



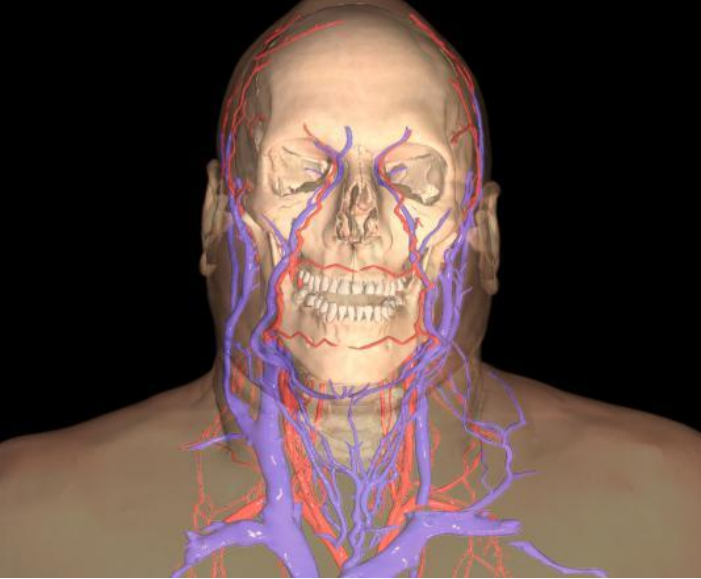


Ultrasound Examination of the Carotid Arteries

CONTENTS

- Anatomy
- Scanning Technique
- Normal appearance and normal flow
- Abnormal appearance
- Wave form analysis
- Artifacts
- Advanced technique
- Conclusion

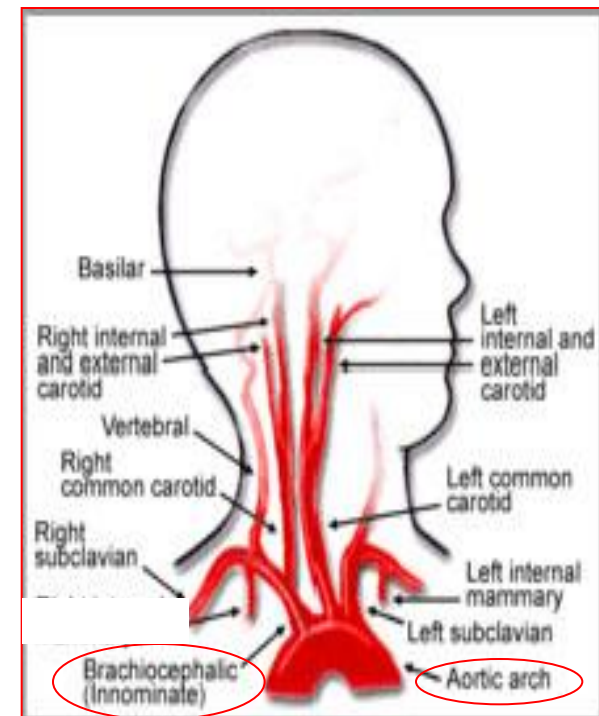
ANATOMY



- There are two common carotid arteries
- one at each side of the neck.

• The right begin at bifurcation of the brachiocephalic artery

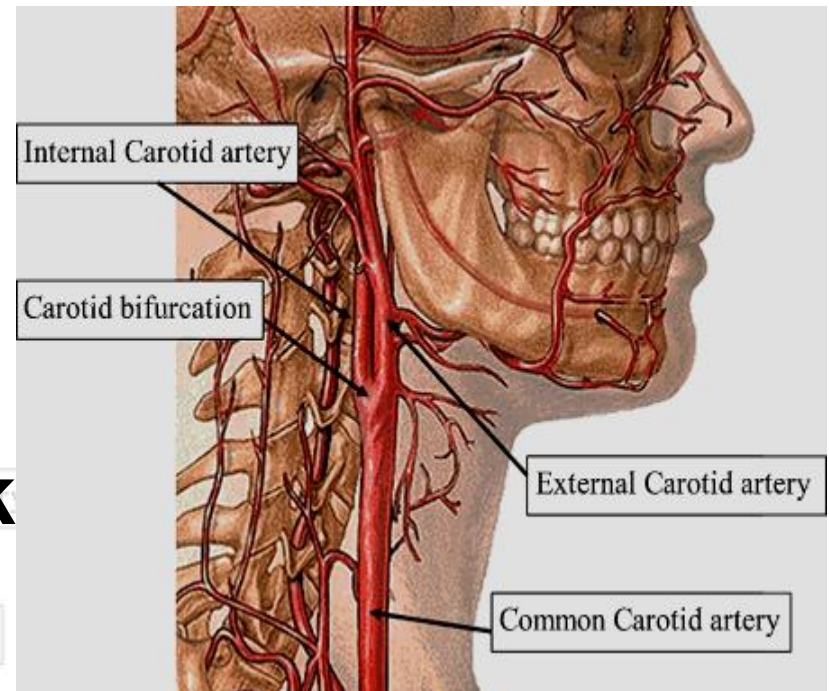
• The left come from the highest part of the arch of the aorta



ANATOMY

Each common carotid artery divided into :

External carotid artery
which supplying the
exterior of the head ,
the face and the
greater part of the neck

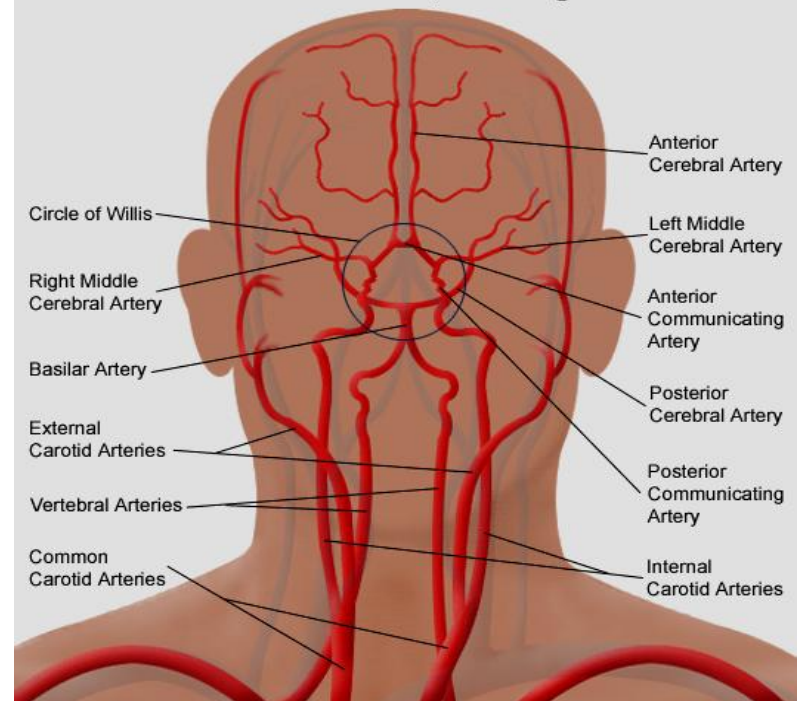


ANATOMY

Each common carotid artery divided into :

Internal carotid artery
which supplying the
remaining part of the
head within the cranial
and orbital cavities.

Arterial Circulation of the Brain, Including Carotid Arteries



Technique



Technique

The position of the patient is supine with head turned slightly away from the side being examined



Technique

Both patient and sonographer must be comfortable because the examination takes 20-30 minutes.



Technique

High frequency
(7-10 MHz) linear
array transducers
are used for the
examination .

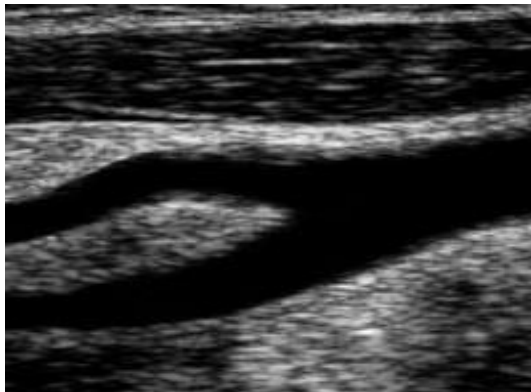


Technique

Carotid sonography requires:

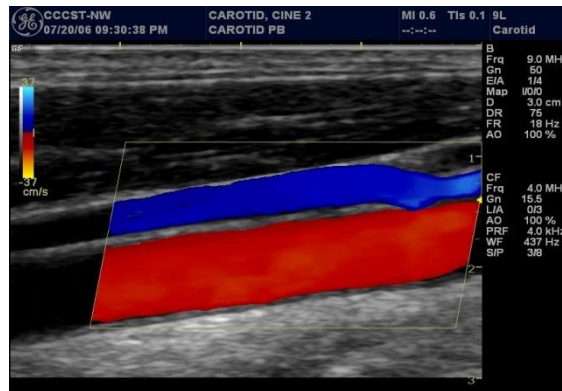
Gray-scale

Is used to detect and evaluate the appearance of carotid plaque.



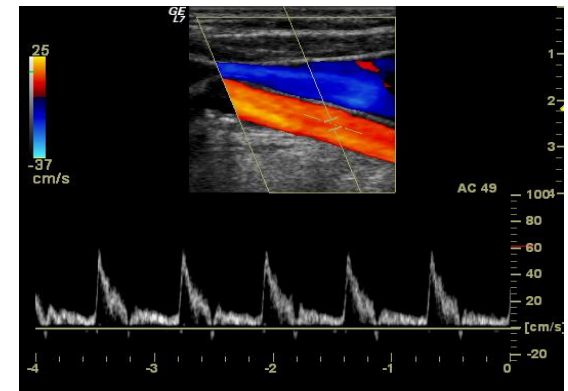
Color Doppler

- Is used to identify vessels,
- to assess the presence of blood flow
- To identify the presence and location of plaque and carotid wall thickening.



Spectral Doppler

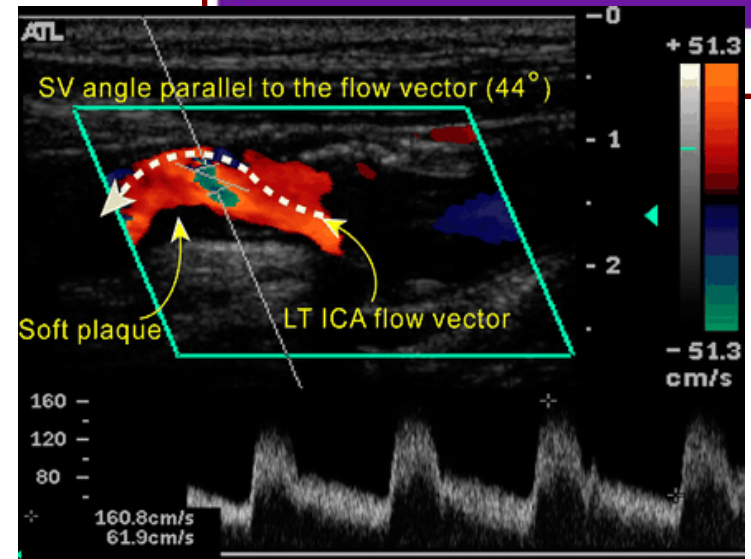
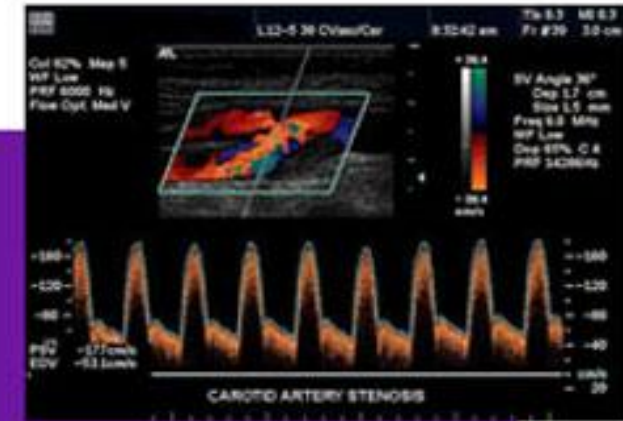
- This allow measurement of blood flow velocity
- Is used to evaluate the severity of stenosis



Technique

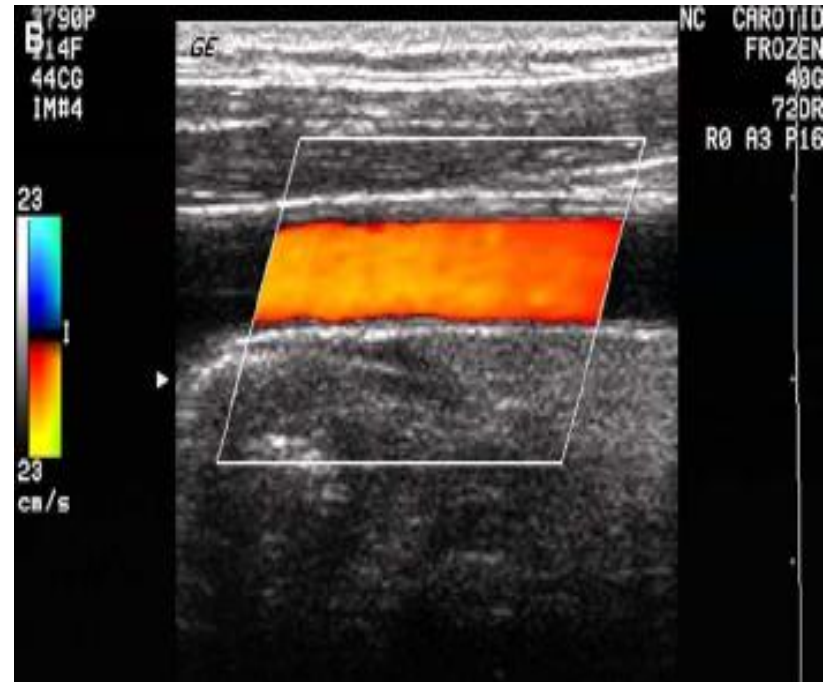
Usually the sample volume must be kept at 1.5 mm and the position of the sample volume in normal artery is in the mid lumen parallel to the vessel wall,

whereas in a diseased vessel it parallel to the direction of blood flow



Technique

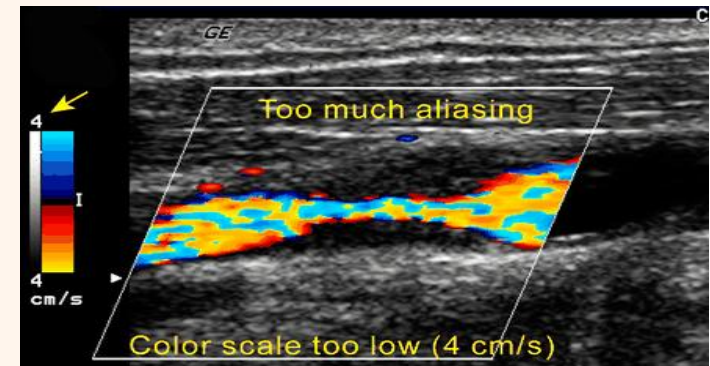
the color velocity scale should be set between 30 and 40 cm/sec (mean velocity). In normal artery



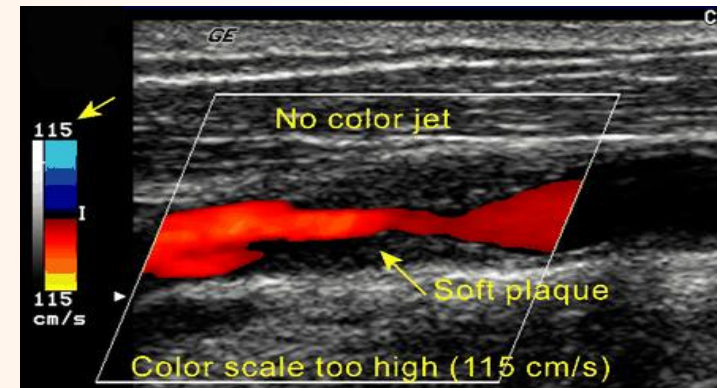
Technique

Choose correct color scale in a carotid artery stenosis

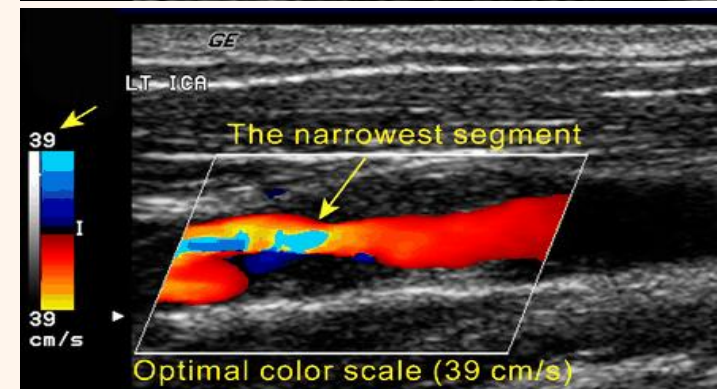
Color Doppler image obtained with the color scale set too low (4 cm/sec) shows aliasing in the ICA.



Color Doppler image obtained with the color scale set too high (115 cm/sec) shows no aliasing.

