BASIC ULTRASOUND

Essential Skills for Veterinary Practitioners

(50 ppt slides)

Overview

- Advantages/Disadvantages
- Generation of Image
- Ultrasound Machine/Transducer selection
- Modes of Ultrasound
- Terminology
- Tissue Appearance
- Scanning Technique

Advantages

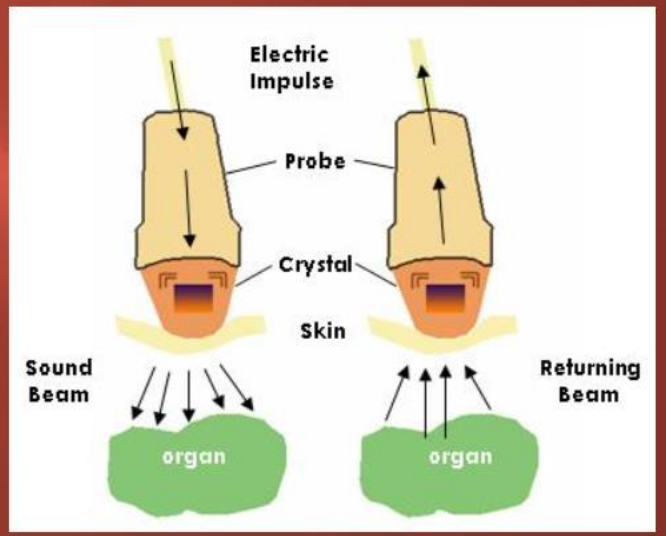
- Real-time
- Portable
- No ionizing radiation
- Inexpensive?
- Side-side comparison
- Patients love it!
- Guide procedures

Disadvantages

- Operator dependent
- Expensive?
- Limited penetration through bone and air
- Imaging deep structures

Generation of image

- Electric field applied to piezoelectric crystals located on transducer surface
- Mechanical vibration of crystals creates sound waves
- Each crystal produces an US wave
- Summation of all waves forms the US beam
- Wave reflects as echo that vibrates transducer
- Vibrations produce electrical pulses
- Scanner processes and transforms to image



Physics

- Frequency 1-18 megahertz (mHz)
  - Lower frequencies = less resolution but deeper penetration
    - E.G. kidney, liver 1-6 mHz
  - Higher frequencies = smaller wavelength
    - capable of reflecting from smaller structures
    - Readily absorbed by tissue = less penetration
    - Higher frequency = higher resolution
    - E.G. Muscles, tendons 7-18 mHz

Basic Components of Ultrasound Machines

- Pulser - applies high amplitude voltage to energize crystals
- Transducer – Converts electrical energy to mechanical (ultrasound) energy and vice versa
  - Two types of transducers
    - Linear - sound wave is propagated in a linear fashion parallel to the transducer surface
      - Ideal for MSK US
    - Curvilinear – increases field of view.
      - Ideal for visualization of deeper structures
- Receiver – detects and amplifies signals

Ultrasound Probe (Transducer)

- Which probe to pick?
  - Surface area of skin/transducer
  - Frequency of emitted sound wave



Ultrasound Probe

- Which probe to pick?
  - Surface area of skin/transducer
  - Frequency of emitted sound wave

Curvilinear Probe

- Large foot print
- Low Frequency = Increased Depth
- Abdominal US



Phased Array Probe

- Smaller foot print
  - (fits between the ribs)
- Low frequency
- Echo or abdominal US



Linear Probe

- Flat foot print
- High frequency
  - Maximum depth 10-13 cm
- Musculoskeletal or vessel US



Hockey Stick Probe



Modes of Ultrasonography

- B-mode (2D mode) – linear array of transducers simultaneously scan a plane through the body
  - Two-dimensional cross-section of tissue
- Doppler mode – Measuring and visualizing blood flow
- Duplex – simultaneous presentation of 2D and doppler information

Terminology

- Acoustical impedance – Sound wave encounters material with different density, and wave is reflected back as an echo
  - Gas or solids – Most of the acoustic energy is reflected -→ impossible to see deeper

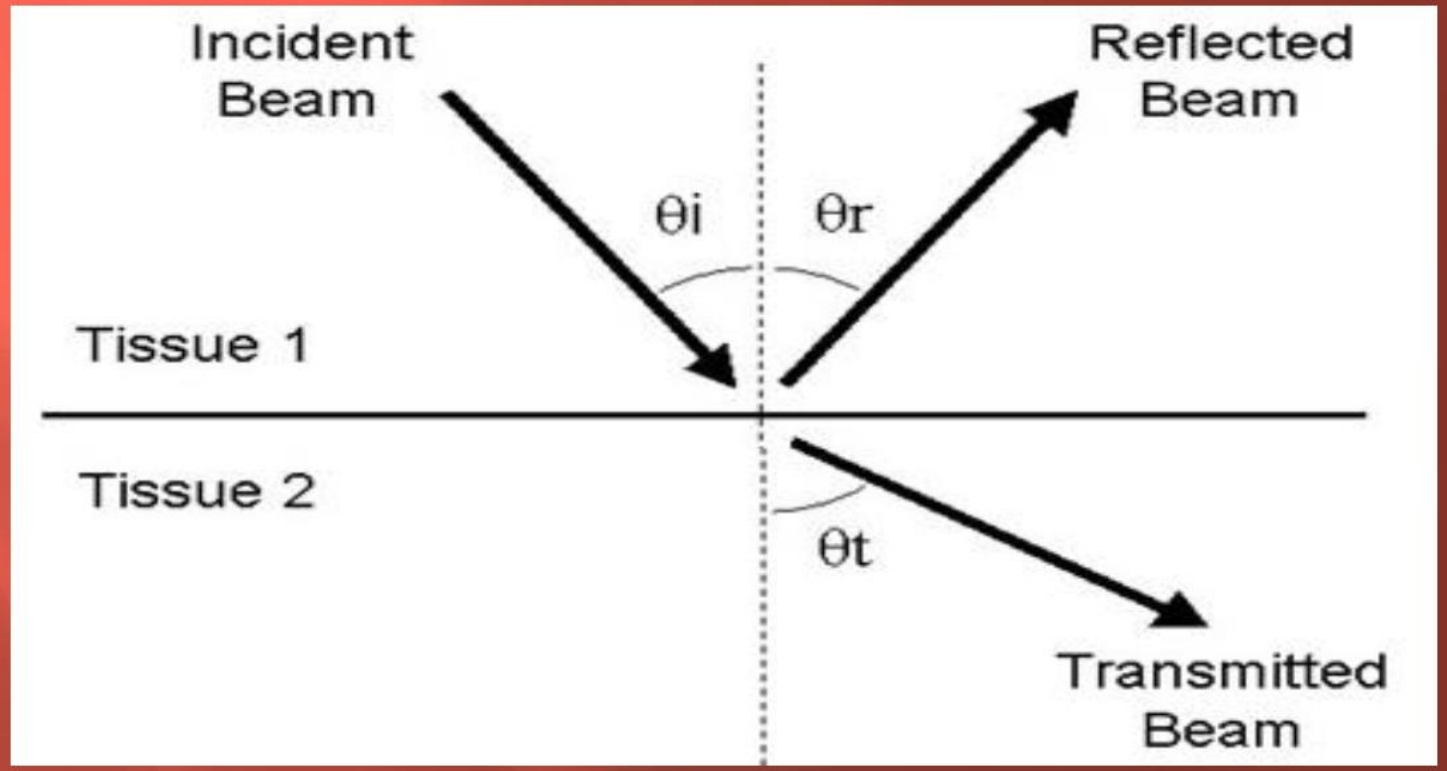
Terminology

- Reflection – some of sound energy strikes a boundary between media and is returned to the transducer
  - > degree of impedance mismatch at tissue interface = >amount of reflection
- Refraction - change in direction of wave propagation when traveling from one medium to another

Terminology

- Angle of incidence
  - US wave hitting a smooth interface at 90 angle will result in a perpendicular reflection
    - Strong, bright signal
  - US wave hitting the surface at an angle < 90 will result in the wave being deflected away from the transducer an an angle equal to the angle of incidence but in the opposite direction (angle of reflection)
    - Weak, darker image

Terminology



Terminology

- Echogenicity – a method of describing the reflecting echos
  - Hypoechoic – Darker (less reflection)
  - Hyperechoic – Brighter (more reflection)
  - Anechoic – Black (No echos)
  - Isoechoic – Equal

Terminology

- Attenuation: A decrease in intensity, power and amplitude as a sound wave travels
- Gain: Adjusting the intensity of the acoustic pulse, with the result being a stronger echo

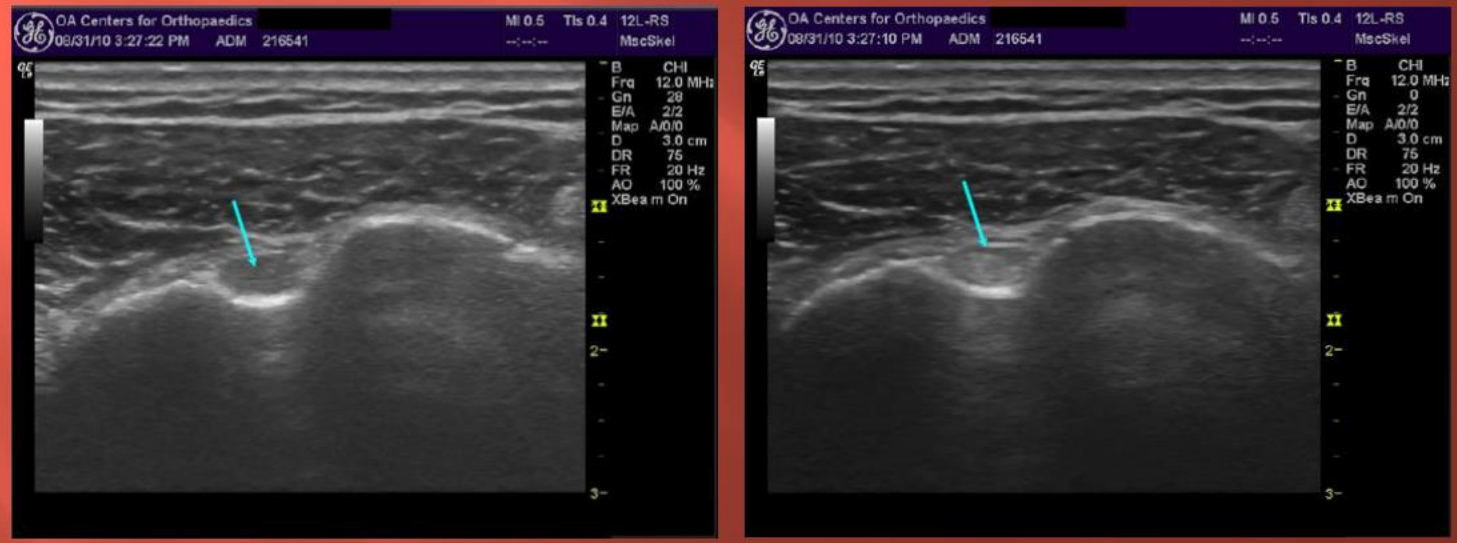
Terminology

- Near field – Top of screen
- Far field – Bottom of screen

Terminology

- Anisotropy
  - Tissue NOT imaged perpendicular to the sound beam
  - Appears artifactually hypoechoic
  - Can be confused with pathology

