131 ($Teff_{1/2}$ in thyroidectomized patients subjected to radioiodine therapy after either recombinant human TSH administration or hormone therapy withdrawal.

Materials and methods. A series of 88 consecutive patients administered with I-131 following thyroidectomy was investigated. Recombinant human TSH has been administered in 32 patients (group A), while the rest 56 patients (group B) had been subjected to hormone therapy withdrawal. Measurements of the dose rate emitted by the patient at mid-thoracic height at a distance of 1 m were obtained 0, 6, 24 and 30 h after I-131 administration. The $T_{1/2}$ was determined from the exponential fit of measured data. Data regarding age, sex, weight, height, diet, administered dose, volume of water drunk, and size of remnant thyroid tissue were recorded.

Results. The mean I-131 $Teff_{1/2}$ was found 8.8 h for group A and 12.4 h for group B, with difference being statistically significantly ($p < 0.05$). Patient size and dose administered were not found to affect $Teff_{1/2}$. Water consumption and size of remnant thyroid tissue were found to moderately affect $Teff_{1/2}$ but statistical significance was not reached.

Conclusion. Administration of recombinant human TSH instead of hormone thyroid withdrawal prior to radioiodine therapy of thyroidectomized patients may enhance elimination rate of residual I-131 activity, and accelerate release from treating facility.

http://dx.doi.org/10.1016/j.ejmp.2016.07.707

DOES CLINICAL INDICATION PLAY A ROLE IN CT RADIATION DOSE IN PEDIATRIC PATIENTS?

V. Tsapaki *, S. Triantopoulou

Konstantopoulio General Hospital of Nea Ionia, 3-5 Agias Olgas Str., 14233, Nea Ionia, Athens, Greece
* Corresponding author.

Introduction. There are many types of medical imaging procedures that are applied on children. Imaging has to take into account the dynamics of a growing body, from pre-term infants to large adolescents. CT imaging, currently the gold standard in the detection of certain pathologies, imparts the highest radiation dose to children.

Purpose. The purpose of the study was to identify the main pathologies for which CT is applied and related radiation doses as reported in the literature in order to facilitate justification and CT optimization.

Materials and methods. A critical analysis of a literature review was performed. Different search engines were used such as PubMed, Google Scholar and Science Direct. Various terms and keywords were used to locate pertinent articles such as Pediatric, Computed tomography, CTDI, DLP, Radiation Dose, Organ dose, Effective dose.

Results. The results showed that the main pathologies for which CT is applied are: Crohn's disease, hydrocephalus, cystic fibrosis and pediatric malignancies - mainly lymphoma. The related radiation dose data are extremely scarce and are in the range of 1–25 mSv, 0.2–15.3 mSv, 0.14–6.2 mSv, and 5–528 mSv, respectively. The radiation doses reported are high especially in pediatric oncology.

Conclusion. Pediatric patients are exposed to high levels of radiation during CT imaging. Literature is lacking reporting of dose in Pediatric CT imaging. More studies need to be realized for the determination of radiation dose in those patients. Special protocols need

to be recommended in order to reduce the exposure of children in radiation.

Disclosure. No Disclosure.

http://dx.doi.org/10.1016/j.ejmp.2016.07.708

HEAD CBCT VS HEAD MSCT IMAGING; COMPARING ORGAN DOSES AND RADIATION RISKS FOR A COHORT OF ORTHOGNATHIC PATIENTS

A. Stratis [a,*], G. Zhang [b], R. Jacobs [a], R. Bogaerts [a], C. Politis [a], E. Shaheen [a], H. Bosmans [b]

[a] *Katholieke Universiteit Leuven, Department of Imaging and Pathology, OMFS-IMPATH Research Group, and University Hospitals Leuven, Department of Oral and Maxillofacial Surgery, Campus St. Rafael, Kapucijnenvoer 33, Leuven 3000, Belgium*

[b] *University Hospitals of Leuven, Department of Radiology, Herestraat 49, Leuven 3000, Belgium*

* Corresponding author.

Introduction. In oral and maxillofacial surgery, a preoperative-full-head-scan is required for treatment planning purposes. Orthognathic patients are traditionally referred to radiology departments for a head CT scan. However, state-of-the-art dental-CBCT-scanners, equipped with large detectors and/or stitching and offset-scanning-methods, enable full head image acquisitions.

Purpose. to calculate organ doses and estimate radiation risks for patients undergoing head-CT and full skull dental-CBCT exams.

Materials and methods. An EGSnrc-based Monte-Carlo (MC) dosimetry tool was used to calculate organ doses in the reference ICRP-female-voxel-phantom for skull protocols in two dental-CBCT-scanners. Promax-3D-Max (Planmeca, FI) employs a 230×260 mm^2 FOV (diameter $\times$ height) using a stitching technique and fixed current during rotation. VGi-evo (Newtom, IT) employs a 240×190 mm^2 FOV and tube current (TCM) modulation. An anthropomorphic phantom (SK 150, The Phantom Laboratory) was scanned to extract the TCM curve which was then employed to the framework in terms of dose-integral-weighting-factors. CT-Expo v2.2 was used to calculate organ and effective doses for ten adult females, undergone head CTs in an Aquilion One (Toshiba, Japan) and a Somatom Definition Flash (Siemens, DE) scanner.

Results. The effective dose (ED) for Promax-3D-Max ranges from 85 to 1090 μSv depending on the operation mode (mAs-settings), whereas for VGI-evo the ED was 265 μSv. For head CT the ED ranges from 1.3 to 1.9 mSv. In all cases the highest doses were observed to salivary glands, oral mucosa, ET, brain, thyroid and RBM.

Conclusion. Dosewise, full-head-dental-CBCT scans demonstrate significantly lower organ doses and lower ED compared to MSCT scanners.

Disclosure. Nothing to disclose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.709

LOW CONTRAST QUALITY ASSESMENT IN CT: HUMAN AND MODEL OBSERVER COMPARISON

M. Biondi [a,*], A. LaPenna [b], E. Vanzi [a], L.N. Mazzoni [a], G. De Otto [a], G.M. Belmonte [a], E. Foderà [b], R. Martini [b], G. Imbriaco [b], F.S. Carbone [c], A. Guasti [d], L. Volterrani [b], F. Banci Buonamici [a]

[a] *Department of Medical Physics, University Hospital of Siena, Siena, Italy*

[b] *Department of Medical, Surgical and Neurosciences, University of Siena, Siena, Italy*

[c] *Department of Diagnostic Imaging, University Hospital of Siena, Siena, Italy*

[d] *Department of Medical Physics, Azienda USL Toscana sud est, Siena, Italy*

* Corresponding author.

Introduction. Actually there is not a widely accepted method for low contrast resolution evaluation in CT scans.

Purpose. To test the performance of a novel ImageJ macro devoted to Catphan CTP515 low contrast automatic analysis by comparing the results with human observers.

Materials and methods. Software and human proportion correct curves (PCC), function of the low contrast object diameter, and corresponding Minimum Detectable Size (MDS) were determined and compared. Software PCC was obtained using the CTP515 1% contrast group of Catphan 600 images, acquired with Discovery 750 (GE healthcare) 64 slices CT scanner varying noise index (NI = 8, 12) and analysed with a non-prewhitening matched filter with an eye filter model observer. The human PCC was calculate with a known exactly signal and background experiment based on 740 canvas consisting of a template object to be recognized and two images ("background" and "signal + background") among which the one containing the object had to be chosen. The experiment was repeated with 4 human observers. Inter-observer and human/model PC agreements were evaluated respectively with ICC test and Pearson correlation coefficient with Student *t*-test.

Results. MDS for software and human were respectively 2.77 mm and 4.42 mm (12 NI), 1.46 mm and 2.96 mm (8 NI). ICCs were 0.89 (8NI) and 0.84 (12NI); correlation coefficient was 0.89 ($p = 0.02$).

Conclusion. The high correlation between human and model showed that the macro represents a valid tool for low contrast resolution analysis. It could be useful in CT protocol optimization also thanks to its easy use.

Disclosure. Authors disclose any relationship that may bias their presentation.

http://dx.doi.org/10.1016/j.ejmp.2016.07.710

DENTAL HYBRID CONE BEAM CT EFFECTIVE AND ORGAN DOSES

A. Loria [a,*], C.R. Gigliotti [a], M. Branchini [a], F. De Cobelli [b], M. Del Maschio [a], A. del Vecchio [a]

[a] *IRCCS San Raffaele Scientific Institute, Italy*

[b] *Università Vita-Salute San Raffaele, Italy*

* Corresponding author.

Introduction. Dental hybrid 3D Cone Beam CT (CBCT) NewTom VGi Evo it is a pure CT scan and, due to the possibility to choose a wide range of exposition parameters, is suitable for maxillofacial and otorhinolaryngology surgery. This particular model allows a real 2D acquisition and not only a two-dimensional reconstruction of a 3D image.

Purpose. The aim of this study is to provide organs and body effective dose measurements in order to optimize the exposure protocols for every clinical application.

Materials and methods. 42 thermo-luminescent dosimeters were placed throughout six layers of the head and neck of a tissue-equivalent phantom, identifying 16 most important OAR. Three field of radiation, corresponding to three areas of interest (maxillofacial, otolaryngology and dental), were considered. The largest field, 24×19 cm^2, was available only in Standard Quality modality, while fields 12×8 cm^2 and 5×5 cm^2 were investigated also with their High-Resolution (HR) modality. Doses delivered by two-dimensional CBCT panoramic view modality and by a digital orthopantomograph exam were compared.

Results. In the worst exposition condition (maxillary 3D scan), effective dose resulted 0.14 ± 0.02 mSv, 0,07 ± 0,03 mSv for otorhinolaryngology 3D scan and 0,05 ± 0,03 mSv for dental. Effective doses for 2D panoramic modality with CBCT and OPT resulted respectively 0.07 ± 0.02 mSv and 0.03 ± 0.02 mSv.

Conclusion. The clinical applications involve very different radiation doses. We can provide accurate dosimetric information to clinicians for each exposition possibilities, in order to allow the best choice for every patient. It is important to choose HR modality only if necessary and traditional OPT should not be replaced by CBCT.

Disclosure. There is not conflict of interest to declare.

http://dx.doi.org/10.1016/j.ejmp.2016.07.711

DIAGNOSTIC REFERENCE LEVELS IN DUTCH CLINICAL PRACTICE

H. Bijwaard [a,b,*], D. Valk [a], I. Waard-Schalkx de [a]

[a] *National Institute for Public Health and the Environment, The Netherlands*
[b] *Inholland University of Applied Sciences, The Netherlands*
* Corresponding author.

Introduction. In the Netherlands Diagnostic Reference Levels (DRLs) have been set for 11 radiological examinations in 2012. The values of these DRLs were chosen on the basis of available scientific literature and expert judgment.

Purpose. The purpose of this study was to determine the level of adaptation of the current DRLs by Dutch hospitals and to support them in implementing the DRLs in clinical practice.

Materials and methods. First, a survey was conducted among 20 Dutch hospitals about the implementation of DRLs in the QA system. Second, a pilot study was carried out in which radiography students performed dose measurements in some hospitals. Finally, this study was enlarged to cover the entire country: 21 hospitals participated.

Results. The survey showed that the majority of Dutch hospitals had not yet implemented the DRLs. The pilot study and its follow-up demonstrated that in nearly all cases compliance to the DRLs can be achieved. For some examinations 75-percentile values could be derived. These values suggest that when updating the DRLs, new values could be set at approximately half the current ones.

Conclusion. The survey showed that many hospitals did not immediately take action when the DRLs were introduced. Their implementation took form when support was offered to hospitals in the form of students helping out with dose measurements. The measurements themselves show that nearly all hospitals comply with the DRLs to a level that suggests that new DRLs could be set at much lower values.

Disclosure. This study was supported by the Dutch Ministry of Health, Welfare and Sport.

http://dx.doi.org/10.1016/j.ejmp.2016.07.712

MULTI HOSPITAL EXPERIENCES IN THE USE OF RDIM SOFTWARES TO OPTIMIZE RADIOLOGICAL PROCEDURES IN COMPUTED TOMOGRAPHY, MAMMOGRAPHY AND INTERVENTIONAL RADIOLOGY

S. Pini *, S. Mazzocchi, A. Ghirelli, E. Rigacci, M. Esposito, S. Russo, G. Zatelli

USL Centro Toscana, Firenze, Italy
* Corresponding author.

Introduction. Radiation Dose Index Monitoring (RDIM) are useful software tools that allow radiological data collection and patient dose monitoring. However its implementation need a thorough acceptance test.

Purpose. Aim of this work is to test the consistency of data processed by two RDIM software and use the dose index information archived to optimize radiological procedures in our hospitals.

Materials and methods. We began in 2012 to monitor dose index data from 7 CTs and 2 angiographic units using CareAnalytics (CA) tool by Siemens. CA processes DICOM RDSR stored in PACS.

Moreover within an Italian project, RDM by Medsquare has been tested since Gen 2015. RDM collects and analyzes doses delivered to patients during medical imaging examinations. One mammographic installation, 2 CTs and 1 angiographic unit has been connected to RDM.

Results. For angiographic procedure we have compared the maximum incident air kerma at the reference point at different times and at different C arm positions with the dose values obtained by softwares. For mammography, data from header DICOM have been positively compared with RDM data. For CT we have compared values obtained from console, CA and RDM.

Conclusion. In our experiences both the software under test seems to be useful tools to monitor radiation dose index. RDM allows wider applications and custom made options.

Disclosure. Nothing to declare.

http://dx.doi.org/10.1016/j.ejmp.2016.07.713

STAFF DOSES IN FLUOROSCOPICALLY GUIDED INVASIVE DIAGNOSTIC AND INTERVENTIONAL UROLOGY PROCEDURES

D. Ivanova [a,*], A. Zagorska [a,b], S. Avramova-Cholakova [a,c], K. Bliznakova [d], Ts. Deyanova [e], R. Dobrikov [e], J. Hristova-Popova [a], D. Kostova-Lefterova [a,f]

[a] *National Center of Radiobiology and Radiation Protection, Sofia, Bulgaria*
[b] *Medical University of Sofia, Sofia, Bulgaria*
[c] *City Clinic, Sofia, Bulgaria*
[d] *Technical University of Varna, Varna, Bulgaria*
[e] *UMHATEM, "N. I. Pirogov", Sofia, Bulgaria*
[f] *National Hospital for Cardiology, Sofia, Bulgaria*
* Corresponding author.

Introduction. The number of fluoroscopically guided invasive diagnostic and interventional urology procedures is increasing during the last few years. This leads to higher staff doses in comparison with other radiology procedures.

Purpose. The aim of this study is to evaluate staff doses in fluoroscopically guided invasive diagnostic and interventional urology procedures. All the data were collected in Emergency Hospital "N. I. Pirogov" on an old fluorography unit with X-ray tube over the table.

Materials and methods. Staff doses for intravenous pyelogram (IVP), percutaneous nephrostomy (PN) and ureteral "double-J" stenting were estimated with the system *RaySafe i2*. It contains four dosimeters, with a wireless connection to a real time display. The dosimeters were worn on the unprotected upper part of the body and measured the personal dose equivalent $H_p(10)$. In order to evaluate the dose of the eye lense in personal dose equivalent $H_p(3)$ two methods were used: thermoluminescent dosimetry and Monte Carlo simulations.

Results. The highest staff dose for PN and "double-J" is received by the urologist (116.7 μSv and 42.6 μSv, respectively), while for the IVP the radiographer has the highest exposure (20.7 μSv). First results for the dose of the eye lense show values of 1.63 mSv for left eye and 5.67 mSv for right eye. Each member of the medical staff was on a different position in respect to the X-ray tube and the

patient which is the main reason for the differences in the staff doses.

Conclusion. The variations in the mean staff doses are mostly due to the interventions themselves, their complexity and the individual treatment of every patient. *RaySafe i2* is very useful and educational system. It can be a helpful tool for decreasing radiation exposure to medical staff.

Acknowledgement. The authors would like to thank RaySafe for the kindly submitted for temporary use *i2* system.

http://dx.doi.org/10.1016/j.ejmp.2016.07.714

DIAGNOSTIC REFERENCE LEVELS OF INTRAORAL DENTAL RADIOGRAPHY IN THE PUBLIC HOSPITALS OF CYPRUS

Stelios Christofides [a,*], Elina Pitri [b], Marios Lampaskis [b], Christos Papaefstathiou [b]

[a] *Biomedical Research Foundation, Nicosia, Cyprus*
[b] *Medical Physics Department, Nicosia General Hospital, Nicosia, Cyprus*
* Corresponding author.

Introduction. Dentists who advise patients to undergo intraoral X-ray examinations must be aware of the associated dose to the patient. Intraoral Dental Diagnostic Reference Levels (DRLs) give an indication of the expected radiation doses.

Purpose. The purpose of this study was to determine the DRLs of the intraoral dental radiology units of the public hospitals in Cyprus.

Materials and methods. Measurements were made on all the twenty intraoral x-ray units of the public hospitals in Cyprus with the intention to establish the DRLs for all the possible intraoral X-ray examinations for children and adults. All units are film based. The measurements were made by a Dose Area Product (DAP) meter (GAMMEX RMI 841-RD) placed at the surface of the dental unit's X-ray cone (FSD 20 cm). A diagnostic radiology dosimeter (Dosimax Plus A) was also placed at an FSD equal to 100 cm to compare the dose reading between the two dosimeters.

Results. DRLS were established at the 3rd quartile for 7 exposure settings corresponding to 12 types of teeth (Adult and children mandibular and maxillary incisor, premolar and molar) with values of 202.06, 161.54, 129.71, 100.79, 80.62, 62.83 and 49.50 $mGycm^2$ and 6.98, 5.72, 4.53, 3.52, 2.85, 2.31 and 1.82 mGy for nominal exposure times of 1000, 800, 640, 500, 400, 320 and 250 ms respectively, at a nominal exposure voltage of 70 kVp.

Conclusion. The DRLs of the present study compare well with other similar published DRLs.

Disclosure. The authors declare that they have no conflict of interest.

http://dx.doi.org/10.1016/j.ejmp.2016.07.715

DETERMINATION OF SIZE SPECIFIC CONVERSION FACTORS TO EFFECTIVE DOSE USING TLD DOSIMETERS IN ANTHROPOMORPHIC PHANTOMS

Stefanos Tanabasidis [a,*], Sofia Kordolaimi [a], Efstathios Efstathopoulos [a], Eleftheria Carinou [c], Ioannis Seimenis [b]

[a] *2nd Department of Radiology, University General Hospital 'Attikon', School of Medicine, National and Kapodistrian University of Athens, Athens, Greece*
[b] *Greek Atomic Energy Commission (GAEC), Agia Paraskevi, Attiki, Greece*
[c] *Medical Physics Laboratory, Medical School, Democritus University, Alexandroupolis, Greece*
* Corresponding author.

Introduction. This study refers to effective dose (ED) estimation using the size-specific dose estimator (SSDE).

Purpose. This work aims at determining DLP_{SSDE}-to-ED (k_{SSDE}) conversion factors where DLP_{SSDE} is the length product multiplied by the appropriate f-factor (AAPM report 204) for chest-abdomen-pelvis (CAP) CT examinations in three weight-adjusted scan protocols and to compare the ED_{SSDE} derived from k_{SSDE} to that derived from k factors available in the literature.

Materials and methods. Three anthropomorphic phantoms of 55 kg, 73.5 kg and 96.2 kg body weight filled with 190 TLDs were scanned on a 64-slice multi-detector CT employing the respective weight-adjusted CAP-CT protocol used in clinical routine. Effective diameter was measured in the abdomen area of the phantoms and DLP_{SSDE} was estimated using the respective f factor. For ED estimation, ICRP 103 tissue weighting factors for all organs inside and outside the irradiation field were used. Relevant k_{SSDE} conversion factors were then calculated. These factors were then applied to 140 patients underwent CAP-CT examinations and the derived ED_{SSDE} values were compared to corresponding ED_kvalues.

Results. In the <60 kg category, ED_{SSDE} was 15.4% higher than ED_k while in the medium category (60–90 kg) the corresponding percentage was 28.3%. For the over-weighted category (>90 kg) no significant difference in ED was observed.

Conclusion. Weight-adjusted DLP_{SSDE}-to-ED conversion factors were determined. In low and medium weight categories, radiation dose may be underestimated when the patient size is not taken into consideration.

http://dx.doi.org/10.1016/j.ejmp.2016.07.716

A REGIONAL SOLUTION FOR PATIENT RADIOLOGICAL DOSE MANAGEMENT

E.A. Garcia-Angosto [a], A. Serna [b,*], A.J. Garcia-Sanchez [a], F. Garcia-Sanchez [a], D. Ramos [b]

[a] *Department of Information and Communication Technologies, Universidad Politecnica de Cartagena (UPCT), Spain*
[b] *Medical Physics Department, Hospital Universitario Santa Lucia, Cartagena, Spain*
* Corresponding author.

Purpose. To highlight a novel methodology for patient dose management of radiological examinations in a regional public health framework.

Material and methods. DoseWatch-GE is a multivendor and multimodality patient dose management software for radiological examinations. The framework in this study is a Region of Spain with 10 hospitals and 1.5 Million population. Dose indexes and examination protocols are recorded in individual patient files. Our methodology is divided into three foundations: (1) standardization of protocols, (2) Setting of Regional Diagnostic Reference Levels (RDRL), and (3) dose optimization.

Results. Nowadays, 60 devices from 10 public hospitals are monitored: 13 CT's, 9 Interventional, 9 Mammo and 23 conventional. Every month the system is collecting approximately: 9000 CT, 800 Interventional, 2500 Mammo and 33000 conventional examinations.

Standardization of protocols must be the first step because examinations nomenclature is highly variable among both manufactures and hospitals. We have established a master protocol list as reference for local protocols, thus allowing coherent data analysis.

RDRL can be established and updated thanks to the massive amount of data available from a wide variety of equipment. This data might serve for future national DRL, currently not available.

Dose optimization is supported by a multidisciplinary Dose Committee (radiologist, medical physicist, technologist, administration

and application specialists), actively searching for dose reduction opportunities, based on comparative analysis with international DRL's and among similar equipments.

Conclusion. We conclude that dose management systems might play an important role in the radiological patient safety task.

Disclosure. None.

http://dx.doi.org/10.1016/j.ejmp.2016.07.717

UNDERSTANDING WORKFLOW IN A RADIOLOGY DEPARTMENT BY CREATIVE USE OF A DOSE-MANAGEMENT SOFTWARE SOLUTION

De Bondt Timo [a,*], Zanca Federica [b], De Roeck Johan [a], Brouhon Lynn [a], Geldof Michel [a], Deferme Filip [a], Parizel Paul [a]

[a] *Antwerp University Hospital, Belgium*
[b] *GE Healthcare, Belgium*
* Corresponding author.

Introduction. The use of a dose-monitoring system has recently become common in radiology departments. In our institution, we make creative use of the system's functionalities to learn about workflow.

Purpose. To establish consistent and safe everyday practice standards throughout the radiology department; to understand the nature and cause of inconsistencies.

Methods and materials. Using DoseWatch (GE Healthcare), we gathered data from 12 imaging modalities within our radiology department (2 computed tomography (CT), 2 mammography (MX), 6 computed radiology (CR), 2 interventional radiology (IR)). Procedures were implemented to 1/standardize procedures (number of views), and 2/justify alerts by an a priori defined list of comments.

Results. Standard number of takes was achieved in 90% for CT, 80% for MX and 92% of CR procedures. Justification of alerts was performed for 78% of CT and 98% of interventional procedures; conversely for CR and mammography this was 0%. Of all justified alerts on CT, the main reported causes were "patient overweight" (39%), "extra series requested by radiologist" (22%) and "performed by request of cardiology staff" (13%). Almost all alerts (96%) for IR were caused by "difficulty of procedure". To understand remaining issues in MX and CR, we need to change the focus/settings of the alert system.

Conclusion. Dose-monitoring software is a useful tool for everyday quality control. It helps us to identify shortcomings in the department. Opportunities for optimization and standardization present themselves by acquiring data from the workfloor, using a standard list of comments for alert-justification.

http://dx.doi.org/10.1016/j.ejmp.2016.07.718

POPULATION DOSE AND FREQUENCY OF PROCEDURES IN MEDICAL EXPOSURE IN SUDAN

Nada A. Ahmed *, S.M. Abubaker, I.I. Suliman

Sudan Atomic Energy Commission, Radiation Safety Institute, Sudan
* Corresponding author.

Introduction. Medical exposure is the major contributor of man-made radiation to the population. Knowing the frequency and levels of doses in each medical exposure procedure as a national level is recommended.

Purpose. The aim of this study was to estimate the frequency and the associated radiation dose during medical examinations in Sudan and to identify the procedures of major contributor to the total collective dose.

Materials and Methods. Radiation dose was measured in 50 hospitals for a total number of more than 3000 patients over the country. The frequency of procedures was estimated from a representative number of governmental and private hospitals.

Results. The frequency of diagnostic procedures was 301 per 1000 population. The 'estimated total annual collective and total annual per caput effective dose were 6800 man Sv and 0.15 mSv, respectively. CT abdomen was the major contributor to the collective dose (18%) from diagnostic procedures with frequency of 5% .The estimated total annual frequency of diagnostic nuclear medicine procedures was 6.14 per 1000 population. The estimated total annual collective and total annual per caput effective dose were 16.3 man Sv and 0.001 mSv, respectively. The major contribution to the collective dose was from bone scan procedures (58%) with frequency of 34%. to the total frequency of nuclear medicine procedures .The most frequent treated radiotherapy site was breast (47%) with average prescribed dose of 42.4 Gy to the target volume in 15 fractions.

Conclusion. This study presented information about the magnitude and distribution of medical exposure in Sudan.

Disclosure. Authors confirm no any relationship bias their presentation.

http://dx.doi.org/10.1016/j.ejmp.2016.07.719

THE EFFECTS OF ELECTROMAGNETIC FIELDS ON HUMAN HEALTH

Ibrahim Duhaini

Rafik Hariri University Hospital, Radiation Oncology Department, Beirut, Lebanon

Since the beginning of the 20th century, we are overwhelmed by the increasing sources of the Electromagnetic Field **(EMF)** that is coming from telecommunication, electricity, appliances, medical equipment, and many other apparatus that we use in our daily life. Although these new technologies became inevitable and indispensable, the EMF they produce may cause health risks and hazards to human.

Some studies show a link between exposure to EMF and increased rate of Leukemia, cancer, brain tumors and other health problems. Also, there is some uncertainty remains as to the actual mechanisms responsible for these biological hazards and which type of fields magnetic or electric or both are of great concern.

It is needless to say that no matter the effects of these EMF be trivial or catastrophic, we should take all the necessary precautions to reduce our exposure to EMF as low as reasonably attainable. For this to occur, all those involved or affected by this exposure should follow the RF safety standards and guidelines set forth by the regulatory authorities like the IEEE, WHO, ICNIRP, and other likewise organizations.

Any failure in taking immediate actions to the above guidelines, the public would be at a high epidemic risk of potentially fatal diseases in the future.

http://dx.doi.org/10.1016/j.ejmp.2016.07.720

THE MEDICAL PHYSICIST AND ADVANCED TECHNOLOGY IN THE FIELD OF SCIENCE AND MEDICINE

Ibrahim Duhaini

Rafik Hariri University Hospital, Radiation Oncology Department, Beirut, Lebanon

Medical physics is the branch of physics concerned with the application of physics to medicine, particularly in the diagnosis and treatment of human diseases. The main areas of interest at present are in the treatment of cancer by ionizing radiation (Radiation Oncology), in diagnostic imaging with X-rays, ultrasound and nuclear magnetic resonance (Diagnostic Radiology), in diagnostic imaging and treatment with radioisotopes (Nuclear Medicine) and in the study of radiation hazards and radiation protection (Health Physics).

Medical physicists are scientists. It is through science that they are able to identify problems and unveil deficiencies. It is also through science that they solve the problems and correct the deficiencies.

From the time when ***Wilhelm Roentgen*** and other physicists made the discoveries which led to the development of Diagnostic Radiology, Radiotherapy, Brachytherapy and Nuclear Medicine, medical physicists have played a pivotal role in the development of new technologies that have revolutionized the way medicine is practiced. In today's health care scene, the medical physicist is essential to the safe and cost effective operation of any creditable medical institution.

There will be exciting and difficult challenges in the field of health care during this century. Count on the science of Medical Physics to help you meet the challenge.

http://dx.doi.org/10.1016/j.ejmp.2016.07.721

BIO-ACOUSTIC LEVITATIONAL ASSEMBLY OF HETEROCELLULAR 3D CONSTRUCTS: 3D MODEL ESTABLISHMENT FOR CELLS RADIATION EFFECT STUDIES IN 3D MICROENVIRONMENT

Charlène Bouyer [a,b,*], Pu Chen [c], Thomas J.N. Nieland [c], Utkan Demirci [c], Frederic Padilla [a,b]

[a] *Inserm, U1032 LabTau, Lyon, France*
[b] *Université de Lyon, Lyon, France*
[c] *Bio-Acoustic MEMS in Medicine (BAMM) Lab, Stanford University, CA, USA*
* Corresponding author.

Introduction. Many tissues are comprised of multilayered structures for which spatial organization and inter-layers cellular communications are essential to sustain their biological functions. Generation of multilayered constructs is motivated by the need to obtain tissue-like structures for many applications including radiobiology studies, where cells microenvironment is playing an important role.

Purpose. While current studies are using 2D monolayer cells culture and recent progress in genomic to study cells molecular response to RX, these 2D structures fail to represent 3D complex cells behavior depending on their surrounding environment, and could also impact radiation effects. We aimed at developing different 3D constructs such as neuronal or epithelial constructs that could be useful for radiobiology studies.

Materials and methods. To generate 3D constructs with native-like spatial organization, a novel strategy was developed using bulk acoustic standing waves, enabling easy, rapid and biocompatible 3D multilayers tissue constructs formation with tunable interlayer spacing and layers thickness. To show the device tunability, different cells types were used.

Results. First, we demonstrate the ability to generate multilayers 3D neural constructs assembling human ESC in fibrin hydrogels and differentiating them in neural cells. Then, to demonstrate the ability to bioengineer heterogeneous multilayers of cells in a single construct, three cell types (HeLa cells with different fluorochromes) were assembled subsequently via layer-by-layer acoustic levitation.

Conclusion. We have developed an acoustic technique to biocompatibly assemble, within minutes, multilayered constructs with multiple cell types in fibrin hydrogels. This acoustical method is potentially useful for broad fields including radiobiology, where 3D constructs could be used to further explore effects of RX in native-like tissue.

http://dx.doi.org/10.1016/j.ejmp.2016.07.722

THE IMPACT OF TEMPERATURE DEPENDENT ELECTRICAL CONDUCTIVITY IN RADIOFREQUENCY ABLATION TREATMENT PLANNING

Ioannis Saroglou [*], Theodoros Samaras

Department of Physics, Aristotle University of Thessaloniki, Greece
* Corresponding author.

Introduction. Radiofrequency ablation (RFA) for cancer therapy is usually performed under a medical imaging modality to evaluate tissue necrosis, albeit with some limitations. In recent years, the advancements in computational resources and their wide availability have rendered individualized treatment planning for RFA feasible. However, this approach involves several limitations and approximations, as well.

Purpose. In the current study we aim at elucidating the importance of assuming a temperature dependence for the electrical conductivity and its effect in the predicted final temperature distribution and necrotic volume.

Materials and methods. The simulated model is a two-compartmental one, which assumes different electrical conductivity in the spherical tumor and the surrounding healthy tissue. A single electrode is entered inside the tumor (monopolar technique). The Laplace and the Pennes bioheat-transfer equations are solved numerically with the finite difference method coded in C, after applying the appropriate boundary conditions. It is assumed that the electrical conductivity in both compartments changes with temperature.

Results. The calculated temperature rise and necrosis volume (as assessed by CEM43 °C above a threshold) change considerably when the electrical conductivity varies with temperature. In fact, various formulations for this temperature dependence have been suggested and they can result in differences larger than 15% in the treatment outcome indicators.

Conclusion. Currently, it is possible to achieve individualized treatment planning for RFA. However, there is scarce information from the literature on the changes of tissue properties at ablative temperatures, which could lead to more accurate predictions of the treatment outcome.

http://dx.doi.org/10.1016/j.ejmp.2016.07.723

MINIMALLY INVASIVE INGESTIBLE DEVICE TO PERFORM ANTI-BACTERIAL PHOTOTHERAPY IN THE STOMACH

Giovanni Romano [a,*], Giuseppe Tortora [b], Silvia Calusi [a], Barbara Orsini [a], Alessio Gnerucci [a], Franco Fusi [a]

[a] *Department of Experimental and Clinical Biomedical Sciences "Mario Serio", University of Florence, viale Pieraccini 6, I-50135 Florence, Italy*
[b] *The BioRobotics Institute, Polo Sant'Anna Valdera, Scuola Superiore Sant'Anna, viale Rinaldo Piaggio 34, I-56025 Pontedera, Italy*
* Corresponding author.

Introduction. In the framework of the growing rate of antibiotic-resistance, new therapeutic solutions are being considered against bacterial infections, among which photodynamic therapy (PDT) is a very attractive perspective. In recent years, innovative solutions for endoscopic illumination have been studied, e.g. for catheter infections, pancreas tumours and stomach infections by *Helicobacter pylori (Hp)*.

Hp colonizes the human stomach with a worldwide infection prevalence exceeding 50%, besides being a class 1 carcinogen agent (World Health Organization). Currently, *Hp* infection is treated with pharmacologic therapies, showing high failure rates mainly due to antibiotic resistance. To overcome this limitation, endoscopic PDT devices have been tested. However, they exhibit clear disadvantages, namely great invasivity and adverse effects.

Purpose. To design and characterize a non-invasive light-emitting device to perform *Hp* phototherapy: an ingestible "LED antibiotic", exploiting the presence of endogenous *Hp* photosensitizers.

Materials and methods. Merging experimental and simulation methods we obtain the light action spectrum for *Hp* phototherapy in the gastric environment. We have designed and assembled the pill containing LED sources, a battery and electronic board. Capsule emission parameters are measured by an integrating sphere and *in vitro* Hp irradiation performed.

Results. The action spectrum for *Hp* phototherapy is peaked in the violet and red spectrum regions. Capsule prototypes show emission parameters compatible with *in vitro* Hp eradication (>99% killing).

Conclusion. Our device has shown emission spectrum, intensity and duration compatible with an effective phototherapy of *Hp*, considering also the treatment repeatability (5–10 capsules in 2–3 weeks). Future clinical trials are envisaged.

Disclosure. GR, GT, BO and FF disclose being also Probiomedica srl (www.probiomedica.com).

http://dx.doi.org/10.1016/j.ejmp.2016.07.724

SMALL FIELD RELATIVE DOSIMETRY USING A SILICON DIODE OF NEW GENERATION

C. Talamonti [a,b,c], M.D. Falco [d,*], A. Bartoli [c], S. Russo [e], C. Iervolino [f], E. Menghi [g], E. Moretti [h], E. Mones [i], C. Fiandra [j], M. Casale [k], G. Pastore [l], C. Oliviero [m], E. DiCastro [n], S. Luxardo [o], A. Vaiano [p], G.H. Raza [q], G. Borzi [r], C. Carbonini [s], R. Consorti [t], M.C. Pressello [u], C. Gasperi [v], L. Barone Tonghi [w], F. Palleri [x], C. Marino [y], V. Ardu [z], S. Linsalata [aa], S. Riccardi [ab], F. Vittorini [ac], L. Spiazzi [ad], F. Rosica [ae], C. Iervolino [af], E. Villaggi [ag], P. Mancosu [ag]

[a] *University of Florence, Italy*
[b] *A.O.U. Careggi, Florence, Italy*
[c] *I.N.F.N., Florence, Italy*
[d] *Policlinico di Chieti, Italy*
[e] *Azienda Sanitaria Firenze, Italy*
[f] *A.0 "S.G.MOSCATI" Avellino, Italy*
[g] *I.R.S.T. Meldola (FC), Italy*
[h] *AOU "Santa Maria della Misericordia" Udine, Italy*
[i] *AOU Maggiore delle Carità Novara, Italy*
[j] *Molinette, Torino, Italy*
[k] *AO "Santa Maria" Terni, Italy*
[l] *Ecomedica Empoli, Italy*
[m] *IRCCS CROB Potenza, Italy*
[n] *Umberto I – Policlinico di Roma, Italy*
[o] *Asl 1 Carrara, Italy*
[p] *USL 3 Pistoia, Italy*
[q] *Ospedale San Pietro Fatebenefratelli, Roma, Italy*
[r] *Centro REM Radioterapia Catania, Italy*
[s] *A.O. Ospedale Niguarda, Milano, Italy*
[t] *Ospedale san Filippo Neri, Roma, Italy*
[u] *AO San Camillo Forlanini, Roma, Italy*
[v] *Usl8, Arezzo, Italy*
[w] *A.R.N.A.S. Garibaldi di Catania, Italy*
[x] *AO Parma, Italy*
[y] *Humanitas Catania, Italy*
[z] *Policlinico San Donato Milanese, Italy*
[aa] *Asl Lucca, Italy*
[ab] *Asl Rieti, Italy*
[ac] *Asl L'Aquila, Italy*
[ad] *Brescia Spedali Civili, Italy*
[ae] *P.O. "Mazzini" ASL di Teramo, Italy*
[af] *AUSL Piacenza, Piacenza, Italy*
[ag] *Humanitas Milano, Italy*
* Corresponding author.

Introduction. Small field dosimetry is increasingly important due to the development of complex treatment techniques. Standard dosimetric procedures are mandatory to ensure the same treatment in each radiotherapy center.

Purpose. A multicentric study on small fields dosimetry for the major linear accelerator manufacturers, using two IBA unshielded silicon diode RAZOR in 30 different institutions in Italy is reported. Data were collected for each linac manufacturer and model with the main objective to provide indications to beginner institutions.

Materials and methods. In and cross-plane beam profiles and Relative Output ratios were measured for each field size at depth = 10 cm and at SSD = 90 cm. The long axis of the diode detector was placed parallel to the beam with the active volume positioned at the isocenter. The profiles were compared in terms of 80–20% penumbra. Output factors were calculated with respect to a jaw-collimated square field of 3×3 cm^2 and as a function of effective field size EOF.

Results. EOF of all linacs were in agreement within a few per mille from 5.6cm to 1cm FS. For FS below 1cm it is evident a different trend depending on different linac models. Data were fitted with a polynomial showing coefficients of determination $R^2 > 0.98$. Penumbra measurements were in agreement each other for each FS and accelerator model.

Conclusion. Multicentric data have been collected with the same instrumentation and protocol setup, providing good accuracy in the measurements and allowing to create gold standard values to be used by those institutions who intend to implement new performing treatment techniques.

http://dx.doi.org/10.1016/j.ejmp.2016.07.725

COMPARISON OF TWO PSYCHOMETRIC FUNCTIONS IN ANALYZING 4-AFC DETECTION RESULTS USING A TASK-BASED STRUCTURED PHANTOM FOR DIGITAL MAMMOGRAPHY

Kristina Tri Wigati [a,*], Lesley Cockmartin [b], Nicholas W. Marshall [b], Djarwani S. Soejoko [c], Hilde Bosmans [b]

[a] *Department of Imaging and Pathology, KU Leuven, Belgium*
[b] *Department of Radiology, University Hospitals of Leuven, Belgium*

[c] *Department of Physics, Faculty of Mathematics and Sciences, University of Indonesia, Indonesia*
* Corresponding author.

Introduction. Detectability of spiculated and non-spiculated mass models and microcalcifications, in a structured background phantom of acrylic spheres and water, was studied for digital mammography via the four-alternative forced-choice (4-AFC) paradigm.

Purpose. To compare the threshold diameters for mass and microcalcification detection using two types of psychometric curves applied on the contrast-detail data.

Material and methods. Ten images of the structured phantom were acquired on 23 digital mammography systems under automatic exposure control. The 4-AFC study was performed with in-house developed software and 5 medical physicists as observers. Percentage correctly detected lesions (PC) was obtained for each target type. Two psychometric curves (Weibull and Logistic functions) were applied to determine the threshold diameters and number of detected targets (at PC = 62.5%).

Results. Both fitting procedures were successfully applied on all systems. After averaging over 23 systems, the threshold diameters for spiculated and non-spiculated masses and microcalcifications, with the Weibull psychometric curves, were 4.0 ± 0.3 mm (R^2 = 0.61 ± 0.08), 4.6 ± 0.7 mm (R^2 = 0.51 ± 0.11), and 0.114 ± 0.003 mm (R^2 = 0.91 ± 0.03) respectively, and the values of 4.0 ± 0.4 mm (R^2 = 0.61 ± 0.08), 4.7 ± 0.6 mm (R^2 = 0.50 ± 0.11), and 0.114 ± 0.003 mm (R^2 = 0.91 ± 0.03) were obtained with the Logistic function. The numbers of detected targets assessed from the two functions were not different (3–4 spiculated masses, 1–2 non-spiculated masses, and 4 groups of microcalcifications). If the PC values were not completely covering the lower and upper than 62.5%, there will be possibility different results occurred from these two functions.

Conclusion. Weibull and Logistic curve fits gave similar and reproducible threshold diameters for the structured phantom.

http://dx.doi.org/10.1016/j.ejmp.2016.07.726

LOW CONTRAST DETECTABILITY ASSESSMENT WITH HOMEMADE SOFTWARE AND DEDICATED PHANTOM: EVALUATION OF RESULTS AND COMPARISON WITH CDMAM ANALYSIS

R. Villa [a,b,*], N. Paruccini [b], C. Pasquali [b], C. Spadavecchia [a,b], A. Baglivi [a,b], A. Radice [b], A. Crespi [b]

[a] *Postgraduated School of Medical Physics, Italy*
[b] *Medical Physics Department, San Gerardo Hospital, ASST Monza, Italy*
* Corresponding author.

Introduction. Contrast detail curve, or LCD, is an important aspect of image quality. LCD curves are usually determined with the Artinis CDMAM phantom.

Purpose. This study proposed a different method to obtain contrast detail curves based on a unique image of a homemade phantom.

Materials and methods. Phantom was made up of an acetate sheet equipped with a central uniform aluminium region (3×3 cm^2, thickness 0.49 mm) and an aluminium step wedge (thickness: 0.2–1 mm) for linear conversion pixel values/millimetres of aluminium. LCD was estimated through a statistical method analysing a square ROI on the uniform aluminium region with a dedicated Matlab program. For each details dimension, it was divided into a matrix of subROIs: contrast thresholds were defined as 3.29 the standard deviation of subROIs mean values, corresponded to a statistical significance of 95%.

Results were then converted in terms of mmAl. Reproducibility and variability with different combinations of kV, mAs and AGD were evaluated. Reliability of the method was evaluated comparing results with CDMAM curves. The effect of human perception was considered through a NPWE model and compared with the results of 2AFC experiment.

Results. Analysis confirmed the reproducibility of the method. The comparison with CDMAM analyses showed a good agreement for each equipment considered in this study, confirming the good reliability of the method. The Human perception was also introduced with good results.

Conclusion. The statistical approach proved to be less time-consuming and in accordance with the automatic readout of CDMAM images, allowing to be adopted in image quality assurance protocols.

http://dx.doi.org/10.1016/j.ejmp.2016.07.727

A STATISTICAL METHOD FOR LOW-CONTRAST DETECTABILITY ANALYSIS IN ANGIOGRAPHY SYSTEMS

A. Radice [b], N. Paruccini [b], C. Spadavecchia [a,b], R. Villa [a,b,*], A. Baglivi [a,b], A. Crespi [b]

[a] *Postgraduated School of Medical Physics, University of Milan, Italy*
[b] *Medical Physics Department, San Gerardo Hospital, ASST Monza, Italy*
* Corresponding author.

Introduction. The current methods for low-contrast detectability (LCD) analysis of angiographic images are time-consuming, observer dependent and the provided phantoms are not compatible with the small fields, especially in cardiology practise.

Purpose. To validate a new statistical approach for LCD, derived from CT, as a quality control test of angiography systems.

Materials and methods. A homemade phantom consisting of a square aluminum target (3×3 cm^2; 0.49 thick) and a 5-step wedge (0,2–1 mmAl) above an acetate sheet was exposed to different modalities ("low/normal/high fluoroscopy"; "cerebral 2 fps"; "cerebral DSA"; "coronary 15 fps") with 10–15–20–25 cm of PMMA. A customer software was developed to automatically calculate the LCD values as following: LCD = $3.29 * \sigma_\mu$, where σ_μ is the pixel values standard deviation from 100 ROI 6×6 pixels^2 within the square target corresponding to a 2.04 mm equivalent diameter's object. At last the LCD values were converted into mmAl using the 5-step wedge.

Results. LCD depends on detector characteristics, phantom thickness/material, air-kerma to the detector, beam quality (kVp and HVL) and image noise. For all the modalities LCD values increase with the PMMA layers and range from 0.02 mmAl ("cerebral DSA"; 10 cm PMMA) to 1,11 mmAl ("low fluoroscopy", 25 cm PMMA). The contrast thresholds with 15 cm PMMA are 0.03 ("cerebral DSA"), 0.26 ("cerebral 2 fps"), 0.38 ("coronary 15 fps"), 0.55 ("normal fluoroscopy"), 0.66 ("high fluoroscopy") and 0.75 mmAl ("low fluoroscopy").

Conclusion. Quantitative measurement of LCD is easy to implement and provides a consistent and reproducible metric of angiographic image quality.

http://dx.doi.org/10.1016/j.ejmp.2016.07.728

COMPARISON AMONG ITERATIVE RECONSTRUCTION TECHNIQUES FOR PHASE-SENSITIVE BREAST TOMOGRAPHY

L. Fardin [a], P. Oliva [b,*], B. Golosio [b], F. Brun [c], L. Rigon [a], R. Longo [a]

[a] *University of Trieste and INFN Section of Trieste, Italy*
[b] *University of Sassari and INFN Section of Cagliari, Italy*
[c] *Elettra – Sincrotrone Trieste S.C.p.A, S.S. 14 km 163.5, 34149 Basovizza, Trieste, Italy*
* Corresponding author.

Introduction. Iterative tomographic reconstruction techniques are particularly interesting when the number of acquired projections is not enough to match the Nyquist criteria. These techniques differ in computational time and image quality.

Purpose. SIRT, SART and CGLS algorithms have been studied in order to evaluate the application of iterative reconstruction methods to low-dose phase-contrast breast tomography, in the framework of the SYRMA-CT project. The number of iterations has been optimized while reducing the number of projections used during the reconstruction.

Materials and methods. The tomographic data set of two large breast tissue samples (9 cm) has been acquired using a monochromatic X-ray beam at 38 keV. Images were acquired in propagation-based phase-contrast mode and a single-material single-distance phase-retrieval algorithm was applied to the projections before reconstruction.

The codes applied are part of the ASTRA Tomography Toolbox. The quality of the images was evaluated using the CNR and few full-reference quality indexes. The reconstruction performed with the filter back-projection including all the acquired projections was considered as gold standard.

Results. According to full-reference indexes the best quality is achieved when the CNR is similar to the one of the gold standard. The number of iterations can be used to optimize the noise preserving the visibility of the details.

Conclusion. Full reference indexes require a gold standard acquired at higher statistics, due to their strong dependence on the noise. The evaluation of a team of radiologists is required to compare full-references quality indexes and diagnostic quality of the reconstructed images.

Disclosure. Nothing to declare.

http://dx.doi.org/10.1016/j.ejmp.2016.07.729

AUTOMATISED DETECTION OF MICROCALCIFICATION IN MAMMOGRAPHY

A. Fanizzi [a,*], S. Tangaro [b], R. Bellotti [a], T.M.A. Basile [a], U. Bottigli [c], L. Losurdo [c], R. Massafra [d], P. Tamborra [d], V. Didonna [d], D. La Forgia [d]

[a] *Università degli Studi di Bari, Dipartimento di Fisica, Bari, Italy*
[b] *Istituto Nazionale di Fisica Nucleare, Sezione di Bari, Bari, Italy*
[c] *Università degli Studi di Siena, Dipartimento di Scienze Fisiche, della Terra e dell'Ambiente, Siena, Italy*
[d] *I.R.C.C.S. Istituto Tumori "Giovanni Paolo II", Bari, Italy*
* Corresponding author.

Introduction. An important area in which an improvement of the imaging techniques would be extremely important, is the diagnosis of breast cancer.

For this purpose, mammography is the principal diagnostic tool used. Although it is effective in the early detection of breast cancer, exists a real need for new automatic approaches that can improve the accuracy of detection of breast cancer in mammogram Images. In fact, a computerized system as a second reader can support the radiologist in the interpretation of these exams by reducing the number of false positives and thus, the biopsy procedures not necessary.

Purpose. In this paper, we propose a Computer Aided Detection System (CAD) for the microcalcification in mammogram images as a diagnostic support tool for radiologists in the analysis.

Materials and methods. We develop a fully automated tool for (1) pre-processing images using the edge detection process described by Canny which was designed to be an optimal edge detector according to particular criteria; (2) region of Interest extraction; (3) Adapted Hough Transform to identify the microcalcification cluster.

The proposed method was evaluated using cases from publicly available mammography dataset such as *Breast Cancer Digital Repository* (BCDR) database.

Results. We present the results obtained in terms of accuracy, sensitivity, false positive for image. The proposed system shows results comparable state of the art.

Conclusion. The proposed method was advantageous in the identification of microcalcifications.

http://dx.doi.org/10.1016/j.ejmp.2016.07.730

FURTHER RESULTS ON THE EVALUATION OF THE PERFORMANCE OF A DIGITAL BREAST TOMOSYNTHESIS SYSTEM IN THE CLINICAL ENVIRONMENT

A. Rodríguez-Ruiz [a,*], M. Castillo [b], J. Garayoa [c], M. Chevalier [b]

[a] *Department of Radiology and Nuclear Medicine, Radboud University Medical Centre, Nijmegen, The Netherlands*
[b] *Department of Radiology, Medical Physics Group, Complutense University of Madrid, Madrid, Spain*
[c] *Radiological Protection Department, Hospital Fundacion Jimenez Diaz, Madrid, Spain*
* Corresponding author.

Introduction. Digital breast tomosynthesis (DBT) is spreading throughout medical centres worldwide. However, there is a wide variability of technical characteristics among DBT systems that need to be assessed for quality control (QC) implementation.

Purpose. After evaluating the technical performance of three commercial DBT systems in a previous work, we pursue to research a fourth system with notorious differences with the previous ones.

Materials and methods. We evaluate a General Electric SenoClaire DBT system with angular range (AR) of 25°, 9 projections, step-and-shoot X-ray tube motion and iterative reconstruction. Tests for assessing the image quality of projections and reconstructed planes were: contrast-to-noise ratio (CNR); spatial resolution, via the in-plane modulation transfer function (MTF) and the in-depth point spread function (Z-PSF), and artefact spread function (ASF). All was implemented in custom-designed phantoms according to literature.

Results. In the reconstructed slices and slabs, CNR has a very weak dependency on PMMA thickness, as opposed to projections, possibly due to the iterative algorithm. The tube travel MTF is 30% larger respect to the measured average from continuous tube movement systems, due to the step-and-shoot setup, while the chest-wall nipple resolution remains similar. The Z-PSF is narrower than systems with larger AR due to the iterative reconstruction but the ASF is similar to systems with a smaller AR, because of a greater angular spacing between projections.

Conclusion. We observe in the clinic some theoretical results when comparing with previously studied DBT systems, and the results could be useful as a guide for future QC procedures.

Disclosure. None to disclose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.731

EFFECT OF PMMA SHIELD ON PHOTONEUTRON DOSE EQUIVALENT IN HIGH ENERGY MEDICAL LINACS

Hashemi Dizaji Seyed Mehdi

Sina Hospital, Iran

High energy photon beams from medical linacs produce, besides the clinically useful photon beams, secondary neutrons. These photoneutrons increase patient dose and may cause secondary malignancies. The effect of PMMA shield on reduction of photoneutron dose equivalent produced by a high energy medical linac is investigated in this study.

To determine the photoneutron dose equivalent by a Varian linac working at 18 MV photonmode, Polycarbonate films was used. Measurements done at distances 0, 10, 20, 50 cm from the center of the X-ray beam for open field and after inserting 1 cm thick PMMA shield in the X-ray field. After electrochemical etching of the PC films, the neutron dose equivalent was calculated.

The results show that by increasing the distance from the center of the X-ray beam towards the periphery, the photoneutron dose equivalent decreases rapidly for both the open and shielded fields and that by inserting the PMMA shield in the path of the X-ray beam, the photoneutron dose equivalent was decreased obviously compared to open field. Results show a PMMA shield, can significantly reduce photoneutron dose equivalent at patient plane.

Although, same amount of X-ray (100 MU) is provided by linac in both shielded and open fields, it can be seen that using the shield causes a considerable decrease in photoneutron dose equivalent ($p < 0.05$). Since PMMA is made of light elements, it absorbs fast photoneutrons readily. So it is predictable that dose equivalent from photoneutrons at patient plane will decrease.

http://dx.doi.org/10.1016/j.ejmp.2016.07.732

AUTOMATED BREAST ULTRASOUND FOR THE DETECTION AND RECONSTRUCTION OF THE BREAST DUCTAL PATTERN

Maria Kallergi [a,*], Mark S. Haynes [b], Vicky Bizini [c], Paulin A. Sheth [d], Leah D. Eshraghi [e], Susan M. Love [e]

[a] *Biomedical Engineering Department, Technological Educational Institute of Athens, Athens, Greece*
[b] *Jet Propulsion Laboratory, CA, USA*
[c] *Attikon Hospital, Athens, Greece*
[d] *University of Southern California, CA, USA*
[e] *Dr. Susan Love Research Foundation, CA, USA*
* Corresponding author.

Purpose. Automated 3D breast ultrasound (ABUS) has shown several advantages over the conventional handheld systems and promising results in screening women with dense breasts. In addition, ABUS seems to offer a unique opportunity for mapping in vivo the normal ducts thus improving our understanding of normal/malignant relationships in the adult female breast. Preliminary results of such a study are reported here.

Materials and methods. Six lactating, nursing volunteers were scanned with the Invenia™ ABUS system (GE Healthcare, WI, USA). The women were imaged before and after breastfeeding their infants. Ductal patterns were generated from the manual segmentations of two experts. Results were qualitatively compared to published work. Descriptive statistics and the *t*-test were applied to characterize the population and variabilities.

Results. Milk filled ducts in lactating women offered a natural contrast agent but empty ducts may also be observed under light breast compression. Most of the ducts were detected and 3D maps were generated. An increased localized activity of milk filled ducts was observed in the lower outer quadrants of all breasts. Ducts from the upper quadrants show involvement in women breastfeeding the longest (11–18 months). Intra- and inter-volunteer variabilities were significant.

Conclusion. The ABUS system provided sufficient information to detect and segment most of the breast ducts. The observed localized activity of the ducts agrees with results from prior similar studies and raises new important issues regarding the role of duct involution on cancer development. Further testing is justified as is the development of computer algorithms for automated 3D ductal structure generation.

http://dx.doi.org/10.1016/j.ejmp.2016.07.733

AN AUTOMATIC METHOD IMPROVING THE RELIABILITY OF SHEAR WAVE ELASTOGRAPHY IN THE DIAGNOSIS OF CHRONIC LIVER DISEASE

Ilias Gatos [a,*], Stavros Tsantis [a], Pavlos S. Zoumpoulis [b], Ioannis Theotokas [b], George C. Kagadis [a]

[a] *Department of Medical Physics, School of Medicine, University of Patras, GR 26504 Rion, Greece*
[b] *Diagnostic Echotomography SA, 317C Kifissias Ave., GR 14561 Kifissia, Greece*
* Corresponding author.

Introduction. Chronic Liver Disease (CLD) is considered as one of the leading causes of death worldwide today. Shear Wave Elastography (SWE) is a recently introduced technique which offers real-time elasticity imaging as well as stiffness quantification over a 2D region-of-interest (ROI). The major challenge for clinicians nowadays is the accurate and on-time estimation of liver fibrosis progress toward an efficient treatment to avoid unnecessary and costly invasive procedures.

Purpose. Classify CLD from SWE imaging by means of an optimized ROI selection procedure and a computer aided diagnosis system.

Materials and methods. The proposed algorithm employs a ROI selection technique (areas with no stiffness variation across-time) to quantify 32 SWE images (16 healthy and 16 with CLD). The selection procedure employs four SWE images from the same area of liver parenchyma having 5 s time distance acquired from each patient. Subsequently, the mean stiffness value of pixels having Stiffness Standard Deviation <2 across time is calculated providing the new ROI for analysis. From each final ROI, 185 textural features were computed. Stepwise multi-linear-regression analysis was utilized to avoid feature redundancy leading to a feature subset feeding a Support Vector Machine (SVM) classifier.

Results. Highest classification accuracy from the SVM-model was 94.3% with sensitivity and specificity values of 93.8% and 94.6%, respectively. Best feature combination for the SVM model comprised the Standard Deviation, Sum-Variance and Contrast features.

Conclusion. A new automatic SWE reliability algorithm for CLD diagnosis has been developed that could prove to be of value to physicians improving the diagnostic accuracy of CLD.

Disclosure. No disclosure.

http://dx.doi.org/10.1016/j.ejmp.2016.07.734

DEVELOPMENT AND OPTIMIZATION OF MAGNETIC NANOPARTICLES FOR TARGETED THERAPY

M. Patitsa [a], A. Tziouni [b], K. Kordatos [b], D.A. Verganelakis [c,*] A. Klinakis [a]

[a] *Bioacademy Research Foundation Academy of Athens, Athens, Greece*
[b] *School of Chemical Engineering NTUA, Athens, Greece*

[c] *Encephalos-Euromedica Medical Diagnostic Center, Athens, Greece*
* Corresponding author.

Introduction. Nanoparticles have a unique role in the field of nanomedicine since they can be used in an extensive range of applications including disease diagnosis, drug delivery and therapy.

Purpose. This study aims at the identification of the optimal magnetic nanoparticle for drug delivery and imaging of tumor cells. A wide variety of nanoparticles have been characterized with respect to drug loading and release, magnetic steering, MR imaging, interaction with cell membranes, in vitro therapeutic efficacy and cytotoxicity and in vivo biocompatibility. The focus of this study is about breast cancer.

Materials and methods. A variety of nanoparticles were produced, such as carbon nanotubes, multi-wall carbon nanotubes and processed accordingly in order to acquire magnetic properties, to encapsulate the chemotherapeutic drug and to coat them in order to protect them from the immune system and limit aggregation.

To assess in vitro cytotoxicity and therapeutic efficacy human breast cancer cells MDA-MB-231 were injected into a number of mice. After an incubation period for the injected cells, nanoparticles were then injected into the mice and imaged using a 1.5 T Signa HDxt system.

Results. A series of MRI experiments in mice with breast cancer demonstrated the correlation between magnetic properties, aggregation, biocompatibility, drug loading, therapeutic effect, size and surface chemistry of the injected nanoparticles. Depending on the desired properties of the nanoparticles different types could be optimal.

Conclusion. The development and optimization of magnetic nanoparticles for targeted therapy of breast cancer cells generated a wide range of interesting results.

http://dx.doi.org/10.1016/j.ejmp.2016.07.735

AIR DENSITY DEPENDENCE OF THE PTW 34013 IONIZATION CHAMBER FOR SOFT X-RAY

J. Torres del Río [a,*], C. Forastero [a], A.M. Tornero-López [b], J.M. de la Vega [a], D. Guirado [a], J. Pérez-Calatayud [c], A.M. Lallena [d]

[a] *Servicio de Radiofísica, Hosp., Univ. Alejandro Otero, Granada, Spain*
[b] *Servicio de Radiofísica, Hosp., Univ. Doctor Negrín, Las Palmas de Gran Canaria, Spain*
[c] *Servicio de Radiofísica, Hosp., Univ. La Fe, Valencia, Spain*
[d] *Departamento de Física Atómica, Molecular y Nuclear, Universidad de Granada, Spain*
* Corresponding author.

Introduction. It has been proved that some ionization chambers, when measuring low energy brachytherapy or soft X-ray sources, show a dependence with the air density that it is not entirely corrected with the usual pressure/temperature correction factor, k_{TP}. This is due to the chamber dimensions and materials forming it.

Purpose. To determine if the response of PTW 34013 chamber, used for dose measurements in superficial radiotherapy, is fully corrected with k_{TP} or a residual air density dependence remains.

Materials and methods. Measurements for 70 and 200 kVp X-ray beams, generated by a MAXISHOT.200 cabinet, have been performed using a pressurized chamber. Raw data have been corrected with k_{TP} and normalized to its value in standard atmospheric conditions (760 mmHg and 20 °C).

Results. The corrected measurements for both beams still show a linear dependence with the normalized density ρ/ρ_0, ρ_0 being the density in standard atmospheric conditions. When the air density is below ρ_0, k_{TP} undercorrects the measurement, and the contrary occurs when $\rho > \rho_0$. In our city, with 700 m AMSL, usual atmospheric conditions will cause 1.2% undercorrection for the 70 kV beam and 2.5% for the 200 kV beam.

Conclusion. Despite its dimensions, the dependence of the PTW 34013 ionization chamber with the air density is not fully corrected with k_{TP}. The weather or the altitude of the place where measurements are carried out will require an additional correction to reach the accuracy level required in radiotherapy.

Disclosure. We thank to PTW for material support.

http://dx.doi.org/10.1016/j.ejmp.2016.07.736

JQC-PET, AN IMAGEJ MACRO FOR THE STANDARDIZATION OF PET/CT QUALITY CONTROL

J. Cortes-Rodicio *, G. Sanchez-Merino, R. Lope-Lope, T. Martin-Gonzalez, J. Ruiz-Pomar, M.A. Garcia-Fidalgo

Servicio de Física Médica, OSI Araba, Hospital Txagorritxu, Vitoria-Gasteiz, Spain
* Corresponding author.

Introduction. Several publications provide guidelines for the implementation of quality assurance and control programs concerning PET/CT systems. Sometimes the tests described involve complex calculus and stages that are difficult to reproduce or could be quite user dependent. In some cases the more cumbersome tests can be performed using proprietary software provided by the vendor of the equipment, but this "black box" solution makes the process rather opaque.

Purpose. The aim is to provide a standardization tool for the procedures of the PET/CT quality assurance for automating the generation of the regions of interest and the analysis. An ImageJ macro has been developed to facilitate the analysis of three PET/CT quality control procedures included in IAEA-Pub 1393.

Materials and methods. We have developed an open macro for the public domain Java image processing and analysis program ImageJ. The phantoms described in the IAEA-Pub 1393 have been used to run the quality assurance procedures in a Philips Gemini TF PET/CT (Philips Medical Systems). Three tests have been implemented: spatial resolution, image quality with accuracy of attenuation and scatter corrections and Uniformity of the reconstructed image.

Results. The results obtained with the software have been compared with those of the commercial software and the literature with good agreement in all cases. The software is available to the community of medical physicists at www.sefm.es.

Conclusion. The use of jQC-PET allows a standard analysis and the independence of the commercial software.

Disclosure. The authors are the developers of the software presented here.

http://dx.doi.org/10.1016/j.ejmp.2016.07.737

A NEW USER FRIENDLY VISUAL ENVIRONMENT FOR BREAST MRI DATA ANALYSIS

A. Danelakis [a], P. Toulas [b], T. Theoharis [a], D.A. Verganelakis [b,*]

[a] *NKUA, Department of Informatics and Telecommunications, Athens 15784, Greece*
[b] *Encephalos-Euromedica Medical Diagnostic Center, Attiki 15233, Greece*
* Corresponding author.

Introduction. In recent years, there has been a great effort for the exploitation of powerful computer systems in order to support clin-

ical decisions, the so-called CDSS (Clinical Desicion Support Systems). After processing imaging data in an automatic way they can provide useful diagnostic information facilitating like this clinical decisions.

Purpose. This study demonstrates the advantages of a newly developed friendly visual CDSS environment for Breast MRI Data Analysis, the co-called BreDAn. This software process all dynamic MRI data prior and post contrast medium injection generating kinematic graphs, color maps of signal increase and decrease and finally detecting high risk breast areas. The great advantage of BreDAn is the automation of the radiodiagnostic process in a reliable manner.

Materials and methods. BreDAn involves a series of steps of MRI Breast data processing, such as data initialization, windowing, intensity filter, intensity curve slope filter, color fragment filter and data display. It has been tested and evaluated using 534 MRI data sets (522 F, age group 31–79 y and 12 M, 55–68 y). A GE Signa HDxt 1.5 Tesla system was used throughout all MRI scans. A description of the MRI protocol is given.

Results. Out of the 534 cases studied, 9.55% of them found to be pathological and 90.45% were non-malignant. All automatically generated results by BreDAn were compared by radiologist's diagnosis and found to be in agreement. BreDAn in practice simulates the radiological diagnostic methodology.

Conclusion. This study illustrates the advantages of BreDAn, a user friendly visual environment for MRI Breast data analysis, which have been tested thoroughly and validated successfully.

http://dx.doi.org/10.1016/j.ejmp.2016.07.738

MRI-ONLY BRAIN RADIOTHERAPY VERIFICATION USING CONE BEAM COMPUTED TOMOGRAPHY

S. Aouadi, R.W. Hammoud *, A. Vasic, S. Paloor, T. Torfeh, P. Petric N. Al-Hammadi

NCCCR, Hamad Medical Corporation, Doha, Qatar
* Corresponding author.

Introduction. CBCT are frequently used for patient treatment verification. Hence, generated synthetic-CT (sCT) for MRI-only treatment planning workflow needs to be assessed for image guided radiation therapy (IGRT) using CBCT as well.

Purpose. For brain cancer patients, we investigated the effectiveness of using sCT that are generated from MRI instead of CT for CBCT-based IGRT.

Material/methods. Twelve patients with co-registered CT and conventional MRI were used to compute a library of patches. For three patients with two CBCT each, two sCT were generated from MRI using "non-local means" patch-based method (NMPBM) or "sparse" patch-based method (SPBM). CT and sCT alignments with CBCT were performed with MI-Powell. MI-Powell performs Powell optimization of mutual information between volumes and estimates alignment Euler angles and translation.

Rigid transformations obtained for CT/CBCT registration were considered as the gold standard. Mean Target Registration Error (mTRE) obtained for sCT/CBCT alignment was computed. mTRE is the average distance between transformed CBCT voxels centers, within head region, by estimated and gold transformation respectively. Moreover, the average errors of displacement (Δt) and orientation ($\Delta\theta$) from CT/CBCT registration transformation were computed.

Results. For sCT_{NMPBM}/CBCT registration assessment, average mTRE = 1.36 ± 0.29 mm, Δt = 0.92 ±0.2 mm and $\Delta\theta$ = 1.02 ±0.34°. For sCT_{SPBM}/CBCT registration assessment, average mTRE = 1.4 ± 0.3 mm, Δt = 0.91 ± 0.21 mm and $\Delta\theta$ = 1.08 ± 0.43°. Both NMPBM and SPBM were therefore accurate and gave an intermediate sCT suitable for CBCT-based IGRT.

Conclusion. Based on our results for brain site, CBCT can be used for patient position verification with sCT as a reference. Further work will be done for assessment in other clinical sites with challenging organ motion.

http://dx.doi.org/10.1016/j.ejmp.2016.07.739

CREATING A TISSUE MIMICKING PHANTOM APPROPRIATE FOR RELAXOMETRY, DIFFUSION IMAGING AND ULTRASOUND ELASTOGRAPHY

Z.G. Portakal [a,b,*], J.W. Phillips [c], S.M. Shermer [d], C.E. Richards [e] E. Spezi [b,f], L.J. Garcia [b], T. Perrett [b], D.G. Lewis [b], N. Tuncel [g]

[a] *Physics, Cukurova University, Adana, Turkey*
[b] *Medical Physics, Velindre Cancer Centre, Cardiff, United Kingdom*
[c] *Institute of Life Science, College of Medicine, Swansea University, Swansea, United Kingdom*
[d] *Physics, Collage of Science, Swansea University, Swansea, United Kingdom*
[e] *College of Medicine, Swansea University, Swansea, United Kingdom*
[f] *School of Engineering, Cardiff University, Cardiff, United Kingdom*
[g] *Physics, Akdeniz University, Antalya, Turkey*
* Corresponding author.

Introduction. To optimize elastography and diffusion weighted imaging (DWI) modalities, it is important to create phantoms that can reliably mimic the properties of human tissue and be used in reference imaging experiments. In this study, we used polyvinyl alcohol cryogel (PVA-C), agar, and agarose gels.

Purpose. To create a tissue mimicking phantom appropriate for relaxometry, non-Gaussian diffusion imaging and ultrasound elastography and to investigate potential relationships between quantities accessible from different imaging modalities for cancer patients such as prostate cases.

Materials and methods. Homogenous gel phantoms were created in different concentrations to set MRI and elastography parameters to be consistent with those found in healthy and diseased prostate tissue. Images were acquired on a 3T scanner for relaxometry and DWI studies. In-house software (MATLAB) was used to analyse the images on a pixel-by-pixel basis. Shear Wave Elastography was used to obtain speed and Young's Modulus of the phantoms.

Results. As qualitative and quantitative assessments, ultrasound and CT were used and the results were identical for each gel phantoms, confirming homogeneity in addition to slice profiles and field maps obtained from MRI. Relaxation times and diffusion coefficients of the phantoms were found as compatible with the previous studies in the literature. A good correlation was observed in agar gels on their elasticity than other phantoms.

Conclusion. Our gel phantoms were developed and evaluated for MRI diffusion and elastography imaging modalities and design to mimic tissue parameters for prostate cancer. The phantoms may also model other tissues to various degrees.

Disclosure. ZGP would like to acknowledge TUBITAK for her financial support with a Project No. 1059B141400677 and Research Fund of Çukurova University, Project No. FDK-2014-2709 during this work. SS acknowledges funding from a Royal Society Leverhulme Trust Senior Fellowship.

http://dx.doi.org/10.1016/j.ejmp.2016.07.741

NEXODOSE™, A USEFUL TOOL TO MONITOR AND OPTIMIZE CT EXPOSURES

M. Sutto [a,b], A. Maldera [a,b], P.E. Colombo [a,*], A. Torresin [a]

[a] *ASST Grande Ospedale Metropolitano Niguarda, Milano Italy*
[b] *Univerisità degli Studi di Milano, Milano Italy*
* Corresponding author.

Introduction. Radiation Dose Index Monitoring (RDIM) systems can help monitoring and optimization of CT exposure, as required by Council Directive 2013/59/Euratom.

Purpose. The purpose of this study is to present preliminary results concerning the use of a RDIM system to monitor CT exposure.

Materials and methods. We retrieve CT exposure data of 2015 (32000 exams) on NexoDose™ from PACS. For each scanner, we analyzed DLP distribution of the most frequently used protocols, encompassing 70% of all CT scans. We set alerts on exams with DLP above 95th percentile or outlier. Notifications of the first two months of 2016 were examined.

Results. In 2015, 33% of all CT scans were head scans. Head DLP is narrow distributed, and less than 3% of the values are outliers. Alert values were set to notify outliers. 30% of all CT scans were enhanced Chest-Abdomen-Pelvis scans. 10% were thorax and abdomen not-enhanced CT scans. DLP distributions for body scans were wider and long tailed. Alerts were set for DLP>95th percentile. For head scans 15 alerts were notified: 5 because the scan was repeated, 3 because one or more series were added and 7 because either mAs were increased or scan was extended. For body scans 68 alerts were notified: 75% were related to increased exposure of bigger patients, which don't need justification.

Conclusion. For head examinations DLP has found to be a good descriptor to monitor and optimize CT exposure. For body scans, high DLP values are mostly patient-size related so another descriptor has to be identified.

http://dx.doi.org/10.1016/j.ejmp.2016.07.742

Physica Medica 32 (2016) 222–250

Contents lists available at ScienceDirect

Physica Medica

journal homepage: http://www.physicamedica.com

Abstracts from the 1st European Congress of Medical Physics: Oral Papers|September 2nd, 2016

VALIDATION OF THE PERFORMANCE OF 3-D DETECTOR ARRAYS FOR RADIOTHERAPY VERIFICATIONS

Wojciech Bulski [a,*], Krzysztof Chełmiński [a], Piotr Sobotka [b]

[a] *Department of Medical Physics, The Maria Skłodowska-Curie Memorial Cancer Centre and it Institute of Oncology, Roentgen str. 5, Warsaw 02-781, Poland*

[b] *Faculty of Physics, Warsaw University of Technology, Koszykowa str. 75, Warsaw 00-662, Poland*

* Corresponding author.

Introduction. Intensity modulated radiotherapy (IMRT/VMAT) is a complex procedure requiring proper dosimetric verification. IMRT dose distributions are characterized by high degree of modulation and by steep dose gradients. The fluence measurements for individual beams or at individual angle are not sufficient for evaluation of total dose distribution and for assuring patient safety.

Purpose. A number of electronic systems which allow for a pretreatment plan verification based on reconstruction of the total dose distributions have been developed recently (Delta4, ArcCHECK, Octavius, etc.). A method of validation of such systems tested on the above listed devices is presented here.

Materials and methods. The method requires anthropomorphic phantoms and dosimetric films. In order to measure dose distributions in various cross-sections of the phantom the film dosimeters were used (Gafchromic EBT-3). The phantoms of the material and shape equivalent to the Delta4, ArcCkeck and Octavious detector arrays were developed. This film dosimetry methodology was used as a benchmark to test and validate the performance of commercially available 3-D verification systems. The gamma formalism was used for evaluation and comparison of the measured and calculated dose distributions.

Results. The results of comparisons of film measurements performed in test phantoms with dose distribution reconstructed with: Delta^4, ArcCHECK and Octavious for a group of patient plans are presented as the percentage of passing points (PPP) for $\Gamma \leqslant 1$ criterion.

Conclusion. The 3-D verification systems and their reconstruction algorithms have to be validated with independent measurements or calculations before use in clinical practice.

http://dx.doi.org/10.1016/j.ejmp.2016.07.457

APPLICATION OF FAILURE MODE AND EFFECT ANALYSIS TO THE PERFEXION GAMMA KNIFE TREATMENT

Marouf Adili [a,*], Safdar Hasan [b], Bilal Mohammed [c], Abdullaziz Alhamad [c]

[a] *Department of Medical Physics, Prince Sultan Medical Military City, Saudi Arabia*

[b] *Department of Radiotherapy Physics, Lancashire Teaching Hospitals, UK*

[c] *Department of Radiation Oncology, Prince Sultan Medical Military City, Saudi Arabia*

* Corresponding author.

Introduction. A new approach was developed by the AAPM TG-100 to address quality management in radiation therapy, based on Failure Mode and Effects Analysis (FMEA) approach.

Purpose. Apply the FMEA to establish quality management system for new installed Perfexion Gamma Knife.

Materials and methods. Each sub-processes in the treatment procedure were outlined, for which the potential failure modes were then derived together with their causes and risks. Risk Probability Number RPN was calculated using multiplication of three variables: probability of failure mode to occur, severity of effect of failure on patient and probability of failure not to be detected. To mitigate the risk, the failure modes with highest RPN were then considered to implement quality control measure.

Results. 81 failure modes were identified. In 57 cases were considered to be of low RPN value, so these failures were considered of little concern.

24 failure modes having high RPN values. 7 out of these failure modes could cause severe patient injury. These failure modes are related to delineation of GTV and organ at risk, setting the shots during planning, prescription of the treatment dose, plan selection and identifying the patient.

The proposed ways to mitigate the risk are: a peer review of the drawing contoured by a second radiation oncologist or neuroradiologist, independent plan review by second physicist, patient file availability with clear identification

Conclusion. FMEA is a unique tool helps in identifying the potential failure, weakest points in the procedure, the actual causes and develop an efficient quality management system.

Disclosure. We have nothing to disclose in relation to the presented work.

http://dx.doi.org/10.1016/j.ejmp.2016.07.458

ALTERNATIVE REGIMENS FOR TREATING PROSTATE CANCER USING EQUIVALENT UNIFORM DOSE AND MONTE CARLO METHODS

Susana Oliveira [a,b,*], Yuriy Rosmanets [c], Pedro Teles [c], Lisete Fernandes [d,e,f], Nuno Teixeira [d], Pedro Vaz [c]

[a] *NOVA Medical Sciences, New University of Lisbon, Campo Mártires da Pátria, 130, 1169-056 Lisbon, Portugal*
[b] *Mercurius Health, Rua Braamcamp, 12, 3°E, 1250-050 Lisbon, Portugal*
[c] *IST/ITN, Instituto Superior Técnico, Technical University of Lisbon, Estrada Nacional 10, 2695-006 Bobadela LRS, Portugal*
[d] *Escola Superior de Tecnologia da Saúde de Lisboa, Polytechnic Institute of Lisbon, Av. D. João II, lote 4.69.01, 1900-096 Lisbon, Portugal*
[e] *Biosystems & Integrative Sciences Institute (BiolSI), Faculty of Sciences, University of Lisbon, Lisbon, Portugal*
[f] *Gulbenkian Institute of Science, Rua da Quinta Grande, 6, 2780-156 Oeiras, Portugal*
* Corresponding author.

Introduction. Conventional radiotherapy treatments are administrated with 2 Gy external beam radiotherapy (EBRT) fractions. It has been postulated that prostate cancer would respond to radiotherapy as a slowly proliferating late-responding normal tissue, benefiting from hypofractionated regimens. Highly conformed brachytherapy is a treatment option either alone or combined with EBRT.

Purpose. To identify alternative radiotherapy regimens for treating prostate cancer using EBRT and low dose-rate brachytherapy (LDRBT) with ^{125}I implants, biologically equivalent to conventional treatments in terms of uniform equivalent dose (EUD).

Materials and methods. The EUD concept was used, together with monte carlo (MC) methods. Two voxel phantoms were segmented from the computed tomography of patients to obtain the energy deposition derived from the MC simulations of EBRT and LDRBT treatments in a voxel-by-voxel basis. The energy deposition was converted in EUD. Equivalent regimens to EUDs of 72 Gy, 80 Gy, 90 Gy, and 100 Gy were determined for increasing fractions of 1.8–5.0 Gy and amounts of LDRBT from 0 Gy (EBRT exclusive) to 145 Gy. The resulting EUD for rectum was also evaluated.

Results. Alternative schemes equivalent, in terms of EUD, were obtained. For example, it is equivalent to an EUD of 72 Gy, 38×2 Gy, 20×3 Gy or 9×5 Gy of EBRT, or 6×5 Gy of EBRT plus 50 Gy of LDRBT. The rectum benefits of higher amounts of LDRBT for EBRT fractionations <2.5 Gy and larger fractions for LDRBT dose <50 Gy.

Conclusion. Alternative regimens for the treatment of prostate cancer with EBRT and LDRBT are proposed. The rational for the use of brachytherapy becomes less relevant with the increasing therapeutic ratio achieved with hypofractionated EBRT.

Disclosure. All authors disclose any conflict of interest relationship that may bias this presentation.

http://dx.doi.org/10.1016/j.ejmp.2016.07.459

NEW QUALITY CONTROL PHANTOM FOR STEREOTACTIC BODY RADIATION THERAPY USING RADIOCHROMIC EBT3 FILM

L.T. Cunha [a,*], P. Pereira [b], A.G. Dias [a]

[a] *Instituto Português de Oncologia do Porto, Medical Physics Department, Porto, Portugal*
[b] *nstituto Português de Oncologia do Porto, Medical Physics Radiobiology and Radiation Protection Group, Porto, Portugal*
* Corresponding author.

Introduction. Stereotactic Body Radiation Therapy (SBRT) is an increasingly used technique. Due to its particular characteristics a patient specific quality control (QC) is mandatory to ensure an accurate dose delivery.

Purpose. To develop a dosimetry system consisting of a phantom for insertion of radiochromic films positioned in orthogonal directions for dose measurements.

Materials and methods. A full film characterization was performed, evaluating megavoltage radiation response, scanning symmetry, angle positioning, after radiation time dependence. Sensitometric curves were performed for a high dose range (1–40 Gy) with 6 MV photons.

A PMMA homogeneous and spherical shape phantom was developed, divided in four identical pieces allowing the positioning of the radiochromic films in an orthogonal disposal.

Several SBRT treatment plans (conformal, IMRT and VMAT) were measured for validation purpose. The comparison between the calculated and measured doses was made using the gamma index criteria (3%/3 mm) in an in-house software and compared with the results of a commercial system.

Results. Optimal conditions for film transmission scanning were obtained as well as the correction factors for high uniformity achievement.

The spherical shape of the phantom revealed to be advantageous allowing several non-coplanar irradiation angles. Due to the homogeneity of this phantom, heterogeneities problems associated to other commercial systems are not relevant.

The passing rate for the gamma index was >95% for the total points analyzed.

Conclusions. The developed phantom and the system characterization result in a suitable phantom/radiochromic system for SBRT plan dose QC. With a single irradiation, dose distribution in orthogonal planes is obtained, with the characteristic high spatial resolution of these films.

Disclosure. The authors have no relevant financial or non-financial relationships to disclose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.460

A NOVEL METHOD FOR SUB-MILLIMETRIC DETERMINATION OF LASER-RADIATION ISOCENTER COINCIDENCE BY MEANS OF A COMPUTED RADIOGRAPHY SYSTEM

M. Benito [a], A. del Castillo [b], H. Perez-Garcia [b,*], D. Miguel [b]

[a] *Hospital Provincial de Zamora, Spain*
[b] *Hospital Clínico Universitario de Valladolid, Spain*
* Corresponding author.

Introduction. A procedure has been devised to check the coincidence of room lasers with the radiation isocenter of a Linac, by performing a starshot test on a Computed Radiography System (CR).

Purpose. Currently Winston–Lutz test, or a starshot film are the gold standard. However, the accuracy of these procedures relies on the skill of the staff member performing the check to precisely position a phantom or marking the film. We propose an observer independent method for conducting this test.

Materials and methods. A Konica CR System is used. The CR plate sensitivity to visible light will be used to accurately determine the laser position. We set the plate without its cover, so light can reach the active area. The plate is irradiated with an open beam that covers all the active area, with a low dose setting, to create a homogeneous background. The starshot pattern is generated by delivering nine 6 MV photon beams, 1×40 field size. The room lasers are switched

on during a short time. We put the cover and read the cassette. The resulting image will consist of a grey background, a darker starshot pattern, and a white cross formed by the pixels reached by laser light. The image can be imported and analysed in PTW Isocheck (TM) software.

Results. With this method coincidence can be determined with an accuracy of 0.1–0.3 mm.

Conclusion. This procedure not only can be used as a substitute of Winston–Lutz test, but also enables improved accuracy.

Disclosure. No conflicts of interest to declare.

http://dx.doi.org/10.1016/j.ejmp.2016.07.461

EFFECT OF SCATTERING ANGLE ON ENERGY LOSS RADIOGRAPHY IMAGING FOR VARIOUS PROTON ENERGIES RELEVANT IN PROTON THERAPY: A SIMULATION STUDY

A. Biegun [a,*], J. Takatsu [b], T. Nakaji [b], M-J. van Goethem [a,c], E.R. van der Graaf [a], E.N. Koffeman [d], J. Visser [d], S. Brandenburg [a]

[a] *KVI-Center for Advanced Radiation Technology, University of Groningen, The Netherlands*
[b] *Department of Radiation Oncology, Graduate School of Medicine, Osaka University, Japan*
[c] *Department of Radiation Oncology, University Medical Center, University of Groningen, The Netherlands*
[d] *National Institute for Subatomic Physics (Nikhef), Amsterdam, The Netherlands*
* Corresponding author.

Introduction. The quality of cancer treatment with protons critically depends on the accurate determination of proton stopping powers (PSPs) of traversed tissues. Nowadays, proton treatment planning is based on stopping powers derived from X-ray Computed Tomography (CT) images leading to systematic uncertainties in the proton range in a patient of 3–4% and even up to 10% in regions containing bone. This may cause no dose in parts of the tumor and overdose in healthy tissues.

Purpose. In order to reduce the uncertainty in the translation of the X-ray CT image into a map of PSPs, we study proton radiography imaging as it delivers PSPs directly, without using a model.

Materials and methods. Using the Geant4 toolkit we simulate the proton radiography system with two position sensitive detectors and an energy detector. The imaged object is placed between the position detectors. The energy loss radiographs of the phantom with various, including tissue-like, materials are obtained. The multiple Coulomb scattering of a proton passing through various materials blurs the energy loss radiography image, but selecting protons travelling along almost straight paths decreases the blurring.

Results. Our simulations show that considering protons with small scattering angles increases sharpness between the material boundaries in the energy loss radiographs, and materials with small density differences are distinguished.

Conclusion. Proton radiography provides a direct information on PSPs of tissues inside the human body improving the accuracy of the calculation of the dose deposition by protons in a patient.

Disclosure. Authors have no relevant financial or nonfinancial relationships to disclose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.462

HIPPOCAMPAL SPARING WHOLE BRAIN IRRADIATION: EXPERIENCE IN OUR DEPARTMENT

P. Dorado Rodríguez [a,*], D. Planes Meseguer [a], R.D. Esposito [a], L. Fernández Fornos [b], S. Miranda Labajos [b]

[a] *Medical Physics Department, ERESA – Hospital General Universitario de Elche, Elche, Alicante, Spain*
[b] *Radiation Oncology Department, ERESA – Hospital General Universitario de Elche, Elche, Alicante, Spain*
* Corresponding author.

Introduction. Hippocampal neural stem-cell injury during whole-brain radiotherapy (WBRT) may play a role in memory decline. Hippocampal sparing whole brain radiotherapy (HS-WBRT) may delay or reduce the frequency and severity of neurocognitive decline in these patients.

Purpose. In this work we present initial data on the first 20 patients treated in our institution with HA-WBRT.

Materials and Methods. 20 patients have been treated in our institution with HS-WBRT, nine prophylactic cranial irradiation for small lung cancer and two for brain metastases, to a dose of 30 Gy (10-15 fractions). RTOG 0933 recommendations were applied for treatment planning. Magnetic resonance imaging (MRI) and computerized tomography (CT) sets were registered for each patient prior to delineation of the hippocampus. Intensity-modulated radiotherapy (IMRT) treatment plans for the Varian 2100CD linear accelerator were generated using the DMPO algorithm of Pinnacle TPS for optimizing a 12 beams solution class.

Results. The value of the maximum dose mean in the hippocampus was 15.63 Gy and the value of mean dose in the whole brain was 30.95 Gy, with a dose range of 36.4–40.2 Gy. The maximum dose to optic nerves and chiasma did not exceed 37.5 Gy. Mean number of segments and monitor units was 100 and 994 respectively. Conformation index mean value was 0.85.

Conclusion. The results obtained in this series of patients of our institution with HS-WBRT are comparable with the published series, fulfilling the recommendations of the RTOG 0933.

Disclosure. Authors disclose any relationship that may bias this work.

http://dx.doi.org/10.1016/j.ejmp.2016.07.463

DEFINITION OF A THRESHOLD FOR PLAN ADAPTATION IN PARTICLE THERAPY

Z. Asim [a,b,*], W. Chen [c], P. Ferreira [b,d], P. Naumann [a], V. Batista [a]

[a] *University Clinic of Heidelberg, Germany*
[b] *Lisbon School of Health Technology, Lisbon, Portugal*
[c] *Heidelberg Ion-Beam Therapy Center (HIT), Heidelberg, Germany*
[d] *Champalimaud Center for the Unknown-Champalimaud Foundation, Lisbon, Portugal*
* Corresponding author.

Introduction. Charged particle beam therapy has been used for its twofold advantageous behavior: offering high precision to the target volume and minimum doses to organs at risk. Treatment outcome of pancreatic patients is compromised by dose limits of the GI tract and dose escalation is critical due to inter-fractional uncertainties.

Purpose. The aim was to assess tissue variations by the accumulated water equivalent path-length variation (Δ-accWEPL) and find a dosimetric threshold point where corrective action should be taken

i.e. re-optimization of the plan, with less computational work and time consumption.

Materials and methods. Two types of analysis were performed by comparing planning-CT and rigidly-registered weekly-CTs for 11 patients: (A) Dose Forward calculation performed using research TPS TRiP98, from the treatment plan clinically applied to the patients. The dose evaluation parameters were V95%PTV, V95%CTV and Gamma-index criteria. (B) WEPL maps were generated using the MeVisLab framework to quantify densities variation as a percentage of voxels, within our defined threshold (±3 mm), of the Δ-accWEPL.

Results. Both Gamma-index and V95%PTV showed tendency to increase or decrease with Δ-accWEPL by strong correlation of 0.73 and 0.6, respectively. A threshold of Δ-accWEPL as 56% interprets more than 3% variations in V95%PTV and gamma passing rate lower than 96.5%. OAR analysis showed high dose impact on large intestine V20, up to 20% increased dose.

Conclusion. The studied method proved to be a prediction tool for physicians in decision making for plan re-optimization need due to inter-fractional density variation, with less computational time and without contouring structures.

Acknowledgment. This work was funded by DFG within KFO 214 and partially supported by BMBF SPARTA (grant agreement number 01lB13001G) Julia Bauer, Wenjing Chen. We would also like to thank the clinical and medical physics team at HIT.

Disclosure. No disclosure.

http://dx.doi.org/10.1016/j.ejmp.2016.07.464

IMPACT OF ITERATIVE METAL ARTIFACT REDUCTION ON DOSE CALCULATION ACCURACY – PHANTOM STUDY

Manuel Maerz [a,*], Anna Morenz [a], Korbinian Puerckhauer [a], Oliver Koelbl [a], Michael Behr [b], Fabian Pohl [a], Barbara Dobler [a]

[a] *Department of Radiation Therapy, University Medical Center Regensburg, Germany*
[b] *Department of Prosthetic Dentistry, University Medical Center Regensburg, Germany*
* Corresponding author.

Introduction. Dose calculation in radiation therapy is based on computed tomography (CT) data. Dental materials cause streaking artifacts that lower image quality and affect dose calculation accuracy.

Purpose. The study investigates the impact of the iterative metal artifact reduction algorithm (iMAR, Siemens Healthcare GmbH) on image quality and dose calculation accuracy depending on different dental materials such as metal alloys and oxide ceramics.

Materials and Methods. A phantom simulating the mouth region composed of different tissue equivalent materials was used. The phantom was equipped with different numbers of cylinders made of non-precious-alloys (CoCr and titanium) and zirconia. CT data were acquired and corrected using two sets of correction parameters. Image quality was determined by comparison to synthetically generated CT data. IMRT and VMAT plans were calculated on each CT dataset using the dose calculation algorithms XVMC (Monaco), Collapsed Cone and Pencil Beam (Oncentra) and compared to 2D dose measurements using Gafchromic films. Dose calculation accuracy was determined using the gamma method.

Results. Image quality could be improved significantly. Absolute deviation of Hounsfield units compared to synthetic CT data decreased from 190 to 84 for standard correction parameters and to 66 for optimized parameters with a dependency on the used dental materials and number of inserts. Dose calculation accuracy improved significantly from a passing rate of 95% for plans calculated on uncorrected to 97% for plans calculated on corrected or synthetic CT data. Accuracy depends on the dental material used. For the phantoms with the largest average Hounsfield units deviations (CoCr, zirconia) the passing rates increase from 91% to 97% on corrected and 96% on synthetic CT data.

Conclusion. Image quality and dose calculation accuracy could be significantly improved when iMAR was used for correction of CT data.

Disclosure. The Authors state that there is no conflict of interest. The work was supported by the Wilhelm Sander Foundation.

http://dx.doi.org/10.1016/j.ejmp.2016.07.465

DOSIMETRIC CHARACTERIZATION OF LINAC SMALL BEAMS USING A PLASTIC SCINTILLATOR DETECTOR: A MULTICENTER STUDY

M. Pasquino [a], M. Stasi [a], P. Mancosu [b], S. Russo [c,*], E. Villaggi [d], C. Gasperi [e], M,. Casale [f], G. Loi [g], L. Strigari [h], R. Miceli [i], G.H. Raza [j], D. Fedele [k], A. Vaiano [l], M.D. Falco [m], E. Moretti [n], F.R. Giglioli [o], R. Nigro [p], C. Talamonti [q], G. Pastore [r], S. Luxardo [s], E. Menghi [t], G. Benecchi [u], S. Clemente [v], C. Marino [w], G. Borzi [x], B. Nardiello [y], V. Ardu [z], L. Paladini [aa], E. Cagni [ab], G. Russo [ac], L. Spiazzi [ad], F. Vittorini [ae]

[a] *Medical Physics Department, AO Mauriziano, Torino, Italy*
[b] *Radiotherapy Department Humanitas, Milano, Italy*
[c] *Medical Physics Department Azienda Sanitaria di Firenze, Firenze, Italy*
[d] *Medical Physics Department AUSL Piacenza, Piacenza, Italy*
[e] *Medical Physics Department USL8 Arezzo, Arezzo, Italy*
[f] *Radiotherapy Department AO Santa Maria, Terni, Italy*
[g] *Medical Physics Department AOU Maggiore della Carita, Novara, Italy*
[h] *IFO, Roma, Italy*
[i] *Medical Physics Department AOU Tor Vergata, Roma, Italy*
[j] *Medical Physics Department Ospedale San Pietro Fatebenefratelli, Roma, Italy*
[k] *Casa di cura S. Rossore, Pisa, Italy*
[l] *Medical Physics Department USL 3, Pistoia*
[m] *Radiotherapy Department Policlinico SS. Annunziata, Chieti, Italy*
[n] *Medical Physics Department AOU Santa Maria della Misericordia, Udine, Italy*
[o] *Medical Physics Department AOU Città della Salute e della Scienza, Torino, Italy*
[p] *Radiotherapy Department O.G.P. S. Camillo de Lellis, Rieti, Italy*
[q] *Medical Physics Department AUO Careggi, Firenze, Italy*
[r] *Radiotherapy Department Ecomedica, Empolli, Italy*
[s] *Medical Physics Department ASL 1, Carrara, Italy*
[t] *Medical Physics Department I.R.S.T., Meldola, Italy*
[u] *Medical Physics Department AO Parma, Parma, Italy*
[v] *Medical Physics Department IRCCS CROB, Rionero in Vulture, Italy*
[w] *Medical Physics Department Humanitas, Catania, Italy*
[x] *Radiotherapy Department Centro REM Radioterapia, Catania, Italy*
[y] *UPMC Ospedale San Pietro Fatebenefratelli, Roma, Italy*
[z] *Radiotherapy Department Policlinico San Donato, San Donato Milanese, Italy*
[aa] *Medical Physics Department USL Lucca, Lucca, Italy*
[ab] *Medical Physics Department Arcispedale S. Maria Nuova, Reggio Emilia, Italy*
[ac] *Malzoni Radiosurgery Center, Agropoli, Italy*
[ad] *Medical Physics Department Spedali Civili, Brescia, Italy*
[ae] *Medical Physics Department ASL 1 Abruzzo, L'Aquila, Italy*
* Corresponding author.

Purpose. In modern radiation therapy accurate dosimetry within small photon fields is a challenge. This study presents a multicenter characterization of MLC-defined small field for the two major linear accelerator manufacturers.

Materials and methods. The project enrolled 31 Italian centers, 15 equipped with Elekta Linacs and 16 equipped with Varian Linacs.

Each center performed TPR, in-plane and cross-plane dose profile of $0.8 \times 0.8\ cm^2$ field and OFs measurements for field sizes ranging from 0.6×0.6 to $10 \times 10\ cm^2$. Set-up conditions were 10 cm depth in water phantom at SSD 90 cm. Measurements were performed using two Exradin W1 plastic scintillator detectors correcting for the Cerenkov effect as proposed by the manufacturer.

Results. Analysis of the measurements performed by 12 Varian and 13 Elekta centers was performed. TPR measurements showed standard deviations within 0.6%; penumbra values of dose profiles showed standard deviations within 0.5 mm. FWHM measurements showed a greater variability. OF measurements showed standard deviations within 1.5% for field size greater than $2 \times 2\ cm^2$; for field size less than $2 \times 2\ cm^2$ measurements' variability increases with decreasing field size. OF values show no dependence from the effective field size.

Conclusions. Relatively high degree of consistency regarding TPR and penumbra values was registered. FWHM and OF instead show greater variability. Our work confirmed the importance of multicenter dosimetric studies and W1 PSD as a candidate for small field clinical radiation dosimetry in advanced radiation therapy techniques.

http://dx.doi.org/10.1016/j.ejmp.2016.07.466

COMPARISON OF CO-60 AND IR-192 IN CT-BASED BRACHYTHERAPY TREATMENT PLANNING FOR GYNECOLOGICAL CANCERS

Kowalik Lukasz

Subcarpatian Cancer Center, Mlochow, Poland

Purpose. Brachytherapy for gynecological cancers is most frequently used on the world. Physical differences between two sources Co-60 and Ir-192 are known but necessary is compared both sources in treatment planning system.

Material and methods. For group 60 patients from Brachytherapy Department of the Subcarpathian Oncological Center which were treat for cervical stamp and cervical carcinoma. For both localization 30 plans were selected and treatment plans were made using Ir-192 and Co-60 sources. In system planning system (Oncentra Brachy, Elekta) were entered target and organs at risk (OARs): rectum, bladder, urethra, and pelvic bones. For cervical stamp cancer cylindrical applicator was used, and for cervical carcinoma Fletcher applicator. To comparison selected in target isodoses 100%, 120%, 150%, 200% and 90% for OARs: isodose 100% and dose in 2ccm, for pelvic bones dose in 0,1ccm. In cervical carcinoma doses in ICRU points (AL, AR) were compared. The results were subjected to statistical significance p comparative factor.

