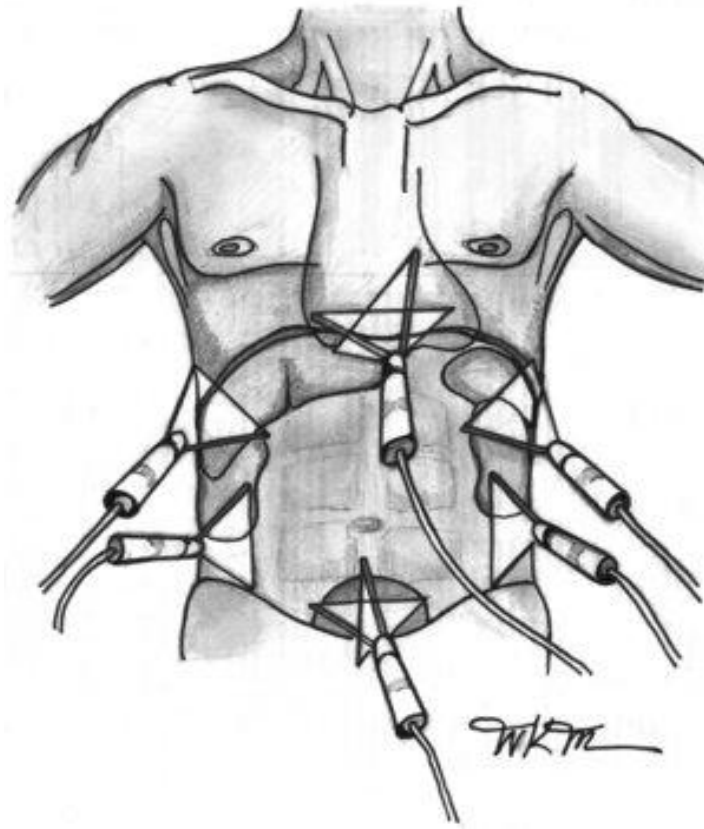


The Essentials of Emergency Department Ultrasound



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Introduction

The main purpose of this text is to teach you, in a rapid and simple manner, how to use a basic ultrasound (U/S) unit to dramatically alter your management of patients in whom you are trying to rule-in or rule-out the presence of one of five life-threatening conditions: non-cardiogenic shock, pericardial tamponade, intra-abdominal hemorrhage, ruptured abdominal aortic aneurysm, and ectopic pregnancy. These aforementioned clinical scenarios as well as biliary, renal, and procedural ultrasound are universally recognized as the key indications for U/S to be performed by emergency physicians. The latter indications will be discussed in this text as well.

To achieve the objective of making you a functional ED sonographer as quickly as possible, all extraneous information has been removed and only the essentials remain. This should not worry you. We already interpret ECGs, X-Rays and CT scans with only a vague idea of how these images were produced. So it is with ultrasound. With the help of this text, you will learn what you need to know to get a usable image on the screen and to interpret that image.

Your primary goal when performing an ED Ultrasound (EDU) is to be a *safe* sonographer. You may be surprised to find that the key to this does not lie in accurately calling an EDU positive or negative. Rather it lies in knowing when an EDU is *inconclusive*. If EDU enables you to acquire high-quality information about your patient, use it. If the information is of uncertain quality, *discard it*. In those cases, you must proceed as though the scan was not done at all and manage the patient the same way you would have before EDU. EDU is only an *adjunct* to your clinical skills, and should in no way take precedence over those skills.

This text is not intended to teach you how to be a formal ultrasonographer. This generally requires one to two years of training, most of which has little or no bearing on Emergency Medicine. Nor is this text meant to teach you how to get the most out of your ED ultrasound machine. As EDU continues to evolve, it is possible that certain advanced applications will begin to be widely used. Should you wish to pursue this avenue you are encouraged to take courses with a more specialized curriculum. As well, the textbooks suggested in the attached reading list can guide the interested physician towards other topics.

Finally, this text must be seen as only the first step in your development as an ED sonographer. Afterwards, you must do regular scans in the context of an established EDU program, in which you will benefit from continual feedback and quality assurance.

Glossary

You can't get away from this. When you learn a new technique in medicine, it comes with a bunch of new terms. Included below are basic terms that will allow you to make sense of what other U/S texts are saying. The language of this text is kept as simple as possible, often following the sonographic term with a more descriptive or intuitive expression (in brackets).

Echogenic: A material that produces echoes (i.e. U/S waves bounce off). The more echogenic a substance is, the ***whiter*** the image it produces on the screen.

Echolucent: A material that does not produce echoes (i.e. allows U/S waves to pass through). The more echolucent a substance is, the ***blacker*** the image it produces on the screen.

Hyperechoic: More echogenic (therefore whiter/brighter) than surrounding tissue.

Hypoechoic: Less echogenic (therefore darker) than surrounding tissue.

Isoechoic: Just as echogenic as (and therefore indistinguishable from) surrounding tissue.

Anechoic: Producing no echoes at all. The resulting image, therefore, will be completely ***black***.

Near-field: The ***top*** half of the U/S screen. Represents that part of the body ***closest*** to the probe.

Far-field: The ***bottom*** half of the U/S screen. Represents that part of the body ***furthest*** from the probe.

Formal Ultrasound: A "formal" for short. A scan done by ultrasound technicians or radiologists, in the Diagnostic Imaging department, with a machine that costs 5-10 times what an EDU machine costs. Also called a "confirmatory study".

Scan: U/S lingo for a sonographic examination. Can cause confusion initially, as people wonder whether one is referring to an ultrasound exam or a CT scan. In this text, "scan" always refers to an ultrasound examination. Can be used as a noun ("That guy needs a scan"), a verb ("We've got to scan this guy") or an adjective ("That guy was just not scanable")

Physics

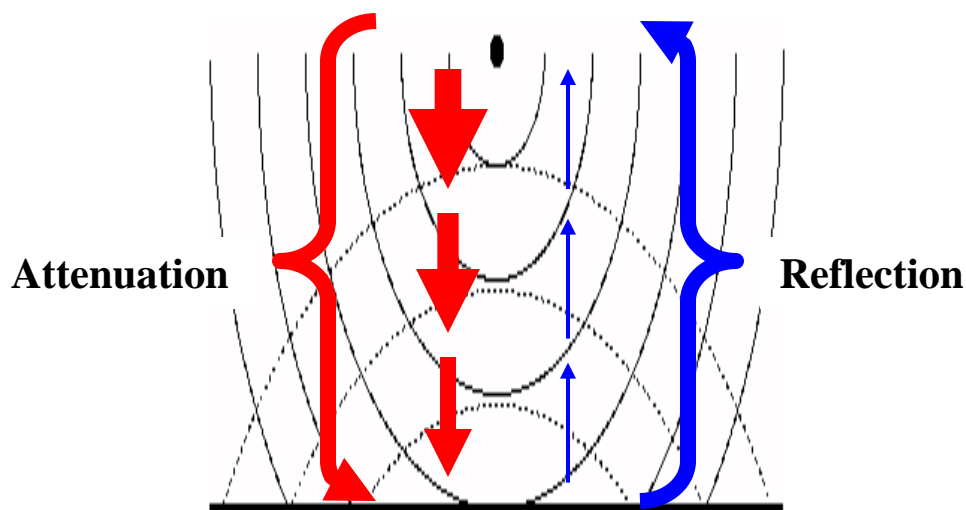
Nature of U/S Waves

Suppose you were to hit two metal spoons against each other. You would produce sound. How far that sound could be heard would depend on 1) how hard you hit the spoons together and 2) the medium through which the sound waves had to travel. If a listener were on the other side of a thick brick wall, he would not hear you at all. On the other hand, if you and your listener were both underwater, he could hear you at a great distance. And if you were in a canyon or a cathedral, you could hear your own echo, but you might have a difficult time telling where the echo was coming from.

You can read whole chapters about the nature of U/S waves, but they behave no differently from any other sound waves. They travel well through some media, worse through others, and can bounce off virtually anything. Keep the above analogy in mind as we discuss the physics involved.

Image Generation

When ultrasound waves are able to pass through a medium, they continually lose some of their energy to the tissues through which they pass, a process called *attenuation*. The energy lost is converted into a negligible amount of heat. Another fraction of the waves' energy is *reflected* back towards the waves' original source. It is this reflected energy, like the "echo" of sonar on a submarine, which enables the U/S machine to generate the image we see on the screen. Don't worry about how it does it; just accept that that's how it works.



Attenuation

A few more words on attenuation. As explained above, U/S waves gradually lose their energy as they pass through tissue. Eventually, they don't have enough energy to generate a reflected echo strong enough for the U/S machine to receive. No echo, no image. So there is a limit to how deep into the body you can see. Does this matter? No. Everything we want to see is well within range of the average EDU probe.

Effects of Different Tissue Densities

Ultrasound waves, as was mentioned, are like any other sound waves: they travel well through some media, less well through others and not at all through some. This is a function of the *resistance (or impedance)* of a particular tissue. In the case of ultrasound, the waves travel very well (low resistance) through liquid (blood/urine), reasonably well through solid organs (liver/spleen) and not at all through bone (high resistance). Gas is a separate issue. The ultrasound waves have no trouble passing through gas but are deflected in all directions. This is called *scatter*¹. The practical implications of this are:

- 1) **Blood** is easy to recognize. Like any other liquid, it appears as a completely anechoic ("black") area on the U/S screen because U/S waves travel so well through it that there is virtually no echo reflected back towards the probe. If you see black where it should not be, call a surgeon.
- 2) **Solid organs** (and urine in a full bladder) can serve as "acoustic windows", allowing the U/S waves to penetrate deep into the body.
- 3) **Bone** reflects 100% of the U/S waves that hit it. All of that reflected energy shows up as a bright, white area on the screen. No waves beyond the bone, however, means no image either. The area behind the bone, therefore, is entirely black. Bone can be the bane of our existence, as the ribs conspire to get in the way at the most inopportune times. However, it can also be very useful, as when the spine serves as an important landmark.
- 4) **Gas**, in our case, is almost always bowel gas (though subcutaneous emphysema and other pathological gas-forming processes can intrude). The deflection of the U/S waves caused by the gas gives the screen a "black snowstorm" appearance, from which no useful information can be obtained. Gas can also be a problem outside the body. If there is air between the probe and the skin, the U/S waves will be scattered before even entering the body. Luckily, this problem can be solved through the application of generous amounts of U/S gel, which forms an acoustic "connection" between the probe and the skin.

¹ Scatter also refers to the deflection of U/S waves that occurs when the probe head is not at right angles to the surface being "interrogated" (looked at). This is not much of an issue for the purposes of this course, but you will need to be aware of this term when you do further reading.

Tissue Interfaces

Our ability to distinguish between structures depends not only on their different densities, but also, and especially, on the *interface* between those different densities. The more pronounced the interface² (e.g. blood against a solid organ, rather than contused splenic tissue against normal splenic tissue), the easier it is to identify the structures or material involved. For example, consider tissue interfaces of an abnormal FAST:

- blood between kidney and liver
- blood between kidney and spleen
- blood between myocardium and pericardium

This contrast makes image *recognition* very easy.

Modes of Transmission

EDU work is done in B (for “Brightness”) mode. The other modes are:

- A (“Amplitude”)
- M (“Motion”)
- D (“Doppler”).

Does this matter? No. Generally, only the B mode is used in the ED.

² Another way of saying this would be “the greater the difference in echogenicity”.

Frequency, Penetration, and Resolution

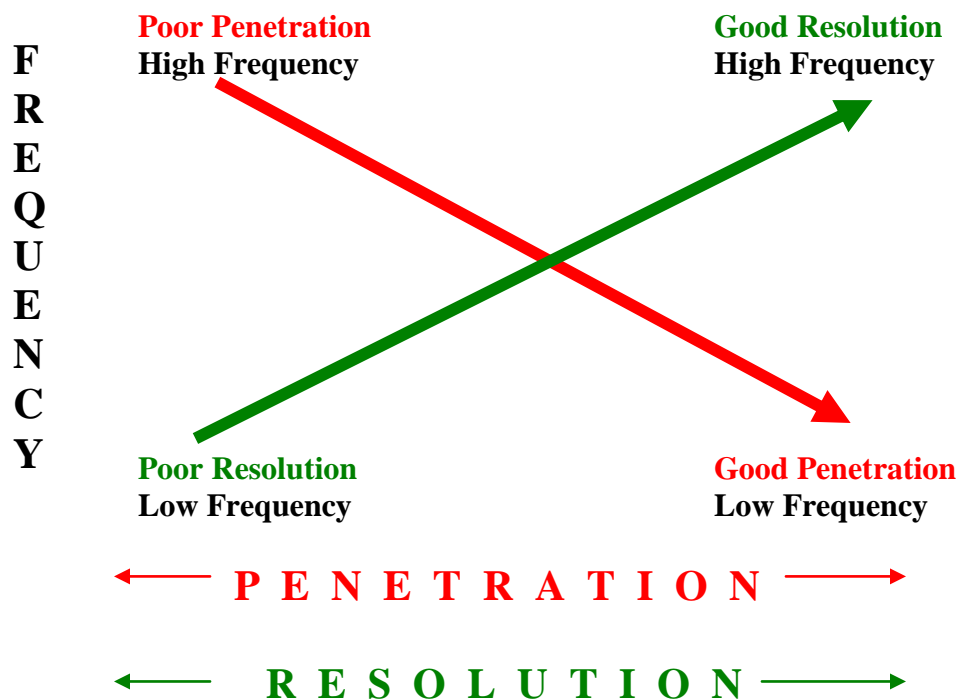
EDU probes have a frequency in the 2.5 - 10.0 MHz range, with the majority being 3.5 MHz³. It is important to understand the relationship a probe's frequency will have to its performance, specifically with regards to *penetration* and *axial resolution* (the ability of the waves to distinguish between two objects at different depths)⁴.

As frequency increases, penetration decreases and resolution increases and vice versa.

LOW FREQUENCY: GOOD PENETRATION, POOR RESOLUTION

HIGHER FREQUENCY: POOR PENETRATION, GOOD RESOLUTION

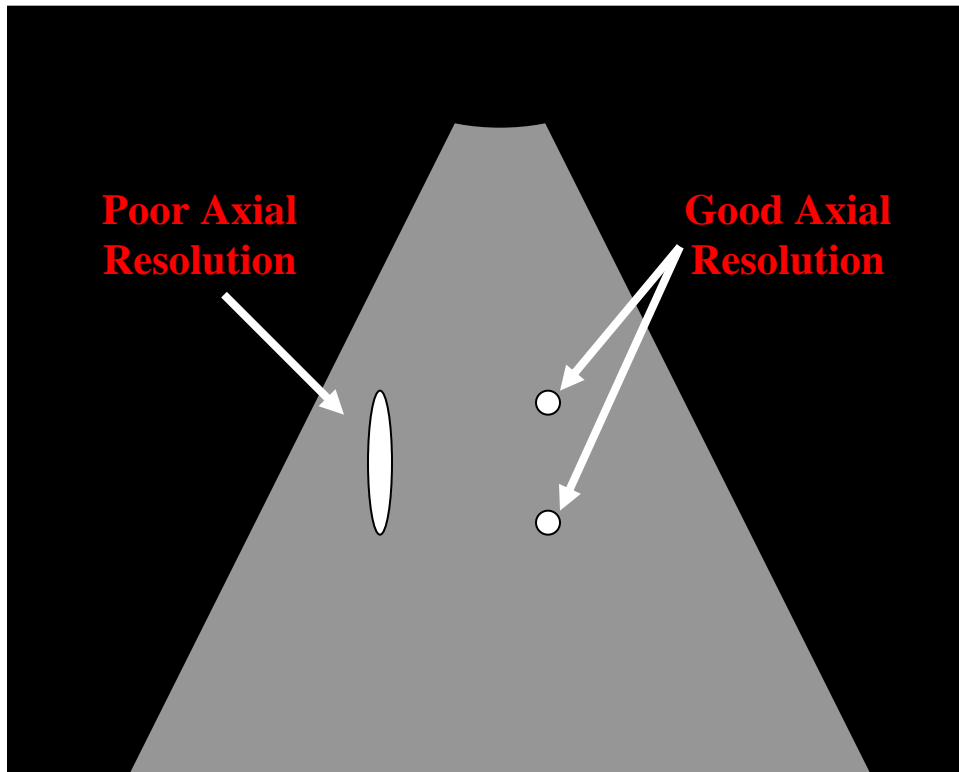
THEREFORE, always use the highest frequency you can that still allows you to penetrate down to the structure of interest.



³ The exception is the endovaginal probe, which is usually a 5.0 MHz probe. A higher frequency is used here because 1) the objects of interest are much *closer* to the probe than they are elsewhere and 2) the objects of interest are much *smaller*.

⁴ There is also the term *lateral resolution*, which refers to the ability of the U/S waves to distinguish between two objects at same depth, but separated along a right-to-left axis. This is not an issue of frequency but rather of focus, and will be addressed later.

Axial Resolution



Axial resolution: The ability of a scan to determine whether a big echogenic blob is actually two smaller echogenic blobs *one on top of the other*. Axial resolution improves as frequency *increases*.

(Note: Get used to the above diagram, which represents the classic pie-shaped ultrasound screen. You'll be seeing it often.)

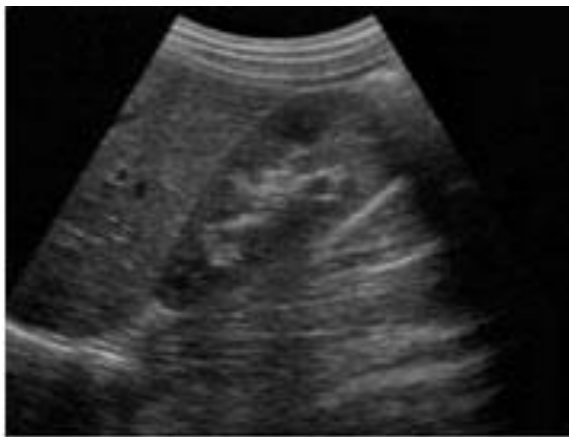
A low frequency probe, therefore, is good for peering deep into the body (into the chest and abdomen) to look at relatively large objects. However, as discussed above, the use of a low frequency probe decreases the axial resolution; i.e., the ability to discern whether or not an echogenic structure is actually two separate structures. Smaller objects, like foreign bodies near the surface, are better identified with a high frequency probe that provides greater axial resolution. Most of what we do in the ED is with a 3.5 MHz probe (plus a 5.0 MHz for the endovaginal work).

Probes

Ultrasound probes (also called “transducers”) suffer from unfortunately confusing nomenclature. We will try to clarify this terminology here. If you get frustrated with these terms, relax. They have little bearing on your ability to obtain a good ultrasound image.

The two key terms are FORMAT and ARRAY

FORMAT refers to the field of view produced by the probe. There are two formats: sector and linear. Sector format probes produce the familiar pie-wedge-shaped field of view. Linear format probes produce a rectangular field of view and are used for viewing objects close to the surface.



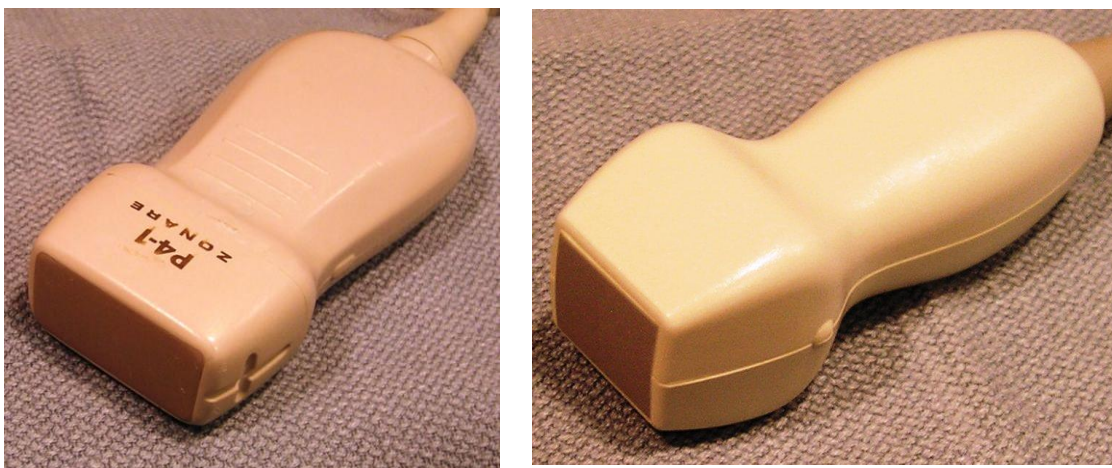
Sector Format
(Pie-shaped Field of View)



Linear Format
(Rectangular Field of View)

ARRAY refers to the way the crystals (the elements which vibrate to produce the ultrasound waves) are arranged. These can be phased, curved, or... linear. But this “linear” has nothing to do with the earlier “linear”. Got that?

Phased array probes have a flat footprint (aka, the probe’s “face” or the area through which sound leaves and returns to the probe) that produces a sector shaped format. The crystals of a phased array probe are clustered to a small area underneath its face. With a smaller footprint, phased array probes tend to be more compact, allowing for greater maneuverability while still being adequate for the task at hand. Phased array probes are often used for imaging the heart as the aforementioned smaller footprint allows for easy intercostal imaging. Abdominal imaging is also possible with lower frequency phased array probes, and again they can be advantageous when working around or between the ribs in either upper quadrant.



Phased Array Probes

Curved array probes, as the name implies, have a curved footprint that produces a sector shaped format. Due to the fact that its crystals are arranged along the length of its curved face, the curved probe produces a sector-shaped image larger than its footprint. Low frequency curved probes are used for deeper imaging in the chest, abdomen, and pelvis, whereas high frequency curved probes are used for endocavitary (i.e.; transvaginal) imaging.



Curved Array Probes

Linear array probes have a flat footprint that produces a rectangular format. As with curved array probes, the crystals of linear probes are arranged along the length of its face. Typically, linear probes are used to view superficial structures, and generally produce higher frequencies.



Linear Array Probes

Understanding EDU Images

Insofar as they are two-dimensional representations of three-dimensional structures, U/S images are not significantly different from X-Ray or CT images. The trick is to generate the image you want. Ultrasound involves two distinct learning curves – image recognition and image acquisition. Image recognition in EDU is easy. Image acquisition can be tricky, and can often be frustrating.

To begin with, the ED sonographer must get used to the different orientations in which images appear on the screen. Then, there are a number of things that can be done to electronically modulate the image (“knobology” in U/S lingo). Both of these will be dealt with in greater detail in the following sections.

To become a competent ED sonographer you will have to first develop the ability to visualize those internal, three-dimensional structures in two dimensions. This is the cognitive challenge of EDU (we’ll talk about the physical challenge later). This is harder than you might think as the planes of view are often off-kilter and the organs imaged are usually only partly seen. Don’t panic! These obstacles can be overcome.

Planes of View

This section has most people scurrying back to their basic anatomy books, because U/S texts like to use the terms that describe certain planes of view more or less interchangeably. For instance, the longitudinal axis is often referred to (technically incorrectly) as the sagittal or the coronal plane. But who cares? What we need to do is agree on two terms, one in which the probe is placed along a line running head-to-toe and one in which it is placed along a line running left-to-right. So, for the purposes of this text:

Longitudinal view: Probe placed along the body (i.e. head to toe).

Transverse view: Probe placed across the body (i.e. left to right).

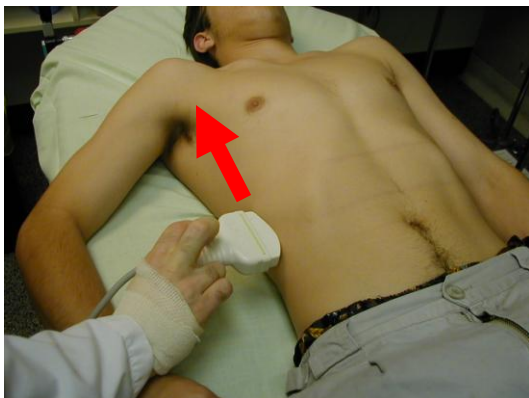
Of these two, the transverse plane will be the easiest to grasp, as it reproduces a CT image: as you look at the screen, the patient’s head is away from you, the patient’s feet are towards you, and the patient’s right side corresponds to the screen’s left side. The longitudinal view is somewhat less intuitive. It will show a wedge-shaped section of the body, with the left side of the screen corresponding to the cephalad direction (illustrated in the next section).

These terms are useful to give you a starting point. Much of our work will be done in views that are not purely longitudinal or purely transverse, but it is easier to start from a known point and modify it (i.e. “start in the longitudinal plane and rotate 90° clockwise”).

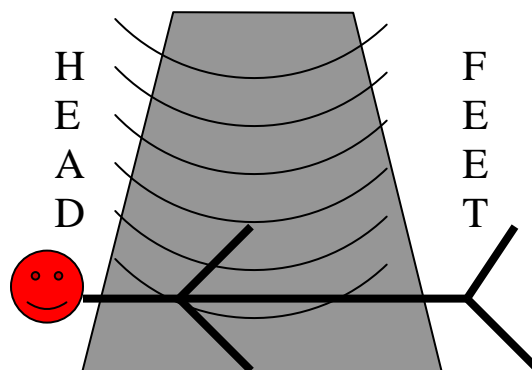
Probe Placement

The first step in generating a high-quality, reproducible image is to be consistent in the way the probe is applied to the body. By convention, this means that when the probe is angled longitudinally (i.e. head-to-toe), the left side of the screen (as you look at it) corresponds to the cephalad side. The probe marker (red arrow) is pointed towards the patient's head. Throughout this text, you will note these red arrows to remind you of the proper probe indicator orientation.

Probe in *longitudinal* view

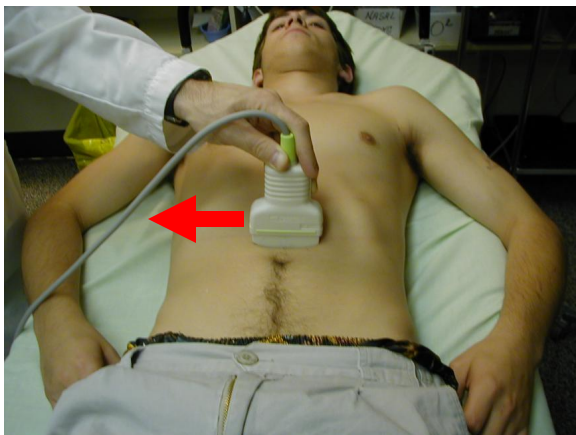


Left side of screen *cephalad*

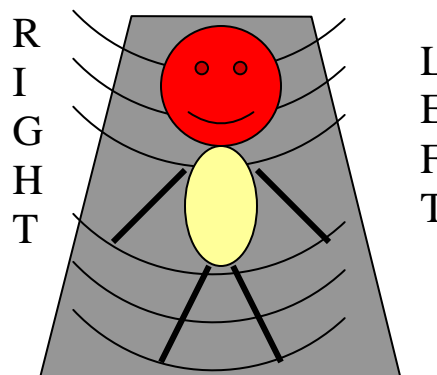


When the probe is in a transverse orientation, the *left* side of the screen (as you look at it) corresponds to the patient's *right*, much like a *CT image*. The probe marker (red arrow) is pointed towards the patient's right.

Probe in *transverse* view



Left side = Patient's *right*



Finally, remember that the part of the body closest to the probe will *always* be at the *top of the screen*, no matter what orientation you are in. Beginners often try to interpret what they see in terms of anterior-posterior, with “posterior” being the bottom of the screen. Get into the habit of thinking in terms of “*near-field*” (monitor top) versus “*far-field*” (monitor bottom).

Probe Orientation

Orienting the probe is usually easy because most of them have a reference mark – a small piece of raised plastic, bar, or groove on one side, which is the side you should orient towards the patient's *head* or towards their *right* side. This isn't always the case, though. Some probes do not have this handy little knob, so get into the habit of manually confirming that your orientation is correct before you place the probe on the patient. To do this, simply tap one side of the probe head and watch the screen. You will easily be able to see whether your finger appears on the left or the right side of the screen. This is analogous to the habit many of us have of tapping our stethoscopes to ensure we have not rotated it the wrong way.

Probe Reference Marks



It is interesting to note that, as a sign of their rugged individualism (or just their contrarian nature), cardiologists orient their probes exactly opposite to the way everybody else does. For them, the indicator points to the patient's left, which means that the left side of the screen will show the left side of the patient. There is no logical reason for this, but they get pretty touchy if you question this practice. The result is that considerable confusion exists in the EDU literature, as some sources show the left ventricle on the right, while others show it on the left. Does this matter? No. The things we are looking for in ED echocardiography (global cardiac function and pericardial effusion) are utterly unaffected by the orientation of the probe.

However, in the interest of consistency, most emergency sonographers have adopted the cardiologist's convention of reversing the direction of the probe indicator for the parasternal and apical cardiac views. In other words, the probe marker is oriented towards the patient's left, instead of the right as with most other emergency ultrasound applications.

Centering the Image

As mentioned above, the probe marker is *always* oriented towards the patient's *right* or towards the patient's *head*. There is a very good reason for this. When scanning, you will be constantly required to "*Center the Area of Interest*", i.e. to bring the image you are most interested in towards the center of the screen. To do this, you will have to move the probe one way or the other. Sounds easy, but it's trickier than you might think. If you follow the rule above (probe always to patient's right or patient's head), then the following directions will also always apply:

In the Longitudinal view

To move the Area of Interest to the *right*, move the probe *cephalad*.

To move the Area of Interest to the *left*, move the probe *caudad*.

In the Transverse view

To move the Area of Interest to the *right*, move the probe to the *patient's right*.

To move the Area of Interest to the *left*, move the probe to the *patient's left*.

By consistently placing the probe on the patient in the *same way* every time, you will more rapidly develop the ability to move the image you see on the screen so as to *Center the Area of Interest*.

Probe Manipulation

There remains the actual physical skill to be considered, and this is quite important in and of itself. Very small movements of the sonographer's hand can result in alterations of the plane being scanned of 10, 20, 30 or even 45 degrees. Since the image you seek may lie in *only one plane*, it can be surprisingly difficult sometimes to align the probe correctly. The key is *slow* hand movements. If you go quickly, you can go right through the plane you are looking for without realizing it. This is particularly true in endovaginal ultrasound, where the structures of interest are much closer to the probe head. This cannot be emphasized enough. Move your hand *sl-o-o-o-o-o-w-ly*.

Although you should move the probe slowly, this does *not* mean not to move the probe along at all. If you do not see what you need with slow hand movements, move the probe in progressively widening circles to scan the area for the structure of interest. Too often novice sonographers fixate on one spot on the skin, making only micro-adjustments of the probe position to no avail.

It is also a good idea to teach yourself to be *ambidextrous* from the beginning. The ED environment often imposes restrictions on where you can stand. Learn to always hold the probe in the hand which is *next to the patient*. This leaves your other hand free to manipulate knobs, adjust the screen, reach for more goo, etc.

Image Modulation

Like a TV set, an EDU machine has various dials and knobs which can be tweaked in an effort to coax out a better image (the above-mentioned “knobology”).

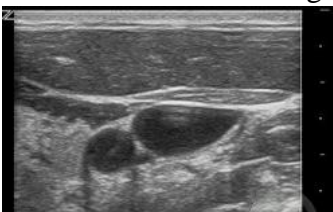
Power

Remember that U/S waves “attenuate” (lose energy) as they go through any tissue. Increasing the power enables you to push U/S waves through tissue in which you are not interested (usually fat) to get to tissue in which you *are* interested (like the aorta). This feature may not be available on the lower-end machines. This is only a problem in the most obese patients (whose aorta may be out of range) or in extremely barrel-chested individuals (whose heart may be too far from the probe to be seen).

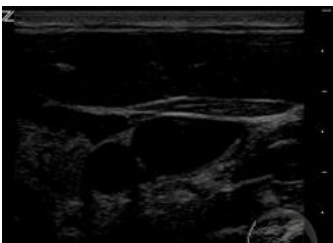
Gain

The gain dial allows you to modulate the strength of the signal returning to the probe. Remember that as more energy returns to the probe, the image on the screen appears whiter/brighter. Conversely, if less energy is reflected to the probe, the image appears darker. Gain allows you to electronically increase the sensitivity of the probe, which allows you to modify the apparent strength of the return. This makes the screen whiter or darker, which enables you to enhance certain structures. If you want to make an *echogenic (white)* structure stand out, you would *increase* the gain. If you were most interested in an *anechoic (dark)* area, you would *decrease* the gain.

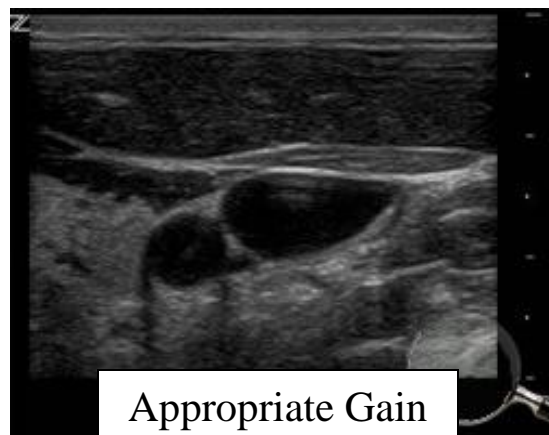
Gain is analogous to the squelch dial on a radio. Turn it down and you hear less static, but you might lose the signal you want to receive. Turn it up, and you have no trouble receiving, but there can be a lot of static. As you develop an “ultrasound eye”, you will find yourself gradually turning the gain down, as you become accustomed to picking out ever more subtle shadings.



Increased Gain



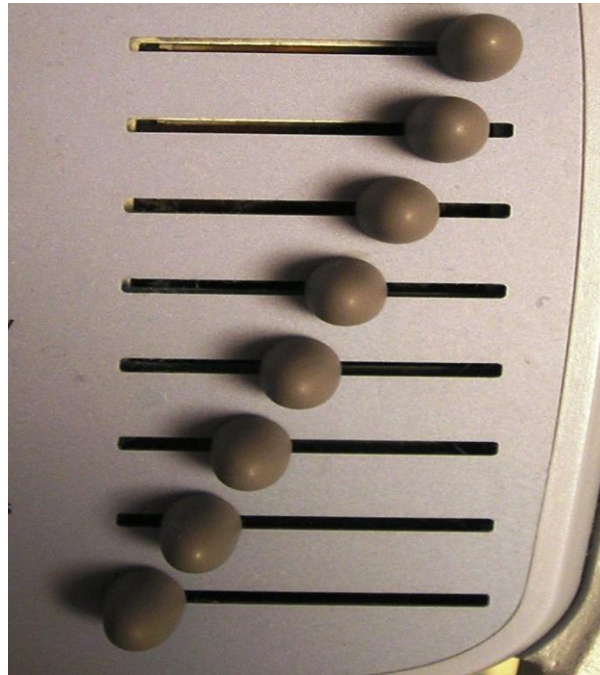
Decreased Gain



Appropriate Gain

Time-Gain Compensation

Some machines have a more sophisticated version of gain called Time Gain Compensation (TGC). This is a series of sliding knobs that look like this:



There is nothing complicated about TGC (except maybe the name). TGC is similar to the equalizer bar on some audio systems which allows you to fine tune the strength of the low versus high frequencies. With TGC, you can fine tune the gain at a specific depth while leaving the rest of the field unaffected.

Remember that sound is progressively *attenuated* as it penetrates tissue, so that for deeper structures in the far field less sound energy is still available to return to the probe. All else being equal, echoes from deep structures in the far field would therefore appear less bright on the screen. You can compensate for this by adjusting the TGC appropriately for any given depth to provide an image with even intensity throughout. A good rule of thumb is to begin all scans with all sliding TGC knobs at the midline, which will then allow you to adjust for attenuation based on the near- and far-field echogenicity of each individual study.

Further, U/S machines also utilize a main gain dial, which controls the overall gain of the entire image as a whole.

Our Emergency Department houses two main ultrasound machines: a Micromaxx manufactured by Sonosite, and a Z.one *ultra* manufactured by Zonare.