Aniostropy


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MscSkel
B CHI
Frq 12.0 MHz
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Tissue Appearances

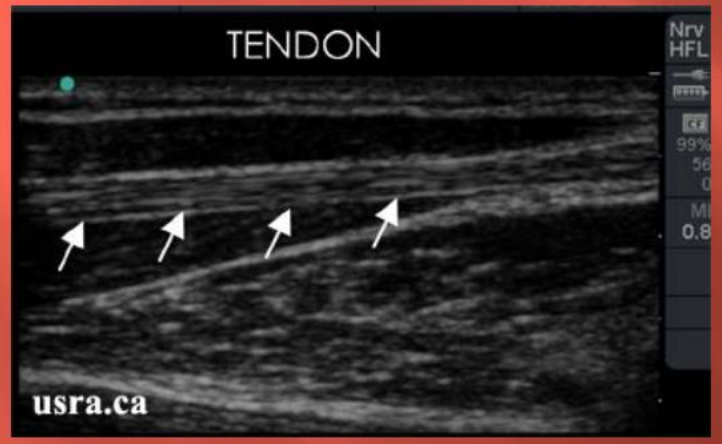
TISSUE	US IMAGE
Veins	Anechoic, compressible
Arteries	Anechoic, pulsatile
Fat	Hyopechoic with irregular hyperechoic lines
Muscle	Hypoechoic, but separated with hyperechoic septa
Tendon	Hyerechoic & fiber-like
Ligaments	Like tendons, but more compact
Bone	Hyperechoic lines with a hypoechoic shadow
Nerves	Starry night appearance: transverse