Results. Statistical analysis of the results showed a statistically significant differences for target in cervical stamp for the cover isodose 200%, $p = 0.04$ and $p = 0.05$ for cervical cancer. For both locations, there was no statistically significant differences in doses in OARs. For ICRU points (AL, AR) there was no statistically significant differences. Obtained for them AL: Co-60 70,12 ± 12,97 Ir-192 70,87 ± 8,48 p = 0,40, AR: Co-60 83,04 ± 26,88, and for Ir −192 82,87 ± 23,49 p = 0,49. All the results are shown in tables (Tables 1–4).

Conclusion. The use of two radiation sources is fully justified in cervical stamp and cervical carcinoma cancer. Statistical analysis of the results found no statistically significant differences for significant value to be taken into account during the planning and evaluation of the treatment plan leading to radiation exposure of the patient. Statistically significant differences were found for targets in both locations for 200% isodose. Doses were smaller for Ir-192 source. These differences were respectively about 1,5% for cervical stamp, and about 2% for cervical cancer. These differences combined with the lack of differences in the other doses is in favor of Co-60 because of increasing the dose into the tumor. Comparable doses are equal for both radiation sources so we know that both sources of radiation can be used in brachytherapy in gynecological cancers.

Table 1
Statistic for PTV in cervical stamp cancer.

	100%		120%		150%		200%		90%	
	Avg	Sd	Avg	Sd	Avg	sd	Avg	sd	Avg	sd
Co 60	92,33	3,16	75,35	4,44	55,69	4,11	36,64	3,39	97,98	1,75
Ir 192	92,54	3,28	74,71	4,69	54,41	4,44	35,03	3,55	98,26	1,82
p	0,40		0,29		0,13		0,04		0,27	

Table 2
Statistic for OARs in cervical stamp cancer.

	Bladder				Bones				Urethra	
	100%		2 ccm		0,1 ccm		2 ccm		2 ccm	
	Avg	Sd	Avg	Sd	Avg	Sd	Avg	Sd	Avg	Sd
Co 60	0,02	0,08	57,62	12,39	27,19	9,26	21,51	7,63	32,68	16,25
Ir 192	0,02	0,07	58,61	13,35	27,93	9,78	23,94	11,85	33,89	16,55
p	0,47		0,38		0,38		0,17		0,39	

	Rectum			
	100%		2 ccm	
	Avg	Sd	Avg	Sd
Co 60	0,11	0,14	70,84	8,42
Ir 192	0,13	0,17	72,34	8,57
p	0,32		0,25	

Table 3
Statistic for PTV in cervical carcinoma cancer.

	100%		120%		150%		200%		90%	
	Avg	Sd	Avg	Sd	Avg	sd	Avg	sd	Avg	sd
Co 60	91,79	2,91	77,04	7,28	58,07	7,39	37,63	5,83	95,07	4,38
Ir 192	91,15	4,06	78,06	4,83	58,70	4,23	37,60	2,95	95,83	3,10
P	0,24		0,26		0,34		0,49		0,22	

Table 4
Statistic for OARs in cervical carcinoma cancer.

	Bladder				Bones				Urethra		Rectum			
	100%		2 ccm		0,1 ccm		2 ccm		2 ccm		2 ccm		100%	
	Avg	Sd	Avg	Sd	Avg	sd	Avg	sd	Avg	sd	Avg	sd	Avg	sd
Co 60	0,13	0,14	80,82	3,67	48,39	11,41	37,92	8,87	47,54	26,62	70,16	6,48	0,07	0,16
Ir 192	0,12	0,15	81,43	4,50	48,25	12,08	39,32	10,95	47,10	27,04	70,03	7,75	0,11	0,19
p	0,46		0,28		0,48		0,30		0,47		0,47		0,20	

http://dx.doi.org/10.1016/j.ejmp.2016.07.467

BRACHYTHERAPY TREATMENT PLANNING FOR PROSTATE CANCER WITH THE USE OF THE COMPUTED TOMOGRAPHY-BASED (CT-BASED) PLANNING SOFTWARE IN PATIENTS AFTER TOTAL PRIMARY AMPUTATION OF THE RECTUM AND EBRT (EXTERNAL BEAM RADIATION THERAPY) DUE TO RECTAL CANCER

Ł. Kowalik *, J. Łyczek, D. Kazalski, M. Sawicki, Jeżewski

Department of Brachytherapy, Podkarpacki Oncology Centre in Brzozow, Poland
* Corresponding author.

Materials . In the group of 6 patients, who have initially been treated with radical surgery by Miles method because of rectal cancer followed by EBRT and who were afterwards diagnosed with locally advanced prostate cancer, the brachytherapy for prostate cancer has been performed.

Methods. The fractionated interstitial brachytherapy was applied in the regimen: 3 times a 12 Gy in an interval of 21 days. Computed tomography (CT) has been used to localize the prostate, applicators and for acquisition to the planning system. Due to mobility of the prostate depending on the position of the body, patients were positioned on the side and individually adjusted for each application. The spinal anesthesia was delivered. Initial, pre-implantation CT allowed to locate the prostate, bladder and bone structures. CT scans were repeated after insertion of the next 3 needles for accuracy reasons. After the placement of applicators, final CT scanning was performed for the implementation to the treatment planning system Oncentra MasterPlan Brachy 4.1

Results. HDR Brachytherapy treatment planning for prostate cancer with the use of CT-based planning software allowed to cover the prostate with the V100% isodose in the range of 87–98% (median 91%). Urethra hasn‘t been visible sufficiently in 2 first cases. After the use of iodinated contrast to fill-up the Foley catheter balloon in other four cases the course of the urethra was defined without doubts. The visibility of the bladder walls was in all cases poor due to Foley catheter insertion and the lack of urine in the bladder.

Conclusions. HDR Brachytherapy treatment planning for prostate cancer with the use of CT-based planning software Oncentra Brachy 4.1 allows to treat selected patients without rectal access. Planning optimization allows to meet ICRU criteria. The use of CT-based HDR brachytherapy planning system should be recommended for patients with locally advanced prostate cancer and the lack of rectum due to earlier operations as the method sufficient in its accuracy and relatively not expensive.

http://dx.doi.org/10.1016/j.ejmp.2016.07.468

INDIVIDUAL APPLICATOR FOR BRACHYTHERAPY FOR VARIOUS SITES OF SUPERFICIAL MALIGNANT LESIONS

Ł. Kowalik *, J. Łyczek, M. Sawicki, D. Kazalski

Department of Brachytherapy, Podkarpacki Oncology Centre in Brzozow, Poland
* Corresponding author.

This paper discusses brachytherapy treatment and individual applicators suitable for difficult to reach locations of superficial malignant lesions. Technique for manufacturing an individual applicator and clinical examples of its use for various locations of cancer are presented.

Several types of brachytherapy applicators are suitable for superficial malignant skin lesions depending on their size and depth. Small skin changes (up to 3 cm) and superficial cancer (to 0.5 cm) are usually treated via Leipzig or Valencia Skin applicators [1]. Freiburg Flap Applicator or HAM are commonly used for extensive skin lesions on uncovered body parts with infiltration depth less than 1 cm [2]. However, skin as well as mucosal cancers located in difficult to reach areas and lesions with irregularly shaped surface require special applicators prepared individually for each patient [3].

Technique of manufacturing an individual applicator

The target volume with adequate margins was defined by a radiation oncologist based on physical examinations and histopathological assessment of tissue. Also, brachytherapy specialists paid special attention to organs at risk (OARs), which should be protected from ionizing radiation. The surface mold was made by a physicist, who assessed its range, size, and fixation methods if possible for a given location e.g.: nose, ear, and fingers. Before we decided about the shape of the applicator and manufacturing techniques it was necessary to select an organ or anatomical site stable and unchangeable during the whole process of treatment (nose, lip, outer ear). Patient's skin was cleaned and dried. Then alginate impression material (KROMOPAN 100) was prepared according to the manufacturer's instructions and placed on patient's skin. It should be taken into account that the material changes its colour during the process of polymerisation. In order to obtain the best possible impression of patient's shape the paste consistency should be adjusted individually.

Setting time was approximately 2 min. Then it's thickness was assessed whether it was sufficient i.e. minimum thickness between 1 and 2 cm. If possible, another layer of alginate material was added using the same technique. Next the impression was removed from patient's skin and the specialist evaluated the accuracy of patient's shape reconstruction [4].

The impression was later used for a gypsum cast of the patient. The cast should be positioned properly in order to reflect all natural curves of the body. Gypsum material is also prepared according to the manufacturer's instructions. The first layer shouldn't be too thick otherwise small cavities in the impression might not be filled with gypsum. Then another layer is poured over the cast. This step should be performed carefully because the cast must be placed in a special holder. As the cast hardens into a rigid form the alginate impression can be removed gently. Corrections of small deficiencies of the cast are allowed. Usually gypsum solidifies completely within 24 h. This period may be shortened if the cast is stored in an air-conditioned room. The final step is the preparation of a surface applicator from skin safe silicone mass.

The process of manufacturing the applicator included the following phases:

- Lead plates were placed on the gypsum cast in order to protect

organs at risk (eyeball, mucosa, etc). The thickness of these plates should be selected in accordance to the radioactive source used for brachytherapy i.e. 6 mm for (192)Ir and 10 mm for (60) Co [5]. Lead plates must be removable. They shouldn't be present during CT scans if we want to limit the number of artifacts in CT images. The plates must be replaced before the first fraction of brachytherapy.

- A layer of silicone was placed on the gypsum cast – it's thickness directly above the planning target volume (PTV) was approximately 5 mm. In the remaining area it was more than 5 mm and more than 10 mm in the area where the applicator would be fixed/stabilised.

- When the surface of the applicator was dry OncoSmart ProGuide Needles were inserted above the PTV. The needles were parallel to each other and the distance between adjacent needles ranged from 3 to 7 mm. The needles covered the whole target volume defined by the radiation oncologist.[6]

- The applicators were covered with another layer of silicone and the remaining parts of the mask were also filled with this material in order to improve its durability. The mask is usually used from 8 to 10 days of treatment.[7]

So prepared mask should be left to dry completely, which may take even 24 h. This period can be shortened by leaving the mask in an air-conditioned room. Than the mask should be carefully removed from the gypsum cast. The specialist should verify if the mask is correctly prepared.

Fiducial markers were placed on the borders of the lesion in order to facilitate the process of defining the planning target volume on CT images. We selected markers carefully because we wanted to avoid any changes in mask positioning. There is another solution used in difficult to reach sites i.e. cutting the inner layer of silicone and inserting the marker inside this cut. However, these cuts may need an additional thin layer of silicone to close them.

Than the mask was placed on the patient and fixed additionally with elastic dressings like Codofix or special Velcro tape for tracheal tubes or oxygen cannulas e.g. Posey foam trach tie. Markers for CT/MRI examinations provided by the manufacturer of OncoSmart ProGuide Needles were placed in the needles. CT scout view allowed to define the range of CT scan and assess adhesion of the mask. CT images were sent to the treatment planning system TPS (Oncentra) and the treatment plan was prepared. It was impossible to define any shape and size of protective plates in our TPS therefore dose values for organs at risks were smaller in reality and differences corresponded to plates' thickness and the material they were made of.

Protective plates should be repositioned on the mask before the first fraction of brachytherapy. They shouldn't affect the shape of the mask on the side of patient's skin.

In order to have full control over the dose delivered to the planning target volume as well as organs at risk, especially when the eyeball is in a close proximity, in vivo dosimetry should be performed during the first fraction at least. [8] MOSFET detectors may be used for this purpose. Micro-MOSFET detectors are very useful for small (approximately 1 mm^2) and difficult to reach surfaces.

Examples presenting the use of individual applicators for HDR brachytherapy:

Fig 1. A patient with multifocal head and neck cancer.
Fig 2. Silicone impressions for a patient with multifocal head and neck cancer.
Fig 3. A patient with multifocal head and neck cancer - CT images and reconstructions in different planes (A,B,C) and a 3D reconstruction (D).
Fig 4. A patient with submandibular cancer.
Fig 5. A patient with submandibular cancer - CT images and reconstructions in different planes (A,B,C) and a 3D reconstruction(D).
Fig 6. A patient with locally advanced squamous cell carcinoma of the nose.
Fig 7. A patient with locally advanced squamous cell carcinoma of the nose - CT images and reconstructions in different planes (A, B, C) and a 3D reconstruction(D).

References

1. Guix B, Finestres F, Tello J, et al.. Treatment of skin carcinomas of the face by high-dose-rate brachytherapy and custom-made surface molds. *Int J Radiat Oncol Biol Phys* 2000;**47**(1):95–102.
2. Aplicator Guide, Applicators and Accessories for HDR & PDR Brachytherapy, Nucletron BV; 2011.
3. Mazeron J, Ardiet J, Haie-Méder C. GEC-ESTRO recommendations for brachytherapy for head and neck squamous cell carcinomas. *Radiother Oncol* 2009;**91**:150–6.
4. Matys R, Kubicka-Mendak I, Łyczek J. Pictorial essay penile cancer brachytherapy HDR mould technique used at the Holycross Cancer Center. *J Contemp Brachyther* 2011;**3**(4):224–9.
5. Baltas Krieger, Zamboglou. *The physics of modern brachytherapy for oncology*. IOP Publishing.; 2006.
6. Musmacher J, Ghaly M, Satchwill K. High dose rate brachytherapy with surface applicators: treatment for nonmelanomatous skin cancer. Journal of Clinical oncology, 2006 ASCO annual meeting proceedings Part I. vol 24, No. 18S (June 20 Supplement); 2006. p. 15543.
7. Owczarek G, Białas B, Smolska B, et al.. Our experience of mold brachytherapy technique for basal cell carcinoma of the face. *J Contemp Brachyther* 2009;**1**(3):188–9.
8. Sabbas AM, Kulidzhanov FG, Presser J, et al.. HDR brachytherapy with surface applicators: technical considerations and dosimetry. *Technol Cancer Res Treat* 2004;**3**(3):259–67.. Jun.
http://dx.doi.org/10.1016/j.ejmp.2016.07.469

TPSDOSE43: A NEW TG-43 BASED DOSE CALCULATION CODE FOR BRACHYTHERAPY

G. Yegin *, S. Sariaydin

Celal Bayar University, Faculty of Science and Letters, Physics Dept., Manisa, Turkey
* Corresponding author.

Introduction. TG-43 formalism is a brachytherapy dose calculation method recommended by AAPM in1995.

Purpose. To develop and make available a TG-43 based dose calculation code for testing or validating dose distributions from other brachytherapy dose calculation engines such as model based dose calculation algorithms (MBDCA).

Materials and methods. TPSDose43 can be used to produce 3d dose distributions around brachytherapy sources by using TG-43 formalism. A user is allowed to provide new TG-43 data sets for any source/seed model. It is optional to use either 1d or 2d formalism. In a geometry, multiple sources can be placed at different locations or else one source can move among different dwell points as it does in the routine treatment planning systems. In 2d dose calculations, the orientation of a source can be taken into account. The code was written in C++.

Results. Dose outputs from TPSDose43 were compared against a well-known Monte Carlo code BrachyDose in certain scenarios where the environment medium is water. Both results were in a very good agreement.

Conclusion. From our test results we concluded that TPSDose43 is fast, flexible and a simple to use brachytherapy dose calculation program. Also, it is a good candidate of a dose comparison tool for MBDCAs.

Disclosure. This study is partly supported by The Scientific and Technological Research Council of Turkey (TUBITAK) under project number: 213E028.

http://dx.doi.org/10.1016/j.ejmp.2016.07.470

DOCUMENTATION OF A NEW INTRACAVITARY APPLICATOR FOR TRANSRECTAL HYPERTHERMIA FOR PROSTATE CANCER CASES

A. Nikolakopoulou [a,*], C. Armpilia [a], C. Antypas [a], E. Karanasiou [c], R. Avgousti [a], E. Apostolou [a], N. Uzunoglou [c], I. Gogalis [a], V. Kouloulias [b]

[a] *1st Radiology Dept, Medical Physics Unit, Medical School, National and Kapodistrian University of Athens, Greece*
[b] *2nd Radiology Dept, Radiotherapy Unit, Medical School, National and Kapodistrian University of Athens, Greece*
[c] *Microwave laboratory, Electrical Engineering and Computer Science, National Technical University of Athens, Greece*
* Corresponding author.

Introduction. A new intracavitary microwave hyperthermia applicator specially designed for heating prostate through the rectal is designed. The aim of this study is to document the new antenna operating at 433 MHz, as well as to assess the SAR distributions in terms of thermometry in a soft tissue phantom.

Materials and methods. The microwave applicator consists of a dipole-type l/2, a reflector and a cooling liquid. To evaluate the SAR distribution the applicator was inserted into the gel-phantom box that mimics the dielectric properties of the normal tissue. The applicator is connected to the power unit to generate the electromagnetic field, which propagates across the antenna. The temperature distribution is detected with a calibrated thermometer, which is implanted into specific locations of the phantom.

Results. The maximum value of the SAR is found on the surface's central area of the antenna, located into the phantom box. The penetration depth of microwaves, defined as the depth at which the rate of SAR is the half of the maximum rate measured at the surface of the antenna, was calculated to be 3 cm. Our measurements confirm the role of the reflector to direct the microwaves towards in a certain area in contrast to other treatment devices which direct SAR distribution symmetrically.

Conclusion. The 2-D SAR characteristics of a new designed applicator were investigated. Our experimental measurements showed that it can be used effectively as a treatment device for prostate cancer demonstrating a clear advantage of other similar devices.

http://dx.doi.org/10.1016/j.ejmp.2016.07.471

IMPACT OF MR GEOMETRIC DISTORTION ON BRACHYTHERAPY IN CERVICAL CANCER

Tarraf Torfeh, Rabih Hammoud *, Ana Vasic, Satheesh Paloor, Suparna Chandramouli, Souha Aouadi, Primoz Petric, Noora Al-Hammadi

Department of Radiation Oncology, National Center for Cancer Care & Research (NCCCR), Hamad Medical Corporation, Doha, Qatar
* Corresponding author.

Introduction. Volumetric imaging and in particular magnetic resonance (MR) has replaced the 2D imaging for brachytherapy treatment planning. However it is recognized that MR images suffer from geometric distortions which can have an impact on target and OARs DVH parameters due to high dose gradient in brachytherapy applications.

Objective. To assess the potential dosimetric impact of MR geometric distortion on the brachytherapy treatment planning for cervical cancer.

Materials and methods. MR dataset for 15 cervical cancer patients were acquired based on GEC ESTRO recommendations. Structures were delineated on the paraaxial images and treatment plans were generated using Oncentra™ TPS. In-house software was developed to calculate the deformable registration between CT and MR images of a control point based phantom and to derive a distortion map of the MR system. Geometrically corrected images were then generated by applying the inverse of the distortion map. Structures were copied and adapted to the corrected datasets and the treatment plans recomputed. Dose Volume Histograms (DVH) were evaluated for High Risk CTV (HRCTV), bladder, rectum, and sigmoid.

Results. Mean geometric distortions were less than 0.5 mm over a Field Of View (FOV) of 350 mm. Differences in D100 and D90 were less than 2% for HRCTV. Differences in D2cc were less than 4% for bladder, rectum, and sigmoid. Preliminary results showed that, for all organs, less than 4% of deviation was observed for D100 and D90.

Conclusions. For an FOV of 350 mm, MR geometric distortion has no significant dosimetric impact on DVH parameters in brachytherapy for cervical cancer.

Disclosure. Authors have nothing to disclose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.472

IN VIVO MEASUREMENTS FOR BIOKINETIC AND MONTE CARLO SIMULATIONS OF ABSORBED DOSE IN PAEDIATRIC PATIENTS USING RADIOPHARMACEUTICALS

J. Costa [a,*], P.Teles [a], R. Parafita [b], A. Canudo [b], D.C. Costa [b], P. Vaz [a]

[a] *Grupo de Proteção e Segurança Radiológica, Centro de Ciências e Tecnologias Nucleares (C2TN), CTN/IST, Polo de Loures. Bobadela, Portugal*
[b] *Medicina Nuclear/Radiofarmacologia – Champalimaud Centre for the Unknown, Fundação Champalimaud, Lisboa, Portugal*
* Corresponding author.

Introduction. The use of radiopharmaceuticals implies calculation of absorbed doses according to MIRD methodology. However, particularly in children, other parameters are thought to be important and determinant for dose calculations. Amongst these are the pharmacokinetics characteristics of each radiotracer and their relationship with organ physiology and pathology, and the patients' anatomical characteristics. Therefore, there is a need to improve dosimetric calculations based on other algorithms taking into account those variables.

Purpose. Improve ^{99m}Tc-DMSA and ^{99m}Tc-MAG3 calculated absorbed doses in children after intravenous administration for diagnostic purposes. Gamma camera and *in vivo* measurements were used to assess the biokinetic data. The specific absorbed fraction (SAF) values are estimated via Monte Carlo simulations and scaled VOXEL phantoms.

Materials and methods. *In vivo* measurements were mathematically analysed in order to obtain a value for the activity as function of time. The simulations were performed using MCNPX and two paediatric VOXEL phantoms (BABY and CHILD) which were scaled to fit several anatomical parameters, such as body weight, height and kidney mass, amongst others.

The biokinetic curves were compared with reference data. Multiple SAF values were obtained to determine absorbed doses in these children.

Results. Deviations from the reference values were found, mainly related to children specific pathology. Furthermore we found SAF values to be strongly dependent on body and organ mass, kidney dimensions and velocity of excretion amongst other anatomical and physiological parameters.

Conclusion. The data strongly suggests that other parameters rather than age and body weight are paramount in calculating absorbed doses in paediatric populations.

http://dx.doi.org/10.1016/j.ejmp.2016.07.473

A MULTICENTER PHANTOM STUDY ON NOISE STRUCTURE IN [F-18] FDG-PET IMAGING

Roberta Matheoud [a], Michela Lecchi [b], Domenico Lizio [a], Babatunde Isiaka [a], Camilla Scabbio [b], Luca Vigna [a,*], Carlo Rodella [c], Luca Indovina [d], Marco Brambilla [a], Orazio Zoccarato [e]

[a] *Departments of Medical Physics, University Hospital, Novara, Italy*
[b] *Department of Health Sciences, University of Milan and Nuclear Medicine Unit, San Paolo Hospital, Milan, Italy*
[c] *Health Physics Unit, Spedali Civili Hospital, Brescia, Italy*
[d] *Department of Medical Physics, Polyclinic Agostino Gemelli, Rome, Italy*
[e] *Unit of Nuclear Medicine S. Maugeri Foundation, IRCCS, Veruno, Italy*
* Corresponding author.

Introduction. Point-spread-function (PSF) modelling seem to be very attractive to obtain superior image quality in [F-18] FDG oncological studies, nonetheless it is known to significantly increase noise variability.

Purpose. To evaluate the impact of PSF/TF on noise structure of iterative reconstructed (IR) images.

Materials and methods. An anthropomorphic phantom with [F-18] FDG clinical concentrations was acquired on Biograph-mCT (Siemens) and Discovery690 (General Electric) PET/CT scanners. Overall, 96 datasets were obtained by varying reconstruction modalities (RM = IR, TF, PSF, TF+PSF), frame (128,256), equivalent iterations number (IT = 63,270), and Gaussian filter (GF = 2, 4, 6 mm).

To limit noise correlation in PET imaging, 6 groups of concentric ROIs (r = 8;10;13;16;19 mm) were drawn on 3 slices at liver level. Fixing slice and ROI size, the signal variation was defined: SV% = 100∗SD/M, were SD,M are standard deviation, mean among the mean count values found for the ROIs, respectively.

Results. SV decreases with ROI size and GF, and increases with IT. Moreover, SV depends on RM, but in different ways on the two PET scanners.

For Biograph-mCT, highest and lowest SV were observed for PSF and TF and for GF = 2, 4, 6 mm mean(range) values were: 7.8% (5.1–10.6), 5.7%(3.1–8.5), 4.5%(2.5–6.7) and 4.5%(2.7–6.4), 3.8% (2.4–5.4), 3.2(2.2–4.5), respectively.

For Discovery690, highest and lowest SV were observed for PSF +TF and IR and for GF = 2, 4, 6 mm the mean(range) values were: 8.3%(6.8–10.5), 8.1%(6.7–10.2), 7.9%(6.6–9.7) and 5.1%(3.5–8.2), 4.5%(3.1–7.0), 4.2%(3.2–6.2), respectively.

Same trends are observed for the range of SV values.

Conclusions. The PET scanners of this study showed different behaviors of SV in relation to RM. Increased SV could lead to degradation of precision in quantitative oncological studies with [F-18] FDG for monitoring treatment response.

http://dx.doi.org/10.1016/j.ejmp.2016.07.474

EXTREMITY DOSES ASSESSMENT OF NUCLEAR MEDICINE STAFF INVOLVED IN ^{99M}TC-RADIOPHARMACEUTICALS PREPARATION: A MULTICENTRE STUDY

O. Zoccarato [a], R. Matheoud [b], D. Zanni [c], L. Vigna [b], R. Campini [a], S. De Crescenzo [c], F. Rottoli [c,*], M. Brambilla [b]

[a] *Strutture Complessa di Medicina Nucleare IRCCS FSM IS Veruno, Novara, (IT), United States*
[b] *Strutture Complessa di Fisica Sanitaria AO Novara, Novara, (IT), United States*
[c] *Strutture Complessa di Fisica Sanitaria ASST GOM Niguarda, Milano, (IT), United States*
* Corresponding author.

Introduction. the skin of the hands of the nuclear medicine's staff involved in preparation and manipulation of unsealed radiopharmaceuticals is the organ at highest risk for irradiation. The dose limit, to be applied to the average of 1 cm^2 of skin regardless the surface of the exposed area, is of difficult assessment. The ORAMED project identified the tip of the index of the non-dominant hand as the point of maximum exposure. Due to the high estimated proportion of workers liable to exceed the extremities annual dose limit (15–20%), the fingers dose monitoring is highly recommended especially in busy labs.

Purpose. To evaluate under routine operating conditions, in 3 nuclear medicine departments, the irradiation dose to the extremities of workers involved in the preparation of ^{99m}Tc-radiopharmaceuticals.

Materials and methods. Two operators for each centre were monitored by using 4 TLD (LiF: Mg, Cu, P) for 2 weeks. For each single task the operational time and the manipulated activities were recorded.

Results. The mean daily ^{99m}Tc activity manipulated was 56 GBq resulting in a mean dose equivalent values of: 38.5, 18.9, 5.4 and 63.7 microSv/GBq for the monitored hand positions: index tip of non-dominant, index base of non-dominant, wrist of non-dominant and index tip of dominant hand respectively.

Conclusion. Conversely to the ORAMED findings, the index fingertip of the dominant hand receives the highest dose. Based on the daily handled activities, the dose limit could be exceeded in 138 working days, thus confirming the concerns raised by many authors.

http://dx.doi.org/10.1016/j.ejmp.2016.07.475

CALIBRATIONS FOR RA-223 CHLORIDE SPECT QUANTITATIVE IMAGING

Synefia Stella [a], Vamvakas Ioannis [a,b], Avgousti Rafaela [a], Souvatzoglou Michael [a], Limouris George [a], Lyra Maria [a,*]

[a] *Radiation Physics Unit, 1st Department of Radiology, National & Kapodistrian University of Athens, Greece*
[b] *Iaso General Hospital, Athens, Greece*
* Corresponding author.

Introduction. Ra-223 chloride has been approved by EMA, EU/1/13/873/001, for radionuclide therapy, by the name Xofigo in a glass vial 6.0 mL of 1100 kBq/mL solution. Its short-range high-LET α-particles may provide a means to destroy micro-metastases. Accurate dosimetry calculations are necessary in Ra-223 SPECT quantitative imaging.

Purpose. Patient-specific dosimetry is essential in Ra-223-chloride therapy estimations. The absorbed doses achieved should be verified, through starting procedures. Calibration and correction factors of the instruments used (Dose Calibrator – SPECT-γ-camera) should be determined.

Materials and methods. Radium-223 has a half-life of 11.4 days. 95.3% fraction of its energy is emitted as α-particles, 3.6% as β-particles and 1.1% as γ-radiation. The γ-rays associated with Ra-223 decay and its daughters allow for radioactivity measurements of Ra-223-Chloride by standard Capintec-CRC-15R and spectrum creation, peak selection in imaging by SPECT-γ-camera.

The most prominently γ-emissions of Ra-223 and its daughters are 269.5 KeV (14%) Ra-223, 271.2 KeV (11%) Rn-219 and 351 KeV (13%) Bi-211.

Results. Capintec-CRC-15R-s/n158895 (pure Argon gas ionization chamber) was calibrated for accuracy, constancy, linearity and geometry.

It was also calibrated with two NIST traceable radium-223 standard vials. Calibration setup in 29-6-2015 determined the calibration number and storage of Ra-223 in calibrator's memory and a user key was created.

Energy spectra of the two samples positioned on the ElScint-SPECT-γ-camera head surface were recorded graphically to study the energy distribution, decide the energy peak selection, the net area under each γ-ray peak, the full-energy-peak efficiency and put right factors.

Conclusion. Correction factors found that should be applied for accurate quantitative imaging measurements in patient-specific therapy by Ra-223-chloride. A protocol with all Ra-223 therapy steps in our institute has completed.

http://dx.doi.org/10.1016/j.ejmp.2016.07.476

MOBILE PET INSERT FOR SIMULTANEOUS PET/MRI IMAGING

Marcin Zielinski [a,*], D. Alfs [a], T. Bednarski [a], P. Białas [a], E. Czerwiński [a], A. Gajos [a], B. Głowacz [a], M. Gorgol [c], B. Jasińska [c], D. Kamińska [a], G. Korcyl [a], P. Kowalski [e], T. Kozik [a], W. Krzemień [e], E. Kubicz [a], M. Mohammed [a], M. Pawlik-Niedźwiecka [a], S. Niedźwiecki [a], M. Pałka [a], L. Raczyński [d], Z. Rudy [a], O. Rundel [a], N.G. Sharma [a], M. Silarski [a], A. Strzelecki [a], A. Wieczorek [a,b], W Wiślicki [d], M. Zieliński [a], B. Zgardzińska [c], P. Moskal [a,*]

[a] *Faculty of Physics, Astronomy and Applied Computer Science, Jagiellonian University, S. Łojasiewicza 11, 30-348 Kraków, Poland*
[b] *Institute of Metallurgy and Materials Science of Polish Academy of Sciences, W. Reymonta 25, 30-059 Kraków, Poland*
[c] *Department of Nuclear Methods, Institute of Physics, Maria Curie-Sklodowska University, Pl. M. Curie-Sklodowskiej 1, 20-031 Lublin, Poland*
[d] *Świerk Computing Centre, National Centre for Nuclear Research, A. Soltana 7, 05-400 Otwock-Świerk, Poland*
[e] *High Energy Physics Division, National Centre for Nuclear Research, A. Soltana 7, 05-400 Otwock-Świerk, Poland*
* Corresponding author.

Access to the anatomical and functional information about the body interior is possible with tomography techniques relying on the registration of radiation from the tissues. Modern medicine offers: Positron Emission Tomography, Magnetic Resonance and Computer Tomography. One of the present technological challenges is to combine the PET and MR scanners to work as single device to provide PET/MR images.

Presented solution of a portable-PET scanner will allow simultaneous registration of PET and MR images utilizing existing MR scanners. The developed device is based on the strip-PET concept consisting of detection modules, each build from a plastic scintillator strip connected at both ends with silicon photomultipliers array. In the proposed solution determination of the point of annihilation along the direction of the gamma quanta flight path, is based on the time difference registered in various detection modules. It is important to stress that the utilized silicon photomultipliers are insensitive to the MR magnetic field. In order to position two tomographic images with respect to each other we will use watermarks, seen by MRI system. Since this method explicitly specify the position of the MRI with respect to PET scanner therefore it enables for synchronize both tomographic images. The advantage of this solution is to eliminate the possibility of artifacts in tomographic images hindering the identification of potentially cancerous lesions.

In the talk we will present developed solution of a mobile-PET insert to MR scanners. The presentation will include the characteristics of a proposed device together with the advantages over present solutions.

http://dx.doi.org/10.1016/j.ejmp.2016.07.477

NOVEL J-PET SCANNER COMBINED WITH POSITRON ANNIHILATION LIFETIME SPECTROSCOPY TECHNIQUE AS A TOOL FOR MORPHOMETRIC IMAGING

Ewelina Kubicz [a,*], D. Alfs [a], T. Bednarski [a], P. Białas [a], E. Czerwiński [a], A. Gajos [a], B. Głowacz [a], M. Gorgol [c], B. Jasińska [c], D. Kamińska [a], G. Korcyl [a], P. Kowalski [e], T. Kozik [a], W. Krzemień [e], M. Mohammed [a], M. Pawlik-Niedźwiecka [a], S. Niedźwiecki [a], M. Pałka [a], L. Raczyński [d], Z. Rudy [a], O. Rundel [a], N.G. Sharma [a], M. Silarski [a], A. Strzelecki [a], Anna Wieczorek [a,b], W. Wiślicki [d], M. Zieliński [a], B. Zgardzińska [c], P. Moskal [a]

[a] *Faculty of Physics, Astronomy and Applied Computer Science, Jagiellonian University, S. Łojasiewicza 11, 30-348 Kraków, Poland*
[b] *Institute of Metallurgy and Materials Science of Polish Academy of Sciences, W. Reymonta 25, 30-059 Kraków, Poland*
[c] *Department of Nuclear Methods, Institute of Physics, Maria Curie-Sklodowska University, Pl. M. Curie-Sklodowskiej 1, 20-031 Lublin, Poland*
[d] *Świerk Computing Centre, National Centre for Nuclear Research, A. Soltana 7, 05-400 Otwock-Świerk, Poland*
[e] *High Energy Physics Division, National Centre for Nuclear Research, A. Soltana 7, 05-400 Otwock-Świerk, Poland*
* Corresponding author.

Positron Annihilation Lifetime Spectroscopy (PALS) allows examining structure of materials at nano and sub-nanometer level. This technique is based on the lifetime and production intensity of ortho-positronium atoms in free volumes of given structures. It is mostly used for studies of organic materials. However there exist also few results, e.g. by groups of Y. C. Jean and R. Pietrzak, showing that morphology of cells is correlated with the PALS parameters.

Jagiellonian Positron Emission Tomograph (J-PET) is a multipurpose detector which will be used for investigations with positronium atoms in life-sciences as well as for medical diagnostics. Such prototype based on plastic scintillators and fully compatible with MRI is currently being developed at the Jagiellonian University in Krakow, Poland.

In this talk results of the first experiments conducted by the J-PET collaboration will be presented.

We performed PALS studies of well known structures such as silica and of some model micro-organisms, e.g. *Saccharomyces cerevisiae* both with dry and aqueous samples allowing to determine the correlation between hygroscopicity of the cell and PALS parameters. As a result, we proved that PALS can be successfully used for studies of living organisms their dynamics and its relation to the cells morphology.

This result opens perspective for simultaneous determination of early and advanced stages of carcinogenesis by observing changes in biomechanical parameters between normal and tumour cells and standard PET examination. J-PET detection system combined with PALS technique will be more accurate and affordable for cancer diagnostics.

Disclosure. Authors disclose any relationship that may bias the presentation.

http://dx.doi.org/10.1016/j.ejmp.2016.07.478

HYBRID TOF-PET/MRI LOCAL TRANSCEIVER COIL

Bartosz Głowacz [a,*], D. Alfs [a], T. Bednarski [a], P. Białas [a], E. Czerwiński [a], A. Gajos [a], M. Gorgol [c], B. Jasińska [c], D. Kamińska [a], G. Korcyl [a], P. Kowalski [e], T. Kozik [a], W. Krzemień [e], E. Kubicz [a], M. Mohammed [a], M. Pawlik-Niedźwiecka [a], S. Niedźwiecki [a], M. Pałka [a], L. Raczyński [d], Z. Rudy [a], O. Rundel [a], N.G. Sharma [a], M. Silarski [a], A. Strzelecki [a], Anna Wieczorek [a,b], W. Wiślicki [d], M. Zieliński [a], B. Zgardzińska [c], P. Moskal [a]

[a] *Faculty of Physics, Astronomy and Applied Computer Science, Jagiellonian University, S. Łojasiewicza 11, 30-348 Kraków, Poland*
[b] *Institute of Metallurgy and Materials Science of Polish Academy of Sciences, W. Reymonta 25, 30-059 Kraków, Poland*
[c] *Department of Nuclear Methods, Institute of Physics, Maria Curie-Sklodowska University, Pl. M. Curie-Sklodowskiej 1, 20-031 Lublin, Poland*
[d] *Świerk Computing Centre, National Centre for Nuclear Research, A. Soltana 7, 05-400 Otwock-Świerk, Poland*
[e] *High Energy Physics Division, National Centre for Nuclear Research, A. Soltana 7, 05-400 Otwock-Świerk, Poland*
* Corresponding author.

In order to enhance diagnostic capabilities Positron Emission Tomography (PET) and Magnetic Resonance Imaging (MRI) devices are combined into a single hybrid device providing an access to both metabolic and morphological information during a single examination. Typically the PET detectors are placed inside the diagnostic volume of the MRI scanner, however being outside the commonly used local transmit-receiver (transceiver) coils such as head or chest coils. Coils are made of plastic parts and metal conductors on which annihilation gamma quanta may scatter before reaching the PET detectors scintillating material. This fact could cause the worsening of PET images spatial resolution and the field-of-view for the PET detectors.

We propose a solution based on a novel PET tomograph concept comprising multiple detection modules, built from polymer scintillation strip ended with silicon photodetectors, arranged circumferentially inside the working volume of the MRI local transceiver coil. The adaptive of the polymer scintillators in both shape and size properties allows for a use of a standard MRI coils constructions to be combined with PET detection system without influence on the coil shape, geometry and material properties optimized so far.

Current work is focused on a dedicated detection electronics development based on silicon photodetectors arrays and digital signal processing unit that will operate in high static magnetic field as well as radiofrequency waves environment of MRI scanner.

The novel approach to the hybrid local coil construction would allow for using any existing MRI system extending its functionality by the PET imaging feature.

Disclosure. Authors disclose any relationship that may bias the presentation.

http://dx.doi.org/10.1016/j.ejmp.2016.07.479

NOVEL PLASTIC SCINITLLATORS FOR THE FULLY DIGITAL AND MRI COMPATIBLE J-PET SCANNER

Anna Wieczorek [a,b,*], D. Alfs [a], T. Bednarski [a], P. Białas [a], E. Czerwiński [a], A. Gajos [a], B. Głowacz [a], M. Gorgol [c], B. Jasińska [c], D. Kamińska [a], G. Korcyl [a], P. Kowalski [e], T. Kozik [a], W. Krzemień [e], E. Kubicz [a], M. Mohammed [a], M. Pawlik-Niedźwiecka [a], S. Niedźwiecki [a], M. Pałka [a], L. Raczyński [d], Z. Rudy [a], O. Rundel [a], N.G. Sharma [a], M. Silarski [a], A. Strzelecki [a], W. Wiślicki [d], M. Zieliński [a], B. Zgardzińska [c], P. Moskal [a]

[a] *Faculty of Physics, Astronomy and Applied Computer Science, Jagiellonian University, S. Łojasiewicza 11, 30-348 Kraków, Poland*
[b] *Institute of Metallurgy and Materials Science of Polish Academy of Sciences, W. Reymonta 25, 30-059 Kraków, Poland*
[c] *Department of Nuclear Methods, Institute of Physics, Maria Curie-Sklodowska University, Pl. M. Curie-Sklodowskiej 1, 20-031 Lublin, Poland*
[d] *Świerk Computing Centre, National Centre for Nuclear Research, A. Soltana 7, 05-400 Otwock-Świerk, Poland*
[e] *High Energy Physics Division, National Centre for Nuclear Research A. Soltana 7, 05-400 Otwock-Świerk, Poland*
* Correpsonding author.

Jagiellonian Postitron Emission Tomography (J-PET) scanner based on plastic scintillators has been developed at the Jagiellonian University. This innovative solution enables cost effective construction of PET detector with large field of view. At present we are working on the solution which would allow for the simultaneous PET and Magnetic Resonance Imaging (MRI). For that purpose we will use silicon photomultiplier (SiPM) readout which can be applied in the strong magnetic field of the MRI scanner.

In this talk we will present results of the development of a novel scintillator material (referred to as the J-PET scintillator). The purpose of the development was the elaboration of scintillator with optical properties allowing for more efficient registration of photons with SiPM array with respect to the presently available plastics scintillators and at the same time with the superior timing characteristics. The novelty of the elaborated concept lies in usage of 2-(4-styrylphenylbenzoxazole) as a scintillation additive – wavelength shifter. The substance has been used for the first time as a scintillator dopant. J-PET scintillators were manufactured via bulk polymerization of styrene or vinyltoluene and the optimal concentration of the 2-(4-styrylphenylbenzoxazole) was set by maximizing the light output and timing properties.

In the talk properties of J-PET scintillators will be presented and discussed in view of its application for the PET/MR imaging, and the performance of the developed material will be compared to the properties of commercially available scintillators.

Disclosure. Authors disclose any relationship that may bias the presentation

http://dx.doi.org/10.1016/j.ejmp.2016.07.480

SPECTRAL CT: ON THE ACCURACY OF CONCENTRATION AND EFFECTIVE ATOMIC NUMBER ESTIMATION

Antonios Papadakis [a,*], John Damilakis [b]

[a] *University Hospital of Heraklion, Crete, Greece*
[b] *University of Crete, Heraklion, Crete, Greece*
* Corresponding author.

Introduction. Spectral CT has been an emerging new clinical innovation that enables better discrimination and characterization of tissues.

Purpose. To assess the accuracy of a new fast kVp-switch spectral CT scanner in estimating the concentration and effective atomic number (Z_{eff}) of iodine (I) in contrast enhanced tissue mimicking vessels.

Materials and methods. A cardiac CT phantom that simulates the chest of a medium-sized patient with respect to density and attenuation characteristics was coupled with four cylindrical vessels filled

with I at 2.5 mg I/ml, 5 mg I/ml, 10 mg I/ml, and 15 mg I/ml. CT acquisitions were performed on a Revolution GSI CT scanner (General Electric, USA). The tube potential was switched from 80 kVp to 140 kVp at 4.8 kHz, while the fast response detector captured the low and high energy data sets. Spectral images in the range of 40–140 keV, iodine density images, as well as Z_{eff} image maps were reconstructed. To investigate the effect of radiation dose on the accuracy of concentration and Z_{eff} estimation, acquisitions were performed at different radiation dose levels.

Results. Measured iodine concentration and Z_{eff} showed a strong correlation with nominal values ($P\langle 0.001$). Measurement error of iodine concentration and Z_{eff} decreased with increasing dose from ±0.489 mg I/ml and ±0.08 at 8.91 mGy to ±0.197 mg I/ml and ±0.02 at 32.01 mGy, respectively.

Conclusion. Fast kVp-switch spectral CT provides accurate measurements of iodine concentration and Z_{eff} allowing for a reliable estimate of blood volume supply in contrast-enhanced tissue vasculatures.

http://dx.doi.org/10.1016/j.ejmp.2016.07.481

BREAST BISMUTH SHIELDING IN CORONARY CT ANGIOGRAPHY: TO SHIELD OR NOT TO SHIELD?

Kostas Perisinakis [a,*], Antonis Tzedakis [b], Antonis E. Papadakis [b], Kostas Pagonidis [c], John Damilakis [a]

[a] *University of Crete, Medical School, Medical Physics Department, Greece*
[b] *University Hospital of Heraklion, Medical Physics Department, Greece*
[c] *University of Crete, Medical School, Radiology Department, Greece*
* Corresponding author.

Introduction. Despite the use of bismuth shields to reduce dose to eye lens and thyroid from CT scans has been reported efficient and recommended, there are conflicting opinions regarding breast bismuth shielding during thoracic CT.

Purpose. To assess breast dose reduction and diagnostic quality degradation associated with the use of bismuth shields in women undergoing coronary CT angiography (CCTA).

Materials and methods. Standard prospective and retrospective 256-slice CCTA exposures with and without breast bismuth shielding were simulated on a series of female anthropomorphic mathematical phantoms of varying size and 45 voxelized phantoms corresponding to patients subjected to CCTA using Monte Carlo methods. Bismuth shielding-induced reduction in dose to breast, lung and esophagus was determined. The effect of breast and thorax size on reduction efficiency was investigated. Shielding-related diagnostic quality degradation was assessed by two experienced radiologists in the series of 45 female patients subjected to CCTA.

Results. Breast bismuth shielding was found to reduce dose to breast, lung and esophagus of anthropomorphic phantoms by 22–33%, 12–21% and 13–20%, respectively. Corresponding mean reduction efficiency determined in voxelized phantoms of 45 CCTA patients was found 8–24%. The diagnostic quality degradation associated with the use of breast bismuth shields during CCTA was found to be unimportant.

Conclusion. Despite the breast dose reduction efficiency of bismuth shielding during CCTA was found lower than corresponding values reported in literature for thoracic CT, the use of breast bismuth shields in CCTA is not to be discouraged since associated diagnostic quality degradation is inconsequential.

http://dx.doi.org/10.1016/j.ejmp.2016.07.482

THE EFFECT OF HEART RATE AND VESSEL ANGULATION ON CORONARY ARTERY STENOSIS EVALUATION FROM CARDIAC CT ANGIOGRAPHY

Kostas Perisinakis [a,*], Antonis E. Papadakis [b], Adam Hatzidakis [c], John Damilakis [a]

[a] *University of Crete, Medical School, Medical Physics Department, Greece*
[b] *University Hospital of Heraklion, Medical Physics Department, Greece*
[c] *University of Crete, Medical School, Radiology Department, Greece*
* Corresponding author.

Introduction. Cardiac CT angiography (CCTA) is considered a valuable tool for non-invasive assessment of coronary artery stenoses in patients with low to intermediate risk for coronary artery disease.

Purpose. To investigate the effect of heart rate and artery orientation on the accuracy of stenosis quantification from CCTA studies.

Materials and methods. A QRM CT cardiac phantom equipped with cardiac motion simulator was subjected to standard prospective and retrospective CCTA image acquisitions on a modern 128-slice CT scanner. CCTA image series were separately produced for three coronary artery phantoms representing stenosis of 25%, 50% and 75% with heart rate varying from 40 to 120 bpm (in 10 bpm steps) and vessel orientation varying from 0° to 40° (in 10° steps) with respect to z-axis. Stenoses were evaluated by an experienced radiologist using a dedicated cardiac CT software for coronary artery assessment and analysis.

Results. Stenosis quantification accuracy was found to be considerably deteriorated for increasing heart rate ($p < 0.05$). Stenosis evaluation inaccuracy was found to escalate as vessel angulation from z-axis was increased. Stenosis was overestimated by 15–65% depending on heart rate, vessel angulation and plaque dimensions.

Conclusion. High inaccuracies in coronary artery may occur for increased heart rate during the CCTA scan acquisition with the effect being more prominent for increased vessel angulations. To suppress stenosis evaluation inaccuracy below 15%, beam heart rate during the examination should be maintained <60 bpm.

http://dx.doi.org/10.1016/j.ejmp.2016.07.483

EVALUATION OF EFFECTIVES DOSES TO PATIENTS AFTER WHOLE BODY COMPUTED TOMOGRAPHY

Adnan Beganović *, Samra Stabančić, Amra Skopljak-Beganović, Maja Gazdić-Šantić, Rahima Jašić, Advan Drljević

Department of medical physics and radiation safety, Clinical Centre of Sarajevo University, Bolnička 25, Sarajevo 71000, Bosnia and Herzegovina
* Corresponding author.

Introduction. Changes in technology of computed tomography (CT) have greatly improved this radiological examination. Image quality was improved, patient doses were lowered, meanwhile the duration of procedure greatly reduced. Use of automatic exposure control (current modulation systems) in CT helped reduction of patient doses. However, the constant change of tube current introduced difficulties when assessing patient dose. Usual dose descriptors, such as computed tomography dose index (C_{vol}) or dose length product ($P_{KL,CT}$), represent average dose. This problem is emphasized in case when larger body volumes are examined, and especially in case of whole body CT that is most commonly used in combination with positron emission tomography (PET). The tube current is changing from very low values in head and neck region to the maximum values in shoulder area or pelvis. Average C_{vol}could underestimate the dose in areas with more radiosensitive organs.

Purpose. The purpose of this study is to develop the methodology to use tube current modulation data for better estimation of patient effective dose.

Materials and methods. In order to address the issue we used the real patient tube current data to estimate the organ dose using available dosimetry calculators. All patients were subject to the whole body PET-CT examination. Code was developed to read DICOM data and perform all necessary calculations.

Results. Analysis of tube current data for 50 patients was performed. The data was used to estimate the effective dose and all organ doses.

Conclusion. The results obtained gave us possibility to more accurately assess the organ doses, and consequently the effective dose to patients. The analysis of tube current data allowed us to optimize patient protocols, making possible improvement of image quality or lowering the patient dose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.484

PATIENT RADIATION EXPOSURE AND INFLUENCING FACTORS AT INTERVENTIONAL CARDIOLOGY PROCEDURES

Katerina Andreou [a,*], Ioannis Pantos [b,c], Efthalia Tzanalaridou [b], Efstathios Efstathopoulos [c], Demosthenes Katritsis [b]

[a] *Department of Medical Physics, Medical School, University of Patras, Greece*
[b] *Athens Euroclinic, Greece*
[c] *2nd Department of Radiology, Medical School, National and Kapodistrian University of Athens, Greece*
* Corresponding author.

Introduction. Interventional cardiology (IC) procedures result in substantial patient radiation doses due to prolonged fluoroscopy time and radiographic exposure.

Purpose. To calculate the radiation burden of patients undergoing various IC procedures and to study the contribution of various influencing factors such as doctor experience, angiography unit type and patient body habitus.

Materials and methods. We retrieved patient and procedural data from the Catheterization and Electrophysiology Laboratory of Athens Euroclinic for IC procedures performed during a prolonged period (1998–2015), specifically: type of IC procedure, type of angiography unit, identity of primary interventional cardiologist, patient sex, weight and height, total Kerma Air Product (KAP) and fluoroscopy time. Patient radiation burden was assessed by effective dose which was calculated from KAP and procedure specific conversion factors.

Results. We considered 6960 hemodynamic procedures, 949 electrophysiology procedures, 908 device implantations and 20 transcatheter aortic valve replacements (TAVR). The mean effective doses were 7.6 ± 6.0 mSv for coronary angiography (including procedures with ventruculography, IVUS, OCT or FFR), 21.5 ± 18.6 mSv for angioplasty, 22.4 ± 16.5 mSv for coronary angiography plus angioplasty, 2.0 ± 3.3 mSv for electrophysiology studies, 13.3 ± 15.7 mSv for ablation procedures, 4.6 ± 9.8 mSv for pacemaker implantations, 11.1 ± 16.1 mSv.for defibrillator implantation and 25.6 ± 6.2 mSv for TAVR. Operator experience had a statistically significant impact on patient exposure since the total KAP of procedures performed by experienced operators was significantly lower and, additionally, procedural KAP of initially inexperienced operators reduced with time. The replacement of an angiography system with image intensifier to a modern system with a flat panel detector reduced procedural KAP. Patient body habitus significantly affected procedural KAP.

Conclusion. The radiation burden of IC procedures varies considerably and it is significantly affected by factors such as operator experience, angiography system type and patient body habitus.

http://dx.doi.org/10.1016/j.ejmp.2016.07.485

REFERENCE LEVELS IN PEDIATRIC INTERVENTIONAL CARDIOLOGY: PRELIMINARY RESULTS FROM THE COCCINELLE STUDY

S. Dreuil [*], H. Baysson, F. De Zordo-Banliat, A. Teyssonneyre, M.O. Bernier

Institute for Radiological Protection and Nuclear Safety, Fontenay-aux-Roses, France
* Corresponding author.

Introduction. The justification as well as the benefit–risk ratio of interventional cardiology procedures (ICP) is well established. However, the increasing use of ICP in pediatric population stresses the need of setting up reference levels and keeping doses to children as low as possible.

Purpose. The present study aims at evaluating radiation dose levels for the most frequent ICP performed in five French reference centers for complex congenital heart disease (CHD).

Materials and methods. For nearly 4,000 ICP performed among pediatric patients (age <16 years) over the period 2009–2013, the date of procedure, the age and weight of the patient were collected. Air kerma-area product (P_{KA}) and fluoroscopy time (FT) were retrieved retrospectively from automatic dose recording. The median, first and third quartiles, minimum and maximum values of P_{KA} and FT were calculated according to patients' age and weight.

Results. The main ICP investigated were: Diagnostic, Patent Ductus Arterious closure, Atrial Septal Defects closure, Valvuloplasty and Angioplasty. Preliminary results will be presented and discussed in the light of methodological limits and in comparison of available reference levels for ICP.

Conclusion. This is the first study in France to focus on children undergoing ICP. In order to have a better evaluation of current practices in pediatric ICP at national level, this work will be extended to the whole French network for CHD. The present work is included in the framework of an epidemiological cohort study, named "Coccinelle" and specifically designed to evaluate long term cancer risks after ICP during childhood.

Disclosure. Nothing to disclose

http://dx.doi.org/10.1016/j.ejmp.2016.07.486

MEASUREMENT OF CONVERSION COEFFICIENTS BETEEN FREE-IN-AIR KERMA AND PERSONAL DOSE EQUIVALENT FOR RQR SPECTRA TO BE USED IN MONITORING OF THE EYE LENS IN NTERVENTIONAL RADIOLOGY

Anna Zagorska [a,b], Zdravko Buchakliev [b], Jenia Vassileva [c,*]

[a] *Medcal University, Sofia, Bulgaria*
[b] *National Centre of Radiobiology and Radiation Protection, Sofia, Bulgaria*
[c] *IAEA, Vienna, Austria*
* Corresponding author.

Introduction. The recommended operational quantity to monitor eye lens exposure in interventional radiology is personal dose equivalent in 3 mm depth: $H_p(3)$. However, there are no conversion coefficients suggested in international standards.

Purpose. The aim of this study was to calculate the air kerma (K_a) to $H_p(3)$ conversion coefficients for a cylindrical phantom based on

measurements with the radiation qualities RQR2 to RQR10 that provide better approximation of X-ray spectra used in interventional radiology, especially compared to narrow spectra applied for calibration of personal dosemeters.

Materials and methods. The conversion coefficients $h_{p,k}(3)$ were determined using the formula

$$h_{p,k}(3) = \frac{H_p(3)}{K_a} = \left(\frac{\mu_{en}}{\rho}\right)_{air}^{mat} BSF \cdot PDD$$

The backscatter factors, BSF, were measured using LiF:Mn,Ti thermoluminescent detectors on a homogeneous cylindrical phantom and free in air kerma. RQRs radiation qualities were reproduced in the Secondary Standards Dosimetry Laboratory – Sofia, Bulgaria. Data for dry air and ICRU soft tissue were taken from NIST.

Results. The Percentage Depth Dose, PDD, for RQR2 to RQR10 were calculated, BSFs were measured and conversion coefficients $h_{pK}(3, RQR, 0°)$ were determined for the new cylindrical phantom. The results are in good agreement with those published by Principi et all.

Conclusions. The conversion coefficients from the air kerma (K_a) to $H_p(3)$ for radiation qualities RQR 2 to RQR 10 can be used in occupational dosimetry for interventional radiology.

http://dx.doi.org/10.1016/j.ejmp.2016.07.487

EFFECTIVENESS OF RADIATION PROTECTIVE DRAPE TO REDUCE EXPOSURE IN FLUOROSCOPICALLY-GUIDED INTERVENTIONAL PROCEDURES

Giulia Tamborino [a], Clarita Saldarriaga Vargas [b], Jérémie Dabin [b,*], Danielle Berus [c], Jo Dens [d,e], Peter Kayaert [c], Joren Maeremans [d], Lara Struelens [b]

[a] *Polytechnic University of Turin (POLITO), Turin, Italy*
[b] *Belgian Nuclear Research Centre (SCK·CEN), Mol, Belgium*
[c] *University Hospital UZ Brussels, Brussels, Belgium*
[d] *Hasselt Univiversity, Hasselt, Belgium*
[e] *Hospital Oost Limburg ZOL, Genk, Belgium*
* Corresponding author.

Introduction. Because of the increasing number of fluoroscopically-guided interventional procedures, physicians may be exposed to high annual dose. Radioprotective equipment is therefore desirable.

Purpose. This study aimed to evaluate the effect of a disposable lead-free drape in reducing scatter radiation exposure for physicians and patients during percutaneous coronary intervention.

Materials and methods. Eye lens and extremity dose measurements, for CTO treatment, performed for about 30 procedures in two Belgian hospitals.

Monte Carlo simulations performed with the MCNP-X code to investigate the influence of parameters such as beam projection, position of operator, shield-combinations, drape shapes and position on the scatter radiation to staff and patient. Doses to selected organs, eye lenses, hands, wrists and legs were calculated.

Results. Simulations showed an effective dose reduction to the physician ranging from 2% to 36%, mainly observable for RAO projections; physician's hands were significantly affected (35% ÷ 80%). If the position of the pad is shifted upward by 5 cm the effective dose could be further decreased with 8%. Maximum 86%, 60% and 44% dose reductions were observed for the patient's genitalia, bladder and gonads, respectively.

Measurements showed reductions ranging from 34% to 90% to the eyes, without the use of glasses, mainly for less complex procedures.

Conclusion. In real practice several projections, shielding devices and operator positions are combined altogether and the overall effect of the pad could be less, but the significant result achieved for the unprotected cardiologist's hands (observable in any set-up) is a significant accomplishment.

http://dx.doi.org/10.1016/j.ejmp.2016.07.488

RISK EVALUATION IN PATIENTS UNDERGOING CORONARY ANGIOGRAPHIC AND ANGIOPLASTIC PROCEDURES WITH RADIAL ACCESS

Luca Vigna [a,*], Domenico Lizio [a], Roberta Matheoud [a], Barbara Cannillo [a], Paolo Chiappino [b], Marco Brambilla [a]

[a] *Medical Physics, AOU Maggiore della Carità, Novara, Italy*
[b] *University of Eastern Piedmont, Novara, Italy*
* Corresponding author.

Introduction. Nowadays interventional cardiac procedures are of concern for the relatively high doses delivered to patients.

Purpose. To estimate the effective dose (E), the organ doses (H_t) and the related risk for cancer induction in terms of radiation exposure-induced death (REID) in patients undergoing coronary angiography (CA) and percutaneous transluminal coronary angioplasty (PTCA) procedures with radial access.

Materials and methods. 65 patients underwent CA and PTCA interventions on a Philips Allura XPer FD10 angiographic equipment.

For each patient, Xray tube voltage, projection, filtration, field dimensions and DAP were obtained by filming the monitor of the workstation during the entire procedure.

E and H_t were evaluated by means of the MonteCarlo code PCXMC that models radiation beam and transport in an anthropomorphic phantom, allowing also the evaluation of REID.

Results. Mean fluoroscopy time, DAP and E were: 3.1 min, 29.9 Gyxcm^2, 9.1 mSv and 8.9 min, 60.9 Gyxcm^2, 20.3 mSv for CA and PTCA, respectively; the correlation with DAP was very good in CA (r = 0.99) and in PTCA (r = 0.93).

For both CA and PTCA, the most irradiated organs were lungs, oesophagus and red marrow, whose mean H_t were 32.5 mSv, 30.7 mSv, 11.6 mSv for CA and 58.5 mSv, 66.7 mSv, 24.9 mSv for PTCA; the highest REIDs were for induction of leukemia (0.04% and 0.08%) and lung cancer (0.14% and 0.20%).

Conclusions. Cardiac interventional procedures with radial access improves patient compliance, reduces haemorrhagic complications compared to femoral access with comparable E and Ht values.

http://dx.doi.org/10.1016/j.ejmp.2016.07.489

METHODS TO ESTIMATE FETAL DOSE FROM FLUOROSCOPICALLY GUIDED PROPHYLACTIC HYPOGASTRIC ARTERY BALLOON OCCLUSION (HABO)

G. Solomou [a,*], K. Perisinakis [a,b], D. Tsetis [a,b], J. Stratakis [a], J. Damilakis [a,b]

[a] *University of Crete, Faculty of Medicine, P.O. Box 2208, Heraklion 71003, Crete, Greece*
[b] *University Hospital of Heraklion, P.O. Box 1352, Heraklion 71110, Crete, Greece*
* Corresponding author.

Introduction. Parturient women diagnosed with abnormal placentation are at high risk of major haemorrhage that may cause maternal death. Despite the risk of a potential damage to adjacent organs and loss of child bearing ability, hysterectomy is the gold standard technique. An alternative effective treatment technique

associated with less complications and preservation of fertility is the prophylactic hypogastric artery balloon occlusion (HABO) under fluoroscopic guidance. However, concerns regarding fetal radiation exposure and the associated radiogenic risks cannot be ignored.

Purpose. To provide methods and data for fetal radiation dose estimation from HABO procedures.

Material and methods. Mathematical phantoms that simulate a pregnant patient at the 9th month of gestation and Monte-Carlo-N-particle (MCNP) transport code were employed. Projection-specific normalized fetal dose (NFD) data for various beam qualities were produced through simulations of the left and right internal iliac arteries. The effects of X-ray field location relative to the fetus, field size and maternal body size on NFD were investigated. To verify MCNP results, fetal dose measurements were carried out by using a physical anthropomorphic phantom simulating pregnancy at the 3rd trimester and thermoluminescence dosimeters (TLDs).

Results. NFD was found to markedly depend on tube voltage, filtration, X-ray field location and size. Presented results have taken into account the effect of maternal body size on NFD. NFD derived from TLDs showed a difference of less than 13.5% compared to those estimated by MCNP simulations.

Conclusion. Methods provided allow for reliable estimation of fetal radiation burden from HABO performed at any institution.

Disclosure. This study was supported by the Greek Ministry of Education and Religious Affairs, General Secretariat for Research and Technology, Operational Program 'Education and Lifelong Learning', ARISTIA (Research project: CONCERT).

http://dx.doi.org/10.1016/j.ejmp.2016.07.490

EVALUATION AND OPTIMIZATION OF CARDIAC AND LEFT ANTERIOR DESCENDING ARTERY DVHS IN RADIOTHERAPY OF LEFT BREAST CANCER PATIENTS

T. Stroubinis [a,*], M. Tolia [b], C. Kappas [a], G. Kyrgias [b], K. Theodorou [a]

[a] *Medical Physics Department, Medical School, University of Thessaly, Biopolis, 41110 Larissa, Greece*
[b] *Department of Radiotherapy, School of Health Sciences, Faculty of Medicine, University of Thessaly, Biopolis, 41110 Larissa, Greece*
* Corresponding author.

Introduction. The potential heart damage in left-sided breast cancer radiotherapy is well known; nevertheless the biological mechanisms are only partially understood. Radiotherapy guidelines impose dose-volume constrains for the whole heart but newer data propose that excessive dose to the Left Anterior Descending artery (LAD) endothelium may cause cardiac toxicity.

Purpose. To evaluate the dose-volume data for the whole heart and LAD and performed dose distribution optimization based on a LAD dose constrain.

Materials and methods. 11 left-sided breast cancer patients were retrospectively selected for this study. All patients underwent 3D-CRT with 2-field tangential irradiation technique. The dose prescription was 50–60 Gy in 2 Gy/fraction. LAD was delineated for all patients and DVHs were calculated and compared. Every plan was acceptable regarding the V25 < 10% heart dose constraint of QUANTEC (IJROBR, 2010). Next, all plans were optimized based on the dose to LAD.

Results. The measured D_{mean} was 2.9 Gy to the heart and 24.8 Gy to the LAD. Volumes below 1.5% of the heart received dose $\geqslant$50 Gy in 6 patients (55%). LAD D_{mean} in 6 cases (55%) was > 20 Gy. Plan optimization based on LAD dose reduction was possible for 5 cases where D_{max} reduced 13.6-38.3% and D_{mean} reduced 35.1–52%.

Conclusion. In left-sided breast cancer 3D-CRT, even when the DVH constrain is met for the whole heart; the LAD receives significant higher doses. In the case that LAD dose is responsible for cardiac toxicity, new dose constrain should be added for plan optimization.

http://dx.doi.org/10.1016/j.ejmp.2016.07.491

DOSIMETRIC COMPARISON OF 3D CHEMICAL DOSIMETERS FOR USE IN MODERN RT/SRS QUALITY ASSURANCE

L. Petrokokkinos [a,*], A. Moutsatsos [a], E.P. Pappas [a], I. Seimenis [b], E. Pantelis [a,c], P. Karaiskos [a,d], P. Papagiannis [a]

[a] *Physics Laboratory, Medical School, National & Kapodistrian University of Athens, Greece*
[b] *Medical Physics Laboratory, Medical School, Democritus University of Thrace, Alexandroupolis, Greece*
[c] *CyberKnife & TomoTherapy Department, Iatropolis Clinic, Chalandri, Athens, Greece*
[d] *Gamma Knife Department, Hygeia Hospital, Marousi, Athens, Greece*
* Corresponding author.

Introduction. QA of modern radiotherapy/radiosurgery techniques is quite challenging, requiring dosimetric systems with fine spatial resolution, water equivalence, lack of energy/dose rate dependence and, hopefully, 3D dose registering.

Purpose. A comparative dosimetric assessment of two 3D dosimeters, one custom and one commercially available, towards a dosimetric system with favorable characteristics for radiotherapy/radiosurgery QA.

Materials and methods. MRI scanned VIP Polymer Gel and Optical-CT scanned PRESAGE radiochromic dosimeters were calibrated side by side. Both were subjected to the same irradiation scheme, in an extensive dose range. The dosimetric characteristics compared included dose sensitivity, dose resolution, dose rate dependence, useful dose range, minimum detectable dose and, ultimately, the uncertainty budget of the measured dose distribution.

Results & conclusion. Both 3D dosimetric systems exhibited measured dose uncertainty appropriate for clinical dosimetry. The dose sensitivity of PRESAGE/OCT was higher resulting to improved dose resolution. This adds up to the increased ease of use of PRESAGE/OCT and availability of a dedicated optical scanner. However the increased noise in comparison to Polymer Gel/MRI and the occurrence of concentric ring and significant edge artifacts render this favorable characteristics debatable. Moreover indications of dose rate and energy dependence due to higher density have to be further investigated in order to end up with a dosimetric system to be used in the verification of complex radiotherapy/radiosurgery treatment plans.

Disclosure. Research conducted with financing by "IKY Postdoc Fellowships of Excellence in Greece – Siemens Programme" in the framework of the Hellenic Republic – Siemens Settlement Agreement.

http://dx.doi.org/10.1016/j.ejmp.2016.07.492

COMPARISON OF TWO FILM DOSIMETRY METHODS FOR DOSE VERIFICATION IN STEREOTACTIC RADIOSURGERY APPLICATIONS

G. Antorkas [a,*], E. Zoros [a], E. Pantelis [a], G. Kollias [b], E. Georgiou [a], P. Karaiskos [a,b]

[a] *Medical Physics Laboratory, Medical School, National Kapodistrian University of Athens, 75 Mikras Asias, 11527 Athens, Greece*
[b] *Gamma Knife Center, Hygeia Hospital, Er. Stavrou 4 and Kifisias, 151 23 Athens, Greece*
* Corresponding author.

Introduction. The increased demand for quality assurance in stereotactic radiosurgery (SRS) applications using small fields with

steep dose gradients can benefit from the high spatial resolution offered by radiochromic films.

Purpose. To evaluate single against triple channel film dosimetry techniques for patient specific dose verification procedures in SRS applications.

Materials and methods. Dose verification of a gamma knife (GK) patient plan (target volume: 3.2 cm^3) was performed using Gafchromic EBT3 films placed in a solid water phantom. The phantom with the films in place followed all steps in the GK treatment chain and irradiated with 12 shots at a maximum dose of 10 Gy using the Perfexion unit. Scanned images were obtained using an Epson V750PRO flatbed optical scanner in 48-bit RGB transmission mode with a resolution of 150 dpi and converted to dose maps using both single- and triple-channel techniques. The 3D Gamma Index (GI) tool was used to quantitatively compare calculated (GammaPlan) against experimental dose distributions, using passing criteria of 1mm distance-to-agreement and 2% local dose-difference, while a threshold of 10% of maximum dose was applied.

Results. Dosimetric results from both techniques revealed an overall excellent agreement between calculated and measured dose distributions. GI maps for the single and triple channel technique showed a passing rate of 95% and 99%, respectively. Moreover, implementation of triple channel technique is simpler, faster and characterized by reduced systematic uncertainties.

Conclusion. Compared to the single channel, triple channel presents better passing rates, thus making it advantageous for dose verification in SRS applications.

http://dx.doi.org/10.1016/j.ejmp.2016.07.493

MONTE CARLO DETERMINATION OF CORRECTION FACTORS FOR DOSIMETRIC MEASUREMENTS IN GAMMA KNIFE PERFEXION SMALL FIELDS

E. Zoros [a,*], E.P. Pappas [a], A. Moutsatsos [a], E. Pantelis [a], C. Paraskevopoulou [b], E. Georgiou [a], P. Karaiskos [a,b]

[a] *Medical Physics Laboratory, Medical School, National Kapodistrian University of Athens, 75 Mikras Asias, 11527 Athens, Greece*
[b] *Gamma Knife Center, Hygeia Hospital, Er. Stavrou 4 and Kifisias, 151 23, Athens, Greece*
* Corresponding author.

Introduction. In the formalism proposed by Alfonso *et al.* (2008) for the dosimetry of small and non-standard photon fields, Monte Carlo (MC) simulation is indicated as a proper means for determining machine-specific reference field ($k^{f_{msr},f_{ref}}_{Q_{msr},Q}$) and clinical radiation fields ($k^{f_{clin},f_{msr}}_{Q_{clin},Q_{msr}}$) correction factors (CFs) assigned to calibration and relative dosimetry measurements, respectively.

Purpose. To determine CFs for the Gamma Knife Perfexion (PFX) radiosurgery unit for a variety of commercially available detectors utilizing MC simulations.

Materials and methods. A recently introduced EGSnrc comprehensive simulation model for the PFX irradiation unit was used. A set of 13 ionization chambers, 6 diodes detectors, TLD microcubes and alanine pellets were simulated based on blueprints provided by the vendors. CFs calculations were performed using the egs_chamber user code. Intermediate Phase Space Scoring and photon cross section enhancement variance reduction techniques were implemented in order to increase time efficiency. MC calculations were performed by a super-computer consisting of 8520 computational threads achieving a combined statistical uncertainty of 0.3%.

Results. Calculated $k^{f_{msr},f_{ref}}_{Q_{msr},Q}$ for ionization chambers commonly used for reference dosimetry in PFX were up to 1.02 (IBA-CC01). Calculations for $k^{f_{clin},f_{msr}}_{Q_{clin},Q_{msr}}$ revealed an overestimation of diode detectors up to 6% for the 4mm-collimator, while CFs for ionization chambers (active volume $\leqslant$0.04cm^3) reached 1.48 (PTW-31015).

Conclusion. A set of CFs were determined for the PFX unit allowing for more accurate dosimetry measurements.

Disclosure. This work was supported by computational time granted from the Greek Research & Technology Network (GRNET) in the National HPC facility -ARIS- under project ID pr001027.

http://dx.doi.org/10.1016/j.ejmp.2016.07.494

A NEW APPROACH IN PATIENT QA: BEAM DELIVERY CHECK AND IN-VIVO DOSIMETRY DURING RADIOTHERAPY TREATMENT

C. Talamonti [a,b,*], C. Arilli [b], L. Marrazzo [b], S. Calusi [a], C. Galeotti [b], Y. Wandel [b], I. Meattini [b], S. Scoccianti [b], S. Pallotta [a,b]

[a] *Università di Firenze, Dipartimento di Scienze Biomediche, Sperimentali e Cliniche Firenze, Italy*
[b] *Azienda Ospedaliera Universitaria Careggi, Firenze, Italy*
* Corresponding author.

Introduction. The development of complex radiotherapy techniques, together with the huge workload of linacs, requires comprehensive QA programs and the development of detectors and softwares allowing for reliable checks of the treatment delivery.

Purpose. The aim of this work was to study the impact in patient QA of the use of the Integral Quality Monitoring (IQM) device (iRTSystems) and the portal imaging with the software SoftDiso (Best Medical) to verify the safe and accurate delivery of the prescribed dose.

Materials & methods. The Anderson-Rando phantom was modified to mimic a female torso by adding two silicon gel breast implants. Standard conformal breast plans were calculated and the large area ionization chamber IQM was mounted on the accelerator gantry. PI acquired during treatments were used for in-vivo dose

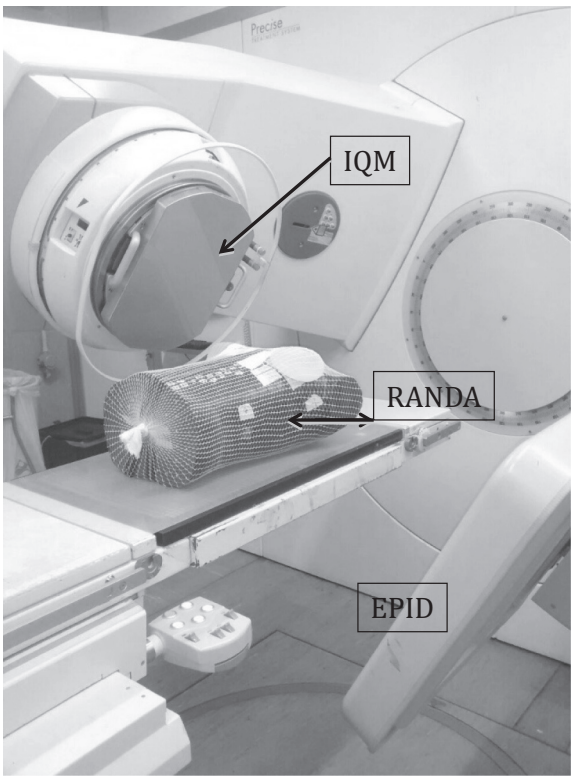

Fig. 1. Experimental setup

measurements using SoftDiso. Small errors induced on plans simulated deviation due to delivery problems and/or wrong positioning of the phantom.

Results. Tests showed good performances of the combined use of the devices to detect errors, which could not be highlighted during the pre-treatment QA. There's correlation between two systems when errors due to small changes in delivered MU are induced. IQM can detect errors when field dimensions are changed of few millimetres while SoftDiso cannot, but is able to detect discrepancy on dose reconstruction with a precision of 5%.

Conclusions. In the clinical practice these devices can play an important role in meeting the needs of modern and upcoming radiotherapy QA, and it allows checking the correct functioning of all components in the radiotherapy chain.

http://dx.doi.org/10.1016/j.ejmp.2016.07.495

DEVELOPMENT AND VALIDATION OF A SOFTWARE TO EVALUATE BREATHING-INDUCED PROSTATE MOTION TRACKED WITH IMPLANTED ELECTROMAGNETIC TRANSPONDERS

C.M.V. Panaino [a], T. Giandini [b], M. Carrara [b,*], S. Frasca [b], B. Avuzzi [b], S. Morlino [b], D. Bosetti [b], N. Bedini [b], S. Villa [b], T. Rancati [b], R. Valdagni [b], E. Pignoli [b]

[a] *Istituto Europeo di Oncologia, Milano, Italy*
[b] *Fondazione IRCCS Istituto Nazionale dei Tumori, Milano, Italy*
* Corresponding author.

Introduction . A system (Calypso, Varian Medical Systems) based on the localization of electromagnetic transponders (ELM-TRNs) permanently implanted in the prostate allows real-time tracking during radiotherapy treatments.

Purpose. Development and validation of a dedicated software for ELM-TRNs signal analysis to quantify the amplitude of the intrafraction prostate motion induced by patient's breathing, both in supine and prone position.

Materials and methods. For each treatment session, the software automatically identifies the breathing frequency on the power density spectrum of the recorded signal and creates a bandpass filter around this frequency. The obtained filter is then applied to selectively compute the breathing-induced harmonic excursion of the prostate around its nominal position.

The software was validated with a moving phantom (QUASAR, Modus Medical Devices), provided with home-made inserts containing three ELM-TRNs. Harmonic motions along the three main directions were tracked at several known frequencies and amplitudes. The calculated frequencies and amplitudes were compared to the expected ones. The software was then applied to signals of patients who underwent radiotherapy treatments in supine or prone position.

Results. The software automatically computed the correct frequencies and amplitudes within a 0.6% and a 110 μm uncertainty, respectively, without any significant difference among the three main directions. The software was demonstrated to properly work on signals acquired both with supine and prone patients.

Conclusion. A software to quantify prostate motion due to patient's breathing was successfully developed, in-phantom validated and applied to supine and prone patients, highlighting significant motion differences between the two setups.

Disclosure. None.

Work partially funded by AIRC-(IG-14300).

http://dx.doi.org/10.1016/j.ejmp.2016.07.496

BOLUS IN OPTIMIZING VMAT BREAST TREATMENTS

A.F. Monti [a,*], M.G. Brambilla [a], L. Sarno [b], C. Carbonini [a], M.B. Ferrari [a], D. Zanni [a], F. Rottoli [a], V. Arienti [b], A. Torresin [a], studente

[a] *Department of Medical Physics, Ospedale Niguarda – Milano, Italy*
[b] *Department of Radiotherapy, Ospedale Niguarda – Milano, Italy*
* Corresponding author.

Introduction. Post mastectomy radiotherapy entails challenges in breast treatment due to thin targets next to lungs, heart, and contrololateral breast. Photon fluence modulation can partially compensate the underdosage at the chest surface due to build up, but dose gradients are often generated inducing hot spots.

Purpose. In this work we propose to associate VMAT treatment and chest bolus to homogenize PTV dose coverage.

Materials and methods. Six patients underwent a CT scan with and without a 10 mm thick bolus. PTVs included the chest wall (PTVc) and regional lymph nodes (PTVn). A 6MV VMAT treatment was optimized for each patient with and without bolus using a TPS Monaco5.1 (Elekta). Plans were compared on the basis of PTVs coverage (V95%, D98% and D2%), dose homogeneity index (HI) and conformity index (CI); and dose to OARs, particularly to lungs, heart, contralateral breast and RVR.

Results. When the bolus is removed, PTVc parameters significantly change. V95%, D98% and CI decrease respectively of 5.9, 4.1 and 11.5%, while D2% and HI increase respectively of 1.4 and 5.9%. No changes affected PTVn while all OARs doses are slightly lower without bolus (less than 1%). Acute skin toxicity was G1 in all patients.

Conclusion. A bolus can improve the PTV coverage at the surface, reducing high dose regions without increasing skin toxicity. Being PTVn deeper into the patient, there are no differences between the two treatments. OARs received approximately the same dose with a not clinically significant small reduction in favour of the treatment without bolus.

Disclosure. No relationships to disclosure.

http://dx.doi.org/10.1016/j.ejmp.2016.07.497

3D POLYMER GEL MRI DOSIMETRY USING A 2D HASTE, A 2D TSE AND A 2D SE MULTI ECHO (ME) T2 RELAXOMETRIC SEQUENCES: COMPARISON OF DOSIMETRIC RESULTS

T.G. Maris [a,d,*], E. Pappas [b,d], T. Boursianis [a,d], G. Kalaitzakis [a,d], N. Papanikolaou [c], L. Watts [c], M. Mazonakis [a], J. Damilakis [a]

[a] *Department of Medical Physics, University of Crete, Heraklion, Crete, Greece*
[b] *Department of Medical Radiologic Technology, Technological Educational Institute of Athens, Athens, Attiki, Greece*
[c] *University of Texas Health Science Center, San Antonio, TX, USA*
[d] *R&D department at RTsafe S.A, Athens, Greece*
* Corresponding author.

Introduction. Polymer gel dosimeters when exposed to ionising radiation increase their magnetic spin-spin relaxation rate (R2 = 1/T2) as a result of their polymerization. R2 can be measured with a variety of relaxometric MRI sequences and it is linearly correlated with the absorbed dose.

Purpose. The aim of this study is to compare a 2D ME-HASTE, a 2D ME-TSE and a 2D ME-SE MR sequences in 3D MRI radiation dosimetry using N-vinylpyrrolidone (VIPAR) based polymer gels.

Materials and methods. A 3D head mimicking patient phantom printed on a commercial 3D printer and 5 calibration glass vials were filled with VIPAR gel material and was irradiated to different radiation doses up to 40 Gy, using a 6 MV LINAC X-ray beam. The phantom and the vials were scanned using a 1.5 T whole body clinical scanner utilizing a 2D-ME-HASTE, a 2D-ME-TSE and a 2D-ME-SE

relaxometric sequences. Correlations of R2 values with absorbed doses were estimated for all three sequences.

Results. R2 (s^{-1}) values, measured by either 2D ME sequence, were linearly correlated to absorbed dose (Gy) for the studied dose range. (R2: mean dose sensitivity 0.08 s^{-1} Gy^{-1}, r: 0.99 $p < 0.005$). 2D-ME-HASTE sequences revealed the best anatomical coverage for the selected irradiation volume, the best SNR and the shortest scanning time.

Conclusion. All 2D ME relaxometric sequences can be used for 3D MRI gel dosimetry using VIPAR gels. 2D-ME-HASTE sequences hold the absolute advantage of being a fast and the most reliable solution in VIPAR MRI gel dosimetry.

http://dx.doi.org/10.1016/j.ejmp.2016.07.498

IMPLEMENTATION OF AN ADAPTIVE RADIOTHERAPY METHOD USING EPID AND GAMMA ANALYSIS FOR HEAD AND NECK AND LUNG CASES

Piron Ophelie *, Varfalvy Nicolas, Archambault Louis

Department of Radiation Oncology, CHU de Quebec, Quebec, Canada
* Corresponding author.

Introduction. The challenge of adaptive radiotherapy is to recognize the morphological changes that induce a sufficient dosimetric impact to affect the treatment delivery and require complete replanning.

Purpose. The objective was to analyze daily EPID images to identify and quantify changes in the anatomy and to detect patients at risk of deviation from their planned treatment.

Materials and methods. EPID images were acquired at every fraction for 50 patients of each of these 2 anatomical sites, head and neck and lung cases. A gamma analysis was performed relative to the first fraction and multiple parameters were extracted from the daily gamma map. The evolution of these parameters were characterized to identify categories of risk of deviation using a k-means clustering. A quarter of these patients had a complete dose evaluation at the end of the treatment by deforming the CT and original contours onto the last CBCT, and by re-computing the dose on the deformed dataset.

Results. Categories of risk were identified for each of the anatomical sites. These categories indicated the degree of errors of the daily treatment relative to the first fraction. The combination of gamma parameters and dosimetric analysis established a threshold for which patients were at risk of deviation. From the re-computing plan data, it been confirmed that patients with a strong dosimetric impact were above this threshold.

Conclusion. Analysis of daily EPID images provides a method to identify patients at risk of deviation from their planned treatment and help for the replanning decision.

http://dx.doi.org/10.1016/j.ejmp.2016.07.499

STAFF DOSE AT DIFFERENT BODY REGIONS AND AT DIFFERENT STAGES OF ^{18}F-FDG PET/CT PROCEDURES

K. Dalianis [b,*], G. Kollias [b], A. Nikaki [a], F. Vlachou [a], R. Efthimiadou [a], J. Andreou [a], V. Prassopoulos [a]

[a] *PET/CT Department, Hygeia SA, Athens, Greece*
[b] *Medical Physics Department, Hygeia SA, Athens, Greece*
* Corresponding author.

Purpose. Personnel monitoring results provide information on routine radiation exposure, assist in work planning and allow control of the workplace. The FDG PET/CT applications have been continuously increasing for diagnostic procedures. Although such an increase is a positive trend for the benefit of patients, the associated risk of radiation exposure of staff needs to be properly evaluated. The aims of this study were to estimate the effective dose for the staff at different body regions and at different stages of the PET/CT procedure.

Method. To estimate the effective dose from external exposure, all 6 members of the staff (2 nurses, 2 medical physicists, 2 technologists) had TLD badges worn at the upper pocket of their overall and digital dosimeters worn at the side pocket. High sensitivity thermolumiscent dosimeters were used. The measurements that were made include 5 different body regions: eye, thyroid, gonads, fingers and body at all stages of the PET/CT procedure: dose segmentation, injection of the radiopharmaceutical, handling the patient and positioning the patient.

Results. Results show that the mean effective dose received by each member of the staff was approximately 12.32 μSv and the mean daily dose/MBq was about 0.03 μSv. All statistical tests show no significant differences between the results for eye, thyroid and body. The staff dose received in at gonads is found to be statistical significant lower when compared to the body dose. About 57% of the staff dose resulted from patient interaction. The maximum doses to fingers were during the segmentation of radiopharmaceutical and the maximum whole body dose was during the injection of the FDG.

Conclusion. The personnel dose results are significantly lower than the recommended annual dose by International Commission for Radiological Protection. However a greater effort should be made to reduce the doses further in line with the ALARA principle.

http://dx.doi.org/10.1016/j.ejmp.2016.07.500

RADIATION EXPOSURE COMPARISON NUCLEAR MEDICINE VS PET/CT

K. Dalianis [b,*], G. Kollias [b], T. Pipikos [a], F. Vlachou [a], R. Efthimiadou [a], J. Andreou [a], V. Prassopoulos [a]

[a] *PET/CT Department, Hygeia SA, Athens, Greece*
[b] *Medical Physics Department, Hygeia SA, Athens, Greece*
* Corresponding author.

Purpose. Personnel monitoring results provide information on routine radiation exposure, assist in work planning and allow control of the workplace. The aim of this study was to compare the gamma dose received by dedicated medical workers operating in the first PET/CT department in Greece and also by dedicated medical workers operating in conventional Nuclear Medicine procedures in the same center. PET/CT studies are restricted to the use of ^{18}F fluorodeoxyglucose (FDG). In addition Tc-99m, Tl-201, Ga-67 and I-131 are the radiotracers mostly used in our Nuclear Medicine department.

Method. To estimate the effective dose from external exposure, all 9 members of the staff (2 nurses, 2 medical physicists, 5 technologists) had TLD badges worn at the upper pocket of their overall and digital dosimeters worn at the side pocket. Nurses and Medical Physicists also had TLD rings. The nurses and technologists 1,2 are working only in the PET/CT department, while technologists 3,4,5 are operating only in the Nuclear Medicine department covering the most common procedures. Medical Physicists 1,2 are operating in both departments.

Results. In the period of January 2015 to December 2015 a total of 977 PET/CT studies and 2322conventional Nuclear Medicine procedures were performed. The collective effective and finger doses received by all 4 members of the PET/CT staff were the following: Nurse 1 received 4.98 mSv as a whole body dose and 44.3 mSv as a hand dose and Nurse 2 received 5.01 mSv whole body dose and 46.7 mSv hand dose respectively. Technologists 1 and 2 received 1,95 mSv and 1,56 mSv as the whole body dose respectively. Medical Physicist 1 received 1,75 mSv whole body dose and 65.3 mSv hand

dose and Medical Physicist received 2 2,17 mSv and 66.1 mSv respectively. Technologists 3,4 and 5 received 1,85 mSv, 1,76 mSv and 1,82 mSv as whole body doses respectively

Conclusion. The personnel dose results are significantly lower than the recommended annual dose by International Commission for Radiological Protection. The higher value of gamma dose for PET/CT workers by comparison with the staff operating conventional Nuclear Medicine procedures is attributable to the higher specific gamma constant of ^{18}F, as well as the longer exposure time required for accurate positioning.

http://dx.doi.org/10.1016/j.ejmp.2016.07.501

PEDIATRIC NUCLEAR MEDICINE DOSIMETRY: A MONTE CARLO STUDY ON S-VALUE VARIABILITY DUE TO PATIENT SPECIFIC CHARACTERISTICS

Vasiliki Iliadou [a,*], Panagiotis Papadimitroulas [a,b], William D. Erwin [c], Theodora Kostou [a], George Loudos [d], George C. Kagadis [a,c]

[a] *Department of Medical Physics, School of Medicine, University of Patras, Greece*
[b] *BET Solutions, Athens, Greece*
[c] *Department of Imaging Physics, The University of Texas MD Anderson Cancer Center, Houston, TX, USA*
[d] *Department of Biomedical Engineering, Technological Educational Institute of Athens Greece*
* Corresponding author.

Introduction. Personalized internal radiopharmaceutical dosimetry is of great interest in the pediatric population, in whom the risk from exposure to ionizing radiation is greatly debated. Our proposed methodology is being evaluated based on the ground truth of realistic Monte Carlo (MC) simulations and anthropomorphic models.

Purpose. Our goal is to compute S-values and quantify the absorbed dose in the majority of organs according to the specified radiopharmaceutical biodistribution and personalized anatomical characteristics. The S-value calculation procedure is validated against already published data, while the S-value variability in children of different anatomical characteristics is studied.

Materials/Methods. A validation study was carried out for the calculation of S-values using monoenergetic photon sources (10 keV–1 MeV). Furthermore, S-values were calculated using the biodistribution of ^{123}I-mIBG derived from clinical data of a 7 years old patient at 4 different time points. Male/female pediatric computational models were used for ages 5, 8 and 14 years respectively, in order to calculate S-values' variability. The GATE MC toolkit was used for the calculation of organ absorbed doses.

Results. Calculated photon liver-to-kidneys S-values were compared to previously reported S-values. The differences were ∼2.6% for photons with energies 10 keV–100 keV, while a higher deviation (30%) was observed for 1 MeV photons. The comparison study for the three ages revealed several variations. S-values deviated ∼95% in liver, for girls with body masses ranging from 10.8 kg to 50.4 kg. Generally, children with similar body-masses had lower than ∼30% variations in specific organs.

Conclusion. Radiopharmaceutical dosimetry shows large variations due to the patients' anatomies, thus personalized characteristics should be considered. Our study is ongoing, extending our investigation to additional pediatric phantoms and for a variety of radiopharmaceuticals.

Disclosure. n/a.

http://dx.doi.org/10.1016/j.ejmp.2016.07.502

SCATTER CORRECTION FOR PLANAR AND SPECT IMAGING WITH FACTOR ANALYSIS

Peter Knoll [a,*], Siroos Mirzaei [a], Arman Rahmim [b]

[a] *Department of Nuclear Medicine, Wilhelminenspital, Vienna, Austria*
[b] *Division of Nuclear Medicine & Molecular Imaging, Department of Radiology, Johns Hopkins University, Baltimore, USA*
* Corresponding author.

Introduction. In order to achieve quantitative data in planar and SPECT imaging, various interactions of photons with matter have to be modelled and compensated. Although correction for photon attenuation has been addressed by including X-ray CT scans, accurate correction for Compton scattering remains an open issue.

Purpose. In this work we propose and assess a novel, user-independent framework applying factor analysis (FA).

Materials and methods. Extensive Monte Carlo simulations for planar and tomographic imaging were performed using the SIMIND software. Furthermore a Jaszczak phantom study (Data Spectrum Corporation, Durham, NC, USA) and ten clinical ^{99m}Tc MDP bone studies were performed using a large-field of view scintillation camera (General Electric's Infinia Hawkeye). In order to use FA for scatter correction, we subdivided the applied energy window into a number of sub-windows, serving as input data. FA results in two factor images (photo-peak, scatter) and two corresponding factor curves (energy spectra).

Results. The data obtained by FA showed good agreement with the energy spectra, photo-peak and scatter images obtained in all Monte Carlo simulated data sets. For the Jaszczak phantom, without scatter correction, the cold sphere contrast ranged from −47.7 to −4.75, while with FA scatter correction, it ranged from −51.5 to −7.52. The cold sphere sector contrast ranged from −16.6 to −0.18 for non-scatter corrected data, and for the FA data, from −16.6 to −0.23.

Conclusion. Factor analysis can be used as a user-independent approach for scatter correction in quantitative nuclear medicine imaging.

Disclosure. Nothing to disclose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.503

A NOVEL STEREOTACTIC FRAME FOR TRUE PET GUIDED BIOPSIES

J. Cortes-Rodicio [a,*], G. Sanchez-Merino [a], M.A. Garcia-Fidalgo [a], I. Tobalina Larrea [b,c]

[a] *Servicio de Física Médica, OSI Araba, Hospital Txagorritxu, Vitoria-Gasteiz, Spain*
[b] *Servicio de Medicina Nuclear, OSI Araba, Hospital Santiago, Vitoria-Gasteiz, Spain*
[c] *Departament of Surgery, Radiology and Physical Medicine, Faculty of Medicine and Odontology, Campus of Vitoria-Gasteiz, University of the Basque Country UPV/EHU, Spain*
* Corresponding author.

Introduction. Most guided biopsies procedures are using a previously acquired PET/CT scan registered with procedural CT images. Other methods use radioactive sources coupled to the biopsy needle that are introduced in the patient. Many drawbacks arise in both cases: incorrect positioning, sterilized needles, expensive sources, radiation protection...

Purpose. We present a novel device to perform true PET guided biopsies that avoids the problems of other procedures.

Materials and methods. A 3D printed device was developed. It consists of four main components: A fixed circular base, an outer rotating crown with a U-shaped fixed piece, a header that moves along the U-shaped piece and a needle holder. The primary base contains three holders where radioactive markers doped with 18-FDG

are introduced. Another marker is attached to the outer end of the needle. Once the device is mounted, a spherical coordinate system is built. Two in-house software programs have been developed to obtain the coordinates of the tumour tissue respect to the frame and to assess the correct position of the needle tip.

Results. For testing purposes of the prototype an alginate tumour phantom was built in which a sphere of 10 mm of diameter and an activity concentration of 4:1 with respect the background is settled. After all biopsy punctures we found the needle tip inside the tumour, with an accuracy of less than 5 mm with respect the center of the target.

Conclusion. A first prototype has been built and tested successfully. Anyway some improvements should be made and more trials have to be done to completely characterize the device.

Disclosure. The authors have applied, with Osakidetza SVS, for a patent for the device described in this publication (P201531185, Oficina Española de Patentes y Marcas, Ministerio de Industria, Energía y Turismo).

http://dx.doi.org/10.1016/j.ejmp.2016.07.504

ON A NEW MECHANISM ON γ-RAY ATTENUATION STRENGTHENED BY NEW DATA

E. Adamides *, A. Kavadjiklis, S.K. Koutroubas, N. Moshonas, A. Tzedakis

AEI Piraeus TT, Petrou Ralli and Thivon, Egaleo, Greece
* Corresponding author.

Introduction. We extended our previous detailed γ-ray attenuation measurements of ^{60}Co γ rays in Pb and Fe to include also Cu, Hg, Al and H_2O.

Purpose. To introduce a new mechanism on γ-ray attenuation in matter.

Materials and methods. ^{60}Co radiation source, slices of the absorbers and a Geiger Müller detector counter in broad and thin beam geometries.

Experiments. We performed detailed measurements of the detected radiation versus the thickness of the absorber and in parallel Monte Carlo simulations for each experiment.

Results. Monte-Carlo calculations were in qualitative agreement with experiment but quantitatively predicted systematically more radiation at the target. We related the differences with the parameters E_γ and Z_{eff} of the photoelectric absorption cross section which guided us to propose a new mechanism on the absorption of γ rays in matter. The γ radiation creates a huge number of electrons and ions passing through the absorber which form a steady state plasma condition increasing slightly the parameters E_b and Z_{eff} of the lattice which in turn can increase measurably the photoelectric absorption thus restoring the agreement between Monte Carlo calculations and experiment.

Conclusion. Based on our large set of data which included absorbers in a wide range of Z_{eff} we strengthened the need for a new mechanism on γ-ray absorption in matter.

http://dx.doi.org/10.1016/j.ejmp.2016.07.505

THE IMPACT OF CELL PROLIFERATION AND RADIONUCLIDE UPTAKE RATE IN RADIO-IMMUNOTHERAPY

Martin Šefl [a,b,c,*], Ioanna Kyriakou [c], Dimitris Emfietzoglou [c]

[a] *Department of Radiation Dosimetry, Nuclear Physics Institute, Academy of Sciencese of the Czech Republic, 180 00 Prague, Czech Republic*
[b] *Department of Dosimetry and Application of Ionizing Radiation, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, 110 00 Prague, Czech Republic*
[c] *Medical Physics Laboratory, University of Ioannina Medical School, 45110 Ioannina, Greece*
* Corresponding author.

Purpose. The instantaneous-uptake model of O'Donoghue ["The impact of tumor cell proliferation in radio-immunotherapy", Cancer 73, 974–980 (1994)] for a proliferating cell population irradiated by an exponentially decreasing dose-rate is being extended to arbitrary uptake rates of the radiopharmaceutical in tumor cells.

Methods. The time derivative of the survival curve is examined and an expression for the minimum of the surviving fraction is deduced along with a new expression for the biological effective dose (BED). Surviving fractions are calculated over a clinically relevant parameter range to establish general trends.

Results. Results are presented for the therapy radionuclides Y-90, I-131, and P-32, assuming uptake half-times 1–24 h, extrapolated initial dose-rates 0.5–1 Gy h^{-1} and a biological clearance half-life of 7 days. Cell doubling time equals 2 days. The exponential-uptake rate of the radiopharmaceutical by the targeted cells appears to have a considerable effect on the survival of a proliferating cell population (even for uptake half-times of only a few hours) and thence might need to be considered in the radiobiological models of tumor cell-kill in radio-immunotherapy. The differences between the exponential-uptake model and the instantaneous-uptake model become larger for high peak dose-rates, slow uptakes, and (slightly) for radionuclides with higher half-life. Moreover, the sensitivity of the cell survival on the uptake was found to be higher for the tumor cells with higher radio-sensitivity.

Conclusion. Neglecting an uptake phase may result in a considerable overestimation of cell kill.

http://dx.doi.org/10.1016/j.ejmp.2016.07.506

"Γ-EYE": A PARADIGM SHIFT IN SCINTIGRAPHIC MOUSE IMAGING

Georgiou Maria [a,*], Papadimitroulas Panagiotis [a], Fysikopoulos Eleftherios [a], Mikropoulos Konstantinos [a], Loudos George [b]

[a] *BET Solutions, R & D, Athens, Greece*
[b] *Technological Educational Institute of Athens, Biomedical Engineering, Athens, Greece*
* Corresponding author.

