Ultrasound Guided Regional Anesthesia

The Basics of Ultrasound Physics

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THE BASICS OF ULTRASOUND PHYSICS

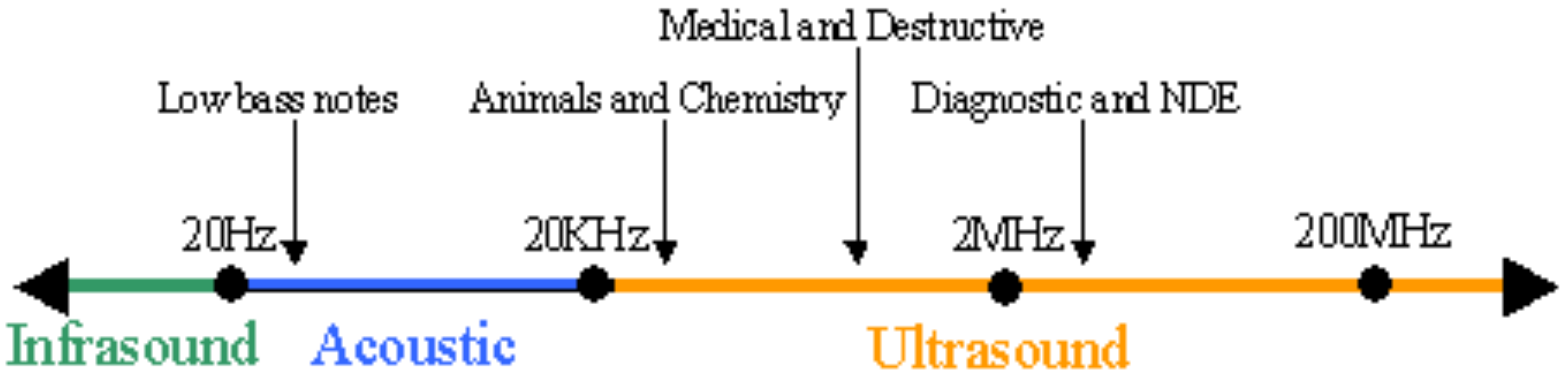
Ultrasound Guidance for Regional Anesthesia

Allows the operator

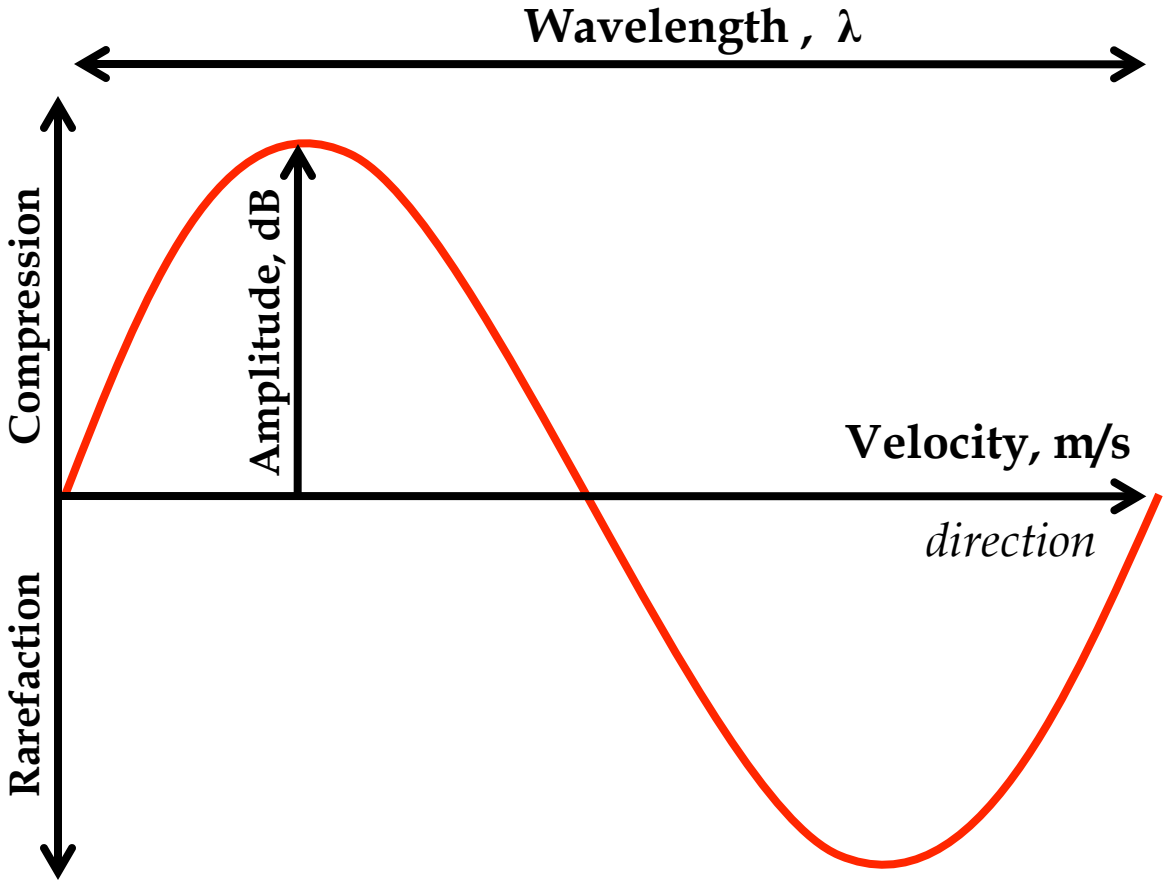
- to see neural structures (as well as vascular, lung bowel)
- guide the needle under real-time visualization
- navigate away from sensitive anatomy
- monitor the spread of local anesthetic

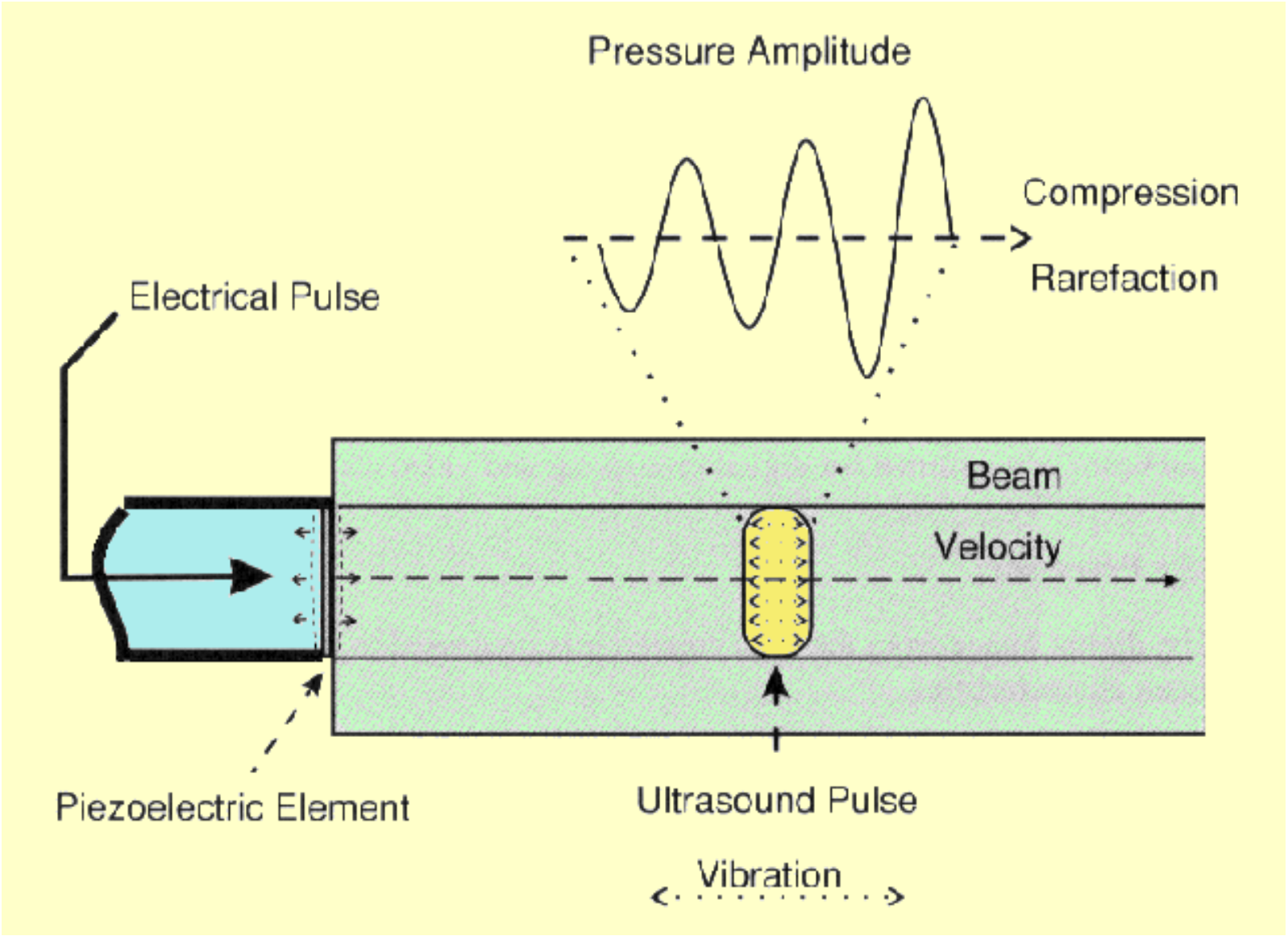
Ultrasound waves

- Infrasound 0-20 Hz
- Audible sound 20 Hz to 20,000 Hz
- Ultrasound >20,000 Hz (or 20 KHz)
- Medical ultrasound 2.5 MHz to 15 MHz



