DUPLEX SCANNING AND COLOR FLOW IMAGING OF THE LOWER EXTREMITIES

CHAPTER 13

CAPABILITIES OF LEA IMAGING

- Determines presence/absence of disease, categorizes severity, and allows localization of disease
- Identifies hemodynamically significant lesions vs. total occlusion
- Determines presence/absence of aneurysms
- Evaluates bypass grafts
- Localizes stenotic lesions prior to endovascular procedures

LIMITATIONS OF LEA IMAGING

- Presence of dressings, skin staples, sutures, or open wounds
- Incisional tenderness, hematomas
- Difficulty imaging calf vessels
- Calcified arteries and atherosclerotic arterial walls in diabetics can cause shadowing

THE DOPPLER EQUATION

- Recap:

$$\Delta f = \frac{2 \times V \times Fo \times \cos\theta}{c}$$

Δf = Doppler frequency shift
V = velocity
Fo = transducer frequency
cosΘ = angle of the ultrasound beam
C = propagation speed (1540 m/s)

Why is there a "2" in the Doppler equation?

THE DOPPLER EQUATION

- Variation of the Doppler Equation can solve for "V":

$$V = \frac{c \times \Delta f}{2 \times Fo \times \cos\Theta}$$

- Interpretations of PSV and EDV is established from using 60-degree angle of insonation
- Vessel tortuosity or curvature will make obtaining a 60-degree angle difficult.
  - As Doppler angles get closer to 0, error production is miniscule
  - As Doppler angles increase over 60, it is not reliable

PATIENT POSITIONING

- Patient is supine with a pillow under their head
- Patient's hip is externally rotated with the knee slightly flexed
  - Start scanning in the inguinal crease
- Prone or lateral decubitus approach is helpful when trying to image the popliteal space
  - Aides in visualization of the tibioperoneal trunk and peroneal artery also

TECHNICAL ERRORS

- Improper system settings for B-mode, spectral Doppler, or color Doppler
- Inability to position patient for adequate access
- Inadequate gel
- Poor sound beam penetration due to edema or obesity

TRANSDUCER

- 5-7 MHz linear transducer
  - Suitable for most lower extremity arterial duplex exams
- May need lower frequency range (2-4 MHz phased array) for some difficult to image areas
  - Can help with vessel color fill in
  - Calf veins, Iliac or Femoral vessels

TECHNIQUE FOR NATIVE ARTERIES

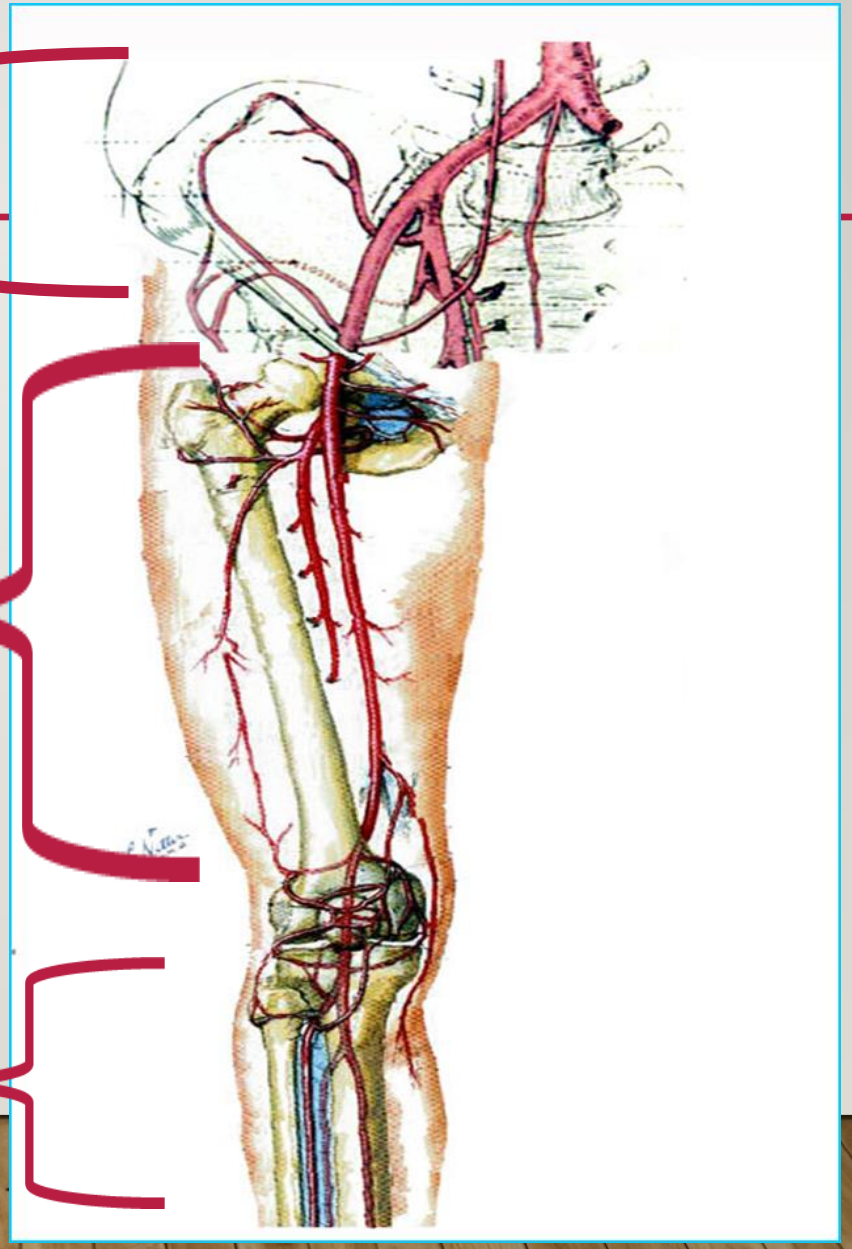
- Evaluate in transverse and longitudinal views, utilizing B-mode for the presence, size, location, and characteristics of plaque
- Spectral analysis including waveforms and measurements of peak systolic velocities should be performed to assess blood flow
  - Maintain a 60-degree angle for measurements
- Color flow should be used to evaluate flow patterns
  - Spectral analysis and color flow should be performed in longitudinal

RECORDED IMAGES

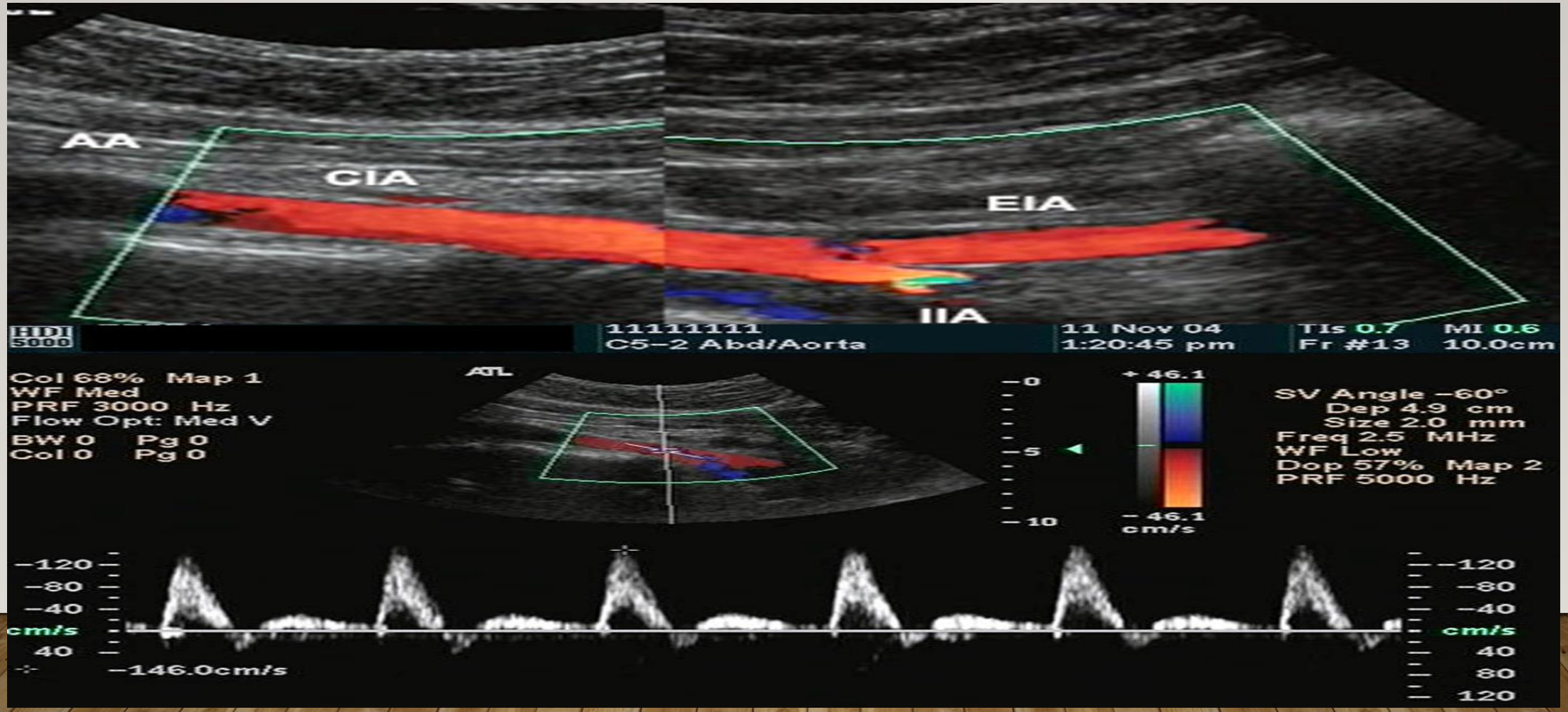
- External Iliac Artery (usually difficult to image due to bowel gas)
- Common Femoral Artery
- Profunda Femoris
- Superficial Femoral Artery (Prox, Mid, and Distal)
- Popliteal Artery (Prox, Mid, and Distal)
- Tibioperoneal trunk
- Anterior Tibial Artery
- Posterior Tibial Artery
- Peroneal Artery
- Dorsalis Pedis