Introduction-purpose. Small animal imaging has been well proven as a robust tool to non-invasively study the biodistribution of various biomolecules. A number of imaging systems are commercially available but with high purchase and maintenance costs. For this reason, we present the "γ-eye", a dedicated γ-camera suitable for in-vivo scintigraphic molecular imaging. The "γ-eye" is a unique benchtop system with $5 \times 10\,\text{cm}^2$ field-of-view for whole-body mouse imaging.

Materials & methods. The "γ-eye" is based on two PositionSensitivePhotomultiplierTubes H8500 coupled to a CsINa pixelated scintillator and a low energy parallel hexagonal hole collimator. The external dimensions of the entire system, including all required electronics, are $45 \times 30 \times 15\,\text{cm}^3$. All studies can be stored as raw data and in DICOM format and are handled through a Database-Manager. The software supports a real-time viewer mode with selectable time frame and a post-processing mode, where various tools are adapted.

Results. The spatial resolution was measured 2 mm @0 mm, the energy resolution for the 140 keV is 26% and the maximum sensitivity of the system is 200 cps/MBq. The quantification ability was

assessed using a phantom of 4 tubes filled with ^{99m}Tc solution with different activities. Our results demonstrate accurate quantitative information even for 10 s scans. The system was tested using a mouse injected with ^{99m}Tc-MDP for bone imaging, a mouse injected with ^{99m}Tc-DMSA for kidneys imaging and finally a mouse injected with ^{99m}Tc-MIBI for heart imaging.

Conclusion. A new low-cost system, suitable for scintigraphic mouse imaging has been developed and evaluated using phantoms and small animals. Its dimensions and cost make it a unique solution for groups activated in the field of small animal nuclear imaging.

http://dx.doi.org/10.1016/j.ejmp.2016.07.507

AUTOMATIC BONE MARROW SEGMENTATION FOR PETCT IMAGING IN MULTIPLE MYELOMA

P. Leydon [a,*], M. O'Connell [b], D. Greene [c], K. Curran [a]

[a] *Complex & Adaptive Systems Laboratory, University College Dublin, Ireland*
[b] *The Mater Private Dublin, Ireland*
[c] *Insight: Centre for Data Analytics, University College Dublin, Ireland*
* Corresponding author.

Introduction. Multiple myeloma (MM) is a malignant hematologic disorder characterized by bone marrow infiltration with neoplastic plasma cells. Approximately 10% of all hematologic cancers are related to MM. Whole-body 18F-FDG PETCT is an extremely useful imaging tool for the assessment of patients with MM. The novel approach developed in this research automatically segments bone marrow regions of interest on both the PET and CT datasets.

Purpose. To automate bone marrow segmentation in PET.

Materials and methods. Firstly, affine linear transforms are applied to the PET dataset and it is aligned to the CT images. Next, a binary mask is created based on a pixel threshold value of cortical bone. A series of image processing steps are performed to remove noise and fill gaps that correspond to bone marrow locations. This process results in a binary mask relating to bone marrow only which can then be applied to the registered PET dataset.

Conclusion. The proposed method offers a fully automated and completely objective approach for segmentation of anatomical regions relating to bone marrow. With further development, this method could be used to evaluate clinical images in order to develop a database of PETCT images against which quantitative statistical comparisons between patients with normal bone marrow metabolism and those with myeloma can be made, establishing a baseline against which future scans may be referenced. In cases where the suspicion of myeloma exists, the tools could be used to support the diagnosis of the disease, and may be useful in staging of the disease in cases positive for myeloma.

http://dx.doi.org/10.1016/j.ejmp.2016.07.508

CELLULAR AND SUBCELLULAR DOSIMETRY OF RADIOISOTOPES USED FOR PET IMAGING

Hocine Nora [a,*], Faivre Lionel [b], Sarda-Mantel Laure [c]

[a] *Institut de Radioprotection et de Sûreté Nucléaire, France*
[b] *INSERM, APHP, France*
[c] *INSERM, IUH, Paris Diderot University, APHP, France*
* Corresponding author.

Introduction. PET/CT imaging may be a useful method to follow and monitor the homing of hematopoietic stem and progenitor cells (HSPC) after HSPC injection in mice. To improve the method of HSPC radiolabelling and to select the best radioisotopes for this technique a cellular dosimetry is required.

Purpose. This early research work is focused on using Monte Carlo code to estimate the dose at cellular and subcellular levels for 3 radioisotopes used in PET: F-18, Cu-64 and Zr-89.

Methods. S-values (absorbed dose per unit cumulated activity) calculations using Monte Carlo (MC) simulations are carried out, nucleus (N), Cytoplasm (Cy), Cellular surface (CS) and radiation source were simulated.

The cells are assumed to be spherical with the radii of the cell and cell nucleus ranging from 4 to 8 μm. Different source-to-target combinations are considered namely nucleus to nucleus ($N \leftarrow N$), cytoplasm-to-nucleus ($N \leftarrow Cy$) and cell surface-to-nucleus ($N \leftarrow CS$).

The S-values (in Gy/Bq.s) were calculated for cell nucleus and cellular surface distribution of radioactivity.

Results. A comparison of MC results with the MIRD values for studied configurations are carried out for the radioisotopes studied. We generally find the largest deviations with MIRD for geometries where the target is at some distance from the source and, therefore, the results depend more strongly upon the plasmic membrane penetration ability of particles.

http://dx.doi.org/10.1016/j.ejmp.2016.07.509

INVERSION OF THE ATTENUATED RADON TRANSFORM USING CUBIC SPLINES

Nicholas E. Protonotarios [a,b,*], Athanassios S. Fokas [a,c], Anastasios Gaitanis [d], George A. Kastis [a]

[a] *Research Center of Mathematics, Academy of Athens, Greece*
[b] *Department of Mathematics, National Technical University of Athens, Greece*
[c] *Department of Applied Mathematics and Theoretical Physics, University of Cambridge, UK*
[d] *Biomedical Research Foundation of the Academy of Athens, Greece*
* Corresponding author.

Introduction. The mathematics of single photon emission computed tomography (SPECT) involve the inversion of a certain integral, namely the attenuated Radon transform. This integral is stored in the form of the so-called *attenuated sinogram*.

Purpose. By modifying the original formulation introduced by one of the authors in 2006, we have presented a slightly different formulation of the *Inverse Attenuated Radon Transform* (IART), which we refer to as *attenuated Spline Reconstruction Technique* (aSRT). The purpose of this study is to evaluate aSRT using simulated SPECT/CT phantoms and compare it with the industry standard, filtered backprojection (FBP).

Materials and methods. We have rederived the analytic formula of the IART, which involves the Hilbert transform of the attenuation correction coefficient as well as of two functions of the attenuated sinogram. For the numerical implementation of these Hilbert transforms we have employed an approximation of custom-made third degree piecewise polynomials, namely cubic splines. Relevant sinograms were generated in STIR (Software for Tomographic Imaging Reconstruction) and were acquired for 30, 60, 120, 180, and 360 projections over 360 degrees. Comparisons with FBP were evaluated using contrast and bias.

Results. Our numerical tests suggest that the new technique can efficiently produce accurate reconstructions for real phantoms.

Conclusion. aSRT provides an alternative to FBP, which incorporates the attenuation correction within the algorithm itself.

G.A. Kastis acknowledges the financial support of the "Alexander S. Onassis Public Benefit Foundation" under grant No. R ZL 001-0. Furthermore, this work was partially supported by the research pro-

gram "Inverse Problems and Medical Imaging" (200/842) of the Research Committee of the Academy of Athens.

http://dx.doi.org/10.1016/j.ejmp.2016.07.510

PATIENT RELEASE CRITERION AFTER IODINE-131 RADIONUCLIDE THERAPY. THE IATROPOLIS CLINIC EXPERIENCE

Christos Antypas [a], Liana Sideri [a,*], Argyris Moutsatsos [a], Evaggelos Pantelis [a], Katerina Salvara [a], Vassilios Voliotopoulos [b]

[a] *Medical Physics Department, Iatropolis Clinic, Athens, Greece*
[b] *Nuclear Medicine Department, Iatropolis Clinic, Athens, Greece*
* Corresponding author.

Introduction. Patient release criteria after radionuclide therapy are based on dose constraints and the potential contamination and exposure to other people with the aim of minimizing doses to family, close friends and other people as low as reasonably achievable. These dose constraints, together with certain recommendations on the behavior of the discharged patient are given in the European Commission's Directive 97 on Radiation Protection and in the IAEA SRS No 63.

Purpose. The aim of the present work is to establish a criterion for patient release after Iodine-131 radionuclide therapy to be followed in our clinic.

Materials and methods. 400 patients were hospitalized in our clinic and treated for Iodine-131 therapy during a twelve month period approximately. For all patients, the equivalent absorbed dose rate @ 1m, R(1m,t), was measured with a survey meter (Victoreen, 451P) at 1 h, 24 h, 48 h and 72 h post administration. The NCRP 155 formalism was used to evaluate the Iodine-131 effective half-life for the patient population under investigation and to calculate the R(1m,t) that should not be exceeded in order to meet the dose constraint of 3 mSv for general public.

Results. According to our measured data, the remaining activity within the patient can be fitted with a single exponential function with an effective half-life of 48 h. The mean R(1m,48 h) was measured 17 μSv/h (min = 2 μSv/h, max = 45 μSv/h). The above measured dose rate results in an equivalent dose less than 3 mSv for the general public and occupancy factor equal to 1.

Conclusion. R(1m,48 h) $\leqslant$30 μ Sv/h was established as a release criterion for Iodine-131 patients in our clinic. This criterion meets the dose constraint of 3 mSv and is considered safe for the general public.

Disclosure. Authors do not have any relationship that may bias this presentation.

http://dx.doi.org/10.1016/j.ejmp.2016.07.511

FRACTIONAL FLOW RESERVE DERIVED FROM CONVENTIONAL CORONARY ANGIOGRAMS AND COMPUTATIONAL FLUID DYNAMICS

Ioannis Pantos MSc [a,b,*], Anastasios Kopanidis PhD [a,c], Efthalia Tzanalaridou MSc [a], Andreas Theodorakakos PhD [d], Efstathios Efstathopoulos PhD [b], Demosthenes Katritsis MD, PhD, FRCP [a]

[a] *Athens Euroclinic, Athens, Greece*
[b] *2nd Department of Radiology, University General Hospital 'Attikon', School of Medicine, National and Kapodistrian University of Athens, Athens, Greece*
[c] *Department of Mechanical Engineering, University of Western Macedonia, Kozani, Greece*
[d] *Department of Mechanical Engineering, Technological Education Institute of Piraeus, Egaleo, Greece*
* Corresponding author.

Introduction. Advances in coronary imaging and computational fluid dynamics enable the assessment of fractional flow reserve (FFR) of coronary lesions non-invasively.

Purpose. Aim of the current study is to explore the accuracy of FFR determination at coronary models obtained from conventional coronary angiography (CCA) without any modification of the imaging acquisition protocol.

Materials and methods. Coronary models were obtained from CCA by a 3D reconstruction algorithm based on the concept of epipolar geometry. Three cases of stenosed left anterior descending (LAD) coronary arteries were considered in which the functional severity of lesions has been assessed by invasive FFR (FFR_{INV}). These cases included a functionally insignificant lesion (FFR_{INV1} = 0.93), a moderate lesion (FFR_{INV2} = 0.85) and a severe lesion (FFR_{INV3} = 0.70). The LAD anatomies were reconstructed, meshed and fed into a CFD solver where realistic generic transient boundary flow conditions were applied. FFR was estimated as the ratio of the calculated total mass flow rate of the stenosed model to that of the model in which the stenotic lesion has been computationally removed.

Results. The computed value of FFR for each case was determined by the ratio of the time integral during two cardiac cycles of the mass flow rate of the stenosed model to that of the "healthy" model. The computationally determined values of FFR (FFR_{CFD}) for the three cases of coronary stenoses were FFR_{CFD1} = 0.95, FFR_{CFD2} = 0.85and FFR_{CFD3} = 0.72 thus differences with the invasively measured values were 0.02, 0.00 and 0.02 respectively.

Conclusion. The developed methodology enables the virtual assessment of the functional severity of atherosclerotic lesions by routine angiography and without requiring invasive measurements or hyperemia induction. This "less invasive" approach when validated to larger patient cohorts could have important implications for patient management and cost.

http://dx.doi.org/10.1016/j.ejmp.2016.07.512

REGULATION OF THE ARTIFICIAL TANNING SECTOR IN GREECE

Aspasia Petri *, Efthymios Karabetsos

Greek Atomic Energy Commission, Non-Ionizing Radiation Office, Patriarchou Grigoriou & Neapoleos str., P.O. Box: 60092, Ag. Paraskevi, Greece
* Corresponding author.

Introduction. The first surveillance action regarding the artificial tanning sector in Greece was recently finalized by the Greek Atomic Energy Commission (EEAE). Results demonstrated noncompliance with the 0.3 W/m^2 erythemal irradiance limit in 65% of the sunbeds measured and inadequate provision of artificial tanning services.

Purpose. EEAE initiated specific actions in order: (i) to raise public awareness regarding artificial tanning, (ii) to synchronize the artificial tanning sector in Greece with the EU requirements and (iii) to introduce the national legislation for the control and regulation of the artificial tanning sector in Greece, since no relevant national legislation exists.

Materials and methods. The requirements set by the ELOT EN 60335-2-27:2013, ELOT EN 16489-1:2014, ELOT EN 16489-2:2015 and ELOT EN 16489-3:2015 technical standards as well as the recommendations provided by the EU and international organizations (e.g. WHO, ICNIRP) were used.

Results. A national code of practice for the provision of the artificial tanning services and an online training course for the sunbeds' operators were developed. Moreover, informative material was developed in order to raise public awareness regarding the artificial

tanning hazards and to guide the users through the approved artificial tanning procedures. Finally, a proposal for the formulation of the upcoming national legislation for the control and regulation of the artificial tanning sector in Greece was introduced.

Conclusion. Results of the first surveillance action conducted in Greece demonstrated the necessity of regulating the artificial tanning sector and underline the importance of continuing the relevant controls and the public awareness campaigns in Greece.

Disclosure. Authors disclose that they don't have any interests or relationships that may bias their presentation.

http://dx.doi.org/10.1016/j.ejmp.2016.07.513

EFFECTS OF ADAPTIVE RESPONSE INDUCED BY LOW-DOSE IONIZING RADIATION ON IMMUNE SYSTEM IN SPLEEN LYMPHOCYTES OF BALB/C MICE

Mohammad Taghi Bahreyni Toossi [a,*], Sepideh Abdollahi Dehkordi [b], Mojtaba Sankian [c], Hosein Azimian [a], Maryam Najafi Amiri [b], Sara Khademi [d]

[a] *Medical Physics Research Center, Mashhad University of Medical Sciences, Mashhad, Iran*
[b] *Departments of Medical Physics, Mashhad University of Medical Sciences, Mashhad, Iran*
[c] *Immunobiochemistery Lab, Bu-Ali (Avecina) Research Center, Mashhad University of Medical Sciences, Mashhad, Iran*
[d] *Departments of Medical Physics and Biomedical Engineering, Tehran University of Medical Sciences, Tehran, Iran*
* Corresponding author.

Introduction. Radioadaptive response (RAR) describes the phenomenan where low dose (called the 'priming dose') of ionizing radiation (IR) reduces harmful effects of subsequent higherdoses of IR (called the 'challenge dose').

Purpose. The aim of this study was to investigate the role of immune system genes in the adaptive response induced by low-dose of ionizing radiation.

Materials and methods. Mice were exposed to γ-rays from a ^{60}Co source, to a series of priming and challenge doses at 31 mGy/min and 449 mGy/min respectively. Challenge dose was delivered 24 h following to priming dose. Expression level of two genes; IFN-γ IL-4 were examined by relative quantitative real-time polymerase chain reaction (RT-PCR) in 24 h after exposure. The non-parametric two independent samples T-test were performed to compare mean of gene expression level.

Results. The results of this study showed that the gene expression of both IL-4 and IFN-γ values significantly reduced after receiving high doses ($P < 0.0001$) whereas IL-4 gene expression level increased after low dose. Interestingly, there was no significant difference between IL-4 and IFN-γ genes expression of the adaptive and control group. Gene expression of TGF-βafter low and high dose and adaptive group significantly reduced ($P < 0.001$). The ratio of IFN-γ/IL-4 for high dose group was increased significantly ($P < 0.0001$).

Conclusion. These results are evident for that ionizing radiation may play a role in Th1 and Th2 cytokine expression immune response shift of Th1 cells toward Th2 after low and high dose radiation. Adaptive response to ionizing radiation induced by low dose of gamma ray can reduce the harmful effect of the radiation.

Disclosure. There is not any relationship that might lead to a conflict of interest. Mashhad University of Medical Sciences (MUMS) has financially supported this work.

http://dx.doi.org/10.1016/j.ejmp.2016.07.514

THE IMPORTANCE OF COLOR QUALITY ASSURANCE OF MEDICAL DISPLAYS

Ir. W.A. Mahn *, Ir. A.A. Becht

Gelre ziekenhuizen, The Netherlands
* Corresponding author.

Introduction. Medical images are increasingly analyzed based on color by departments such as Nuclear Medicine, Dermatology, Plastic Surgery, Pathology and Gastroenterology to mark a tumor, to observe hematoma and to discriminate between benign and malignant tissues.

Purpose. The purpose of this research is to create awareness concerning the importance of color quality assurance and to develop and test a method to review color displays analog to the Grayscale Standard Display Function.

Materials and methods. In our hospital several displays (diagnostic, medical review, professional and consumer display) were measured with a luminance-colorimeter (Iba: LXchroma). Since standardized color test patterns don't exist, test patterns were developed according to the DICOM standard analog to the TG-18LN steps for each primary (RGB) and secondary color (CMY). The chromaticity coordinate and luminance of each color-contraststep was measured. The metric distance within the perceptive color space CIE1976 (CIEDE2000) between the steps for each color was calculated. A distance of $\geqslant 2.3$ corresponds to a just noticeable difference (JND), which was empirically determined using MacAddams-ellipses.

Results. Results show that the measured displays poorly visualize the provided contrast steps. Furthermore, the available color space of the display could be restricted due to the small luminance range.

Conclusion. Medical displays should be included in a color quality assurance program to prevent possible misdiagnosis, although there are no practical guidelines or standard criteria available yet.

The color contrast behavior of a medical display could be reviewed using the CIEDE2000 metric, but display manufactures should focus on calibration possibilities to optimize the CIEDE2000 metric to the empirical JNDs.

Disclosure. Nothing to disclose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.515

HAMP QUALITY ASSURANCE PROTOCOL OF HYPERTHERMIA SYSTEMS

S. Triantopoulou [a,*], C. Antypas [b], P. Karaiskos [c], C. Armpilia [b], K. Platoni [a], V. Kouloulias [d]

[a] *Medical Physics Unit, 2nd Department of Radiology, Attikon Hospital, National and Kapodistrian University of Athens, Greece*
[b] *Medical Physics Unit, 1st Department of Radiology, Aretaieion Hospital, National and Kapodistrian University of Athens, Greece*
[c] *Medical Physics Laboratory, Medical School, National and Kapodistrian University of Athens, Greece*
[d] *Radiotherapy Unit, 2nd Department of Radiology, Attikon Hospital, National and Kapodistrian University of Athens, Greece*
* Corresponding author.

Introduction. Hyperthermia is an anticancer modality that uses non-ionizing radiation and performed in conjunction with radiotherapy or chemotherapy. The efficacy of hyperthermia depends on the controlled temperature increase of the tumor cells to 40– 45 °C. Treatment complications and side-effects are minimized when the temperature rise is maintained within the therapeutic range during the whole treatment session.

Purpose. To establish a protocol for quality assurance (QA) of Hyperthermia equipment in Greece in order to demonstrate the

need of system performance evaluation by medical physicists assuring proper operation of such equipment.

Materials and Methods. The proposed protocol is the result of the Hyperthermia Committee of the Hellenic Association of Medical Physicists (HAMP) in an attempt to standardize the quality assurance procedures followed in hyperthermia applications in Greece. QA procedures proposed are based on national and international experience and on corresponding protocols of other national and international committees taking into account and incorporating the latest achievements and equipment currently used in hyperthermia applications.

Results. The protocol suggests QA procedures for all types of hyperthermia methods such as superficial, intracavitary, deep-tissue heating and whole-body Hyperthermia as well as frequency for each test. Basic quality control tests include performance evaluation and testing of the correct operation of the thermometry equipment, the generator, the power measurement device, and the applicators. Tests for electrical and radiation safety are also included. The proposed necessary equipment should be accordingly calibrated and consists of a thermometer, a heat insulated container, a muscle-equivalent phantom, a power meter, a 50-ohm load, a digital frequency counter and an isotropic radiation survey meter.

Conclusion. HAMP established a protocol for quality assurance of all types of Hyperthermia systems to be followed by medical physicists in Greece for efficient treatment delivery with patient and personnel safety. The protocol has been approved by the Hellenic Society of Oncologic Hyperthermia.

Disclosure. No disclosure.

http://dx.doi.org/10.1016/j.ejmp.2016.07.516

LET QUENCHING CORRECTION IN SOLID STATE DOSIMETERS

G. Gambarini [a,b,*], E. Artuso [a], G. Camoni [a], G. Colombo [a], M. Felisi [a], A. Gebbia [a], E. Massari [a], I. Veronese [a,b], D. Giove [b], M. Carrara [c], F. d'Errico [d]

[a] *Department of Physics, Università degli Studi di Milano, Milano, Italy*
[b] *National Institute of Nuclear Physics (INFN), Section of Milan, Milano, Italy*
[c] *Fondazione IRCCS Istituto Nazionale dei Tumori, Milano, Italy*
[d] *Scuola di Ingegneria, Università di Pisa (Italy) and Yale University, School of Medicine, New Haven, CT (USA)*
* Corresponding author.

Introduction. The increasing improvement and application of hadrontherapy calls for appropriate dosimetric methods. A general limit of solid state dosimeters is the quenching of the sensitivity with increasing radiation LET.

Purpose. Aims of this work are the study of the quenching phenomena observed in various dosimeters exposed to charged particles, and the development of a reliable, general method to amend the measured values in order to achieve correct dose values.

Materials and methods. The investigated dosimeters were laboratory-made Fricke-gel dosimeters, gafchromic EBT3 films and thermoluminescence detectors (TLDs).

Fricke-gel dosimeters and EBT3 films were analyzed by detecting variations in optical density (ΔOD). In photon fields, ΔOD is proportional to the absorbed dose, but in charged particles fields it is affected by the quenching effect. TLDs were read out with a Harshaw/Bicron TLD unit.

Irradiations were performed with photons, protons of various energies and charged particles generated by thermal neutrons.

Results. A method for correcting the 2D dose maps acquired with gel dosimeters and EBT3 films exposed to hundreds of pencil beams of protons (as is done in radiotherapy) is proposed. The response correction is done with our original code that utilizes the treatment plan file as input data. Our algorithms are based on quenching correction maps obtained by comparing measured and calculated Bragg peaks images. Analogous methods for TLDs are in development.

Conclusion. The proposed methods for amending the dosimeter responses have proved to be very promising.

Disclosure. Authors declare no relationship that may bias the presentation.

http://dx.doi.org/10.1016/j.ejmp.2016.07.517

EFFECT OF SHIELDING ON PELVIC AND ABDOMINAL IOERT DOSE DISTRIBUTIONS

Alessandro Esposito [a,c,d,*], Taxiarchis Sakellaris [a], Patrícia Limede [a], Filipa Costa [b], Luis T. Cunha [b,c], Anabela Gregório Dias [b,c], Joana Lencart [b,c], Sandra Sarmento [b,c], Carla Carmelo Rosa [a,d]

[a] *INESC-TEC, Porto, Portugal*
[b] *Medical Physics, Radiobiology and Radiation Protection Group, Research Centre, Portuguese Institute of Oncology, Porto, Portugal*
[c] *Medical Physics Department, Portuguese Institute of Oncology, Porto, Portugal*
[d] *Departamento de Física e Astronomia, Faculdade de Ciências, Universidade do Porto, Porto, Portugal*
* Corresponding author.

Introduction. Intra-Operative Electron Radiation Therapy (IOERT) uses high-energy electron beams to irradiate the tumour bed during surgery, while healthy tissues are shielded or moved away. Monte Carlo (MC) simulations are a powerful tool to study the dosimetric effects of shields, with high level of detail and visualization.

Purpose. To obtain graphical and quantitative evaluations, which can be used by radiation oncologists to optimize the use of shielding during pelvic and abdominal IOERT.

Materials and methods. For this work, an adapted LINAC Varian CLINAC 2100CD was used. The IOERT model was built on the basis of Varian MC Package using BEAMnrc and EGSnrc, and assessed by Gamma analysis (2%, 2 mm). The minimum lead thickness required for an efficient shield was determined and several shielding configurations were simulated to build a set of clinically relevant scenarios. The effect of bone beneath the shielded tissue was studied.

Results. 98% of Gamma points <1 in reference and non-reference conditions proved the reliability of IOERT model. A lateral hot-spot is a consequence of insufficient shielding. Sufficient shield thickness ensures consistent dose reduction near the surface, but lateral scattering phenomena enlarge the dose distribution deeper in the phantom. This effect is more relevant when a bevelled applicator is used. The presence of bone reduces the magnitude of this effect.

Conclusion. Radio-oncologists need to be aware of the effect of lateral scattering when using shielding and bevelled applicators. Since lateral scattering is independent from shield thickness, only a geometrical rearrangement can minimize this effect.

Disclosure. The authors have no relevant financial or non-financial relationships to disclose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.518

MONTE-CARLO DOSE COMPUTATION IN RADIOTHERAPY FOR LUNG AT VERY LOW DENSITY

Sara Beilla [a,*], Tony Younes [a], Laure Vieillevigne [a,b], Manuel Bardies [a], Xavier Franceries [a], Luc Simon [a,b]

[a] *CRCT UMR1037 Inserm / Universite Toulouse III Paul Sabatier, 2 avenue Hubert Curien, CS 53717, 31037 TOULOUSE CEDEX 1, Toulouse, France*

[b] *IUCT Oncopole, Département Ingénierie et Physique Médicale, F31000 Toulouse, France*
* Corresponding author.

Introduction. In radiotherapy, some limits of clinical algorithms have been reported in low-density media. When patients are treated during Deep Inspiration Breath-Hold (DIBH), lung density can fall to 0.12 g cm^{-3}. Dose calculation with this density must be validated, in particular for Stereotactic (SBRT) treatment.

Purpose. We propose to evaluate the performance of Eclipse AAA algorithm (Varian) for SBRT lung treatment (including DIBH) with a Monte-Carlo model based on Geant4 (GATE). GATE, AAA, and measurements are compared for several phantoms including lung heterogeneity.

Materials and methods. A model of the Varian TrueBeam head was modelled using GATE. Validation was achieved by comparison with measurements in a homogeneous water tank for several static fields (3×3 to 20×20 cm^2) and four beam modes. Subsequently, two phantoms containing layers of water-equivalent material and cork, corresponding to lung during DIBH and free-breathing (0.12 and 0.24 g cm^{-3}) were implemented. Percentage depth dose (PDD) measured by Gafchromic films were compared to AAA and GATE.

Results. GATE model showed a good agreement with experimental results in homogeneous and heterogeneous phantoms. In lung heterogeneity, differences were observed between AAA and measurements. These differences are higher for small fields and lower densities. As an example, for 3×3 field size inside a 0.12 g cm^{-3} heterogeneity, relative dose was 56,6%, 56,2%, and 67,5% for measurement, GATE, and AAA respectively.

Conclusions. In very low densities, AAA quickly showed its limits while GATE was validated. This will allow us to perform calculations for non measurable cases, for example patients treated by SBRT during DIBH.

http://dx.doi.org/10.1016/j.ejmp.2016.07.519

EXPERIMENTAL CHARACTERIZATION OF THE NEUTRON SPECTRA GENERATED BY A HIGH-ENERGY CLINICAL LINAC USING NEUTRON ACTIVATION METAL DETECTORS

E. Vagena [a,*], K. Theodorou [b], S. Stoulos [a]

[a] *Laboratory of Atomic and Nuclear Physics, School of Physics, Aristotle University, Thessaloniki, Greece*
[b] *School of Medicine, University of Thessaly, Larisa, Greece*
* Corresponding author.

Introduction. Electron linacs accelerate high-energy electron beams to impinge on high Z targets producing bremsstrahlung photons. Due to high operational energy of this type of linacs a significant number of neutrons are created by (γ,n) reactions.

Purpose. The main objective of this work is to report the results of an experimental characterization of the neutron spectra generated by a high-energy clinical LINAC. The photoneutron contamination of an ELEKTA is investigated in detail in its 15 MV photon mode.

Materials and methods. We developed a technique for neutron dosimetry based on neutron activation of different metal detectors. This system offers the possibility to measure neutrons over a wide energy range at intense and complex mixed n–g fields. To obtain the neutron spectrum from the activation technique, measurements must be unfolded. A method for unfolding the neutron energy spectra has been developed using the Minuit minimization.

Results. The unfolded procedure reproduced reasonably well the physical expectation of two peaks in the spectrum. Both peaks are located in the correct energy region; from 1e-8 to 1e-6 MeV the thermal component and from 0.05 to 1 MeV the fast. The fast part of the spectrum gives two peaks at energies of 0.1 and 0.8 MeV. The thermal peak corresponds to the 15% of the total neutron fluence and the fast component covers ~70% of the neutron spectrum.

Conclusion. The unfolded procedure using the Minuit minimization reproduced reasonably well the physical expectation of two peaks in the spectrum.

http://dx.doi.org/10.1016/j.ejmp.2016.07.520

EPR ANALYSIS OF DOSIMETRIC PROPERTIES OF VARIOUS ORGANIC MATERIALS FOR RADIOTHERAPY APPLICATIONS

A. Belahmar [*], M. Mikou, A. Mamadou Saidou, M. Bougteb

Laboratory: Analysis of Systems and Information Processing, Hassan 1st University, Faculty of Science and Technology; BP 577, 26000 Settat, Morocco
* Corresponding author.

Introduction. Electron Paramagnetic Resonance (EPR) spectroscopy is a sensitive, precise and nondestructive technique. It is used in this study to analyze alanine, sugar and glucose irradiated by electrons. These materials are available and nontoxic, their irradiation produces free radicals in which the concentration is relatively proportional to the absorbed dose. In this work, we analyze and compare the dosimetric properties of these materials with the aim of using them for in vivo dosimetry in radiotherapy.

Purpose. In this study we compare the dosimetric properties after electron irradiation of alanine, sugar and glucose, by considering their sensitivity to irradiation, the shape of obtained dosimetric curves and the stability of EPR spectra during storage period.

Materials and methods. Several samples of alanine, sugar and glucose are irradiated by 6 MeV electrons (Dose range: 0–20 Gy) provided by a linear accelerator "Clinac 2300DHX" used in radiotherapy care. After irradiation, EPR measurements on samples are undertaken using a "Magnettech – MS400" spectrometer. These measurements are processed using peak to peak and double integration methods.

Results. Suitable sensitivity to irradiation observed for the used materials (Threshold dose: alanine, 1 Gy; sugar, 1.5 Gy; glucose, 2 Gy),

- Good linearity of dosimetry curves in the dose range used.
- Weak fading of EPR signal during storage period after irradiation especially in the case of alanine and sugar.

Conclusion. In this preliminary study, the obtained results showed that alanine and sugar are very promising materials for their applications in *in vivo* dosimetry in radiotherapy.

Disclosure. Authors do not have any relationships with commercial entities to disclose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.521

MULTICHANNEL FILM DOSIMETRY VS 2D-ARRAY SEVEN29 FOR VMAT LUNG SBRT

J.F. Mata-Colodro [a], A. Serna [a,*], V. Puchades-Puchades [a], D. Ramos-Amores [a], J.A. Vera-Sanchez [b], M. Alcaraz-Banos [c]

[a] *Department of Medical Physics, Santa Lucia Universitary Hospital, Cartagena, Spain*
[b] *Department of Medical Physics, Sant Joan de Reus Universitary Hospital, Tarragona, Spain*
[c] *Department of Radiology and Physical Medicine, Faculty of Medicine, University of Murcia, Spain*

* Corresponding author.

Introduction. Volumetric Modulated Arc Therapy (VMAT) can achieve high conformation and gradient levels required to deliver Stereotactic Body Radiation Therapy (SBRT). Quality Assurance (QA) usually includes a 2D gamma analysis.

Here we compare two different QA procedures for VMAT lung SBRT treatments.

Materials and methods. Fourteen patients were selected. Dose per fraction ranged between 7.5 and 18 Gy. OCTAVIUS phantom (PTW) was used in both QA arrangements:

1. PTW 2D-ARRAY seven29 consists of a matrix of 729 cubic vented ionization chambers spaced 1 cm. To duplicate the resolution from 1 to 0,5 cm the ‘‘Merge” algorithm included in Verisoft software was used.
2. EBT3 radiochromic film with multichannel dosimetry was used. Also we applied the ‘‘efficient protocol” (Lewis, Mike and Yu, 2012) that provides specific calibration curves for each individual irradiation. Scanning was made with an Epson 10000XL, resolution was 72 dpi. Dose maps were created with Matlab.

Gamma analysis criteria of 3%/3 mm and 2%/2 mm relative to maximum (MD) and local (LD) doses were performed.

Results. 3%/3 mm criteria: MD analysis produced averaged pass rates of 100% in both test. LD analysis gave 99.1% for EBT3 and 97.2% for 2D-array.

A. 2%/2 mm criteria: MD analysis for EBT3 gave 98.9% and 90.8% for 2D-array. Also LD analysis gives 93.5% and 86.8% respectively.

EBT3 provides more resolution and gives higher pass rates compared with 2D array. 3%/3 mm seems not to be an appropriate criterion. 2%/2 mm was more sensitive and gives pass rates above 96% and 91% for maximum and local dose respectively.

Conclusion. 2%/2 mm local dose gamma analysis of EBT3 using multichannel dosimetry gives excellent results for VMAT lung SBRT.

Disclosure. None.

http://dx.doi.org/10.1016/j.ejmp.2016.07.522

DOSIMETRIC EVALUATION OF THE DOSE CALCULATION ACCURACY OF DIFFERENT ALGORITHMS FOR TWO DIFFERENT TREATMENT TECHNIQUES DURING WHOLE BREAST IRRADIATION

P. Pacaci *, M.S. Cebe, H. Mabhouti, G. Codel, E. Serin, E. Sanli, M. Doyuran, E. Kucukmorkoc, A. Altinok, D. Canoglu, N. Kucuk, H. Acar, H. Caglar

Istanbul Medipol University, Radiation Oncology Department, Turkey
* Corresponding author.

Purpose. In this study, dosimetric comparison of field in field (FIF) and intensity modulated radiation therapy (IMRT) techniques used for treatment of whole breast radiotherapy (WBRT) were made. The dosimetric accuracy of treatment planning system (TPS) for Anisotropic Analytical Algorithm (AAA) and Acuros XB (AXB) algorithms in predicting PTV and OAR doses was also investigated.

Methods. Two different treatment planning techniques of left-sided breast cancer were generated for rando phantom. FIF and IMRT plans were compared for doses in PTV and OAR volumes including ipsilateral lung, heart, left ascending coronary artery, contralateral lung and the contralateral breast. PTV and OARs doses and homogeneity and conformality indexes were compared between two techniques. The accuracy of TPS dose calculation algorithms was tested by comparing PTV and OAR doses measured by thermoluminescent dosimetry with the dose calculated by the TPS using AAA and AXB for both techniques.

Results. IMRT plans had better conformality and homogeneity indexes than FIF technique and it spared OARs better than FIF. While both algorithms overestimated PTV doses they underestimated all OAR doses. For IMRT plan, PTV doses, overestimation up to 2.5% was seen with AAA algorithm but it decreased to 1.8% when AXB algorithm was used. Based on the results of the anthropomorphic measurements for OAR doses, underestimation greater than 7% is possible by the AAA. The results from the AXB are much better than the AAA algorithm. However, underestimations of 4.8% were found in some of the points even for AXB. For FIF plan, similar trend was seen for PTV and OARs doses in both algorithm.

Conclusions. When using the Eclipse TPS for breast cancer, AXB the should be used instead of the AAA algorithm, bearing in mind that the AXB may still underestimate all OAR doses.

http://dx.doi.org/10.1016/j.ejmp.2016.07.523

SIMULTANEOUS MEASUREMENT OF IRON CONCENTRATION AND FAT INFILTRATION IN THE LIVER WITH A SINGLE-BREATHHOLD 16-ECHO GRADIENT ECHO SEQUENCE

E.D. Gotsis [a,*], D.E. Gotsis [b], P. Karaiskos [b], I. Seimenis [c]

[a] *Institute Euromedica-Encephalos, Halandri, Greece*
[b] *University of Athens, Medical School, Department of Medical Physics, Athens, Greece*
[c] *Democritus University of Thrace, Medical School, Medical Physics Laboratory, Alexandroupolis, Greece*
* Corresponding author.

Introduction. In the past few years there have been several methods to determine fat infiltration of the liver, some of them being expensive commercial applications for MRI or expensive services provided by some companies to which the MRI data are sent for evaluation. β-Thalassemia patients with liver iron overload and fat infiltration require determination of both.

Purpose. To develop and certify a method for simultaneous determination of iron overload and fat infiltration of the liver with a 16-echo single breath-hold gradient echo sequence and compare the calculated results of fat infiltration with those determined by Proton MR spectroscopy (MRS) of the liver.

Materials and methods. 500 patients were examined at 1.5 Tesla (Signa HDxt, GE, Milwaukee, USA) with a 16-echo sequence at two different echo time ranges (a short and a long one for moderate and low iron overload, respectively). A least-squares-fit of the acquired data yielded $T2^*$ values and fat fraction. MR spectra from the liver were acquired from 40 patients.

Results. The agreement for liver fat infiltration determined by the proposed MRI technique and the MRS method was excellent. The gradient echo method is sensitive enough for fat fractions as low as 1%. Fat infiltration results are accurate for iron concentrations as high as 10 mg/g dry tissue.

Conclusion. The gradient-echo method is quick and accurate and is a reliable alternative to other expensive methods. Furthermore it provides iron overload and fat infiltration determination simultaneously, in a single breath-hold.

Disclosure. None of the authors has anything to declare.

http://dx.doi.org/10.1016/j.ejmp.2016.07.524

IN VIVO PROTON MR SPECTROSCOPY OF GLIOMATOSIS CEREBRI: DIAGNOSIS AND EXPLORATION OF TUMOR METABOLISM

E.D. Gotsis [a,*], D.S. Gkotsi [b], G. Pissakas [c], I. Seimenis [d]

[a] *Institute Euromedica-Encephalos, Halandri, Greece*
[b] *Univeristy of St Andrews, Department of Chemistry, St Andrews, Scotland, United Kingdom*
[c] *General Hospital "Alexandra", 2nd Oncologic Clinic, Athens, Greece*
[d] *Democritus University of Thrace, Medical School, Medical Physics Laboratory, Alexandroupolis, Greece*
* Corresponding author.

Introduction. Gliomatosis cerebri was not recognised as a separate entity till a few years ago and it was thought to be a rare entity. Advanced imaging methods and *In Vivo* Proton MR spectroscopy (MRS) have contributed to the safe diagnosis of the disease, which is not such a rare entity as once thought.

Purpose. To explore the capabilities of *In Vivo* Proton MR Spectroscopy not only for diagnosing the disease but also for exploring the metabolism of the tumor cells.

Materials and methods. In an extended period of 16 years, 147 patients were diagnosed with gliomatosis cerebri by *In Vivo* MR Spectroscopy (single voxel at selected areas and 3D Spectroscopic Imaging). Metabolic maps of choline and creatines showed tumor infiltration. For some patients serial MRS was also performed.

Results. In virtually all cases except one – a patient diagnosed with gliomatosis cerebri for whom the biopsy showed limbic encephalitis – biopsy confirmed a "glioma" or in cases without biopsy the progress of the disease confirmed the MRS diagnosis. What was a surprise was that in most cases creatine concentration was higher than normal leading to the notion that part of the tumor cells maintain for some time normal cell metabolism (aerobic glycolysis). With advance of time, the metabolism switches to the primitive tumor cell metabolism.

Conclusion. *In Vivo* Proton MR Spectroscopy is a potent probe for the diagnosis of gliomatosis cerebri as well as for exploring tumor cell metabolism.

Disclosure. None of the authors has anything to declare.

http://dx.doi.org/10.1016/j.ejmp.2016.07.525

TREATMENT PLAN VERIFICATION IN MRGFUS FOR BONE METASTASIS PAIN PALLIATION

D. Bianchini *, F. Marcocci, E. Menghi, V. D'Errico, E. Mezzenga, A. Sarnelli

Medical Physics Department, Istituto Scientifico Romagnolo per lo Studio e la Cura dei Tumori (IRST) IRCCS, Meldola (FC), Italy
* Corresponding author.

Introduction. Focused ultrasound are recently introduced as alternative therapy for pain palliation caused by bone metastases. The heat absorption and propagation in the soft tissues and in the bones strongly depends on the correct focalization of the ultrasonic beam through the interfaces. The real-time thermal map provided by the MRI gives to the interventional radiologist the feedback for the online treatment planning.

Purpose. The present work is focused on the verification of planning therapy system of a MRgFUs system giving a verification of the propagation and the accumulation of the temperature in bones in particular for the pelvic bone.

Materials and methods. In this work it has been studied the Philips Sonalleve HIFU installed on Ingenia 3T. The thermal maps has been studied on a multi-interface phantom with albumin-agarose gel volumetric detector. The planned volume ablation temperature has been compared with the T2 imaging modification on the phantom. A dedicated software has been developed for the extraction of the thermal image maps from the system and for the evaluation of the cumulative thermal dose. A first approach has been proposed for the evaluation of the plan in term of DVH (dose/volume histogram).

Results. High impedance interfaces create local depositions of energy along the sonicated surfaces. The plan cumulative dose verification gives constraints to the physicians on sonication cells positioning.

Conclusion. The MRgFUs feedback planning gives partial information of the heat deposition. The bone phantom is used to evaluate the real cells volume. The de-focalization created by bones demonstrate the needs of preplanning system dedicated to bones treatments.

http://dx.doi.org/10.1016/j.ejmp.2016.07.526

A METHOD FOR FAST 3D IMAGING OF CONTRAST ENHANCED VESSELS OR CATHETERS USING MAGNETIC RESONANCE PROJECTIONS

M. Unan [a], I. Seimenis [b,*], A.G. Webb [c], N.V. Tsekos [a]

[a] *Medical Robotics Laboratory, Dept of Computer Science, University of Houston, Houston, TX, USA*
[b] *Democritus University of Thrace, Medical School, Medical Physics Laboratory, Alexandroupolis, Greece*
[c] *C.J. Gorter Center for High Field MRI, Leiden University Medical Center, Leiden, Netherlands*
* Corresponding author.

Introduction. With a plethora of soft-tissue contrast mechanisms, lack of ionizing radiation and on-the-fly computer controller adjustment of imaging parameters, MRI has emerged as an alternative modality for guiding interventions. However, due to its inherent low signal sensitivity, conventional MRI cannot achieve the high speeds of X-ray fluoroscopy.

Purpose. To address this, we describe a novel approach for 3D MRI of tubular structures such as blood vessels or catheters, based on the collection of thick slab spatially matched projections.

Materials and methods. The implemented method includes the following: three elements. (1) Collection of three orthogonal projections of the same volume that contains the structure with a GRE (TR/TE = 26.07/3.71 ms, angle = 75°, matrix = 256 × 256, FOV = 200 × 200 mm^2, slice = 200 mm). (2) Segmentation of the 2D structures on the three projections. (3) Reconstruction of the 3D structure by back projection. The method was tested on phantoms with vessel-mimicking structures made of tubing filled with 2% Gd-agent in a fatty matrix. The ground truth was an MRA (128 slices, TR/TE = 3.8/1.52 ms, angle = 40°, matrix = 384 × 264, FOV = 191 × 131 mm^2, slice = 1.3 mm).

Results. The 3D centerline of the rendered structures was extracted and then found to be virtually the same (±pixel) to this extracted from a multislice MRA of the same structure.

Conclusion. The method can accurately image 3D tubular object in 20 s as compared to 186 s with the used MRA.

Disclosure. None of the authors has anything to declare.

http://dx.doi.org/10.1016/j.ejmp.2016.07.527

ASSESSMENT OF TOTAL GEOMETRIC DISTORTION IN MR IMAGES USED IN INTRACRANIAL STEREOTACTIC RADIOSURGERY

Mukhtar Alshanqity [a], Eleftherios P. Pappas [b,*], Pantelis Karaiskos [b], Argyris Moutsatsos [b], Khalid Alsafi [a], Hani Lababidi [a], Evangelos Georgiou [b]

[a] *King Fahad Medical City, Riyadh, Saudi Arabia*

[b] *Medical Physics Laboratory, Medical School, National and Kapodistrian University of Athens, 75 Mikras Asias, 115 27 Athens, Greece*
* Corresponding author.

Introduction. In Stereotactic Radiosurgery (SRS), MR-images are widely used for target localization and delineation in order to take advantage of the superior soft tissue contrast they exhibit. However, spatial dose delivery accuracy may be deteriorated due to geometric distortions inherent in MRI.

Purpose. To develop and implement a quality control procedure for the assessment of total geometric distortion in MR-images clinically employed in SRS treatment planning.

Materials and methods. A specially designed acrylic-based phantom was utilized. In particular, the phantom encompasses five planes on which 947 3-mm diameter holes are drilled. The centers of mass of these holes serve as control points for geometric distortion detection. In terms of imaging the phantom is both CT and MR compatible. The phantom was MR-imaged at 1.5T (GE-Optima) and 3T (Siemens-Skyra). CT-detected control point locations served as the reference distribution. Distortion evaluation was performed for three typical pulse sequences used for SRS treatment planning using in-house developed software. The effect of specific imaging parameters on geometric distortion was also investigated.

Results. Overall geometric accuracy of the 1.5T scanner was found slightly superior than the 3.0T scanner for the specific sequences investigated (mean distortion values: 0.6 mm and 0.8 mm, respectively). However, the 1.5T unit exhibits increased distortion on *z*-axis in regions distant from the scanner's isocenter (maximum detected distortion was 2.7 mm). Accuracy of the developed distortion detection algorithm was estimated to be 0.24 mm.

Conclusion. Phantom and methods developed in this multicenter study were found efficient for distortion characterization of MR pulse sequences used in SRS.

http://dx.doi.org/10.1016/j.ejmp.2016.07.528

FEASIBILITY OF FAT FRACTION QUANTIFICATION BY MEASURING J-COUPLING RELATED SIGNAL MODULATION IN MULTI ECHO FAST SPIN ECHO SEQUENCES

K. Nikiforaki [a,*], T. Boursianis [c], G.C. Manikis [a], K. Marias [a], A. Karantanas [c], T.G. Maris [b]

[a] *Computational Medicine Laboratory, Institute of Computer Science, Foundation for Research and Technology, Heraklion, Greece*
[b] *Department of Medical Physics, University of Crete, Heraklion, Greece*
[c] *Department of Radiology, University of Crete, Heraklion, Greece*
* Corresponding author.

Introduction. Echo spacing in Fast Spin Echo techniques can affect signal intensity mainly of fatty tissue and is presented as effectively prolonged T2 relaxation time (magnetic fat liquefaction).

Purpose. The aim of this study is to measure signal intensity in multi echo Fast Spin Echo techniques with variable echo spacing in order to examine the feasibility of fat quantification from J-coupling related signal modulation.

T2 maps were calculated from all different acquisition schemes.

Materials and methods. A phantom containing porcine fat, vegetable oils, gadolinium doped agarose gels that mimic fat magnetic relaxation properties, double distilled water at controlled temperature of 36–38 °C was scanned at 1.5 T utilizing a single slice multi echo SE technique with equidistant echoes of variable TE intervals (6.7–40 ms).

Results. Fat signal modulation as a function of echo spacing varied significantly between short and long echo spacing acquisitions (28.97–56.26%) and this dependence could be approximated by a linear sequence ($\Delta S_{fat} = S_{short\ ESP} - S_{long\ ESP} = 3.38{*}n{*}TE + 27.18$, residual 7,88 for n ranging from 1 to 12) for a wide range of routinely used TEs in clinical practice (13.4–160.8 ms) while effect on water was minimal ($\Delta S_{water} = 22.11\%$, SD for same TE range: 0.53). Difference of calculated T2 relaxation times between sequences with different echo spacing ranged from 9.5 to 35%.

Conclusion. Echo spacing in MESE sequences may serve as a metric of signal manipulation and fat quantification. Bright fat sequences should be avoided for T2 relaxation parametric maps.

http://dx.doi.org/10.1016/j.ejmp.2016.07.529

PRELIMINARY STUDY FOR NON-INVASIVE MAGNETIC RESONANCE IMAGING AND SPECTROSCOPY OF THE EYE: A NOVEL TECHNIQUE FOR MONITORING PHARMACOKINETICS OF OCULAR DRUG DELIVERY

Irene Tsiapa [a,b,*], Themistoklis Boursianis [a], Georgios Kalaitzakis [a], Katerina Nikiforaki [a], Efrosini Papadaki [c], George Bontzos [b], Apostolos H. Karantanas [c], Miltiadis K. Tsilimbaris [b], Thomas G. Maris [a]

[a] *Department of Medical Physics, University of Crete, Heraklion, Crete, Greece*
[b] *Department of Ophthalmology, University Hospital of Crete, Heraklion, Greece*
[c] *Department of Radiology, University of Crete, Heraklion, Crete, Greece*
* Corresponding author.

Introduction. Conventional pharmacokinetic methods for studying ocular drug delivery are invasive and cannot be conveniently applied to humans. The development of non-invasive techniques in monitoring pharmacokinetics of ocular drug delivery is of vital importance.

Purpose. The aim of this study was to develop a novel clinical technique that permits monitoring of in vivo intravitreal drug pharmacokinetics based on both Hydrogen Magnetic Resonance Spectroscopy (H-MRS) and/or quantitative Magnetic Resonance Imaging (qMRI) methodologies.

Materials and methods. Advanced qMRI and H-MRS were performed using a high resolution clinical MRI eye protocol based on T1w and T2w 3D-sequences as well as a standard single voxel. H-MRS protocol utilizing a clinical 1.5T whole-body scanner enforced with a specially designed small coil apparatus for signal detection. H-MRS single voxel dimensions were ($1.5 \times 1.5 \times 1.5\ cm^3$). In vitro and ex vivo experiments were performed using pig eyes as reference standards and Flurbiprofen (a non-steroidal anti-inflammatory ocular drug) in concentrations 0.04 M–2 mM. All measurements performed at a fixed temperature of 37 °C utilizing an in-house developed temperature monitor/controller device.

Results. High resolution qMRI images and MRS spectra of the vitreous with and without the presence of ocular drugs at different concentrations were obtained. Characteristic H-MRS peaks on 1.5 and 7 ppm were observed on both Flurbiprofen concentrations. Differences on the relative NMR signal measurements were obtained using various Flurbiprofen concentrations. Characteristic water H-MRS peak on 4.7 ppm was observed in vitreous samples proved a valuable means for the assessment of pharmacokinetics on ocular drug delivery.

Conclusion. A clinical protocol of H-MRS and/or qMRI will become feasible with the development of a rapid, inexpensive, and automated technique that could be easily integrated on any conventional clinical MRI examination.

http://dx.doi.org/10.1016/j.ejmp.2016.07.530

HIGH RESOLUTION 3D MRI PROTOCOL OPTIMIZATION OF CORNEAL NEOVASCULARIZATION IN RABBITS

Irene Tsiapa [a,b,*], Themistoklis Boursianis [a], Efrosini Papadaki [c], Apostolos H. Karantanas [c], Penelope Bouziotis [d], Miltiadis K. Tsilimbaris [b], Thomas G. Maris [b]

[a] *Department of Medical Physics, University of Crete, Heraklion, Crete, Greece*
[b] *Department of Ophthalmology, University Hospital of Crete, Heraklion, Greece*
[c] *Department of Radiology, University of Crete, Heraklion, Crete, Greece*
[d] *Institute for Nuclear and Radiological Sciences, Technology, Energy and Safety, National Center of Scientific Research "Demokritos", Aghia Paraskevi-Athens, Greece*
* Corresponding author.

Introduction. Increasing interest in developing reliable and reproducible models to study angiogenesis has emerged due to recent advances in the treatment of eye disease with pathologic angiogenesis.

Purpose. The purpose of this study was to evaluate Corneal Neovascularization in rabbits using High Resolution Magnetic Resonance Imaging (HR-MRI).

Materials and methods. Animal experiments were performed with institutional Animal Care Committee approval. Corneal neovascularization was induced with a silk suture of the corneal stroma in 3 rabbits. A High-Resolution (HR) $84 \times 84 \times 600\ \mu m^3$ MRI protocol was developed on a 1.5-T clinical system and applied in the left eyes, utilizing a small field of view surface coil. The area of corneal neovascularization was evaluated before and after the intravenous injection of different concentrations (0.2–0.02 mmol/kgr) of gadolinium-DTPA. Signal-to-Noise Ratios (SNR) and Contrast-to-Noise Ratios (CNR) amongst specific eye anatomical areas were calculated for each sequence.

Results. The neovascularized area was clearly visualized using MRI system. High concentration of gadolinium provides better delineation and visualization of the neovascularized area as compared with lower concentrations of the contrast agent. Even though the highest concentration of the contrast agent provides the best overall image quality, the neovascularized area presents high SNR even with the lowest concentration of the contrast agent.

Conclusion. MRI offers unique advantages over existing ocular imaging techniques, including the ability to image multiple layers without depth limitation and to provide multiple clinically relevant data in a single setting.

http://dx.doi.org/10.1016/j.ejmp.2016.07.531

WHOLE BRAIN WHITE MATTER INTEGRITY MEASURES ON PATIENTS WITH MODERATE TO SEVERE TRAUMATIC BRAIN INJURY (TBI). FA AND ENTROPY ANALYSIS

Charalambos Yiannakkaras [a,*], Nikos Konstantinou [b,c], Eva Pettemeridou [c], Fofi Constantinidou [b,c], Eleni Eracleous [d], Savvas S. Papacostas [e], Ioannis Seimenis [a]

[a] *Department of Medical Physics, Medical School, Democritus University of Thrace, Alexandroupolis, Greece*
[b] *Center for Applied Neuroscience, University of Cyprus, Nicosia, Cyprus*
[c] *Department of Psychology, University of Cyprus, Nicosia, Cyprus*
[d] *Medical Diagnostic Center "Ayios Therissos", Nicosia, Cyprus*
[e] *Neurology Clinic B', The Cyprus Institute of Neurology and Genetics, and The Cyprus School of Molecular Medicine, Nicosia, Cyprus*
* Corresponding author.

Introduction. Mean Fractional Anisotropy (FA) along with Longitudinal and Transverse Apparent Diffusion Coefficients (ADC) are the established measures in assessing white matter (WM) integrity in TBI patients. A question is raised whether mean FA performs better than Shannon Entropy (SE) as a measure of discrimination between controls and patients with moderate to severe TBI.

Purpose. To assess WM integrity in moderate to severe TBI patients utilizing the established diffusion tensor measures, and compare FA with Shannon Entropy as measures of assessment of WM integrity.

Materials and methods. A group of 13 patients with moderate to severe TBI, 2–8 years post-ictus, has been compared with a group of 14 matched healthy controls. Diffusion Tensor Imaging (DTI) data were obtained at 3T with a pulse sequence employing 32 diffusion-encoding gradient directions. After data preprocessing, Tract Based Spatial Statistics (FSL-FMRIB) for FA, whole-brain histogram analysis for SE and Receiver Operating Curve (ROC) analysis for both FA and SE have been performed.

Results. Higher axial and transverse diffusivity and lower FA have been observed in TBI patients ($p < 0.02$) compared to controls. Area Under Curve (AUC): Skeletonized mean FA (0.8, $P = 0.007$), Global mean FA (0.8, $P = 0.0066$) and SE (0.8, $p = 0.008$).

Conclusion. Axial and transverse diffusivity are increased in TBI patients compared to controls. Diffuse Axonal Injury (DAI) is evident as global reduction of FA in TBI patients, which is driven by increased transverse diffusion changes. No significant difference is observed between FA and SE in TBI patient discrimination.

Disclosure. The authors declare no conflicts of interest including financial, consultant, institutional, and other relationships that might lead to bias or a any other conflict of interest. This work was supported by the Cyprus Research Promotion Foundation through a grant co-funded by the Cyprus Government and the European Regional Development Fund (F.C., PI; NEW INFRASTRUCTURE/STRATEGIC/0309/37). The authors would like to thank the study volunteers who participated in the project.

http://dx.doi.org/10.1016/j.ejmp.2016.07.532

Physica Medica 32 (2016) 251–273

Contents lists available at ScienceDirect

Physica Medica

journal homepage: http://www.physicamedica.com

Abstracts from the 1st European Congress of Medical Physics: Oral Papers|September 3rd, 2016

RELATIVE EFFICIENCY OF EBT3 RADIOCHROMIC FILMS TO PROTON AND CARBON ION BEAMS

Roberta Castriconi [a], Mario Ciocca [b], Alfredo Mirandola [b], Carla Sini [c], Sara Broggi [c], Marco Schwarz [d,e], Francesco Fracchiolla [d,e], Giovanni Mettivier [a], Paolo Russo [a,*]

[a] *Università di Napoli Federico II, Dipartimento di Fisica "Ettore Pancini", and INFN Sezione di Napoli, Napoli, Italy*
[b] *Centro Nazionale di Adroterapia Oncologica, Pavia, Italy*
[c] *Ospedale San Raffaele di Milano, Milano, Italy*
[d] *U.O. Protonterapia, Ospedale di Trento, Trento, Italy*
[e] *Trento Institute for Fundamental Physics and Applications (TIFPA), Istituto Nazionale di Fisica Nucleare (INFN), Trento, Italy*
* Corresponding author.

Introduction. Radiochromic films (EBT3) are adopted for dosimetric verification and for QA for radiotherapy; however, their use in hadrontherapy is limited to QA procedures. Indeed, a quenching effect occurs consisting of an under-response of the EBT3 film to ion beams with respect to MV-photon beams, at equal dose levels, due to the ion track structure.

Purpose. To investigate the response of EBT3 films irradiated with protons and carbon ions with respect to photons and electrons.

Materials and methods. The response of EBT3 films to protons and ^{12}C was investigated and compared in terms of Relative Efficiency (*RE*) with photons and electrons response (dose range 0.4–20 Gy).

Results. For protons (63–230 MeV) the *RE* is constant at 0.984 ± 0.004. For ^{12}C (115–400 MeV/u) the *RE* is less than unity. The line fit slope for each energy is consistent with zero and the intercepts are 0.695 ± 0.007 (115 MeV/u), 0.773 ± 0.007 (400 MeV/u) and 0.864 ± 0.007 (250 MeV/u).

Conclusion. For protons (63–230 MeV) the response of EBT3 is not different from that of photons within experimental uncertainties (2%). For ^{12}C (115–400 MeV/u) EBT3 films show an under-response with respect to photon beams. For ^{12}C ions the response of EBT3 film is dependent on the energy and the under-response is of about 31% for 115 MeV/u, 14% for 250 MeV/u and 23% for 400 MeV/u.

http://dx.doi.org/10.1016/j.ejmp.2016.07.534

EMPOWERING RADIATION THERAPY EFFECT THROUGH A NANOTECHNOLOGY BASED ENZYMATIC THERAPY

R.D. Esposito [a,*], D. Planes Meseguer [a], P. Dorado Rodríguez [a], V.M. Barberá [b], M. Saceda [c], L. Fernandez Fornos [d]

[a] *Medical Physics Department, ERESA-Hospital General Universitario de Elche, Elche (Alicante), Spain*
[b] *Molecular Genetics Laboratory, Hospital General Universitario de Elche, Elche (Alicante), Spain*
[c] *Celular and Molecular Biology Institute, Miguel Hernández University, Elche (Alicante), Spain*
[d] *Radiation Oncology Department, ERESA-Hospital General Universitario de Elche, Elche (Alicante), Spain*
* Corresponding author.

Introduction. One of the main effects during interaction of radiation with aqueous molecules contained into living cell is free radicals generation. D-Amino acid oxidase (DAO) enzyme also generates free radicals.

Purpose. Starting from this evidence we decided to investigate the combined effects of radiotherapy and DAO on primary cultures of glioblastoma multiforme (GBM), in order demonstrate the supposed improvement of the results obtained by the sole radiation.

Materials and methods. We used primary cultures of GBM obtained from patients' removed tumors.

Recombinant DAO enzyme is obtained from cultures of E. coli. Enzyme is immobilized on magnetic nanoparticles with coated magnetite core Dietil-amino-etil cellulose.

Cultures were irradiated at doses of 7 Gy and 15 Gy with photons of 6 MV produced by a linear accelerator for radiotherapy. After irradiation some samples were treated with DAO both free and immobilized in magnetic nanoparticles.

Biological effects on culture cells were measured by flow cytometry to determine cell cycle phases distribution.

Results. Results obtained by our group on primary cultures of GBM, show a dramatic potentiation of radiation effects after DAO, both free or immobilized in magnetic nanoparticles, was added to irradiated samples.

Conclusion. We were able to demonstrate that incubation of primary cultures of glioblastoma with DAO enzyme after irradiation with 6 MV X-Rays radiation, enhances the effect of radiation, increasing the fraction of dead cells. This effect is probably caused by the increase of free radicals induced DAO in addition to those produced by irradiation. Nanoparticles immobilized DAO is more stable than the free enzyme and therefore its enhancer effect is even greater.

Disclosure. Authors disclose any relationship that may bias this work.

http://dx.doi.org/10.1016/j.ejmp.2016.07.535

CHARACTERIZATION OF YTTERBIUM-DOPED SILICA OPTICAL FIBRE AS SCINTILLATOR DOSIMETER

I. Veronese [a,b,*], E. Mones [c], G. Loi [c], S. Cialdi [a,b], M. Gargano [a], N. Ludwig [a], E. D'Ippolito [a], M. Fasoli [d], N. Chiodini [d], A. Vedda [d]

[a] *Department of Physics, Università degli Studi di Milano, Milano, Italy*
[b] *National Institute of Nuclear Physics (INFN), Section of Milan, Milano, Italy*
[c] *Medical Physics Department, Azienda Ospedaliera Maggiore della Carità, Novara, Italy*
[d] *Dipartimento di Scienza dei Materiali, Università degli Studi di Milano Bicocca, Milano, Italy*
* Corresponding author.

Introduction. Scintillator dosimeters (SD) have been a research topic by many groups over the last decade. The recent availability of a commercial system (Exradin W1 by Standard Imaging) represents a significant accomplishment. The attractiveness of SD would be furtherly enhanced by a scintillator free from any spectral superposition with the Cherenkov light, so to avoid any sensitive calibration procedure for the stem effect correction. Yb-doped silica optical fibres, thanks to their near-infrared (NIR) emission, proved to be a promising option.

Purpose. This study aims to characterize the dosimetric properties of Yb-doped fibers in radiotherapy and to compare their results with those obtained by various reference dosimeters like micro ion-chambers, the commercial SD, and diodes designed for small field dosimetry.

Materials and methods. Yb-doped fibres were prepared by sol–gel. The scintillation was detected with a laboratory-made photon counting system based on an avalanche photodiode (APD), using a long-pass filter at 950 nm. Irradiations were carried out with photons and electron beams generated by a Varian Trilogy accelerator.

Results. The NIR scintillation proved to be unaffected by the stem effect, even in unfavorable large field irradiations. The system showed a satisfactory reproducibility, good sensitivity, linear dose-rate response, independence of the signal (total counts) of dose rate and impinging beam orientation. The results were in good agreement with reference dosimeters in terms of relative dose profiles and output factors.

Conclusion. Findings pave the way to the engineering design of the system, which could be an interesting option also for real-time in-vivo dosimetry applications.

Disclosure. Authors declare no relationship that may bias the presentation.

http://dx.doi.org/10.1016/j.ejmp.2016.07.536

LOW DOSE CHARACTERIZATION OF FRICKE GEL DOSIMETERS BY OPTICAL ABSORBANCE AND MR RELAXATION METHODS

G. Gambarini [a,b,*], I. Veronese [a,b], L. Bettinelli [a], M. Felisi [a], N. Ludwig [a], M. Gargano [a], M. Carrara [c], G. Collura [d,e], S. Gallo [d,e], A. Longo [d,e], M. Marrale [d,e], L. Tranchina [f], F. d'Errico [g]

[a] *Department of Physics, Università degli Studi di Milano, Milano, Italy*
[b] *National Institute of Nuclear Physics (INFN), Section of Milan, Milano, Italy*
[c] *Fondazione IRCCS Istituto Nazionale dei Tumori, Milano, Italy*
[d] *Dipartimento di Fisica e Chimica, Università degli Studi di Palermo, Palermo, Italy*
[e] *National Institute of Nuclear Physics (INFN), Section of Catania, Catania, Italy*
[f] *ATeN Center, Università degli Studi di Palermo, Palermo, Italy*
[g] *Scuola di Ingegneria, Università di Pisa, Italy & Yale University, School of Medicine, New Haven, CT, USA*
* Corresponding author.

Introduction. Fricke gel dosimeters allow measurements of 3D dose distributions and can be an effective tool for dosimetry verifications in radiotherapy. Various authors have reported drawbacks of the gels affecting the accuracy in case of low dose measurements.

Purpose. This study aims at investigating such drawbacks and at establishing the conditions for an optimal use of the gels.

Materials and methods. Our dosimeters consist of gels infused with a Fricke ferrous sulphate solution combined with xylenol orange (XO). Two kinds of xylenol orange (XO) and two different gelling agents (gelatin from porcine skin and Agarose) were utilized. Gels are red out by light absorption techniques: images of absorbance in two wavelength regions (around 430 nm and 585 nm) are acquired with a CCD camera. Absorbance spectrum measurements were done with a compact spectrometry based on optical fibres. Magnetic resonance (MR) measurements of Longitudinal Relaxation Time (T1) were also performed.

Results. Different trends characterized the absorbance spectra of dosimeters obtained with different gelling agents or different XOs. Moreover, the trends were different for different absorbed doses and varied over a few hours after irradiation.

Conclusion. The variation of the absorbance spectra is consistent with various previously unexplained effects reported in literature and may explain them. The results are a valid aid for a better use of these dosimeters and warrant further studies of the changes in the Fricke gel matrices after irradiation.

Disclosure. Authors declare no relationship that may bias the presentation.

http://dx.doi.org/10.1016/j.ejmp.2016.07.537

RADIATION SAFETY TRAINING IN MEDICINE

Ibrahim Duhaini

Rafik Hariri University Hospital, Radiation Oncology Department, Beirut, Lebanon

The use of radiation in Medicine has been on the rise in many countries. A lot of diagnostic and therapeutic procedures may expose patients and staff to high radiation dose which can be reduced to low levels to ensure the safety and protection against the harmful effects of radiation exposures. The objective of this presentation is to ensure the following:

1. Implementing an effective radiation safety strategy
2. Examining the role of the hospitals in creating a radiation safety program
3. Enforcing radiation safety practice for patients, staff, physicians and visitors.
4. Providing regular radiation safety education to concerned staff
5. Identifying opportunities to improve radiation safety performance

By adhering to the principles and doctrines of radiation safety set forth by international organizations, the safety culture among radiation workers will be enhanced and the productivity as well as performance of the protocols will be optimized.

http://dx.doi.org/10.1016/j.ejmp.2016.07.538

FIRST SURVEY OF MAMMOGRAPHY PRACTICE IN SUDAN: RADIATION EXPOSURE AND SETTING NATIONAL DIAGNOSTIC REFERENCE LEVELS

I.I. Suliman *, S. Awad, Alaa Mahdi, N. Ahmed

Sudan Atomic Energy Commission, P.O. Box 3001, Khartoum, Sudan
* Corresponding author.

Introduction. Radiation dose in mammography is evaluated in terms of the Mean glandular dose (MGD) because the glandular tissues are believed to be the most sensitive to radiation-induced carcinogenesis.

Purpose. The purpose of this study was to estimate mean glandular dose levels (DG) in six mammography systems in Khartoum, Sudan, and to propose national diagnostic reference in Sudan.

Materials and methods. Doses were estimated in terms of the Mean Glandular Dose (MGD) in 400 examinations in 204 women who underwent Cranio-Caudal (CC) and Medio-Lateral oblique (MLO) mammography in seven clinics in Khartoum state, Sudan. incident air kerma (IAK) was first estimated from X-ray tube output measurements and patient exposure factors. MGD was then estimated from IAK using conversion coefficients that a count for breasts glandularity and the difference in the X-ray spectrum used.

Results. The mean MGD for CC and MLO was (4.45 ± 2.2) mGy and (4.15 ± 2.1) mGy, respectively. The MGD per image was (4.3 ± 1.15) mGy and the MGD per woman was (8.6 ± 2.22) mGy. The MGD values were compared with results from the literature. Significant variations in MGD were observed and revealed important considerations for dose optimization and will be used for setting national diagnostic reference levels.

Conclusion. The study offered the first projection of radiation exposure in X-ray mammography in Sudan and thus offered the opportunity for dose optimization and setting national diagnostic reference levels.

Disclosure. Authors do not have any relationship that may bias their presentation.

http://dx.doi.org/10.1016/j.ejmp.2016.07.539

COMPARISON OF OCCUPATIONAL DOSES AND PRACTICE OF THE INTERVENTIONAL CARDIOLOGISTS IN ONE DEPARTMENT

D. Kostova-Lefterova *, H. Mateev, A. Aleksandrov

National Cardiology Hospital, Bulgaria
* Corresponding author.

Introduction. Occupational dosimetry is a challenge in interventional cardiology. Many professionals do not regularly use their personal dosimeter and it is difficult to assess the reason for higher doses when they appear.

Purpose. Comparison of the practice and personal doses of five different interventional cardiologists was done. The purpose of the study was to answer the question: Which is the reason for higher personal doses – radiology practice or complexity of the procedures?

Materials and methods. The survey was done for two months period in one department in Bulgaria with two angiography units. Total number of 412 patient data – 232 CA, 113 PCA, 41 procedures for acute myocardial infarction and 26 procedures of higher complexity, was collected. An additional dosimeter was used for assessment of the cardiologists' practice and dose. Both of the dosimeters were worn under their lead aprons. The additional dosimeter was worn for procedures of lower complexity and the main one – for all procedures done during the survey. A comparison of the received doses from the different dosimeters was done.

Results. For two of the cardiologists, A and B, the results of the additional dosimeters worn during procedures of lower complexity showed similar results (0.21 mSv (A) and 0.18 mSv (B)). The main dosimeter worn during all types of procedures showed two times higher dose for A (1.36 mSv) compared to B (0.63 mSv). The average values of the doses for patients treated by A are two times higher for CA compared to B but also the complexity of the procedures is of higher magnitude. The analysis of the practice, patient doses and complexity of the procedures was done for all five interventional cardiologists.

Conclusion. The main reason for higher occupational doses is a combination of complexity of the procedure, the individual treatment of every patient and the difference in the radiology practice.

http://dx.doi.org/10.1016/j.ejmp.2016.07.540

PROPOSED DOSE REFERENCE LEVELS IN RADIOGRAPHY PROCEDURES IN SUDAN

Nada A. Ahmed *, T.S. Mohammed, E.H. Basheir, A.B. Farah, I.I. Suliman

Sudan Atomic Energy Commission, Radiation Safety Institute, Sudan
* Corresponding author.

Introduction. ICRP introduced the term "diagnostic reference level (DRL)" as a tool of optimization to help avoid radiation dose to the patient that does not contribute to the clinical purpose of a medical imaging task.

Purpose. The purpose of this study was to measure patient radiation dose during the most common seven performed conventional diagnostic procedures and to propose DRLs values for these exams in Sudan.

Materials and methods. Third quartile values of the distributions of mean Entrance Skin Air Kerma (ESAK) observed for the most common radiography examination were proposed as DRL values in Sudan .Representative sample of patients "at least 10 patient in each exam" from 30 governmental and private hospitals distributed over the country were included. ESAK was calculated by measuring the X-ray tube output and the corresponding technical and exposure factors for each patient.

Results. Proposed DRLs in mGy were settled to be 0.63 for chest PA, 2.3 for skull PA, 1.61 for skull LAT, 4.0 for abdomen, 2.59 for Lumber Spine AP and 10.8 for Lumber Spine lateral.

Conclusion. This result considered to be the first proposed DRL for general radiography procedures in Sudan.

Disclosure. Authors confirm No any relationship bias their presentation.

http://dx.doi.org/10.1016/j.ejmp.2016.07.541

TOWARDS BREAST CANCER ROTATIONAL RADIOTHERAPY WITH SYNCHROTRON RADIATION

Francesca Di Lillo *, Giovanni Mettivier, Antonio Sarno, Paolo Russo

University of Naples Federico II, Dept. of Physics "Ettore Pancini" & INFN Sect. of Naples, Naples, Italy
* Corresponding author.

Introduction. Rotational kilovoltage external beam radiotherapy (kV-EBRT) for breast cancer with orthovoltage tubes was recently proposed by a team at University of California at Davis, as an alternative to the typical 6-MV photon beams with breast tangential fields produced by a clinical accelerator. On this scientific basis, we propose to implement EBRT in breast cancer therapy, using a monochromatic synchrotron radiation (SR) beam and dedicated setup for irradiating the pendant breast (SR-EBRT). The same platform could

be adopted to perform a computer tomography dedicated to the breast for tumor 3D localization and beam centering.

Purpose. To investigate, with a feasibility study in a breast phantom, the proposed technique SR-EBRT.

Materials and methods. The experimental plan includes dose distribution measurements with TLDs, radiochromic films and ionization chambers in cylindrical PMMA phantoms at ESRF and at the Australian Synchrotron.

Results. The use of the high-flux SR beam will permit dose delivery times comparable to the one of conventional radiotherapy. Preliminary data indicated that a 7:1–10:1 tumor-to-skin ratio from 60 keV to 180 keV could be achieved, and the possibility of realizing dose-painting by multiple rotations.

Conclusion. A SR beam down to 60 keV can be adopted for SR-EBRT of breast cancer with a skin sparing close to that of orthovoltage EBRT at 320 kVp. SR-EBRT at low energy (60–80 keV) might be coupled to gold nanoparticles injection for dose-enhanced breast SR-EBRT.

Disclosure. Nothing to declare.

http://dx.doi.org/10.1016/j.ejmp.2016.07.542

TBI WITH A TRANSLATIONAL TECHNIQUE: A 15-YEAR EXPERIENCE

T. Koligliatis [b,*], P. Komi [a], E. Vasilakou [a], N. Pappas [a], A. Tsilimidou [b], K. Kouvati [b], B. Zambatis [a]

[a] *Radiation Therapy Dep., St. Savvas' Hospital, Athens, Greece*
[b] *Medical Physics Dep., St. Savvas' Hospital, Athens, Greece*
* Corresponding author.

Introduction. TBI has been long used as a conditioning regimen prior to BMT. There are both stationary and translational techniques depended on the facilities available in a radiotherapy department.

Purpose. To present our 15 years of experience on TBI with a translational technique. Dose computations, practical approaches and technical limitations are discussed.

Materials and methods. The translational TBI technique (theratron Co^{60} unit and a moving couch) has been employed for patient irradiation prior to BMT. 252 patients, varying in age from 6 to 55 years old (mean 35 ± 5), have been treated, submitted from the majority of BMT departments in Greece.

The computations take place using a commercial TPS (theraplan-plus) to calculate the dose to either lung taking patient inhomogeneities into account. Patient translation has been approached with photon beams next to each other ((50×30) cm, SSD = 149 cm), along the axis of the patient, with a 2 cm space interval. The average dose to each lung is then obtained from DVH and each filter thickness determined. Bolusing is used to minimize patient thickness variation.

Results. The average dose to each lung is ∼750 cGy whereas the midline dose at the umbilicus is 1200 cGy (2 fractions × 3 days). Filter thickness may not be constant (i.e. 1 mm lead strip added close to lung middle). Electron beams (10–12 MeV) are employed to irradiate the area of the thoracic wall under the filter to reach a dose of 1000 cGy. The estimated overall lung burden is ∼850 cGy for 60% of either lung. A limitation of this technique is the size of a patient due to maximum field size available (maximum = 55 cm) and in some cases patient thickness (maximum = 30 cm).

Conclusion. The translational TBI technique provides superior dose uniformity compared to stationary ones at the expense of time and longer preparation.

http://dx.doi.org/10.1016/j.ejmp.2016.07.543

AN ANALYTICAL MODEL OF TUMOUR RESPONSE TO RADIOTHERAPY TO INVESTIGATE BIOLOGICAL PARAMETERS OF CHORDOMA TREATED BY X-RAYS, PROTONS AND CARBON IONS

Vassiliki Kanellopoulos [a,d,*], Norman F. Kirkby [b], Rajesh Jena [c], Manjit Dosanjh [d], Karen J. Kirkby [b]

[a] *Department of Radiation Oncology, Technische Universität München, Klinikum rechts der Isar, Ismaninger Straße 22, 81675 München, Germany*
[b] *Manchester Academic Health Science Centre, Institute of Cancer Sciences, University of Manchester, The Christie NHS Foundations Trust, Wilmslow Road, Manchester M20 4BX, UK*
[c] *Oncology Centre, Cambridge University Hospitals NHS Foundation Trust, Hills Road, Cambridge CB2 2QQ, UK*
[d] *European Organization for Nuclear Research CERN, CH-1211 Geneva 23, Switzerland*
* Corresponding author.

Introduction. At present, cancer treatment protocols are mostly evidence-based while deducted from clinical trials and applied to other patient groups. Cancer modelling could be an alternative tool, hence there is a strong need to develop models which capture essential interactions and help to understand treatment outcome better.

Purpose. Clinical data is commonly used to extract information on patient level of survival or regression probabilities for a certain treatment set-up. This study introduces a mathematical model which allows to acquire a deeper insight on biological properties of a tumour using clinical data of patients treated with conventional radiotherapy and particle therapy.

Materials and methods. We introduce a physiological tumour growth model combined with a treatment model considering different cell radiosensitivities for proliferating and quiescent cells. A patient population model is constructed expecting biological parameters can be sampled from probability distributions. Using Monte–Carlo simulation the model parameters can be fitted to data from clinical trials.

Results. The model is applied to recurrence curves of chordoma following radiotherapy with X-rays, protons and carbon ions. The probability distribution of radiosensitivities of tumour cells treated by different beam qualities is determined, showing a narrowing of the distribution width and a higher mean sensitivity towards high LET radiation.

Conclusion. Results could be used to assist in designing clinical trials and predict clinical outcome for individual patients, in particular give treatment indications for hadron therapy.

Disclosure. None.

http://dx.doi.org/10.1016/j.ejmp.2016.07.544

EPID-BASED IN VIVO DOSIMETRY FOR COMPLEX VMAT TREATMENTS DOSE VERIFICATION IN CLINICAL ROUTINE

Savino Cilla [a,*], Anna Ianiro [a], Francesco Deodato [a], Gabriella Macchia [a], Andrea Fidanzio [b], Luigi Azario [b], Vincenzo Valentini [a,b], Alessio G. Morganti [c], Angelo Piermattei [b]

[a] *Fondazione di Ricerca e Cura "Giovanni Paolo II", Università Cattolica del Sacro Cuore, Campobasso, Italy*
[b] *Policlinico Universitario A. Gemelli- Università Cattolica del S. Cuore, Roma, Italy*
[c] *DIMES Università di Bologna - Ospedale S.Orsola Malpighi, Bologna, Italy*
* Corresponding author.

Introduction. Due to the increasing complexity of radiotherapy treatments, comprehensive quality assurance programs are mandatory to check the proper functioning of the whole radiotherapy

chain. In vivo dosimetry (IVD), a direct method of measuring radiation doses to cancer patients during treatment, has shown unique features to trace deviations between planned and actually delivered dose distributions.

Purpose. To assess the usefulness of EPID-based IVD for complex VMAT treatments in clinical routine.

Materials and methods. 80 patients (30 with head-neck tumor, 30 with pelvic tumors and 20 patients with extracranial metastases) treated with Elekta were enrolled. IVD tests were evaluate by means of (i) R ratio between daily in-vivo isocenter dose and planned dose and (ii) γ-analysis between EPID integral portal images in terms of percentage of points with γ-value smaller than one (γ%) and mean γ-values (γmean), using a global 3%-3 mm criteria. Alert criteria of ±5% for *R* ratio, γ% <90% and γmean >0.67 were chosen.

Results. A total of 980 transit EPID images were acquired. The mean R ratio was equal to 1.001 ± 0.015 for all patients with more than 95% of tests were within 5%. For HN, pelvic and SBRT treatments, γ% and γmean metrics reported 85.9%, 83.1% and 95.4%, and 93.3%, 92.1% and 98.1% of tests within alert criteria, respectively. The systematic use of IVD revealed relevant discrepancies in a few H–N patients due to major anatomical variations and variations due to random anatomical changes in terms of filling of rectum/bladder in pelvic tumors. No discrepancies were detected in SBRT patients.

Conclusion. IVD was able to detect when delivery was inconsistent with the original plans, allowing physics and medical staff to promptly act in case of major deviations.

http://dx.doi.org/10.1016/j.ejmp.2016.07.545

QUALITY CONTROL IN DIAGNOSTIC IMAGING USING IMAGES OF PATIENT STUDIES

Pieternel van der Tol *, J. Michiel den Harder, Lisa Bravaglieri, Wouter J.H. Veldkamp, Jacob Geleijns

Radiology Department, Leiden University Medical Center, Leiden, The Netherlands

* Corresponding author.

Introduction. Weekly lean quality checks (LQC) of imaging devices using simple phantoms are commonly performed in many hospitals, aiming at early detection of changes in image quality or radiation dose.

Purpose. We propose to monitor the constancy of imaging devices by deriving quality parameters from images of routine clinical studies.

Materials and methods. Chest images of patients were collected from a DR system (Oldelft). As an indicator of image quality, an estimation of noise was derived by application of a spatial high-pass filter to patient images and normalization to the local signal intensity in the original images. As an indicator of dose constancy, the DAP was extracted from DICOM meta-information (LQC) and used to calculate the tube output [mGy/mAs] (clinical images).

Results. Preliminary results using LQC and clinical images collected during 10 months are given in relative peak-to-peak (PtP) and standard deviation (stdev).

For noise levels, LQC resulted in PtP 22% and stdev 5.2%, clinical images resulted in PtP 36% and stdev 6.6%. For dose, LQC resulted in PtP 33% and stdev 8.5%, clinical images resulted in PtP 30% and stdev 7.5%.

Conclusion. The similar results for LQC and clinical images show it is feasible to perform regular quality checks of diagnostic imaging devices using patient images.

To validate the potential of this approach to detect changes, low quality images will be analysed with the same algorithms. Additionally, the methodology will be extended to other anatomies and imaging modalities. This will enable performance monitoring of all diagnostic imaging devices, without the need for weekly phantom constancy tests.

Disclosure. Nothing to disclose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.546

CREATION OF A PAEDIATRIC HEAD VOXEL MODEL DATABASE FOR DOSIMETRIC APPLICATIONS

N. Touyz [a,*], A. Stratis [c], G. Zhang [c], R. Jacobs [b], R. Bogaerts [b], H. Bosmans [c]

[a] *Katholieke Universiteit Leuven, Faculty of Medicine, Belgium*
[b] *Katholieke Universiteit Leuven, Department of Imaging and Pathology, OMFS-IMPATH Research Group, Campus St. Raphael, Kapucijnenvoer 33, Leuven 3000, Belgium*
[c] *University Hospitals of Leuven, Department of Radiology, Herestraat 49, Leuven 3000, Belgium*
* Corresponding author.

Introduction. CBCT is a recently introduced imaging modality in dentomaxillofacial radiology with increasing applications to paediatric cohorts. To accurately estimate the radiation induced risk via Monte Carlo (MC) simulations, age and gender specific head and neck voxel models should be built. These models will enable organ dose calculations and accurate risk estimation via effective dose (ED) or Life Attributable risk (LAR).

Purpose. To design a head and neck voxel model database for MC dosimetry.

Methods and materials. Our voxel models were based on organ segmentation of CT image datasets with following characteristics: represent a complete head; have a good low contrast resolution (as the many soft tissues are close in density), have the thyroid included in the scan. Using our PACS database, 13 datasets of paediatric patients from 5 to 14 years old were found to meet the requirements for further processing. From each CT scan, 22 organs were manually segmented on an organ by organ using ImageJ, Matlab tools and human atlases (example: http://headneckbrainspine.com/Neck-CT.php). Organ masses were compared to ICRP reference values.

Results. 13 paediatric voxel phantoms were created and compared favourably with ICRP values: 7 males and 6 females. The in-plane resolution of the phantoms, determined by the axial voxel size dimensions, ranges from 0.21×0.21 mm^2 to 0.48×0.48 mm^2; the *z* resolution ranges from 0.6 mm to 3.22 mm.

Conclusion. The database for paediatric CBCT applications can now be used for detailed dose and risk applications.

http://dx.doi.org/10.1016/j.ejmp.2016.07.547

EVALUATION OF BREAST SOFTWARE MODEL FOR X-RAY 2D AND 3D MAMMOGRAPHY IMAGING

Yanka Baneva [a,*], Lesley Cockmartin [c], Hilde Bosmans [c], Nicholas Marshall [c], Giovanni Mettivier [d], Paolo Russo [d], Kristina Bliznakova [b]

[a] *Medical University of Varna, Varna, Bulgaria*
[b] *Technical University of Varna, Varna, Bulgaria*
[c] *Medical Imaging research Center, University Hospitals Leuven, herestraat 49, B 3000 Leuven, Belgium*
[d] *University of Naples – Federico II, Naples, Italy*
* Corresponding author.

Introduction. Physical test phantoms are a valuable tool in the assessment of novel breast imaging techniques. In order to optimize

issues such as image processing or reconstruction, lesion detection performance, image quality and radiation exposure, dose evaluation, it is important that they reproduce the characteristics of 2D and 3D breast images as precisely as possible.

Purpose. Recently, a physical phantom with a structured background has been introduced for both 2D mammography and breast tomosynthesis. The purpose of this work is to create the 3D software version of the physical phantom and use it for further phantom optimization and extrapolation to CT imaging.

Materials and methods. The software breast phantom simulates an acrylic semi-cylinder container of height 48 mm and diameter 200 mm filled with water and acrylic beads of different diameters. Planar projections in mammography and tomosynthesis were simulated for the same conditions as with the Siemens Inspiration system. Tomosynthesis slices were reconstructed with in-house developed reconstruction software.

Results. Visually, an excellent agreement between simulated and real images is observed. Parameters like fractal dimension, power law exponent β and second order statistics (skewness, kurtosis) of projection and tomosynthesis reconstructed images are under evaluation and will be presented at the conference.

Conclusion. The software breast phantom showed a close match with its physical version. If the mathematical analysis of the images confirms the agreement, the software platform will be used to predict performance for CT imaging and to study the effect of other background structures than beads.

http://dx.doi.org/10.1016/j.ejmp.2016.07.548

A UTILITY TO READ AUTOMATICALLY DICOM FORMAT DATA FOR GAMOS/GEANT4 SIMULATION

Pedro Arce [a,*], Juan Ignacio Lagares [a], Diego Azcona [b]

[a] *Medical Applications Unit, CIEMAT, Madrid, Spain*
[b] *Clínica Universitaria de Navarra, Navarra, Spain*
* Corresponding author.

Introduction. The simulation of a real clinical radiotherapy treatment requires using the detailed information about patient, acceleration and plan. Modern machines can provide this information in DICOM format, but Monte Carlo codes are not able to treat it.

Purpose. To provide a tool to automatically read the data on patient anatomy, including RT structures, and the RT plan parameters and prepare the corresponding Monte Carlo jobs.

Materials and methods. We have developed in GAMOS/Geant4 framework a set of tools based on DCMTK to read a patient anatomy in DICOM format and transform the Hounsfield values into Geant4 materials. The DICOM RT Structure files are also read and combined with the anatomy to identify the voxels that are included in each structure. Another tool converts the many parameters of a RT plan into Monte Carlo parameters. Several utilities help the user check for the correct interpretation of the DICOM parameters.

Results. The tool has been applied to read many different DICOM patient anatomies from different providers. A full radiotherapy treatment has been simulated and the dose calculated and written in DICOM format has been compared with the one obtained using the vendor TPS.

Conclusion. A simple way is provided to automatically convert a radiotherapy treatment in DICOM format to GAMOS/Geant4 parameters so that real clinical treatments can be easily simulated.

http://dx.doi.org/10.1016/j.ejmp.2016.07.549

A PET/SPECT/X-RAY PROTOTYPE FOR WHOLE BODY MOUSE IMAGING

Georgiou Maria [a,*], Fysikopoulos Eleftherios [b], Rouchota Maritina [c], Fragogeorgi Eirini [b], Mikropoulos Konstantinos [b], Papadimitroulas Panagiotis [a], Kagadis George [c], Loudos Georgios [b]

[a] *BET Solutions, R & D – Athens, Greece*
[b] *Technological Educational Institute of Athens, Biomedical Engineering – Athens, Greece*
[c] *University of Patras, Rio, Patra, Greece*
* Corresponding author.

Introduction. In this work we present a hybrid, prototype SPECT/PET/CT system, suitable for whole-body small animal imaging. The integrated SPECT/PET/CT system has three components and is mounted on a computer-controlled rotating gantry.

Purpose. The main goal of this work is to provide a robust infrastructure for animal studies on national and regional level.

Materials and methods. The SPECT component is based on two H8500 Position-Sensitive-Photomultiplier-Tubes, a $1 \times 1 \times 5\text{mm}^3$-NaI(Tl) pixelated scintillator and a general purpose hexagonal collimator. The PET components are based on the same PSPMTs coupled to $2 \times 2 \times 5\ \text{mm}^3$ BGO pixelated scintillators. The X-Ray detector is a high speed, low noise and high sensitivity flat panel detector, model C10900D-40 from Hamamatsu. It is based on the CMOS technology and it is suitable for real-time static and CT imaging with high dynamic range. The X-ray tube, SourceBlock™ by Source-Ray Inc, integrates an X-ray tube and a high voltage generator into one physical package. The SB-80-500 model has a 33 μm minimal focal spot, a variable voltage 35–80 kVp and 20–500 μA current.

Results. The SPECT system has been evaluated with phantoms and small animals and has a 1.5 mm spatial resolution for ^{99m}Tc, while it can provide fast images for dynamic mice studies. Two additional collimators allow imaging of higher energy isotopes. The spatial resolution of the PET system is equal to 2.5 mm, while further optimization is possible by using proper reconstruction algorithms and corrections. The X-ray system provides high resolution (10 μm) anatomical images of mice, which are fused with the functional images of PET/SPECT.

Conclusions. The presented system provides unique infrastructure to support preclinical research on national and regional level.

http://dx.doi.org/10.1016/j.ejmp.2016.07.550

QUANTITATIVE ANALYSIS OF SENTINEL LYMPH NODE DETECTION USING A NOVEL SMALL FIELD OF VIEW HYBRID GAMMA CAMERA (HGC)

M.S. Alqahtani [a,b,*], J.E. Lees [a], S.L. Bugby [a], L.K. Jambi [a,c], B.S. Bhatia [a,d], W.R. McKnight [a], N.S. Dawood [a], A.H. Ng [e], A.C. Perkins [e]

[a] *Space Research Centre, Department of Physics & Astronomy, University of Leicester, LE1 7RH, UK*
[b] *Radiological Sciences Department, College of Applied Medical Sciences, King Khalid University, Postcode: 3665, Zip code 61481, Abha, Saudi Arabia*
[c] *Radiological Sciences Department, College of Applied Medical Sciences, King Saud University, Postcode: 10219, Zip code 11433, Riyadh, Saudi Arabia*
[d] *Clinical Imaging Group, Sandwell and West Birmingham Hospital NHS Trust, West Bromwich B71 4HJ, UK*
[e] *Radiological Sciences, School of Medicine, University of Nottingham, NG7 2UH, UK*
* Corresponding author.

Introduction. The Hybrid Gamma Camera (HGC) is being developed to enhance the localisation of radiopharmaceutical uptake in targeted tissues during surgical procedures such as sentinel lymph node (SLN) biopsy.

Purpose. To assess the capability of the HGC, a lymph-node-contrast (LNC) phantom was constructed for an evaluative study simulating medical scenarios of varying radioactivity concentration and SLN size.

Materials and methods. The phantom was constructed using two methyl methacrylate PMMA plates (8 mm thick). The SLNs were simulated by drilling circular wells of diameters ranging between 10 mm and 2.5 mm (16 wells in total) in one plate. These simulated SLNs were placed underneath scattering material with thicknesses ranging between 5 mm and 40 mm. The second plate contains four rectangular wells to simulate background activity uptake surrounding the SLNs. The activity used ranged between 4 MBq and 0.025 MBq for the SLNs. The background activity was 1/10 of the SLNs activity. The collimator to source distance was 120 mm.

Results. Signal to Noise Ratio (SNR) analysis and spatial resolution measurements of the simulated SLN were used to compare the imaging sets over acquisition times ranging between 60s and 240s. The HGC successfully detected 87.5% to 100% of the SLNs through 20mm of scattering material, and it could detect 75% to 93.75% of the SLNs through 40mm of scattering material. Measurement of Full-Width-at-Half-Maximum (FWHM) for the detected SLNs ranged between 9.5 mm and 12 mm.

Conclusion. The HGC is capable of detecting low activity uptake in small SLNs indicating its usefulness as an intraoperative imaging system during surgical SLN procedures.

Disclosure. MSA, SLB, LKJ, BSB, WRM, NSD and AHN have no conflicts of interest to declare. Both JEL and ACP have interests in a Universities of Leicester and Nottingham spin out company called Gamma Technologies.

http://dx.doi.org/10.1016/j.ejmp.2016.07.551

ASSESSMENT OF LOW ENERGY X-RAY IMAGING FOR MAGNETIC AND GOLD NANOPARTICLES

Maritina Rouchota [a,*], George Loudos [b,c], Eleni Efthimiadou [d], George C. Kordas [d], George C. Kagadis [a]

[a] *Department of Medical Physics, School of Medicine, University of Patras, Greece*
[b] *Institute of Nuclear & Radiological Sciences, Technology, Energy & Safety, NCSR "Demokritos", Greece*
[c] *Department of Biomedical Engineering, Technological Educational Institute of Athens, Greece*
[d] *Sol-Gel Laboratory, Institute for Advanced Materials, Physicochemical Processes, Nanotechnology & Microsystems, NCSR "Demokritos", Greece*
* Corresponding author.

Introduction. Gold and magnetic nanoparticles (NPs) are already used as contrast agents in CT and MRI diagnosis respectively, as well as in hyperthermia treatments. In both cases it is very important to be able to determine in vivo the distribution of the NPs. This can be done by radiolabeling the NPs or via MRI. These methods however present serious drawbacks in terms of cost and complexity.

Purpose. The purpose of this study is to explore and standardize a procedure of in vivo X-ray imaging for magnetic and gold NPs for diagnostic and pre-therapeutic purposes, using this low-cost, simple, readily available technology.

Materials and methods. The measurements were carried out on a prototype bench top x-ray system, consisting of an X-ray tube of a maximum beam energy of 80 keV and a minimum focal spot of 33 μm and of a CMOS detector with an active area of 12 × 12 cm and a spatial resolution of 0.1 mm. NPs samples of concentrations ranging between 1 and 500 mg of substance/ml were studied and compared with standard iodine solutions.

Results. All substances are found to present significant contrast enhancement properties and are used to create a standardized imaging procedure with respect to their concentrations. Gold nanoparticles are easily seen in lower concentrations and dual energy subtraction offers a greater differentiation in the observed attenuation properties. Localization and distribution information can be obtained in vivo through X-ray imaging.

Conclusion. A standardized procedure of in vivo X-ray imaging is set up for magnetic and gold NPs for diagnostic and pre-therapeutic purposes.

Disclosure. There is no relationship to be disclosed that may bias this presentation.

http://dx.doi.org/10.1016/j.ejmp.2016.07.552

PHASE-SENSITIVE BREAST CT WITH MONOCHROMATIC BEAM TOWARDS THE CLINICAL TRIAL

R. Longo [a,*], F. Arfelli [a], R. Bellazzini [b], A. Brez [b], F. Brun [c], M.A. Cova [d], P. Delogu [e], F. Di Lillo [f], D. Dreossi [c], C. Fedon [a], B. Golosio [g], G. Mettivier [f], M. Minuti [b], P. Oliva [f], M. Pichera [b], L. Rigon [a], P. Russo [f], A. Sarno [f], G. Spandre [b], M. Tonutti [d], G. Tromba [c], F. Zanconati [d]

[a] *University of Trieste & INFN, Trieste, Italy*
[b] *INFN Pisa & PiXirad Imaging Counters srl, Pisa, Italy*
[c] *Elettra-Sincrotrone Trieste S.C.p.A, Basovizza, Trieste, Italy*
[d] *Trieste University Hospital, Italy*
[e] *University of Pisa & INFN, Pisa, Italy*
[f] *University of Naples "Federico II" & INFN, Napoli, Italy*
[g] *University of Sassari & INFN, Sassari, Italy*
* Corresponding author.

Introduction. The first clinical trial of phase-contrast mammography with monochromatic beam was performed at Elettra, the Italian Synchrotron Radiation facility. A lower Mean Glandular Dose (MGD) and a higher specificity were achieved compared to the digital mammography for the patient cohort (more than 70).

