

Ultrasound

“The Stethoscope of the Future”

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Goals

At the end of this presentations, you should be able to:

- Compare ultrasound to other imaging modalities in terms of advantages and disadvantages
- Understand the basics of how ultrasound images are created
- Appreciate some of the applications for ultrasound
- Interpret some common ultrasound images

Most medical fields have applications for ultrasound imaging

- Anesthesiology
- Cardiology
- Critical Care Medicine
- Dermatology
- Emergency medicine
- Endocrinology
- Family practice
- Gastroenterology
- Geriatrics
- Gynecology
- Internal Medicine
- Interventional Radiology
- Neonatology
- Nephrology
- Neurology

The future

- Portable units are getting smaller and more affordable for small practices. (\$12,000-\$30,000 for basic portable units vs. over \$100,000 for full sized machines)
- Units today are the size of a laptop computer and there is even one available that is the size of a PDA.



Benefits of Ultrasound

- One of the biggest benefits of ultrasound is its cost. It is much cheaper than a CT scan or MRI.
- Most types of ultrasonography do not require contrast less risk for the patient.
- There is no proven negative bioeffects of ultrasound when its dosing is at clinical imaging levels.
- No ionizing radiation, but it does have thermal and mechanical effects on living tissue.



More Benefits of Ultrasound

- Ultrasound is safe for all ages including before birth.
- There is no patient weight limit for ultrasound machines.
- Speeds up diagnostic process => improves patient care.
- There are some applications where ultrasound images are better at detecting disease than MRI or CT images.

Limitations of Ultrasound

- Ultrasound does not have the spatial resolution that can be seen in MRI and CT images.
- Image quality can be heavily influenced by the skill of the sonographer.
- Ultrasound works best on soft tissues or fluid filled mediums. It does not work well on mediums such as bone or gases (normal lungs are not imaged well with ultrasound because they are filled with air).



The Physics Behind Ultrasound Imaging

Ultrasound is a sound wave that has a frequency greater than 20,000 Hz.

Human hearing is between 20 Hz and 20,000 Hz

Sound Waves

- Sound waves require a medium to exist.
- Sound is a mechanical wave meaning that it physically interacts with the medium it travels through by causing vibrations in the molecules.
- Sound is also a longitudinal wave because the particles in the medium move in the same direction as the wave.
- Sound travels in a straight line.

Wave Characteristics

- There are 7 parameters of sound:
 - Period: time it takes for one wave cycle (seconds)
 - Frequency: numbers of cycles per unit time (Hertz)
 - Amplitude: magnitude of wave (decibels)
 - Power: strength of sound (watts)
 - Intensity: concentration of energy in the wave (watts/m²)
 - Propagation Speed: speed the wave travels through the medium (m/s)
 - Wavelength: distance that one cycle occupies (mm)
- These decrease as the wave travels through the body.

How Parameters Affect Imaging

- There is a trade off between depth of image and image quality. Deeper images are accomplished at the expense of higher image quality and resolution.
- A greater depth of view is seen with an increase in:

- Period

- Amplitude

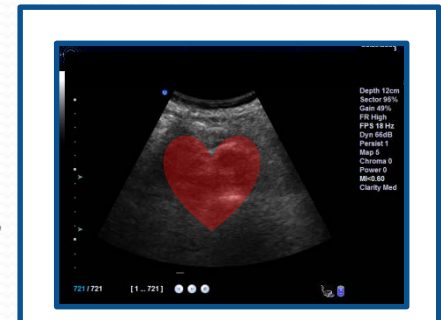
- Power

- Intensity

- Better

- Higher

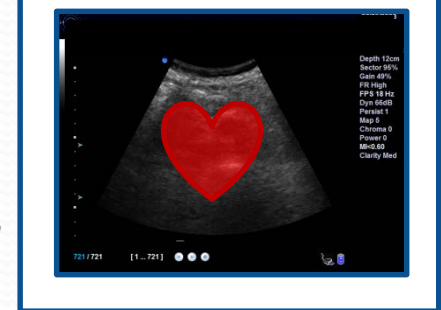
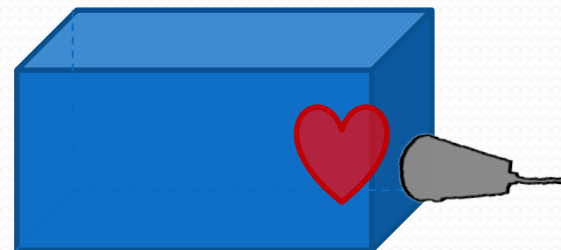
- Signal



seen with:

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Attenuation

- Attenuation is the weakening of the ultrasound wave as it travels through the medium.
 - Attenuation is increased for higher frequencies and for further distances in the medium for the wave to travel.
 - Lower frequencies must be used to measure greater depths because of attenuation.
 - Attenuation is caused by absorption, reflection, and scattering.
 - Bone is a great absorber and the lungs are great scatterers therefore ultrasound does not work as well.

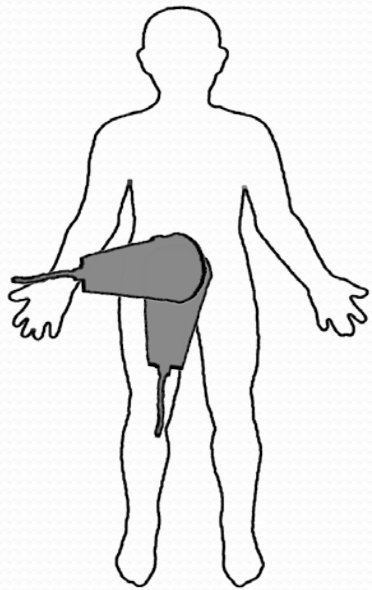
Pulsed Ultrasound

- Continuous waves cannot create an image, so short pulses of ultrasound are sent from and received by the transducer.
- Only one pulse of ultrasound is allowed to travel in the body at a time.
- Generally shorter, narrower pulses create higher quality images.
- Most of the time ultrasound systems are listening for reflected pulses and are only transmitting sound 0.1-1% of the time.

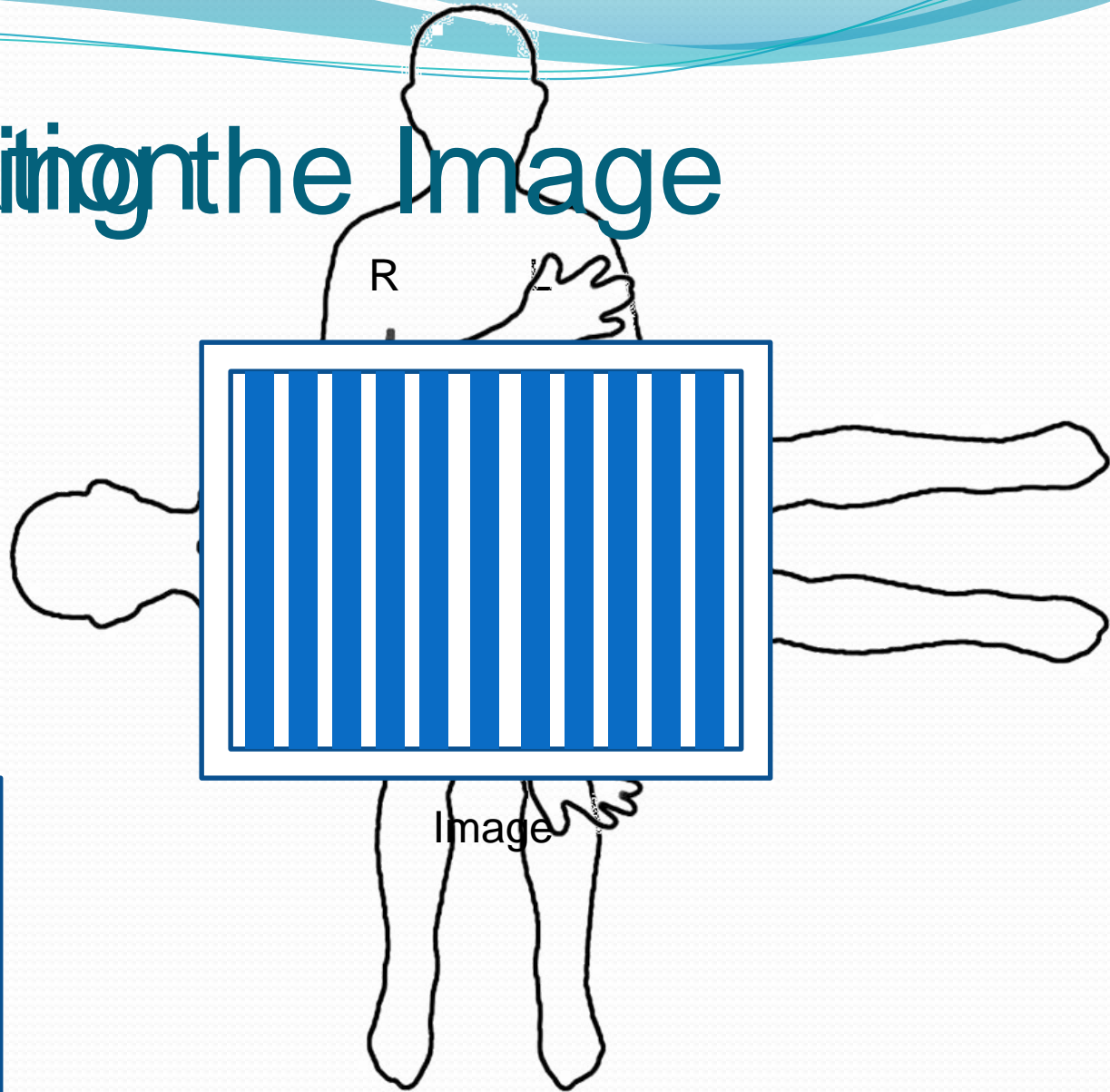
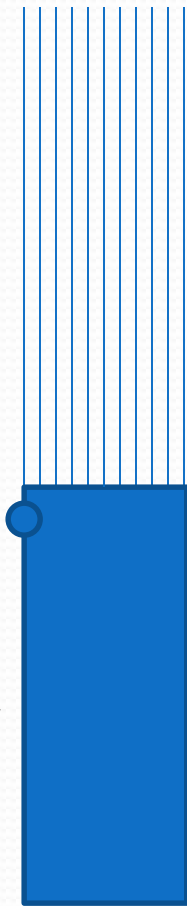
Echoes

- Echoes are what the transducer listens for and translates into electrical energy to create an image.
- Echoes are generated by impedance (acoustic resistance) differences in the medium. A medium that is very dense and/or has a fast propagation speed has a high impedance.
- The final image is created by combining the information from several different echoes, each generated from a unique pulse with different spatial origins.