Tissue Appearances



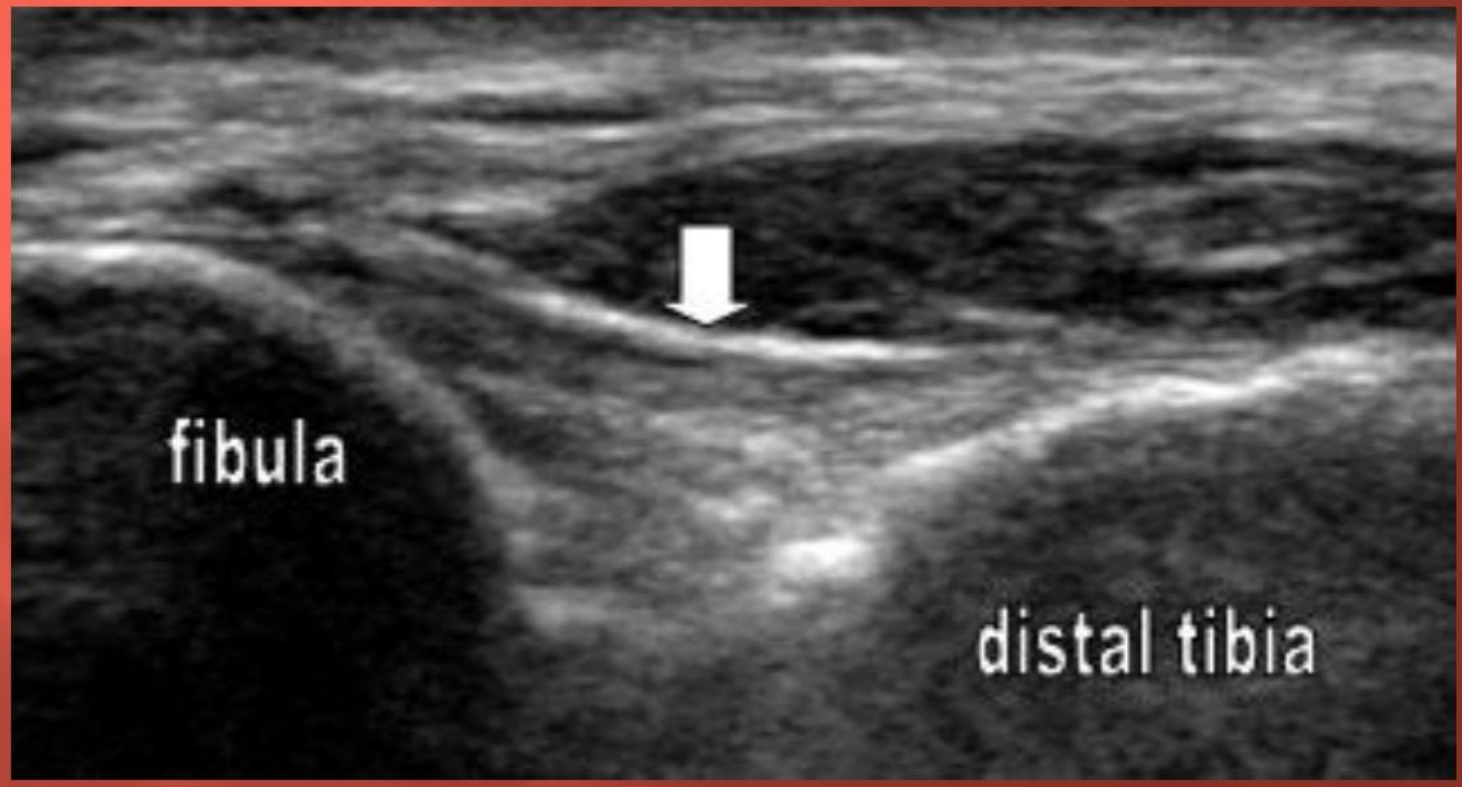


Tissue Appearances

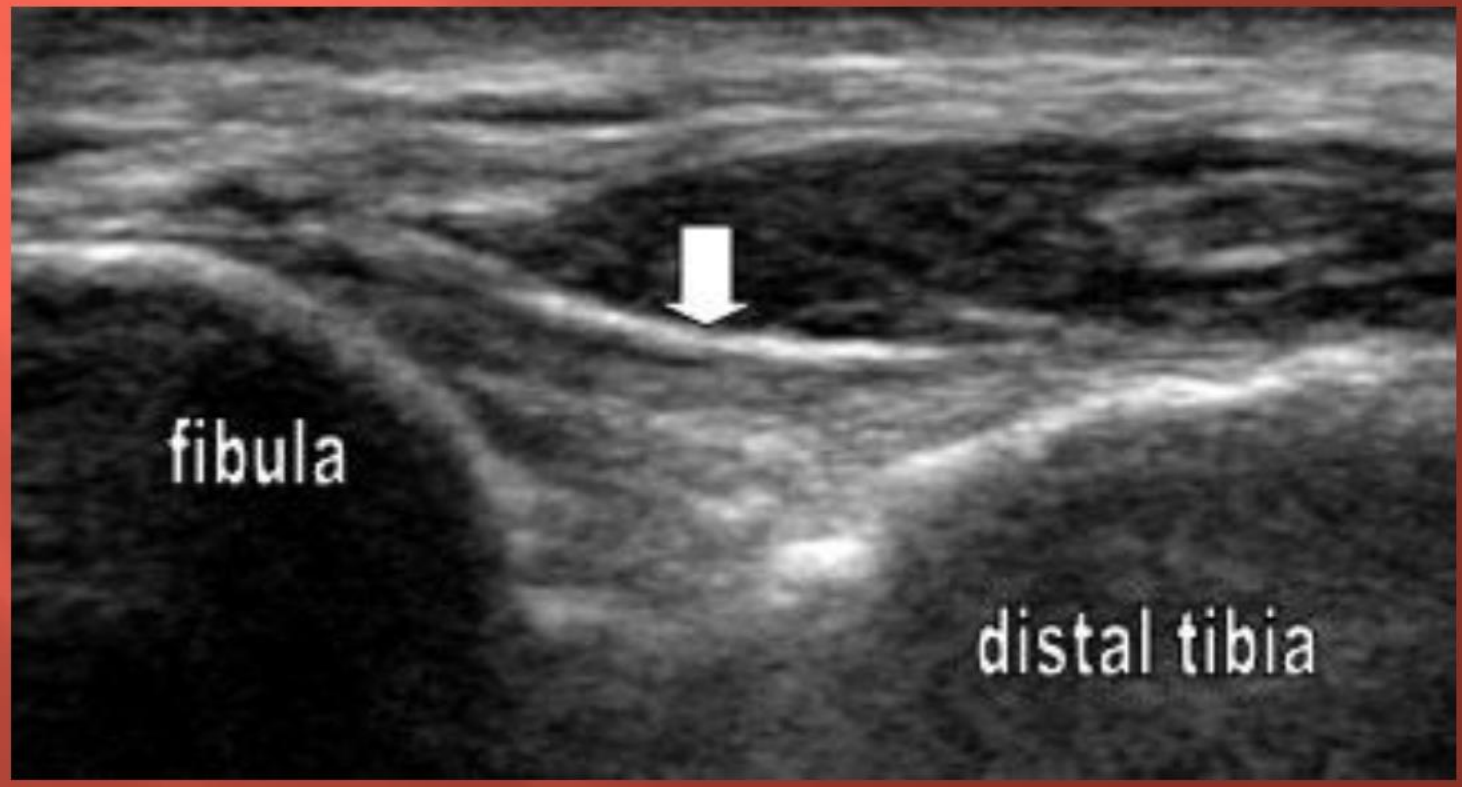




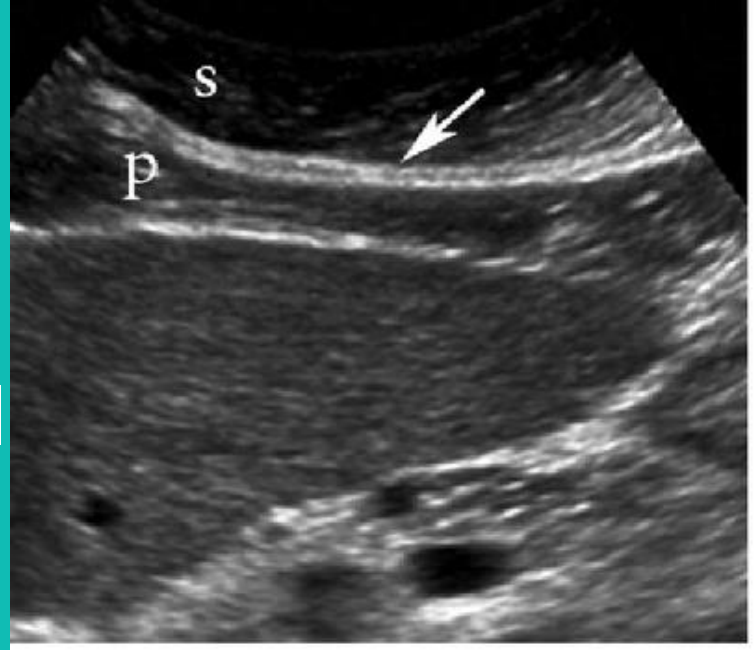
Tissue Appearances



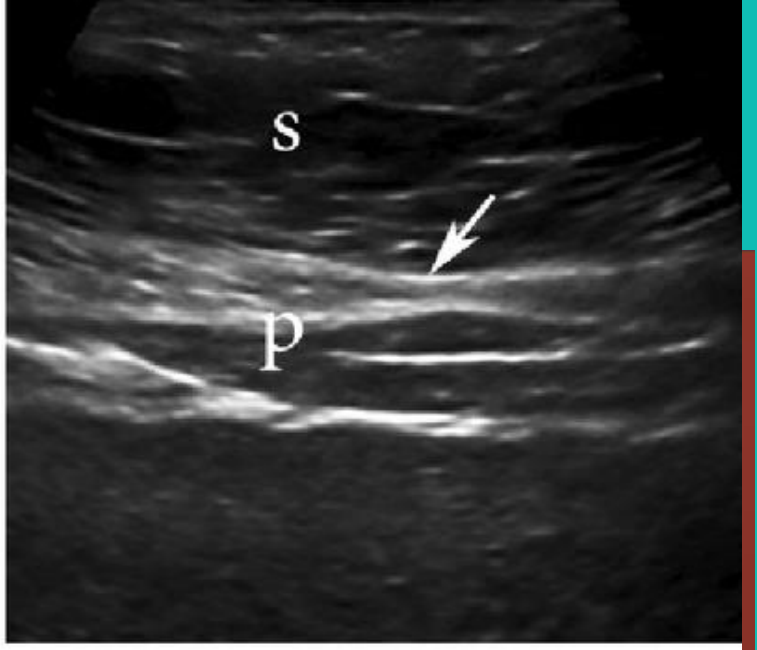
Tissue Appearances



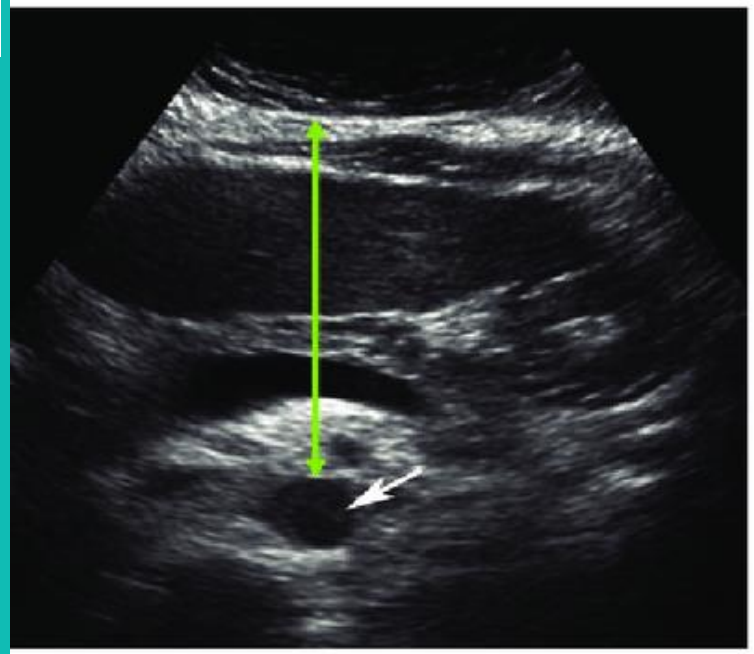
In ultrasound imaging, normal fat typically appears as hyperechoic structures with well-defined borders and acoustic shadowing. Artifacts, however, manifest as irregular, non-anatomic echoes that may vary with transducer position and are not associated with anatomical structures.



(a)



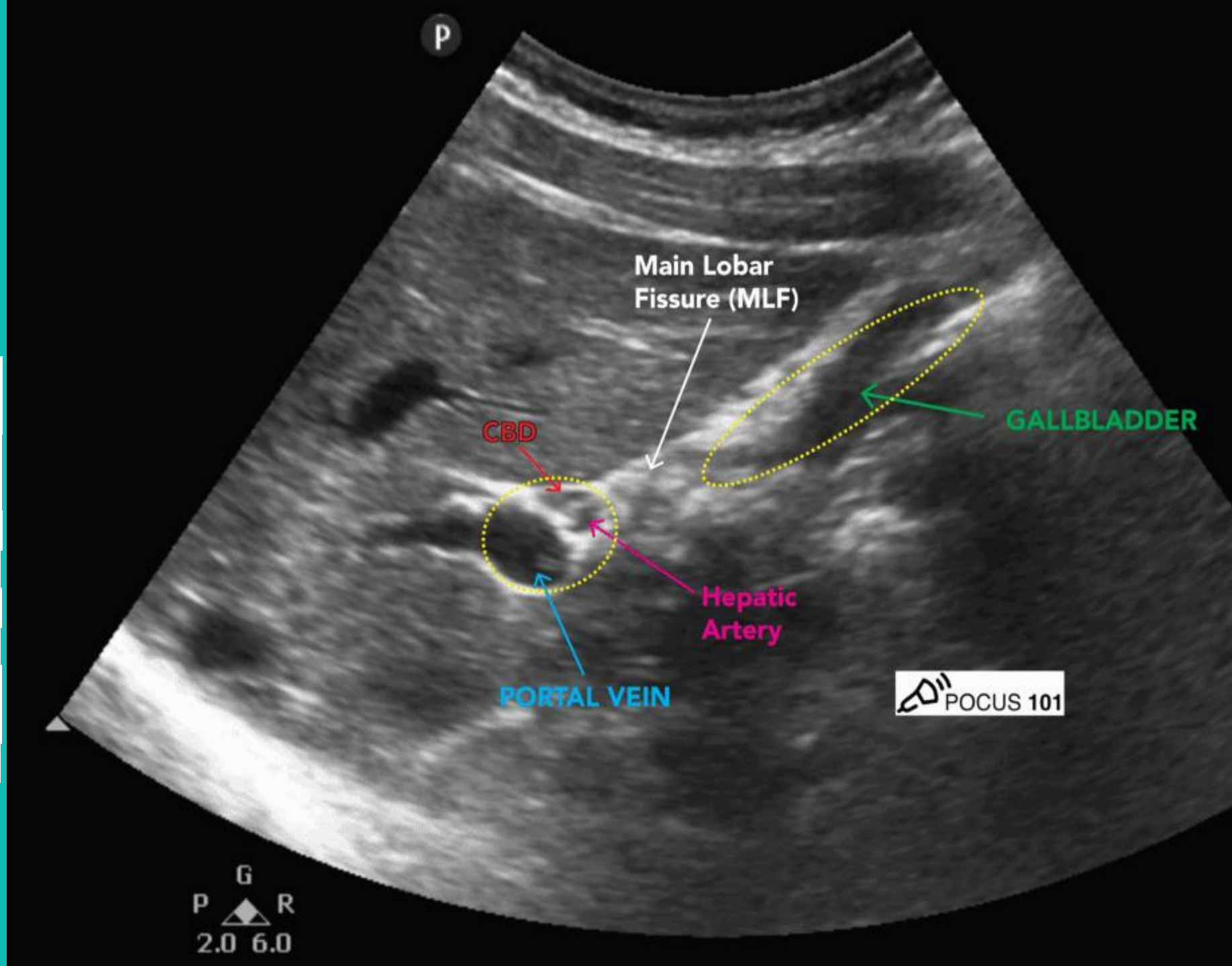
(b)