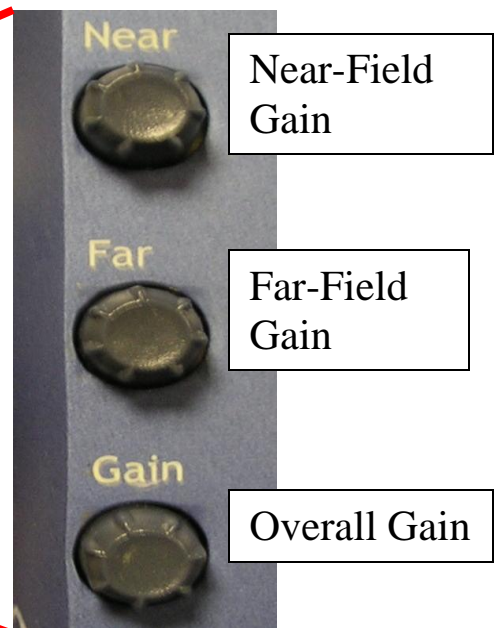
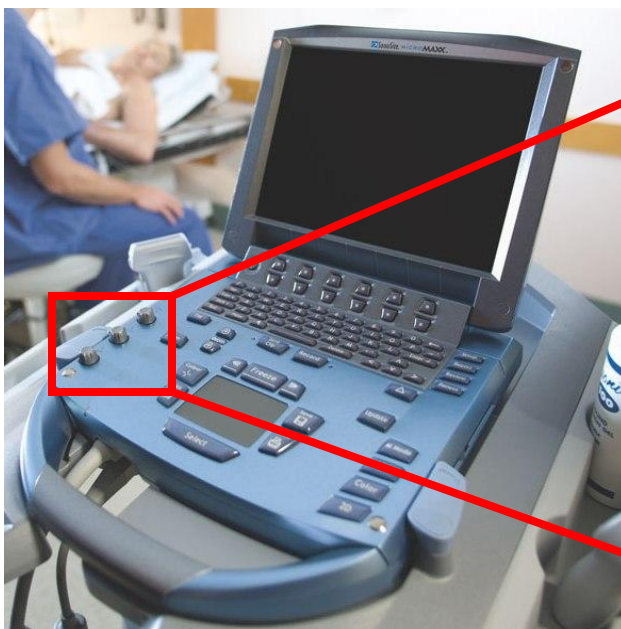


Sonosite Micromaxx

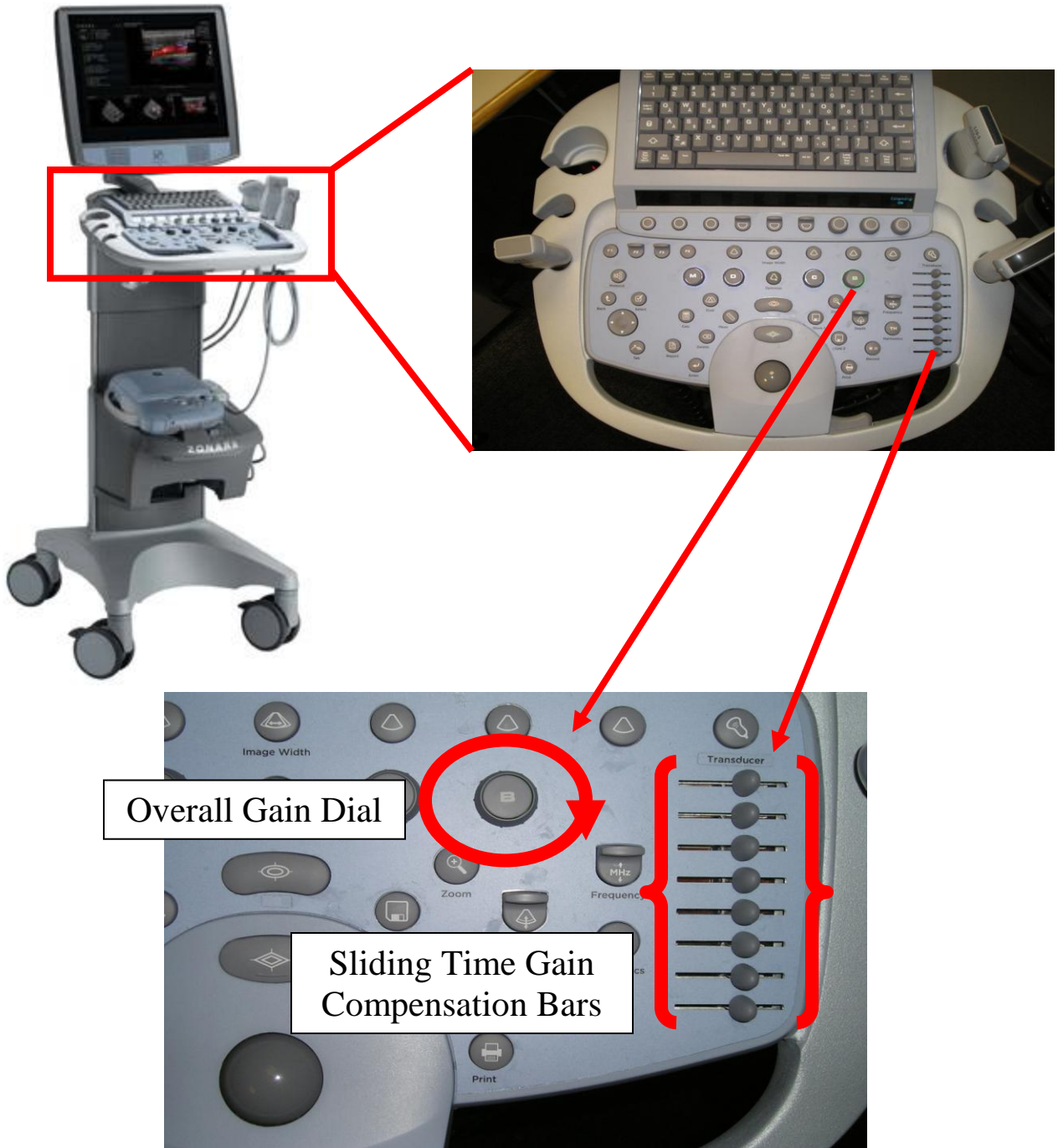


Zonare Z.one *ultra*

The Sonosite, allows you to control the gain of the image as a whole, or the gain in the near- or far-field individually by turning one of three dials located at the left side of its face.



The Zonare allows you to control the overall gain by turning a dial that exists around the B-mode button located at its mid-right face. The Zonare will also allow you to control the near- and far-field gain individually with a series of sliding time gain compensation bars at its far right face.



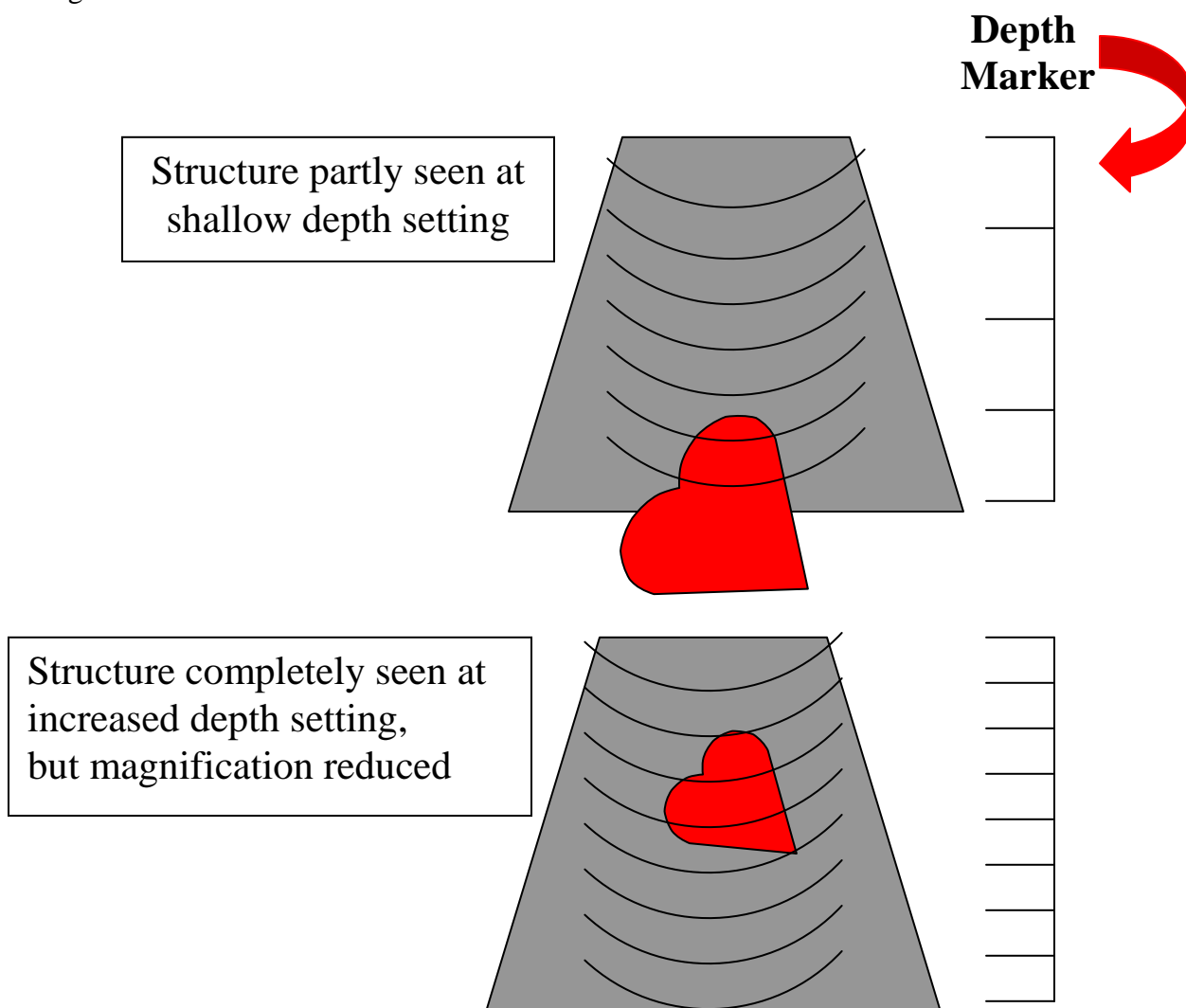
Depth

The U/S machine receives echoes from various depths in the body. You can regulate how much of that depth is displayed on the screen. You will use maximum depth when trying to find a deep object (e.g. the heart of a barrel-chested COPD'er) and minimum depth when looking for a shallow object (the hepatorenal space in a skinny child). The corollary here is that ***the less the depth, the greater the magnification*** – objects seen on minimum depth will appear larger than when seen on greater depth settings.

Depth essentially adjusts the field of view to bring the image “closer,” or move the image “further away.” Depth can be thought of as a “zoom in” or a “zoom out” function (not to be confused with the actual *zoom* button on the U/S machine).

You can determine the current depth setting at a glance by looking at the centimeter marks on the side of the screen and the corresponding numeric value listed below these marks. Practically speaking, the more centimeter markings there are, the greater the depth.

As a general rule, set the depth to near maximum whenever you begin a new scan. Once you have the structure(s) of interest on the screen, you can decrease the depth to achieve magnification.





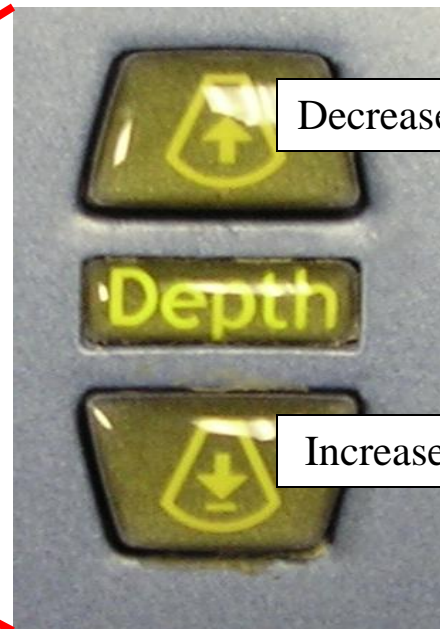
Decreased Depth



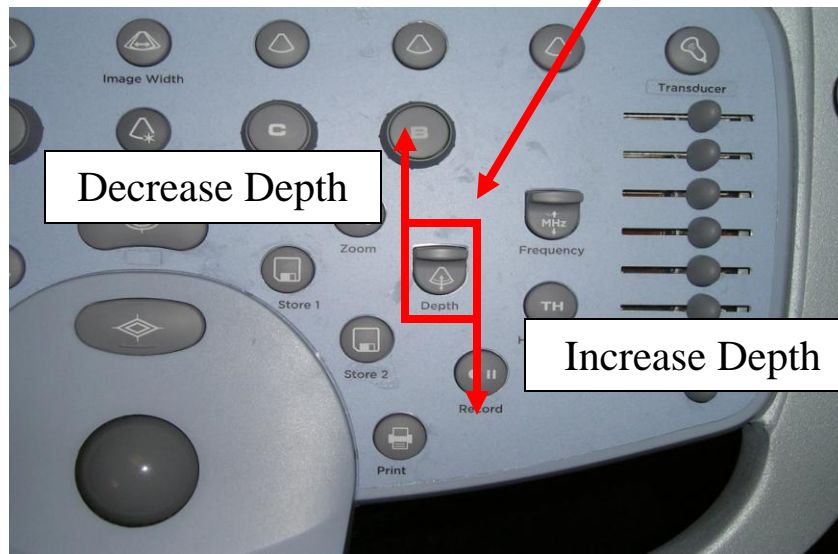
Increased Depth

Further examples of depth are illustrated by these images of the internal jugular vein (IJV) and carotid artery (CA). As you can see, at decreased depth, the IJV and CA appear closer or “zoomed in,” while at increased depth these same structures appear farther away, or “zoomed out.”

The Sonostite allows you to increase or decrease depth by pressing the appropriate vertically oriented button located on the left side of its face.



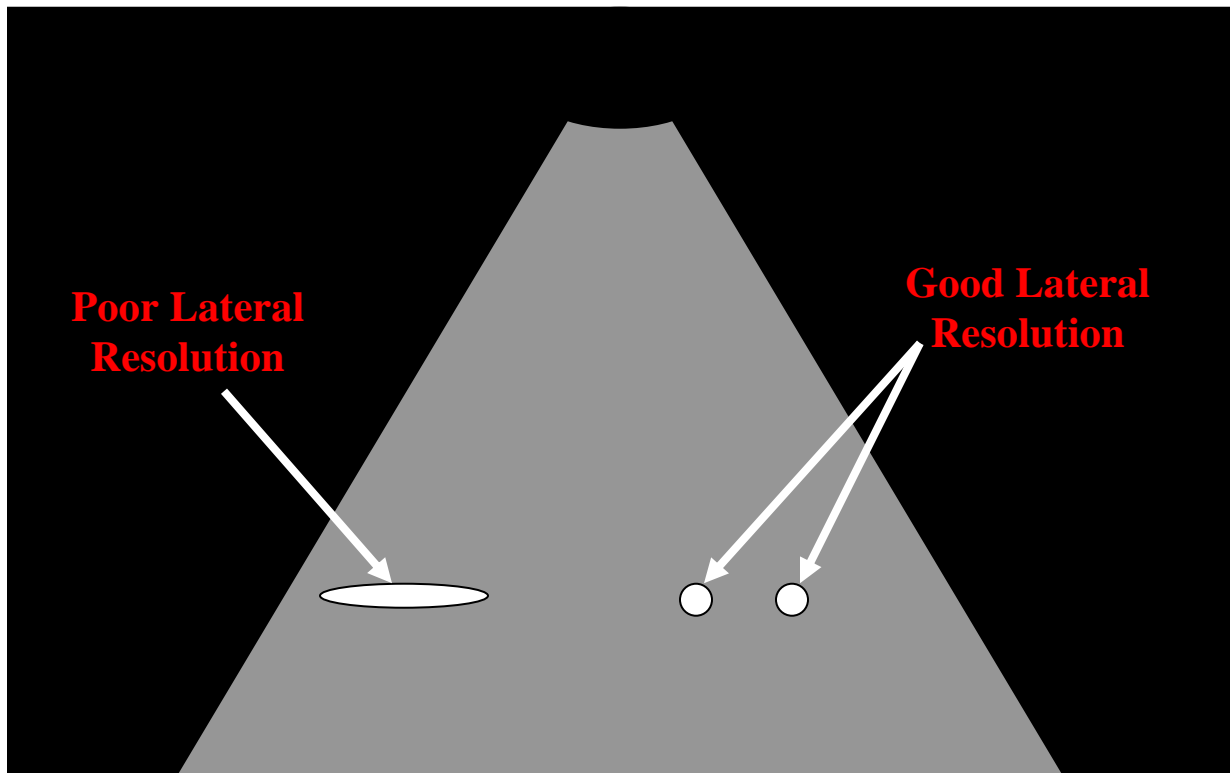
The Zonare allows you to control depth by toggling a control button located on the right side of its face.



Focus

Some machines allow you to focus the U/S waves at a particular depth. This enables you to improve the *lateral resolution*⁵ at that depth. In other words, you are better able to distinguish that a big echogenic blob is actually two smaller echogenic blobs at the same depth. This is of limited utility, with the possible exception of twin gestations (and even there it would fall into the “nice to know” category, rather than the “need to know”).

Lateral resolution



⁵ Sometimes called *transverse* resolution.

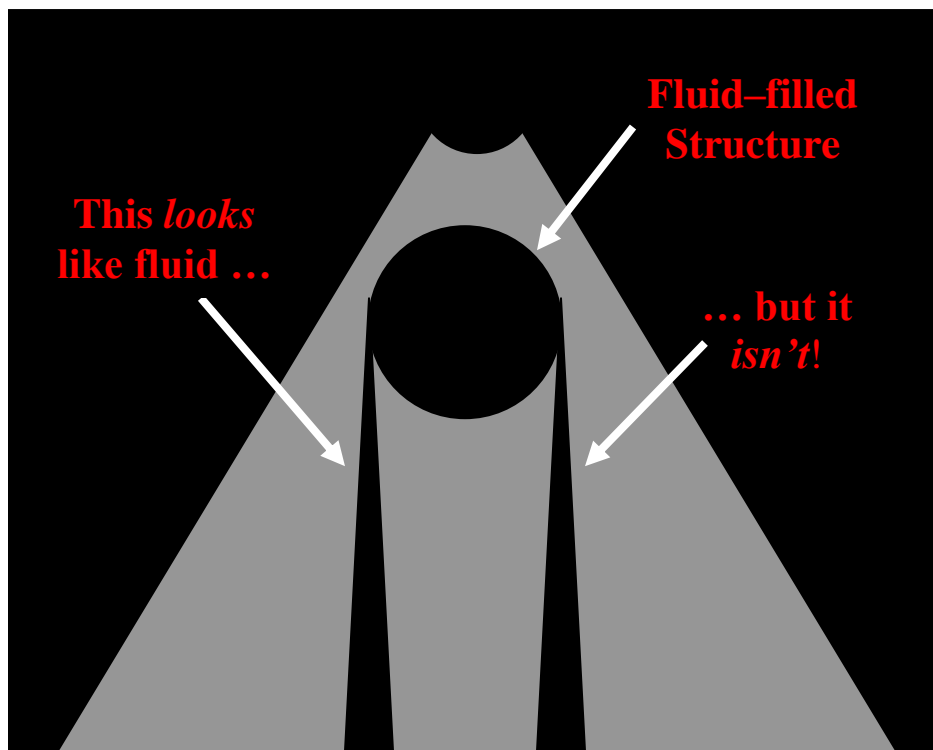
Artifact

As with everything that comes out of Diagnostic Imaging, there is always the question of whether or not the image you are looking at is real or not. There are several ways a U/S machine can try to fool you, but fortunately the things we are looking for are not easily affected. However, you should be anware of the following three types of artifact because 1) they are the most common, and 2) the first two can imitate free fluid – something in which we are most interested.

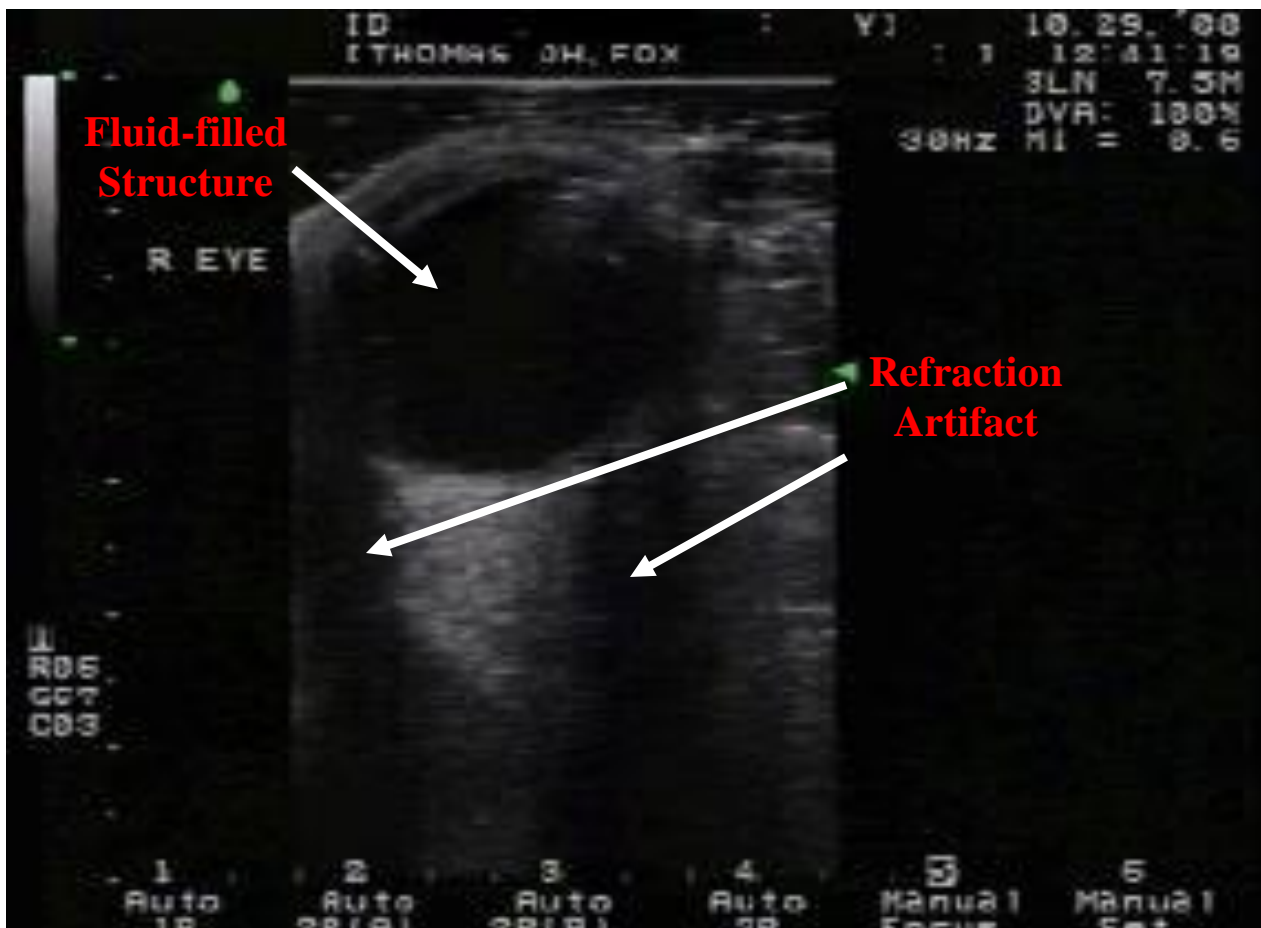
Refraction

As the name implies, this occurs when the U/S waves are deflected from their original path by passing close to a large, curved, fluid-filled structure (in our case, usually the bladder or gallbladder). The result is a shadow-like image that seems to project from the edges of the curved structure. Also called edge artifact.

Refraction



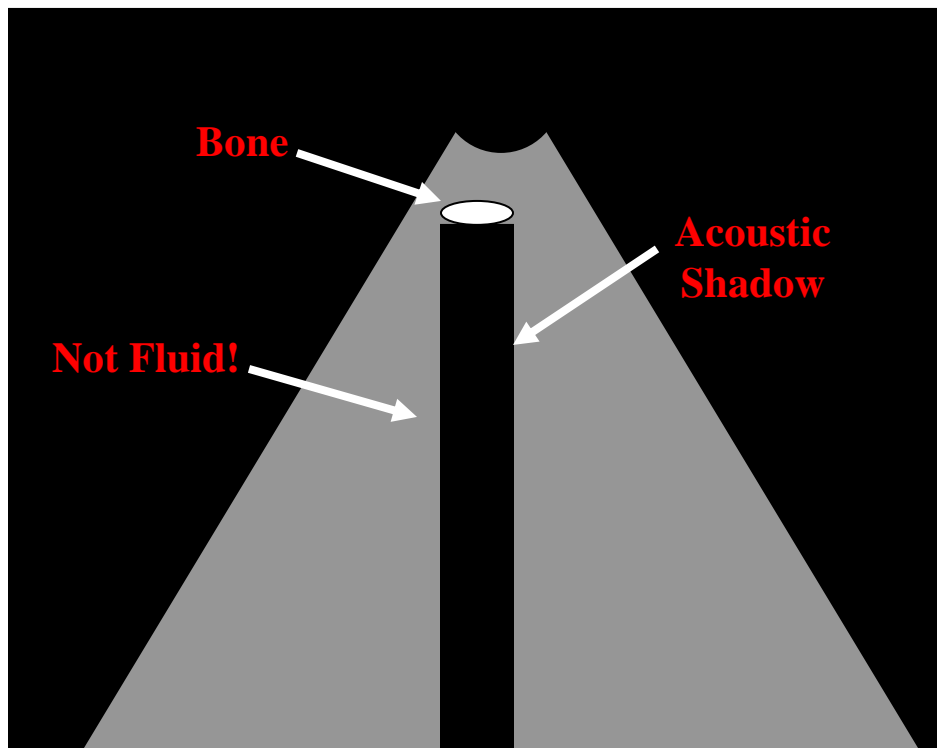
Refraction



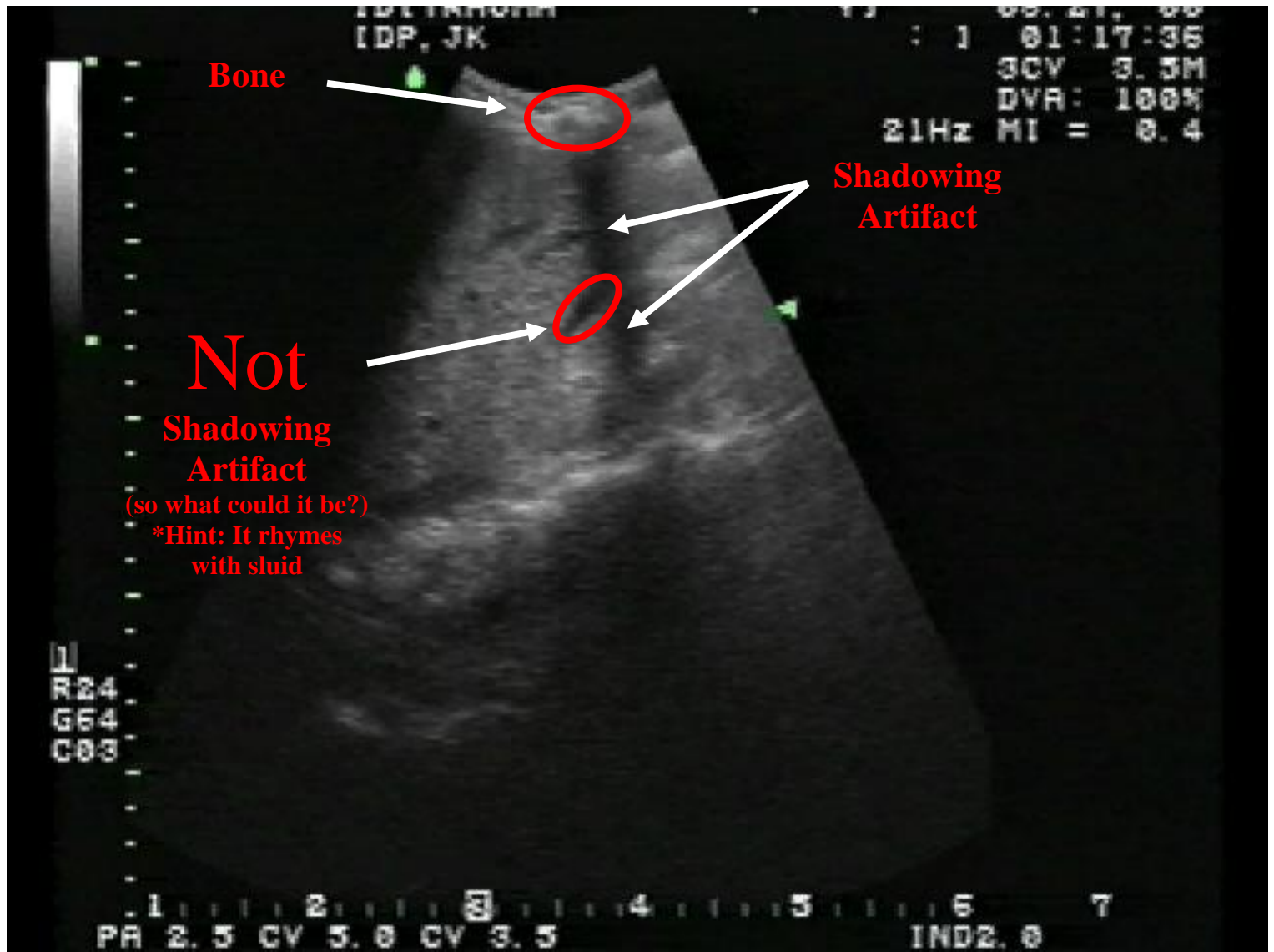
Shadowing

When U/S waves hit something that blocks their path (in our case, usually a rib), everything behind the blocking structure appears black. You could be tricked into thinking it was fluid, except that it looks like a shadow (hence the term “acoustic shadow”).

Shadowing



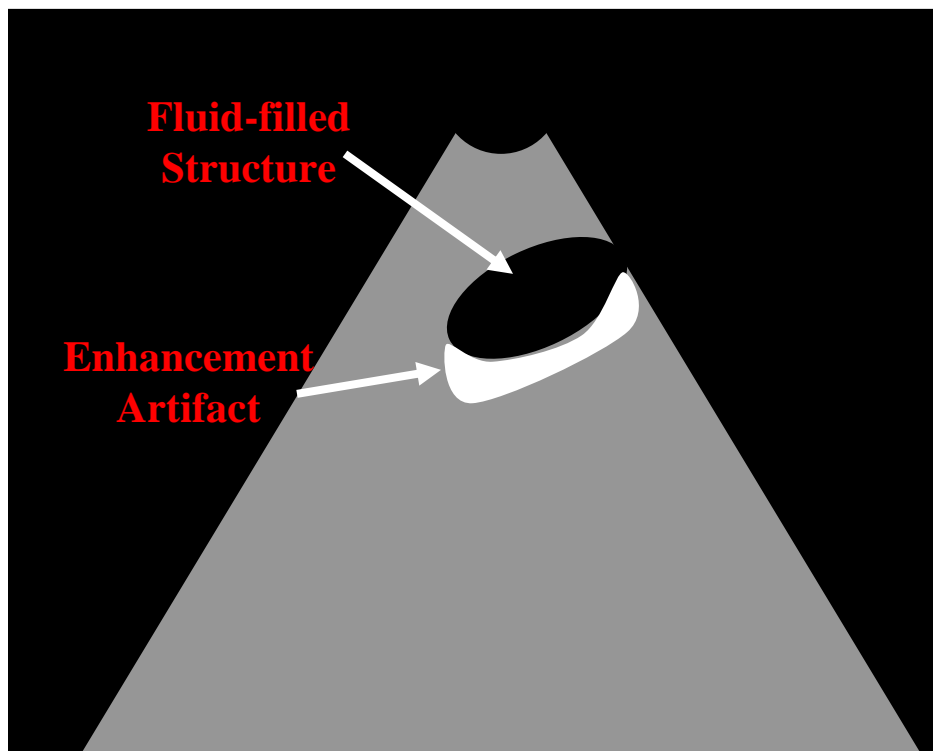
Shadowing



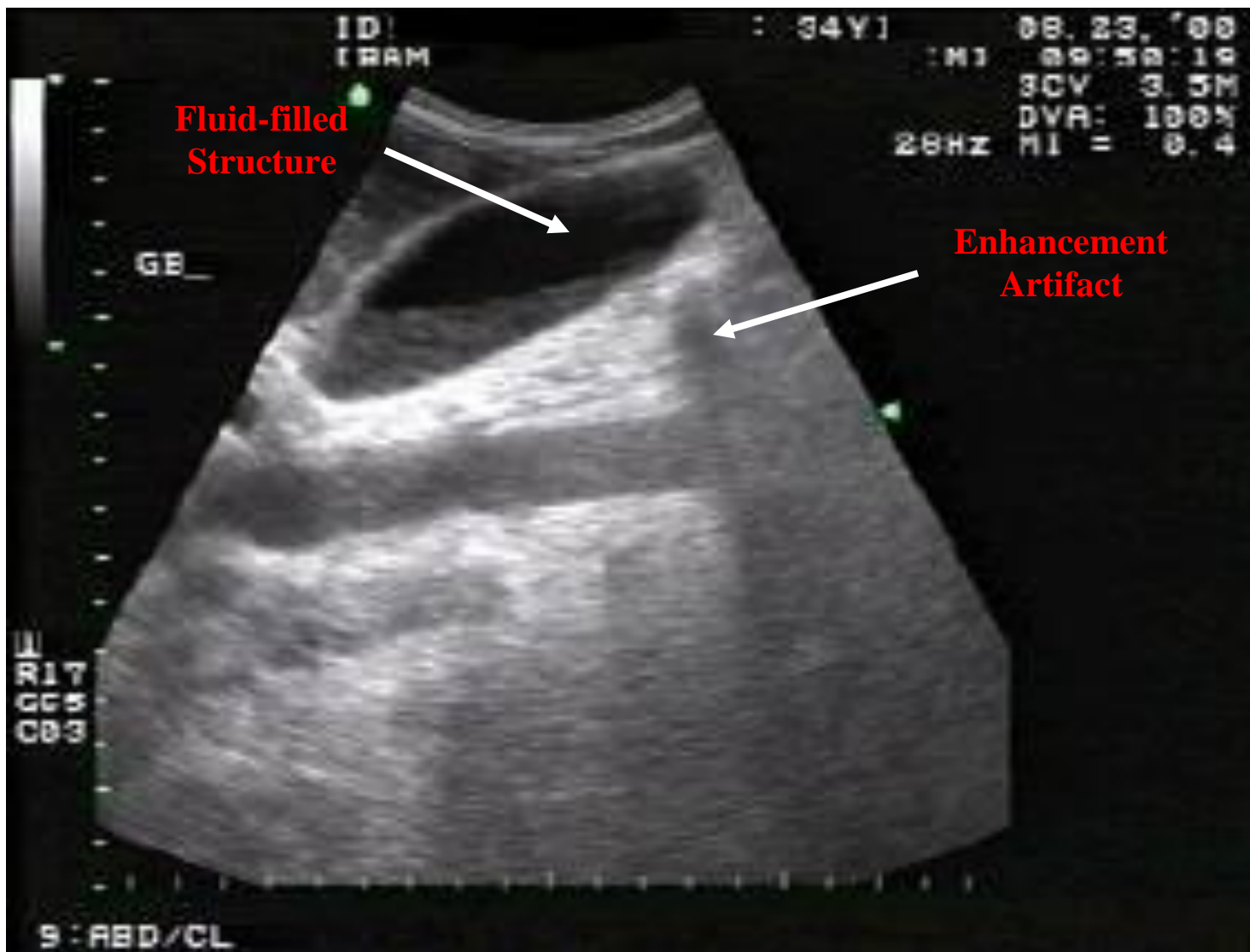
Enhancement

The flip side of shadowing. When U/S waves go through something that hardly attenuates (i.e., absorbs, scatters, or slows) them down at all, namely *fluid*, the tissues on the far side glow more brightly than the tissues beside them. The bladder, the gallbladder and any fluid-filled cystic structure can do this. The waves go through fluid without any difficulty and therefore retain nearly all of their energy. Upon entering denser tissue on the far side, this excess energy makes the posterior wall of the fluid-filled structure light up more brightly than adjacent tissues.

Enhancement



Enhancement



A Few Final Tips

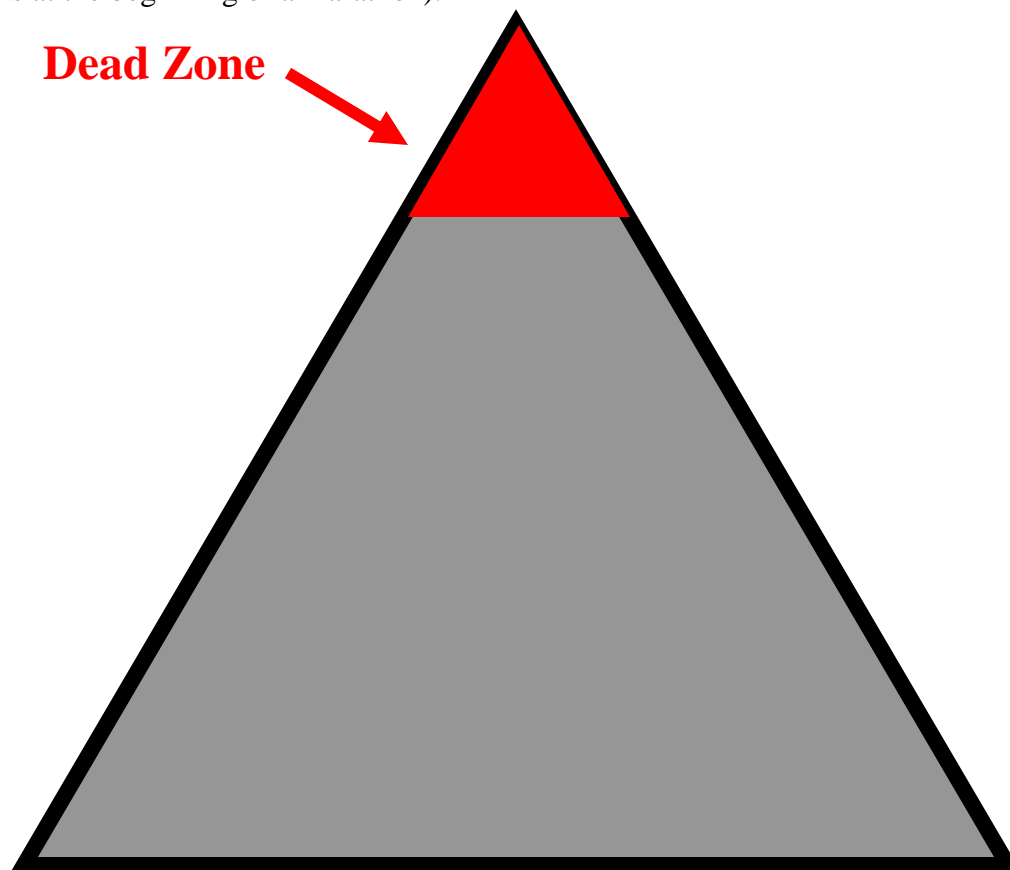
It is helpful to darken the room if you can, but this is not essential⁶. The things we are looking for (except for early gestations) are usually easily seen, even in fairly well-lit environments.

