E-Shock Wave in Physical Therapy

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Objectives

Following completion of this lecture the student will be able to:

- Describe the mechanical characteristics of ESW.
- Identify musculoskeletal pathology that may benefit from ESWT.
- Discuss the biological effects of ESW on soft tissue and bone.
Outline

- Essential and History
- Principle of Production
- Characteristics of ESW & Energy production
- Physiological Effects & Mechanism of Action
- Clinical Applications
- Adverse effects of ESW
- Evidence-Base of ESWT
ESWT: Essential and History

- Therapeutic shockwave was first introduced into medicine over 30 years ago for kidney stones.

- Recently, ESW was used for musculoskeletal disorders in the early 1980's.

- By the early 1990s, reports to start to appear in the journals and conference about use of ESW for soft-tissue problems.

- Although becoming much more popular (especially in Europe and to some extent in the UK), it is still a relatively new technology for musculoskeletal/tissue repair intervention.
ESWT: Definition

- **Shock-wave** is an acoustic large-amplitude compression wave, with high pressure peak, adjustable in a limited frequency range with one the wave side, the positive pressure increases in a short time follows at negative pressure.

The characteristics of a shock wave are:

- **HIGH** Peak pressure typically \( \approx 100\text{MPa} \)
  - 50-80MPa
  - 35-120MPa
- Fast pressure rise duration \(<10\text{ns}\)
- Short life duration \(\leq 10\text{µsec}\)
- Narrow effective beam (2-8mm diameter)
- Frequency range 16HZ-20MHz
- Pause of negative pressure
Types
- Electrohydraulic
- Electromagnetic
- Piezoelectric
- Radial or Electro-pneumatic
Focus and unfocus
<table>
<thead>
<tr>
<th>Focus</th>
<th>Radial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electromagnetic, electrohydraulic, 100-1000 Bar</td>
<td>Generator</td>
</tr>
<tr>
<td>≈0.2μsec</td>
<td>Pressure</td>
</tr>
<tr>
<td>0.01-1.50mJ/mm² (high)</td>
<td>Pulse duration</td>
</tr>
<tr>
<td>Large &gt; 12 cm, Deep</td>
<td>Energy flux density</td>
</tr>
<tr>
<td>1-3</td>
<td>Penetration depth</td>
</tr>
<tr>
<td>Higher</td>
<td>Effect</td>
</tr>
<tr>
<td>1-3</td>
<td>Treatment sessions</td>
</tr>
<tr>
<td>3-5</td>
<td>Adverse effect</td>
</tr>
<tr>
<td>Pneumatic</td>
<td>1-10 Bar</td>
</tr>
<tr>
<td>0.2-0.5msec</td>
<td>Radial</td>
</tr>
<tr>
<td>0.01-0.05mJ/mm² (slow)</td>
<td>Small &lt; 3 cm, Superficial</td>
</tr>
<tr>
<td>3-5</td>
<td>Tissue</td>
</tr>
<tr>
<td>Lower</td>
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Energy Flux Density (mJ/mm²)

Degree of energy transmitted to the tissues
Measure of the energy flux /square area (mm²)

- Low (<0.08 mJ/mm²)
- Medium (0.08 to 0.28 mJ/mm²)
- High (0.28 to 0.60 mJ/mm²)

Pulses Per Dose
Ranges from 1000 to 3000
Energy Flux Density

LOW: Up to 0.08mJ/mm²
MEDIUM: Up to 0.28mJ/mm²
HIGH: > 0.28mJ/mm²

Rompe et al, 1998
ESWT-Mechanism of Action

Indirect

Biological

Direct

Mechanical

Physical
ESWT - Physical & mechanical of Action

Mechanical

Physical

Molecular ionization
Increase cell membrane permeability.

Physical effects

**CAVITATION**
- Changing of membrane permeability
- Gas bubble expansion
- Gas bubble compression

**MICRO-STREAMING**
- Changing of membrane permeability and ionic flow
- Bubble rotation & associated fluid movement along cell membranes
ESWT-Biological effects

Physical S.W. energy

Biological responses

BMP → eNOS → VEGF → PCNA → Neovascularization

Improved blood supply

Bone repair

Tissue regeneration

Tendon repair
ESWT-Physiological Effects

1-Mechanical stimulation

2-Increased local blood flow and Neovascularization

3-Increase in cellular activity release of
   (BMP, eNO, VEGF, & inflammatory cytokines)

4-Reduction of concentration of Substance P
   (decrease pain/edema)

5-Transient analgesic effect on afferent nerves

6-Break down calcific deposits
   (primarily, but not exclusively in tendon)

7-Increase of collagen production
ESWT-Indications

- Tennis elbow (Epicondilitis humeri radialis)
- Greater trochanteric pain syndrome
- Patellar tip syndrome
- Plantar fasciopathy
- Subacromial pain syndrome
- Golfer’s elbow (epicondylitis humeri ulnaris)
- Medial tibial stress syndrome
- Achilles tendinopathy
ESWT-Indications

Supraspinatus tendon

Common extensor tendon

Patella tendon

Achilles tendon

Plantar fascia
ESWT-Clinical Application

**Treatment Dose Issues**

**Applied energy (mJ/mm²)**
- LOW (up to 0.08mJ/mm²)
- MEDIUM (up to 0.28mJ/mm²)
- HIGH (> 0.28mJ/mm²)

**Numbers of shocks**
- Shock number between 1000 - 2000,
  - Some research has tried as few as 100-500
  - 500 more effective than 100
  - 1000-2000 shocks/session is most commonly applied range

**Number of ttt sessions**
- A single session BUT only for High level treatment – using local anesthesia – not physiotherapy.
- 3–5 sessions at low energy levels, for the majority of patients.

No RCT trials yet to determine the maximally effective therapy session number and interval (3days-3weeks).
ESWT-Achilles Tendinopathy

- Insertional: within 2 cm of its insertion.
- Mid-substance: 2-6 cm proximal to its insertion

S/S: Pain, swelling, and impaired performance

11 studies reviewed
ESWT produces greater short-term and long-term improvements in pain function compared to other non-operative treatments (rest, footwear modification, NSAIDs, stretching, or strengthening)

Therapy parameters
- pressure: 2–3 bars
- frequency: 5–10 Hz

Patient position: lying on back supported with knee

Frequency of treatments: 5–10 days
Number of treatments: 3–5 sessions
ESWT-Contraindications

- Lung tissue appears to be damaged and should be avoided
- The epiphysis it would make sense to avoid
- Patients who are haemophiliac/ on anticoagulant therapy.
- Malignancy
- Metal implants
- Infection in the local area should be treated with strong caution
- Joint replacements - come up with a mixed result
Adverse events are equivalent to those of conventional ESWT –

- Transient pain
- Subcutaneous hematoma (up to 4%)

Local symptoms are much more common in RSWT due to lower penetration energy area.

- Local irritation does not appear to be of lasting clinical significance.

Side effects usually come and go within 3 to 5 days