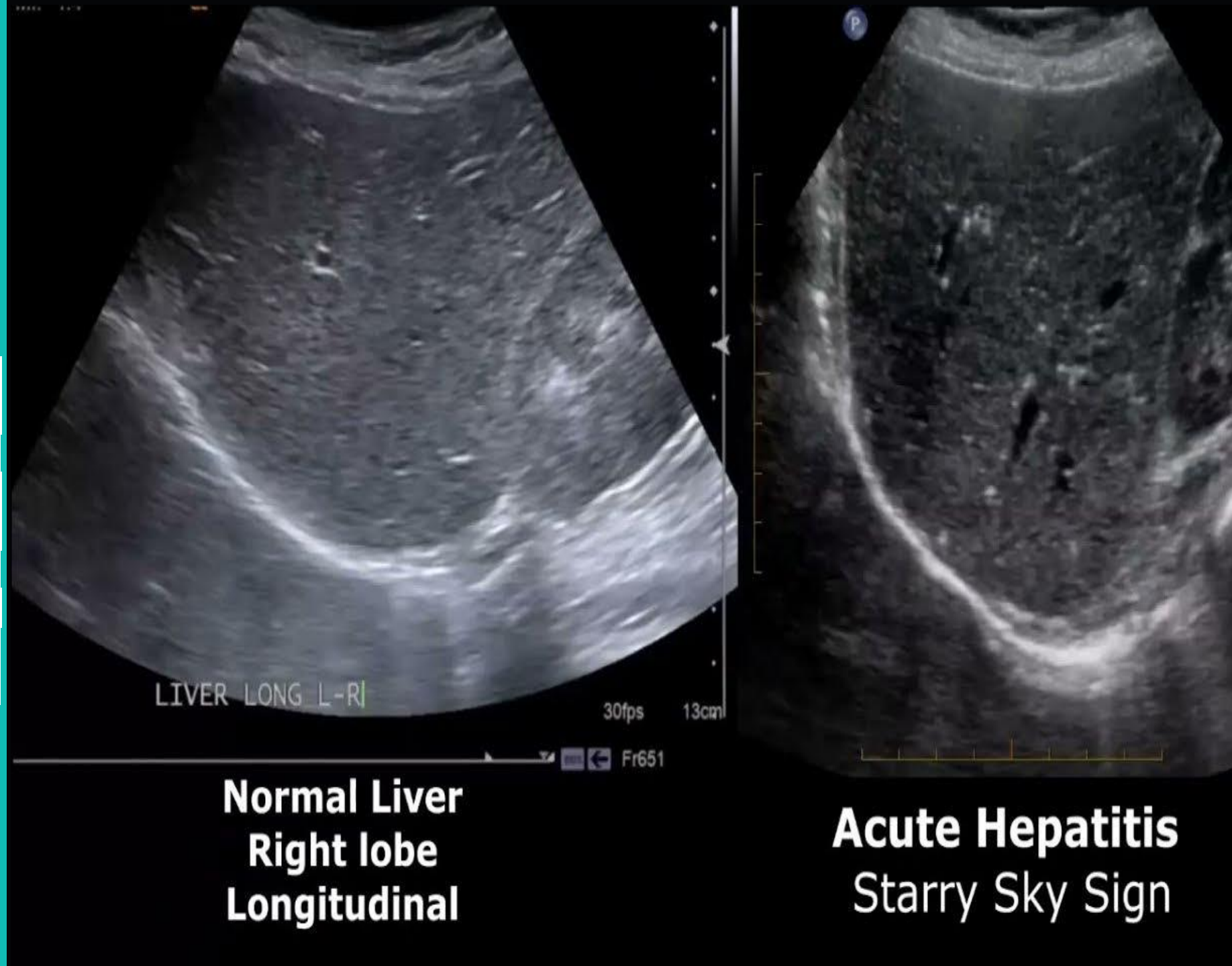
(c)

s/c Fat

In medical ultrasound imaging, the portal vein typically appears as a tubular structure with pulsatile flow, while the hepatic artery appears smaller and may exhibit a pulsatile waveform. Bile ducts, on the other hand, are non-pulsatile tubular structures often observed adjacent to the portal vein, with echogenic walls and may demonstrate a "double-duct" sign when dilated.

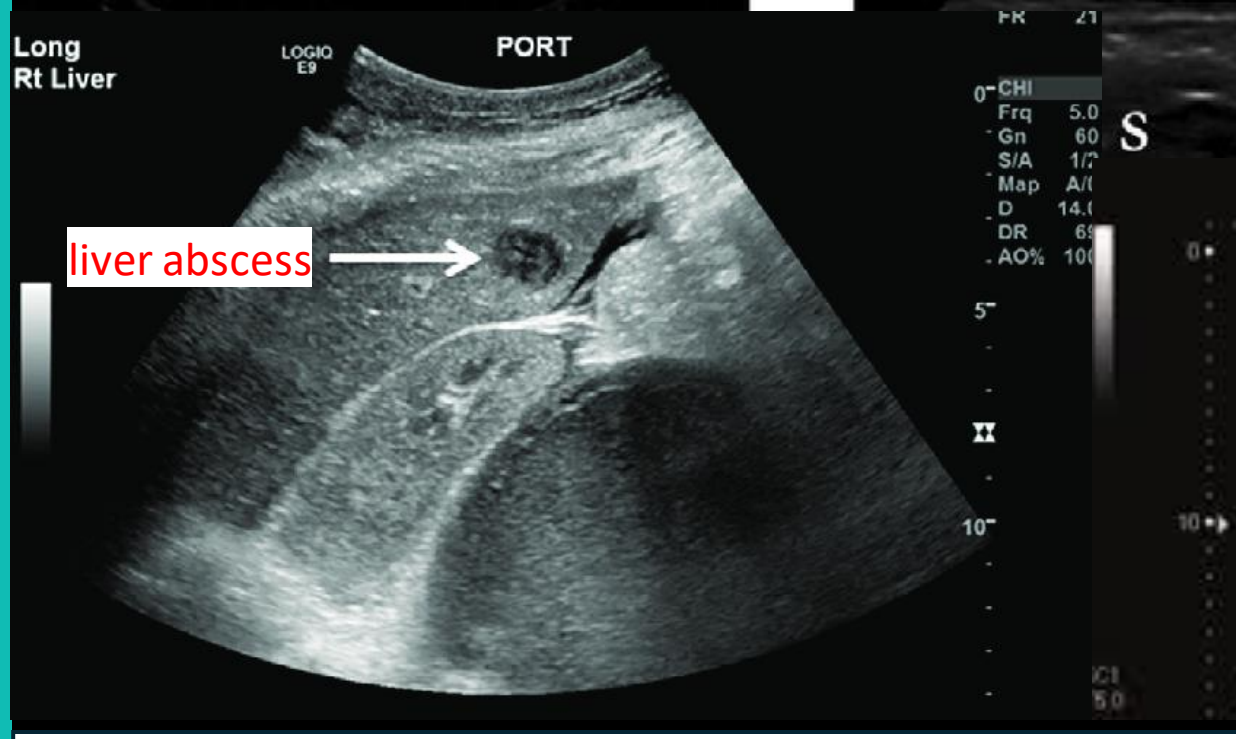


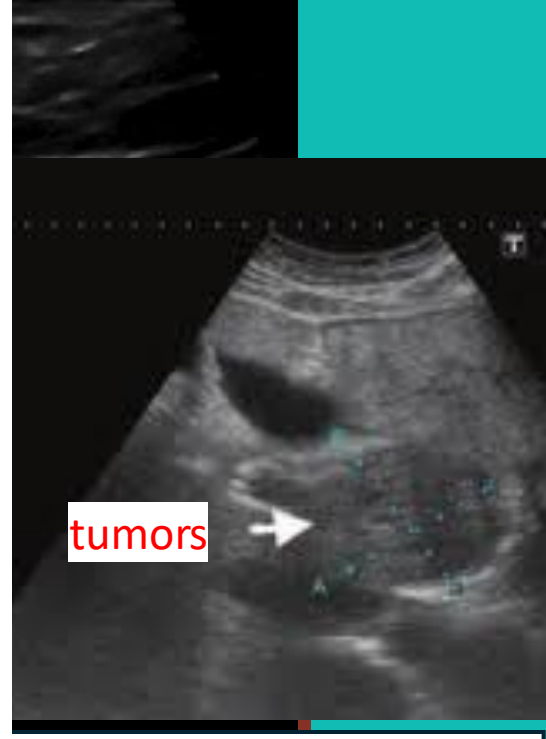
In ultrasound images, a normal liver typically appears homogeneous with smooth contours and echogenicity similar to the renal cortex. In hepatitis, the liver may show heterogeneous echotexture, irregular contours, and possibly increased echogenicity due to inflammation and fatty infiltration.



In ultrasound imaging, a normal liver appears echogenic with a fine texture and sharp borders, while a fatty liver may exhibit increased echogenicity with decreased visualization of vascular structures and diaphragmatic margins. Additionally, a fatty liver may show hepatomegaly and a bright liver appearance, especially in severe cases, due to fat accumulation..





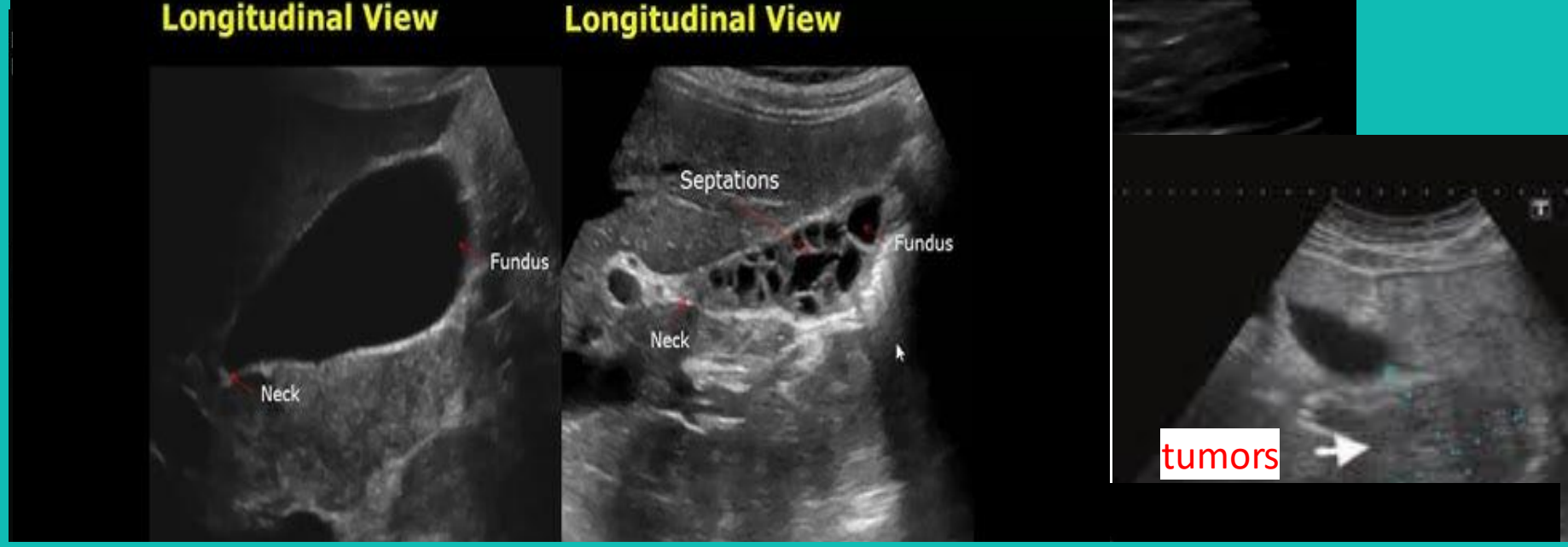


In ultrasound images, a liver abscess typically appears as a hypoechoic lesion with irregular borders and internal echoes indicative of pus or fluid