Get comfortable. Whenever possible, bring the patient to a comfortable height so that you can manipulate the probe with a minimum of hand/arm effort. This will make it more likely that you will move your hand slowly and deliberately. And don't hesitate to go from one side of the bed to the other if you can't reach a particular area easily.

Ultrasound gel is needed to ensure there is no air between the probe head and the body (remember the scattering effect of air on U/S waves). Use lots of gel. No, use **LOTS** of gel! You can't have too much gel. Warn the patient that the gel will be cold, unless you are considerate enough to have used a gel warmer (which we don't have).

Several machines have knobs which control contrast and brilliance. These are analogous to the controls on your television set and completely intuitive. They can be left in a mid-range position and ignored, or modified according to personal taste and visual acuity.

The first few centimeters of the screen are a "dead zone" from which no useful information can be obtained. Never try to interpret what you see there. Think of it as an area where the U/S waves are still too close together to be able to work well (like the runners at the beginning of a marathon).



⁶ It does give the resuscitation effort that "cool EDU" look, though.

Documentation

Whew! After all of that physics, image generation/modulation, and artifact discussion, you're probably ready to start scanning. Unfortunately, **before** you begin a scan in the ED, you **must** enter both your as well as the patient's identification information into the ultrasound machine. Without this information, it is impossible to determine who is being scanned, and who is doing the scanning (which is important for quality assurance, billing, credentialing, etc...).

When using the Sonosite, the first step toward entering patient information involves pressing the "patient" button located on the right side of its face.



Once the patient button is pushed, you will observe a screen on the monitor that looks like this:

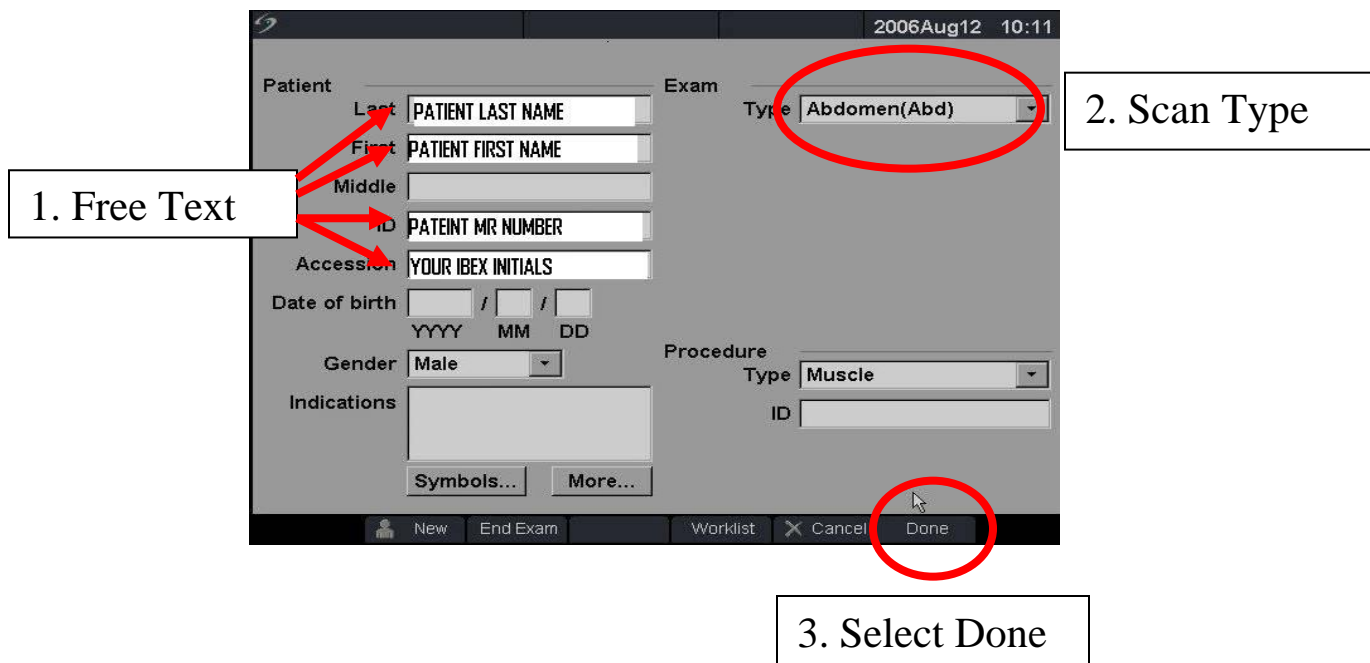
2006Aug12 10:11

Patient		Exam	
Last	<input type="text" value="PATIENT LAST NAME"/>	Type	<input type="text" value="Abdomen(Abd)"/>
First	<input type="text" value="PATIENT FIRST NAME"/>		
Middle	<input type="text"/>		
ID	<input type="text" value="PATIENT MR NUMBER"/>		
Accession	<input type="text" value="YOUR IBEX INITIALS"/>		
Date of birth	<input type="text"/> / <input type="text"/> / <input type="text"/>		
	YYYY MM DD		
Gender	<input type="text" value="Male"/>	Procedure	<input type="text" value="Muscle"/>
Indications	<input type="text"/>	Type	<input type="text" value="Muscle"/>
		ID	<input type="text"/>
<input type="button" value="Symbols..."/> <input type="button" value="More..."/>			
<input type="button" value="New"/> <input type="button" value="End Exam"/>		<input type="button" value="Worklist"/> <input type="button" value="Cancel"/> <input type="button" value="Done"/>	

By moving the onscreen arrow with the Sonosite's fingerpad, choose each text box by pressing the select button at the machine's midface.



Type the patient's first and last name, as well as the patient's medical record number. To identify yourself as the sonographer, enter your IBEX initials in the *Accession* box. Next, make sure the appropriate machine settings are active for the scan that you are planning by highlighting the correct option in the dropdown menu at the screen's upper right. Lastly, select the "Done" option at the screen's lower right. You are now ready to perform your scan.



A similar method exists when using the Zonare. The patient key is located at the upper right corner of the machine's keyboard.



Once pressed, you will see a screen on the monitor that looks like this:

Patient Information Hide Info

Exam: Preset:

Last:

First: Middle: Gender:

ID: Accession:

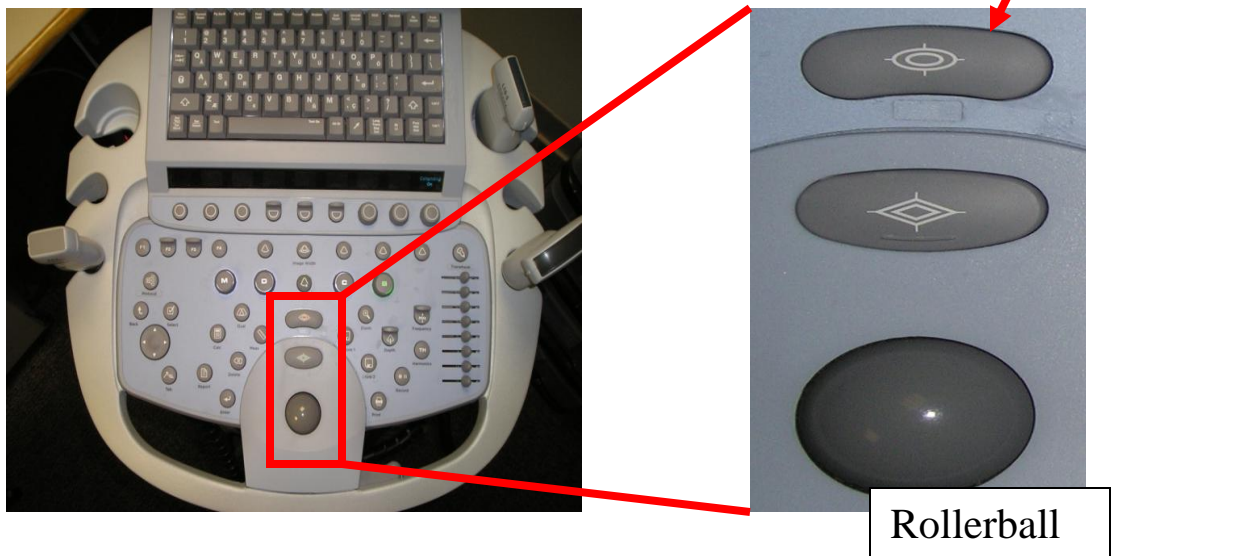
DOB: - (MM-DD-YYYY) Age:

Operator:

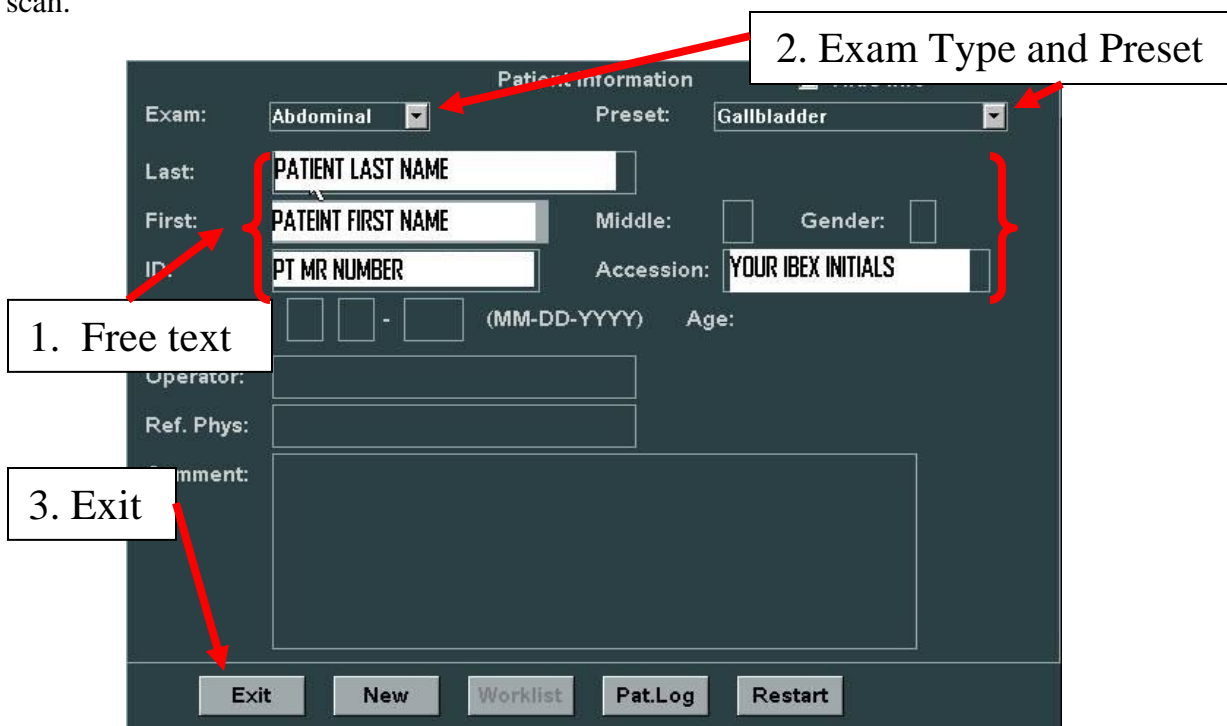
Ref. Phys:

Comment:

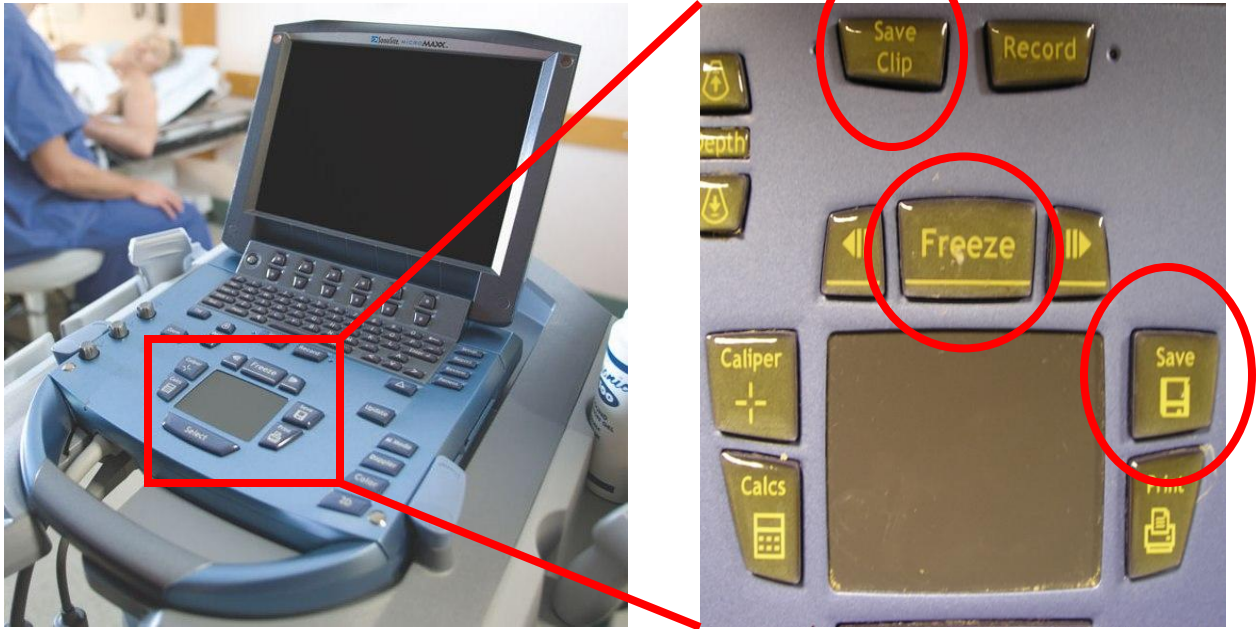
Using the rollerball at the Zonare's lower midface, choose each text box with the onscreen arrow and the machine's select button labeled with two ovals.



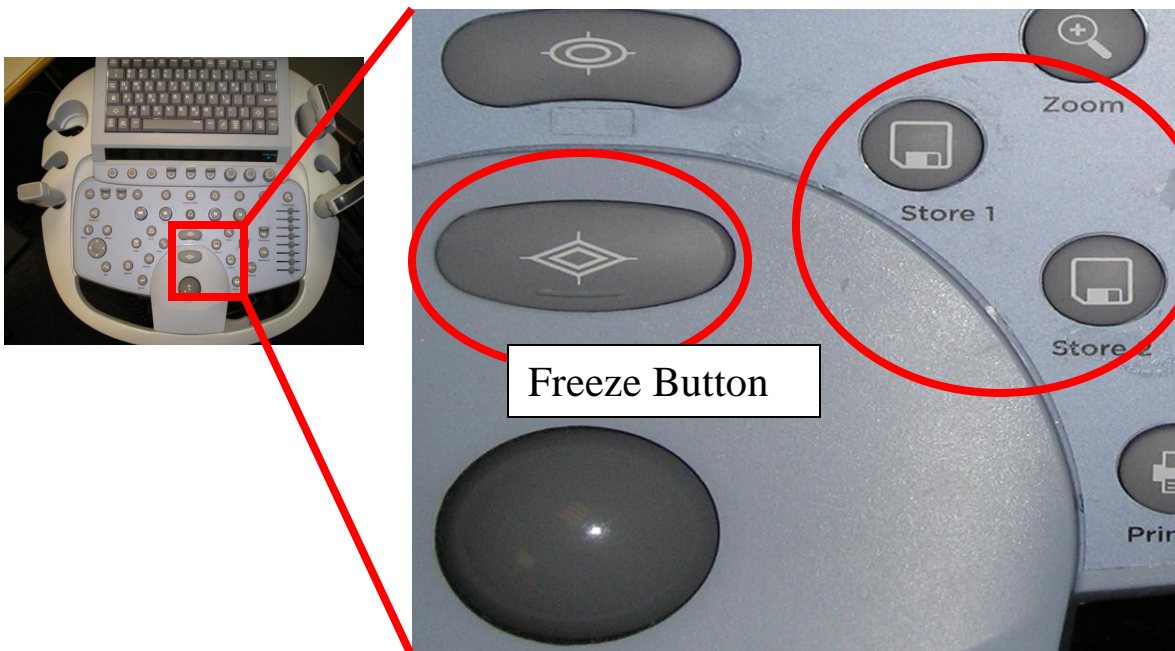
Again, type in the patient's first and last name, and medical record number. Then type your IBEX initials in the *Accession* box. Make sure the appropriate settings are selected in both the exam and preset dropdown menus in both upper screen corners. Lastly, select the "Exit" option at the screen's lower right corner. You are now ready to perform your scan.



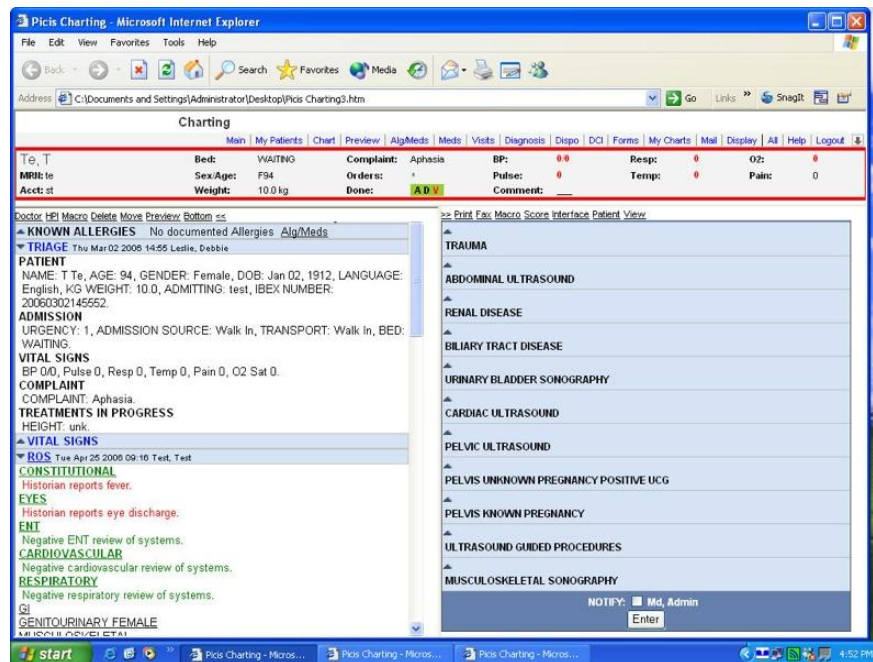
Now that you are ready to scan, there is just one more thing to discuss in regards to documentation, and that is documentation itself. Once you have identified the structure you are looking for, you must save that image onto the machine's hard drive. With both the Sonosite and Zonare, it is possible to save a still image as well as a movie clip. To freeze and save an image using the Sonosite, first press the “**Freeze**” button, then the “**Save**” button, each located at the midportion of the machine's face. To save a movie clip using the Sonosite, press the “**Save Clip**” button while actively scanning.



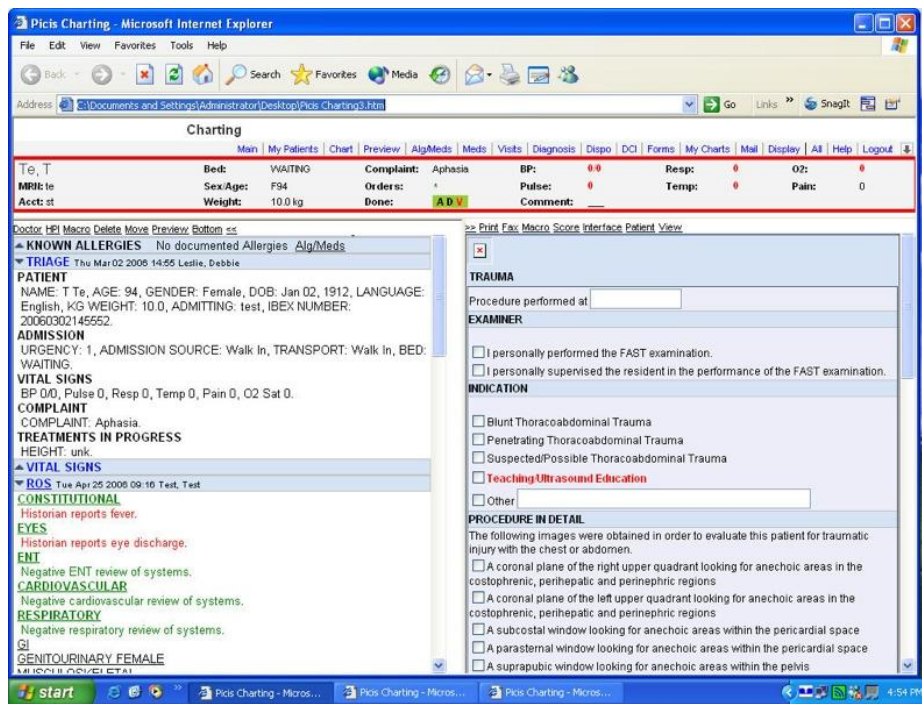
To freeze and save an image using the Zonare, first press the button labeled with two diamonds located just underneath the select button. This is the freeze button. Then, press either “**Store**” button located just to the right of the freeze button. To save a movie clip using the Zonare, press either “**Store**” button while actively scanning.



After performing and saving your scan, the last step of documentation involves actually documenting your findings in IBEX/PICIS. Templates for each type of ultrasound scan can be found under the “MD Procedures” link in each individual patient chart. By selecting the “Ultrasound” option from the list of procedures, you will see a screen that looks like this:



Click on the upward arrow next to the type of scan that you performed to reveal a template that looks like this:



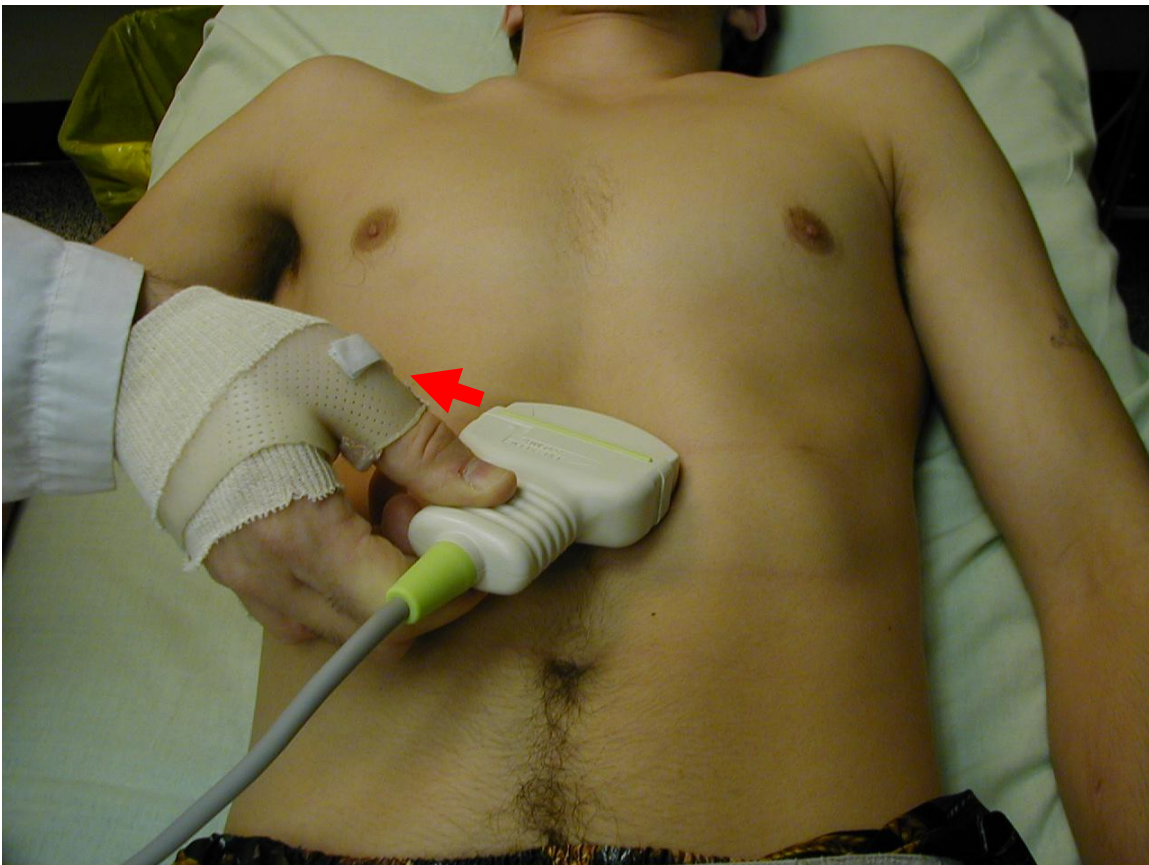
Now simply check the boxes corresponding to the indications and findings of the ultrasound you just performed. Keep in mind that documenting your ultrasound in the patient’s medical record is just like anything else – if you don’t document it, it never happened.

Cardiac EDU

The first practical section in this text deals with echocardiography. The reason for this is that it is often the easiest image to generate.

Although Cardiac EDU can be done from a number of directions, by far the best approach is the *subcostal view*. This means that you place the probe head at the right subcostal margin, and aim for the right shoulder. Gradually rotate the probe toward the patient's chin until the heart comes into view. Generally, one holds the probe with your hand on top, as you often need to flatten the probe against the skin significantly to acquire a good image of the heart. The image below actually shows the examiner using an underhand technique.

The Subcostal View



This is sometimes called the subxiphoid view. There are several other views, which will be briefly discussed later including (but not limited to) the parasternal, and the apical. The subcostal view is technically easy and it enables you to perform your scan while staying out of the way of colleagues who may be intubating, placing chest tubes, performing CPR, etc... (the chest is prime real estate during a resuscitation).

If you do not immediately see the heart⁷, perform an AP sweep (i.e. tilt the probe until it is in a true transverse plane and then sweep slowly until the probe is almost flat on the patient's abdomen). Still can't see the heart? Try repositioning the probe so that you are scanning almost straight up (i.e. towards the neck rather than the right shoulder) and repeat the AP sweep.

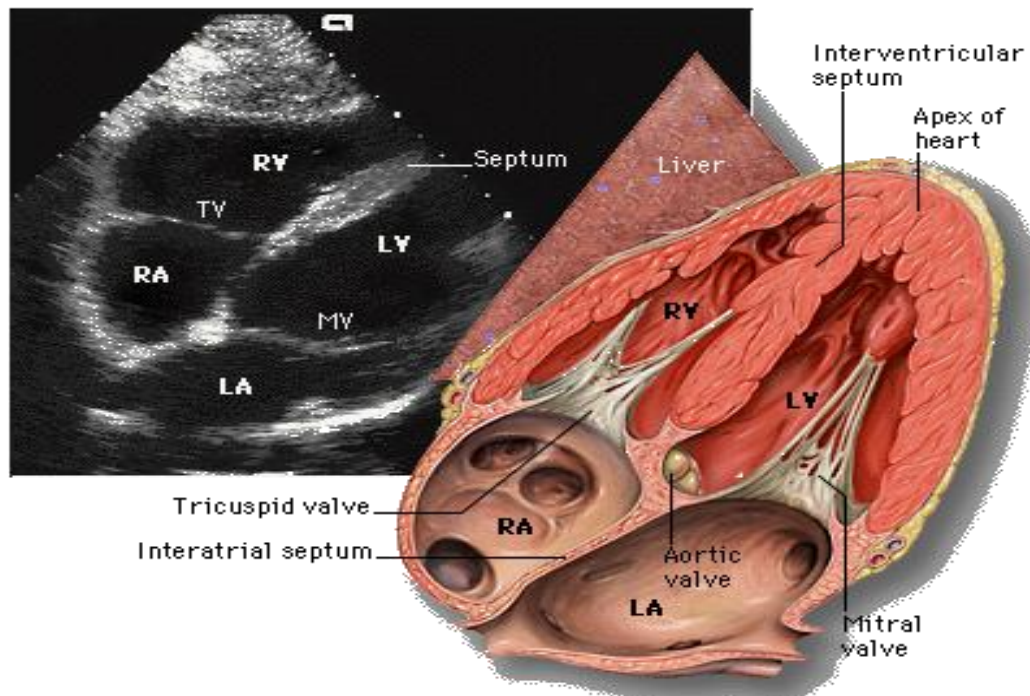
Once you have confidently identified your target, adjust the depth until ***one quarter of the field is beyond the heart*** (generally at a total depth of at least 20 cm). In this position, you should be able to appreciate the following structures (from near-field to far-field):

- Liver
- Pericardium
- RV
- LV and RA (at the same level, LV to the right of the screen)
- LA
- Pericardium again

You may even be able to see the valves flapping around.

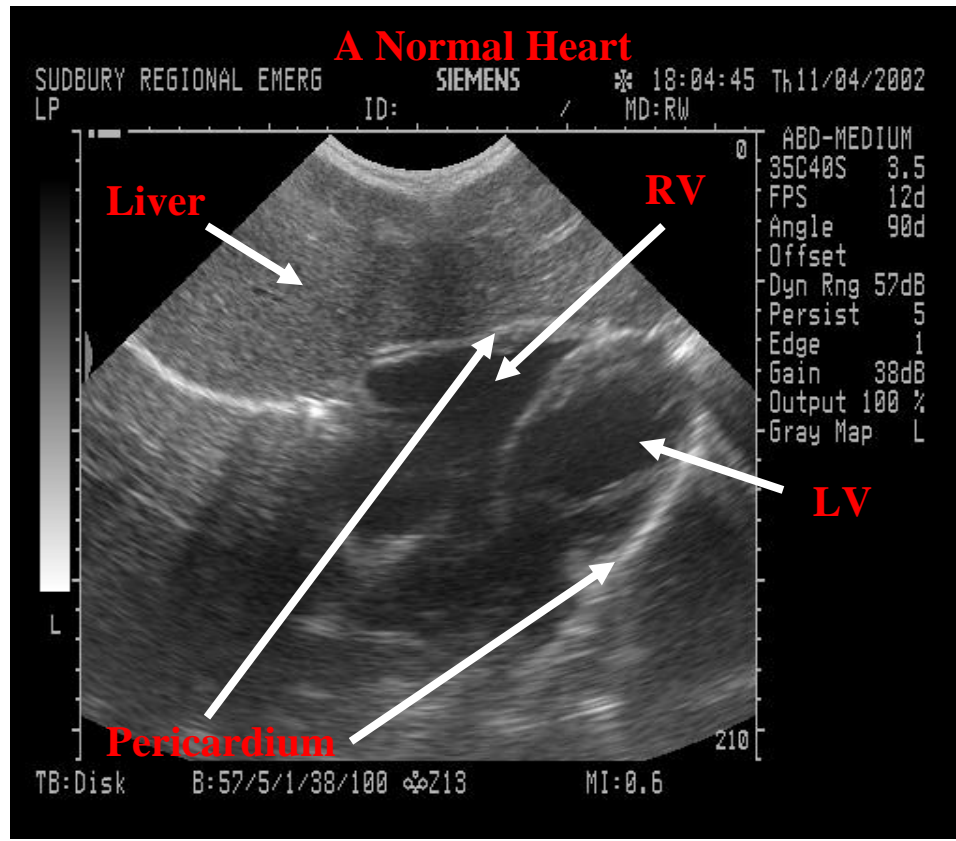
A good landmark to remember with the subcostal *or* parasternal view is that the right ventricle is always the most anterior chamber closest to the probe. Once the RV is identified, the orientation of the other chambers is usually readily apparent.

Subcostal View



⁷ A mostly black structure - because it is fluid-filled - within a bright, white envelope.

It is then necessary to sweep completely through the heart, passing from anterior to posterior and back again, watching the heart disappear completely at each extreme. This is called “*sweeping through the Area of Interest*”. Get used to this expression, as you will hear it over and over again. Unlike CT or plain radiography, EDU is a *dynamic* image. It is necessary to pass completely through an area (slo-o-o-wly) to ensure that no pathology has been missed.



The pericardium, being a tough, fibrous structure, provides an excellent interface for U/S waves. As such, it shows up as a bright, white, fairly thick line surrounding the heart. This can be made even more obvious by turning the *gain higher than normal*.

It is essential to confidently identify the pericardium. The rest (e.g. heart chambers) is secondary. Once you are sure you have recognized the pericardium, the thing moving around inside it is... the heart. Pretty simple, huh? Once you have done this, you can address the two key questions of Cardiac EDU:

1) Is there normal global cardiac activity?

2) Is there a pericardial effusion?

Evaluating Cardiac Activity

As you will eventually experience, recognizing grossly normal cardiac activity is simple. You can easily see the heart contracting at a frequency roughly equal to your own heart rate. Also, you can see fluid-filled structures (fluid is black on the screen) being squeezed, and the black area either diminishing greatly or disappearing altogether. This is the blood being squeezed out of the various chambers. It is not important to be sure whether one chamber is beating more effectively than another. It is only necessary to decide whether, as a unit, the heart is beating normally or hardly at all. Once you have made this determination, you have two clear diagnoses:

1) Heart not beating

Unless there is a **defibrillatable** rhythm on the monitor (VF, VT), this is ***asystole***. This is ***not*** survivable. The patient is dead. Stop whatever you are doing. Consult Pathology.

The one possible exception to this would be the pediatric hypoxic arrest. Remember that kids aren't dead till they're well-oxygenated and dead.

2) Heart beating vigorously

In the context of unexplained hypotension, this finding suggests that the cause is non-cardiogenic and therefore ***potentially correctable***. The readily reversible causes of this condition being hypovolemia, hypovolemia, hypovolemia and tension pneumothorax⁸, this should lead you to provide:

- fluids
- fluids
- fluids
- chest tubes (?bilateral)

and should lead you on a search for heretofore ***unsuspected blood loss***.

There is of course the possibility that you will see something in between: a heart beating, but in a way that does not seem normal. This would be the case in ischemic hypokinesia and metabolic derangements, for instance. In the setting of a large pulmonary embolus, the RV may appear distended or even larger than the LV. With profound hypovolemic shock, the chambers may nearly fully collapse with systole. However, some of these are subtle diagnoses and may be difficult to make. In Cardiac EDU, you should be making the determination of normal (i.e. vigorous) cardiac activity or absence of cardiac activity. If you are unable to be certain of one these two diagnoses, you must declare the scan to be ***indeterminate*** and proceed with the management of the patient without drawing any conclusions from said scan.

⁸ This condition can also occur with severe acidosis or hyperkalemia, but in these settings the heart will not really be beating normally and you should interpret the scan as being indeterminate.

Other possibilities would include a massive PE or catastrophic valve failure. Unfortunately, neither of these conditions is likely to be survivable in the setting of severe hypotension.

Evaluating the Pericardium

The goal here is to determine whether or not there is a pericardial effusion (the diagnosis of cardiac tamponade is a *clinical* one: the presence of hypotension, neck vein distension, muffled heart sounds, tachycardia, narrow pulse pressure, and possibly pulsus paradoxus).

While the pericardium normally contains up to 50 cc of lubricating fluid, this will not be easily appreciable on U/S. With the patient in the supine position, pericardial effusions will become apparent at the following levels:

~ 100 ml: posteriorly, only in systole
 100-300 ml: posteriorly, throughout the cardiac cycle
 >300 ml: anteriorly and posteriorly

This will appear as an extra black area inside the pericardium which does not change in shape (or only changes very slightly) during systole. As mentioned above, it is vitally important to scan through the *entire* heart.

If you discover a pericardial effusion, you now have to determine its cause and its effect. In trauma cases, the cause will be apparent, while in medical ones it may take a little digging.