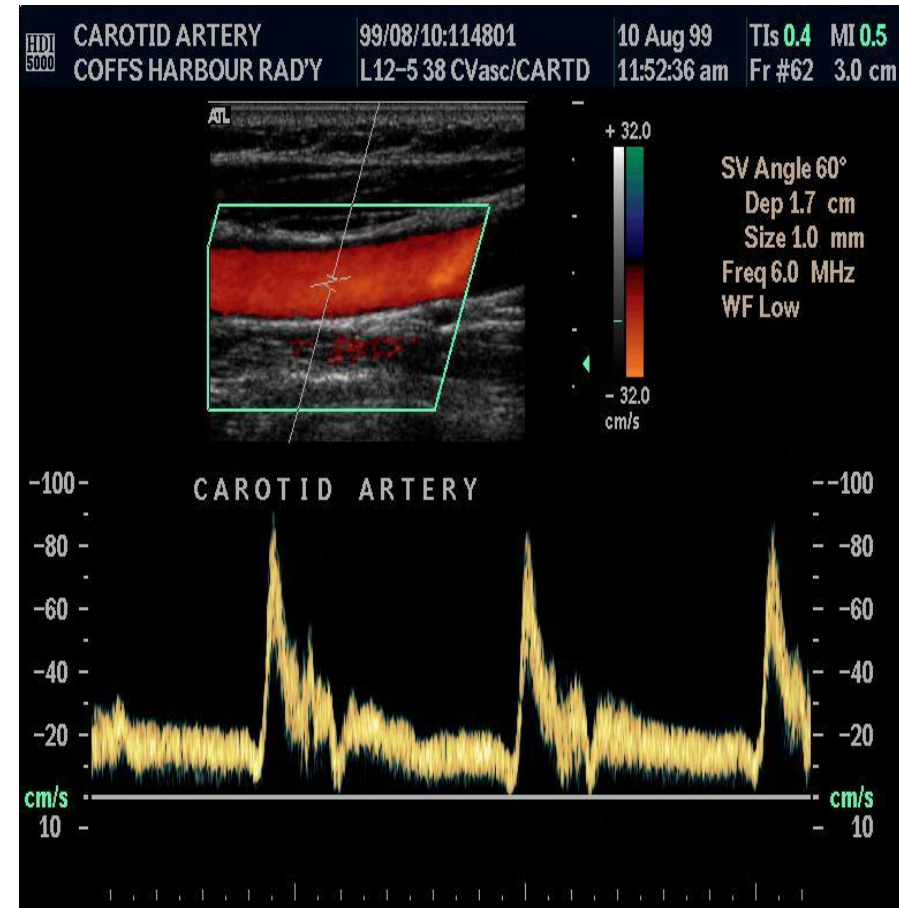


Color Doppler image obtained with the optimal color scale setting shows the region of highest velocity, which corresponds to the narrowest segment of the ICA.



Technique

- The Doppler angle must be kept at < 60 degrees to minimize measurement error.



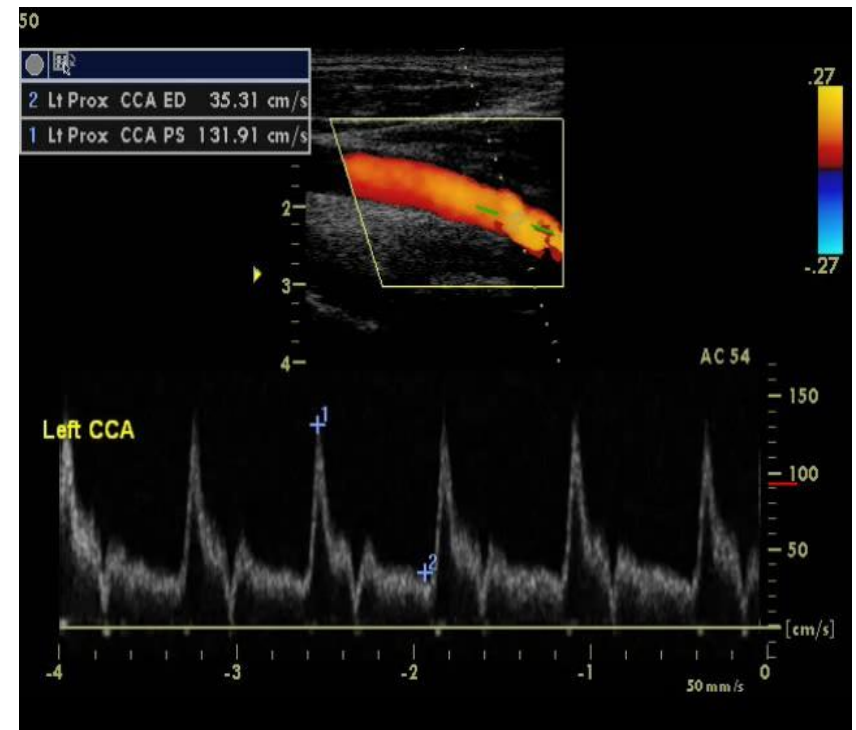
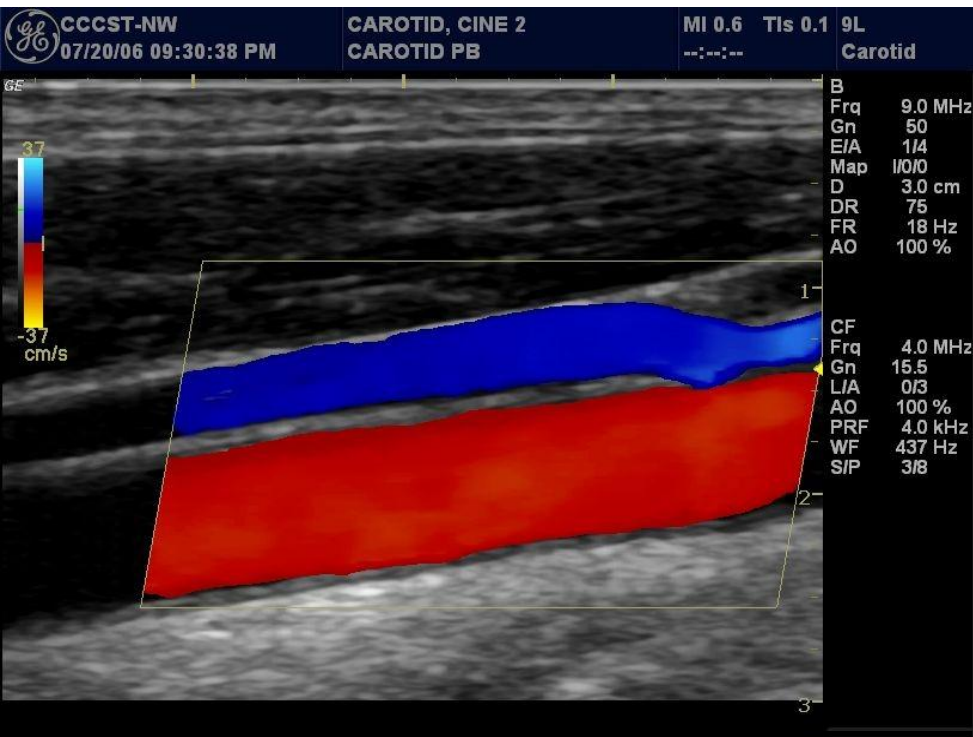
Required images

Transverse image



Required images

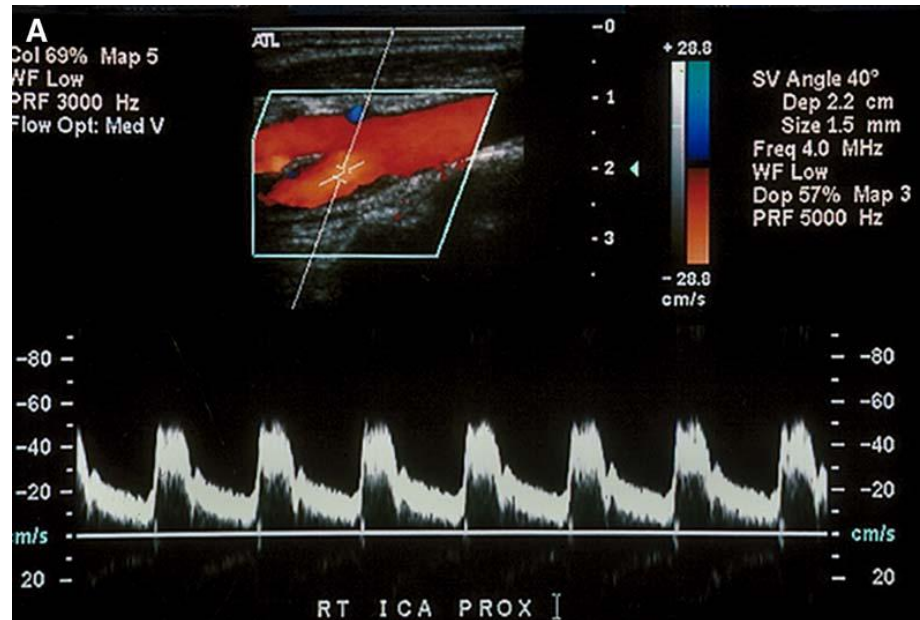
Longitudinal image



Longitudinal color Doppler and spectral waveforms of the CCA proximal/mid/distal

Required images

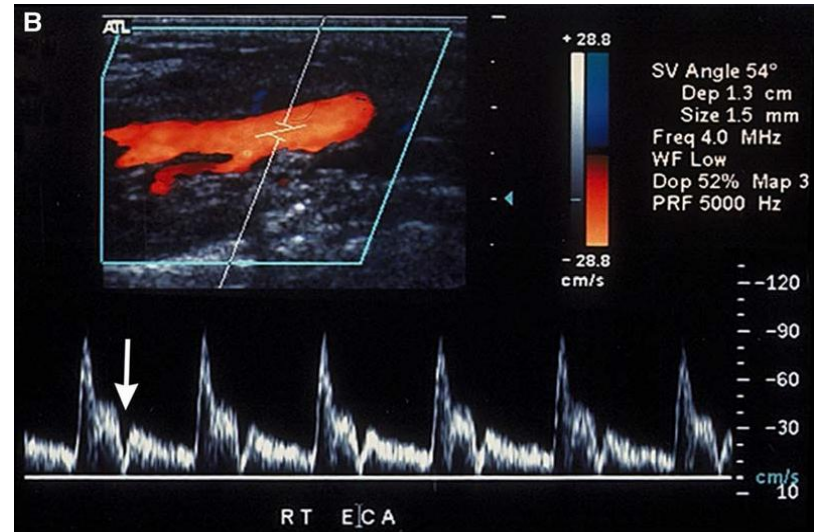
Longitudinal image



Longitudinal color Doppler and spectral waveforms of the ICA origin / mid / distal

Required images

Longitudinal image

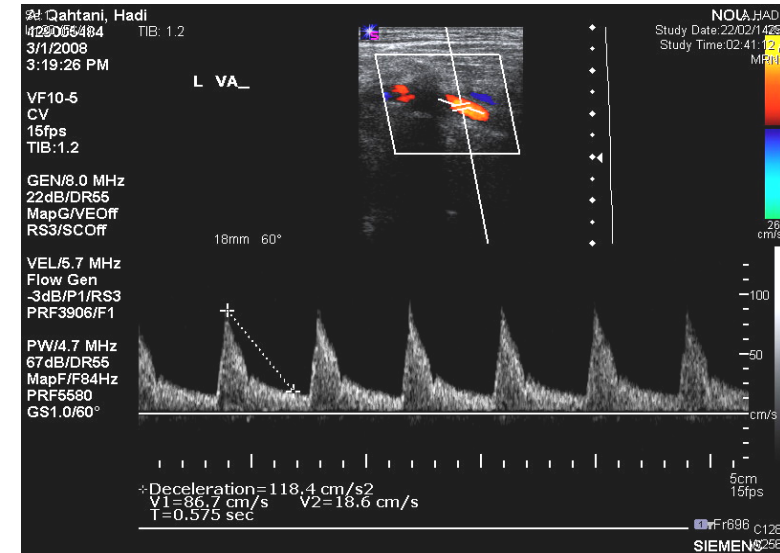


Longitudinal color Doppler and spectral waveforms
of the ECA

Required images

Longitudinal image

- Identify the vertebral artery between the transverse processes of the cervical vertebrae by slight parallel posterolateral movement and lateral angulation of the transducer.

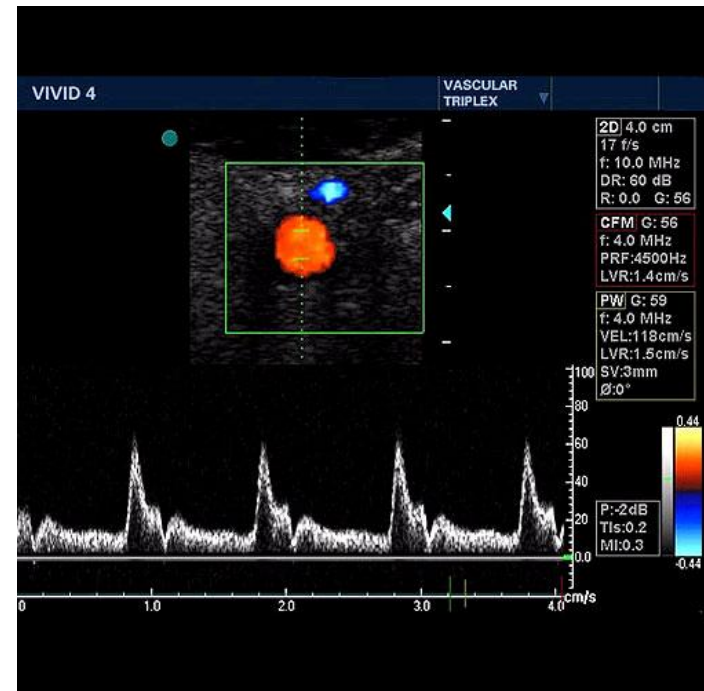
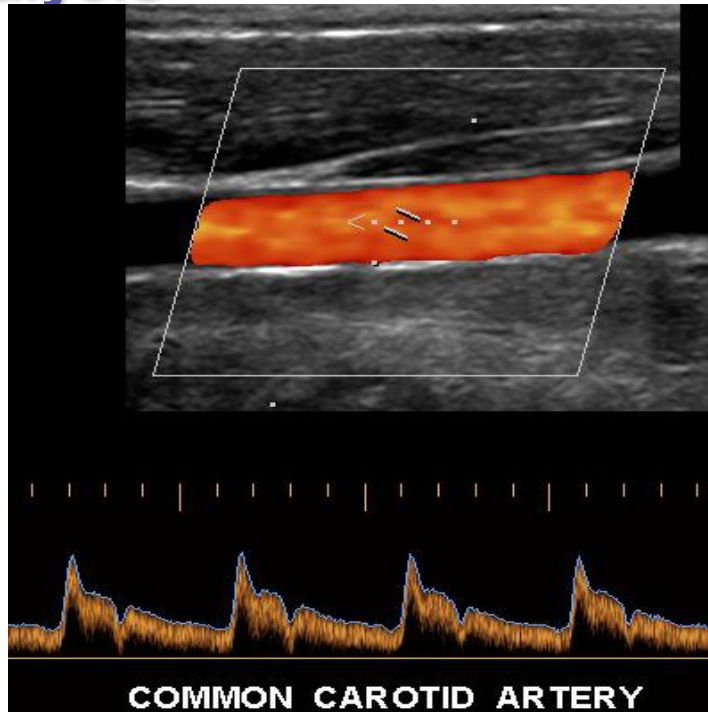


Normal appearance and normal flow

NORMAL CAROTID ULTRASOUND

Identify common carotid artery

- Pulsatile walls
- Smaller caliber than jugular vein
- Systolic peak and diastolic endpoints in between that of external and internal carotid arteries on spectral analysis



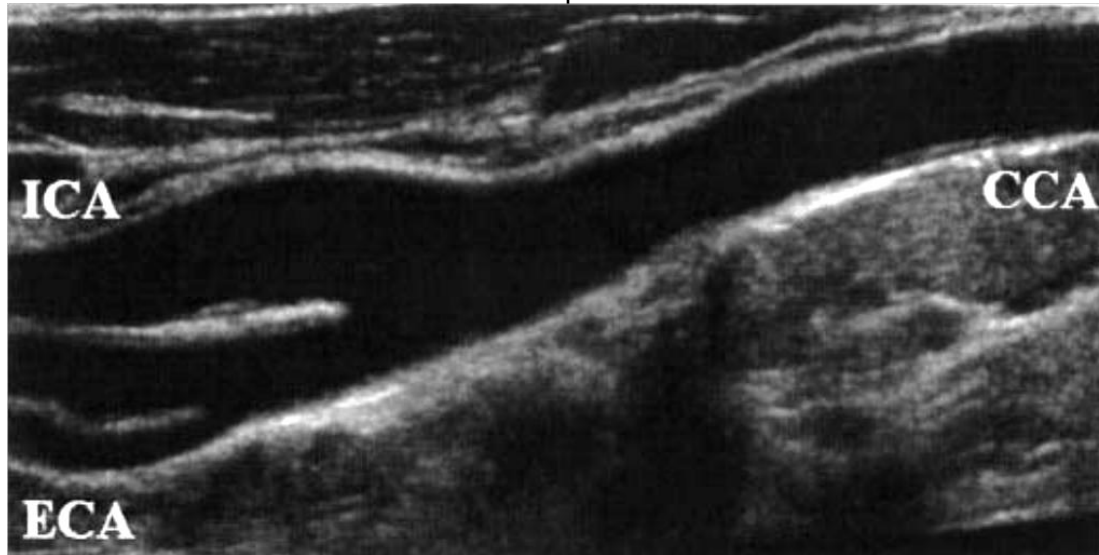
Charcctristics of the ICA and ECA

Internal Carotid Artery

- Gray-scale US
- ▶ larger vessel lumen (~6mm)
- ▶ Postero-lateral location
- ▶ No branch vessels

External Carotid Artery

- Gray-scale US
- ▶ Smaller vessel lumen(~3-4)
- ▶ Antero-medial location
- ▶ Has branch vessels

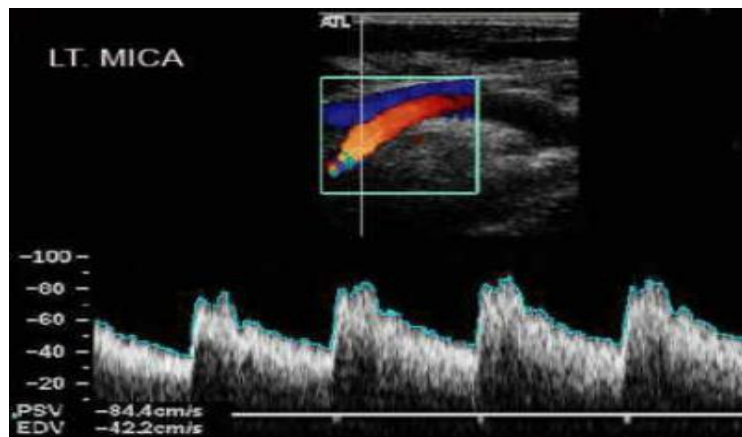


Charcctristics of the ICA and ECA

Internal Carotid Artery

Spectral Doppler US

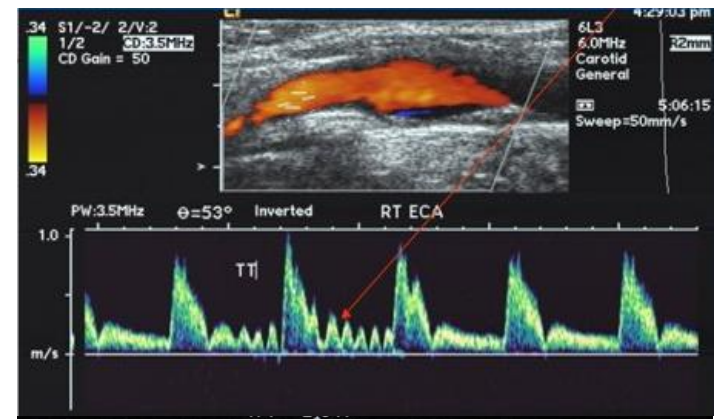
- ◆ Low systolic velocity
- ◆ Broad systolic peak
- ◆ High- velocity diastolic flow
- ◆ Diastolic velocity dose not return to baseline
- ◆ Tapping on the temporal artery has not effect on the Doppler waveform .