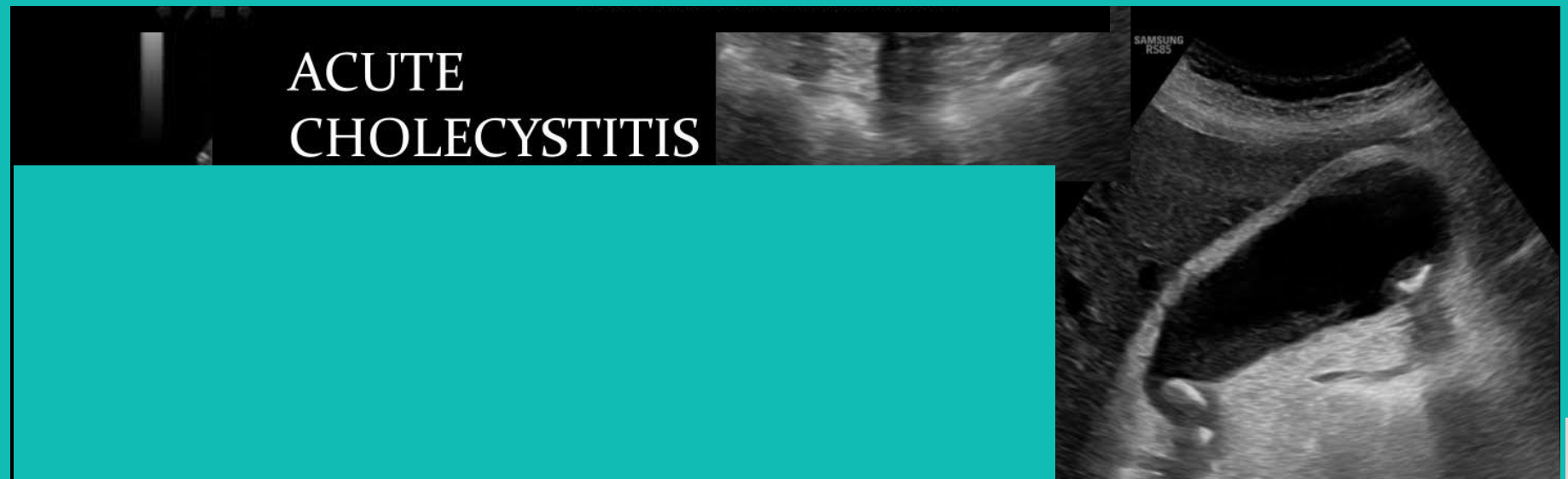
Cysts present as well-defined, anechoic structures with posterior acoustic enhancement,

while tumors may demonstrate various echogenic patterns, irregular borders, and possibly vascularization on Doppler imaging.





In ultrasound images, a normal gallbladder appears as a pear-shaped, anechoic structure with thin, smooth walls and no signs of inflammation. Inflamed gallbladder, however, may show thickened, irregular walls, pericholecystic fluid, and the presence of gallstones, along with tenderness on palpation.



In ultrasound images, gallbladder stones typically appear as hyperechoic structures with acoustic shadowing, whereas sludge presents as non-dependent, low-level echoes with layering and lack of shadowing.

Additionally, sludge may demonstrate dynamic changes in position with patient repositioning, while stones remain fixed within the gallbladder lumen.

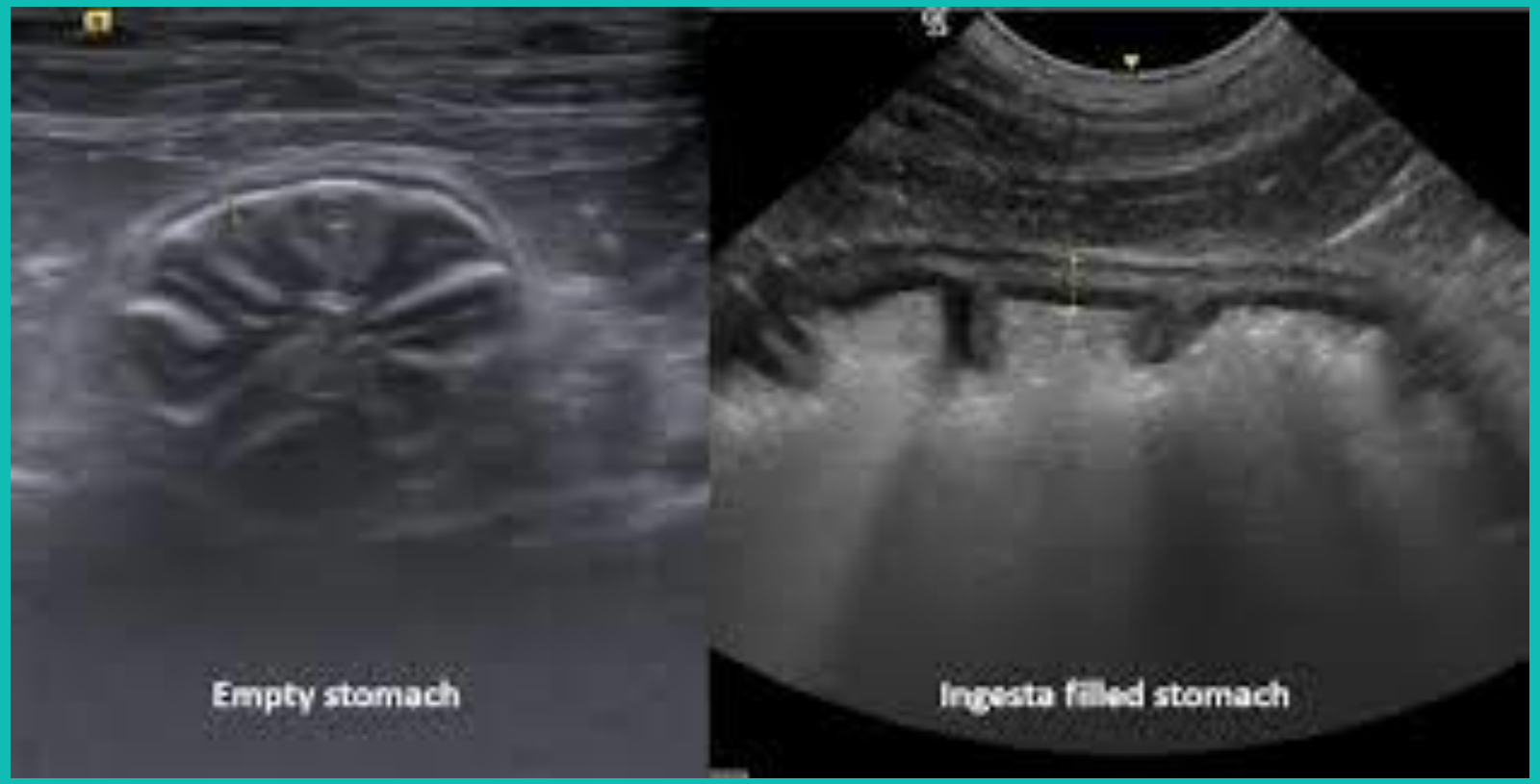




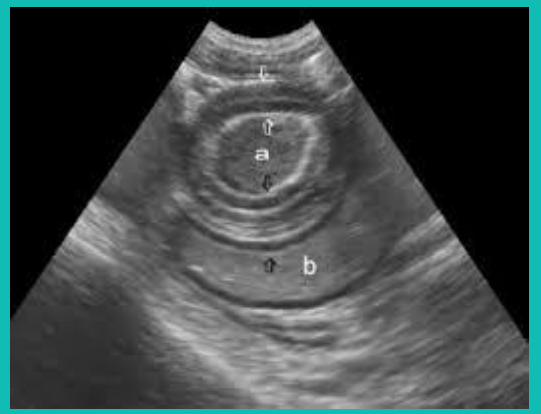
In ultrasound images, the stomach typically appears as a distensible, fluid-filled structure with gastric contents and peristaltic movement.

Intestines exhibit peristalsis, thin walls, and multiple loops in various orientations.

Intussusception, however, presents as a target or doughnut-shaped mass with alternating layers of hypoechoic and echogenic rings, often associated with the telescoping of bowel loops.