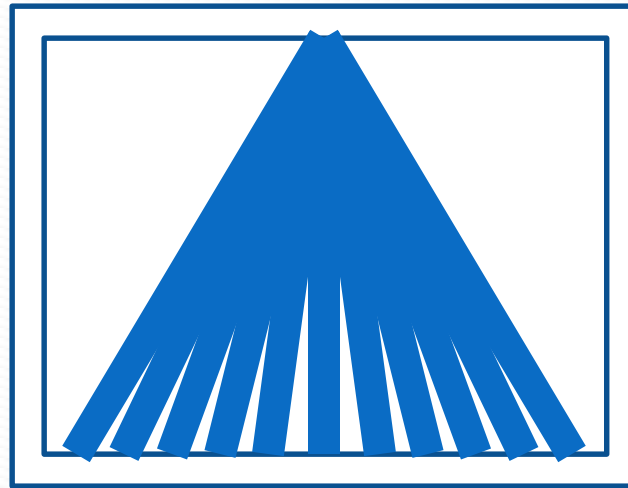
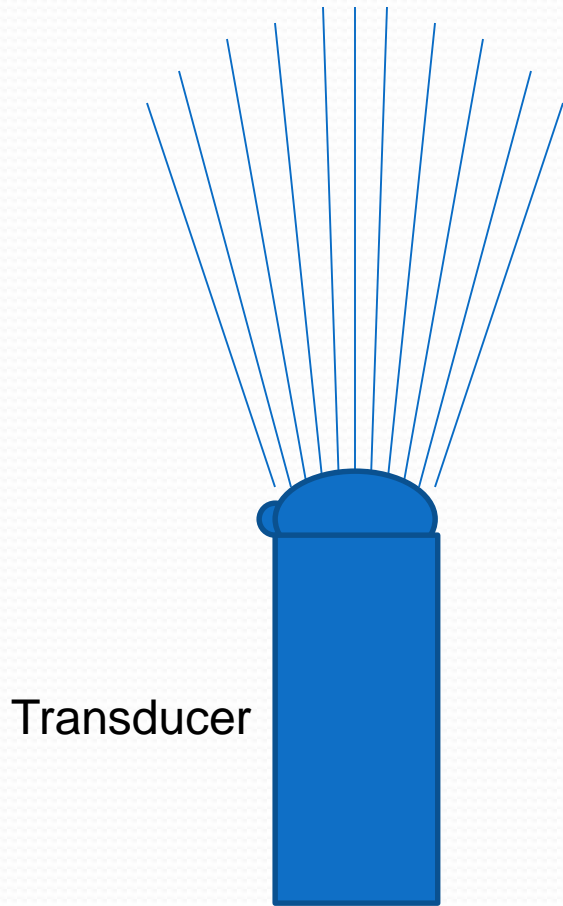
Orientation of the Image