External Carotid Artery

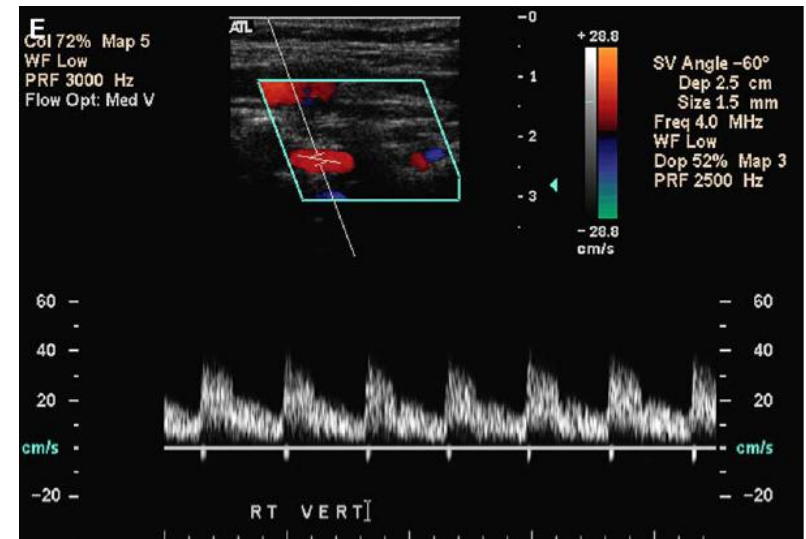
Spectral Doppler US

- ◆ High systolic velocity
- ◆ Sharp, narrow systolic peak
- ◆ Low- velocity diastolic flow
- ◆ Diastolic velocity approach zero baseline
- ◆ Tapping on the temporal artery effect on the Doppler waveform



Vertebral artery

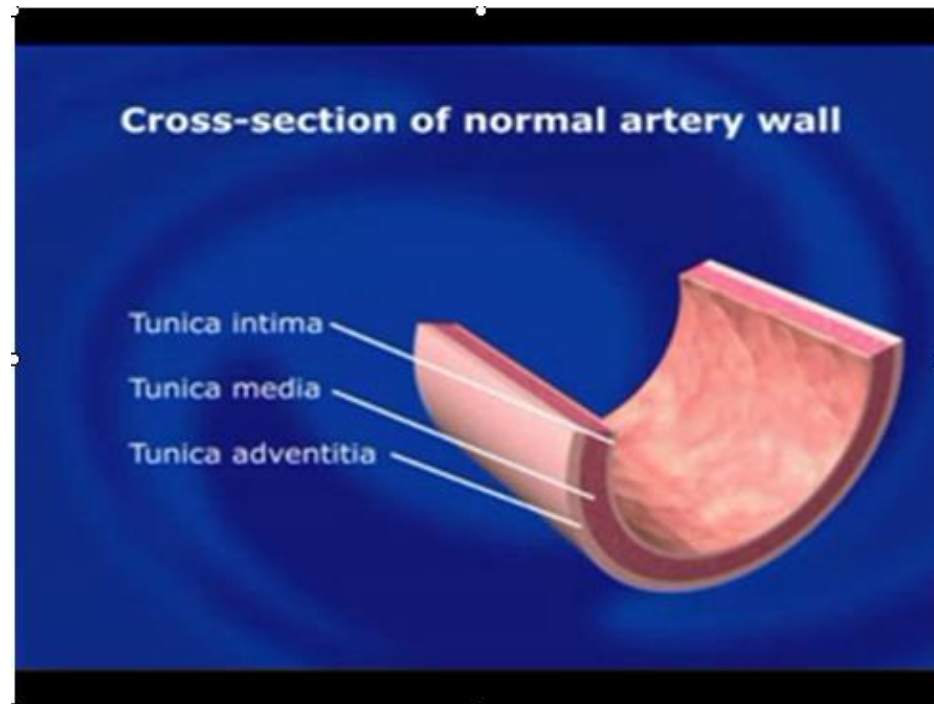
- Low resistance flow
- Low velocity



Thickness of the Carotid Wall

- ✦ Is the a physiologic marker for atherosclerosis disease
- Diffuse thickening of the carotid artery , measurable by:

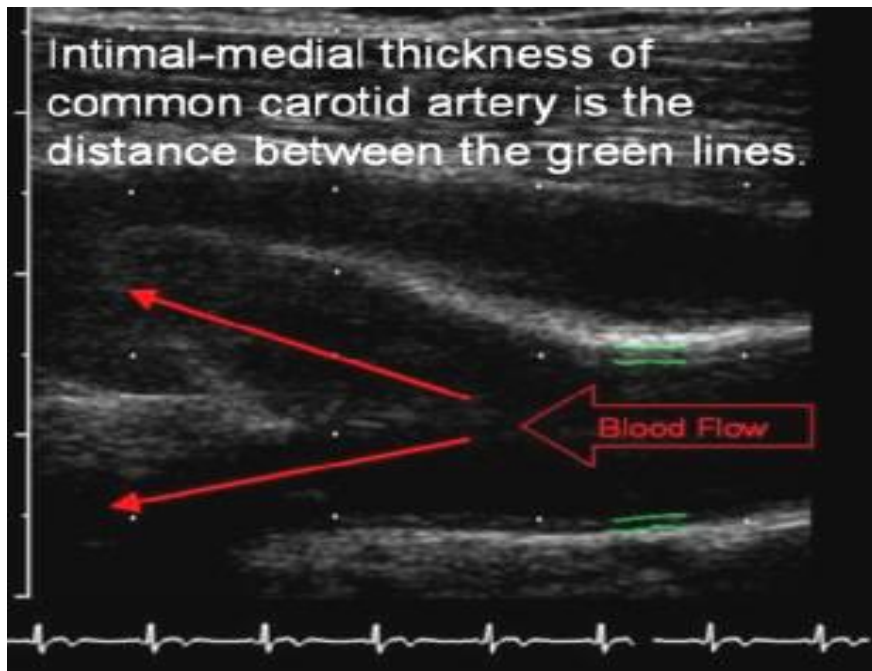
The intima-media thickness (IMT)



The intima-media thickness (IMT)

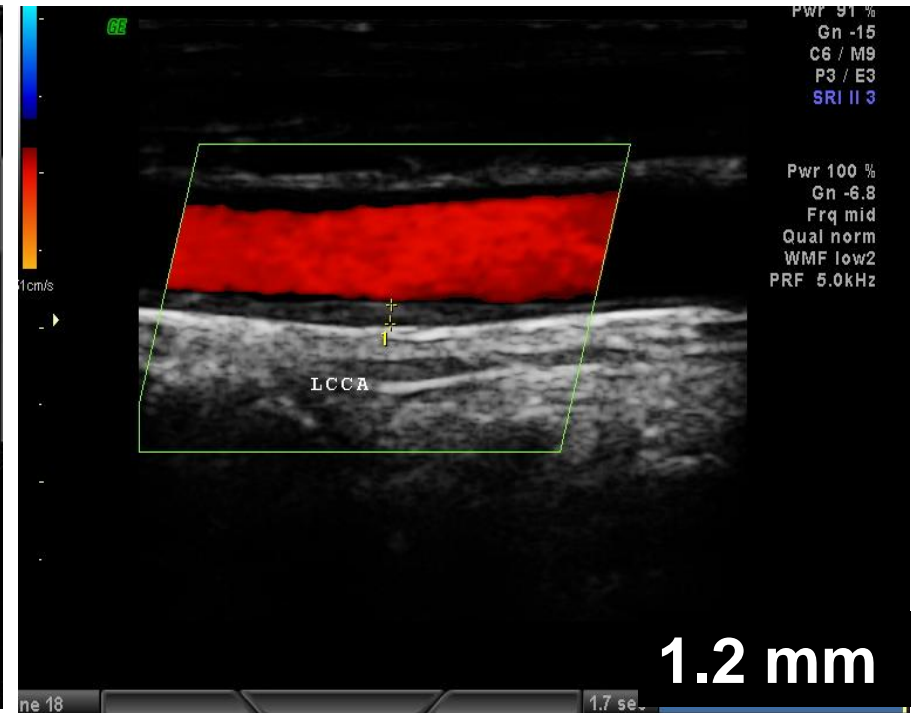
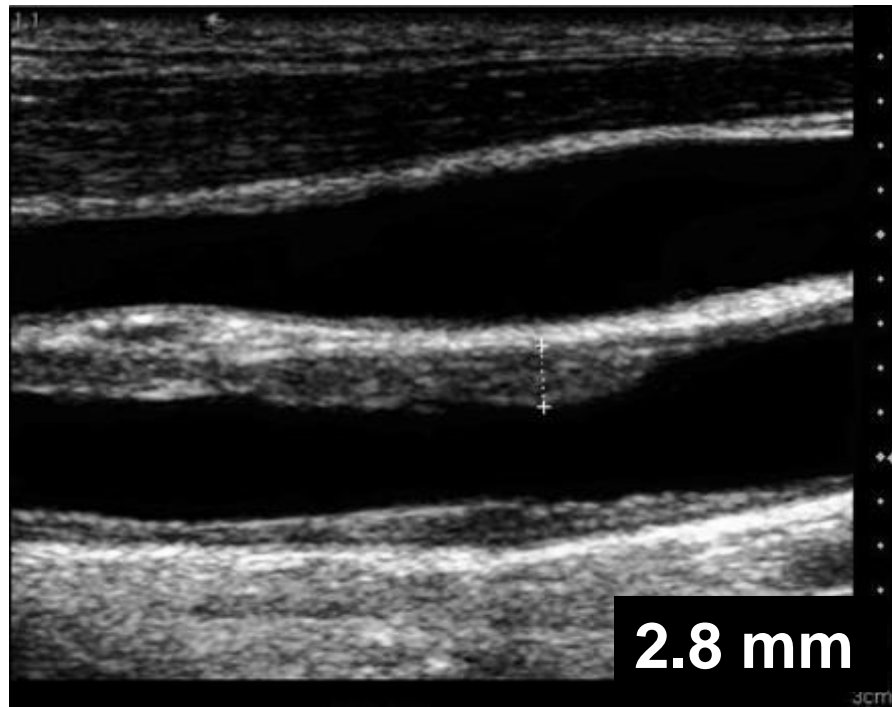
Is measured on the far arterial wall as the distance between:

the echogenic lumen-intima interface and the hypoechoic media-adventitia interface



The intima-media thickness (IMT)

Thickening >1.3 mm is abnormal.

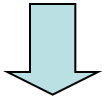


IMT measurements must be obtained from a gray-scale image, not from a color Doppler image.

Abnormal appearance

PLIAQUE CHARACTERIZATION

It is characterized as



Low echo plaque

- It contains a large amount of lipid material.
- It is difficult to image

Moderate echo plaque

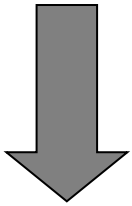
- It is fibrous plaque made up of collagen and lipids

Strong echo plaque

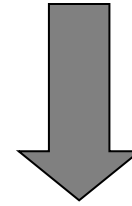
- It has strong reflections caused by vessel calcification.

PLIAQUE CHARACTERIZATION

•Atherosclerotic plaque may be

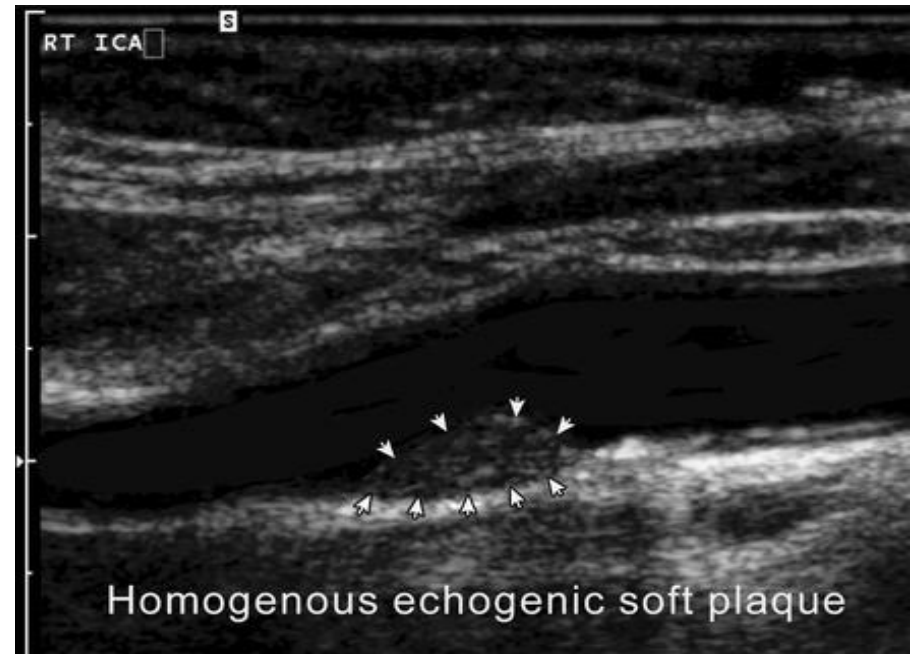
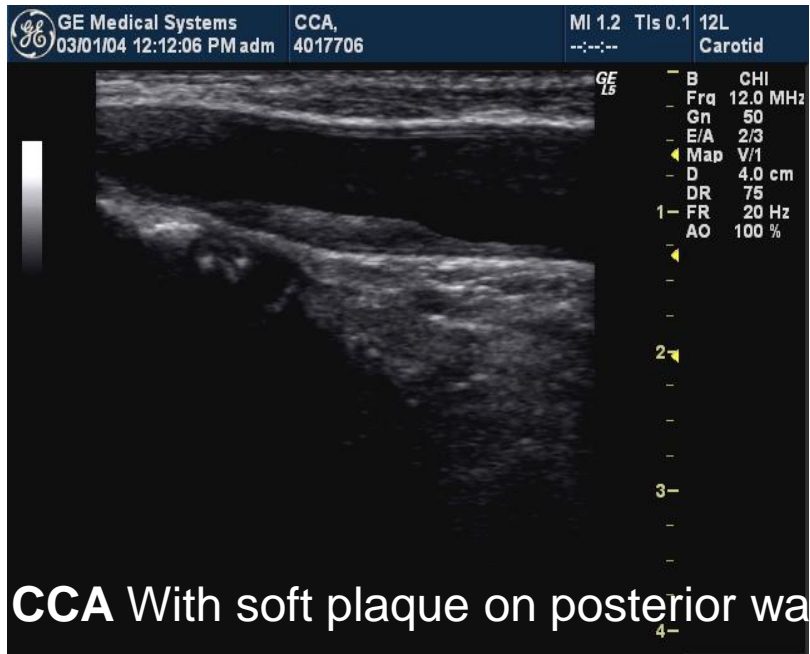