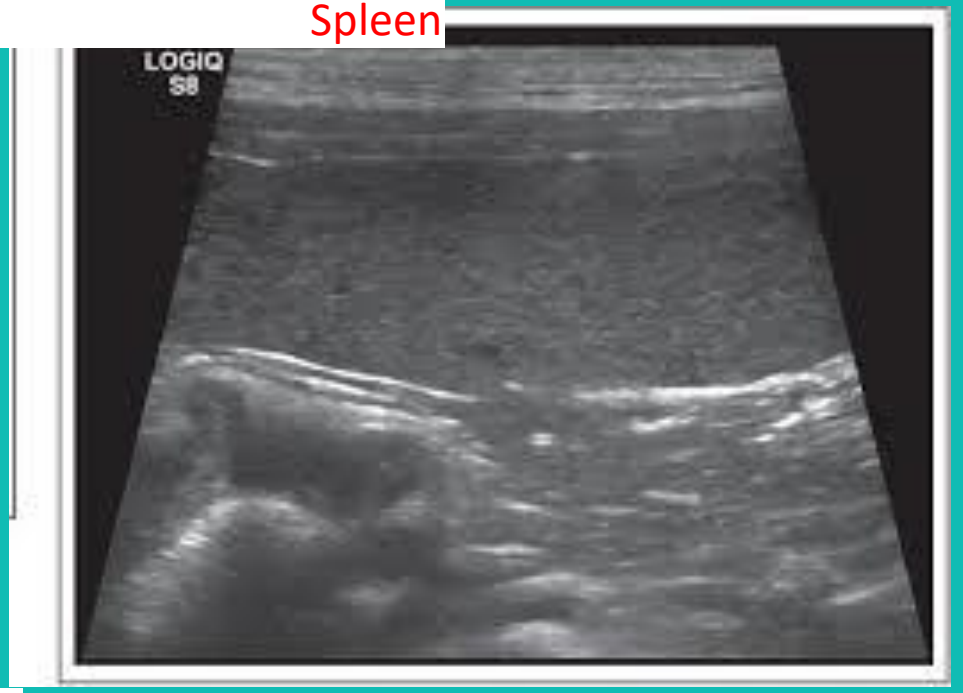




Liver



Spleen



In ultrasound imaging, the liver appears as a homogeneous, echogenic structure with a smooth capsule and a more posterior location compared to the spleen.



The spleen typically appears smaller than the liver, with a finely granular texture, and may demonstrate splenic artery and vein entering and exiting its hilum, aiding in its differentiation from the liver.



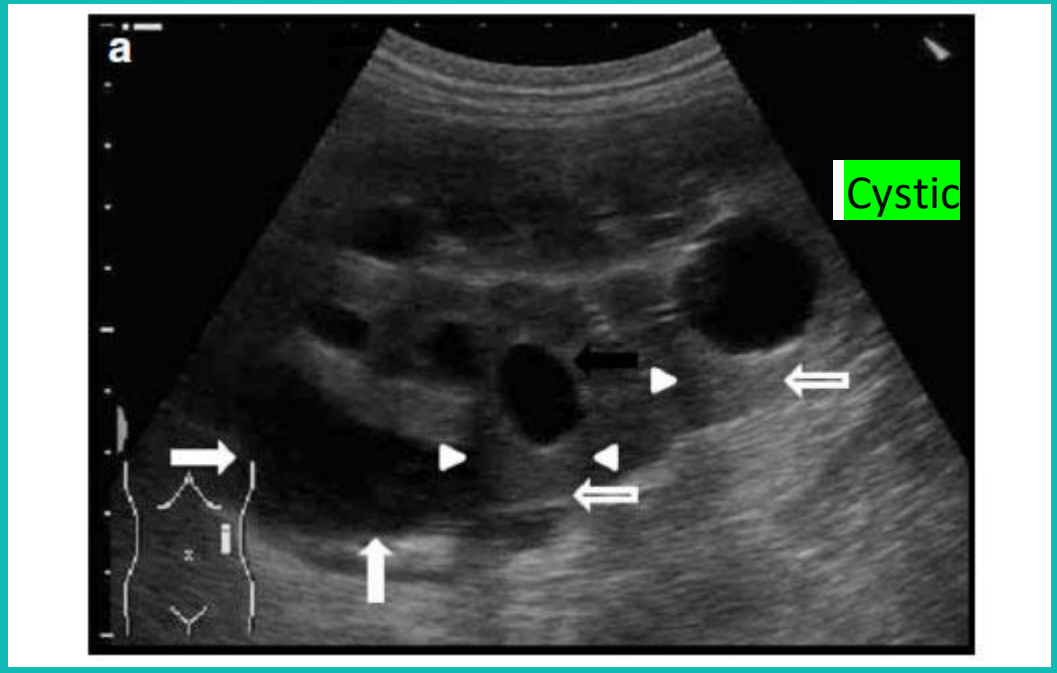
FIGURE 1. LONGITUDINAL SECTION OF A KIDNEY OBTAINED USING ULTRASONOGRAPHY/ SECCIÓN LONGITUDINAL DE UN RIÑÓN OBTENIDA MEDIANTE ULTRASONOGRAFÍA.



In ultrasound images, a normal kidney appears as a smooth, oval structure with a distinct corticomedullary differentiation and a hypoechoic renal sinus.

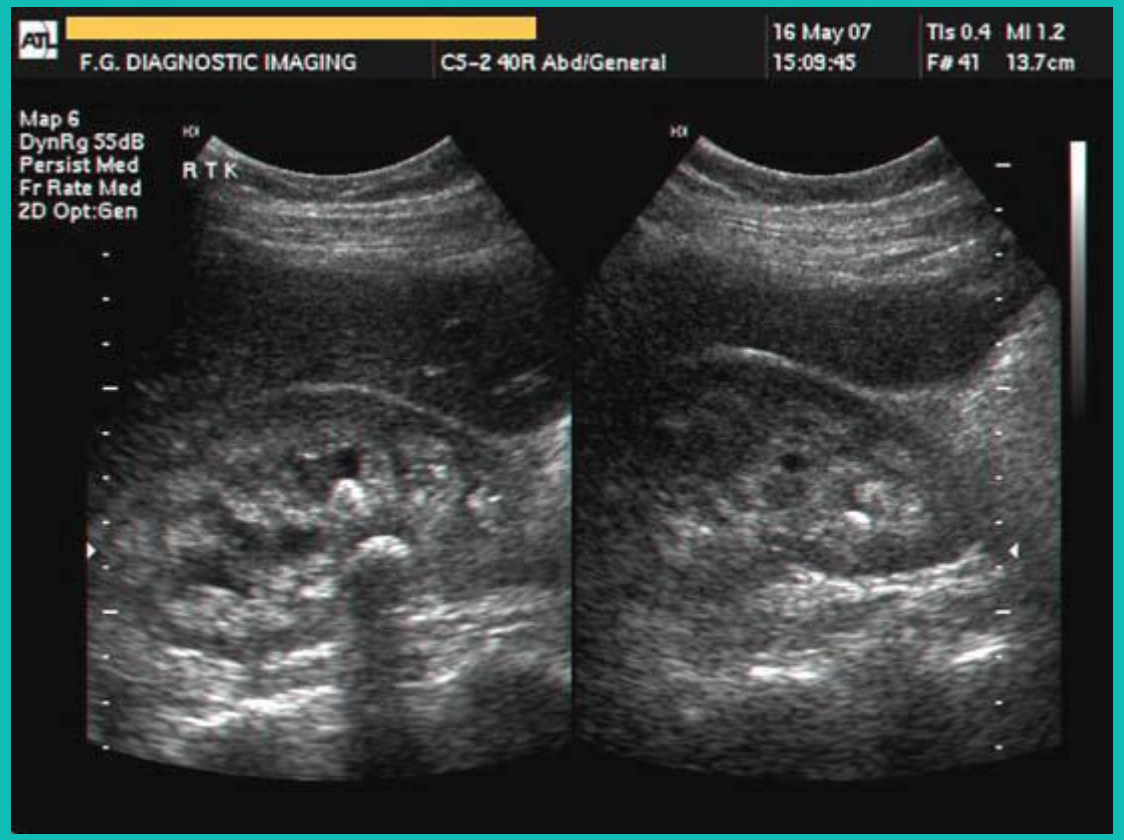
Chronic kidney disease (CKD) may manifest as small, echogenic kidneys with loss of corticomedullary differentiation and irregular contours due to scarring.

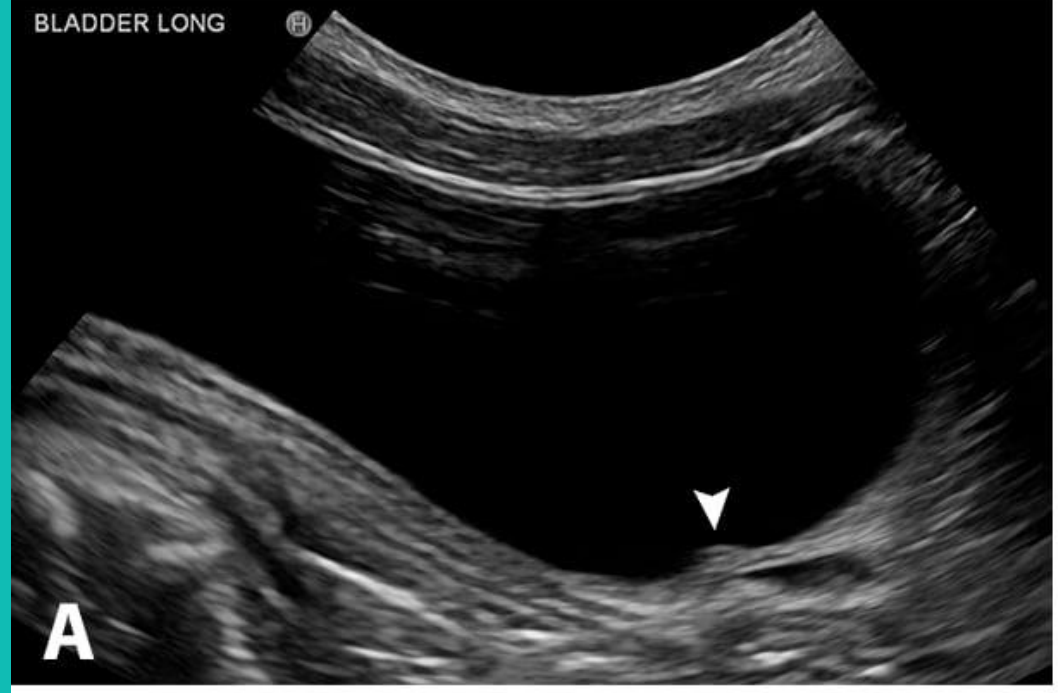
Cystic kidneys present with multiple anechoic or hypoechoic round structures throughout the renal parenchyma, representing cysts, often accompanied by cortical thinning and loss of normal renal architecture.