IMAGING NATIVE ARTERIES

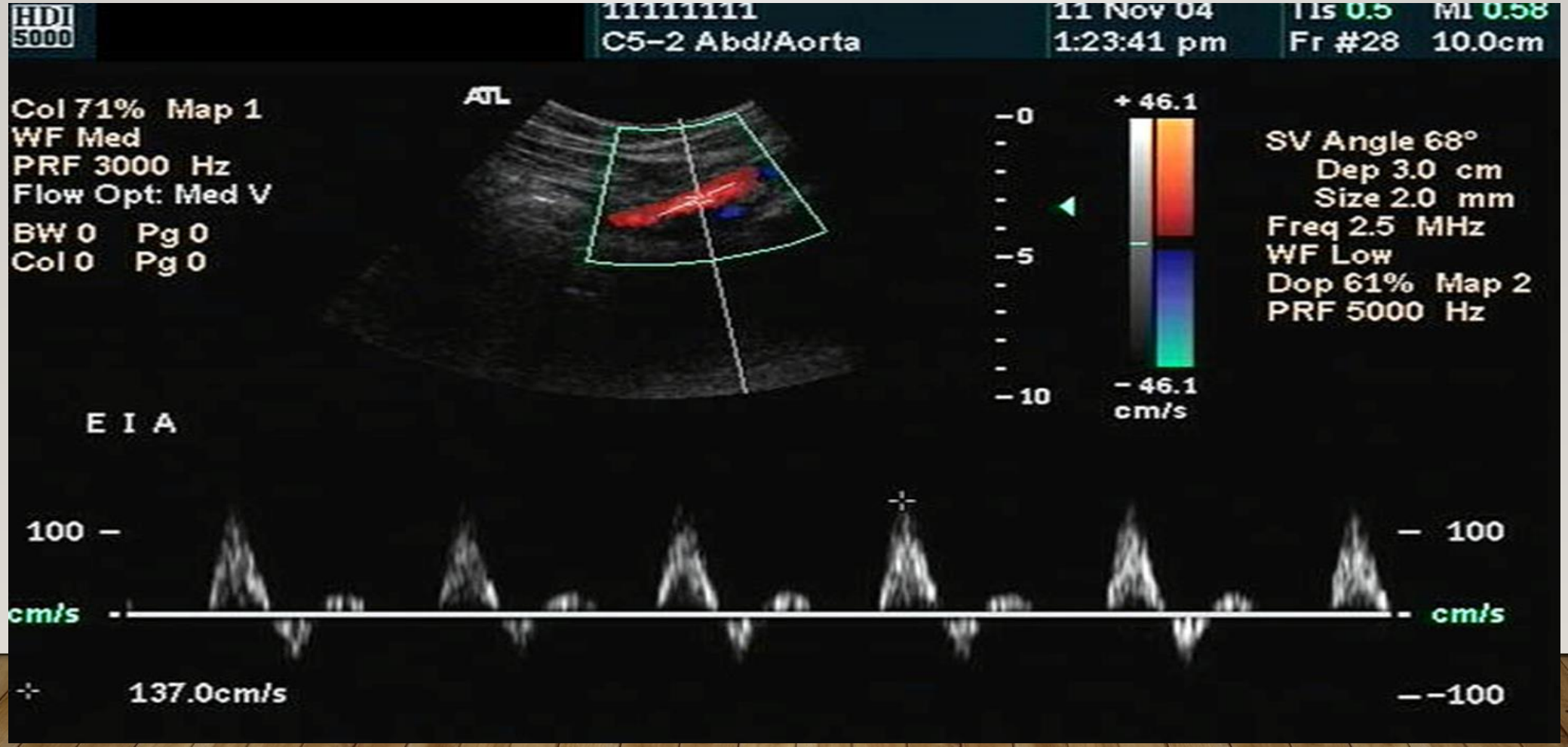
- **Aorto-Iliac - *difficult***
- **Fem-popliteal – *easiest***
- **Tibial arteries - *tedious***



