EMERGENCY

EMIG: Medical Student O&G Workshop

Today:
Clinical School
4:30pm

Notes adapted from ACEM college resources and FOAM Ultrasound Sites

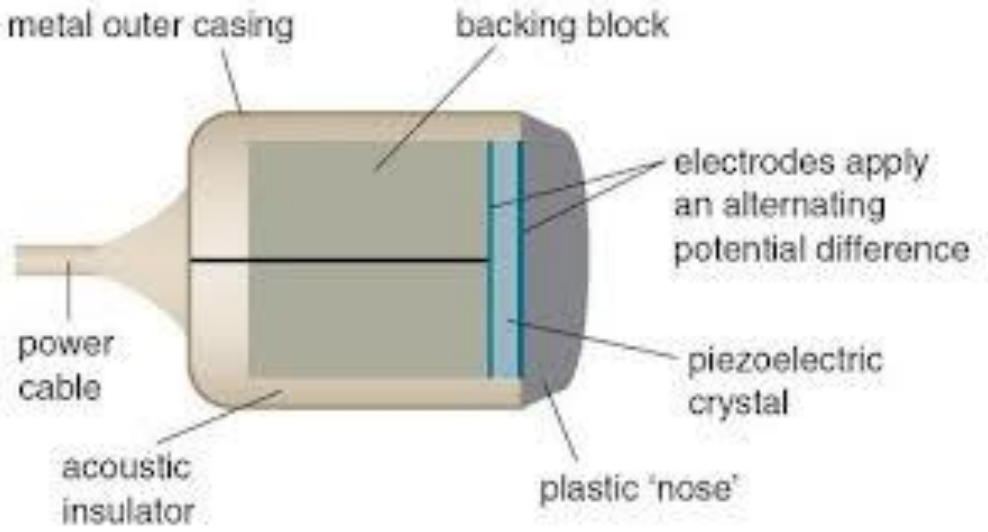
Basic Ultrasound

Transducers

The transducer contains the piezoelectric element or crystal. This crystal produces the ultrasound beam which travels into the body and then reflects off the tissues back to the crystal.

The transducer translates one form of energy to another. An ultrasound transducer contains a piezoelectric crystal that can translate electrical signals into mechanical energy or mechanical energy into electrical signals.

The transducer uses a pulse echo technique to obtain an image. Initially, a sound wave is produced by electricity within the transducer and directed into the patient. The reflected sound waves are received by the transducer and converted into electrical signals, and an image can be created.



TYPES OF TRANSDUCERS

Linear array transducers produce rectangular images and offer the best overall image quality.

Curved array transducers combine advantages of the sector and linear formats and are optimally used when the sonographic window is large.

Sector array transducers produce slice of pie shaped images and are optimal for examining larger organs from between the ribs.

<u>THESE TRANSDUCERS WILL BE SHOWN TO YOU BY YOUR FACILITATOR</u>

Basic Ultrasound

Obtaining an Image – First Steps

1. **Turn on the Ultrasound Machine – place on left side of patient within reach**
2. **Adjust the bed to a comfortable height**
3. **Apply Gel to the Transducer**
4. **Select the type of scan (e.g. obstetric)**
5. **Orientate yourself to the probe (gently tourch the transducer) – normally the dot or emblem on the top right of the screen aligns with the dot or mark on the transducer ---- Orientate yourself to the patient: scan in two planes with the 'dot' on the probe to the patient's right side or towards the patient's head.**
6. **NOW YOU ARE READY TO SCAN!!**

Basic Ultrasound

How to Improve your Image

1. Use more GEL
2. Alter transducer frequency (increase or decrease)
3. Place focal zone at area of interest
4. Narrow field of view
5. Decrease depth of tissue of interest
6. Avoid non-uniform tissue which causes beam distortion
7. Move the patient! (e.g get them to roll on their side)
8. Try tissue harmonics.

This works with mid-depth structures but doesn't usually help with very superficial or deep structures.

Physics

Medical ultrasound imaging consists of using high-pitched sound bouncing off tissues to generate images of internal body structures.

Frequency

Frequency refers to the number of cycles of compressions in a sound wave per second, with one cycle per second being 1 hertz. While the term ultrasound generally refers to sound waves with frequencies above 20,000 Hz (the frequency range of audible sound is 20 to 20,000 Hz), diagnostic ultrasound uses frequencies in the range of 1-10 million (mega) hertz.

Wavelength

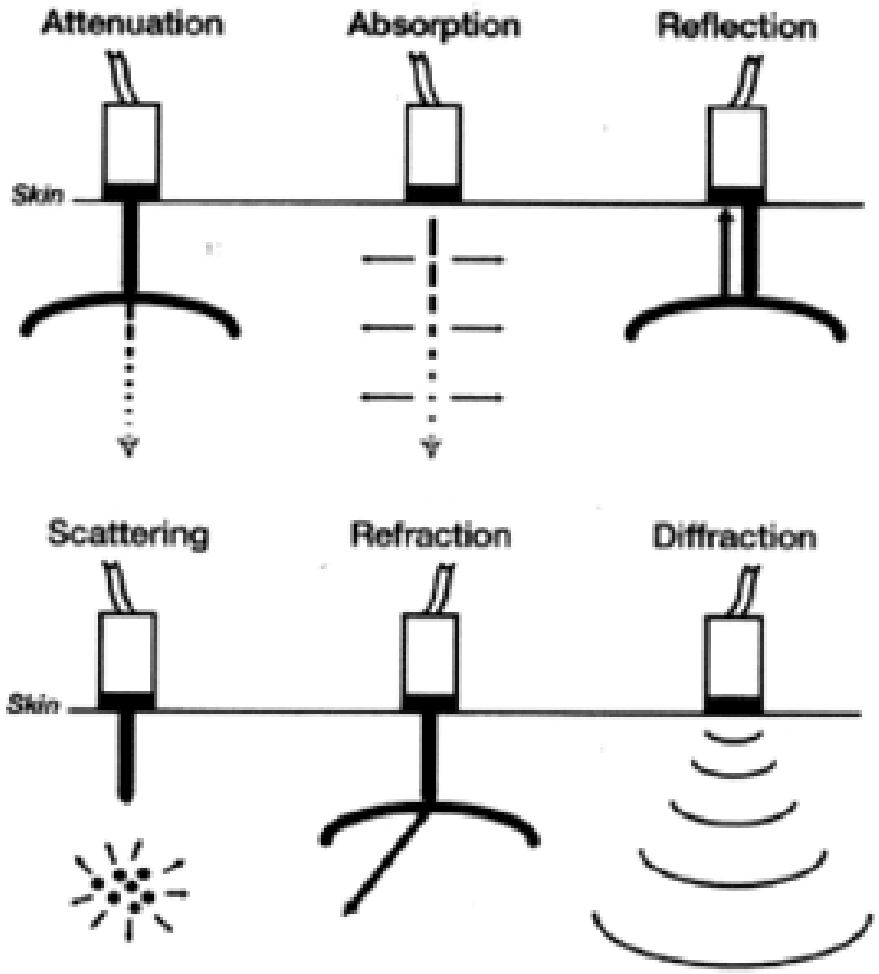
The wavelength is the distance traveled by sound in one cycle, or the distance between two identical points in the wave cycle i.e. the distance from a point of peak compression to the next point of peak compression.

It is inversely proportional to the frequency.

Wavelength is one of the main factors affecting axial resolution of an ultrasound image.