Transducer



Transducers



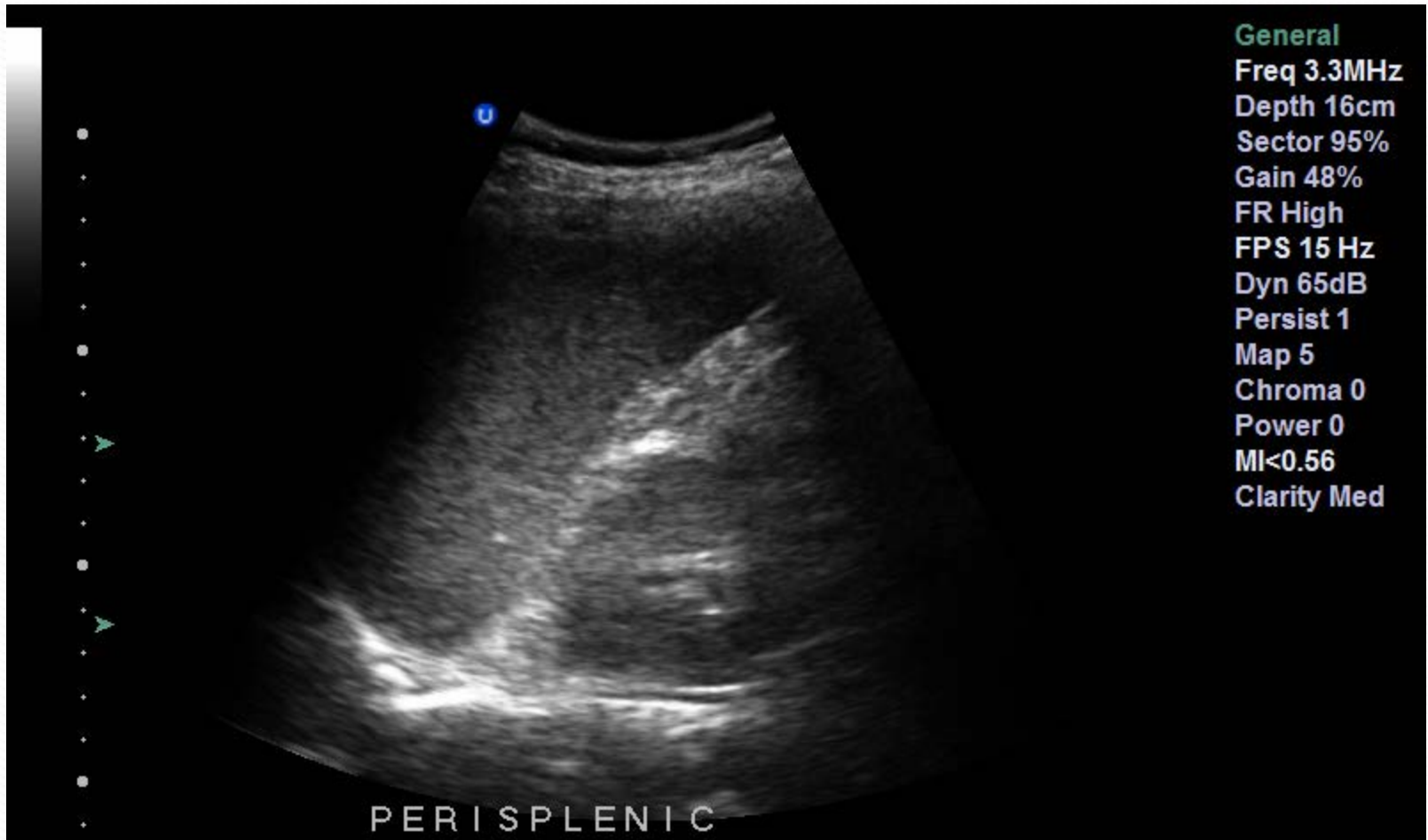
Image

Ultrasound Images

Normal Anatomy

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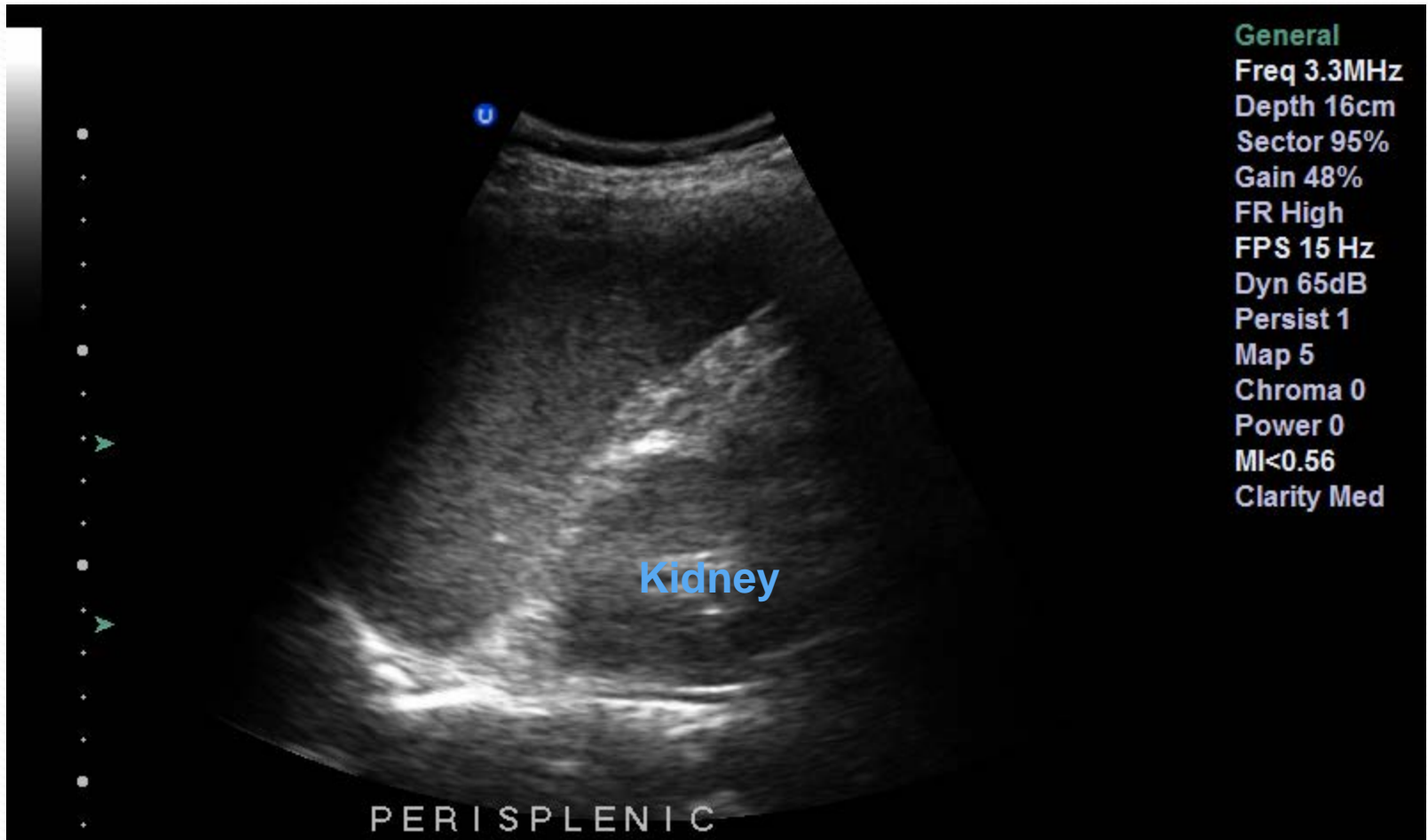
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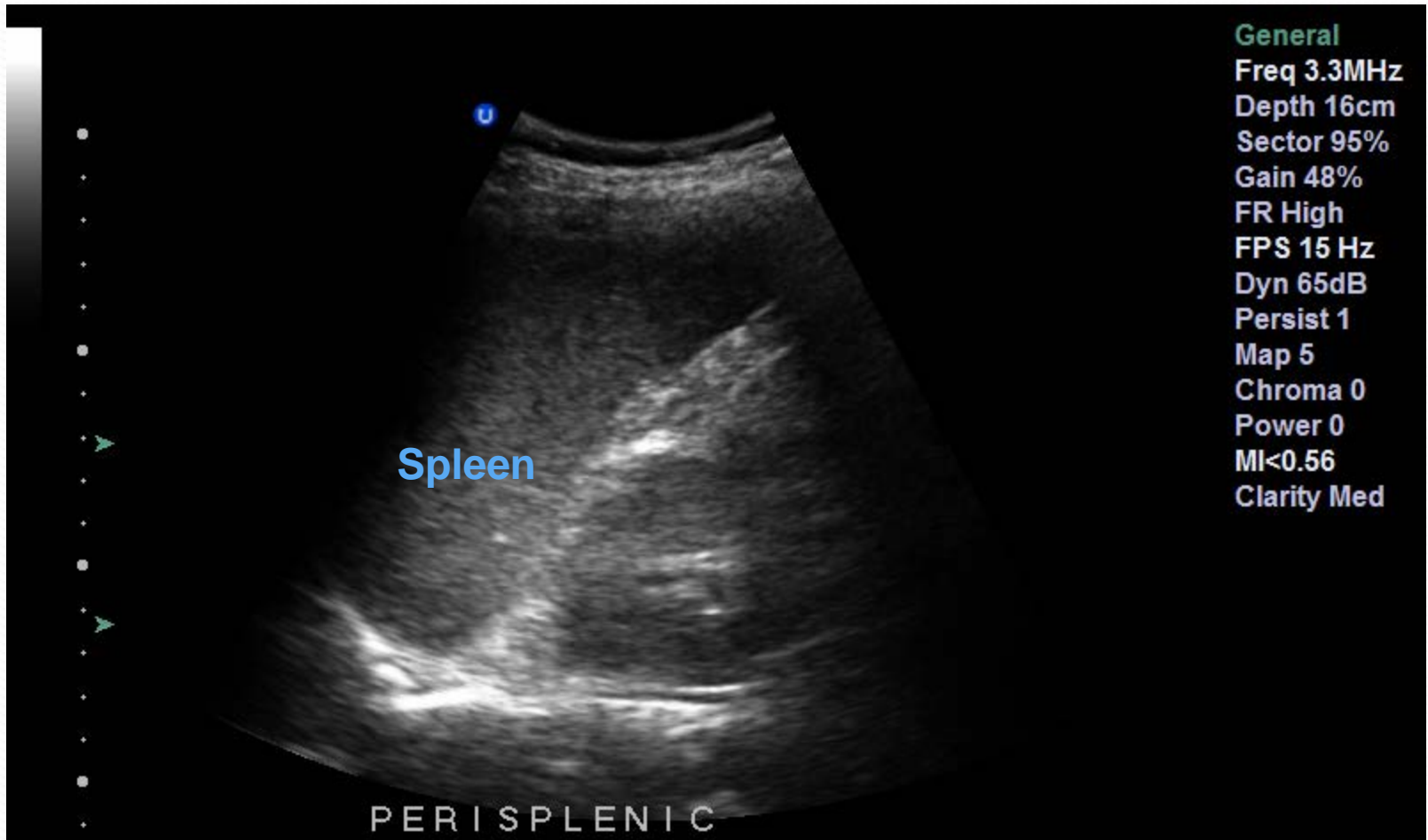
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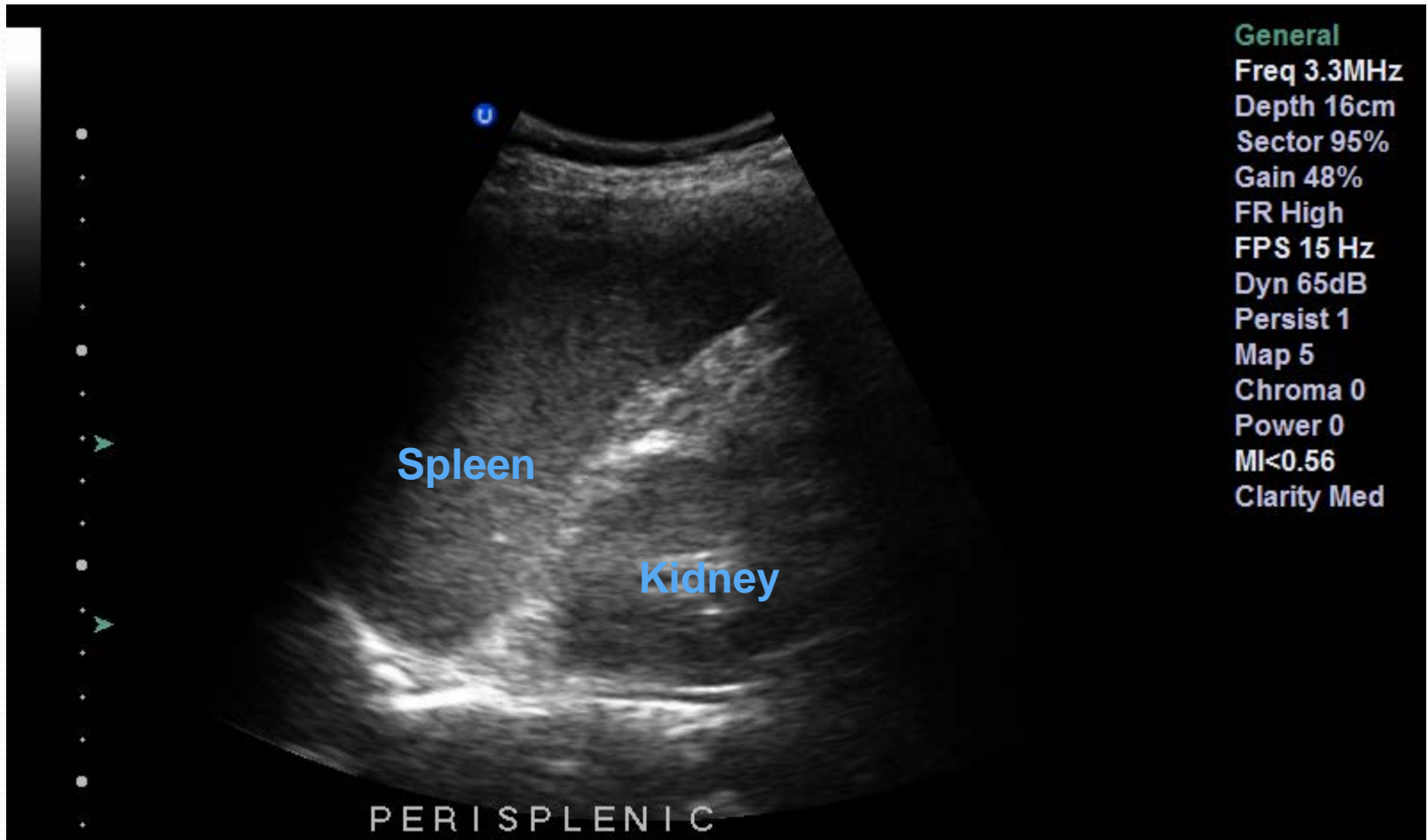
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This view can be used to check for fluid (such as blood) in the perisplenic space and is part of the FAST exam. (Focused Assessment with Sonography for Trauma). Fluid would appear as a black line around part of the spleen.



This is another FAST exam view
Do you know what is seen in this image?