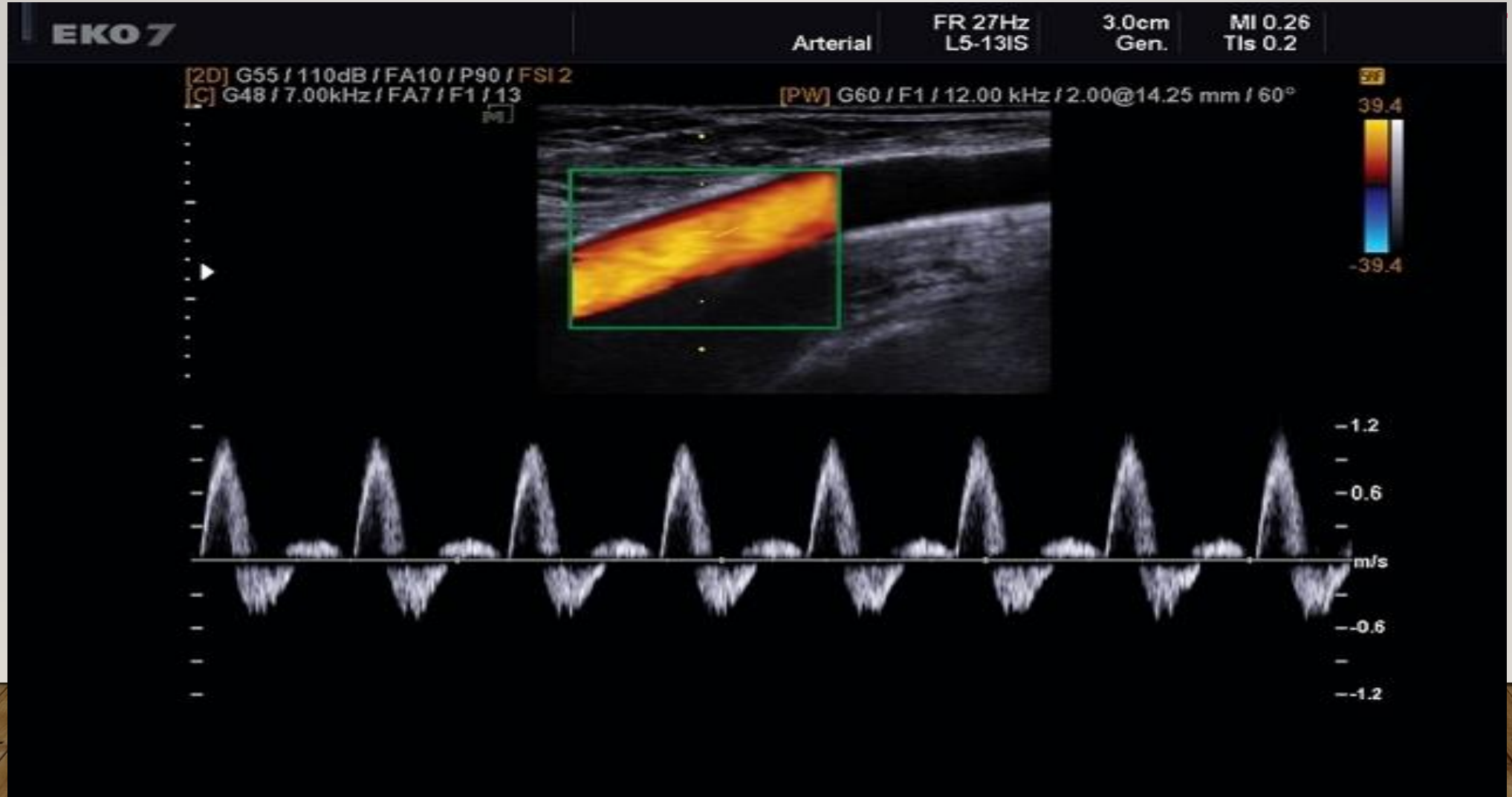
COMMON ILIAC ARTERY



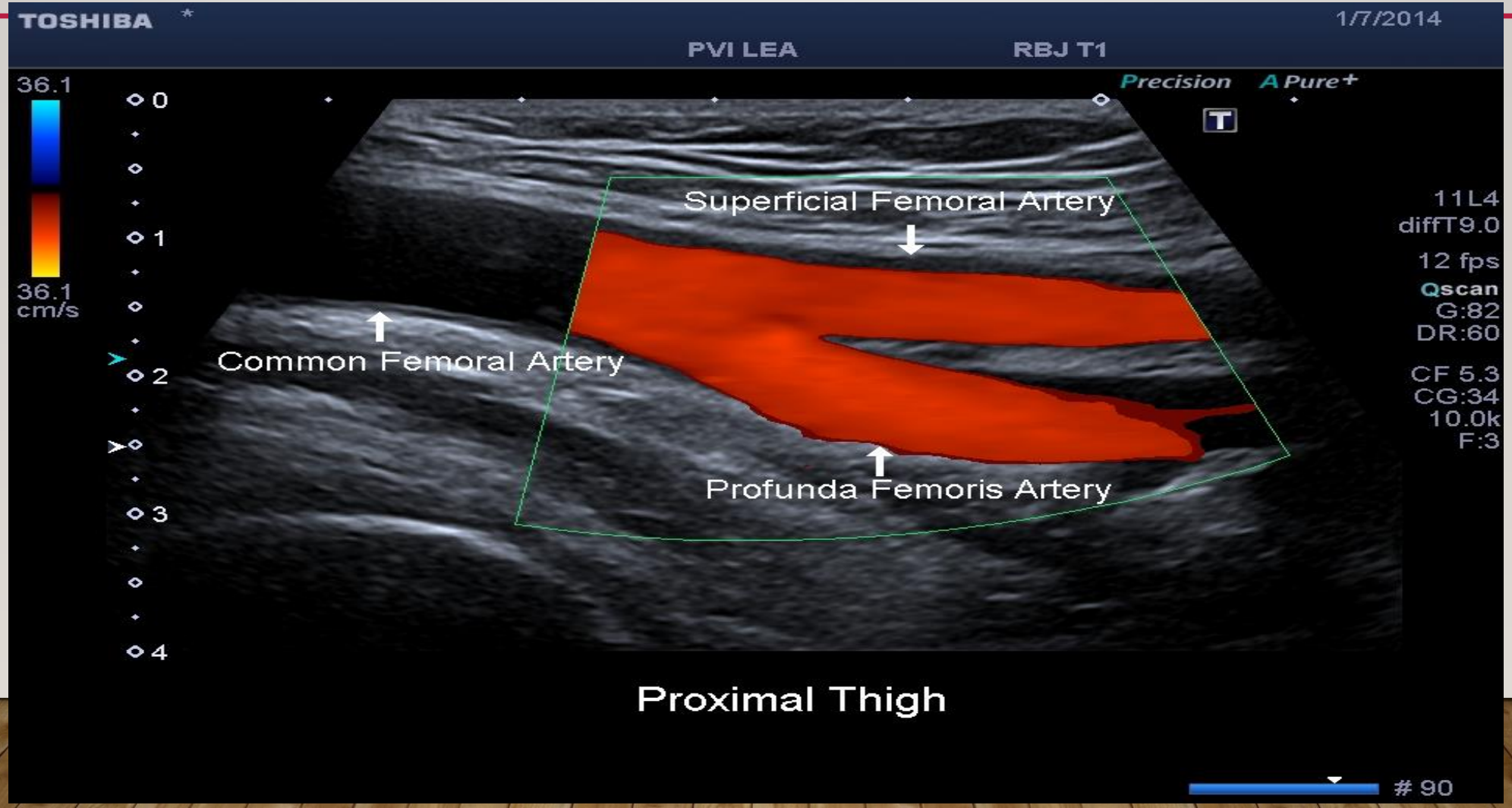
EXTERNAL ILIAC ARTERY



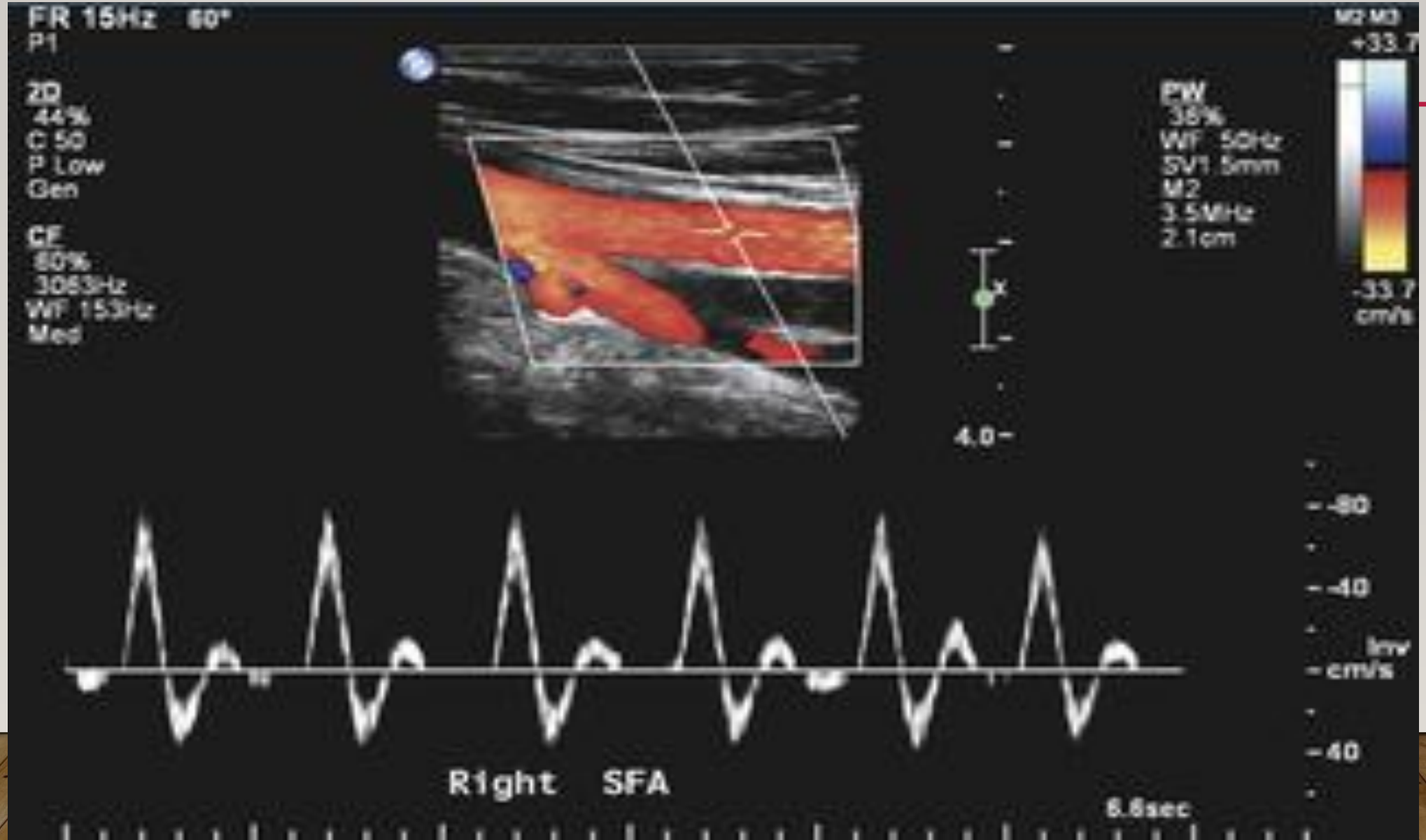
COMMON FEMORAL ARTERY



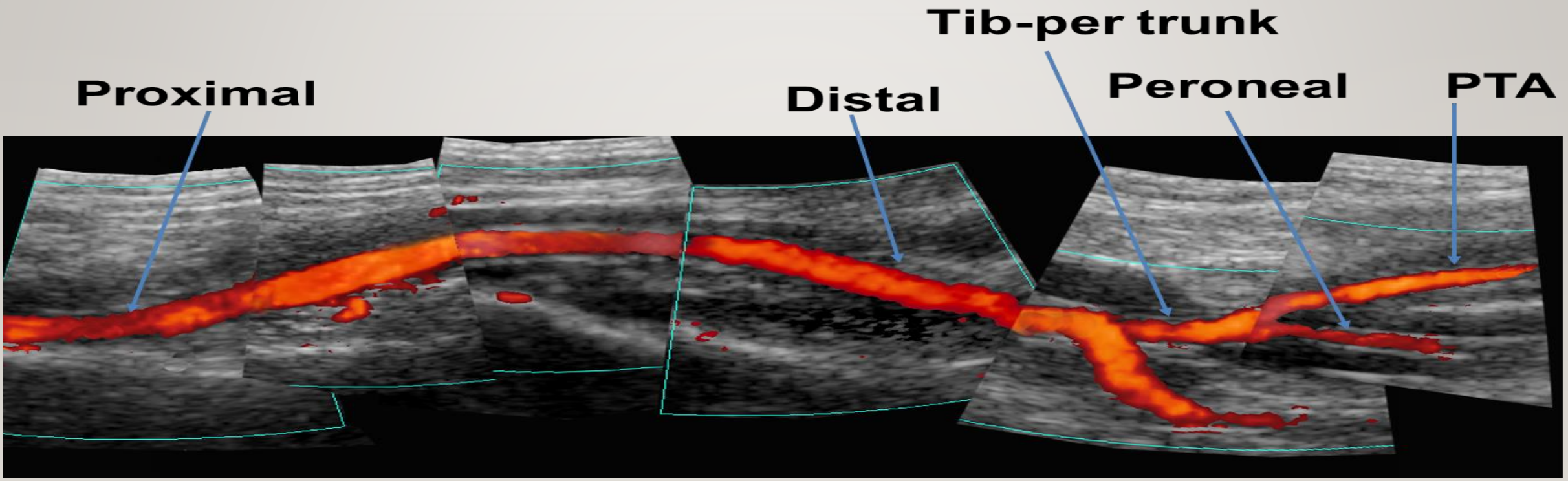