Purpose. The SYRMA-CT project (SYnchrotron Radiation for MAmmography – Computed Tomography) aims to perform the first clinical trial of phase-sensitive breast CT with monochromatic beam. High image quality and low dose are expected according to the results of the first mammography trial.

Materials and methods. A large area CdTe single photon counting detector (PIXIRAD-8) is used. Phase-retrieval algorithm are applied, thus exploiting propagation based phase-contrast imaging (PPCI).

The dose system of the beamline has been calibrated to match the energy requirement up to 40 keV. Due to the peculiar irradiation modality, ad hoc Monte Carlo simulations and experimental measurements were performed for dose evaluation.

Results. Images of surgical samples included in large test objects (up to 12 cm diameter) were acquired at 38 keV in clinical compatible dose conditions (MGD ~5 mGy). Phase-retrieval pre-processing was applied improving the CNR of the high-resolution images with $(120\ \mu m)^3$ voxel size.

Conclusion. The upgrade of the mammographic facility of the Elettra laboratory towards a new clinical trial is going on. Image quality and dose assessment indicate its feasibility with monochromatic beam. This clinical trial will allow the evaluation of PPCI breast CT in optimal conditions and will give indication for the translation to the hospital of phase-sensitive techniques.

Disclosure. Nothing to declare.

http://dx.doi.org/10.1016/j.ejmp.2016.07.553

FAT SUPPRESSED PROTON DENSITY MRI INCREASES THE SENSITIVITY IN THE DETECTION OF CERVICAL CORD MULTIPLE SCLEROSIS LESIONS

E. Karavasilis *, A. Athanasakos, G. Velonakis, G. Argiropoulos, L.S. Poulou, P. Toulas, I. Gkerles, E. Xenos, P.E. Efstathopoulos, L.N. Kelekis

Second Department of Radiology, University General Hospital 'Attikon', School of Medicine, National and Kapodistrian University of Athens, Athens, Greece

* Corresponding author.

Introduction. MR imaging is widely used method to aid in the detection of multiple sclerosis (MS) lesions in the cord. Improving the sensitivity of the detection of MS lesions can be useful in the medical diagnosis and could lead to a better approach and heal of the disease.

Purpose. The aim of this study was to compare T2-weighted turbo spin-echo (TSE) combined with spectral adiabatic inversion recovery technique for fat suppression (SPAIR) with proton density (PD) SPAIR in the detection of cervical MS plaques.

Materials and methods. Twenty five patients with clinically confirmed MS were examined on a 3.0T MR system. T2 and PD TSE SPAIR sequences were obtained in sagittal plane, using the same in plane resolution and slice thickness. The images set were assessed by two independent observers for the lesion detectability and image quality. Quantitative measurements of lesion-to-cord contrast ratio and lesion-contrast-to-noise ratio were obtained. All the lesions were verified with axial T2 multi echo gradient echo images.

Results. Fifteen of the scanned patients had MS lesion detected. PD_TSE_SPAIR sequence was most efficient in detection of MS lesions, demonstrated increased lesion contrast ratios about 15%, and also provided better image quality than T2_TSE_SPAIR. Twenty percent of lesions (3/20) that were not statistically significantly different from background cord signal on the T2 sequence.

Conclusion. PD_TSE_SPAIR sequence had high sensitivity to the detection of MS lesions compared to T2_TSE_SPAIR and should be included in the core sequences to the spinal MRI protocol for the assessment of suspected demyelinating disease.

Disclosure. There is not any disclosure.

http://dx.doi.org/10.1016/j.ejmp.2016.07.554

STRUCTURAL ALTERATIONS IN PATIENTS WITH SCHIZOPHRENIA: AN ADVANCED NEUROIMAGING VBM STUDY

A. Mentzelopoulos [a,*], E. Karavasilis [a], F. Christidi [b], E. Spilioti [c], L. Mantonakis [c], E. Savvidou [c], P.E. Efstathopoulos [a], E. Anyfandi [c], E. Kattoulas [c], G. Nikiforidis [c], N. Smyrnis [c], L.N. Kelekis [a]

[a] *Second Department of Radiology, University General Hospital 'Attikon', School of Medicine, National and Kapodistrian University of Athens. Athens, Greece*

[b] *First Department of Neurology, Aeginition Hospital, Medical School, National and Kapodistrian University, Athens, Greece*

[c] *Department of Psychiatry, National and Kapodistrian University of Athens, Aeginition Hospital, Athens, Greece*

* Corresponding author.

Introduction. Schizophrenia has been lately, increasingly, linked with morphological changes in brain's structure which can be associated with functional deficits.

Purpose. The aim of this study was the evaluation of the gray matter volume (GMV) changes in patients with schizophrenia compared to healthy controls (HC) using voxel-based morphometry (VBM).

Materials and methods. Twenty two patients with schizophrenia and nineteen age- and gender-matched healthy volunteers underwent high resolution 3DT1-weighted anatomical images on a 3T MRI system using an 8-channel sense head coil. Optimized VBM method was used to estimate the GMV and ROI analyses was conducted to identify brain structural changes in known regions from literature.

Results. Patients with schizophrenia showed decreased GMV in left insula ($k = 205$ voxels $p = 0.001$), right insula ($k = 150$ voxels $p = 0.001$), left hippocampus ($k = 490$ voxels $p = 0.001$), right hippocampus ($k = 116$ voxels $p = 0.001$), right anterior cingulate cortex (ACC) ($k = 177$ voxels $p = 0.001$), right superior temporal gyrus (STG) ($k = 179$ voxels $p = 0.001$), left parahippocampal gyrus ($k = 563$ voxels $p = 0.001$), right parahippocampal gyrus ($k = 220$ voxels $p = 0.001$) relative to healthy comparison subjects.

Conclusion. Patients with schizophrenia demonstrated volumetric alterations in frontal and temporal areas consistent with other studies. Advanced neuroimaging techniques such as VBM when combined with other structural methodologies, might be useful in evaluating both local and global morphological changes in schizophrenia.

Disclosure. We acknowledge the Philips Medical System for providing all necessary research keys for MR/DTI sequence acquisition. The contributors had no role in study design, data collection and analysis or preparation of the abstract.

http://dx.doi.org/10.1016/j.ejmp.2016.07.555

INTERACTIVE WEB SITE AND APP FOR EARLY MAGNETIC RESONANCE EDUCATION

Lars G. Hanson

Danish Research Centre for MR, Copenhagen University Hospital Hvidovre, Denmark

Center for Magnetic Resonance, DTU Elektro, Technical University of Denmark, Lyngby, Denmark

Introduction. Teaching and understanding basic Magnetic Resonance (MR) is a challenge. This is clear from the educational literature that often repeats misinterpretations of quantum mechanics reminiscent of its earliest formulations (see www.drcmr.dk/MR that also links to the developed software). Modern quantum formulations of MR are much closer to classical descriptions than to typical quantum inspired myths frequent in literature. This opens for intuitive educational computer simulation using modern web technologies offering excellent interactive possibilities for experimentation.

Purpose. An educational web page and a corresponding free Android app, *CompassMR*, were developed for teaching of basic MR. They simulate Compass Magnetic Resonance that is easy to understand by all, and serves as an excellent starting point for introducing precession, nutation, FIDs and spectra, that are also simulated.

Materials and methods. The web page was developed in JavaScript/HTML5 which is increasingly supported by modern browsers. A corresponding Android app was made using the PhoneGap web service that also offers iPhone and Windows phone support (but due to cost, currently no app is offered for these).

Results. The web page works well, e.g. in recent Chrome and Firefox browsers that supports HTML5. Soon after release, the corresponding app was running on more than 60 devices worldwide, and got top ratings.

Conclusion. Modern web technologies are suited for designing much needed educational simulation tools for MR.

Disclosure. Nothing to disclose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.556

NUMERICAL SIMULATION AND EXPERIMENTAL VALIDATION OF MAGNETIC NANOPARTICLE HYPERTHERMIA

Costas Papadopoulos [a,*], George Loudos [b,c], Eleni Efthimiadou [d], George Kordas [d], George Kagadis [a]

[a] *Department of Medical Physics, School of Medicine, University of Patras, Greece*
[b] *Institute of Nuclear & Radiological Sciences, Technology, Energy & Safety, NCSR "Demokritos", Greece*
[c] *Department of Biomedical Engineering, Technological Educational Institute of Athens, Greece*
[d] *SOL-GEL Laboratory, Institute of Nanoscience and Nanotechnology, NCSR "Demokritos", Greece*
* Corresponding author.

Introduction. Magnetic Nanoparticle Hyperthermia constitutes one of the latest promising treatments for cancerous tumors. The basic principle of hyperthermia lies on the necrosis of cancer cells for temperatures above the threshold of 42 °C, while healthy tissue undergoes negligible damage.

Purpose. The objectives of the conducted research included the setup and validation of a numerical simulation based on Rosensweig's analytical relationships, in order to calculate the volumetric power dissipation due to magnetic nanoparticles in the matrix fluid or tissue (SAR – Specific Absorption Rate or SLP – Specific Loss Power).

Materials and methods. To simulate the experimental setup, as well as the heating process a numerical model was developed using Comsol Multiphysics software. Comsol solvers use FEM (Finite Element Methods) for approximating partial differential equations. To validate the numerical simulation, water based ferrofluids containing superparamagnetic iron oxide nanoparticles (Fe_3O_4) in different concentrations were prepared. The samples were exposed to an alternating magnetic field produced by a solenoid connected to an "Easy Heat" system. Optical fiber was immersed in the subject ferrofluid in order to measure its temperature. The acquired data were processed to obtain hyperthermia heating curves. The geometry, parameters and variables of the experiment were implemented to Comsol Multiphysics.

Results. The simulated magnetic field, was validated using analytical expressions. Small divergence was observed, since Comsol software uses partial differential equations to compute the field amplitude and gradient accurately. The results produced by the numerical simulation concerning the heating process, were in agreement with those obtained during the experimental procedure.

Conclusion. In this study, the numerical simulation of ferrofluid heating was validated. The successful analytical description of this in vitro application, encourages the development of advanced models, designed for simulating in vivo applications.

http://dx.doi.org/10.1016/j.ejmp.2016.07.557

FACTORS AFFECTING EXPOSURE PARAMETERS DURING DIAGNOSTIC CORONARY CATHETERIZATION

M. Habibi *, N. Kollaros, P. Karyofyllis, I. Mastorakou, V. Voudris

2nd Department of Invasive Cardiology, Onassis Cardiac Surgery Centre, Athens, Greece
* Corresponding author.

Introduction. Diagnostic cardiac catheterization represents an important source of radiation. Although transradial access (TRA) is being increasingly used in interventional cardiology, there are concerns about a possible increase in radiation exposure as compared to transfemoral access (TFA).

Purpose. The aim of this study is the comparison of radiation exposure parameters between coronary angiography procedures performed via left radial artery, right radial artery or femoral artery and the detection of factors that contribute to increased radiation dose.

Materials and methods. We analyzed collected data on radiation exposure for a total of 1165 consecutive diagnostic coronary angiographies excluded those concerning patients with aortocoronary bypass grafts. Dose area product (DAP) and fluoroscopy time (FT) were used as a means of radiation exposure measurement.

Results. The mean patients' age was 66 ± 11 years and BMI 28.4 ± 4.6 kg/m^2. Femoral access was used in 36.7% of the procedures, right radial access (RRA) in 50% and left radial access (LRA) in 13.3%. TRA was associated with increased FT (4.6 ± 3.3 vs 3.0 ± 2.5 min, $p < 0.001$) and DAP (31.9 ± 18.2 vs 28.6 ± 15 Gy·cm^2, $p = 0.001$). There were no differences regarding FT and DAP between RRA and LRA. Hypertension, the presence of ascending aorta aneurysm and the presence of coronary artery disease were predictors of increased exposure parameters, whereas diabetes mellitus was predictor of increased DAP.

Conclusion. TRA is associated with increased exposure parameters as compared to TFA, but there are no differences between RRA and LRA. Hypertension, ascending aorta aneurysm and coronary artery disease are adversely affecting exposure parameters.

http://dx.doi.org/10.1016/j.ejmp.2016.07.558

VALIDATION MEASUREMENTS FOR THE RETROSPECTIVE CALCULATION OF EYE LENS DOSES OF INTERVENTIONAL CARDIOLOGISTS

Eleftheria Carinou [a,*], Panagiotis Askounis [a], Danielle Berus [b], Olivera Ciraj-Bjelac [c], Isabelle Clairand [d], Peter Covens [b], Jérémie Dabin [e], Joanna Domienik [f], Jad Farah [d], Joanna Jurewicz [f], Renato Padovani [g], Lara Struelens [e]

[a] *Greek Atomic Energy Commission (GAEC), Athens, Greece*
[b] *University of Brussels (VUB), Brussels, Belgium*
[c] *Vinca Institute for Nuclear Sciences (VINCA), Belgrade, Serbia*
[d] *Institute for Radiological Protection and Nuclear Safety (IRSN), Paris, France*
[e] *Belgian Nuclear Research Centre (SCKCEN), Mol, Belgium*
[f] *Nofer Institute of Occupational Medicine (NIOM), Lodz, Poland*
[g] *International Centre for Theoretical Physics (ICTP), Trieste, Italy*
* Corresponding author.

Introduction. The eye lens radiation-induced risk has been assessed for various population groups. In the framework of the European epidemiological study, EURALOC, an attempt is made to determine a possible dose-response relationship by targeting interventional cardiologists, a group of high exposure values.

Purpose. In the study, eye lens doses are assessed using two approaches: combining self-reported data on working practices and eye lens doses from literature (approach 1); and converting the whole-body dose values to eye lens doses (approach 2). Eye lens dose measurements are performed to validate both approaches and to determine their associated uncertainties.

Materials and methods. Eye lens dose measurements are performed on cardiologists in routine practice using commercially available dedicated eye lens dosemeters. Furthermore, whole-body dose values are obtained from whole-body dosemeters worn above the lead apron at the chest left position. Exposure information including tube orientation, operator position and orientation are collected.

Results. The first values of eye lens doses measured in routine clinical conditions are in good agreement with eye lens dose estimates obtained with the two approaches No systematic errors have been found which is encouraging in order to continue using either of

the two approaches for the estimation of eye lens doses and the final benchmarking against lens opacities.

Conclusion. Preliminary measurements in clinical conditions validate the two suggested complementary dosimetric methodologies: the first, based on self-reported occupational history while the second, starts from personal whole body doses to determine the eye lens dose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.559

A MC STUDY ON THE EYE LENS DOSE DISTRIBUTION FOR MEDICAL STAFF IN INTERVENTIONAL RADIOLOGY

Anna Zagorska [a,b], Kristina Bliznakova [c], Annalisa Trianni [d], Jenia Vassileva [e,*]

[a] *Medical University, Sofia, Bulgaria*
[b] *National Centre of Radiobiology and Radiation Protection, Sofia, Bulgaria*
[c] *Technical University of Varna, Varna, Bulgaria*
[d] *Udine University Hospital, Udine, Italy*
[e] *IAEA, Vienna, Austria*
* Corresponding author.

Introduction. Recent studies showed equivalent dose at a depth of 0.07 mm, H_p (0.07) to be adequate in some cases to monitor the eye lens in interventional radiology, instead of equivalent dose at a depth of 3 mm, H_p (3).

Purpose. The aim of this study was to investigate by Monte Carlo calculations the dose deposition within the eye lens and contribute to the choice of the appropriate dose quantity.

Materials and methods. The *XRayImagingSimulator* was used to model the patient, the operator and the interventional diagnostic unit as well as to calculate the dose within the operators eyes by use of Monte Carlo techniques. Eye lens were placed in three different depths within the eye: 2.3 mm, 3.3 mm, 4.3 mm, representing mean depth and the limits found in a normal adult population. The primary spectra were calculated for 70 kV tube voltage, 12° tungsten target, 3 mm aluminum inherent filtration with an additional copper filtration (0.1 mm, 0.3 mm, 0.6 mm, 0.9 mm) according to IPEM 78 Publication.

Results. The calculated total absorbed dose in the eye lens depends on the initial incident spectra. This quantity normalized to the eye dose, is between 1.8% and 2.3% in the studied cases and increases with increasing the depth of the eye lens' location. Comparison to experimental data is also provided.

Conclusions. The equivalent dose at a depth of 3 mm H_p (3) is likely to be the appropriate quantity for the best estimate of the eye lens dose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.560

ITALIAN REPORT FOR RADIOPROTECTION OF NEONATAL INTENSIVE CARE UNIT (NICU) PATIENTS

A. del Vecchio [a], A. Loria [a], M. Campoleoni [a,*], A. Ciccarone [a], E. Genovese [a], C. Minari [a], N. Parruccini [a], S. Strocchi [a], G. Zatelli [a], M. Agosti [b], F. Vimercati [c]

[a] *Associazione Italiana di Fisica Medica (AIFM), Italy*
[b] *Società Italiana di Neonatologia (SIN), Italy*
[c] *Federazione delle Società Medico-Scientifiche Italiane (FISM), Italy*
* Corresponding author.

Introduction. Clinical improvements are increasing survival chances of preterm infants. It is necessary to conciliate survival and future quality of life, especially for therapeutic choices involving radiation exposures of newborns.

Purpose. Within this context, the Italian Association of Medical Physics (AIFM) is drafting a report to establish good standards practices for every professional involved in NIC Units.

Materials and methods. Data from 16 Italian institutions were processed, investigating attenuation properties of 7 different models of incubators with measurements simulating in-contact and in-potter detector positioning. The incidence of clinical questions to justify X-ray exams was investigated. Even more significant, an overview of the actual practical procedures and radiographic techniques was performed, pointing out several criticalities.

Results. Measurements show that only two incubator models provide a 10% attenuation while others are over 30%. Furthermore, filtering the radiation beam with 1 mm Al + 0.1 mm Cu results in attenuation decrease of 20–30%. The presence of a scale may introduce a further 40% attenuation.

Some criticalities were observed in practical procedures as lack of knowledge of instruments and protocols, bad patients positioning, detector artifacts and improperly use of gonads shield devices. Finally, we estimated the distribution of entrance air KERMA at patient surface and median DAP, that resulted 10 mGy cm^2, lower than European reference level of 14 mGy cm^2.

Conclusion. Our study pointed out a great variability of practices, protocols and radiation exposures parameters, requiring the drafting of a report to establish common guidelines. Nevertheless the drafting of protocols is assigned to the single institution that has to comply with the technical requirements reported in the document.

Disclosure. There is no conflict of interest to declare.

http://dx.doi.org/10.1016/j.ejmp.2016.07.561

CORRECTION OF SCATTERING EFFECTS IN CONE BEAM CT

Kasch Kay-Uwe

Beuth Hochschule fuer Technik Berlin, Germany

Introduction. Cone Beam CT (CBCT) is becoming widely used in Radiation Therapy, not only to verify set-up accuracy but more and more to recalculate treatment plans according to changes indicated at time of set-up (e.g. tumor shrinking, anatomy changes etc.). The problem here is incorrect Hounsfield numbers due to scatter effects inherent to CBCT.

Purpose. This works aims at a first approximation for scatter corrections in CBCT.

Material and methods. First a method was developed to measure scatter spectra of a white beam incident on water and emitted by a commercial X-ray tube. From these spectra scattering cross sections were derived. Further experimental results were then utilized to derive scattering cross sections based on semi-theoretical approaches originally put forward by Morin and Hubbel. After comparison and verification the cross sections were eventually fed into algorithms specifically developed to correct for scatter perturbations in CBCT.

Results. A method has been established to derive scattering cross sections of a white beam emitted by an industrial X-ray tube. These results can then be used in a second step (algorithm) to correct for scatter perturbations in CBCT.

Conclusions. The work presented shows the feasibility of scatter corrections in water for a commercial CBCT. The used semi-theoretical approach can be extended and applied to other materials eventually leading to a data base applicable to a full-fledged scatter correction in CBCT.

http://dx.doi.org/10.1016/j.ejmp.2016.07.562

TC PROTOCOL OPTIMIZATION: A QUANTITATIVE APPROACH

M. Biondi [a,*], A. La Penna [b], E. Vanzi [a], L.N. Mazzoni [a], G. De Otto [a], G.M. Belmonte [a], E. Foderà [b], R. Martini [b], G. Imbriaco [b], F.S. Carbone [c], A. Guasti [d], L. Volterrani [b], F. Banci Buonamici [a]

[a] *Department of Medical Physics, University Hospital of Siena, Siena, Italy*
[b] *Department of Medical, Surgical and Neurosciences, University of Siena, Siena, Italy*
[c] *Department of Diagnostic Imaging, University Hospital of Siena, Siena, Italy*
[d] *Department of Medical Physics, Azienda USL Toscana sud est, Siena, Italy*
* Corresponding author.

Introduction. Every year the number of performed CT scans is dramatically increasing, so that protocol optimization in terms of dose and image quality is mandatory.

Purpose. To evaluate the efficacy of a novel objective method to compare different CT protocols based on a functional (F) encompassing signal to noise ratio (SNR), low contrast resolution (LCR) and CTDI.

Materials and methods. Catphan 600 was scanned with a Discovery 750 (GE healthcare) 64 slices CT scanner varying tube voltage (kV = 100, 120, 140) and noise index (NI = 8, 12). Images were reconstructed using the standard FBP algorithm. LCR was assessed with CTP515 analysis, SNR was evaluated for every CTP404 insert And CTDI was recorded from consolle. An F value was calculated for each protocol as follows:

$$F^{prot}(\alpha) = (1-\alpha)\left(\frac{\sum w_{ins} SNR_{ins}^{prot}}{\overline{SNR_{ins}}} + \frac{\overline{LCR}}{LCR^{prot}}\right) + \alpha \frac{\overline{CTDI}}{CTDI^{prot}}$$

where average values were computed over all the protocols used and α is weighting factor which was varied between 0 and 1 to differently balance dose and quality aspects. For each selected α higher *F* values are associated with a better trade-off between image quality and dose.

Results. For α values between 0 and 0.6 higher *F* values were obtained for 120 kV/8 NI; for $0.7 \leqslant \alpha \leqslant 1$ the best trade-off was found for 100 kV/12 NI.

Conclusion. The proposed CT protocol optimization approach provided an objective way to balance between dose and image quality in phantom. Further studies are in progress to assess the performances of the method in vivo.

Disclosure. Authors disclose any relationship that may bias their presentation.

http://dx.doi.org/10.1016/j.ejmp.2016.07.563

WEB BASED NATIONAL PATIENT DOSE SURVEY IN DIAGNOSTIC AND INTERVENTIONAL RADIOLOGY. PRELIMINARY RESULTS AND ANALYSIS OF SURVEY PERFORMANCE

F. Simeonov [a,*], D. Kostova-Lefterova [a], D. Ivanova [a], J. Vassileva [b]

[a] *National Centre of Radiobiology and Radiation Protection, Sofia, Bulgaria*
[b] *International Atomic Energy Agency, Vienna, Austria*
* Corresponding author.

Introduction. According to the Bulgarian regulation for radiation protection of medical exposure, the National Centre of Radiobiology and Radiation Protection (NCRRP) is responsible for performing national dose surveys in diagnostic and interventional radiology and nuclear medicine and for establishing of national diagnostic reference levels (DRLs).

Purpose. In the period 2014–15 NCRRP have developed web based platform with main goal to establish new national DRLs by collecting data from most of the facilities in the country.

Materials and methods. In collaboration with software company centralized database was developed. The database can be accessed via internet browser, allowing pre-registered user remote sending of survey data. Electronic questionnaires with the necessary technical and dosimetric information were prepared. Short but clear manuals are also included to guide users, and to minimize errors. Since many of the X-ray systems in Bulgaria are still analogue, the platform at this stage also allows manually enter patient data by the user.

Results. Users from Bulgarian hospitals was trained and encouraged to enter data. During the test period more than 300 individual patient data sets, from 8 clinical departments, were sent in the database of platform. Currently medical physicists and radiographers from more than 20 clinical departments collect and enter data in the platform.

Conclusion. Patient data gathered from number of hospitals and different type of examination was used to test the platform. Every hospital or clinical department participated in the survey can establish the local DRLs and initiate optimization of their own protocol.

http://dx.doi.org/10.1016/j.ejmp.2016.07.564

LOCAL DIAGNOSTIC REFERENCE LEVELS IN CHILDREN'S CT EXAMINATIONS ACCORDING TO THE NEW EUROPEAN GUIDELINES

Makri Triantafyllia *, Tsilimidou Artemis, Syrgiamiotis Vasilis, Xatzigiorgi Christiana

Radiological Imaging Department, General Pediatric Hospital of Athens "Agia Sofia", Greece
* Corresponding author.

Introduction. The determination of paediatric DRLs is a difficult task mostly due to the large variation in children's somatometric characteristics. In children until now the DRLs were expressed as a function of patient age. The newest EU Guidelines on paediatric DRLs recommend that the grouping parameters should be patient weight for all body examinations and patient age for all head examinations.

Purpose. This study intends to express the local DRLs for CT examinations in accordance to new EU recommendations for patient grouping parameters: age and weight.

Materials and methods. Exposure parameters and dosimetric data such as CTDIvol and DLP values, were recorded from system's console for 396 routine Head CT, 162 Thorax CT and 92 Abdomen CT examinations, along with data concerning children's age and somatometric characteristics. Two parameters for the data grouping were applied: age, and weight. The DRLs were calculated for the considered examinations, for five age groups (0–1 month, 1–12 months, 1–5, 5–10 and 10–15 years) and five weight groups (<5, 5–15, 15–30, 30–50, 50–80 kg).

Results. The relationship of paediatric dose with age and somatometric characteristics was studied in detail. Dosimetric data were found to vary significantly among age and weight groups for the same type of examination. Both CTDIvol and the DLP values increase with age and weight. DLP seems to represent a better index of patient dose.

Conclusion. Patient dose levels may vary considerably as a function of age, size or weight and therefore DRLs for several ages, size or weight groups need to be defined.

Disclosure. None.

http://dx.doi.org/10.1016/j.ejmp.2016.07.565

A 9-YEARS FOLLOW-UP OF OCCUPATIONAL RADIATION DOSES IN AN INTERVENTIONAL CARDIOLOGY DEPARTMENT

D. Kostova-Lefterova [a,*], H. Mateev [a], A. Aleksandrov [a], E. Ivanova [a], J. Vassileva [b]

[a] *National Cardiology Hospital, Bulgaria*
[b] *International Atomic Energy Agency, Austria*
* Corresponding author.

Introduction. There is a much concern regarding occupational radiation dose of the interventional cardiologists with numerous papers presenting their results during the last 10 years.

Purpose. A 9-years follow-up of interventional cardiology personal dosimetry records was done in one department with two angiography units in a big university hospital in Bulgaria.

Materials and methods. Personal dosimetry records of twelve cardiologists were recorded using personal thermoluminescent dosemeters worn under their lead aprons. Different analysis of the number and complexity of procedures was done.

Results. The number of procedures performed in the department increased from 3018 in 2007 to the maximum of 3256 in 2008, with a minimum of 2235 in 2012, followed by a new increase to 2440 in 2013, and reaching a constant level of approximately 2310 patients during the last two years. A number of individual doses in the range of 15.5–19.5 mSv per year were recorded from the dosemeter under the apron, close to the regulatory dose limit of 20 mSv per year. Strong increase in individual doses for a number of cardiologists was observed during the last 5 years, following the changes in the organization of the department and the team members. The reason for such a trend is in the uneven distribution of the number of patients between the cardiologists and the uneven distribution of the most complicated interventional procedures.

Conclusion. The observed trends prompted actions on better organization and control, and a program for increasing the radiation protection awareness was introduced in 2014, which resulted in 2 fold decrease in personal doses for some of the staff members. The most effective actions involved increased radiation protection awareness and training, steps for patient-dose reduction using all available dose reduction options of the angiography equipment and the systematic use of radiation protection tools including ceiling-suspended protective screens.

http://dx.doi.org/10.1016/j.ejmp.2016.07.566

OPTIMIZATION OF IMRT TECHNIQUES FOR TWO DOSE LEVELS IRRADIATION OF LARYNX CANCER

Ali Youssoufi, Mohamed Bougtib, Mohamed El Baraka, Morad Erraoudi, Farida Bentayeb *

Faculty of Sciences (LPHE, M-S), University Mohammed V, Rabat, Morocco
* Corresponding author.

Introduction. The radiation treatment of head and neck is a very delicate task because the target organ is usually surrounded by many sensitive organs. The optimization of the dose received by the patient represents consequently a great challenge to overcome.

Purpose. The aim of this work is to optimize the performance of IMRT technique for two dose level irradiation of advanced Larynx cancer.

Material and methods. A retrospective planning study was conducted on a sample of 10 patients with Larynx cancer. PTVs were delineated for 2 different dose levels. All plans were generated with 6 MV for Varian Clinac DHX. Optimization and calculations were done in the Varian Eclipse system. IMRT plans included 7 equally placed beams using sliding window technique. Two IMRT plans were generated for each patient using different gantry angles (IMRT1, IMRT2) and the third; IMRT3 using dose fractioning combining the IMRT1 and IMRT2 techniques.

Results. Better coverage of all PTVs is obtained in IMRT3 technique showing the best homogeneity and conformity. For spinal cord, brainstem and vertebrae the IMRT3 technique show significant reductions of maximum dose. The MU's are almost the same for all techniques. Finally, the mean HTID give a significance difference in favor of IMRT3 that decrease the hot spot in the total dose.

Conclusion. IMRT3 technique allows the best PTV coverage and OAR sparing, and dose homogeneity. HTID results are lowest in IMRT3. The IMRT3 seems to spare spinal cord and brainstem significantly better than IMRT1 and IMRT 2 techniques.

http://dx.doi.org/10.1016/j.ejmp.2016.07.567

EPID-BASED DOSIMETRY USING A COMMERCIAL SOFTWARE: GAMMA ANALYSIS AND DVH METRICS FOR VMAT PRE-TREATMENT AND IN VIVO QA

Villaggi Elena

Azienda USL Piacenza, Italy

Introduction. 3D EPID-based dosimetry can play a key role in the chain of verification procedures in VMAT treatments. Anatomical-based metrics could improve evaluation through meaningful clinical dosimetric parameters both for pre-treatment and in vivo QA.

Purpose. To evaluate the use of a commercial software to reconstruct dose from EPID measurements for pre-treatment verification and transit dosimetry using 3D patient-based metrics.

Materials and methods. Dosimetry Check is used for pre-treatment and in vivo 3D evaluations applied to ten VMAT treatments for various anatomical sites (prostate, head & neck, spine and abdomen), planned by Eclipse and delivered by Clinac 2100CD, equipped with a S1000 EPID. Furthermore, for each case, a verification plan is delivered to an homogeneous elliptical shaped solid water phantom to compare in vivo-phantom dose reconstruction and dose measurements by a micro ionization chamber CC01.

Results. Whole dose grid 3D gamma evaluation is performed with criteria 3%-3 mm and 5%-3 mm. Gamma metrics is applied to specific ROI of interest: PTV, CTV and OARs. DVHs are compared in terms of D2, D98, D50 and OARs constraints values used during planning. Differences between pre-treatment and in vivo reconstructed dose are mostly within 3% (5% in sites with small inhomogeneities). Isodose levels reconstructed from Dosimetry Check in phantom are within 3% compared to absolute dose measured by micro ionization chamber.

Conclusion. Patient-based metrics can be used to evaluate results in terms of target coverage and OAR constraints, improving QA evaluation for VMAT treatments. Further studies are needed to evaluate action levels for ROI-based gamma evaluation and critical DVH goals.

http://dx.doi.org/10.1016/j.ejmp.2016.07.568

HIGH DOSE RADIOTHERAPY CAN BE PRESERVED NORMAL TISSUES FROM BYSTANDER EFFECTS OF IRRADIATED TUMORS

Mohammad Taghi Bahreyni Toossi [a,*], Shokouhozaman Soleymanifard [b], Sara Khademi [c], Hosein Azimian [a], Shokoufeh Mohebi [d]

[a] *Medical Physics Research Center, Mashhad University of Medical Sciences, Mashhad, Iran*
[b] *Medical Physics Department, Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran*
[c] *Departments of Medical Physics and Biomedical Engineering, Tehran University of Medical Sciences, Tehran, Iran*
[d] *Medical Physics Department, Reza Radiation Oncology Center, Mashhad, Iran*
* Corresponding author.

Introduction. Radiation induced bystander effect (RIBE) is dependent to several parameters including total dose, dose rate, radiation quality, tissue type and volume of tissue irradiated in radiotherapy.

Purpose. The present study was designed to assess uncertainties in high dose RIBE.

Materials and methods. In this study, we used QU-DB and MRC5 cell lines. One hour following irradiation the medium transfer technique was used to induce bystander effect. Three end point was used in this study are MTT assay (to evaluate percentage of survival), colony assay (to evaluate survival fraction) and MN assay (for assessing chromosome aberrations).

Results. RIBE in both MN and survival fractions was decreased in doses higher than 4 Gy in lung tumoral cell line. After these two tests, we ensured that bystander effect has actually decreased at doses above 4 Gy. In other words high doses of ionizing radiation can produce a "negative feedback". We did the dilution assay to evaluate for finding the main reason of RIBE reduction. In this test, by reducing the dilution of transferred media, the bystander effect (MN formation) was recreated.

Conclusions. This observation verified the negative feedback theory and reject activation of repair systems by more biological signals induced in target cells (as another theory). According to our results and because the dose range we used in the present study are as same as doses used in high dose radiotherapy techniques (e.g. Radiosurgery, brachytherapy etc.), we concluded it is promising that normal tissues can be preserved during high dose radiotherapy from dead signals generated by irradiated tumors.

Disclosure. There is not any relationship that might lead to a conflict of interest. Mashhad University of Medical Sciences (MUMS) has financially supported this work.

http://dx.doi.org/10.1016/j.ejmp.2016.07.569

ASSESSMENT OF THE DOSIMETRIC IMPACT WHEN MODELLING COMPLEX-SHAPED MULTI-LEAF COLLIMATORS IN MONTE CARLO SIMULATIONS

Á. Perales [a,*], M.A. Cortés-Giraldo [a], M.I. Gallardo [a], H. Miras [b], R. Arráns [b]

[a] *Dep. Atomic, Molecular and Nuclear Physics, Universidad de Sevilla, Seville, Spain*
[b] *Dep. Medical Physics, Hospital Universitario Virgen Macarena, Seville, Spain*
* Corresponding author.

Introduction. We present a code, developed with the GEANT4 Monte Carlo (MC) toolkit, to model automatically complex-shaped multi-leaf collimators (MLC) by means of geometrical parameters provided by the vendor. In this work, we reproduce the Siemens 160-MLC, which leaves present a complex curved shape, and assess the dose impact found in small fields when using geometry models of different levels of detail.

Purpose. To evaluate with MC simulations the dosimetric impact of using a simplified geometry model of the 160-MLC and of certain geometry parameters of this MLC design.

Materials and methods. Dose measurements were carried out with radiochromic films inserted between solid water slabs. The dosimetric tests were: (I) Leaf ends field, to verify the penumbra shape sensitivity against the discretization level set to simulate the curved leaf ends. (II) Transmission, to adjust leaf density and real distance between opposite leaves from intra- and interleaf radiation leakage profiles. (III) Picket fence, to fit the leaf tilt angle with respect of the divergent ray emerging from the source.

Results. We found a variation in penumbra tails of up to 0.5 mm for varying leaf end discretization levels. Picket fence dose distributions showed that a 0.1°variation of the leaf tilt angle can lead to an underdosage variation on the dose distribution larger than 3%.

Conclusion. We present a versatile code which can reproduce accurately the singularities of complex MLC designs, which is of key importance for dose calculation of small fields with likely clinical implications.

Disclosure. Authors have no conflicts of interest.

http://dx.doi.org/10.1016/j.ejmp.2016.07.570

OPTIMIZATION OF MINIMAL BEAM SIZE FOR SPATIAL FRACTIONATION OF THE DOSE USING IONS

W. González *, C. Peucelle, Y. Prezado

IMNC-UMR 8165, CNRS, Paris 11 Universities, 91406 Orsay Cedex, France
* Corresponding author.

Introduction. Minibeam radiation therapy (MBRT) has proven to be a promising approach to increase the tolerance of normal tissue. Hadron therapy could benefit from this effect and provide a lower impact on non-targeted tissues to allow its administration at higher doses. We proposed a new approach allying the inherent advantages of ions with MBRT combines hadron therapy with minibeam radiation therapy.

Although the biological basis playing a role in MBRT are not well established, one participant is the so-called dose–volume effect; the smaller the field size, the higher the tolerances.

Purpose. Determine the minimum field size for Hadron MBRT that could still be used providing satisfactory dose distributions.

Materials and methods. For that purpose the Monte Carlo simulations (GATE v6.2 (Geant4.9.5)) of arrays of rectangular ions (C, O, Ne, Ar, Si and Fe) minibeams impinging in a water tank were evaluated. The minibeam sizes ranged from 50 to 600 μm × 2 cm.

Results. As figures of merit, depth dose, transversal profile, FWHM and contribution of nuclear fragments were evaluated. Although the biological experiments are needed to ultimately prove the method, physical aspects are established in this work.

Conclusion. The minimum minibeam size depends on the ion, but our results show beam sizes below 300 μm × 2 cm will not be adequate for Hadron MBRT.

http://dx.doi.org/10.1016/j.ejmp.2016.07.571

INTER OBSERVER VARIATION IN DELINEATING LUMPECTOMY CAVITY AND CTV FOR PATIENTS UNDERGOING APBI USING INTRA-OPERATIVE IMPLANTS AND ITS IMPACT ON IMPLANT DOSIMETRY

Ritu Raj Upreti [a,*], Ashwini Budrukkar [b], Tabassum Wadasadawala [b], Shagun Mishra [b], Lavanya Naidu [b], Rima Pathak [b], Deepak D. Deshpande [a]

[a] *Department of Medical Physics, Tata Memorial Centre, Mumbai 400012, India*
[b] *Department of Radiation Oncology, Tata Memorial Centre, Mumbai 400012, India*
* Corresponding author.

Introduction. 3D conformal brachytherapy utilized limited source positions in catheters and thus may impact dosimetry for inter observer variation in target delineation.

Purpose. To investigate the inter observer variations in lumpectomy cavity (LC) and clinical target volume (CTV) delineation and their dosimetric impact.

Material and methods. Delineation of LC and CTV was done by five radiation oncologists on 20 patients of interstitial breast implant. Cavity visualization index (CVI), four point scale ranging from (0-excellent) to (3-poor) was developed for open cavity technique and assigned for each patient. Total 200 contours for all five observers and 100 geometrical optimized plans were made.

Spatial concordance (CI), average shift in the center of mass (COM) and SD of structure volume were quantified among all observers and statistically analyzed. Variation in source dwell positions for each tube and volume encompassing prescription isodose (Vmax/Vmin) among observers was estimated.

Results. The mean ± SD CI of LC and CTV was 0.54 ± 0.08 and 0.58 ± 0.08. Mean assigned CVI was 0.85 ± 0.81. CI tends to decrease and shift in COM increase significantly ($p < 0.05$) as CVI increased. Out of total 309(15.7 ± 3.3) implanted catheters, 20% catheters had no change, 37% and 20% catheters having variations more than 3 and 5 dwell positions (5 mm step size) respectively. The mean Vmax/Vmin of prescription isodose was 1.18 (range 1.03–1.56).

Conclusion. Significant correlation of CVI was observed with CI and COM shift. Inter observer variations have shown the impact on the source positions along catheters and thus have dosimetric impact on irradiation of breast tissue with prescription isodose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.572

IMPLEMENTATION IN CLINICAL USE OF A NEW PLAN VERIFICATION SOFTWARE FOR CONFORMATIONAL AND MODULATED TREATMENTS

A. Barateau, J. Mesgouez, D. Autret, M. Bremaud, C. Di Bartolo, S. Dufreneix *, C. Legrand

Department of Medical Physics, Integrated Center for Oncology, Angers, France
* Corresponding author.

Introduction. Single point monitor units check is mandatory for all treatment plans in France. However, this check is not reliable for intensity modulated plans because of high dose gradients. A recently released solution called Mobius3D allows performing multiple treatment plan verifications.

Purpose. To evaluate this new software for 3D-conformational and intensity modulation treatment plans and to study the different metrics available for treatment plan verification.

Materials and methods. Single point dose calculations of 144 static fields selected by experimental design were compared to the TPS calculation (AAA, Eclipse, Varian). For intensity modulation plans, a DLG correction was determined by measurements in a cylindrical homogeneous phantom. Finally, several metrics were compared for 30 VMAT treatment plans.

Results. The mean difference between TPS and Mobius3D calculations for static fields is −0.2 ± 0.8% with a maximum of −2.5% in homogeneous medium but differences up to 5.7% were observed in the thoracic phantom. With a DLG correction set to −1.5 mm, the VMAT treatment plans had a mean gamma analysis inside the body of 96.2% but some went down to 66.4% due to regions located outside the fields. Results of the gamma analysis inside the PTV or the mean dose delivered to the PTV were more homogeneous.

Conclusion. A large tolerance level was applied in presence of heterogeneities for 3D-conformational. For intensity modulation treatment plans, the gamma analysis inside the PTV was considered reliable knowing that Mobius3D also provides gamma analysis for organs at risk.

Disclosure. No disclosure.

http://dx.doi.org/10.1016/j.ejmp.2016.07.573

DEVELOPMENT OF EXTERNAL DOSIMETRY AUDITS FOR ADVANCED TECHNOLOGY IN RADIOTHERAPY DOSE DELIVERY: AN IAEA COORDINATED RESEARCH PROJECT

J. Izewska [a], P. Wesolowska [a], W. Lechner [b], D. Georg [b], M. Tomsej [c,e,*], D. Followill [d], S. Kry [d], M. Tenhunen [e], J. Povall [f], D. Thwaites [g]

[a] *International Atomic Energy Agency, Division of Human Health, Vienna, Austria*
[b] *AKH, Vienna, Austria*
[c] *CHU Charleroi A. Vésale, Charleroi, Belgium*
[d] *IROC Houstonn QA Center, U.T. MD Anderson Cancer Center, Houston, USA*
[e] *University Hospital Helsinki, Finland*
[f] *St James' Institute of Oncology, University of Leeds, Leeds, UK*
[g] *University of Sydney, Australia*
* Corresponding author.

Introduction and purpose. An IAEA co-ordinated research project (CRP) is under implementation that develops methodology for remote dosimetry audits of IMRT techniques to be offered to radiotherapy centres by national audit networks in low and middle income countries.

Materials and methods. The CRP involves four audit steps: (i) remote verification of TPS calculation of small beam output factors relevant to IMRT (ii) dosimetry audit of MLC positional performance for IMRT using radiochromic film, (iii) film audit of single clinical IMRT field dose delivery and (iv) 'end-to-end' dosimetry audit for multiple field IMRT techniques using TLDs and radiochromic films. New procedures, phantoms, instructions and data sheets for audited centres were developed at the IAEA and tested through multinational pilot studies. Research groups from 14 countries participate in the CRP.

Results. The results of the first CRP step show agreement within 1% of participants' TPS output factors and the reference data for field sizes $\geqslant 4 \times 4\ cm^2$ but dose overestimation by TPSs by 2–3% for field sizes $\leqslant 3 \times 3\ cm^2$. The second step confirmed that most audited MLCs perform as expected. The results of the third CRP step show that TPS plans prepared by participants and delivered to films agree

well; however, comparison of gamma analysis techniques highlighted differences among centres. The fourth step 'end-to-end' IMRT audit is on-going.

Conclusion. A four step methodology for remote dose audits of IMRT and related beam characteristics has been developed at the IAEA and is being tested before dissemination to national audit networks operating across the world.

Disclosure. No conflicts of interest.

http://dx.doi.org/10.1016/j.ejmp.2016.07.574

ASSESSMENT OF PORTAL DOSIMETRY ACCURACY AS A QA TOOL FOR VMAT CLINICAL TREATMENT PLANS USING DOLPHIN/COMPASS TOOLS

M. Tomsej *, A. Monseux, V. Baltieri, C. Leclercq, A. Sottiaux

CHU Charleroi A. Vésale, Charleroi, Belgium
* Corresponding author.

Introduction and purpose. Thanks to intensity modulated radiotherapy and dynamic arctherapy techniques, the degree of complexity of modern radiotherapy treatments has reached an important level, especially when attempting to better spare organs at risk, while trying to escalate the dose to target volumes. In order to achieve this, quality has to be ensured through the whole RT quality assurance chain.

At CHU de Charleroi, patients with head and neck and pelvic cancers are treated on a Novalis powered by Truebeam STx (VARIAN) linac using VMAT technique, and thus patient specific QA is performed for each single clinical treatment plan.

Materials and methods. VMAT patient QA is known to be very time and energy consuming; our current routine methodology is based on a 2D coronal plane comparison containing measured and calculated absorbed fluences in the detector plane in a phantom. Portal dosimetry of each clinical treatment arc is also performed and looks attractive thanks to its rapid measurement and potential efficiency but is not a dose measurement. As measurement with flat panel for portal dosimetry shows a totally different geometry, in terms of measurement conditions, both measurements cannot be correlated.

Therefore, for localizations requiring high intensity modulation such as head and neck and some challenging pelvic cases, a special methodology has been developed in order to be able to compare such fluences. This is made feasible thanks to a new dosimetry equipment acquiring radiation at the exit of the collimator, called DOLPHIN using COMPASS software in the framework of a scientific collaboration with IBA Dosimetry. Basically, the aim of this detector system is to reconstruct the dose into the patient CT, injecting delivered fluence instead of the calculated one from the TPS model software.

Results. Until now, more than 30 clinical cases have been investigated but the feasibility is demonstrated. So far, good agreement between predictions and measurements is obtained. Actually, for 14 clinical arcs evaluated (for all localizations), in average 97.4% of the pixels passed, and 0.5% of the points are between 1 and 1.05 for a gamma criterion of 3%–3 mm. Results for more than 30 patients will be presented sorting out dosimetry information from different localizations.

Conclusion. For all cases – including head and neck and pelvic localizations- analyzed and showed in this study, measurements performed by linac flat panel and considered detector showed excellent agreement.

http://dx.doi.org/10.1016/j.ejmp.2016.07.575

DOSIMETRIC CONFIRMATION OF MONITOR CHAMBER POSITIONING FOLLOWING A CAROUSEL PULLOUT ON A VARIAN TRUEBEAM LINAC

Albert Sabbas *, William Daling, J. Keith DeWyngaert

New York Presbyterian Hospital, Weill Cornell Medical Center, New York, NY, United States
* Corresponding author.

Introduction. The carousel assembly in a TrueBeam is different from that on the C-Series linacs. In addition to the foils and filters the carousel now positions the monitor chamber and field light using four motorized motion axes. The chamber is positioned in the beam during the Prepare phase and is retracted during the Preview phase.

Purpose. The Chamber Fault interlock prevents beam-on conditions when the monitor chamber is not correctly positioned. To correct this fault it may be necessary to pullout the carousel assembly, inspect and resolve issues with the chamber moving mechanism. We describe a set of dosimetric measurements serving as baselines and repeated following a carousel pullout.

Materials and methods. We used the Profiler2 which comprises of two sets of diode arrays. The Profiler is mounted on the collimator head. In addition to the array calibrations which are necessary for relative profile measurements, we obtained absolute dose calibrations for each of the nine energies. Radial and transverse profiles were then acquired at two different depths.

Results. The CAX doses at each of the depths were used to evaluate both the output and energy constancy and the profiles were used to derive the radial and transverse symmetries. These four dosimetric indicators were compared, following a carousel pullout, to their baseline values.

Conclusion. We have implemented an efficient and effective set of measurements to dosimetrically characterize each beam. They serve as baselines for evaluating correct monitor chamber placement following repairs involving the carousel.

Disclosure. None.

http://dx.doi.org/10.1016/j.ejmp.2016.07.576

THE REPRODUCTION FOR THE ABSORBED-DOSE TO WATER OF THE CLINICAL ACCELERATOR PHOTON BEAMS

Sunjun Jin *, Kun Wang, Yaodong Fan, Zhipeng Wang, Ji Huang, Xiaoyuan Yang, Jian Zhang

National Institute of Metrology, Beijing 100029, China
* Corresponding author.

Introduction. The absorbed-dose to water(D_w) of the clinical accelerator photon beams is a fundamental quantity in radiation oncology. The accuracy of D_w has been maintained by the exposure or air kerma standard of ^{60}Co γ radiation in the past few decades. The rapid development of radiation oncology requires the improvement of dissemination system and calls for an absolute measurement of D_w.

Purpose. Perform the study for the reproduction and determine the value of D_w via an absolute measurement method.

Materials and methods. A water calorimeter is used to conduct the measurement of D_w. The related corrections such as the non-uniformity of the photon radiation field, the heat conduction, the heat conduction as well as the heat defect of water are clarified by the experiment.

Results. The D_w of 6 MV, 10 MV photon beams is reproduced and compared to the results from a transfer chamber, which is traced to the absolute measurement result in NRC. The discrepancy is less than 0.7%.

Conclusion. The value of D_w of the 6 MV and 10 MV clinical accelerator photon beams has been successfully reproduced via a water calorimetric method. The present work is a preliminary step to participate in the key comparison of BIPM, which is about the absorbed-dose to water of the clinical accelerator photon beams.

Disclosure. Authors should disclose any relationship that may bias their presentation. Please enter disclosure information here.

http://dx.doi.org/10.1016/j.ejmp.2016.07.577

A COMPARATIVE PLAN ANALYSIS: CONSTANT AND VARIABLE DOSE RATE VMAT AND STEP-AND-SHOOT IMRT IN HEAD AND NECK CANCER

Didona Annamaria *, Aristei Cynthia, Zucchetti Claudio, Tarducci Roberto, Panizza Moira Bianca, Frattegiani Alessandro

Santa Maria della Misericordia Hospital, Medical Physics Department, Perugia, Italy
* Corresponding author.

Introduction. IMRT is recognized as a powerful technique to improve quality of dose distribution in head and neck (HN) radiotherapy.

Purpose. To compare Constant and Variable Dose Rate VMAT (CDR,VDR respectively) to Step-and-Shoot IMRT (S&S-IMRT) for treatment of HN cancer.

Materials and methods. S&S-IMRT, CDR and VDR plans were created for 10 patients. 3 PTVs were defined (prescribed doses 66 Gy, 60 Gy and 54 Gy, 30 fr). OARs included mandible (MA), spinal cord (SC), brain stem (BS), parotids (PA), salivary glands (SG), esophagus (ES), larynx (LA) and thyroid (TH). S&S-IMRT plans consisted of seven 6 MV coplanar beams; CDR and VDR plans consisted of two 6 MV arcs (182° to 178°; clockwise and counterclockwise direction). All plans were performed with Pinnacle3 TPS (v 9.8).

Dose distributions were compared by evaluating PTVs' D_{mean}, $D_{2\%}$, $D_{50\%}$, $D_{98\%}$ and Homogeneity Index (HI); for MA, SC, BS $D_{2\%}$; for PA, SG, ES, LA and TH D_{mean} and a number of different dose-volume data in $V_{20\ Gy}$–$V_{50\ Gy}$ range. To compare efficiency, MUs and treatment delivery time were evaluated.

Results. Concerning PTVs coverage, all techniques were equivalent although VMAT ones significantly improved HI and decreased $D_{2\%}$. For OARs significantly better results were found for VMAT techniques with reduction in the volume of LA, TH and ES receiving medium and high doses. Compared with S&S-IMRT, VMAT techniques reduced delivery times although MUs were higher.

Conclusion. VMAT techniques offer better results and CDR is an additional option of rotational arc radiotherapy for linacs without variable dose rate with a lower cost.

http://dx.doi.org/10.1016/j.ejmp.2016.07.578

ON THE SPATIAL SENSITIVITY OF A 3D DOSIMETRIC PHANTOM

E. Apostolou *, R. Avgousti, C. Armpilia, A. Nikolakopoulou, A. Zygogianni, C. Antypas

Radiology Dept, Medical Physics Unit, Medical School, National and Kapodistrian University of Athens, Greece
* Corresponding author.

Purpose. The aim of this study is to evaluate the spatial sensitivity of the 3D dosimetric phantom Delta^4 (Scandidos, Uppsala, Sweden) investigating whether phantom set up errors affect or not the measurement's results during plan verification.

Materials and methods. The Delta^4 phantom is used to verify a test IMRT prostate plan that was created on Oncentra v4.3 (Nucletron, Electa) treatment planning system. The patient plan was transferred to the Delta^4 geometry and was delivered on a 6 MV photon beam SIEMENS Oncor Impression linac. The measurements' results are evaluated using the gamma index criteria (3%/3 mm) and the application of the plan is considered successful with an over 90% gamma index passing rate. The reference (no-shift) plan was delivered on the linac with a ±3 mm shift of the phantom at lateral, longitudinal and vertical direction.

Results. The gamma index passing rate was measured at no-shift position 99.7%. For shifts in every direction gamma index was measured lower than 99.7% for each other position, but still over the passing rate limit 90%.

The maximum and minimum gamma index passing rate for lateral direction was measured 96.7% (at +3 mm shift) and 89.6% (at −3 mm shift) respectively, for longitudinal direction 99.4% (at −3 mm shift) and 84.3% (at −3 mm shift) respectively and for vertical direction 96.2% (at −3 mm shift) and 88.7% (at −3 mm shift) respectively.

Conclusion. In this study, the testing of the spatial sensitivity of Delta^4 phantom indicates that for 3%/3 mm gamma-index criteria the phantom lacks sensitivity for shifts less than 3 mm.

http://dx.doi.org/10.1016/j.ejmp.2016.07.579

ELECTRON DEPTH DOSE CURVES IN INHOMOGENEOUS MEDIUM FOR RADIATION THERAPY: A SIMULATION APPROACH

A.S. Jagtap [a,c,*], B.J. Patil [b], S.S. Dahiwale [a], V.N. Bhoraskar [a], S.D. Dhole [a]

[a] *School of Basic Medical Sciences, Department of Physics, Savitribai Phule Pune University, Pune 7, India*
[b] *Abasaheb Garware College, Karve Road, Pune 411004, India*
[c] *SAMEER, IIT Powai Campus, Mumbai 400076, India*
* Corresponding author.

Introduction. MeV energy electron beam is used very often for skin cancers treatment. Most of the time the percentage depth dose (PDD) and depth of maximum dose deposited (Dmax) is to be calculated based on homogenous medium. But the dose distribution can be significantly altered in the presence of tissue inhomogeneity such as bone, lung, and air cavities.

Purpose. It is difficult to determine dose distribution within or around small inhomogeneity because of enhanced electron scattering effects, therefore, accurate knowledge of dose distribution in homogeneous and inhomogeneous medium is very important for the delivery of accurate dose and treatment.

Materials and methods. In present work, EGSnrc Monte Carlo code has been used for the calculation of PDD curves in homogeneous and inhomogeneous medium. The bone of varying thickness is considered in water phantom to study effect of tissue inhomogeneity. Electron beam of energies 4–20 MeV have been used for the simulation purpose.

Results. The PDD has been estimated for the case of homogenous medium of water and bone and also for the case of bone of different thicknesses inserted before and after the build-up region in water phantom. It has been observed that the values of R90, R50, Rp have been decreased linearly with the bone thickness for all electron energies. Also it has been found that below the depth of inhomogeneity, PDD has increased by 10% for 0.8 cm of bone at 12 MeV.

Conclusion. It is concluded that because of inhomogeneity, PDD beyond inhomogeneity increases and after Dmax it decreases. This data could be useful for the clinicians to define dose prescription

point during electron beam therapy and can achieve the perfection of treatment.

http://dx.doi.org/10.1016/j.ejmp.2016.07.580

EFFECTS OF INTERRUPTIONS FOR PUBLIC HOLIDAYS IN SPAIN ON RADIOTHERAPY TREATMENTS

J.M. de la Vega [a,*], B. Ríos [b], J. Torres del Río [a], R. Guerrero [a], I. Castillo [c], D. Guirado [a]

[a] *Servicio de Radiofísica, Complejo Hospitalario de Granada, Spain*
[b] *Servicio de Radioterapia, Hospital Vithas Xanit de Benalmadena, Hospital Carlos Haya de Málaga, Spain*
[c] *Servicio de Radioterapia, Complejo Hospitalario de Granada, Spain*
* Corresponding author.

Introduction. In Spain there are 14 public holidays (PH) per year in which radiotherapy treatments are not administered. This reason causes 45% of the unscheduled stops registered in our department and a loss in local control probability (LCP) of the disease, or the increase of likelihood of biochemical failure (BF) in cases of prostate tumors.

Purpose. Our department has an interruptions management program since 2011. This work shows the benefit that it would have been obtained on 2292 radiotherapy treatments (1 March 2011 to 15 August 2015) if treatments had not stopped on PH.

Materials and methods. To study the impact of PH working, the disappearance of these interruptions in each patient will be simulated. This will cause overall treatment time (OTT) to decrease. This decrease in OTT will result in an improvement of the LCP, or a decrease in BF. This absolute improvement, named B_{treat}, is calculated from the published data of the influence of OTT in final outcomes of radiotherapy combined with the OTT data obtained in our patient sample.

Results. The mean value of B_{treat} are: 1.7%, 1.5%, 0.5%, 0.7% and 1.1% for head and neck, lung, cervix, breast and prostate cancer respectively. In addition 13.3%, 11.1%, 0.0%, 7.9% and 9.4% of these treatments had a $B_{treat} > 4\%$ due to PH working.

Conclusion. The effects of PH working improve the outcome of fractionated radiotherapy in certain pathologies, specially HN, lung and prostate cancer, with a relatively low cost and could be implemented in any radiotherapy service.

http://dx.doi.org/10.1016/j.ejmp.2016.07.581

RADIOBIOLOGICAL EFFECTS OF CANCER STEM CELL-TARGETING THERAPY IN A HEAD AND NECK CANCER MODEL

Loredana G. Marcu [a,b,*], David Marcu [a]

[a] *Faculty of Science, University of Oradea, Romania*
[b] *School of Physical Sciences, The University of Adelaide, SA 5005, Australia*
* Corresponding author.

Introduction. Cancer stem cells (CSC) represent a subpopulation of cells that are responsible for treatment failure. While altered fractionation radiotherapy is a powerful tool in head and neck cancer (HNC) treatment, CSCs require targeting therapy in order to be eradicated. All-trans-retinoic acid (ATRA) was shown to have cell cycle effects that sensitise CSC response to treatment.

Purpose. The aim of this work was to optimise HNC treatment using targeted therapies and to evaluate the effect of such agents on the tumour population as a whole.

Materials and methods. A Monte Carlo model was developed to grow a hypoxic HNC consisting of all lineages of cancer cells. The biological input parameters led to a pre-treatment CSC population of 5.9%. The Linear Quadratic model was employed to simulate radiotherapy. The effects of ATRA, namely differentiation, cell arrest and apoptosis were modelled, based on literature data.

Results. While the effect of differentiation was marginal, cell arrest induced by ATRA resulted in 14.4 Gy lower dose as compared to radiotherapy-alone for the same tumour response. The effect of apoptosis decreased the total dose needed for CSC eradication with a further 10.8 Gy. However, the tumour population as a whole was not notably affected, as the quiescent cells appear to dictate the shape of the survival curve.

Conclusion. ATRA exhibits a powerful effect on CSCs when combined with radiotherapy. Nevertheless, the model showed that quiescent cells should not be neglected, as their radioresistance is a potential threat if cells are recruited into the cell cycle.

http://dx.doi.org/10.1016/j.ejmp.2016.07.582

RADIOBIOLOGICAL ANALYSIS FOR EVALUATION OF SIB HYPOFRACTIONED TREATMENT IN H&N DISEASE

L. La Rosa, A. Occhipinti, A. Pedalino *, A. Rabito

Medical Physics Department, ASP 7 Ragusa, Italy
* Corresponding author.

Introduction. In this work we have analyzed a method to calculate a SIB hypofractionated treatment, starting from the prescription of a conventional treatment including a sequential boost (1.8–2 Gy/fr).

Purpose. To calculate the SIB hypofractionated treatment we have started from the Biological Equivalent Dose (BED) calculation: we have estimated BED value for tumoral tissues (BED_T) and normal tissues (BED_{SANI}).

Materials and methods. We have analyzed cases of patients with head and neck disease. We have started from the conventional treatment prescription and, according to the isoeffect theory, we (have) calculated the SIB hypofractionated treatment, evaluating BED_T and BED_{SANI}.

To estimate, from a statistical point of view, the effects of the hypofractionated treatment compared to the conventional treatment including the sequential boost, two radiobiological quantities have been used: TCP (Tumor Control Probability) e NTCP (Normal Tissue Complication Probability).

At last, we compared the prescribed conventional treatment and the hypofractionated treatment calculated, basing on the DVH obtained from the two techniques, for tumors and OAR, and on the TCP and NTCP calculation.

Results. The accomplished assessments show, as expected, that in Hypofractionated treatment (SIB) we observe increasing TCP values, corresponding to a higher probability of tumor local control, as well as a decreased probability of damaging normal tissues ($NTCP_{SIB} < NTCP_{conv}$).

Conclusion. This method to calculate the SIB hypofractionated treatment appears to be very successful in reducing the overall treatment time and in achieving a greater effect on the tumor and a reduced impact on normal tissues.

Disclosure. None.

http://dx.doi.org/10.1016/j.ejmp.2016.07.583

NTCP SHIFT IN RADIOTHERAPY OF LUNG CANCER WHEN CHANGING EITHER THE RADIOBIOLOGIC MODELS OR THE PHOTON DOSE CALCULATION ALGORITHMS

Abdulhamid Chaikh *, Jacques Balosso

Department of Radiation Oncology and Medical Physics, University Hospital of Grenoble, France
University Grenoble-Alpes, Grenoble, France
* Corresponding author.

Introduction and purpose. In radiotherapy the tumor control and the Normal Tissues Complication Probability (NTCP) are directly correlated to the delivered dose. The purpose of this work is to evaluate and quantify the variations of NTCP for lung when changing radiobiological models or dose calculation algorithms.

Materials and methods. Twelve radiotherapy treatment plans were generated. The doses were calculated using the former Pencil Beam Modified Batho (PB-MB) with 1D density correction and the Anisotropic Analytical Algorithm (AAA). Data derived from dose volume histograms (DVH) for healthy lung were compared. NTCP for lung pneumonitis was computed using two radiobiological models: Lyman et al. (LKB) and Equivalent Uniform dose (EUD). Seven sets of radiobiological parameters were tested to explore the best correlation predicting the NTCP, based on dosimetric data, using Spearman's rank test. The bootstrap method was used to estimate the 95% confidence intervals, and the Wilcoxon paired test to calculate *p*-values.

Results. The DVHs showed that AAA predicted higher dose for lung than PB-MB. Consistently, AAA predicted significantly higher NTCP values than PB-MB with $p < 0.01$; this difference can reach 20% depending on radiobiological parameters and models. Spearman's test indicated a strong correlation with mean dose, V20 and V30.

Conclusion. This study confirms that relevant radiobiological parameters should be re-established for the most recent, and now recommended, algorithms such as AAA or AcurosXB to obtain trustable predictions of pneumonitis toxicity and avoid over/under estimated NTCP. This is critical if medical decisions have to be based on NTCP estimations.

Disclosure. None.

http://dx.doi.org/10.1016/j.ejmp.2016.07.584

QUANTIFICATION OF THE IMPACT OF ELECTRONS TRANSPORT MODEL ON DVH METRICS AND RADIOBIOLOGICAL INDICES FOR LUNG RADIOTHERAPY PLANS

Abdulhamid Chaikh *, Jacques Balosso

Department of Radiation Oncology and Medical Physics, University Hospital of Grenoble, France
University Grenoble-Alpes, Grenoble, France
* Corresponding author.

Introduction and purpose. to evaluate and quantify the impact of the calculation of electrons transport on dose distribution and radiobiological predictions for lung radiotherapy.

Materials and methods. The dose was calculated using the former Modified Batho (PB-MB) method and the Anisotropic Analytical Algorithm (AAA). Data derived from DVH, for target and lung, were compared. To compare dose distribution, 2D gamma (γ) index was applied. The radiobiological indices, TCP and NTCP, were compared using Lyman and EUD models. Spearman's rank test was used to explore the best correlation coefficient (ρ) predicting the dose difference. The bootstrap method was used to estimate the 95% confidence intervals, and Wilcoxon paired test to calculate *p*-values.

Results. For the same prescribed dose, the plans generated with AAA predicted less dose and a more heterogeneous dose distribution inside the target, with $p < 0.05$ MB predicted a better coverage of the target, overestimating the TCP while underestimating the NTCP, with $p < 0.05$. The γ analysis showed that the difference between MB and AAA could reach up to ±10% confirming the results obtained from TCP/NTCP. The data showed a good correlation between TCP with D95%, as well as NTCP with mean dose, V20 and V30, with $\rho > 0.7$.

Conclusion. The electrons transport, taken into account by AAA, showed a significant impact on delivered dose, dose distribution and TCP/NTCP. Readjusting the prescribed dose and a better optimization to protect the organs at risks should be considered and discussed when using new algorithms as AAA type.

Disclosure. None.

http://dx.doi.org/10.1016/j.ejmp.2016.07.585

EFFECTS OF LOW-DOSES IONIZING RADIATION ON IL-4, IFN-*Γ* AND TGF-*B* genes expression in spleen lymphocytes of BALB/C mice

Mohammad Taghi Bahreyni Toossi [a,*], Maryam Najafi Amiri [b], Mojtaba Sankian [c], Hosein Azimian [a], Sepideh Abdollahi Dehkordi [b], Sara Khademi [d]

[a] *Medical Physics Research Center, Mashhad University of Medical Sciences, Mashhad, Iran*
[b] *Departments of Medical Physics, Mashhad University of Medical Sciences, Mashhad, Iran*
[c] *Immunobiochemistery Lab, Bu-Ali (Avecina) Research Center, Mashhad University of Medical Sciences, Mashhad, Iran*
[d] *Departments of Medical Physics and Biomedical Engineering, Tehran University of Medical Sciences, Tehran, Iran*
* Corresponding author.

Introduction. While the widespread application of ionizing radiation in diagnostic and therapeutic medical procedures is unavoidable, Effects of low doses of ionizing radiation LDIR (low doses of ionizing radiation) are not quite obvious. Moreover, it has been showed that LDIR could affect our immune system.

Purpose. The aim of this study was to appraise the effects of LDIR on the inflammation genes expression levels of the immune system.

Materials and Methods. Balb/C mice were exposed to 20, 50 and 100 mGy WBI by gamma rays from a Cobalt-60 source. Lymphocytes of their spleen were extracted 24 h after exposing the animal for gene expression analysis. IL-4, IFN-γ and TGF-β expression levels were examined by relative quantitative real-time PCR and IFN-γ/IL-4 ratio was evaluated. To compare means values of gene expression the independent samples *T*-test was performed.

Results. The results of this study are evident that low doses of gamma radiation can induce changes on the expression level of the investigated genes and IFN-/IL-4 ratio in Balb/C spleen lymphocytes. A significant reduction of IL-4, IFN-γ and TGF-β genes and an increase of IFN-γ/IL-4 ratio has been induced in the group with 20 mGy of LDIR, while IFN-γ/IL-4 ratio was not changed following to 50 and 100 mGy of gamma irradiation.

Conclusion. Our result revealed that 20 mGy dose of gamma radiation can activate protection mechanisms as apoptosis and therefore cause the reduction of investigated genes and immune response shifting to Th1 and thereupon humoral immunity. However no shift to immune response has been observed in the groups which have received doses of 50 and 100 mGy. These results may be of importance to radiation workers and autoimmune patients.

Disclosure. There is not any relationship that might lead to a conflict of interest. Mashhad University of Medical Sciences (MUMS) has financially supported this work.

http://dx.doi.org/10.1016/j.ejmp.2016.07.586

THE EFFECT OF CONCURRENT RADIATION AND CALCIUM IN TWO CANCER CELL LINES

Jessica Billberg [a,c,*], Stine Krog Frandsen [b], Julie Gehl [b], Faisal Mahmood [b,c]

[a] *Department of Medical Radiation Physics, Lund University, 221 85 Lund, Sweden*
[b] *Radiotherapy Research Unit, Department of Oncology, Herlev Hospital, University of Copenhagen, Herlev Ringvej 75, DK-2730 Herlev, Denmark*
[c] *Radiotherapy Research Unit (RRU), Department of Oncology, University of Copenhagen, Herlev and Gentofte Hospital, 2730 Herlev, Denmark*
* Corresponding author.

Introduction. Calcium is an important ubiquitous second messenger regarding the maintenance of cellular homeostasis, and is therefore tightly regulated. Calcium induces cell death when internalised into cancer cells after permeabilization of the cell membrane by electroporation. It is established that radiation causes damage to the lipids and proteins of the cell membrane; and ionizing radiation also causes permeabilization of the cell membrane by peroxidation of the phosphor-lipid layer.

Purpose. To investigate the survival of two cancer cell lines exposed to high levels of calcium in combination with irradiation.

Materials and methods. Two cancer cell lines are used in this study; H69 (small cell lung cancer) and SW780 (bladder cancer). 30.000 cells in 50 µl Hepes buffer with or without 5 mM $CaCl_2$ is irradiated in open air with X-rays of 100 kV in the dose range of 0–16 Gy using an X-ray system (Gulmay D3100). To verify the given dose GAFCHROMIC™ EBT3 dosimetry film and TLD are used.

Results. The expected outcome (results acquired within one month) is a decrease in the survival of cancer cells exposed to calcium concurrently with ionizing radiation compared with cells that has been exclusively exposed to radiation.

Conclusion. If the results confirm the hypothesis that cell survival decreases by exposing cancer cells to calcium and ionizing radiation, this would support the idea of using calcium in cancer treatments. Addition of calcium in radiation therapy might increase the effect of the treatment and thus substituting calcium for chemotherapeutic agents could be an efficient and inexpensive treatment.

http://dx.doi.org/10.1016/j.ejmp.2016.07.587

MEDICAL PHYSICISTS CERTIFICATION PROCESS AND EXAMINATION IN THE MIDDLE EAST

Ibrahim Duhaini

Rafik Hariri University Hospital, Radiation Oncology Department, Beirut, Lebanon

Certifying medical physics is becoming an essential part in recruiting medical physicists in hospitals across the Middle East region. Due to the lack of a comprehensive post graduate programs in MP in most of ME countries; hospitals find it very difficult to hire MP without the proper credentials and clinical experiences. Also, MP in the region find it very difficult to apply and travel for certification in Europe or North America due to visa and other related issues. So, if these certifying bodies are welling to cooperate with MEFOMP and/or similar organizations in the ME region so that certifications will be offered in the region for the region in a way to ease the process and save efforts and resources from the burdens of MP.

Certifying Medical Physicist requires an individual to obtain a university degree at the level of Master degree in Medical Physics, this is followed with at least a one year of clinical residency program in the Medical Physics fields applied in a Hospital.

The existing local/national certifying organization exam models are utilized as reference to design the final exam structure which can be customized for the medical physicists that will be working in the Middle East.

Three Exam Model proposals will be discussed here, all of which aim to evaluate the competencies of the individual medical physicist knowledge and skills by following various examination approaches.

http://dx.doi.org/10.1016/j.ejmp.2016.07.588

SUSTAINABILITY OF THE EUROPEAN TRAINING AND EDUCATION OF THE MEDICAL PHYSICS EXPERT IN DIAGNOSTIC RADIOLOGY (EUTEMPE-RX)

Stelios Christofides [a,*], Virginia Tsapaki [b], Carmel J. Caruana [c], Hilde Bosmans [d]

[a] *Biomedical Research Foundation, Nicosia, Cyprus*
[b] *Konstantopoulio General Hospital, Athens, Greece*
[c] *Medical Physics Department, Faculty of Health Sciences, University of Malta, Malta*
[d] *Department of imaging and pathology, University of Leuven, Belgium*
* Corresponding author.

Introduction. EUTEMPE-RX (http://www.eutempe-rx.eu/) is an EU funded project that provides state-of-the-art education for Medical Physicists in diagnostic and interventional radiology at expert level. Its sustainability is crucial for the high level of education and training of Medical Physicists in this specialty hence ensuring radiation safety in Europe and beyond.

Purpose. To present the plans for a sustained continuation of EUTEMPE-RX under the umbrella of the EUTEMPE Network.

Materials and methods. The work-out of a business plan for sustainability of the EUTEMPE-RX course modules is a project task. Given the overwhelming level of satisfaction expressed by the present EUTEMPE-RX participants, the quality EUTEMPE-RX manual was considered the best basis for future actions. The present modules will be repeated and parallel programmes will be developed for Nuclear Medicine and Radiation Oncology.

Results. The major sustainability achievements so far have been the creation of a Memorandum of Understanding for continued efforts among current project partners and the foundation of the EUTEMPE network. The structure, quality manual and terms of reference for the Boards and Committees of the EUTEMPE Network have been established and the population of these is being solicited. The programme for the second round of EUTEMPE-RX modules will be available soon.

Conclusion. A sustainability business plan for EUTEMPE-RX is being developed. The EUTEMPE-RX modules will be repeated in the near future and possibly expanded to other specialties of medical physics. Demand will decide the sustainability of EUTEMPE Network.

Disclosure. The authors declare that they have no conflict of interest.

http://dx.doi.org/10.1016/j.ejmp.2016.07.589

PRODUCING THE NEXT GENERATION OF MEDICAL PHYSICS LEADERS IN EUROPE: EUTEMPE-RX MODULE MPE01 'DEVELOPMENT OF THE PROFESSION AND THE CHALLENGES FOR THE MPE (D&IR) IN EUROPE'

Carmel J. Caruana [a,*], Eliseo Vano [b]

[a] *University of Malta, Msida, Malta*
[b] *Complutense University, Madrid, Spain*
* Corresponding author.

Introduction. Although Medical Physics scientific education is very well developed, leadership education is not. This is having a negative effect on the profession and needs to be remedied urgently.

Purpose. To develop, deliver and evaluate an EQF Level 8 leadership educational module for Medical Physics (Diagnostic and Interventional Radiology) within the EUTEMPE-RX project.

Materials and methods. A survey of the literature was carried out to identify present professional issues in Medical Physics and elements of good practice in leadership curricula in healthcare. A leadership curriculum for Medical Physics was subsequently developed, delivered and evaluated.

Results. The module helps participants acquire the knowledge, skills and competences necessary to assume a leadership role in their own country and in Europe. It includes legal, strategic planning, management, governance, professional development and educational issues – all discussed in the context of specific case studies in D&IR. Participants had the opportunity to discuss the major challenges directly with the present European leaders of the profession. Given the comprehensive nature of the module the number of CPD points awarded by EFOMP to participants was 160. The module was oversubscribed and extremely well received by the participants who awarded very high ratings in their evaluation.

Conclusion. A repeat module is scheduled: online phase starts November 2016, face-to-face Prague 6 – 10 Feb, 2017. Subscription will open soon at the EUTEMPE-RX website.

Disclosure. None.

http://dx.doi.org/10.1016/j.ejmp.2016.07.590

IMPLEMENTATION OF THE "ANTHROPOMORPHIC PHANTOMS" EDUCATIONAL MODULE FROM THE EUROPEAN EUTEMPE-RX COURSE

Kristina Bliznakova [*], Ivan Buliev, Zhivko Bliznakov

Technical University of Varna, Varna, Bulgaria
* Corresponding author.

Introduction. Anthropomorphic phantoms play a critical role in the contemporary development of Diagnostic Radiology. The *Anthropomorphic Phantom* educational module has been successfully developed to provide education and training of Medical Physics Experts in the field of Radiology.

Purpose. The aims were to familiarize the participants with the role of the physical and virtual anthropomorphic phantoms and the possibility of performing virtual clinical trials using existing and new Diagnostic and Interventional Radiology technologies.

Method. The *Anthropomorphic Phantoms* module is one of the 12 modules of the EUTEMPE-RX course. Teaching methodology includes e-learning and face-to-face approaches. The course is organized in a blended format that includes lectures, computer-based exercises, visits to hospital for experimental work and discussion sessions. The online part was developed on SEKOIA platform and included 10 chapters with state of the art reviews in the field, introduction to software used for X-ray imaging and examples.

Results. The face-to-face part started on September 7, 2015 at the Technical University of Varna, and lasted one week. Lectures and practical work were delivered to seventeen participants from 14 European countries. All lectures were led by worldwide recognized researchers in the field of anthropomorphic phantoms and their use in the research and clinical practice. The focus was on the practical work and the development of a work project. All participants passed successfully the exam.

Conclusions. The main aims of the module were successfully obtained. Selected project works are currently under detail development and will be submitted for publication.

http://dx.doi.org/10.1016/j.ejmp.2016.07.591

NEW EUROPEAN RECOMMENDATIONS FOR MP STAFFING LEVELS – APPLICATION TO PORTUGAL

R. Figueira [a,b,*], E. Poli [a,c], J. Isidoro [a,d]

[a] *Divisão de Física Médica da Sociedade Portuguesa de Física, Portugal*
[b] *Centro Hospitalar de São João, Porto, Portugal*
[c] *Centro Hospitalar Lisboa Norte, Portugal*
[d] *Centro Hospitalar e Universitário de Coimbra, Coimbra, Portugal*
* Corresponding author.

Introduction. The publication of the EC Guidelines on the Medical Physics Expert (RP174) and the updated EFOMP Policy Statement 7.1 provided european countries with a new reference for medical physics staffing levels according to the different areas of application.

Purpose. To characterize the current portuguese situation and, using these newly published recommendations, identify the number of medical physicists required per area and compare with the existing situation.

Materials and methods. Official data from Health Ministry documents, quantifying the number of radiological installations, equipments and clinical workload, were used as input for the calculation of the necessary staffing levels according to the recommendations. In parallel, data from a 2015 survey conducted by DFM-SPF were used to characterize the actual situation. A comparison between both was made for each area.

Results. Based on the comparison between the recommended number of medical physicists and the current number, the real needs of the country were identified. The presence of medical physicists in Radiotherapy and Nuclear Medicine, although below the recommended number, is well established. That is not the case in Diagnostic and Interventional Radiology where there is a real lack of presence of medical physicists.

Conclusion. This study allowed to identify areas of main concern in terms of medical physics staffing levels. The results highlight the existing deficit in the number of professionals and will be presented to national health authorities. It can be used as a tool for planning future education and training requirements to provide the country with the necessary qualified medical physicists to guarantee the quality and security of the radiological medical procedure

Disclosure. The authors have nothing to disclose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.592

A MULTIMODALITY NETWORK PLATFORM FOR ONCOLOGIC SOLUTION

F. Di Rosa *, R. Costa, G. Politi, D. Sardina

Azienda Sanitaria Provinciale di Caltanissetta (Sicilia), Fisica Sanitaria, UOC Radioterapia, Italy
* Corresponding author.

Introduction. Two facilities, located in different geographical areas and related to a single Radiotherapy Department, need a massive storage of multimodal DICOM images. A network connection is required in order to share all clinical, physical and dosimetric information.

Purpose. We design and implement a server infrastructure to perform a real time connection for the full management of a Radiotherapy Department.

Materials and methods. We developed a server architecture dedicated to radiotherapy requirements based on an advanced DICOM forwarding rules: RTPACS. The combination of this system with an advanced DICOM viewer assures a full support of DICOM standard extension.

The use of a DICOM server, embedded with programmable SQL databases, offers all solutions to satisfy the requirements for a long-term storage allowing the clinical plan evaluation free by TPS vendor.

Results. RTPACS provides easy access to the single patient waiting list and a multidisciplinary and multicenter study of a same patient: a treatment can be planned, valued, approved and delivered independently in both facilities. Such system ensures a continuative service avoiding treatment interruptions caused by machine maintenance or downtime. Moreover, RTPACS constitutes a tool to manage, compare and storage the quality controls results performed by images.

Conclusion. A network implementation joining two far facilities of the same Department answers to the needs and cares of the oncologic patient. It represents an innovative, easy and affordable solution that provides a service we cannot find in our territorial area. A unique radiotherapy data management permits a better organization of human resources.

Disclosure. Authors disclose any relationship that may prejudice their presentation.

http://dx.doi.org/10.1016/j.ejmp.2016.07.593

ACCURACY OF THE SMALL FIELD DOSIMETRY USING ACUROS XB AND AAA DOSE CALCULATION ALGORITHMS OF ECLIPSE TREATMENT PLANNING SYSTEM WITHIN AND BEYOND HETEROGENEOUS MEDIA FOR TRUBEAM 2.0 UNIT

G. Codel *, E. Serin, M.S. Cebe, H. Mabhouti, P. Pacaci, E. Sanli, M. Doyuran, E. Kucukmorkoc, A. Altinok, D. Canoglu, N. Kucuk, H. Acar, H. Caglar

Istanbul Medipol University, Radiation Oncology Department, Turkey
* Corresponding author.

Purpose. In this study, the comparison of dosimetric accuracy of Acuros XB and AAA algorithms were investigated for small radiation fields incident on homogeneous and heterogeneous geometries.

Methods. Small open fields of Truebeam 2.0 Unit $1 \times 1.2 \times 2.3 \times 3.4 \times 4\ cm^2$ were used for this study. The fields were incident on homogeneous phantom and phantom containing lung, air, and bone inhomogeneities. Using the same film batch, the net OD to dose calibration curve was obtained using Trubeam 2.0 for 6 MV, 6 FFF, 10 MV, 10 FFF, 15 MV energies by delivering 0–800 cGy. Films were scanned 48 h after irradiation using an Epson 1000XL flatbed scanner. The dosimetric accuracy of Acuros XB and AAA algorithms in the presence of the inhomogeneities was compared against EBT3 film dosimetry

Results. Open field tests in a homogeneous phantom showed good agreement between two algorithms and measurement. For Acuros XB, the minimum gamma analysis passing rates between measured and calculated dose distributions were 99.3% and 98.1% for homogeneous and inhomogeneous fields in the case of lung and bone respectively. For AAA, the minimum gamma analysis passing rates were 99.1% and 96.5% for homogeneous and inhomogeneous fields respectively for all used energies and field sizes. In the case of the air heterogeneity, the differences were larger for both calculations algorithms. Overall, when compared to measurement, the AcurosXB had better agreement than AAA.

Conclusions. The Acuros XB calculation algorithm in the Eclipse TPS is an improvement over the existing AAA algorithm. Dose discrepancies were observed for in the presence of air inhomogeneities.

http://dx.doi.org/10.1016/j.ejmp.2016.07.594

ACCURACY OF THE SMALL FIELD DOSIMETRY USING THE MONTE CARLO AND SEQUENTIAL DOSE CALCULATION ALGORITHMS OF MULTIPLAN TREATMENT PLANNING SYSTEM WITHIN AND BEYOND HETEROGENEOUS MEDIA FOR CYBERKNIFE M6 UNIT

E. Serin *, G. Codel, M.S. Cebe, H. Mabhouti, P. Pacaci, E. Sanli, M. Doyuran, E. Kucukmorkoc, A. Altinok, D. Canoglu, N. Kucuk, H. Acar, H. Caglar

Istanbul Medipol University, Radiation Oncology Department, Turkey
* Corresponding author.

Purpose. In this study, dosimetric accuracy of Monte Carlo (MC) advanced dose calculation and sequential algorithms of Multiplan treatment planning system were investigated for small radiation fields incident on homogeneous and heterogeneous geometries.

Methods. Small open fields of fixed cones of Cyberknife M6 unit 10×10 to $50 \times 50\ mm^2$ were used for this study. The fields were incident on phantom containing lung, air and bone inhomogeneities and also homogeneous phantom. Using the same film batch, the net OD to dose calibration curve was obtained using CK with the 60 mm fixed cone by delivering 0–800 cGy. Films were scanned 48 h after irradiation using an Epson 1000XL flatbed scanner. The dosimetric accuracy of MC and sequential algorithms in the presence of the inhomogeneities was compared against EBT3 film dosimetry

Results. Open field tests in a homogeneous phantom showed good agreement between two algorithms and film measurement For MC algorithm, the minimum gamma analysis passing rates between measured and calculated dose distributions were 99.7% and 98.3% for homogeneous and inhomogeneous fields in the case of lung and bone respectively. For sequential algorithm, the minimum gamma analysis passing rates were 98.9% and 92.5% for homogeneous and inhomogeneous fields respectively for used all cone sizes. In the case of the air heterogeneity, the differences were larger for both calculation algorithms. Overall, when compared to measurement, the MC had better agreement than sequential algorithm.

Conclusions. The MC calculation algorithm in the Multiplan TPS is an improvement over the existing sequential algorithm. Dose discrepancies were observed for in the presence of air inhomogeneities.

http://dx.doi.org/10.1016/j.ejmp.2016.07.595

INVESTIGATION OF THE AGFA HIGH DOSE CASSETTE FOR QUALITY ASSURANCE IN RADIOTHERAPY

I.A. Tsalafoutas *, P. Birmbakos, K. Kourinou, P. Georgolopoulou

Medical Physics Department, General Anticancer Oncology Hospital of Athens 'Agios Savvas', 171 Alexandras Avenue, 115 22 Athens, Greece
* Corresponding author.

Introduction. The Agfa CR system is comprised by the CR 35-X digitizer, the NX workstation and the CR RT1.5 high dose cassette (HDC). The HDC has a nominal tolerance of about 400 MU and is designated for portal imaging in radiotherapy, during irradiation of the patient with the full field dose.

Purpose. To investigate the characteristics of the HDC and its applicability to radiotherapy quality assurance (QA) tests.

Materials and methods. The HDC was irradiated with doses in the range of 0.02–4.1 Gy, using different: (a) field sizes, (b) irradiation geometries and, (c) beam energies (6 MV, 15 MV, wedged fields), in order to determine the dependence of its response on the above conditions.

Results. An exponential equation was found to accurately reproduce dose from pixel values, for single irradiated $10 \times 10\ cm^2$ fields. However, this equation was not accurate for irradiations made using other field sizes, multiple and complex field irradiations. Typical errors were within ±20% but larger errors were observed in some extreme irradiation conditions. The main problems identified were: the increased response of the HDC to lower energy scattered photons and the non-uniformities observed across its area. However, concerning geometry, the accuracy of distance measurements was better than ±0.2 mm. The HDC was also proven useful for testing the dynamic multileaf collimator and the enhanced dynamic wedges.

Conclusion. The HDC is very useful as a first level QA tool, mainly for geometrical tests but also for dosimetry tests, when relative rather than absolute dosimetry issues are under investigation.

http://dx.doi.org/10.1016/j.ejmp.2016.07.596

CRANIO-SPINAL IRRADIATION OF PEDIATRIC PATIENTS USING VOLUMETRIC MODULATED ARC THERAPY

C. Paraskevopoulou *, M. Synodinou, G. Kollias, N. Yakoumakis, E. Koutsouveli, P. Karaiskos, C. Dardoufas

Radiation Oncology Center, Hygeia Hospital, Er. Stavrou 4 and Kifisias, 151 23 Athens, Greece
* Corresponding author.

Introduction. Cranio-spinal irradiation (CSI) used for the management of certain primary brain tumours is one of the most challenging processes in radiation planning and delivery. Volumetric modulated arc therapy (VMAT), a recent advantage of radiotherapy technology can provide highly conformal radiation dose distributions around complex target volumes, while minimizing the dose to adjacent organs at risk (OARs), in an efficient way (i.e. reasonable treatment delivery times comparable to 3D conformal radiotherapy).

Purpose. To report the treatment of cranio-spinal irradiation with volumetric modulated arc therapy in comparison to the commonly used conventional 3D conformal radiotherapy (3D-CRT).

Materials and methods. Five children were treated with CSI using VMAT on an Elekta Versa linear accelerator. Multiple arc arrangements with two isocentres were used. Supine position was utilized for all patients. Plan quality and DVH-indices used for plan evaluation and approval were compared to corresponding values derived using 3D conformal plans.

Results. VMAT plans were found superior in all criteria clinically used for plan evaluation and acceptance including dose distributions, plan quality indices such as target coverage and dose homogeneity as well as doses to OARs and thus VMAT was used for patient treatments.

Conclusion. The use of VMAT provides excellent target coverage and sparing of the adjacent OARs, with absorbed doses well within the published pediatric dose constraints, in relatively short treatment time (less than 5 min) and thus being superior in treating patients requiring CSI compared to the currently used 3D-CRT.

http://dx.doi.org/10.1016/j.ejmp.2016.07.597

CORRECTION FACTORS FOR THE IBA RAZOR DIODE FOR OUTPUT FACTOR MEASUREMENTS IN PERFEXION GAMMA KNIFE SYSTEM

N. Yakoumakis *, G. Kollias, C. Paraskevopoulou, E. Koutsouveli, P. Karaiskos

Medical Physics Department, Hygeia Hospital, Er. Stavrou 4 and Kifisias, 151 23 Athens, Greece
* Corresponding author.

Introduction. A new formalism has been recently proposed for the dosimetry of small and non-standard fields. In terms of output factor (OF) measurements, a correction factor k(Q(clin),Q(msr)) (f(clin),f(msr)) is introduced, that accounts for differences in the detectors response in a given clinical field, f(clin), with regard to the machine-specific reference field, f(msr).

Purpose. To derive these correction factors for the 4 mm and 8 mm collimators of Perfexion Leksell gamma knife (LGK) system for the new Razor diode detector providing by IBA for small filed dosimetry.

Materials and methods. In Perfexion system, f(msr) is defined by the 16 mm collimator. OF measurements were performed for the 4 mm and 8 mm collimators (f(clin)), using the solid water, 16 cm in diameter LGK dosimetry phantom, along with a custom made insert facilitating accurate detector positioning. The k(Q(clin),Q(msr)) (f(clin),f(msr)) factor of the Razor diode detector was determined, by comparing the ratio of detector readings in f(clin) (4 mm and 8 mm collimators) and f(msr) (16 mm collimator) to corresponding MC reference OF data.

Results. Razor diode was found to slightly overestimate both f(clin) OFs with overestimation being greater for the smaller 4 mm collimator reaching up to 4% and almost negligible (<0.6%) for the 8 mm collimator.

Conclusion. IBA Razor diode can be safely used for OF measurements in gamma knife perfexion system. However, a correction of the order of 4% must be used for accurate determination of the smallest 4 mm collimator.

http://dx.doi.org/10.1016/j.ejmp.2016.07.598

MONTE CARLO SIMULATION OF DIFFERENT SOURCE CONFIGURATIONS FOR A NEW DESIGN OF ROTATING GAMMA KNIFE SYSTEM

G. Mora [a,*], O. Chivani [b], J. Li [b], C.M. Ma [b]

[a] *Institute of Biophysics and Biomedical Engineering, Faculty of Sciences, Lisbon University, Portugal*
[b] *Radiation Oncology Department, Fox Chase Cancer Center, Philadelphia, USA*
* Corresponding author.

Introduction. A new design of Gamma Knife consist of 30 $^{60}C0$ source capsules, two circular primary collimators (diameter of 6.60 mm and 6.10 mm) and four different changeable collimators. The sources (diameter of 2.8 mm) are distributed in six groups of five sources in the spherical geometry. Each source is individually colli-

mated to obtain four different circular fields at the isocenter (3 mm, 3.5 mm, 6 mm and 8 mm).

Purpose. To determine the characteristics of the Co^{60} beam emerging from a new design of Gamma Knife system and to calculate dose distributions at the isocenter distance for different source configurations and collimator openings

Materials and methods. We have used the BEAM-Monte Carlo code to realistically model the geometry design, including source capsules, primary and secondary collimators. The shielding of the head was also simulated. The dose distributions at the isocenter distance are calculated using GEPTS in a previous designed spherical component module for the circular field sizes studied.

Results. The spectra of particles emerging from each source-collimator configuration is calculated.The radial photon fluence does not vary significantly inside the collimator openings. The spectra of particles from different source groups are compared.

Conclusion. The ^{60}Co beam emerging from each group source configuration was characterized but our preliminary results do not allow to properly determine the variation of spectra of particles at isocenter as function of source group position. Further investigations are needed.

http://dx.doi.org/10.1016/j.ejmp.2016.07.599

SECONDARY RADIATION DOSES IN IMRT TECHNIQUES

Kinga Polaczek-Grelik [a,b,*], Jakub Derus [a], Agnieszka Giłka [a], Aneta Kawa-Iwanicka [a], Marta Stefańczyk [a]

[a] *Cancer Diagnosis and Treatment Center Katowice, Poland*
[b] *University of Silesia in Katowice, Department of Medical Physics, Poland*
* Corresponding author.

Introduction. The probability for developing the secondary cancer related to low peripheral doses during teleradiotherapy is nowadays of increasing interest. Among the components of the secondary dose photoneutrons and activated radionuclides should be discussed.

Purpose. Investigation of the secondary neutron and induced gamma radiation doses during intensity modulated radiation therapy employing Step&Shoot, sliding window and VMAT techniques.

Materials and methods. Elekta Synergy linacs with Agility MLC, working in 10 MV and 15 MV modes were used. Six plans with a 15 Gy fractional dose to PTV in mediastinum were studied and realized at anthropomorphic male phantom.

Neutron flux was measured by the activation of indium ^{115}In foils. Neutron dosemeter LB 123N was also used. The induced gamma-activity of linac head was investigated using high-purity germanium spectrometer. Doses were assessed using fluence-to dose conversion coefficients.

Results. The dominant activation dose comes from ^{28}Al, ^{56}Mn and ^{187}W isotopes and may reach 2 μSv/h 10 cm from the linac head. Neutron flux densities are of the order of 10^3–10^4 cm^{-2} s^{-1} for slow and 10^4–10^5 cm^{-2} s^{-1} for fast neutrons. Additional doses connected with neutrons are ~0.5 mSv/MU for 10 MV beam and within the range of 0.8–1.7 mSv/MU for 15 MV beam. Variation of neutron doses across the patient body is within 13%, for studied plans.

Conclusion. The neutron flux can be even 3.5 times lower whereas gamma-ray doses 5 times lower for 10 MV than for 15 MV beams in IMRT techniques.

Disclosure. No conflict of interest.

http://dx.doi.org/10.1016/j.ejmp.2016.07.600

THE DOSIMETRIC COMPARISON OF TRUEBEAM AND CYBERKNIFE TREATMENT PLANNING SYSTEMS DOSE CALCULATION ACCURACY FOR BRAIN SRS TREATMENT ON RANDOPHANTOM

H. Mabhouti *, E. Sanli, M.S. Cebe, G. Codel, P. Pacaci, E. Serin, M. Doyuran, E. Kucukmorkoc, A. Altinok, D. Canoglu, N. Kucuk, H. Acar, H. Caglar

Istanbul Medipol University, Radiation Oncology Department, Turkey
* Corresponding author.

Purpose. Brain stereotactic radiosurgery (SRS) involves the use of precisely directed, single session radiation to create a desired radiobiologic response within the brain target with acceptable minimal effects on surrounding structures or tissues. In this study, the dosimetric comparison of target and OAR doses in Truebeam 6 FFF and Cyberknife M6 machines were made.

Methods. Treatment planning were done using 2 full arc VMAT technique with 6 FFF beam on the CT scan of Randophantom simulating the treatment of sterotactic treatments for one brain metastasis. The dose distribution were calculated using Eclipse treatment planning system (TPS) with Acuros 13 algorithm. In addition treatment planning for same target volume were also done for Cyberknife M6 machine using Multiplan TPS with Monte Carlo algorithm. Target and brainstem, chiasm, optic nerve, lense median doses were measured using OSL dosimeters. The measured and calculated doses were compared.

Results. The calibration of OSL dosimetry were done at first. Target dose measurements made using the OSL dosimetry for both Cyberknife and Truebeam within the measurement uncertainty of 3.1%. The max differences between OSL measured and Eclipse calculated OARs doses were 3.3%,4.5%,5.6% and 6.2% for brainstem, chiasm, optic nerve, lense doses respectively. For cyberknife treatment, the max differences between OSL measured and Monte Carlo calculated OARs doses were 0.9%,1.2%,1.6% and 2.2% for brainstem, chiasm, optic nerve, lense doses respectively.

Conclusion. The study shows that dosimetrically comparable plans are achievable Cyberknife and Linac. However, a better conformity, target coverage, less OAR dose and insteeper dose fall off away from the target is achieved with Cyberknife. Monte carlo calculation algorithm predicts the OARs doses more accurately than Acuros algorithm.

http://dx.doi.org/10.1016/j.ejmp.2016.07.601

Physica Medica 32 (2016) 274–283

Contents lists available at ScienceDirect

Physica Medica

journal homepage: http://www.physicamedica.com

Abstracts from the 1st European Congress of Medical Physics: Oral Papers|September 4th, 2016

VERIFICATION OF TREATMENT PLANS FOR SKIN CANCER IN BRACHYTHERAPY WITH THE USE OF TLD TECHNIQUE

Beata Kozłowska[a,*], Monika Paluch-Ferszt[a], Marcin Dybek[b]

[a] *Institute of Physics, Department of Nuclear Physics and Its Applications, University of Silesia, Uniwersytecka 4, 40-007 Katowice, Poland*

[b] *Radiotherapy Department, Katowice Oncology Center, Raciborska 27, 40-074 Katowice, Poland*

* Corresponding author.

Introduction. Thermoluminescent detectors (TLDs), especially those made of LiF phosphor doped with magnesium and titanium (LiF:Mg,Ti) are widely used in dosimetric methods for ionizing radiation measurements.

Purpose. Dosimetric system *in vivo* in brachytherapy is less developed than that for teletherapy due the fact that not all detectors are able to register low-energy photons emitted from radioactive isotopes sources used in brachytherapy. A detector which satisfies requirements presented in the AAPM Task Group no. 43 report from 2004 and is recommended in the report is TLD-100. This kind of detector was used in presented studies.

Materials and methods. Dose measurements were performed in selected individual skin cancer cases localized in the head-and neck and pelvis areas. All treatment plans were performed in the Abacus 3.2 Varian Medical Systems for brachytherapy HDR. Each patient obtained his individual mask built from polymer clay, Wood's alloy or Orfit material. Prior to the patient's irradiation all treatment plans were verified with TL-100 detectors placed *in situ* at particular places of the individual masks for each cancer case.