homogeneous



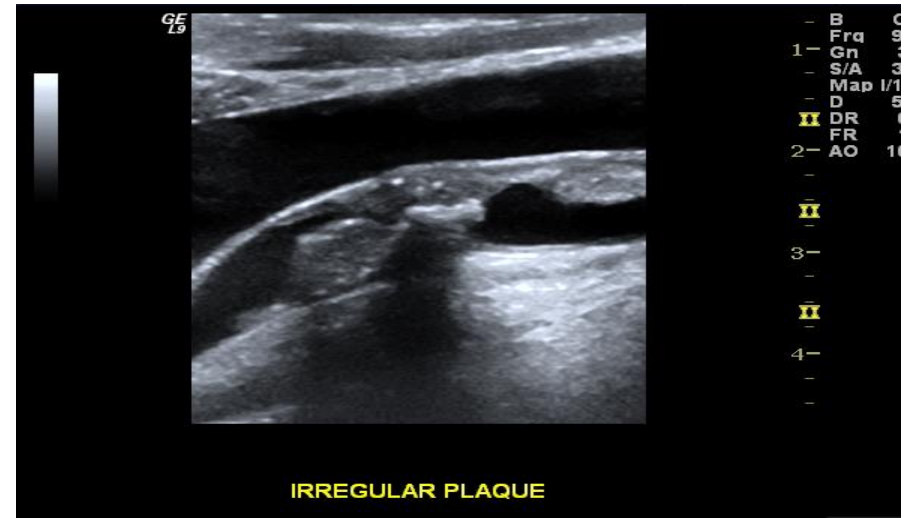
heterogeneous

PLIAQUE CHARACTERIZATION



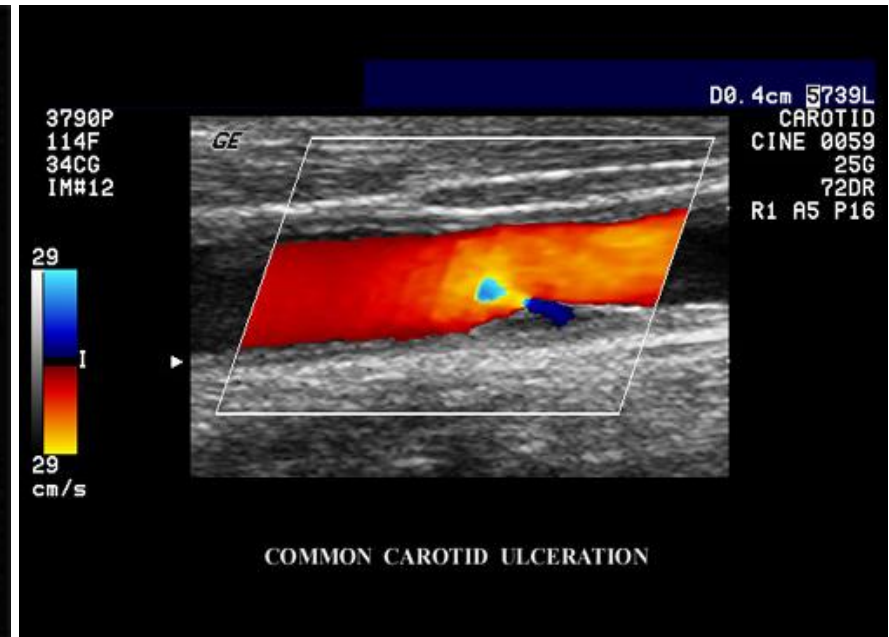
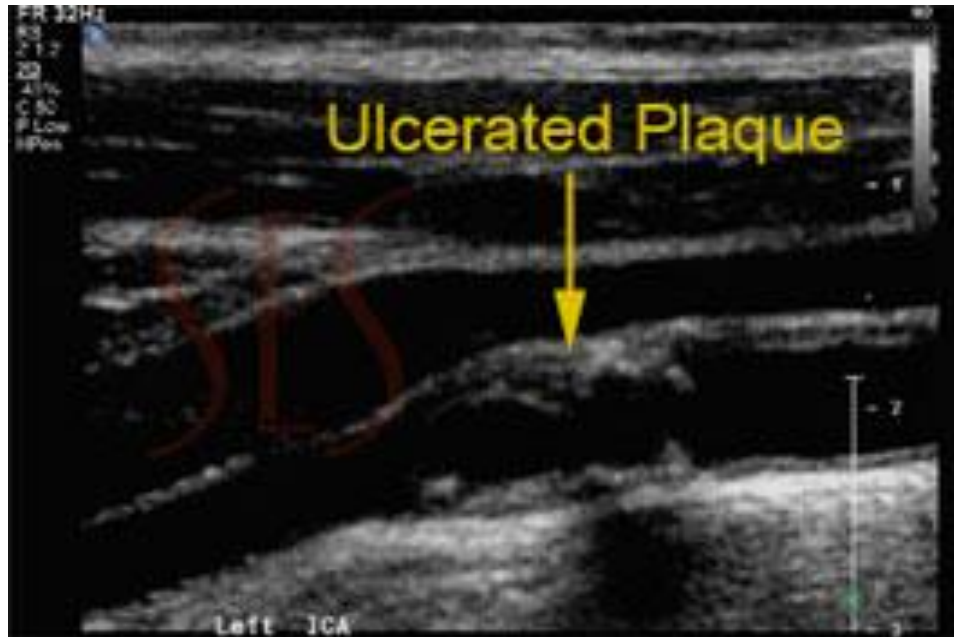
- Homogenous plaque consist of uniform , low-level echoes comparable in echogenicity to muscles of the neck.
- The surface of the plaque is smooth .

PLAQUE CHARACTERIZATION



- Heterogeneous plaque is complex in appearance plaque containing an echo-poor area which represent : intraplaque hemorrhage or amorphous lipid deposits.
- the surface is irregular .

PLIAQUE CHARACTERIZATION

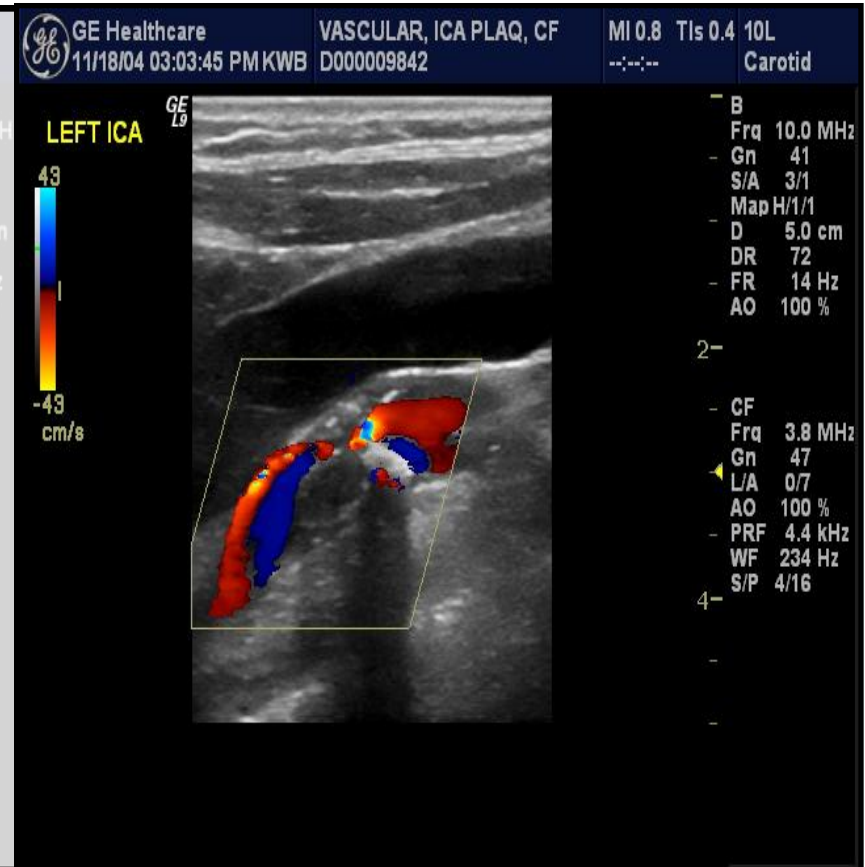


Ulcerated plaque may be detected by reversal flow within the plaque

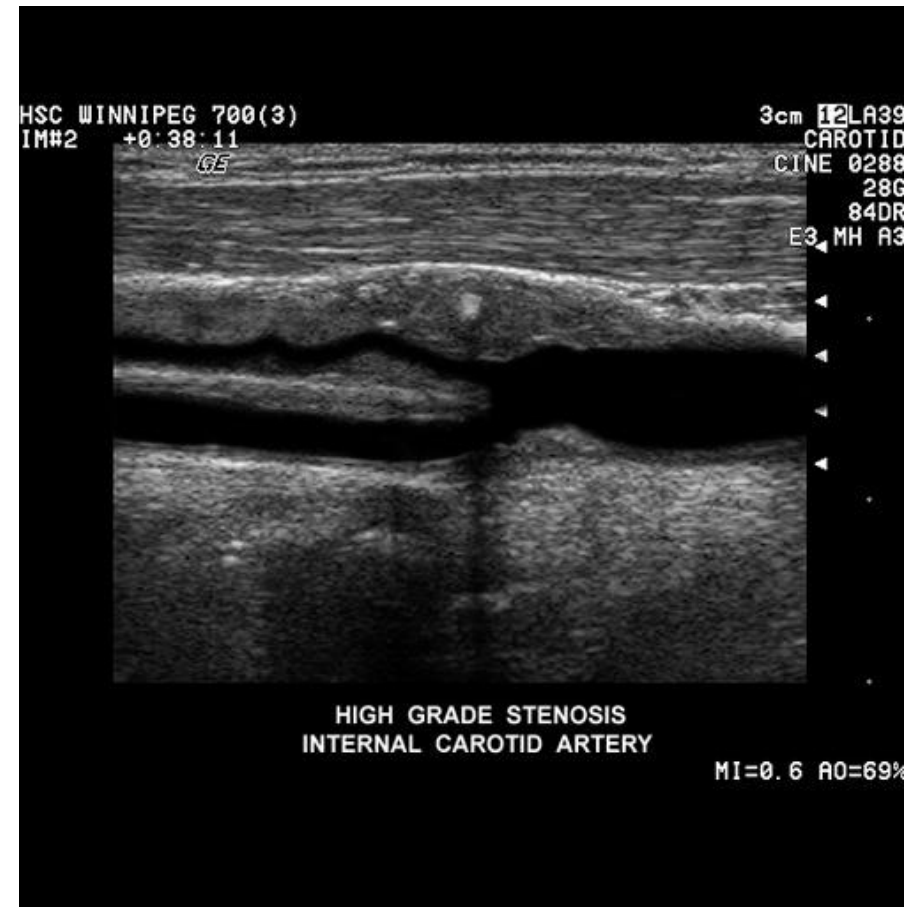
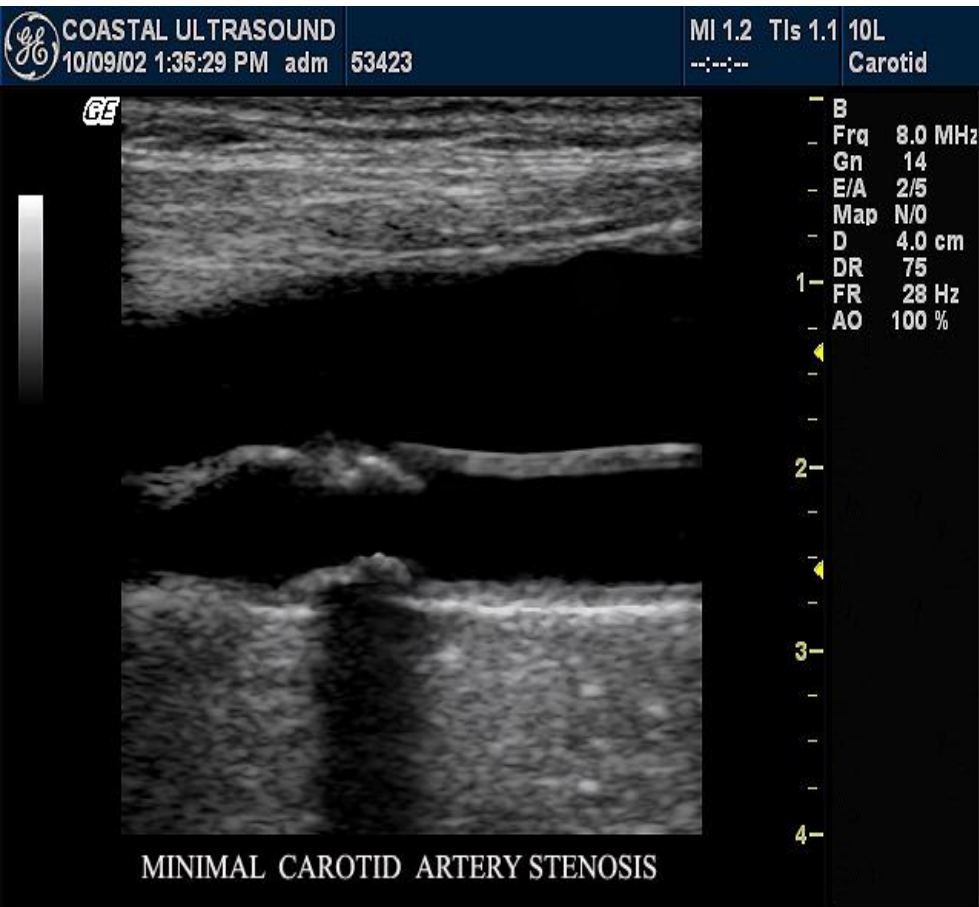
Stenosis

- Stenosis of an artery may reduce blood flow through the vessel.
- Stenosis produce a high resistance flow pattern with little flow and high velocity.

IRREGULAR PLAQUE



Stenosis



STENOSIS %	PEAK SYSTOLIC VELOCITY	END DIASTOLIC VELOCITY	PEAK SYSTOLIC VELOCITY RATIO	END DIASTOLIC VELOCITY RATIO
NORMAL	<120	<40	<1.5	<1.8
30%	>120	>40	<1.5	<1.8
30-50%	>120	>40	>1.5	<1.8
50-60%	150-200	50-60	>2.0	>1.8
60-70%	200-250	60-80	>2.5	2.5-3.0
70-80%	250-300	80-100	>3.0	>3.5
80-90%	300-400	>125	>3.5	>4.0
90-99%	>400	>150	>4.5	5.5
100%	NO FLOW	ZERO	ZERO	ZERO

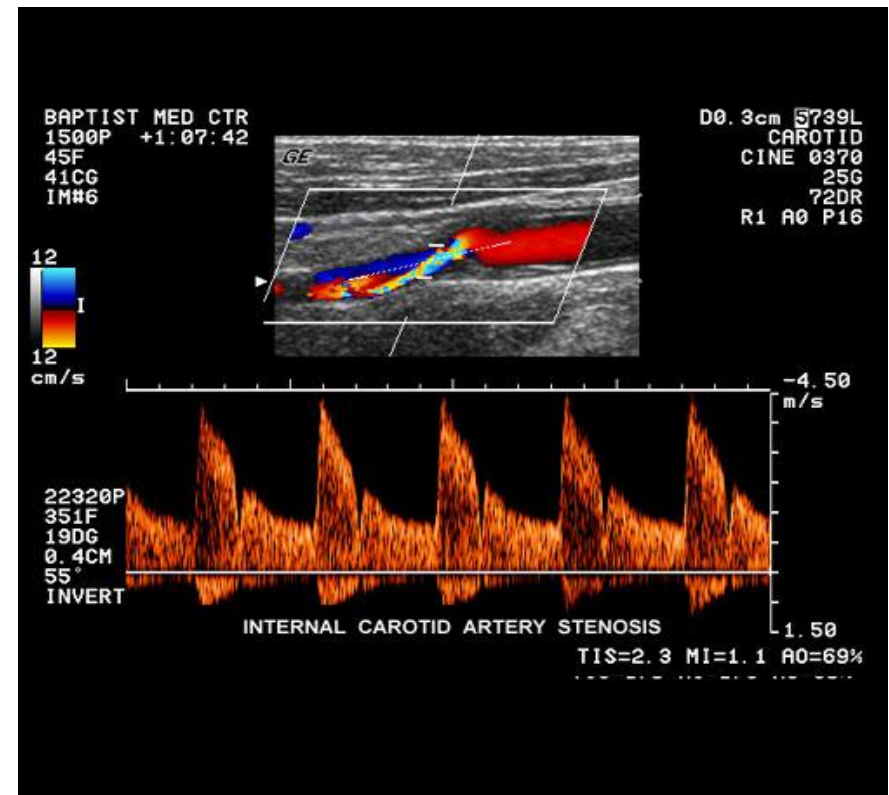
Table 1: Doppler criteria for internal carotid artery diameter stenosis detection developed by the Society of Radiologists in Ultrasound consensus conference

	ICA PSV cm/s	Plaque/diameter	ICA/CCA ratio = PSV _{ICA} /PSV _{CCA}	ICA EDV cm/s
Normal	<125	None	<2	<40
<50%	<125	<50%	<2	<40
50%–69%	125–230	≥50%	2–4	40–100
≥70 to near occlusion	>230	≥50%	>4	>100
Near occlusion	High, low, or undetectable	Visible	Variable	Variable
Total occlusion	Undetectable	Visible, no detectable lumen	N/A	N/A

Stenosis

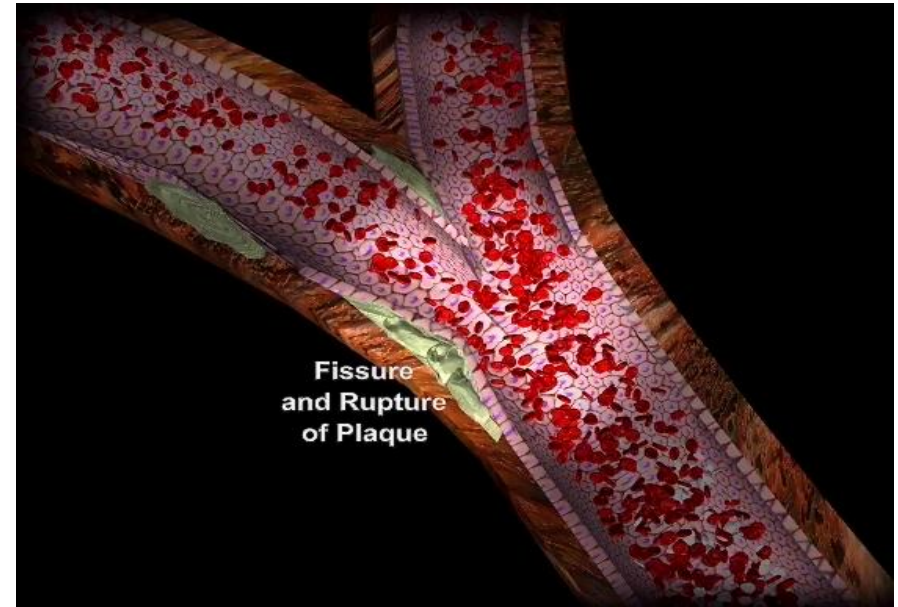
- There is elevation of the peak systolic velocity to 255 cm/sec, this corresponds to an approximate 80% diameter stenosis

IRREGULAR PLAQUE

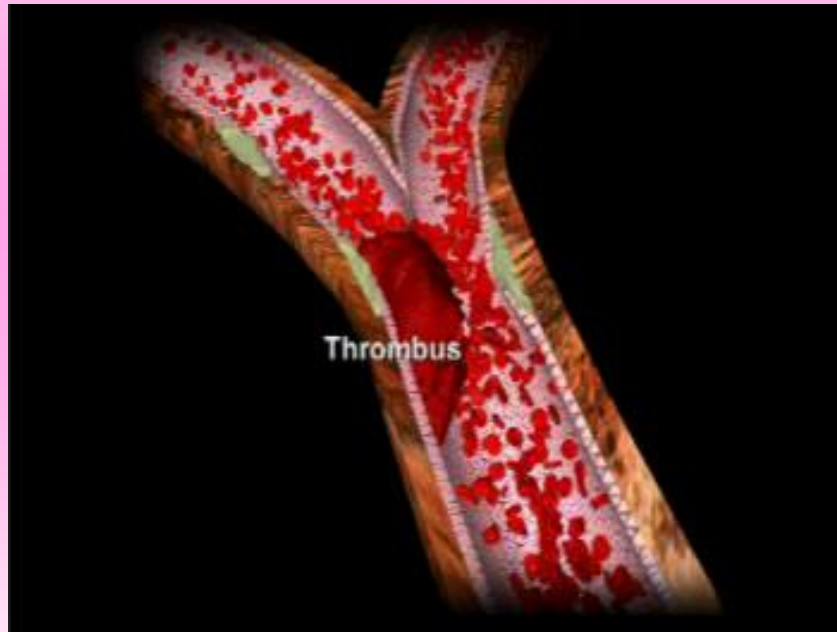


OCCCLUSION

- Color and spectral Doppler signals are absent in the vessel.