The smaller the wavelength (and therefore higher the frequency), the higher the resolution, but lesser penetration. Therefore, higher frequency probes (5 to 10 MHz) provide better resolution but can be applied only for superficial structures and in children. Lower frequency probes (2 to 5MHz) provide better penetration albeit lower resolution and can be used to image deeper structures.

Propagation Velocity = the velocity at which sound travels through a particular medium and is dependant on the compressibility and density. Usually, the harder the tissue, the faster the propagation velocity.



Boundary	% Reflected
Fat/ muscle	1.08
Fat/kidney	0.6
Soft tissue/water	0.2
Bone/fat	49
Soft tissue/air	99

Emergency USS Indications

- Focused Abdominal Sonography in Trauma (FAST)
- Early Pregnancy Ultrasound
- Abdominal Aortic Aneurysm (AAA) and Inferior Vena Cava (IVC)
- Peripheral and Central Venous Access

- Other advanced indications
  - Echo and ‘RUSH’ Protocol
  - Procedural Guidance
  - Bladder Ultrasound
  - Renal Ultrasound
  - ‘E-FAST’ and Chest Ultrasound
  - Ocular Ultrasound
  - Foreign body removal

Ultrasound Glossary

- Anechoic
- Fluids such as blood, urine and bile appear black or anechoic.

- Attenuation
- Progressive weakening of the ultrasound beam as it passes through the tissues.

- B Mode Brightness Modulation
- Echo signals are amplified, electronically processed, pre and post processing to compensate for loss of energy with depth in tissue. Displayed in shades of grey {strong reflectors = white; echo free areas appear black}.

- Duty Factor
- The ratio of time spent sending signals to the time spent receiving signals. The duty factor for diagnostic ultrasound is less than 1%.

- Frequency
- The number of times the wave is repeated per second.

- Gain
- This refers to the overall brightness of the image.

- Hyperechoic
- Bone transmits very little sound energy and therefore produces a bright image (hyperechoic).

- Image Resolution
- Spatial- detects anatomically separate structures
- Contrast- show tissues of different characteristics
- Temporal- changes over time eg. cardiac
- Colour- Spatial and temporal aspects of blood flow

- Interfaces
- Differences or variations in acoustic impedance. The magnitude of the acoustic impedance mismatch determines the strength (amplitude) of the echo arising from it, described as “strong” or “weak” reflector.

- Piezoelectric Element
- A substance capable of converting electrical energy to sound energy and vice versa. This conversion is called the piezoelectric effect.

- Period Time taken for one wave cycle.

- Probe See *transducer*

- Pulse Duration The time taken to complete one short burst of sound waves in pulse echo mode.

- Pulse Echo Mode A system where the transducer sends a short burst or “pulse” of sound waves and then waits for the “echo” to return.

- Resolution The ability to distinguish between two close objects. High resolution means a clear picture and is improved by using higher frequency ultrasound; related to frequency. Resolution is a trade-off for penetration. 2-3 MHz- Multipurpose 5 MHz- Moderate resolution 7 MHz- High resolution 12-14 MHz- Ultra high resolution.

- Sagittal Plane
- Divides the body into a right half and a left half. (NB see also *transverse plane*, below)

- Spatial Pulse Length
- The distance occupied by one short burst of sound waves in pulse echo mode. Short SPL improves resolution. Short SPL obtained by using higher frequency.

- Spatial Resolution
- Axial - along the axis of the US beam.
- Lateral - perpendicular to the beam axis (less accurate).

- Scan Converter The Gray scale image depends on:
- - Strength of echoes and
- - The length of time until the echo returns (distance from the transducer).

- Shadow An object that does not let ultrasound through casts an acoustic shadow. On the screen one sees the bright object with a black shadow distally.

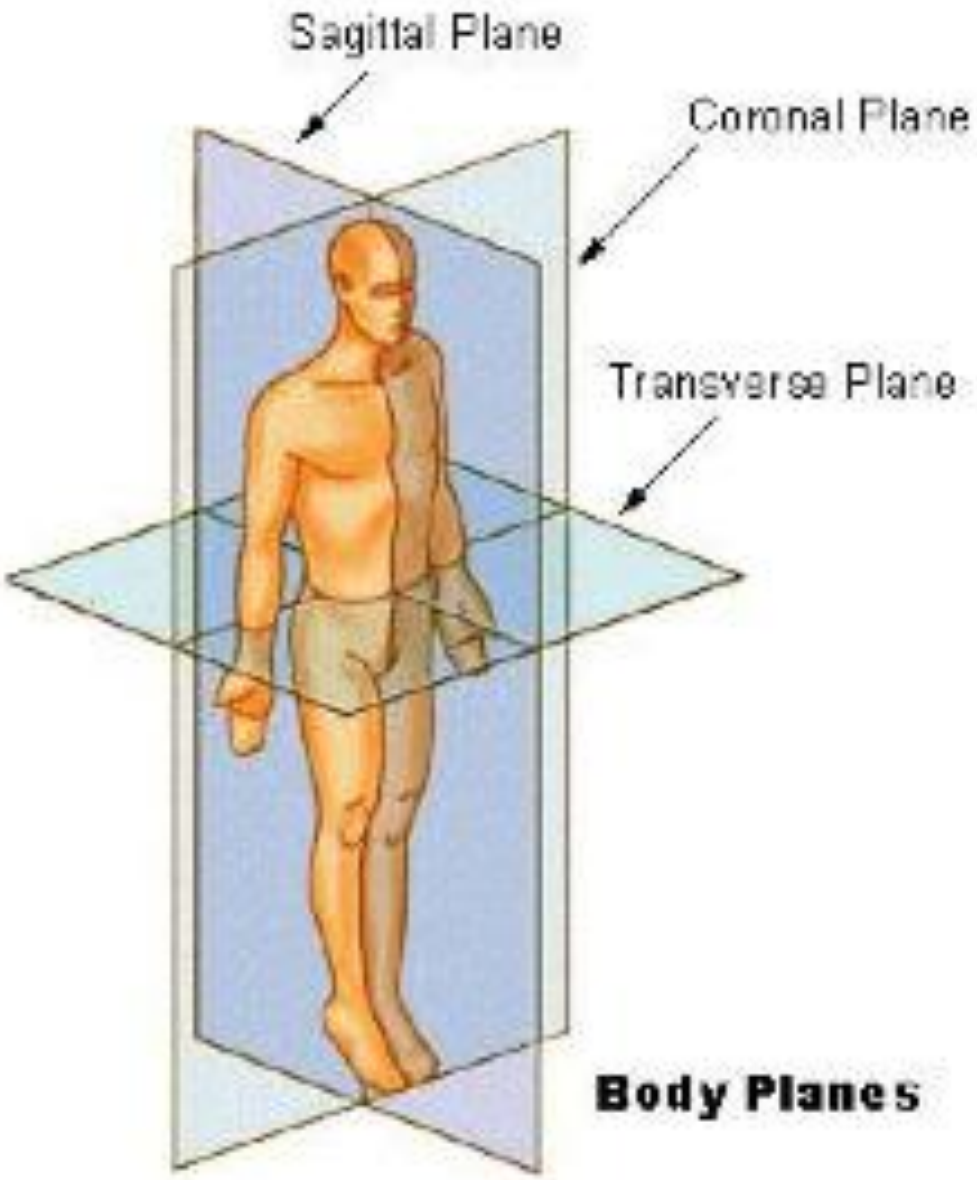
- T.G.C.
- Time Gain Compensation knobs allow one to augment weaker echoes to obtain an even picture. Echoes from deeper structures have to pass through more tissue and are therefore weaker than echoes from superficial structures. TGC allows you to adjust for this.