Results. Dose verifications were performed for defined stops of the radioactive ^{192}Ir source for 10 selected treatment plans. The highest spread of doses was equal to 0,7% while the acceptable difference between the planed and measured doses in clinical dosimetry is <~5%.

Conclusion. TL detector is a good tool for treatment plans verifications and quick detection of possible mistakes in brachytherapy.

http://dx.doi.org/10.1016/j.ejmp.2016.07.603

FORWARD PLANNING OR INVERSE PLANNING? IN MEDIO STAT VIRTUS

D. Planes Meseguerl *, R.D. Esposito, P. Dorado Rodríguez

Medical Physics Department, ERESA – Hospital General Universitario de Elche, Elche (Alicante), Spain

* Corresponding author.

Introduction. Implementation of inverse planning algorithms into modern treatment planning systems (TPS) has supposed an improvement of the planning process especially in cases where intensity modulated planning solutions are desirable. On the other hand this improvements drastically reduced control that user might have over planning parameters. This situation generated an interesting debate among those who support forward planning and those who support an inverse planning approach.

Purpose. In this work we explore a third possibility to which we refer as *initialized inverse planning* and that may be considered a step in the middle between forward and inverse planning strategies. This methods actually combines flexibility of the first and optimization capability of the latter.

Materials and methods. TPS used in this work is Pinnacle^3 by Philips and its *Direct Machine Parameter Optimization* (DMPO) inverse planning algorithm. Our *initialized inverse planning* approach (to which we refer as iDMPO) starts from the solution provided by a forward planning strategy which is then optimized by the DMPO algorithm. In this second step we impose tighter constraints than the one reached with forward planning.

Results. In this work we compare this three methods (forward, inverse with DMPO and iDMPO) in the specific case of prostate cancer treatments. Nevertheless conclusions are also applicable to other treatments.

Conclusion. Results show that with iDMPO technique it is possible to improve treatments dosimetric results, compared to the forward planning, imparting lower doses to organs at risk while delivering more homogeneous dose distributions to target volumes and thus reaching the pure inverse planning approach solution.

Disclosure. Authors disclose any relationship that may bias this work.

http://dx.doi.org/10.1016/j.ejmp.2016.07.604

RADIOTHERAPY IN PATIENTS WITH PACEMAKERS AND IMPLANTABLE CARDIOVERTER DEFIBRILLATORS: WHAT IS NEXT?

Guadalupe Martín Martín[a,*], Elena Moreno Merino[b], M[a] Nieves Estival Ortega[b], Rocío Bermúdez Luna[c], Alfonso Lopez[c]

[a] *Medical Physics Service. Hospital Universitario de Fuenlabrada, Madrid, Spain*

[b] *Cardiology Service. Hospital Universitario de Fuenlabrada, Madrid, Spain*

[c] *Medical Physics Service. Hospital Universitario de Fuenlabrada, Madrid, Spain*

* Corresponding author.

Introduction. Practical recommendations for patients undergoing radiation therapy with Cardiac Implantable Electronic Devices (CIEDs) were published in 2012 from the Dutch Society of Radiotherapy.

Purpose. Our goal was to validate this guideline and to investigate whether we could advise for or against some specific recommendations.

Materials and methods. Between 2009 and 2016, 56 patients with CIEDs were treated in our institution. Dose to the CIED was assessed for every patient who was classified according to his risk. Patients were evaluated before, during and after radiotherapy by a cardiologist following guideline recommendations.

Results. Our patient focus group consisted of 39, 15 and 1 patients categorized into low, medium and high risk groups, respectively. The median age was 75 (range 54–98) years. Most treatments were prostate primaries (20%), brain metastasis (16%), head and neck primaries (9%) lung primaries (7%), and esophagus (5%). The prescribed dose ranged from 8 to 78 Gy with a daily dose ranging from 1.8 to 8 Gy. The maximum doses to the CIEDs were 179.1 cGy, 751 cGy and 1270 cGy, for the low, medium and high risk groups, respectively. Radiation therapy was safely delivered in all patients.

Conclusion. Our data support the fact that radiation dose seems to play a lesser role in inducing CIEDs malfunctions. Beam energy appears to be the essential factor in inducing these damaging effects according to the literature. Based on our work the following suggestions could be advocated: inactivation of antitachycardia therapies during RT as well as heart rhythm monitoring seems to be redundant and photon beam energy should be limited to $\leqslant$10 MV.

http://dx.doi.org/10.1016/j.ejmp.2016.07.605

A METHOD FOR ASSESSING THE DOSIMETRIC CONSISTENCY OF SINGLE PHASE 4DCT DOSE ACCUMULATION BASED ON DEFORMING IMAGE REGISTRATION

Flavio Enrico Nelli, Jeffrey Roy Harwood *

Andrew Love Cancer Centre, University Hospital Geelong, Geelong, VIC, Australia

* Corresponding author.

Introduction. The interplay effect in FFF-VMAT SBRT deliveries can produce clinically relevant discrepancies between planned and delivered doses to moving targets. To assess the impact of motion on treatment delivery, dose distributions calculated on each phase of a 4DCT scan can be accumulated in a single phase using deforming image registration (DIR). The use of this technique as a treatment quality assurance tool requires dosimetric validation.

Purpose. To develop a method for assessing the accuracy of DIR-based dose accumulation on 4DCT scans.

Materials and methods. Software was developed to interface with Eclipse TPS to calculate dose distributions on moving targets. This software splits each VMAT arc into partial arcs synchronized with the 4DCT scan. Dose matrices calculated on each breathing phase are accumulated on a single reference phase using the DIR dose accumulation algorithm in MIM Maestro software. For treatments planned on a cylindrically symmetric phantom with the target moving parallel to the symmetry axis and perpendicular to the VMAT arc's planes, dose distributions calculated with a moving X-ray source are equivalent to those calculated with a moving phantom. Using a moving source to evaluate dynamic deliveries does not rely on DIR dose accumulation and therefore provides a novel method for verifying DIR-based dose accumulation algorithms on 4DCT datasets.

Both methodologies were used for calculating dose distributions on the 20% phase of a 4DCT of a QUASAR phantom fitted with a cylindrical cedar insert containing a 3 cm acrylic target. The insert was moved following a 14 BPM realistic breathing trace with total amplitudes of 2 cm and 1 cm. Planar dose distributions along the principal axis were compared using gamma analysis.

Results. Gamma analysis was performed using ΔD = 2%, Δx = 2 mm (10% D_{max} threshold). The minimum passing rates were 99.1% and 99.2%, corresponding to the sagittal planes of the 2 cm and 1 cm amplitude movement.

Conclusion. The methodology presented here provides an easy and reliable way of assessing the performance of 4DCT DIR dose accumulation. The tested DIR accumulation algorithm performed exceptionally well, considering the ill-posed registration problem.

http://dx.doi.org/10.1016/j.ejmp.2016.07.606

CAN AUTOMATED ANALYSIS OF SEQUENTIAL RETINAL IMAGES OF PEOPLE ATTENDING DIABETIC RETINOPATHY SCREENING PREDICT FUTURE REFERRAL TO OPHTHALMOLOGY?

Sam Philip [a], Arfan Ahmed [b], Gordon Prescott [c], Roger Staff [b], Peter Sharp [d,*], Jiawei Xu [b], John Olson [a]

[a] *Grampian Diabetes Research Unit, Aberdeen, UK*
[b] *Aberdeen Biomedical Imaging Centre, University of Aberdeen, UK*
[c] *Institute of Applied Health Sciences, University of Aberdeen, UK*
[d] *Medical Physics, University of Aberdeen, UK*
* Corresponding author.

Introduction. Providing systemic screening to a growing diabetes population is a challenge for most screening programmes. We have previously developed software for the automated detection of diabetic retinopathy which is now routinely used within the Scottish Diabetic Retinopathy Screening programme.

Purpose. In this study we explored whether automated analysis of sequential retinal images of people attending screening can predict future referral to ophthalmology.

Materials and methods. We developed software to automatically measure whether the same microaneurysm (MA), the main indicator of retinopathy, appeared in sequential images and whether new MAs appeared, how close the MAs were to the fovea, the number of MAs within each quadrant of the retina, and the presence of other indicators of retinopathy, namely exudates and haemorrhages. A retrospective cohort study was conducted using 12,754 subjects to assess whether these features predicted retinopathy development.

Results. A number of the novel features were independently associated with retinopathy progression of retinal images. These were higher MA counts close to the fovea, higher MA turnover between screening episodes and higher probabilities of haemorrhages anywhere in the image and exudates close to the fovea. We developed a model to estimate the risk of progression over the next 15 months. The sensitivity, specificity, PPV and NPV were 83.6%, 79.5%, 8.5% and 99.5%, respectively. We also developed a model for the risk of progression over the next 5 years.

Conclusion. Features of retinopathy derived from automated analysis of sequential photographs can help predict the risk of progression to retinopathy needing referral to ophthalmology.

http://dx.doi.org/10.1016/j.ejmp.2016.07.607

DETAILED MEASUREMENTS OF EXPOSURE TO ELECTROMAGNETIC RADIATION OF THE POPULATION OF NEAPOLI-SYKIES AREA

Charalampos Koulouris *, Christina Athanasopoulou, Stefania Chantzi, Nausika Servitzoglou, Anastasios Siountas

Medical Physics Laboratory, Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece

* Corresponding author.

Introduction. The exposure to electromagnetic fields is of great concern to the majority of population due the large expansion of the use of mobile phones and telecommunication antennas.

Purpose. The purpose of this study was to measure the intensity of electromagnetic fields to the municipality of Neapoli-Sykies and perform detailed measurements at specific places of interest on two different times.

Material and method. The study took place in 3 stages.

a) A quick check of the whole area of the municipality.

An isotropic aerial was put on a wooden tripod and fastened on the roof of a car. The aerial was connected to the spectrum analyser FSH4, R&S. Each measurement covering the range 30 MHz–3 GHz lasted two minutes while the car was still. The exact position was acquired using a GPS device. The resulting data and measurement values of 1.109 points were entered in a geographic information system.

b) Detailed measurements.

At a second stage we acquired analytical measurements of each of eight frequency regions at 150 specific points of interest, namely base station antennas, schools, playgrounds and sport facilities.

c) Detailed measurements in a later time.

The detailed measurements were repeated after six months and all were entered in the same geographic information system.

Results. All measurements of the first stage, covering the frequency zone of 30 MHz–3 GHz, were well below the lowest limit of 21,7 V/m. The measurements of the second stage were also below the proposed limits of each region and they were no statistical differences between the two measurements for each point.

Conclusion. The intensities of electromagnetic fields on the whole and on every specific region are below the national limits.

http://dx.doi.org/10.1016/j.ejmp.2016.07.608

OCCUPATIONAL EXPOSURE TO ELECTROMAGNETIC FIELDS – THE SITUATION IN GREECE

G. Gourzoulidis [a,c,*], P. Tsaprouni [b], N. Skamnakis [b], C. Tzoumanika [b], E. Karastergios [b], A. Gialofas [b], E. Kalampaliki [b], A. Achtipis [a], C. Kappas [c], T.G. Maris [d], E. Karabetsos [b]

[a] *Hazardous Agents Department, OHS Directorate, Hellenic Ministry of Labor, Greece*
[b] *Non-Ionizing Radiation Office, Greek Atomic Energy Commission, Greece*
[c] *Medical Physics Lab, Medical School, University of Thessaly, Greece*
[d] *Medical Physics Lab, Medical School, University of Crete, Greece*
* Corresponding author.

Introduction. Electromagnetic Fields (EMF) cover the biggest part of the non-ionizing spectrum (0–300 GHz) and affect not only the general public but mainly the workers. The legislative gap of occupational EMF exposure is covered by the Directive 2013/35/EU.

Purpose. The three years period allowed for the implementation of the Directive into national law (1.7.2016), was used by the Hellenic Ministry of Labor, in conjunction with the Non-Ionizing Radiation Office of the Greek Atomic Energy Commission, to assess and measure the occupational EMF exposure in selected workplaces where EMF levels may reach high values.

Materials and methods. EMF measurements in the whole spectrum covered by the Directive were performed in certain installations of the Public Power Corporation S.A., the National Railway Organization, the Piraeus Port Authority S.A., the Hellenic Radio Television, in industrial sites and in hospitals with Magnetic Resonance Imaging systems.

Results. Very few measurements exceed the Action Levels set by the Directive but the vast majority of them don't even exceed the limits for the exposure of the general public. Overexposures are detected locally and are manageable through technical and organizational actions based on the principles for Occupational Health and Safety (OHS).

Conclusion. A national occupational EMF exposure database is created that forms the basis not only for the EMF exposure assessment but also for the OHS management in total.

Disclosure. Authors disclose that they don't have any relationship that may bias their presentation.

http://dx.doi.org/10.1016/j.ejmp.2016.07.609

DIGITAL BREAST TOMOSYNTHESIS: DOSE AND IMAGE QUALITY CHARACTERIZATION

K. Fezzani [a], J. Sage [a,*], I. Fitton [b], L. Hadid [c], A. Moussier [d], N. Pierrat [e], A. Martineau [f], C. Etard [a]

[a] *IRSN, Fontenay-Aux-Roses, France*
[b] *Hôpital Européen Georges Pompidou, Paris, France*
[c] *Hôpital Jean Verdier, Bondy, France*
[d] *Institut Gustave Roussy, Villejuif, France*
[e] *Institut Curie, Paris, France*
[f] *Hôpital Saint-Louis, Paris, France*
* Corresponding author.

Introduction. Digital Breast Tomosynthesis (DBT) offers a gain in sensitivity and in specificity for detection of breast cancers compared to 2D mammography, due to tissues' overlapping reduction. The introduction of this technique within the French breast cancer screening program is being considered by the authorities in the coming years.

Purpose. The aim of the study is to compare different DBT systems in term of dose and image quality. The evaluation of different image quality phantoms could lead to recommendations for incoming French regulatory internal quality control.

Materials and methods. Five French hospitals with three different tomosynthesis systems and seven specific phantoms have been included in the study. Average Glandular Dose and SDNR are assessed for different thicknesses of PMMA. Regarding image quality, reconstructed images are analyzed on global score, spatial resolution, geometrical distortion and homogeneity aspects.

Results. Preliminary results on dose and image quality for different models and modes are expected in May 2016 and will be discussed, as well as image quality and phantoms' sensibility at different dose levels.

Conclusion. The diversity in design of Digital Breast Tomosynthesis systems leads to an expected variability in terms of image quality and dose with breast thickness. Particular attention should be paid to the increase of the dose. Work at a national level on the regulatory quality control of tomosynthesis systems should be initiated as soon as possible in France.

Disclosure. FITTON I: co-inventor of Tomomam® phantom.

http://dx.doi.org/10.1016/j.ejmp.2016.07.610

GEANT4 CALCULATION OF NORMALIZED GLANDULAR DOSE COEFFICIENTS IN COMPUTED TOMOGRAPHY DEDICATED TO THE BREAST

Antonio Sarno *, Giovanni Mettivier, Francesca Di Lillo, Paolo Russo

University of Naples Federico II, Dept. of Physics "Ettore Pancini" & INFN Sect. of Naples, Naples, Italy
* Corresponding author.

Introduction. Normalized glandular dose coefficients (gN_{CT})for computed tomography dedicated to the breast with a polychromatic X-ray source are available for estimating the mean glandular dose in a breast CT scan. However, a number of assumptions and simplifications are introduced in their derivation using Monte Carlo (MC) codes, both on breast geometry and on photon tracking and energy deposition details.

Purpose. To investigate, via MC simulations, four different factors which affect DgN_{CT} calculation: (1) skin thickness, (2) electron tracking energy cutoff, (3) source position and (4) glandular tissue distribution.

Materials and methods. The MC code was developed using GEANT4. The breast was simulated as a cylindrical homogenous mixture of fat and glandular tissue. Skin thickness was varied from 1.45 to 4 mm. Monochromatic (8–80 keV) DgN_{CT} have been calculated and the polychromatic DgN_{CT} were computed by weighting them for typical X-ray tube spectra adopted for breast CT. A heterogeneous breast model as a mixture of adipose and randomly disposed glandular tissue voxels was investigated.

Results. Default GEANT4 electron energy cutoff leads to a DgN_{CT} overestimation up to 1.6% at 60 keV. The skin thickness affects DgN_{CT} values by about 1% (30–80 keV). DgN_{CT} values calculated for a heterogeneous breast differ by 2% with respect to a homogeneous tissue mixture approximation. The X-ray source position also affects the DgN_{CT} determinations, and setup-specific dose coefficients should be adopted.

Conclusion. Some factors which influence DgN_{CT} MC calculations have been investigated and new polychromatic DgN_{CT} coefficients have been computed in breast CT.

Disclosure. Nothing to declare.

http://dx.doi.org/10.1016/j.ejmp.2016.07.611

PHASE-CONTRAST DIGITAL BREAST TOMOSYNTHESIS VS PHASE-CONTRAST BREAST CT: AN IMAGE QUALITY PHANTOM STUDY WITH SYNCHROTRON RADIATION

Giovanni Mettivier [a,b,*], Kristina Bliznakova [c], Ivan Buliev [c], Francesca Di Lillo [a,b], Antonio Sarno [a,b], Paolo Russo [a,b]

[a] *Univerisity of Naples – Federico II, Naples, Italy*
[b] *INFN, Napoli, Italy*
[c] *Technical University of Varna, Varna, Bulgaria*
* Corresponding author.

Introduction. Digital Mammography is a fundamental technique in breast cancer diagnosis. DM returns a two-dimensional representation of a three-dimensional object. Therefore, tissues belonging to different planes are all projected on the same X-ray image plane. Digital Breast Tomosynthesis (DBT) and Breast Computed Tomography (BCT) are two forms of 3D X-ray breast imaging for diagnostic exam developed to overcome this limitation.

Recently, it has been shown that for the generation of the radiographic contrast it is possible to exploit also the information related to the wave phase shift introduced in the propagation of X-rays in matter.

Purpose. To compare image quality in monochromatic DBT and BCT scans with propagation based phase contrast imaging of a 3D breast phantom.

Materials and methods. The CIRS Model 020 BR3D is used to evaluate the image quality in the two modalities. The standard package consists of 6 slabs of thickness of 1 cm, each slice is produced by tissue equivalent materials in an approximate 50/50 ratio by weight. The central slab of the stack contains assortments of simulated microcalcifications, fibers and masses. The experiment was conducted on the biomedical beamline ID 17 at the European Synchrotron Radiation Facility. The comparison will be made in terms of noise, contrast, CNR, SNR and spatial resolution, for simulated masses and microcalcifications.

Results. First measurements show slightly higher values for CNR and C for masses in CT images than in DBT images.

Conclusion. The image quality in DBT and BCT monochromatic images of a 3D breast phantom was evaluated.

http://dx.doi.org/10.1016/j.ejmp.2016.07.612

CONTRAST AND DEPTH RESOLUTION OF BREAST LESSIONS IN A DIGITAL BREAST TOMOSYNTHESIS SYSTEM

Andreas E. Petropoulos [a,*], Spyros G. Skiadopoulos [a], Gerasimos A.T. Messaris [b], Anna N. Karahaliou [a], Lena I. Costaridou [a]

[a] *Department of Medical Physics, School of Medicine, University of Patras, Patras, Greece*
[b] *Department of Medical Physics, University Hospital of Patras, Patras, Greece*
* Corresponding author.

Introduction. Digital breast tomosynthesis (DBT) provides a quasi-three-dimensional structural information of the breast, solving the issue of overlapping mammographic parenchyma in breast lesion visualization.

Purpose. This study investigates the effect of lesion position along the *z*-axis and breast thickness on image quality of DBT reconstructed images.

Materials and methods. Mass objects (size: 3 mm) of varying nominal contrast values (1.5%, 2%, 3% and 4%) and microcalcification objects (size ~300 μm) at two different nominal contrast values, of a mammographic phantom (Leeds, TORMAM), were imaged with a DBT system (Hologic, Selenia Dimensions) at clinical settings. Four object positions along the *z*-axis were investigated by increasing test object distance from the detector, considering a breast thickness of 45 mm. In addition, for a specific phantom position along the *z*-axis, four breast thickness values (17, 30, 45, 65 mm) were investigated. Image quality metrics considered are CNR at focal plane and depth resolution, estimated using the full-width-at-half maximum (FWHM) of the artifact spread function (ASF) of lesion objects.

Results. Lesion CNR at focal plane remained constant for increasing object-detector distance, while increasing with objects' nominal contrast, as expected. CNR decreased for increasing phantom thickness, for both lesion types. Depth Z-resolution differed with respect to lesion size at detector plane, as estimated by ASF, yielding 30.5 ± 4.3 mm for masses and 3.3 ± 0.4 mm for microcalcifications. Finally, lesion depth resolution was not affected by position along *z*-axis or phantom thickness.

Conclusion. Breast thickness and lesion size should be considered when assessing DBT image quality.

http://dx.doi.org/10.1016/j.ejmp.2016.07.613

SURVEY OF CT PRACTICE IN SUDAN: UPDATES ON RADIATION EXPOSURE AND SETTING NATIONAL DIAGNOSTIC REFERENCE LEVELS

I.I. Suliman *, M. Mohamed, S. Ahmed, I. Osman, N. Ahmed

Sudan Atomic Energy Commission, P.O. Box 3001, Khartoum, Sudan
* Corresponding author.

Introduction. The increase in the use of mutislice CT in Sudan has resulted in an increased examinations frequency and population radiation burden. Dose surveys are important for medical exposure control.

Purpose. The aims of this survey were to updates on radiation exposure, and use the results in setting national diagnostic reference levels.

Materials and methods. Scan parameters were collected from 840 CT examinations in patients carried out in eight CT scanners comprising one (128 Slice), five (64 Slice) and two (16 Slice) mulitislice CT scanners in Khartoum State, Sudan. CTDIvol and DLP and effective dose were calculated by using CT-Expo 2.5 CT dosimetry software were compared with published data.

Results. Doses are presented Brian, PNS, and Chest, pulmonary, Abdomen-Pelvis, Pelvis, KUB and CTU CT examinations. Mean CTDIvol ranged: from 63.8 to 16.4 mGy in Brain and KUB; respectively; Mean DLP ranged from 1744 to 670 mGy.cm in CTU and Pelvic CT; respectively; While mean effective dose ranged from 21.71 to 1.96 mSv in CTU and BNS; respectively. The results presented wide variations in technique and radiation dose for similar examinations indicating significant room for dose optimisation.

Conclusion. 75 percentile of hospital mean doses obtained in this study were used to propose a national DRLs. Study highlighted the radiation protection challenge and dose consequences of Mutislice CT in a developing country.

Disclosure. Authors do not have any relationship that may bias their presentation.

http://dx.doi.org/10.1016/j.ejmp.2016.07.614

RADIATION DOSE COMPARISON BETWEEN V/P-SPECT AND CT-ANGIOGRAPHY IN THE DIAGNOSIS OF PULMONARY EMBOLISM

J. Isidoro [a,*], P. Gil [a], G. Costa [a], J. Pedroso Lima [a,d], F. Caseiro Alves [b], N.C. Ferreira [c,d]

[a] *Serviço de Medicina Nuclear, Centro Hospitalar e Universitário de Coimbra, Portugal*
[b] *Serviço de Imagiologia, Centro Hospitalar e Universitário de Coimbra, Portugal*
[c] *Instituto de Biofísica e Biomatemática, Faculdade de Medicina da Universidade de Coimbra, Portugal*
[d] *ICNAS – Instituto de Ciências Nucleares Aplicadas à Saúde, Universidade de Coimbra, Portugal*
* Corresponding author.

Introduction. CT pulmonary angiography (CTPA) has become the preferred diagnostic tool in patients suspected of having pulmonary embolism (PE). Ventilation/perfusion single photon emission computed tomography (V/P-SPECT), despite yields similar diagnostic output, it is left to cases were CTPA is inappropriate. Radiation burden should play an important role in modality selection especially in follow-up studies, young woman and pregnant patients.

Purpose. The aim of this study is to compare CTPA versus V/P-SPECT, routine protocols of our institution, regarding radiation dose to the more exposed organs (lung and breast) or the embryo/fetus.

Materials and methods. In our institution the CTPA protocol includes contrast media administration and scan parameters: 100 kVp, 700 mA, 0,5s/rot, pitch 0,984.

In V/P-SPECT protocol: ventilation was performed after inhalation of ^{99m}Tc-Technegas, reaching 30 MBq in the lungs; perfusion was performed after i.v. administration of 60–120 MBq ^{99m}Tc-MAA.

Radiation dose to lungs and breast form CTPA was estimated using the "ImPACT CT Patient Dosimetry Calculator", the embryo/fetus dose was estimated for different gestational stages (0–7, 8–12, 13–25 and 26–40 weeks) using the web based calculation tool "COnceptus Dose Estimation" (CODE). V/P-SPECT organs and embryo/fetus doses were estimated based on published dose data normalized to administered activity (mGy/MBq).

Results. Embryo/fetus absorbed doses are similar for CTPA and V/P-SPECT. Doses to lungs is 1.7–2.6 and to breast is 25–41 times higher from CTPA compared with V/P-SPECT.

Conclusion. For the diagnosis of PE in woman, if both imaging modalities are available, it is recommended to proceed with V/P-SPECT rather than CTPA due to the considerable lower radiation dose to the breast.

Disclosure. Authors disclose any relationship that may bias their presentation.

http://dx.doi.org/10.1016/j.ejmp.2016.07.616

CLINICAL APPLICATION OF A CT DOSE REDUCTION SIMULATOR

A. Serna [a,*], M.A. Chans [b], A. Ramos [b], D. Ramos [a]

[a] *Medical Physics Department, Hospital Universitario Santa Lucia, Cartagena, Spain*
[b] *Diagnostic Imaging Department, Hospital Universitario Santa Lucia, Cartagena, Spain*
* Corresponding author.

Purpose. To validate an exposure reduction algorithm for head CT examinations in clinical practice.

Material and methods. CT images from Head Adult protocol in a Siemens CT Somatom Definition AS+ was used for this study.

Dose reduction was simulated through the addition of noise to each pixel value of the original image. A homogeneous phantom was used to measure the autocorrelation function, which is convolved with a white noise matrix to get the spatially correlated statistical noise to be added. A Matlab code was written to perform this task.

Firstly, the algorithm was validated using two phantoms, i.e. a homogeneous and an anthropomorphic heterogeneous phantom, CT-scanned with different exposure reductions, up to 75%, from the original reference mAs. Noise values comparison between CT-simulated and CT-real images was done.

Secondly, from our PACS 10 patients previously CT-scanned, with subtle pathologies and normal brain, were selected. CT-simulated images, up to an exposure reduction of 50%, were reviewed by two experienced radiologists, not aware of the applied exposure reduction.

Results. The algorithm reproduces well the image noise variation with the reduction of the mAs. Differences were less than 2% in both phantoms in the exposure range analysed.

CT-simulated images with exposure reductions equal or larger than 30% were clearly identified by both radiologists. Mostly, a 20% reduction was deemed appropriate for clinical diagnosis.

Conclusion. Dose reduction simulation software might be a powerful tool for patient dose optimization.

http://dx.doi.org/10.1016/j.ejmp.2016.07.617

RADIATION RISK OF CANCER FROM MEDICAL IMAGING IN END STAGE KIDNEY DISEASE PATIENTS: ITALIAN NATIONWIDE SURVEY

Luca Vigna [a,*], Domenico Lizio [a], Marco Brambilla [a], Andreana De Mauri [b], Carmine Zoccali [c], Maurizio Postorino [d]

[a] *University Hospital of Novara, Medical Physics Dept., Novara, Italy*
[b] *University Hospital of Novara, Nephrology Dept., Novara, Italy*
[c] *National Research Council, Clinical Physiology Institute, Reggio Calabria, Italy*
[d] *Azienda Ospedaliera Reggio Calabria, Nephrology, Reggio Calabria, Italy*
* Corresponding author.

Purpose. End Stage Kidney Disease patients are exposed to ionizing radiation during imaging studies. The variability in diagnostic imaging policies and the accompanying risk across Renal Units are unknown. We studied this variability at centre level and quantified the associated risks at patient level, by estimating the organ doses (H_T) and the Risk of exposure-induced cancer death (%) (REID).

Materials and methods. Fourteen nephrology departments enrolled 739 patients on hemodialysis (HD) and 486 kidney transplant patients (KTP), recording the details of the radiological procedures performed over one year.

H_T were derived using Montecarlo based simulation software for conventional diagnostic radiology procedures and for Computed Tomography. H^T were derived using tabulated conversion factors for cardiac interventional radiology and nuclear medicine procedures.

Results. The average REID was 0.047 ± 0.12 % and the corresponding 5-years cancer risk attributable to ionizing radiation exposure was 1 every 424 patients. The median REID was 0.009% and the 3rd quartile was 0.03%. The average REID was significantly higher in HD than in KTP (0.06 ± 0.13 i.e. 1:333 patients for 5-years vs 0.03 ± 0.09 i.e. 1:666 patients for 5-years; $p < 0.001$). The variation of average REID among participating centres was highly significant ($F = 3.23$; $p < 0.001$) ranging from a minimum of 0.009% to a maximum of 0.09%.

Conclusion. The excess cancer risk attributable to medical exposure is highly variable among centres (a tenfold variation), suggesting that protocols of individual patient's follow up with medical imaging are not standardized. On average, KTP have a lower exposure than HD patients (a twofold variation).

Disclosure. None to declare.

http://dx.doi.org/10.1016/j.ejmp.2016.07.620

COMPARISON OF THE DOSIMETRIC RESPONSE OF 4-ELEMENT BEOSL AND TLD-100 PASSIVE PERSONAL DOSIMETERS

L. Oliver [a,b,*], C. Candela [a], J.D. Palma [a], M.C. Pujades [a], A. Soriano [a], J. Alabau [a], J. Martínez [a], V. Mestre [a], J.C. Ruiz [a], J. Vilar [a], N. Llorca [a]

[a] *National Dosimetry Centre (CND), Instituto de Gestión Sanitaria, Valencia, Spain*
[b] *Fundación Instituto Valenciano de Oncología (IVO), Valencia, Spain*
* Corresponding author.

Introduction. Thermoluminescent dosimeters (TLD-100, ThermoFisher-Scientific, USA) and optically stimulated dosimeters based on beryllium oxide (BeOSL, Dosimetrics GmbH, Germany) are passive personal dosimeters.

Purpose. The aims of this study were to verify that the 4-element version of both systems satisfy the IEC-62387 dosimetric requirements, and to compare them.

Materials and methods. The TLDs tested were those provided by the National Dosimetry Centre (CND), with a home-made dose calculation algorithm, whereas BeOSLs were as distributed by Dosimetrics. The tests performed were: coefficient of variation, non-linearity, photon angular and energy dependency, reusability and time dependency, as well as detection threshold and energy estimation accuracy.

Results. Both systems satisfy the IEC-62387 requirements for the tests described above. Among the advantages of BeOSLs, these have lower energy dependency (Hp(10) accuracy is better than 11% between 16.1 keV and 662 keV) and can be read more than once with good accuracy when re-reading correction is applied (<3% variation beyond 1 mSv between at least 5 consecutive re-readings). Also, each dose value provided is the average of 5 measurements, with a consistency check. However, the CND dose algorithm for TLDs provides more accurate energy estimations, which are used to correct their higher energy dependency. In addition, TLD readers provide glow curves that can be used to identify misreading of any of the 4 elements.

Conclusion. The TLDs and BeOSLs tested satisfy the dosimetric requirements to be used as personal dosimeters. The choice between one of them might depend on the importance given to the different criteria studied.

http://dx.doi.org/10.1016/j.ejmp.2016.07.621

IMPLEMENTATION OF THE EFOMP PROTOCOL FOR QUALITY CONTROL IN DIGITAL MAMMOGRAPHY IN A MULTI-HOSPITAL/VENDOR CONTEXT

A.Savini [a,*], F. Bartolucci [a], C. Fidanza [a], F. Rosica [a], F. Capone [b], G. Orlandi [a]

[a] *Medical Physics Department, AUSL4, Teramo, Italy*
[b] *Radiology Department, AUSL4, Teramo, Italy*
* Corresponding author.

Introduction. The European Federation of Organisations in Medical Physics (EFOMP) has recently released a protocol for quality control (QC) in digital mammography with the intent of harmonizing and simplifying the QC procedures across the European countries.

Purpose. The aim of this work was to report our experience regarding the implementation of the EFOMP protocol for QC in digital mammography in a multi-hospital/vendor context.

Materials and methods. QC tests suggested by the EFOMP protocol were merged with mandatory tests by national (Italian) regulations in order to build a local QC protocol. The protocol was applied to one DR and three CR mammography systems developed by different vendors. Time needed for routine QCs was measured. A fast weekly test was implemented to assess the long term reproducibility of relevant quantities (dose and SNR).

Results. By employing one physicist and one technologist, the time needed for routine QC was: 4.5 h ± 0.5 h (annual tests), 2.5 h ± 0.5 h (semiannual tests), 0.2 h ± 0.1 h (weekly tests). For weekly tests, coefficients of variation of dose and SNR were below 6.0% (four-months period evaluated). By applying the developed protocol, two major and five minor anomalies were identified and corrected.

Conclusions. The EFOMP protocol could be adapted to local (Italian) regulations with minor modifications. Flexibility and simplification of routine QCs were advantageous in a busy multi-hospital/vendor context.

Disclosure. None.

http://dx.doi.org/10.1016/j.ejmp.2016.07.622

UNCERTAINTY ESTIMATION OF POPULATION DOSES FROM MEDICAL PROCEDURES

C.J. Hourdakis *, S. Vogiatzi, S. Economides, M. Nikolaou, K. Karfopoulos, V. Kamenopoulou

Greek Atomic Energy Commission (EEAE), Ag. Paraskevi, Attiki, Greece
* Corresponding author.
URL:http://www.eeae.gr

Introduction. "Collective dose", S (person-Sv) and "average effective dose per person of population", $\bar{E}_{per\text{-}caput}$ (mSv/caput) are useful indicators concerning population exposure to ionizing radiation. Estimation of relevant uncertainties is necessary for avoiding misleading interpretation of results.

Purpose. This study presents the uncertainty estimation of the Greek population doses from medical procedures. The work was performed in the framework of 'PRISMA' project within GSRT's KRIPIS action, funded by Greece and the European Regional Development Fund of the EU under the O.P. Competitiveness and Entrepreneurship, NSRF 2007–2013.

Materials and methods. S and $\bar{E}_{per\text{-}caput}$ were assessed for 2014. The sources of uncertainty were identified and Type A or B uncertainty values were assigned, based on data sets for: (a) dosimetric quantity measurements, (b) patient average effective dose E (mSv) calculation per procedure, (c) procedure frequency and (d) extrapolation to countrywide scale.

Results. E uncertainties ranged from 20% to 80% ($k = 1$, ~67% c.l.). S and $\bar{E}_{per\text{-}caput}$ uncertainties were estimated 13% and 8% for diagnostic radiology and nuclear medicine procedures respectively and 12% for all medical diagnostic procedures ($k = 1$, ~67% c.l.).

Conclusion. The large variety of medical diagnostic procedures resulted in high uncertainty for E. Nevertheless, S and $\bar{E}_{per\text{-}caput}$ uncertainties appeared compressed. Reporting data on population exposure to ionizing radiation with the relative uncertainties increases the reliability of findings and conclusions.

Disclosure. Authors have not any relationship that may bias this presentation.

http://dx.doi.org/10.1016/j.ejmp.2016.07.623

MEDICAL RADIATION EXPOSURE OF THE GREEK POPULATION

Nikolaou M. *, Vogiatzi S., Kalathaki M., Simantirakis G., Koukorava C., Economides S., Hourdakis C.J., Kamenopoulou V.

Greek Atomic Energy Commission, P.O. Box 60092, 153 10 Agia Paraskevi, Greece
* Corresponding author.
URLs:http://www.eeae.gr

Introduction. Medical exposures contribute the largest to the population man-made radiation exposure, mainly due to the high frequency of diagnostic examinations and the patient doses involved.

Purpose. A research project was carried out by the Greek Atomic Energy Commission (EEAE) to assess the collective dose and the average annual effective dose to the Greek population from x-ray and nuclear medicine procedures. This work was performed in the framework of 'PRISMA' project within GSRT's KRIPIS action, funded by Greece and the European Regional Development Fund of the EU under the O.P. Competitiveness and Entrepreneurship, NSRF 2007–2013.

Materials and methods. For each type of diagnostic and interventional procedures, the estimation of the annual collective effective dose, S, (person-Sv) and per caput dose, $E_{per\text{-}caput}$, (mSv/caput) required information on the frequency and the mean patient effective dose, E_{pat}, (mSv).

Results. In 2014, approximately 6.7 million diagnostic and interventional procedures were performed in Greece. The estimated frequency, i.e. number of procedures per 1000 citizens was: 447 for plain radiographies, 135 for computed tomography scans, 7 for interventional procedures, 2 for fluoroscopic procedures and 20 for nuclear medicine procedures. The annual effective dose per caput was estimated to 1.7 mSv from diagnostic radiology and 0.1 mSv from NM procedures.

Conclusion. The main contribution to the collective dose due to x-ray procedures appeared from CT scans. The collective effective dose and the annual per caput dose from NM procedures have decreased in the last 5 years.

http://dx.doi.org/10.1016/j.ejmp.2016.07.624

CONE BEAM CT RADIATION DOSE IN DENTAL IMPLANT SURGERY

N. Stefanopoulou [b], N. Fotos [a,*], V. Tsapaki [a], G. Kouratiadis [c], N. Krompas [b]

[a] *Konstantopoulio General Hospital, Athens, Greece*
[b] *Branemark Osseointegration Center, Athens, Greece*
[c] *Dentomedica S.A., Athens, Greece*
* Corresponding author.

Introduction. New applications of CT are still shown, the most prominent example of which is the development of Cone Beam Computed Tomography (CBCT) for dental and maxillofacial imaging. The majority of studies related to CBCT dental radiation dose are based on anthropomorphic phantoms. Patient clinical studies on radiation dose are still scarce.

Purpose. The purpose of this study was to measure patient radiation exposure in terms of Kerma Area Product (KAP) and effective dose (Ef) in implant dentistry.

Materials and methods. The X-ray system used was a CS 9300 Carestream system. Patient sample included 177 individuals undergoing one or more CBCT examinations. Data recorded included: KAP, tube voltage (kV), tube current (mA), exposure time (s), field of view (FOV), patient age (A) and clinical indication.

Results. Patient sample mean age was 56 years. Women were 52.5% and men 47.5%. Patients had either 1 (80.2%), 2 (14.7%), 3 (2.35%) or >3 (2.3%) CBCT exams. Protocol details were: 80–90 kV, 4–5 mA, 8 s and a fixed FOV of 10×10 cm^2. Mean ± sd KAP was 523 ± 119 mGycm^2. A conversion factor of 0.08 mSv/Gycm^2 was used to calculate Ef. Mean ± sd Ef was 42.4 ± 9.6 μSv. A coarse comparison was done with international data from phantom studies. This showed that our results were at the low part of the dose range reported in the international literature

Conclusion. The radiation dose values presented provide a baseline for future reference. More clinical studies are needed in order to derive more robust results on radiation dose levels in dental CBCT.

Disclosure. Authors should disclose any relationship that may bias their presentation. Please enter disclosure information here.

http://dx.doi.org/10.1016/j.ejmp.2016.07.625

QUALITY CONTROLS FOR CBCT DEVICES: THE EFOMP GUIDELINE FOR QUALITY ASSURANCE OF IMAGES AND DOSE

H. las Heras de [a,*], O. Rampado [b], J. Andersson [c], I. Hernandez Giron [d], M. Nilsson [e], A. Dasu [f], J. Holroyd [g], C. Theodorakou [h], A. Torresin [i]

[a] *Research and Communication, QUART GmbH, 85604 Zorneding, Germany*
[b] *S.C. Fisica Sanitaria, A.O.U. Città della Salute e della Scienza di Torino, Corso Bramante 88, 10126 Torino, Italy*
[c] *Department of Radiation Sciences, Radiation Physics, Umeå University, SE-901 85 Umeå, Sweden*

[d] *Radiology Department, Leiden University Medical Center (LUMC), Albinusdreef 2, 2333ZA, Leiden, The Netherlands*
[e] *Department of Radiation Physics, Skane University Hospital, SE-205 02 Malmo, Sweden*
[f] *Department of Radiation Physics and Department of Medical and Health Sciences, Linköping University, 581 83 Linköping, Sweden*
[g] *Public Health England, Chilton, Didcot, Oxfordshire, OX11 0RQ, UK*
[h] *The Christie NHS Foundation Trust, Wilmslow Rd, Manchester, M20 4BX, UK*
[i] *Medical Physics Department, Ospedale Niguarda Ca' Granda, 20167 Milano, Italy*
* Corresponding author.

Introduction. Current guidelines for quality control of CBCT devices consider the available applications (dental, radiotherapy, interventional radiology and guided surgery) as different entities. However, the data acquisition and reconstruction methods are similar. Henceforth, the evaluation parameters for image quality and dose can be unified.

Purpose. The purpose of this guideline (under discussion since January 2014 within an EFOMP working group) is to present an objective, practical and unifying procedure for quality control of all imaging CBCT applications

Materials and methods. The parameters used for image quality assessment are uniformity, accuracy of density values (or Hounsfield units where appropriate), geometrical evaluation, noise, low contrast resolution (including contrast to noise ratio) and high contrast resolution.

Results. Detailed procedures using free software and commercially available test phantoms are described. The dosimetric quantities under consideration are CTDI, kerma area product and detector incident air kerma. Recommended action levels and test frequency are indicated together with references wherever possible.

Conclusion. This guideline includes the minimum tests that should be performed to ensure reliable, safe and consistent performance of CBCT devices. This minimum has been sought to guarantee compatibility with all manufacturers and existing European documents (DIN 6868161, HPACRCE010 and RP 172 for dental applications).

Disclosure. Nothing to disclose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.626

OPTIMIZATION OF HEAD RADIOGRAPHIC EXAMINATION PROTOCOLS IN PEDIATRIC PATIENTS

M. Atsalaki [a,*], G. Solomou [a], A.E. Papadakis [b], J. Damilakis [a,b]

[a] *University of Crete, Faculty of Medicine, P.O. Box 2208, Heraklion 71003, Crete, Greece*
[b] *University Hospital of Heraklion, P.O. Box 1352, Heraklion 71110, Crete, Greece*
* Corresponding author.

Introduction. Head radiography comprises a common examination protocol in clinical routine. Diagnostic decisions are associated with the detected injuries. Consequently, image quality of the x-ray examinations is essential for the early diagnosis and appropriate treatment, especially for the sensitive population of children. Therefore each examination protocol should be appropriately optimized to achieve images of high diagnostic quality and minimum radiation burden to patients.

Purpose. To optimize the radiographic technique for head examination protocols in pediatric patients.

Methods and materials. Three anthropomorphic phantoms (ATOM Phantoms, CIRS, Norfolk, VA) representing the average individual as neonate, 5-year-old, and 10-year-old child were employed. The phantoms were subjected to head radiographs using a state of the art digital radiographic system (AGFA GAEVART, DX-D600) for various tube voltages (50–125 kVp) and current settings (0.2–50 mAs). For each exposure, image quality objective parameters, including contrast to noise ratio values (CNR) were estimated to determine figure of merit (FOM) in the optimization process. The technique associated with the higher CNR value for the same FOM was considered as the optimized method.

Results. Dose reduction of up to 88% was recorded for the same CNR value when decreasing tube voltage. CNR was found to be improved decreasing tube voltage for all ages of pediatric phantoms. However, due to larger exposure time, motion artifacts may be conspicuous.

Conclusion. A reliable optimization methodology for head radiographs in pediatric patients was presented. The method described may be also applied in other anatomical regions.

http://dx.doi.org/10.1016/j.ejmp.2016.07.627

LESSONS LEARNED FROM RADIATION DOSE INDEX MONITORING SYSTEM IMPLEMENTATIONS: CHALLENGES AND OUTCOMES

Camille Lafay, Donat Thery, Federica Zanca *

GE Healthcare, Buc, France
* Corresponding author.

Introduction. Many facilities have implemented a radiation dose index monitoring (RDIM) system, due to increasing public concern over the use of ionizing radiation, to comply with national and European regulations or for accreditation purposes.

Purpose. To present the challenges and the outcomes associated with the implementation of an RDIM system across several European facilities.

Methods and materials. Trough the installation of a dose-monitoring software (DoseWatch, GE Healthcare) in 21 European facilities, processes and dose data were collected from CT, Mammography, RF and CV/IR systems, to evaluate challenges and outcomes. The application of a Dose Excellence Program, based on the Justification of high doses, on the Standardization of protocols in terms of RADLEX mapping and on the optimization of protocols was evaluated, to determine measurable outcomes.

Results. For all sites major challenges were the "labelisation" of the procedures and the automated reporting for performance indicators tracking. Examples of outcomes are: an increased number of standardized numbers of series per protocol (up to >90% for some sites), as well as a high number of justified alerts (up to 100% in several sites). Of all justified CT alerts, the most reported reason was patient overweight or extra series needed, for CV/IR it was the difficulty of the procedure and for RF it was the use of fluoroscopy for positioning.

Conclusion. The deployment of a Dose Excellence Program along with a standardized JSO report allowed all sites to move from dose tracking to dose management, trough increased awareness and sustainability of the project.

http://dx.doi.org/10.1016/j.ejmp.2016.07.628

THE POTENTIAL USE OF A WEARABLE DEVICE TO MONITOR ULTRAVIOLET RADIATION EXPOSURE IN CLINICAL STAFF

Graham Hart [a,*], David Rawlings [b]

[a] *YourRPA, 96 Sefton Road, Morecambe LA3 1UD, UK*
[b] *Northern Medical Physics and Clinical Engineering, NCCC Block Level 2, Freeman Hospital, Freeman Road, High Heaton, Newcastle upon Tyne NE7 7DN, UK*
* Corresponding author.

Introduction. Measurement of staff radiation exposure to ultraviolet (UV) radiation in Dermatology and other Departments currently relies on measurements using fixed detecting equipment. Although staff do not usually receive direct UV exposure, they may be exposed through scattered UV radiation from hand & foot units, moveable panels or whole body irradiation units.

Purpose. The paper aims to investigate whether the 'Sunbeat', a novel ambulant UV monitor developed for measurement of personal solar UV exposure, could be used to measure clinical staff UV exposure.

Materials and methods. The Sunbeat device was compared against a local International Light IL1400 meter calibrated to national standards for unweighted irradiance using banks of both R-UVA and Philips TL01 narrow-band UVB fluorescent tubes with different levels of irradiance for both UVA and UVB under fixed geometry. Simultaneous adjacent measurements were then made of scattered UVA and UVB levels with the Sunbeat device and the local calibrated meter. Individual correction factors were then applied to the local calibrated meter readings to produce eythemally effective irradiance.

Results. When compared to the local calibrated meter, the Sunbeat device exhibited a linear response for both the measurements in the fixed geometry and ambulant scattered UV measurements. The Sunbeat device could measure scattered UV levels down to approximately 0.1 μW cm^{-2} erythemally effective irradiance for both UVA and TL01 UVB.

Conclusion. The Sunbeat device has the potential to be used as a UV dosimeter for clinical staff. This may aid the demonstration of compliance with national regulations made under the EU Artificial Optical Radiations Directive.

Disclosure. The Authors do not have any disclosures that may bias their presentation.

http://dx.doi.org/10.1016/j.ejmp.2016.07.629

NUMERICAL EVALUATION OF OFFERS FOR MEDICAL RADIOLOGICAL EQUIPMENT

Bozidar Casar

Institute of Oncology Ljubljana, Ljubljana, Slovenia

Introduction. Essential contribution and role of medical physics experts in the preparation of technical specifications for expensive medical radiological equipment has been already widely recognized. Beyond the preparation and review of the equipment specifications, the responsibility of medical physicist is often also to prepare a system for final evaluation of offers. Formulas for fair comparison of bids are proposed in order to ensure effective and transparent purchasing process.

Purpose. The goal of this work was to find an appropriate evaluation point system for tendering process when medical radiological equipment is to be purchased. Such system should be transparent and financially beneficial for hospitals.

Materials and methods. It was assumed that apart of technical specifications, prices for equipment and for post warranty maintenance contracts are the most important parameters for the evaluation of offers for medical radiological equipment. These parameters were analysed in order to find adequate formulas to fulfil the goals of this work.

Results. For the financial evaluation of bids, set of formulas is proposed in order to encourage bidders to submit offers with the lowest prices. Prices for equipment and maintenance contracts of all bids are combined in order to eliminate any unreasonable pricing.

Conclusion. A system for evaluation of financial part of medical radiological equipment offers is presented and formulas for calculation of received points are proposed. The benefit of the introduction of such system into the tender documentation can be two-folded: evaluation procedure of offers is transparent and hospitals can get acceptable financial offers.

http://dx.doi.org/10.1016/j.ejmp.2016.07.630

ADC HISTOGRAM ANALYSIS FOR PREDICITING HIGHLY AGGRESSIVE BREAST CARCINOMAS

Marialena I. Tsarouchi [a,*], Anna N. Karahaliou [a], Katerina G. Vassiou [b], Spyros G. Skiadopoulos [a], Lena I. Costaridou [a]

[a] *Department of Medical Physics, School of Medicine, University of Patras, 26504 Patras, Greece*
[b] *Department of Anatomy, School of Medicine, University of Thessaly, Biopolis, 41110 Larissa, Greece*
* Corresponding author.

Introduction. Diffusion Weighted Imaging (DWI) has demonstrated increased potential in identifying imaging-based biomarkers for cancer diagnosis, prognosis and monitoring response to therapy.

Purpose. This study investigates the feasibility of apparent diffusion coefficient (ADC) histogram statistics in identifying highly aggressive breast carcinomas, by investigating correlation to established prognostic indices.

Materials and methods. The dataset consists of 43 histologically verified invasive ductal carcinomas (IDC) of patients undergoing breast DW-MRI at 3 T (b-values 0, 900 s/mm2). ADC maps were generated for a slice representative of lesion largest diameter. An expert radiologist delineated lesion contour on ADC map, defining the lesion region of interest to be subjected to histogram analysis. Feature extraction considered mean, standard deviation, skewness, kurtosis, entropy, maximum, minimum and range of ADC. The ability of ADC histogram features in identifying tumor grade, estrogen receptor (ER) and progesterone receptor (PR) status was investigated.

Results. Median value of feature ADC mean was 1.034×10^{-3} mm^2/s, 0.869×10^{-3} mm^2/s and 0.971×10^{-3} mm^2/s in grade I, grade II and grade III lesions, respectively. Median value of ADC kurtosis was 0.176, 1.165 and 1.289 in grade I, grade II and grade III lesions, respectively. ER positive lesions demonstrated increased median value of ADC entropy (5.828), reflecting increased ADC heterogeneity, as compared to ER negative ones (5.480). Median value of ADC entropy was 5.842 and 5.486 in PR positive and PR negative lesions, respectively.

Conclusion. ADC histogram analysis may contribute in breast cancer prognosis by identifying high grade tumors and predicting ER and PR status.

http://dx.doi.org/10.1016/j.ejmp.2016.07.631

EXPLOITING AN ADVANCED DTI SEGMENTATION TECHNIQUE TOWARDS DIFFERENTIATION OF GBM AND MET

Alexandros Vamvakas [a,*], Ioannis Tsougos [b], Nikolaos Arikidis [a], Eftychia Kapsalaki [c], Ioannis Fezoulidis [c], Lena Costaridou [a]

[a] *Department of Medical Physics, School of Medicine, University of Patras, 26504 Patras, Greece*
[b] *Medical Physics Department, Medical School, University of Thessaly, Biopolis, 41110 Larissa, Greece*
[c] *Radiology Department, Medical School, University of Thessaly, Biopolis, 41110 Larissa, Greece*
* Corresponding author.

Introduction. It is commonly accepted that differentiation between glioblastoma multiforme (GBM) and solitary metastases (MET), relying on conventional Magnetic Resonance Imaging (MRI), in daily clinical practice, remains controversial.

Purpose. In the frame of such differentiation by means of quantitative image analysis of advanced MR techniques, such as Diffusion Tensor Imaging (DTI), the initial step of tumor segmentation is essential.

Materials and methods. In this study a proposed state-of-the-art segmentation technique was implemented, based on isotropic (p) and anisotropic (q) maps, derived from diffusion tensor decomposition. The unsupervised k-medians clustering of the 2D (p,q) histogram ($k = 16$, account for 16 different types of brain tissues) results in whole brain segmented maps, where brain tumor lesions present distinctive boundaries. The technique has been tested on a case sample of 10 GBM and 10 MET patients, who underwent preoperative DTI scans at 3Tesla.

Results. Initial pilot evaluation of the produced brain color maps, by expert observers, demonstrated a potential role of specific tissue segments in precise determination of tumor's margins, including intratumoral/peritumoral regions. In addition, due to its automated character, the technique is expected to deal with observer variabilities, introduced by manual ROI sampling of the above mentioned tumor regions, representing the current clinical standard.

Conclusion. The technique implemented lends itself to 3D tumor modeling and is expected to contribute in GMB and metastases differentiation, by means of 3D surface quantitative descriptors, complemented by 3D whole tumor texture analysis.

http://dx.doi.org/10.1016/j.ejmp.2016.07.632

EDUCATION AND TRAINING FOR RADIATION PROTECTION EXPERTS WORKING IN THE MEDICAL FIELD

Stephen Evans [a,*], Stelios Christofides [b], Cornelius Lewis [c], Virginia Tsapaki [d]

[a] *European Federation of Organisations for Medical Physics, United Kingdom*
[b] *Biomedical Research Foundation, Nicosia, Cyprus*
[c] *King's College Hospital, London, United Kingdom*
[d] *Konstantopoulio General Hospital, Athens, Greece*
* Corresponding author.

Introduction. A course has been developed to provide the Knowledge, Skills and Attitudes (KSAs) for Radiation Protection Experts (RPEs) working in the medical field as part of the ENETRAP III (http://enetrap3.sckcen.be/) EC funded project.

Purpose. The training is designed to ensure that successful course participants are able to provide competent radiation protection advice to employers, staff and members of the public in the medical field.

Materials and methods. The course contains a one week face-to-face module with lectures and workshops designed to ensure the KSA requirements are satisfied. Nine months prior to the face-to-face module, registered course participants are tasked to understand the Knowledge required of RPEs and provide portfolios evidencing the required Skills and Attitudes. Detailed guidance and formative assessments are provided using an IAEA e-learning platform (http://clp4net-nkm.iaea.org/). Draft portfolios are sent to the faculty for comment and are then discussed in an open forum during the face-to-face module to provide opportunities for further improvements and reflection.

Results. Candidates that have successfully completed the course will have fulfilled the required content for the portfolios and passed both an oral assessment on their portfolio and a multiple choice examination at the end of the face-to-face module.

Conclusion. Successful course participants will be able to provide evidence to an authorised body to seek accreditation as an RPE in the medical field under Council Directive 2013/59/Euratom (BSS).

Disclosure. The authors declare that they have no conflict of interest.

http://dx.doi.org/10.1016/j.ejmp.2016.07.633

IMPROVEMENT OF AN OBJECTIVE MODEL OF COMPRESSED BREASTS UNDERGOING MAMMOGRAPHY

A. Rodríguez-Ruiz [a,*], S.S.J. Feng [b], J.R. Mann [c], C.J. D'Orsi [d], I. Sechopoulos [a]

[a] *Department of Radiology and Nuclear Medicine, Radboud University Medical Centre, Nijmegen, The Netherlands*
[b] *Wallace H. Coulter Department of Biomedical Engineering, Georgia Institute of Technology and Emory University, Atlanta, GA, USA*
[c] *Department of Radiology, Brigham and Women's Hospital, Boston, MA, USA*
[d] *Department of Radiology and Imaging Sciences, Emory University, Atlanta, GA, USA*
* Corresponding author.

Introduction. Mammography clinical performance still has room for improvement, and the development of image processing algorithms with an objective model of compressed breasts could help in this task.

Purpose. To develop an accurate model of compressed breasts undergoing mammography based on objective analysis, able to represent the shape of acquired clinical mammography views and also generating realistic paired cranio-caudal (CC) and medio-lateral oblique (MLO) view shapes from a same breast.

Materials and methods. We improve an existing model by overcoming the bias of detector size, removing the nipple and extraneous tissue, pairing the CC and MLO views from a same breast, and incorporating the pectoralis contour. The shapes of the breast in 872 mammograms were automatically detected, and then reduced to a model with linearly independent variables via principal component analysis. We tested its ability to represent 100 independent mammograms by measuring the average distance error (ADE).

Results. The model based on twelve principal components (containing 99.2% of the total variance of the data) was found to depict breast shapes with high fidelity (ADE = 1.31 mm), while fewer components still provide adequate representation (ADE = 3.60 mm). The histograms of the first twelve parameters were successfully fitted with Gaussian distributions and can be used to generate new contours.

Conclusion. Our model can successfully generate paired CC and MLO view shapes from the same simulated breast, as well as characterize with high accuracy clinical acquired mammograms with a small set of parameters, which can aid dosimetry and scatter correction research.

Disclosure. None to disclose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.634

Physica Medica 32 (2016) 284–339

Contents lists available at ScienceDirect

Physica Medica

journal homepage: http://www.physicamedica.com

Abstracts from the 1st European Congress of Medical Physics: E-Posters

COMPARISON OF THE PHYSICAL PROPERTIES OF CO-60 AND IR-192 SOURCES – RETURN OF COBALT?

Kowalik Lukasz

Szpital Specjalistyczny w Brzozowie Podkarpacki Ośrodek Onkologiczny im, Ks. B. Markiewicza 36-200 Brzozów, ul. Ks. Bielawskiego 18, Poland

Purpose. Comparison of radioactive sources of Co-60 and Ir-192 using in HDR brachytherapy produced by the most popular companies in European market. Assessment of costs of exploitation equipment for brachytherapy and the cost of implementation the procedures.

Materials and methods. Comparison included: construction, distribution of radiation (radial function, anisotropy), step, method of source movement and active length radiation sources of the isotope Ir-192 produced by Nucletron, Varian and BEBIG, and for radioactive isotope Co-60 produced by BEBIG.

Results. Afterloaders equipped with source Ir-192 produced by Nucletron and BEBIG have similar physical structure of capsule with radioactive isotope, which has comparable effect on distribution of radiation. Varian afterloader is equipped with two Ir-192 radiation sources, active length used during radiation is longer what influences on treatment planning. Isotopes of Ir-192 and Co-60 has different average photon energy produced during radioactive decay ($E_{Ir\text{-}192}$ = 380 keV, $E_{Co\text{-}60}$ = 1,25 MeV) and different half-life ($T_{1/2Ir\text{-}192}$ = 72,8 day, $T_{1/2Co\text{-}60}$ = 5,26 year) which brings differences in radial distribution of the radiation, its range and distribution of radiation around capsule containing the isotope. BEBIG's afterloader with isotope Co-60 has different Times of irradiation of the patient (the difference between 10% and 20%), frequency of replacement source (every 5 years vs every three months) which affects on globally much lower operating costs.

Conclusions. Equipping new brachytherapy department should take into account the number of treated patients, the most common location of tumors in witch brachytherapy will be using and costs of exploitation brachytherapy devices. Very important are presented factors.

http://dx.doi.org/10.1016/j.ejmp.2016.07.096

INDIVIDUALIZED ASSESSMENT OF THE PROBABILITY FOR DEVELOPING IN-FIELD SOLID TUMORS FROM RADIATION THERAPY FOR TESTICULAR CANCER

Michalis Mazonakis [a,*], Efrossyni Lyraraki [b], John Damilakis [a]

[a] *Department of Medical Physics, Faculty of Medicine, University of Crete, PO Box 2208, 71003 Iraklion, Crete, Greece*

[b] *Department of Radiotherapy and Oncology, University Hospital of Iraklion, 71110 Iraklion, Crete, Greece*

* Corresponding author.

Introduction. Testicular cancer is a highly treatable malignancy which is usually presented in young adults.

Purpose. The purpose of this study was to combine individualized dosimetric data with an advanced non-linear risk model for the patient-specific assessment of the probability for solid cancer induction after three-dimensional conformal radiotherapy for testicular cancer.

Materials and methods. Ten patients with early stage seminomatous testicular cancer were subjected to a planning computed tomography scan. Treatment plans were generated with an 18 MV photon beam delivering 20 Gy in 10 fractions to para-aortic lymph node region. Differential dose-volume histograms were defined with a bin width of 0.01 Gy for radiosensitive organs exposed to primary radiation. For each study participant, the organ equivalent dose (OED) of colon, stomach and liver and the associated lifetime risk for carcinogenesis were estimated with a mechanistic model. This model accounts for the effects of cell repopulation and target dose fractionation.

Results. The range of the calculated OEDs of the colon, stomach and liver was found to be 251.3–500.4 cGy, 37.3–79.8 cGy and 43.0–70.3 cGy, respectively. The patient-specific lifetime probability for the appearance of colon malignancies varied from 0.74% to 1.94% by the patient's age at the time of irradiation and the organ radiation exposure. The corresponding lifetime risk ranges for stomach and liver cancer induction were equal to 0.42–0.81% and 0.14–0.22%, respectively.

Conclusion. The knowledge of the patient-specific probability for developing solid tumors prior to radiotherapy for testicular cancer may facilitate treatment decisions and improve risk management.

Disclosure. There is not any relationship that may bias our presentation.

http://dx.doi.org/10.1016/j.ejmp.2016.07.097

CALCULATION OF CONVERSION FACTOR RELATING MEASURED PATIENT ENTRANCE SKIN DOSE AND SCANNER REGISTERED COMPUTED TOMOGRAPHY DOSE INDEX DURING SINUS EXAMINATION

Khaled Soliman *, Abdullah Alrushoud

Medical Physics Department, Prince Sultan Military Medical City Riyadh, Saudi Arabia

* Corresponding author.

Introduction. Radiochromic films (RF) have successfully been used in measuring radiation doses in computed tomography (CT). The films were reported to have the ability to picture radiation dose profile, to measure entrance surface dose (ESD), and the peak surface dose (PSD).

Purpose. The objective of this work was to study the feasibility of using RF as in vivo dosimeters to measure ESD from patients undergoing routine CT examination of the sinus and relate the measurements to the scanner calculated computed tomography dose index ($CTDI_{vol}$) available at the scanner console.

Materials and methods. Gafchromic XR-QA2 film strips were calibrated against the reading from a 300 mm long pencil type ionization chamber calibrated in terms of CT dose length product (DLP). The in vivo measured ESD and PSD from 12 patients using films were used to calculate the conversion factors: $C_S = ESD/CTDI_{vol}$ and $C_{PK} = PSD/CTDI_{vol}$.

Results. The calculated conversion coefficients C_S and C_{pk} were 0.88 and 1.18 respectively. The films were easily and effectively implemented as In-vivo dosimeter during CT imaging of the sinus allowing for a more accurate estimate of typical surface doses found in CT imaging.

Conclusion. The films had the advantage of not interfering with the patient setup and did not produce any image artifacts. The method can be used to study other CT examinations specially the ones with larger beam width and high pitch factor, to predict the peak skin dose, to examine the CT dose profile and the radiation dose distribution during annual QA.

Disclosure. we have nothing to disclose in relation with the presented work.

http://dx.doi.org/10.1016/j.ejmp.2016.07.098

MEASUREMENTS OF DOSE RATE CONSTANT CORRECTED FOR SELF ATTENUATION FROM PATIENTS INJECTED WITH ^{18}F (FDG)

Khaled Soliman, Ahmed Alenezi *

Medical Physics Department, Prince Sultan Military Medical City, Riyadh, Saudi Arabia
* Corresponding author.

Introduction. Variations in FDG biodistribution and organ uptake levels are patient specific and vary with organs sizes and disease types. Radiation self-attenuation and scatter characteristics are assumed to be patient specific and may have comparable variations among populations. A new study from different population type or race could positively contribute to the overall average value applicable in clinical practice.

Purpose. The aim of this paper is to recommend a value for the radiation dose rate constant measured at one meter from patients injected with ^{18}F-FDG to be applied in clinical practice.

Materials and methods. We have measured the dose rates from 67 patients all injected with ^{18}F-FDG just before voiding using a calibrated ionization chamber; The injected activity was corrected for decay and used to calculate the dose rate per unit activity constant. The injected activity range was [147–485] MBq and we found an average dose rate constant of 96 ± 14 $\mu Sv\ h^{-1}\ GBq^{-1}$.

Results. we recommend the use of 96 $\mu Sv\ h^{-1}\ GBq^{-1}$ as radiation dose rate constant evaluated at one meter from patients; this result is in agreement with the current literature in ^{18}F-FDG PET/CT imaging practice. We have examined the geometrical factors affecting the measured dose rate values, specifically the point and line source models.

Conclusion. We have presented an overview of the literature that reports dose rate constant values calculated using different assumptions, and suggest the most appropriate one to be used in the case of occupational radiation dose estimates without performing actual dose rate measurements on the patient.

Disclosure. we have nothing to disclose in relation with the presented work.

http://dx.doi.org/10.1016/j.ejmp.2016.07.099

COMPARISON OF THE MRI SEQUENCES IN IDEAL FIDUCIAL MAKER-BASED RADIOTHERAPY FOR PROSTATE CANCER

Tanaka Osamu *, Iida Takayoshi, Hattori Mitsuyoshi, Hirose Shigeki, Kawaguchi Daisuke, Komeda Hisao

Gifu Municipal Hospital, Gifu, Japan
* Corresponding author.

Introduction. Contouring the prostate using CT alone is difficult. MRI is used in registration of CT and MRI using fiducial markers. However, visualization of the marker itself can be difficult in MRI.

Purpose. The aim of this study was to determine the optimal MRI pulse sequence to define the marker, as well as the prostate gland, by comparing five sequences.

Methods and materials. A total of 21 consecutive patients with prostate cancer were enrolled. We obtained five sequences of T1-weighted spin-echo ([TR]/[TE]): (607/12) (T1WI), T2-weighted fast spin-echo (3000/80) (T2WI), T2*-2D-weighted gradient echo (4000/80) (T2*2D), T2*-3D-weighted gradient echo [TR/TE1/deltaTE](37/14/7.3) (T2*3D), and contrast-enhanced T1-weighted spin-echo (607/12) (CE-T1WI). A qualitative image analysis of the sequence was also performed by three observers.

These observers subjectively scored all images according to the following five evaluation items: definition of the outline of the prostate; apex vs. soft tissue; base vs. bladder; base vs. seminal vesicle; and gold fiducial marker detection. A score of 1–3 (1 = poor, 2 = moderate, 3 = good) was assigned to all items. A higher score was regarded to indicate better visualization.

Results. T2*2D and T2*3D were strongly superior to other sequences and significantly superior in terms of fiducial marker definition. T2*3D was slightly superior to T2*3D, but this difference was not significant.

Conclusion. We recommend that a T2*3D examination is initially performed, followed by a T2*2D sequence if necessary.

http://dx.doi.org/10.1016/j.ejmp.2016.07.100

A PROTOTYPE OF HIGH RESOLUTION PARALLEL BEAM OPTICAL COMPUTED TOMOGRAPHY SCANNER

Mobarakeh Mahdavizadeh [a,*], Seied Rabi Mahdavi [b], Nima Bahmani [c]

[a] *Master of Iran University of Medical Science, Tehran, Iran*
[b] *Associate Professor of Iran University of Medical Science, Tehran, Iran*
[c] *Master of Sahand University of Technology, Tabriz, Iran*
* Corresponding author.

Introduction. There is a pressing need for a three-dimensional (3D) dosimetry system, appropriate for clinical use, to enable comprehensive verification of the dose distributions typical of modern radiation therapy.

Purpose. For this aim we introduced a dosimetry system that consist of a polymer gel dosimeter (MAGIC-F) and a prototype of laboratory dedicated level Optical Computed Tomography (OCT) scanner.

Materials and methods. The OCT was designed and constructed based on a broad beam visible light source and a two-dimensional charge-coupled device (CCD) detector. In this study spatial resolution parameter was determined. One of the methods for evaluating the spatial resolution of an optical CT scanner is to calculate the modulation transfer function (MTF).

Results. The system could scan a sample around 25 min completely then a set of cross sectional images is reconstructed from projections. The reconstructed images from optical scanner were analyzed to evaluate spatial resolution. The result indicated 10% modulation was 3.6 cycle/mm. That is means the system has sub millimeter resolution.

Conclusion. It has been observed that the prototype Optical parallel beam scanner is reliable the perspective of resolution for scanning gels for radiotherapy applications. The cost of fabrication scanner is lower than the commercial models. This scanner is a laboratory dedicated level Optical Computed Tomography of course it can be improved and develop in future.

http://dx.doi.org/10.1016/j.ejmp.2016.07.101

OPTIMUM WAVELENGTH OF ULTRAVIOLET RAYS IN GAFCHROMIC EBT2

T. Katsuda [a,*], R. Gotanda [b], T. Gotanda [c], T. Akagawa [d], N. Tanki [e], T. Kuwano [f], A. Noguchi [g], K. Yabunaka [h]

[a] *Faculty of Human Relation, Tokai Gakuin University, Gifu 504-8511, Japan*
[b] *Department of Radiological Sciences, Ibaraki Prefectural University of Health Sciences, Ibaraki 300-0394, Japan*
[c] *Faculty of Health Sciences, Junshin Gakuen University, Fukuoka 815-8510, Japan*
[d] *Department of Radiological Technology, Tokushima Red Cross Hospital, Tokushima 773-8502, Japan*
[e] *Center for life science technologies, RIKEN, Hyogo 650-0047, Japan*
[f] *Graduate School of Health Sciences, Okayama University, Okayama 700-8558, Japan*
[g] *Faculty of Health Sciences, Osaka Butsuryo College, Osaka 593-8328, Japan*
[h] *Graduate School of Medicine, The University of Tokyo, Tokyo 113-0033, Japan*
* Corresponding author.

Introduction. Gafchromic films have been used for the measurement of X-ray dose in diagnostic radiology. UV-A ray can be used as a substitute for X-rays in the double exposure technique to compensate for nonuniformity error of Gafchromic EBT2.

Purpose. When using a UV-A light emitting diode (UV-A LED), it is necessary to determine the optimal UV-A wavelength to react with the active layer of Gafchromic EBT2. Therefore, changes in the optical density of Gafchromic EBT2 induced by UV-A were investigated by irradiating it at various wavelengths with UV-A LED.

Materials and methods. At first, Gafchromic EBT2 was pre-irradiated using a uniform UV-A by using fluorescent lamp for 60 min from a distance of 72 cm to reduce nonuniformity error. Second, Gafchromic EBT2 was irradiated for 60 min from a distance of 5.3 cm using a UV-A LED at a wavelength of 353–410 nm. The maximum, minimum, and mean ± standard deviation of pixel values of the subtraction images were evaluated using 0.5 inch of circular region of interest (ROI). The most sensitive wavelength of UV ray was decided. In addition, UV strength was measured in each UV-A LED.

Results. When a UV-A LED wavelength of 375 nm was used, the mean ± SD of pixel value of Gafchromic EBT2 was indicated highly pixel value. It was 8915.25 ± 608.86. A 375 nm wavelength UV-A was most effective and sensitive for Gafchromic EBT2.

Conclusion. The 375 nm wavelength of UV-A is available as a substitute for X-rays in the double exposure technique.

Disclosure. Research supported by JSPS KAKENHI Grant Number 26460740.

http://dx.doi.org/10.1016/j.ejmp.2016.07.102

RADIATION DOSE ASSESSMENT OF RADIOSENSITIVE ORGANS USING MOSFET DETECTORS AND MONTE-CARLO BASED DOSIMETRY SOFTWARE PCXMC DURING DENTAL CONE BEAM COMPUTED TOMOGRAPHY EXAMINATIONS

Khaled Soliman, Salman Altimyat *, Mousa Bakkari

Medical Physics Department, Prince Sultan Military Medical City, Riyadh, Saudi Arabia
* Corresponding author.

Introduction. Dental cone beam computed tomography is a new imaging modality increasingly being used in the oral and maxillofacial radiology, mainly for implant planning and assessment of general bony and dental pathological conditions. European Commission, Radiation Protection No 172, Cone beam CT for dental and maxillofacial radiology, 2012 report mentions; that Medical Physicists are required to routinely monitor radiation doses from such modality.

Purpose. We propose to establish an easily implemented method to assess the radiation dose delivered to the radiosensitive organs during imaging.

Materials and methods. The MOSFET detectors were used to measure the patient eye and thyroid gland radiation doses by placing them directly over the area covering the mentioned organs of the anthropomorphic adult female phantom. The measured doses were compared with the calculated doses using PCXMC software (version 2.0).

Results. Absorbed doses in (mGy) to the skin in the region of the eyes and thyroid were measured. MOSFET detectors calibration factor was obtained by direct comparison with calibrated standard ionization chamber. The uncertainty factor was 15% for the kV range used by the scanner. The most common DCBCT examination is the full arch high resolution scan conducted at our hospital using the WhiteFox CBCT scanner. The average measured eye and thyroid doses were 4.3 and 1.2 mGy respectively. The obtained results seem to agree with other published dosimetric studies.

Conclusion. The presented method can be used to routinely monitor radiation doses delivered to radiosensitive organs as result of imaging studies using DCBCT scanners in clinical environment.

Disclosure. we have nothing to disclose in relation with the presented work.

http://dx.doi.org/10.1016/j.ejmp.2016.07.103

X-RAY RESPONSE OF A DIGITAL DETECTOR FOR DENTAL RADIOGRAPHS

N. Kalyvas [a,b,*], P. Maragkaki [b], A. Bakas [a,c], G. Fountos [a,b], V. Koukou [a], N. Martini [a], C. Michail [a,b], I. Valais [a,b], I. Kandarakis [a,b]

[a] *Laboratory of Radiation Physics Materials Technology and Biomedical Imaging, Faculty of Technological Applications, Technological Educational Institute of Athens, Greece*
[b] *Department of Biomedical Engineering, Technological Educational Institute of Athens, Greece*
[c] *Department of Medical Radiologic Technologists, Technological Educational Institute of Athens, Greece*
* Corresponding author.

Introduction. Current dental imaging technology offers indirect detectors capable of digital imaging. These detectors incorporate a scintillator coupled to a photoreceptor.

Purpose. The purpose of this work is to study the X-ray response of a commercially available SCHICK CDR CMOS detector for dental radiography, in terms of detector response (mean pixel value and standard deviation) per incident air-kerma and the spatial resolution.

Materials and methods. The detector was uniformly exposed at a Del Medical Eureka X-ray radiographic system at high voltages of 60 kV and 70 kV. The range of the incident air-kerma, measured with the RTI PIRANHA X-ray multimeter, was varying between 0.047 mGy and 0.225 mGy. The mean pixel value and the standard deviation of the derived DICOM images were measured with RadiAnt (Medixant) available software. Spatial resolution was optically estimated by visualizing the image of an irradiating Type1-83 bar pattern. All images were evaluated in 'for presentation' format, in 8 bit format.

Results. The detector shows linear response up to 0.170 mGy for 60 kV and up to 0.145 mGy for 70 kVp. For higher air-kerma, mean pixel values tend to saturated at 255 grey level value. The saturation was faster at 70 kV. The coefficient of variation, as well as the standard deviation was found to reduce with respect to incident air-kerma for both X-ray tube voltages. Spatial resolution was observed approximately 10 lp/mm at 60 kVp and 9 lp/mm at 70 kVp.

Conclusion. The observed digital detector was found to have better resolution and dynamic range characteristics at 60 kVp.

Disclosure. No disclosure.

http://dx.doi.org/10.1016/j.ejmp.2016.07.104

COMMISSIONING AND IMPLEMENTATION OF MOBIUS, A COMMERCIAL INDEPENDENT CALCULATION SYSTEM FOR IMRT

Bangiri Anna *, Harron Elizabeth, McKenna Angela, Langmack Keith, Revill Geraldine, Jolliffe Greg, Littler Jonathan

Nottingham University Hospitals NHS Trust, UK
* Corresponding author.

Introduction. At NUH VMAT and Tomotherapy patient plans were checked using patient-specific QA (PSQA). Mobius was purchased to aid with the reduction of PSQA time (pre-treatment and on linac).

Methods. Tomotherapy plans were exported to Mobius and the results were compared with those acquired from our existing PSQA system (Delta4 and CheckTomo). The gamma pass rate and the percentage difference in the 95% coverage of the PTVs were used to determine acceptability.

Mobius is currently being commissioned for IMRT from OMP and Monaco TPSs. Beam model data within Mobius were adjusted to reflect local equipment.

MobiusFX monitors the communication between the linac and R&V system (Mosaiq). The accuracy of the delivery was assessed by checking linac parameters (MU, gantry, collimator, and MLC movements). The system was also tested by creating deliberate errors in DICOM plan files.

Results. The gamma pass rates for Mobius and CheckTomo were comparable, but not for the Delta4. The tolerances for the 95% coverage difference were set from the mean ± 2 S.D. Tolerances for the gamma pass rate were 96%, 94% and 95% for 5, 2.5 and 1 cm jaws respectively.

The same metrics with Tomotherapy will be used for VMAT to assess plan acceptability and the tolerances will be selected as above.

Preliminary results suggest that MobiusFX detects large errors in the beam delivery, and plan transfer between TPS and Mosaiq.

Discussion and conclusion. On Tomotherapy the PSQA workload was reduced, from 3 h/week to 1 h/2 weeks.

The FX module workflow is viable and efficient.

http://dx.doi.org/10.1016/j.ejmp.2016.07.105

COMPUTED TOMOGRAPHY RADIATION DOSE IN A REGIONAL SURVEY

A. Serna [a,*], E.A. Garcia-Angosto [b], A.J. Garcia-Sanchez [b], F. Garcia-Sanchez [b], D. Ramos [a]

[a] *Medical Physics Department, Hospital Universitario Santa Lucia, Cartagena, Spain*
[b] *Department of Information and Communication Technologies, Universidad Politecnica de Cartagena (UPCT), Spain*
* Corresponding author.

Purpose. To evaluate the patient dose in computed tomography (CT) examinations and contribute to the stablishment of dose reference levels using a dose management system.

Material and methods. Data from 5 CT hellical multi-slice scanners (16–128 slices) in 3 public hospitals were surveyed (4 Siemens, 1 General-Electric) during 3 months. Three typical examinations were selected: head (1445 cases), thorax (579 cases) and abdomen-pelvis (1055 cases). GE-Dosewatch was used to register patient dose indexes, CTDIvol and DLP, and the technical parameters. The statistical analysis was done in Matlab.

Results. Both the CTDIvol and the DLP data approximate well to a log-normal distribution function whereas the scanned length fits better to a normal distribution.

Median CTDIvol of head scans ranged 33.0–63.8 mGy, thorax 6.7–9.7 mGy and abdomen-pelvis 10.0–12.1 mGy. Median DLP of head scans ranged 527–1162 mGy cm, thorax 218–334 mGy cm and abdomen-pelvis 383–453 mGy cm.

We noticed that same CT model scanners use different technical examinations parameters, resulting in dose variations up to 30%. A dose optimization process was initiated to standardize the scanning protocols, thus expecting a dose reduction around 20% in some cases.

Patient size selection was not deemed necessary due to the high number of cases per examination, more than 100. A drawback of this massive data is the presence of extreme outliers, and thus data filtering is mandatory.

Conclusion. Dose management systems provide an efficient tool to overview and optimize radiological dose levels.

Disclosure. None.

http://dx.doi.org/10.1016/j.ejmp.2016.07.106

ELECTRON BEAM OUTPUT OF AN ELEKTA SLI-PLUS LINEAR ACCELERATOR FOR IRREGULAR SHAPED FIELDS AND FOR EXTENDED SSD

S. Papatheodorou *, G. Malatara

University Hospital of Patras, Medical Physics Department, Patras, Greece
* Corresponding author.

Introduction. A dosimetric study of the electron beam output of the ELEKTA Sli-Plus linear accelerator is being presented: (a) when customized electron cutouts are used in order to shape the field, (b) when the treatment is performed in extended Source-Skin Distance.

Purpose. We have investigated how the machine output varies when electron cutouts of different shapes and sizes are inserted into the beam with the aim to establish a method to predict the beam output in similar circumstances. In order to determine the effective SSDs and the position of the effective point source, the Inverse Square Law (ISL) method has been used for all electron energies and applicators in order to correct the output at extended SSDs applying the ISL correctly.

Materials and methods. An extended set of output measurements has been performed using electron beams blocked by customized

electron cutouts. Measurements have also been carried out in a water phantom at the depth of maximum dose as a function of the air gap *g* between the far end of the applicator and the phantom surface. Measurements have been compared to calculations with the Oncentra Masterplan treatment planning system.

Results & conclusion. Our results indicate that the electron beam output does not vary significantly with the insertion of an electron cutout into the beam and therefore, the monitor units determined for a given electron applicator can be used for the blocked beam as well. Monitor Units can also be safely determined by using the SSD_{eff} in order to account for the change in output and depth-dose distribution.

Disclosure. The authors declare that they have no conflict of interest or any relationship that may bias their presentation.

http://dx.doi.org/10.1016/j.ejmp.2016.07.107

DOSE-VOLUME PREDICTORS OF RADIO-INDUCED COMPLICATIONS AFTER RADIOSURGERY FOR UVEAL MELANOMA

C.R. Gigliotti [a,*], A. del Vecchio [a], L.A. Perna [a], C. Fiorino [a], G. Modorati [b], M. Di Nicola [b], P. Mortini [c], P. Picozzi [c], A. Franzin [c], A. Bolognesi [d], R. Calandrino [a]

[a] *Medical Physics Department, San Raffaele Scientific Institute, Milano, Italy*
[b] *Ophthalmology Department, San Raffaele Scientific Institute, Milano, Italy*
[c] *Neurosurgery Department, San Raffaele Scientific Institute, Milano, Italy*
[d] *Radiotherapy Department, San Raffaele Scientific Institute, Milano, Italy*
* Corresponding author.

Introduction. Uveal melanoma (UM) is a life threatening intraocular malignant tumor. Gamma Knife Stereotactic Radiosurgery (GKSRS) is a well-assessed strategy for conservative treatment of UM providing good results for survival, local control and eye preservation.

Purpose. Our aim is to develop predictive models for radio-induced effects in UM patients treated with exclusive GKSRS.

Materials and methods. Medical records and 3D dosimetry data of critical structures of 66 patients were retrospectively reviewed. Cox's proportional hazard model was used to identify clinical and dosimetric variables as independent risk factor for most clinically relevant GKSRS-related complications: radiation vasculopathy(RV), radiation papillopathy (RP) and neovascular glaucoma(NVG), visual acuity(VA) reduction >20% (VA20%) and complete loss of basal VA (VA100%). ROC curve analysis allowed predicting cutoff values of significant variables.

Results. The 2 years incidences were: RV 10%, RP 12%, NVG 14%, VA20% 59% and VA100% 27%. A clear relationship with D1% to optic nerve (ON) was found for RP and RV. Also, for RV, the prescription isodose-ON distance (PIOND) and the anterior to equator position of the tumor resulted as protective variables. The V20 of posterior segment and tumor thickness were predictive for NVG. Multivariate analyses resulted in two variables predictive model both for VA20% and VA100%, including tumor largest diameter and D1% to ON. A second predictive model, including PIOND, was found for VA100%.

Conclusion. We found clinical and dosimetric variables to predict the risk of main side effects after GKSRS for UM. These results may provide new dose constraints to critical structures potentially able to reduce toxicities.

Disclosure. Antonella del Vecchio has a contract as starter-up with Elekta Instrument AB. No other conflict of interest to declare for the other authors.

http://dx.doi.org/10.1016/j.ejmp.2016.07.108

ULTRAVIOLET RAY WAVELENGTH IN GAFCHROMIC XR-RV3 AND XR-SP2 FILMS

T. Kuwano [a,*], Y. Takeda [a], T. Katsuda [b], R. Gotanda [c], T. Gotanda [d], T. Akagawa [e], N. Tanki [f], A. Noguchi [g], K. Yabunaka [h]

[a] *Graduate School of Health Sciences, Okayama University, Okayama 700-8558, Japan*
[b] *Faculty of Human Relation, Tokai Gakuin University, Gifu 504-8511, Japan*
[c] *Department of Radiological Sciences, Ibaraki Prefectural University of Health Sciences, Ibaraki 300-0394, Japan*
[d] *Faculty of Health Sciences, Junshin Gakuen University, Fukuoka 815-8510, Japan*
[e] *Department of Radiological Technology, Tokushima Red Cross Hospital, Tokushima 773-8502, Japan*
[f] *Center for Life Science Technologies, RIKEN, Hyogo 650-0047, Japan*
[g] *Faculty of Health Sciences, Osaka Butsuryo College, Osaka 593-8328, Japan*
[h] *Graduate School of Medicine, The University of Tokyo, Tokyo 113-0033, Japan*
* Corresponding author.

Introduction. Gafchromic films have been used for the measurement of X-ray dose in diagnostic radiology. Correlation between color density change and ultraviolet (UV) wavelength of Gafchromic XR-RV3 and XR-SP2 were studied. UV irradiation is considered as an X-ray substitute in the double exposure technique. It is one of the correction methods for the nonuniformity error of Gafchromic XR-RV3 and XR-SP2.

Purpose. It is to determine the UV suitable wavelength of a UV light emitting diode (UV LED) that is used as a substitute for X-rays in the double exposure technique for the Gafchromic XR-RV3 and XR-SP2.

Materials and methods. UV LED that UV rays at a wavelength of 353 nm and 5-nm increments from 360 to 400 nm were used. Gafchromic XR-RV3 or XR-SP2 was irradiated with UV of different wavelengths through the 30 mm diameter of irradiation hole for 2 and 4 h, at a distance of 53 mm, respectively. Gafchromic XR-RV3 or XR-SP2 was fixed onto an acrylic plate of 3 mm thickness for assistance with scan. A circular region of interest (ROI) of 0.5 inch for measurements of pixel value was set in the center of the UV irradiation region. The mean pixel values ± standard deviation (SD) was obtained.

Results. Indicated high pixel value of Gafchromic XR-RV3 and XR-SP2 were 1276.81 ± 254.30 (395 nm) and 576.46 ± 219.75 (400 nm), respectively.

Conclusions. The irradiation of Gafchromic XR-RV3 and XR-SP2 with homogeneous UV rays by the UV-LED wavelengths of 395 or 400 nm can correct the nonuniformity error of the active layer efficiently.

Disclosure. Research supported by JSPS KAKENHI Grant Number 26460740.

http://dx.doi.org/10.1016/j.ejmp.2016.07.109

INTERFRACTIONAL SETUP CORRECTIONS USING HEXAPOD ROBOTIC COUCH FOR VMAT HEAD AND NECK TREATMENTS

E.M. Ambroa Rey *, R. Gómez Pardos, D. Navarro Giménez, A. Ramirez Muñoz, M. Colomer Truyols

Medical Physics Unit, Radiation Oncology Department, Consorci Sanitari de Terrassa, Barcelona, Spain
* Corresponding author.

Introduction. Inaccurate alignment of the radiation beam with the patient can lead to critical organs to receive an unwanted high dose or the tumor to receive a reduced dose producing a loss in tumor control.

Purpose. To establish the interfractional setup error, for VMAT head and neck patients, using a kilovoltage cone beam CT (CBCT) and a robotic treatment couch (Hexapod) for accurate patient positioning in six degrees of freedom.

Materials and methods. A total of 315 fractions from 10 H&N patients were evaluated. The Hexapod corrected the misalignments and a pre-treatment CBCT verification was obtained.

For each patient the daily variations of the three principal axes (X, Y and Z) and three rotational movements (pitch, roll, and yaw) were extracted.

The following parameters were calculated: the mean of the setup corrections (M), the standard deviation (random error) and the standard deviation of all the means measured for each patient (systematic error).

Results. The overall mean displacements are (0.0, −0.5, 0.3) mm for the translations and (0.60, −0.45, −0.11) degrees for the rotations. The random errors are (2.2, 2.3, 2.6) mm and (1.29, 1.35, 1.28) degrees. The systematic errors are (1.7, 1.6, 2.0) mm and (0.86, 1.01, 0.98) degrees.

Conclusion. The M values were equal or less than 0.5 mm for the translational axes. We obtained relatively larger random errors than systematic errors in both translational and rotational movements.

This result agrees with the literature for head and neck displacements.

Disclosure. None declared.

http://dx.doi.org/10.1016/j.ejmp.2016.07.110

VALIDATION OF LUNG STEREOTACTIC ABLATIVE BODY RADIOTHERAPY (SABR) TREATMENTS WITH FLATTENING FILTER FREE (FFF) BEAMS

Ioannis Floros *, Anna Bangiri, Greg Jolliffe, Jonathan Littler, Elizabeth Harron, Angela Mckenna, Keith Langmack

Nottingham University Hospitals NHS Trust, United Kingdom
* Corresponding author.

Introduction. To commission and dosimetrically validate MONACO TPS for lung SABR treatments using FFF beams.

Materials and methods. EBT3 films were used and the region of interest was the Field Edge Area (FEA): 20–80% of dose maximum. The film was placed in water and lung phantom and three field sizes were used. Profiles were measured from the film and the FEA was calculated and compared to that from the TPS. Clinical plans were created using three fractionation regimes (54Gy/3#, 55Gy/5#, 60Gy/8#) for each of four patients. Each plan was delivered twice on the Quasar phantom, with a breathing trace and statically, and on the Delta4 phantom.

Results. The profile differences between films and Monaco TPS were primarily within 1mm for all field sizes and at all depths. The largest difference in lung was 0.7, 1.2 and 1.0 mm in the cross-line direction for 10×10, 5×5, and 2×2 cm^2 respectively. The respective differences in the inline direction were 2.2, 1.2 and 1.0 mm. The FEA calculated with Monaco was overall broader than that measured. All the delivered plans had a gamma pass rate better than 98.3% (3 mm/3%)on the Delta4. The Quasar results had a mean absolute dose difference of 1.1% (S.D. 0.7) and 1.3% (S.D. 0.9) for the static and the breathing traces respectively.

Conclusion. The excellent agreement with EBT3 indicates that Monaco satisfactorily predicts profiles in lung. The differences observed could be due to partial volume effect. FFF Lung SABR treatments were fully verified and excellent agreement was found with the Quasar and the Delta4 for all clinical plans.

http://dx.doi.org/10.1016/j.ejmp.2016.07.111

PATIENT EFFECTIVE DOSE DURING PACEMAKER IMPLANTATION AT A FLAT PANEL AND IMAGE INTENSIFIER ANGIOGRAPHY SYSTEM

E. Vlastou [a,*], J. Antonakos [a], E. Simeonidou [b], P. Flevari [b], D. Leftheriotis [b], S. Deftereos [b], E. Efstathopoulos [a]

[a] *2nd Department of Radiology, University of Athens, Greece*
[b] *Unit of Interventional Cardiology, 2nd Department of Cardiology, University of Athens, Greece*
* Corresponding author.

Introduction. Pacemaker implantation is a minimally invasive technique performed under fluoroscopic guidance.

Purpose. This study aims to compare effective dose (ED) delivered to patients at pacemaker implantation procedures by two angiographic systems of different image capture technology; one with flat panel detector (FPD) and one with image intensifier (II).

Materials and methods. A retrospective analysis of 62 procedures performed at Attikon University Hospital of Athens has been conducted. Data concerning dose area product (DAP), fluoroscopy time and patient's weight and height have been collected. The ED has been calculated, multiplying DAP with a conversion factor of 0.2 mSv/(Gy* cm^2) and the results have been divided in categories accordingly to patients' BMI and fluoroscopy time.

Results. ED, presented as median and range values, for normal, over weighted and obese patients that have been operated under a FPD X-ray system, in a fluoro time less than five minutes was 0.49 mSv (0.09–1.1 mSv), 0.67 mSv (0.4–1.2 mSv) and 1.18 mSv (1–1.3 mSv) respectively. The corresponding values for an II system were 0.50 mSv (0.5–0.8 mSv), 2.49 mSv (1.86–3.58 mSv) and 1.70 mSv (0.8–3.3 mSv). For fluoro time greater than five minutes in FPD imaging, ED for the three BMI categories was 1.57 mSv (0.7–3.7 mSv), 0.74 mSv (0.45–1.26 mSv) and 2.93 mSv (1.78–3.45 mSv), while for the II angiography system ED was 12.29 mSv (1.88–49.27 mSv), 28.36 mSv (6.27–15.43 mSv) and 35.27 mSv (5.84–158,73 mSv).

Conclusion. Obtained results indicate statistically significant higher radiation burden associated with II system compared to FPD system used for pacemaker's implantations ($p < 0.05$).

Disclosure. All authors confirm that none relationship may bias this presentation.

http://dx.doi.org/10.1016/j.ejmp.2016.07.112

EXCESSIVE USE OF RADIOGRAPHS AT THE RADIOLOGY EMERGENCY DEPARTMENT

Papageorgiou Evangelia [a,*], Chionidou Roussoudan [b], Karagounis Mihalis [b], Markou Andreas [b], Vasakos Theodoros [b], Zarmpali Niki [b]

[a] *Medical Physics Dept., Hippokratio General Hospital, Thessaloniki, Greece*
[b] *Radiology Dept., Hippokratio General Hospital, Thessaloniki, Greece*
* Corresponding author.

Introduction. Crowding at the Radiology Lab of a Hospital's Emergency Department (ED) is a well-known situation which is thought to be attributed to the excessive amount of radiographs the non-urgent patients are referred for.

Purpose. The scope of this research was to register and study the non-urgent patients and their doses in association with the diagnostic value of their radiographs.

Materials and methods. Patients' data were recorded and the doses were calculated for non-urgent ambulatory adult patients who were referred for X-rays at the Radiology ED at Hippokratio General Hospital of Thessaloniki. For each patient an index of the exam's diagnostic value (DVI) was assigned which was the ratio of the dose of his radiographs that had positive findings to the total dose from all the radiographs he was referred to.

Results. Data were collected for 400 non-urgent patients. A total number of 732 radiographs were taken. The majority were chest, abdomen and knee. A statistically significant difference was found between the number of x-rays referred and both gender and the onset of symptoms. The annual collective dose (ACD) of the non-urgent patients was estimated to be 2.51 manSv. There were no radiological findings for 78% of the radiographs. Average DVI was 0.26. Limb injuries were the most frequent referrals with the highest number of X-rays per patient and the lowest DVI and ACD. Abdominal pain had the highest ACD. Cervical/Lumbar-pain had the highest DVI with the onset of symptoms being more than a week before. The lowest DVIs and the highest ACDs had the patients referred by surgeons, pathologists and orthopedists.

Conclusion. The number of radiographs could be decreased in the cases of limb injuries, abdominal pain and cervical/lumbar-pain after a more detailed clinical evaluation and changes in reference protocols for decreasing dose, crowding and cost in the ED.

Disclosure. No disclosure information.

http://dx.doi.org/10.1016/j.ejmp.2016.07.113

DOSE REDUCTION IN COMPUTED TOMOGRAPHY USING ADAPTIVE STATISTICAL ITERATIVE RECONSTRUCTION (ASIR). A PHANTOM STUDY

Emmanouil Papanastasiou [a,*], Evanthia Papazoglou [a], Eleni Katrakylidou [a], Afroditi Haritanti [b], Anastasios Siountas [a]

[a] *Medical Physics Laboratory, Aristotle University of Thessaloniki, AHEPA University Hospital, 54636 Thessaloniki, Greece*
[b] *Department of Radiology, Aristotle University of Thessaloniki, AHEPA University Hospital, 54636 Thessaloniki, Greece*
* Corresponding author.

Introduction. Computed Tomography (CT) has been an invaluable tool in medical diagnosis, but its increasing use has been also responsible for a significant increase in population radiation exposure. Iterative reconstruction algorithms have been recently introduced in clinical practice, in an attempt to decrease CT radiation dose.

Purpose. The purpose of this work was to investigate quantitatively the relationship between image quality and dose in CT and to establish the effectiveness of ASIR in reducing radiation dose, without compromising image quality.

Materials and methods. A CT image quality phantom was scanned in a 64-slice GE Optima CT660 scanner, using a typical head acquisition protocol with mA modulation, at 8 different Noise Index levels, corresponding to a $CTDI_{vol}$ range of 18.7–91.2 mGy. Scanned data were used to reconstruct 5 mm slices, using (a) only FBP and (b) FBP blended with 3 ASIR levels (20%–40%–60%). Mean CT number, image noise (SD) and CNR were measured in appropriately selected slices in all reconstructed images by three different observers.

Results. A reduction in image noise by 35–55% for the same radiation dose was observed in the ASIR reconstructed images compared to FBP, whereas images with similar noise levels could be produced using ASIR with 55–75% less dose compared to FBP. Similarly, ASIR with at least 40% blending, was found to increase CNR by 20–45% compared to FBP at the same radiation dose, and could produce images with comparable CNR with 20–60% less dose compared to FBP.

Conclusion. ASIR can be very effective in reducing the radiation dose in CT, while preserving image quality.

http://dx.doi.org/10.1016/j.ejmp.2016.07.114

IMPACT OF (VIRTUAL) SET-UP ERRORS ON DVH DOSE RESULTS IN IMRT PLANS FOR HEAD-NECK CANCER

C. Armpilia *, A. Zygogianni, R. Avgousti, E. Apostolou, A. Nikolakopoulou, C. Antypas

1st Radiology Dept, Medical Physics Unit, Medical School, National and Kapodistrian University of Athens, Greece
* Corresponding author.

Introduction-purpose. The aim of this study is to evaluate the impact of isocenter shift in three directions (lateral, longitudinal and vertical) on DVH results in IMRT plans for head and neck cancer treatment, in order to simulate possible set-up errors and its effects on treatment outcome.