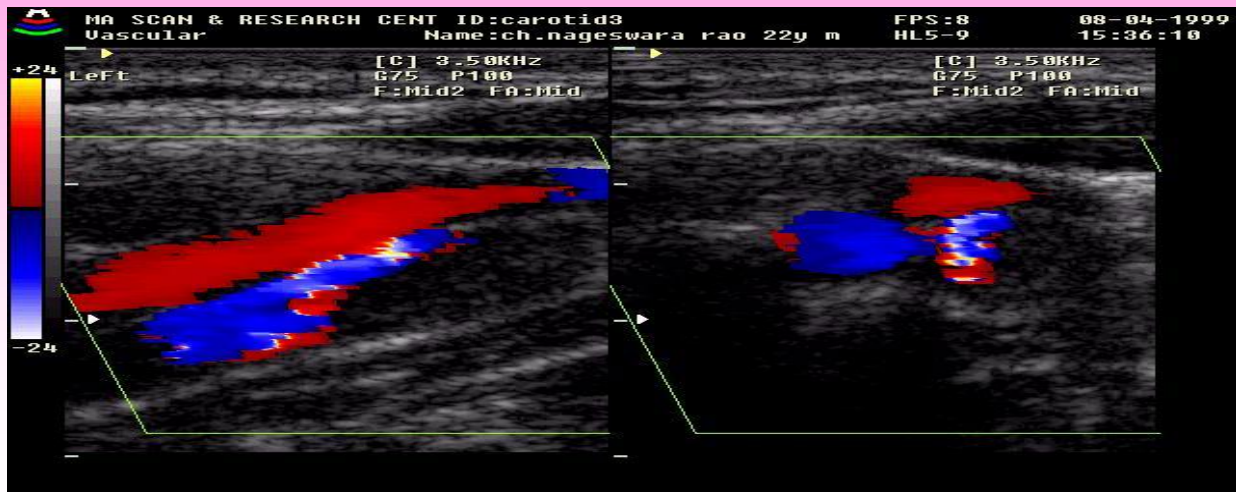
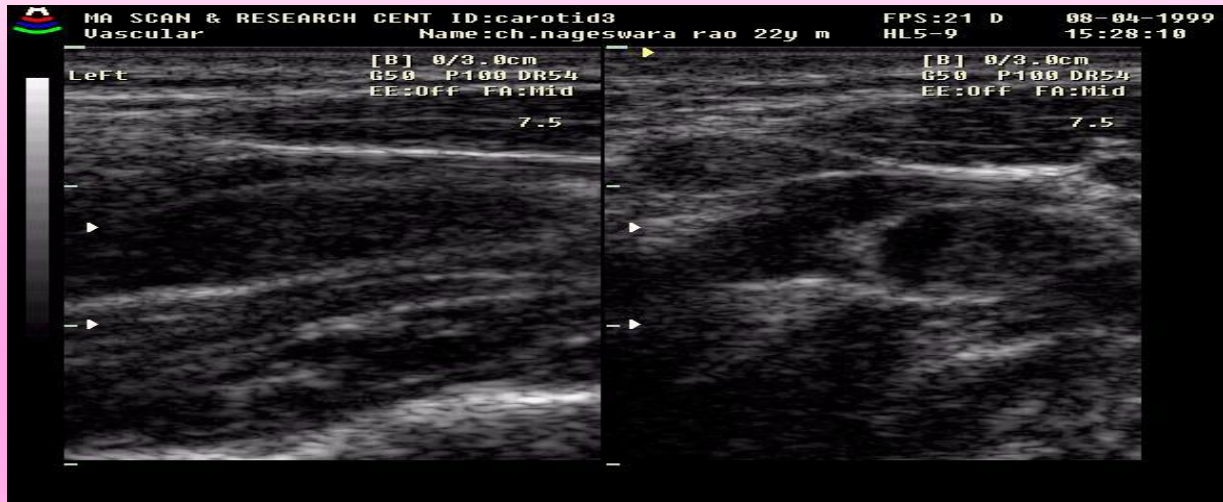


BLOOD CLOT



A thrombus that travels from the blood vessel to another location is called an embolus

BLOOD CLOT



BLOOD CLOT



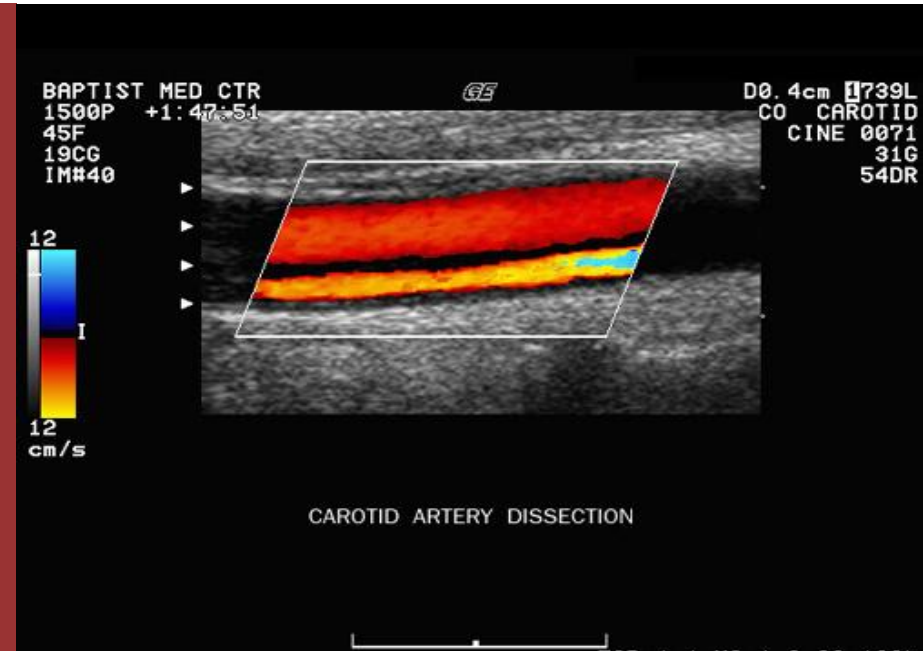
Carotid Artery Dissection

■ Gray scale image of a traumatic carotid dissection

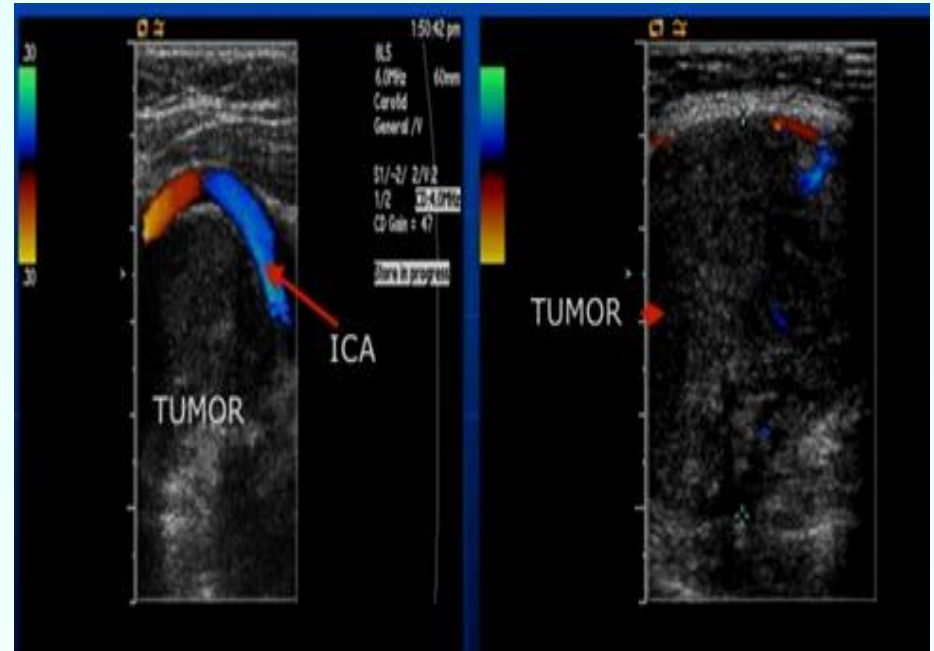
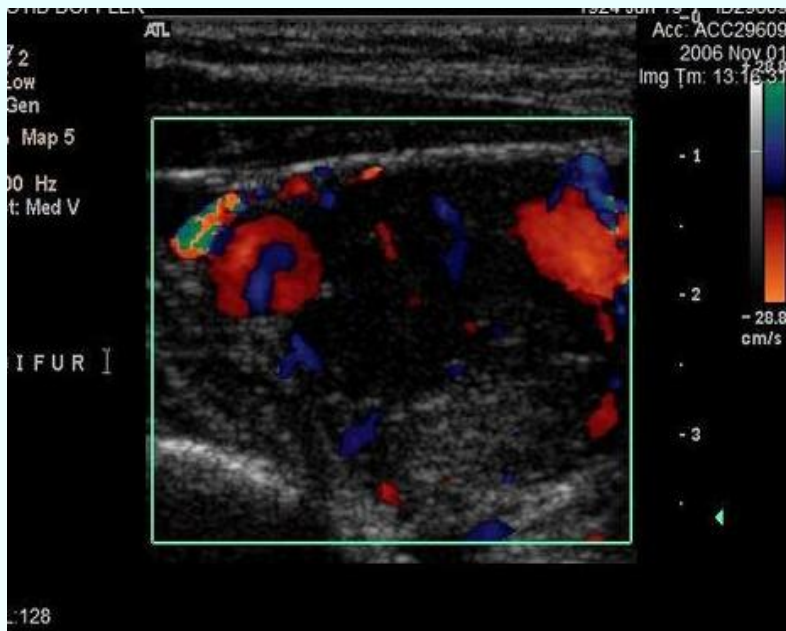


Carotid Artery Dissection

■ carotid artery dissection shows the "false" lumen as separate from the normal lumen.

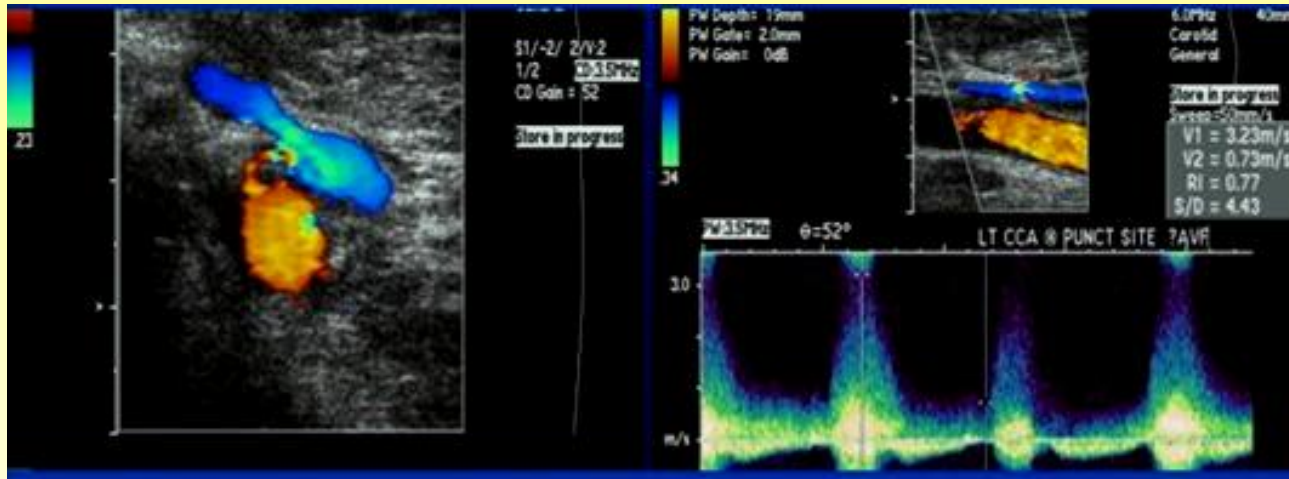


CAROTID BODY TUMOR



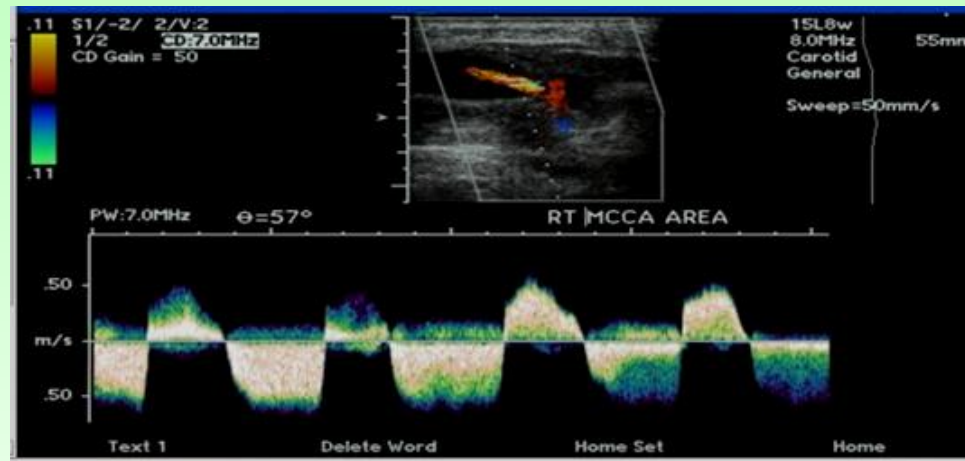
- Highly vascular mass at the bifurcation of ICA/ECA

Carotid arteriovenous fistula



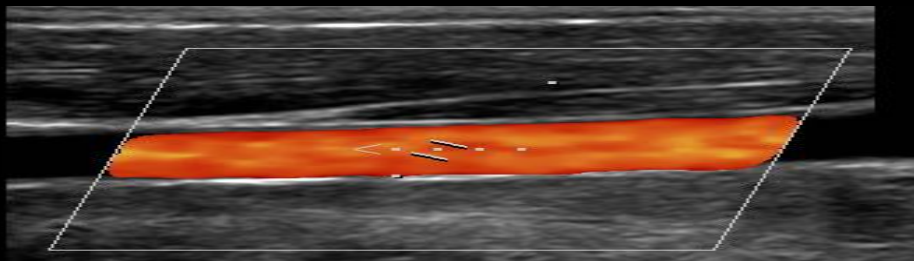
- Usually traumatic
- Low resistance flow of high velocity throughout the cycle
- Arterial peaks
- Flow above and below the baseline

Carotid Pseudoaneurysm



- Pulsating hematoma
- Connects with the artery
- To and fro flow above and below baseline

E
Col 72% Map 5
WF Low
PRF 3000 Hz
Flow Opt: Med V



+20.8
-20.8
cm/s

SV Angle -60°
Dep 2.5 cm
Size 1.5 mm
Freq 4.0 MHz
WF Low
Dop 52% Map 3
PRF 2500 Hz