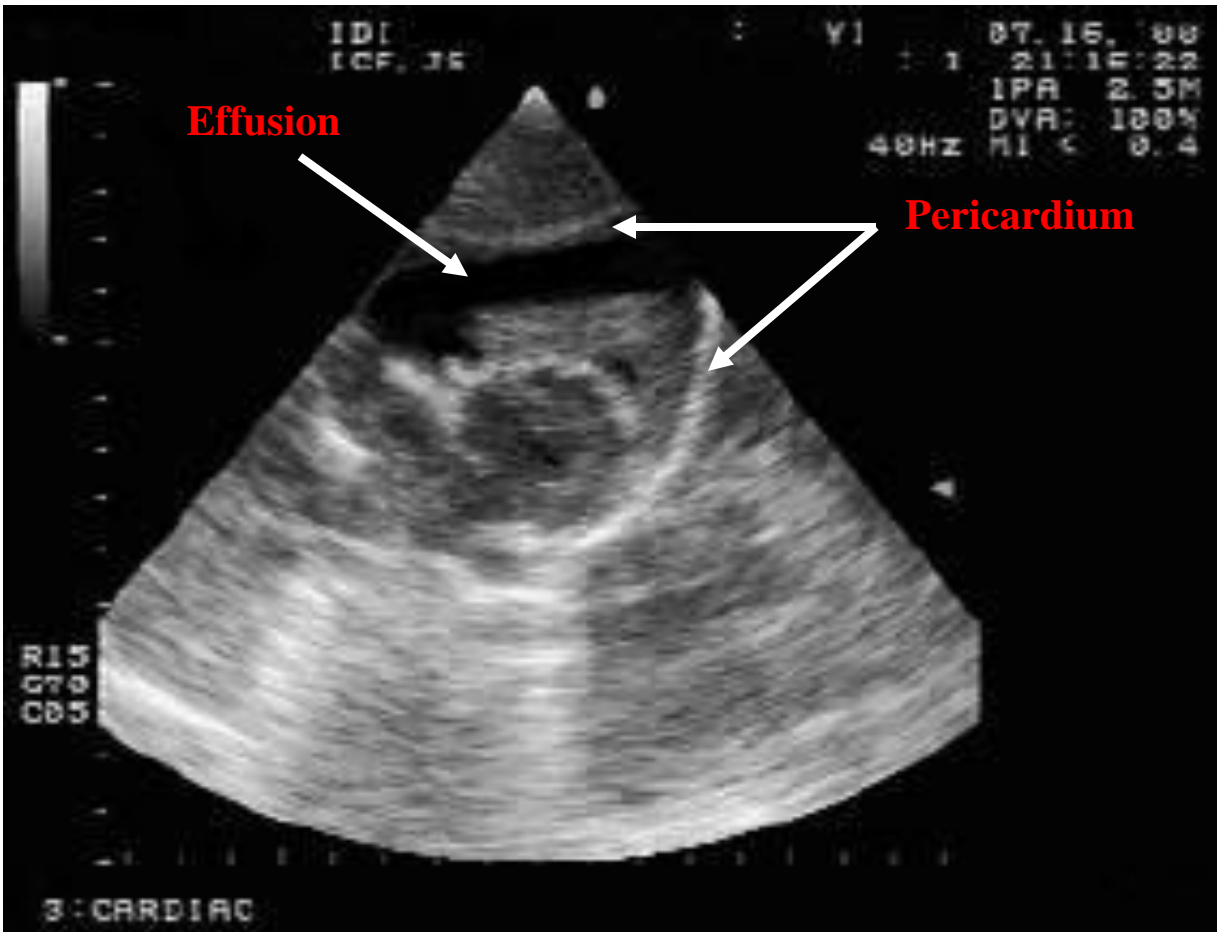
Judging the effect requires a little clinical judgment. The normal pericardium can only accommodate 100-200 ml of fluid before hemodynamic compromise occurs *if it accumulates rapidly*. In trauma cases, the patient most likely had a normal pericardium before being shot or run over. It is therefore reasonable to assume that the pericardial effusion is responsible for some, if not all, of the hypotension. This should lead you to perform an *emergent pericardiocentesis*.

In medical cases, where the accumulation may have taken place over weeks or months, the pericardium can stretch to accommodate several times more fluid than it can in the acute setting. Tamponade will come on slowly in these patients, and they will initially present with increasing shortness of breath and fatigue, rather than signs of shock. It is also possible that the pericardial effusion has nothing to do with the patient's vital sign abnormalities. For example, the presence of hypotension and pericardial effusion, combined with bradycardia and a temperature of 34.2°C, should suggest the diagnosis of myxedema.

There are echocardiographic signs of tamponade, ranging from the fairly obvious (decreased chamber volume) to the fairly subtle (my favorite being "RV/RA free wall collapse in mid-to-late diastole"). However, in EDU it is mandatory to describe pericardial effusions as being present or absent, and not to stray onto thinner ice. As mentioned at the beginning of this section, the diagnosis of tamponade should remain a *clinical* one. In trauma, the effusion is almost certainly to blame, while in medical cases it is only likely. Having said that, the converse holds true for both trauma and medical cases:

No effusion, No tamponade.

Pericardial effusion



A Few Final Tips

If you are having trouble bringing the heart into view, it may be because it is too high in the chest. This is particularly true in the case of broad-chested persons. In these situations it can be very helpful to ask the person to breathe in slowly. This drops the diaphragm and, by extension, the heart, bringing the target organ closer to the probe. This may not always be possible with an emergency patient, but it can make all the difference in someone who can cooperate.

In the trauma patient, possible confounders include free fluid in the abdominal and pleural spaces, but you can avoid these pitfalls by using only the subcostal approach. As there is no pleural reflection between the xiphoid and the heart, there can be no pleural effusion there either. As for abdominal free fluid, it may be found around the liver but it will not conform to the heart border. As mentioned above, the key structure to identify is the pericardium. This will enable you to be certain whether the fluid you are seeing is intrapericardial or not.

A source of false positives that cannot be avoided is the presence of epicardial fat. This strip of tissue can sometimes be quite echolucent and remarkably thick. However, the giveaway is that it will almost always appear only *anteriorly*. As you will recall, effusions appear *posteriorly* first (due to gravity), and never only anteriorly. It is worth mentioning that fat pads are *far from rare* in the elderly, obese patient.

If a patient has an excess of adipose tissue (something that has been known to happen in our practice) you can get a slightly better view by flexing the legs (which relaxes the abdominal muscles).

Emphysema can also pose a problem by placing air (which scatters the U/S waves) between the probe and the heart.

One Last Thing...

You'll notice that the image on page #43 demonstrates the sonographer obtaining the subcostal view with the probe's indicator pointed toward the patient's right side. This is technically incorrect, but deliberately so. Why? Remember, our cardiology compatriots orient their probes exactly opposite to the way that we do, which means the probe's indicator should be pointed toward the patient's left side when performing a subcostal exam (see page #19). However, most subcostal cardiac images in the ED are obtained in the context of trauma (see FAST - starting on page #73) when the ultrasound machine is in an *abdominal* setting (which is OK). With the machine in an *abdominal* setting, cardiology "backwardness" no longer applies; i.e, the probe's indicator stays pointed toward the patient's right. Again, having the heart oriented correctly on the subcostal view does not affect what we are looking for – pericardial effusion and/or wall motion abnormalities. The next section focuses on additional cardiac views assuming the ultrasound machine is in a *cardiac* setting; thus, the descriptions of probe orientation reflect cardiology's "backwards" approach.

Other Cardiac Views

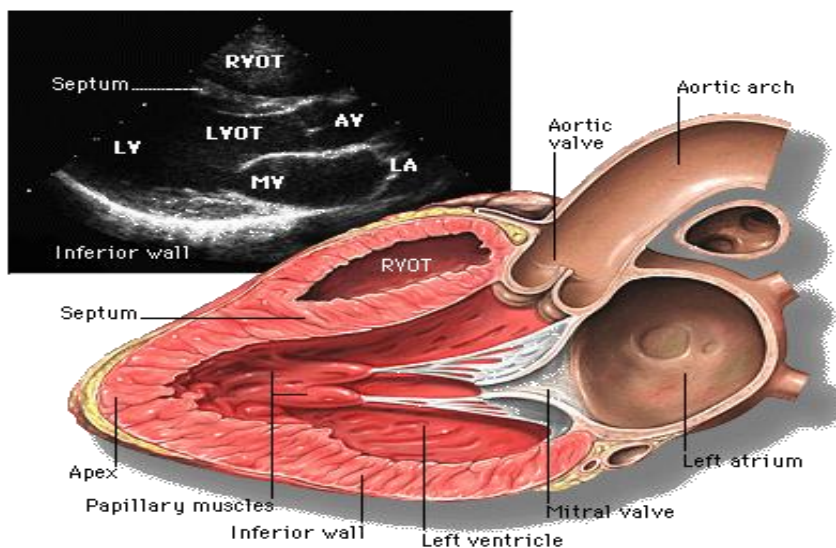
Until now, we have spoken only of the subcostal cardiac view. While the subcostal view is the 1) easiest cardiac view to perform, 2) the best view to use when looking for a pericardial effusion in the context of trauma or unexplained hypotension, and 3) the workhorse of ED echocardiography, several other cardiac views exist, and are worth mentioning – the parasternal (both long and short), as well as the apical (both 2- and 4-chamber). These additional cardiac views can be helpful in evaluating gross wall motion abnormalities and overall cardiac function.

The parasternal view is performed by placing the probe perpendicular to the chest wall at the left border of the sternum in the 4th or 5th intercostal space. With the indicator pointed towards the patient's right shoulder, the parasternal **long** view is obtained by scanning along the plane aligned from the right shoulder to the left hip⁹.



Parasternal Long View

Structures that can be visualized with the parasternal long view include (from anterior to posterior): the right ventricular free wall, right ventricle and outflow tract, interventricular septum, left ventricle and outflow tract, and the posterior left ventricle. Additionally, it is



⁹ While subcostal views are best obtained with the patient supine, parasternal and apical views are generally best obtained with the patient in the left lateral decubitus position.

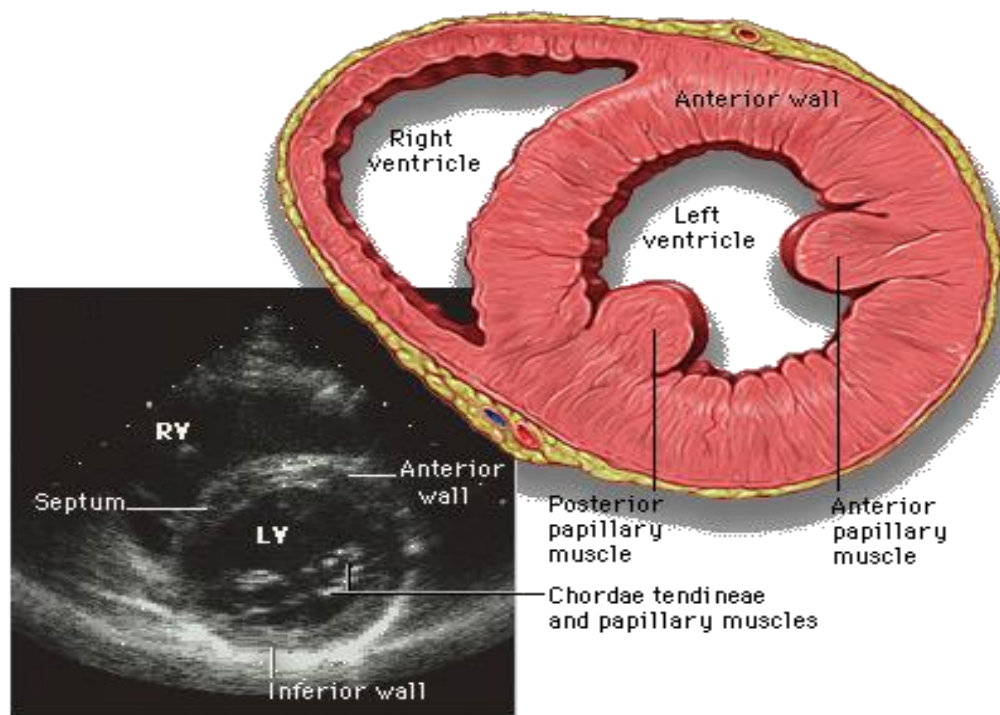
also possible to see the left atrium and its inflow tract to the left ventricle.

Once an adequate parasternal long view has been documented, the parasternal *short* view is obtained by rotating the probe 90° clockwise (indicator toward patient's left shoulder).



Parasternal Short View

Parasternal short views can be obtained at the base of the heart, the level of the mitral valve, the level of the papillary muscles, and at the apex. However, the view obtained at the level of the papillary muscle is the most important because it allows identification of several different walls of the left ventricle. Structures that can be visualized with the parasternal short view at the level of the papillary muscle include (from left to right): the right ventricle, the interventricular septum, the left ventricle, and the free lateral left ventricular wall.

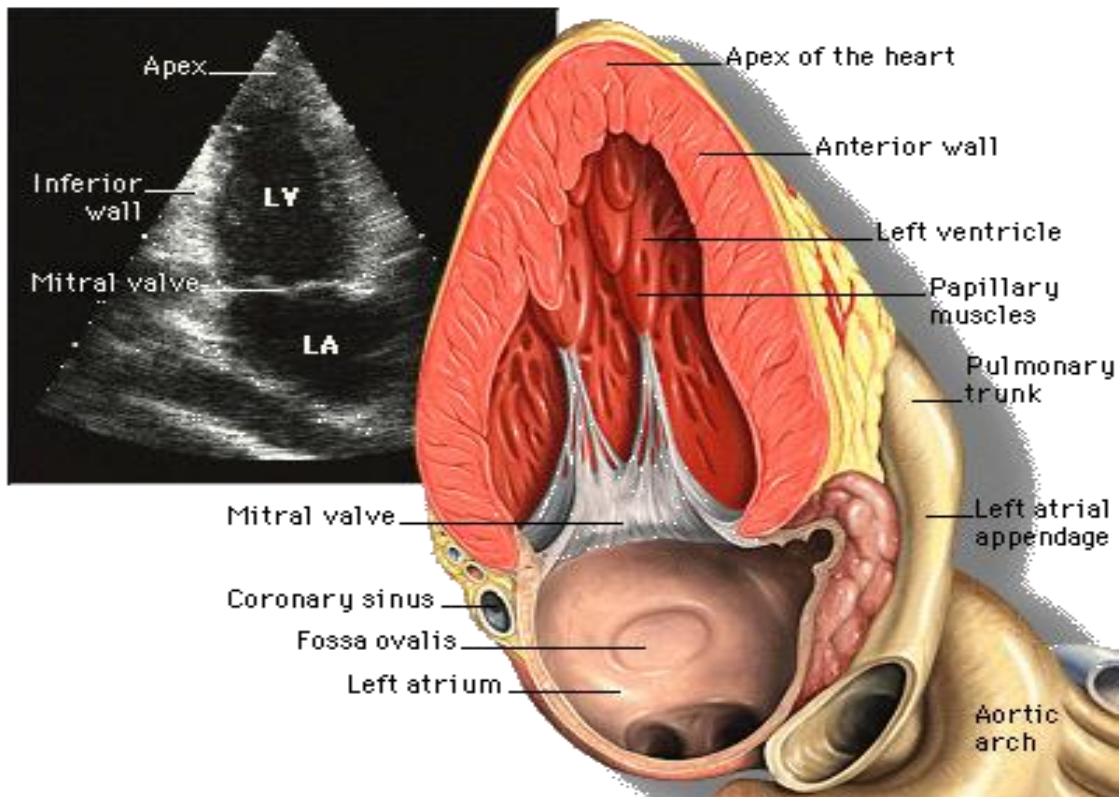


Apical views are obtained by placing the probe at the apex of the heart, usually where the point of maximal impulse is felt, generally in the 5th intercostal space at the left lateral chest wall. To obtain an apical 2-chamber view, the probe's indicator is pointed up toward the patient's head, with a scan plane aimed in the direction of the patient's right shoulder.



Apical 2-Chamber View

The apical 2-chamber view allows the visualization of the apex of the left ventricle, the left ventricle, the mitral valve, and the left atrium.

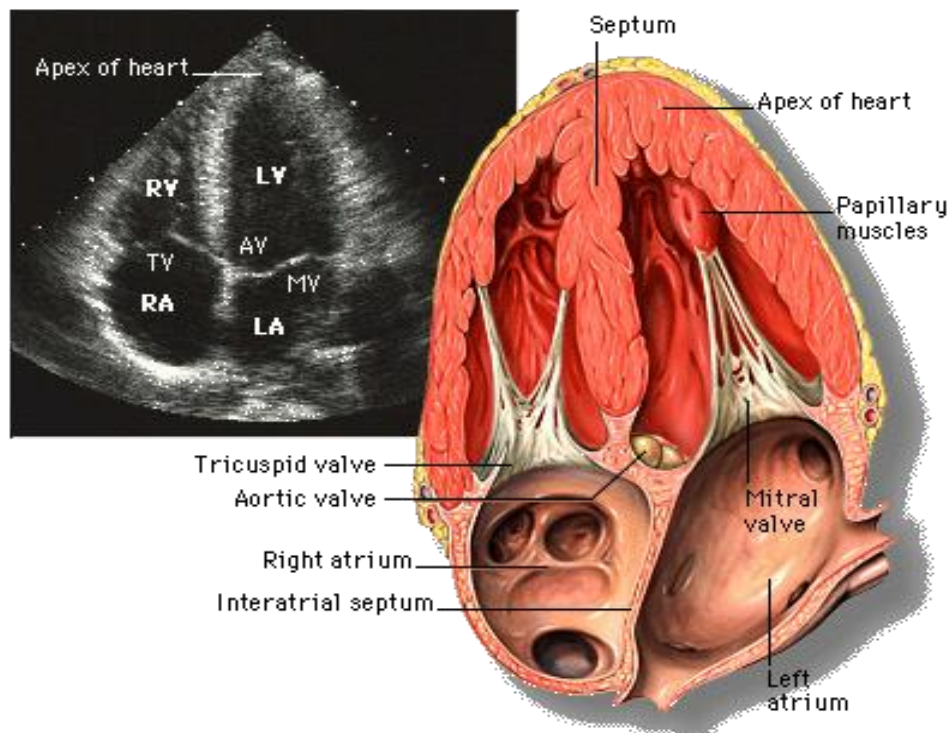


From the position of the apical 2-chamber view, the apical 4-chamber view is obtained by rotating the probe 90° clockwise (indicator toward patient's left posterior axillary line).

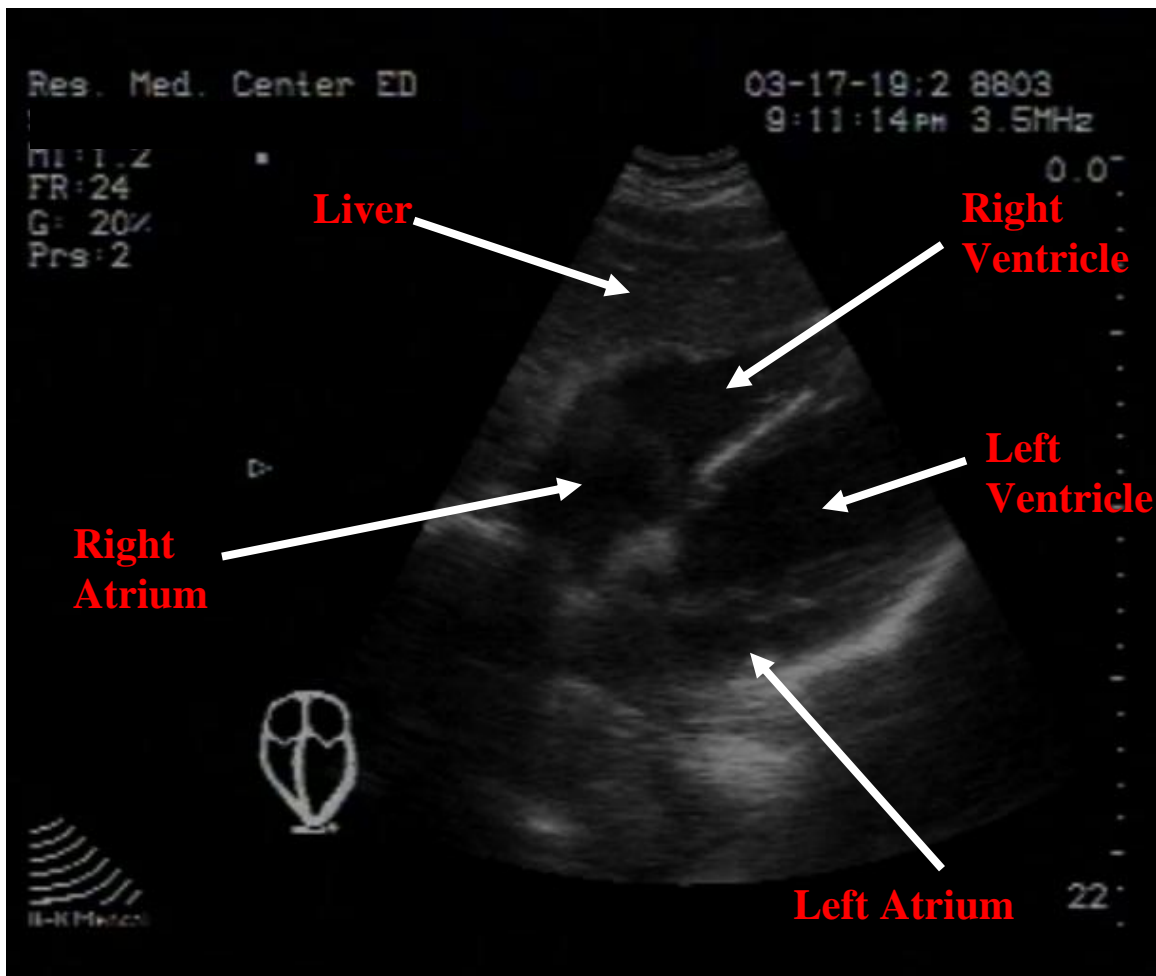


Apical 4-chamber View

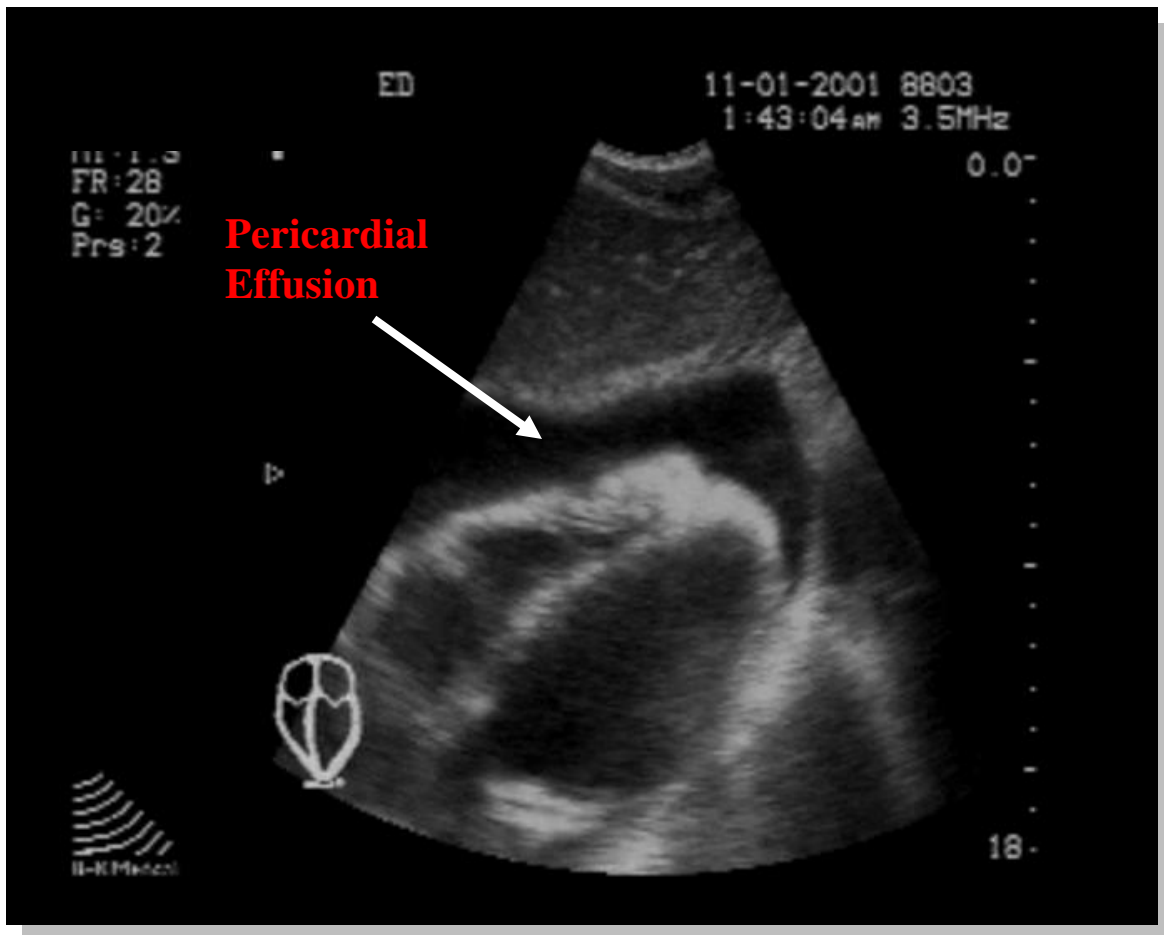
As the name implies, the apical 4-chamber view allows the visualization of all four chambers of the heart simultaneously.



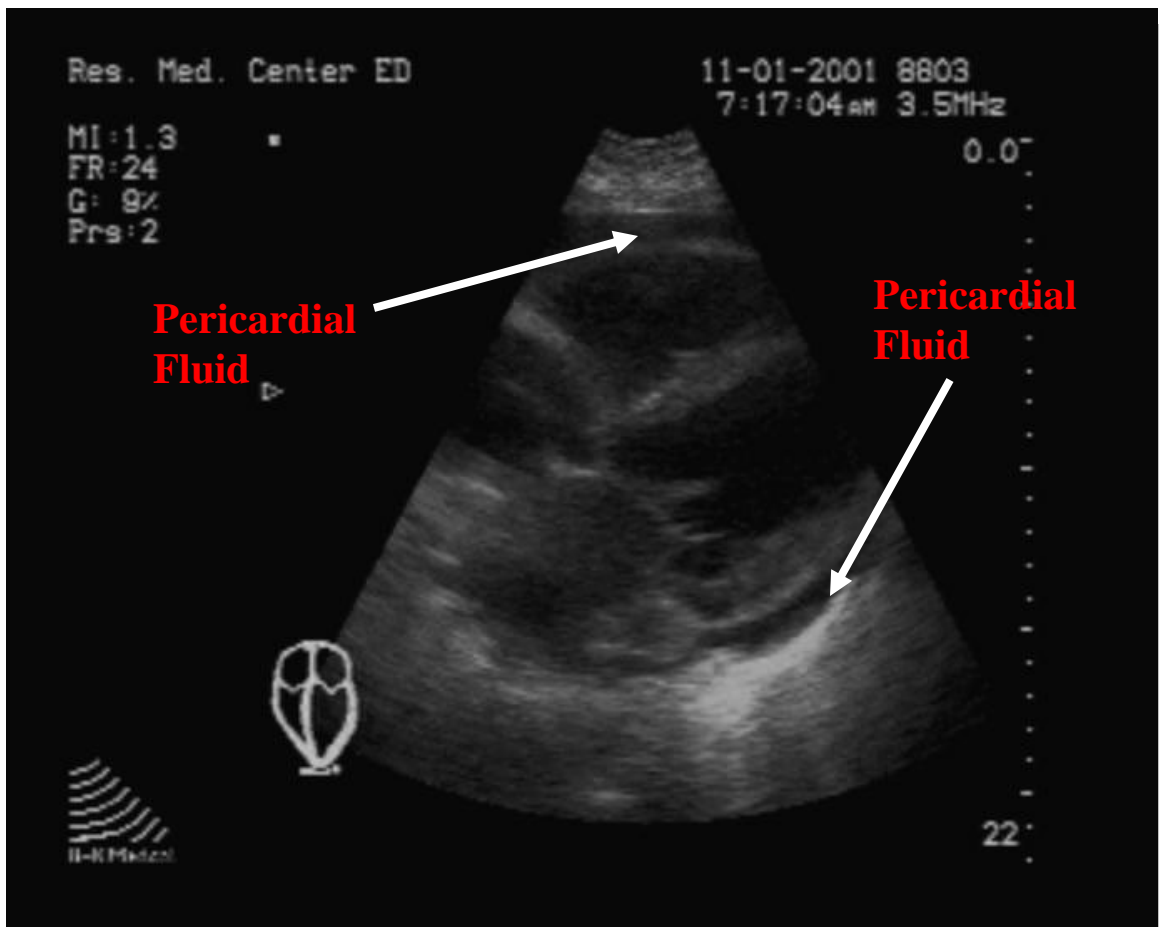
More Cardiac EDU Images



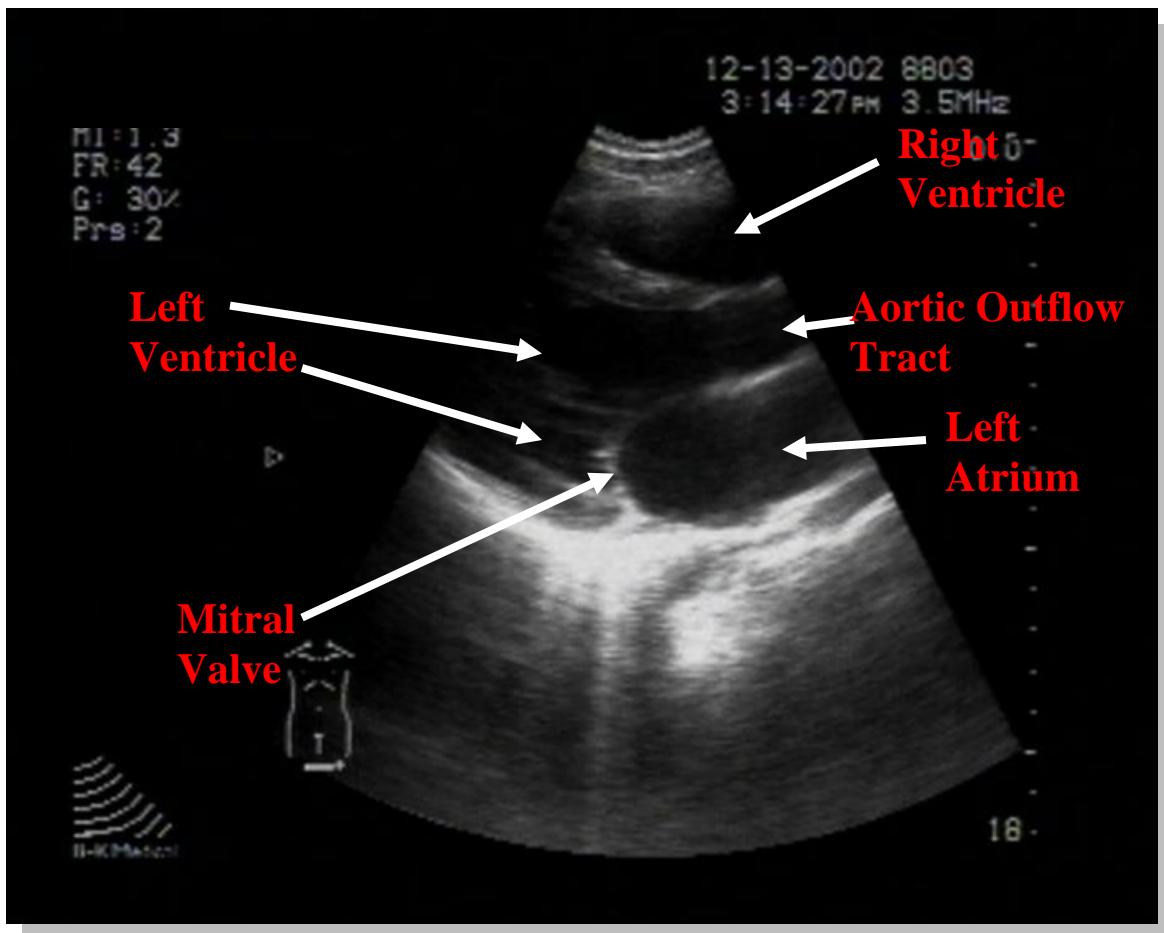
This image represents a normal subcostal view of the heart. The probe marker should be pointed towards the patient's right side to obtain this orientation. The tip of the liver is visualized anteriorly. The right ventricle is the most anterior chamber next to the liver, with the left ventricle sitting underneath. The right and left atria are paired with their respective ventricles.



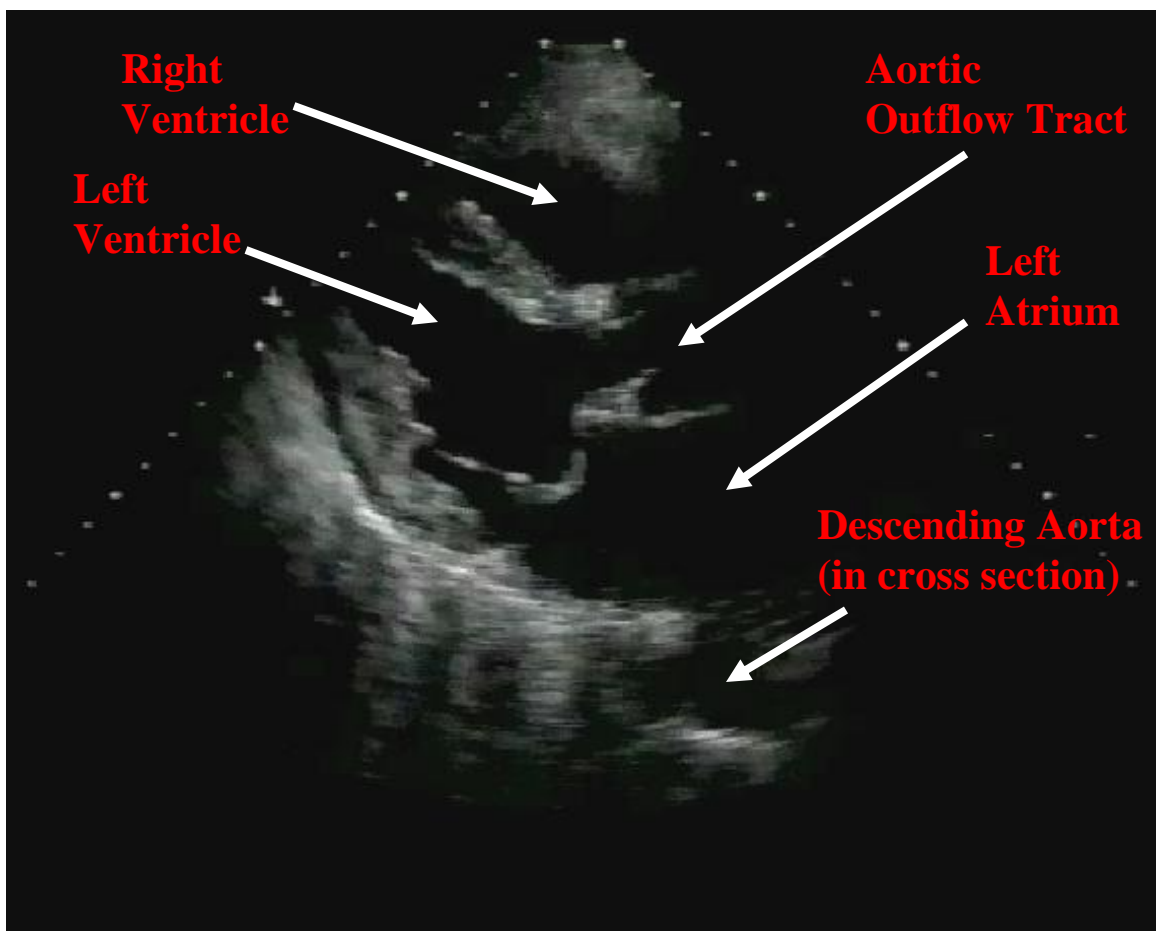
A large pericardial effusion is visualized in this subcostal cardiac image. The liver is identifiable anteriorly at the top of the image.



This image depicts a subcostal cardiac view. A moderate pericardial effusion is noted both anteriorly at the top of the image as well as posteriorly at the bottom of the image.



This image demonstrates a parasternal long view. The probe is positioned along the left sternal border at the 4th or 5th intercostal space with the indicator toward the patient's right shoulder. As in the subcostal view, the right ventricle is the most anterior chamber at the top of the image. The left ventricle is at the left side of the image, and the left atrium is at the bottom right. The aortic outflow tract is above the left atrium. No pericardial effusion is noted.



This image demonstrates a normal parasternal long cardiac view, with the probe oriented longitudinally along an axis that stretches from the patient's right shoulder to their left hip (indicator toward right shoulder).

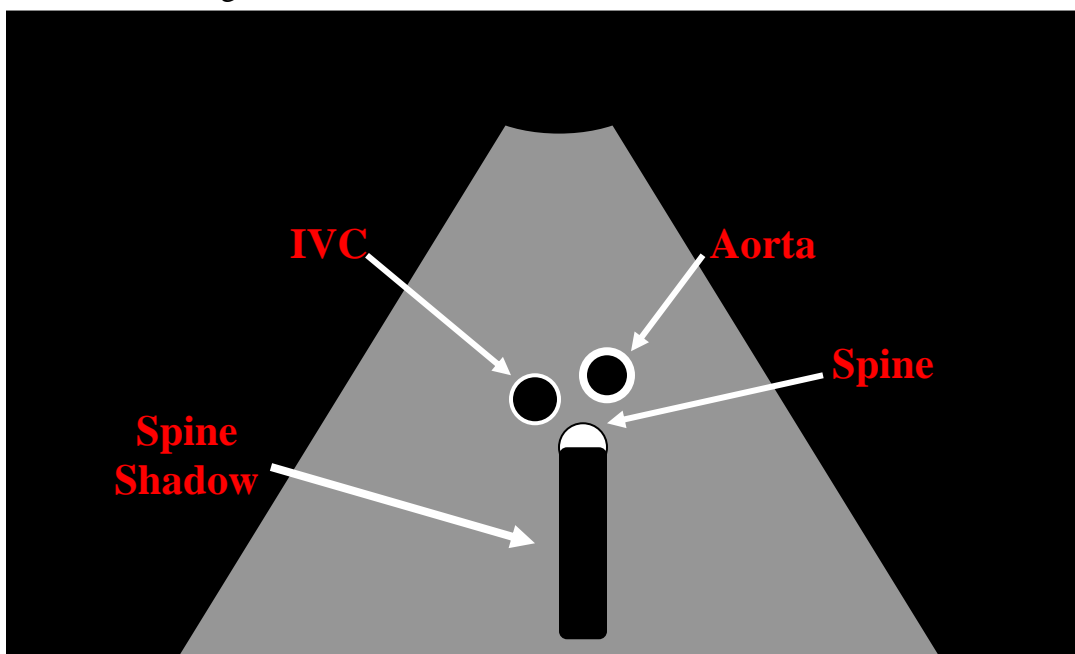
Aortic EDU

Scanning the abdominal aorta is both simple and frustrating. The structure you are looking for is not very difficult to identify... when you can see it. Unfortunately, our patients rarely take the time to do a proper bowel prep before coming to the Emergency Department. As a result, it is very common for bowel gas to intrude, and for significant scatter to be present. As well, the typical patient in whom you want to eliminate AAA is typically... how shall we say... adipose-challenged. This presents the U/S waves with significant resistance and can make scanning impossible simply by placing the aorta out of range.