- Transducer
- The object held in the hand. The transducer contains the piezoelectric element or crystal. This crystal produces the ultrasound beam which travels into the body and then reflects off the tissues back to the crystal.

- Ultrasound
- Audible frequency range ends at 20 000 Hz. Anything above 20 000 is defines as ultrasound. Frequencies used for medical imaging are above 1 million Hz (1 megahertz). When people say a transducer is a “3.5” or a “5.0” they mean 3.5 or 5.0 megahertz.

- Transverse
- Plane divides body into a top half and a bottom half.

- Wavelength
- The distance occupied by one wave cycle. Resolution improves with higher frequency ultrasound. Unfortunately, higher frequencies cannot penetrate deeply into the tissue. An obese patient may require a lower frequency to obtain enough penetration. Along with the penetration comes worse resolution.



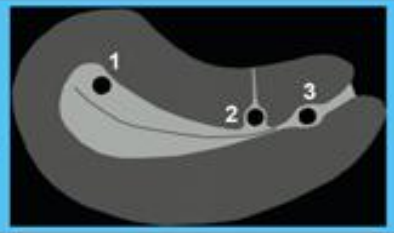
Body Planes

Normal Ultrasound in Pregnancy

Reference Material

LS Uterus:
Fan from side-to-side

Potential Pitfalls
1. Normal pregnancy
2. C-Scar ectopic
3. Cervical ectopic

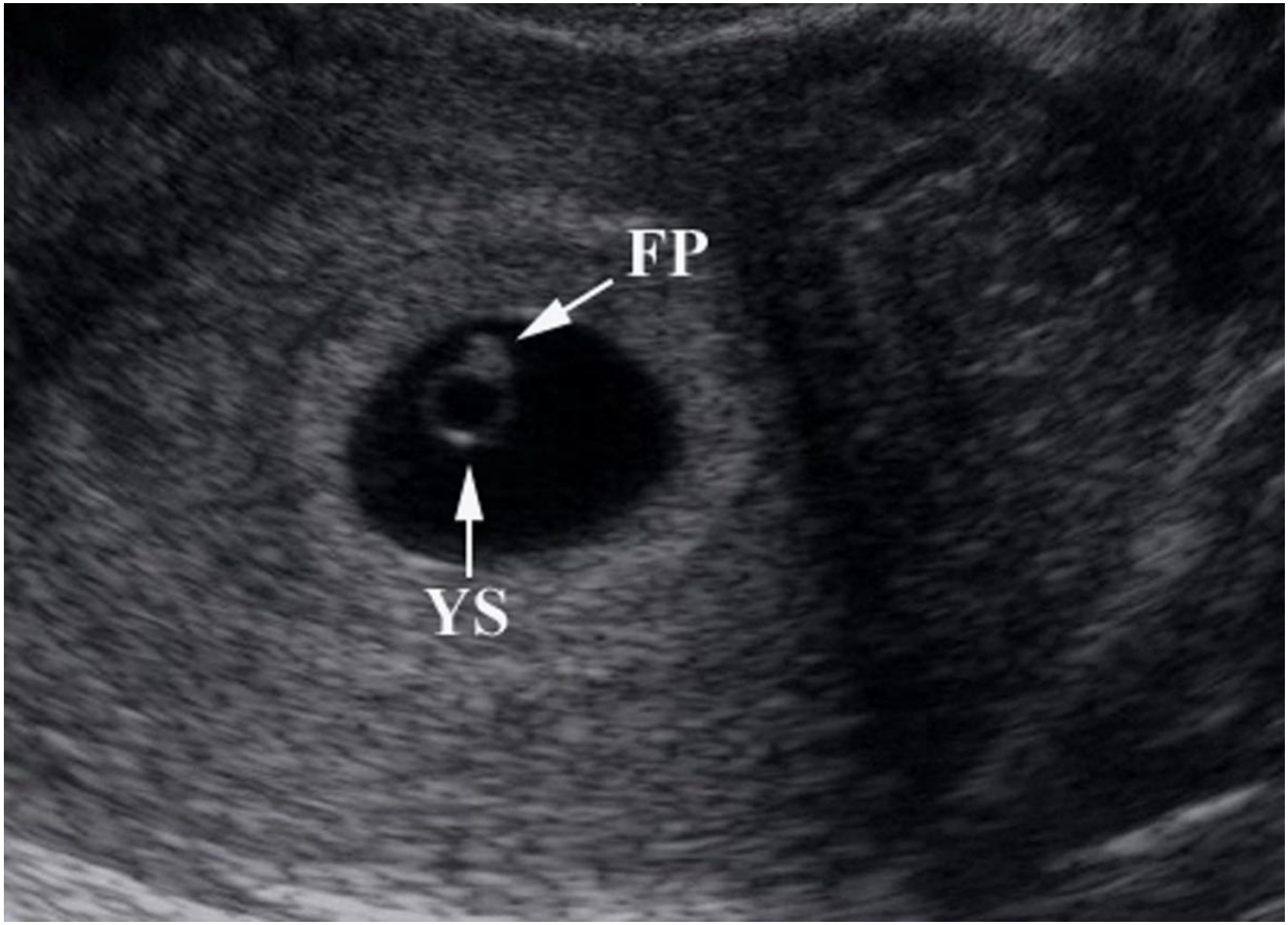


TS Uterus:
Fan from the Fundus through to Cervix

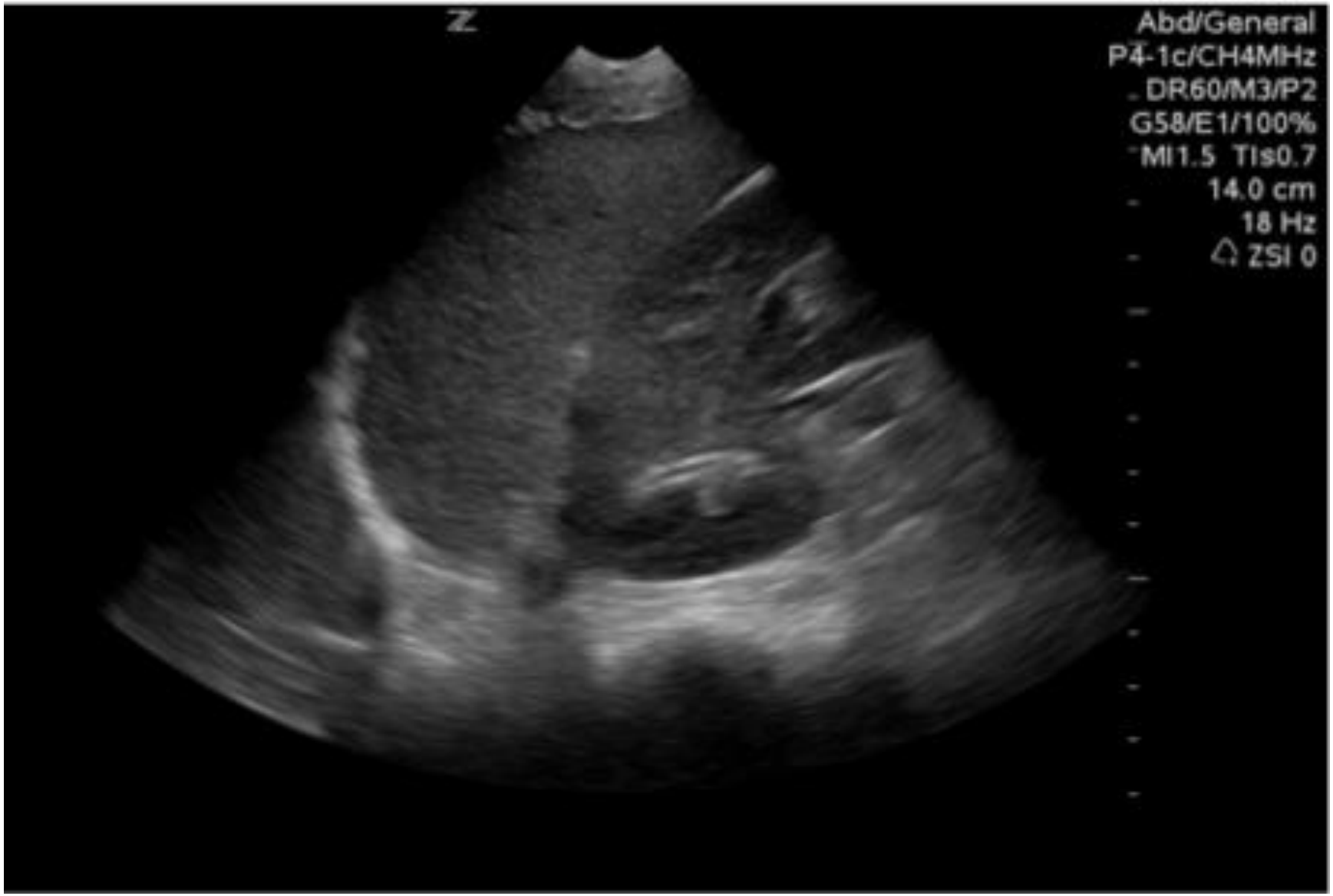
Potential Pitfalls
1. Normal pregnancy
4. Cornual ectopic