Waveform analysis

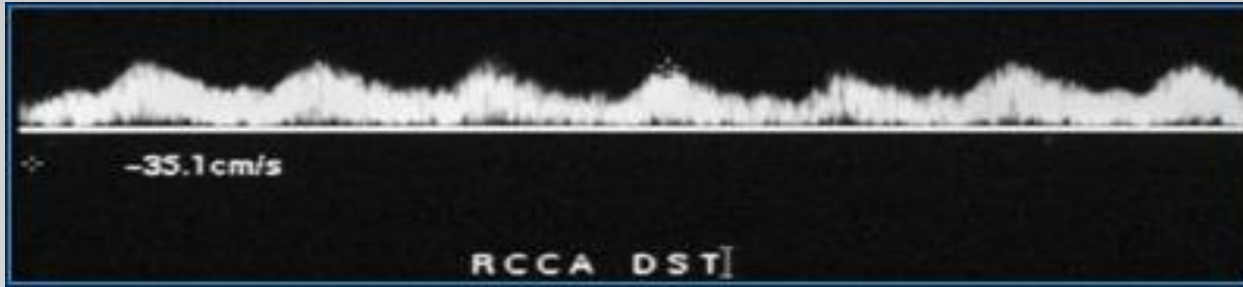
TARDUS PARVUS

PULSUS BISFERIENS

PULSUS ALTERNANS

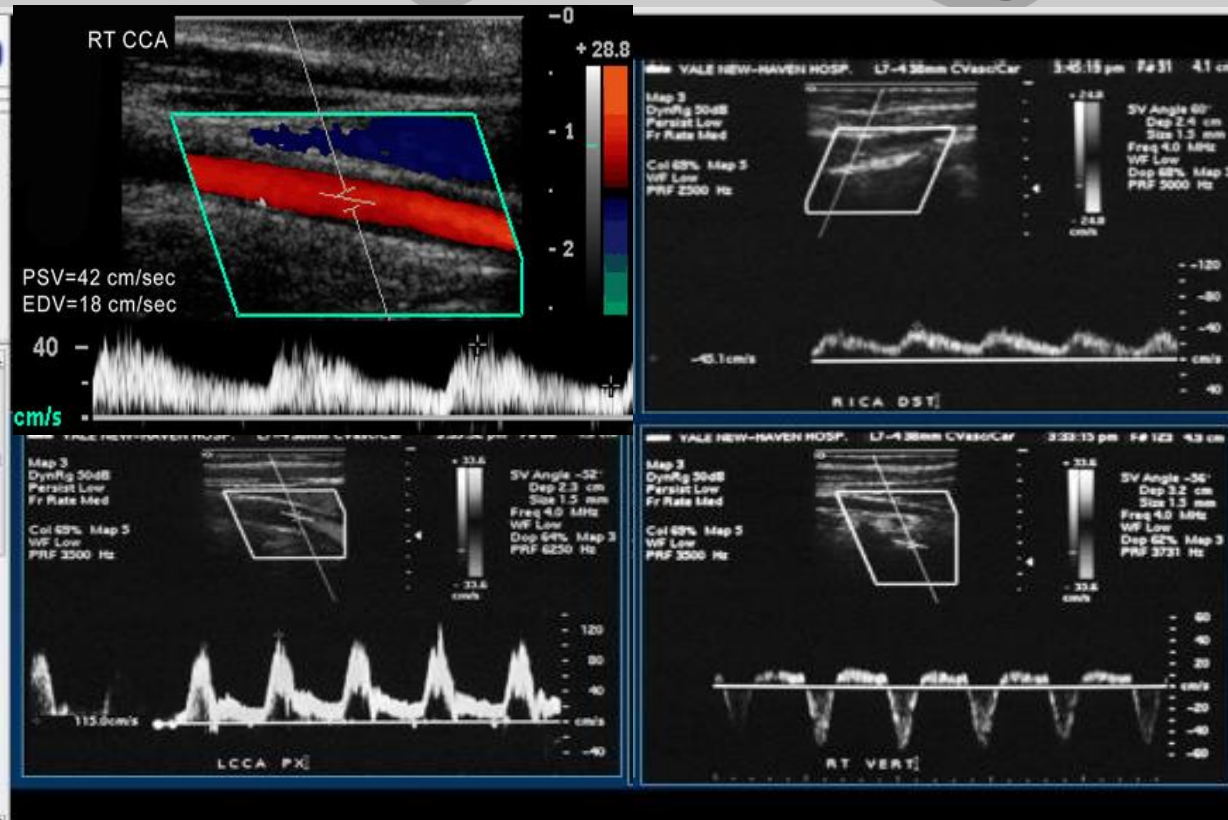
KNOCKING WAVEFORM

TARDUS PARVUS WAVEFORM



- Delayed systolic upstroke.
- Decreased PSV.
- Rounded systolic peak .
- Observed distal to severe stenosis.

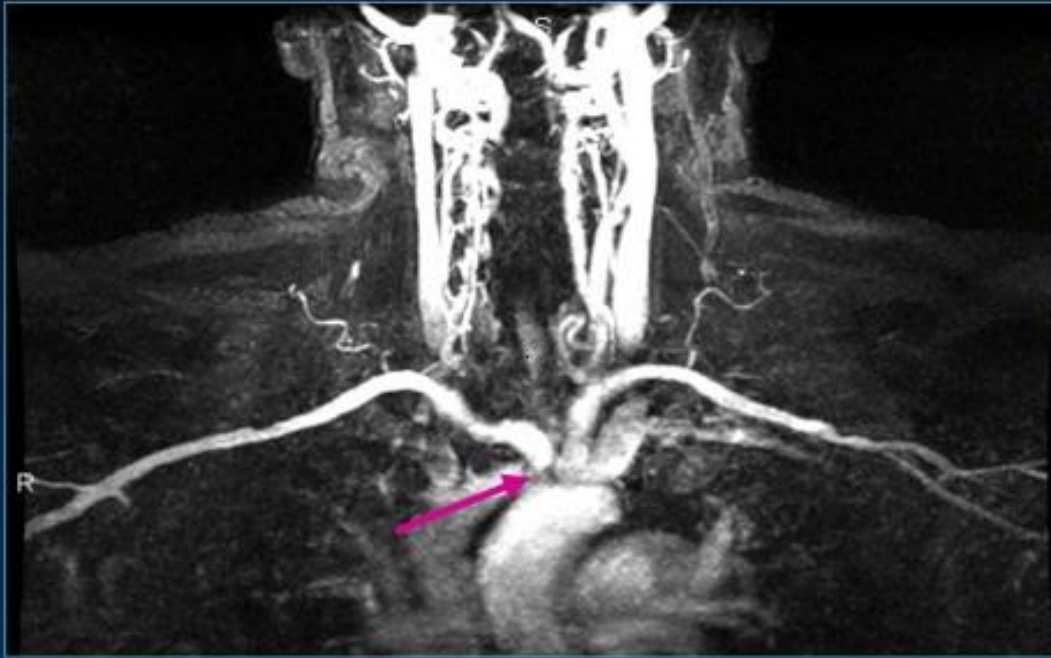
TARDUS PARVUS WAVEFORM



Tardus parvus waveform in distal R CCA and R ICA
The PSV is normal and the systolic upstroke is sharp in L CCA.

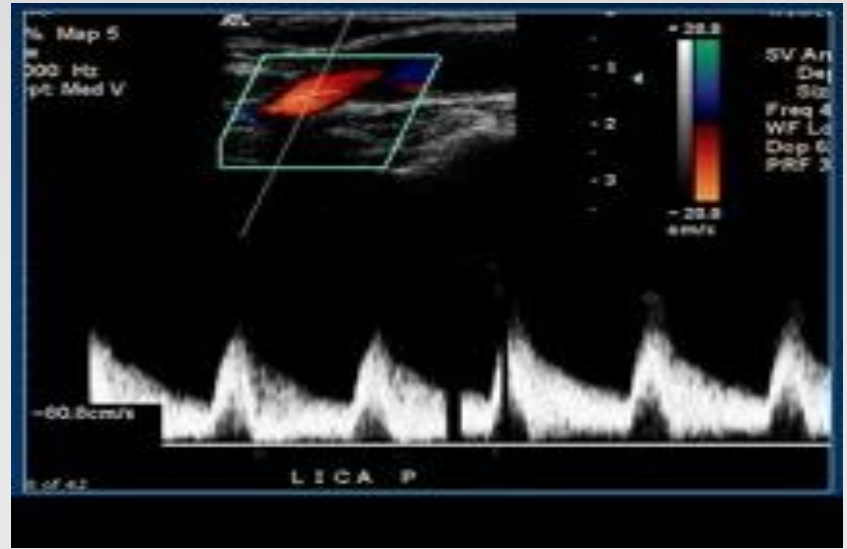
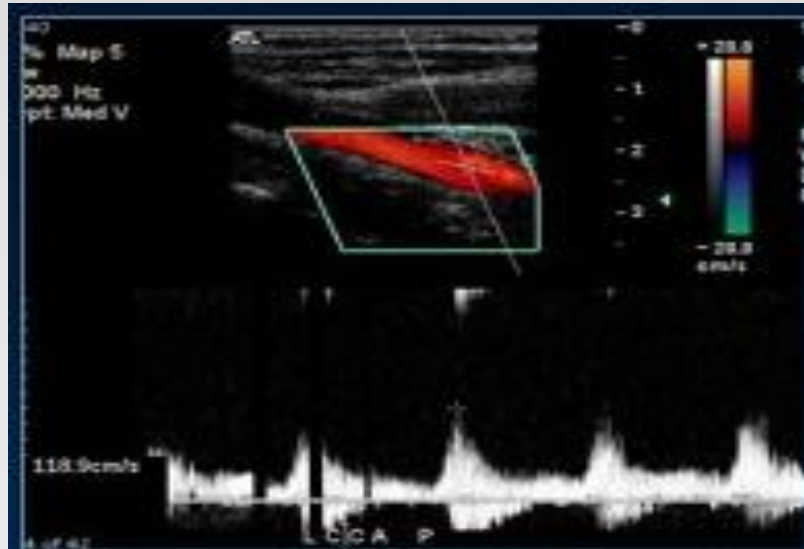
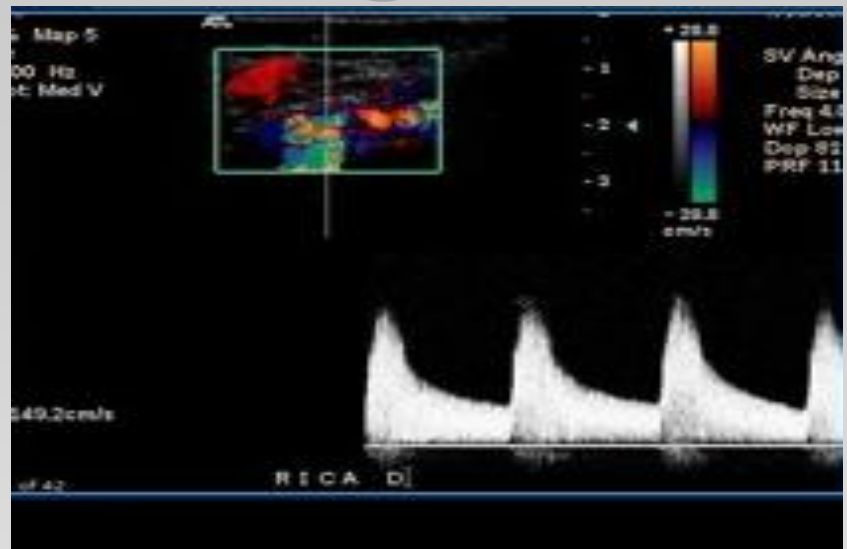
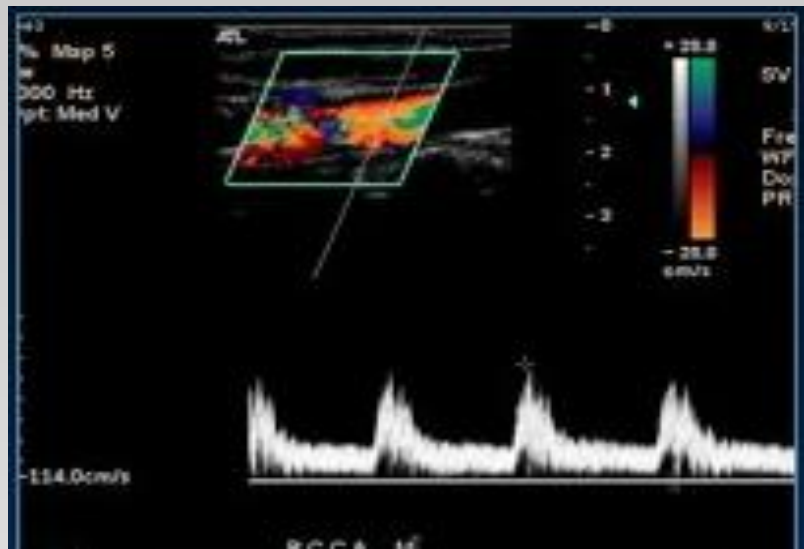
The reversed flow in the right vertebral artery

TARDUS PARVUS WAVEFORM



Stenosis of Innominate Artery

TARDUS PARVUS WAVEFORM

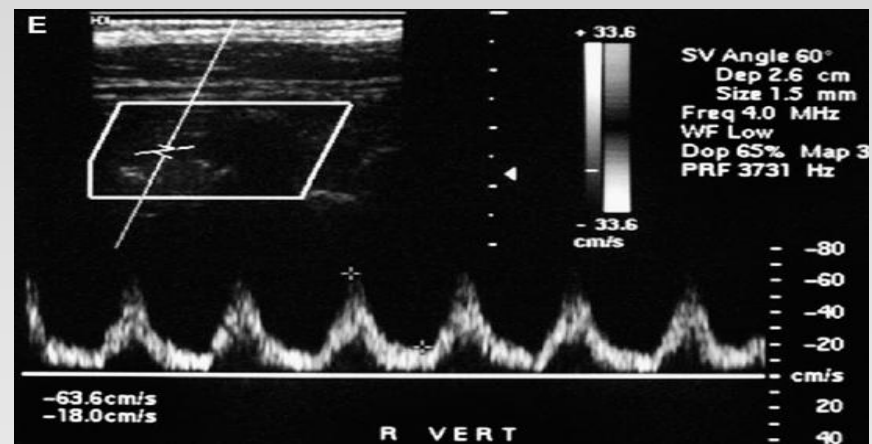
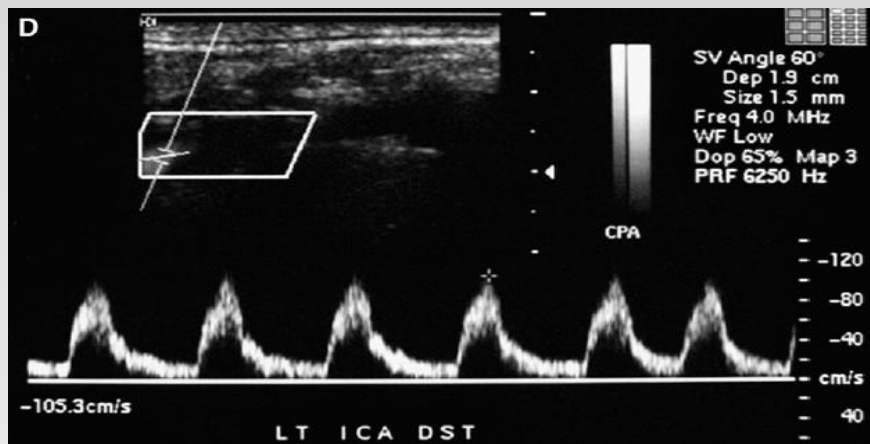
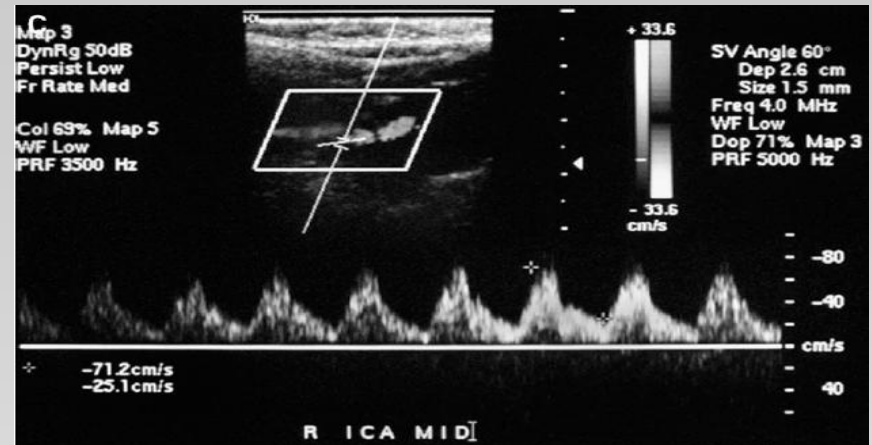
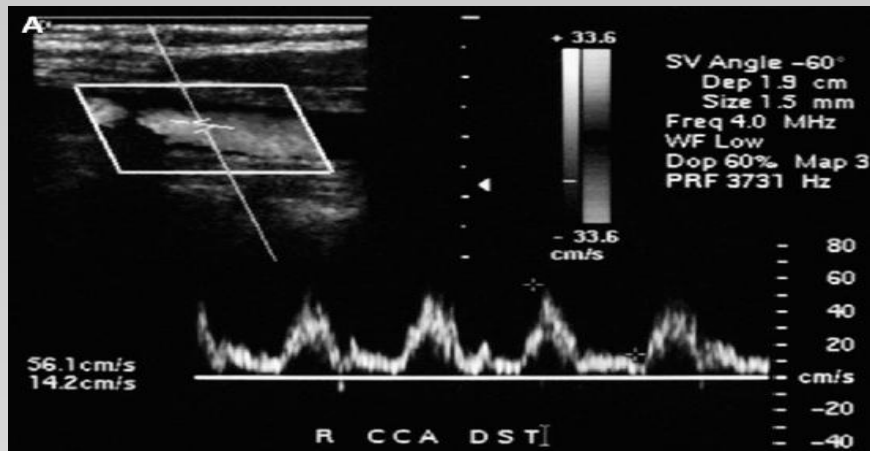