SFA/PFA BIFURCATION



SUPERFICIAL FEMORAL ARTERY

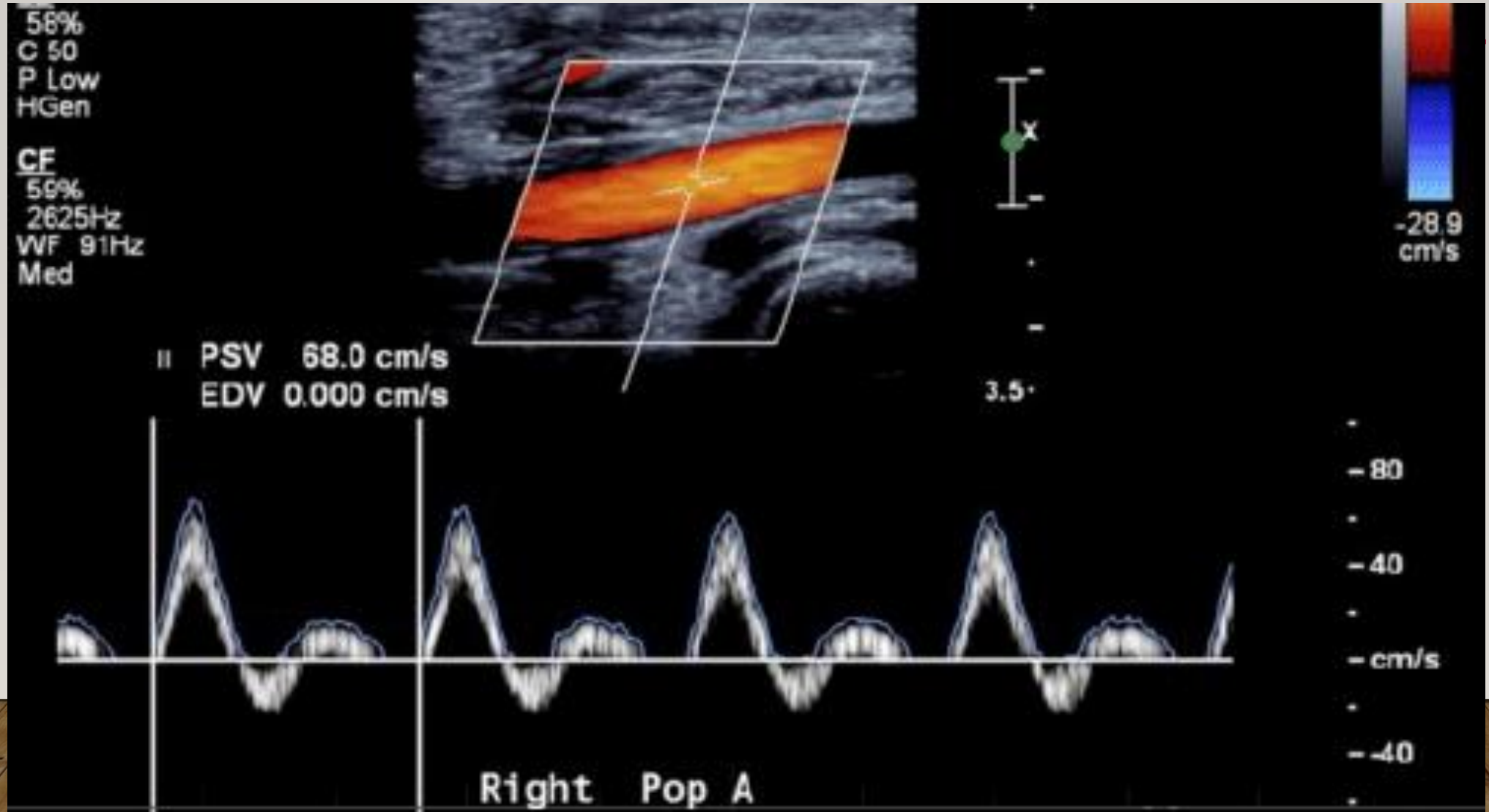


POPLITEAL ARTERY

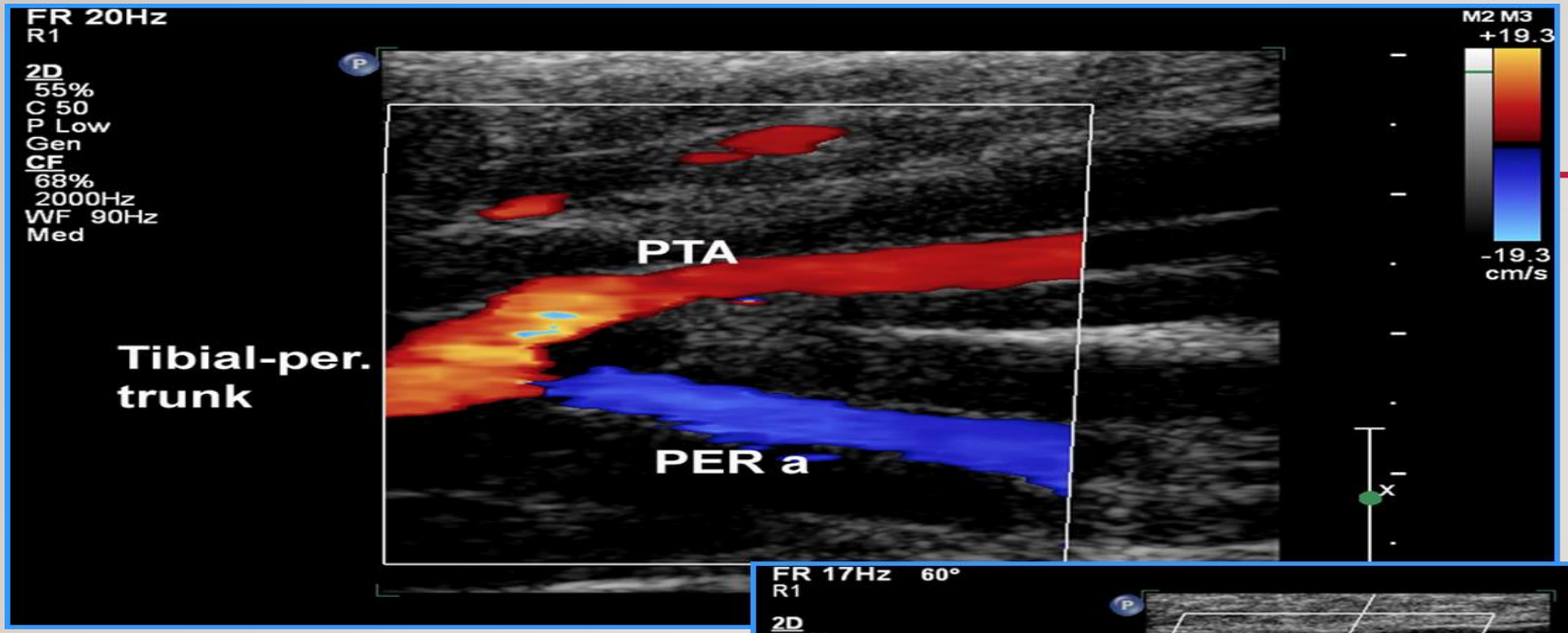


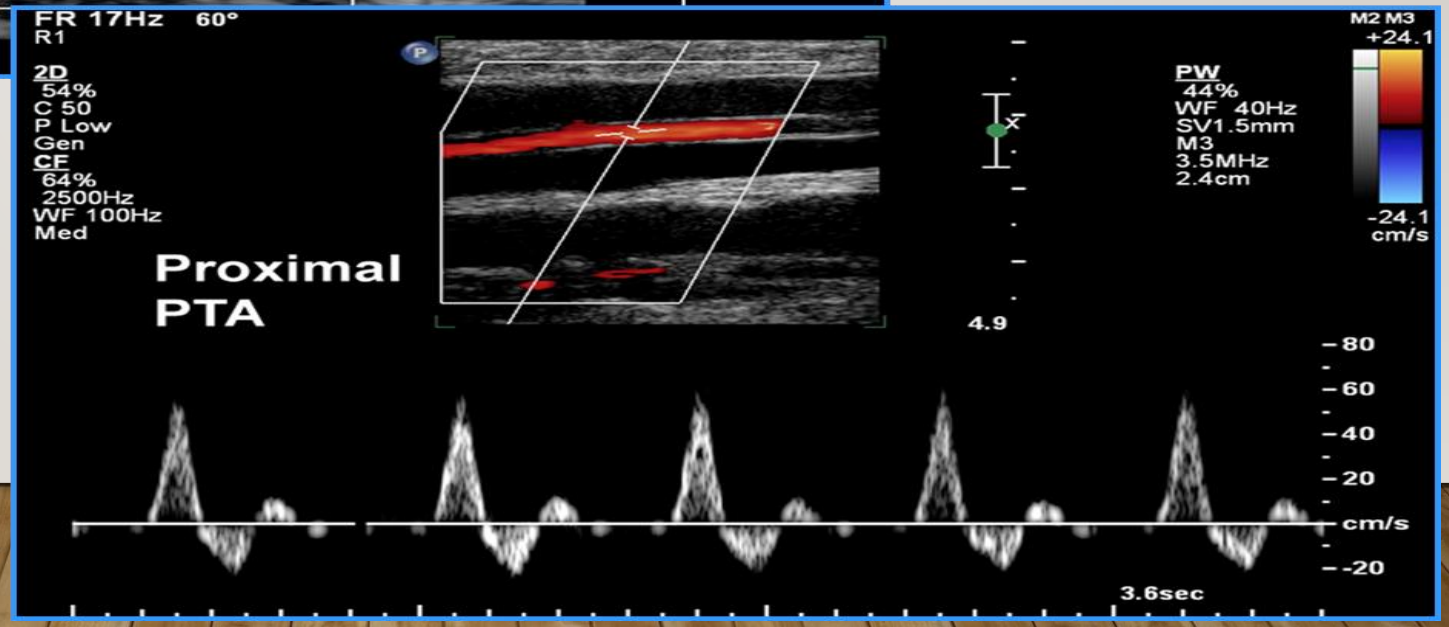
Scan with leg externally rotated or with patient prone