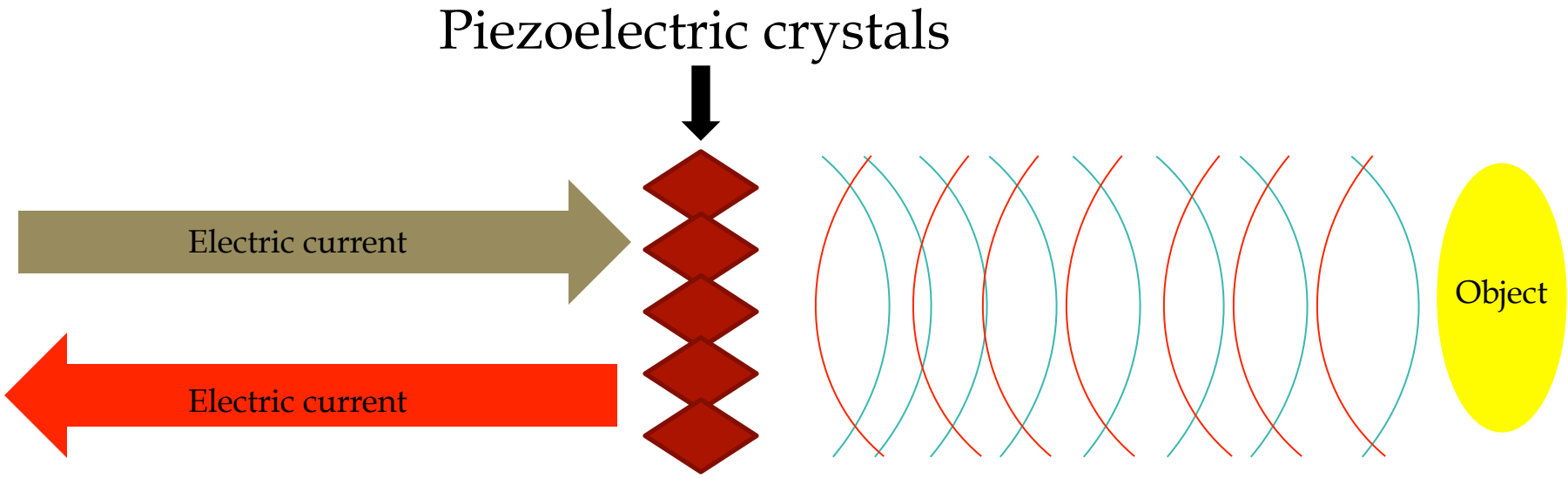
Anatomy of a wave





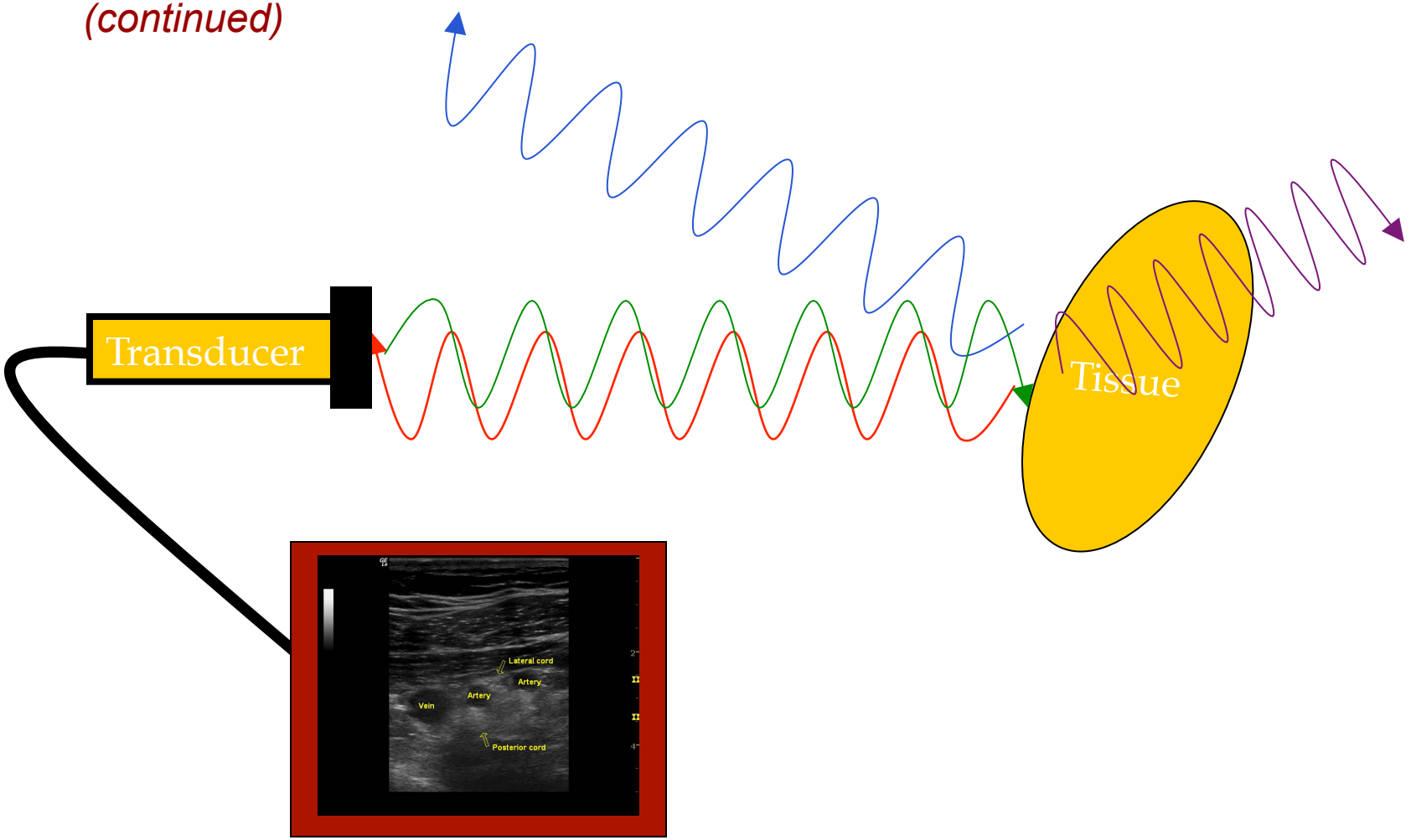
http://www.sprawls.org/ppmi2/USPRO/

Formation of ultrasound image



Formation of ultrasound image

(continued)

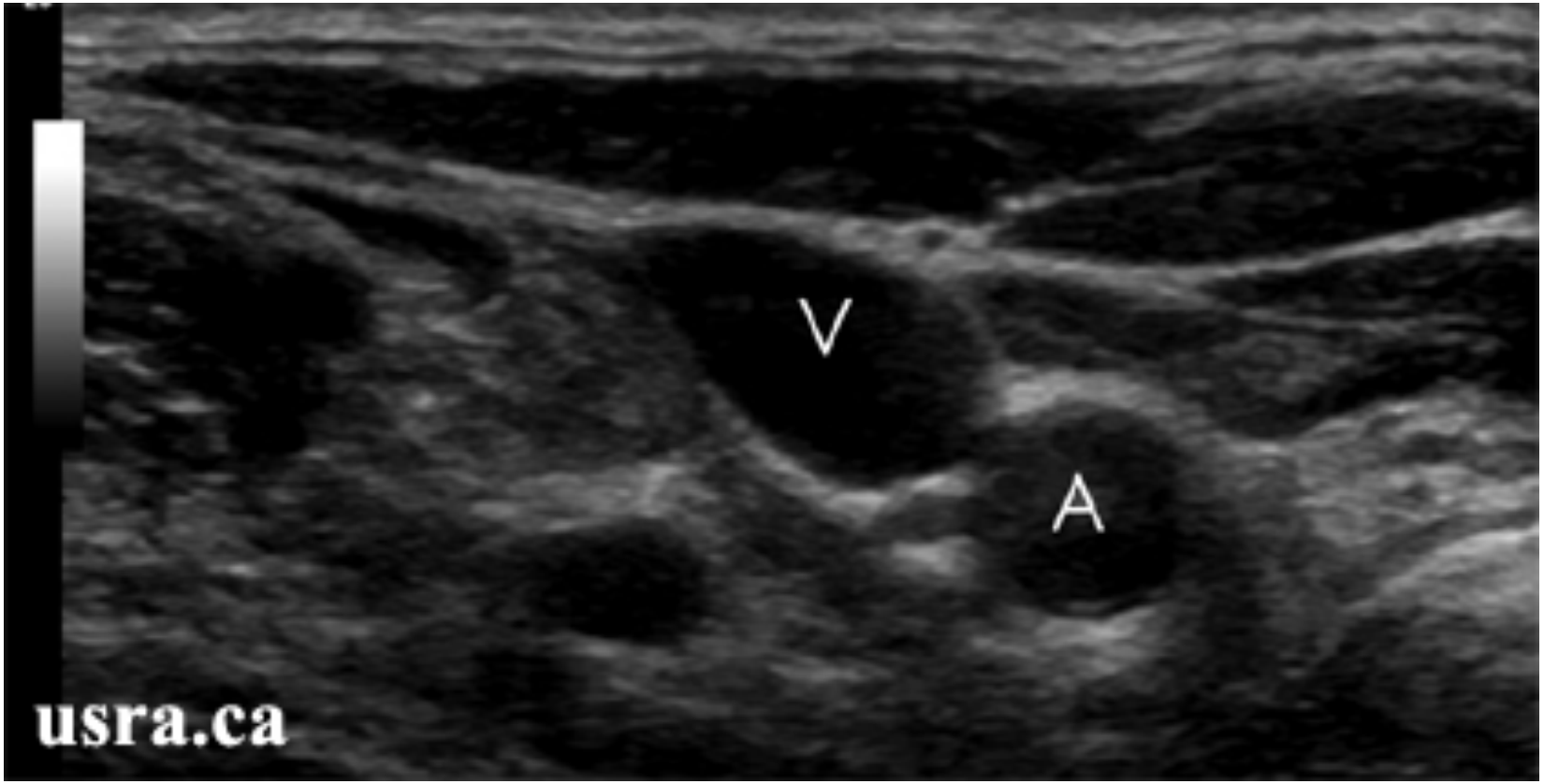


Appearance of anatomic structures

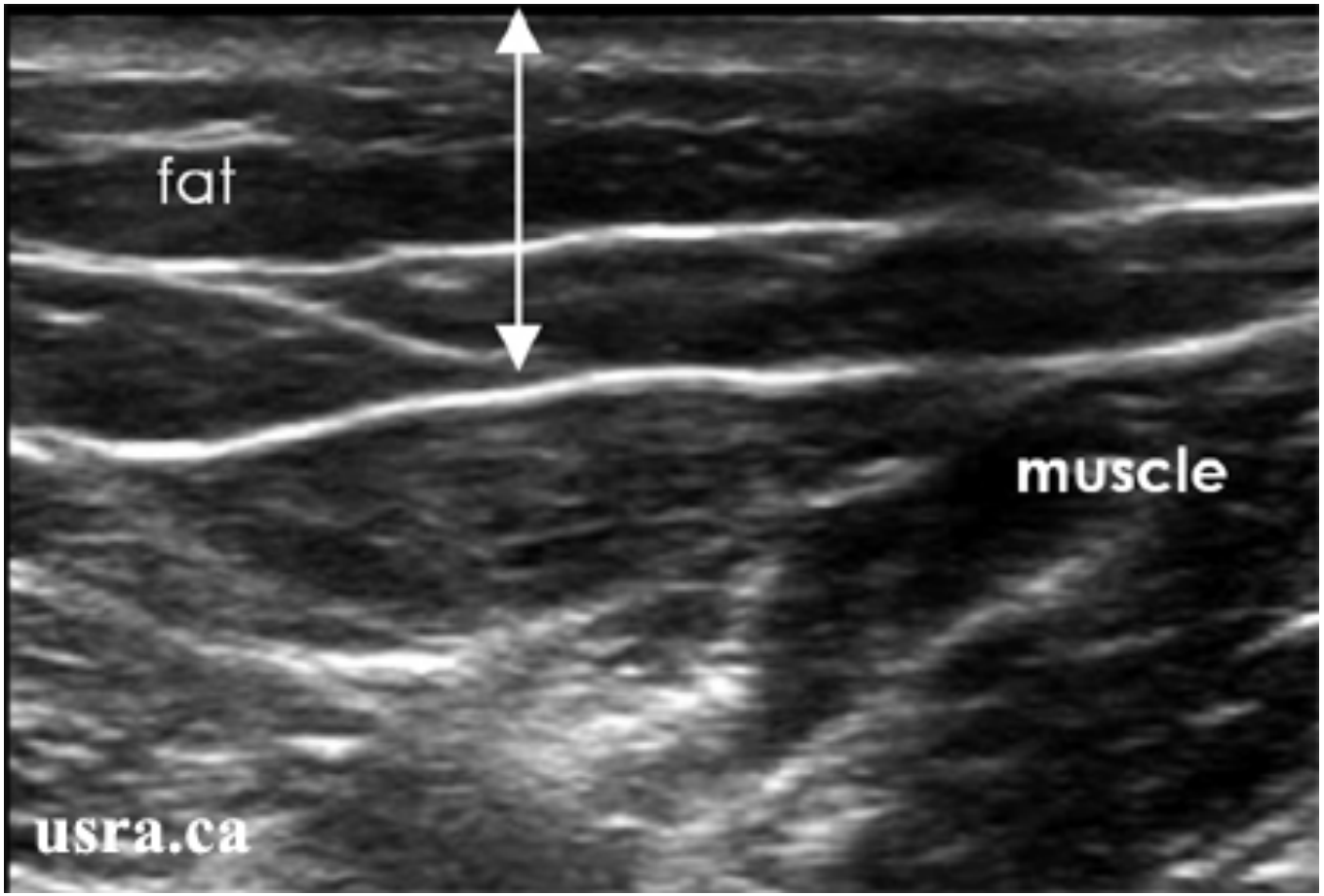
- **Hyper-echoic**:
  - White structures/areas on the screen
  - Ultrasound waves are reflected
  - Tendons, fascia, bones…

- **Hypo-echoic**:
  - Dark structures/areas on the screen
  - Ultrasound waves are not reflected
  - Vessels, cysts...

Echogenicity: Fluid



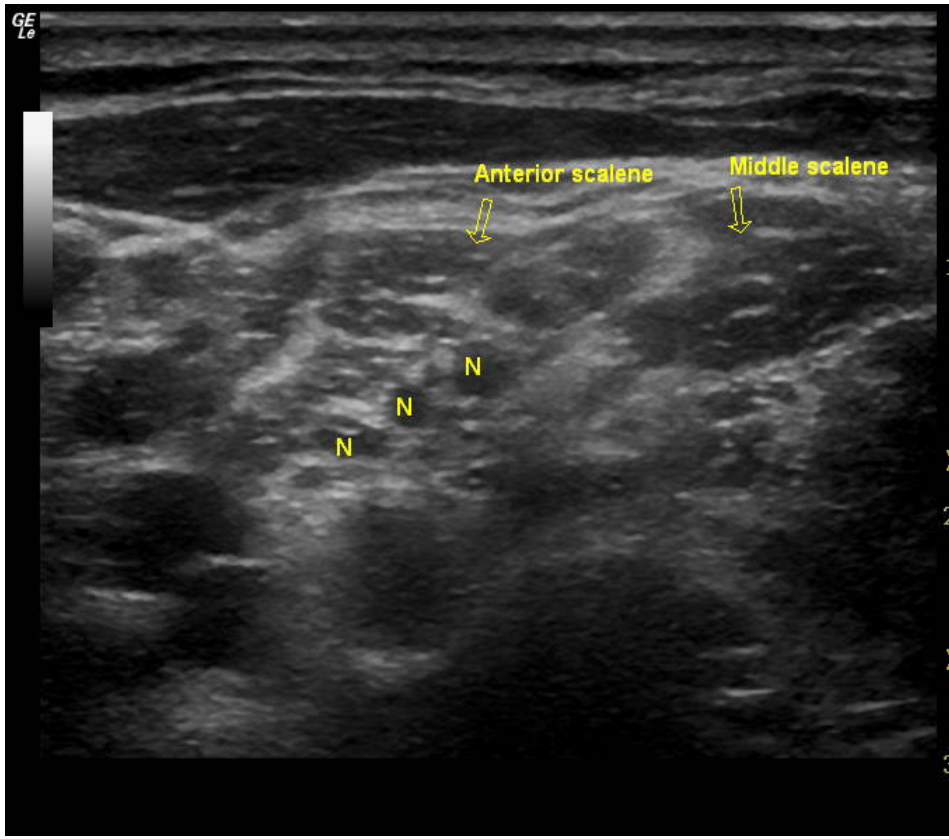
Echogenicity: Fat and Muscle

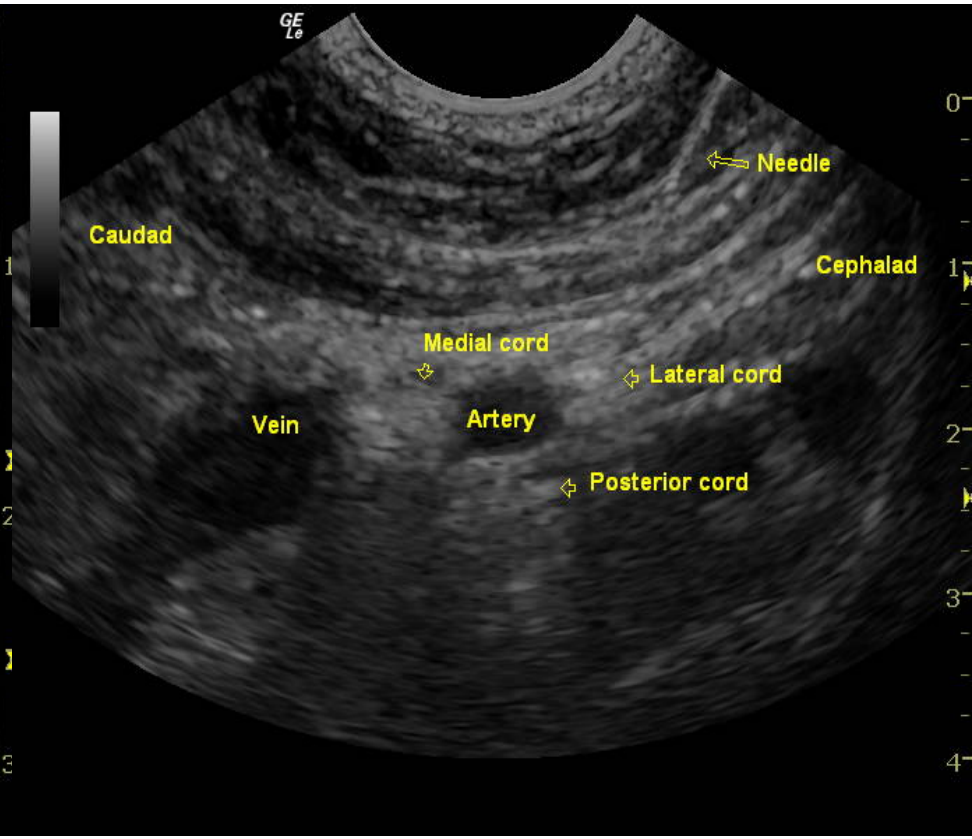


Appearance of anatomic structures

(continued)