Gestation (weeks)	β-HCG (Varies by laboratory)	US Appearance	Gestation Sac (GS) (mm)	Crown Rump Length (mm) (CRL)	Notes These values assume adequate views and good equipment. Suspected early pregnancy failure must be confirmed by an expert
4	40-4480		2 (at 4+3)	N/A	Must have YS to confirm IUP
5	270-28700		5	N/A	**Usually** see YS by GS 10mm (TV) & GS 20mm (TA)
6	3700-84900		12	3.5	Should see cardiac activity by CRL 7mm TV
7	9700-120000		19	9.5	Should see embryo by GS 25mm TV
8	31100-184000		26	16	β-HCG should increase at least 66% every 48 hours
9	61200-152000		32 Grows 1mm per day for first 8 weeks	23 Grows 1mm per day for first 10 weeks	Discriminatory Zone TV = 1500 IU/mL TA = 6000 IU/mL Values may vary between different laboratories

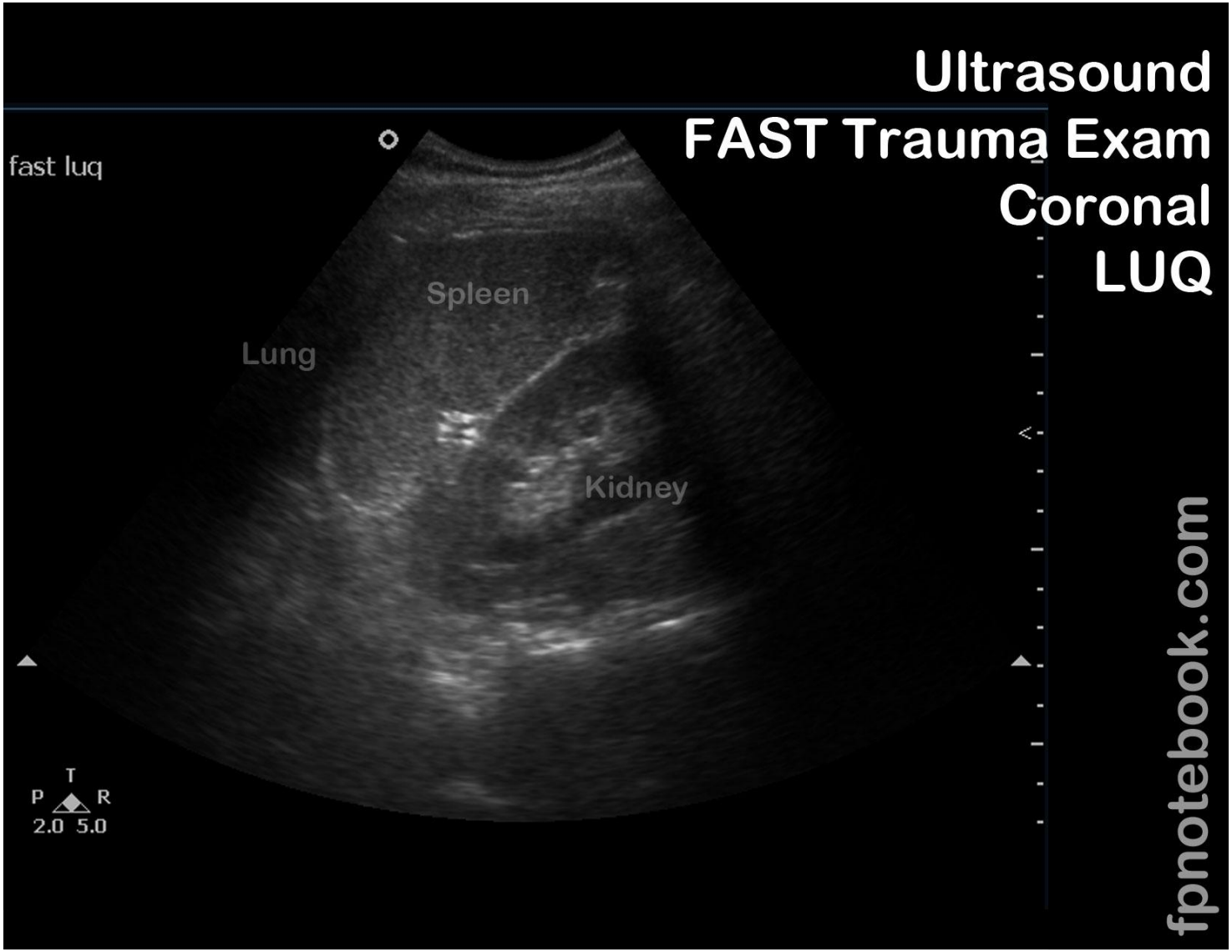
Normal Early Pregnancy



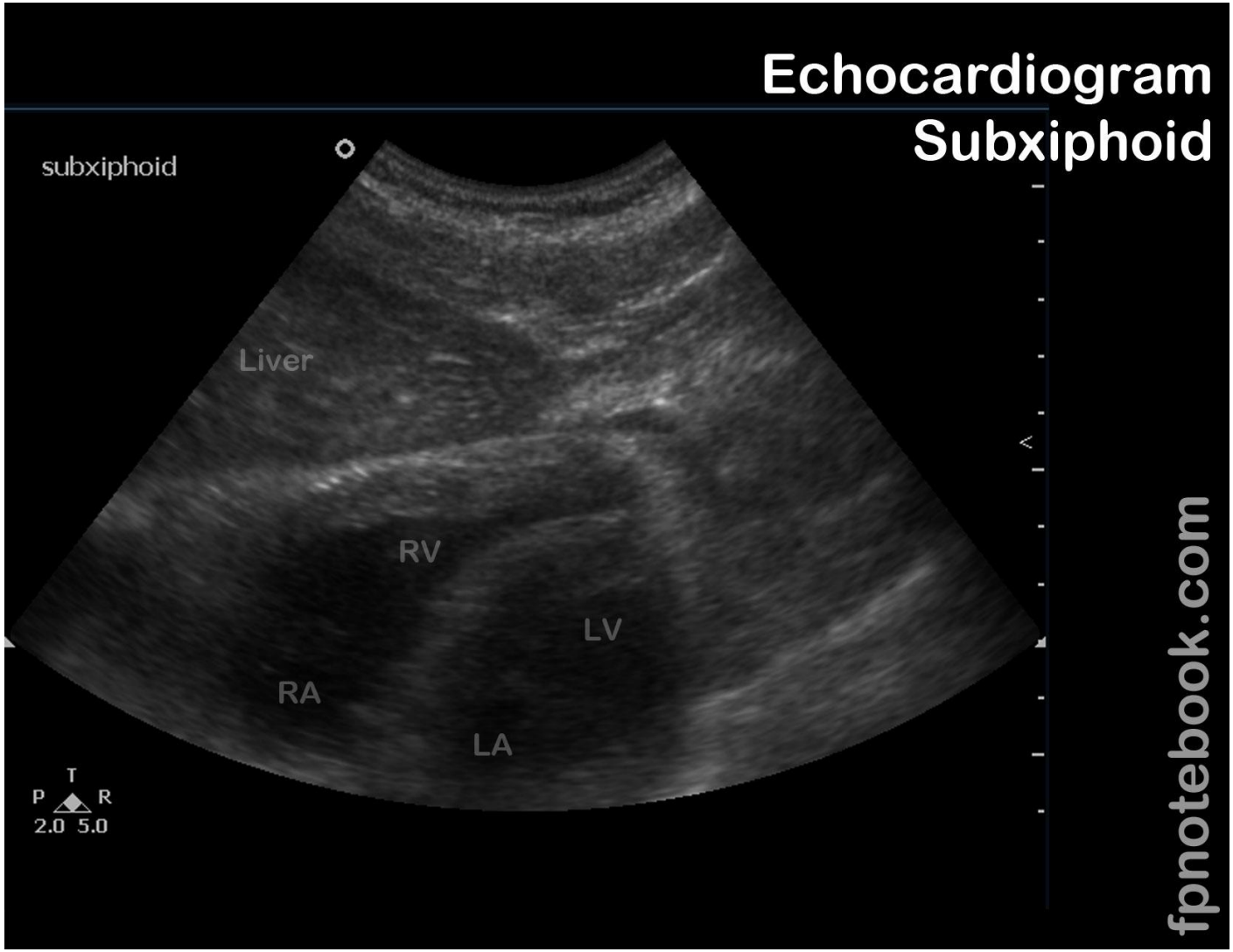
Normal FAST Scan RUQ



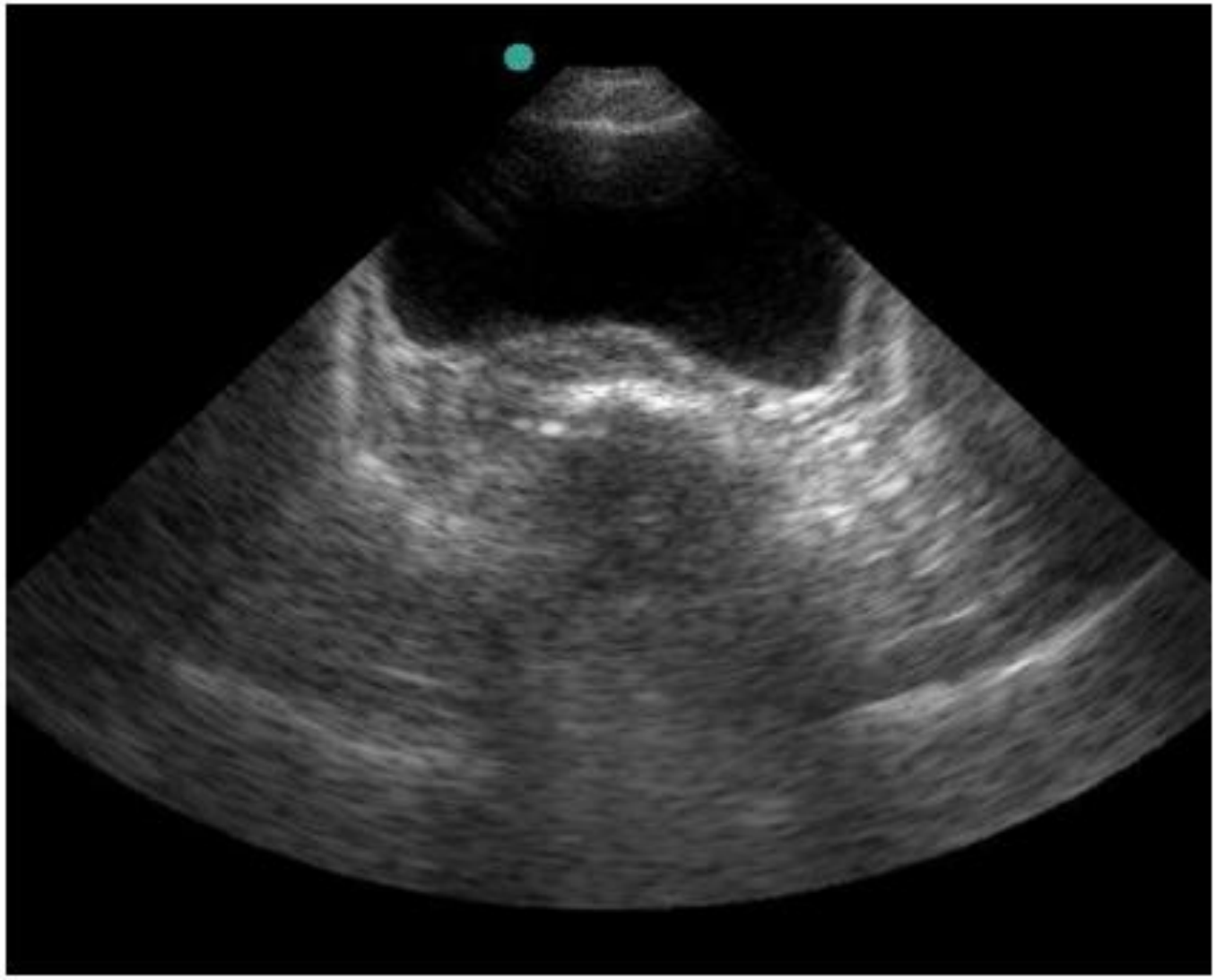
Normal Fast Scan LUQ



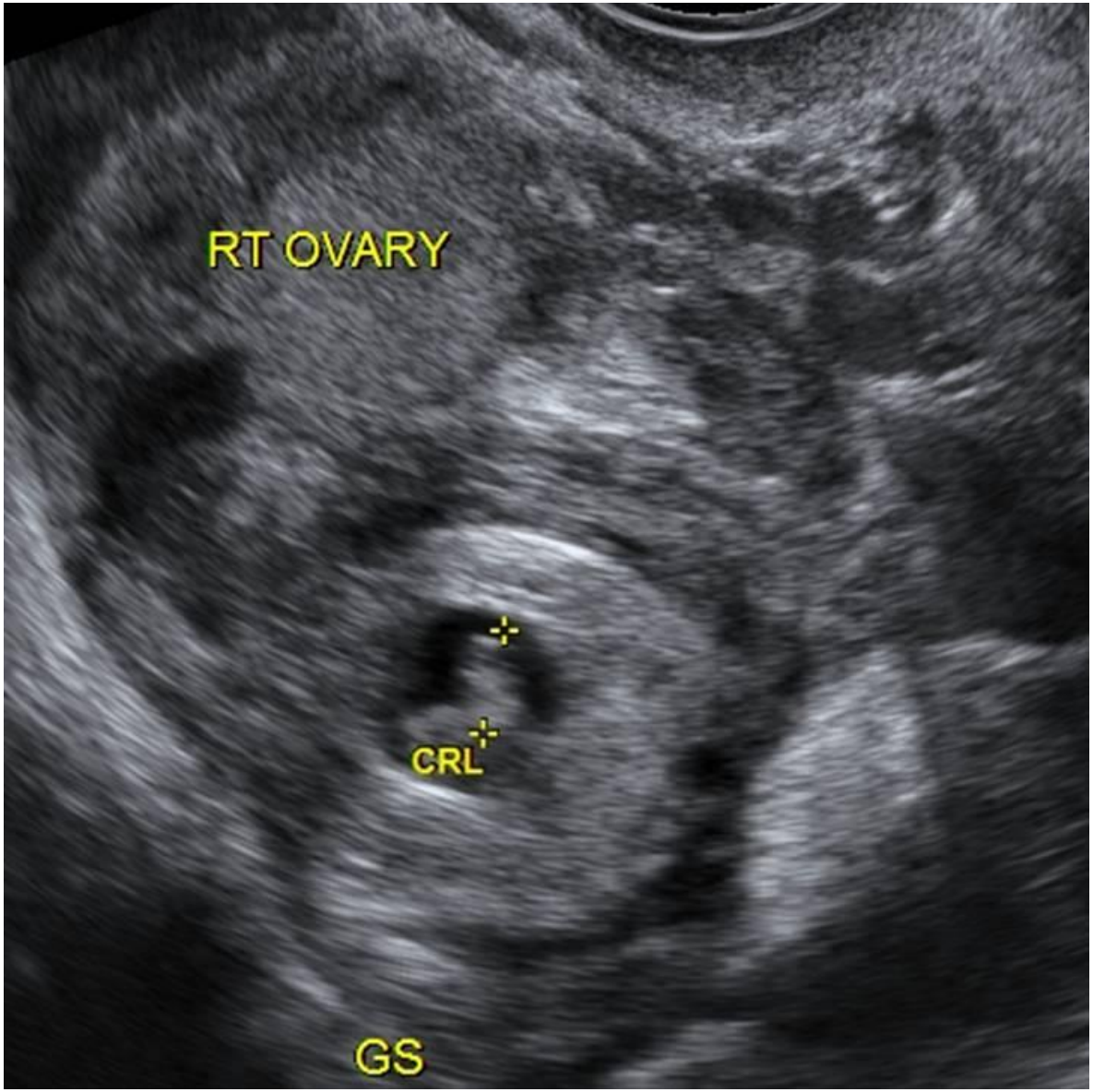
Normal FAST – Heart



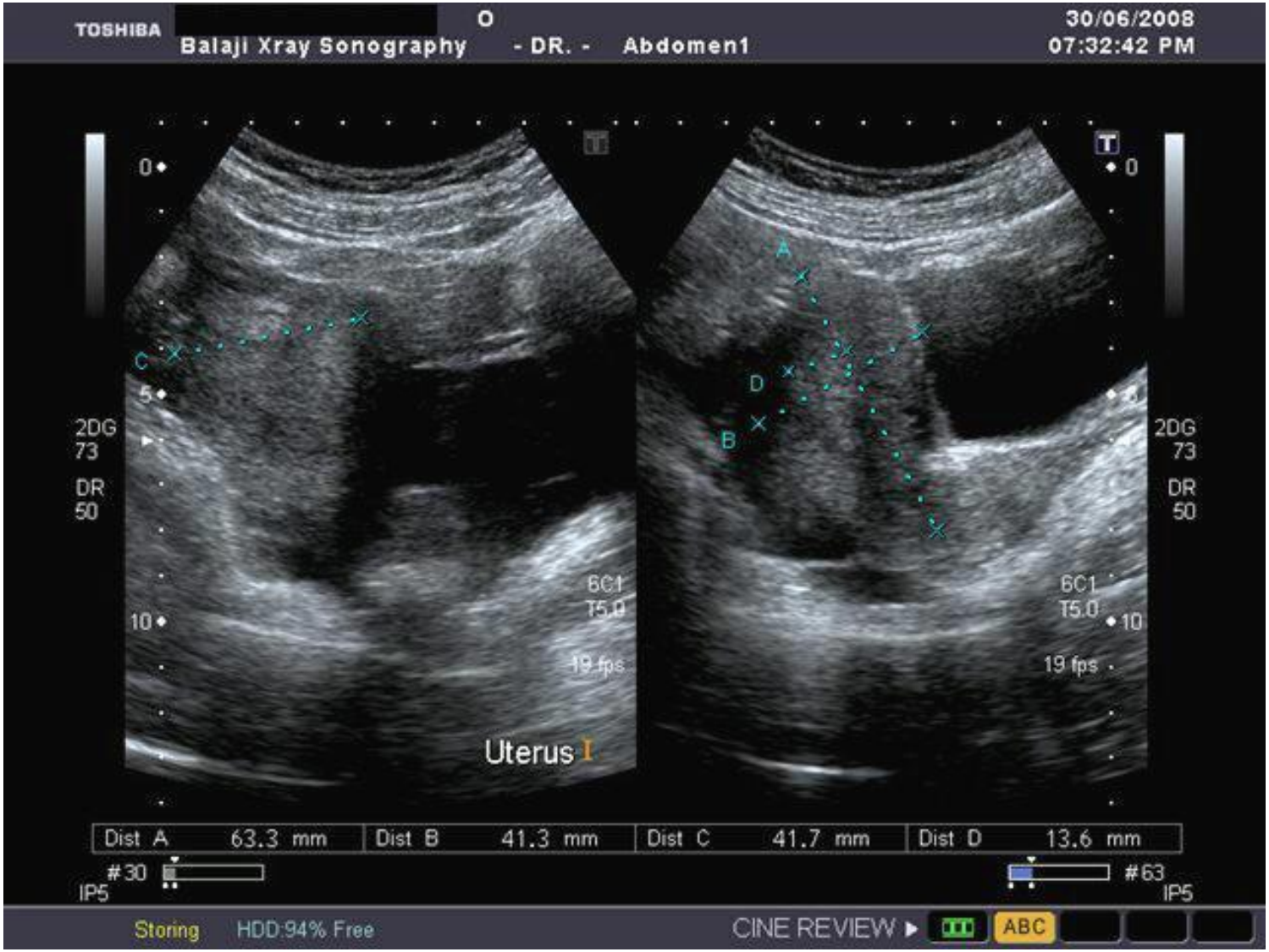
Normal FAST – Pelvis