POPLITEAL ARTERY

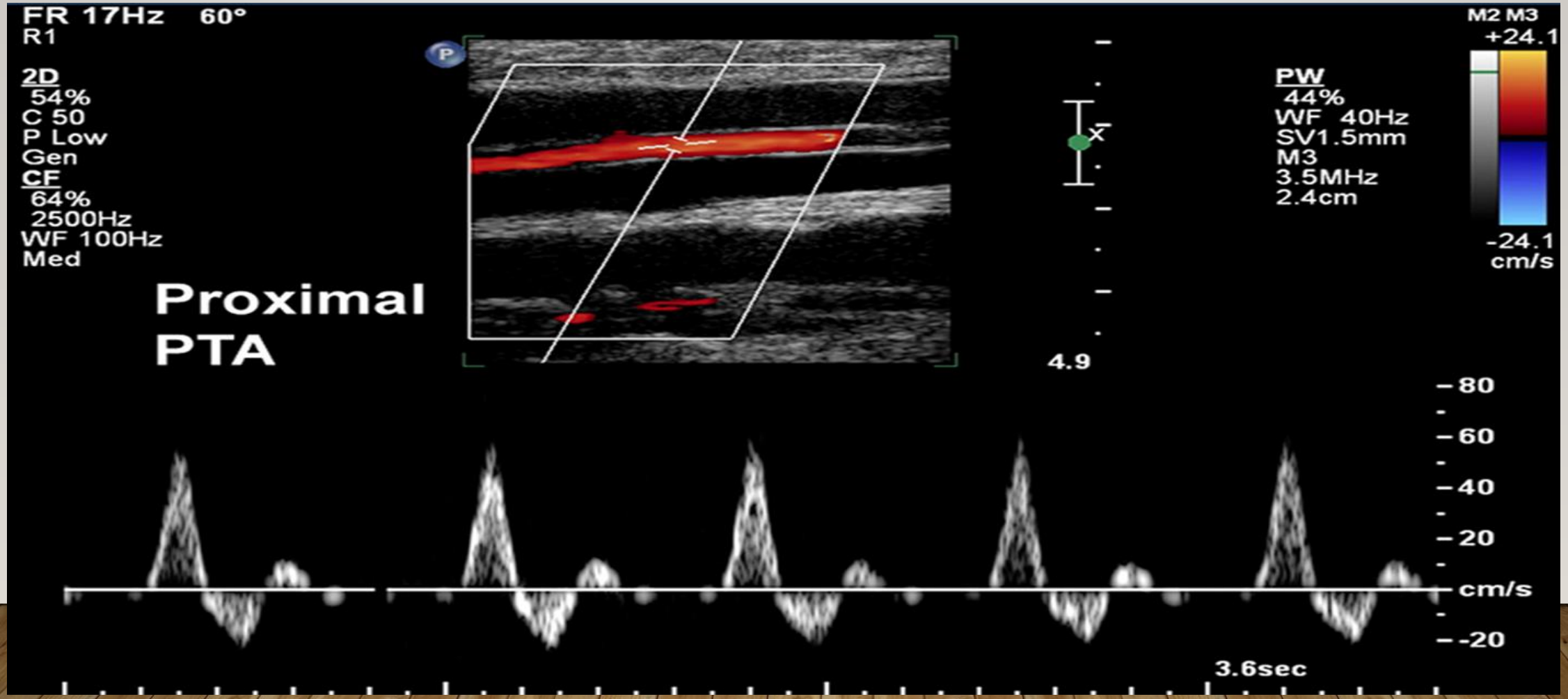


TIBIO-PERONEAL TRUNK

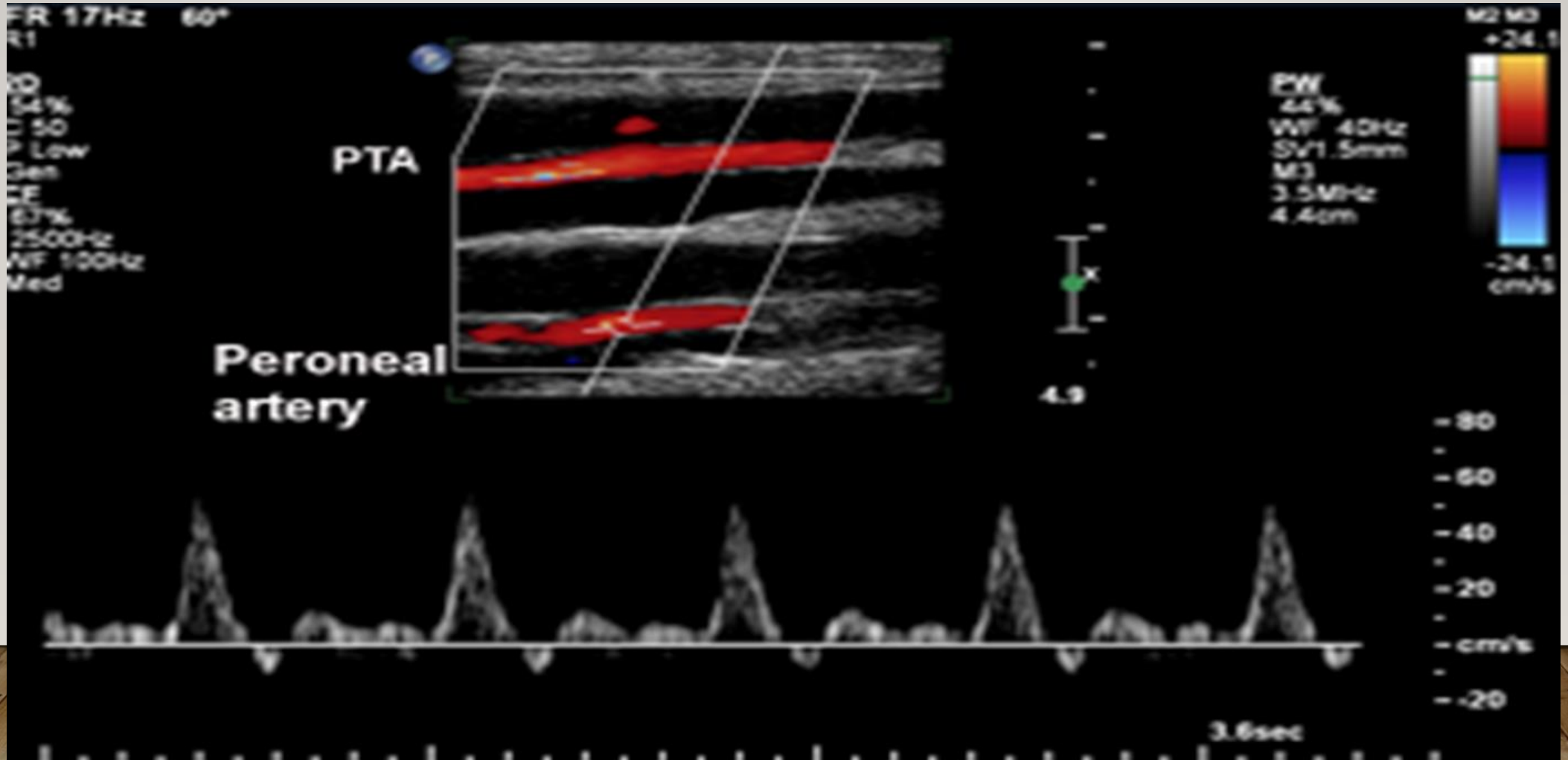




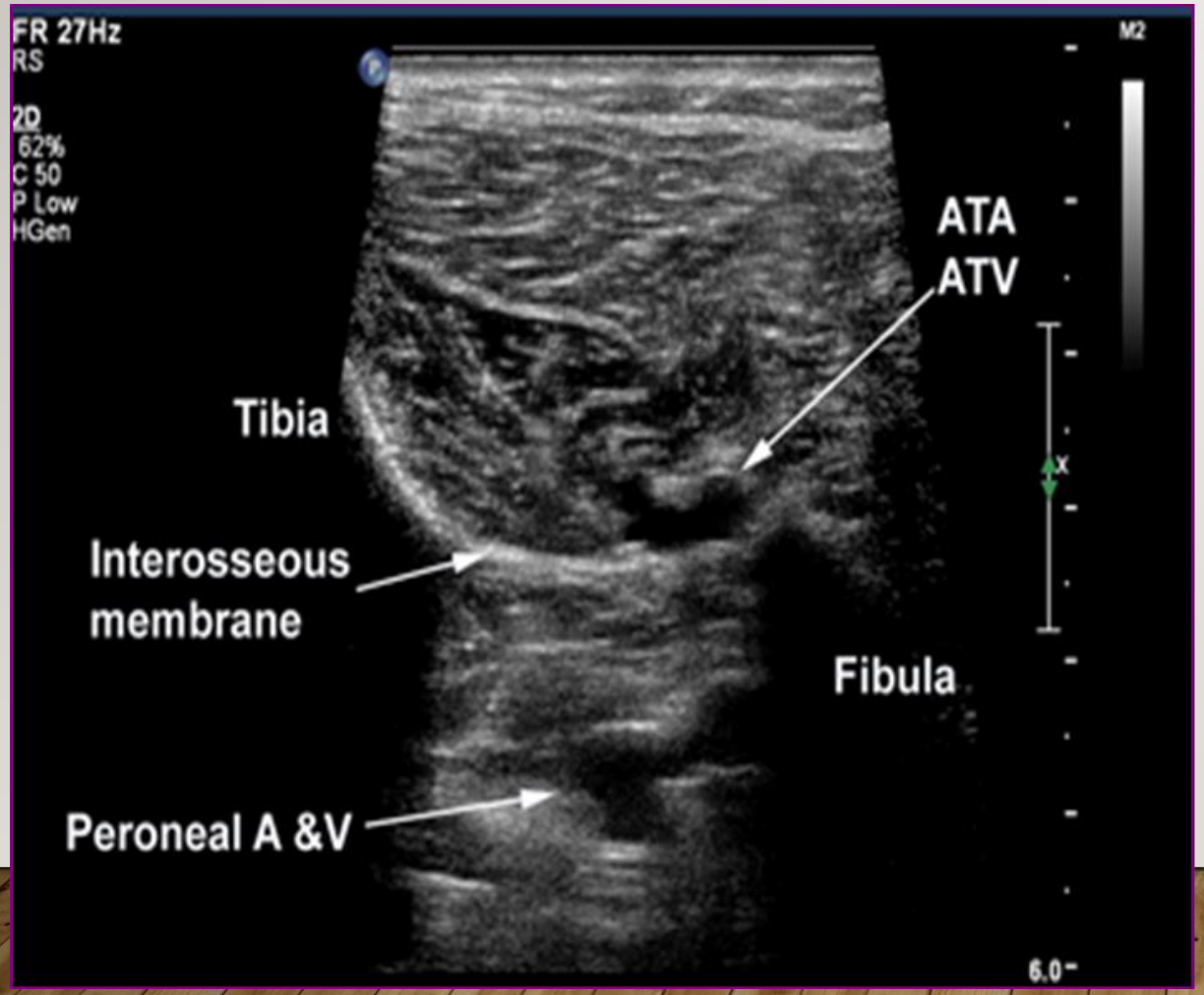
POSTERIOR TIBIAL ARTERY

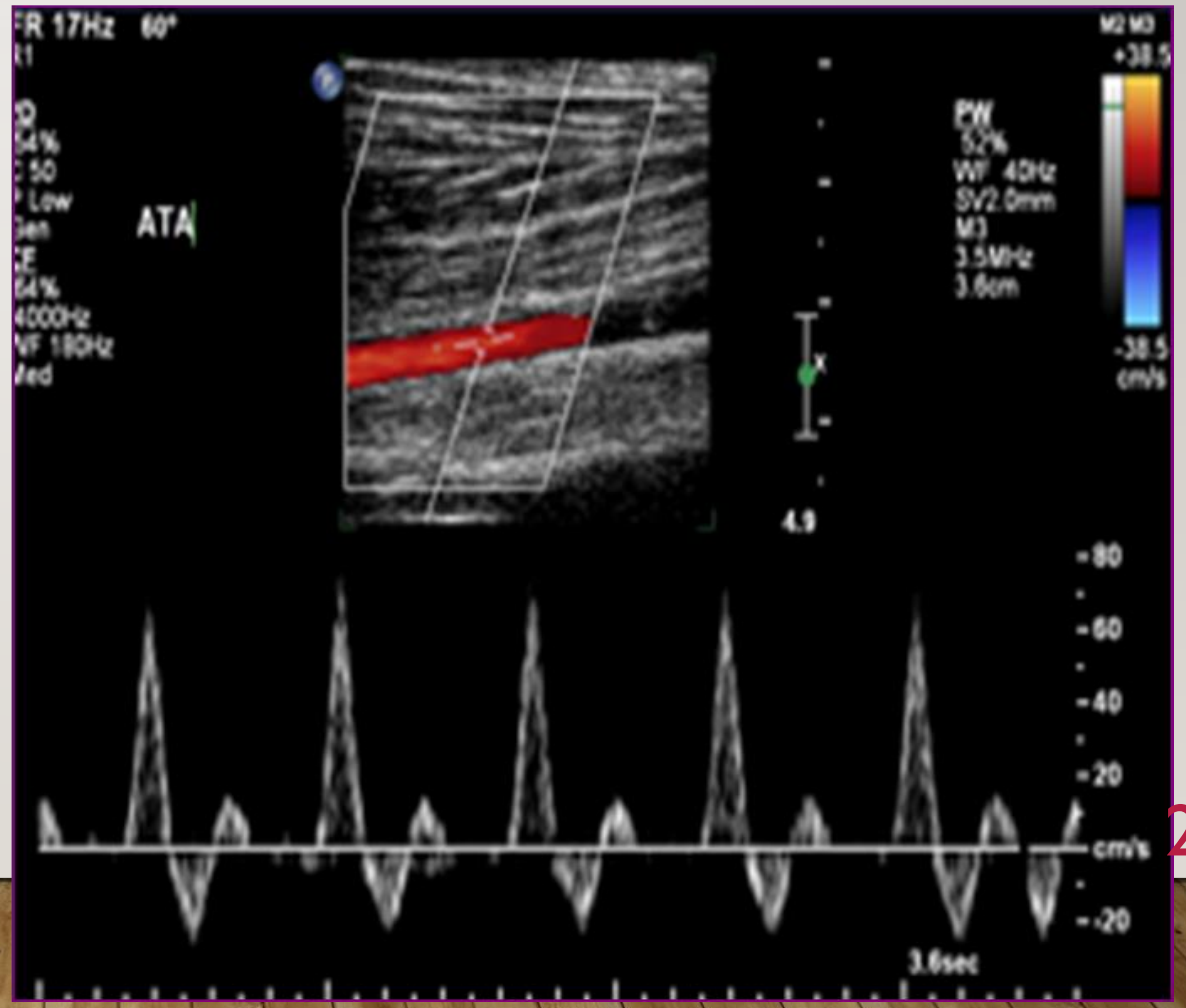


PERONEAL ARTERY

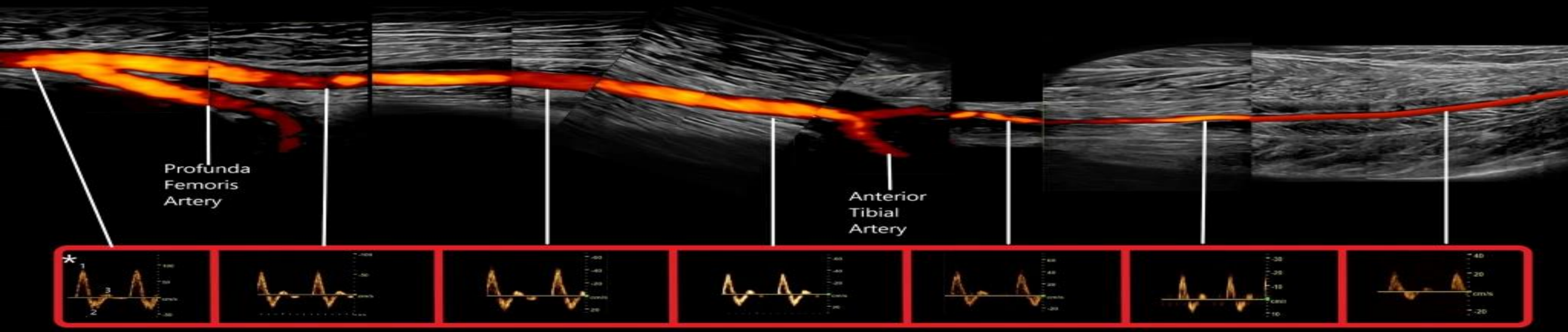


ANTERIOR TIBIAL ARTERY





Lower Extremity Artery



Common Femoral Artery

Superficial Femoral Artery Proximal

Superficial Femoral Artery Mid to Distal

Popliteal Artery

Posterior Tibial Artery Proximal

Posterior Tibial Artery Mid

Posterior Tibial Artery Distal

*Normal spectral waveform is triphasic

Tibioperoneal Trunk