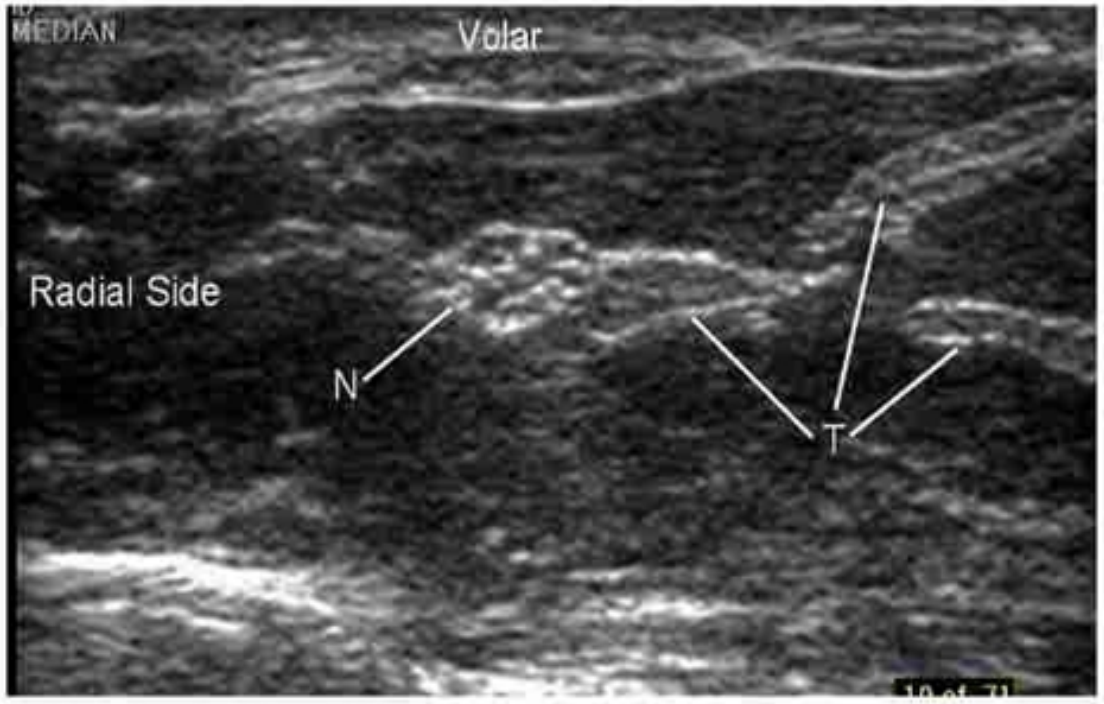
- Nerves appear differently at different locations





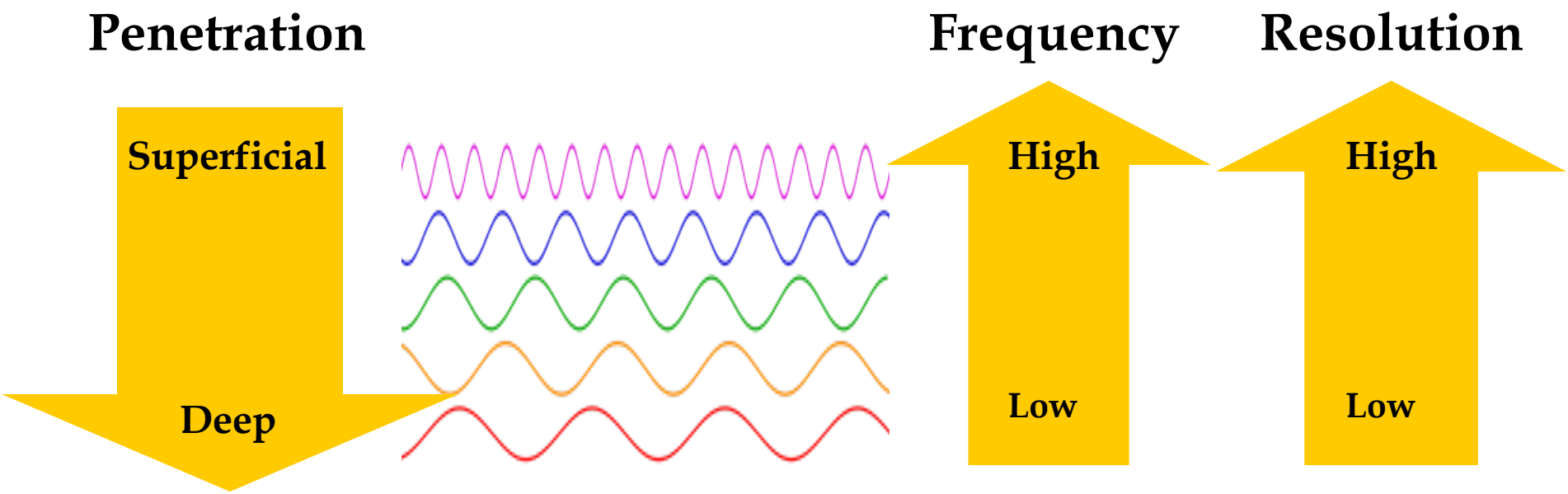
Structures with similar appearance on ultrasound

- Nerves
- Tendons
- Ligaments



Sites B *et.al. The Internet Journal of Anesthesiology*. 2005(10) 1.