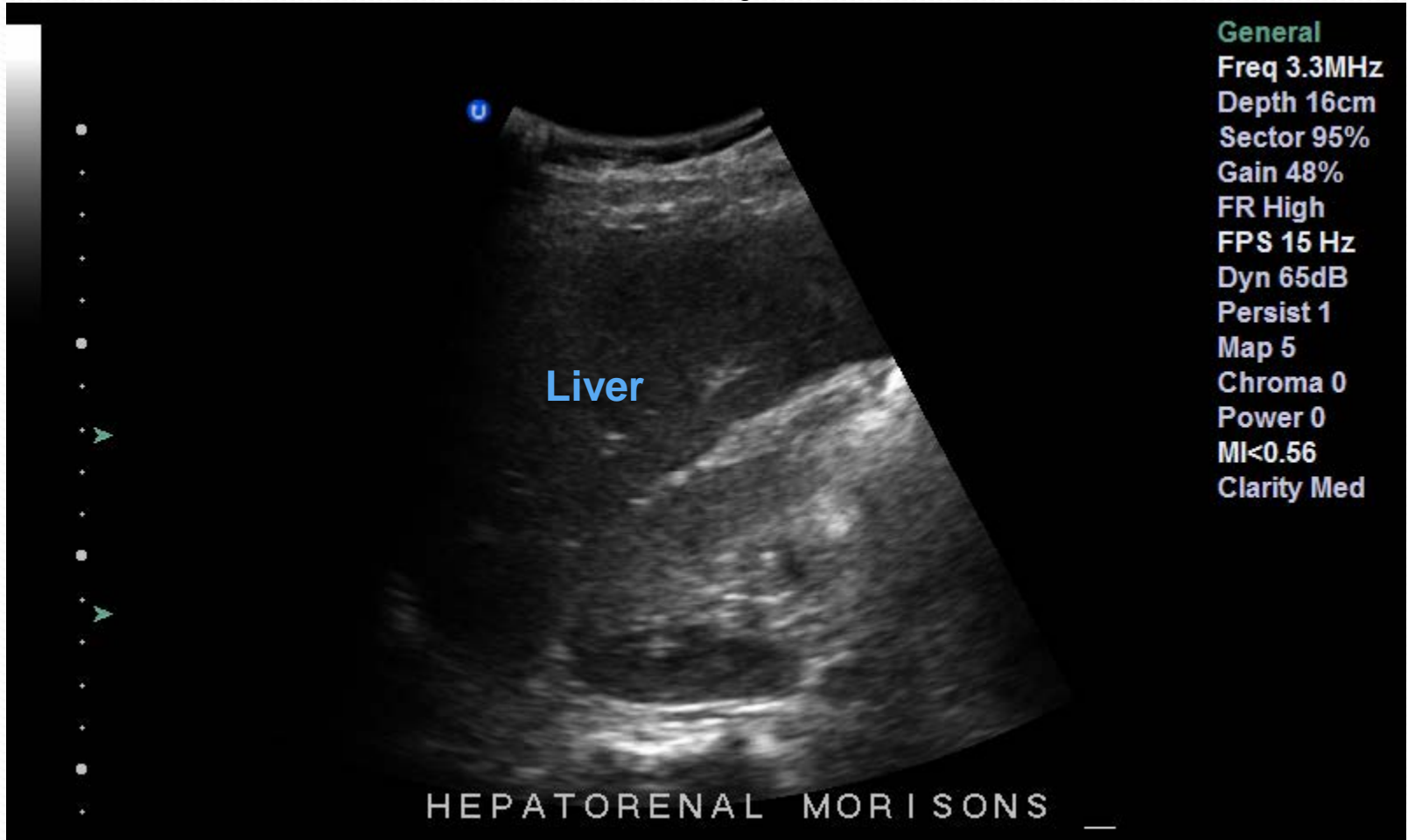
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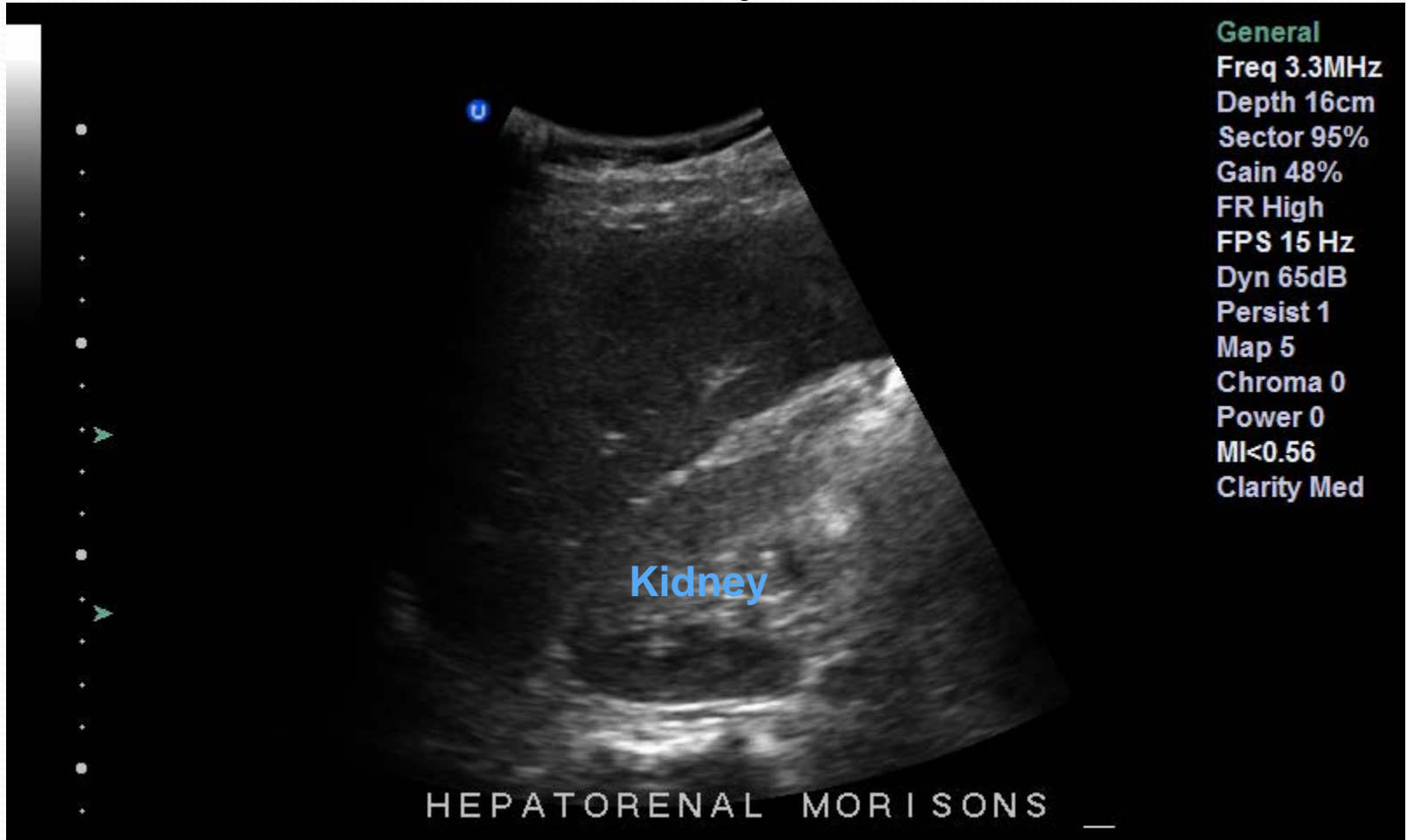
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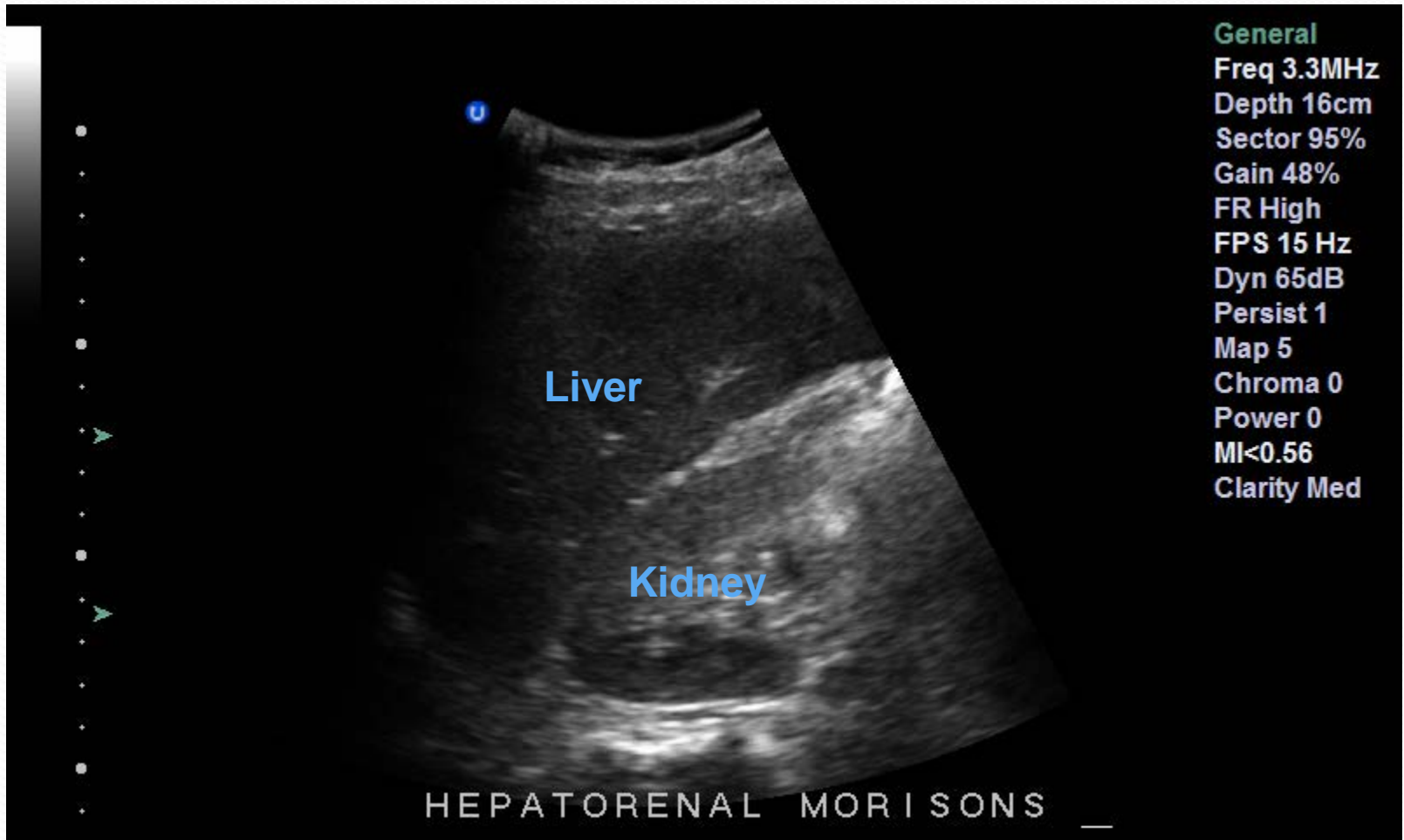
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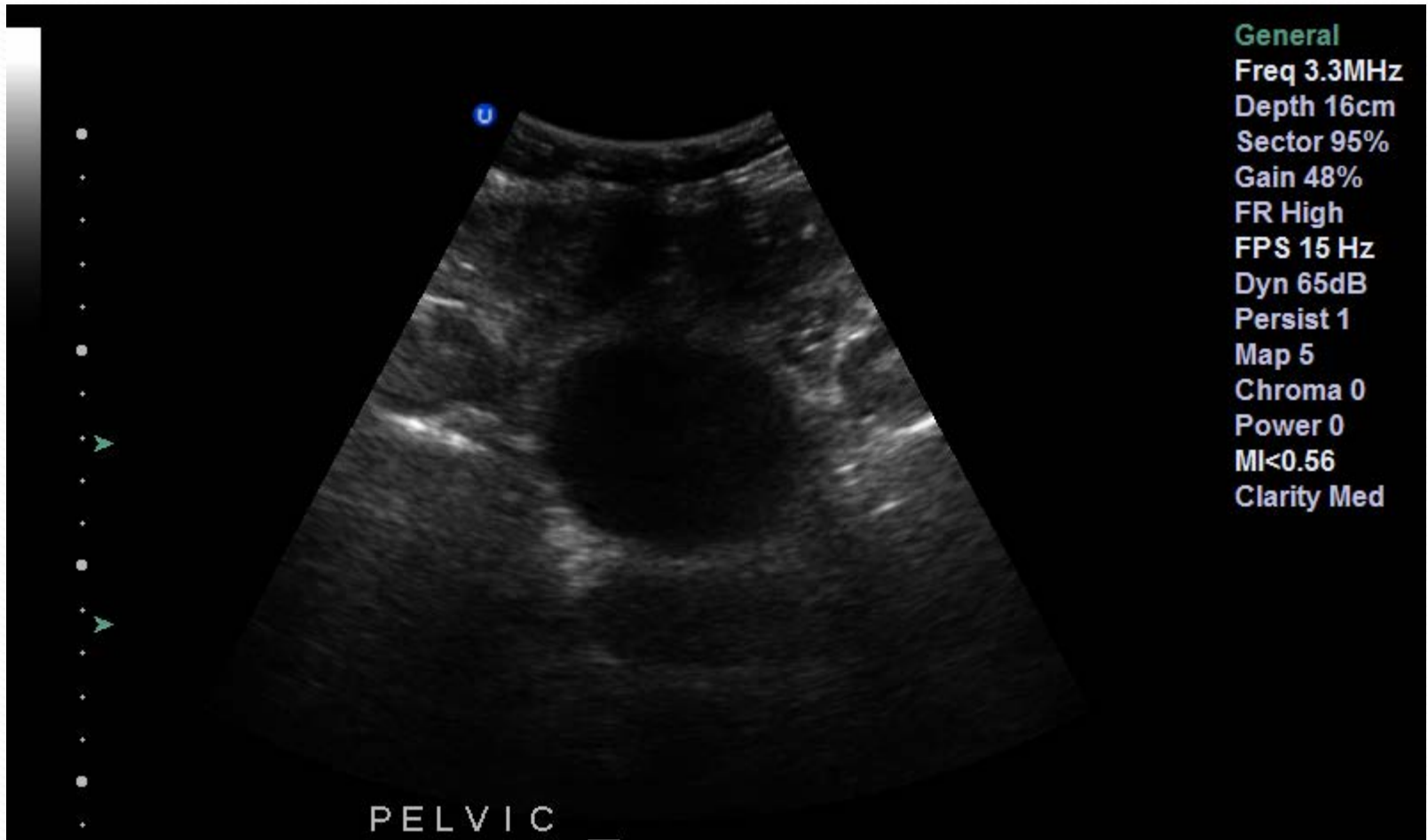
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This is the hepatorenal view used with the FAST exam. This is use to check for fluid in Morrison's pouch which is located between the liver and kidney in this view.