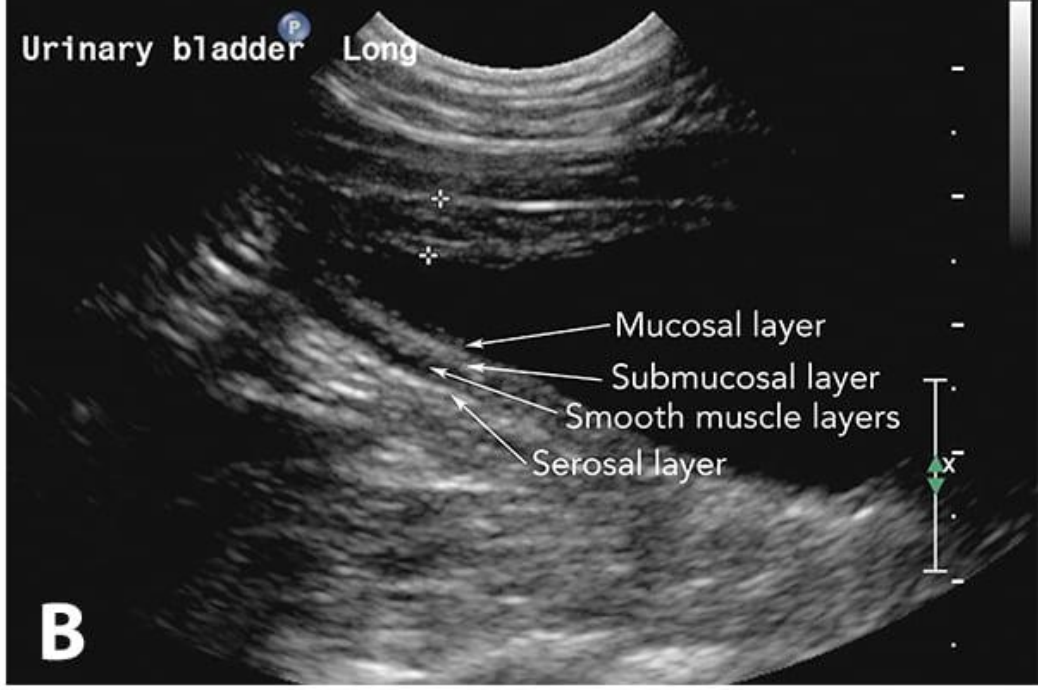


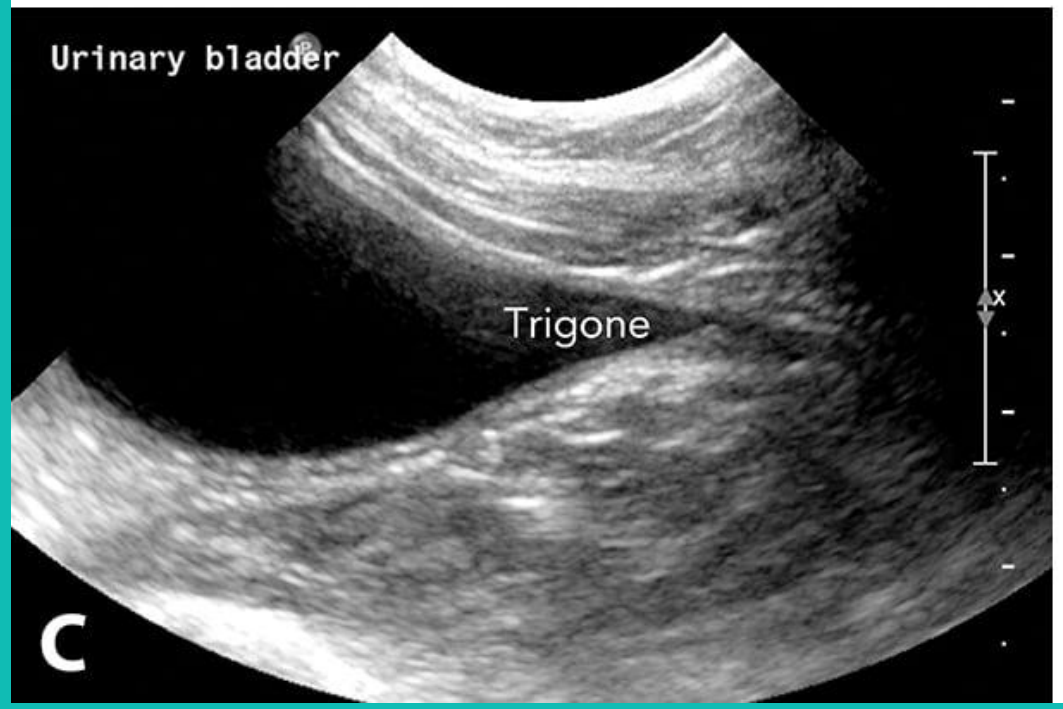
In ultrasound images, nephroliths typically appear as hyperechoic structures with posterior acoustic shadowing, located within the renal pelvis or calyces.
They may vary in size and shape, presenting as well-defined, mobile structures within the renal collecting system.

Color Doppler imaging can help differentiate nephroliths from other renal masses by demonstrating absent or minimal vascularity within the stone.





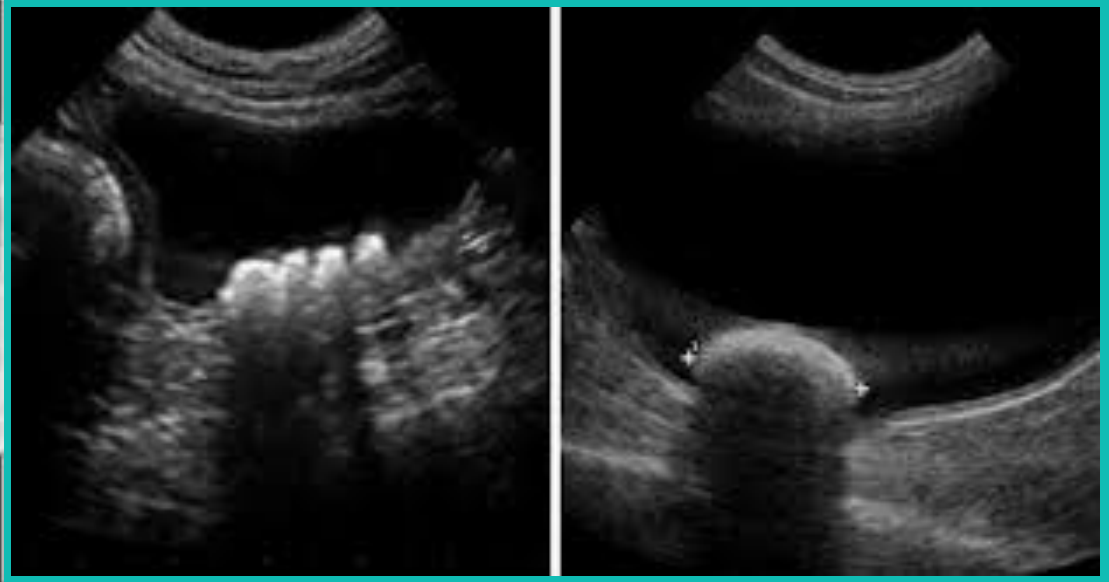




In ultrasound images of a normal urinary bladder in dogs, it appears as a smooth-walled, pear-shaped structure located in the pelvic cavity. The bladder wall is typically thin and uniform in thickness, with an anechoic lumen filled with urine. Additionally, the bladder may change in shape and size depending on its level of distention and the amount of urine it contains.

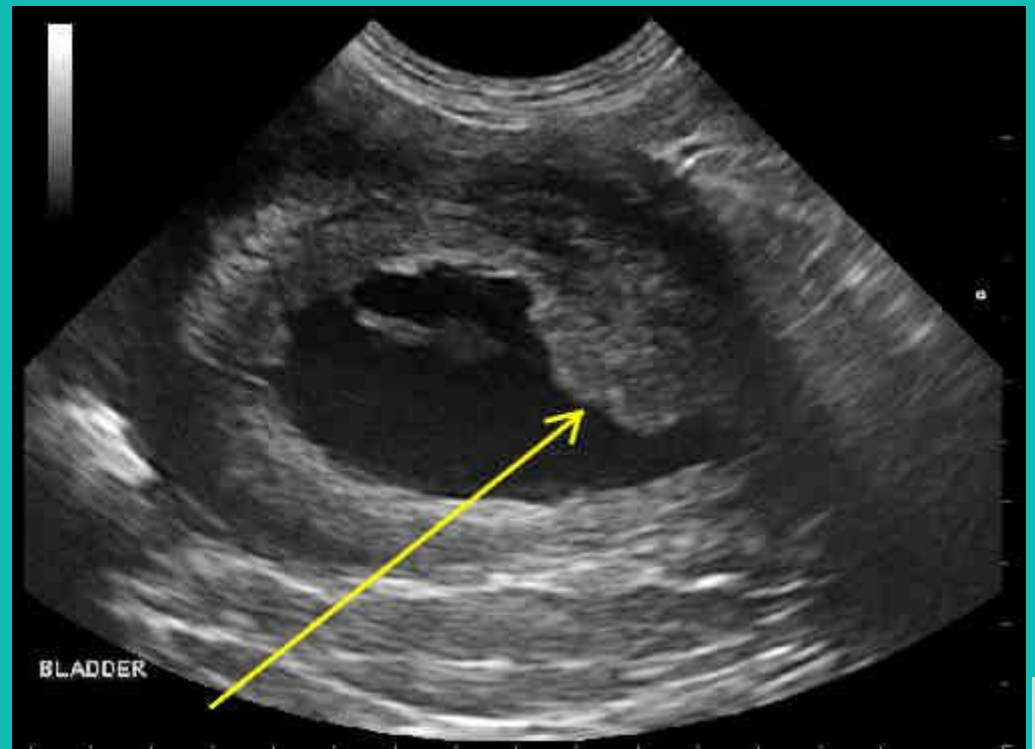
In ultrasound images, uroliths in dogs' bladders typically appear as echogenic structures with variable shadowing within the bladder lumen.