KEY CONCEPT: Penetration and Resolution



Transducers and Image Resolution

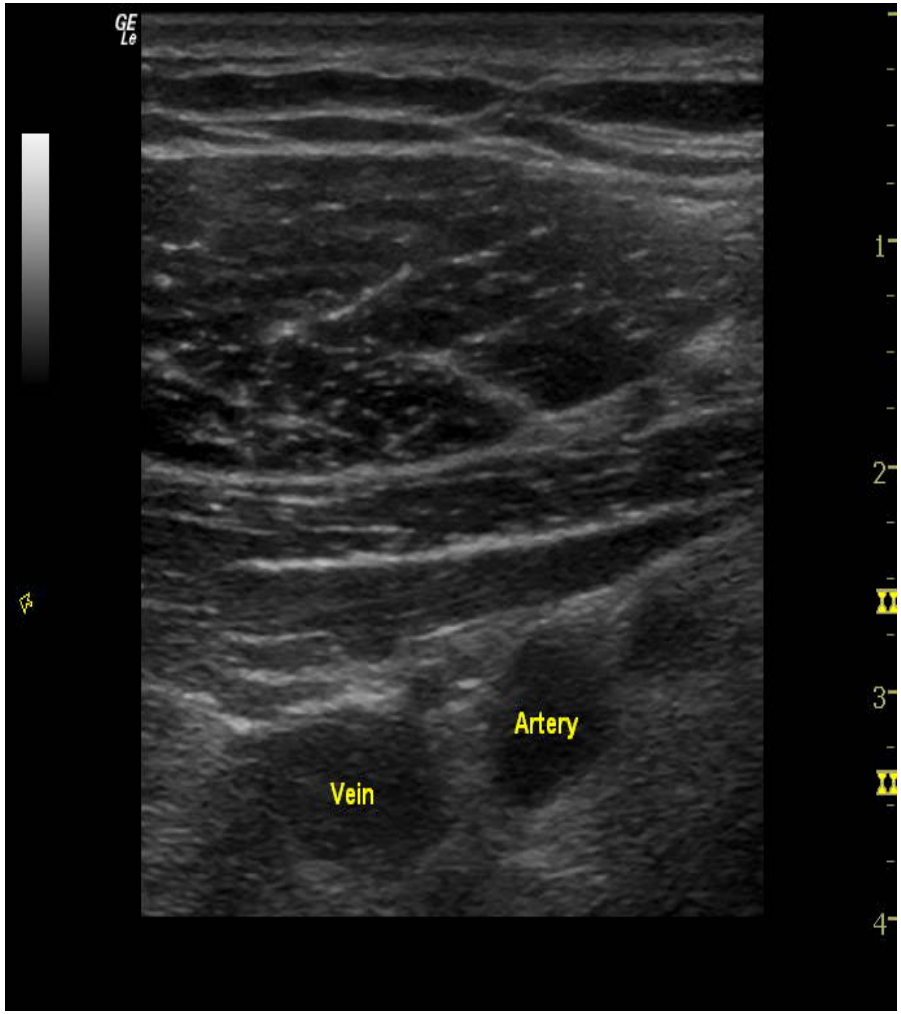
5-13 MHz

Good spatial resolution; limited penetration depth

4-11 MHz

Greater penetration depth; decreased resolution

Infraclavicular PNB Appearance



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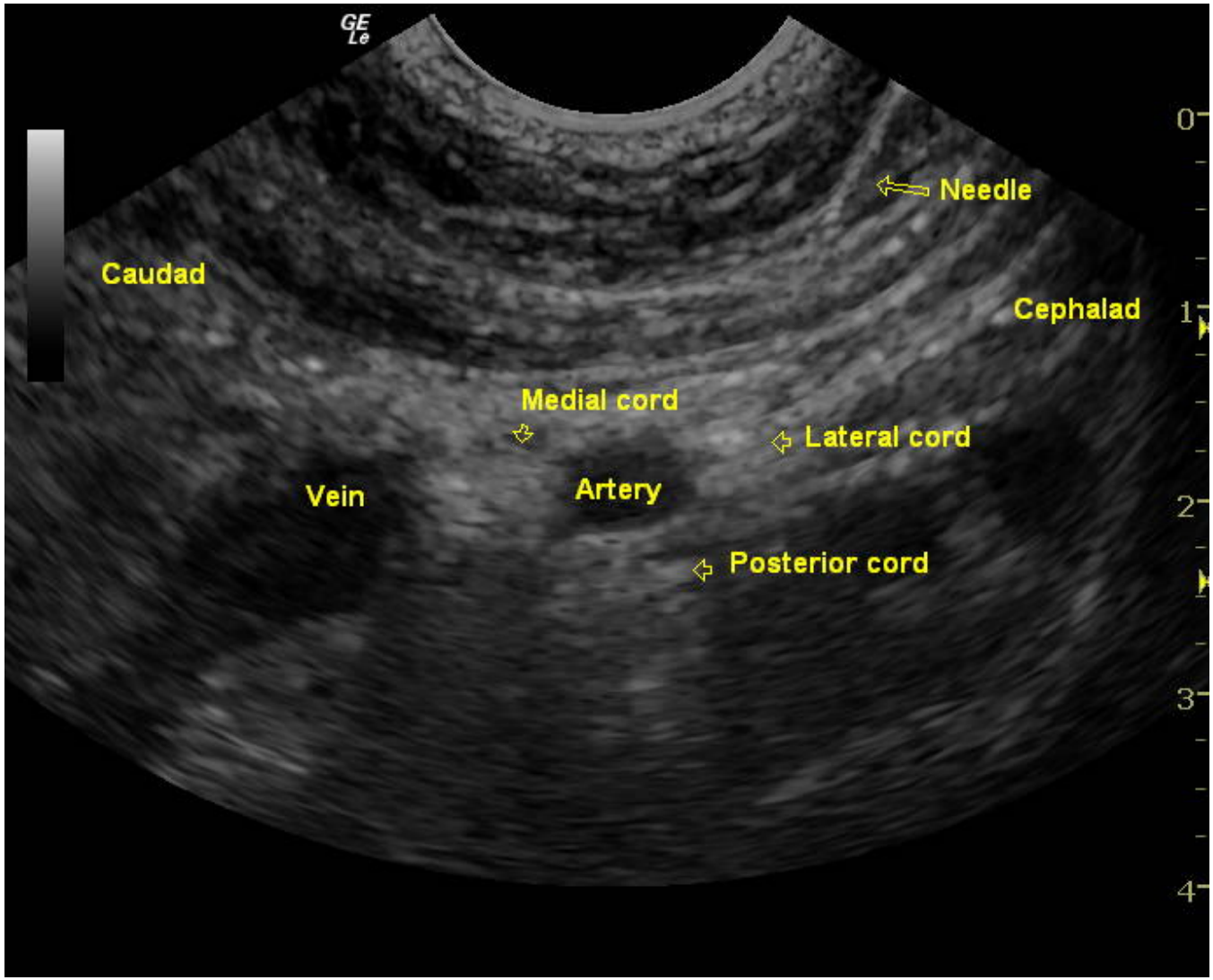
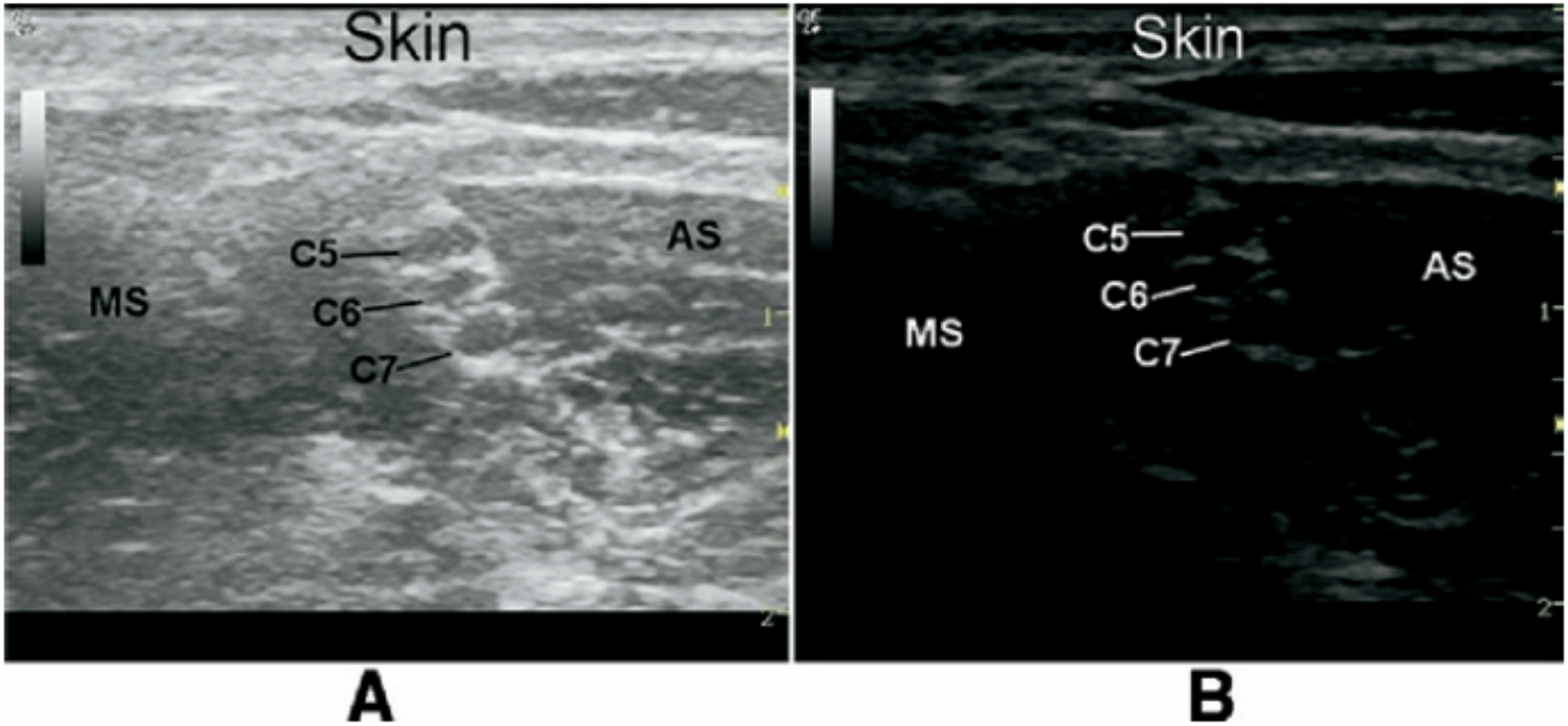
Infraclavicular PNB Appearance



Gain

- Allows the operator to artificially change the intensity of the returning beam



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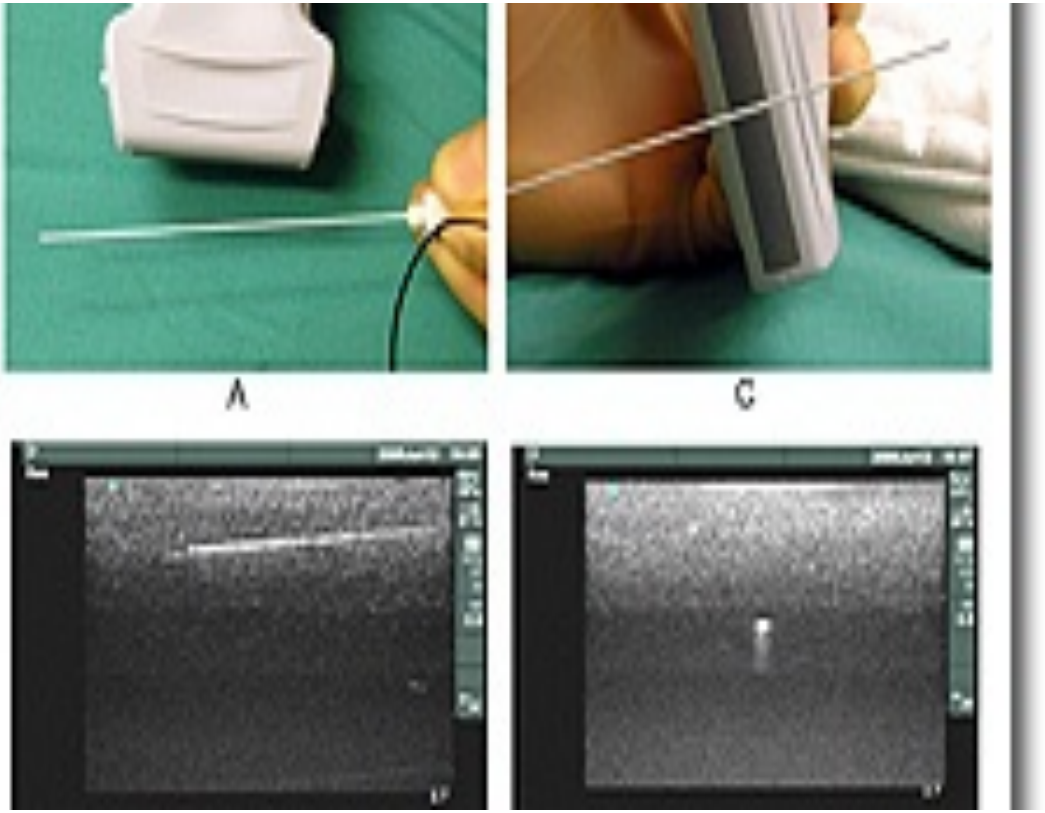
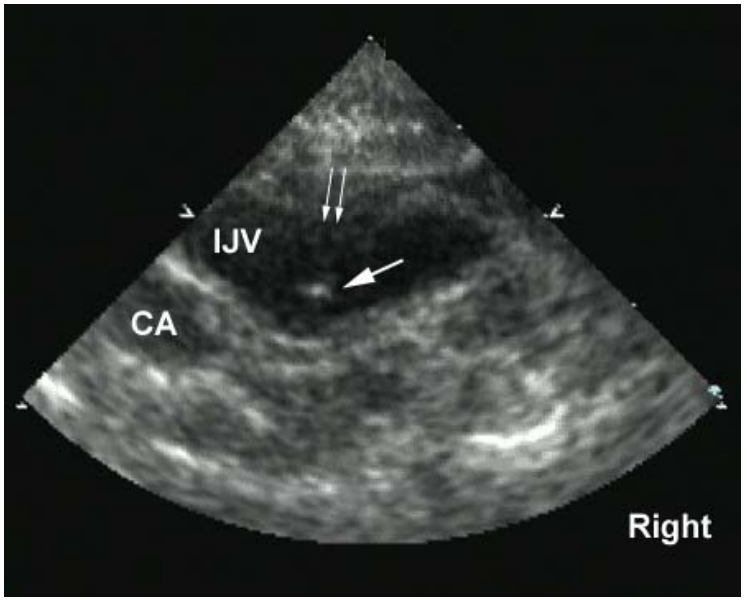
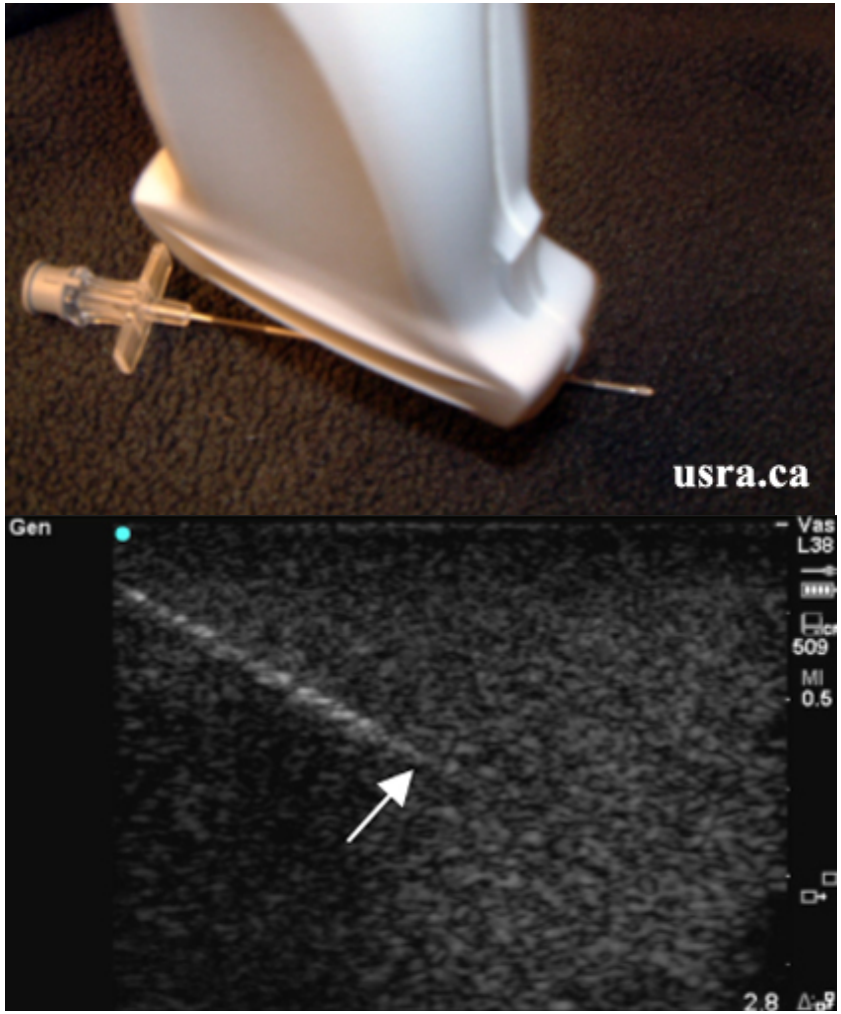
NEEDLE APPROACH