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MISCELLANEOUS INFORMATION

- Arteries should:
  - Be free of internal echoes
  - Have a well-defined intimal surface
  - Be thin walled
- Waveforms obtained should:
  - Be triphasic
  - Have a narrow frequency range (no spectral broadening)

MISCELLANEOUS INFORMATION

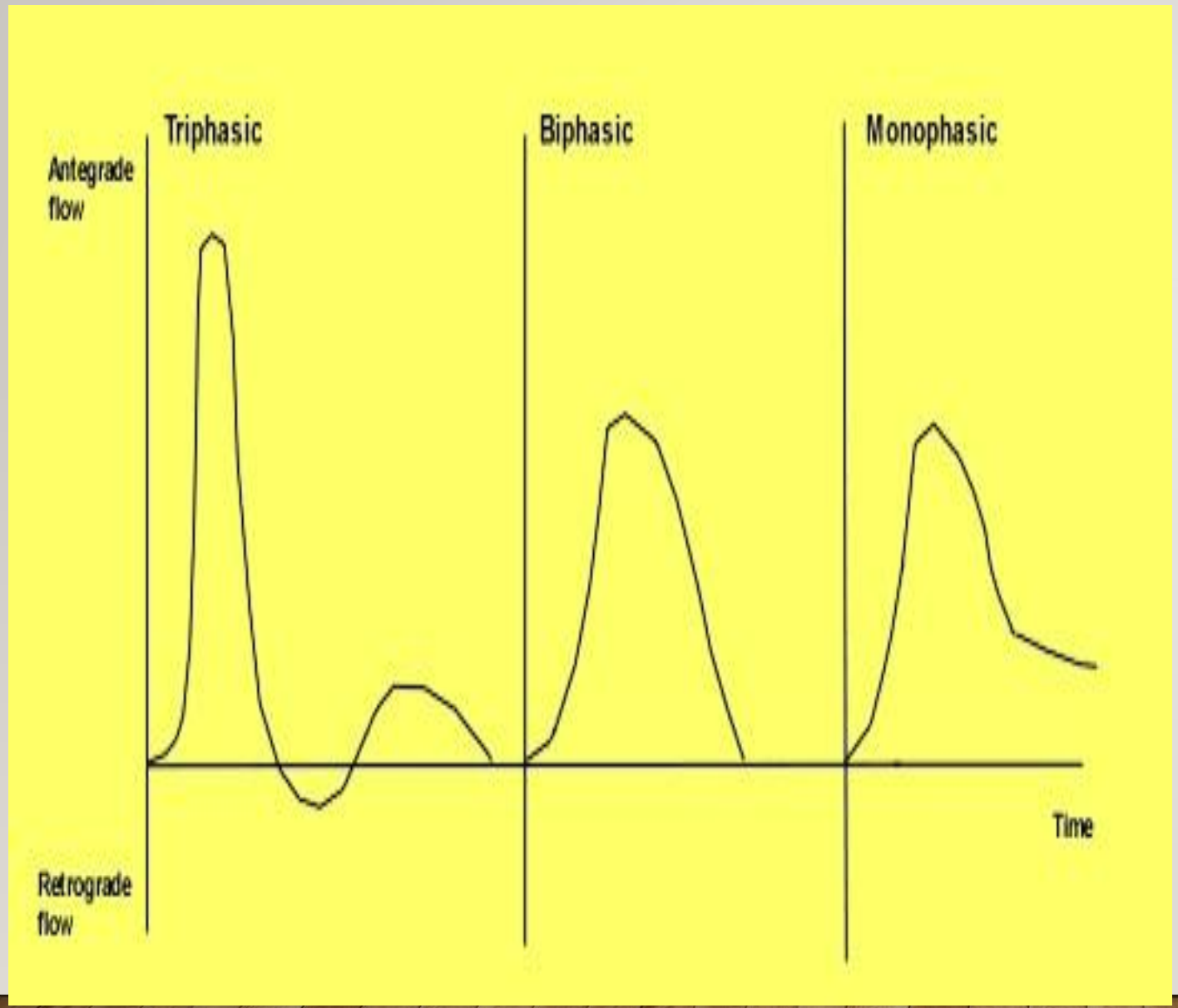
- Stenosis will:
  - Result in an increased flow velocity
  - Demonstrate spectral broadening
- In normal patients:
  - The peak systolic velocity decreases between the Common Femoral and Proximal Superficial Femoral
  - The peak systolic velocity decreases between the Distal Superficial Femoral and Popliteal