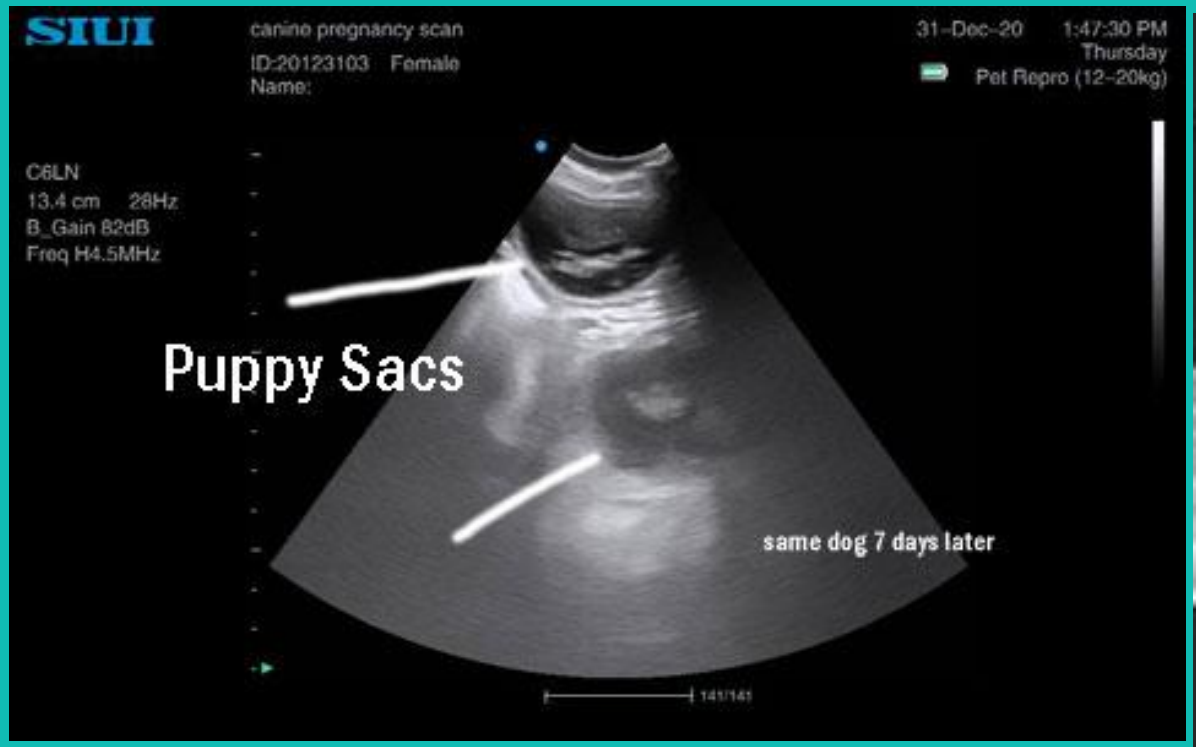




Cystitis presents as bladder wall thickening, increased echogenicity, and possibly irregularity of the bladder mucosa, often accompanied by hyperechoic debris within the urine. Bladder cancer may manifest as focal or diffuse thickening of the bladder wall, irregular margins, and invasion into surrounding tissues, with possible evidence of mass effect or vascularization on









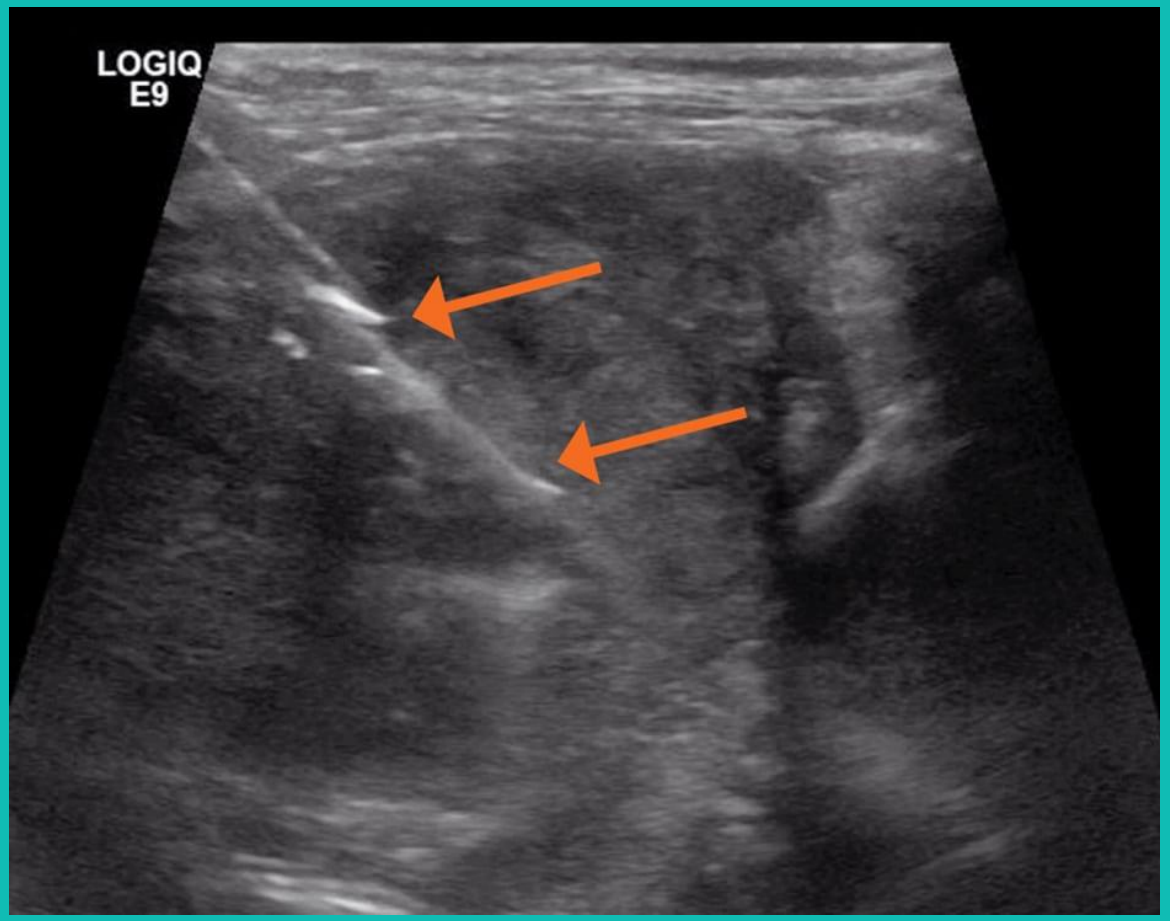
In ultrasound images, at around 30 days of pregnancy in dogs, fetal sacs or gestational sacs may be visualized as small, round structures with echogenic borders within the uterine horns.

By 50 days of gestation, the fetal sacs have developed into distinct, oval-shaped structures with visible fetal skeletons, including the spine and long bones. Additionally, at 50 days, fetal movement may be observed, and fetal heartbeats can often be detected using Doppler ultrasound, providing further confirmation of pregnancy advancement.

Ultrasound-guided fine-needle aspiration cytology (FNAC) in dogs involves first identifying the target lesion using ultrasound imaging, ensuring proper positioning for safe and effective sampling.

Once the lesion is identified, a fine-gauge needle is inserted through the skin and advanced into the lesion under real-time ultrasound guidance to avoid vital structures. The needle is then attached to a syringe, and multiple passes are made within the lesion to collect cellular material for cytological evaluation.

Careful attention is paid to needle placement and angle to ensure representative sampling and minimize the risk of complications such as hemorrhage or organ perforation.



After the procedure, the collected samples are smeared onto glass slides, stained, and evaluated microscopically by a veterinary pathologist to provide a diagnosis. Finally, post-procedural monitoring is essential to identify and manage any potential complications and to ensure the well-being of the patient.

Basic Scanning Technique

- Locate area of interest with ultrasound
- Adjust the depth of the sound beam
  - Structure of interest is visible and centered in the image
- Select desired optimization setting from on-screen menu
  - Res = best resolution possible
  - Gen = balance between resolution and penetration
  - Pen = best penetration possible

Basic Scanning Technique

- Adjust gain
  - Amplifies return echos (adjusts brightness of the image)
    - May use autogain
    - May adjust for near or far field

Basic Scanning Technique

- Image orientation
  - Index Mark
    - Orientates probe to your screen
    - Keep on left side of the screen
  - Proximal aspect of a structure on the left side of the image and the distal aspect on the right
  - Describing orientation
    - Two views
      - Transverse
        - Cross section
      - Longitudinal
        - Long axis

Scanning Technique

- Heel-toe when transducer is rocked or angled along the long axis of the transducer
- Toggle – transducer is angled from side to side

Practical Tips:

- Use highest frequency that allows US to image the depth of the structures of clinical interest
  - Image depth decreases as frequency of US increases
  - Move focal zone on screen to level at area of interest
- Youtube
  - Excellent source for Sonsosite product information and instruction on ultrasound

Ultrasound Curriculum

- Four parts
  - Introduction to US
  - OB US
  - MSK US
  - FAST (Focused Assessment with Sonography for Trauma)
    - Will include venous US
- gfresidency.com

References

- Arntfield, Robert, EML Ultrasound Rounds
- Dixon, J. Bryan "Basics of Musculoskeletal Ultrasound"
- Hecht, Suzanne "Musculoskeletal Ultrasound"
- Jacobson "Fundamentals of Musculoskeletal Ultrasound" Jacobson
- Primack, Scott J. "Musculoskeletal Ultrasound"
- SonoSite M-Turbo Product Training Part 3: How to Perform and Exam
- Wikipedia "Medical Ultrasonography"


Thank
You