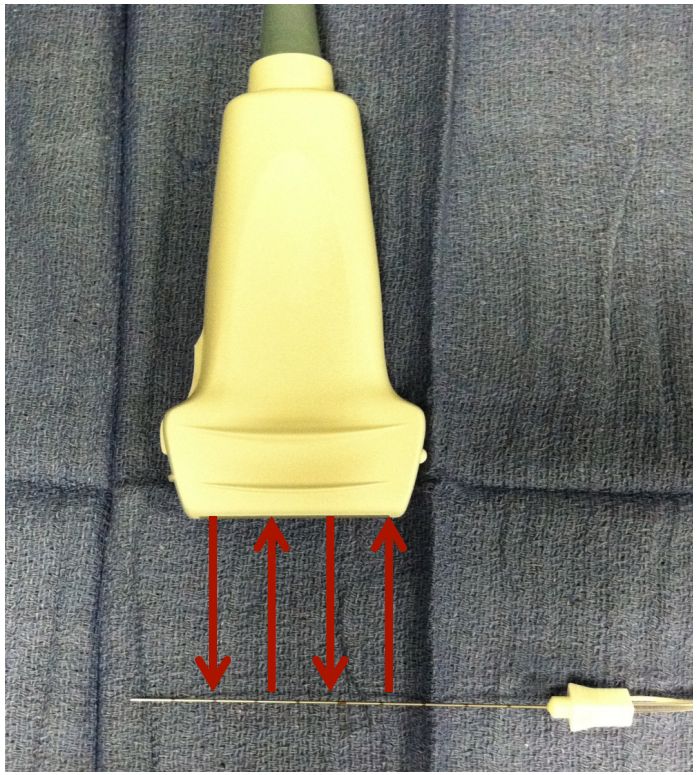
Needle Visualization

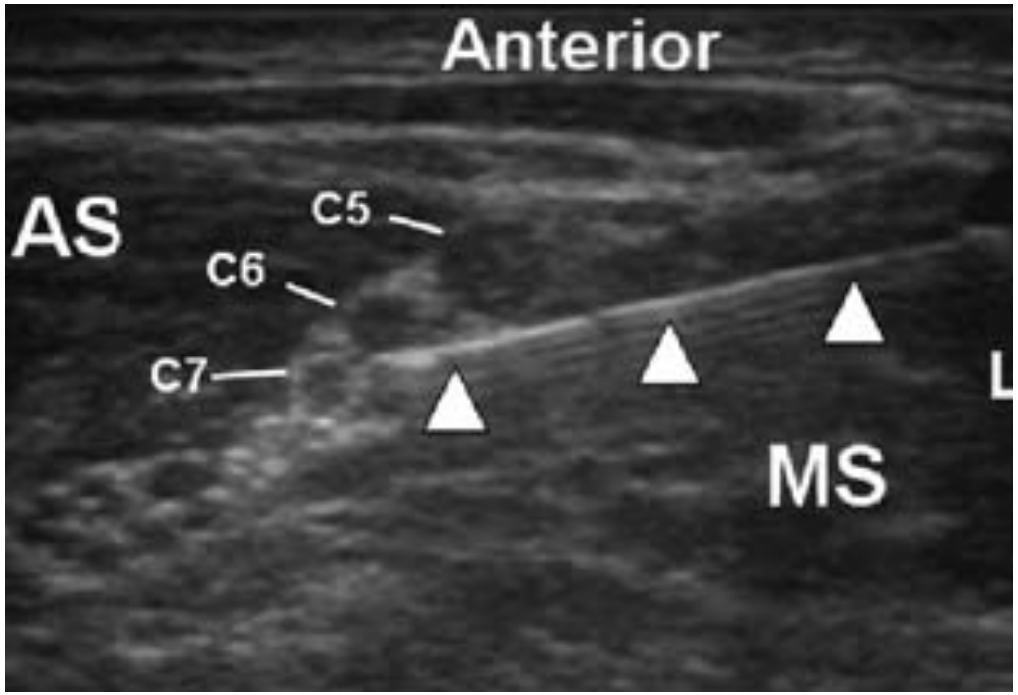


- Oblique Plane

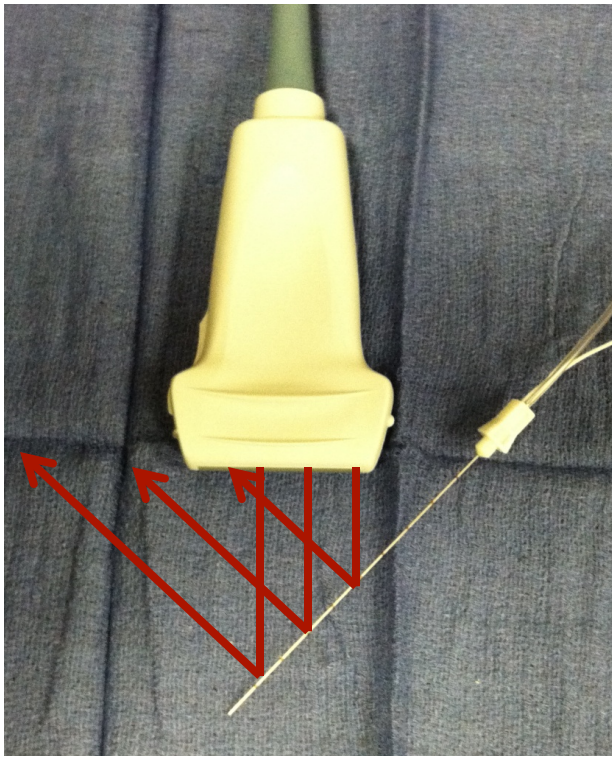
WHERE'S THE TIP???

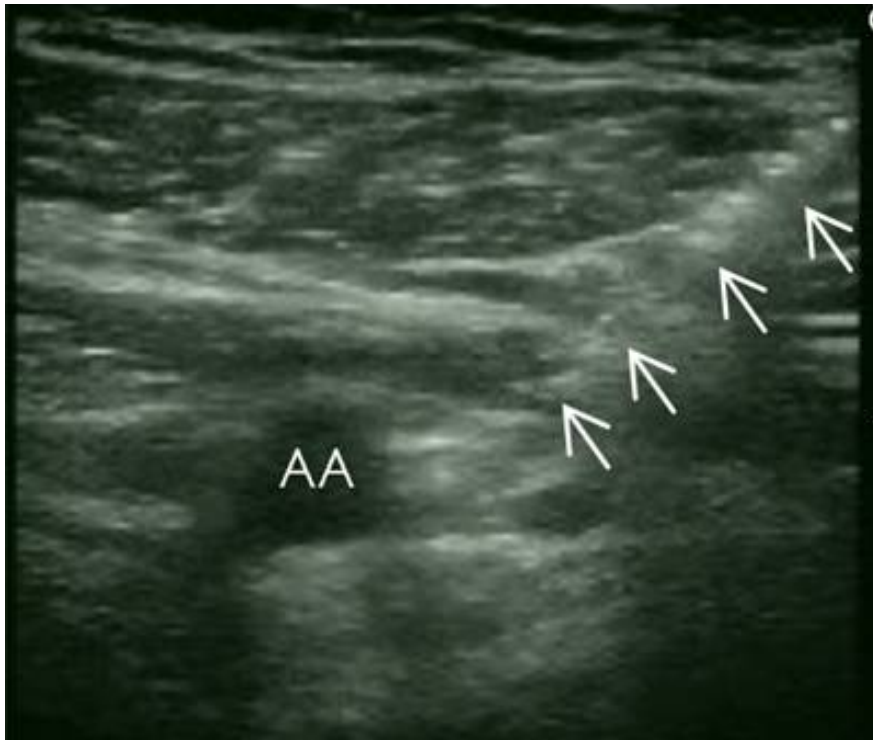
Needle Visualization





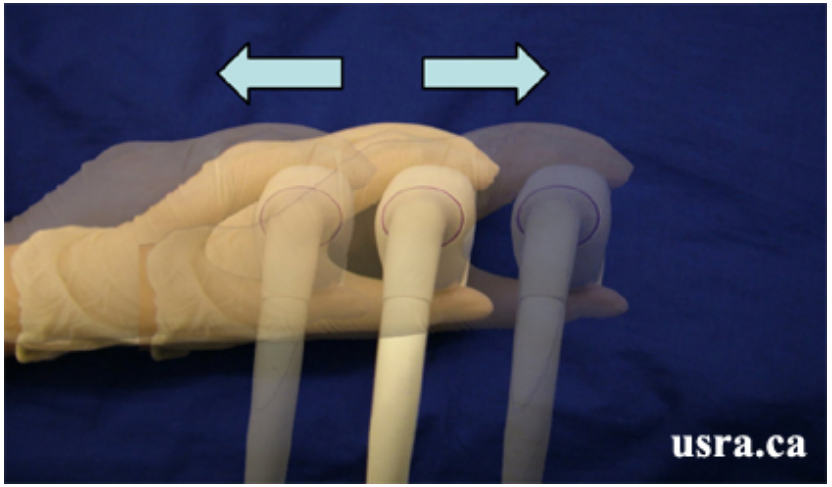
Needle Visualization



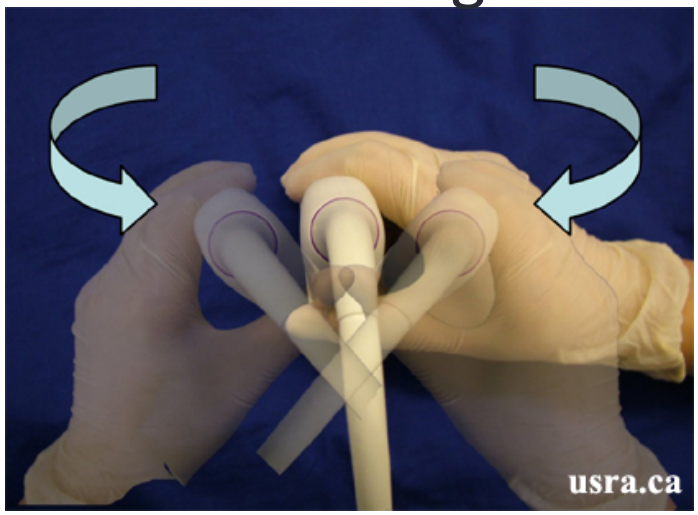


Transducer Movement

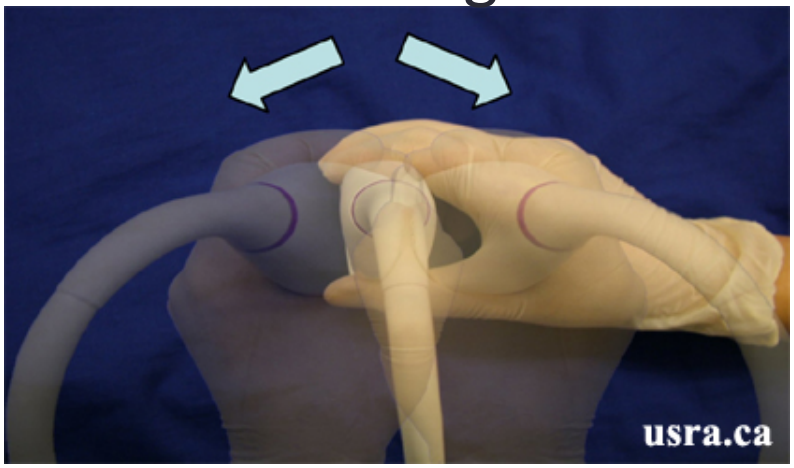
Sliding



Rotating



Tilting



Ultrasound Guided Regional Anesthesia

Neuraxial Anesthesia

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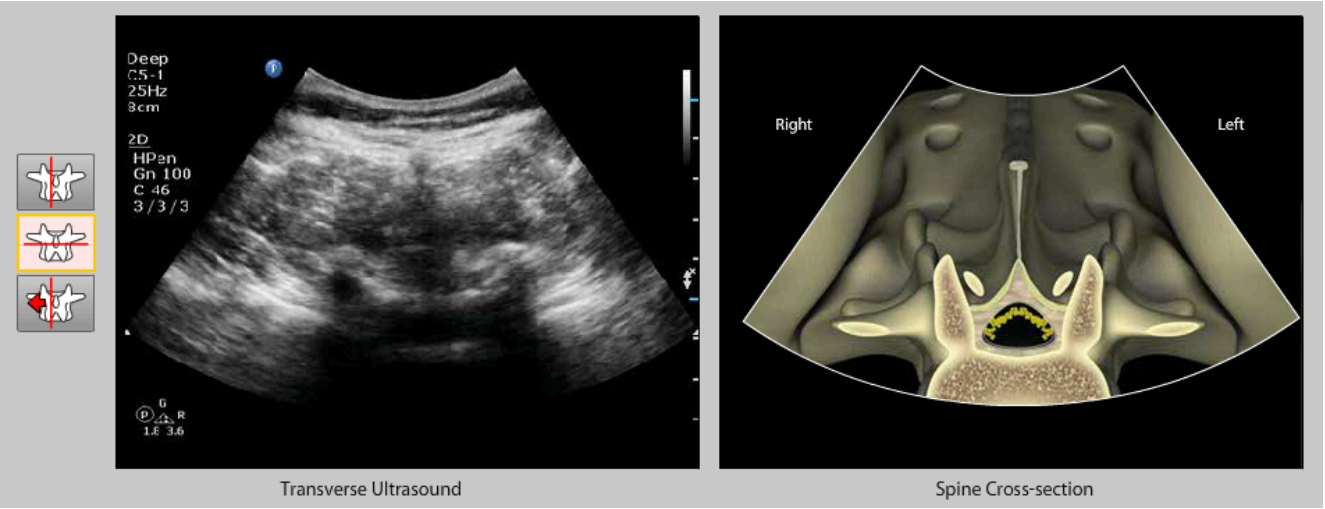
Ultrasound Guided Neuraxial Anesthesia



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Ultrasound for Neuraxial Anesthesia

- Permits passage of US waves through an interlaminar window providing imaging of the vertebral canal revealing a path into which a needle can be passed

- Also aids in identifying:
  - Intervertebral level
  - An estimation of the depth to epidural and to intrathecal spaces
  - The location of important landmarks (**midline** and **interlaminar spaces**)

- When should it be used?
  - Obesity/poor surface anatomy
  - S/p spinal surgery
  - Distorted spinal anatomy (elderly pts or scoliosis)
  - Pregnancy and preeclamptic patients with presacral edema

Anatomy

- The“interlaminar space” and “interspinous spaces” refer to the gaps between adjacent laminae and spinous processes

- Lumbar Spine: laminae do not overlap (as they do in T-spine) and there is a distinct interlaminar space between adjacent vertebrae

- The posterior epidural space has a triangular cross-section, typically 7 mm wide in the the midline in an anteroposterior dimension

- Conus medullaris is located a L1 vertebral body in most adults (varies from T12 – L3)*

Sonoanatomy of the Spine

- A curved-array, low frequency probe (2 – 5 MHz) allows for a wider field of view and deeper penetration

- Initial depth setting of 7 – 8 cm is appropriate for most patients; adjust depth, focus, and gain as needed

- 3 basic orientations of the the ultrasound probe and beam:
  - 1) Paramedian sagittal (sagittal plane lateral to midline)
  - 2) Paramedian sagittal oblique
  - 3) Transverse

Sonoanatomy of the Spine

- Bony structures appear as white, hyperechoic linear structures with a dense acoustic shadow (black)

- Connective tissue structures (ligaments &fascial membranes) are also hyperechoic, however have a lesser acoustic impedance thereby allowing limited visualization of deeper structures