Materials and methods. IMRT step and shoot plans for ten patients with head and neck cancer were created on the Oncentra TPS according to RTOG 0615 protocol. Three PTVs were outlined with prescribed dose of 54 Gy (PTV54), 59.4 Gy (PTV59.4) and 70 Gy (PTV70) in 33 fractions. Each treatment plan was recalculated for isocenter shift of ±3 mm in all directions. DVHs were regenerated for PTVs and critical structures for all shifted plans.

Results. Mean values of V51.3, V57 and V66.5 were calculated in standard plan for PTV54, PTV59.4 and PTV70 as 95.3 (SD = 1.3), 93.5 (SD = 0.9 and 95.3 (SD = 1.8) respectively. The maximum deviation n PTV70 coverage was found in the posterior direction 5% less than the standard plan value. Both PTV59.4 and PTV50 showed a decrease in coverage within a range of 4–8% either in the anterior or in the longitudinal direction.

The mean D2 values calculated for spinal cord and brainstem for the standard plan were 42.0 Gy (SD = 2.1) and 42.6 Gy (SD = 2.1) respectively. The greatest deviation for shifted plans was found in the posterior direction 11% more than the standard (no shift) value. The average D50 for left and right parotids were 26.4 Gy (SD = 1.2) and 27 Gy (SD = 1.3) respectively. The greatest deviation was found reciprocally in the lateral direction 13% less than the standard plan value.

Conclusion. In this study, isocenter shift of ±3 mm reveals significant deviations of calculated DVH parameters. Such possible set-up errors could result in non-adequate PTV coverage and in dose values for critical structures outside of compliance criteria. These results

indicate the importance of daily IGRT and subsequent patient setup correction for efficient IMRT treatment outcome.

http://dx.doi.org/10.1016/j.ejmp.2016.07.115

EYE LENS RADIATION EXPOSURE IN GREEK INTERVENTIONAL CARDIOLOGY PERSONNEL

Zoi Thrapsanioti [a,*], Panagiotis Askounis [a], Ioannis Datseris [b], Miltiadis Papathanasiou [c], Eleftheria Carinou [a]

[a] *Greek Atomic Energy Commission, Greece*
[b] *"OMMA" Ophthalmological Institute of Athens, Greece*
[c] *2nd Ophthalmology Department, Attikon University Hospital, Athens, Greece*
* Corresponding author.

Introduction. The exposure of the radiosensitive eye lenses to ionizing radiation can lead to radiation-induced cataract, which is usually detected earlier than the age-related cataract.

Purpose. In the framework of the study, measurements of the eye lens doses of Interventional Cardiologists (ICs) were performed. An attempt was made to calculate retrospectively their eye lens doses and compare them with the probability for radiation-induced cataract.

Materials and methods. The study included ICs from different health centers of Athens and unexposed workers. Each participant underwent two clinical eye examinations and the detected lens opacities (nuclear, cortical or posterior subcapsular) were classified according to LOCS III protocol. Moreover, the lens doses of the ICs were measured using special designed eye dosemeters.

Results. 43 ICs (mean age = 48.8 ± 6.7 years) and 22 unexposed workers (mean age = 48.2 ± 5.0 years) participated at the study. The mean dose to the eye lenses of the ICs per month was 0.74 ± 0.53 mSv, while the maximum annual dose was calculated 28 mSv/yr, much higher than the occupational annual dose limit of 20 mSv/yr.

Regarding the lens opacities, the two groups did not differ significantly in the prevalence of either nuclear or cortical lens opacities, whereas 4 ICs where detected with early stage subcapsular sclerosis.

Conclusion. Though no statistically significant difference was observed in the cohort, the measured doses and the cumulative ones indicate that the ICs receive high eye lens doses. In order to minimize the radiation induced risk at the eye lenses, the use of radioprotective equipment and appropriate training on this issue is highly recommended.

http://dx.doi.org/10.1016/j.ejmp.2016.07.116

OPTIMIZATION OF MINIBEAM GENERATION BY MECHANICAL COLLIMATION IN PROTON MINIBEAM RADIATION THERAPY

C. Guardiola *, C. Peucelle, Y. Prezado

Laboratoire d' Imagerie et Modelisation en Neurobiologie et Cancerologie (IMNC), Centre National de la Recherche Scientifique (CNRS). Campus universitaire, Bat. 440, 15 rue Georges Clemenceau – 91406 Orsay Cedex, France
* Corresponding author.

Introduction. The dose tolerances of normal tissues continue being the main barrier in radiotherapy. To lower it, we recently proposed a novel concept: proton minibeam radiation therapy (pMBRT). It allies the inherent advantages of protons with the normal tissue preservation observed when irradiated with submillimetric spatially fractionated beams. The tumor receives a homogeneous dose distribution, while normal tissues benefit from the spatial fractionation of the dose.

Purpose. We have recently implemented this technique at the Orsay proton therapy clinical center. This work aims at optimizing the minibeam generation by means of a mechanical collimation.

Materials and methods. Monte Carlo simulations (GATEv7.1) were used to evaluate different irradiation configurations, e.g. collimator dimensions and materials (Brass, Tungsten, Iron and Nickel). Clinically relevant energies were used. Neutron contamination, Peak-to-valley dose ratios (PVDR) and beam penumbras were used as figures-of-merit.

Results. The neutron dose due to the minibeam collimator was found to be lower than 0.002% of the primary dose. A tungsten collimator provides the higher PVDR, but the generated neutron yield is 3 times higher than in other materials. Brass seems to provide the best compromise between PVDR values and neutron contamination.

Conclusion. A mechanical collimation only increases the biologic neutron dose by 0.04% of the peak surface dose therefore it is suitable for pMBRT. An optimized collimation for pMBRT, providing the best compromise between a high PVDR and low neutron generation, has been obtained.

http://dx.doi.org/10.1016/j.ejmp.2016.07.117

DETECTIVE QUANTUM EFFICIENCY (DQE) OF THE DEXELA 2923MAM DETECTOR ACCORDING TO IEC 62220-1-1:2015

V. Koukou [a,*], N. Martini [a], I. Vasiloudis [b], L. Klimi [b], C. Michail [b], I. Valais [b], N. Kalyvas [b], A. Bakas [c], I. Kandarakis [b], G. Nikiforidis [a], G. Fountos [b]

[a] *Department of Medical Physics, Faculty of Medicine, University of Patras, Rion, 265 00 Patras, Greece*
[b] *Radiation Physics, Materials Technology and Biomedical Imaging Laboratory, Department of Biomedical Engineering, Technological Educational Institute of Athens, Egaleo, 122 10 Athens, Greece*
[c] *Medical Radiological Technology, Faculty of Health and Caring Professions, Technological Educational Institute of Athens, 122 10 Athens, Greece*
* Corresponding author.

Introduction. In recent years, digital X-ray imaging devices such as complementary metal oxide semiconductors (CMOS) are widely used in almost all the imaging field applications.

Purpose. The purpose of the present study was to determine the Detective Quantum Efficiency (DQE) of the Dexela 2923MAM CMOS detector, following the new IEC 62220-1-1:2015 International Standard.

Materials and methods. DQE was assessed after the experimental determination of the Modulation Transfer Function (MTF) and the Normalized Noise Power Spectrum (NNPS). The CMOS sensor had a pixel size of 74.8 μm coupled to a 200 μm CsI:Tl screen. The MTF was measured following both the IEC 62220-1:2003 and IEC 62220-1-1:2015 methods, while NNPS was determined by 2D Fourier transforming uniformly exposed images. Both parameters were assessed by irradiation under the RQA-3 beam quality.

Results. The detector response function was linear for the exposure range under investigation. MTFs calculated following the 62220-1:2003 protocol, were found overestimated for spatial frequencies higher than 2 cycles/mm. DQE values, determined with the IEC 62220-1:2003 method, were also found overestimated (spatial frequencies higher than 2 cycles/mm), due to the influence of both MTF and NNPS. The influence of both additive and multiplicative lag effects were found below 0.005, insuring that lag contributes less than 0.5% of the effective exposure.

Conclusion. The artificially overestimated MTF values resulting following the 2003 protocol is attributed to the MTF averaging,

which also averages noise, that is transferred more efficiently than signal through the imaging chain.

Disclosure. This work was supported by Grant E.040 from the Research Committee of the University of Patras (Programme K. Karatheodori).

http://dx.doi.org/10.1016/j.ejmp.2016.07.118

SMALL FIELDS DOSIMETRY: OUTPUT FACTORS AND CORRECTION FACTORS DETERMINATION FOR AN ELKETA AXESSE MEDICAL LINAC EQUIPPED WITH CIRCULAR CONES

A. Girardi [a,*], C. Fiandra [a], E. Gallio [b], F.R. Giglioli [b], R. Ragona [a]

[a] *University of Turin, Department of Oncology-Radiation Oncology Unit, Turin, Italy*
[b] *City of Health and Science University Hospital of Turin, Medical Physics Unit, Turin, Italy*
* Corresponding author.

Introduction. The peculiarities of small beams (high dose gradient, source occlusion, lack of lateral electronic equilibrium) and the features of the detector (active volume dimension, components with high-Z materials) make the dosimetry very challenging.

Purpose. The aim of this work is to determine small fields output factors (OF) for several detectors and correction factors for active detectors for comparison with a passive dosimeter.

Materials and methods. Small fields beams, ranging from 5 mm to 30 mm in diameter, were defined using circular cones. OF measurements were performed with six active detectors (ionizing microchambers air-filled: Exradin A26, Exradin A16; ionizing microchamber isooctane-filled: PTW microLion; plastic scintillator: Exradin W1; diode: Razor IBA) and one passive detector (Gafchromic EBT3 films).

Results. Exradin W1 and A26 shown excellent agreement with EBT3 films (better than 2%). A significant underestimation was observed for Exradin A16, particularly for the smallest field, up to 12%. The results obtained with the PTW microLion and the IBA RAZOR indicate a dose overestimation for the smaller radiation fields, up to 4% and 7% for the 5 mm-diameter field for microLion and RAZOR respectively.

Conclusion. The present study points out that it is crucial to apply the appropriate correction factors in order to provide accurate measurements in small beam geometry. The results show that the Exradin W1 and Exradin A26 can be used for small fields dosimetry without correction factors. The correction factors should be employed for the other detectors, in particular for field diameter smaller than 10 mm.

Disclosure. Nothing to declare.

http://dx.doi.org/10.1016/j.ejmp.2016.07.119

EXPERIMENTAL AND ANALYTICAL DOSE ASSESSMENT OF PATIENT'S FAMILY MEMBERS TREATED WITH I-131

Marzieh Ebrahimi [a], Vahid Changizi [a,*], Mohammad Reza Kardan [b], Seyed Mahdi Hosseini Pooya [b], Parham Geramifar [c]

[a] *Department of Technology of Radiology and Radiotherapy, Allied Medical Sciences School, Tehran University of Medical Sciences, Tehran, Iran*
[b] *Radiation Application Research School, Nuclear Science and Technology Research Institute, AEOI, Tehran, Iran*
[c] *Research Center for Nuclear Medicine, Shariati Hospital, Tehran University of Medical Sciences, Tehran, Iran*
* Corresponding author.

Radiation exposure to the patient's family members is one of the major concerns during thyroid cancer radionuclide therapy. The aim of this study was to measure the total effective dose of the family members by means of thermoluminescence personal dosimeter, and compare with those calculated by analytical methods.

Eighty five adult family members of fifty one patients volunteered to participate in this research study. Considering the minimum and maximum range of dose rate from 15 μsv/h to 120 μsv/h at patient s' release time, the calculated mean and median dose values of family members were 0.45 mSv and 0.28 mSv, respectively.

Moreover, almost all the family members doses were measured to be less than the dose constraint of 5 mSv recommended by Basic Safety Standards.

Considering the influence parameters such as patient dose rate and administrated activity, the total effective dose of family members were calculated by TEDE and NRC formulas and compared with those of experimental results. The results indicated that, it is fruitful to use the quantitative calculations for releasing patients treated with I-131 and correct estimation of patient s' family doses.

http://dx.doi.org/10.1016/j.ejmp.2016.07.120

COMPARATIVE STUDY BY MONTE CARLO SIMULATION OF RPL GD-301, TLD-100 AND AL_2O_3:C DETECTORS RESPONSES

Abdel-Hai Benali

Biology Department, University Echahid Hamma Lakhdar, El-oued Algeria, Algeria
Laboratory SNIRM, Physics Faculty, University of Sciences and Technology Houari Boumediène, LP 32 El-Alia Bab Ezzouar, Algiers, Algeria

Introduction. For the monitoring of patient dose in external radiation therapy, the luminescent dosimeters are widely used, where the physical processes of their three types (thermoluminescence (TLD), radiophotoluminescence (RPL) and optically stimulated luminescence (OSL)) are very similar.

Purpose. The purpose of this work was to compare the dosimetric proprieties of three kind of luminescent detectors, RPL glass dosimeter, commercially known as GD-301, with lithium fluoride TLD-100 (LiF:Mg,Ti) and carbon-doped aluminum oxide (Al2O3:C).

Methods and materials. In our study, a Monte Carlo simulation with MCNP5 was carried out to estimate the responses of these dosimeters in terms of absorbed dose, output factor, the angular and energy dependence.

Results. In this work we found that the difference between the output factor was less than ±4.2% for the three dosimeters. The variations in sensitivity for angles up to ±80° from the central axis of the beam were approximately 1% and 1.5% for the GD-301 and Al_2O_3:C, respectively. The energy dependence of the RPL and OSL dosimeters were found to be within 1% and 3.1% for 6 and 15 MV X-ray beam, respectively, for the TLD is stated as less than a 1.1% for the both beams.

http://dx.doi.org/10.1016/j.ejmp.2016.07.121

PYLINAC: A TOOLKIT FOR PERFORMING TG-142 QA RELATED TASKS ON LINEAR ACCELERATOR

Ali Zaila, Marouf Adili *, Saleh Bamajboor

Department of Medical Physics, Prince Sultan Medical Military City, Saudi Arabia
* Corresponding author.

Introduction. In a new radiotherapy center, with multi-modality linear accelerator, the quality control (QC) procedure becomes more complicated and more time consuming. Pylinac is a free software provides TG-142 QC tools.

Purpose. Is to evaluate the safe use of the software and accuracy in analyzing the QC tests.

Materials and methods. Pylinac (//github.com/jrkerns/pylinac) contains 8 high-level modules for automatically analyzing images and data generated by linear accelerator. we have tested 4 modules which are star-shot, VMAT, picket fence and CBCT module. It use either scanned film images, EPID or CBCT DICOM images. The software process the images and performs all measurements required by the QC protocol, then the results were compared with results from the standard analysis method

Results. Current QC procedure is based on visual observation of certain features in acquired images and be able to detect any deviation, such as MLC position or isocenter position. This approach is also a subjective task as it depends on the person who is performing the analysis. Using Pylinac software gives a superior result compared with the routine analysis way as it gives the result in sub millimeter for the star-shot and the picket-fence tests. In the VMAT test the software has the ability to analyze the whole image, rather than performing the test on specific positions on the image.

Conclusion. The software was able to perform all the tests and detect any deviation with the same accuracy as manual method, also it performs the analysis in a significantly shorter time.

Disclosure. We have nothing to disclose in relation to the presented work.

http://dx.doi.org/10.1016/j.ejmp.2016.07.122

EVALUATION OF A NEW TEST PATTERN FOR DAILY QUALITY ASSURANCE OF MEDICAL DISPLAY MONITORS

Hideki Fujita [a,*], Nao Kuwahata [a], Hidetoshi Yatake [b], Toshizo Katsuda [c], Haruyuki Fukuda [a]

[a] *Saiseikai Nakatsu Hospital, Japan*
[b] *Kaizuka City Hospital, Japan*
[c] *Tokai Gakuin University, Japan*
* Corresponding author.

Introduction. In the visual evaluation of daily quality assurance (QA) of medical display monitors, some well-established test patterns are available; however, the same pattern is always used. Therefore, it is difficult to detect luminance deterioration.

Purpose. We developed the new software for the daily QA of monitors (mdQA), in which randomized object (RO) patterns were generated. The RO patterns had a low-contrast object consisting of a randomly located sphere. In the present study, we evaluated whether these RO patterns can detect luminance deterioration.

Materials and methods. The mdQA was developed using Microsoft Visual Basic 2010 Express. The digital driving level (DDL) and the standard deviation (SD) of the RO pattern background, as well as the size and contrast of the object, were adjustable. In this study, the DDL and SD were set at 130 and 20, respectively. The object diameter was determined at 30 pixels. Contrast values varied from 4 to 8 pixels. We produced 40 patterns with and without the object using the mdQA. A receiver operating characteristic analysis was performed for the two different display luminance (400 and 320 cd/m^2) using a 2-megapixel color liquid crystal display (LCD) monitor. Ten radiation therapists observed the patterns and scored the confidence rate using a continuous scale.

Results. There was a statistically significant difference between the two LCD monitor conditions ($p < 0.01$).

Conclusion. The developed mdQA enables the creation of RO patterns for the daily QA of medical display monitors; these RO patterns are useful in detecting luminance deterioration.

Disclosure. None.

http://dx.doi.org/10.1016/j.ejmp.2016.07.123

ENERGY RESPONSE CHARACTERISTICS OF RADIOCHROMIC FILM AT CT RADIATION QUALITY

R. Gotanda [a,*], H. Sato [a], E. Nakajima [a], K. Noguchi [b], T. Gotanda [c], T. Akagawa [d], N. Tanki [e], T. Kuwano [f], T. Katsuda [g]

[a] *Department of Radiological Sciences, Ibaraki Prefectural University of Health Sciences, Ibaraki 300-0394, Japan*
[b] *Graduate School of Health Sciences, Ibaraki Prefectural University of Health Sciences, Ibaraki 300-0394, Japan*
[c] *Faculty of Health Sciences, Junshin Gakuen University, Fukuoka 815-8510, Japan*
[d] *Department of Radiological Technology, Tokushima Red Cross Hospital, Tokushima 773-8502, Japan*
[e] *Center for Life Science Technologies, RIKEN, Hyogo 650-0047, Japan*
[f] *Graduate School of Health Sciences, Okayama University, Okayama 700-8558, Japan*
[g] *Faculty of Human Relation, Tokai Gakuin University, Gifu 504-8511, Japan*
* Corresponding author.

Introduction. Radiochromic films (RF) have been developed for measurement of the absorbed dose of low-energy photons and to measure CT dose profiles. RF are self-developing and radiation sensitive, and the amount of darkening is proportional to the absorbed dose. RF are easy to handle due to their insensitivity to interior room light.

Purpose. In this study, energy response of GAFCHROMIC XR-QA2 film (XR-QA2) was evaluated to obtain an accurate measurement of CT dose.

Materials and methods. The measured dose and energy range of the XR-QA2 was designed to be 2–500 mGy and 20–200 kVp. XR-QA2 is a reflective-type film, and a flatbed scanner was used for the measurement of image density. To obtain the calibration curves, XR-QA2 were irradiated at 0–120 mGy (air-kerma) using 10–150 kVp (10 kVp intervals) photon beam with industrial X-ray System(Titan;GE). For image density acquisition, XR-QA2 were scanned before and after irradiate using a flatbed scanner (Epson GS-11000) in RGB (48 bit) mode, 150 dpi.

Results. The calibration curves varied according to the tube voltage. The energy response was best at 50 kVp and decreased according to increase tube voltage within the range of 50–150 kVp. Additionally, energy response was decreased rapidly below 40 kVp.

Conclusion. The dose differences were around 10% at 80–140 kVp. This indicated that single calibration curve is not adequate for CT dosimetry performed at different energies.

To obtain an accurate measurement of CT dose, calibration curve has to make based on used energy.

Disclosure. We have no disclosure and financial support.

http://dx.doi.org/10.1016/j.ejmp.2016.07.124

DEEP INSPIRATION BREATH-HOLD TECHNIQUE USING AN ARDUINO

P. Gallego [a,*], J. Pérez-Alija [a], E. Ambroa [b], S. Olivares [a], S. Loscos [a], P. Agustí [a]

[a] *Radiation Oncology Department, Hospital Plató, Barcelona, Spain*
[b] *Medical Physics Unit, Radiation Oncology Department, Consorci Sanitari de Terrassa, Barcelona, Spain*
* Corresponding author.

Introduction. A large effort has been made in recent years to develop techniques to reduce the dose to normal tissue (especially heart dose) for patients receiving radiation treatment for breast cancer.

Purpose. The aim of this work was both to develop a DIBH method using an Arduino Uno microcontroller board (SmartProyects, Ivrea, Italia) and a simple software to visualize the patient's level of inspiration. This method provides a cheaper solution to the more expensives commercial ones.

Materials and methods. Arduino is an open-source electronics platform based on an easy-to-use hardware and software. We plugged a tri-axial low-g digital acceleration sensor (Bosch's *BMA180)* to our Arduino board. This accelerometer is then placed on the patient and used as a surrogate to measure the expansion of the patient's thorax during breathing.

We measure the orientation change in our BMA180 inside the gravitational field. However, this orientation change is good enough to accurately measure the changes in the patient's breath cycle.

Results. We were able to build a DIBH system using both an Arduino board and an accelerometer. We visualize the patient's breathe cycle with an In-house software and establish a threshold based on its amplitude. We provide patients with a real-time breathe cycle visualization, so they can have a visual feedback mechanism in order to properly hold their breath when required.

Conclusion. We have developed an In-house DIBH system with all the functionalities required to implement this technique in our clinic. Building this system is really cheap and amounts to nearly 60 Euros.

Disclosure. There is no conflict of interest.

http://dx.doi.org/10.1016/j.ejmp.2016.07.125

PRACTICAL USE OF DYNALOGS ANALYSIS IN SEVEN LINACS IN IMRT AND VMAT TECHNIQUES OVER THAN 20 MONTHS

D. Pimparel [*], J. Lencart, J.A.M. Santos

Medical Physics Department, Portuguese Institute of Oncology, Porto, Portugal
Medical Physics, Radiobiology and Radiation Protection Group, Research Centre, Portuguese Institute of Oncology, Porto, Portugal
* Corresponding author.

Introduction. Dynalog files's (DLGf) analysis can provide important information about deviations from planned and actual movement (positioning and velocity) of the MLC, during an IMRT or VMAT treatment delivery. Pre-treatment verification (QA) allows the comparison of the calculated and delivered dose distributions. In case of failure, the treatment plan must be reviewed and possible sources of fault must be tracked.

Purpose. The aim of this study is to substantiate a possible correlation between MLC behavior (through the analysis of the DLGf using FractionCheck software) and the failure of the QA procedure.

Materials and methods. Data from IMRT and VMAT DLGf acquired from May 2014 to February 2016 in 7 linacs was statistical analyzed as a complementary data source for the QA procedures. The analyzed results were expressed in "Warning" and "Fail" accordingly to the tolerances in TG142 report. Other parameters were also analyzed by the software: RMS, Beam-On, 95P, MaxRMS, MaxLag and Gamma-function distribution. Results were reviewed considering several factors: gantry angle, MLC maintenance, day time, pathology's type, mechanical and dosimetric tests results and network upgrade.

Results. No correlation between Dynalog information and the results obtained from the QA measurements (VerySoft analysis) was verified. For an increase in the dose rate, the 95P's, MaxRMS's and RMS's (for each leaf) parameters worsen.

Conclusion. Although the information obtained from DLGf can be very useful in some particular situations, it does not predict the outcome of IMRT or VMAT QA procedures. MLC's performance does not depend on the treatment's pathology, gantry angle, or day time due to possible linac's overheating.

Disclosure. The authors have no relevant financial or non-financial relationships to disclose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.126

COMPARISON OF THREE DOSE CALCULATION METHODOLOGIES FOR 90-Y MICROSPHERES RADIOEMBOLIZATION

V. Antunes [a,b,*], J.A.M. Santos [a,b,c]

[a] *Medical Physics, Radiobiology and Radiation Protection Group, Research Centre, Portuguese Institute of Oncology, Rua Bernardino de Almeida, 4200-072 Porto, Portugal*
[b] *Medical Physics Department, Portuguese Institute of Oncology, Rua Bernardino de Almeida, 4200-072 Porto, Portugal*
[c] *Instituto de Ciências Biomédicas Abel Salazar da Universidade do Porto, Rua J Viterbo Ferreira 228, 4050-313 Porto, Portugal*
* Corresponding author.

Introduction. According to 2013/59/Euratom BSS, for all medical exposure of patients for radiotherapeutic purposes, including Nuclear Medicine, doses in target volumes shall be individually planned. Furthermore, doses to non-target volumes (e.g organs-at-risk) shall be as-low-as-reasonably-achievable and consistent with the intended radiotherapeutic purposes. For Y-90 microspheres radioembolization, three methods of activity calculation to be administered are usually used: empirical, body-surface-area (BSA) and partition methods.

Purpose. Accuracy and effectiveness of dose distribution calculation in the liver was compared using these three methods.

Materials and methods. A Tc-99m:MAA SPECT/CT image is used to predict microspheres distribution, possible gastro-intestinal implication and to estimate dose distribution after radioembolization. A 90-Y SPECT/CT image is acquired after the radioembolization and compared with the previous Tc-99m:MAA images. Dose calculation using the three methods and based in the 99m-Tc and 90-Y SPECT/CT images were systematically evaluated for 15 patients.

Results. Administered activities based on the three methods can show large variations for the same patient, leading to very different dose distributions (e.g. 70% in the tumor and healthy liver parenchyma). Different Tc-99m:MAA and Y-90 microspheres distribution also occur and is a major problem which can imply healthy liver parenchyma irradiation higher than the maximum dose recommendation (70 Gy).

Conclusion. Empirical and BSA methods are not suitable for a minimal acceptable accuracy of dose distribution calculation (10–20%). Although the partition model is the most accurate, different Tc-99m:MAA and Y-90 microspheres distribution leads also to large errors in the final dosimetry calculation. New approaches, such as the use of 99m-Tc labeled microspheres instead of Tc-99m:MAA, should be pursued.

Disclosure. The authors have no relevant financial or non-financial relationships to disclose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.127

DOSIMETRIC COMPARISON OF VOLUMETRIC MODULATED ARC THERAPY AND INTENSITY-MODULATED RADIOTHERAPY FOR BILATERAL HIP PROSTHESES PROSTATE CANCER PATIENT

Morera Daniel *, Marí Adrià

Hospital Universitario Son Espases, Palma de Mallorca, Spain
* Corresponding author.

Introduction. Volumetric Modulated Arc Therapy (VMAT) is a common technique for prostate cancer patients, due to the conformation of the dose distribution. The high atomic number of the hip prostheses, avoiding beam entry through the prostheses, makes this treatment complicated.

Purpose. Compare the dosimetric quality of intensity-modulated radiotherapy (IMRT) with VMAT for the treatment of prostate cancer in patients with bilateral hip prostheses.

Materials and methods. Plans for IMRT and VMAT were optimized, prescribing 78 Gy/39 fractions. First a soft-tissue density was overridden to the artifact CT areas, and both prostheses were contoured to avoid them during the treatment. Three IMRT treatment plans were proposed, 7-field, 9-field and 11-field, all optimized with constrained beam inverse planning, fixing jaws during the optimization. Two VMAT treatment plans were optimized with avoiding sectors (AS), one with large AS, and one with small AS, both VMAT plans were optimized with two arcs.

Results. IMRT technique has better dose distribution than VMAT technique. 11-field IMRT showed the best dose conformation, and in VMAT technique, small AS was the best solution. 11-field IMRT Homogeneity Index was 0.046 against 0.077 of the VMAT small AS. 11-field IMRT Rectum V50 was 28.50% versus 40.90% for VMAT small AS. UM and treatment had better results in VMAT technique. UM were significantly larger for IMRT, a 60.36% for 11-field IMRT compared with VMAT small AS.

Conclusion. 11-Field IMRT showed better conformation across PTV and lower rectal and bladder dose comparing to the other plans analyzed, despite of its larger treatment time and number of UM.

http://dx.doi.org/10.1016/j.ejmp.2016.07.128

HOW THE CHOICE OF BEAM ANGLES AFFECTS THE DOSIMETRY OF OARS IN IMRT OF THE PROSTATE

Spiridon V. Spirou

TEI Athens, Greece

Introduction. IMRT has been in clinical use for nearly 20 years, yet the issue of optimal beam directions remains open. Although there exist many beam angle optimization algorithms, none has established itself yet, nor is it clear how to assess the optimality of results.

Purpose. To investigate how the choice of beam angles in IMRT of the prostate affects the dosimetry of the rectum, bladder and the large bowel.

Methods and materials. Five patients, previously treated with a 5-beam IMRT plan to 86.4 Gy, were selected for this study. Candidate beams were defined every 20° in a 360° arc around the isocenter. Treatment plans were generated for each set of 5 beams taken out from the set of the candidate beams (total 8568 plans per patient). For each patient, all other constraints and parameters, except the beam angles, were kept fixed as in the clinical plan. All plans were normalized so that rectum Dmax was 99%. The dosimetric effect was assessed using D54, D87.5 and V47 for the rectum; Dmax, D54 and V47 for the bladder, and Dmax for the large bowel.

Results. All dosimetric indices varied between 2- and 3-fold. Subsequently, the best 5% of plans with respect to each index were analyzed (428 plans). Lateral beams were the most favored for every index. Secondly, anterior beams were favored for the rectum but not for the bladder or the large bowel.

Conclusion. The choice of beam directions may significantly affect the dosimetry of the rectum, bladder and large bowel.

http://dx.doi.org/10.1016/j.ejmp.2016.07.129

COMPARISON OF RADIATION DOSE IN ABDOMEN-PELVIS AND TRUNK IMAGING BETWEEN 64 SLICE AND 16 SLICE CT

Corina Mariana Pera [a,b,*], Olga Irina Girjoaba [c], Alexandra Cucu [d], Malaescu Iosif [a]

[a] *West University of Timisoara, Romania*
[b] *Emergency Hospital Resita, Romania*
[c] *Academica Medical Center, Romania*
[d] *National Institute of Public Health, Romania*
* Corresponding author.

Introduction. Development of CT techniques led to a rapid increase in the frequency of use of CT procedures, some of the most irradiating multiphase scanning clinical protocols being the abdomen-pelvis and trunk.

Purpose. The purpose of this study was to compare the radiation dose received by patients during abdomen-pelvis and trunk protocols, made using two CT equipments, one of 64 slices and one of 16 slices.

Materials and methods. Exposure parameters and patient data were collected for groups of 30 patients for every protocol and every CT equipment. Average values CTDIvol and DLP (dose-length product) were compared for the two units CT. DLP values were calculated also for each patient using ImpactDose software package.The effective doses were estimated for each patient using the model from the RP 154 publication, as well as using the ImpactDose software.

Results. For the abdomen-pelvis examinations, the average values for DLP and effective dose are substantially higher for 64-slice CT versus 16-slice CT, although the average CTDIvol is lower for 64-slice versus 16-slice. In the case of trunk examinations, the average CTDI is substantially lower for 64-slice CT versus 16-slice CT, the average values for DLP and effective dose having the same trend.

For 64-slice CT, comparing the value obtained for abdomen-pelvis with the value for trunk, we notice that DLP is lower for trunk, although the scanned length is higher, the reason being the values for CTDI much lower for trunk. For 16-slice CT, CDTI values are close for the two procedures, such that the DLP value for trunk is higher than for abdomen-pelvis.

Conclusion. The study shows the importance of optimizing multiphase scanning protocols, since they can lead to high levels of doses received by patients due the large numbers of examination sequences, although the CT equipments have values for CTDI and DLP per examination sequence below the baseline.

http://dx.doi.org/10.1016/j.ejmp.2016.07.130

COMPARATIVE BETWEEN IMRT AND 3D-CRT FOR UPPER GI MALIGNANCIES

A. Seguro Fernandez [a,*], A. Ureña Llinares [b], L. Diaz Gómez [c], M.A. Iborra Oquendo [b]

[a] *Medical Physics Department, Hospital Rey Juan Carlos, Móstoles, Spain*
[b] *Medical Physics Department, Hospital Universitario Puerta del Mar, Cádiz, Spain*
[c] *Radiotherapy Oncology Department, Hospital Universitario Puerta del Mar, Cádiz, Spain*
* Corresponding author.

Introduction. Adjuvant therapy after surgery in patients diagnosed with tumors of the upper abdominal area is a standard of care. In the field of radiotherapy is a challenge for proximity to PTV of multiple organs at risk (OARs) including spinal cord, liver, kidneys, lungs or heart.

Purpose. Our goal of this study is to demonstrate the benefit of intensity modulated radiotherapy (IMRT) over 3D conformal therapy (3D-CRT) on OAR protection and improvement in planning target volume (PTV) coverage.

Materials and methods. 11 patients were selected with upper digestive tract neoplasms with adjuvant treatment indication. The 3D-CRT technique involved two lateral fields and one or two oblique, with different table angles to avoid most volume of kidneys. IMRT technique involved several multi-field coplanar inverse planning. The prescription dose was 45 Gy in 25 fractions. Dose–volume histograms, dose homogeneity and dose to OAR were evaluated.

Results. Both techniques are adequate with good coverage in the V95 with no evident differences in PTV dose homogeneity. IMRT was superior to 3DCRT with improvements in reducing the volume of both kidneys in the low dose region (V15) and liver as well (V30), achieving a lower spinal cord maximum dose. This can be explained by more number of the beams used in the IMRT technique. However, there were no significant improvements in PTV coverage.

Conclusion. IMRT is a recommended technique for better protection of organs at risk without improving PTV coverages for upper GI malignancies.

No conflict of interest.

http://dx.doi.org/10.1016/j.ejmp.2016.07.131

RADIATION DOSES RECEIVED BY PATIENTS IN DIGITAL MAMMOGRAPHY: A FIRST INVESTIGATION IN MOROCCO

Soumaya Boujemaa [a], Hilde Bosmans [b], Farida Bentayeb [a]

[a] *Faculty of Sciences, University Mohammed V, Rabat, Morocco*
[b] *Medical Imaging Research Center, Department of Radiology, University Hospitals Leuven Herestraat 49, B 3000 Leuven, Belgium*

Introduction and objective. Digital mammography is being introduced worldwide for breast cancer diagnosis and screening. While the technique is known to offer a good image quality–dose balance, its introduction in specific regions should be investigated. Present study focuses on the absorbed radiation dose, and more in particular on estimations of average glandular dose (AGD).The present work concerns a dosimetric study in digital mammography in Morocco.

Materials and methods. A dosimetric study was conducted in a Moroccan university hospital with system full-field digital mammography, Siemens Mammomat Inspiration. The average glandular dose of about hundred patients was calculated taking into account the entrance dose (tube output), half value layer and thickness of the compressed breast. Dose values were calculated with PMMA phantoms.

Results. The results showed that almost values were located below the achievable dose limit curve of the European Guidelines. For average thickness of 55 mm, the AGD is about 1.24 mGy for the Clinical–Caudal (CC) view and 1.32 mGy for the Mediolateral–Oblique (MLO) view with the same SD = 0.3. The results show also that the mean patients AGD is about 30% lower than that given by the PMMA.

Conclusion. The results show an increase in the average glandular dose as a function of breast thickness. Average and maximal doses are in line with values obtained in European studies.

This study will now be performed in more Moroccan hospitals and the data obtained could be used to work at breast cancer screening in our country.

http://dx.doi.org/10.1016/j.ejmp.2016.07.132

BETATRON WITH VARIABLE ENERGY FOR IORT

Evgeniia Sukhikh [a,b,*], Leonid Sukhikh [b], Evgeniy Malikov [b]

[a] *Tomsk Regional Oncology Center, Lenin Ave., 115, Tomsk 634050, Russia*
[b] *National Research Tomsk Polytechnic University, Lenin Ave., 30, Tomsk 634050, Russia*
* Corresponding author.

Introduction. Since 2014 years in Tomsk Polytechnic University a new generation of betatrons for intraoperative radiation therapy (IORT) has been developing which has typical diameter approx. 70 cm at 6 MeV energy. The main advantages of the betatrons are that they operate at large frequency (400 Hz) at rather low pulse current, they have low energy spread and the relatively low cost of a device (typically $200,000).

Purpose. The purpose of the project is to develop and test the compact betatron with adjustable energy of the extracted electron beam.

Materials and methods. The depth dose distribution was measured along axis using plane-parallel Marcus ionization chamber and Gafchromic EBT-3 polymer film. Dosimetry was carried out following TG-51 and TRS-398 international protocols. The polymer films were calibrated using 10 MeV electron beam of Electa Axcess accelerator and 6 MeV electron beam of previous generation IORT betatron with constant energy. All measurements were performed in tissue-equivalent phantom with zero air gap.

Results. The investigation of 3D dose distributions generated by new type of IORT source based on betatron was carried out in the energy range 2–6 MeV with 500 keV steps. In addition the radiation background distribution near the betatron was measured and it would be used for design of biological protection.

Conclusion. According to the measured data it was proved that the extracted electron beam has designed energy that could be changed. The dose distributions allow assume that the compact IORT source based on betatron could be developed in the nearest future.

http://dx.doi.org/10.1016/j.ejmp.2016.07.133

INVESTIGATION OF DEPTH DOSE DISTRIBUTION FROM ELECTRON BEAM AT SHALLOW DEPTH BY MEANS OF GAFCHROMIC EBT3 POLYMER FILMS AND IONIZATION CHAMBER

Leonid Sukhikh [a,*], Evgeniia Sukhikh [b,a], Valentina Babicheva [a], Evgeniy Malikov [a]

[a] *National Research Tomsk Polytechnic University, Lenin Ave., 30, Tomsk 634050, Russia*
[b] *State Regional Autonomic Healthcare Institution "Tomsk Regional Oncology Center", Lenin Ave., 115, Tomsk 634050, Russia*
* Corresponding author.

Introduction. Radiochromic film Gafchromic EBT3 can be used in the geometry when it is parallel to the beam axis allowing obtain absorbed dose depth distribution in a phantom during "single shot" of an accelerator. This method is useful for characterization of the electron beams of intraoperative accelerators because for this modality one needs a precise knowledge of the dose depth distribution starting from the phantom surface.

Purpose. The purpose of this work is to compare experimentally and in simulation depth dose curves obtained using Gafchromic EBT3 film and ionization chamber.

Materials and methods. The experimental comparison of the depth dose curves was carried out using 6 and 9 MeV electron beams of Elekta Synergy accelerator and 6 MeV electron beam of intraoperative therapy betatron. The dose distributions were measured by ionization chambers and by Gafchromic EBT3 films in different phantoms.

The Monte-Carlo simulation of the process was carried out using PCLab software developed at Tomsk Polytechnic University that allows simulation of the beam interaction with the matter.

Results. Experimental results show that percentage depth dose measured by the film at the shallow depths is less than the one measured by ionization chamber. Simulation results show the same difference. The simulation also shows that depth dose distribution "measured" by the film is close to the one in the pure water.

Conclusion. Results show that depth dose distribution from electron beam in water measured by radiochromic film is more precise at shallow depths than the one measured by ionization chamber.

http://dx.doi.org/10.1016/j.ejmp.2016.07.134

DOES INTRAVOXEL INCOHERENT MOTION (IVIM) INTRODUCE A NEW BIOMARKER IN MRI?

A. Karapanagos, E. Karavasilis *, P.E. Efstathopoulos, L.S. Poulou, A. Athanasakos, G. Velonakis, G. Argiropoulos, P. Toulas, A. Passalis, C. Lioulios, L.N. Kelekis

Second Department of Radiology, University General Hospital 'Attikon', School of Medicine, National and Kapodistrian University of Athens, Athens, Greece

* Corresponding author.

Introduction. Intravoxel Incoherent Motion (IVIM) imaging is a method that provides quantitative assessment all of the microscopic translational motions that could contribute to the signal acquired with diffusion weighted imaging (DWI) in MRI. The fundamental idea was that the molecular motion of water is randomly oriented in the capillary network at ultralow b values of diffusion imaging, mimicking a random walk. Diffusion parameters derived from IVIM model – perfusion F, true-ADC (D_{slow}), pseudo-ADC (D_{fast}) – have roused the researcher's interest.

Purpose. The aim of this study is to quantify the IVIM model diffusion parameters in patients with brain lesions compared to the normal appearing symmetric regions of the brain.

Materials and methods. Patients underwent DWI on a 3T MRI system using an 8-channel sense head coil. DWI was performed with axial single-shot spin echo planar imaging (EPI) sequence with 10b values (0, 10, 15, 50, 80, 100, 200, 400, 700, 1000 s/mm^2). The IVIM model diffusion parameters of D_{slow}, D_{fast} and F were calculated using a biexponential curve fitting model based on Levenberg–Marquardt algorithm applied in an in-house platform in Matlab. The statistical analysis between contra lateral regions was based on Student's t tests.

Results. Perfusion fraction F measured in brain damage regions showed significantly increased values compared to normal appearing symmetric regions. Parameters D_{slow} and D_{fast} had no statistical significance.

Conclusion. The F parameter may consist a new sensitive biomarker for providing additional information to conventional diffusion parameters and predicting preliminary brain damage.

http://dx.doi.org/10.1016/j.ejmp.2016.07.135

USEFULNESS OF DIFFERENT DTI PARAMETERS IN IDENTIFYING NEURODEGENERATIVE PROCESS: EVIDENCE FROM AMYOTROPHIC LATERAL SCLEROSIS

E. Karavasilis [a,*], F. Christidi [b], P. Toulas [a], P.E. Efstathopoulos [a], M. Rentzos [b], V. Zouvelou [b], S. Xirou [b], I. Evdokimidis [b], L.N. Kelekis [a]

[a] *Second Department of Radiology, University General Hospital 'Attikon', School of Medicine, National and Kapodistrian University of Athens, Athens, Greece*

[b] *First Department of Neurology, Aeginition Hospital, Medical School, National and Kapodistrian University, Athens, Greece*

* Corresponding author.

Introduction. Diffusion Tensor Imaging (DTI) reveals in vivo abnormalities in white matter (WM) fiber structure and has improved our knowledge of disease pathophysiology in several central nervous system (CNS) pathologies with WM involvement, especially through the analysis of different DTI indices.

Purpose. To investigate the sensitivity of DTI parameters using tract based spatial statistics (TBSS) in amyotrophic lateral sclerosis (ALS), as a CNS disease with predominant WM involvement.

Material and methods. We included 58 participants (36 patients with ALS and 22 healthy controls). All of them were scanned on 3.0T MR system, with 30-directional DTI and 3D-T1-weighted anatomical sequences. Whole-brain WM analysis was conducted using FSL and TBSS to estimate fractional anisotropy (FA), axial diffusivity (Ad) and radial diffusivity (Rd). Voxelwise statistical analysis was performed via a permutation-based inference for nonparametric statistical thresholding (5000 permutations). Two sample *t*-tests were applied to evaluate local alterations in DTI parameters ($p < 0.05$ with family-wise error correction for multiple comparisons).

Results. In ALS patients we observed significant decreased FA and increased Rd ($p < 0.05$) in several WM areas (right > left), including corticospinal tract (CST), body of the corpus callosum and superior longitudinal fasciculus. Rd changes were more diffuse and found along the CST axis (WM of precentral gyrus, corona radiata, internal capsule). No changes were detected for Ad ($p > 0.05$).

Conclusion. Decomposing the commonly used DTI parameters (FA and Mean Diffusivity) into Ad and Rd may be useful in identifying widespread WM changes in ALS and proved as a potential sensitive index for CNS neurodegenerative process.

Disclosure. F.C. acknowledges support from the IKY Fellowships of Excellence for Postgraduate Studies in Greece – Siemens Program. We also acknowledge the Philips Medical System for providing all necessary research keys for MR/DTI sequence acquisition. The funders and/or contributors had no role in study design, data collection and analysis or preparation of the abstract. Finally, we would like to thank the patients with ALS and their families, as well as healthy volunteers for their willingness to participate to the present study.

http://dx.doi.org/10.1016/j.ejmp.2016.07.136

PATIENT RADIATION DOSE DURING ATRIAL SEPTAL DEFECT OCCLUDER

N. Kollaros [b,*], V. Tsapaki [a], A. Salametis [b], A. Tsoutsinos [b], C. Plemmenos [b], I. Mastorakou [b], S.C. Apostolopoulou [b]

[a] *Konstantopoulio General Hospital, Athens, Greece*
[b] *Onassis Cardiac Surgery Center, Greece*
* Corresponding author.

Introduction. Atrial septal defect (ASD) is an abnormal opening in the wall between the two atrias of the heart. A catheter-based treatment in a heamodynamic room is a well established procedure. International literature has extremely limited data on related radiation dose levels.

Purpose. To determine radiation dose (RD) fluoroscopy time (FT) and Number of images (I) in ASD treatment in both paediatric and adult patients in a major cardiosurgery center in Greece.

Materials and methods. A sample of 161 patients were included in the study, divided in the following age categories: (1) 5–10 y, (2) 10–15 y, (3) 15–18;y and (4) >18 y. The X-ray machine used was a Siemens Artis Zee digital flat panel system. Various clinical (weight, body mass index, (BMI), etc.) and radiation related data (Kerma Area Product (KAP), fluoroscopy time (T) and number of images (F)) were recorded.

Results. Median W (kg), BMI (kg/m^2), KAP (Gycm^2), T (min) and F for the 4 weight categories were: (1) 25, 15.5, 5.8, 6.6 and 639, (2) 50, 21.5, 9.3, 4.6 and 409 (3) 58.5, 21.2, 11.6, 5.7 and 575 and finally (4) 58.0, 19.5, 5.8, 3.2 and 639. The correlation of various factors with KAP was investigated. Apart from fluoroscopy time there was no other factor that significantly correlated with radiation dose.

Conclusion. This study presents age-stratified radiation data for ASD occluder heart catheterizations. Fluoroscopy time or number of images are not adequate measures for monitoring radiation exposure. These values will be used as baseline for our future research on the subject.

http://dx.doi.org/10.1016/j.ejmp.2016.07.137

DOSE COMPARISON OF TWO IMAGING TECHNIQUES FOR THE DETECTION OF MYELOMA LESIONS

P. Tsionopoulou [a,b,*], S. Kordolaimi [b], T. Athanasakos [b], N. Sideri [b], O. Papakonstantinou [b], G. Sakellaropoulos [a,b], G. Nikiforidis [a,b], E. Efstathopoulos [b]

[a] *Department of Medical Physics, School of Medicine, University of Patras, Greece*
[b] *2nd Department of Radiology, University General Hospital 'Attikon', School of Medicine, National and Kapodistrian University of Athens, Athens, Greece*
* Corresponding author.

Introduction. Multiple myeloma (MM) is a hematological malignancy, theactivity of which is not clear yet. Skeletal survey and computed tomography are two commonly used imaging techniques for the detection of myeloma lesions.

Purpose. The aim of this study is to compare the effective doses received by patients suspected for MM who were simultaneously evaluated with radiographs and whole body CT (WBCT) scan.

Materials and methods. Patients underwent a conventional radiography (CR) and a computed tomography (CT). Concerning CR, seventeen views of human body were obtained for 10 patients and the effective dose (ED) was then estimatedutilizing the dose area product (DAP)-to-ED conversion coefficients reported in NRPB-R262 (whole body except for extremities) and NRPB-W4 (for extremities). Forthe CT examinations, the acquisition and dosimetric data of 53 patients undergone WBCT either withfiltered back-projection (FBP) or iterative reconstruction (iDose, Philips) algorithm were retrospectively recorded and ED was estimated by utilizing sex- and age- specific DLP-to-ED conversion factors available in literature.

Results. The ED of the patients underwent WBCT were2.33 ± 1.14 mSv and 7.06 ± 6.16 mSv for iDoseand FBP protocols, respectively while the corresponding ED from the CR procedures were 2.12 ± 0.80 mSv.

Conclusion. Low radiation exposure, almost equal to that of CR, can be achieved with the CT scan when iterative reconstruction algorithm is implemented in the acquisition data.

http://dx.doi.org/10.1016/j.ejmp.2016.07.138

EXPERIMENTAL DETERMINATION OF THE EPITHERMAL NEUTRON SENSITIVITY OF A NEW IONIZATION CHAMBER

H. Sato [a,*], E. Nakajima [a], R. Gotanda [a], S. Endo [b], M. Suda [c], T. Hamano [c], M. Hoshi [b]

[a] *Department of Radiological Sciences, Ibaraki Prefectural University of Health Sciences, Ibaraki 300-0394, Japan*
[b] *Research Institute for Radiation Biology and Medicine, Hiroshima University, Kasumi 1-2-3, Minami-ku, 734 Hiroshima, Japan*
[c] *Research Center for Radiation Emergency Medicine, National Institute of Radiological Sciences, 4-9-1 Anagawa, Inage, Chiba 263-8555, Japan*
* Corresponding author.

Introduction. The resulting improvement in the accuracy of the determination of the dose from gamma rays and epithermal and fast neutrons is important in view of the required accuracy for dosimetry in accelerator based neuron sources.

Purpose. A new ionization chamber detector is being developed for the epithermal neutron dosimetry at accelerator based neuron sources. To obtain a high accuracy in the dosimetry of an epithermal neutron beam used for boron–neutron capture therapy (BNCT), the neutron sensitivity of dosimeters applied to determine the various dose components in polyethylene phantom has been investigated.

Materials and methods. Well-stabilized neutron filed of Neutron exposure Accelerator System for Biological Effect Experiments (NASBEE) in National Institute of Radiological Sciences (NIRS) was used in this study. The epithermal neutron sensitivity LBO ionization chamber, tissue equivalent ionization chamber, and optically stimulated luminescence (OSL) dosimeters has been experimentally determined in a neutron beam fields.

Results. The epithermal neutron values much higher than theoretically expected were obtained and a variation up to a factor of 1.8 was found between values for the epithermal neutron sensitivity. The ratio of a gamma dose and a thermal neutron dose was 23% in a depth of 30 mm.

Conclusion. The new epithermal ionization chamber response characteristic was evaluated at the accelerator based neutron sources field.

Disclosure. This work was supported by JSPS Kakenhi Grant Number 15K00544.

http://dx.doi.org/10.1016/j.ejmp.2016.07.139

VERIFICATION "AUTO FIELD ALIGNMENT" TREATMENT PLANNING TOOL BY USING "IN VIVO" DOSIMETRY IN BREAST AND SUPRACLAVICULAR MATCHING REGION

Maria Dilvoi *, Ioannis Kagkiouzis, George Patatoukas, Kalliopi Platoni, Efrosini Kypraiou, Adromachi Kougioumtzopoulou, Nikos Trogkanis, Efstathios Efstathopoulos, Vassilis Kouloulias

2nd Department of Radiology, University General Hospital 'Attikon', School of Medicine, National and Kapodistrian University of Athens, Athens, Greece

* Corresponding author.

Introduction. Accurate multiple field alignment is of vital importance in irradiating breast cancer patients with positive supraclavicular lymph nodes.

Purpose. The purpose of the current study is to present a series of dosimetric measurements using LiF TLDs that took place in our radiation therapy department in order to verify that the ideal match designed "in silico" using the auto field alignment tool (TPS Eclipse version 13, Varian), is delivered accurately "in vivo", in breast cancer patients with positive supraclavicular lymph nodes.

Materials and methods. Ten patients were selected and auto field matching was applied. In vivo TLD dosimetry was performed along the interception axis and dose was compared to the one derived by the TPS.

Results. Measured and expected doses in breast and supraclavicular isocenter do not differ statically ($p = 0.4410$, $p = 1.0000$, respectively). The difference between measured and expected doses does not exceed 5%. Moreover, measured and expected doses in junction region do differ statically ($p = 0.0214$). In this region, large deviations occurred (−15% to 10%).

Conclusion. Results showed significant deviation between measured and expected doses in a non-systematic way indicating that junction region is sensitive to minor random errors such as patient movement. Use of monoisocentric technique could minimize these errors and improve dosimetric results in junction region.

http://dx.doi.org/10.1016/j.ejmp.2016.07.140

EXTRACTING DICOM METADATA FROM PACS RECURSIVELY OVER LOCAL NETWORK

Dimitris Papamichail [a,*], Agapi Ploussi [b], Sofia Kordolaimi [b], Ioannis Saradeas [b], Nikolaos L. Kelekis [b], Efstathios P. Efstathopoulos [b]

[a] *1st Department of Radiology, Medical School, National and Kapodistrian University of Athens, Vas. Sofias 76, Athens 11528, Greece*
[b] *2nd Department of Radiology, University General Hospital 'Attikon', School of Medicine, National and Kapodistrian University of Athens, Athens, Greece*

* Corresponding author.

Introduction. Explosive growth in the number of biomedical images in recent years requires new techniques to manage the information collected. Picture archiving and communication systems (PACS) can address the image data management issue, but PACS generally lack any methods for searching images and querying the metadata based on Database Management System (DBMS) records.

Purpose. The objective of this study is to develop an automated method to address the problem of requiring DICOM metadata from PACS over local network.

Materials and Methods. Algorithms have been developed in JAVA to query the specified DICOM files from the PACS server and extract all metadata. The application allows users to query the metadata of a specific group of patients. The extracted information is automatically formatted and presented to the authorized end user as a Microsoft Excel file for data and further trend analysis. This project has placed increasing emphasis on the security aspect of patient's personal data by encrypting the data over network transmission.

Results. A client application has been designed to make requests to the database of the remote server. The integrity and time efficacy of the method has been evaluated with a test sample of 171 DICOM files, while the accuracy of the data has been manually validated.

Conclusion. We believe that we have created a useful and time efficient tool for extracting the image metadata from PACS using a remote computer within local network. The simplicity and the compatibility of the application allows any untrained user to exploit this new technology.

Disclosure. None.

http://dx.doi.org/10.1016/j.ejmp.2016.07.141

DETAILED MICROARCHITECTURE ANALYSIS OF BREAST TUMORS USING DIFFUSION TENSOR IMAGING

M. Bakosis [a], M. Vlychou [b], A. Poultsidi [c], C. Kappas [a], K. Theodorou [a], I. Fezoulidis [b], K. Vassiou [b,d], I. Tsougos [a,*]

[a] *Medical Physics Department, Medical School, University of Thessaly, Biopolis, Larisa, Greece*
[b] *Radiology Department, Medical School, University of Thessaly, Biopolis, Larisa, Greece*
[c] *Surgery Department, Medical School, University of Thessaly, Biopolis, Larisa, Greece*
[d] *Department of Anatomy, Medical School, University of Thessaly, Biopolis, Larisa, Greece*

* Corresponding author.

Introduction. Conventional breast MRI has shown high diagnostic sensitivities for the detection of breast cancer, whereas relatively low specificities have been reported, resulting in many unnecessary biopsies of benign lesions.

Purpose. The main purpose of this study was to investigate whether diffusion measures of anisotropy (DWI & DTI) can improve the discrimination between benign and malignant lesions. Moreover, using detailed DTI microstructure analysis, we sought to investigate the contribution of the architecture of breast fibroglandular tissue in the differential diagnosis of malignancy.

Methods and materials. The study included 58 women with a total of 86 breast lesions. DTI and DWI were performed complementary to dynamic contrast MRI. Apparent diffusion coefficient (ADC), mean diffusivity (MD) and fractional anisotropy (FA) were measured for lesions and contralateral breast parenchyma of each patient. All values were compared between malignant, benign lesions and the normal parenchyma by univariate and multivariate analyses.

Results. The FA values showed high variation and hence moderate statistical significance. Nevertheless the analysis of DTI vector maps and parametric maps, revealed significantly lower values of the tumor's orthogonal diffusion coefficients $\lambda 1$, $\lambda 2$, $\lambda 3$ comparing to normal breast and benign tissue. Despite the significant overlap the FA values of malignant tissue were significantly higher than normal and benign tissue ($p = 0.002$). ROC curve analysis was also performed for every discrimination factor studied.

Conclusion. ADC measures have accurate discrimination ability in all cases. Careful microstructural analysis revealed significantly lower values of the tumor's prime diffusion coefficient $\lambda 1$, and may be used as a potential indicator.

http://dx.doi.org/10.1016/j.ejmp.2016.07.142

HIPPOCAMPAL ANALYSIS, USING DIFFUSION TENSOR IMAGING (DTI) AND SURFACE BASED ANALYSIS (SBA), TO ASSIST IN TEMPORAL LOBE EPILEPSY (TLE) RESEARCH. PRELIMINARY RESULTS

D. Tsivaka [a,c], E. Kapsalaki [b,c], K. Fountas [b,c], K. Theodorou [a,c], I. Fezoulidis [b,c], I. Tsougos [a,c,*]

[a] *Medical Physics Department, Medical School, University of Thessaly, Biopolis, Larisa, Greece*
[b] *Radiology Department, Medical School, University of Thessaly, Biopolis, Larisa, Greece*
[c] *Neurosurgery Department, Medical School, University of Thessaly, Biopolis, Larisa, Greece*
* Corresponding author.

Introduction. Epilepsy is the fourth most common, serious neurological disorder. Especially in Drug-Resistant Epilepsy (DRE), which is mostly treated with surgical intervention, the detection of a structural brain lesion is of paramount importance for the pre-surgical workup to identify the seizure focus.

Purpose. In this study we sought to investigate the contribution of advanced MRI techniques, combined with Surface-Based Analysis (SBA) to the exploration of epilepsy underlying pathophysiology.

Methods and materials. MRI, DTI and Spectroscopy (MRS) were acquired from a group of 35 young healthy adults (19-years old) and five young patients (19–25 years old) with TLE, using a 3T scanner. Hippocampal volumes were measured on high resolution T1-weighted MRI using the FreeSurfer software package which is based on SBA. Furthermore the DTI eigenvalues λ_1, λ_2, λ_3, Fractional Anisotropy (FA) and Mean Diffusivity measurements were performed from two different software packages, Functool GE Healthcare and ExploreDTI.

Results. Hippocampal volume reduction is detected by automated segmentation via FreeSurfer in patients with TLE compared to the hippocampal volume measurements of the healthy adults. Using extracted data for hippocampal volume, Mean Diffusivity, FA, DTI eigenvalues and MRS, from the group of healthy volunteers, we generated a normative database in order to facilitate potential differentiation between physiological and pathological hippocampus.

Conclusion. In conclusion, our initial results indicate a strong contribution of advanced MRI combined with SBA towards the optimization of TLE diagnosis.

http://dx.doi.org/10.1016/j.ejmp.2016.07.143

GAMMA INDEX VARIATION IN THE VERIFICATION OF STEP & SHOOT IMRT

Paschalis Theodoros *, Patatoukas Georgios, Silivridou Katerina, Spyrakos Michalis, Armpilia Christina

Medical Physics Unit, Radiotherapy Department, Athens Medical Center, Greece
* Corresponding author.

Introduction. IMRT plan verification is one of the most important parameters in the modern radiotherapy chain in order to achieve high quality and reproducible treatment delivery.

Purpose. The purpose of this study is to present a detailed analysis of the variation of gamma index (γ-index), which is used as a primary quantitative parameter in IMRT plan verification.

Materials and methods. We retrospectively considered 60 Prostate and 30 Head and Neck (H&N) step and shoot IMRT cases treated in our department. All plans were created on the Oncentra v4.5 TPS (Elekta, Sweden), using 5–7–9 beams, maximum 10 segments/beam and minimum 4 cm^2 segments. Plan verification was implemented using the ArcCheck phantom (SunNuclear, FL, USA). γ-index was calculated at 3%–3 mm and at 2%–2 mm using a 10% threshold value with and without global correction.

Results. γ-Index (3%/3 mm, global) for Prostate and H&N was 97.1 ± 1.7 and 97 ± 2.1 respectively, γ-index was 9% less when not using global corection factor. 1 mm *y*-shift variation occurred in 70% of verification plans, while *x*-shift was negligible. Correcting for *y*-shift, γ-index was 0.4% and 0.9% higher for prostate and H&N respectively. γ-index variation showed no dependance upon the number of beams used.

Conclusion. Arccheck is an efficient QA tool for individual patient verification, exhibiting γ-index >97% and high reproducibility of results. Further work is done to correlate γ-index values with ROI specific passing rates, as estimated by the 3DVH software analysis.

http://dx.doi.org/10.1016/j.ejmp.2016.07.144

RADIATION DOSE COMPARISON IN BRAIN CT EXAMINATIONS AMONG 3 PUBLIC HOSPITALS

Sofia Kordolaimi [a,*], Agapi Ploussi [a], Vassileios Syrgiamiotis [b], Triantafillia Makri [b], Christiana Hatzigiorgi [b], Nikolaos Evlogias [c], Athanasia Stratigopoulou [c], Efstathios Efstathopoulos [a]

[a] *2nd Department of Radiology, University General Hospital 'Attikon', School of Medicine, National and Kapodistrian University of Athens, Athens, Greece*
[b] *MRI-CT Medical Imaging Department, General Childrens' Hospital of Athens Ag. Sophia, Greece*
[c] *Department of Radiology, General Children's Hospital, Palea Penteli, Greece*
* Corresponding author.

Introduction. The higher risk from radiation and the longer life expectancy of children render the estimation of the radiation dose a vital need especially for common radiation-induced procedures like Brain CT. However, effective doses from pediatric Brain CT procedures are scarce in literature.

Purpose. The aim of this presentation is to estimate effective doses for pediatric Brain CT examinations performed in 2 public pediatric hospitals and 1 public general hospital.

Materials and methods. For that purpose, 160 patients from pediatric hospital 1 (PH1), 130 patients from pediatric hospital 2 (PH2), and 16 patients from general hospital (GH) underwent Brain CT examinations by utilizing age-adjusted scanning protocols was retrospectively reviewed. Acquisition and dosimetric data were extracted from the DICOM header. Age- specific DLP to effective dose conversion coefficients, according to ICRP 103, were applied to console-displayed DLP data.

Results. The effective doses for the age categories of 0–1 y, 1–5 y, 5–10 y and 10–15 y were 3.6 ± 1.3 mSv, 3.9 ± 1.6 mSv, 2.9 ± 1.4 mSv, and 2.8 ± 1.1 mSv for PH1, no data for 0–1 y, 2.4 ± 1.4 mSv, 2.3 ± 0.9 mSv, and 2.2 ± 0.8 mSv for PH2 and 3.6 ± 1.3 mSv, 2.5 ± 1.3 mSv, 1.3 ± 0.8, and 1.7 ± 1.0 mSv for PH, respectively.

Conclusion. Although CT protocols varied in terms of acquisition parameters and scanning mode, this variety is not depicted in the effective doses which are comparable among the various hospitals for the same age group. Either way, thorough optimization of CT scanning protocols is vital in each and every hospital that treats pediatric patients.

http://dx.doi.org/10.1016/j.ejmp.2016.07.145

DOSIMETRIC EVALUATION OF MONTE CARLO BASED TREATMENT PLANNING SYSTEM IN ANTORPHOMORPIC PHANTOM

Đeni Smilović Radojčić [a], David Rajlić [a], Manda Švabić Kolacio [a], Dario Faj [b], Slaven Jurković [a,c,*]

[a] *University Hospital Rijeka, Medical Physics Department, Krešimirova 42, Rijeka, Croatia*
[b] *Faculty of Medicine, University of Osijek, J. Huttlera 4, 31000 Osijek, Croatia*
[c] *Department of Physics, Faculty of Medicine, University of Rijeka, Braće Branchetta 20, 51000 Rijeka, Croatia*
* Corresponding author.

Introduction. Implementation of advanced radiotherapy techniques makes high demands on the treatment planning system (TPS).

Purpose. Dosimetric evaluation of calculation algorithm built in Monte Carlo (MC) based TPS.

Materials and methods. Dose distributions of different complexity were calculated using Elekta Monaco TPS. Both calculation methods (Dose to Water-D2W and Dose to Medium-D2M) for 6MV photon beam were verified using 2D detector and ionization chambers of different volumes in inhomogenous phantom.

Results. Comparison of measured and calculated data in point of 'tissue' and low density medium show good agreement regardless the calculation method. In high density medium deviation was much higher. Also, deviations of measured and values calculated as D2W and D2M, respectively, were larger and of opposite signs. To overcome this we propose to define minimum volume of water cylinder to be placed within high density medium. This volume should allow that D2W and D2M calculated doses differ less than 0.5% and consequently good agreement with measurements. Furthermore, 2D methodology used for patient specific dosimetry was used to evaluate TPS accuracy, but antrophomorphic thorax phantom was used instead of the homogeneous one. Anlayze shows that gamma criterion 3% or 3mm was not fulfilled when inhogeneities are inside treated volume.

Conclusion. MC TPS evaluation using point dose measurements show large uncertainties within high density medium. It can be overcome by using proposed approach. Also, despite the manufacturer's claim of 2D verification superiority over point measurements, our investigation shows otherwise when measurements in inhomogeneous phantom are considered.

http://dx.doi.org/10.1016/j.ejmp.2016.07.146

WHICH IMPACT OF TUMOR DENSITY VARIATIONS ON ABSORBED DOSE IN EXTERNAL RADIOTHERAPY

Sara Beilla [a,*], Nicolas Chauveau [b], Anne Laprie [b,c], Manuel Bardiès [a], Xavier Franceries [a]

[a] *Université Toulouse III-Paul Sabatier, UMR1037 CRCT, F-31000 Toulouse, France*
[b] *Toulouse NeuroImaging Center, Université de Toulouse, Inserm, UPS, France*
[c] *IUCT-Oncopole, Medical Physics Department, F-31000 Toulouse, France*
* Corresponding author.

Introduction. Dosimetry in external radiotherapy is based on tomodensitometry images that are required to be previously calibrated and assume that the electron density is comparable to the mass density. In Magnetic Resonance Imaging, and in particular diffusion sequence, significant heterogeneities have been shown. These heterogeneities result in density variations within the tumor, e.g. glioblastomas.

Purpose. The aim of this study is to evaluate slight influence of mass density variations within the tumor via a dosimetric study. This can then be used to quantify the impact of those variations on modifications of dose 3D distribution.

Materials and methods. This study is devoted to dosimetric calculations realization using TPS Eclipse AAA used in clinical. Treatments were carried out with 5 X-ray beams of 6 MeV, in optimized dynamic Intensity-Modulated-Radiotherapy. Mass density changes of GTV for the same treatment plans have been tested from 1.04 (default tumor density) to 1.8 $g.cm^{-3}$ in steps of 0.1.

Results. Dose-volume-histograms and profiles studies show a slight dose increase in surface GTV for the highest densities with significant changes isodose curves. Conversely, upon leaving the GTV, an under dosage of the tumor has been observed from a density variation from 1.04 to 1.2 $g\,cm^{-3}$. It was noted that density differences of 0.5 and 0.8 $g\,cm^{-3}$ caused failure to respect the prescribed dose limits of ±3% in brain volumes of 1.5 and 25 cm^3, respectively.

Conclusion. Dose distributions variations were recorded by densities changes. From a change of 0.5 g/cm^3 within the tumor, dose prescriptions limits are not any more guarantees.

http://dx.doi.org/10.1016/j.ejmp.2016.07.147

PHOTON AND ELECTRON BEAM PENUMBRA DETERMINATION USING DIFFERENT MEASURING SYSTEMS

Pantelis Kalavrezos [a,b,*], Kalliopi Platoni [a], George Patatoukas [a], Maria Dilvoi [a], Elena Vlastou [a], Vasileios Kouloulias [a], Efstathios Efstathopoulos [a], Ioannis Seimenis [b]

[a] *2nd Department of Radiology, University General Hospital 'Attikon', School of Medicine, National and Kapodistrian University of Athens, Athens, Greece*
[b] *Medical School, Demokritus University of Thrace, Alexandroupolis, Greece*
* Corresponding author.

Introduction. The penumbra region is an intrinsic characteristic of any beam, weather photon or electron. Therefore, its correct determination constitutes a vital part in the dosimetric chain of a modern radiation therapy department.

Purpose. The purpose of this study is to compare and analyze results concerning the penumbra size determination obtained using six different measuring systems.

Materials and methods. Penumbra measurements were performed for two photon beams (6, 15 MV) for 4×4, 10×10 and 25×25 cm^2 square field sizes and for five electron beams (6, 9, 12, 16, 20 MeV) using a 10×10 cm^2 applicator at several depths. Six different measuring systems were used: (a) a Semiflex, (b) a Markus, (c) a Roos ionisation chamber, (d) a one dimensional Linnear Array (LA48, PTW), (e) a p-type diode (PTW 60008) and (f) an e-type diode (PTW 60017). All measurements were taken with standard water phantom geometry (MP3, PTW) using water as medium.

Results. Our results indicate that penumbra size determination is strongly dependant on the measuring system. More specifically, the diodes showed the narrowest penumbras followed by the LA48, while the largest penumbras were presented by the ionisation chambers. In terms of effectiveness, the LA48 method showed significant lower beam-on time.

Conclusion. Regarding penumbra size determination, the LA48 method is acceptable in terms of accuracy, and it is associated with considerable time-saving compared to other measuring systems. When the greatest possible accuracy is required, the use of silicon diode dosimeters is recommended.

http://dx.doi.org/10.1016/j.ejmp.2016.07.148

LINAC BEAM DATA MEASUREMENT USING A DETECTOR ARRAY

P. Birmpakos *, K. Kourinou, P. Georgolopoulou, I. Tsalafoutas

Medical Physics Department, "St. Savvas" General Anticancer Oncologic Hospital of Athens, Greece

* Corresponding author.

Introduction. As new treatment advances are implemented in a radiotherapy department, the QA workload increases requiring more resources. Unplanned maintenance work in the middle of the daily linac schedule also demands quick methods to check beam parameters without sacrifices in the quality of measurements. New measurement modalities that can simplify procedures are thus of great value.

Purpose. To investigate the reliability of a detector array when beam adjustments are carried out by the linac engineer or QA work is being undertaken. Detector arrays provide an attractive alternative to water phantoms due to their compactness and ease of setup.

Materials and methods. A multi-axis ion chamber array (IC PROFILER™, SUN NUCLEAR) was used to collect reference data for clinical linac beams. Energies measured were photons of 6, 15 and 18 MV and electrons in the range 6 to 18 MeV. The data were compared to corresponding scans and point measurements obtained using the PTW MP3 (Freiburg, Germany) water phantom for the respective beams. Parameters checked were output constancy, dose rate dependence, energy constancy, beam profiles in cardinal and diagonal directions, beam flatness and symmetry and electron applicator output constancy. The array allowed also a quick check of beam startup characteristics and the verification of beam parameter stability at various gantry angles.

Results. All parameters (constancy, output factors, energy dependence, dose rate, beam symmetry and flatness), measured with the multi-axis chamber array and the water phantom for the various beams, were in accordance within 1% at most. The detector array provides comparable results and combines the reliability of a water phantom with the advantage of reduced linac time taken up by solid phantom setups.

Conclusion. The detector array has shown to have the reliability needed to substitute the water phantom for acquiring linac beam data. This is particularly useful for QA measurements and checking linac parameters during and after unplanned technical interventions.

http://dx.doi.org/10.1016/j.ejmp.2016.07.149

TL DETECTORS IN VERIFICATION OF PLANNING SYSTEM'S FOR CONFORMAL AND VMAT TECHNIQUES OF X-RAY EXTERNAL BEAM

Monika Paluch-Ferszt [a,*], Beata Kozłowska [a], Marcin Dybek [b]

[a] *Institute of Physics, Department of Nuclear Physics and Its Applications, University of Silesia, Uniwersytecka 4, 40-007 Katowice, Poland*
[b] *Radiotherapy Department, Katowice Oncology Center, Raciborska 27, 40-074 Katowice, Poland*

* Corresponding author.

Introduction. X-ray beam is the most widely used source for external beam radiotherapy.

The dosimetry of these beams is controlled by thermoluminescent detectors (TLD) due to their small size and wide range of measured doses.

Purpose. This work presents the evaluation of the absorbed doses in TLD and calculated in treatment planning systems for conformal and VMAT techniques. Radiotherapy Department Silesia Oncology Center routinely uses computerized treatment planning systems Oncentra MasterPlan and Monaco in dose calculation in the patient's body treated with external X-ray fields. The evaluation of the impact of preliminary conditions to the dose distribution in clinical and QA cases can be found in many papers. The way of the calculation correctness verification in heterogeneous medium is different for each radiotherapy department.

Materials and methods. There were prepared three different treatment plans for cancer therapy in pelvis, chest and head areas with the use of 6 MV beams in conformal and VMAT techniques. Dose calculations were performed with the Colapsed Cone Convolution and the Monte Carlo algorithms for anthropomorphic phantom and were compared with dose measured by calibrated TL detectors placed inside the phantom during irradiation.

Results. The results for all cases fulfill expectations for required accuracy in the treatment planning system regarding inhomogeneity correction.

Conclusion. It was observed that the dose uncertainty values are 5–10% for the area of the cancer tissue. These points are placed in the region with the high dose values and a high gradient of dose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.150

ANALYSIS OF IMAGE QUALITY AND DOSE FOR INTERVENTIONAL PROCEDURES: ALLURA XPER VS CLARITY

M. Damen, P. van der Tol *, I. Hernández-Girón, J. Geleijns

Radiology Department, Leiden University Medical Center (LUMC), The Netherlands

* Corresponding author.

Introduction. At Leiden University Medical Center ~1800 complex interventional procedures are performed yearly, on an AlluraXper FD20 (Philips) interventional X-ray system. The system was recently upgraded to Clarity which claims to provide high quality images at a lower patient dose compared to the previous setting.

Purpose. To compare the image quality and dose of the AlluraXper system before and after the Clarity upgrade.

Materials and methods. The measurements were performed using the default clinical fluoroscopy modes. For the low dose mode, a lower pulse rate is used in clinical practice. Scatter dose was measured using an anthropomorphic phantom and a Keithley 600cc ion chamber at the radiologists' position. The Leeds TOR-18FG phantom combined with $28 \times 28 \times 25$ cm^3 PMMA was used for image quality assessment. ImageJ was used for image analysis.

Results. For one of the most frequently used FOV (37 cm), staff dose was reduced between 30% and 40% after upgrade. The modulation transfer function (MTF) improved after Clarity upgrade. For the low dose mode, and FOV 37 cm, MTF50% was 1.5 cy/mm and 1.8 cy/mm, and MTF10% was 2.6 cy/mm and 2.7 cy/mm. For the medium dose mode, and FOV 37 cm, MTF50% was 1.6 cy/mm and 1.8 cy/mm, and MTF10% was 2.3 cy/mm and 2.4 cy/mm. The settings for the dose modes are not the same before and after upgrade. In an initial cohort of 100 patients, analysis of the dose reports showed a reduction up to 30% in dose-area-product after the Clarity upgrade.

Conclusion. The Clarity upgrade results in staff and patient dose reduction while improving image quality in terms of MTF.

Disclosure. Nothing to disclose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.151

EVALUATION OF POSITIONING UNCERTAINTY FOR FRAMELESS RADIOSURGERY FOR THREE IGRT METHODS WITH A HEAD PHANTOM

Ll. Prats Cabacés *, I. Sancho Kolster, C. Picón Olmos

Institut Català d' Oncologia, Gran Via de l' Hospitalet, 199-203 08908, Hospitalet de Llobregat, Barcelona, Spain

* Corresponding author.

Introduction. A BRAINLAB system for frameless radiosurgery is commissioned obtaining patient positioning accuracy with the STEEV head phantom (CIRS).

Purpose. Firstly the position accuracy for frameless radiosurgery has been compared with three different IGRT methods: EXACTRAC (BRANLAB), OBI-2D (VARIAN) and CBCT (VARIAN) with EXACTRAC registration.

Secondly the uncertainty of image registration between MRI (PHILIPS INGENIA SYSTEMS 3.0T) and CT (PHILIPS BIG BORE) has been evaluated with IPLANRT image 4.1.1 software.

Materials and methods. Phantom positioning was done with automatic registration and with equivalent X-ray parameters for the three IGRT methods. Measurement was done 5 times, every of these the phantom with mask was replaced. Position accuracy was evaluated with the tool "detect Winston-Lutz pointer" from EXACTRAC.

CT and MRI images of a multimodality fillable sphere insert in the phantom were registered. The registration was evaluated with IPLANRT image software finding the center of the sphere in each modality.

Results. For the three IGRT techniques the accuracy obtained was (0.466 ± 0.071)mm for EXACTRAC, (0.744 ± 0.209)mm for OBI-2D and (0.750 ± 0.386)mm for CBCT registered with EXACTRAC.

For MRI was obtained (0.300 ± 0.1)mm.

The total uncertainty for EXACTRACT IGRT system is (0.554 ± 0.374)mm ($k = 2$).

Conclusions.

- The positioning system EXACTRAC have less uncertainty than both OBI-2D and CBCT registered with EXACTRAC for cranial SRS.
- The total uncertainty for the EXACTRAC including IGRT and also image registration between CT and MRI is (0.554 ± 0.374)mm.

http://dx.doi.org/10.1016/j.ejmp.2016.07.152

PERIPHERAL NEUTRON DOSE MODEL VERIFICATION FOR REAL IMRT CASES

L. Irazola [a,b,*], J.A. Terrón [b,a], B. Sánchez-Nieto [c], M. Romero-Expósito [d], F. Sánchez-Doblado [a,b]

[a] *Departamento de Fisiología Médica y Biofísica, Universidad de Sevilla, Spain*
[b] *Servicio de Radiofísica, Hospital Universitario Virgen Macarena, Sevilla, Spain*
[c] *Instituto de Física, Pontificia Universidad Católica de Chile, Santiago, Chile*
[d] *Departament de Física, Universitat Autònoma de Barcelona, Bellaterra, Spain*
* Corresponding author.

Introduction. Peripheral doses are directly related to second cancer risk after radiotherapy. Our group developed a methodology to estimate neutron contribution to peripheral organ doses by terms of two general models, namely abdomen and head and neck [PMB-2012;57:6167–6191].

Purpose. This work aims to verify the validity of these models in real treatments, in order to evaluate the need of further improvements for specific locations beside the two generic ones.

Materials and methods. Neutron doses were calculated in 12 representative organs from measured thermal neutron fluences with TNRD detectors at 16 points inside the phantom [MedPhys-2014;41:112105], for two high energy (15 MV) treatments (lung and prostate). Following the methodology described in [R&O-2013; 107:234–241], these neutron doses were estimated by terms of number of delivered MU and facility characterization. Abdomen model was used for the prostate case while both (abdomen and head&neck) for the lung one (due to isocenter position respect to models). Then measurements have been compared to estimations obtained with the prediction models [MedPhys-2015;42:276–281].

Results. Values generally agreed within the 30% uncertainty range established for the models and the 15% for the measurement. Abdomen model has shown to fit better for the lung. Further studies should be needed to improve generic models in some specific locations such as skin or organs close to the field-edge.

Conclusion. The generic model has shown to be good enough to cover frequent high-energy specific treatments as those studied here. It seems to be no need of more specific models, while some improvements have to bee done for particular points.

http://dx.doi.org/10.1016/j.ejmp.2016.07.153

RADIATION TREATMENT OF PATIENTS WITH CARDIAC PACEMAKER: WEDGE TYPE EFFECT ESTIMATION

K.M. Kourinou [a,*], P. Birmpakos [a], P. Georgolopoulou [a], S. Betsou [a], A. Miliadou [b], G. Koukourakis [b]

[a] *Medical Physics Department, "St. Savvas" G. Anticancer Hospital of Athens, Greece*
[b] *Radiation Oncology Department, "St. Savvas" G. Anticancer Hospital of Athens, Greece*
* Corresponding author.

Introduction. An increasing number of pacemaker patients are receiving radiotherapy in various sites in our department. The need hence arises to accurately determine the radiation burden of pacemaker devices for radiotherapy patients, given the limited tolerance of such devices reported by manufacturers and select the best treatment parameters during the design of their treatment plan.

Purpose. This study aims to investigate the dependence of pacemaker dose on the type of wedge filter implemented in the radiotherapy machine, comparing the effect of dynamic wedges of various angles to the effect of the universal motorized wedge.

Materials and methods. In this study two different linear accelerators were used. All measurements were performed with 6 MV photon beams, at a range of distances from the field centre, for wedged and open beams. Dose was measured for dynamic wedges 15°, 30°, 45° and 60° and corresponding motorized wedge angles, for various wedge orientations. Moreover, the above estimated doses were compared with the data from two different treatment planning systems.

Results. The effect of the wedge filter can elevate the pacemaker dose significantly compared to that of an open field. Comparing the wedge designs measured in this study, the use of a dynamic wedge decreases the pacemaker burden. The pacemaker estimated dose from treatment planning systems diverged from the measured values.

Conclusion. This study provides data about the pacemaker exposure for different wedge systems. Furthermore, the treatment planning system's dose estimation errors can not be neglected.

http://dx.doi.org/10.1016/j.ejmp.2016.07.154

USE OF 4D CT TO ESTIMATE THE DOSE GIVEN TO GTV IN VMAT LUNG SBRT

J.F. Mata-Colodro [a], A. Serna [a,*], V. Puchades-Puchades [a], D. Ramos-Amores [a], M. Alcaraz-Banos [b]

[a] *Department of Medical Physics, Santa Lucia Universitary Hospital, Cartagena, Spain*
[b] *Department of Radiology and Physical Medicine, Faculty of Medicine, University of Murcia, Spain*
* Corresponding author.

Introduction. The use of 4DCT to defining the Internal Target Volume (ITV) is a tool to safely minimize the necessary margins to take into account breathing movement in lung Stereotactic Body Radiation Therapy (SBRT). Treatment planning is performed using a conventional CT with slow table speed, producing a plan accepted for treatment (TP).

In this work we study the dosimetric degradation produced when recalculate a TP plan on the 4DCTs.

Materials and methods. 4DCT consists of a set of 8 CTs obtained by retrospectively sorted image data accordingly with a respiratory cycle. These eight CTs are used for ITV delimitation being the envelope of the GTVs delimited on each individual CT.

Seven patients with a significant GTV breathing movement were selected. Plans consisted on two or four VMAT partial arcs with collimator rotation of 30° and 330°. PTV's planning objective is 98% volume covered by 98% of prescription dose.

TP plans were recalculated on the 4DCTs. Hence, eight plans were generated (4DP). Average histograms of GTVs and ITV in 4DP and TP respectively were compared.

Results. Result showed that the dosimetric coverage of GTV (for 4DP plans) is lower than for ITV (for TP plans). In three patients, averaged GTV histograms (4DP) resulted in a dose covering of 97.5%, 96.7% and 95.7% of the prescription dose to 98% of GTV volume.

The inherent dosimetric heterogeneity of these treatments and the blurring effect in GTV due to use a slow CT for planning, could explains these discrepancies.

Conclusion. Appropriate dose coverage of ITV might not be enough to ensure a GTV appropriate irradiation.

Disclosure. None.

http://dx.doi.org/10.1016/j.ejmp.2016.07.155

NEUTRON STREAMING ALONG SHIELDING PENETRATIONS OF HIGH ENERGY MEDICAL ACCELERATORS USING MCNP AND ADVANTG CODES

I.E. Stamatelatos [a,*], T. Vasilopoulou [a], P. Georgolopoulou [b]

[a] *Institute of Nuclear & Radiological Sciences, Technology, Energy & Safety, National Centre for Scientific Research 'Demokritos', Greece*
[b] *Department of Medical Physics, General Anticancer-Oncologic Hospital of Athens, 'Saint Savvas', Greece*
* Corresponding author.

Neutron streaming along penetrations in the shielding of high energy medical accelerators may result in an undesirable radiation dose to the personnel of the radiation therapy facility. However, accurate estimation of the neutron dose is generally difficult due to the long neutron paths and complex geometries encountered.

Monte Carlo methods have been used to estimate the neutron fluence and optimize the shielding design. Nevertheless, significant discrepancies have been observed between calculated and measured dose rates. These differences have been attributed to uncertainties in the definition of the neutron source, nuclear and material composition data, model geometry approximations, as well as uncertainties related to the variance reduction techniques employed in the calculations.

In this work, a detailed study of the neutron fluence in the treatment room and along the shielding penetrations of an 18 MV medical linac is discussed. Simulations were performed using Monte Carlo code MCNP enabling accurate modeling of the complex shielding geometry investigated. Moreover, the automated variance reduction parameter generator ADVANTG was used to accelerate tally convergence and significantly increase the tally figure of merit (FOM) relative to the analog simulation.

The results of the simulations were compared against measurements performed using activation detectors and a satisfactory agreement was observed. The effect of different input parameters on the neutron streaming results was examined.

http://dx.doi.org/10.1016/j.ejmp.2016.07.156

THE PILOT STUDY OF ON-SITE END-TO-END IMRT AUDIT IN RADIOTHERAPY IN THE CZECH REPUBLIC WITH THE HEAD ANTHROPOMORPHIC PHANTOM

Irena Koniarová [a,b,c,*], Ivana Horáková [a], Vladimír Dufek [a,d]

[a] *National Radiation Protection Institute, Prague, Czech Republic*
[b] *Czech Technical University, Faculty of Nuclear Sciences and Physical Engineering, Prague, Czech Republic*
[c] *Faculty Hospital Královské Vinohrady, Department of Radiotherapy and Oncology, Prague, Czech Republic*
[d] *Na Bulovce Hospital, Department of Medical Physics, Prague, Czech Republic*
* Corresponding author.

Introduction. In the Czech Republic, intensity modulated radiation therapy (IMRT) became a standard type of treatment. Each department has established the quality controls for IMRT plans but these controls can miss some aspects because they are not "end-to-end" tests. National Radiation Protection Institute (NRPI) has developed a tool for comprehensive verification of IMRT head plans.

Purpose. The aim of this work was to propose and test on-site audit that would verify the whole process of radiotherapy of head tumors.

Materials and methods. Anthropomorphic head phantom including bones, soft tissues, and cavities was adjusted for the purposes of the audit. Apertures for chambers were drilled and volumes were marked out in the phantom to distinguish PTV and OARs unambiguously. Two treatment sites can be verified separately (nasopharynx and glioblastoma). Verification of point doses with ionisation chambers and planar doses with films in PTV and organ at risk can be performed as well as planning process control.

Results. Methodology has been tested within the pilot study at 3 departments with photon beams (including rotational techniques) and one department with proton beams. The audit can be performed globally. The results might show interesting intercomparison among departments covering dosimetry part of treatment as well as differences in contouring standards, planning standards, plan evaluation parameters, patient set-up accuracy.

Conclusion. NRPI has developed and tested methodology of "end-to-end" audit for head and brain IMRT treatment.

Disclosure. This work has been supported by the project No. TB04SUJB001. Authors have no potential conflict of interest to disclose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.157

INCORPORATION OF GEOMETRICAL INFORMATION ON STRUCTURE POSITION TO GAMMA ANALYSIS RESULTS FOR PORTAL DOSIMETRY BASED IMRT PROSTATE VERIFICATION

Irena Koniarová [a,b,c,*], Kamila Foltýnová [c,d]

[a] *National Radiation Protection Institute, Prague, Czech Republic*
[b] *Czech Technical University, Faculty of Nuclear Sciences and Physical Engineering, Prague, Czech Republic*
[c] *Faculty Hospital Královské Vinohrady, Department of Radiotherapy and Oncology, Prague, Czech Republic*
[d] *Technical University of Ostrava, Faculty of Electrical Engineering and Computer Science, Ostrava, Czech Republic*
* Corresponding author.

Introduction. Gamma analysis became a standard tool to evaluate the agreement between planned and delivered fluence/dose distribution. The importance of points out of tolerance limit is always the same, because the analysis does not include any information on position of relevant structures for the current Beam's eye view (BEV). We have suggested the method for incorporation this into the gamma analysis result.

Purpose. The aim of this work was to create the application in Matlab software that would use the corrective matrix to be applied to the result matrix of gamma analysis from portal dosimetry with EPID for each new prostate IMRT patient to warn about unacceptable results in the most critical areas.

Materials and methods. The results of gamma analysis for 30 prostate patients were analyzed. Patients were treated with 5 fields sliding window IMRT on Clinac DHX. Gamma map has been matched with BEV projection of PTV, rectum, and bladder for current patient. The sum matrix of BEV over all patients for each gantry angle was created to show the most frequent BEV localization of current structure. The weighting matrix was created to be applied to the gamma analysis results of prostate IMRT increasing the importance of unsatisfactory results at areas where projections of organs are most probable.

Results and conclusion. The weighting matrix is the result of optimization process which took into account frequent position of BEVs and frequent position of pixels out of tolerance within gamma analysis.

Disclosure. Authors have no potential conflict of interest to disclose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.158

IN VITRO BLOOD FLOW ANALYSIS USING MAGNETIC RESONANCE ANGIOGRAPHY

Kazerou Aspasia *, Patatoukas George, Argiropoulos George, Efstathopoulos Efstathios

2nd Department of Radiology, University General Hospital 'Attikon', School of Medicine, National and Kapodistrian University of Athens, Athens, Greece
* Corresponding author.

Introduction. The study of pulsatile flow through a stenosis is motivated by the need to obtain a better understanding of the impact of flow phenomena on atherosclerosis and stroke. MRI techniques have been employed to characterize flow emerging from a stenotic tube.

Purpose. In this study, estimation of hemodynamic parameters was achieved by means of a flow phantom. The phantom simulated pulsatile blood flow. In vitro measurements simulated blood flow to a satisfactory degree, under various assumptions for flow.

Materials and methods. Signal to noise ratio (SNR) is indicative of the loss of signal as fluid flows across the stenosis. Rectangular ROIs were designed upstream and downstream a glass made stenosis, and pre- and post-stenotic SNR values were calculated. The severity of stenosis was calculated as the percentage rate of maximum velocity upstream and downstream the stenosis to the intrastenotic velocity.

Results. SNR values upstream the stenosis, are higher than all respective values downstream, as expected from theory. Calculations lead to SNR percentage loss values of: 54.15% (60 bpm), 71.08% (75 bpm), 68.7% (100 bpm) and 72.63% (for 120 bpm). Overall, percentage stenotic values extracted by MR showed a strong dependence on the rate of flow pulsatility.

Conclusion. Understanding the imaging parameters of turbulence in flow is crucial for the comprehension and interpretation of the flow across a stenosis. Complete understanding of the interrelationship between pressure, flow, and symptoms for cardiovascular stenoses is a critical problem, in the solution of which MRA seems to be playing a vital role.

http://dx.doi.org/10.1016/j.ejmp.2016.07.159

A COMPARISON OF DOSE AREA PRODUCT FROM DIFFERENT ANGIOGRAPHY PROCEDURES

E. Vlastou [a,*], J. Antonakos [a], E. Efstathopoulos [a], N. Kafkas [b], N. Makris [b], C. Besios [b], P. Raptou [b]

[a] *2nd Department of Radiology, University General Hospital 'Attikon', School of Medicine, National and Kapodistrian University of Athens, Athens, Greece*
[b] *KAT Hospital, Athens, Greece*
* Corresponding author.

Introduction. The increased use of Interventional Radiology (IR) techniques the last decade and the extend fluoroscopy time during IR procedures deliver high radiation dose to patients and raised serious concerns about exposure to ionizing radiation.

Purpose. The purpose of this study is to evaluate the radiation exposure to patients during different IR procedures. The measurement of Dose Area Product (DAP) values and fluoroscopy time, allows a relative estimation of patients' effective dose in interventional operations.

Materials and methods. A retrospective analysis of 333 procedures performed during last year at KAT General Hospital of Athens, the biggest trauma hospital of Greece in Athens has been conducted. All the procedures were performed on an image intensifier angiography system (Siemens Axiom Artis). Data concerning dose area product (DAP) and fluoroscopy time have been collected and divided in categories according to the type of procedure – technique.

Results. DAP, presented as median and range values, for 210 coronary angiographies (CA), 75 coronary angioplasty procedures (PCI), 19 cerebral Digital Subtraction Angiography (DSA) and 29 lower limbs DSA was 3.10 $mGy*m^2$ (0.26–25.39 $mGy*m^2$), 6.58 $mGy*m^2$ (1.33–18.28 $mGy*m^2$), 5.43 $mGy*m^2$ (0.65–14.80 $mGy*m^2$) and 30.03 $mGy*m^2$ (0.02–137.87 $mGy*m^2$) respectively. The corresponding values for fluoroscopy duration were 5.99 min (1.4–32 min), 12.98 min (4.3–32.2 min), 17.82 min (6–103 min) and 10.1 min (1–63.7 min).

Conclusion. Obtained results indicate that PCI procedures deliver statistically higher doses compared to CA procedures. Furthermore, radiation exposure was significantly greater for lower limbs DSA compared to cerebral DSA technique.

Disclosure. All authors confirm that none relationship may bias this presentation.

http://dx.doi.org/10.1016/j.ejmp.2016.07.160

ANALYSIS OF NEUTRON FLUX AROUND MEDICAL ELECTRON LINEAR ACCELERATOR PLACED IN THE ROOM RECONSTRUCTED AFTER DECOMMISSIONING OF ^{60}CO UNITS USING MONTE CARLO SIMULATION

Hrvoje Brkić [a], Ana Ivković [a,b], Marina Poje Sovilj [c], Mladen Kasabašić [a,b], Slaven Jurković [d,e], Dario Faj [a,*]

[a] *Faculty of Medicine, University of Osijek, J. Huttlera 4, 31000 Osijek, Croatia*
[b] *University Hospital Centre of Osijek, Josipa Huttlera 4, 31000 Osijek, Croatia*
[c] *Department of Physics, University Josip Juraj Strossmayer, Trg Ljudevita Gaja 6, 31000 Osijek, Croatia*
[d] *University Hospital Rijeka, Medical Physics Department, Krešimirova 42, Rijeka, Croatia*
[e] *Department of Physics, Faculty of Medicine, University of Rijeka, Braće Branchetta 20, 51000 Rijeka, Croatia*
* Corresponding author.

Introduction. Increased neutron flux around high energy medical electron linear accelerators placed in the rooms reconstructed after decommissioning of ^{60}Co unit has been reported before.

Purpose. The main limitation of the reported room was the space. Extremely short maze was used and walls were strengthened by lead. In this study, Monte Carlo simulation is used to analyze the reasons for increased neutron flux.

Materials and methods. A model of 18 MV photon beam linear accelerator with the room was built using the MCNP611 code. Points at several locations and different accelerator orientations were used to evaluate the neutron and photon ambient dose equivalent to which medical personnel could be exposed. Also, the different maze lengths was used in simulation to evaluate its significance for neutron protection. Then neutron sources, spectra, flux and dose equivalent were analyzed.

Results. Calculated neutron dose equivalent was not negligible from the aspect of personal dosimetry with almost 2 mSv/year per person in area occupied by staff (conservative estimation). The wall enhancement by lead was new source of photoneutrons. Simulated longer mazes significantly decreased neutron flux near the room door. Both, the lead enhancements and different lengths of mazes changed neutron spectra significantly in chosen points.

Conclusion. The study confirms that shielding from neutron radiation should be thoroughly analyzed if high energy linear accelerators are put in the room where the space constraints exist. The lead enhancement of walls and short mazes should be avoided. If this is not possible, lower energy photon beams should be used.

http://dx.doi.org/10.1016/j.ejmp.2016.07.161

CHANGES IN ELECTRON DENSITY RELATIVE TO WATER DUE TO THE CONCENTRATION OF CONTRAST AGENT IN A CT SIMULATION AND DOSIMETRIC IMPLICATIONS

H. Perez-Garcia *, A. del Castillo, D. Miguel, D. Alonso, J.M. de Frutos, C. Pérez, C. Andrés, M. Agulla, R. Torres

Hospital Clínico Universitario de Valladolid, Spain
* Corresponding author.

Introduction. Contrast agents for radiotherapy are used to improve accuracy in delineating organ at risk and treatment volumes. These agents modify Hounsfield Units (HU) and tissues electron densities relative to water (EDRW) what are used for determining absorbed dose in external radiotherapy by treatment planning systems (TPS).

Purpose. To evaluate changes in EDRW as a function of the concentration of the contrast agent (CCA) in an aqueous solution and to assess dosimetric implications.

Materials and methods. Different amounts of iodine contrast Omnipaque® 350 mg/ml of GE Healthcare are gradually introduced in a water phantom. The amount of contrast added is previously measured so each CCA is known. CT images were acquired using a clinical TC GE HiSpeed Nx/I for each concentration value. HU are measured by a 20×20 square ROI and transformed into EDRW by the characterized HU-to-EDRW calibration curves. EDRW value is plotted against the CCA. Percentage Depth Dose (PDD) is predicted by Eclipse TPS using the Analitytical Anisotropic Algorithm (AAA) v.11.0.31 in each aqueous solution and normalized to water in order to evaluate absorbed dose.

Results. EDRW increases linearly with the CCA. The normalized PDD shows an overdose of 1% when EDRW increases 1.5%, or 2% when EDRW increases 2,5% at 10 cm depth.

Conclusion. Using a CT with contrast in radiotherapy treatment planning as potentially source of error in the calculation of absorbed dose should be evaluated in each case.

Disclosure. No conflicts of interest to declare.

http://dx.doi.org/10.1016/j.ejmp.2016.07.163

NEW USES HYDROGEL AS COMPENSATION BOLUS AND TO FILL AIR CAVITIES

H. Perez-Garcia *, A. del Castillo, D. Miguel, C. Andrés, M. Agulla, D. Alonso, J. de Frutos, C. Pérez, R. Torres

Hospital Clínico Universitario de Valladolid, Spain
* Corresponding author.

Introduction. Electron beams over an irregular surface produce localized hot and cold spots in the underlying medium due to scattering. This fact usually reduces the quality of the treatments. In practice, such sharp dose edges may be smoothed with an appropriately shaped bolus which has similar properties to the tissue when it is irradiated.

Purpose. To present hydrogel (by Varihesive® ConvaTec) as a compensation bolus for clinical treatments

Materials and methods. Hydrogel material is radiologically characterized by a CT images using a clinical TC GE HiSpeed Nx/I. HU are measured and Percentage Depth Dose (PDD) is predicted by Eclipse TPS using the Analitytical Anisotropic Algorithm (AAA) v.11.0.31 in water and hydrogel. PDD is measured in water and hydrogel with a Ross chamber (PTW) and compared with previous results (characterized HU-to-ED calibration curves were needed). A practical case of hydrogel use is shown in a vulva cancer treatment: filling skin folds.