This is another FAST exam view
Do you know what is seen in this image?

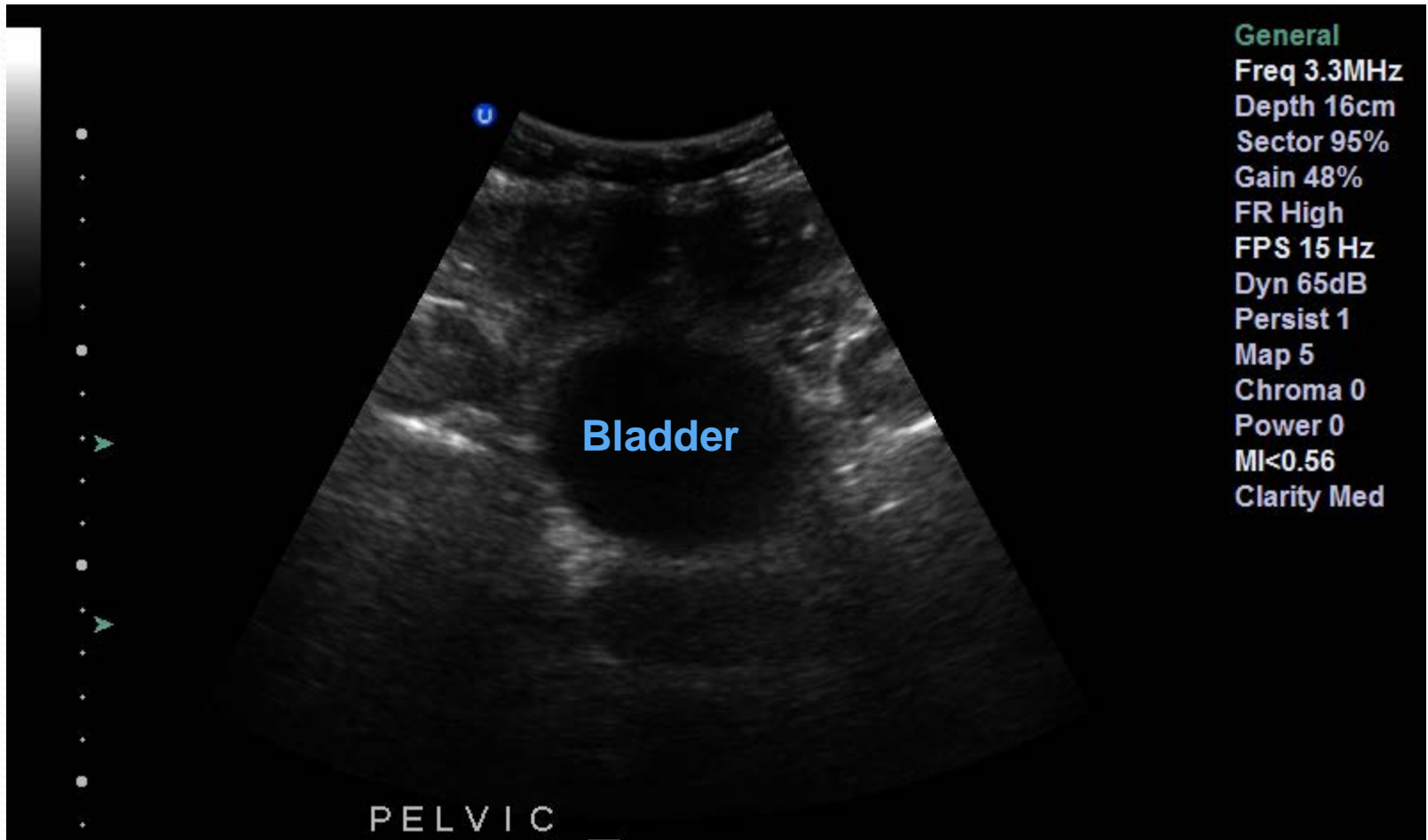
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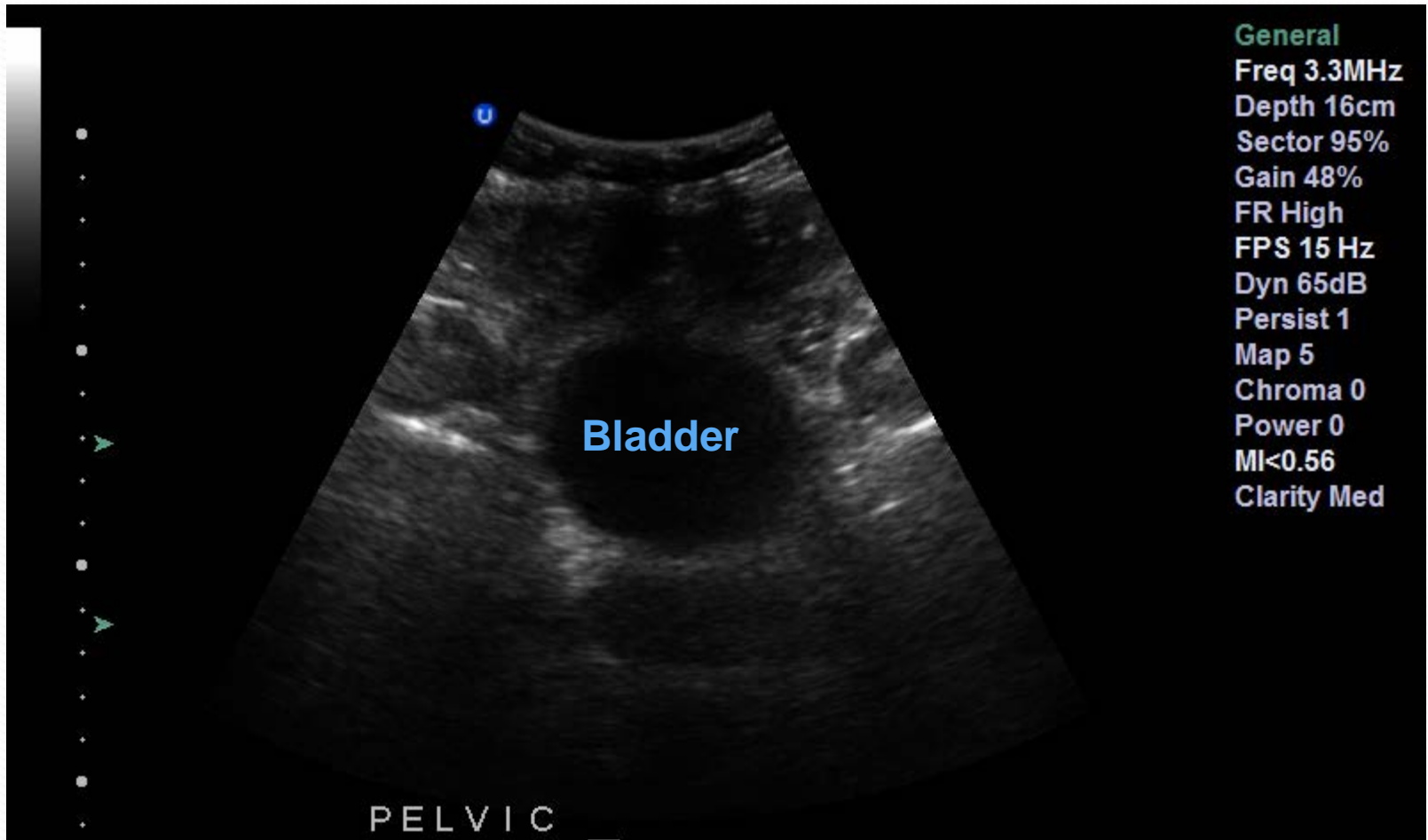
This is another FAST exam view
Do you know what is seen in this image?

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Next 

The pelvic view of the FAST exam checks for free peritoneal fluid that accumulates outside of the bladder.