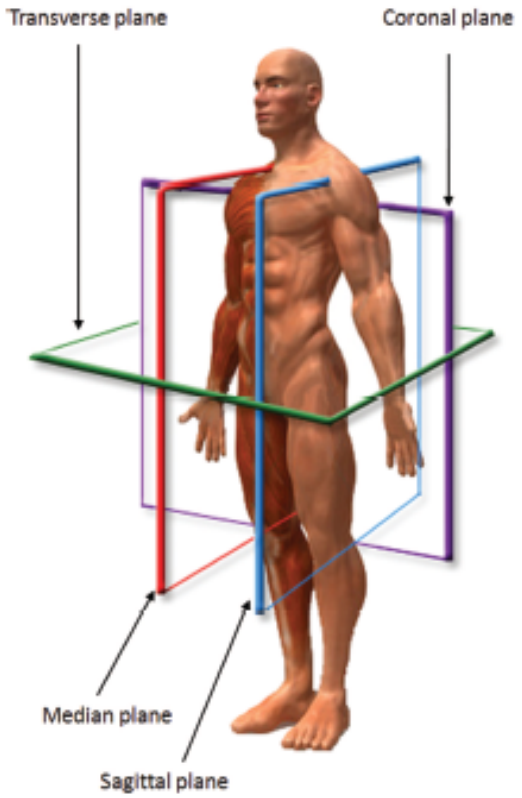
- Fat and fluid have appear hypoechoic (dark) and have a very low acoustic impedance

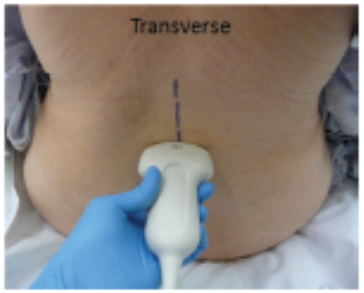
Ultrasonographic Views of the Spine

5 Basic Views

1. PS Transverse Process View
2. PS Articular Process View
3. PS Oblique View
4. Transverse Spinous Process View
5. Transverse Interlaminar View

Anatomic Planes and
US Probe Orientations





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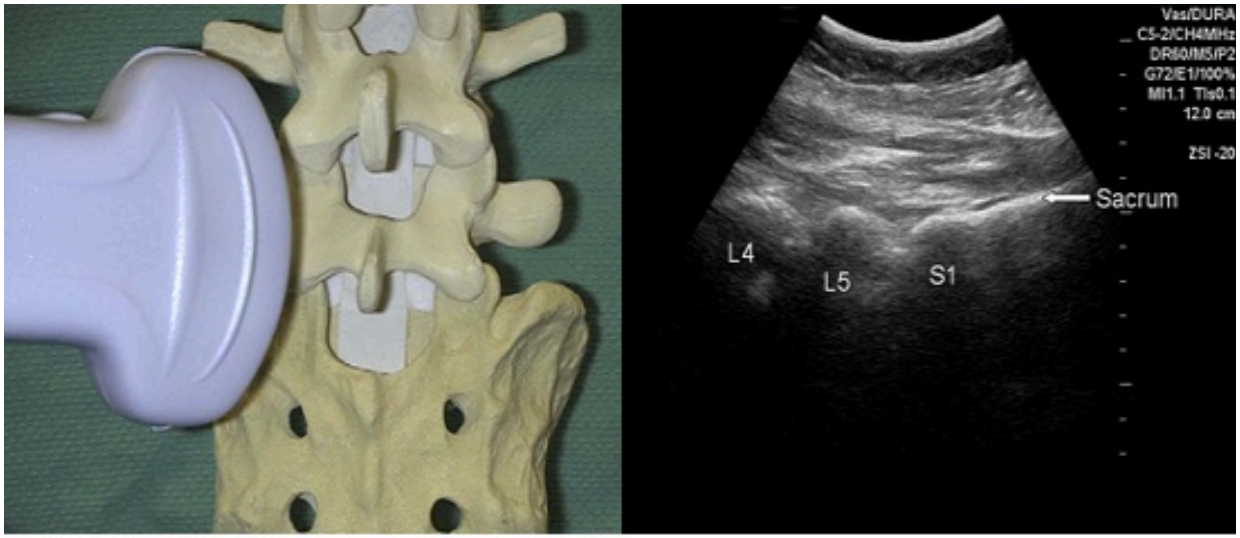
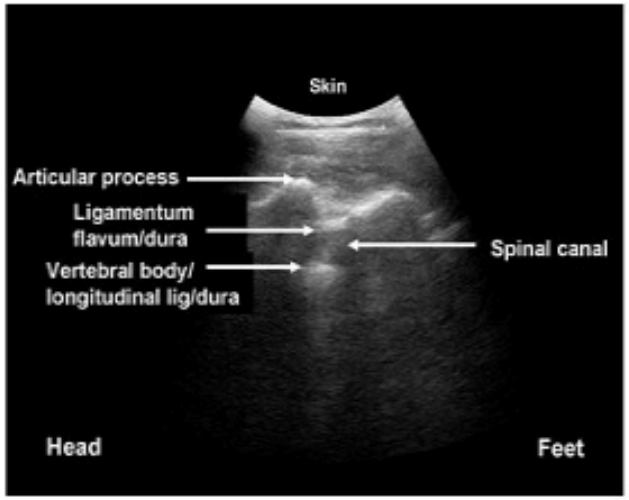
Longitudinal Views

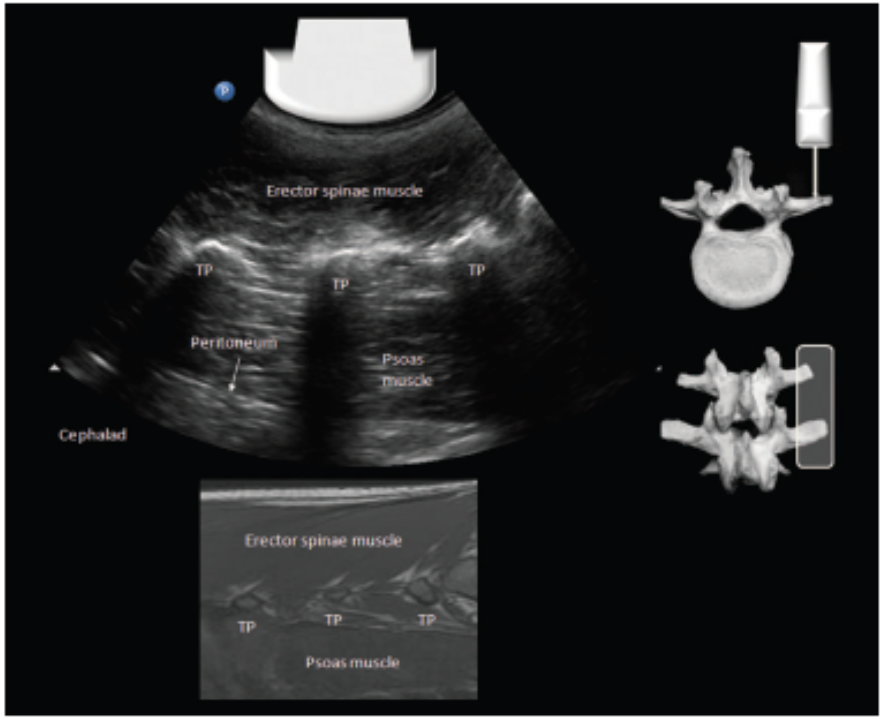




http://pie.med.utoronto.ca/OBAnesthesia/OBAnesthesia_content/OBA_spinalUltrasound_module.html

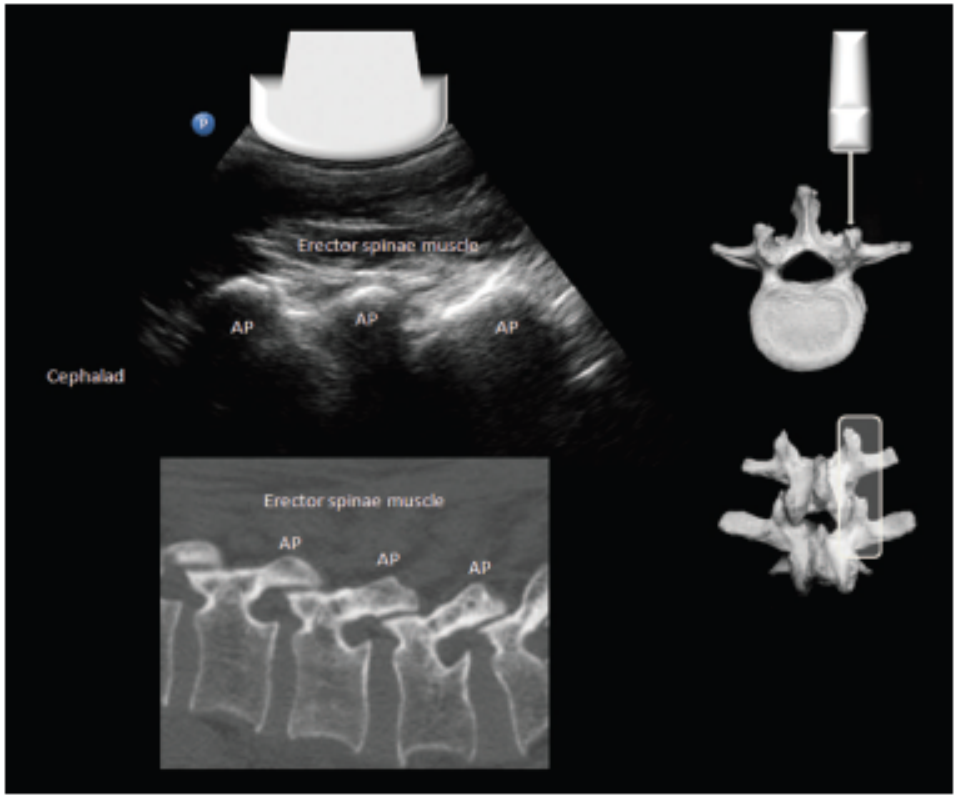
#1 Parasagittal Transverse Process View

- Place probe in a PS orientation 3 – 4 cm from the midline just above the upper border of the sacrum
- TPs of successive lumbar vertebrae are visualized – “Trident Sign”
- Psoas major m. is visible btw acoustic shadows and deep to the TPs



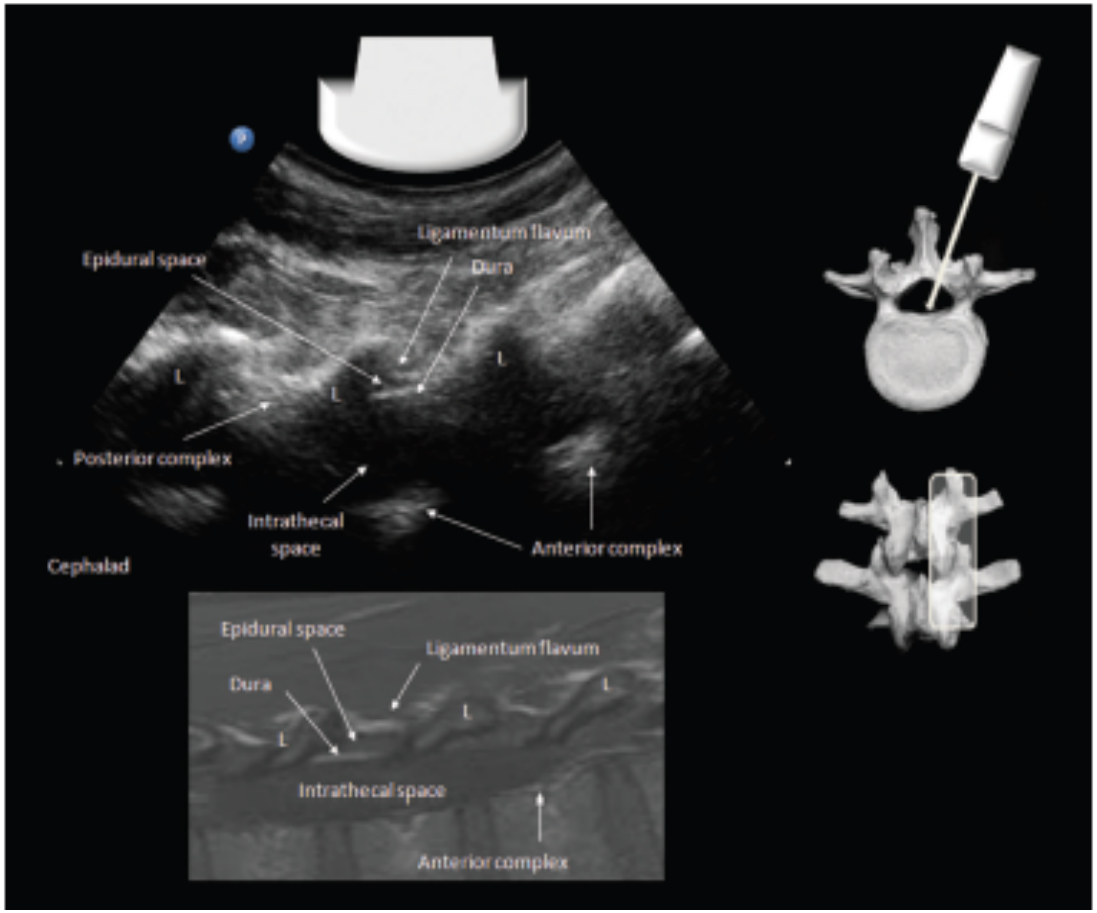
#2 Parasagittal Articular Process View

- From TP view, slide the probe medially until a continuous hyperechoic line of “humps” is seen
- Each hump represents the facet joint between a superior and inferior articular process



#3 Parasagittal Oblique View

- From previous view, tilt the probe toward the midline
- Sloping hyperechoic laminae form a “sawtooth”-like pattern
- Intervening gaps represent the paramedian interlaminar spaces*