TARDUS PARVUS WAVEFORM



- Stenosis of the origin of Lt CCA

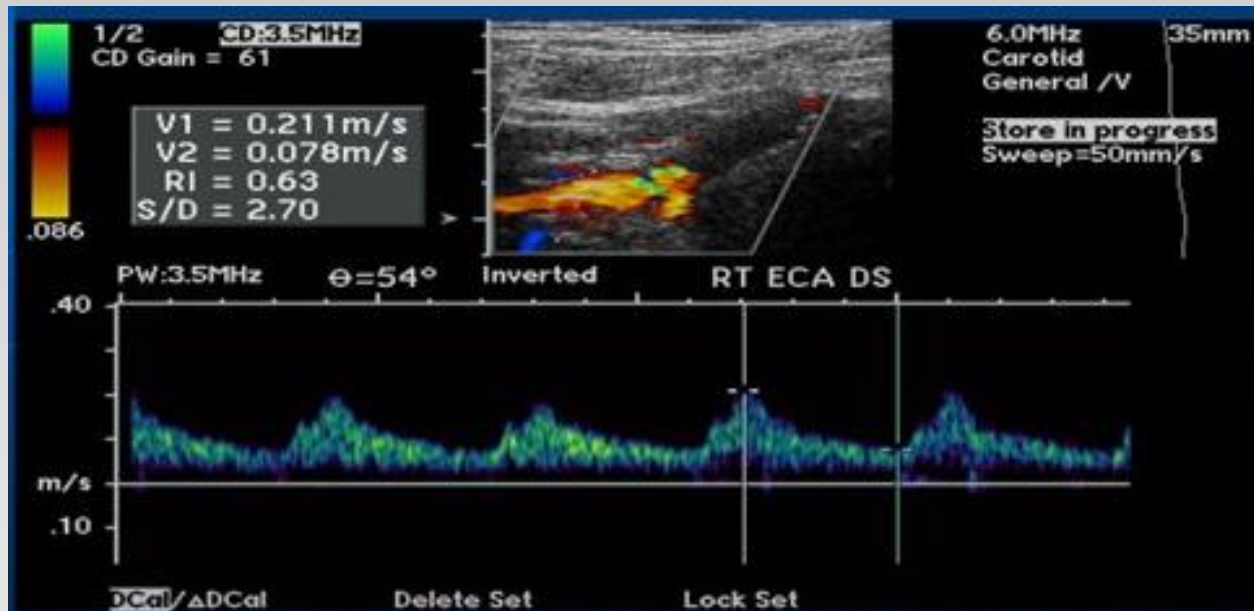
TARDUS PARVUS WAVEFORM



A tardus parvus waveform is noted in both CCAs, ICAs, ECAs, and both vertebral arteries in patients who have aortic stenosis

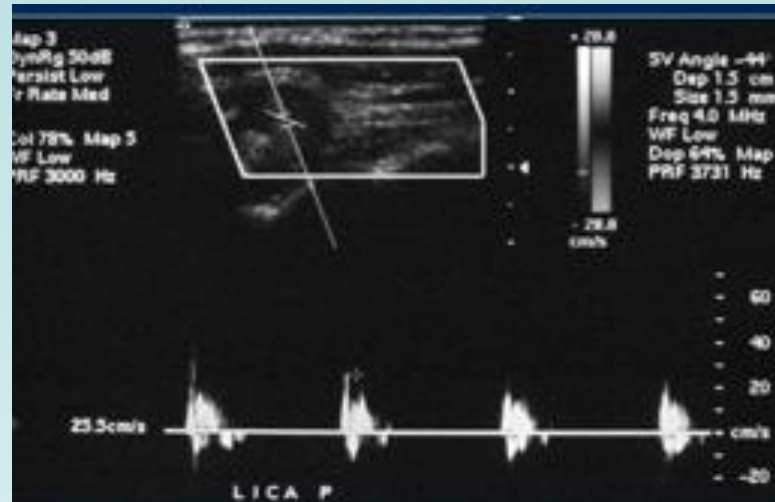
TARDUS PARVUS WAVEFORM

ICA and CCA occlusion



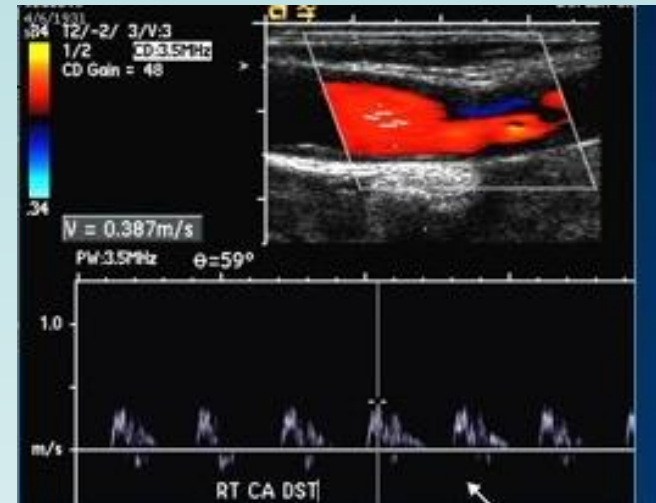
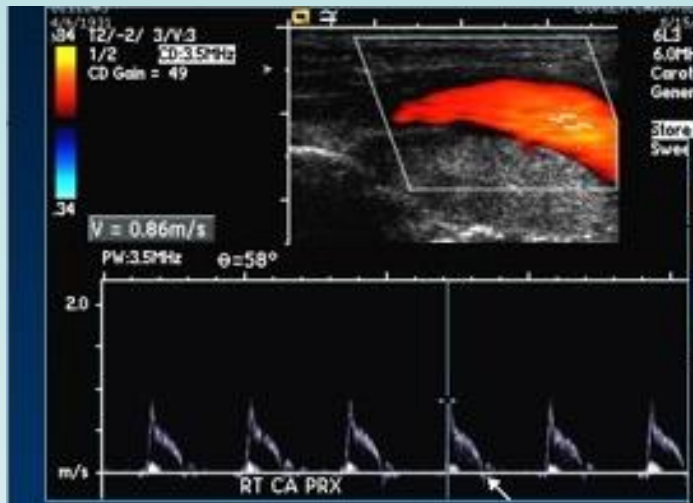
- Ipsilateral ECA flow is tardus parvus

KNOCKING WAVEFORM

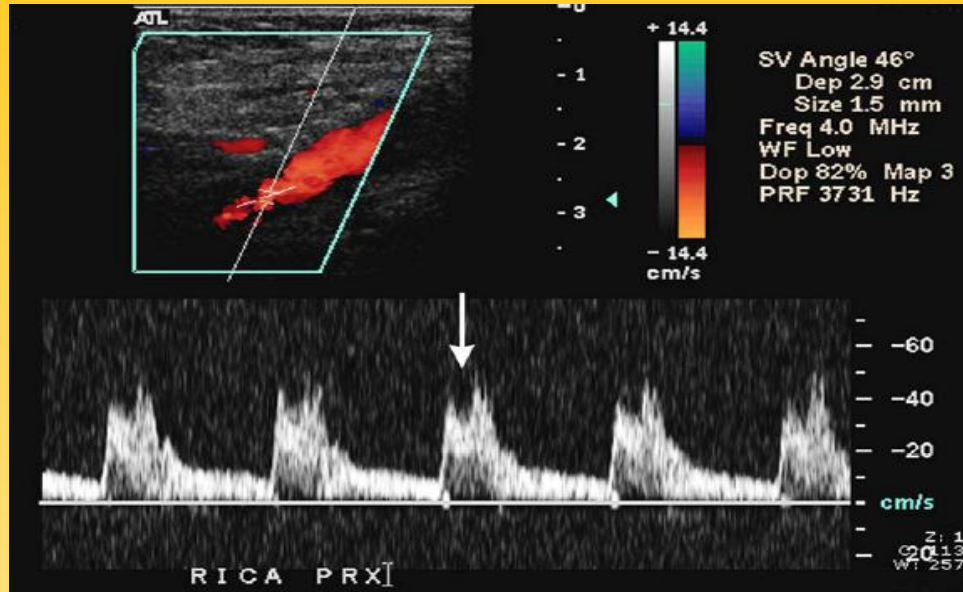


- Low PSV
- Little , reversed , or no diastolic flow
- Observed proximal to an occlusion or high grade stenosis

KNOCKING WAVEFORM

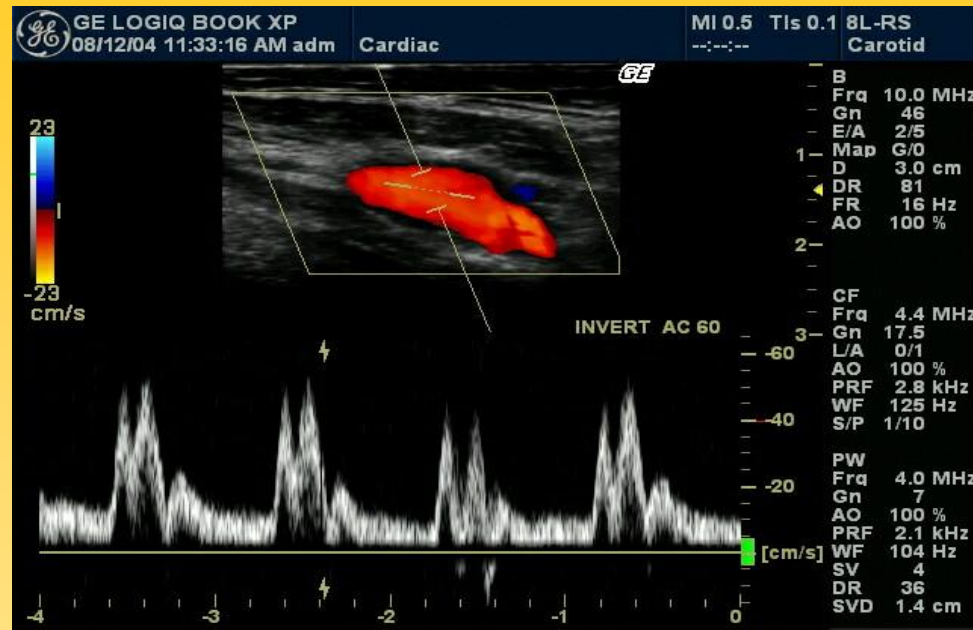


PULSUS BISFERIENS



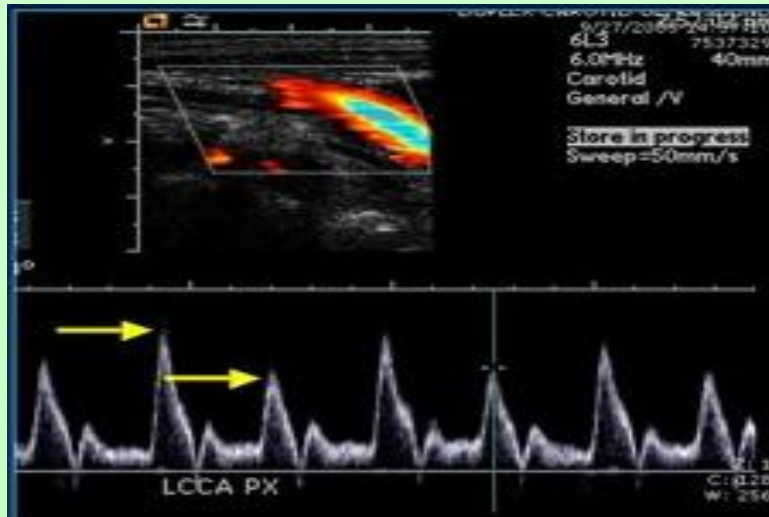
- A waveform characterized by two systolic peaks with an interposed midsystolic retraction.
- Second systolic peak higher than first

PULSUS BISFERIENS



➤ Observed this waveform in aortic insufficiency related or unrelated to aortic stenosis or hypertrophic obstructive cardiomyopathy.

PULSUS ALTERNANS



Alternating peak systolic height with a regular cardiac rhythm.

A variety of clinical conditions, such as

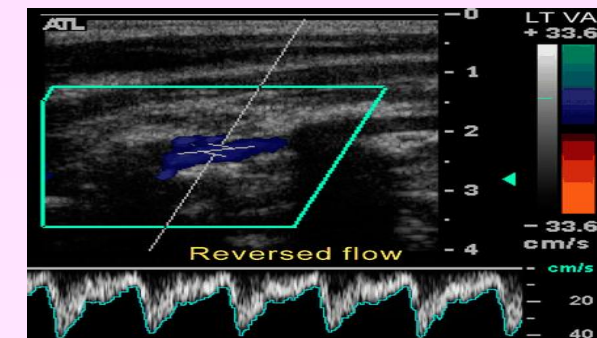
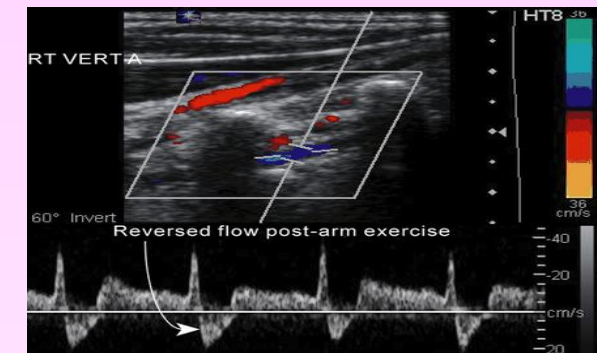
- Intrinsic myocardial disease (ischemia, cardiomyopathy)
- Metabolic disease hypocalcemia, or
- obstruction or compression of the IVC.

ABNORMAL VA WAVEFORM

vertebral artery waveform is described a "bunny waveform"

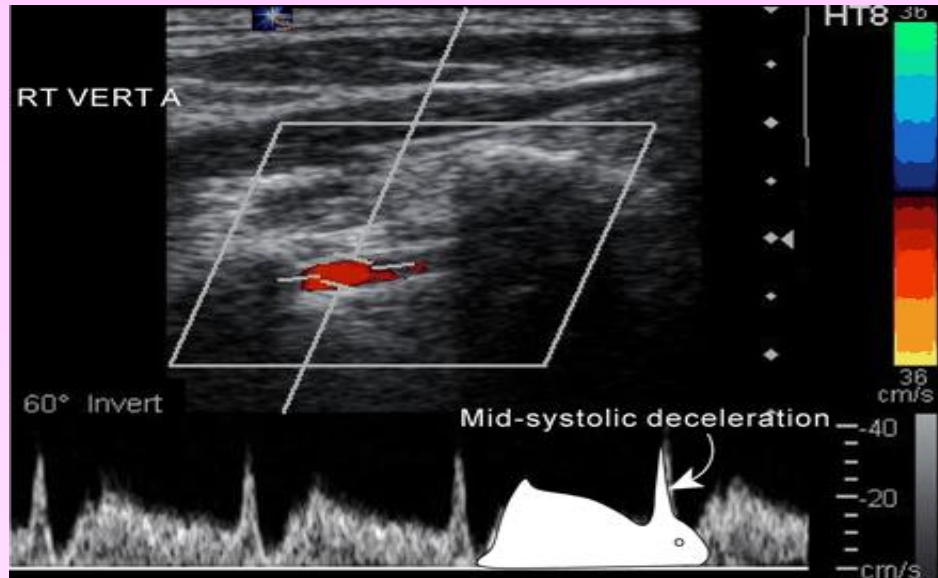
The vertebral bunny

- ✓Pre-steal waveform
- ✓Spectrum of waveform changes with varying degree of subclavian steal.



ABNORMAL VA WAVEFORM

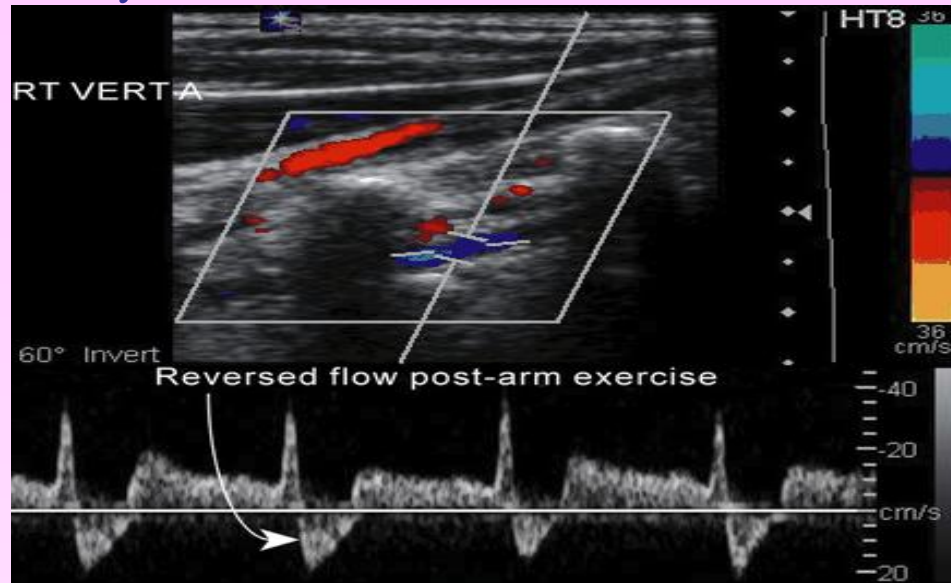
Occult subclavian steal



PW Doppler spectral image of the right vertebral artery shows midsystolic deceleration with antegrade late-systolic velocities

ABNORMAL VA WAVEFORM

partial subclavian steal

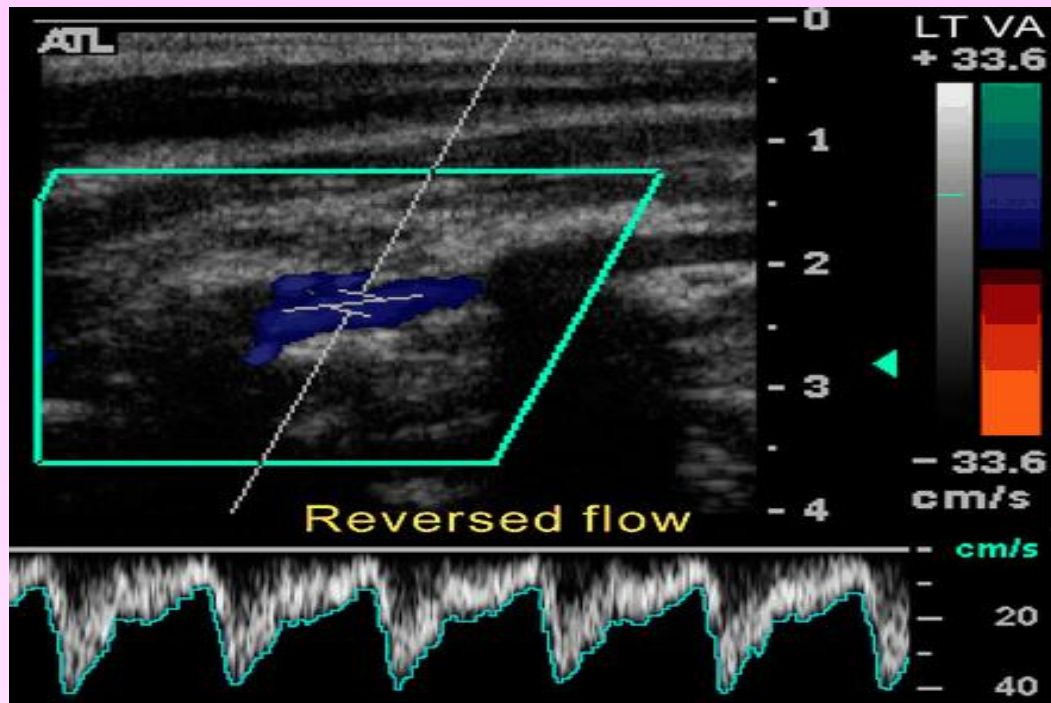


PW Doppler spectral image obtained after the patient exercised the right arm (by opening and closing the hand for 2 minutes).