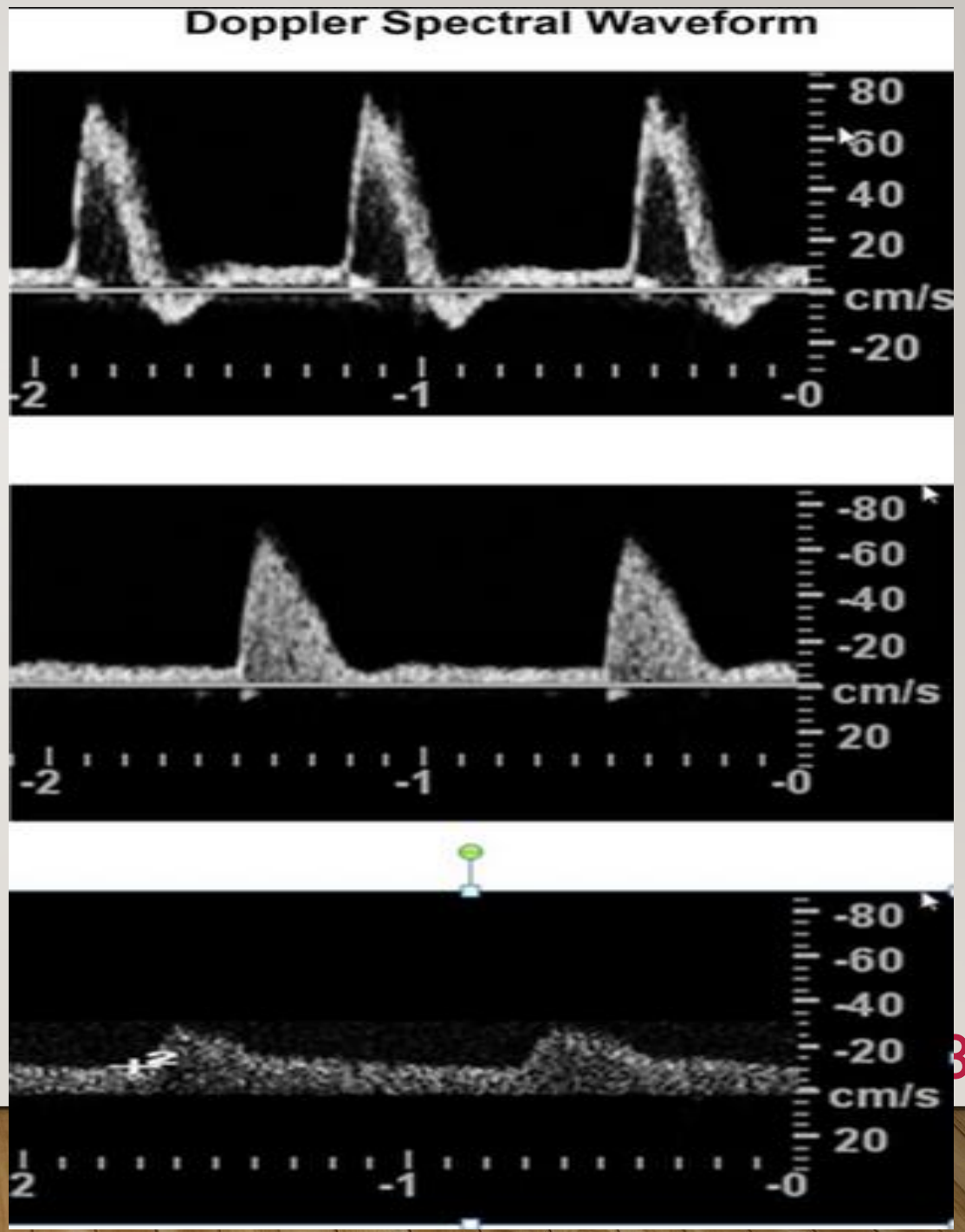
MISCELLANEOUS INFORMATION

- Peak systolic velocities are measured for each vessel and at various segments (prox, mid, distal) if the vessel segment is long
  - If disease is suspected, measure at smaller intervals
- Characterize Doppler signals: Triphasic (normal), Biphasic (normal or abnormal), Monophasic (abnormal)
- In areas of stenosis, measure:
  - Pre-stenotic PSV
  - PSV at the stenotic region
  - Post-stenotic PSV (look for turbulence)

HELPFUL HINTS

- Major arteries lie right beside major deep veins, so use the veins as landmarks in the event the arteries are occluded
- Long-standing occluded vessels are often contracted and difficult to identify
  - To be certain an artery is occluded you must identify it
- Identify stenotic regions and confirm with spectral Doppler
- If artery is diseased, use a low color PRF as flow may be slow


Triphasic
Biphasic
Monophasic
Antegrade flow
Retrograde flow
Time


Doppler Spectral Waveform
80
60
40
20
cm/s
-20
-2
-1
-0
-80
-60
-40
-20
cm/s
20
-2
-1
-0
-80
-60
-40
-20
cm/s
20
-1
-0

INTERPRETATION

- Normal Doppler signal:
  - Triphasic
  - Biphasic (normal for some patients without significant arterial disease)
- Abnormal Doppler signal:
  - Biphasic (can also be normal)
  - Monophasic
- Changes in temperature or muscle clenching can dramatically change the waveforms (especially distal segments)

VELOCITY RATIOS

- Velocity Ratio: = $\frac{\text{Stenotic Peak Systolic Velocity}}{\text{Pre-Stenotic Peak Velocity}}$

Stenosis (Diameter Reduction)	Velocity Ratio
Normal	<1.5:1
30-49%	1.5:2.1
>50%	2:1 (velocity increases >100%)
50-75%	2:1-4:1
>75%	4:1
Total Occlusion	NO FLOW!

Degree	% Stenosis	Features
Mild	1-19%	Normal velocities and triphasic waveform but spectral broadening is minimal
Moderate	20-49%	Increased PSV by 30-50% with marked spectral broadening, triphasic but reverse flow component may be diminished
Severe	50-99%	Increased systolic velocity >100% with marked spectral broadening with monophasic waveform
Total occlusion		No flow. Systolic "thumping" may be heard proximal to occlusion

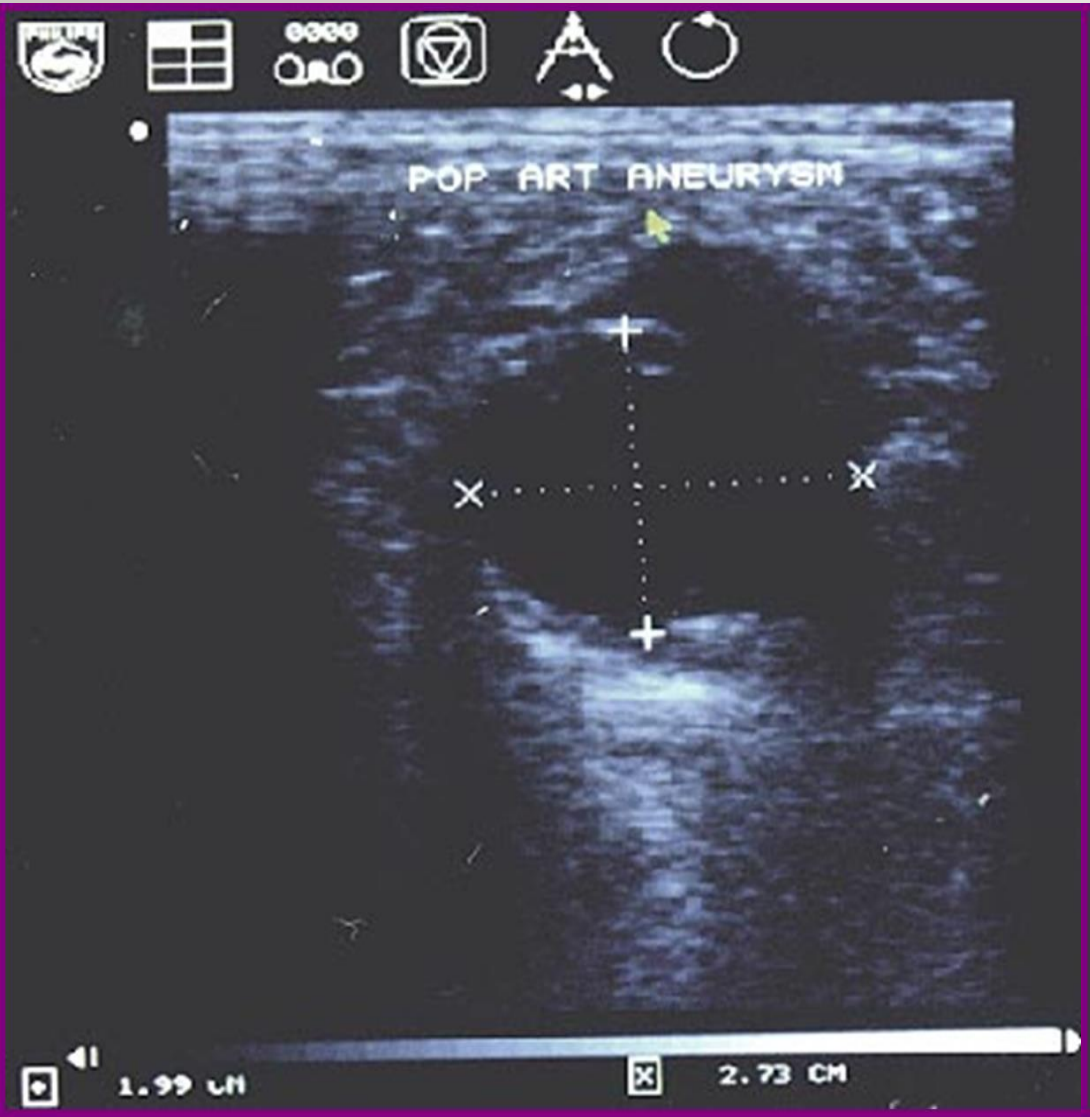
TECHNICAL CONSIDERATIONS

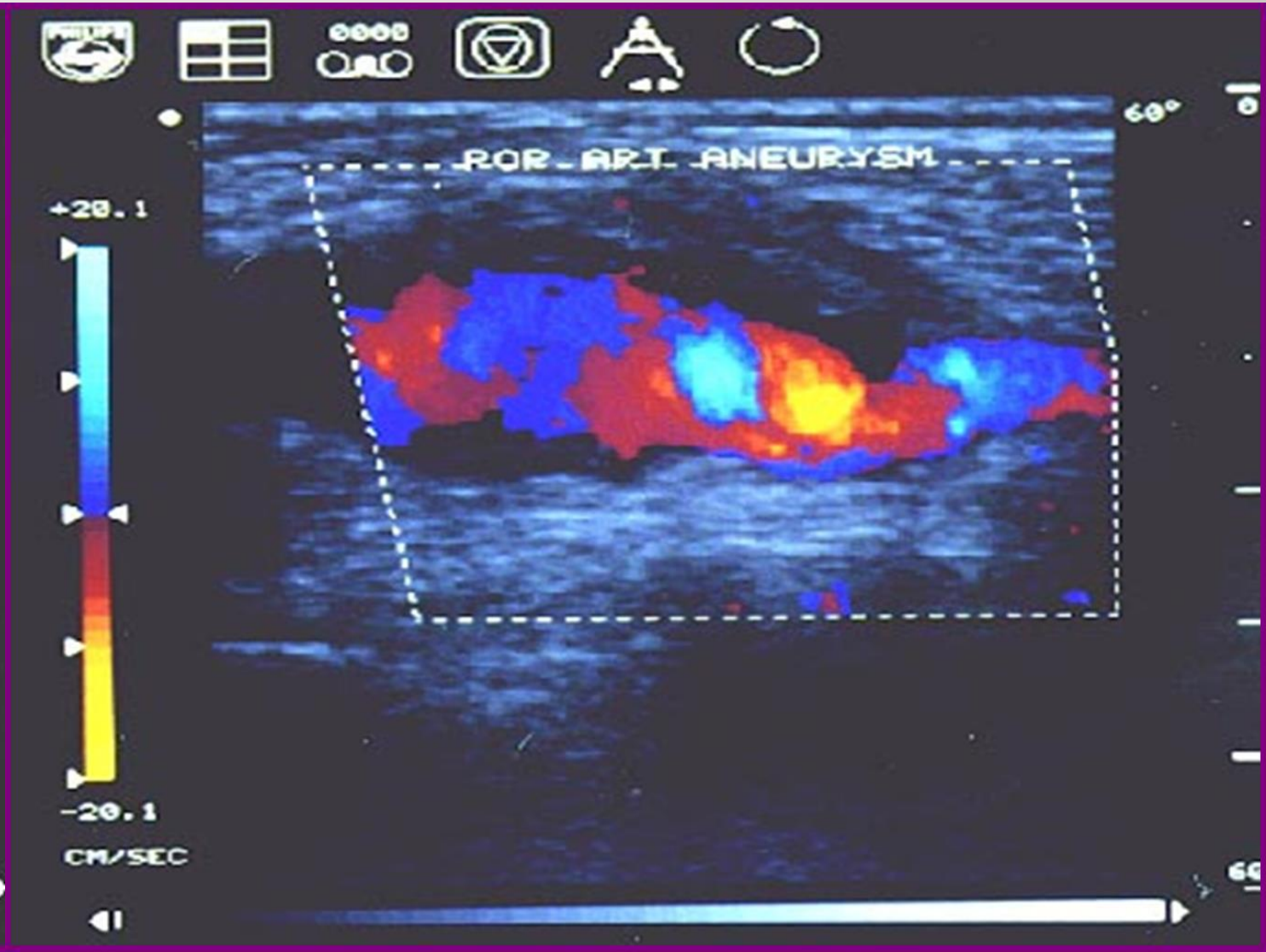
- Color Doppler system settings should be adjusted to allow the normal arterial segment as a "mid-red" to allow for detection of less severe disease
- Remember: a change in vessel angle will create aliasing just as a stenotic segment will!