This is another FAST exam view
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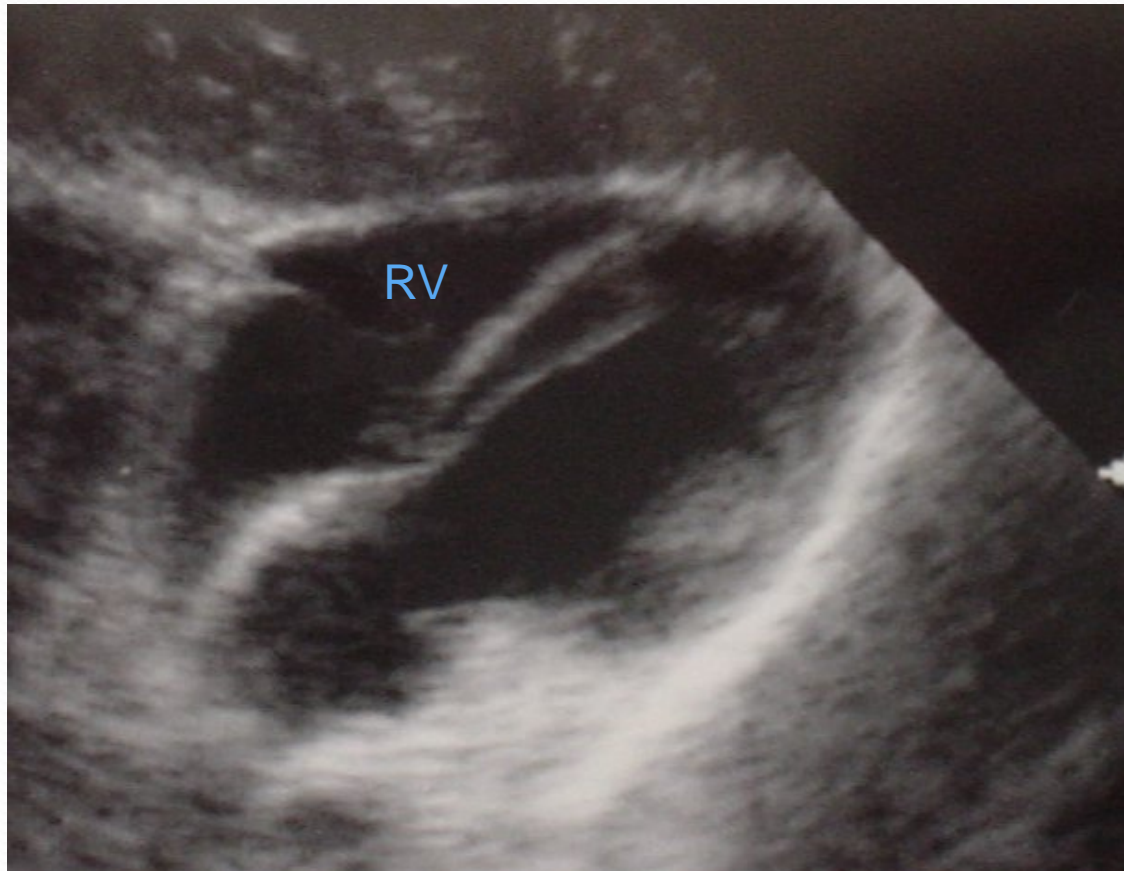


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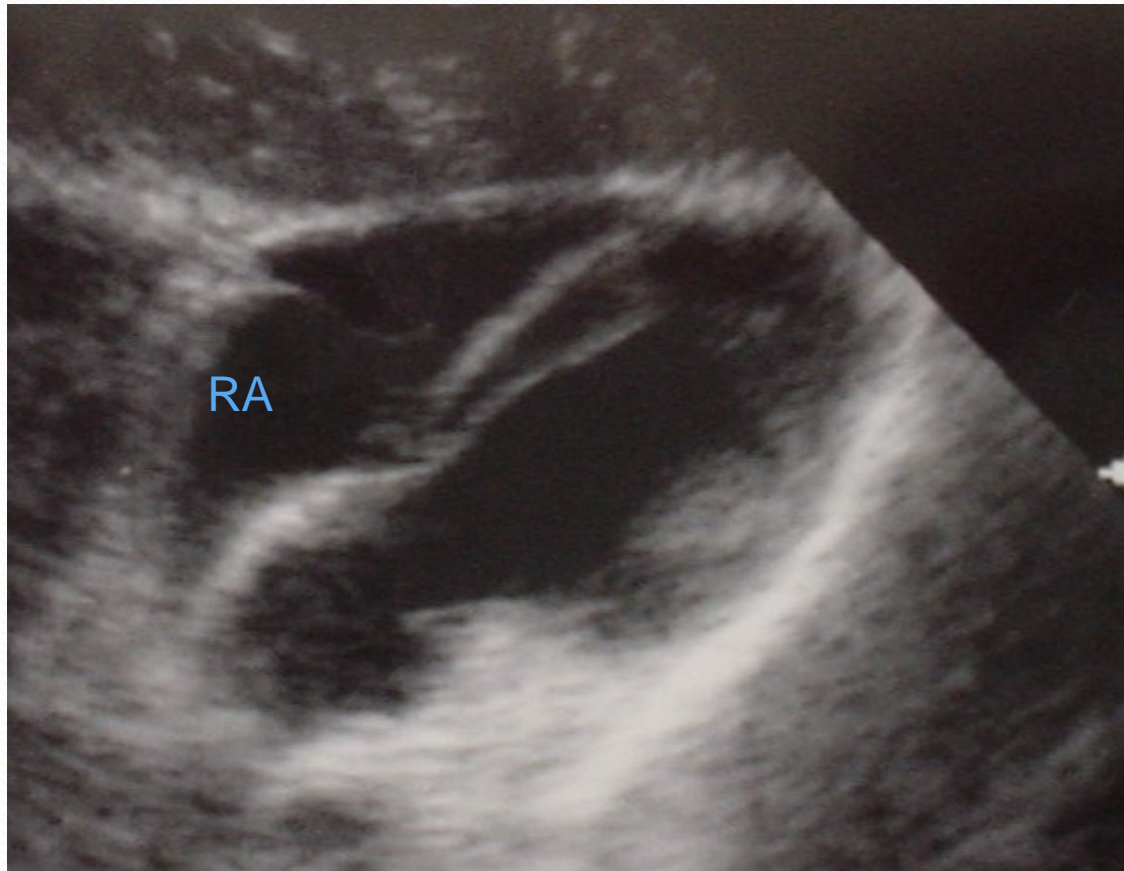


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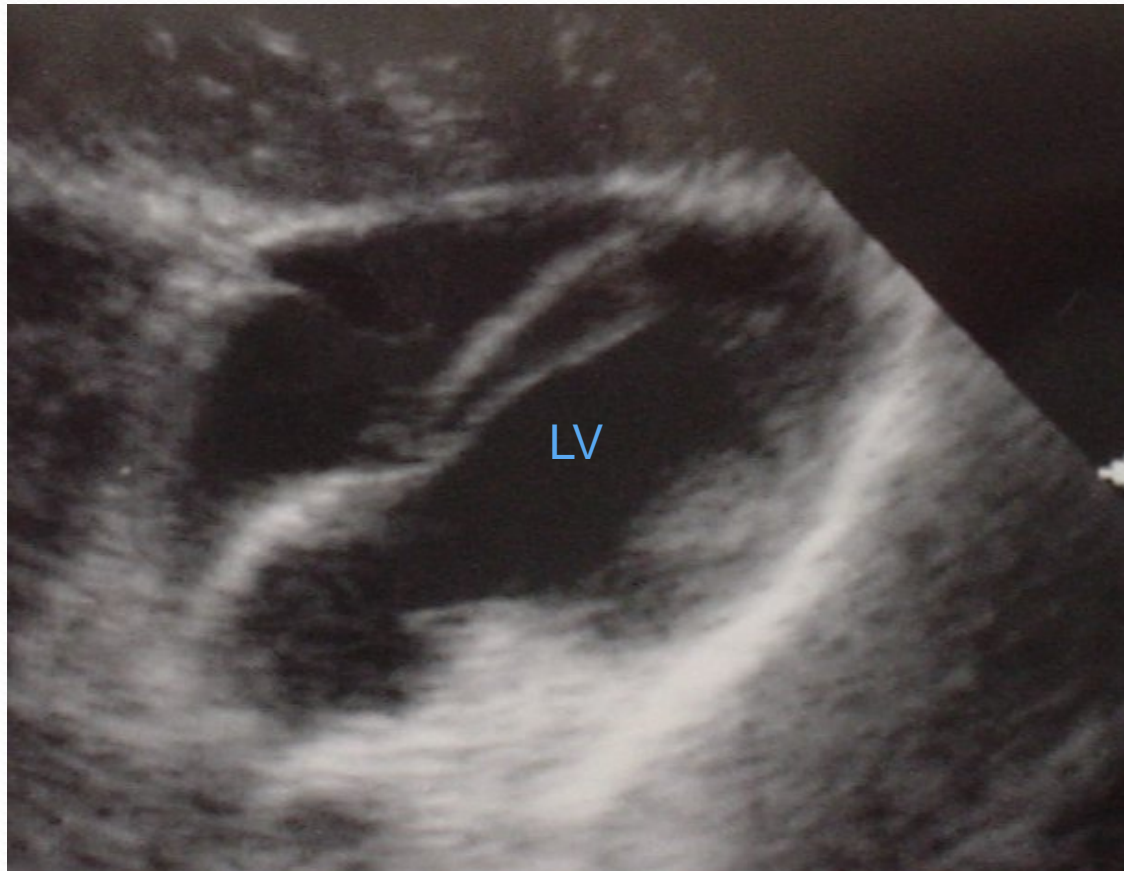