The Doppler spectrum shows midsystolic deceleration with retrograde late-systolic velocities. The subclavian artery "steals" blood from the vertebral artery to supply the ischemic arm.

ABNORMAL VA WAVEFORM

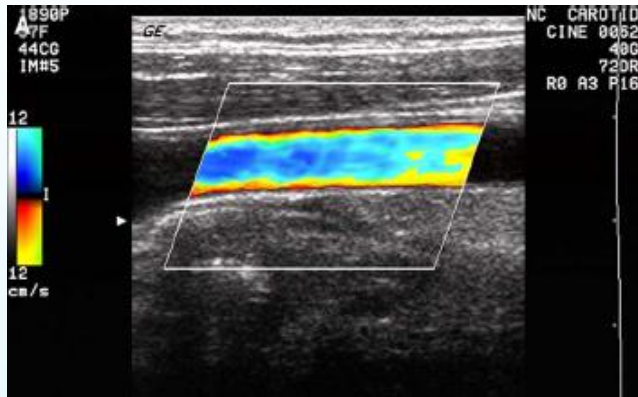
Complete subclavian steal



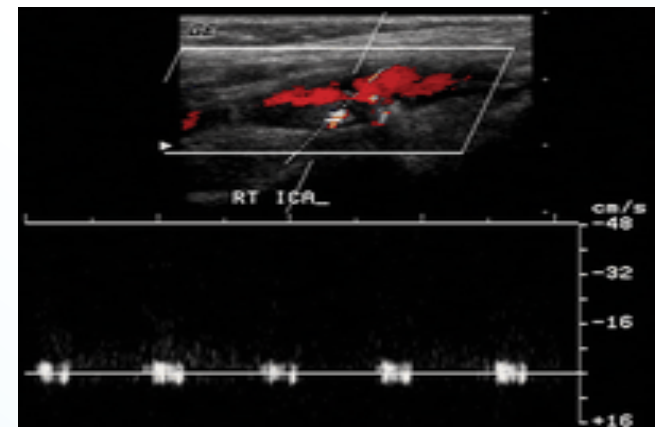
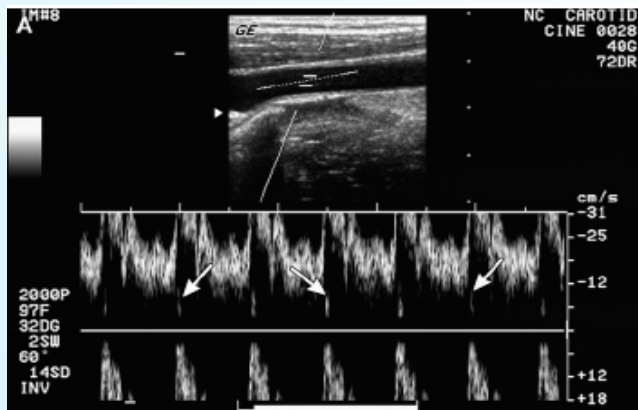
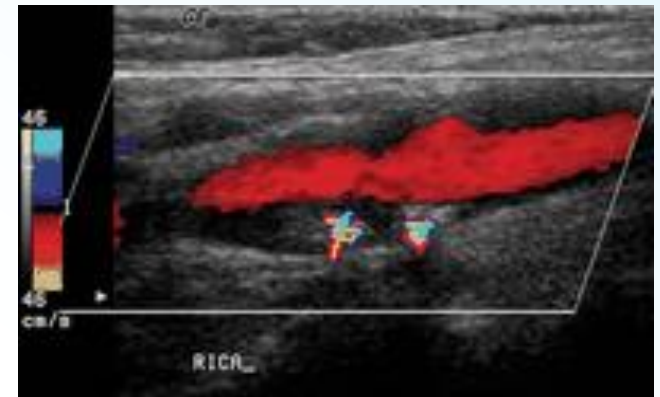
PW Doppler spectral image of the left vertebral artery shows completely reversed flow

Artifacts

ALIASING



TWINKLE



Tissue harmonic imaging

Speckle reduction

3-D and 4-D

Advanced Technique

Contrast media enhancement

Direct flow imaging

Compound scanning

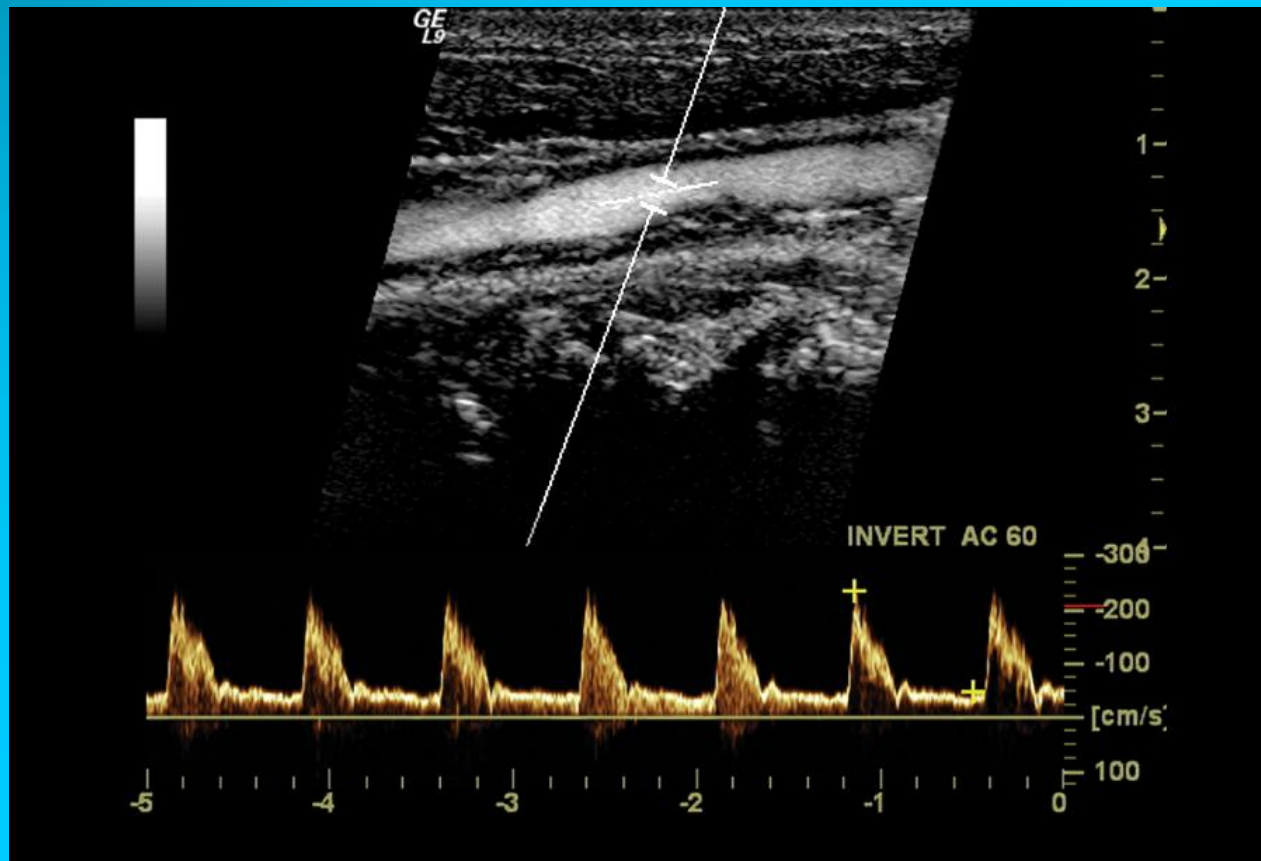
Tissue harmonic imaging



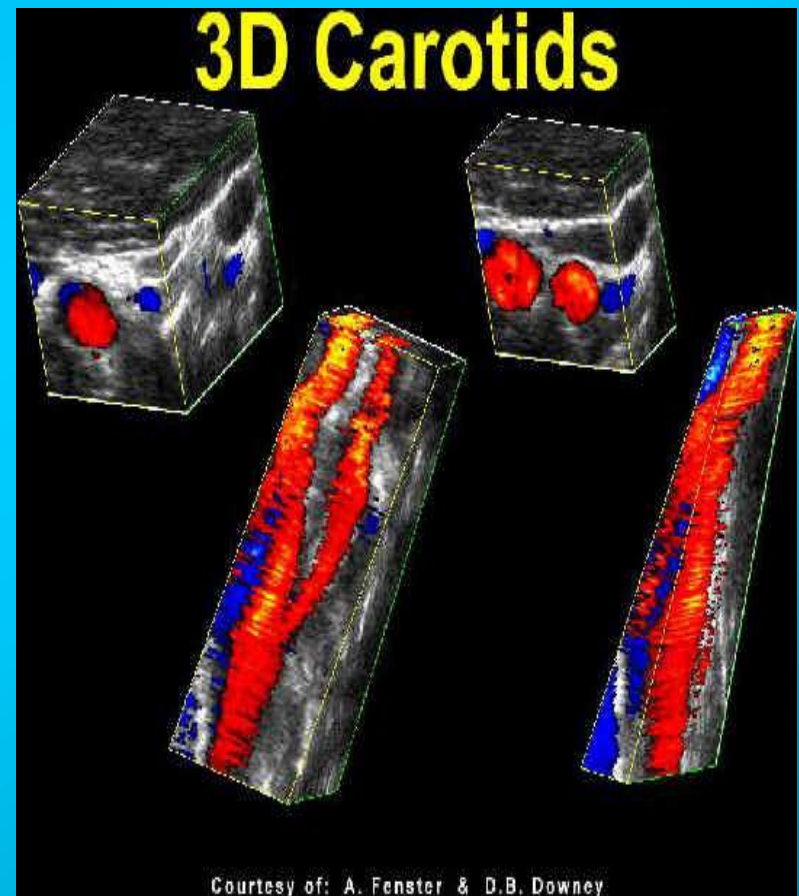
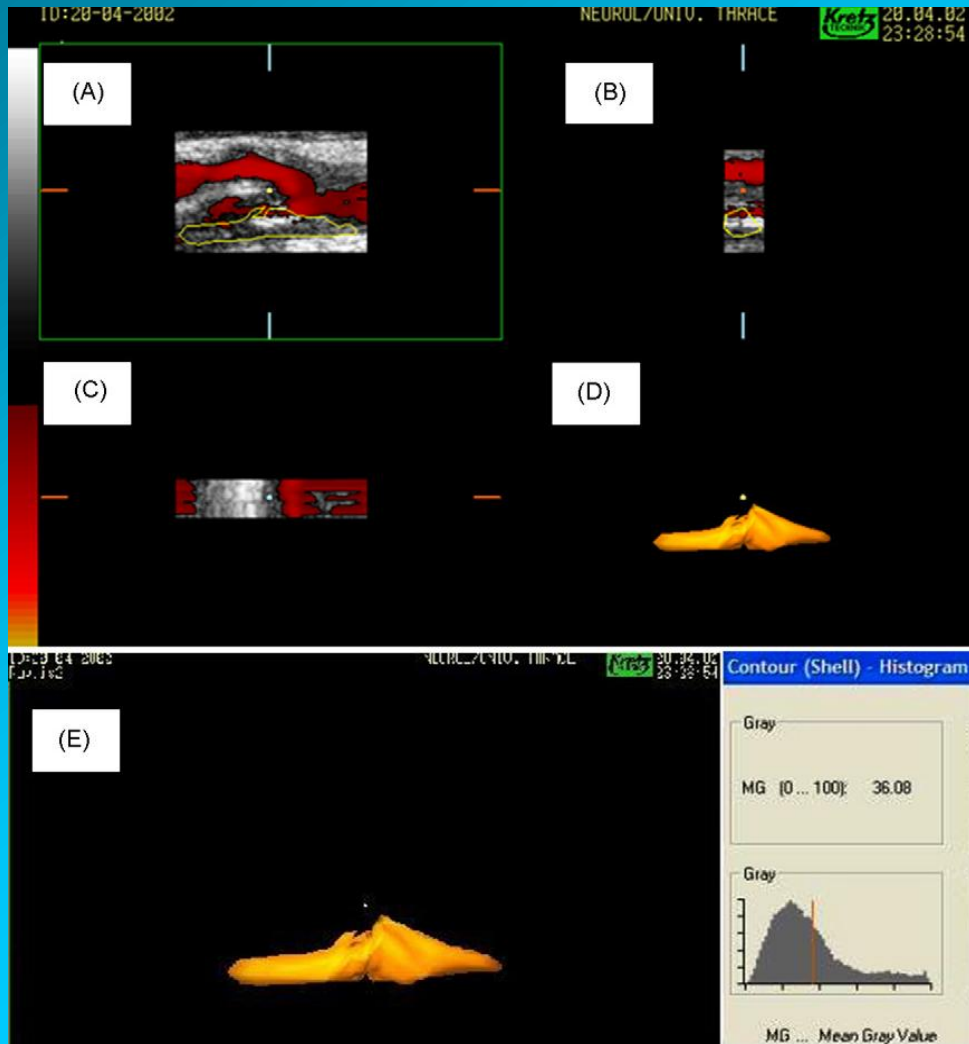
contrast media



B-FLOW imaging

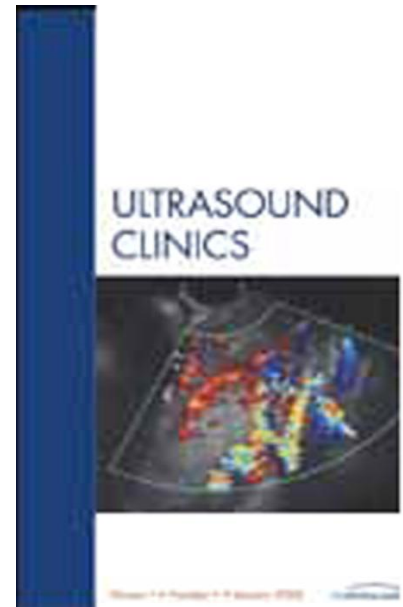
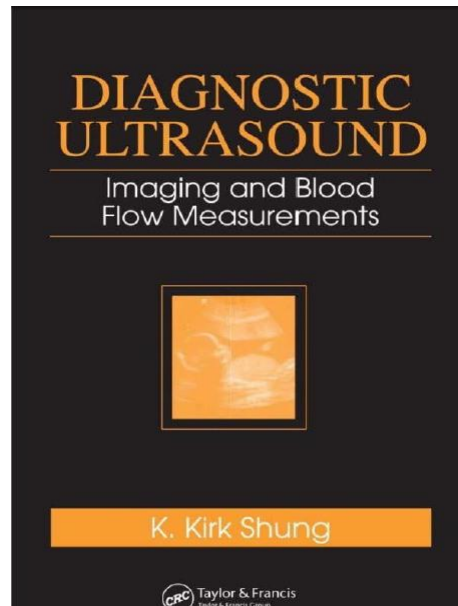
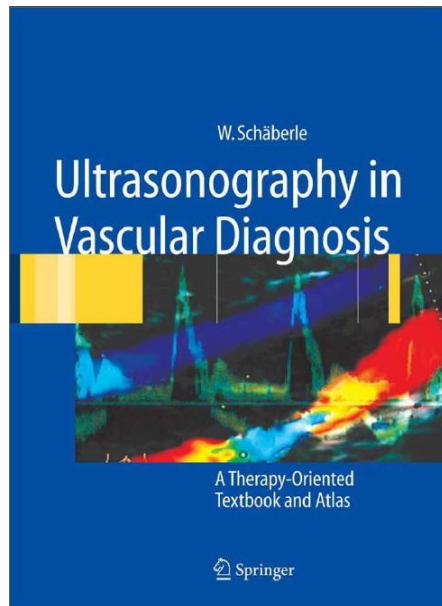


3D imaging



References

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Thank you