*Window to ***anterior*** and ***posterior complexes***

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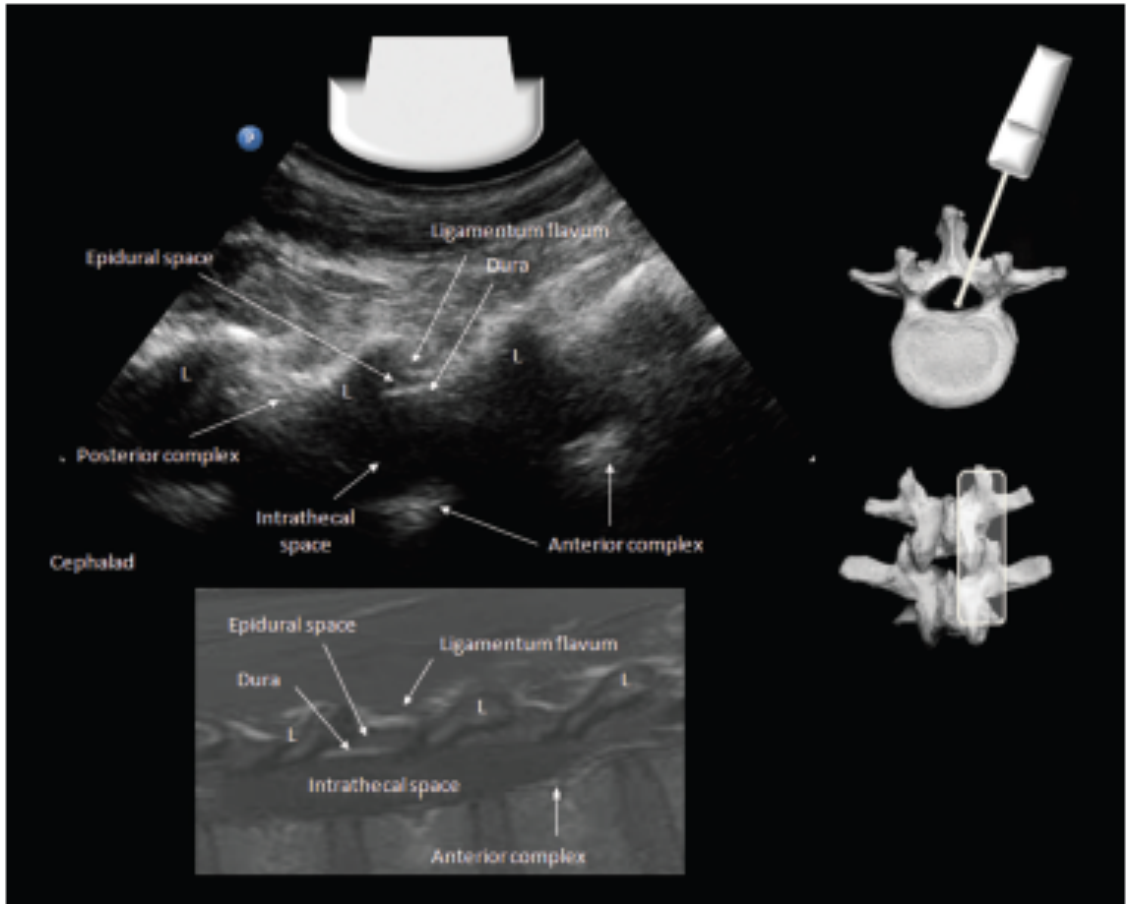
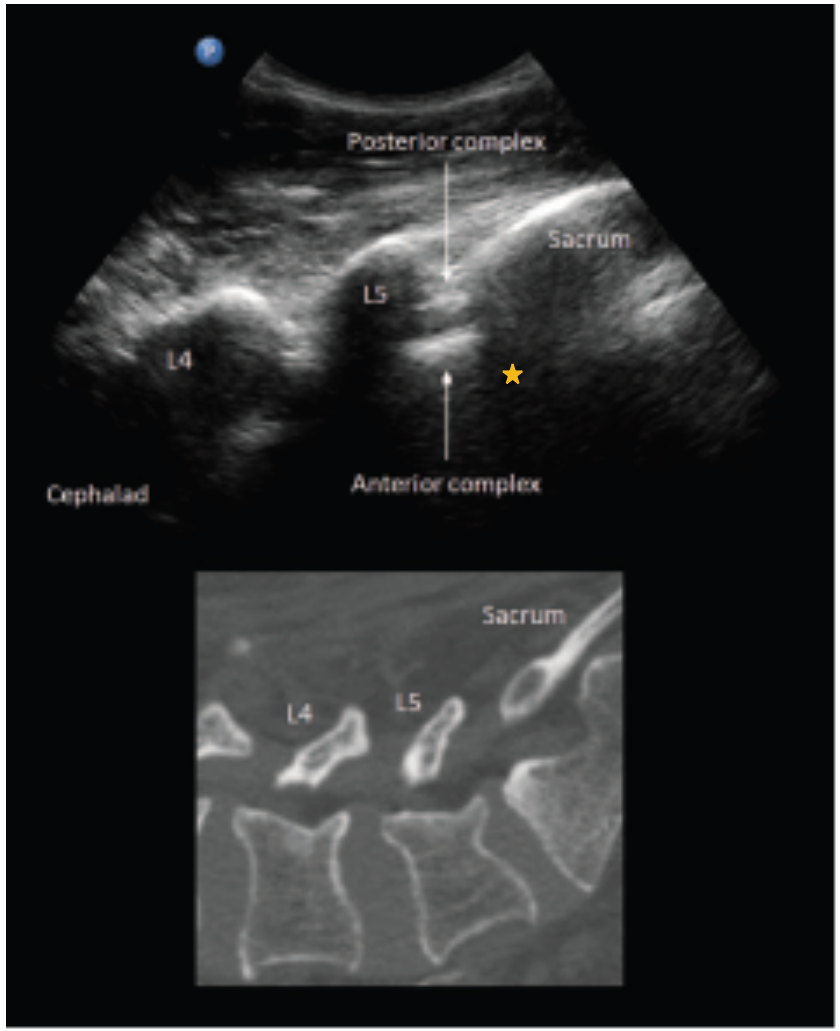
Interlaminar Spaces of the Parasagittal Oblique View

- From superficial to deep:
  - Posterior Complex
    - Ligamentum flavum
    - Epidural space
    - Posterior dura mater
    - Intrathecal space
  - Anterior Complex
    - Anterior dura
    - Post longitudinal ligament
    - Posterior vertebral body

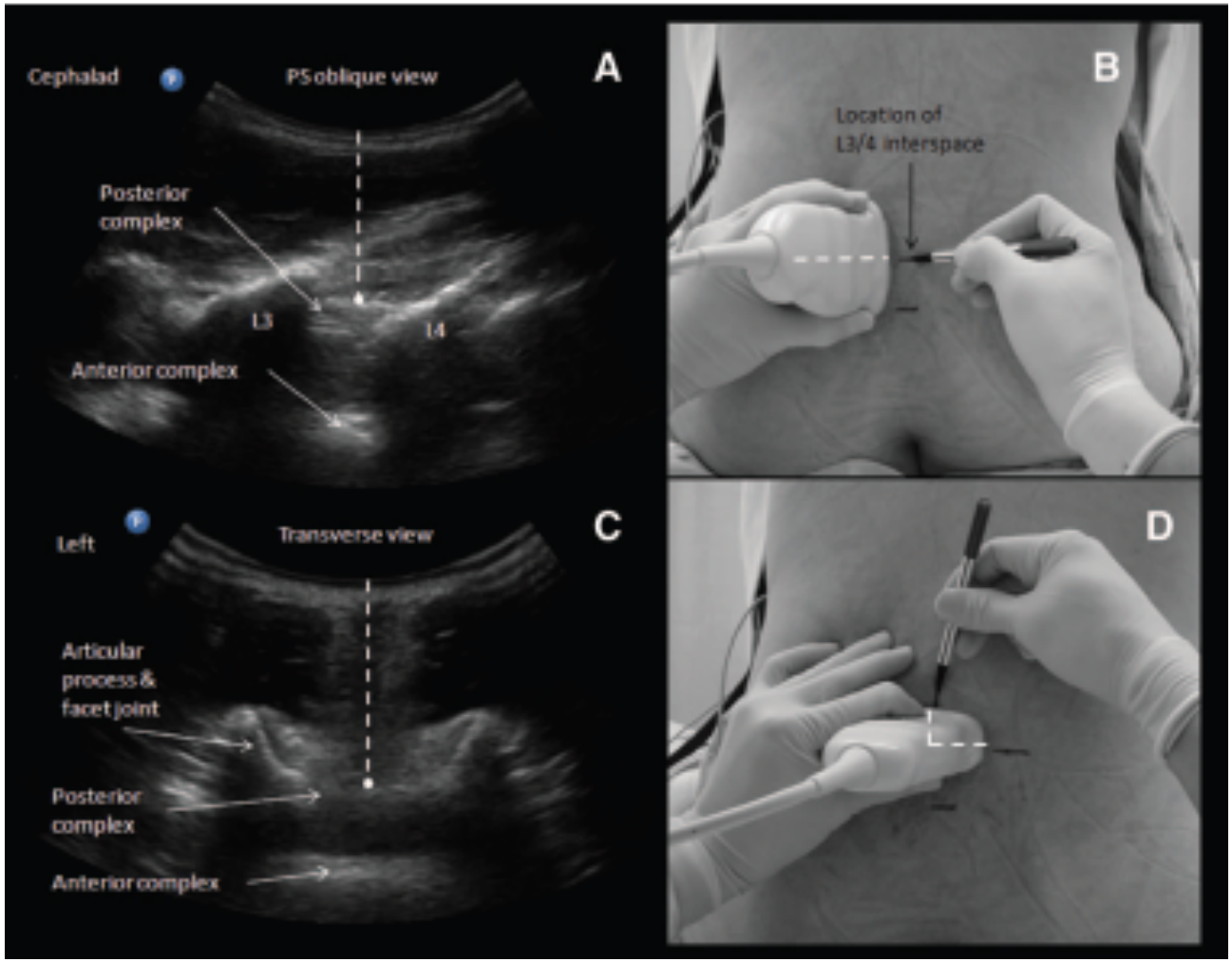


Accurate identification of intervertebral spaces

- Slide the probe caudad while maintaining a PS oblique orientation, until the **horizontal hyperechoic line of the sacrum** comes into view
- Center L5–S1 intervertebral space on the screen
- This location corresponds with the midpoint of the probe's long side
- Same approach to count up



Surface Marking for *Needle Insertion*



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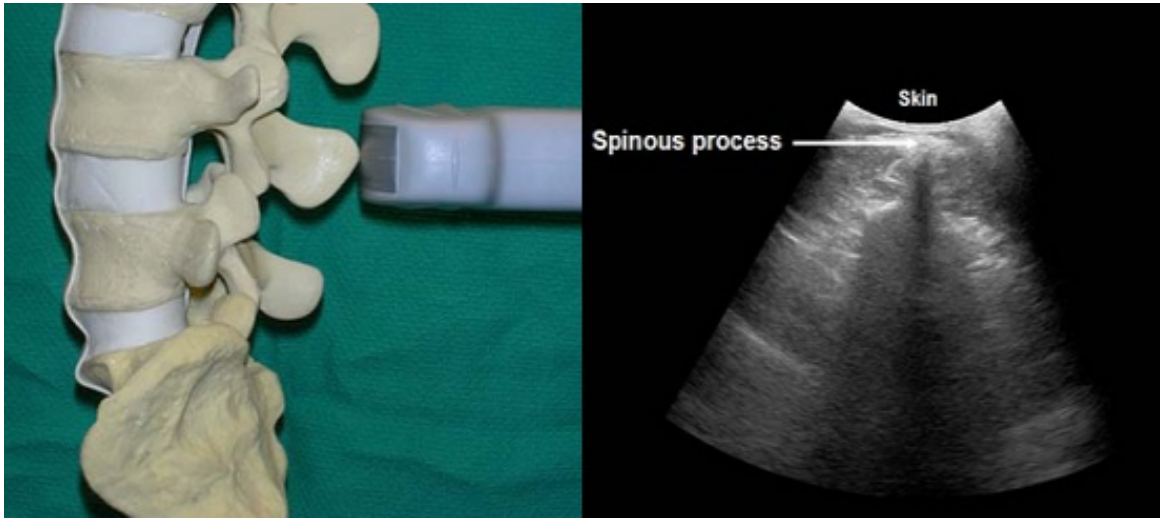
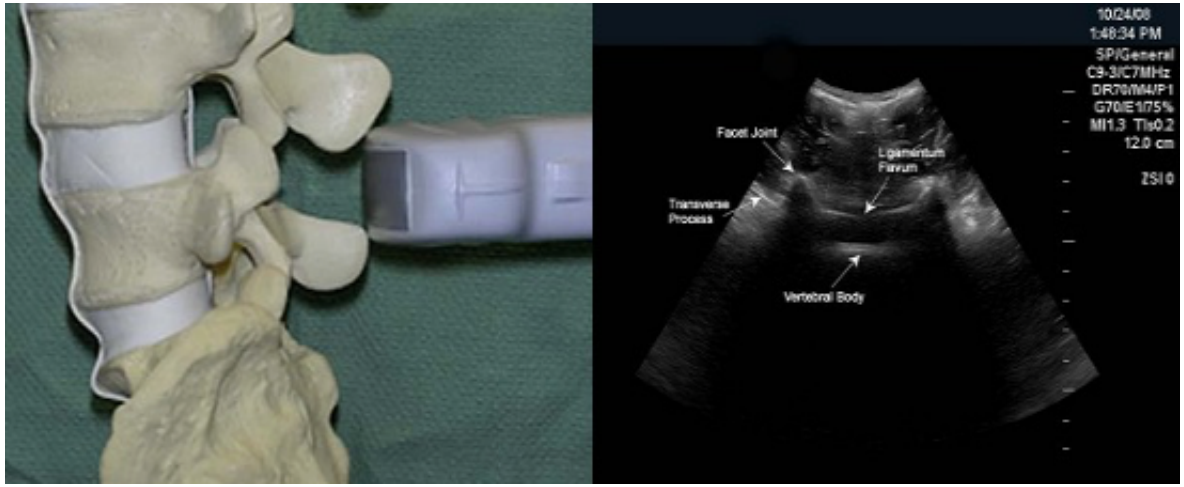
Transverse Views