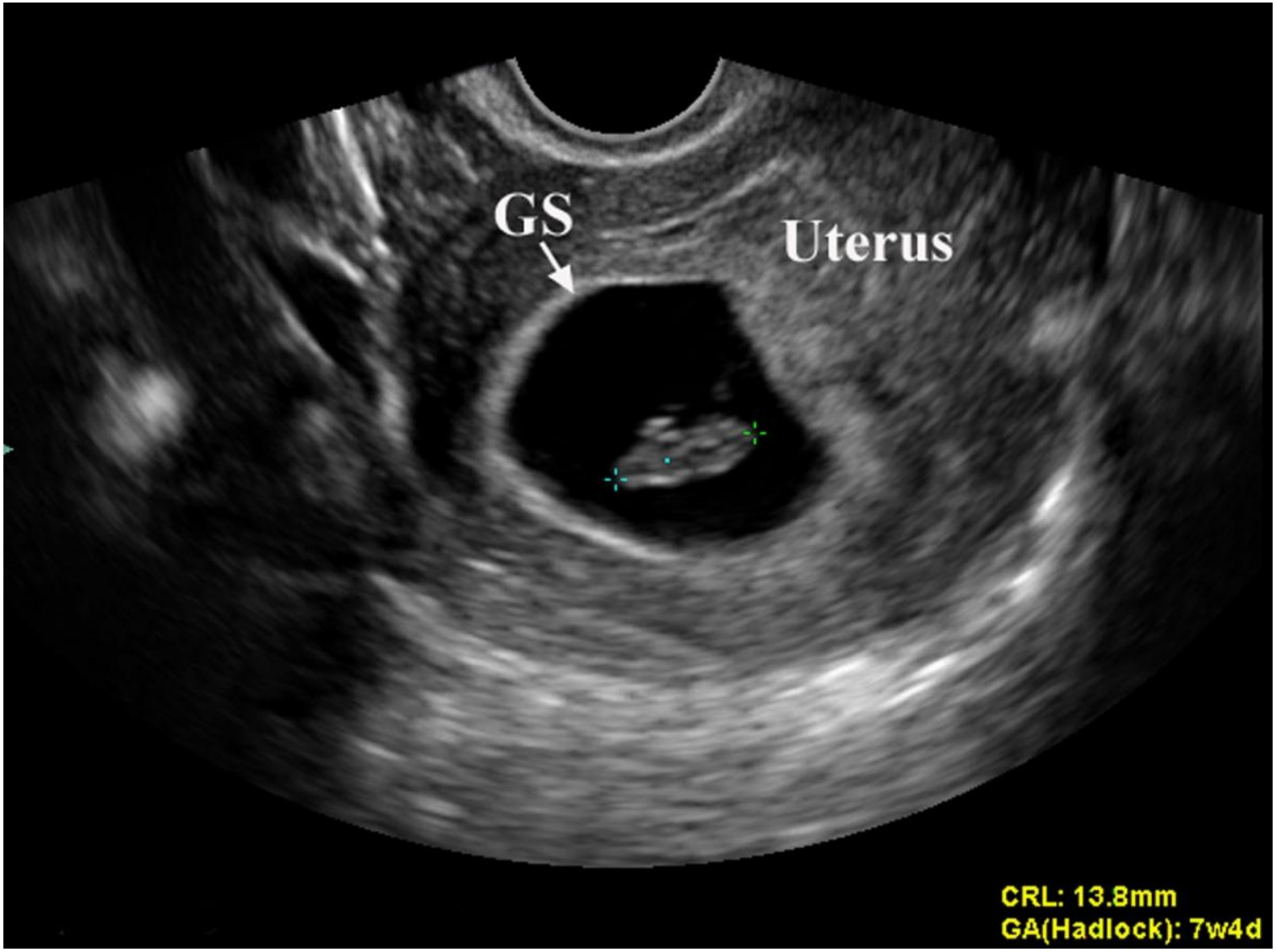
Ectopic Pregnancy 1

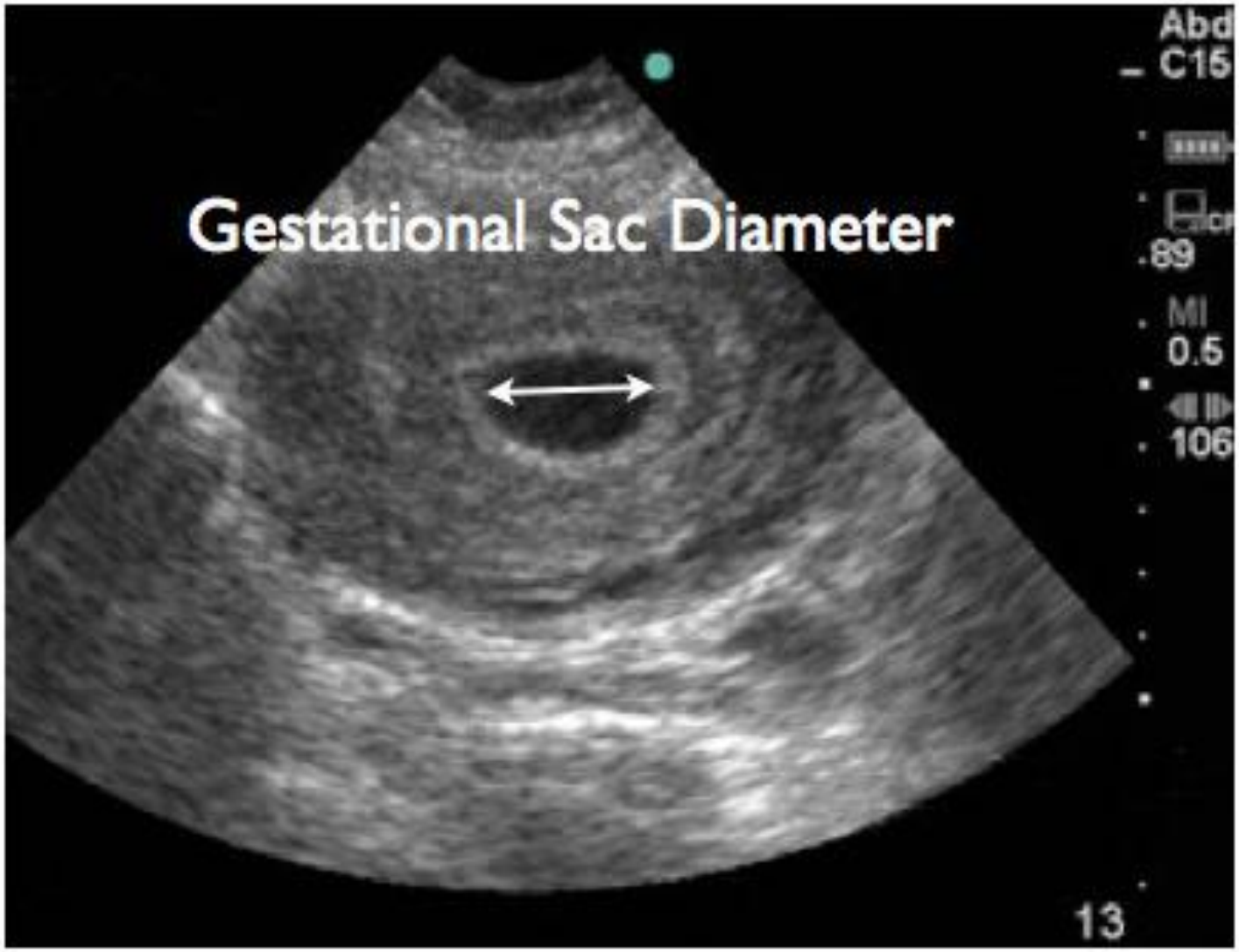


Ectopic Pregnancy 2



Crown Rump Length

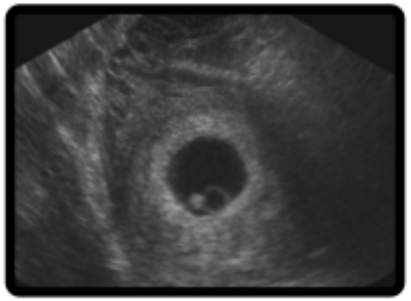




Trans-abdominal ultrasound image showing measurement of gestational sac diameter.

Trans-vaginal ultrasound image demonstrating crown-rump length measurement.