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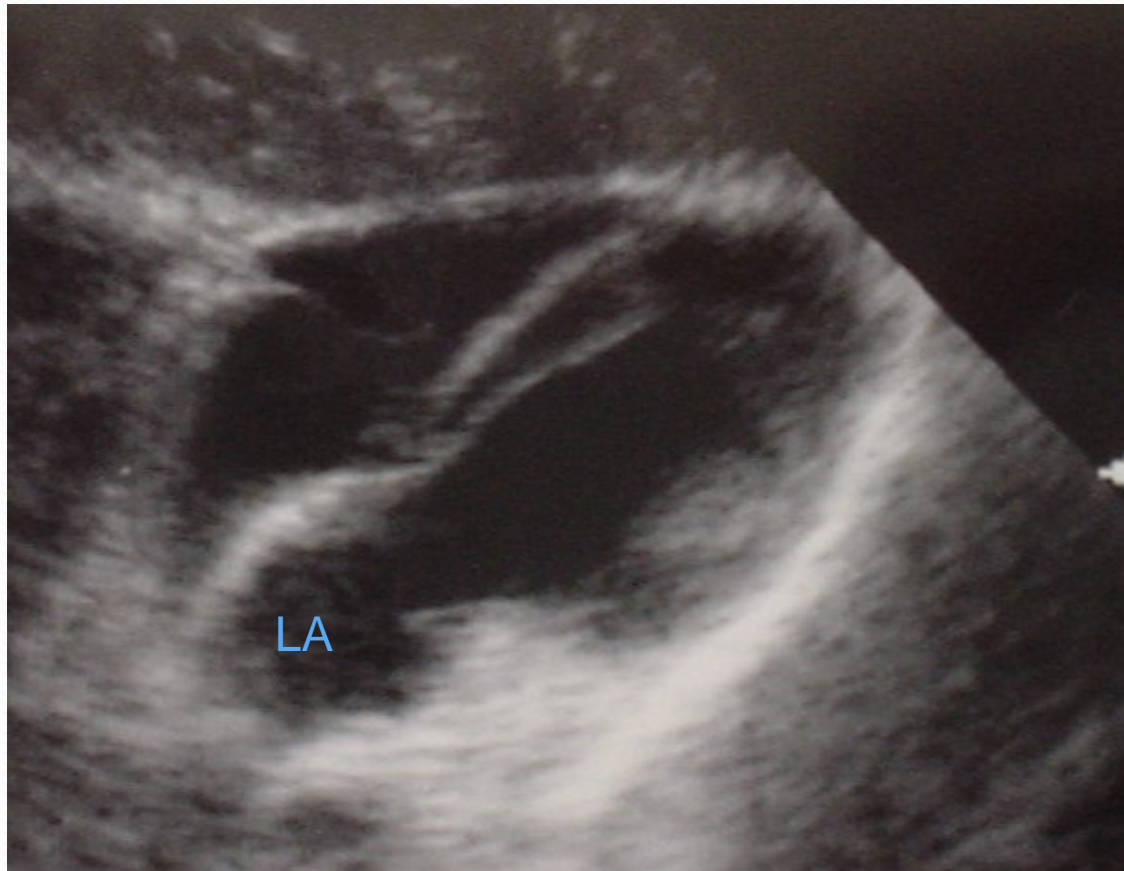


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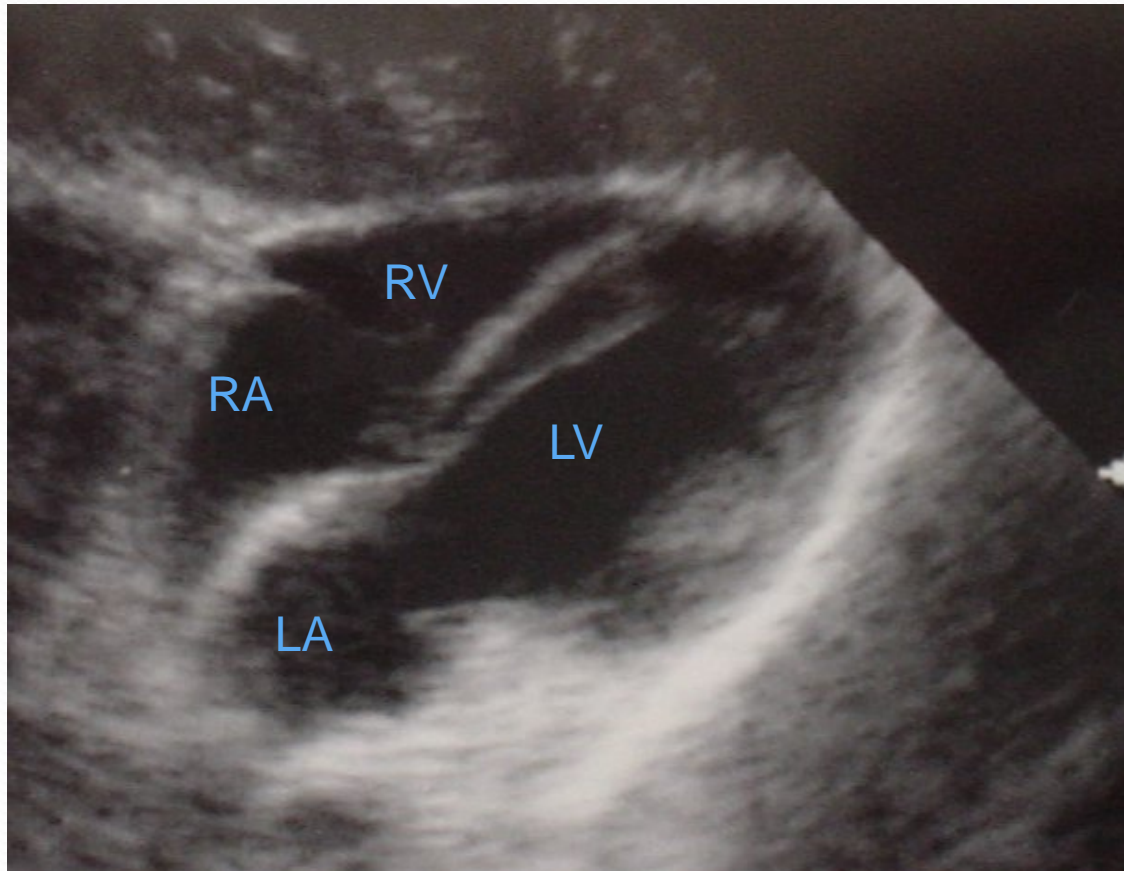
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Next 

The normal subxyphoid view of the FAST exam checks for pericardial effusion/tamponade. Liver is in the near field.



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Case Studies with Ultrasound

Case #1

A 25 year old male present to the Emergency Department by ambulance. He was involved in a motor vehicle crash at highway speeds. He presents confused and smelling of alcohol. He complains of abdominal pain. On exam you notice a firm tender abdomen. Nursing tells you his blood pressure in 76/42.

Ultrasound helps you evaluate 2 of these areas.
Physical exam helps evaluate long bones and
external injuries. The retroperitoneum is best seen
on CT

Knowing this you perform a FAST exam

FAST

(Focused assessment with sonography for trauma)

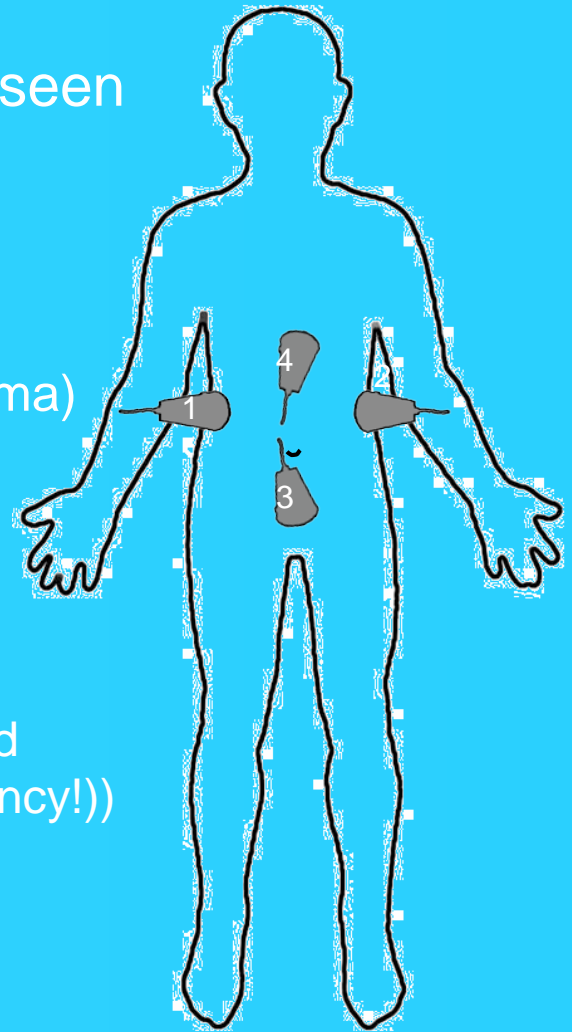
4 views

Hepatorenal

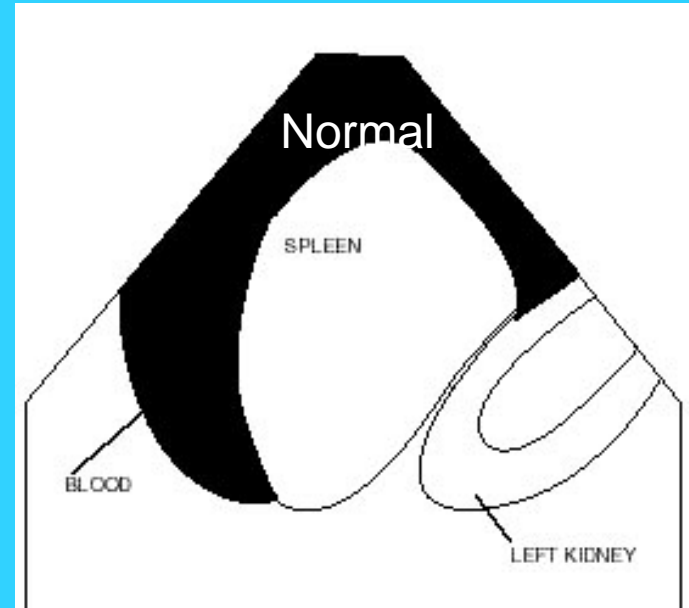
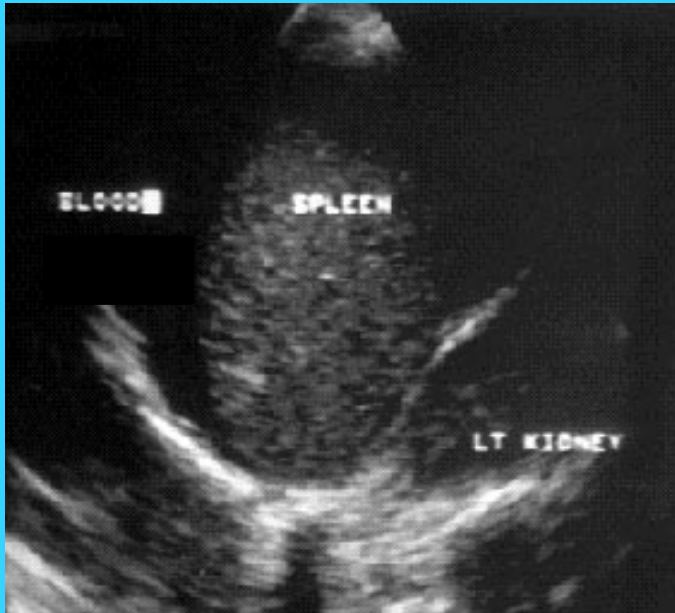
Splenorenal

Pelvic

Cardiac (to evaluate for pericardial effusion and
tamponade (blood fills pericardium=emergency!))