Given the above, this is a good time to re-emphasize that golden rule of EDU – *only call the ones you are sure of*. A significant proportion of your abdominal aortic scans will be inconclusive and you must have the competence – and the humility – to identify when this is so. Learn to be like the radiologists, and blame the “inadequate study” on the patient, the equipment, the phase of the moon, etc... but don’t call it normal if you aren’t 100% sure.

The Essential Landmarks – The Spine and the Spine Shadow

Scanning the aorta must be done from the diaphragm to the iliac bifurcation, *entirely in the transverse plane*. Remember to keep the probe indicator pointed towards the patient’s right for proper orientation, or you may reverse the aorta and IVC on the image! To start, place the probe just caudal to the xiphoid process. Unfortunately, the abdomen is full of vessels, and at the level of the xiphoid process, you should see one or two (or more) circular echogenic (white) structures with fluid inside (black). To identify the aorta, first locate the spine, which appears as a bright, hyperechoic curvilinear structure in the far-field. Given its hyperechogenicity, the spine casts a dark acoustic shadow posteriorly, aptly named the spine shadow. The aorta is found immediately anterior and slightly to the left (screen right) of the spine. Once the aorta is identified, move the probe caudally, keeping the aorta centered in the field of view. At approximately the level of the umbilicus, you should see the aorta bifurcate into the right and left iliac arteries.



Identifying the Aorta

The obvious question now is how to differentiate the aorta from the IVC. While it is true that the aorta is usually on the patient's left (screen right), there are up to 10% of normal individuals in whom this is not true¹⁰. As well, make sure you are **NOT** fooled by a large pulsating vessel. The proximity of the IVC to the aorta can make it pulsate very nicely.

The features that *definitively* identify the aorta are:

- 1) ***Non-compressibility***. Push the probe into the patient. If the echogenic circle flattens and the black fluid disappears, you are pushing on the IVC.
- 2) ***Thickness of the vessel wall***. A little harder to appreciate at first, at least until you have seen a few side-by-side. The aortic wall is clearly thicker than that of the IVC, making it significantly more echogenic (brighter).
- 3) ***Lack of respiratory variability***. The IVC will collapse slightly when the patient inspires, as negative intrathoracic pressure draws blood into the chest, temporarily depleting it. You can exaggerate this by asking the patient to sniff hard. This creates an even greater negative intrathoracic pressure than normal respiration, and should cause the IVC to collapse completely. Interestingly, the “sniff test” will be negative (i.e. the IVC will *not* collapse) when right-sided pressures are high. It can therefore be used to support the diagnosis of tamponade. Obviously, this will not be appreciable in the patient who is being ventilated and is no longer generating negative intrathoracic pressure.

It is fairly common to see a single large vessel, in which case you will have to use only non-compressibility and lack of respiratory variability (and, of course, the proximity of the spine) to correctly identify the aorta.

¹⁰ Or at least that's what the textbooks say. What is more common, however, is for the IVC to be **undetectable**. This is not a problem since, as you can see, the criteria for identifying the aorta can be applied **without comparing it to the IVC**.

Technique and Image Interpretation

Having identified the aorta, as mentioned, you then follow it all the way to the *iliac bifurcation*, while staying in the *transverse plane*. At the bifurcation, you should see the single lumen of the aorta become two smaller lumens. If throughout this entire distance you have noted that the diameter of the aorta is less than 3 cm (echogenic outer wall to echogenic outer wall)¹¹, you are done. Your patient does not have an AAA¹². ***Note:** Don't forget to evaluate the patient for aneurysmal dilatation of the iliac arteries. Iliac arteries should not be greater than 1.5cm in diameter.

If the diameter appears enlarged at any point, the diagnosis of AAA is made¹³. However, it must be noted that while EDU is *excellent* at identifying *dilation* of the AAA, it is *incapable* of identifying *rupture* of that lesion. This is because most ruptures extend retroperitoneally, an area that EDU is not able to evaluate. As well, there will usually be no free fluid in the abdomen. There are exceptions to this rule, of course, and any positive Aortic EDU should be immediately followed by a FAST scan¹⁴ to look for free fluid.

It remains important, therefore, to *put the EDU findings in the right clinical context*. Take two patients with a 5 cm aorta, abdominal pain and unexplained hypotension. If the first is complaining of back pain and has diminished femoral pulses, call the vascular surgeon. But remember that there are a lot of people walking around with 5 cm aortas. If the second patient has RUQ pain and a temperature of 39.8°C, the correct diagnosis would be septic cholecystitis, not ruptured AAA. Again, we see that EDU is merely an *adjunct* to your clinical skills.

¹¹ This describes the vast majority of fusiform AAAs, although a distal segment 1.5 times wider than the uninvolved proximal segment also qualifies. Sacular aneurysms (which, like the name implies, look like sacs attached to the aorta) are much less common, but equally well seen on EDU.

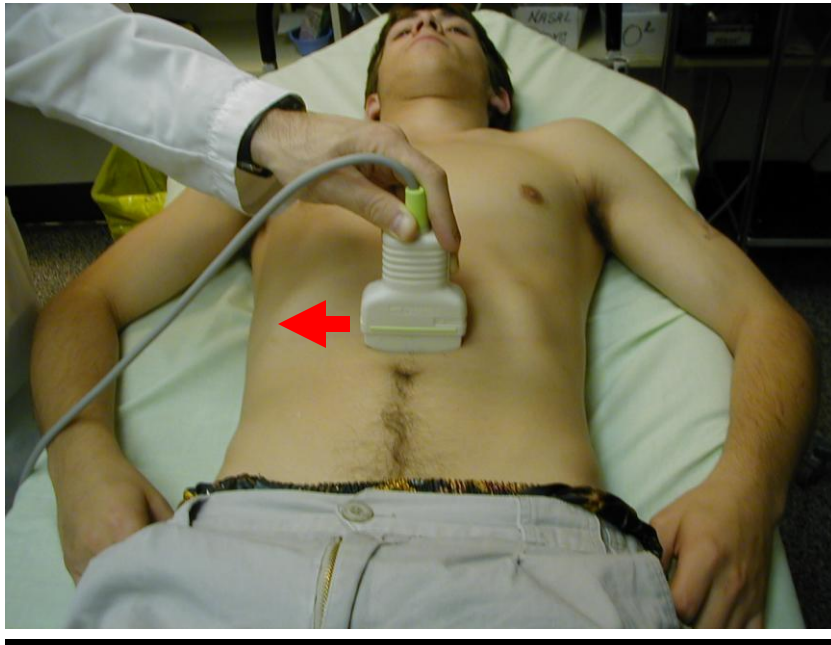
¹² Be careful not to be fooled by thrombus in the lumen, which can be somewhat echogenic and leave a normal-looking fluid (black) center. Make sure you identify the *vessel wall* during your (slow!) sweep.

¹³ Note that, in the setting of a dilated AAA, it is *not necessary to find the bifurcation*. This anatomical landmark is often distorted beyond recognition by the aneurysm. But who cares? If you find a dilated AAA, you have found a critically important image. You must now *place that image in the clinical context*.

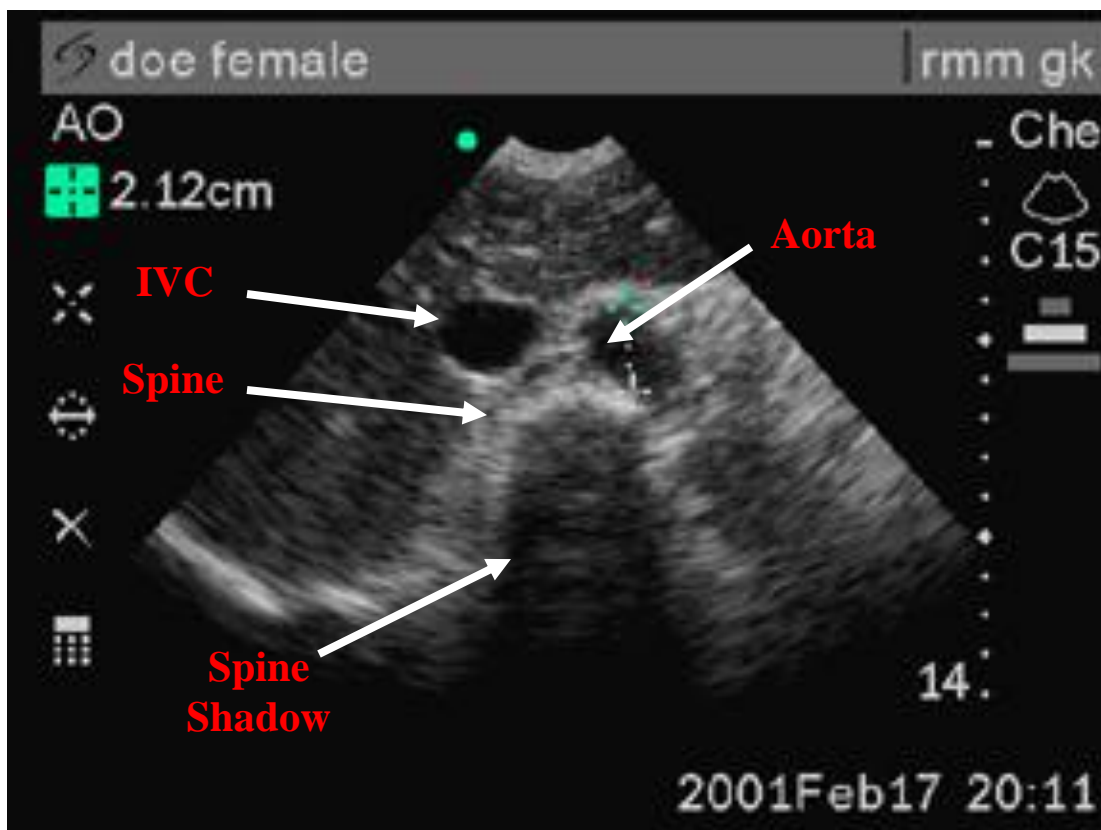
¹⁴ Focused Assessment with Sonography for Trauma – discussed in the next section.

Aortic Scan

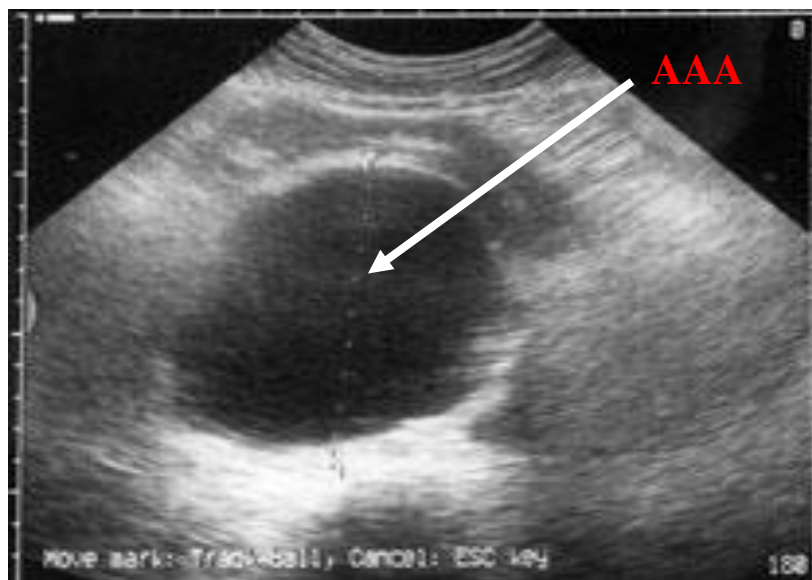
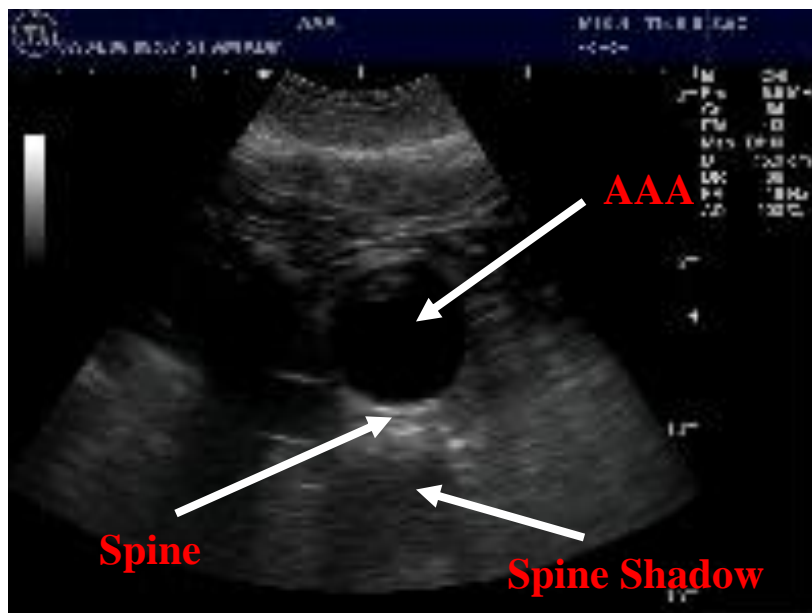
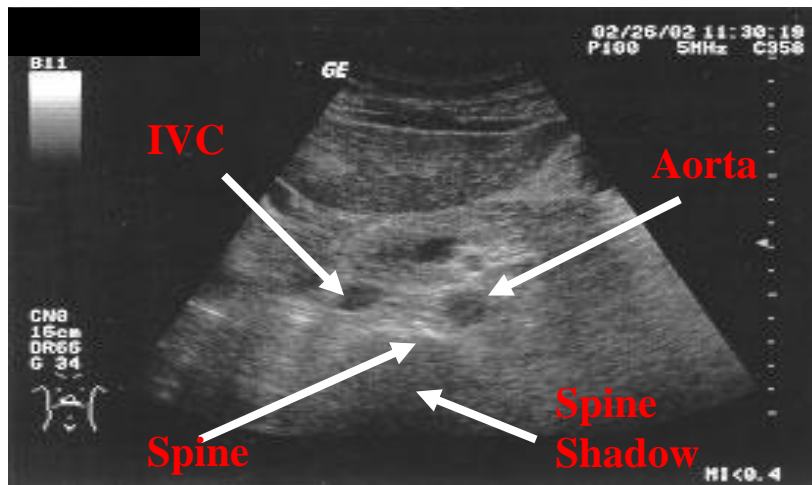
From the outside....



...and from the inside.



Further Examples



A Few Additional Tips

Remember what was said about the difficulty of imaging the aorta. Emergency patients often come with bellies so full of bowel gas, beer, and baloney that nothing can be done, even by experts with high-end machines, to obtain an ultrasound image of the aorta. **Do not be surprised if you are only able to see 50% of the aortas that you attempt to image.** Do not be surprised if, in a year of doing EDU regularly, you are only able to see 80%. In these cases, CT (possibly with resuscitation gear at hand) or direct-to-OR are your only options for the unstable patient.

Before giving up in the face of massive bowel gas, however, you can try to locate the aorta by moving the probe *off-center* to one side or the other. Keep your aim focused on where the *spine* should be. Sometimes, moving off the midline a few centimetres can dramatically improve your image quality. You can also supply gentle external downward pressure the ultrasound probe to displace loops of gas-filled bowel out from in front of the aorta.

If you feel you have located the aorta, it is a good idea to magnify the image by *decreasing the depth*. This makes it easier to follow the structure. Make sure that the key landmark – the spine, with its spine shadow – remains clearly visible and well-centered.

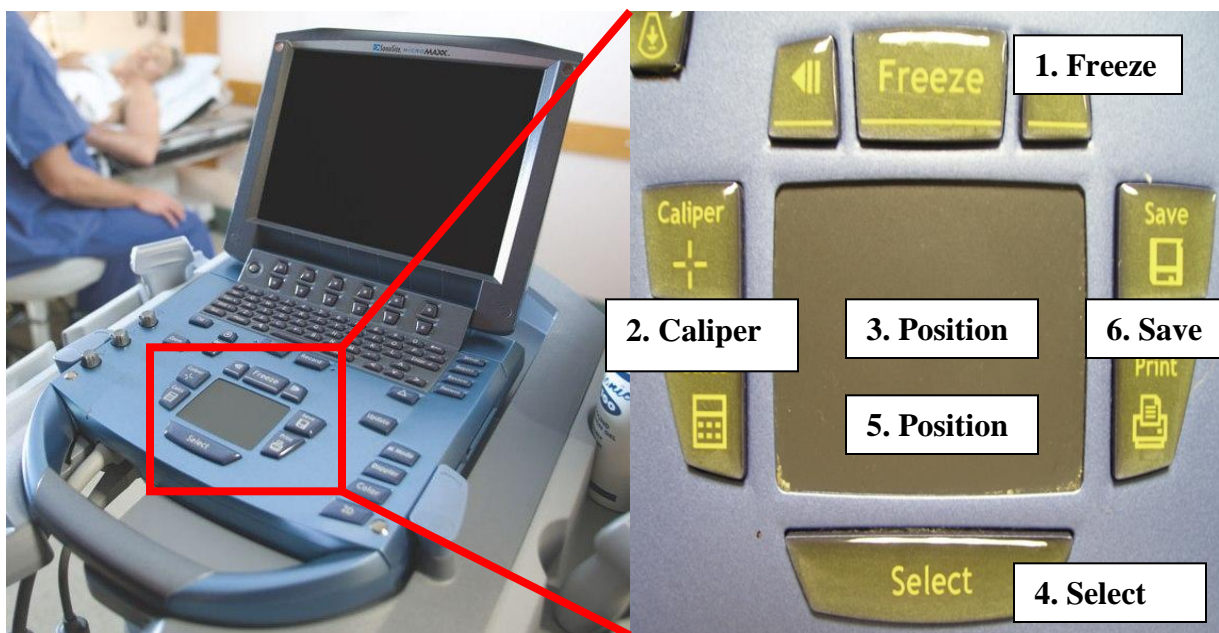
The key area of interest, the vessel wall, is a very echogenic structure (bright, white). Like the pericardium, it is better visualised if the gain is slightly *increased*.

One Last Thing...Measuring

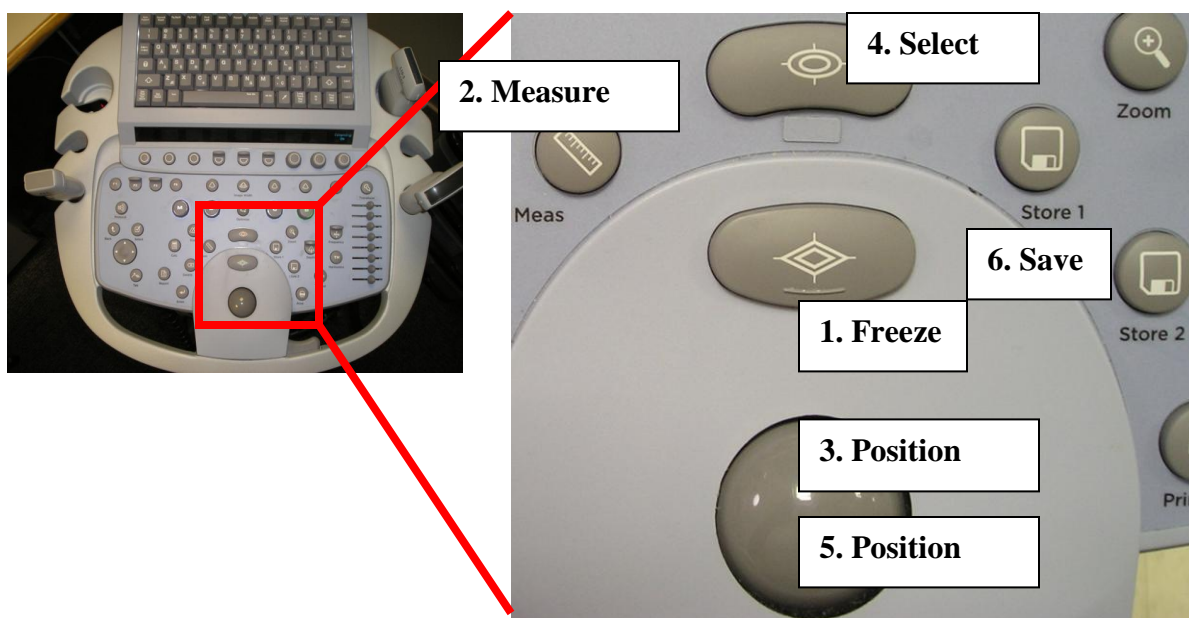
As mentioned, the diagnosis of an abdominal aortic or iliac artery aneurysm using EDU hinges on the ability to measure the diameter of the aorta or the iliac arteries in a transverse plane. How then, does one measure an object using either of the ultrasound machines?

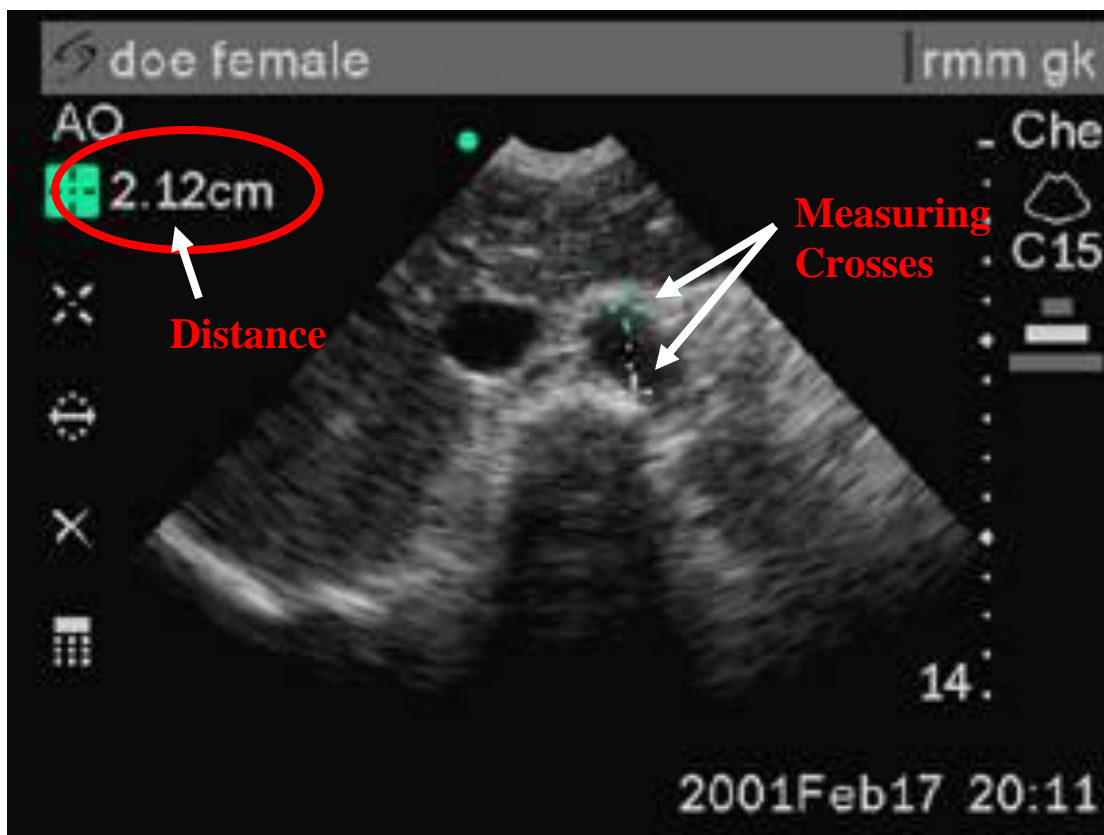
Regardless of the machine being used, the first step in obtaining a good measurement is to center a clear image of the structure of interest on the machine's monitor. Once centered, the process for measuring an object is somewhat similar when using either the Sonosite or the Zonare.

Starting with the Sonosite, once you are satisfied with the object's position and image, freeze that image on the monitor by pressing the "**Freeze**" button located at the midportion of the machine's face. Next, press the "**Caliper**" button marked with a cross located to the lower left of the "**Freeze**" button. You will now see on the monitor two crosses connected by a dotted line. One of the crosses appears white and is labelled "A," while the other cross appears blue without label. Use the fingerpad to position the blue cross at the starting position of your measurement; i.e, the anterior outer wall of the aorta. Once the blue cross is in appropriate position, press the "**Select**" button located underneath the fingerpad. By pressing the "**Select**" button you will see the two crosses on the monitor switch appearances; i.e, the blue cross positioned at the initial measure point will now appear white with the "A" label, and the previous white, "A" labelled cross will now appear blue. In addition to switching appearances, the "**Select**" button also "locks" the previously positioned blue cross where you placed it on the monitor. Now use the fingerpad to position the new, blue cross at the endpoint of your desired measurement; i.e., the posterior wall of the aorta. After both crosses are in the correct positions, the final distance between the two is displayed in centimeters at the left lower corner of the monitor's screen. Lastly, save the final image with measurement, press the "**Freeze**" button to unfreeze the image, and continue with your scan.



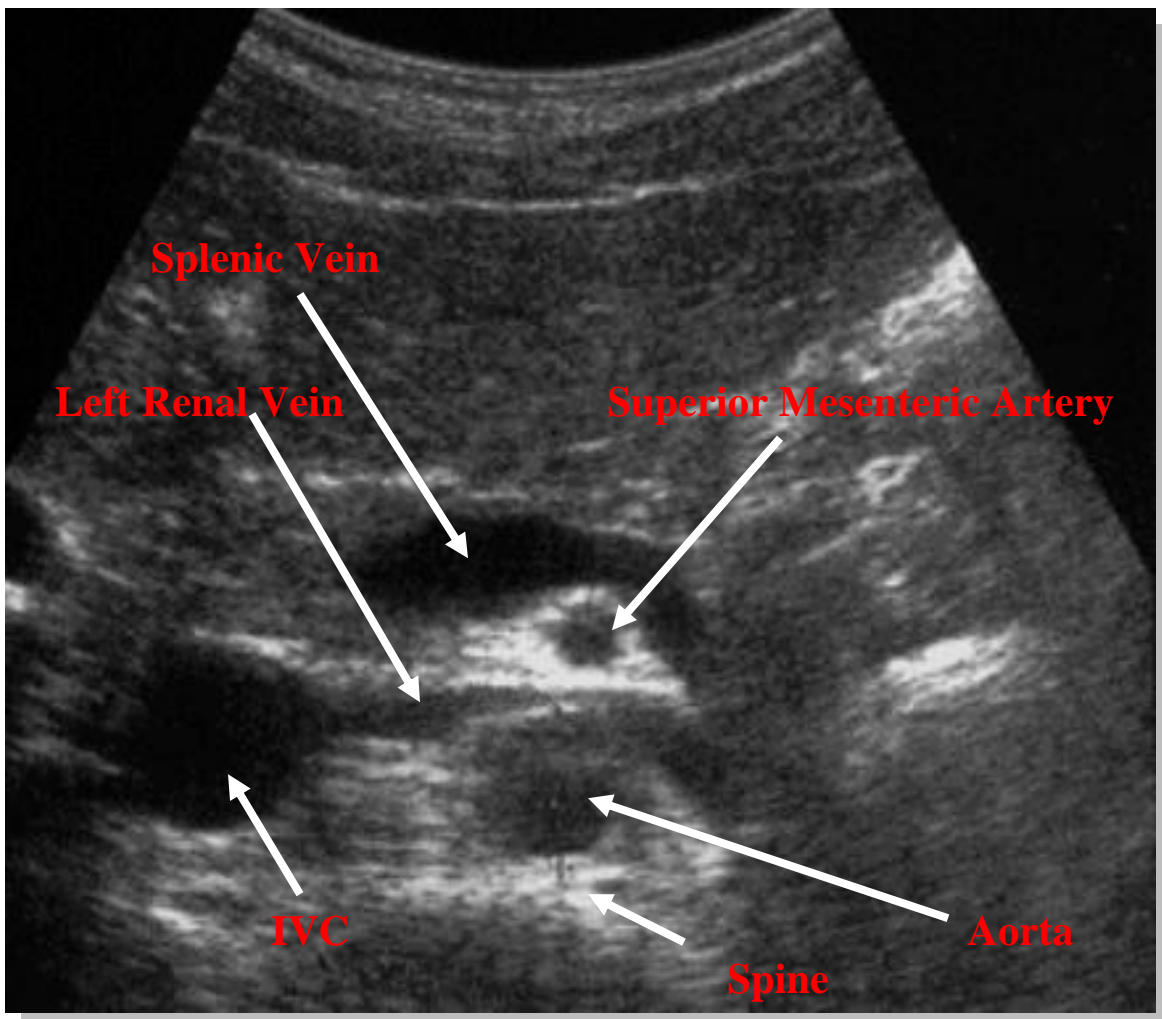
When using the Zonare, once you are satisfied with the object's position and image, freeze that image on the monitor by pressing the diamond labelled button immediately above the rollerball at the machine's lower midface. Next, press the "Measure" button labelled with a ruler just to the left of the freeze button. Once the "Measure" button is selected, a single blue cross appears on the monitor's screen. Use the rollerball to position the blue cross at the initial measure point; i.e., the anterior wall of the aorta. Now, press the select button labelled with two ovals just above the freeze button. The initial blue cross will now appear white, and will be connected to a second blue cross by a dotted line. Use the rollerball to position the second blue cross at the endpoint of your desired measurement; i.e., the posterior wall of the aorta. The distance between the two crosses is displayed in centimeters at the right lower corner of the monitor's screen. Save the final image with measurement, press the diamond labelled freeze button to unfreeze the image, and continue with your scan.



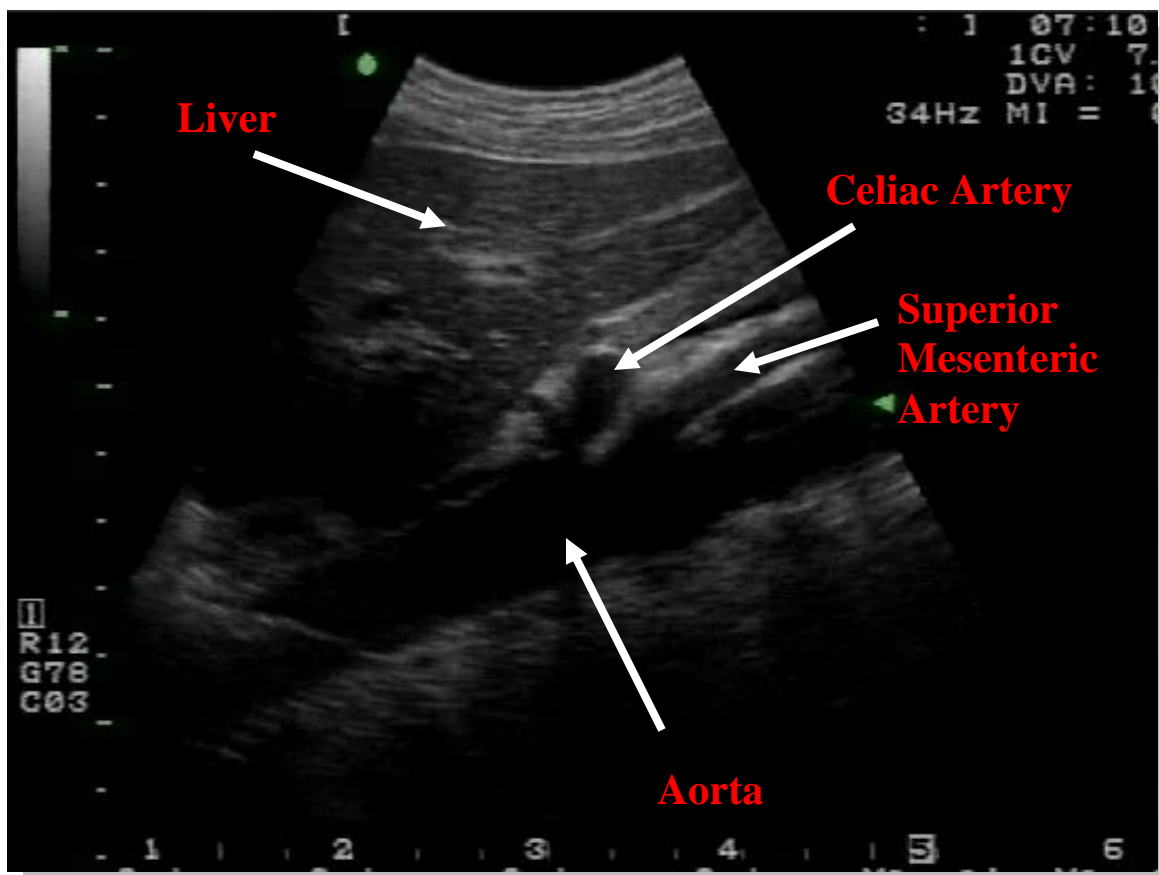


This image of the aorta was displayed earlier in this text; however, now note the two measuring “crosses” positioned at the anterior and posterior walls of the vessel. Also note the distance between the measuring crosses in the upper left corner of the image. Although this image was not made with either the Sonosite or Zonare, it is essentially a near exact representation of what you will observe on either machine’s monitor when measuring a structure.

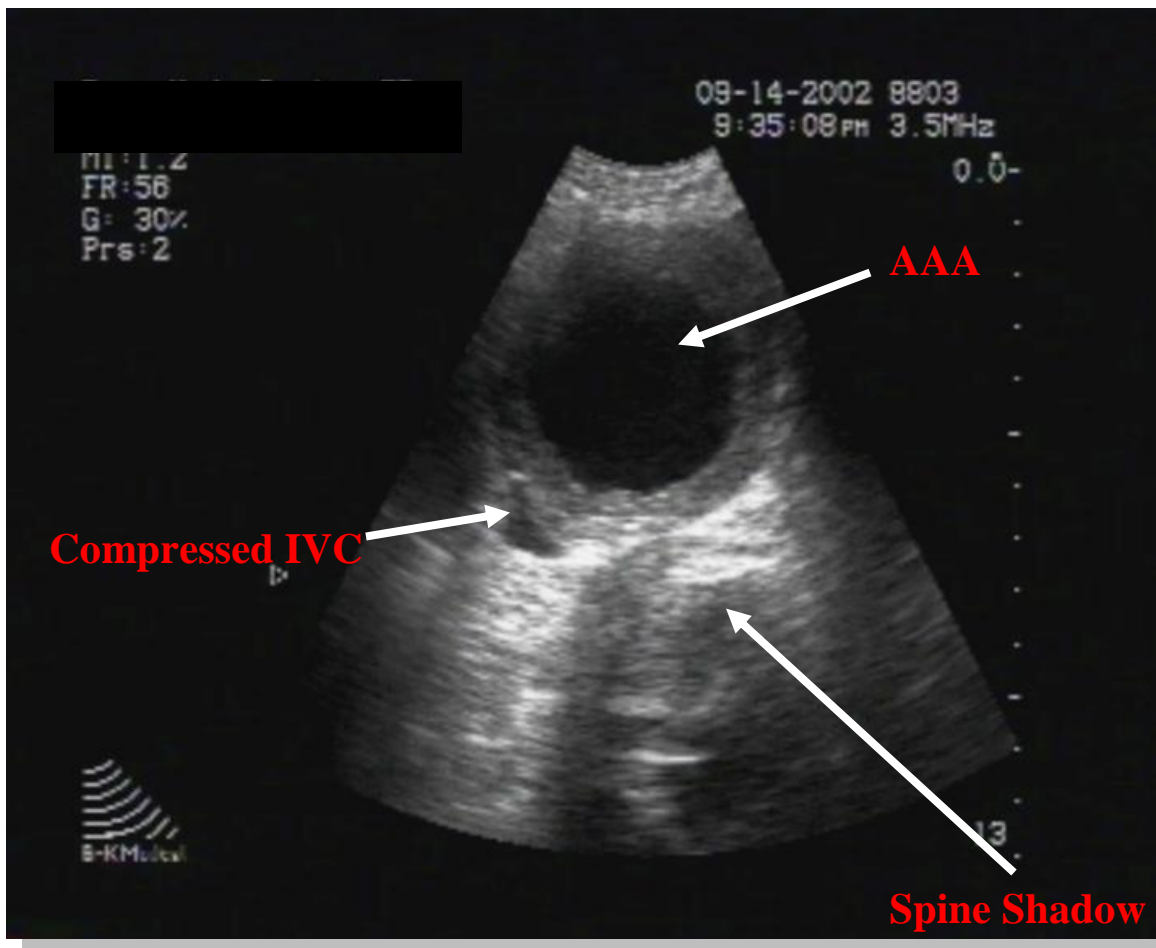
More Aortic EDU Images



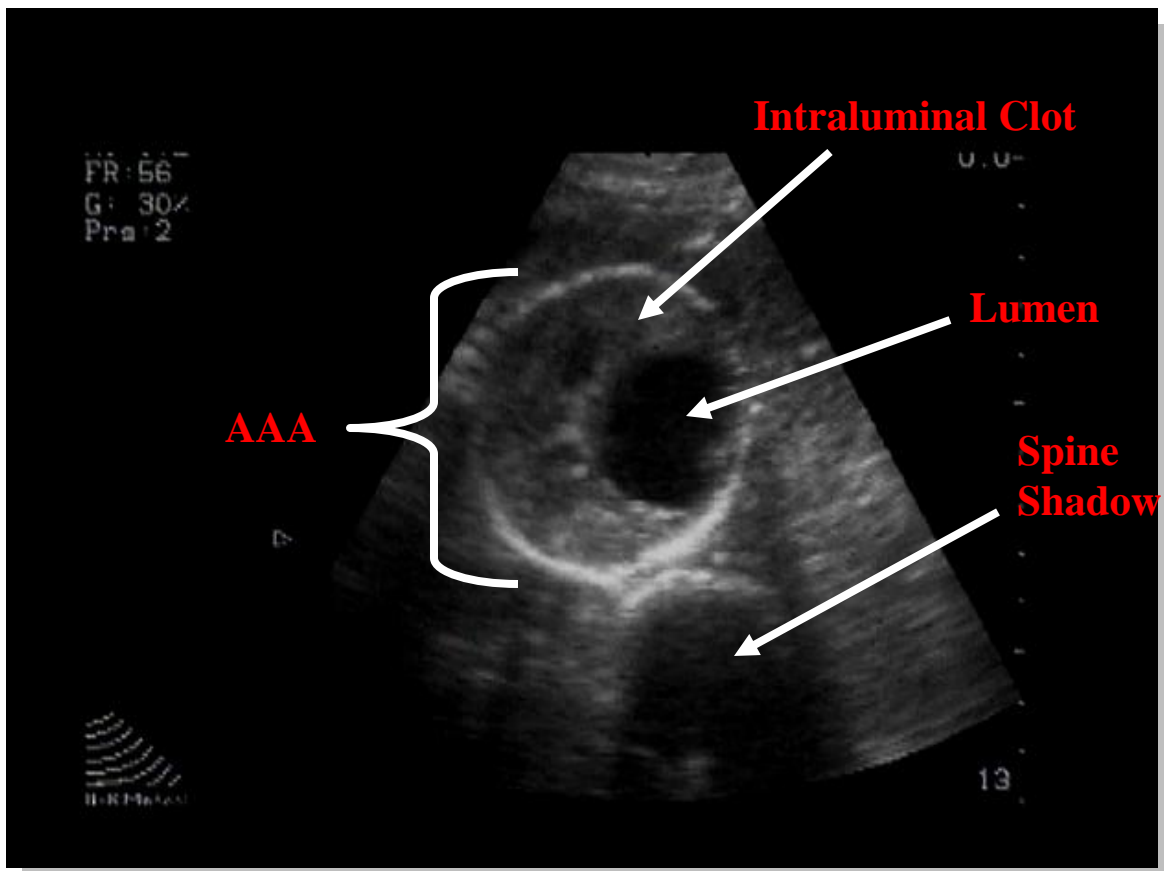
This image depicts the proximal aorta in transverse view, with the probe perpendicular to the skin in the epigastrium with the probe marker pointed towards the patient's right. This view provides additional vascular landmarks to distinguish between the aorta and the IVC.