Transverse Spinous Process View

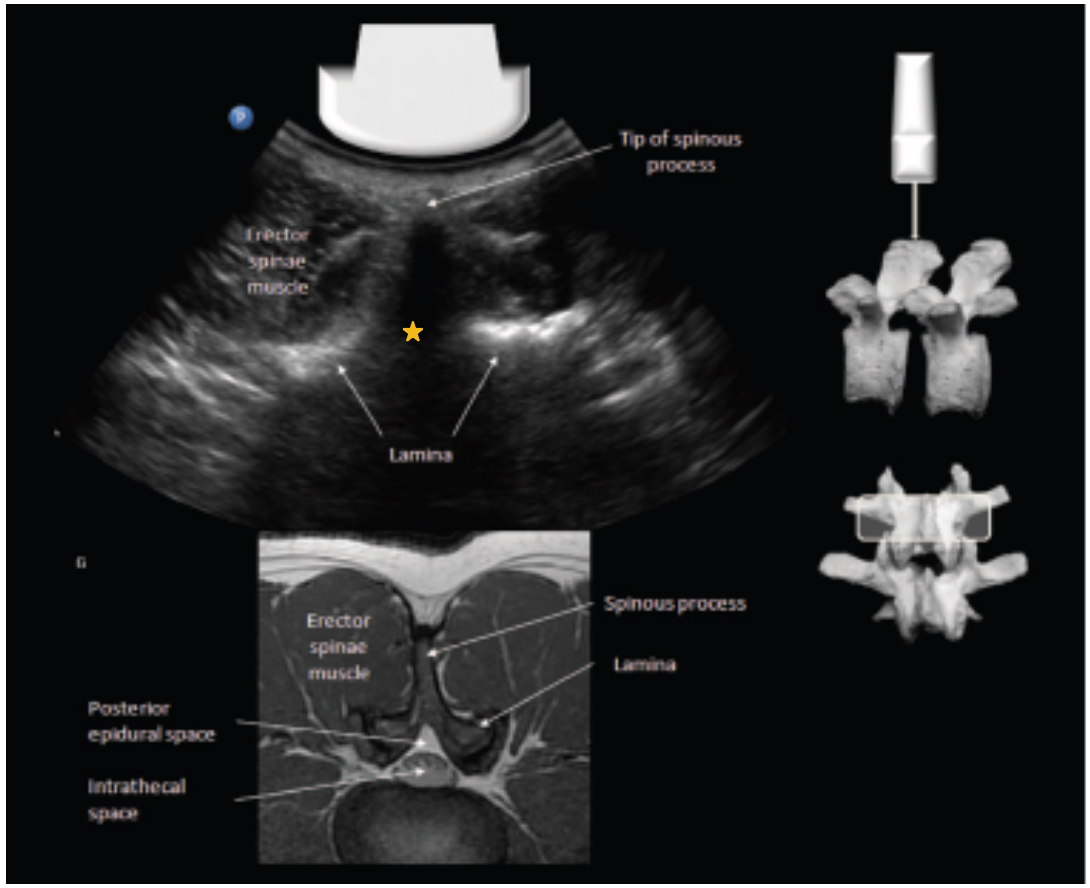


Transverse Interlaminar View

http://pie.med.utoronto.ca/OBAnesthesia/OBAnesthesia_content/OBA_spinalUltrasound_module.html

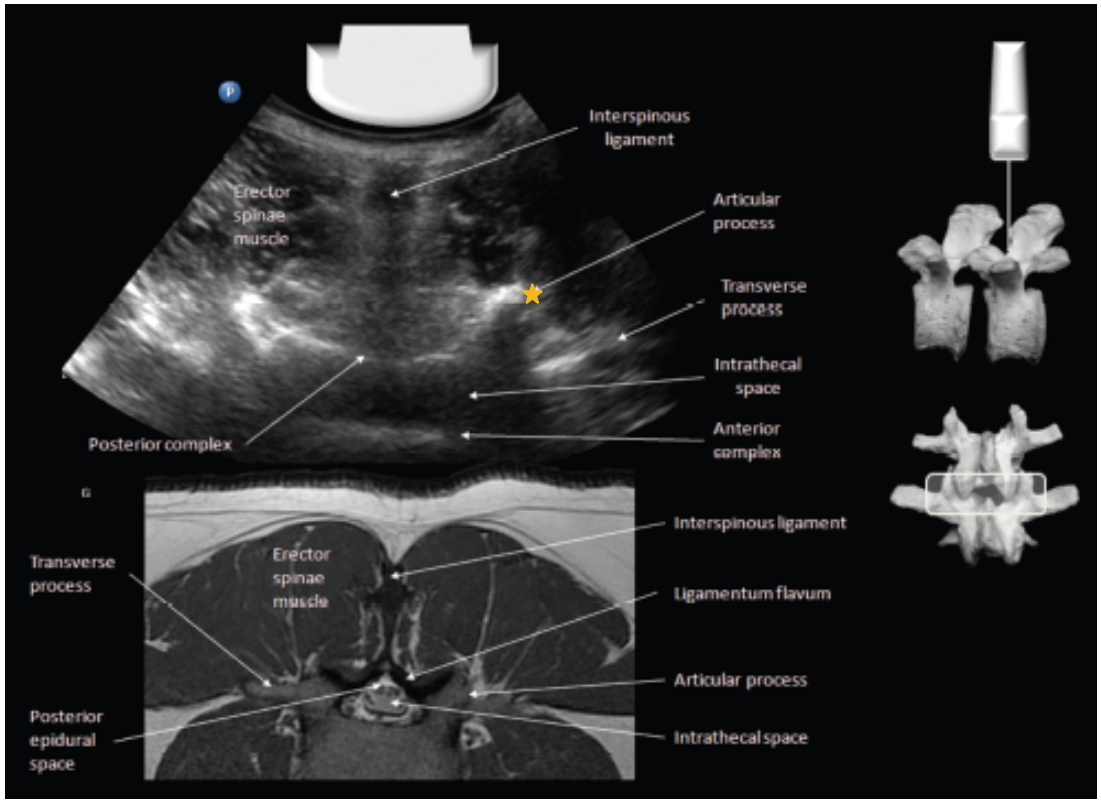
#4 Transverse Spinous Process View

- Rotate probe 90 deg and centered on neuraxial midline
- The tip of the SP is visualized as a superficial hyperechoic line with acoustic shadowing beneath
- Hyperechoic lamina is visible on either side of the spinous process, but all other structures of interest are obscured by bony acoustic shadowing

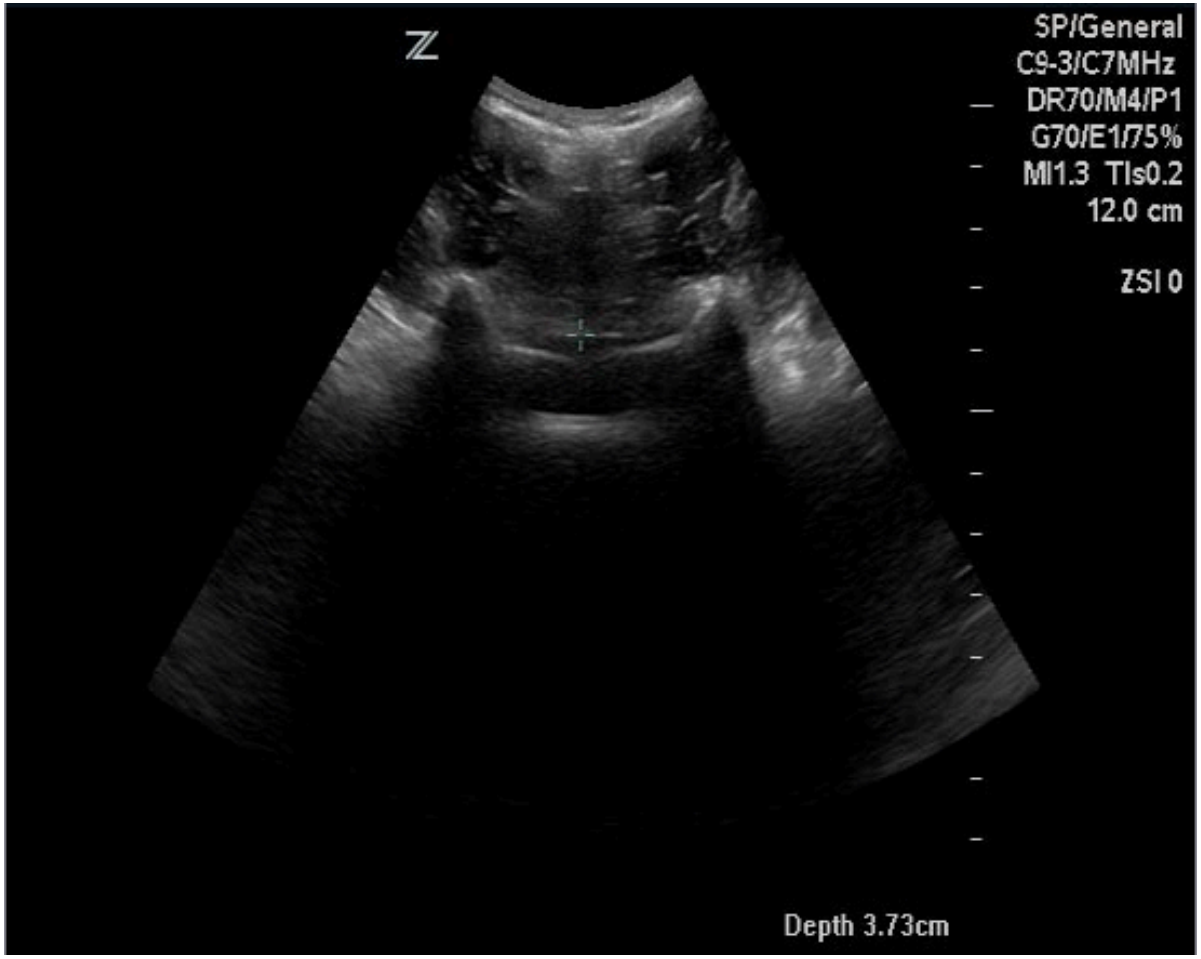


#5 Transverse Interlaminar View

- Slide the probe cephalad/ caudad from the spinous processes
- Midline is indicated by the dark vertical stripe of interspinous ligament
- Estimate the required needle insertion depth by measuring depth from skin to posterior complex



“Flying Bat” sign



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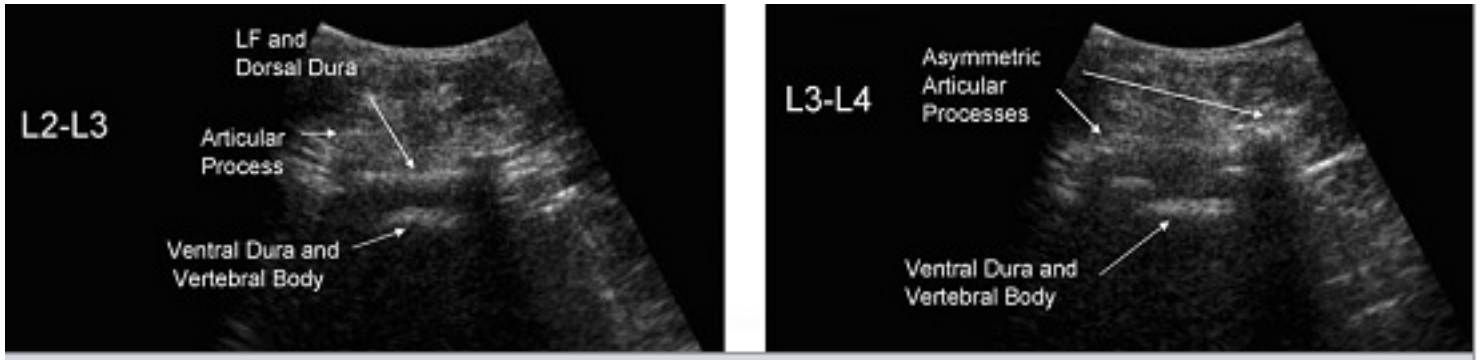
Atypical Sonogram



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Conclusions

- Ultrasound: a promising technical advance in spinal and epidural techniques
- Bedside ultrasound can be extremely useful to facilitate spinal and epidural anesthesia placement by providing the following information:
  - the exact interspace at which the puncture should be performed, which is especially important in spinals,
  - the best interspace,
  - the ideal insertion point,
  - the angle of the puncture,
  - the distance from the skin to the epidural space, and
  - anatomical abnormalities, such as scoliosis

Conclusions

- Providing a superior teaching tool for spinals and epidurals, as it facilitates the learning curve, and may increase safety during the learning curve,
  - shortening the duration of procedures,
  - increasing the comfort of procedures,
  - decreasing the number of attempts and the associated trauma,
  - possibly decreasing the number of accidental dural punctures,
  - forecasting difficult epidurals (similar to difficult intubations),
  - transforming difficult epidurals into easy epidurals, and
  - helping in the selection of the best equipment for the spinal/ epidural.