You place the U/S probe and find:



He is taken directly to the OR (avoiding a CT and a delay) where he is found to have a Grade IV ruptured spleen. Your timely intervention saved his life.

Case 2

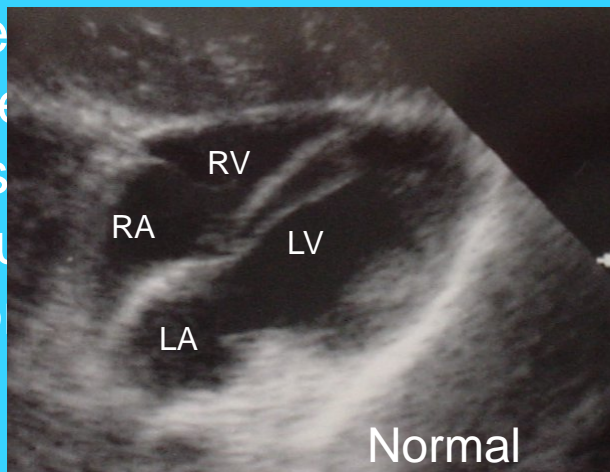
A 70 year old man presents after a self inflicted gun shot wound to the chest. His airway is intact. Breath sounds are decreased over the left lung. He has distended neck veins and is hypotensive (BP = 68/42)

You attempt a FAST exam.

The cardiac view shows:

As you are looking at his heart

He performs a FAST exam. He checks for free fluid in his chest. He finds a small amount of free fluid in the pericardial space. This is a sign of a cardiac tamponade. He performs a FAST exam. He checks for free fluid in his chest. He finds a small amount of free fluid in the pericardial space. This is a sign of a cardiac tamponade.



Case 3

You are a surgeon working at a small hospital when you are called to the emergency department.

A 72 year old woman presents with c/o sudden onset abd pain and back pain.

She passed out at home earlier and is now confused.

She is noted to be pale appearing and in moderate distress. Vital signs show her to be hypotensive and tachycardic. Her abdomen is distended and firm. You think you might feel a pulsatile abdominal mass.

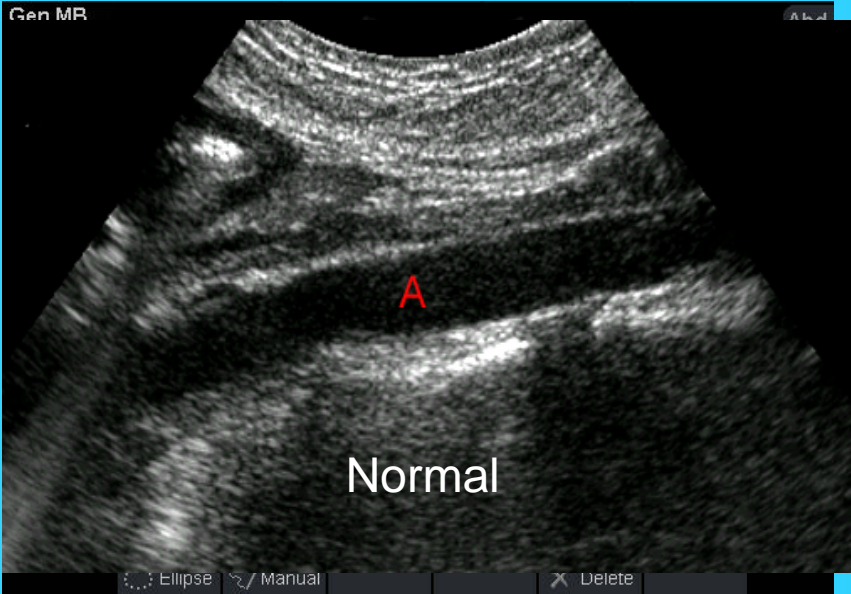
You have 3 options

- Go directly to the OR and hope your assessment is accurate

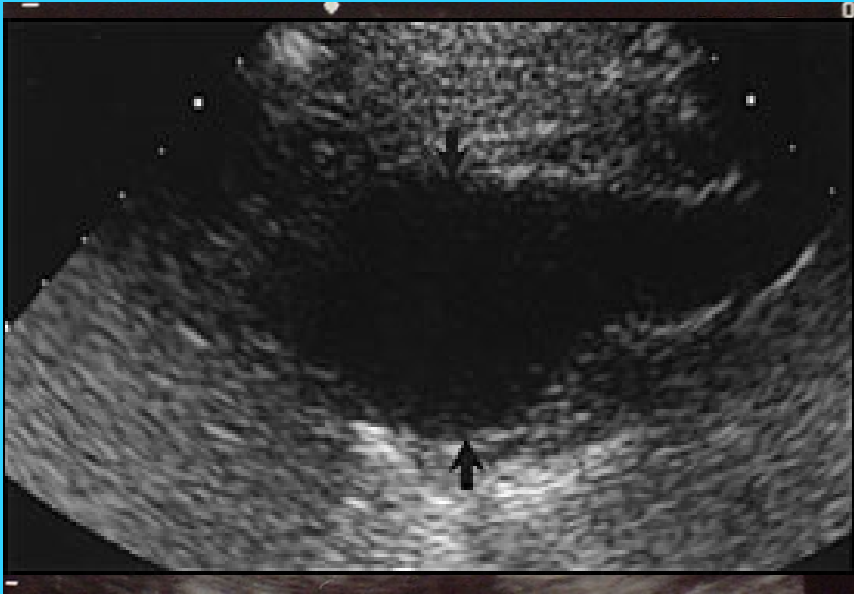
- Go to the CT scanner to confirm your suspicions and hope the patient doesn't get worse during the scan

- Perform a bedside U/S.

You find one aortic abdominal aneurysm (AAA) and the patient is taking directly to the OR for repair



Transverse View



Longitudinal View

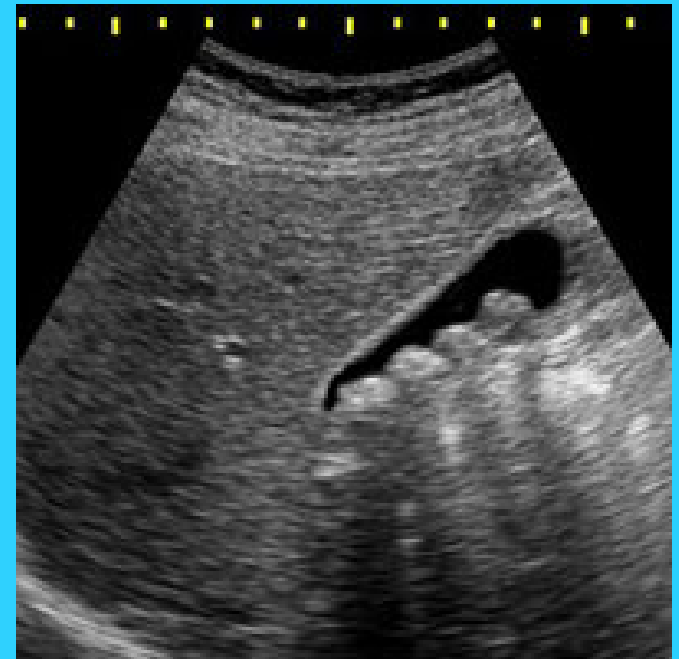
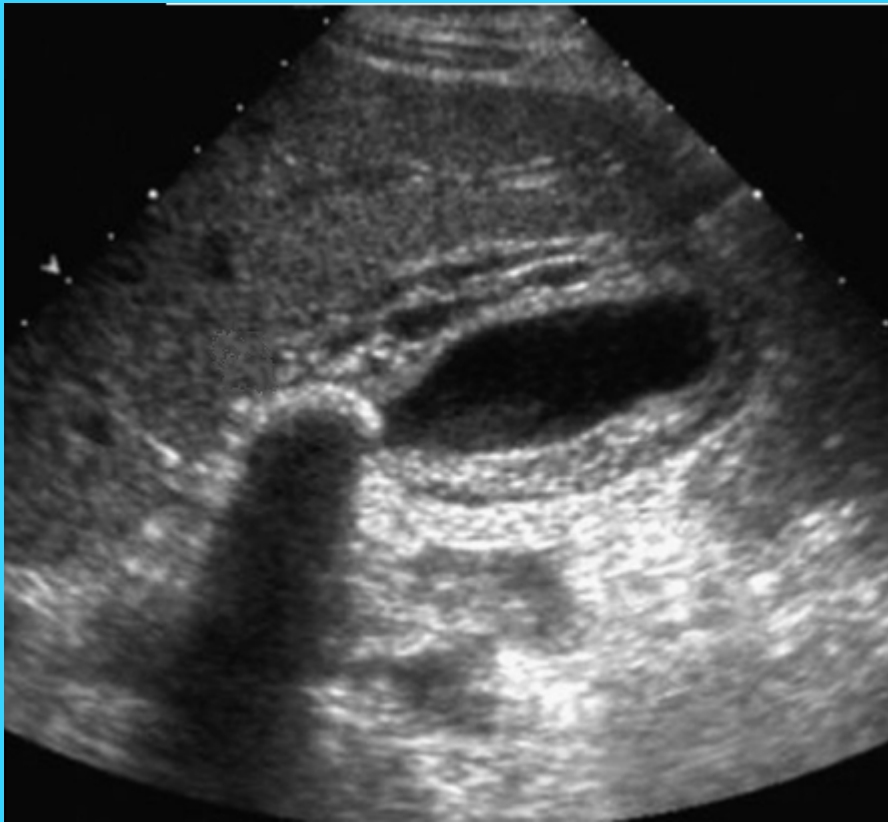
Case 4

A 48 year old female presents with abdominal pain to your clinic. Her medical history is significant for HTN, GERD, obesity, and having had 4 children. She complains of worsening abdominal pain with eating fatty foods.

You suspect

- A. gall bladder dz
- B. pancreatitis
- C. reflux
- D. peptic ulcer dz

You send her for an urgent ultrasound and find:



Summary

- Ultrasonography has a wide variety of applications and has several advantages in that it is less costly, can be used on any patient, is portable, and is quick and speeds up the diagnostic process
- Ultrasonography is limited in that it does not have as good of resolution as CT/MRI and it does not image bone or healthy lungs (air) well.
- Ultrasound images are made by echoes that are transformed into electrical energy based on propagation speed.
- There is a tradeoff between resolution and the depth that can be imaged.
- Fluid (blood) is hypoechoic and appears black.

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