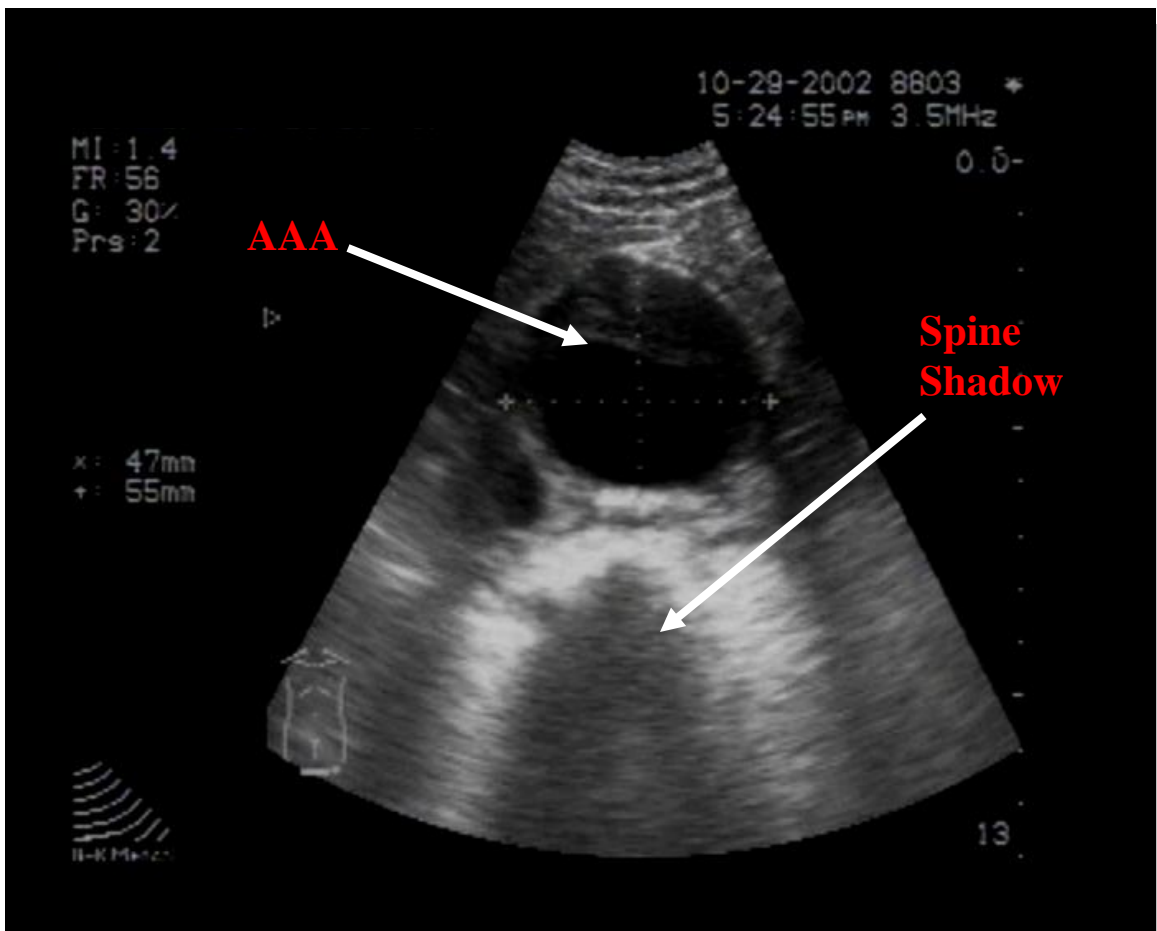
The above image represents the proximal abdominal aorta in a longitudinal plane (probe indicator toward the patient's head). Note the liver as well as the first two branches off of the aorta. Although it is a good habit to always image and document desired structures in multiple planes (i.e., tranverse *and* longitudinal), measurements of the aorta *should not* be made in a longitudinal plane as they tend to not be very accurate.



A large abdominal aortic aneurysm is visualized, measuring approximately 6 cm in diameter (each mark on the right border always represents 1 cm). Note the prominent spine shadow posteriorly. A compressed IVC is also seen. Remember, ultrasound is not sensitive for detecting acute aneurismal leaks.



This is an image of an abdominal aortic aneurysm, measuring approximately 7cm in greatest diameter. Note the intraluminal clot. The aneurysm diameter is measured from the outer walls, not the remaining lumen. The spine shadow is also clearly seen.



This image demonstrates an aortic aneurysm measuring up to 5.5 cm in diameter.

Focused Assessment with Sonography for Trauma (FAST)*

EDU got its start here – the evaluation of the abdomen for the presence of free fluid. The value of EDU in this setting is incontrovertible. If you see free fluid in the right clinical context (i.e. trauma and hemodynamic instability), you're done. The patient needs to go to the OR. On the other hand, if a FAST scan reveals no abnormality, additional workup is needed, such as CT or admission with serial physical exams and FAST scans. The FAST scan is the best *preliminary* test in the setting of trauma or hemodynamic instability – it is not a definitive test. Don't even think about discharging a trauma patient based only on a negative FAST scan. In addition to seeing free fluid in an unstable patient, there are three other possible clinical pathways.

1) FAST positive (free fluid seen), patient stable

Generally, a CT will be obtained in these cases. However, consultation with the trauma surgeon(s) should be sought.

2) FAST negative, but patient unstable (or clinically suspicious)

Clinical judgement always takes precedence. Never allow a negative FAST to reassure you if there is something worrisome about the patient's presentation. You are right. The machine is wrong. Consult the trauma surgeon(s). If the situation warrants it, go directly to the OR. Otherwise, be prepared to take the patient to CT with full resuscitation gear. You may also want to consider the option of redoing the FAST, particularly if other imaging resources are unavailable or not an option.

3) FAST negative, patient stable

Performing serial FAST scans in the stable patient who has been the victim of a high-risk trauma will allow you to detect intra-abdominal hemorrhage before any signs of hemodynamic instability become apparent. A clearly negative FAST (one which remains negative over several hours and several repeat scans) is very reassuring.

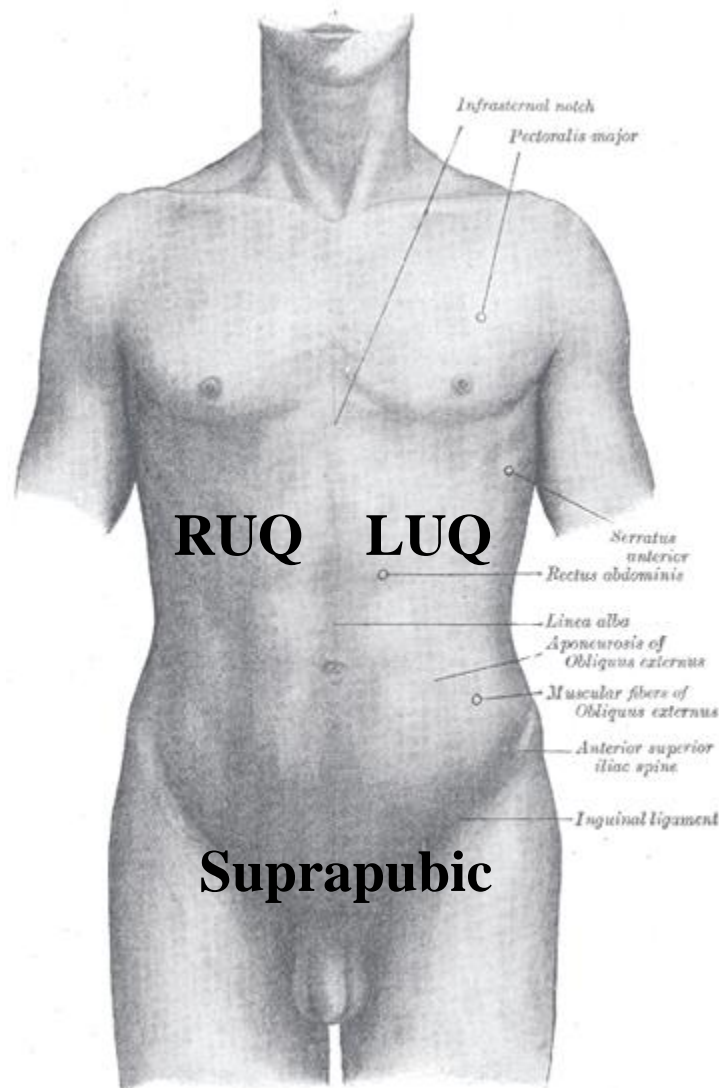
* As the name implies, the traditional indication for the FAST scan is trauma; however, FAST is now indicated in the clinical context of undifferentiated hypotension and cardiopulmonary arrest.

Planes of View

FAST differs from the other EDUs in that you will now be scanning primarily in the *longitudinal* plane. This plane generates images which are somewhat less intuitive than those found in the transverse plane, so it is worthwhile repeating the following two points:

- 1) Always keep the probe indicator oriented towards the patient's *head*.
- 2) If you do 1), the left side of the screen will correspond to the *cephalad* direction.

Scans of the abdomen during a FAST are done in the **RUQ**, **LUQ** and **Suprapubic** regions. The subcostal cardiac view as described in the cardiac EDU chapter is considered the 4th component of a FAST¹⁵.

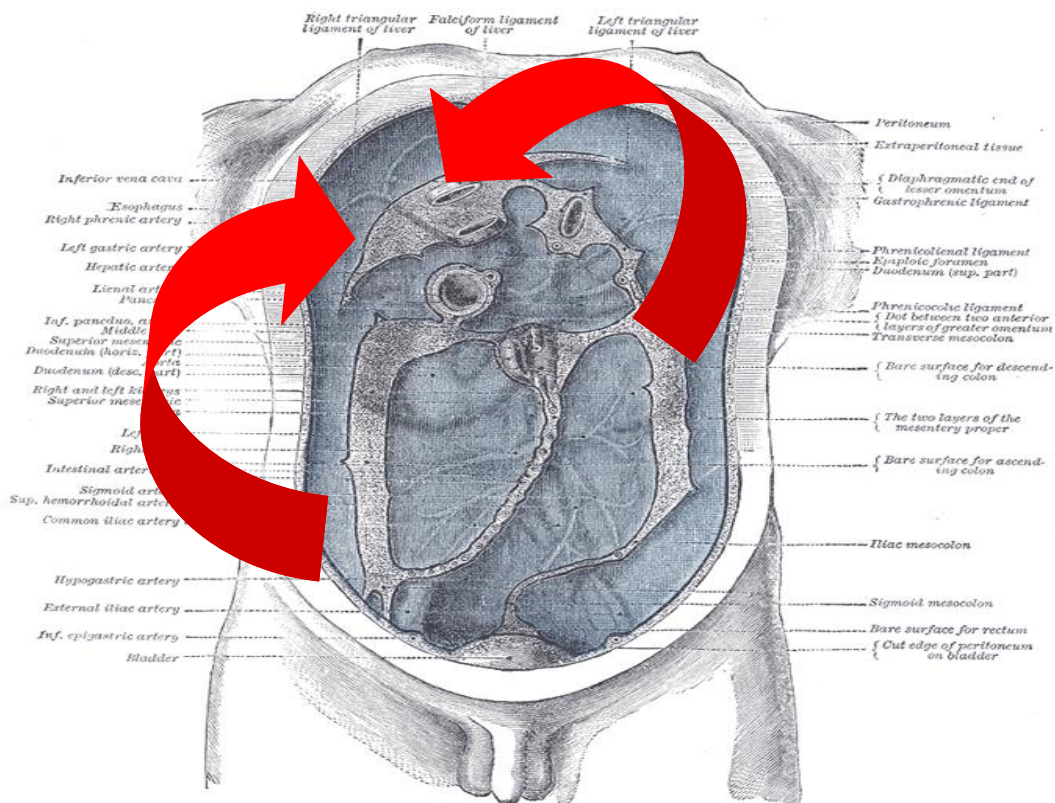


¹⁵ The subcostal cardiac view is typically the easiest view to determine the presence or absence of a pericardial effusion; however, in cases where a clear subcostal view cannot be obtained, the parasternal long view is considered the next best view for trying to identify a pericardial effusion.

Right Upper Quadrant View

This is the single most important part of the FAST scan. The RUQ contains the hepatorenal space (aka Morison's pouch), the second lowest part of the supine abdomen. However, since the lowest part - the pelvis - has such little volume, any clinically significant intraperitoneal bleed will quickly overflow into the RUQ via the right paracolic gutter. As for bleeding in the LUQ, it will be diverted directly to the RUQ (i.e. without going via the relatively lower pelvis) by the phrenicolic ligament. Once in the RUQ, the fluid will collect between the kidney and the liver, forming a black stripe between these two solid organs. The excellent tissue interface created here makes this easy to see.

All roads lead to.... The RUQ*



* in the *supine* patient.

The hepatorenal view alone will detect massive hemoperitoneum in 82%-90% of hypotensive patients with an abdominal source of bleeding. FAST is able to reliably detect free fluid in the abdomen only if the effusions are over 250-500 cc (in the adult). This should not be seen as a limitation. On the contrary, it indicates that the test has appropriate specificity for clinically significant injuries without being overly sensitive.

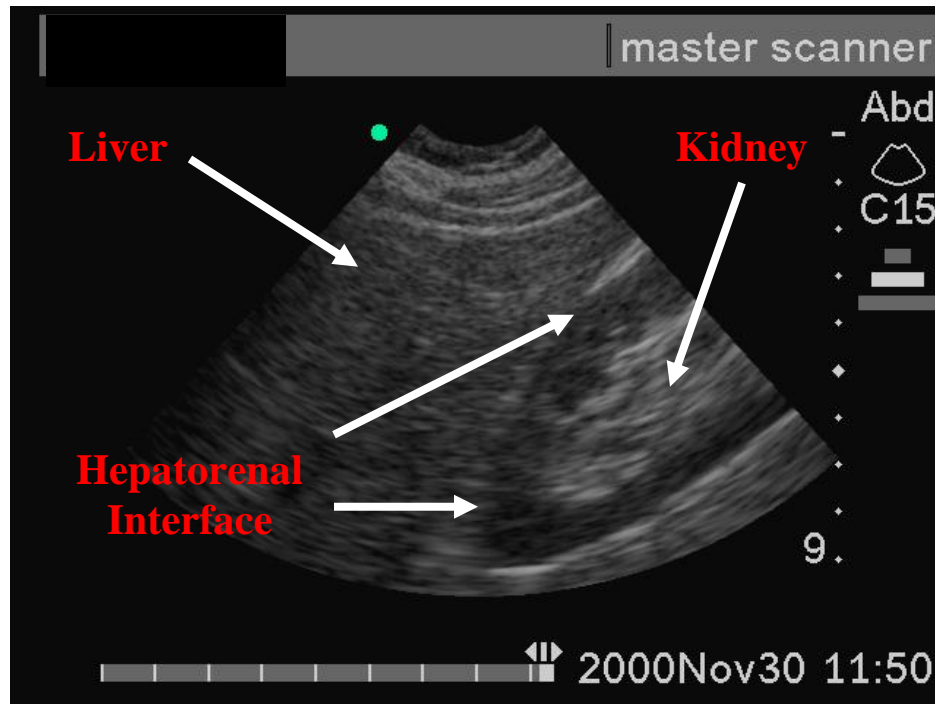
The RUQ scan is performed by placing the probe in a longitudinal orientation (indicator toward patient's head) roughly where you would expect the kidney to be (generally at the level of the costal margin in the anterior-to-mid axillary line), and then sweeping slowly anteriorly and posteriorly. If this fails to generate a recognizable image, you can try to angle the probe slightly cephalad and then slightly caudad, repeating the anterior-posterior sweeps in both positions. The next thing to try is to move cephalad or caudad one or two rib spaces¹⁶ and try the entire sequence again. If you are having a difficult time with this, you are almost certainly placing the probe too *anteriorly*. The kidney is in the retroperitoneum, not halfway between the spine and the umbilicus. Think “posterior axillary line”, to the point where your fingers holding the probe are actually in contact with the stretcher.

RUQ Scan

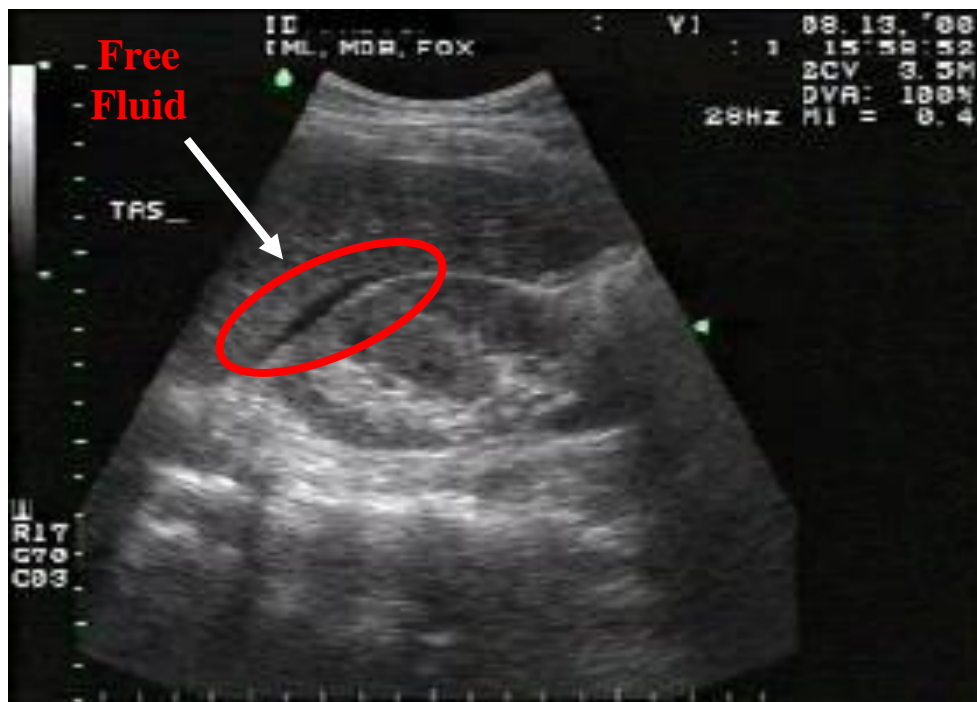


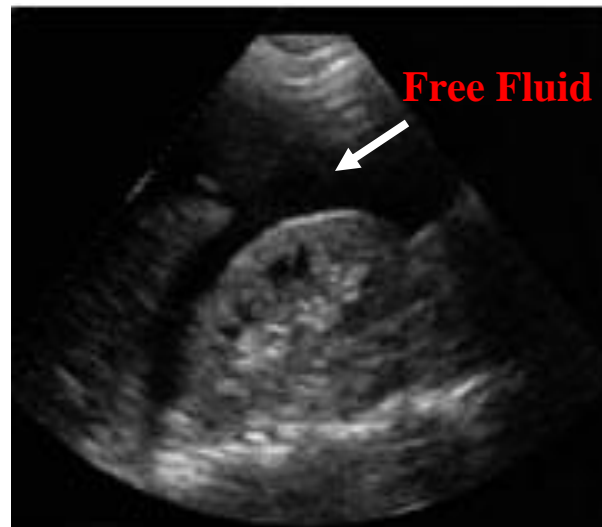
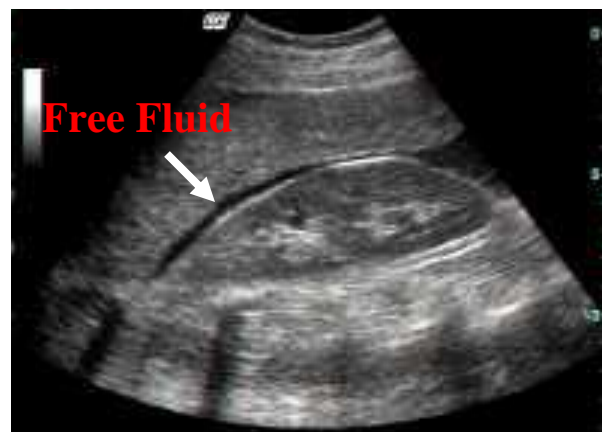
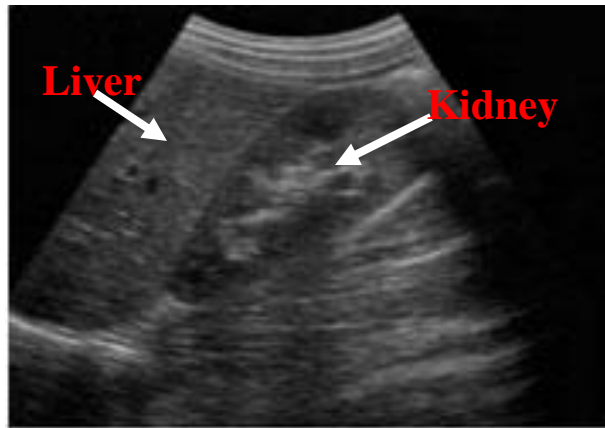
¹⁶ In contradistinction to the slo-o-o-o-w movements favored everywhere else, repositioning the probe in this situation should be done quite aggressively. This will be made obvious on the course.

RUQ Scan - Normal



RUQ Scan - Positive





Further examples of a normal RUQ (top) versus abnormal RUQ FAST exams. Note the marked amount of free fluid in the bottom image.

Left Upper Quadrant View

The LUQ is anatomically interesting. As mentioned above, the phrenicolic ligament will eventually divert LUQ fluid to the RUQ (without passing through the pelvis). However, there is enough potential space in the LUQ for a clinically significant bleed to accumulate. *Early* detection of bleeding from splenic or left diaphragmatic injury is accomplished with this scan.

The LUQ scan is technically more difficult to do because the spleen is:

- *Smaller than the liver, giving you a smaller target to hit.
- *More mobile than the liver, making it possible for fluid to accumulate on either side of it and not just in the splenorenal pouch.
- Higher and more posterior than the liver, placing more ribs in the way.
- Close to the stomach and its contents, which may appear as free fluid, or obscure the spleen.

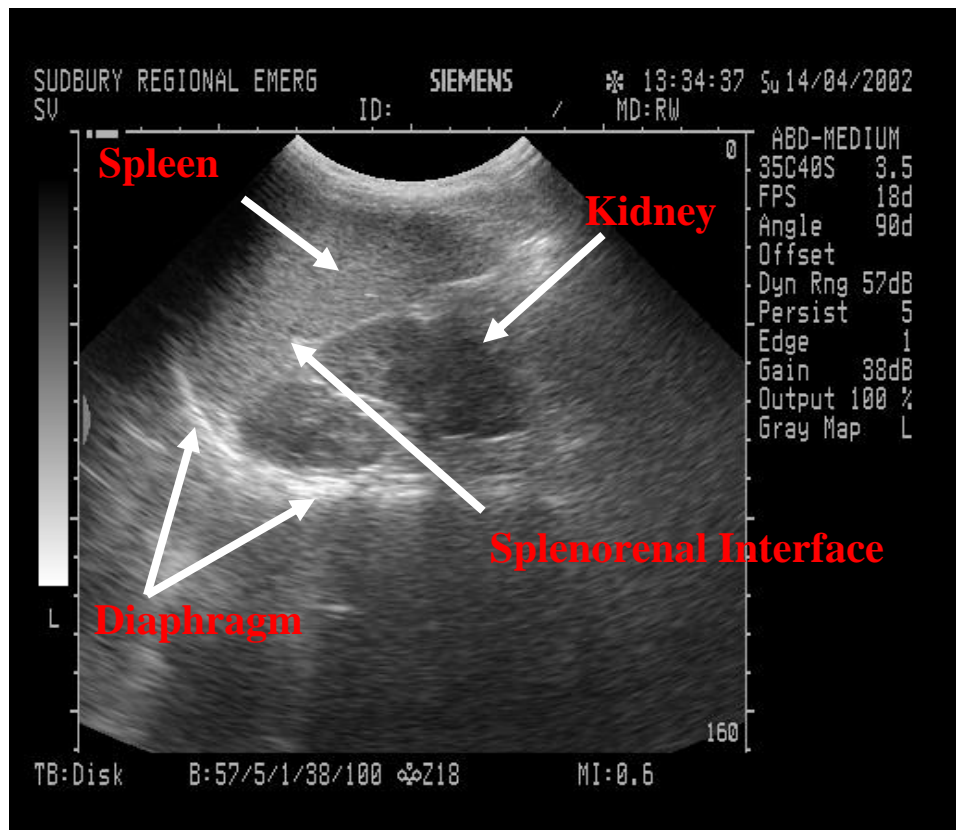
To perform the LUQ scan, place the probe at the patient's posterior axillary line, in a position more superior than where you found the liver-kidney interface in the RUQ. The LUQ scan itself is executed in the same fashion as the RUQ scan - by slowly sweeping the probe anteriorly and posteriorly until recognizable structures are visualized. As with the RUQ, you may have to rest your hand on the stretcher in order to get the probe as posterior as necessary to visualize the splenorenal pouch. Also keep in mind that despite the example on the next page, most (if not all FAST scans) are performed with the examiner standing on the patient's right. This often results in the examiner having to stretch across the patient's body in order to reach the LUQ. During this stretch, there is a natural tendency to "cock" or flex your wrist and hand toward the ceiling. With your wrist in this flexed position, it is difficult if not nearly impossible to identify the splenorenal pouch as the scanning plane is also pointed at the ceiling and not at the LUQ. Be conscious of your own body position when reaching across the patient to perform the LUQ scan, and try to keep your wrist at neutral as possible.

*Also increases the possibility that bowel (and the hated bowel gas) will intrude.

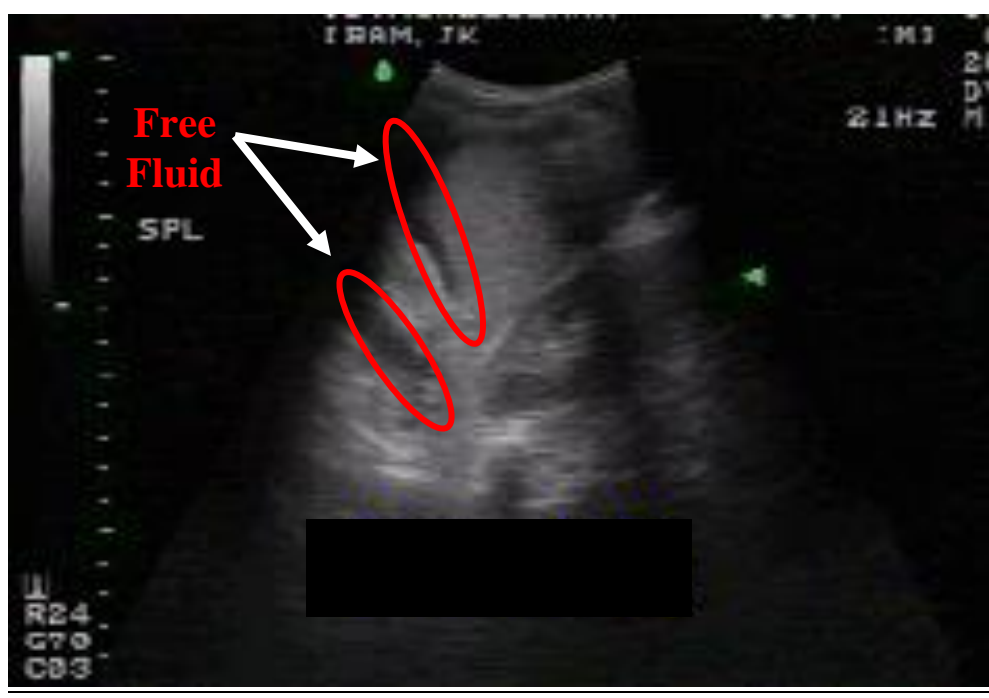
LUQ Scan

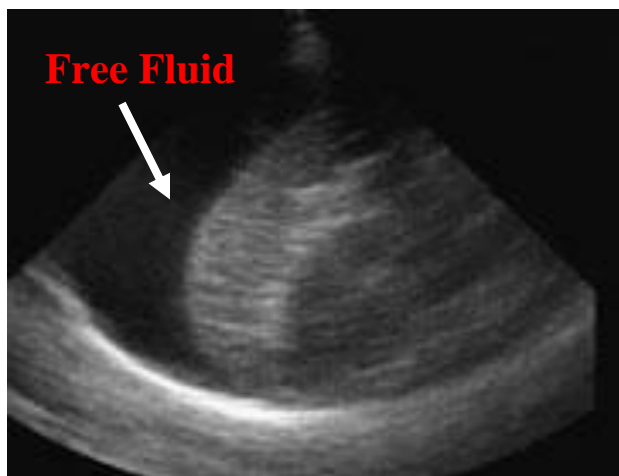
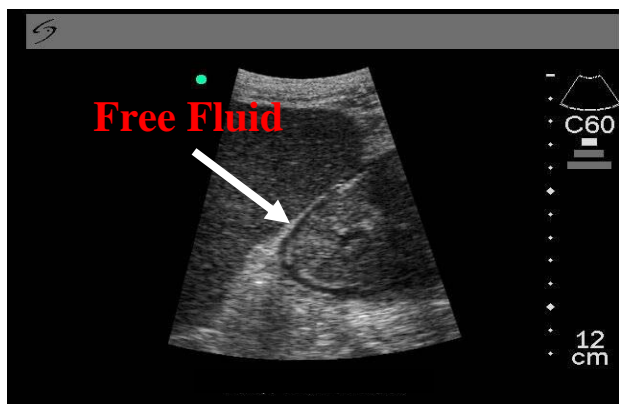
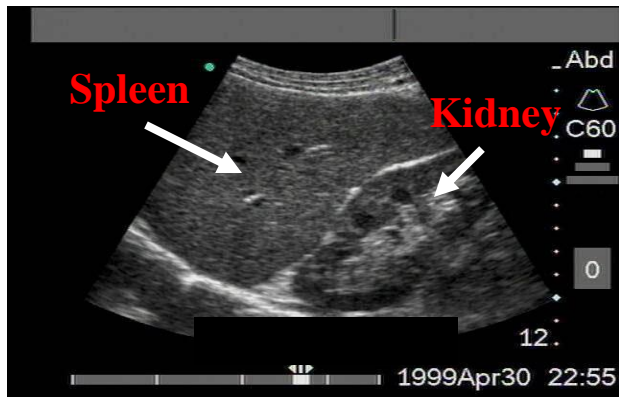


LUQ Scan - Normal



LUQ Scan - Positive





Further examples of a normal LUQ (top) versus abnormal LUQ FAST exams. Note the marked amount of free fluid above the spleen in the bottom image.

FAST Traps

The following points apply equally to both upper quadrants. First the bad news: sources of *false positives*:

- 1) ***Perinephric fat*** can fool you, as it can be just echolucent (i.e. black) enough to look like free fluid. Always compare the two sides. The perinephric fat deposits will be roughly symmetrical, so if you are getting the same image on both sides, your patient needs a dietician, not a surgeon.¹⁷
- 2) ***Is it blood?*** Ascites, Continuous Ambulatory Peritoneal Dialysis (CAPD) fluid, and urine from a ruptured bladder all look identical to free blood. Your history and physical will give you clues as to the presence of the first three¹⁸. Urine could give you real problems in the setting of trauma, but only if there was so much urine that it made it look like massive intra-abdominal hemorrhage had taken place. You would then be confronted with a stable patient and a very worrisome scan. Fortunately, this is a rare occurrence, and one in which we already know what to do: ***follow your clinical instincts and ignore the scan***. If the patient has not bled, they will remain stable and the worrisome image will resolve over time.
- 3) ***Intraluminal bowel and intragastric fluid*** can also fool you, as it also looks exactly like free fluid. Unlike the other sources of false positives, this is a common occurrence, but fortunately peristalsis usually gives this away.

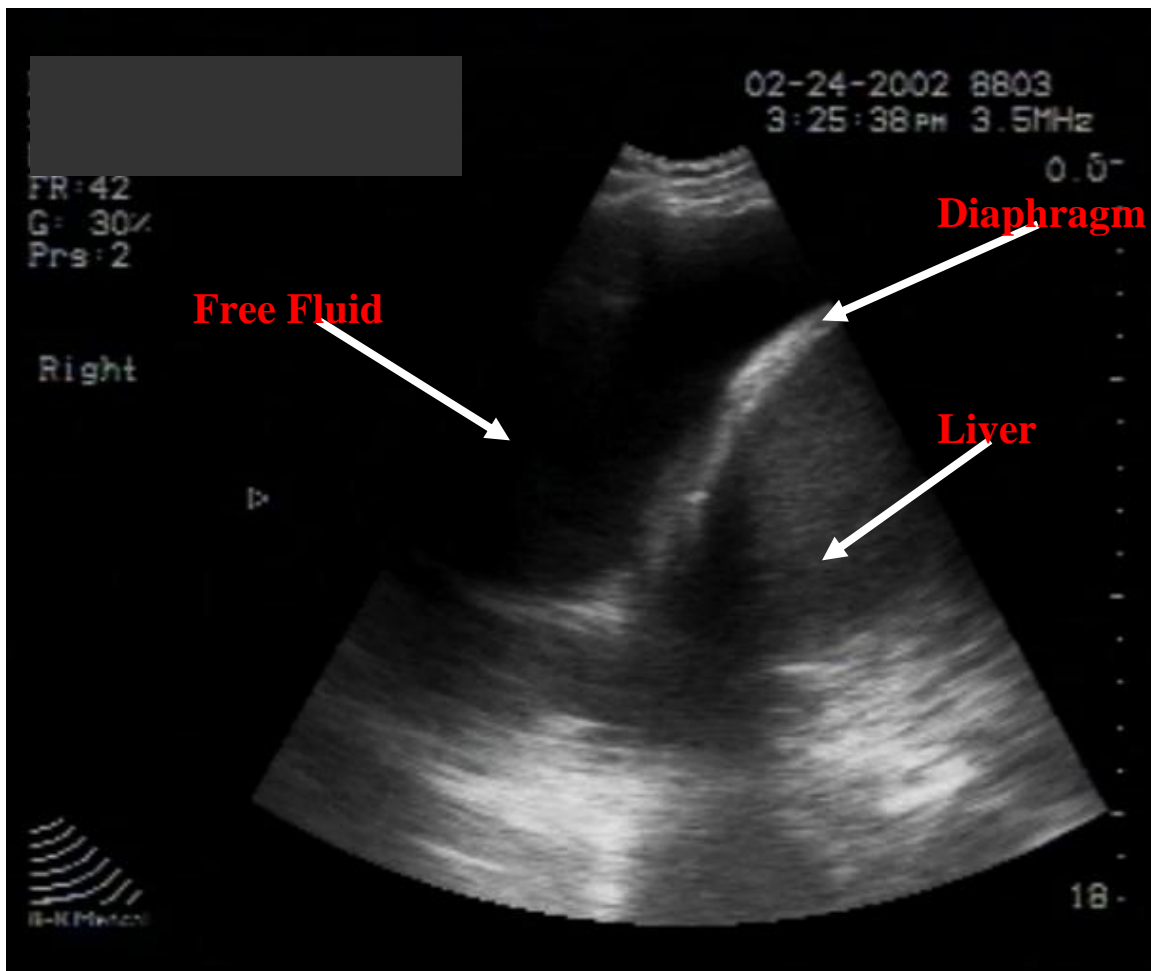
And the sources of *false negatives*:

- 1) ***Adhesions*** from prior surgeries can be so extensive that the free fluid will loculate in unknown (and unknowable) locations in the abdomen. Although this is quite rare, it underlines the necessity to always see EDU as an adjunct to your clinical practice. If you are clinically concerned that the patient is hemorrhaging internally and your EDU scan is negative, ***go with your clinical suspicion***. History beats physical, history and physical beats imaging.
- 2) ***Delayed presentations***. In the unlikely event that a patient arrived 12-24 hours ***after*** having bled internally, it is possible for the blood to have clotted. This will appear as an echogenic (i.e. grey/white) area that can be easily missed. Of course, if they are still alive the day after their bleed, their need for an emergency operation can be questioned.
- 3) ***LUQ variability***. Because of the spleen's aforementioned qualities (higher, smaller, more posterior, more mobile), LUQ free fluid can sometimes accumulate medial and/or superior (i.e. cephalad) to it and ***not only in the splenorenal interface***. It is therefore important to always image a significant portion of the ***diaphragm*** before declaring an LUQ scan to be negative. Although only a few millimetres thick, the diaphragm's density makes it stand out as a bright echogenic line, generally curving

¹⁷ As rule, obese patients are poor EDU subjects. However, this tends to be less of a problem in the RUQ and LUQ as all but the most obese tend to have much less adipose tissue on their sides than on their front.