Results. Measured PDD and calculated PDD are very similar to each other. Obtained results show hydrogel and water have equivalent dosimetric properties. In the clinical case analyzed, hydrogel is shaped to the curvature of the patient's skin where the conventional laminar bolus is not able to cover.

Conclusion. Hydrogel and water are radiological equivalent materials. Hydrogel can be used as a compensation bolus or to fill air cavities.

Disclosure. No conflicts of interest to declare.

http://dx.doi.org/10.1016/j.ejmp.2016.07.164

PATIENT DOSES IN A BIPLANE ANGIOGRAPHY SYSTEM

C. Andres, M. Agulla, R. Torres, H. Perez-Garcia *, A. del Castillo, D. Miguel, J. de Frutos, D. Alonso, C. Perez, M. Gomez

Hospital Clínico Universitario de Valladolid, Spain
* Corresponding author.

Introduction. The development of biplane angiography systems is a huge advance in neurointerventional procedures but also a possible increase in patient doses.

Purpose. This work aims to evaluate dosimetric parameters associated with doses to patients during the first year of use of a biplane angiography system

Materials and methods. The angiography system analyzed was a Siemens Artist Zee biplane. Intervention's parameters were obtained by means of the radiation dose structured report. 358 interventions were analyzed according to the following parameters: radiation time, skin dose, dose at interventional reference point and dose-area product (DAP). Average (±95% CI) and the maximum values of each data series were obtained

Results. On average, each intervention needed 39:03 ±4:05 min of radiation time (71.2% due to plane A) with a maximum value of 7:12:34 h. DAP was, on average, 136 ±11 $Gycm^2$ (80.8% due to plane A) with a maximum of 1435 $Gycm^2$. Patient skin dose was, on average, 0.55 ± 0.07 Gy for plane A and 0.51 ± 0.09 Gy for plane B with maximum values of 4.24 Gy (plane A) and 4.20 Gy (plane B)

Conclusion. Patient doses from a biplane angiography system are evaluated. Results show patient dose values significantly greater than those obtained in other interventional procedures. DAP and irradiation time were considerably higher for the plane A (usually craniocaudal). However, the skin dose for both planes shows similar values.

Disclosure. The authors declare that they have no conflicts of interest.

http://dx.doi.org/10.1016/j.ejmp.2016.07.165

AN APPROACH TO VMAT ON RADIATION THERAPY TREATMENTS OF PELVIC AND PARAAORTIC LYMPH NODES

A. del Castillo [a], D. Miguel [a], H. Perez-Garcia [a,*], M. Benito [b], M. Sanchez-Belda [a], D. Alonso [a], J. de Frutos [a], C. Andrés [a], M. Agulla [a], C. Pérez [a], M. Gomez [a], R. Torres [a], F. Lopez-Lara [a]

[a] *Hospital Clínico Universitario de Valladolid, Spain*
[b] *Hospital Provincial de Zamora, Spain*
* Corresponding author.

Introduction. When large volumes need to be irradiated multiple organs at risk are involved. There is no doubt about the preeminence for conformal index and sparing of critical structures for VMAT, but an alternative regarding the use of single or multiple isocenter shows a subject for detailed analysis.

Purpose. To compare VMAT in treatment of pelvic and paraaortic lymph nodes using single or double isocenter.

Materials and Methods. A set of five patients are selected. For every patient an expert radiation oncologist contoured on CT images volumes and organs according to the RTOG guidelines. Plans were done in Eclipse 11 using Accuros XB algorithm for 6MV X-rays from a Clinac 2100-120MLC, using VMAT double full rotation arc with collimator rotation 30°-330°. For isocenter placement the Arc Geometric tool are used, for double isocenter only we allowed only longitudinal couch movement between isocenters.

The same plan objectives are used for every single isocentre plan, but for organs at risk adjustments are made during optimization in order to get the best result for each case. When using double isocentre the VMAT paraaortic plan is used as dose base for VMAT pelvic optimization.

Results. Single isocenter shows higher irradiated volumes V5 are 1–2% and V20 up to 14%, sparing for liver and kidneys are improve for the double isocenter but with an average increase of 10% in monitor units each plan.

Conclusion. Double isocenter plan improves organ sparing but worse PTV dose homogeneity.

Disclosure. No conflicts of interest to declare.

http://dx.doi.org/10.1016/j.ejmp.2016.07.166

OCCUPATIONAL RADIATION EXPOSURE DURING CERTAIN INTERVENTIONAL PROCEDURES

A. Zailae [b,*], A. Sulieman [a]

[a] *King Saud Medical City (KSMC), Ministry of Health, Kingdom Riyadh, Saudi Arabia*
[b] *Prince Sattam bin Abdulaziz University, College of Applied Medical Sciences, Radiology and Medical Imaging Department, Alkharj, Saudi Arabia*
* Corresponding author.

Introduction. Interventional radiology procedures, which are minimally invasive procedures, have the potential to expose both patients and staff to a significant radiation doses.

Purpose. The purposes of this study were to measure staff radiation dose during interventional cardiologic procedures before and after training program of radiation protection.

Materials and methods. Staff were monitored using thermoluminescent dosimeter (TLD) chips for 118 procedures (27 procedures before the training program and the 91 procedures after the training program). Staff doses were monitored in 5 locations: forehead, thyroid, leg and chest.

Results. The mean radiation dose for cardiologist were before the training program were 0.9 mGy for the forehead, 0.95 mGy for the thyroid, 1.42 mGy for the chest, 1.31 mGy and 1.44 mGy for the leg and for the hand and the total effective dose was 0.09 mSv while the mean radiation doses for assistant were 0.78 mGy for the chest, 0.91 mGy for the hand and the total effective dose was 0.06 mSv.

Conclusions. A reduction of radiation dose for staff up to 45% was obtained after the training program. High patient and staff exposure is due to the lack of training and experience and protective tools. Interventional procedures remain operator dependent; therefore, continuous training is crucial.

Disclosure. Authors have nothing to disclose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.167

ADVANCED MAGNETIC RESORANCE IMAGING AND THE CONTRIBUTION OF BRAIN SPECT IN THE DIFFERENTIAL DIAGNOSIS OF CEREBRAL TUMORS'

V. Tsitsia [a,*], V. Valotasiou [b], K. Fountas [c], E. Kapsalaki [d], I. Fezoulidis [d], P. Georgoulias [b], K. Theodorou [a], I. Tsougos [a]

[a] *Department of Medical Physics, University of Thessaly, Larisa, Greece*
[b] *Nuclear Medicine Department, University of Thessaly, Larisa, Greece*
[c] *Neurosurgery Department, University of Thessaly, Larisa, Greece*
[d] *Radiology Department, University of Thessaly, Larisa, Greece*
* Corresponding author.

Purpose. The exciting new advances in MRI and Nuclear Medicine and the growing demands in Neuro-oncology make the need for diagnostic information combination evident. Under this perspective

a protocol of pre-surgical brain tumor evaluation is applied in collaboration of the Medical Physics/Radiology/Neurosurgery/Nuclear Medicine departments of the University of Thessaly, which aims to correlate advanced MR techniques and Brain SPECT for the optimization of differential diagnosis.

Materials-methods. 22 patients (5 meningiomas, 9 high-grade gliomas, 3 metastases, 2 oligodendrogliomas, 1 neurocytoma, 1 lymphoma, 1 gliosarcoma) were included in the pre-surgical imaging protocol. Image fusion of the data derived from the advanced MRI techniques and brain SPECT was performed in Xeleris workstation (GE Healthcare).

MRI techniques. The MRI protocol included a standardized series of brain sequences as well as ^{1}HMRS, DWI, DTI and PWI and was performed on a 3-Tesla MRI whole body scanner (GE, Healthcare, Signa® HDx).

Brain SPECT: The Brain SPECT was obtained 20–30 min after iv injection of 25 mCi tracer activity. The radiopharmaceutical was prepared using Myoview™, (GE Healthcare Ltd) that was reconstituted with technetium-99m pertechnetate (99mTcO4-) sterile solution.

Results. Our preliminary results show positive correlation between ^{99}Tc uptake and MR Spectroscopy and DSC MRI. Furthermore, brain SPECT gives additional diagnostic information and may help considerably in the differential diagnosis between metastases and gliomas as well as between atypical meningiomas and high-grade gliomas.

Conclusion. Image fusion of advanced MR techniques and brain SPECT using Tc-99 gives the opportunity of a more realistic approach and hence may optimize patient treatment.

http://dx.doi.org/10.1016/j.ejmp.2016.07.168

ICTP, TRIESTE UNIVERSITY, ITALIAN AND CROATIAN MEDICAL PHYSICS: A TRAINING OPPORTUNITY FOR YOUNG PHYSICISTS FROM DEVELOPING COUNTRIES

R. Padovani [a,*], R. Longo [b], L. Bertocchi [a], E. Milotti [b], L. Rigon [b], M. De Denaro [c], M. Brambilla [d], E. Capra [e], C. Cavedon [f], P. Francescon [g], H. Hrsak [h], C. Foti [i], M. Paiusco [j], R. Ropolo [k], A. Torresin [l], A. Turra [m], A. Valentini [n]

[a] *Abdus Salam International Centre For Theoretical Physics (ICTP), Trieste, Italy*
[b] *Dept. Of Physics & INFN, Trieste University, Trieste, Italy*
[c] *Medical Physics Dpt, University Hospital, Trieste, Italy*
[d] *Medical Physics Dpt, University Hospital, Novara, Italy*
[e] *Medical Physics Dpt, CRO, Aviano (Pn), Italy*
[f] *Medical Physics Dpt, University Hospital, Verona, Italy*
[g] *Medical Physics Dpt, General Hospital, Vicenza, Italy*
[h] *Medical Physics Dpt, Oncology Hospital, Zagreb, Croatia*
[i] *Medical Physics Dpt, University Hospital, Udine, Italy*
[j] *Medical Physics Dpt, IOV, Padova, Italy*
[k] *Medical Physics Dpt, Cittá Della Salute, Torino, Italy*
[l] *Medical Physics Dpt, Niguarda Hospital, Milano, Italy*
[m] *Medical Physics Dpt, University Hospital, Ferrara, Italy*
[n] *Medical Physics Dpt, S. Chiara Hospital, Trento, Italy*
* Corresponding author.

Introduction. The Abdus Salam International Centre for Theoretical Physics (ICTP) and the Trieste University have initiated in 2014 a Master of Advanced Studies in Medical Physics a two-years training programme in Medical Physics. The programme is designated to provide young promising graduates in physics, mainly from developing countries, with a post-graduated theoretical and clinical training suitable to be recognised as Clinical Medical Physicist in their countries.

Presently, the 3 cycles of the programme has seen 49 participants from 33 Countries: Africa (19), Asia (11), Central and South America (14), and Europe (5), selected from more than 400 applicants per year. Scholarships are awarded to candidates from developing countries with support of the IAEA, TWAS, KFAS, IOMP, EFOMP and ICTP.

Material and methods. The programme is developed following the recommendations of IOMP and IAEA for education and clinical training. In the first year 332 lectures and 228 h of exercises are devoted to all main fields of medical physics. The second year is spent in one of the 12 medical physics department of the hospitals' network for the clinical training in: radiation oncology or diagnostic and nuclear medicine, on a programme developed adapting the IAEA (TCS37, TCS47 and TCS50) and AFRA guidelines.

Conclusions. IOMP, EFOMP and IAEA are seeing this initiative as an answer to the growing demand of Medical Physicists in developing Countries, representing an important European contribution to the development of medical physics in the developing world.

http://dx.doi.org/10.1016/j.ejmp.2016.07.169

TEMPORAL CHARACTERISTIC OF THE SCANNER INFLUENCING DOSIMETRY USING RADIOCHROMIC FILM

T. Gotanda [a,*], T. Katsuda [b], R. Gotanda [c], T. Akagawa [d], N. Tanki [e], T. Kuwano [f], Y. Kawaji [a], T. Shimono [a], K. Fukuda [a], T. Mizumoto [a]

[a] *Faculty of Health Sciences, Junshin Gakuen University, Fukuoka 815-8510, Japan*
[b] *Faculty of Human Relation, Tokai Gakuin University, Gifu 504-8511, Japan*
[c] *Department of Radiological Sciences, Ibaraki Prefectural University of Health Sciences, Ibaraki 300-0394, Japan*
[d] *Department of Radiological Technology, Tokushima Red Cross Hospital, Tokushima 773-8502, Japan*
[e] *Center for Life Science Technologies, RIKEN, Hyogo 650-0047, Japan*
[f] *Graduate School of Health Sciences, Okayama University, Okayama 700-8558, Japan*
* Corresponding author.

Introduction. Recently developed radiochromic films can easily measure the absorbed doses by using a flat-bed scanner. However, in a GAFCHROMIC EBT3 (EBT3) radiochromic film, the precision of the measurement was compromised because of the change in density caused by the scan timing of image acquisition using a flat-bed scanner.

Purpose. The purpose of this study was to investigate the temporal light source change of a flat-bed scanner affecting the density of EBT3.

Materials and methods. EBT3 without irradiation was used to remove non-uniformity error caused by irradiation. EBT3 was scanned every hour (0–6 h) from power activation to investigate the temporal light source change of a flat-bed scanner (EPSON ES-10000G). In addition, five consecutive scans were performed every hour. Scan parameters were RGB (48 bit) mode, 100 dpi, the reflection mode. Image data of EBT3 was divided into R, G, and B modes, and the R (16 bit) mode was used. The region of interest has a diameter of 75 pixels in the center of the EBT3 sheet.

Results. The density gradually decreases after power activation and became the plateau 5 h later. After the first scan, a low density is observed: the density was stable after the third scan.

Conclusion. To improve repeatability of EBT3, the scan must be performed only after 5 h power activation. In addition, the image data obtained after the third consecutive scan must be used.

Disclosure. We have no disclosure and financial support.

http://dx.doi.org/10.1016/j.ejmp.2016.07.170

CT-GUIDED SPINAL INFILTRATION: PATIENT DOSE EVALUATION

Cretti Fabiola [a,*], Lunghi Sandro [b], Rizzi Pierluigi [a]

[a] *ASST Papa Giovanni XXIII, Bergamo, Italy*
[b] *ASST Lecco, Lecco, Italy*
* Corresponding author.

Introduction. In light of ICRP recommendations, Computer Tomography (CT) patient dose is considered, in interventional context.

Objective. To evaluate patient dose for CT-guided spinal infiltration, using a multi-detector scanner Philips 64 Brillance.

Methods. 211 dose reports were downloaded retrospectively from the digital archive, concerning 172 subjects, 91 males and 81 females (age 56 ± 17 years). Lateral (LL) and anterior-posterior (AP) thicknesses of the region of interest were measured from the images, in order to correct CTDI with size specific factors accordingly to AAPM report 204. Dose Length Product (DLP) values were converted to effective doses by using coefficients derived from CTDosimetry.xls (ImpaCTscan.org), SR250 data set and ICRP 103 tissue weighting factors. Also sex differences were considered. Skin doses were estimated too, using CTDIs and correction factors derived from film dosimetry.

Results. Differences between corrected and uncorrected individual CTDI ranged from −12% to +78% (mean +32%). DLP was on average 192 (±104) mGy*cm, with no significant differences between males and females, whereas mean effective doses were 3.9 ± 2.2 mSv and 2.6 ± 1.5 mSv for females and males respectively. Mean peak skin dose was 62 (±27) mGy.

Conclusion. In many cases CT-guided spinal injection represent the method of choice for back pain treatment. In lumbar disk herniation, because of the nature of the disease, surgery is rarely needed, so spinal injection is often the best way to obtain a long lasting pain relief. The relatively low radiation dose, assessed in our work for this procedure, confirms the safety of this minimally invasive technique.

http://dx.doi.org/10.1016/j.ejmp.2016.07.171

HOUNSFIELD CT-VALUES CORRECTION WITH THE IMAR® SOFTWARE, IMPACTS ON DOSIMETRICS CALCULATION FOR RADIATION THERAPY

Muraro Stephane [a], Galliano Geoffrey [b]

[a] *Physicist, France*
[b] *Student Physicist, France*

Introduction. iMAR® is a software developed by Siemens for the raw data reconstruction acquired with CT scan for dosimetry planification. This software is used in the event of presence of metal object which causes artefacts on the scan images.

Purpose. Metal artifacts create uncertainty in contours, add time for manual correction, and might lead to inaccuracies in dose calculation. The iMAR® algorithm used for this software must allow a depiction of the Hounsfield Units (HU) values getting closer to the reality, i.e without artefacts. To do that, several tests are conducted to demonstrate the efficiency of this product.

Materials and methods. Siemens SOMATON Scope 24-slice is used for CT scan.

Phantom created in the department of radiotherapy with a lot of inserts. These inserts come to QUASAR™ phantom and CIRS Model 062. We compared several kind of acquisitions with different parameters of reconstructions while alternating the use, or not, of the iMAR algorithm. The dosimetry realized in the TPS Eclipse® to process the treatment plan is based on the HU values calculated in the CT scan acquisition. Therefore an HU values comparison between images with/without iMAR® software will be made to guaranty an optimal treatment.

Results. The first studies show a significant improvement of the UH values and the result are an optimization and precision of treatments processing.

Conclusion. Use iMAR® Siemens software can improve quality in the CT scan acquisition to enhanced contouring and more accurate dosimetry of the radiotherapy treatment.

http://dx.doi.org/10.1016/j.ejmp.2016.07.172

SPARSE PATCH-BASED METHOD APPLIED TO MRI-ONLY RADIOTHERAPY PLANNING

S. Aouadi, A. Vasic, S. Paloor, R.W. Hammoud, T. Torfeh, P. Petric, N. Al-Hammadi

NCCCR, Hamad Medical Corporation, Doha, Qatar

Introduction. Replacing CT/MRI in radiotherapy chain with MRI-only will remove CT/MRI fusion uncertainties and avoid the patient the dose of ionizing radiation from CT.

Purpose. We propose to generate pseudo-CT (pCT) from conventional MRI and to assess it for MRI-only brain radiotherapy planning (RTP).

Material/methods. In twelve patients with brain tumors, CT and contrast-enhanced T1-weighted MRI were registered. A library of patches was built by extracting 2D patches, defined as MRI squares of 5 × 5voxels, in each voxel location and labelling them with corresponding HU values. Each patch in target MRI was reconstructed from a sparse linear combination of database patches locally searched. The sparse coefficients were estimated by optimizing the Elastic-Net (EN) objective function. EN was enhanced by additional penalty term based on the structural similarity between target and database patches.

Radiological and dosimetric assessments of pCT were done for all patients using leave one out cross-validation. Mean absolute error between CT and pCT radiological paths (MAE_{WEPL}) over a grid were computed. VMAT planning was performed on CT and pCT for PTVs delineated in homogenous (PTV1) and heterogeneous regions (PTV2) and compared. Percentage of dose metrics deviations (PDMD) for PTVs and OARS were computed.

Results. Radiological path estimation was accurate with MAE_{WEPL} = 2.6 ± 0.4 mm. Good agreement with conventional planning techniques was obtained; the highest PDMD were $D_{98\%}$ = 0.05 ± 0.1 for PTV1, $D_{98\%}$ = −0.81 ± 0.47 for PTV2 and D_{mean} = 0.35 ± 0.7 for left lens.

Conclusion. We presented a novel technique to generate pCT for MRI-only brain RTP. In the future, we will investigate its use for PET/MR attenuation correction.

http://dx.doi.org/10.1016/j.ejmp.2016.07.173

NOWADAYS PROTON THERAPY: DOUBLE SCATTERING VERSUS PENCIL BEAM SCANNING MODE

Anna Michaelidesová [a,b,d,*], Jana Konířová [a,c], Jana Vachelová [a], Vladimír Vondráček [b], Marie Davídková [a,d]

[a] *Nuclear Physics Institute, Czech Academy of Sciences, Řež, Czech Republic*
[b] *Proton Therapy Center Czech, Prague, Czech Republic*
[c] *Institute of Molecular Genetics, Czech Academy of Sciences, Prague, Czech Republic*
[d] *Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Prague, Czech Republic*
* Corresponding author.

Introduction. Pencil beam scanning mode is becoming widely used in proton therapy. The biological consequences of the use of pencil beam scanning instead of double scattering mode have not been studied in detail yet. Most of the biological studies of relative biological effectiveness of protons were carried out using double scattering mode. The dose rates in pencil beam scanning are locally essentially higher than those in double scattering mode, which could affect the cell response.

Purpose. The main purpose of this study was to study the *in vitro* biological consequences of the use of pencil beam scanning in comparison to double scattering mode.

Materials and methods. Cell culture samples (normal human fibroblasts, medulloblastoma cell line DAOY) were irradiated by both modes using the same proton energies and doses. The initial energy of protons used for the irradiations was selected according to the clinical options in double scattering. The same energy was then adjusted for the pencil beam scanning mode. Several parameters (cell survival, apoptosis level, double strand break induction) of the cells were followed in various times post irradiation.

Results. The cell survival was found to be lower for the pencil beam scanning mode in both studied positions in the Bragg curve (plateau, peak). The apoptosis level and the induction of double strand breaks were found to be higher for pencil beam scanning mode.

Conclusion. We suggest that pencil beam scanning mode is slightly more efficient than double scattering mode.

Disclosure. No conflict.

http://dx.doi.org/10.1016/j.ejmp.2016.07.174

DEVELOPMENT OF METHODS FOR MRI LONGITUDINAL STUDIES

A. Grucka [a], Francesco Sensi [b,c], Francesco Brun [a], M. Ukmar [e], A. Chincarini [c], R. Longo [a,d,*]

[a] *INFN Sezione di Trieste, Italy*
[b] *University of Genova, Italy*
[c] *INFN Sezione di Genova, Italy*
[d] *University of Trieste, Italy*
[e] *University hospital of Trieste, Italy*
[*] Corresponding author.

Introduction. MRI longitudinal studies have been proposed to detect abnormal brain changes in the early phase of the Alzheimer's disease (AD) during its asymptomatic phase.

Purpose. In order to obtain a very high sensitivity in MRI longitudinal studies a number of technical issues have to be addressed.

Materials and methods. In the present study a high resolution MRI protocol focused on the medial temporal lobe mainly conceived for 1.5T MRI device is developed. A grey-level reference object was designed to be used during acquisition to help image post-processing when gray-level comparison is required. A prospective study on healthy volunteers is ongoing.

An image analysis protocol for longitudinal studies has been developed, including pre-processing (gray level normalization, image registration) and voxel-based time-course analysis. The protocol has been tested on the MIRIAD dataset.

Results. The new acquisition and gray-level normalization technique was applied and comparison indexes (PSNR, SSI, NCC) have been calculated to demonstrate the increased reproducibility of the images.

The image processing developed for this study demonstrates that the time-course of brain atrophy let us differentiate normal and AD subjects with repeated images acquired in less than 2 years.

Conclusion. Applying our imaging techniques, longitudinal studies will likely be more accurate than the study based on MIRIAD dataset. Therefore we expect that repeated images with our acquisition and normalization protocol will allow the discrimination between normal and AD subjects with a reduced number of images acquired in a period of about one year.

Disclosure. Nothing to declare.

http://dx.doi.org/10.1016/j.ejmp.2016.07.175

EVALUATION OF THE DOSE DISTRIBUTION ACCORDING TO TUBE VOLTAGE IN PEDIATRIC HEAD CT EXAMINATION

K. Noguchi [a,*], R. Gotanda [b], H. Sato [b], E. Nakajima [b], T. Gotanda [c], T. Akagawa [d], N. Tanki [e], T. Kuwano [f], T. Katsuda [g]

[a] *Graduate School of Health Sciences, Ibaraki Prefectural University of Health Sciences, Ibaraki 300-0394, Japan*
[b] *Department of Radiological Sciences, Ibaraki Prefectural University of Health Sciences, Ibaraki 300-0394, Japan*
[c] *Faculty of Health Sciences, Junshin Gakuen University, Fukuoka 815-8510, Japan*
[d] *Department of Radiological Technology, Tokushima Red Cross Hospital, Tokushima 773-8502, Japan*
[e] *Center for Life Science Technologies, RIKEN, Hyogo 650-0047, Japan*
[f] *Graduate School of Health Sciences, Okayama University, Okayama 700-8558, Japan*
[g] *Faculty of Human Relation, Tokai Gakuin University, Gifu 504-8511, Japan*

Introduction. In pediatric computed tomography (CT) examination, CT scanning with low tube voltage is suggested for increase the contrast enhancement. When the tube voltage is lowered, the tube current is raised to keep the image quality. Additionally, the dose distribution varies according to tube voltage and patient size.

Purpose. In this study, the dose distributions according to tube voltage were evaluated using developed phantoms and radiochromic film for CT dose dosimetry.

Materials and methods. The phantom shape was cylindrical and diameters were 100 and 140 mm. The dose distributions in the phantom were measured by GAFCHROMIC XR-QA2 film. The scanning tube voltages of CT (Supria; Hitachi Medical Corporation) were 80, 100, 120 and 140 kV. The tube currents were set based on CTDI-vol (48.8 mGy) displayed on the CT console.

Results. In 100 mm phantom, the maximum doses of center or peripheral at 80 and 140 kV were 90.0 or 109.5, and 66.7 or 84.8 mGy, respectably. The maximum dose areas were at the surface in all tube voltage. However, the mean center dose was larger than mean peripheral dose. Additionally, the ratios of center to peripheral were increased according to increase tube voltage.

Conclusion. The results indicated the dose distribution in pediatric head CT become complex according to tube voltage and phantom size. Furthermore, tube current is important factor in determining the maximum dose. To appreciate the radiation risk, the pediatric CT dose should be evaluated by the dose distributions for each patient size and tube voltage.

Disclosure. We have no disclosure and financial support.

http://dx.doi.org/10.1016/j.ejmp.2016.07.176

EFFECT OF RECONSTRUCTION PROCESSING METHODS AND ANALYSIS IN THE QUANTIFICATION OF BRAIN SPECT STUDIES WITH DATSCAN™

Diogo Faria [a], Joana Vale [a,*], João Manuel R.S. Tavares [b], José Manuel Oliveira [a], Durval Costa [c]

[a] *HPP-Medicina Molecular Porto, Portugal*
[b] *Departamento de Engenharia Mecânica, Faculdade de Engenharia, Universidade do Porto, Porto, Portugal*
[c] *Champalimaud Centre for the Unknown, Fundação Champalimaud, Lisboa, Portugal*
* Corresponding author.

Introduction. DaTSCAN (^{123}I–FP–CIT) brain SPECT studies have great clinical impact in differential diagnosis of movement disorders in particular to confirm the presence or otherwise of dopaminergic degeneration in the nigrostriatal pathway. Several quantitative algorithms have been described to obtain more objective data to enable higher confidence in the diagnosis, inter-group analysis and longitudinal evaluation of the same individual.

Purpose. To investigate the impact of different types of image reconstruction processing in the quantification of specific uptake binding (SUB) and striatum size.

Materials and methods. Retrospective study of 22 consecutive individual studies, reconstructed iteratively and analytically with different parameters, with and without attenuation correction (Chang method) in a total of 18 sets of images. The SUB and striatal dimensions (considering an elliptical shape: longest axis – antero-posterior – width – right-left – depth – cephalo-caudal) were obtained using an automatic computational tool.

Results. The results show no statistically significant differences in the SUB between the different types of reconstruction (ANOVA $p = 0.121$ left $p = 0.301$ on the right).

There is statistically significant differences in the volumetric dimensions (ANOVA $p = 0.000$).

There is a strong correlation between SUB values obtained by filtered back projection reconstruction (Hanning filter with critical frequency of 1.0) with and without Chang correction for attenuation (R2 = 0.961 left, R2 = 0.964 on the right).

Conclusion. Calculation of SUB is not significantly affected by reconstruction methods. Attenuation correction increases SUB values. Calculation of striatal dimensions is strongly affected by reconstruction methods. Well defined protocols are needed that need to be maintained throughout clinical practice.

Disclosure. The authors of this abstract don't have any arrangement or affiliation with any product or services used or discussed in this paper nor any potential bias against another product or service.

http://dx.doi.org/10.1016/j.ejmp.2016.07.177

ASSESSING THE FEASIBILITY OF SIMULATING DIFFERENT TUBE CURRENT LIMITS IN NOISE ORIENTED ATCM SYSTEMS

B. Mendes [a,b,*], F. Dias [a,b], D. Oliveira [a,c], S. Sarmento [a,b]

[a] *Centro de Investigação, Instituto Português de Oncologia do Porto Francisco Gentil (IPOPFG), E.P.E, Porto, Portugal*
[b] *Serviço de Física Médica, IPOPFG E.P.E., Porto, Portugal*
[c] *Departamento de Física e Astronomia, Faculdade de Ciências, Universidade do Porto, Porto, Portugal*
* Corresponding author.

Introduction. Automatic tube current modulation (ATCM) allows automatic dose tailoring in Computed Tomography (CT), according to patient size and anatomical region. In noise-oriented ATCM systems, it is advisable to set minimum and maximum values of tube current (Imin and Imax). Large-scale databases are changing the way medical physicists compare data. Therefore, it is important to understand how an incorrect value of Imin or Imax may be detected from large scale dose distributions.

Purpose. To characterize noise oriented ATCM systems from two different vendors, and assess the feasibility of simulating different values of Imin and Imax, for a patient population examined with optimized settings.

Materials and methods. A RS-330 Lung/Chest Phantom (RSD, USA) was imaged with different acquisition settings, using scanners GE Lightspeed and Toshiba Aquilion RXL. The tube current as a function of couch position, I(z), was extracted from DICOM headers. For each Imin and Imax, I(z) was compared with the full range curve thresholded to the desired values.

Results. The I(z) curves obtained suggest a series of equally-spaced modulation points. Between successive modulation points, I(z) varies almost linearly. The settings of Imin and Imax change the values of I attained at each modulation point, and therefore simulated and real I(z) curves are slightly different. This difference decreases when modulation points are closer together (finer sampling). The sampling depends on equipment and collimation settings.

Conclusion. With detailed sampling, differences between simulated and real I(z) curves are below 5%. This difference increases when sampling is less detailed, particularly for lower Imax.

Disclosure. The authors have no relevant financial or non-financial relationships to disclose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.178

COMPARISON BETWEEN INTENSITY MODULATION TECHNIQUES IN THE PROSTATE CANCER TREATMENT

S. Fondelli [a,*], S. Russo [b], I. Peruzzi [b], R. Barca [a], M. Esposito [b], B. Grilli Leonulli [a], L. Paoletti [a], F. Rossi [a], P. Alpi [a], A. Ghirelli [b], S. Pini [b], P. Bastiani [a]

[a] *Radioterapia, Azienda USL Toscana Centro – Firenze, Italy*
[b] *Fisica Sanitaria, Azienda USL Toscana Centro – Firenze, Italy*
* Corresponding author.

Introduction. Comparison between VMAT and IMRT, in terms of plan quality is great topic discussion in literature.

Purpose. Aim of this work is to assess VMAT dosimetric results compared to IMRT ones on prostate site.

Materials and methods. A comparison was made between IMRT and VMAT plans on the first 30 consecutive patients treated with VMAT moderately hypofractionated radiotherapy: 70.2 Gy/26 fractions of 2.7 Gy.

IMRT and VMAT plans were elaborated by TPS Elekta Monaco® using a rabiobiological optimization approach. Plans were compared by evaluating $D_{105\%}$, $D_{95\%}$, $D_{93\%}$, $D_{90\%}$, D_{mean} and $D_{0.5\%}$ for the PTV coverage, while for Organs at Risk (OARs), in addition to D_{mean} and $D_{0.5\%}$, the % of organ receiving 57, 61, 65.8 and 68.4 Gy (rectum), 57, 61, 65.8 and 68.4 (bladder), 35, 39.5 and 43.9 Gy (femoral heads) were considered of interest.

Results. Dosimetric analysis shows that PTV coverage is better with VMAT technique and that PTV D_{mean} is higher than about 1 Gy in VMAT treatments: median value for the PTV D_{mean} was 70,6 Gy in VMAT technique vs 69,7 Gy in IMRT. Regarding OARs sparing, VMAT technique offers a higher sparing of bladder (of about 5% of volume at 57,61 and 65 Gy) and femoral heads (of about 15% of volume at 30 Gy).

Conclusions. Respect to IMRT, VMAT offers higher plan quality with a better PTV coverage. Regarding OARs, VMAT offers higher sparing of bladder and femoral heads. Besides, VMAT is able to pro-

vide a considerable reduction in treatment time offering a better delivery efficiency.

http://dx.doi.org/10.1016/j.ejmp.2016.07.179

RELATIVE DOSIMETRY IN SMALL FIELDS: WHICH DETECTOR TO CHOOSE?

S. Dufreneix *, S. Josset, C. Di Bartolo, D. Autret

Department of Medical Physics, Integrated Center for Oncology, Nantes – Angers, France

* Corresponding author.

Introduction. Small field dosimetry is a challenging area. Since no ideal detector exists, it is recommended that at least three different suitable types be used. However, only one set of measurement is used by the treatment planning system.

Purpose. To compare several detectors and select the adequate one.

Materials and methods. Profiles, percent-depth-dose and output factors were conducted on a Novalis TrueBeam STx in MLC shaped beams with a field size of 3, 2, 1 and 0.5 cm for three energies (6 MV, 6 MV FFF and 16 MV) as well as in circular cones of 15–4 mm diameter at 6 MV and 6 MV FFF. Depending on the configuration, various detectors were chosen between the Razor diode (IBA), the 60017 diamond (PTW), the CC01 ion chamber (IBA), the SFD diode (IBA) and EBT3 films. For circular cones, a comparison with the C-serie Novalis of another center was conducted.

Results. By analyzing the measurements, the following results were high lightened: due to its large sensitive volume (2.2 mm), the diamond was found inadequate for fields smaller than 6 mm diameter. Both diodes were found in agreement but showed some discrepancies with the film due to their high Z material which virtually sharpens the penubra. The deviations observed between the two Novalis were attributed to the different positions of the jaws.

Conclusion. In order to keep a unique detector for all small fields measurements, the Razor diode was selected for all energies.

Disclosure. No disclosure.

http://dx.doi.org/10.1016/j.ejmp.2016.07.180

EVALUATION OF A SMALL FIELD OF VIEW SIPM ARRAY DETECTOR BASED ON A LGSO:CE PIXELLATED SCINTILLATOR

S. David, E. Fysikopoulos, N. Kalyvas *

Department of Biomedical Engineering, Technological Educational Institute of Athens, Athens, Greece

* Corresponding author.

Introduction. Silicon photomultiplier arrays can be used in dedicated small field of view animal imaging detectors and especially in those used to head PET/MR studies in mice due to their small size and flexibility. Ce doped LGSO scintillator crystal is based on a mixture of LSO and GSO orthosilicates (Lu_{2x-} Gd_{2-2x} SiO_5:Ce – LGSO:Ce) and has attracted researcher's attention because of high density of 7 g/cm^3, high light output (~32000 ph/MeV) and fast scintillation decay time (~40 ns).

Purpose. The purpose of this study is to investigate the behavior of the ArraySL-4 (4×4 element array of 3×3 mm^2 silicon photomultipliers) optical detector coupled to a 6×6 LGSO:Ce scintillator array, with $1.9 \times 1.9 \times 5$ mm^3 crystal size elements, for possible applications in small field of view PET imaging detectors. Evaluation was carried out with ^{137}Cs radioactive source and results regarding energy resolution and peak to valley ratio are presented.

Materials and methods. We have developed a symmetric resistive charge division circuit to read out the signal outputs of 4×4 pixel SiPM array reducing the 16 pixel outputs to 4 position signals. The 4 position signals were acquired using a free running sampling technique. An FPGA (Spartan 6 LX150T) was used for triggering and signal processing of the pulses acquired using free running Analog to Digital Converters.

Results and conclusion. Evaluation shows a clear visualization of all discrete scintillator elements. The mean peak to valley ratio of the profiles on the image was measured equal to 13 while the mean energy resolution was measured equal to 18%.

http://dx.doi.org/10.1016/j.ejmp.2016.07.181

PRE-TREATMENT QUALITY ASSURANCE OF 220 RAPIDARC PLANS ANALYZED WITH EPIQA SOFTWARE

C. Pellegrini, V. Ardu *

Radiotherapy Department, IRCCS Policlinico San Donato, Milano, Italy

* Corresponding author.

Introduction. Delivery complexity of volumetric modulated arc-therapy (VMAT) requires a pre-treatment verification process. Electronic portal imaging based on a-Si flat panels are utilized for dosimetric purposes mainly for IMRT pre-treatment verification (QA).

Purpose. This work is a retrospective analysis of a large dataset of RapidArc routine pre-treatment QA. We report results and analysis of our procedure that combines EPID images and EpiQA commercial software for dose distribution reconstruction.

Materials and methods. Dose distribution of 220 patients treated with a VMAT technique on Varian DHX-2100 were analyzed. Tumor sites of selected patients were: 70 esophagus, 100 head-neck and 50 lung. The detector reading, for each arc, is converted to a dose map and compared with the TPS (Eclipse) dose distribution, calculated with a virtual water-phantom (0,125 cm calculation grid). Gamma evaluation index was performed to quantitatively compare measured and calculated results using 3%-3 mm, 4%-3 mm and 4%-4 mm agreement criteria.

Results. Good result were found for all districts. The average values of G<1 for 3%-3 mm criteria are 98% for lung and esophagus and 97% for head-neck district. Head-neck district present a larger number of arcs with G > 1,5, probably due to the higher modulation.

Conclusion. EPID images and EpiQA software use for pre-clinical verification show a very good agreement between calculated and measured dose. This QA procedure is easy also in complex treatments such as VMAT. We plan to investigate this study with a calculation grid of 0,25 cm, obtaining a considerable time sparing. Furthermore we would like to compare results obtained with EpiQA software with other systems for pre-treatment QA.

Disclosure. All authors disclose any financial and personal relationships with other people or organizations that could inappropriately bias this presentation.

http://dx.doi.org/10.1016/j.ejmp.2016.07.182

A DOSE KERNEL BASED ANALYTICAL ALGORITHM FOR VOXEL DOSE CALCULATION IN NUCLEAR MEDICINE

Spiridon V. Spirou [a,*], Theodora Kostou [b], Panagiotis Papadimitroulas [c]

[a] *Department of Biomedical Engineering, Technological Educational Institute of Athens, Greece*
[b] *Department of Medical Physics, School of Medicine, University of Patras, Greece*
[c] *BET Solutions, R&D Department, Athens, Greece*
* Corresponding author.

Introduction. Dose calculation in Nuclear Medicine is performed using the MIRD formalism, which calculates the average dose in each organ, rather than in each voxel. This precludes the development of dose-volume organ constraints, as is done in Radiation Therapy.

Purpose. To develop a voxel-based analytical dose calculation algorithm that relies on individual radionuclide dose kernels.

Methods. First, using ray-tracing techniques, the algorithm calculates the path, in 3D, from the source voxel to the target voxel. Then, in each voxel traversed, the fractional energy absorbed and the fractional energy transmitted are calculated using the radionuclide dose kernels. The dose kernels, i.e. the dose as a function of distance, have been previously calculated in spherical geometry for various radionuclides and homogeneous media using the GATE Monte Carlo toolkit. At each step, the dose kernel curve is read beginning at the fractional energy already deposited as a correction to account for photon spectral changes.

Results. The algorithm was compared with GATE for various geometric setups containing different materials, as well as the XCAT computational anthropomorphic model, using ^{99m}Tc. Agreement is to within a few percent for relatively homogenous regions, worse at interfaces or in highly inhomogeneous regions.

Conclusion. A 3D voxel-based analytical dose calculation algorithm that relies on pre-calculated dose kernels has been developed. Discrepancies between the algorithm and Monte Carlo simulations can be attributed to the fact that the dose kernels have been calculated in homogeneous media and, therefore, do not sufficiently predict interface effects and scatter dose between different materials.

http://dx.doi.org/10.1016/j.ejmp.2016.07.183

QUALITY MANAGEMENT SYSTEM FOR LASER EQUIPMENT: THE EXPERIENCE OF USL UMBRIA 2

M. Paolucci *, R. Di Lorenzo, A. Didona, E. Lotti

Medical Physics Department, Azienda USL Umbria 2, Foligno, Italy
* Corresponding author.

Introduction. The development process of USL Umbria 2 Quality Management System (QMS) led, from 2008, to ISO9001:2008 Certification of the Medical Physics Department (MPD) activities.

Purpose. In this framework, in addition to the application of its own QMS, the MPD works in partnerships with all departments and structures which use ionizing and non-ionizing radiation facilities included medical LASER equipment.

Materials and methods. QMS for LASER equipment consists of:

- Design of work processes, with realization of the related forms and safety signs.
- Recognition of laser equipment and environmental and individual protection devices within our medical institution.
- Realization of a dedicated Quality Assurance program, with the implementation of a technical protocol, planning and execution of quality and functional tests using calibrated measuring devices, recording and storage system of Quality Controls performed.
- Design and realization of Laser Safety Management System with draft of Safety Guidance and training course program for hospital staff exposed to LASER risks.

Results. Our project has been performed over a period of about six years, its application led to an optimization of the distribution of the LASER equipment in all the USL Umbria 2 health facilities (17 structures, including hospitals and health districts), where classes 3B and 4 LASER equipment are installed and used for various applications.

Conclusions. The quality and functional checks, included staff training, have highlighted the need to continuous verification in order to provide the proper protection to patients and operators during clinical activities.

http://dx.doi.org/10.1016/j.ejmp.2016.07.184

SAD VS SSD METHODS FOR CYBERKNIFE OCR MEASUREMENTS

Joana Vale *, Guilherme Campos, Fernanda Ponte

Radioncologia Júlio Teixeira SA – CUF Porto Instituto, Portugal
* Corresponding author.

Introduction. Commissioning of Cyberknife (CK) system at Radiooncologia department Júlio Teixeira S.A started in February 2016. The MultiPlan TPS requires OCR (off-center-ratio) processed data at a fixed SAD (source-to-axis distance) of 800 mm. Accuray physics essencial guide allows the user to measure the OCR either at fixed SSD (source-to-surface distance) or at SAD.

Purpose. Compare SSD and SAD methods for OCR measurements on Cyberknife commissioning acquisitions.

Materials and methods. Data was acquired on a MP3 water phantom using a SRS60018 Diode, TANDEM electrometer and measuring system MEPHYSTOmc^2 from PTW.

OCR measurements for fixed cones in CK were performed by making orthogonal scans at 15, 50, 100, 200, 300 mm depths.

Data was processed by averaging each side of the crossplane and inplane scans (each point in the OCR curve is the average of four measured values).

SSD method was performed with a constant 800 mm target-to-water surface distance being geometrically corrected for an SAD equivalent setup and the SAD method profiles were obtained by moving the robot over the Z axis and the Diode depth adjusted to maintain the 800 mm SAD.

Results. The coefficient of determination was calculated point by point for SSD and SAD curves (60, 50 and 40 mm cones). Differences observed where only significant at penumbra with values for 60 mm cone <1.6%, 50 mm cone <2.5%; and 40 mm cone <5,6%.

Conclusions. Both methods are acceptable. Since SSD are more straightforward it was the chosen method for further data acquisition.

Disclosure. The authors of this abstract don't have any arrangement or affiliation with any product or services used or discussed in this paper nor any potential bias against another product or service.

http://dx.doi.org/10.1016/j.ejmp.2016.07.185

FROM XRAY TO DISPLAY: A QUALITY MANAGEMENT SYSTEM WORKFLOW FOR PRODUCTION AND VISUALIZATION OF RADIOLOGICAL IMAGES

R. Di Lorenzo *, M. Paolucci, A. Didona, E. Lotti

Medical Physics Department, Azienda USL Umbria 2, Foligno, Italy
* Corresponding author.

Introduction. In 2013 the unification of two different public health companies led to the need of technological integration of RIS-PACS system in order to optimize the patient data management of all the diagnostic radiology department.

Purpose. Implementation of a quality assurance program, following the national and international laws and regulations, of xray imaging production and visualization system, integrated in the ISO 9001:2008 standards.

Materials and methods. Quality Assurance (QA) program is developed in many steps, starting from census and classification of all the equipment (Computed Radiography, Direct Radiology, Work Station, ecc.), through acceptance tests and constancy test program, made in association with the radiology department staff.

The activity involved different instrumentation and home-made software, made by open source solution, dedicated to the management of data acquisition and analysis.

Results. Quality management system allows us to check in real time all the display, using a dedicated software platform controlled from the Medical Physics Department office, with a time sparing related to the huge extension of the local health trust.

Conclusions. The QA program of CR and DR system, after three years, led the possibility to renew the oldest equipment and, at the same time, the optimization of the image quality related to dosimetric parameters, following the ALARA principles, with a better uniformity of image reporting.

http://dx.doi.org/10.1016/j.ejmp.2016.07.186

STUDY OF A TREATMENT PLANNING SYSTEM EFFICIENCY TO ESTIMATE THE ABSORBED DOSE BY PACEMAKERS IN EXTERNAL RADIOTHERAPY

S.M. Gutiérrez *, S. Silva, F. Dias, J.A.M. Santos, J. Lencart

Medical Physics Department, Portuguese Institute of Oncology, Porto, Portugal
Medical Physics, Radiobiology and Radiation Protection Group, Research Centre, Portuguese Institute of Oncology, Porto, Portugal
* Corresponding author.

Introduction. The number of patients with pacemakers receiving radiation therapy is increasing. It is well known that these devices are sensible to radiation and, according with the AAPM TG-34 guidelines, pacemakers should not be irradiated with primary radiation fields. Absorbed dose should be estimated before treatment and should not exceed 2 Gy.

Purpose. The purpose of this work was to assess the accuracy of Varian Eclipse Treatment Planning System (TPS) used to estimate the absorbed dose by pacemakers.

Material and methods. Two VMAT plans (faciocervical and oesophagus areas), previously used to treat patients with pacemakers, were simulated in a Rando phantom. Doses were computed on the Eclipse TPS. In both plans, the distance between the pacemakers and the border of the treatment fields was less than 15 cm. Gafchromic EBT3 films were used to measure dose. For each plan, a piece of film was placed between phantom slices at estimated pacemaker position. The plans were delivered in a Varian Trilogy linac. 2D calculated dose distributions were compared with the dose distributions of irradiated films using the software DoseLab. Calculated absorbed dose on the pacemaker was estimated by the dose-volume histogram (DVH).

Results. Irradiated films showed higher doses in the pacemaker than the TPS prediction: 5% in the oesophagus and 13% in the faciocervical plan. In the former case, the pacemaker is closer to the field border (8 cm vs 10.2 cm, respectively).

Conclusions. The TPS underestimates dose in the region where pacemakers are usually placed. Other methodologies should be implemented in the future to improve dose estimation.

Disclosure. The authors have no relevant financial or non-financial relationships to disclose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.187

DOSIMETRIC EVALUATION OF VOLUMETRIC MODULATED ARC THERAPY FOR BILATERAL BREAST CARCINOMA

Morera Daniel *, Marí Adrià, Romero Juan

Hospital Universitario Son Espases, Palma de Mallorca, Spain
* Corresponding author.

Introduction. Patients with bilateral breast carcinoma are usually treated with two sets of tangential beams with different iso-centers. Single iso-center Volumetric Arc Therapy (VMAT) treatment plan can give several logistical advantages, avoiding also the overlapping of tangential fields.

Purpose. Perform a dosimetric study to evaluate the enforcement of Volumetric Modulated Arc Therapy (VMAT) on bilateral breast carcinoma radiotherapy.

Materials and methods. Treatment plans for 5 patients, previously treated with 50.4 Gy/28 fractions, using 3D Conformal Radiotherapy planned with a standard tangential field technique, were replanned with VMAT technique. The PTV used in the optimization was expanded 2 cm to the external direction, in order to correct respiratory movement. VMAT plans were optimized with 2-arcs, 3-arcs and 4-arcs, all plans using one iso-center, avoiding angles between 140° and 220°.

Results. VMAT presents evident logistical advantages for bilateral breast treatment; one iso-center reduces patient setup time, and treatment time. 4-arcs plan and 3-arcs plan had similar dosimetric results, being 2-arcs plan the worst solution. Comparing to the standard tangential field technique, VMAT had better PTV dose coverage (Conformity Index improved in a 13%), avoiding hotspots, which can appear on 3DCRT standard tangential field technique. VMAT also reduces high doses to OARs. On the other hand, VMAT increase lower doses to the whole body, increasing slightly the mean heart dose.

Conclusion. VMAT technique showed logistical advantages for the treatment of bilateral breast carcinoma, but also dosimetric improvements. 3DCRT had greater high doses to OARs, but save lower doses to the whole body.

http://dx.doi.org/10.1016/j.ejmp.2016.07.188

THE ADVANTAGES OF USING AVERAGE ATTENUATION METRICS TO EXPRESS PATIENT SIZE IN COMPUTED TOMOGRAPHY DOSE OPTIMIZATION

S. Sarmento, B. Mendes *, M. Gouvêa

Centro de Investigacao, Servico de Fisica Medica, IPOPFG, Porto Portugal
* Corresponding author.

Introduction. Dose comparisons are essential to the process of dose optimization in computed tomography (CT). Large-scale databases, and size-specific dose estimates (SSDE), made comparisons

less dependent on patient size. However, quantification of patient size would still be useful, to allow comparisons between different patient populations and different scanners. Moreover, when optimizing acquisition protocols after installation of a new scanner, dose data will be collected first for a small number of patients, and it is important that this can be compared with an established standard.

Purpose. To assess the feasibility of using the water equivalent diameter (Dw) instead of patient weight to quantify patient size.

Materials and methods. Existing data from a previous survey was re-analyzed using Dw metrics. Two different values of Dw were obtained for each exam: the midscan or central Dw (Dw_c) used for calculation of SSDE, and the average value of Dw in the scanned region (Dw_a). The data pertained to adult chest and chest-abdomen-pelvis (CAP) exams, in two 16 slice CT scanners (a GE Lightspeed and a Toshiba Aquilion RXL).

Results. The volume CT dose index (CTDIvol) and the SSDE were plotted as a function of patient weight, body mass index (BMI), Dw_c and Dw_a. The use of Dw_a was found to reduce the dispersion of the data, relative to all the other metrics used, allowing a clearer visualization.

Conclusion. Dw_a proved a robust and useful metric to characterize patient size, which can be used for comparisons of both small and large data sets.

Disclosure. The authors have no relevant financial or non-financial relationships to disclose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.189

AIR BUBBLE ARTEFACT: A NEW TYPE OF ARTIFACT ON CT HEADS

S. McVey *, S. Dundas, K. Avinash

Ninewells Hospital and Medical School, Dundee, Scotland, UK
* Corresponding author.

Introduction. An artefact was observed on CT head scans which was inconsistent in occurrence and mimicked pathologies. It was not initially identified on quality control checks and phantom studies. It was confirmed by the manufacturer to be due to the presence of air bubbles in the tube oil cooling system.

Purpose. A review of the sequence of events was undertaken to assess the clinical impact of the artefact and identify action to be taken locally and by the manufacturer to prevent a recurrence.

Materials and methods. Routine quality control tests were performed and reviewed by the Lead Radiographer and Medical Physics Expert. The artefact was investigated further with the CTDI Perspex head phantom scanned using the clinical acquisition protocol. The artefact was not originally identified on these images. The site contacted the manufacturer who were able to remotely identify the cause of the artefact.

Results. Images relating to the investigation were reviewed following information from the manufacturer. The artefact was found to be present on routine quality control images and on CTDI Perspex head phantom images when viewed at a narrow window width of 40. All images passed the quantitative tests based. Clinical scans were reviewed by the radiologists to assess the clinical impact and identify inappropriate clinical events.

Conclusion. The air bubble artefact mimicked pathologies and could result in inappropriate clinical events. Routine quality control tests were not adequate to detect the artefact. These have been modified to address this in future.

http://dx.doi.org/10.1016/j.ejmp.2016.07.190

SNR DEPENDENCE ON HARDWARE INSTALLATION AND PATIENT IMMOBILIZATION IN FMRI EXAMINATIONS. MR IMAGING PROTOCOL OPTIMIZATION

T. Boursianis [a,*], G. Kalaitzakis [b], K. Nikiforaki [c], I. Tsiapa [a], E. Papadaki [b], A. Karantanas [b], T.G. Maris [a]

[a] *Department of Medical Physics, University of Crete, Heraklion, Crete, Greece*
[b] *Department of Radiology, University of Crete, Heraklion, Greece*
[c] *Computerized BioMedicine Laboratory, FORTH, Heraklion, Crete, Greece*
* Corresponding author.

Introduction. The primary form of fMRI uses the blood-oxygen-level dependent (BOLD) contrast imaging. In BOLD fMRI imaging, the signal-to-noise ratio (SNR) is extremely low and statistical methods are used to extract quantitative data. SNR of the images obtained has to be maintained as high as possible.

Purpose. The aim of this study is to estimate the SNR dependence on the video and audio device hardware as well as the patient immobilization in event related functional MRI examinations.

Materials and methods. A head mimicking phantom printed on a commercial 3D printer was scanned on a clinical 1.5 T whole-body clinical scanner utilizing a standard fMRI sequence protocol. Both anatomical and functional MR sequences were used for data acquisition. SNR parametric maps were produced and were fused on both anatomical and functional MR images obtained. The phantom was scanned before and after the installation of all the fMRI stimulus devices (visual and audio). Further examination conditions referring to immobilization of the phantom and cable looping were also studied separately.

Results. SNR is reduced down to 30% when the hardware cables were looped. Immobilization of the head mimicking phantom affected SNR by reducing its value to a level of 10%. The whole fMRI hardware installation also affected SNR with discrepancies at a level of 10%.

Conclusion. The fMRI hardware pre-installation and patient immobilization are important factors that have to be taken into consideration before performing an fMRI examination, as they can both affect the already extremely low SNR of the obtained images.

http://dx.doi.org/10.1016/j.ejmp.2016.07.191

ASSESSMENT AND OPTIMISATION OF STAFF RADIATION EXPOSURE IN NUCLEAR MEDICINE AT VILNIUS UNIVERSITY HOSPITAL SANTARISKIU KLINIKOS

K. Skovorodko [a,*], B. Griciene [a,b]

[a] *Radiation Protection Division, Vilnius University Hospital Santariskiu Klinikos, Santariškiu g.2, LT-08406, Vilnius, Lithuania*
[b] *Department of Radiology, Nuclear Medicine and Medical Physics, Faculty of Medicine, Vilnius University, Santariskiu g.2, Vilnius, Lithuania*
* Corresponding author.

Introduction. The assessment of occupational exposure in Nuclear Medicine (NM) is constant and mandatory process. Radiation protection safety culture, quality assurance programme, different protective measures and acquired automated infusion systems, which affect the doses of optimization, were implemented in NM department.

It is important to evaluate NM staff doses and influencing factors especially in PET/CT facilities.

Purpose. To assess external and internal exposure doses of NM workers during SPECT and PET/CT procedures using different protective measures, automatic dispenser and injection systems

and to estimate the important factors for radiation exposure optimisation.

Materials and methods. The study was performed at NM department of Vilnius University Hospital Santariskiu Klinikos during 2008 - 2015. More than 200 dose measurements were performed with TLD (whole body, rings). In April 2014, PET/CT facilities were installed and 195 measurements were performed by electronic dosimeters (POLIMASTER PM1610B-01) during procedures, such as activity preparation, dispensing, injection, patient positioning and discharge. IMBA software was used for internal dose assessment. For direct measurements of internal exposure, the whole body (HP Ge) detector and thyroid counters (NaI(Tl)) were used.

Results. Annual doses of NM workers in most cases were <1 mSv. The estimated dose received by the staff from one PET examination working with automatic radiopharmaceutical infusion system was 1.96 μSv and working with automatic fractionator with ion chamber for syringes was 2.22 μSv.

Conclusion. The estimated dose values are far below established dose limits. Staff doses can be reduced by implementing radiation safety culture and using a properly shielded system.

http://dx.doi.org/10.1016/j.ejmp.2016.07.192

CONFIGURATION OF THE PRIMO SOFTWARE TO SIMULATE INTENSITY MODULATED RADIATION THERAPY THROUGH DYNALOG FILE

Susana Dias [a,c], Alessandro Esposito [a,c,*], Sofia Silva [a,b], Luis T. Cunha [a,b], Anabela Gregório Dias [a,b], Diana Pimparel [b], Joana Lencart [a,b], João A.M. Santos [a,b,d]

[a] *Medical Physics, Radiobiology and Radiation Protection Group, Research Centre, Portuguese Institute of Oncology, Porto, Portugal*
[b] *Medical Physics Department, Portuguese Institute of Oncology, Porto, Portugal*
[c] *Departamento de Física e Astronomia, Faculdade de Ciências, Universidade do Porto, Porto, Portugal*
[d] *Instituto de Ciências Biomédicas Abel Salazar, Universidade do Porto, Porto, Portugal*
* Corresponding author.

Introduction. Varian DynaLog files contain information on the Multi Leaf Collimator (MLC) actual configuration, and gantry and collimator angles during Intensity Modulated Radiation Therapy (IMRT). The Monte Carlo (MC) simulation of an actual IMRT procedure allows studying the dosimetric effect of possible mismatches between planned and actual delivery. The PRIMO software is a MC software targeted to External Radiotherapy environment. Nevertheless, IMRT is not part of the implemented options.

Purpose. To configure PRIMO to simulate an actual IMRT procedure by DynaLog files manipulation.

Materials and methods. A Varian 2300CD LINAC associated to a 120HD MLC was simulated. Static simulations were primarily performed to verify the LINAC and MLC models against experimental data. A dynamic irradiation with MLC modulation was split into a sequence of static segments. PRIMO was configured by introducing the DynaLog files information and the procedure was simulated on a solid water phantom. Gafchromic films were used to measure actual dose distribution and to compare it with the simulations through a 2D Gamma analysis.

Results. More than 95% of Gamma points <1 were found in static simulations. PRIMO was efficiently configured to simulate an IMRT procedure based on the DynaLog file of the actual irradiation. Preliminary results showed up to 90.8% of Gamma points <1 with respect to the measurement.

Conclusion. A workflow was developed to configure PRIMO to simulate IMRT through the direct introduction of DynaLog files. These results represent an initial study towards a clinically useful implementation of IMRT simulation using PRIMO.

Disclosure. The authors have no relevant financial or nonfinancial relationships to disclose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.193

IMAGE PROCESSING AS A POTENTIAL TOOL FOR CT DOSE OPTIMIZATION

J. Amorim [a,b], B. Mendes [b,c,*], E. Ribau [d], M. Gouvêa [d], S. Sarmento [b,c]

[a] *Departamento de Física e Astronomia, Faculdade de Ciências, Universidade do Porto, Porto, Portugal*
[b] *Centro de Investigação, Instituto Português de Oncologia do Porto Francisco Gentil (IPOPFG), E.P.E, Porto, Portugal*
[c] *Serviço de Física Médica, IPOPFG E.P.E., Porto, Portugal*
[d] *Serviço de Radiologia, IPOPFG E.P.E., Porto, Portugal*
* Corresponding author.

Introduction. Automatic tube current modulation (ATCM) is an important tool for dose optimization in computed tomography (CT). Optimization of ATCM parameters is usually done by trial and error. In a 2009 study by IAEA, image processing (noise addition) was used to simulate lower dose acquisitions.

Purpose. The aim of this work is to assess the potential of image processing as a routine auxiliary tool for CT dose optimization.

Materials and methods. In this first stage, only CT exams without iterative reconstruction (IR) were considered. A process to add noise to DICOM® images was developed, to simulate acquisitions with lower tube current (I). This was tested using phantom images, acquired with different I values, and then applied to real exams. CT images in the liver region were selected from 13 archived exams, and dose reductions of 15% and 33% were simulated. Two experienced Radiologists evaluated the original and virtual images in terms of diagnostic quality, noise and artifacts.

Results. Standard deviation (SD) in virtual images of phantoms agreed well with the expected values, within the range of variation observed for acquisitions with the same parameters. Diagnostic quality scores were slightly lower for the virtual images, but the results obtained highlight the subjectivity of image quality evaluation. Some virtual images were classified as having less artifacts than the original ones, as a result of reduced sampling.

Conclusion. This study was well received by radiologists, and implemented using commonly available software. The challenge is to develop a robust method of image quality evaluation.

Disclosure. The authors have no relevant financial or nonfinancial relationships to disclose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.194

DOSIMETRY AUDIT PROGRAM IMPLEMENTATION: CHALLENGES AND POSSIBLE SOLUTIONS IN A DEVELOPING COUNTRY

F. Herrera-Martinez *, M. Rodriguez-Ponce, A. Arellano-Carmona

Instituto Nacional de Cancerología, Mexico City, Mexico
* Corresponding author.

Introduction. Although radiation has been used worldwide for many decades for treatment in oncology, not only in the most classic way (cobalt-60 and squared fields) but into more novel techniques, many countries around the globe are just receiving for the very first time a Linac, and in some particular cases, the ultimate technology

after being working with a cobalt machine. This situations are presenting complications not only for the operator, or the medical physicist in charge but to the regulator authorities too. Is QC turns more complicated? Is my current norm enough? This quality parameters are enough for a special technique? What do I have to check in an audit? In most of this cases, even with the international recommendations about how to do this step forward, all of this "to do" list are focused mainly in the operations leaving aside an important part for the patient safety: regulation.

Purpose. Suggest not only certain changes but some additions too in order to obtain a feasible quality control, based mainly on international recommendations and the clinical experience.

Method. Careful analysis of the main mismatches of the regulations with the new technology and treatment techniques.

Result and conclusion. An alternative to the current machine audit procedure according to the available treatment machines and techniques at the audited installation involving all steps in the radiation treatment procedure.

http://dx.doi.org/10.1016/j.ejmp.2016.07.195

EVALUATION OF RAPIDARC OPTIMITATION STRATEGIES USING OBJETIVE FUNCTION VALUES

F.A. Derecho Torres, M. Baeza Trujillo, F.J. Luís Simón *

Hospital Universitario Virgen del Rocío. Seville, Spain
* Corresponding author.

Introduction. Eclipse treatment planning system includes various optimization strategies than can be employed to improve the quality of the ultimate treatment plan for RapidArc

Purpose. The purpose of this study is to analyze the new strategies included in the PRO3 optimization algorithm for three phantoms and to examine the results using the final objective function values.

Materials and methods. Three phantoms were created in Eclipse 10.0 with varying shapes and locations for the planning target volumes and organs at risk. These phantoms were taken from Oliver et al. described in Med Phys. (Vol. 11, No. 1, Winter 2010)

A baseline optimization consisting in a single 358º arc with collimator at 45º was applied to all phantoms. Seven different strategies were evaluated and compared to the baseline strategy using the reporting objective function. Each strategy was compared against baselines using paired Student's t-test.

Results. The strategies that resulted with a significant difference from the baseline were: add an 358º arc with a collimator at 315º ($p < 0,025$), using the fit and shield option before optimization ($p < 0,01$) and fit the isocenter with an arc geometry tool and finetune fields ($p < 0,05$).

Conclusion. In our study, we conclude that the optimal collimator angle that minimized target function value is 45º.

From the seven different strategies, only three of them produced significant different final objective function values from baseline. These three strategies are: ad a new arc with orthogonal collimator angle from baseline, using the fit and shield option and fit the isocenter with arc geometry tool.

http://dx.doi.org/10.1016/j.ejmp.2016.07.196

RANGE ASSIGNMENT OF PROTONS IN 18-OXYGENATED DOSIMETRY GEL USING MR-PET IMAGING

M. Runz, A. Runz *, P. Mann, M. Witte, O. Jäkel

Division of Medical Physics in Radiation Oncology, German Cancer Research Center (DKFZ), Im Neuenheimer Feld 280, 69120 Heidelberg, Germany
Heidelberg Institute for Radiation Oncology (HIRO), National Center for Radiation Research in Oncology, Im Neuenheimer Feld 280, 69120 Heidelberg, Germany
* Corresponding author.

Introduction. When treating patients in radiation therapy with heavy ions the produced radioactivity can be used to determine particle ranges and/or the agreement with the target volume to be irradiated using positron emission tomography (PET). We present a method that combines dosimetry and PET data to verify proton ranges using phantom measurements.

Purpose. Qualitative methods for the determination of proton energy range using a combination of polymer gel dosimetry and PET.

Materials and methods. Polymer dosimetry-gel (PAGAT) was used to produce a radiation-induced polymerization which can be measured by magnetic resonance imaging (MRI). An additional enhancement of 21.75% of dosimetry-gel with oxigen-18 produces fluorine-18 by means of nuclear reaction with proton irradiation at the Heidelberg Ion-Therapy -Center (HIT) which can be measured with PET. The structure was tested for different kinds of beam applications: (i) pencil beam, (ii) pencil beam scanning and (iii) spread-out Bragg peak. Combined measurements were carried out on a MR/PET hybrid imaging device at the DKFZ.

Results. MRI analysis and calculations showed good compliance with respect to beam shape and energy range. The location of dose enhancement could be verified with PET. Due to the low resolution, however, no precise statements about the beam shapes and ranges could be made.

Conclusion. Oxygen-18 enriched PAGAT gels can be used to combine standard dosimetry gel evaluation and PET measurements. They showed a significant F-18 increase at the high dose area of MRI data. Improvements in the detection of beam shape and range can be realized using a small animal PET and/or by increasing the Oxyen-18 concentration.

http://dx.doi.org/10.1016/j.ejmp.2016.07.197

TOTAL BODY IRRADIATION'S DOSIMETRIC FEATURES BY VOLUMETRIC MODULATED ARC THERAPY METHOD

B. Tas [a,b], I.F. Durmus [a,*], S. Tokdemir Ozturk [b]

[a] *Department of Radiation Oncology, Yeni Yuzyil University Gaziosmanpasa Hospital, Istanbul, Turkey*
[b] *Department of Physics, Gebze Technical University, Kocaeli, Turkey*
* Corresponding author.

Purpose. To compare three different types of volumetric modulated arc therapy(VMAT) planning tecniques using Elekta Versa HD lineer accelerator to deliver total body irradition(TBI) treatment.

Methods. Five TBI patient's treatment planning performed using Monaco5.1® treatment planning system with three different VMAT tecniques for each patient.First one was single arc VMAT tecnique, second one was double arc VMAT tecnique and third one was 2 fields arc VMAT tecnique for one isocentre.The VMAT-TBI tecnique con-

sisted of three isocentres and three overlapping arcs.The prescribed dose was 95% of target volume receiving dose of 12 Gy.Mean dose to lung and kidney were restricted less than 9.0 Gy.

Results. An average total delivery time was determined 835 ± 86 seconds and an average monitor unit (MU)s was determined 2202 ± 254 MUs for double arc VMAT technique. This study demonstrates that double arc VMAT technique has got less MUs than other technique but an average delivery time is %17 more than single arc VMAT technique. When we compared organ at risk (OAR)s, we had less dose and better dose coverage to target with double arc VMAT technique.

Conclusion. The tecnique for TBI using VMAT was found feasible. The results show that dose coverage of target and OAR's doses also depend significantly VMAT techniques. Based on the results we have decided to plan TBI in our clinic with double arc VMAT technique.

http://dx.doi.org/10.1016/j.ejmp.2016.07.198

HODGKIN LYMPHOMA (HL) TREATMENT USING VARIAN ECLIPSE IRREGULAR SURFACE COMPENSATOR. A DOSIMETRIC ANALYSIS AND CLINICAL RESULTS

F. Herrera-Martinez *, D. Toledano-Cuevas, M. Rodriguez-Ponce, J. Altamirano-Garcia

Instituto Nacional de Cancerología, Mexico city, Mexico
* Corresponding author.

Introduction. A recommended technique for a radiation therapy treatment for HL is a mantle field technique. This technique in most of the cases represents a challenge for the dose calculation not only for the irregularity and size of the field but for the anatomical area to cover; going from the neck to mediastinal region and in some cases up to the axillar regions, thus represents an important problem when the required dose distribution has to be uniform enough to achieve coverage suggested standards, especially for those anatomies with short neck and/or fat chests which leaded to an undesired hot spots on neck and chin mostly and their correspondent side effects. In order to avoid this and improved the treatment, since 2010, mantle techniques are treated with compensators observing improvements in the dose distribution obtained.

Purpose. To improved quality on mantle technique for HL diminishing side effects.

Method. Each of this treatment plans were calculated using the Varian Eclipse irregular surface compensator calculation technique and verified using gamma index criteria. Each plan were compared with the blocked field of the same size, shape and energy.

Results and conclusions. On the dosimetric comparisons we observed a hot spots from 5% to 12% lower than the observed with a conventional technique and an improved hot spot localization according to clinical criteria. Clinically, side effects expected according to experience with blocked fields were diminished on about 70% of the cases on a five years follow-up.

http://dx.doi.org/10.1016/j.ejmp.2016.07.199

INDIVIDUALIZED DOSIMETRY FOR PATIENTS WITH GRAVES' DISEASE

F.J. Luís Simón [a,*], I. Cuenca Cuenca [b], D. Jimenez Felstrom [a], E. Lopez Rodriguez [b]

[a] *Medical Physics Department, Hospital Universitario Virgen del Rocío, Seville, Spain*
[b] *Medicine Nuclear Department, Hospital Universitario Virgen del Rocío, Seville, Spain*
* Corresponding author.

Introduction. Following Directive 2013/59 Euratom, all therapeutic exposures of target volumes shall be individually planned and their delivery appropriately verified. We have developed a homemade software for I-131 dosimetry in hyperthyroid patients using gammacamera and capture probe for prior and post treatment.

Purpose. This study describes the dosimetry method, the differences between pre and post treatment purposes, and compare its results.

Materials and methods. We base our procedure on the EANM Dosimetry Committee Guidelines using an INa Probe for uptake measurements at 2, 24 and 96 h after administration of 25 μCi tracer activity (also measured before its administration) and two Tc-99m planar images to estimate the thyroid mass. A two compartimental model is used to calculate the required activity to achieve 160 Gy to the target. Two uptake measurements are acquired at 96 and 168 h post-treatment to calculate the real absorbed dose to the thyroid, using a monocompartimental model and dead time correction for saturation effect through a previous probe calibration curve. 78 patients treated during 2015 have been analyzed.

Results. 163,1 Gy and 37,7 Gy are the average and standard deviation of administered absorbed doses, ranging from 87,3 Gy to 240,1 Gy. The mean activity to be administered according the used model is 9,1 mCi which differs from previously used (Marinelli algorithm, 7,3 mCi) and administered (8,9 mCi). Differences of means between activities by Marinelli and by our method using t-Student are significant ($p < 0.05$)

Conclusion. Individualized pre and post treatment dosimetry for hyperthyroidism I-131 therapy is mandatory.

http://dx.doi.org/10.1016/j.ejmp.2016.07.200

^{177}LU-OCTREOTATE PEPTIDE RECEPTOR RADIONUCLIDE THERAPY OF NEUROENDOCRINE TUMOURS: DOSIMETRY OF PERSONNEL AND CAREGIVERS

A.P. Stefanoyiannis *, T. Liotsou, S. Ioannidou, S.N. Chatziioannou

Nuclear Medicine Unit, University General Hospital of Athens "Attikon", 1 Rimini St, Athens 12462, Greece
* Corresponding author.

Introduction. The clinical application of ^{177}Lu-Octreotate Peptide Receptor Radionuclide Therapy (PRRTs) is well-established. The relatively long physical half life of ^{177}Lu, along with the fact that it is both a betta and gamma emitter, necessitates investigation of the radiation burden to the personnel and caregivers involved.

Purpose. The purpose of this study was to measure the effective dose to the personnel per administered dose, as well as the effective dose to the caregivers during the immediate p.i. period.

Materials and Methods. Dosimetry measurements were performed for both personnel and caregivers involved in 45 administrations between June '13–December '15. Personnel whole-body doses were recorded on a monthly basis. Dose rate measurements at 1 m distance from the patient were recorded, at time instances 0–30 min and 30–120 min p.i. TLD dosimeters were provided to caregivers to assess their exposure in the time intervals 0–3 days, 3–7 days and 0–7 days p.i.

Results. The personnel's average dose was 32.7 μSv/administered dose. The average dose rate at 1 m distance from the patient 0–30 min p.i. was 47 μSv/hr (range:15–100 μSv/hr), decreasing to 26 μSv/hr 30–120 min p.i. (range:10–50 μSv/hr). The average recorded dose to caregivers was 0.065 mSv in the first 3 days p.i. (range:0–0.14 mSv), 0.035 mSv in the next 4 days p.i. (range:0–0.15 mSv) and 0.100 mSv in the whole dosimetric period (range:0–0.29 mSv).

Conclusion. ^{177}Lu-Octreotate PRRT can be safely performed on an outpatient basis, as long as individualised radiation protection instructions are provided and followed by the caregivers.

http://dx.doi.org/10.1016/j.ejmp.2016.07.201

TESTING OF BEAM CHARACTERISTICS OF PHYSIOTHERAPY ULTRASOUND TRANSDUCERS BY ANALYZING THERMAL IMAGES

Gordana Žauhar [a,c,*], Đeni Smilović-Radojčić [b], Zoran Kaliman [c], Tea Schnurrer Luke Vrbanic [d], Slaven Jurković [a,b]

[a] *University of Rijeka, Medical Faculty, Department of Medical Physics and Biophysics, Rijeka, Croatia*
[b] *Clinical Hospital Rijeka, Medical Physics Department, Rijeka, Croatia*
[c] *University of Rijeka, Department of Physics, Rijeka, Croatia*
[d] *Clinical Hospital Rijeka, Department for Physical and Rehabilitation Medicine, Rijeka, Croatia*
* Corresponding author.

Introduction. The clinical effects of ultrasound used for physiotherapy depend on applied intensity and time of insonation. Output intensities of 0.1–3.0 W/cm^2 are typically applied for therapeutic purposes in pulsed or continuous modes. In order to accurately measure the output characteristics of ultrasonic therapy transducers, an evaluation of effective radiating area (ERA) and beam homogeneity must be made regularly in order to prevent patient damage.

Purpose. Implementation of the method based on use of thermochromic tile in clinical environment for the verification of ultrasound fields produced by transducers used for physiotherapy.

Materials and methods. In this work non-standardized method developed at National Physical Laboratory (NPL) was used for quality assurance of ultrasound therapy beams. The method consists of exposing thermocromic tile to the ultrasonic beam thereby forming an thermal image of the intensity profile of transducer. The image is in turn photographed and analyzed using software developed for that purpose.

Results. Several physiotherapy ultrasound transducers clinically used were tested by use of thermocromic tile in the hospital environment. Thermal images were postprocesed in order to estimate effective radiating area and beam nonuniformity ratio (BNR) for tested transducers.

Conclusion. Results of our measurements have shown that thermocromic tile can be used for rapid check of ultrasound transducers in the hospital environment. Furthermore, our work has also shown that it is possible postprocess thermal images in order to calculate some beam parameters such as effective radiating area (ERA) and beam nonuniformity ratio (BNR).

http://dx.doi.org/10.1016/j.ejmp.2016.07.202

TOWARDS TASK-BASED ASSESSMENT OF PET PERFORMANCE: SYSTEM AND OBJECT DQE ACROSS DIFFERENT RECONSTRUCTION ALGORITHMS

A. Samartzis [a,*], G. Fountos [b], G.A. Kastis [c], E. Kounadi [d], I. Datseris [a], I. Kandarakis [b], G. Nikiforidis [e]

[a] *"EVANGELISMOS" General Hospital/Nuclear Medicine Department, Ypsilantou 45-47, 10676 Athens, Greece*
[b] *Technological Educational Institute (TEI) of Athens/Department of Medical Instruments Technology, Ag. Spyridonos, 12210 Athens, Greece*
[c] *Research Center of Mathematics, Academy of Athens, Athens 11527, Greece*
[d] *"ALEXANDRA" General Hospital/Department of Medical Physics, Vasilisis Sofias 80, 11528 Athens, Greece*
[e] *University of Patras/Department of Medical Physics, Medical School, Rio, 26500 Patras, Greece*
* Corresponding author.

Introduction. Detective quantum efficiency (DQE) of an imaging system is an indicator of the image quality metrics of the system taking into consideration detector efficiency.

Purpose. To investigate a measurement method for evaluating the DQE of a PET imaging system across reconstruction algorithms.

Methods and materials. A novel and highly homogeneous, high – activity flood source was prepared, placed between two semi cylindrical PMMA blocks and imaged in a PET/CT scanner. The modulation transfer function (MTF) was calculated from the line spread function (LSF) of the transverse slice of the thin flat source. The normalized noise power spectrum (NNPS) was also calculated from the coronal slice of the same source. Furthermore, the DQE was calculated from the number of photons emitted from the plane source which is a measure for the incoming SNR^2. The authors adapted the DQE concept to reconstruction, in order to quantify the impact of reconstruction algorithm on image quality.

Results. The effect of 2D (with septa) and 3D (without septa) scanning modes on DQE was investigated and statistical significant differences were found ($p < 0.05$). The reconstruction DQE was determined for conventional and fully 3D iterative reconstruction algorithms, with several combinations of iterations and subsets.

Conclusion. The determination of DQE via MTF and NNPS, could be useful in characterizing different PET/CT systems in terms of image quality metrics and detector efficiency. Moreover, DQE could be a useful criterion for the evaluation of different PET reconstruction algorithms.

Disclosure. The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of the research reported.

http://dx.doi.org/10.1016/j.ejmp.2016.07.203

FMRI STUDIES PRIOR AND POST ACUPUNCTURE TREATMENT CONCERNING SMOKING CESSATION

K. Theodoratou [a], F. Christidi [b], P. Toulas [c], D.A. Verganelakis [c,*]

[a] *ICMART, SAMAG, Alimos, Greece*
[b] *Aiginiteion Hospital, Athens, Greece*
[c] *Encephalos-Euromedica Medical Diagnostic Center, Halandri, Greece*
* Corresponding author.

Introduction. Acupuncture has been widely reported to be a popular and safe intervention for smoking cessation. This study demonstrates the potential effects of acupuncture treatment for smoking cessation using the MRI technique of functional Magnetic Resonance Imaging (fMRI).

Purpose. Substance dependence or addiction is nowadays understood in a multifactorial etiological model, which includes psychological, neurobiological, genetic, social and environmental factors. This study illustrates patterns of fMRI activation in various specific brain anatomies, such as frontal, temporal parietal, occipital and cerebellum that correlate with smoking.

Materials and methods. Participants of both genders were volunteers willing to quit smoking. The inclusion criteria were age (28–42 y) and rate of smoking >15 cigarrettes per day and had no previous experience of acupuncture treatment. Group A received real acupuncture, Group B sham acupuncture and Group C was the control group with no smokers. Acupuncture points used: Du-20, LI-20, LI-4,TB-5, ST-36, LIV-3 and treatments lasted for 20 min.

fMRI was applied prior and post acupuncture treatment during the first 24 hours of smoking cessation. During the fMRI experiment

a series of smoking related images were presented to each participant via a set of goggles in a block time-design manner.

Results. Increased brain response areas were observed, such as: dorsolateral prefrontal, primary motor gyrus, parahippocampal gyrus, hippocampus, insula, posterior cingulate cortex, somatosensory cortex, visual areas and external basal ganglia. Differences between Groups A and B, as well as interesting correlations between acupuncture points, fMRI findings and neurobiological areas are presented.

Conclusion. Our results provide evidences over a pattern of slightly different brain activation following real and sham acupuncture after a short term smoking abstinence. The observed differences are in areas involved in drug addiction and smoking maintenance/abstinence literature.

http://dx.doi.org/10.1016/j.ejmp.2016.07.204

ELEKTA ONCENTRA 4.3 VS. MONACO 5.0.04: A COMPARISON BETWEEN 3DCRT DOSE CALCULATION ALGORITHMS

A. Torresin [a,*], C. Cadioli [a], M.G. Brambilla [a], A.F. Monti [a], C. Carbonini [a], M.B. Ferrari [a], F. Rottoli [a], D. Zanni [a], G. Alberta [b]

[a] *Department of Medical Physics, Ospedale Niguarda, Milano, Italy*
[b] *Elekta S.p.A., Centro Dir. Colleoni, Palazzo Andromeda, Ingr. 3, Agrate Brianza, Italy*
* Corresponding author.

Introduction. Each treatment planning system (TPS) must be accurately commissioned before its clinical use. Calculated and measured dose distributions have to be compared in different irradiation conditions.

Purpose. In this work, we verified the degree of similarity between 3DCRT dose distributions calculated by two different TPSs produced by the same company.

Materials and methods. Elekta Oncentra 4.3 and Monaco 5.0.04 dose distributions were analyzed to investigate the performances of their nominally identical calculation algorithms. A software provided by Elekta Support was used. Three different energy beams from an Elekta Synergy, equipped with MLCi, were investigated. Calculated depth dose curves, profiles and absolute dose were compared with measured data. ESTRO booklet 7 criteria were applied. For relative data, the gamma-index confidence limit was the reference analysis parameter; for absolute doses, the percentage difference between calculated and measured values was considered. Tolerances were adapted to irradiation geometry complexity.

Results. In homogeneous phantom, the two systems showed a similar behavior, except in some particular situations for high energy beams. In particular, percentage dose differences between calculations and measurements were greater than tolerances for high energy small size fields in both systems. In inhomogeneous phantom, the two systems generated approximately the same results.

Conclusion. Both TPSs can be considered adequate for clinical use for low and medium energies. For high energy, particular fields should be accurately tested and a Monaco reprocessing could be useful. For low and medium energy beam, a new processing could be helpful to improve Monaco behavior in profile tails.

Disclosure. No relationships to disclosure.

http://dx.doi.org/10.1016/j.ejmp.2016.07.205

DOSE RATES FROM PATIENTS LEAVING A UNIT AFTER PET/CT WITH ^{18}F (FDG AND CHOLINE) ARE SAFE

R. Parafita [a,b,*], A. Canudo [a,b], D. Dantas [a,b], B. Freitas [a,b], S. Chaves [a,b], V. Santos [a,b], D.C. Costa [a]

[a] *Champalimaud Centre for the Unknown, Fundação Champalimaud, Lisbon, Portugal*
[b] *MercuriusHealth, Lisbon, Portugal*
* Corresponding author.

Introduction. There is a general assumption that the dose rates from patients submitted to radiopharmaceutical clinical investigations are low and therefore, no specific radiological protection measures are needed regarding close relatives, general population and the environment.

Purpose. To collect data to confirm this assumption comparing the results with the only known dose rate restriction value of 50 μSv/h (Florida Administrative Code, NUREG 1492) reported in the literature.

Materials and methods. Data was collected from 504 consecutive patients undergoing PET/CT investigations, with ^{18}F labelled molecules at the time of leaving the unit. All measurements were made at 1 meter at the level of the urinary bladder with patients standing.

Results. In 318/504 (63%) of the cases, the dose rate was lower than 6.15 μSv/h.

In 236/504 (46.8%) the BMI was >18.5 and <24.9 BMI with an average dose rate of 6.38 μSv/h.

Using the recommended administered activities of ^{18}F-DG or ^{18}F-Choline the dose rate was lower than the proposed limit, when patients remain 3–4 h in the unit post-injection. For the worst case scenario, when patients are sent out of the unit just 1–2 h after the injection, the dose rate was always much lower than 50 μSv/h.

Conclusion. Our data confirm that for these types of diagnostic procedures there is no significant additional radiological risk to patients' relatives, general public and the environment.

Disclosure. None.

http://dx.doi.org/10.1016/j.ejmp.2016.07.206

THE NEED TO IDENTIFY OCCUPATIONAL EXPOSURE TO LASER RADIATION IN GREECE

M. Makropoulou [a,*], C.J. Hourdakis [b], A. Serafetinidis [a], I. Sianoudis [c], A. Achtipis [d], C. Kappas [e], I. Tsougos [e], T.G. Maris [f], G.A. Gourzoulidis [d,e]

[a] *Physics Department, School of Applied Mathematical and Physical Sciences, National Technical University of Athens, Greece*
[b] *Licensing and Inspection Department, Greek Atomic Energy Commission, Greece*
[c] *Department of Optics & Optometry, Technological Educational Institute (TEI) of Athens, Greece*
[d] *Hazardous Agents Department, OHS Directorate, Hellenic Ministry of Labor, Greece*
[e] *Medical Physics Department, Medical School, University of Thessaly, Greece*
[f] *Medical Physics Department, Medical School, University of Crete, Greece*
* Corresponding author.

Introduction. Optical radiation, part of the non-ionizing spectrum, covers the UV, the IR and the visible regions. The relevant occupational exposure legislation, Directive 2006/25/EC, employs

limits and Occupational Health & Safety (OHS) regulations for laser (coherent) and non-coherent artificial optical radiation (AOR).

Purpose. Although ten years have passed from the release of the aforementioned Directive, poor progress has been made for its practical implementation, mainly regarding the risk assessment by a qualified expert. The Hellenic Ministry of Labor, following a non-coherent AOR survey, in conjunction with the National Technical University of Athens and the Greek Atomic Energy Commission took the initiative to identify the field.

Materials and methods. Lasers are widespread mainly in health care facilities, industry, cosmetic applications, research and entertainment, but there is no homogenized safety approach country-wide. Selected workplaces have been chosen for evaluation of their OHS applied and for measurement of the appropriate optical quantities. The role of the Laser Safety Officer has been discussed as well.

Results. Mapping of the extent of laser applications in Greece has been performed together with an initial testing of selected crucial workplaces, as representative pilot studies. Major challenge and objective is the development of dedicated risk assessment checklists and of QA protocols for laser applications, further specified for medical applications.

Conclusion. The creation of a national occupational exposure database and of approved safety and QA protocols for laser procedures seems reasonable after the collaboration of the involved Authorities.

Disclosure. Authors disclose that they don't have any relationship that may bias their presentation.

http://dx.doi.org/10.1016/j.ejmp.2016.07.207

NEUTRON CONTAMINATION IN CONVENTIONAL 3DCRT TREATMENT AND STEP AND SHOOT IMRT TECHNIQUE USING 10 MV PHOTON BEAM

Sharib Ahmed *, Mansoor Rafi, Rabia Jamil, M. Fahad Khan, Amir Maqbool, Altaf Hashmi

Sindh Institute of Urology and Transplantation, Karachi, Pakistan
* Corresponding author.

Introduction. Linear accelerator is a device that can able to generate high energy photon from 4 MV to 25 MV, and these beams are used for radiation therapy.

There are different treatment techniques using now a days to deliver radiation externally but most common is 3DCRT (3D conformal radiotherapy) and Intensity modulated radiation therapy. The major issue arises using photon beam having energy ~10 MV and above is the productions of secondary neutron which can maximize the patient absorb doses.

Purpose. The aim of the study is to evaluate 3D conformal radiation therapy and step and shoot intensity modulated radiation therapy (ssIMRT) techniques for less neutron contamination that lead to minimum patient exposure from neutrons.

Material and methods. For this purpose five treatment plan of breast were made on both 3DCRT and ssIMRT using 10MV photon. Linear accelerator Elekta Synergy is used to deliver these plans and for measuring neutrons dose in primary beam, a portable, Ludlum neutron detector is used which is placed on patient's couch.

Results. Obtained data shows that the mean values with standard error for each technique was found to be 14.56 mSv ± 0.38 and 25.07 mSv ± 1.2 for 3D CRT and ssIMRT, respectively. Mean difference between two techniques for neutron contamination was found to be 10.5 mSv.

Conclusion. It can be concluded from the study that contamination of neutrons increases by a factor of 10.5 when we move from 3D CRT to ssIMRT. This is because of increase no. of MUs that are being used in ssIMRT. Although ssIMRT therapy provides better plan optimization for target than 3DCTR but contains greater neutron contamination.

http://dx.doi.org/10.1016/j.ejmp.2016.07.208

TWO SHIELDING PROTECTION DISKS SYSTEMS IN BREAST INTRAOPERATIVE IRRADIATION

Andrea Pentiricci [b,*], Massimiliano Paolucci [a], Giampaolo Rossi [b], Roberto Di Lorenzo [a], Giuseppe Felici [c], Alessia Ciccotelli [c]

[a] *Medical Physics Department, Azienda USL Umbria 2, Foligno, Italy*
[b] *Medical Physics Department Azienda USL Umbria 1, Città di Castello, Italy*
[c] *Sordina IORT Technologies SpA, Italy*
* Corresponding author.

Introduction. Intraoperative electron beam radiotherapy (IOERT) consists in treating tissue suffering from neoplastic processes, made accessible by surgery. Even if the particular characteristics of the beam define the target area, the presence of organ at risk (OAR) around the irradiation field has to be considered.

Purpose. The aim of this study is to evaluate the effectiveness of shielding protection disk used in breast intraoperative irradiation to protect OAR.

Materials and methods. We used two different dosimetric system (Gafchromic™ films and Mosfet dosimeters), for characterization of the attenuation properties of different shielding protection disks, using two different accelerators.

The dosimetric systems were calibrated using the same LINAC. The attenuation factor of the shielding disks has been carried out with clinical IOERT irradiation of 10 Gy in solid phantom. The disks were positioned at depth of maximum dose (D_{max}), and at the depth of 90% dose (D_{90}), corresponding to the typical depth of dose prescription in IOERT irradiation.

Results. PMMA measurements show an attenuation factor less than 50% for all beam qualities, using both accelerators; the PTFE&Stainless Steel disks attenuate almost all the radiation (<1%). The results have been confirmed by Mosfet dosimeters measurements in the same experimental setup.

Conclusions. The PTFE&Stainless Steel disks show better attenuation characteristics compared to the PMMA ones, despite the presence of backscattering involves a slight overdose in the tumour area; their use is suitable as protection device in breast IOERT. The consistency of these different dosimetric systems lead to a feasible application for in-vivo dosimetry.

http://dx.doi.org/10.1016/j.ejmp.2016.07.209

COMPARISON BETWEEN FFF BEAMS AND FF BEAMS FOR EARLY STAGE BREAST CANCER'S IMRT TREATMENT

B. Tas [a,b], I.F. Durmus [a,*], S. Tokdemir Ozturk [b]

[a] *Department of Radiation Oncology, Yeni Yuzyil University Gaziosmanpasa Hospital, Istanbul, Turkey*
[b] *Department of Physics, Gebze Technical University, Kocaeli, Turkey*
* Corresponding author.

Purpose. To evaluate monitor unit(MU)s and treatment delivery time for flattening filter free(FFF) beams and flattening filter(FF) beams while planning early stage breast cancer patient's intensity modulated radiotherapy(IMRT) treatment.

Methods. Nine early stage breast cancer patients treatment planning calculated using Monaco 5.1® with eight FF beams for IMRT

treatment. All patients were planned simultaneously integrated boost (SIB) technique and all plans were normalized 60 Gy dose to the 95% of tumor bed and breast dose was 50 Gy. All plans were reoptimized with FFF beams using the same optimization parameters. 6MV FFF beam had got maximum 1800 MU/minute dose rate, and 6MV FF beams had got maximum 600 MU/minute dose rate. We compared MUs and total delivery time for both plans.

Results. We determined an average MUs difference with FFF beams %12 more than FF beams and an average total delivery time difference with FFF beams %2 more than FF beams for early stage breast cancer patient's IMRT planning.

Conclusion. The results show that IMRT plans with FFF beams are not decreasing total delivery time for early stage breast cancer patients because of large field size however high dose rate. Therefore, we are treating early stage breast cancer patient's IMRT plan with FF beams in our clinic.

http://dx.doi.org/10.1016/j.ejmp.2016.07.210

DOSIMETRIC STUDY OF PROSTATE BRACHYTHERAPY, USING MONTE CARLO SIMULATIONS AND VOXEL PHANTOMS

M. Furtado [a,*], P. Teles [b], C. Laporte [c], N. Khalfallah [c], D. Broggio [d], D. Costa [e], P. Vaz [b]

[a] *Departamento de Física, Campus Alameda, Instituto Superior Técnico, Universidade de Lisboa, Avenida Rovisco Pais 1 1049-001 Lisboa, Portugal*
[b] *GPSR, C2TN, Pólo de Loures, Instituto Superior Técnico, Universidade de Lisboa, Estrada Nacional 10, 2686-953 Sacavém, Portugal*
[c] *Centre de Cancerologie Paris-Nord 6 av. Charles Péguy 95200 Sarcelles, France*
[d] *IRSN/PRP-HOM/SDI/LEDI, 31, avenue de la Division Leclerc, 92262 Fontenay-aux-Roses, France*
[e] *Serviço de Medicina Nuclear-Radiofarmacologia, Champalimaud Centre for the Unknown, Fundação Champalimaud, Avenida Brasília 1400-038 Lisboa, Portugal*
* Corresponding author.

Introduction. Prostate brachytherapy is a radiotherapy technique whereby a set of sealed radioactive seeds are inserted in the prostate. In clinical practice, the absorbed dose in the prostate is determined using specific software. In this study, Monte Carlo (MC) simulations in a segmented voxel phantom of a real patient are used to determine the absorbed dose and the DVH in the prostate in comparison with those obtained from a conventional treatment planning procedure. The advantages of using this new method to determine absorbed dose over conventional treatment planning are discussed.

Purpose. To estimate the absorbed dose and the DVH in the prostate and surrounding organs, using MC simulations and a voxel phantom segmented from CT images in comparison with values obtained from treatment planning software.

Materials and methods. CT images of a patient submitted to low-dose rate brachytherapy (LDR) using Iodine-125 seeds were used to produce a voxel phantom. The MC simulations were performed with MCNPX software. The clinical absorbed dose and DVH were determined using the software Interplant®.

Results. The voxel phantom was successfully created and defined to detail. The seeds' disposition used in the treatment planning was also recreated. The doses on the prostate as well as surrounding organs were calculated and compared with those registered in the treatment planning procedure.

Conclusion. MC simulations in a segmented voxel phantom can be used as an alternative method for prostate brachytherapy treatment planning. This method has advantages over the ones used in clinical practice. These advantages include accounting for several parameters not fully considered during conventional treatment planning such as the prostate swelling, the use of real tissue parameters, post-implantation displacement of the seeds. The quantification of these parameters is provided and discussed in detail.

http://dx.doi.org/10.1016/j.ejmp.2016.07.211

NUMERICAL CALCULATION OF TEMPERATURE INCREASE DURING MRI DUE TO THE PRESENCE OF TOTAL HIP REPLACEMENT IMPLANTS

Vasileios Gkyrinis, Theodoros Samaras *

Department of Physics, Aristotle University of Thessaloniki, Greece
* Corresponding author.

Introduction. Patients carrying active or passive implants are often excluded from MRI scanning, because of the potential tissue heating, due to the RF radiation emitted by volume or surface coils. Several studies have tried to quantify the resulting temperature rise and, consequently, assess implant compatibility.

Purpose. The purpose of the current study is to demonstrate the feasibility of evaluating with numerical modeling the worst-case temperature rise in tissues undergoing MRI scanning, due to total hip replacement implants.

Materials and methods. The simulated setup includes two different CAD models of a total hip replacement implant embedded in the ASTM F2182 phantom filled with tissue mimicking gel. The phantom is placed inside a birdcage RF coil resonant at 64 MHz (1.5T). The SEMCAD-X package is used to solve numerically with the FDTD technique the coupled electromagnetic and heat-transfer problems, in order to calculate the temperature rise in the gel. The results are obtained for a continuous exposure of 20 min to 2 W/kg whole-body SAR, which is the limit for normal operating mode.

Results. The results show that the maximum energy deposition appears at the tip of the implant stem. The temperature rise in the gel at this point can reach 12 °C, depending on the materials of the implant. There is also a local maximum in the temperature rise next to the implant head, but its value is half or less than that at the tip.

Conclusion. It is possible to successfully apply modern computational techniques in the timely assessment of medical implants compatibility, thus shortening their development process and increasing patient safety.

Disclosure. Authors declare that they have no competing interests.

http://dx.doi.org/10.1016/j.ejmp.2016.07.212

INDICATIONS FOR INTENSITY MODULATED RADIATION THERAPY USING FIELD-IN-FIELD AND ELECTRONIC COMPENSATOR FOR THE TREATMENT OF LARGE LEFT BREAST VOLUMES

Noora Al-Hammadi, Tarraf Torfeh, Sally Sheim, Primoz Petric, Satheesh Paloor, Rabih Hammoud *

Department of Radiation Oncology, National Center for Cancer Care & Research (NCCCR), Hamad Medical Corporation, Doha, Qatar
* Corresponding author.

Introduction. Breast cancer is the most commonly treated cancer at the National Center for Cancer Care and Research in Qatar for which different radiotherapy (RT) techniques have been developed recently.

Purpose. To evaluate three RT techniques for large left sided breast cancer patients; the 3D wedges technique using Varian Enhanced Dynamic Wedge™ (3DW), the forward planning IMRT with

field in field (FIF) and the forward planning IMRT with electronic compensator (EComp) using the Varian multileaf collimator.

Materials and methods. Thirty patients were included in our study. Treatment plans were created and compared according to dose volume histogram in terms of dose homogeneity within the target volume and dose to OARs as well as conformity indices. Coverage improvement of FIF and EComp over 3DW was also quantified using dose improvement index.

Results. Target volumes receiving 95% of the dose for the PTV were equal to 89.0 ± 4.1, 94.2 ± 2.19 and 96.8 ± 0.98 for 3DW, FIF and Ecomp respectively. Average value of the dose improvement index was equal to 8.92% and 5.97% for EComp and FIF respectively. No statistically significant difference in lung and heart sparing was observed. An advantage of FIF and EComp over 3DW was observed in the sparing of the contralateral breast.

Conclusion. EComp and FIF proved to be superior to the 3DW technique with regard to improving dose homogeneity within the PTV and dose to normal tissues. Results showed that EComp is superior for a PTV volume $\geqslant$1500cc, or a separation $\geqslant$25 cm, or a combination of PTV volumes $\geqslant$1200cc and separation $\geqslant$22 cm.