Trans-vaginal ultrasound image showing yolk sac and fetal pole.



intrauterine gestational sac with yolk sac

pseudogestational sac in ectopic pregnancy with no yolk sac and free fluid

Rule out Ectopic

Early pregnancy **and**
Abdominal pain **or**
Vaginal bleeding **or**
Syncope

Stable?

Vital signs

no

Resuscitate

sonography vs. OR
vs. CT if stabilized

yes

Fertility Therapy?

yes

OB Assessment

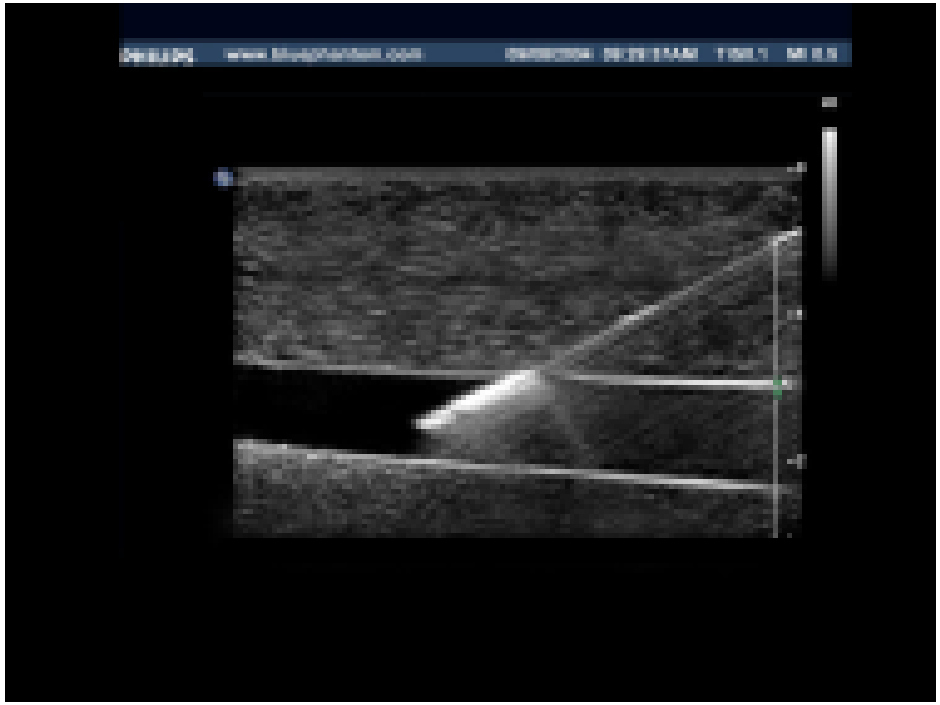
Ultrasound

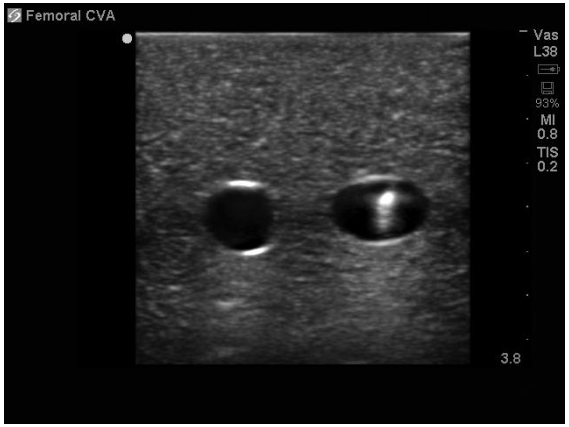
patients undergoing fertility therapy are at higher risk of heterotopic pregnancy and other dangerous conditions such as ovarian hyper-stimulation syndrome

no

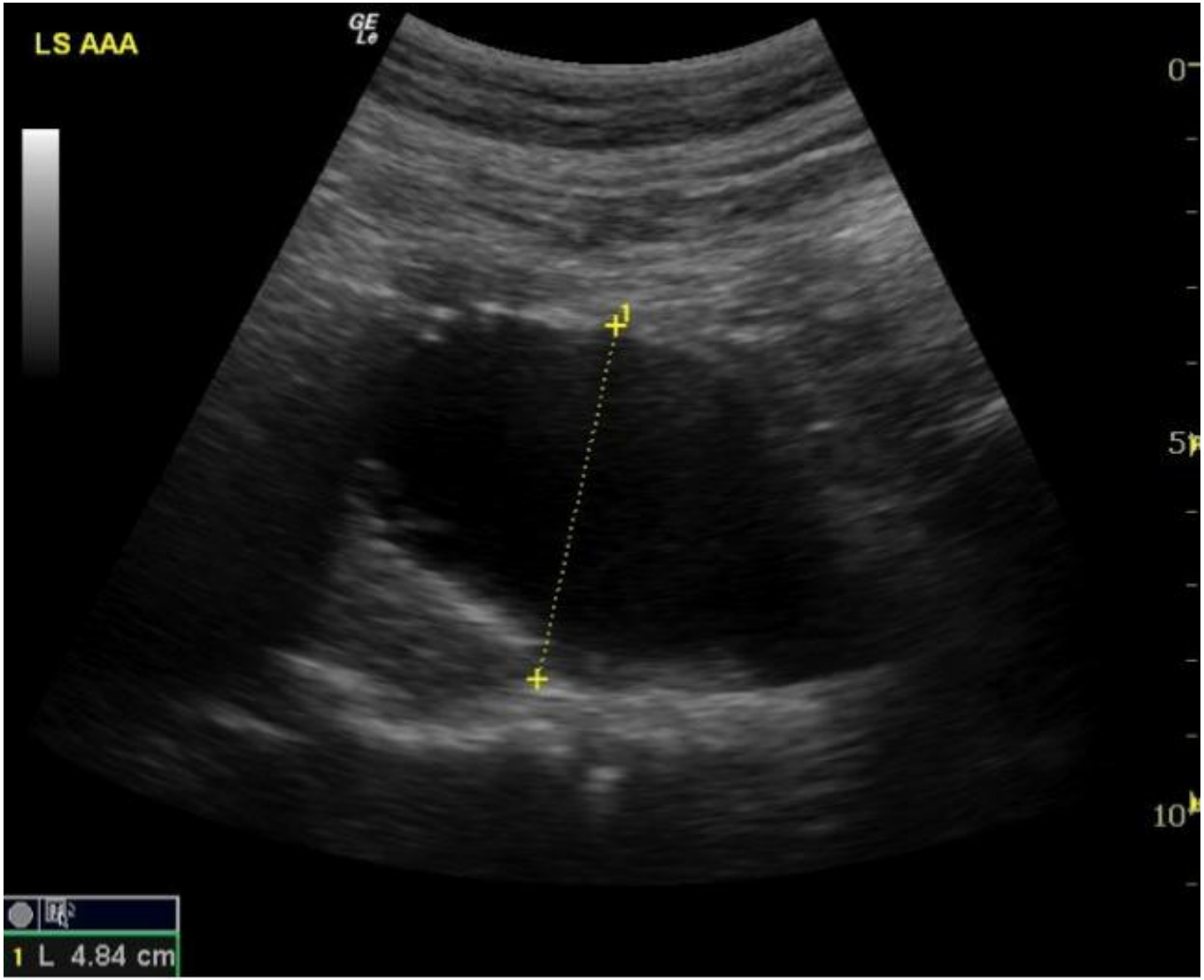
Trans-abdominal Sonography

Ultrasound IV Access





AAA



Normal Aorta