¹⁸ Stigmata of liver disease, presence of CAPD catheter.

upwards from the 6 o'clock position to 9 o'clock or better. Although less important, it is also a good habit to image the diaphragm in the RUQ as well. Not only is it possible to find anechoic fluid between the spleen/liver -diaphragm interface, one may also observe anechoic fluid *above* the diaphragm, indicating a hemothorax.



Positive Hemothorax

FAST Tricks

And now the good news: how to get the most out of your upper quadrant scans.

- 1) Make sure you start your scan in a *true longitudinal plane* and at *maximum depth*. This greatly facilitates proper orientation.
- 2) Placing the patient in *5° of Trendelenburg* position for 15-20 minutes can help to deliver free fluid to the RUQ and LUQ. It seems that this maneuver decreases by one third the amount of free fluid needed for the ED sonographer to be able to detect it.
- 3) *Angling the probe ~30°* will help to get the rib shadows out of the way. Obviously, you would rotate the probe counter clockwise in the RUQ and clockwise in the LUQ (just think about the way the ribs run). Or simply remember that the *cephalad* end of the probe goes *down*.
- 4) If the patient is stable enough, they can assist you by *taking a deep breath* and holding it for several seconds. This will bring the hepatorenal and splenorenal spaces down into the abdomen and away from the ribs.
- 5) As mentioned before: “*When in doubt, Rescan*”. This is particularly important in the upper quadrant trauma scans, where the pathology may not be as immediately apparent as in other areas or conditions. Fortunately, the ease of EDU makes this a simple thing to do.

From the Department of Redundancy Department: Upper Quadrant Scanning – Pearls

The exhortation, mentioned earlier, to make your hand movements *slo-o-o-o-o-w*, is most important here. The heart and the aorta are fairly large targets that are not influenced by the patient's respiration. The RUQ and the LUQ offer smaller targets that can move dramatically with inspiration and expiration. It is possible to scan through the fluid collection in the hepatorenal or splenorenal space very quickly and without realizing you have done so. This would lead to the worst possible scan outcome – a false negative. **Do not** go down that road.

To ensure that your technique has been adequate, follow these steps every time:

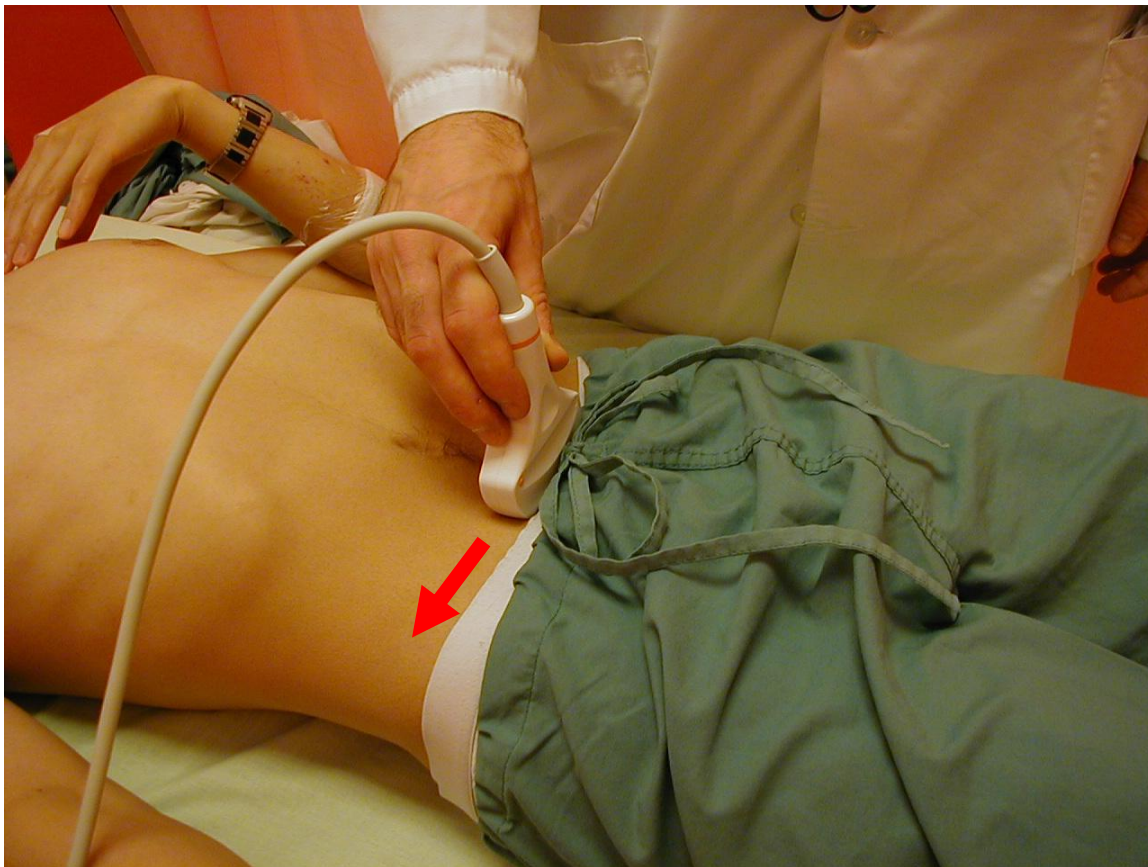
- 1) Identify the hepatorenal or splenorenal interface, with the probe in a ***true longitudinal*** orientation at first.
- 2) Sweep through the entire interface, moving anteriorly, until it disappears.
- 3) Now sweep through the entire interface moving posteriorly. You should be able to watch the interface reappear, then disappear again.
- 4) Return to mid-position. Note that these sweeps will have to be done ***at the same time*** as you tilt the probe 30° or more (***cephalad end towards the bed***) to avoid the ribs. In other words, the probe is moving in ***two planes simultaneously***. This is something a lot of people find tricky and which we will practice a lot during the course.

If you have done the above slowly and deliberately, making certain that you have visualized the entire area of interest, and you see no black stripes anywhere... you're done. A true negative.

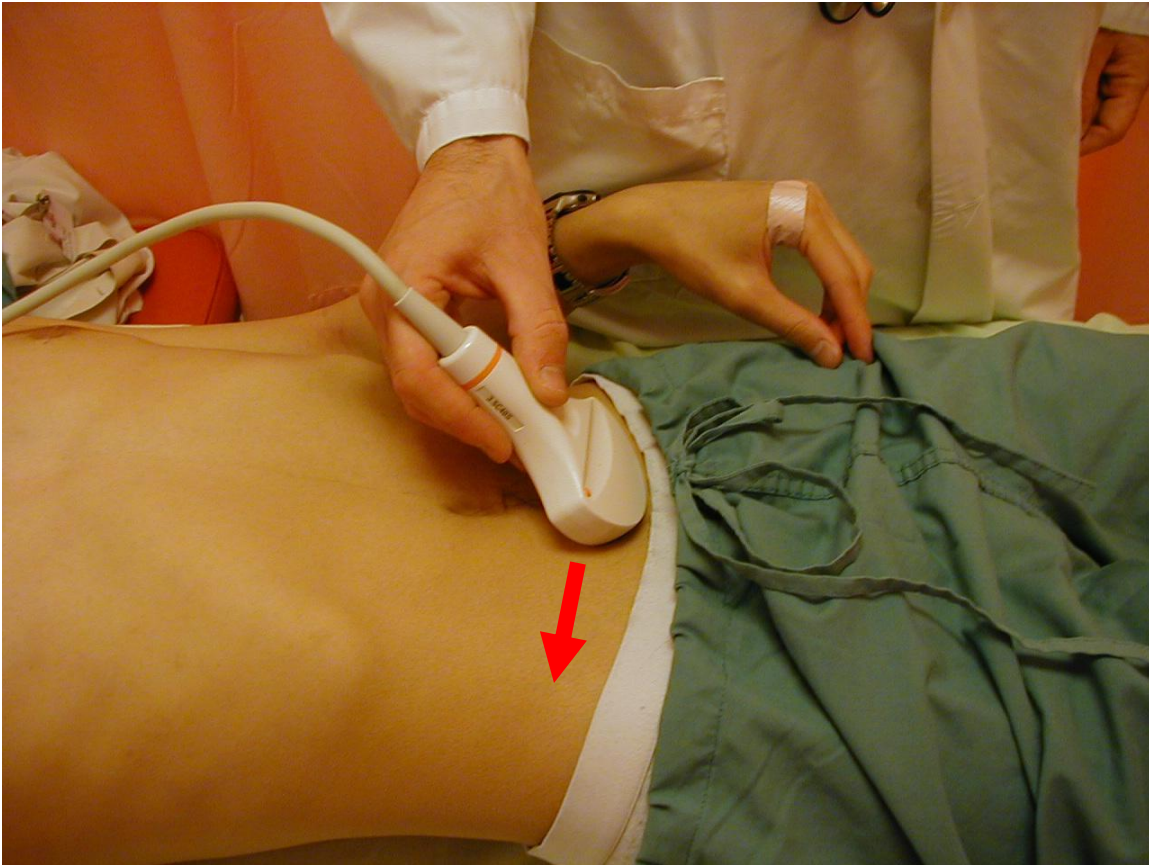
Suprapubic View

The 3rd component of the FAST scan is not very technically difficult to do, and it can detect minor bleeds more quickly, particularly if they originate in the pelvic area. The suprapubic scan aims to visualize the rectovesicular pouch in men and the rectouterine pouch (aka Pouch of Douglas) in women. Start by obtaining transverse view 2-3 cm above the symphysis pubis (starting at 0° and angling 30° - 45° caudally).

First, place the probe *transversely*...



... then angle to 30° - 45° caudad.



After obtaining the transverse view, rotate the probe 90° clockwise to obtain a longitudinal view of the pelvis. This view allows visualization of the rectovesicular and rectouterine pouches.

The suprapubic view can be quite frustrating, until you realize that radiologists fill the bladder to look there, so you can too. If the patient has no contraindications to the placement of a urinary catheter¹⁹ then you can go ahead and instill 250 cc of NS into the bladder and clamp the catheter. This gives you a perfect “acoustic window” through which to peer deep into the pelvis. The bladder will appear as a black mass at the top of the screen. Anything else black should be cause for concern.

You will recall that, when looking for the pericardium (a white structure) you were told to increase the gain. Here in the pelvis, you are looking for free fluid (small black structures), so it is wise to *decrease* the gain. This is particularly true if you are scanning through a full bladder, as there is likely to be considerable enhancement (see page #33).

¹⁹ High riding or absent prostate, blood at the meatus, scrotal hematoma, perineal ecchymoses, or an unstable pelvic fracture.

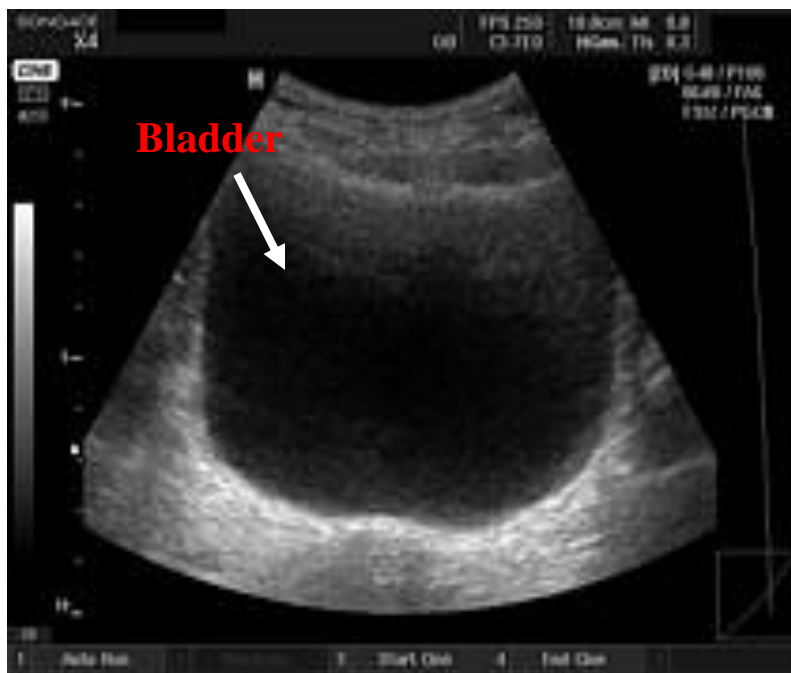
The suprapubic view can also be frustrating due to the possibility of false positives. Generally, these arise from:

- Women, who always have small amounts of fluid in the rectouterine pouch (although generally less than EDU can reliably detect)
- Bowel loops containing fluid (though peristalsis usually gives these away)
- The prostate, which can be quite hypoechoic (i.e. black). This is generally only seen if you are scanning too far caudally. If in doubt, confirm that what you are looking at is the prostate by having someone do a simultaneous rectal exam. Ask them to push on the prostate and if the area you are wondering about moves, it's the prostate.

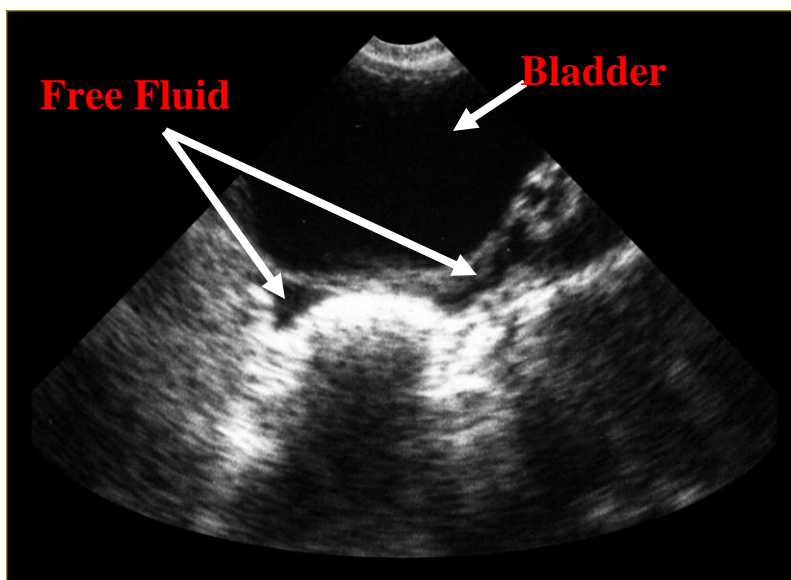
If the patient is entirely stable, they can be placed in the reverse Trendelenburg position, which will decrease the amount of free fluid that can be reliably detected in the pelvis by 50%.

*Note that if you are unable to fill the bladder, it may be challenging to do a suprapubic scan.

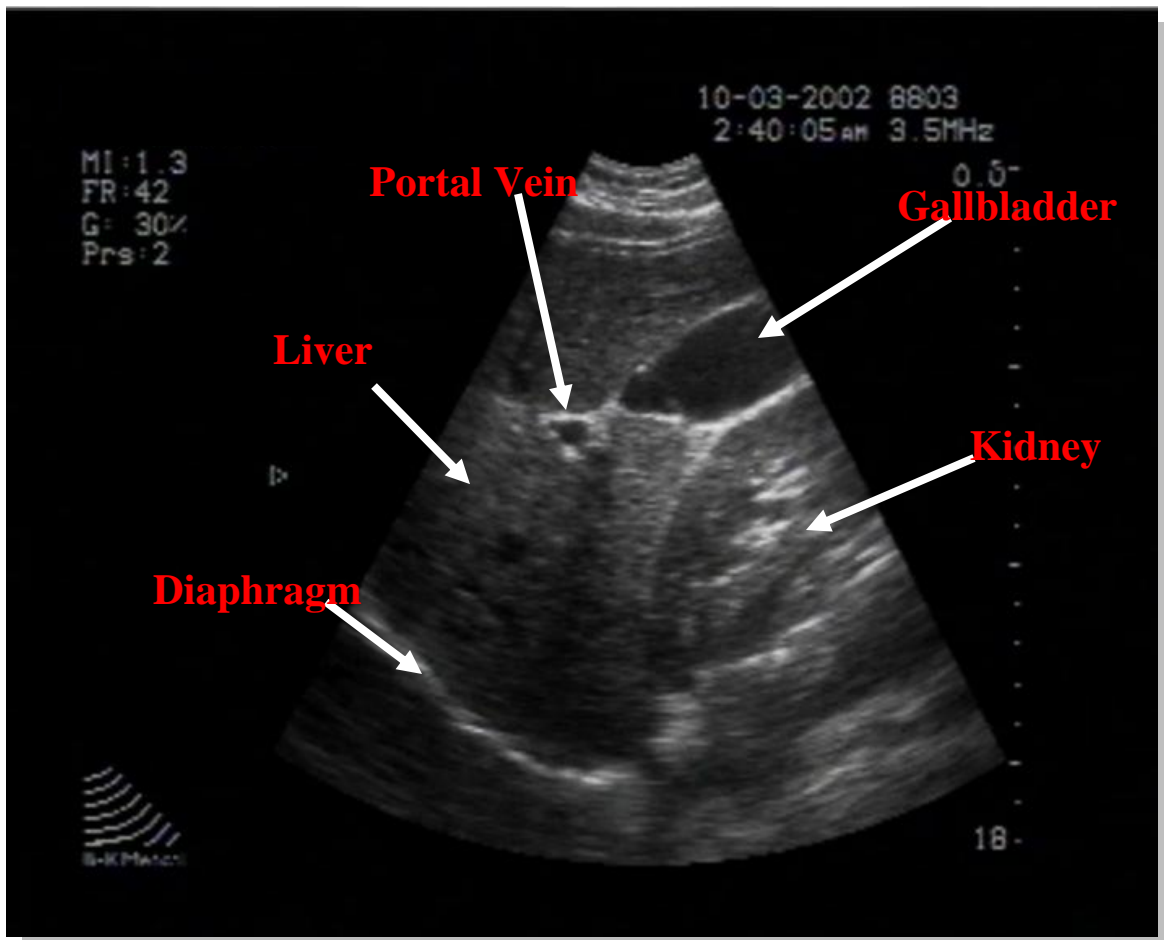
Suprapubic Scan - Normal



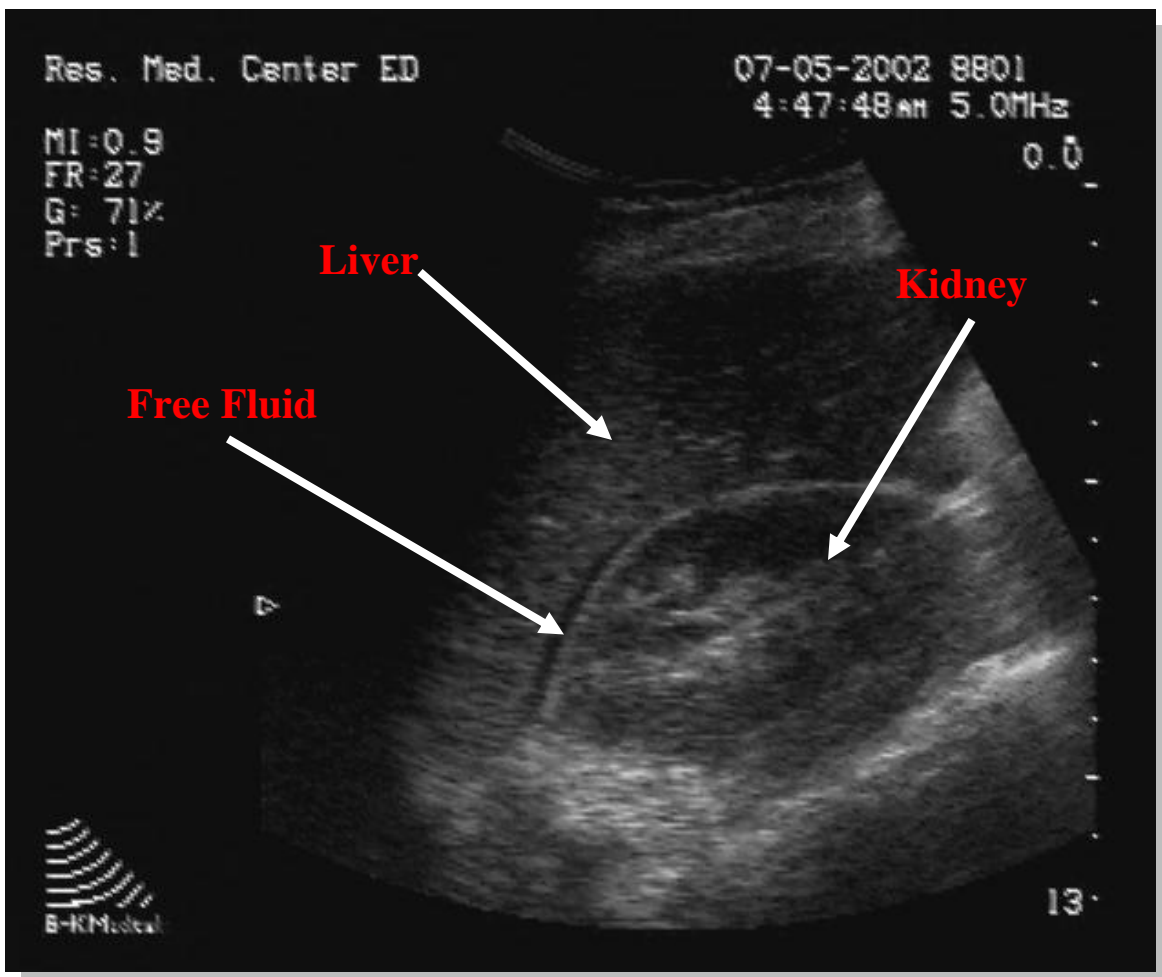
Suprapubic Scan - Positive



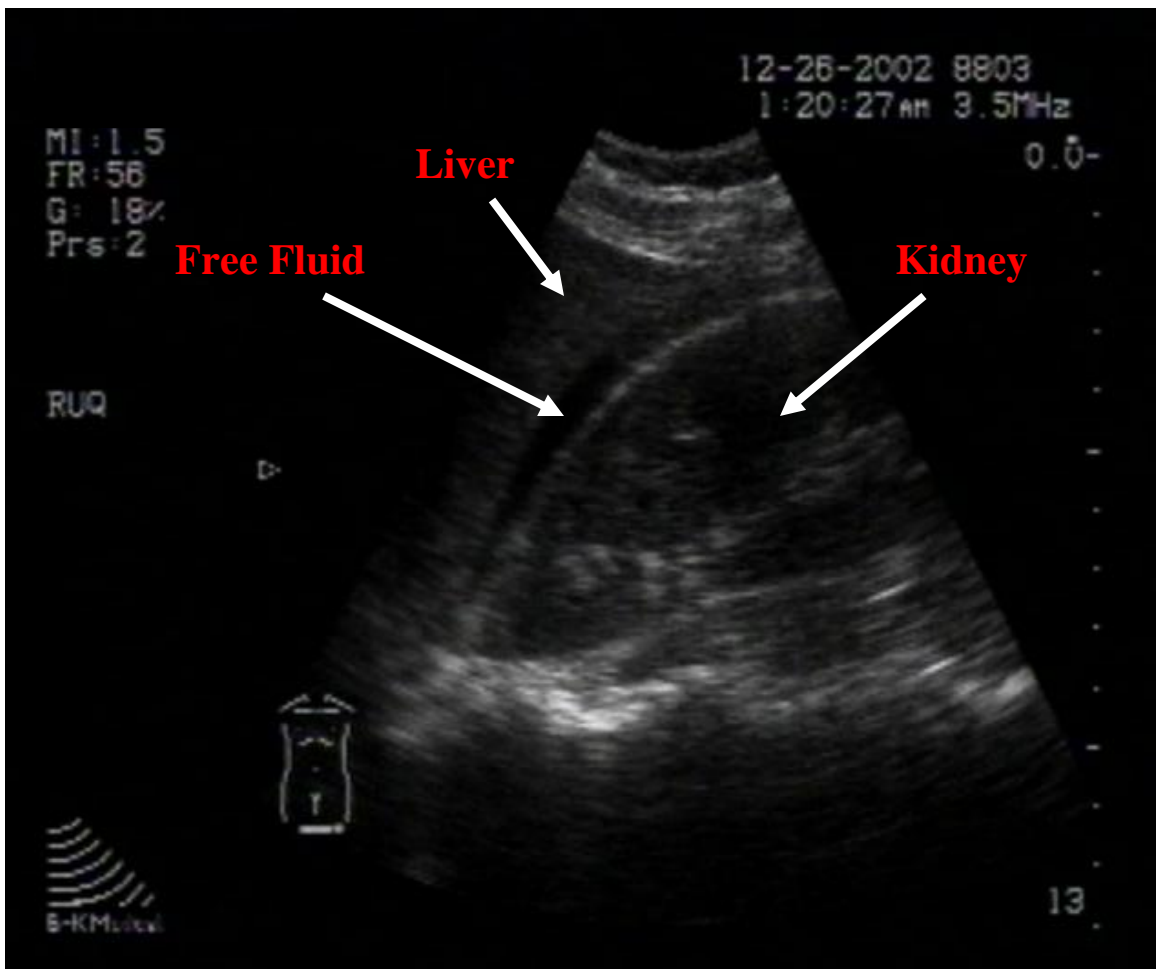
More FAST Images



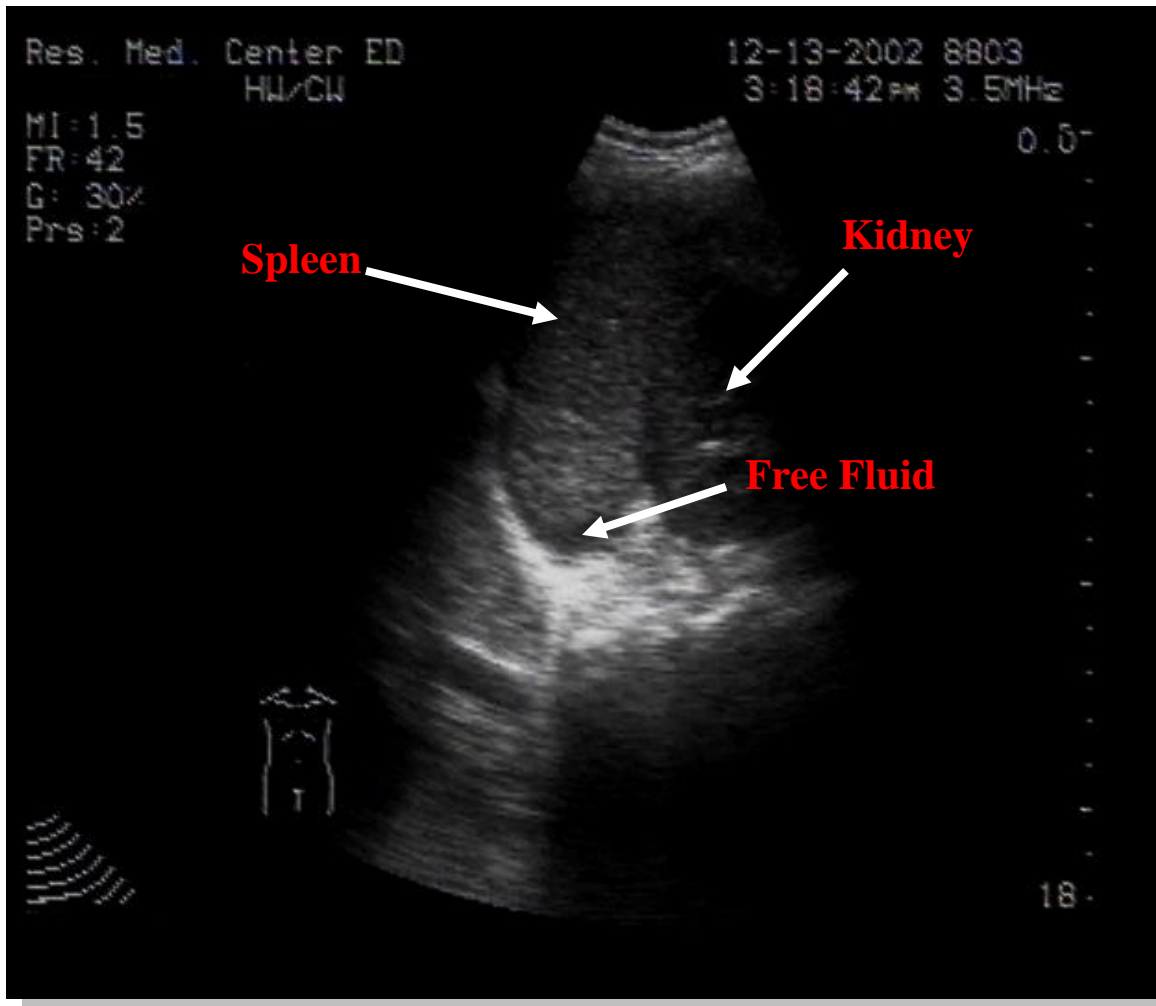
This image demonstrates a normal right upper quadrant (RUQ) view. Note the liver on the left side of the image. The right kidney is visualized on the right side of the image. The gallbladder is also visualized in its usual position anterior to the portal vein – more on the identification of the gallbladder is discussed in a subsequent chapter.



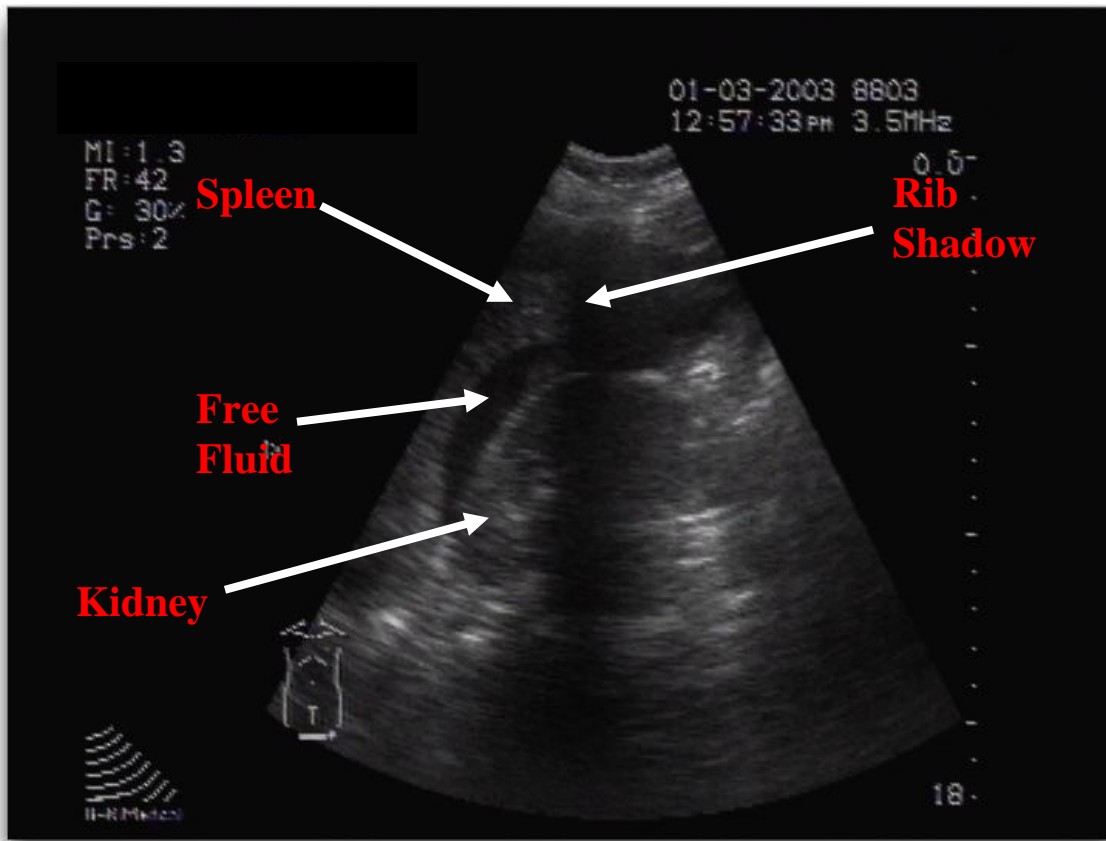
An anechoic “dark” stripe is seen between the liver and kidney in this RUQ view, representing free intraperitoneal fluid. The fluid lies in the potential space formed by the reflection of the peritoneum, defined as Morrison’s pouch.



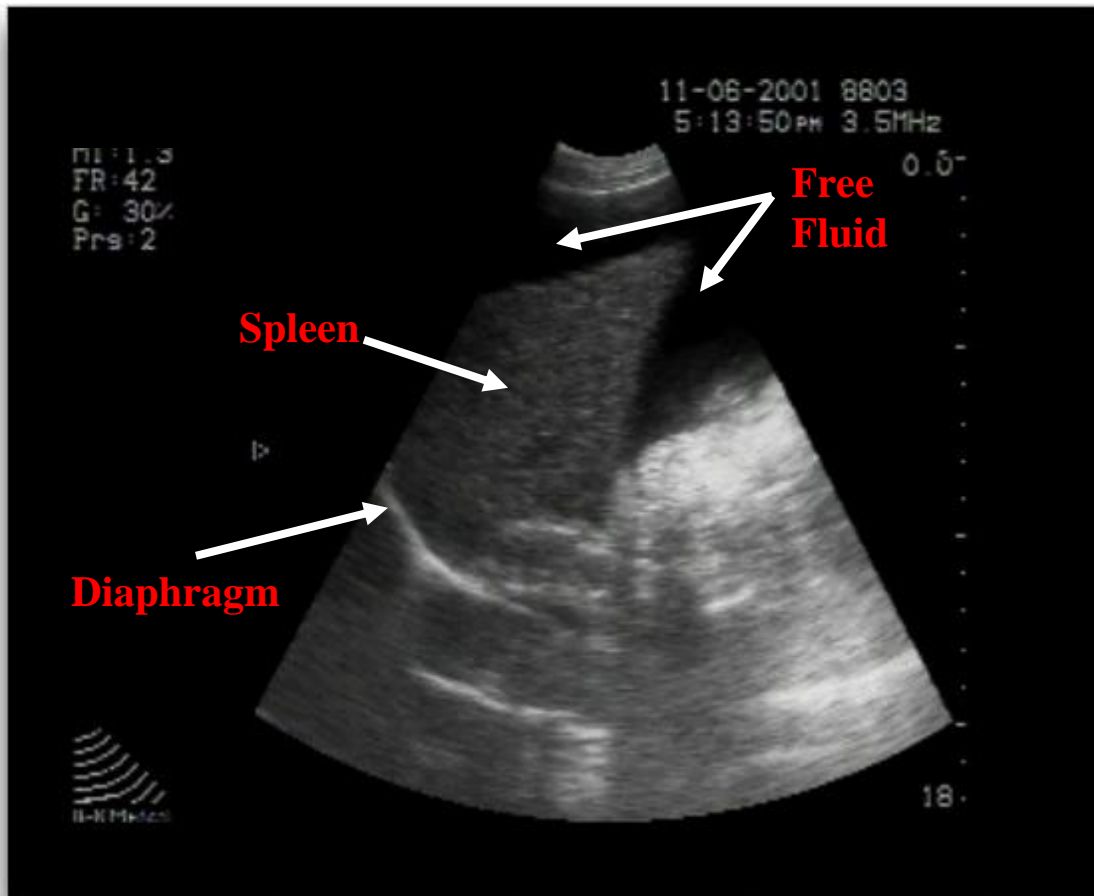
Free intraperitoneal fluid is visualized in Morrison's pouch between the liver and kidney in this right transverse view from a FAST exam. If this patient were hemodynamically unstable due to traumatic injuries, immediate exploratory laparotomy would be indicated.