Disclosure. Authors have nothing to disclose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.213

CLINICAL COMMISSIONING OF THE INCISE™ MULTILEAF COLLIMATOR FOR CYBERKNIFE M6™ SYSTEM

Tarek El Kaissi, Tarraf Torfeh, Adam Shulman, Rabih Hammoud *, Noora Al-Hammadi

Department of Radiation Oncology, National Center for Cancer Care & Research (NCCCR), Hamad Medical Corporation, Doha, Qatar
* Corresponding author.

Introduction. The National Center for Cancer Care and Research (NCCCR) at Hamad Medical Corporation in Qatar is amongst the first institutions in Asia and Europe to have the CyberKnife® M6 FIM system (Accuray, Inc., Sunnyvale, CA, USA) including Fixed Collimators, Iris Variable Aperture Collimator and InCise™ Multileaf Collimator.

Purpose. To report our commissioning experiences of the CyberKnife M6 InCise™ Multileaf Collimator system.

Materials and methods. Accuray guidelines were used to conduct measurements. A detailed description of the equipment used, the mechanical alignment, the verification procedures, and the alignment of the detector motion with the radiation beam is described. Incise MLC testing was conducted as per Accuray procedure. Further MLC tests were developed to verify its feasibility under certain clinical settings.

Results. Our results were within the manufacturer specifications. Results for both the Sun Nuclear Edge detector and PTW SRS diode 60018 were found to be comparable. Measurement conditions specified by Accuray were sufficient; however the use of a reference chamber introduced additional noise for the continuous profile acquisitions. As compared to fixed and IRIS collimators, the incise MLC produced acceptable results with an average of 20% decrease in treatment delivery time.

Conclusions. Our results are amongst the first set of data reported on the InCise™ MLC and were within the manufacturer specifications. These results will be used to develop a benchmark reference for periodic Quality Control (QC).

Disclosure. Authors have nothing to disclose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.214

A PARALLEL SOLUTION FOR THE NUMERICAL STUDY OF TRANSCRANIAL MAGNETIC STIMULATION USING THE SCALAR POTENTIAL FINITE DIFFERENCES METHOD

Stefanos Mavros, Theodoros Samaras *

Department of Physics, Aristotle University of Thessaloniki, Greece
* Corresponding author.

Introduction. In transcranial magnetic stimulation (TMS) coils are used for the stimulation of human brain cortex. Numerous coil designs have been proposed and tested for different applications, both diagnostic and therapeutic.

Purpose. The objective of the current study is the fast and accurate calculation of the induced electric field and current density distribution inside the human head, in order to allow for the design of coils fulfilling specific treatment requirements.

Materials and methods. In order to avoid the intense computation of finite and boundary element meshes we developed a parallel in-house code, which implements a finite difference method. It calculates the magnetic scalar potential inside a human head model, given the electric conductivity distribution and the magnetic vector potential from 3D thin-wire coils. Tissue conductivity values can be derived either from volumetric data of realistic, voxelized human models, or from DICOM data segmentation. The numerical code was validated using analytical solutions of induced electric field in homogeneous conductive spherical models.

Results. The simulation gives information on focality, depth of stimulus, peak value and orientation of the induced electric field for different coil topologies. These characteristics of the TMS are different for various areas of the brain cortex. Furthermore, they show not only intra- but also inter-subject changes that can easily be quantified.

Conclusion. Our code can calculate the induced electric fields from TMS coils in the tissues of a human head model. The results can be derived within reasonable computational times and, therefore, the code can be used in the future to design coils with given specifications.

Disclosure. Authors declare that they have no competing interests.

http://dx.doi.org/10.1016/j.ejmp.2016.07.215

THERMOGRAPHIC IMAGE ANALYSIS IN SCOLIOSIS

A. Papapouliou [a,*], I. Kalatzis [a], N. Kalyvas [a], A. Skouroliakou [b]

[a] *Department of Biomedical Engineering, Technological Educational Institute of Athens, Greece*
[b] *Department of Energy Technology Engineering, Technological Educational Institute of Athens, Greece*
* Corresponding author.

Introduction. Infrared thermal imaging is a useful tool for assessing skin temperature distribution. Scoliosis could result in alterations of the symmetry of skin temperature pattern in the back area of the trunk.

Purpose. The purpose of the study is to develop thermographic image analysis techniques to obtain indices that characterize perispinal skin temperature distribution in children suffering from scoliosis.

Materials and methods. Thermograms of the back area from 40 children (30 suffering from different types of scoliosis and 10 serving as the control group) were obtained. Image analysis methods were performed to obtain quantitative indices to characterize homogeneity as well as temperature differences on the thermograms. Obtained indices were evaluated using statistical methods as to their ability to

differentiate between normal and pathologic cases and also related to type of scoliosis.

Results. Skin temperature distribution and homogeneity were quantitatively characterized. Temperature homogeneity is altered as a consequence of scoliosis, between the concave and convex sides of the spine curvature. Alterations tend to depend on the degree of scoliosis. The combination of parameters resulting from thermographic image analysis can effectively describe skin temperature pattern.

Conclusion. Image analysis techniques can reveal alterations of skin temperature distribution due to scoliisis. Thermography has the potential to serve as a complementary tool on the evaluation of scoliosis development and treatment.

http://dx.doi.org/10.1016/j.ejmp.2016.07.216

MULTIMODAL MAGNETIC RESONANCE IMAGING AND SPECTROSCOPY FOR PROSTATE CANCER SCREENING AND STAGING

Sophie Shermer [a,*], Ioannis Papadopoulos [a], Gizem Portakal [b], Jonathan Phillips [c], Rhodri Evans [c]

[a] *College of Science (Physics), Swansea University, Swansea SA2 8PP, United Kingdom*
[b] *Physics, Çukurova University, Adana, Turkey*
[c] *College of Medicine, Medical Imaging, Swansea University, Swansea SA2 8PP, United Kingdom*
* Corresponding author.

Introduction. Multi-modal magnetic resonance imaging (MRI) combining T2-weighted imaging with advanced techniques such as diffusion-weighted imaging (DWI), dynamic contrast and proton spectroscopy is a promising tool for prostate cancer screening, staging and treatment planning.

Purpose. Evaluation and optimization of multi-modal MRI techniques for prostate cancer screening, staging and treatment planning.

Materials and methods. Participants at high risk of prostate cancer underwent MRI scans including T2-weighted imaging, DWI using echo planar readout, 3D chemical shift imaging (CSI) and dynamic contrast enhanced imaging on a 3T Siemens scanner with data acquisition using spine and surface coils only. The results were analyzed using vendor-supplied and in-house software and scored according to the "Prostate imaging reporting and data system (PI-RADS)" scoring system.

Results. Despite the promise of spectroscopic biomarkers as a diagnostic tool, the CSI spectra acquired using standard sequences proved generally of insufficient quality for reliable biomarker estimation. Scanner produced metabolite maps proved highly variable and prone to misidentification of metabolites due to poorly resolved peaks. Apparent diffusion coefficient (ADC) maps appeared diagnostically more useful although low signal and noise floor issues at higher b-values also affected the estimation of ADCs and apparent kurtosis observed at low b-values, casting some doubt on the reliability of high kurtosis values reported in the literature for prostate diffusion kurtosis imaging (DKI).

Conclusion. Reliable quantification of spectroscopic biomarkers for prostate cancer requires improved protocols for CSI and spectroscopy. Apparent kurtosis observed for diffusion weighted images acquired at low maximum b-values are require further validation.

http://dx.doi.org/10.1016/j.ejmp.2016.07.217

GEOMETRIC, DVH AND PLAN QUALITY DIFFERENCES INDUCED FROM DIFFERENT PATIENT IMAGE REGISTRATION METHODS USED IN GAMMA KNIFE APPLICATIONS

G. Prentou [a], E. Pappas [a], E. Koutsouveli [b], P. Nomikos [b], E. Georgiou [a], P. Karaiskos [a,b,*]

[a] *Medical Physics Laboratory, Medical School, National and Kapodistrian University of Athens, 75 Mikras Asias, 11527 Athens, Greece*
[b] *Gamma Knife Center, Hygeia Hospital, Er. Stavrou 4 and Kifisias, 151 23 Athens, Greece*
* Corresponding author.

Introduction. In gamma knife (GK) radiosurgery, target and organs at risk (OARs) delineation is performed directly in MR images after they have been registered to the Leksell coordinate system (LCS). This registration can be performed either using the fiducial markers generated in the MR images by the N-shaped rods on the Leksell MR localization or through anatomical-based co-registration to corresponding registered (using the fiducial markers) CT images.

Purpose. To compare the two different methods used in GK radiosurgery for MR image registration and assess geometric differences and differences induced in plan quality and DVH-indices clinically used for plan evaluation and acceptance.

Materials and methods. A plan cohort formed by 20 patients with acoustic neuroma and pituitary adenoma treated using GK radiosurgery was used. Anonymized patient images, structures and dose distributions derived using the two different registration methods were imported to an independent software for dose distribution, DVH analysis and comparison.

Results. Geometric differences of the order of 1mm (mean value: 0.9 ± 0.4 mm) between the two different registration methods were observed. These differences can considerably influence plan evaluation indices of both target and OARs leading to dose differences of the order of 10% in D95% values of target volume (mean value: 8 ± 6%). Dose differences of similar degree were observed in D_{max} and D^{3}_{30mm} values of OARs.

Conclusion. Despite being relatively small (of the order of 1 mm), geometric differences between the two registration methods used in GK radiosurgery may affect considerably plan quality due to high dose gradients encountered in such applications.

http://dx.doi.org/10.1016/j.ejmp.2016.07.218

ASSESSING THE CALCULATION ACCURACY OF CLINICAL INDICES USING DICOM-CT BASED PHANTOMS APPLICABLE IN MODERN RADIOTHERAPY TECHNIQUES

L. Petrokokkinos [*], A. Moutsatsos, E. Pantelis, P. Karaiskos, E. Georgiou, P. Papagiannis

Medical Physics Laboratory, Medical School, National & Kapodistrian University of Athens, Greece
* Corresponding author.

Introduction. Treatment-plan evaluation and acceptance in radiotherapy is based on clinical indices, whose calculation depends on volume calculation of the target and surrounding OARs. Current external beam radiotherapy QA approaches include independent verification of clinical dose calculations on commercially available TPSs. These can be facilitated by dose distributions planned on virtual, DICOM-CT based phantoms.

Purpose. To assess the accuracy of TPS calculation algorithm aspects besides the dosimetric algorithm, using an independent verification scheme employing virtual phantoms.

Materials and methods. DICOM-CT based virtual phantoms were prepared employing geometrical shapes simulating typical OARs and target in a Head. The CT series were imported in commercially available TPSs used in modern radiosurgery/radiotherapy techniques. An irradiation scheme was planned bearing similar objectives/constraints in each case. The exported dose distributions along with the structures' volumes were used to independently calculate isodose curves and relevant clinical indices in MATLAB, which were compared with relevant TPS calculations in terms of accuracy.

Results & conclusion. In instances where TPS calculated dose grid is mapped on the CT grid, resolution rather than voxel size was found to be dominant. Otherwise the accuracy was found to depend on slice thickness and FOV, being however always less than 10%. Maximum deviations were observed for small structures with large angles relative to the discretization direction.

Disclosure. Research implemented within framework of Action "Supporting Postdoctoral Researchers" of Operational Program "Education and Lifelong Learning" (Action's Beneficiary: General Secretariat for Research and Technology), co-financed by ESF and Greek State.

http://dx.doi.org/10.1016/j.ejmp.2016.07.219

ABSORBED DOSE ESTIMATION TO FAMILY MEMBERS OF PATIENTS TREATED WITH RADIOIODINE FOR THYROID CANCER

K. Hatziioannou [a,*], K. Badiavas [a], E. Papanastasiou [b], I. Seimenis [c], G. Loukidis [a,c], I. Iakovou [d]

[a] *Department of Medical Physics, Papageorgiou General Hospital, Thessaloniki 56403, Greece*
[b] *Medical Physics Laboratory, Aristotle University, AHEPA University Hospital, Thessaloniki 54636, Greece*
[c] *Medical Physics Laboratory, School of Medicine, Democritus University of Thrace, 68100, Greece*
[d] *3rd Nuclear Medicine Department, Aristotle University, Papageorgiou General Hospital, Thessaloniki 56403, Greece*
* Corresponding author.

Introduction. Thyroid remnant ablation with radioiodine is a well-established treatment for patients with Differentiated Thyroid Carcinoma (DTC) following thyroidectomy. After 3–4 days of hospitalization, these patients return home, presenting a possible radiation hazard to their family members.

Purpose. This work aims at estimating the radiation burden to the cohabitants of DTC patients treated with radioiodine, after hospital release.

Materials and methods. 724 patients (183/541 men/women) suffering from DTC were treated with radioiodine activities ranging from 1850 to 9250MBq. Thyroid Hormone Withdrawal (THW) was applied in 305 patients (42.1%), whereas 419 (57.9%) patients were prepared with recombinant human TSH (rhTSH). Radioiodine T_{eff} was calculated from dose rate measurements at 1 and 2 m from the patients, performed at regular time intervals throughout their hospitalization. All patients were discharged 3–4 days post-treatment and were provided with written and oral instructions about radiation protection precautions. Patients were grouped according to their family status and radiation doses to their cohabitants were estimated based on appropriate exposure scenarios.

Results. Mean radioiodine T_{eff} was 15.3 h (range 1.9–37.5 h). T_{eff} in the rhTSH group was lower than the THW group (14.5 h and 17.1 h respectively, $p\langle 0.05$). Mean absorbed doses to all family members were estimated to be well below the corresponding dose constraints. Maximum dose to any child was slightly above 0.5 mSv, whereas maximum dose to any non-relative co-traveller was <0.2 mSv.

Conclusion. Provided necessary precautions are followed, radiation burden to the family members of DTC patients treated with radioiodine following thyroidectomy can be kept lower than the corresponding dose constraints.

http://dx.doi.org/10.1016/j.ejmp.2016.07.220

EVALUATION AND CORRECTION OF PATIENT-INDUCED DISTORTION IN MR IMAGES USED IN STEREOTACTIC RADIOSURGERY

Eleftherios P. Pappas [a,*], Ioannis Seimenis [b], Argyris Moutsatsos [a], Emmanouil Zoros [a], Evangelos Georgiou [a], Pantelis Karaiskos [a]

[a] *Medical Physics Laboratory, Medical School, National and Kapodistrian University of Athens, 75 Mikras Asias, 115 27 Athens, Greece*
[b] *Medical Physics Laboratory, Medical School, Democritus University of Thrace, 2nd building of Preclinical Section, University Campus, 68100 Alexandroupolis, Greece*
* Corresponding author.

Introduction. Geometric disposition in MR images is partly attributed to patient/object induced distortions stemming from susceptibility differences and chemical shift artifacts.

Purpose. To develop and implement a procedure for patient-induced distortion characterization, as well as to evaluate and compare three distortion correction schemes in MR images used for target localization in stereotactic radiosurgery.

Materials and methods. A specially designed phantom was modified to accommodate two cylindrical-shape volumes lying in close proximity to control points (CPs) for distortion correction. These volumes, simulating brain metastases, were filled with Gd-solution, while the rest phantom was filled with standard copper sulfate solution. Following 1.5T MRI, Gd-induced distortion was estimated using CPs disposition analysis. Moreover, three distortion correction schemes were employed: the phase difference map (based on a dual-echo gradient echo sequence), as well as the average-image and the signal integration techniques (both based on frequency-encoding direction reversal). Residual distortion was assessed by comparing with corresponding CT scans.

Results. Gd-induced distortion results in a structure disposition of the of the order of 1 mm. The phase difference method proves excellent at high-signal regions but lack of phase information at low-signal areas results in unwrapping errors. The signal integration method relies on the accuracy of edge detection and noise removal at low-signal areas. The average-image technique is a simple and efficient method to improve geometric accuracy in such applications.

Conclusion. Patient-induced distortion in MR images should be considered and corrected for high fidelity target localization. One should be aware of the relative advantages/drawbacks of alternative correction schemes.

http://dx.doi.org/10.1016/j.ejmp.2016.07.221

MODEL BASED QUANTIFICATION OF VISCERAL AND SUBCUTANEOUS ABDOMINAL ADIPOSE TISSUE VOLUME ON CT DATA

George E. Manios [a,*], Michael Mazonakis [a], Costas Voulgaris [b], Apostolos Karantanas [b], John Damilakis [a]

[a] *University of Crete, Faculty of Medicine, Department of Medical Physics, Heraklion, Crete, Greece*
[b] *University of Crete, Faculty of Medicine, Department of Radiology, Heraklion, Crete, Greece*
* Corresponding author.

Introduction. Abdominal obesity is associated with increased risk for morbidity. The quantification of visceral and subcutaneous abdominal fat volume is an important task.

Purpose. The present study aims to deploy and evaluate a method for the direct quantification of visceral (VAF) and subcutaneous abdominal fat (SAF) volume on CT data, based on a parallel trapezium geometrical model.

Materials and methods. VAF and SAF volume estimations were performed on abdominal CT scans from 10 consecutive patients through systematic slice sampling using a sampling intensity of 1/10. Areas of VAF and SAF were defined on 4 or 5 slices of the complete abdominal imaging with a fixed HU threshold. Thereafter, the volumes were calculated assuming a linear variation of the fat area between consecutive slices and a parallel trapezium shape for the tissues of interest. The obtained estimations were compared with respective volumes measured on the entire abdominal image sets by the reference technique of manual planimetry.

Results. VAF and SAF volumes measured by the proposed model did not statistically differ from the planimetric reference volumes (VAF: P = 0.543; SAF: P = 0.568). Correlations between the estimates of the two methods were found to be strong (VAF: r = 0.996; SAF: r = 0.988). The 95% limits of agreement between the two techniques, evaluated by Bland–Altman plots, were acceptable (VAF: −23.4%, +13.2%; SAF: −14.8%, +10.9%). The measuring process of the model-based method did not exceed 4 min per subject.

Conclusion. The adoption of the parallel trapezium model may reduce the user effort, providing accurate quantification of abdominal fat volumes.

http://dx.doi.org/10.1016/j.ejmp.2016.07.222

IMPLEMENTATION OF A QUALITY CONTROL PROTOCOL IN DIGITAL BREAST TOMOSYNTHESIS (DBT)

C. Stancampiano [a], L. Boschiroli [a], M. Campoleoni [b,*], L.O. Vismara [a]

[a] *ASST Nord Milano, Milan, Italy*
[b] *Fondazione IRCCS Ca' Granda Ospedale Maggiore Policlinico, Milan, Italy*
* Corresponding author.

Introduction. DBT is a new image system that needs to be evaluated in terms of image quality and performance.

Purpose. The aim of this work is the implementation of a quality control protocol in digital breast tomosynthesis with the aid of different phantoms and the comparison of results obtained on two Hologic Selenia Dimensions mammography systems.

Materials and methods. We analyzed several aspects of DBT systems such as X-ray generation, image receptor, image quality of the reconstructed images and dosimetry. We evaluated focal spot motion measuring projection, the exposure time and the time for a complete scan. We verified the stability of the exposure distribution over the projections. We also measured image receptor response, uncorrected defective detector elements and detector homogeneity on reconstructed images. We assessed in-plane projection and system MTF at different positions above the bucky with edge phantoms made of different materials and thicknesses. We also measured in-plane projection MTF using a tungsten wire. We evaluated Z-resolution with different diameter aluminum spheres and a tungsten wire. We made an artifact analysis with different phantoms and we assessed NNPS for the standard breast thickness at clinically selected parameters and with different doses. We investigated in-plane image quality in different noise conditions with CDMAM phantom. Finally, we assessed AGD for different breast thicknesses to be compared with AGD in FFDM for the same thicknesses and with AGD displayed by the system.

Results and conclusion. The performance of the two different equipment tested were comparable and close to the values found in literature.

http://dx.doi.org/10.1016/j.ejmp.2016.07.223

DIGITAL BREAST TOMOSYNTHESIS: MEAN GLANDULAR DOSE ESTIMATION USING MONTE CARLO CODE

E. Tzamicha [a,*], A. Dimitriadis [a], H. Gonis [c], E. Georgiou [a], V. Tsapaki [b], N. Yakoumakis [a], E. Yakoumakis [a]

[a] *Medical Physics Dpt., University of Athens, Greece*
[b] *Medical Physics Dpt. Konstantopoulio General Hospital of Nea Ionia, Attiki, Greece*
[c] *Medical Physics Dpt., Laiko Hospital of Athens, Greece*
* Corresponding author.

Introduction. 3D breast imaging using the technique of digital tomosynthesis may have the ability to improve the visualization of tissues which would be superimposed on a conventional mammogram. Early results with digital tomosynthesis are promising.

Purpose. To estimate mean glandular dose (MGD) from tomosynthesis imaging of the breast using Monte Carlo code and voxel phantom in standing posture.

Materials and methods. EGSnrc Monte Carlo code was used to simulate the interaction of photons with matter included a female voxel phantom (breast thickness of 2-8 cm and 50% glandular fraction). For the selection of X-ray spectrum, Automatic Exposure Control of Digital Breast Tomosynthesis was used. For each imaging condition were computed the glandular dose for the zero degree projection angle and the glandular dose for non-zero projection angles in 2° steps (scan range was −25° to +25°). The calculations were made for the X-ray spectra from a W target (tube voltage range 25–40 kV) filtered by Rh.

Results. Acquisition of a cranio-caudal view resulted in an MGD ranging from 0,318 to 2,347 mGy. For a breast with a thickness of 5 cm and 50% glandular fraction, the MGD was 2.061 mGy. There is no significant difference between the MGD for CC and MLO mode.

Conclusion. The results of this study are limited to providing the MGD to voxels phantoms of various thickness and only 50% glandular fraction. Future studies of the resulting dose from various glandular fractions are needed.

http://dx.doi.org/10.1016/j.ejmp.2016.07.224

GLANDULAR DOSE IN DIGITAL MAMMOGRAPHY: MONTE CARLO METHOD USING VOXEL PHANTOMS

E. Tzamicha [a,*], A. Dimitriadis [a], I.A. Tsalafoutas [c], E. Georgiou [a], V. Tsapaki [b], E. Yakoumakis [a]

[a] *Medical Physics Dpt., University of Athens, Greece*
[b] *Medical Physics Dpt., Konstantopoulio General Hospital of Nea Ionia, Attiki, Greece*
[c] *Athens General Anticancer-Oncology Hospital "Agios Savvas", Athens, Greece*
* Corresponding author.

Introduction. In breast, the glandular tissues are of high sensitivity to radiation and for this reason the mean dose to the glandular tissues is the most suitable dosimetric quantity. According to the IAEA protocols the Mean Glandular Dose (MGD) is derived from measurements of the incident Air Kerma at the surface of phantom and of the HVL, using tabulated conversion coefficients. Disadvantage of the method is the fact that for calculations use a very simple model of the breast.

Purpose. The purpose of this study is to assess the mean glandular dose in breast using Monte Carlo code and voxel phantoms in standing posture.

Materials and methods. Fifty different phantoms (breast's thickness from 2 to 8 cm for both CC and MLO modes and for glandular fractions in the range of 1.0–100%) and EGSnrc Monte Carlo code was used to calculate the interaction of photons with matter and estimate the MGD to the breast. The calculations were made for the x-ray spectra from a Mo target (tube voltage range 26–32 kV) filtered by Rh.

Results. For breast phantoms of 2.0–8.0 cm thick and 0.1–100% glandular fraction CC view acquisitions can result in a MGD of 0.452–2.572 mGy. In MLO view acquisitions MGD values ranged between 0.486 and 2.089 mGy. MGD is decreased with increasing glandularities and with increasing breast thickness in general.

Conclusion. The voxel phantoms is a powerful tool for the study of breast dosimetry. When there is some knowledge of the distribution of glandular tissue within the breast, the results of this study can be used to provide for individual cases.

http://dx.doi.org/10.1016/j.ejmp.2016.07.225

DEVELOPMENT OF THE AUTOMATIC ADJUSTMENT SYSTEM FOR THE APPROPRIATE RADIOPHARMACEUTICAL DOSE

E. Nakajima [a,*], H. Sato [a], G. Gotanda [a], S. Nakajima [a], K. Noguchi [b]

[a] *Department of Radiological Sciences, Ibaraki Prefectural University of Health Sciences, Ibaraki 300-0394, Japan*
[b] *Graduate School of Health Sciences, Ibaraki Prefectural University of Health Sciences, Ibaraki 300-0394, Japan*
* Corresponding author.

Introduction. In nuclear medicine examination, it is required to adjust appropriately radiopharmaceutical dose for patient by the patient's age and physique.

Purpose. In this study, the system for adjusting an appropriate radiopharmaceutical dose automatically was developed.

Materials and methods. This system of the developed can calculate appropriate radiopharmaceutical dose based on some guideline of scientific society, and adjust the quantity of solution in syringe by inputting some patient information and the substance of examination. The text data of the information about adjustment are saved on PC after adjusted the quantity of solution. Further the label for pasting on syringe is outputted with a printer. Also the difference between the quantity of solution in syringe filled at dispenser and the calculated volume has been investigated by using various type of radiopharmaceuticals.

Results. This system consisted of a barcode reader, a PC, a dispenser and a label printer. The size of dispenser is 130 mm × 380 mm × 285 mm, and the weight is 4730 g. The difference between the quantity of solution in syringe filled at dispenser and the calculated volume with PC was 2% or less, and it was shown that it is satisfactory in the practical needs.

Conclusion. This system adjusts automatically an appropriate radiopharmaceutical dose just inputting some patient information and the substance of examination. This system is efficient of a quality assurance of nuclear medicine examinations.

Disclosure. We have no disclosure and financial support.

http://dx.doi.org/10.1016/j.ejmp.2016.07.226

INDIVIDUAL MONITORING OF INTERNAL AND EXTERNAL CONTAMINATION IN DIAGNOSTIC OR THERAPEUTIC USE OF RADIONUCLIDES IN MEDICINE

G. Sarti *, F. Busca, F. Del Dottore, S. Sanniti

Medical Physics and Clinical Engineering Unit, AUSL della Romagna, Ghirotti Str 286, 47521 Cesena, FC, Italy
* Corresponding author.

Introduction. Monitoring of internal exposure and external contamination for nuclear medicine workers requires frequent measurements due to the short physical half- lives of most radionuclides used in this field.

Purpose. The aim of this study was to develop screening procedures performed at the workplace by local staff using standard laboratory equipment to detect whether potential intake has occurred following ISO/DIS 16637, draft 2014 "Monitoring and internal dosimetry for staff exposed to medical radionuclides as unsealed sources"

Material and method. Daily measurements of the ambient dose rate with scintillation detector and surface contamination monitor in front of the abdomen, thyroid and hands to detect whether potential intake or superficial contamination has occurred.

Results. For radionuclides with very short physical half-lives such as 99mTc and 18, screening procedures consist in performing daily measurements of the ambient dose rate in front of the abdomen. For pure beta emitters, i.e. 90Y the procedure consists in measuring hand contamination immediately after use. Such measurements (triage monitoring) do not enable to determine the committed effective dose, but are adequate to verify that a given threshold is not exceeded.

If the thresholds are exceeded, the survey (special monitoring) is will deepen (for example with in-vitro measurements in escreta samples)

Conclusions. Screening measurements for detecting potential radioactivity intake and surface contamination of the hands by nuclear medicine workers enable an acceptable monitoring practical and economic.

http://dx.doi.org/10.1016/j.ejmp.2016.07.227

A QUALITY ASSURANCE TEST FOR THE VALIDATION OF THE SPATIAL AND DOSIMETRIC ACCURACY OF A NEW TECHNIQUE FOR THE TREATMENT OF MULTIPLE BRAIN MESTASTASES

G. Kalaitzakis [a,g,*], N. Papanikolaou [b], T. Boursianis [a,g], E.P. Pappas [c,g], V. Lahanas [c,g], D. Makris [c,g], S. Stathakis [d], L. Watts [b], E. Efstathopoulos [e], T.G. Maris [a,g], E. Pappas [f,g]

[a] *Department of Medical Physics, University of Crete, Heraklion, Crete, Greece*
[b] *University of Texas Health Science Center, San Antonio, Texas, USA*
[c] *Medical Physics Laboratory, Medical School, National and Kapodistrian University of Athens, Athens, Attiki, Greece*
[d] *Cancer Therapy and Research Center, San Antonio, Texas, USA*
[e] *Second Department of Radiology, Medical School, National and Kapodistrian University of Athens, Athens, Attiki, Greece*
[f] *Department of Medical Radiologic Technology, Technological Educational Institute of Athens, Athens, Attiki, Greece*
[g] *R&D department at RTsafe S.A, Athens, Greece*
* Corresponding author.

Introduction. Radiation treatment planning, delivery and patient monitoring have been enriched with the increased use of MRI in radiotherapy clinical practice. MRI Polymer gel dosimetry has been proposed as a sensitive 3D dosimetry and QA tool.

Purpose. To develop and implement a QA test for the validation of spatial and dosimetric accuracy of a recently introduced dynamic conformal arcs technique for the treatment of multiple brain metastases.

Materials and methods. A 3D head avatar phantom with radiologically bone-equivalent material, filled with a sensitive polymer gel dosimeter was fabricated using anonymized CT scans of a specific patient. Irradiation was performed utilizing a single setup isocenter dynamic conformal arcs technique. A 1.5 T MRI clinical scanner was used as the reading device for dose quantification on gel material. Calculated and measured 3D dose distributions were compared in terms of spatial agreement as well as dose profiles, 3D gamma indices (5%/2 mm, 15% dose threshold), DVHs and dose-volume indices.

Results. A spatial agreement within 2 mm was observed between high dose regions and gel polymerized areas on MRI. Detected offset is a combination of MR-CT registration inaccuracies, set-up errors and MRI-related geometric distortions. Comparison of relative dose profiles showed good dosimetric agreement between the two datasets, while corresponding 3D gamma index passing rate reached 90%. Dosimetric agreement was further verified in terms of DVH comparison, especially for structures lying in high dose areas.

Conclusion. The 3D head avatar phantom and methods used, demonstrated efficacy in validating spatial and dosimetric accuracy of the specific radiotherapy technique.

http://dx.doi.org/10.1016/j.ejmp.2016.07.228

DOSIMETRIC TREATMENT PLANNING IN NUCLEAR MEDICINE THERAPIES

G. Sarti *, C. Fabbri, F. Busca, F. Del Dottore, S. Sanniti

Medical Physics and Clinical Engineering Unit, AUSL della Romagna, Ghirotti Str 286, 47521 Cesena, FC, Italy
* Corresponding author.

Introduction. Dosimetric studies are presented for the 90Y Radiopeptide therapy and the 131I thyroid treatments.

Purpose. In the ^{131}I thyroid treatments, the PreTherapeutic dosimetry has the purpose of identifying the optimal activity to be administered to the target in a single solution and in the metastases to evaluate the dose to red marrow. In the Radiopeptide therapy timed in 6–8 cycles, after the first and last cycle PostTherapeutic Dosimetric verification is performed.

Materials and methods. CT-PET and CT-SPECT systems were characterized for the activity quantification for dosimetrIc evaluation

- Sensitivity in cps/MBQ, reproducibility and linearity
- Partial volume post imaging correction, Recovery Coefficients curves with method isovolume ecc.
- Segmentation method of the targets with variable threshold at differents Lesion/Background ratios
- 3D uniformity analysis

Results. For lesions of known volume >5 ml and homogeneous distributions, the error associated with the evaluation of the activity may be regarded as not higher than 20%

- For lesions of volume not known, for target segmentation we use the method to variable threshold
- Verification of non-uniform 3D distributions of activity is affected by the low uniformity tomographic (30%).
- In 90Y PET/CT, quantification (MBq/ml) was in presence of a minimum detectable activity concentration (0,2–0,7 MBq/ml).

Conclusions. The error associated with the absolute quantification for the radioisotopes gamma emitter and for ^{90}Y (Bremsstrahlung SPECT-CT or low sensitivity PET-CT) is within about 20%.

http://dx.doi.org/10.1016/j.ejmp.2016.07.229

DOSE FROM TOMOSYNTHESIS OF THE BONY ANATOMY: COMPARISON WITH DIGITAL RADIOGRAPHY AND CT

M. Sutto [a,b], P.E. Colombo [a], A. Maldera [a,b], A. Torresin [a,*]

[a] *ASST Grande Ospedale Metropolitano Niguarda, Milano, IT, United States*
[b] *Università degli Studi di Milano, Milano, IT, United States*
* Corresponding author.

Introduction. Digital x-ray tomosynthesis can be employed to evaluate MSK/orthopedic conditions, such as revelation of subtle fractures, avoiding CT scan when standard exam is not sufficient.

Purpose. The purpose of this study is to evaluate effective doses from tomosynthesis of bony anatomy and compare them with doses from CT and digital radiography.

Materials and methods. We simulated tomosynthesis acquisitions of the hip, lumbar spine and shoulder using PCXMC20Rotation. Tomosynthesis projections were simulated using parameters from FujiFilm FDR AcSelerate with fixed mAs/projection, FID = 130 cm, 0.2 mm Cu filtration. For the same anatomical district, we also simulated radiographs with PCXMC2.0 and CT scans, performed on a Siemens Somatom Definition CT scanner, with CT-Expo (120 kVp, Z-current modulation). Effective doses were computed for all techniques.

Results. Hip tomosynthesis [60 projections (60° total angle), 5 mAs/projection, 80 kVp] delivers an effective dose of 0.8 mSv, 15 times the dose of an AP radiograph of the same anatomy and 20% of the dose delivered by CT [$CTDI_{vol,}$ mean = 9.5Gy].

Shoulder tomosynthesis [60 projections (60° total angle), 4mAs/projection, 65 kVp] delivers an effective dose of 0.4 mSv, 3 times the dose delivered by an AP radiograph of the same anatomy and 20% of the dose delivered by CT [$CTDI_{vol,}$mean = 12Gy].

Finally, lumbar spine tomosynthesis [45 projections (40° total angle), 12.5 mAs/projection, 100kVp] delivers an effective dose of 1.8 mSv, 8 times the dose of a LL+AP radiograph and 22% of the dose delivered by CT [$CTDI_{vol,}$mean = 17Gy].

Conclusion. Dosimetric evaluation of radiographic tomosynthesis for bony anatomy shows that it spares 80% of the dose of a CT scan.

http://dx.doi.org/10.1016/j.ejmp.2016.07.230

DBT IMAGE QUALITY INVESTIGATION: A PHANTOM STUDY

A. Maldera [a,b], E. Artuso [a,b,*], P.E. Colombo [a], A. Torresin [a]

[a] *ASST Grande Ospedale Metropolitano Niguarda, Milano, IT, United States*
[b] *Università degli Studi di Milano, IT, United States*
* Corresponding author.

Introduction. Digital breast tomosynthesis (DBT) is a widely used imaging modality employing a limited number of projections to reconstruct the breast volume. Despite its large use in clinical practice, an objective evaluation of DBT reconstructed imagesis a hard

task since the majority of the systems produces and exports images strongly affected by the post processing algorithm.

Moreover only few phantoms are available for this need.

Purpose. The aim of this study is to investigate how, a newly developed phantom (Tomophan®), can be used to assess image quality of unprocessed images exported by Fujifilm® system.

Materials and methods. The system studied allows exporting raw reconstructions. Moreover, it offers two acquisition modalities: standard and high resolution (ST/HR-mode).

The phantom was exposed in AEC mode with both modalities. Tomophan® allows different IQ analysis to be performed. We chose to investigate in plane and cross plane spatial resolution by adapting standard metrics: MTF and PSF. For these two parameters, significant differences were expected. Moreover a CNR measure was done.

Results. Results obtained using the TomophanQA®software confirm that acquisition in HR-mode produces better results in terms of in plane resolution [$MTF_{0.5}$(HR/ST) = 2.7/1.8 mm^{-1} (x-direction) $MTF_{0.5}$(HR/ST) = 1.6/1.3 mm^{-1} (y-direction)] and cross plane z-resolution [FWHM(HR/ST) = 1.6/4.3 mm].

CNR evaluation demonstrates that in HR-mode a doubled entrance dose is needed to get the same CNR value as ST-mode.

Conclusion. Objective image quality assessment in DBT could be easly assessed with the Tomophan® phantom. Caution is recommended when performing this analysis on processed image due to non linear signal transformation of post processing.

Disclosure. Nothing to disclose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.231

PATIENT SURFACE AND ISOCENTER DOSE IN FLUORO-CT

J. Pereira [a,b,*], M.F. Pereira [a,b], S. Sarmento [c,d], A.D. Oliveira [a,b], J.G. Alves [a,b], M.J. Sousa [e], L. Cunha [c,d], A.G. Dias [c,d], B. Mendes [c,d], J.V. Cardoso [a], L.M. Santos [a], M. Gouvêa [f], J.A.M. Santos [c,d]

[a] *Universidade de Lisboa (UL), Instituto Superior Técnico (IST), Laboratório de Protecção e Segurança Radiológica (LPSR), Estrada Nacional 10 (ao km 139, 7), 2986-066 Bobadela LRS, Portugal*
[b] *UL-IST, Anav (C2TN), Bobadela LRS, Portugal*
[c] *Instituto Português de Oncologia do Porto Francisco Gentil, EPE (IPOPFG E.P.E.), Serviço de Física Médica, Rua Dr. António Bernardino de Almeida, 4200-072 Porto, Portugal*
[d] *IPOPFG E.P.E., Centro de Investigação, Porto, Portugal*
[e] *IPOPFG E.P.E., Serviço de Radiologia de Intervenção, Porto, Portugal*
[f] *IPOPFG E.P.E., Serviço de Radiologia, Porto, Portugal*
* Corresponding author.

Introduction. In CT exams the quantities used to estimate the dose, for example, the CTDI, the $CTDI_{vol}$ and the DLP, are related with isocenter and peripheral phantom measurements. However, during fluoro-CT (CTF) scans executed in the IPOPFG a set of dose profile measurements lead to the conclusion that the patient skin surface dose can be an important dose parameter usually not considered.

Purpose. The aim of this work was to perform measurements of dose profiles at the isocenter of the gantry and at the surface of patients undergoing CTF procedures allowing comparison of the dose levels.

Materials and methods. The measurements were performed using a Gafchromic XRQA film (International Speciality Products, Wayne, NJ, USA) and a 4-slice Toshiba Asteion CT-scanner, operated with 8-mm beam collimation and 0.75 s rotation time.

Results. Several dose profiles were obtained free-in-air at the isocenter and at patient surface. Due to the specificities of the CFT practice it was found that in the body region exposed to radiation the dose level can reach rather high values, not described by the CTDI or DLP quantities which are referenced to the isocenter dose levels.

Conclusion. The comparison between isocenter and surface dose profiles pointed out the need to revise the CTDI concept in order to consider patient skin dose which is, in general, positioned out of the axis of rotation of the X-ray tube rotation.

http://dx.doi.org/10.1016/j.ejmp.2016.07.232

RAMAN OPTICAL ACTIVITY APPLIED TO BIOLOGICAL SYSTEMS

Diego Mendes dos Santos [a], Marcella Cogo Muniz [a], Gustavo Gonçalves Dalkiranis [a], Fernando Costa Basílio [a], Adriano de Queiroz [a], Alexandre Marletta [a], Renata Cristina de Paula [a,b], Sydnei Magno da Silva [b], Raigna Augusta da Silva Zadra Armond [a,*]

[a] *Institute of Physics from Federal University of Uberlândia, Brazil*
[b] *Institute of Biomedical Sciences from Federal University of Uberlândia, Brazil*
* Corresponding author.

Introduction. Raman Optical Activity (ROA) provides information about of chirality in molecules with high relevance for health area. In the present work, we implemented new technique to measure the ROA spectra of chiral molecules per Raman Spectroscopy by Ellipsometry (RaSE). ROA quantifies the small difference in the intensity of Raman scattering for chiral molecules in incidence of polarized circularly laser light and RaSE measures the Raman scattering by Stokes parameters, which describe the polarization state of light.

Purpose. Study of *L. infantum* parasite the etiological agent of Visceral Leishmaniasis by RaSE technique.

Materials and methods. DNA sample of L. *infantum* was extracted of a crop from parasite in the promastigote phase in according to the manual procedure of extraction kit user NucleoSpin® Tissue – Genomic DNA from Tissue, Chapter. 5: Standard protocol for human or animal tissue and cultured cells. This procedure provided us a DNA concentration $S = 17{,}5$ ng/μL and $V = 50$ μL. RaSE spectra were obtained as excitation light linear in polarization set up that can be decomposed in two circular polarization to obtain Stokes parameters that describes the signal ROA.

Results. Raman spectra showed vibration bands in the range of 400–1700 cm^{-1} corresponding to DNA constituents. S3 Stokes parameter indicated a chirality preponderance of LCP light over RCP light.

Conclusion. Raman spectra assigned vibration mode of DNA and indicated a chirality preponderance. We will study *L. infantum* by RaSE-ROA in order to obtain information on the structure that is lost with the use of other techniques.

http://dx.doi.org/10.1016/j.ejmp.2016.07.233

FETAL DOSE ESTIMATION IN A CASE OF UNINTENDED PREGNANCY DURING BRAIN RADIOTHERAPY

R. Figueira *, T. Reis, A. Carvalho, C. Souto, M. Sousa, A. Monteiro, D. Inácio, L. Osório

Serviço de Radioterapia, Centro Hospitalar São João, Porto, Portugal
* Corresponding author.

Introduction. Pregnancy during radiotherapy is not a common clinical situation. We describe a fetal dose estimation necessary before starting a course of radiotherapy for a brain tumor in a patient unexpectedly pregnant at the time scheduled for the beginning of treatment.

Purpose. To estimated the dose to the fetus during the programmed course of radiotherapy before deciding if the patient should advance with the treatment or not.

Materials and methods. The initial plan was optimized to avoid fetus exposure to radiation without compromising dose to the target volume. We considered the real patient distances between plan isocenter and 3 critical points: uterus fundus, umbilical and pubis. Using an anthropomorphic phantom and solid water slabs we positioned an ionizing chamber at different depths, corresponding to these points, and determined the estimated doses for the complete course of radiotherapy.

Results. The maximum dose value measured was 2,5 cGy, well below the 10 cGy reported tolerance value. After explaining the situation to the patient and the risks involved, a decision was taken to go on with the treatment as planned. A set of 3 pairs of TLD dosimeters was used over the patient belly, in these same positions during every treatment fraction. The TLDs readings at the end confirmed the estimated values measured in the phantom.

Conclusion. The previous evaluation of the estimated dose to the fetus allowed the patient to successfully complete the radiotherapy course. The pregnancy went on normally and the patient delivered a healthy child.

Disclosure. The authors have nothing to disclose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.234

RADIOACTIVE WASTE MANAGEMENT OF Y-90 MICROSPHERES USED FOR RADIOEMBOLIZATION TECHNIQUE

A. Carvalho *, R. Figueira, T. Reis, C. Souto, M. Sousa

Serviço de Medicina Nuclear, Centro Hospitalar de São João, Porto, Portugal

* Corresponding author.

Introduction. The radioembolization technique is used for the treatment of liver tumors, with the implantation of glass microspheres doped with yttrium-90 (Y-90). Specific radiation protection procedures, particularly those regarding radioactive waste managements are required. Several publications indicate the presence of radionuclidic impurities in those microspheres, resulting in additional radiation safety concerns, with possible impact on the minimum radioactive waste storage time.

Purpose. Determination of the effective half-life time of Y-90 radioactive waste samples, in order to establish a minimum storage time before discharge, and the identification of potential radionuclide impurities of Y-90.

Materials and methods. Exposure rate and surface contamination measurements were performed on plastic containers containing residues from Y-90 microsphere delivery procedures. The gamma energy spectrum analysis of the decayed Y-90 samples was also obtained using a NaI(Tl) detector.

Results. Waste emission values higher than those expected for a pure Y-90 decay were measured, even after 30 days after the procedure, suggesting the presence of impurities. An larger effective half-life time days was determined when compared with pure Y-90. Spectrum peaks were observed suggesting the presence of Y-88.

Conclusion. For samples decayed up to 3 months, these findings impose an increase of the waste decay time for Y-90 waste containers when compared with pure Y-90. Spectrum analysis suggests the presence of Y-88. Further analysis are being made in samples decayed greater than 6 months, that include the spectrum acquisition in order to assess the presence of other potential impurities.

Disclosure. The authors have noting to disclose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.235

INVESTIGATION OF OPTIMAL BEAM MARGINS FOR LINAC-BASED STEREOTACTIC EXTRACRANIAL RADIOTHERAPY (SBRT) WITH VMAT TECHNIQUE: A "PARETO FRONTS" APPROACH

Savino Cilla [a,*], Anna Ianiro [a], Francesco Deodato [a], Gabriella Macchia [a], Angelo Piermattei [b], Vincenzo Valentini [a,b], Alessio G. Morganti [c]

[a] *Fondazione di Ricerca e Cura "Giovanni Paolo II", Università Cattolica del Sacro Cuore, Campobasso, Italy*

[b] *Policlinico Universitario A. Gemelli- Università Cattolica del S. Cuore, Roma, Italy*

[c] *DIMES Università di Bologna – Ospedale S.Orsola Malpighi, Bologna, Italy*

* Corresponding author.

Introduction. In stereotactic body radiotherapy (SBRT), the objectives of ablative high-dose to the tumour and minimal dose to the surrounding normal tissues are inherently in conflict. Pareto fronts are a powerful mathematical strategy to formalize the trade-off between a given set of mutually contradicting objectives.

Purpose. To determine the optimal block margin and prescription isodose for both optimal target coverage and normal tissue sparing in SBRT treatments of liver metastases using VMAT technique.

Materials and methods. Three spherical-shaped targets (PTVs = 20, 55 and 101cc) were selected. A single fraction dose of 26 Gy was prescribed (PD). VMAT plans were generated with Ergo++ TPS using a 6 MV single arc. Pareto fronts based on (i) different MLC block margin around PTV (ranging from +4 mm to −2 mm) and (ii) different prescription isodose surface (IDS) ranging from 50% to 100% of PD were produced. For each block margin, the greatest IDS fulfilling the two criteria: 95% and 99% of PTV volume reached 100% and 90% of PD, respectively, was considered as providing the optimal clinical plan for PTV coverage. Liver Dmean were used against the PTV coverage (1-V100) to generate the fronts. Conformity (CI = V100/PTV), gradient (GI = V50/V100) and homogeneity (HI = D2%/PD) indexes were calculated to compare different plans

Results. About 300 plans were calculated to generate the fronts. The fronts for 1mm MLC margin provided the best plans in terms of minimal liver irradiation; optimal clinical plans were obtained for IDS equal to 77–82%. GI shows a U-shaped behaviour with respect to prescribed IDS, CI and HI indexes, with minimum values at 1mm for all metrics. The location of these minimal points was found independent of tumour dimensions. Minimal GI values were found at HI values approximately equal to 1.3.

Conclusion. Pareto fronts provides a rigorous strategy to choice clinical optimal plans in SBRT treatments. We show that a 1 mm MLC block margin provides the best results with regard healthy liver tissue irradiation and steepness of dose fallout.

http://dx.doi.org/10.1016/j.ejmp.2016.07.236

QA OF ELEKTA AGILITY MLC WITH PORTAL SYSTEM

Fernando Tato de las Cuevas *, Pablo Domingo Fernandez

Medical Physics Department, Hospital Universitario de Canarias, Tenerife, Spain

* Corresponding author.

Introduction. Quality assurance (QA) of Multileaf collimation (MLC) is one of the main points of any LINAC QA program. The Agility MLC has different properties than most of the MLCs, like less interleaf transmission.

Purpose. Make a MATLAB (Mathworks, Inc.) software for MLC quality assurance (QA) using the electronic portal imaging device (EPID) in an Elekta Synergy with Agility head and make this process as fast as possible.

Materials and methods. A software was developed in MATLAB (Mathworks, Inc.) with some changes respect other common methods:

- To localize the isocenter projection is used an Elekta tray with radiopaque marks, instead the open field radiation center method, because of being faster.
- To correct the collimator angle is used the filtered back projection method, because is not possible using the interleaf leakage, as this MLC has low interleaf transmission.
- Elekta iCOMCAT software was employed to generate the strip-test with multiple segments as a unique treatment, as is much faster than creating and irradiating a beam for each segment. With iView Elekta software is difficult to acquire a complete image of each full segment as iView is not fast enough, so fluency corrections of these segments were performed, in order to avoid erroneous pixel values that give erroneous leaf positions.

Results. The differences in leaf positions compared with other method are beyond 0.1 mm. The acquisition and analysis for one strip-test take less than 4 min.

Conclusion. The methodology employed analyzes a MLC strip-test in an Elekta LINAC in a fast and precise way.

Disclosure. None.

http://dx.doi.org/10.1016/j.ejmp.2016.07.237

QUALITY ASSURANCE OF DOSIMETRIC PARAMETERS WITH VARYING GANTRY ANGLE WITH ARCCHECK

Fernando Tato de las Cuevas *, Pablo Domingo Fernandez

Medical Physics Department, Hospital Universitario de Canarias, Tenerife, Spain

* Corresponding author.

Introduction. Quality assurance of dosimetric parameters potentially affected by gantry angle in a lineal accelerator (LINAC) is an important task in any quality assurance (QA) program, more with techniques like volumetric art-therapy (VMAT). The accessibility to the raw data of the ArcCheck (Sun Nuclear, FL) gives to this phantom the potential to do LINAC QA.

Purpose. Check the constancy of various LINAC parameters with varying gantry angle: open field beam shape, beam quality, monitor unit system (MUS), wedge factor and wedge angle. These parameters are not properly analyzed by ArcCheck software.

Materials and methods. The LINAC to perform the QA is an Elekta Synergy. For each gantry angle (0°, 90°, 270° and 180°) is irradiated an open and a wedge field. The beam data is collected by the ArcCheck software and exported in dose format to an Excel worksheet. To check the beam shape and MUS, an Excel macro processes the data of the diodes nearest to the crosshair projection. Two diodes at different depths are used to check the beam quality. These parameters are compared with the LINAC reference state.

Results. The deviations of the different parameters obtained from ArcCheck measures are consistent with those obtained with other equipment (less than 1% different between them). The measurement, data import and calculation time in Excel worksheet takes less than 5 min.

Conclusion. The implemented software makes the ArcCheck an adequate phantom to perform LINAC QA of diverse dosimetric parameters. This machine QA is also a very fast process.

Disclosure. None.

http://dx.doi.org/10.1016/j.ejmp.2016.07.238

ALGORITHM FOR QUANTIFICATION OF PULMONARY SEQUELAE IN CHEST X-RAY

Marcela de Oliveira [a,*], Guilherme Giacomini [a], Matheus Alvarez [a], Paulo Marques Câmara Pereira [b], Sergio Marrone Ribeiro [b], Diana Rodrigues de Pina [b]

[a] *Department of Physics and Biophysics/Biosciences, Institute of Botucatu, São Paulo State University (UNESP), Botucatu, Brazil*
[b] *Department of Tropical Diseases and Diagnoses Imaging/Botucatu Medical School, São Paulo State University (UNESP), Botucatu, Brazil*
* Corresponding author.

Introduction. Tuberculosis (TB) is one of the oldest infectious diseases in the world. Even after effective treatment, TB leaves pulmonary sequela that compromises patients' life quality. Sequelae evaluations are usually performed subjectively through chest X-ray radiographs. While new treatments for TB are being developed, the necessary tools for monitoring patients in treatment and quantification of the sequelae remain limited.

Purpose. The main purpose was to objectively quantify the pulmonary impairment pre- and post-treatment of patients with pulmonary TB through an computational algorithm.

Materials and methods. We used 20 X-ray exams, pre- and post-treatment of 10 patients with TB. Lung area and affected regions were manually segmented in both postero-anterior (PA) and profile projections.

We selected regions-of-interest in both affected and normal regions and obtained by the Signal Difference to Noise Ratio (SDNR). Values of SDNR were related to the relative thickness of lung affected in CT scans. Thus the algorithm used this relationship to estimate the relative thickness of pulmonary impairment from X-ray exams PA projection.

Results. We observed a mean pulmonary impairment of 5.21% (±3.35) before treatment and 1.26% (±0.72) after treatment. This shows a reduction of 72.54% between pre- and post-treatment.

Conclusion. The computational algorithm allows the quantification of pulmonary impairment through chest X-ray radiographs. Detection and quantification aided by computer systems is of great importance for reliable assessment of pulmonary involvement, assisting radiologists in the diagnosis. Future studies will help the choice of the correct treatment for TB patients.

Disclosure. The authors declare that there is no conflict of interest.

http://dx.doi.org/10.1016/j.ejmp.2016.07.239

LARGE SCALE ADOPTION OF STATISTICAL PROCESS CONTROL (SPC) FOR VOLUMETRIC MODULATED ARC THERAPY PATIENT-SPECIFIC QUALITY ASSURANCE: A RETROSPECTIVE ANALYSIS ON 1400 PATIENTS

Savino Cilla [a,*], Anna Ianiro [a], Francesco Deodato [a], Gabriella Macchia [a], Marica Ferro [a], Vincenzo Picardi [a], Angelo Piermattei [b], Alessio G. Morganti [c], Vincenzo Valentini [a,b]

[a] *Fondazione di Ricerca e Cura "Giovanni Paolo II", Università Cattolica del Sacro Cuore, Campobasso, Italy*
[b] *Policlinico Universitario A. Gemelli- Università Cattolica del S. Cuore, Roma, Italy*
[c] *DIMES Università di Bologna – Ospedale S.Orsola Malpighi, Bologna, Italy*
* Corresponding author.

Introduction. Statistical Process Control (SPC) is a tool widely used in industrial engineering for monitoring, controlling and, ideally, improving a process through statistical analysis. This technique

can be applied to quality assurance (QA) practice in radiotherapy in order to characterize the treatment process variability.

Purpose. To apply SPC strategy to our routine VMAT pre-treatment verification QA.

Materials and methods. In the last years, more than 1400 patients were treated with Elekta VMAT at our institution. Plans were re-grouped according to treatment technique and disease sites: (1) 611 high-modulated complex SIB treatments (head-neck, brain, gynecological, ano-rectal; (2) 348 prostate treatments and (3) 445 liver, lung and other metastasis treated with extracranial stereotactic radiotherapy (SBRT). Groups 1 and 2–3 plans were optimized with Oncentra Masterplan (dual-arc) and Ergo++ (single arc) TPS. A total of 4030 dose measurements were performed with the PTW Seven29 array/Octavius phantom, both on coronal and sagittal planes. Doses comparison were evaluated using 3%/3 mm γ-analysis. Two metrics were evaluated: (a) points-percentage with g-value less than one (g%) and (b) mean gamma (gmean). Clinical specifications were: $g\%$ >90% and gmean <0.67. Shewhart charts were used to calculate the central (CL), upper control (UCL) and lower control limits (LCL). The processes capability was evaluated by means of Cpk indexes.

Results. γ pass-rate values significantly depend on plan complexity. For $g\%$, CL and LCL were 93.9% and 89.4%, 99.1% and 96.6%, and 99.3% and 97.6%, for group 1, 2 and 3 respectively. For gmean, CL and UCL were 0.416 and 0.585, 0.361 and 0.557, and 0.304 and 0.427, for groups 1, 2 and 3 respectively. In all cases, the control limits are well within the clinical specifications. The Cpl/Cpu capability indices for $g\%$ and gmean resulted equal to 0.61 and 1.06 in group 1; 2.59 and 1.12 in group 2; 3.77 and 2.10 in group 3, respectively. $g\%$ process for group 1 was not capable at 3%/3 mm, but with 5% – 3 mm specification for g%, CL and LCL resulted 98.3% and 96.2% and Cpl was 2.84.

Conclusion. SPC is useful to quantifiably demonstrate the QA process conformance to clinical specifications.

http://dx.doi.org/10.1016/j.ejmp.2016.07.240

ON THE USE OF PRESAGE DETECTORS FOR THE DOSIMETRY OF HELICAL TOMOTHERAPY SMALL FIELDS

A. Moutsatsos [a,*], E. Pantelis [a,b], C. Antypas [b], L. Petrokokkinos [a], E.P. Pappas [a], E. Zoros [a], P. Pantelakos [b], E. Georgiou [a], P. Karaiskos [a]

[a] *Medical Physics Laboratory, Medical School, National and Kapodistrian University of Athens, Greece*
[b] *CyberKnife & TomoTherapy Department, Iatropolis Clinic, Ethnikis Antistasis 54-56, Chalandri, Athens, Greece*
* Corresponding author.

Introduction. The use of small fields in modern radiotherapy techniques has stretched the importance of verifying the delivered 3D dose distributions characterized by steep dose gradients and complex shapes. In the absence of an ideal dosimeter a multi-detector approach is essential.

Purpose. To apply 3D PRESAGE dosimetry for the verification of helical TomoTherapy dose distributions and assess possible corrections of the A1SL ion-chamber response for a head-and-neck plan.

Materials and methods. A plan-class specific reference field (f_{pcsr}), as recommended by TG-148, and a typical head-and-neck irradiation plan were delivered to a PMMA phantom incorporating appropriate inserts for A1SL ion-chamber, film and PRESAGE dosimeters. Irradiation of f_{pcsr} permitted the evaluation of the corresponding k (Q_{pcsr}, f_{pcsr}; Q_{ref}, f_{ref}) correction factor for the A1SL chamber, through comparison to PRESAGE measurements. PRESAGE dosimetry results for the head-and-neck plan, were compared to TPS calculations and corresponding measurements from 1D/2D dosimeters commonly employed for TomoTherapy QA purposes.

Results. Although within experimental uncertainties A1SL chamber was found to overestimate the dose at f_{pcsr} by almost 2%, in agreement with published results using alanine dosimeters. Agreement within uncertainties was also observed between planned and presage-measured dose distribution for the head-and-neck plan, exhibiting local gamma index passing rates >90%. When placed within a homogeneous dose distribution, the response of A1SL seemed to be correction free.

Conclusion. Besides water equivalence and exquisite spatial resolution, necessitated for small field dosimetry and determination of appropriate correction factors, PRESAGE dosimeters offer the advantage of 3D dose verification.

Disclosure. Research supported by an IKY fellowship of excellence for postdoctoral research in Greece–Siemens Program.

http://dx.doi.org/10.1016/j.ejmp.2016.07.241

SWOT ANALYSIS OF THE CURRENT SITUATION OF MEDICAL PHYSICISTS IN PORTUGAL

R. Figueira [a,b,*], E. Poli [a,c], J. Isidoro [a,d]

[a] *Divisão de Física Médica da Sociedade Portuguesa de Física, Portugal*
[b] *Centro Hospitalar de São João, Porto, Portugal*
[c] *Centro Hospitalar Lisboa Norte, Portugal*
[d] *Centro Hospitalar e Universitário de Coimbra, Coimbra, Portugal*
* Corresponding author.

Introduction. During 2015 DFM-SPF (Medical Physics Division of the Portuguese Physics Society) conducted a survey for the characterization of the Medical Physics situation in Portugal. Among other questions participants were asked to identify the Strengths, Weaknesses, Opportunities and Threats (SWOT) of the profession.

Purpose. The purpose was to conduct a SWOT analysis of the current situation of Medical Physics in Portugal contributing for the strategic development of the profession and for the identification of potential actions to be taken to improve the situation.

Materials and methods. Based on the responses from 83 portuguese medical physicists, a SWOT matrix was created to identify common Strengths, Weaknesses, Opportunities and Threats. The analysis was directed to design appropriate actions that could successfully lead to strategic outcomes.

Results. The most commonly identified Strengths were the dedication, commitment and competence of the professionals. The Weaknesses were the lack of professional recognition/regulation and, the lack of training/qualification of new professionals. As Opportunities, the most frequently mentioned were the implementation of the new BSS directive and the growing need for medical physicists due to new installations. The pressure from other professionals like radiographers or biomedical engineers sometimes employed to perform medical physicist's tasks, the coming of foreigners with recognized qualifications and the unclear legislation, were the main Threats mentioned.

Conclusion. A SWOT analysis has been employed with success and in this case was a useful tool in providing guidance to the portuguese medical physicists to develop a strategic action plan to improve the current situation.

Disclosure. The authors have nothing to disclose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.242

A RETROSPECTIVE STUDY FOR OCCUPATIONAL EFFECTIVE DOSES AMONGST AND WITHIN EMPLOYEES OF A NUCLEAR MEDICINE DEPARTMENT

Psarouli Efthymia

Medical Physics Dept., Ippokratio General Hospital of Thessaloniki, Greece

Routine monitoring of occupational radiation exposure is done primarily to demonstrate compliance with dose limits.

Analysis of past and present dose records provides a useful tool in the management of institutional radiation safety programs.

In this study, an analysis of annual dose records from 1995 to 2015 is performed with the data from a nuclear medicine department where both radionuclide treatment and diagnostic imaging are done at a large scale. All radiation employees in the department were educated on their own subjects and experienced in their duties. They have been receiving periodic trainings about radiation protection. In this way, the annual effective dose values are limited to the minimum.

Large variation in the mean annual dose exists among the different occupational groups. Among the workers, technologists received the largest annual effective dose. The study evaluates differences in occupational exposure within this group of workers performing the same procedure, and the efficacy of safety protocols.

Continuing education and optimization of working technics can help minimize the radiation exposure of the workers. Limits can be assured to remain well below the acceptable values by incorporating the mechanism of job rotations.

http://dx.doi.org/10.1016/j.ejmp.2016.07.243

PATIENT SPECIFIC PLAN VERIFICATION OF A VMAT PLAN USING 3D POLYMER GEL DOSIMETER IN A PHANTOM REPRODUCING PATIENT ANATOMY

P. Karaiskos [a,*], G. Kollias [a], E. Koutsouveli [a], C. Paraskevopoulou [a], T.G. Maris [b], T. Boursianis [b], E. Pappas [c]

[a] *Medical Physics Department, Hygeia Hospital, Athens, Greece*
[b] *Medical Physics Department, University of Crete, Heraklion, Greece*
[c] *Medical Radiologic Technology Department, Technological Educational Institute of Athens, Greece*
* Corresponding author.

Introduction. Patient specific plan verification becomes necessary in the advent of complex treatment delivery options with current linear accelerator technology.

Purpose. To use a patient-specific end-to-end quality assurance approach for plan verification and overall accuracy evaluation of a Volumetric Modulated Arc Therapy (VMAT) irradiation.

Materials and methods. Patient CT-scans were used to construct a phantom reproducing the patient anatomy in terms of external surface and bone structures using 3D-printing technology. The phantom was filled with a polymer-gel dosimeter and utilized to accurately reproduce every link in the treatment chain and irradiated using a 6 MV flattening filter free (fff) Elekta Versa linear accelerator. Upon irradiation, the phantom was MRI-scanned using a specially designed T2 pulse sequence and T2-maps were converted to 3D relative dose measurements. MR-images were imported to Monaco-TPS and co-registered to patient CT-images. TPS dose calculations were exported and used for dose comparison with measurements in an independent software.

Results. Radiation-induced polymerization area was clearly evident in the T2-images and found to coincide to the high-dose target area while organs at risk (OARs) were adequately spared in agreement with the TPS dose distribution. In addition, a quantitative evaluation was performed by comparing measured and TPS-calculated 3D dose-maps in terms of dose distributions, gamma index maps and Dose Volume Histogram (DVH) indices clinically used for plan evaluation and acceptance.

Conclusion. A patient-specific plan verification method offering the unique characteristic of providing 3D-dose distribution measurements in patient anatomy, including DVHs was implemented and revealed accurate delivery of the VMAT plan.

http://dx.doi.org/10.1016/j.ejmp.2016.07.244

MONTE CARLO SIMULATION OF A 6 MV VARIAN LINAC PHOTON BEAM USING GEANT4-GATE CODE

P. Gonias [a,*], P. Zaverdinos [b], G. Loudos [c], C. Kappas [a], K. Theodorou [a]

[a] *Medical Physics Department, Medical School, University of Thessaly, Biopolis 41110 Larissa, Greece*
[b] *Medical Physics Department, Metropolitan Hospital, Athens, Greece*
[c] *Department of Medical Instruments Technology, Technological Educational Institute of Athens, Athens 12210, Greece*
* Corresponding author.

Introduction. Monte Carlo simulation of radiation transport is considered to be one of the most accurate methods of radiation therapy dose calculation. Various codes have been used during the years and have been validated for clinical photon beams. GEANT4 Monte Carlo simulation code is originally created for high energy physics and GATE package for the simulation of SPECT/PET systems. New platform of GATE incorporate simulation processes for clinical photon beams by linear accelerators.

Purpose. The aim of this work is the validation of a GEANT4-based GATE Monte Carlo (MC) 6 MV photon beam delivered by a medical linear accelerator.

Materials and methods. The head of the medical linear accelerator (VARIAN CLINAC 23 EX) of the Metropolitan Hospital was simulated based on the manufacturer's detailed information using the Gate v.7.0 GEANT4 MC code. Two-phase simulation process has been followed: calculation of the phase space (PH) from the linac head and PH transport to a water phantom. The results were compared with measured PDD and OAR data for different field sizes and the simulated model was validated.

Results. The simulated and measured dose distributions were in good agreement, in the order of 1%. The statistical relative uncertainty was below of 0.6% for a 10×10 cm^2 field in all dosels. Gamma index comparisons were performed: more than 90% simulated points passed the clinical 3%/3 mm gamma criterion.

Discussion and Conclusion. The GATE v.7.0 Monte Carlo simulation code has been validated for 6 MV photon beam of a VARIAN medical linear accelerator.

http://dx.doi.org/10.1016/j.ejmp.2016.07.245

FRACTAL DIMENSION AND LACUNARITY OF TRACTOGRAPHY IMAGES OF THE HUMAN BRAIN

A. Provata [a], P. Katsaloulis [a], J. Hizanidi [a], D.A. Verganelakis [b,*]

[a] *Institute of Physical Chemistry, NCSR Demokritos, Athens, Greece*
[b] *Encephalos-Euromedica Medical Diagnostic Center, Athens, Greece*
* Corresponding author.

Introduction. Diffusion Tensor Imaging (DTI) is a novel technique that mirrors the complex architecture of the neuron axons fiber networks in the human brain.

Purpose. The aim of this work is to measure the structural complexity of brain neurons' using 2 dimensional tractography DTI images and compare the complexity of the textures originating from healthy brain neurons.

Materials and methods. Two-dimensional diffusion tensor images from a group of healthy subjects were studied. The generated neuronal tracts by various ROIs on the DTI maps were processed using the Box Counting method and measure self-similarity. The Hausdorff fractal dimension D_f was then calculated. Lacunarity studies were also performed in order to describe the complex interconnectivity of neurons.

Results. Average fractal dimensions were calculated based on the current resolution of the 2D images for different observational angles. High lacunarity derived values indicate the interconnection in the neurons' distribution as well as clustering and connectivity of the neuron imaged ensemble.

Conclusion. The results of this study demonstrate firstly that, the average estimated fractal dimension of tractography images for healthy subjects is $D_f = 1.60$ and secondly statistical self-similarity features.

http://dx.doi.org/10.1016/j.ejmp.2016.07.246

MEASUREMENTS OF PEDIATRIC RADIATION EXPOSURE DURING BARIUM IMAGING PROCEDURES

A. Sulieman [a,*], B. Elhag [b], K. Alzimami [c], C. Kappas [d], K. Theodorou [d]

[a] *Radiology and Medical Imaging Department, College of Applied Medical Sciences, Prince Sattam bin Abdulaziz University, P.O. Box 422, Alkharj 11943, Saudi Arabia*
[b] *Radiology and Medical Imaging Department, Alghad International Colleges for Applied Medical Sciences, Almadinah Almunawra, Saudi Arabia d King Abdulaziz University, School of Medicine, Radiology Department, Saudi Arabia*
[c] *Radiological Sciences Department, College of Applied Sciences, King Saud University, P.O. Box 10219, Riyadh 11433, Saudi Arabia*
[d] *Medical Physics Department, University Hospital of Larissa, PO Box 1425, Larissa 41110, Greece*
* Corresponding author.

Radiological imaging has been considered a vital tool in the diagnosis of gastrointestinal tract (GIT) disorders. Gastrointestinal radiography (GIR) has been a major and first-choice method for diagnosing GIT diseases with barium as contrast media since its emergence in 1910. Radiographic examination of children, especially neonates, attracts particular interest because of the increased opportunity for expression of delayed radiogenic cancers as a consequence of relative longer life expectancy. Barium studies are of particular interest because it constitutes 5% of the total number of radiological examinations and 17% of the collective doses. Although, the task is important, there are few data on radiation doses to infants and children undergoing barium procedures.

The current study intends to evaluate the radiation dose to pediatric patients during barium studies and to estimate the effective doses and radiation risk of the aforementioned procedures. A total of 43 pediatric barium procedures were performed in this study. 21.7% of the sample was barium meal, 8.6% were undergone barium swallow while 69.5% of the sample were barium enemas. Entrance surface air kerma (ESAKs) were calculated from patient exposure parameters using DosCal software. Effective doses (E) were calculated using published conversion factors and methods recommended by the national Radiological Protection Board (NRPB).

The mean film numbers was 12.4, 8.9 and 8 for barium meal, barium enema and barium swallow, respectively. The maximum number of X rays was obtained in barium meal (21 film per a single procedure). The mean patient doses per procedure were 2.1 ± 0.8 mGy, 3.0 ± 23 mGy and 1.2 ± 0.2 mGy for barium meal, swallow and enema, respectively. The mean effective doses were 0.3 mSv, 1.0 mSv and 0.2 mSv at the same order. The dose values in this study were higher than previous studies. The unnecessary radiation exposure can be reduced significantly by reducing the number of films and screening time. Diagnostic reference level is recommended to improve the practice.

Disclosure. Authors have nothing to disclose.

http://dx.doi.org/10.1016/j.ejmp.2016.07.247

DAILY CLINAC QA RESULTS WITH ARCCHECK IN ELEKTA SYNERGY

Fernando Tato de las Cuevas *, Pablo Domingo Fernandez

Medical Physics Department, Hospital Universitario de Canarias, Tenerife, Spain
* Corresponding author.

Introduction. ArcCheck (Sun Nuclear, FL) is a 4D detector phantom designed to check helical treatments in radiotherapy. The phantom software and detectors data accessibility makes possible to use this phantom in LINAC QA (lineal accelerator quality assurance).

Purpose. Develop a daily LINAC QA program using ArcCheck phantom that checks dosimetry parameters and evaluate the results after 5 months.

Materials and methods. The LINAC is an Elekta Synergy. The QA steps are:

- Full arc warning up beam (FAW). Warms up the ionization chamber placed inside the phantom with a beam that covers the whole phantom (20 cm inplane, 2.5 cm crossplane). Make a gamma analysis with 20% threshold comparing the measured with the reference state.
- Static beam. Irradiate a 10×10 cm static field and import the detectors dose from an Excel Workbook that evaluates beam shape, beam quality factor, dose output and diodes signal degradation.
- Irradiate a VMAT treatment. Make a gamma analysis comparing the measured with the reference data in order to check monitor unit system, gantry speed and MLC reproducibility

Results.

- FAW: The result in SNC patient must be a uniform dose distribution in the detector matrix. It has detected misalignments in sagittal laser direction as low as 0.3°.
- Static beam: All measured parameters are in tolerance.
- VMAT treatment: The gamma analysis has a coincidence of more than 95% every day.

These results are in agreement with other QA test. All QA take less than 8 min.

Conclusion. The daily QA developed is fast, complete and effective.

Disclosure. None.

http://dx.doi.org/10.1016/j.ejmp.2016.07.248

ISCHEMIC STROKE DETECTION IN NON-ENHANCED COMPUTED TOMOGRAPHY EXAMINATIONS

Allan F.F. Alves [a,*], Ana J.M. Sampaio [a], Nadine H.P.B. Maues [a], Marcela de Oliveira [a], Ana L.M. Pavan] [a], Carlos C.M. de Freitas [c], Nitamar Abdala [d], D.R. Pina [b]

[a] *Institute of Biosciences of Botucatu/Department of Physics and Biophysics, Unesp, Botucatu, Brazil*
[b] *Faculty of Medicine of Botucatu/Department of Tropical Diseases and Imaging Diagnosis, Botucatu, Brazil*
[c] *Faculty of Medicine of Botucatu/Department of Neurology, Psychology and Psychiatry, Botucatu, Brazil*
[d] *Medical School of São Paulo/Institute for Research and Education in Diagnostic and Therapeutic Medicine, São Paulo, Brazil*
* Corresponding author.

Introduction. Stroke is a worldwide concern, only in Brazil it accounts for 10% of all registered deaths. Early diagnosis is essential to avoid irreversible cerebral damage. Non-enhanced computed tomography (NECT) is the main diagnostic techniques used to diagnose stroke through the Alberta Stroke Program Early CT Score (ASPECTS) which is a subjective method that increases the detection rate.

Purpose. The aim of this work was to implement an image segmentation and enhancement algorithm to detect ischemic stroke lesions in NECT scans.

Materials and methods. We evaluated 10 patients diagnosed with ischemic stroke. Analyzes were performed in two axial slices, one at the level of the thalamus and basal ganglion and one adjacent to the top edge of the ganglionic structures. We used different image processing techniques such as morphological filters, discrete wavelet transform and Fuzzy C-means clustering to both enhance and distinguish ischemic tissues from normal brain tissues. Subjective analyzes were performed by a neuroradiologist according to the ASPECTS scale to quantify ischemic areas. These subjective analysis results were compared with objective analyzes performed by the computational algorithm.

Results. Morphological filters actually improved the ischemic areas. The comparison in area of the ischemic region contoured by the neuroradiologist and by the computational algorithm showed no deviations greater than 12%.

Conclusion. These results show the importance of a computer aided diagnosis software to assist neuroradiology decisions, especially in critical situations such as the choice of treatment for ischemic stroke.

Disclosure. The Authors declare that there is no conflict of interests.

http://dx.doi.org/10.1016/j.ejmp.2016.07.249

CONE BEAM CALIBRATION CURVES IN DOSE CALCULATIONS FOR A VMAT HEAD AND NECK RADIOTHERAPY TREATMENT

M.A. Carrasco Herrera [a,*], F.J. Luis Simón [a], C. Santa Marta Pastrana [b]

[a] *Medical Physics Department, Virgen del Rocío hospital (Sevilla), Spain*
[b] *Universidad Nacional de Educación a Distancia (UNED), Spain*
* Corresponding author.

Introduction. Cone beam computer tomography (CBCT) dose calculation can provide many advantages for adaptive radiotherapy despite the loss of accuracy associated, mainly due to beam scatter that causes Hounfield number (HU) inconsistency.

Purpose. Analyze the differences between CT and CBCT dose calculation for a volumetric modulated arc therapy (VMAT) treatment, using different calibration curves.

Materials and methods. It has been used an Alderson RANDO phantom with tissue equivalent material. CBCT images were obtained in a Varian's On-Board Imager (v1.4), using a standard dose head protocol. Planning CT images were obtained in a Toshiba Aquilion LB. A VMAT plan has been calculated in Eclipse (v10) using 4 calibration curves for CBCT images: Standard, Varian CBCT calibration, measured with a CATPHAN 504 phantom and measured with a CIRS 062M phantom, placed between RANDO slices.

For each image was defined 54 point in different areas (air, bone, soft tissue) and clinical structures (PTV, spinal cord, parotids, mandible, oropharynx). HU and dose were obtained for CT and CBCT points and dose–volume–histogram for clinical structures.

Results. For the points analyzed the average difference was 45 HU (standard deviation 147), the average dose difference was less than 2% for all calibration curves. CBCT-DVHs were in excellent agreement with CT-DVHs. Minimum, maximum, mean and median doses agreed very well. In general, differences were less than 2%. The smallest differences were obtained for CIRS-calibration curve.

Conclusion. CBCT images for a head and neck treatment can be used to calculate dose in adaptive radiotherapy in order to evaluate changes with the original treatment using the calibration curves analyzed.

http://dx.doi.org/10.1016/j.ejmp.2016.07.250

VOLUMETRIC ANALYSIS OF THE MAXILLARY SINUS IN RHINOSINUSITIS PATIENTS

Guilherme Giacomini [a], Marcela de Oliveira [a,*], Ana Luiza Menegatti Pavan [a], Fernando Antônio Bacchim Neto [a], Seizo Yamashita [b], João Maurício Carrasco Altemani [c], Diana Rodrigues de Pina [b]

[a] *Department of Physics and Biophysics/Biosciences Institute of Botucatu, São Paulo State University (UNESP), Botucatu, Brazil*
[b] *Department of Tropical Diseases and Diagnoses Imaging/ Botucatu Medical School, São Paulo State University (UNESP), Botucatu, Brazil*
[c] *Medical Sciences College – FCM-UNICAMP, Campinas, Brazil*
* Corresponding author.

Introduction. Rhinosinusitis (RS) is an extremely common condition. It causes significant physical symptoms, negatively affects quality of life, and can substantially impair daily functioning. The RS incidence of in the maxillary sinus (MS) is comparatively high. Therefore, computed tomography (CT) of the sinuses is recommended for diagnostic and management purposes. Volume values for MS can be helpful in evaluating the RS, treatment planning and evaluation of the outcome. However, this is not always possible in the clinical routine, and if possible, it involves much effort and/or time.

Purpose. The aim of this study was to develop an automatic tool to quantity the volume of MS and MS free air in CT exams of patients with rhinosinusitis.

Materials and methods. The research involved 30 patients. The tool for automatic MS quantification, developed in Matlab, uses a hybrid method, combining watershed and region growing techniques. Our results were compared with radiologist manual segmentation.

Results. From the comparison, the linear regression showed a strong association and low dispersion. The Bland–Altman analyses showed no significant differences (95% confidence interval). The mean percentage difference between both methods was 9.2% and 10.4% for MS and MS free-air volumes, respectively.

Conclusion. In conclusion, the developed tool to quantify MS volume proved to be robust, fast and efficient, when compared with manual segmentation. Furthermore, it avoids the intra and inter-observer variations caused by manual and semi-automatic methods. Thus, it may be useful in the diagnosis and treatment determination of RS, providing additional information to physician.

Disclosure. The authors declare that there is no conflict of interest.

http://dx.doi.org/10.1016/j.ejmp.2016.07.251

STUDY OF PERSONAL DOSIMETRY EFFICIENCY IN PROCEDURES OF ABDOMINAL AORTIC ANEURISM IN INTERVENTIONAL RADIOLOGY

Fernando A. Bacchim Neto [a], Allan F.F. Alves [a], Maria E.D. Rosa [a], Marcela de Oliveira [a,*], Carlos C.M. de Freitas [b], Regina Moura [c], Diana R. Pina [d]

[a] *Departamento de Física e Biofísica, Instituto de Biociências, Botucatu, Brazil*
[b] *Departamento de Doenças Tropicais e Diagnóstico por Imagem, Faculdade de Medicina de Botucatu, Botucatu, Brazil*
[c] *Departamento de Neurologia, Psicologia e Psiquiatria, Faculdade de Medicina de Botucatu, Botucatu, Brazil*
[d] *Departamento de Doenças Tropicais e Diagnóstico por Imagem, Faculdade de Medicina de Botucatu, Botucatu, Brazil*
* Corresponding author.

Introduction. Interventional Radiology provides unquestionable benefits and replaces extremely invasive and difficult recovery procedures for the patient; however, excessive exposure to radiation can cause severe damage to patients and requires health care for professionals. The assessment of doses received under typical conditions procedures in routine sectors are essential. Thermoluminescent dosimeters are the most widely used radiation dosimeters due to its measurement accuracy and good proportionality response in the diagnostic energy range.

Purpose. The objective of this paper is to evaluate the currently dosimetry technique employed in medical staff during interventional radiology procedures.

Materials and methods. In each evaluated procedures, dosimeters were fixed at the following locations: a few inches below the eye lens (on top of the surgical mask), thyroid, chest, gonads, hand (bottom of the pulse) and foot, above the radiological protection vests as lead apron and thyroid shield. Equivalent doses rate profiles were estimated based on TLD readings related to the duration of each procedure.

Results. The equivalent dose rate profile shows a tendency of difference between dose rate found in the chest in relation to the abdomen, hands and feet. Statistically, dose rates found in the hands differ from those found in the chest with $p = 0.05$.

Conclusion. These results suggest that only a dosimeter placed on the chest does not describe faithfully the radiation doses in these professionals. Two dosimeters placed at the height of the abdomen of professionals, one inside the lead protections and other outside, may indicate more accurately the effective dose.

Disclosure. The authors declare that there is no conflict of interest.

http://dx.doi.org/10.1016/j.ejmp.2016.07.252

BREAST TISSUE SEGMENTATION BY FUZZY C-MEANS

Ana Luiza Menegatti Pavan [a], Marcela de Oliveira [a,*], Matheus Alvarez [a], Ana Júlia Martins Sampaio [a], Andre Petean Trindade [b], Sergio Barbosa Duarte [c], Diana Rodrigues de Pina [b]

[a] *Department of Physics and Biophysics/Biosciences Institute of Botucatu, São Paulo State University (UNESP), Botucatu, Brazil*
[b] *Department of Tropical Diseases and Diagnoses Imaging/Botucatu Medical School, São Pualo State University (UNESP), Botucatu, Brazil*
[c] *Brasilian Center of Physics Research, Rio de Janeiro, Rio de Janeiro, Brazil*
* Corresponding author.

Introduction. Mammography is a worldwide image modality used in screening breast cancer. Due to its large availability, mammograms can be used to measure breast density. Women with high mammographic density have a four-to-sixfold increase in their risk of developing breast cancer. Therefore, studies have been made to accurately quantify mammographic breast density. In clinical routine, radiologist perform subjective image evaluations through BIRADS (Breast Imaging Reporting and Data System).

Purpose. The aim of this work was develop an automatic methodology to estimate the percentage of mammographic breast density using digital mammography. We used Fuzzy C-means Clustering (FCM) to segment fibroglandular and adipose tissues from breast mammography, using Matlab software.

Materials and methods. The algorithm uses FCM features (mean, standard deviation, kurtosis, entropy and others) to automatically segment tissues using mammograms. The mammographic breast tissue percentage was measured by the relation between fibroglandular tissue and the sum of fibroglandular and adipose tissues. The percentage was compared with the assessment made by radiologists using BIRADS system for each evaluated image.

Results. The comparison between methods shows 93% of concordance between the developed method and BIRADS system. The differences between methods, although small, were mainly attributed to subjective visual analysis made by radiologists.

Conclusion. The proposed method can automatically segment fibroglandular and adipose tissues with high performance. These results will be used in a complete work, which will estimate the volumetric breast density through digital mammography. The volumetric breast density will be used to calculate the mean glandular dose.

Disclosure. The authors declare that there is no conflict of interest.

http://dx.doi.org/10.1016/j.ejmp.2016.07.253

ALGORITHM TO QUANTIFY THE ABDOMINAL COMMITMENT IN NEWBORNS

Ana Julia Martins Sampaio [a], Marcela de Oliveira [a,*], Matheus Alvarez [a], Guilherme Giacomini [a], André Petean Trindade [b], Sergio Marrone Ribeiro [b], Rozemeire Garcia Marques [c], Diana Rodrigues de Pina Miranda [b]

[a] *Department of Physics and Biophysics/Biosciences Institute of Botucatu, São Paulo State University (UNESP), Botucatu, Brazil*
[b] *Department of Tropical Diseases and Diagnoses Imaging/Botucatu Medical School, Sao Paulo State University (UNESP), Botucatu, Brazil*
[c] *Department of General Bases of Surgery/Botucatu Medical School, Sao Paulo State University (UNESP), Botucatu, Brazil*
* Corresponding author.

Introduction. Necrotizing enterocolitis (NEC) is a intestinal disorders involving systemic inflammatory responses in premature infants. The disease affects 1–3% of neonatal intensive care unit admissions. The NEC diagnosis and management must be based on both clinical signs, symptoms and findings on abdominal radiographs. These findings may help to predict or detect the presence of complications that require surgery. Determination of the clinical severity of NEC and possibly early prediction of its course are desirable objectives and perhaps prerequisites of successful therapy.

Purpose. The purpose of this investigation was to evaluate features extracted of abdominal radiographs, through image processing, as indicators of disease severity in patients with NEC.

Materials and methods. This study was a retrospective evaluation of 20 newborns diagnosed with NEC. A semiautomatic algorithm was developed in Matlab for the objective evaluation of the abdom-

inal radiographs. The abdominal involvement region was manually segmented by a radiologist and assessed objectively through texture features (skewness and kurtosis). The results were compared between two groups: neonates treated medically and treated surgically.

Results. The results of both groups were compared using *t*-student test. The analyses showed significant statistic differences ($p < 0.05$) for the assessed features.

Conclusion. The proposed method can semi-automatically analyze the abdominal involvement in NEC patients. These indicators may help guide clinical management and surgery decision by adding new information to the exam.

Disclosure. The authors declare that there is no conflict of interest.

http://dx.doi.org/10.1016/j.ejmp.2016.07.254

DOSE OPTIMIZATION IN COMPUTED TOMOGRAPHY COMPARING AUTOMATIC TUBE CURRENT MODULATION AND FIXED TUBE CURRENT TECHNIQUES

Nadine H.P.B. Maués [a], Allan F.F. Alves [a], Fernando A. Bacchim Neto [a], Maria E.D. Rosa [a], Marcela de Oliveira [a,*], Sérgio Marrone Ribeiro [b]

[a] *Departamento de Física e Biofísica, Instituto de Biociências, Botucatu, Brazil*
[b] *Departamento de Doenças Tropicais e Diagnóstico por Imagem, Faculdade de Medicina de Botucatu, Botucatu, Brazil*
* Corresponding author.

Introduction. High radiation doses received, especially in young patients, have a great importance with the known risk cancer development. Computed Tomography examinations correspond to 70% of all radiation doses in diagnostic imaging modalities. With advances in CT scanners, some features such as automatic tube current modulation (ATCM) permits acquiring high quality images with low radiation doses. However, without an optimization process, the protocols used in CT routine induce low-quality images that compromise the reliable medical diagnosis or induce radiation doses questioning the ALARA principle.

Purpose. The purpose of this study was to evaluate the radiation dose of fixed mA techniques and tube current modulation techniques in CT the abdomen-pelvis protocol.

Material and methods. We fixed three current protocols (300 mA, 250 mA and 200 mA) and one ATCM protocol (SD 10.0) performed in a 16-slice Toshiba CT scanner with "SureExposure3D" ATCM system. Protocols were applied in an anthropomorphic phantom (Alderson-Rando Phantom) for a dosimetric evaluation and to determine organ absorbed doses. The effective doses, *E*, were also calculated according to ICRP 103.

Results. The ATCM technique SD 10.0 has the lowest amount of absorbed dose. The larger *E* was found in the protocol with 300 mA. The difference to the SD protocol 10.0, which showed lower *E*, was of 79.49%.

Conclusion. ATCM protocols can be an excellent alternative to dose reduction in CT scans, since it does not impair the diagnostic image quality.

Disclosure. The authors declare that there is no conflict of interests.

http://dx.doi.org/10.1016/j.ejmp.2016.07.255

DOGS CHEST HOMOGENEOUS PHANTOM FOR IMAGE OPTIMIZATION

Maria E.D. Rosa [a], Marcela de Oliveira [a,*], Ana L.M. Pavan [a], Allan F.F. Alves [a], Luis C. Vulcano [b], Diana R. Pina [c]

[a] *Botucatu Institute of Biosciences – UNESP, Botucatu, SP, Brazil*
[b] *Faculty of Veterinary Medicine and Animal Science – UNESP, Botucatu, Brazil*
[c] *Tropical Diseases and Department, Botucatu Medical School – UNESP, Botucatu, SP, Brazil*
* Corresponding author.

Introduction. There has been an increasing substitution of image acquisition screen-film systems for computed radiology (CR) equipment without technical charts adequacy. To carry out a radiographic examination in veterinary patient is required human assistance for restraint this, which can compromise image quality by generating dose increasing to the animal and for Occupationally Exposed. The image optimization procedures are performed with the use of homogeneous phantoms.

Purpose. We propose the development of a homogeneous phantom of canine chest to be applied to optimization of images for the CR system.

Materials and methods. A database with retrospectives chest images of computed tomography (CT) was created. The thickness of biological tissues was quantified in 80 animals, separated in groups of 20 animals according to their weights: Small, Medium, Large and Giant. An algorithm was developed to classify and quantify biological tissues present images and convert them in simulator materials. To classify tissues presents, membership functions were created from the retrospective CT scans according to the type of tissue (adipose, muscle, bone trabecular or cortical and lung tissue).

Results. Biologic tissue thickness was converted in equivalent material thicknesses (acrylic simulating soft tissues, aluminum simulating bones and air to the lung). Four different homogeneous phantoms were obtained, Small with 5 cm of acrylic, 0,14 cm of aluminum and 1,8 cm of air; medium with 8,7 cm of acrylic, 0,2 cm of aluminum and 2,4 cm of air; large with 10,6 cm of acrylic, 0,27 cm of aluminum and 3,1 cm of air and giant with 14,8 cm of acrylic, 0,33 cm of aluminum and 3,8 cm of air.

Conclusion. The canine homogeneous phantom is a practical tool, which will be employed to optimize veterinary X-ray procedures.

Disclosure. The authors declare that there are no interest conflicts.

http://dx.doi.org/10.1016/j.ejmp.2016.07.256

OPTIMIZATION OF CT PATIENT DOSE: FIRST RESULTS FROM A DOSE MANAGEMENT PROJECT

A.J. Santos Rubio [a], F.J. Luis Simón [a,*], G. Sánchez Carmona [a], M. Fajardo Cascos [b], E. Merchante García [b], R. Rodríguez Romero [b]

[a] *Servicio de Radiofísica, UGC Integral Oncology – Hospital U. Virgen del Rocío, Seville, Spain*
[b] *Servicio de Radiodiagnostico – UGC Diagnostic Image - Hospital U. Virgen del Rocío, Seville, Spain*
* Corresponding author.

Purpose. The goal of this study is to demonstrate the impact and benefits of the implementation of a dose management project in a radiological protection department to analyse the results after three years collecting dose data.

Materials and methods. In mid-2013 our hospital decided to implement the dose monitoring tool of General Electric (DoseWatch™). A dose management team was created, including two radiologists and two physicists, one of them as the team leader. The project began with a dedicated CT for pediatrics (Philips Brilliance) and a RF device (Philips DigitalDiagnost). In 2015, the project was extended to 2 more CT's (GE Lightspeed and Toshiba Aquilion) and a dedicated pediatric cardiac catheterization device (Siemens Artis-Zee). A dose alert threshold based on statistical approaches was established for each protocol to control and compare the dose with the european dose reference levels.

Results. CT analysis has been done, segmenting in different age ranges [0–5, 6–10, 11–15, 16–20, >21]. Study has been focused on Abdomen, Thorax and Head practices. Median CTDIvol were compiled in tables for each protocol. For example for skull and age ranges above the values obtained were: 4.1 mGy; 4.2 mGy; 4.1 mGy; 4.06 mGy; 30.4 mGy.

Conclusion. The implementation of a dose management project is really important for the hospital to minimize the radiation risks.

The creation of a dose team and the use of a dose monitoring tool are crucial to control and optimize the dose.

Implementation of the DoseWatch™ tool eases to the dose team to analyse and compare dose values in different devices, protocols and modalities.

Disclosure. There is no bias in this work and no relationships with influence on the results.

http://dx.doi.org/10.1016/j.ejmp.2016.07.257

EXPERIMENTAL DETERMINATION OF IONIZATION CHAMBER OVERALL CORRECTION FACTOR IN MEDIUM-ENERGY X-RAY BEAMS

M. Pimpinella *, M. Pinto, A.S. Guerra

National Institute of Ionizing Radiation Metrology, ENEA-INMRI, Rome, Italy

* Corresponding author.

Introduction. According to the IAEA TRS 398, in kilovoltage X-ray beams the calibration factor in terms of absorbed dose to water ($N_{D,w,Q}$) for an ionization chamber can be derived from its calibration factor in terms of air kerma ($N_{K,Q}$) if the chamber overall correction factor, p_Q, is known. However, literature p_Q values are lacking, especially when referring to the reference depth of 2 g/cm^2.

Purpose. To determine the p_Q factor at 2 g/cm^2 depth using a new absorbed-dose-to-water (D_w) primary standard based on an in-water-phantom graphite calorimeter recently established for medium-energy X-ray beams.

Materials and methods. $N_{D,w,Q}$ factors are directly determined against the D_w primary standard. Using the same beam qualities, the $N_{K,Q}$ factors are also determined. Values of p_Q are obtained by comparing the $N_{D,w,Q}$ factors with the analogous calibration factors derived by $N_{K,Q}$ using the IAEA TRS 398 formalism. Ratios of mean mass-energy absorption coefficients, water to air, are taken from literature.

Results. For a Farmer type ionization chamber, the p_Q factor was respectively 1.002 and 1.012 for the 180 kV and the 250 kV medium-energy quality of the CCRI series, with a relative combined standard uncertainty of 2%. This figure is going to be reduced to around 1% with the ongoing improvements on the new D_w primary standard.

Conclusion. The new D_w primary standard based on graphite calorimetry, although affected by a larger uncertainty compared to primary standards based on water calorimetry, allows independent measurements of p_Q factors for ionization chambers currently used in radiotherapy dosimetry.

http://dx.doi.org/10.1016/j.ejmp.2016.07.258

ASSESSMENT OF RADIATION DOSE RECEIVED BY PROSTATE CANCER AND CRITICAL ORGANS IN 2D AND 3D TREATMENT PLANNING

Hiba Omer [a,*], Yousra Khairi Mohamed [b], Abdelmoneim Suleiman [c]

[a] *College of Medicine, University of Dammam, Dammam, Saudi Arabia*
[b] *Alneelain University, Khartoum, Sudan*
[c] *Radiology and Medical Imaging Department, College of Applied Medical Sciences Prince Sattam bin Abdulaziz, University K.S.A, Saudi Arabia*

* Corresponding author.

Introduction. The goal of radiotherapy treatment planning is to design a beam configuration which will deliver a homogeneous dose to the specified planning target volume (PTV), ensuring that normal tissue receives a reasonably low dose and that critical organs receive less than their tolerance doses.

Purpose. This study was to compare between 2-dimensional and 3-dimensional techniques for external-beam radiation treatment for prostate cancer.

Materials and methods. Dose homogeneity within the target volume and doses to critical organs, OAR were evaluated. CT scans of 30 patients with localized prostate cancer were acquired and transferred to the treatment planning systems (TPS). The target volume and uninvolved structures were contoured on axial CT slices throughout the volume of interest. A comparison of the two treatment techniques was performed using isodose distributions, and dose-volume histograms.

Results. The dose distribution in 2D and 3D technique were found the same; however, in 2D technique delivers unnecessary radiation doses to the rectum and bladder.

For the rectum it was found that the average (V70, V75 and D95) in 2D technique 35.5%, 32.2%, 34% while for 3D: 8.4%, 0.2%, 12%, respectively.

For the bladder it also found the average (V40, V65) in 2D technique 80.8%, 74.9% while for 3D 20.4%, 17%, respectively, also the right and left hip in 2D technique the average V50 were 17%, 20%, while for 3D technique were 4%, 3% respectively; so these indicates that the doses in organ at risk in 3D were within limit while in 2D higher than the allowable limit causing a risk to OAR.

Also for the planning target volume the average (V95%, V107%) in 2D technique 90.6%, 5.7% while, for 3D technique 94.9%, 3.8 respectively.

Conclusion. 3D conformal radiotherapy was shown to be more effective than 2D conventional radiotherapy in decreasing dose to rectum, bladder and both hip but dose distribution, homogeneity and dose coverage to PTV the same. There was no statistical difference between 2D and 3D radiotherapy in terms of V95% or V107% keeping a minimum of 95% dose coverage for PTV and a maximum dose below 107% as recommended by the ICRU planning guidelines.

http://dx.doi.org/10.1016/j.ejmp.2016.07.259

DOSE REASSESSMENT METHOD IN THERMOLUMINESCENT DOSIMETRY BY USING THE PTTL PHENOMENA – A USEFULL TOOL

Maciej Budzanowski *, Anna Sas-Bieniarz, Anna Bubak, Renata Kopeć

Institute of Nuclear Physics Polish Academy of Science (IFJ PAN), ul. Radzikowskiego 152, 31-342 Kraków, Poland

* Corresponding author.
URL: http://www.ifj.edu.pl

Introduction. Reassessment of doses in film and OSL dosimetry is well known and standard method in contrary to TL dosimetry. By using the phototransferred thermoluminescence (PTTL) method which consist of the first readout, UV exposure and second readout it is possible to reassess doses in TL dosimetry.

Purpose. The PTTL method was developed and applied to reassess doses in whole body and ring dosimetry at Laboratory of Individual and Environmental Laboratory at IFJ PAN.

Materials and methods. Standard MTS-N (LiF: Mg, Ti) sintered thermoluminescent detectors (4.5 mm diameter and 0.9 mm thickness for whole body dosimeters and 0.7 mm thickness for ring dosimeters) have been applied. Some of them were used in routine control since 12 years. The TL detectors were read in automatic RE200 (Rados Oy, Finland) readers. After readout the PTTL method was applied. Detectors were subjected to UV radiation (254 nm length) and read once again in a reader.

Results. The PTTL method was applied to dose reassessment in individual and ring dosimetry. The reassessed doses are observed to be linear over the dose range 5–100 mSv in whole body dosimetry and 5–1000 mSv in ring dosimetry.

Conclusion. Due to checking behavior of different batches and different dose history it is possible to observe influence of residual dose to the PTTL effect. By using the PTTL method it is possible to reassess doses in whole body and ring dosimetry.

http://dx.doi.org/10.1016/j.ejmp.2016.07.260