DIAGNOSIS OF ANEURYSMS

- Increase in diameter of 50% or greater than the native artery is indicative of an aneurysm
- Investigate for thrombus inside the aneurysm and take appropriate measurements
- Patient history will help to determine true vs. pseudoaneurysm
  - i.e. recent catheter procedure such as angiography, heart catheterization, or trauma

ANEURYSMS

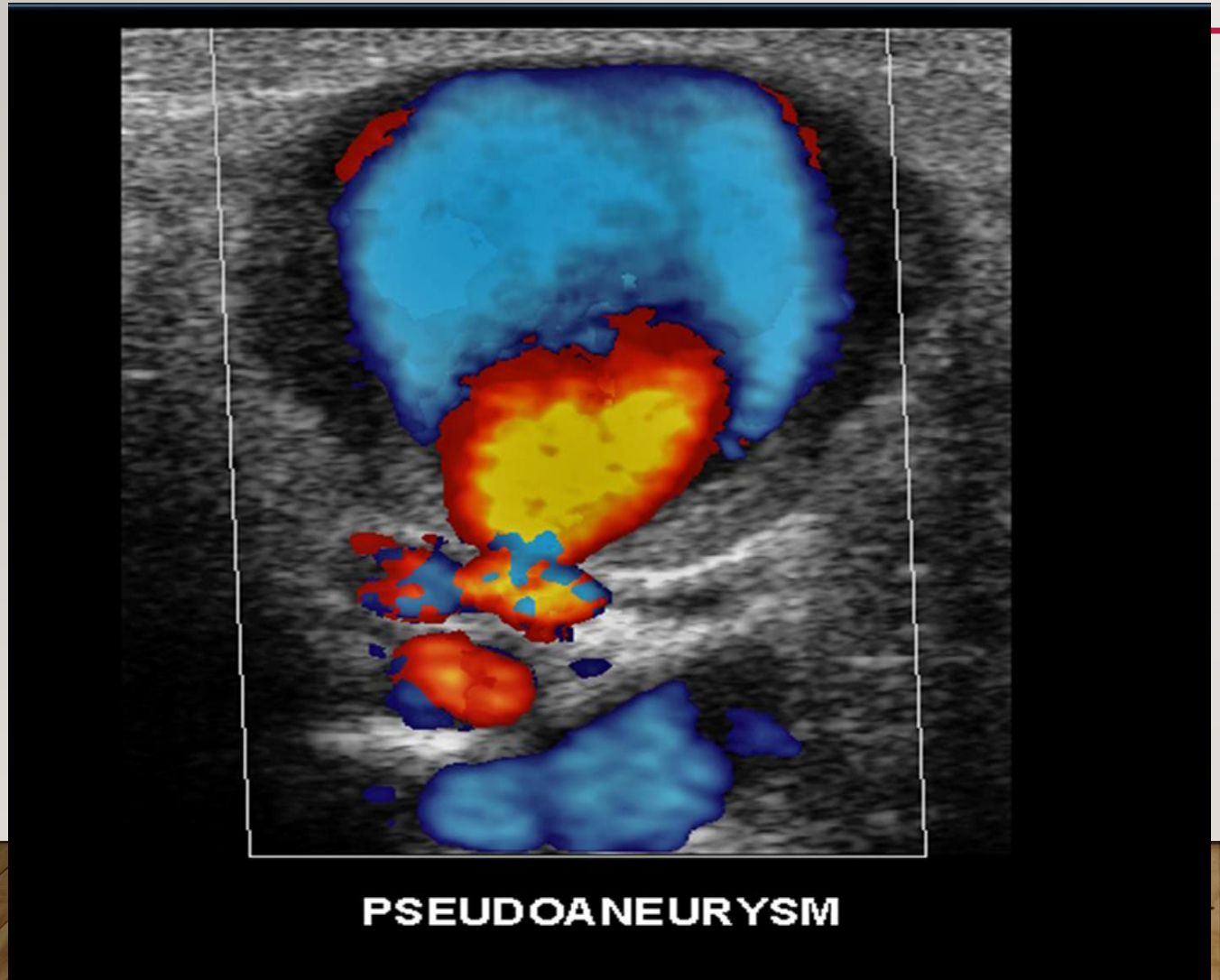

POP ART ANEURYSM
1.99 cm
2.73 CM

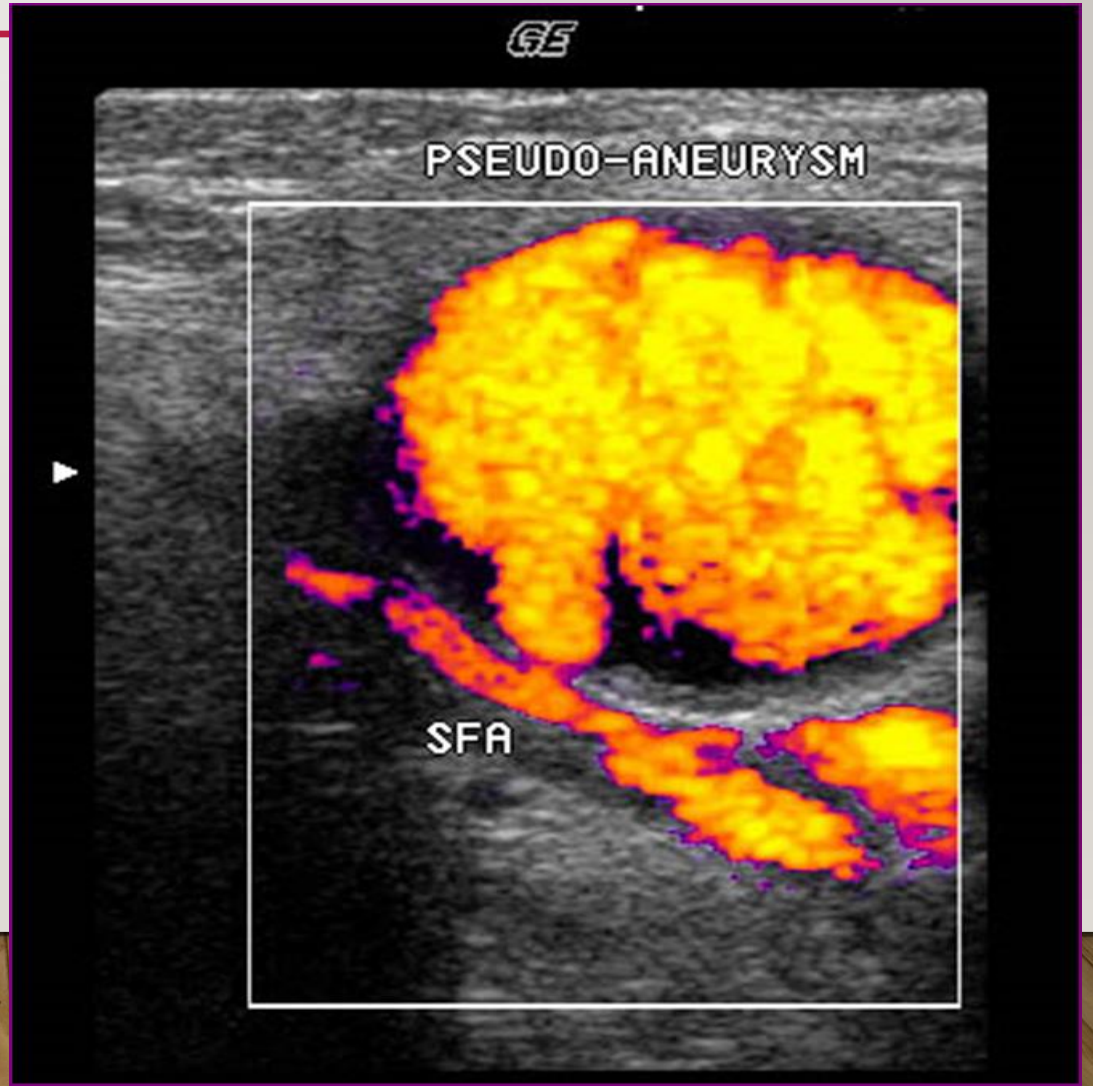

ROP ART ANEURYSM
+20.1
-20.1
CM/SEC
60°

ANEURYSMS

- Treatment:
  - Surgical repair
    - Coiling or stenting
    - EVAR
    - Grafting

PSEUDOANEURYSM





PSEUDOANEURYSM

- 60% thrombose spontaneously
- Treatment:
  - Surgical repair
  - Manual compression with transducer
  - Thrombin injection