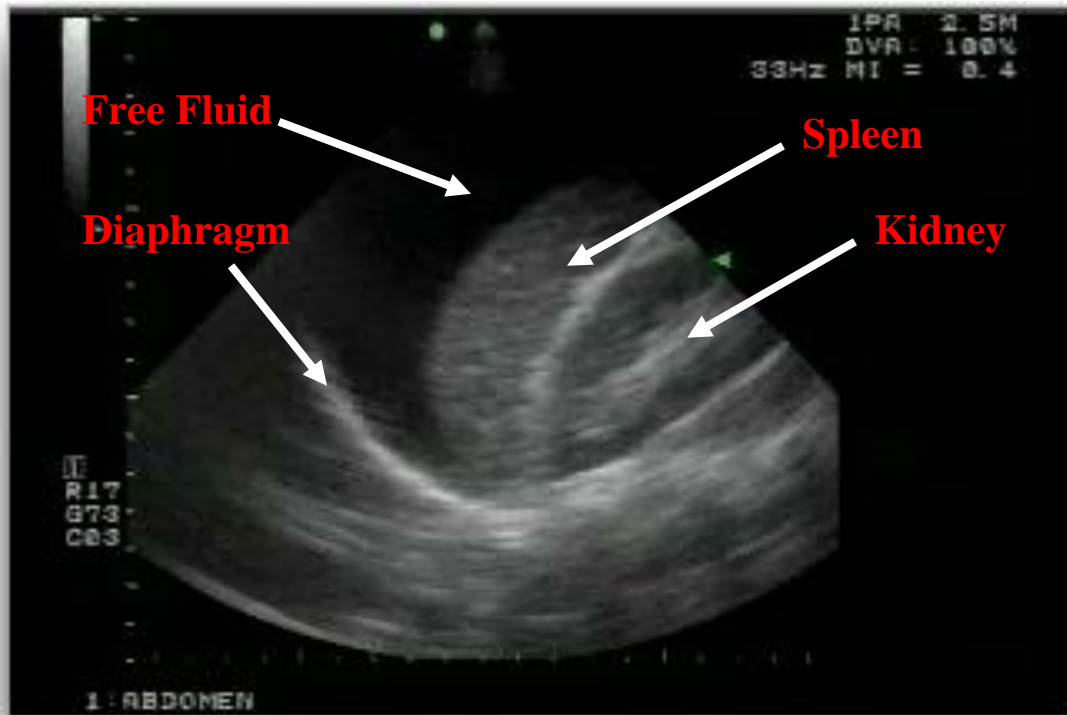
Free intraperitoneal fluid is seen between the spleen and kidney in this FAST scan image of the LUQ.



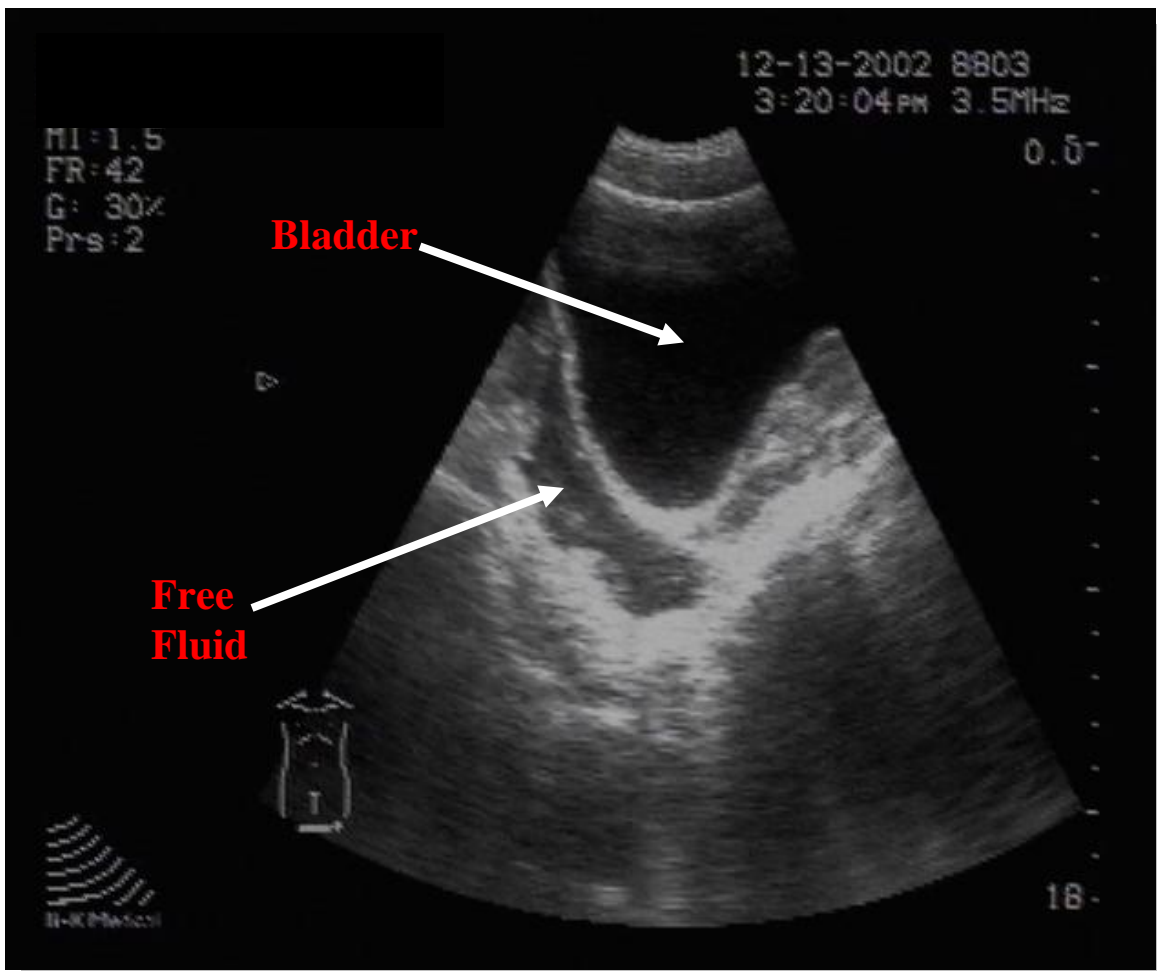
This image represents a LUQ view of a FAST exam. Note the large amount of free intraperitoneal fluid. Note the rib shadow down the middle of the image.



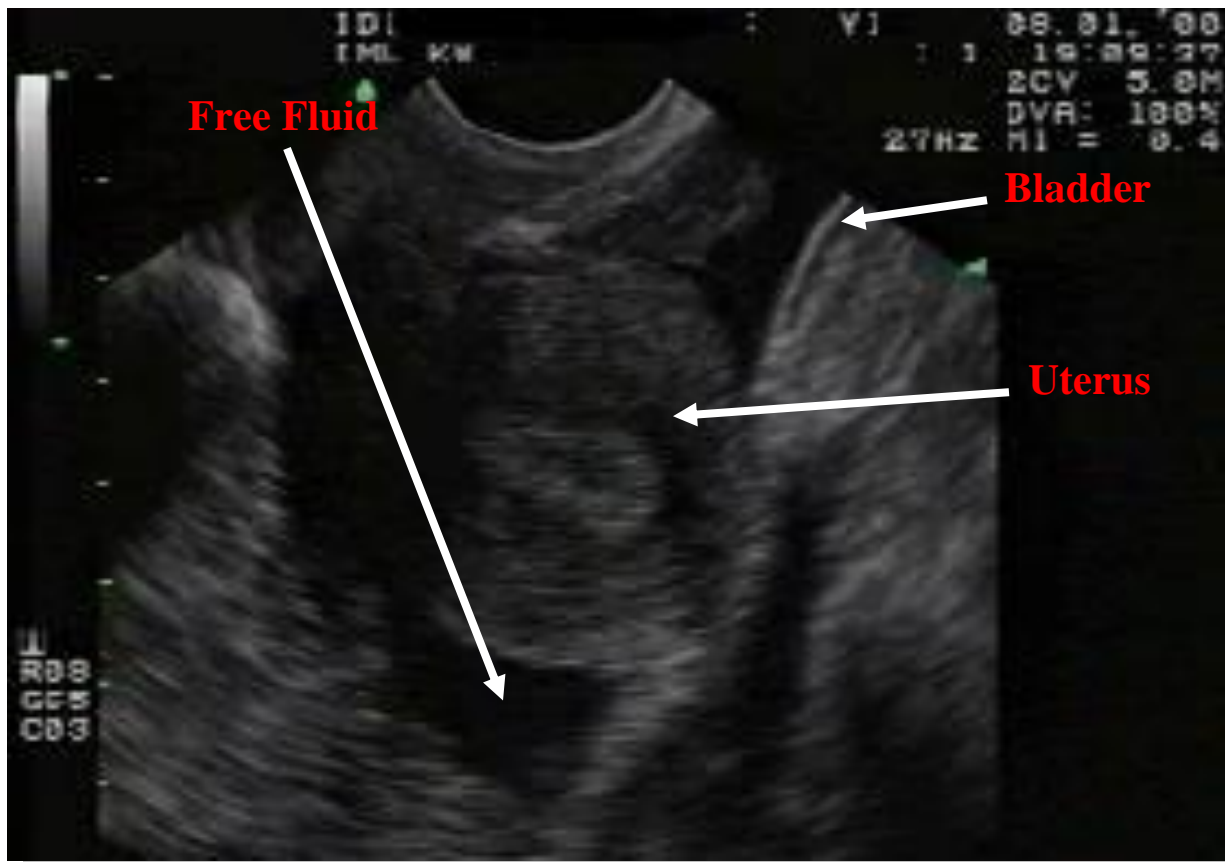
This image represents a LUQ view of a FAST exam with a very large amount of free intraabdominal fluid surrounding the tip of the spleen. The diaphragm is highly reflective and hyperechoic (white) in appearance. The kidney is not visualized.



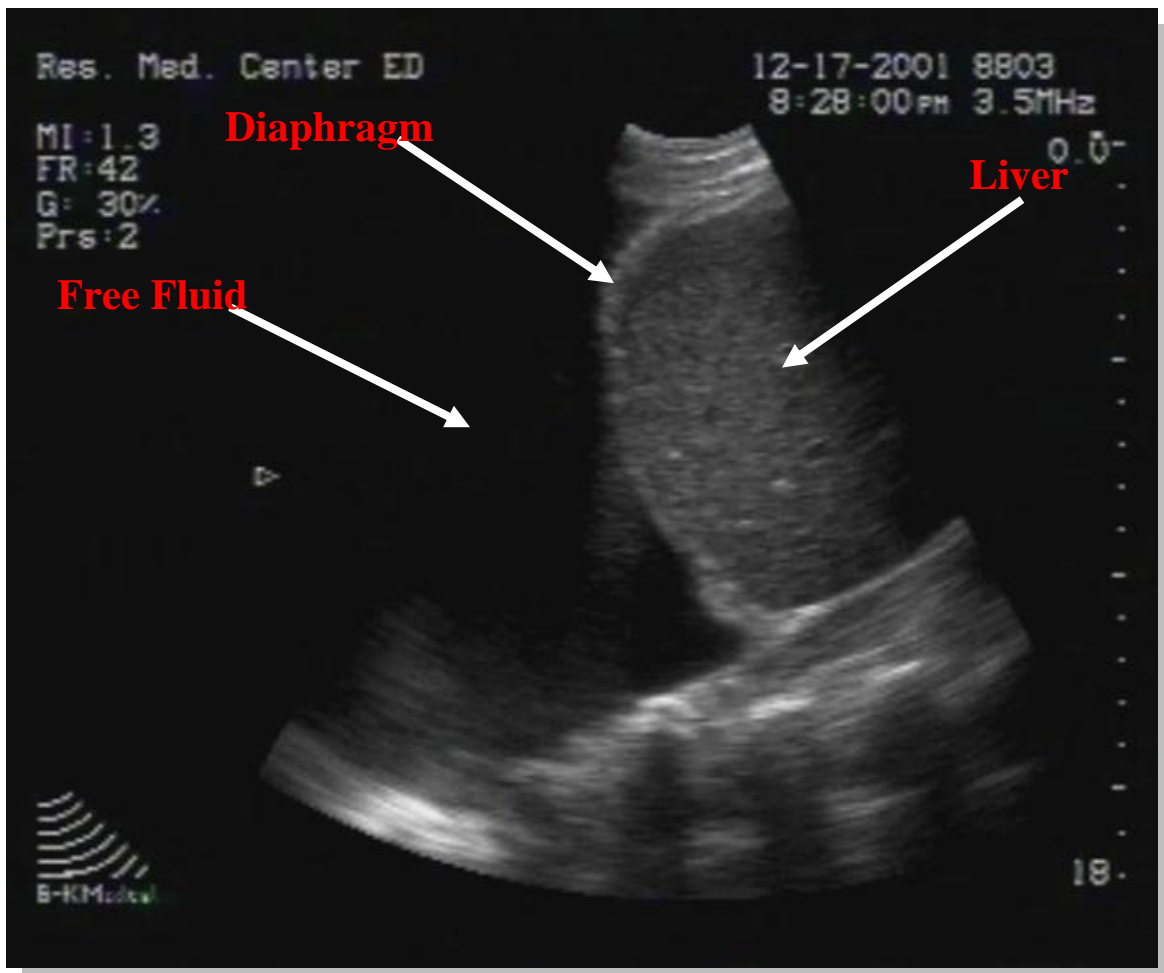
This image depicts a LUQ view from a FAST exam. Unlike the liver, the spleen is not adhered to the diaphragm. Free intraperitoneal fluid may therefore be seen sub-diaphragmatically as in this image. One must be sure to scan the whole perimeter of the spleen to avoid missing small amounts of free fluid.



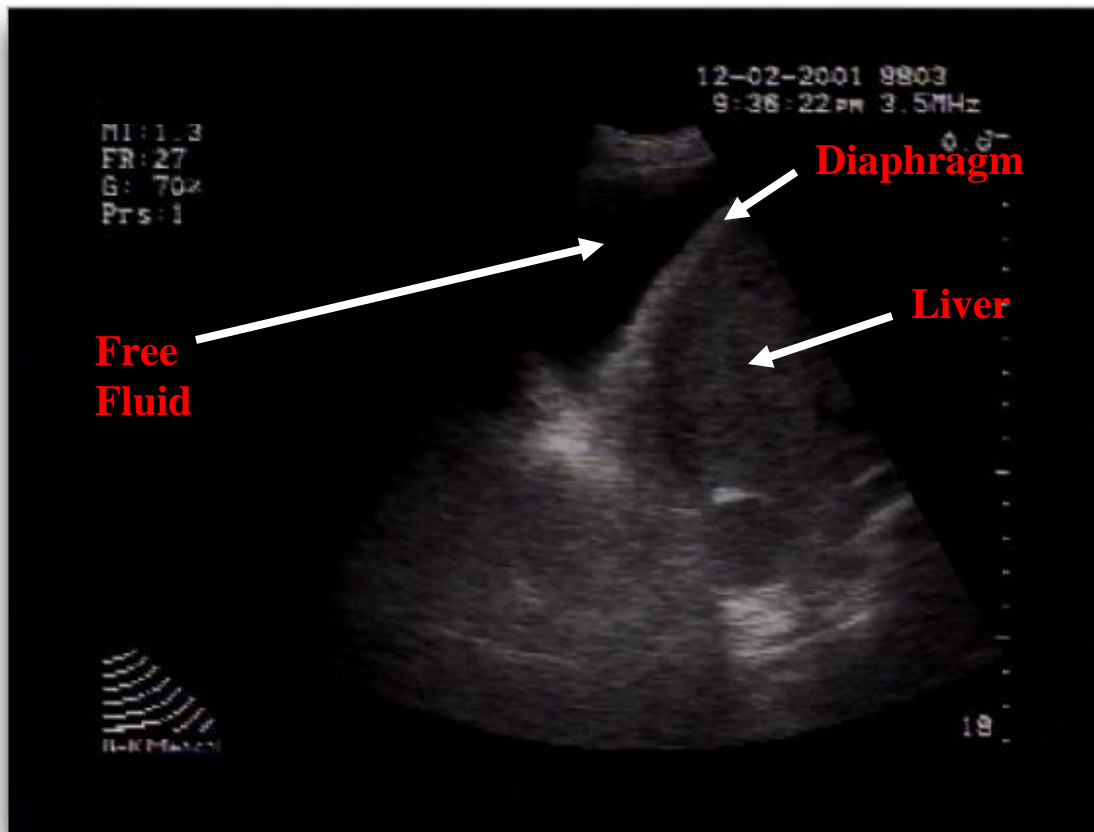
A large amount of free intraperitoneal fluid is visualized posterior to the bladder in this longitudinal suprapubic view. A few bowel loops are outlined by the fluid. Ideally, this view should be obtained with a full bladder (i.e., prior to insertion of a catheter or a clamped Foley catheter).



Free intraperitoneal fluid is visualized posterior to the uterus in the pouch of Douglas on this longitudinal suprapubic view.



The diaphragm appears as a hyperechoic structure closely attached to the liver. The large anechoic (black) area on the left side of the image represents fluid in the right chest.



The image demonstrates a large amount of free fluid in the right hemithorax. The diaphragm appears hyperechoic (white) and is attached to the liver.

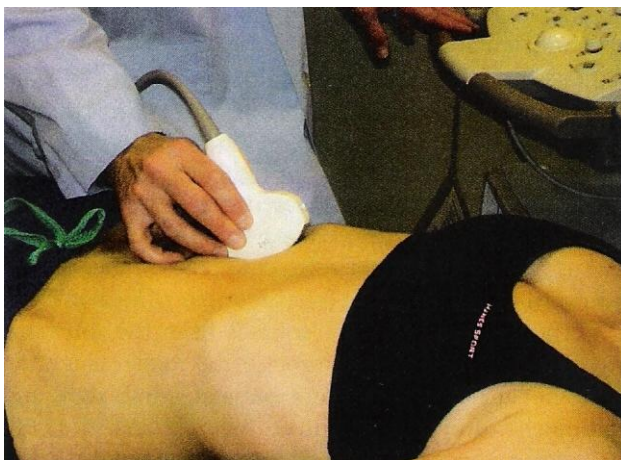
Biliary EDU

Introduction

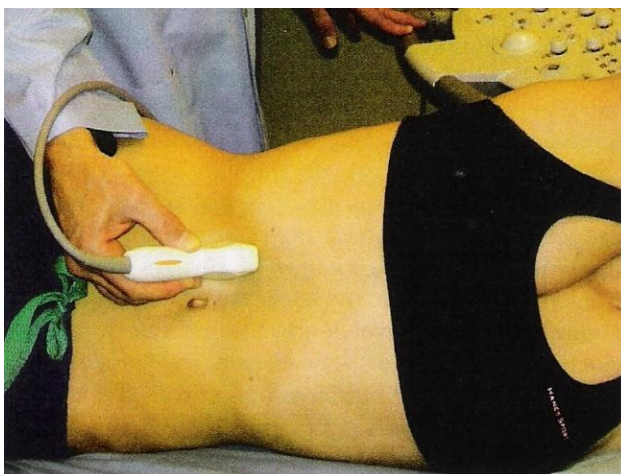
With abdominal pain being the principal reason for patients visiting the ED, and biliary tract disease being the most common diagnosis in ED patients ≥ 50 years old, an understanding of biliary EDU is enormously advantageous as it allows for rapid, accurate bedside diagnosis of biliary colic, cholecystitis, and choledocholithiasis.

Technique

Patient positioning and respiration probably play a more important role in biliary EDU than any other scan discussed to this point. Ideally, a patient's gallbladder lies inferior enough to the liver that the patient can be scanned "as usual" while lying in a supine position. However, when supine, a patient's ribs may overlie the gallbladder making direct visualization difficult. In these instances, the chance of obtaining a good biliary EDU are improved by 1) pulling the gallbladder out from underneath the acoustic interference of the ribs by placing the patient in the left lateral decubitus position, or 2) having the diaphragm shift the gallbladder down by asking the patient to take and hold a deep breath.



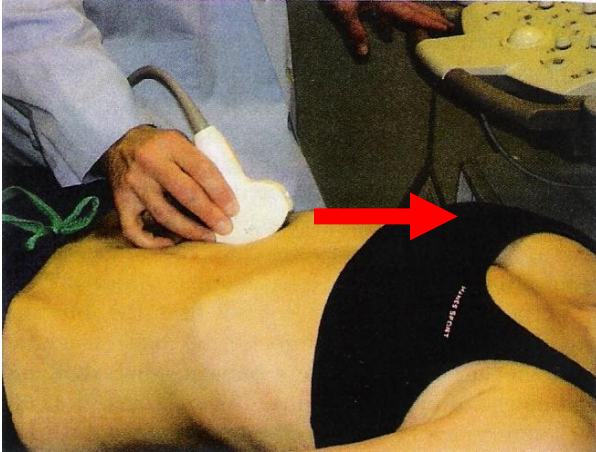
Supine
Position



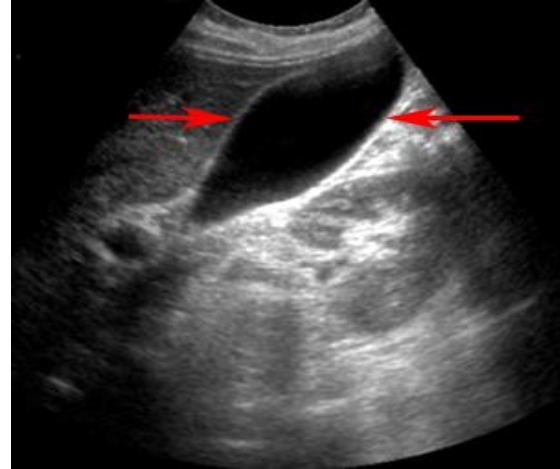
Left Lateral
Decubitus Position

Identifying the Gallbladder

Start by placing the probe in a longitudinal plane (indicator toward patient's head) under the right costal margin along the midclavicular line. Some texts also describe the "X minus 7" approach which suggests initially placing the probe longitudinally in the RUQ at a position 7 centimeters away from the xiphoid process. From this position, sweep through the RUQ to find the gallbladder, which will appear as an anechoic (black) elongated structure. If unable to readily visualize the gallbladder, use the tricks of patient positioning and respiration described above.

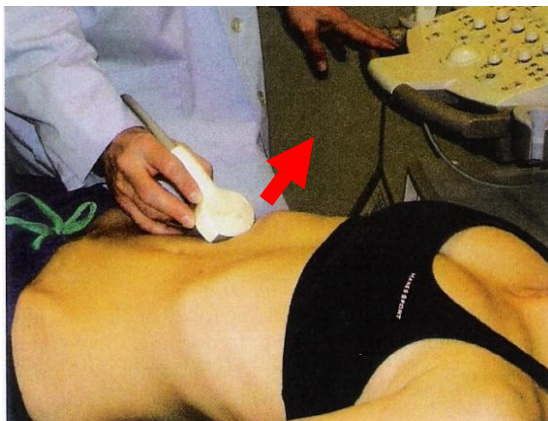


Longitudinal Plane

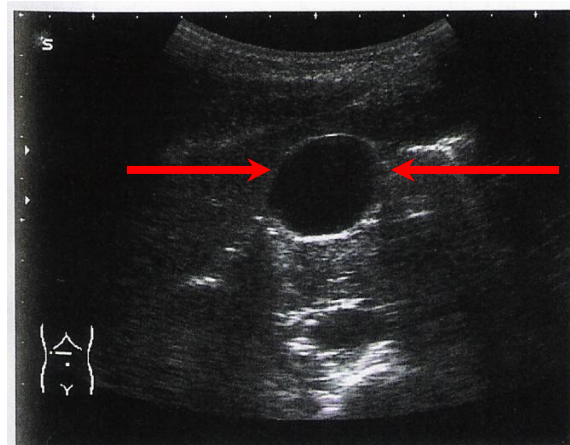


Longitudinal gallbladder

Alternatively, the gallbladder can also be found by starting the scan in a transverse rather than a longitudinal plane and identifying a strongly reflective, hyperechoic (white) thick fibrous band known as the main lobar fissure which connects the main portal vein to the gallbladder. By identifying this hyperechoic main lobar fissure, it is possible to "follow" this structure medially to the anechoic gallbladder.



Transverse Plane

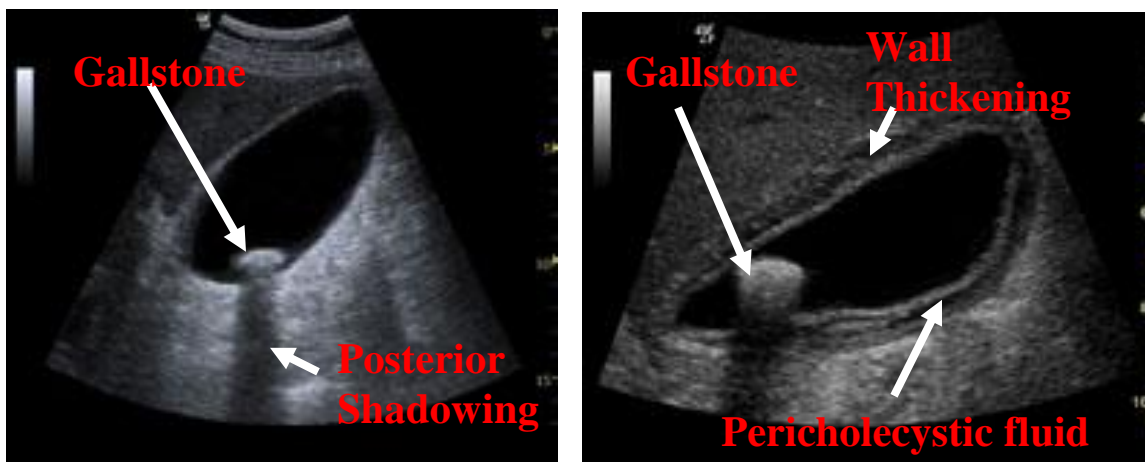


Transverse gallbladder

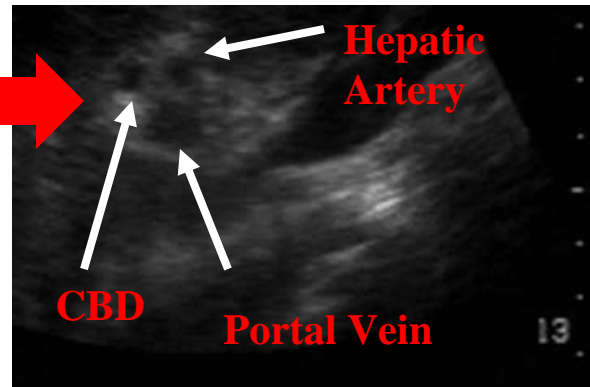
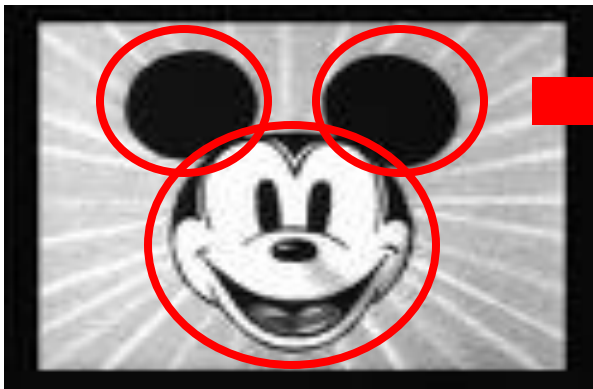
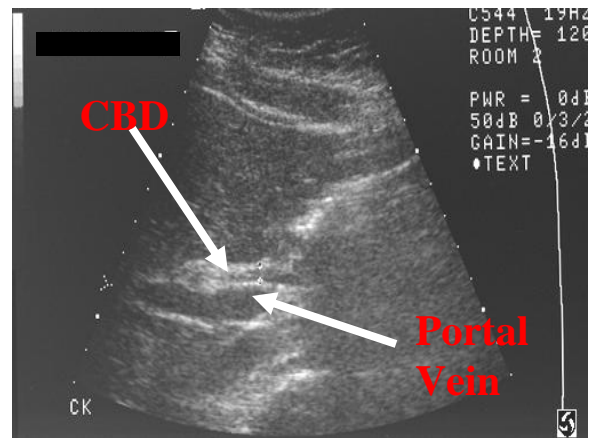
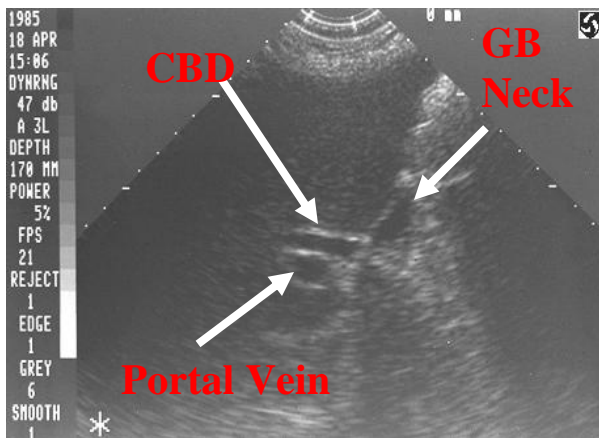
Once identified, the gallbladder should be scanned from the fundus to the neck in both a longitudinal *and* transverse plane. If the gallbladder was initially found in a longitudinal plane (indicator pointed toward the patient's head), the transverse plane is obtained by rotating the probe 90° counterclockwise (indicator pointed toward the patient's right) while keeping the gallbladder centered on the screen. Alternatively, if the gallbladder was initially found in a transverse plane (indicator pointed toward the patient's right), the longitudinal plane is obtained by rotating the probe 90° clockwise (indicator pointed toward the patient's head).

Identifying Pathology

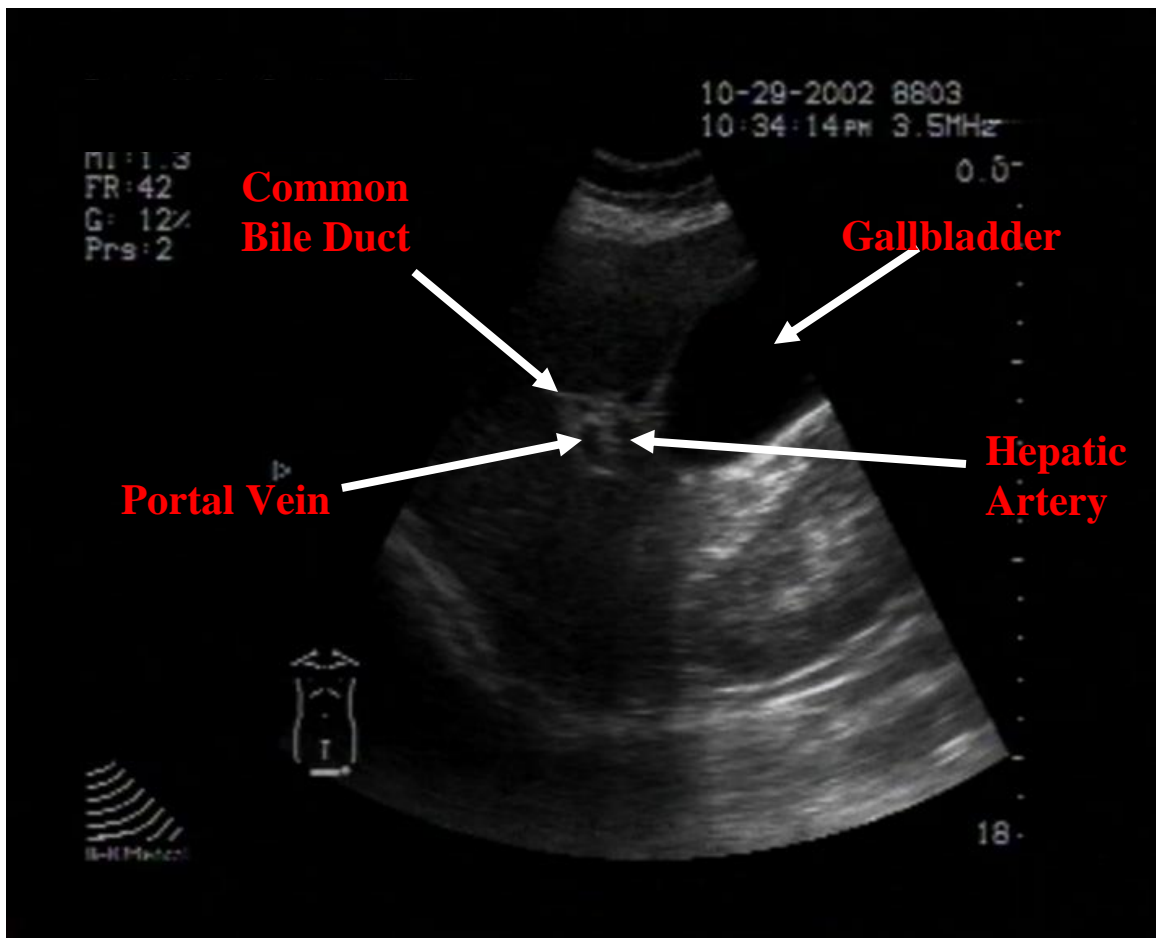
The gallbladder should be scanned for the presence or absence of gallstones, determination of wall thickness, the presence or absence of pericholecystic fluid, and the presence or absence of a sonographic "Murphy's Sign." Further, the common bile duct should be measured before the scan is complete. Gallstones appear as bright, hyperechoic foci within the gallbladder. Given that they are highly reflective, gallstones also produce posterior acoustic shadowing. Unless impacted in the neck of the gallbladder, gallstones tend to rest in the most dependent layer of the gallbladder and will move if the patient changes positions. If gallstones are identified, other EDU findings consistent with acute cholecystitis include wall thickening, pericholecystic fluid, and the presence of a sonographic Murphy's sign as eluded to above. To accurately measure the gallbladder wall, chose an area on the *anterior* wall perpendicular to the imaging plane. A measurement greater than 3mm is considered abnormal. Pericholecystic fluid appears as an anechoic (black) outline adjacent to the gallbladder wall, and a sonographic Murphy's sign is considered positive if the patient reports maximal tenderness elicited by pressure from the probe over the visualized gallbladder.



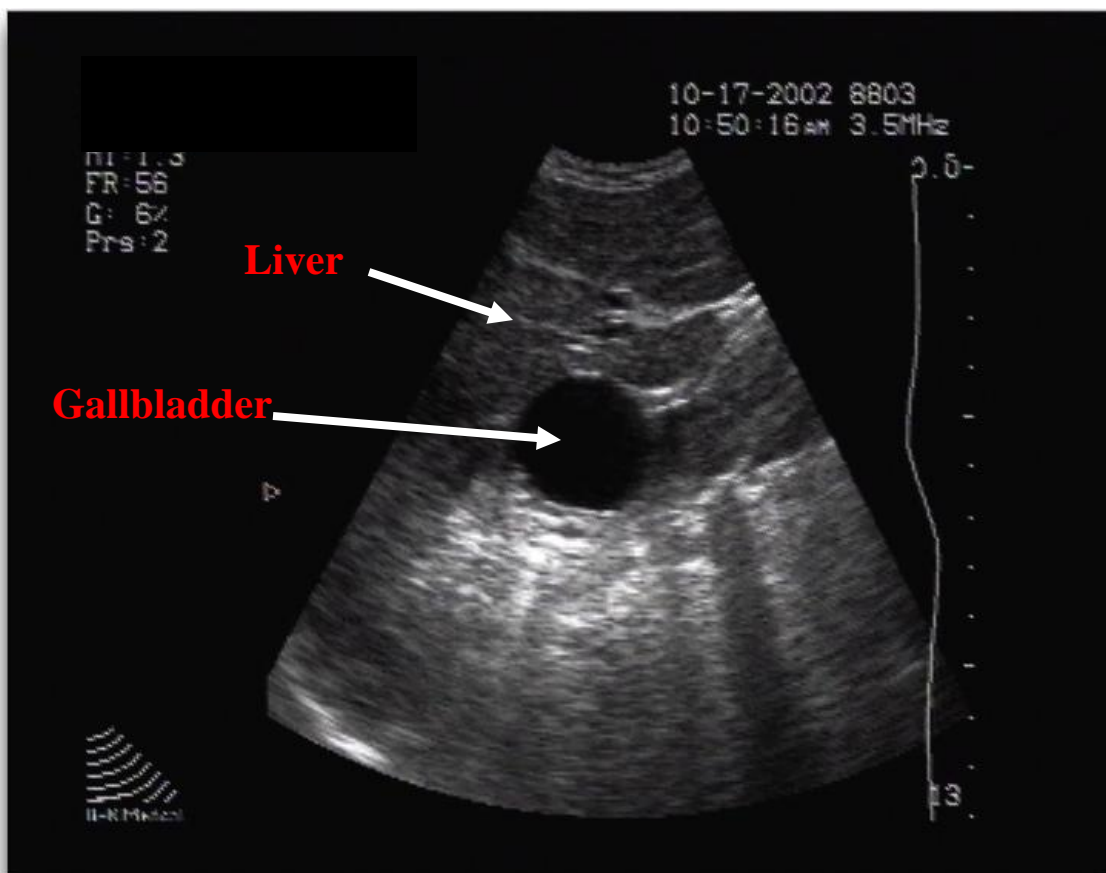
Identification of the common bile duct (CBD) can be challenging. The CBD has a close association with the main portal vein. To find the CBD in a longitudinal plane, first identify the gallbladder neck. From the gallbladder neck, the main portal vein appears laterally (screen left) as an anechoic (black) elongated structure with bright hyperechoic (white) walls. The CBD generally appears as a second anechoic elongated structure located just anterior to (on top of) the main portal vein. From this position, a transverse view (probe rotated 90° counterclockwise) of the CBD will produce the classic “Mickey Mouse Sign” of the entire portal triad with the portal vein being the “face,” the CBD being the “right ear,” and the hepatic artery being the “left ear” (see below). Measurement of the CBD is made from inner wall to inner wall in the longitudinal plane. EDU texts typically list a normal CBD measurement to be less than 7mm. However, a more accurate, normal measurement of the CBD is ascertained by allowing a patient 1mm of length per decade of life. Thus, a patient in their 40s should have a CBD length no greater than 4mm. A dilated CBD in the appropriate clinical context may indicate choledocholithiasis.



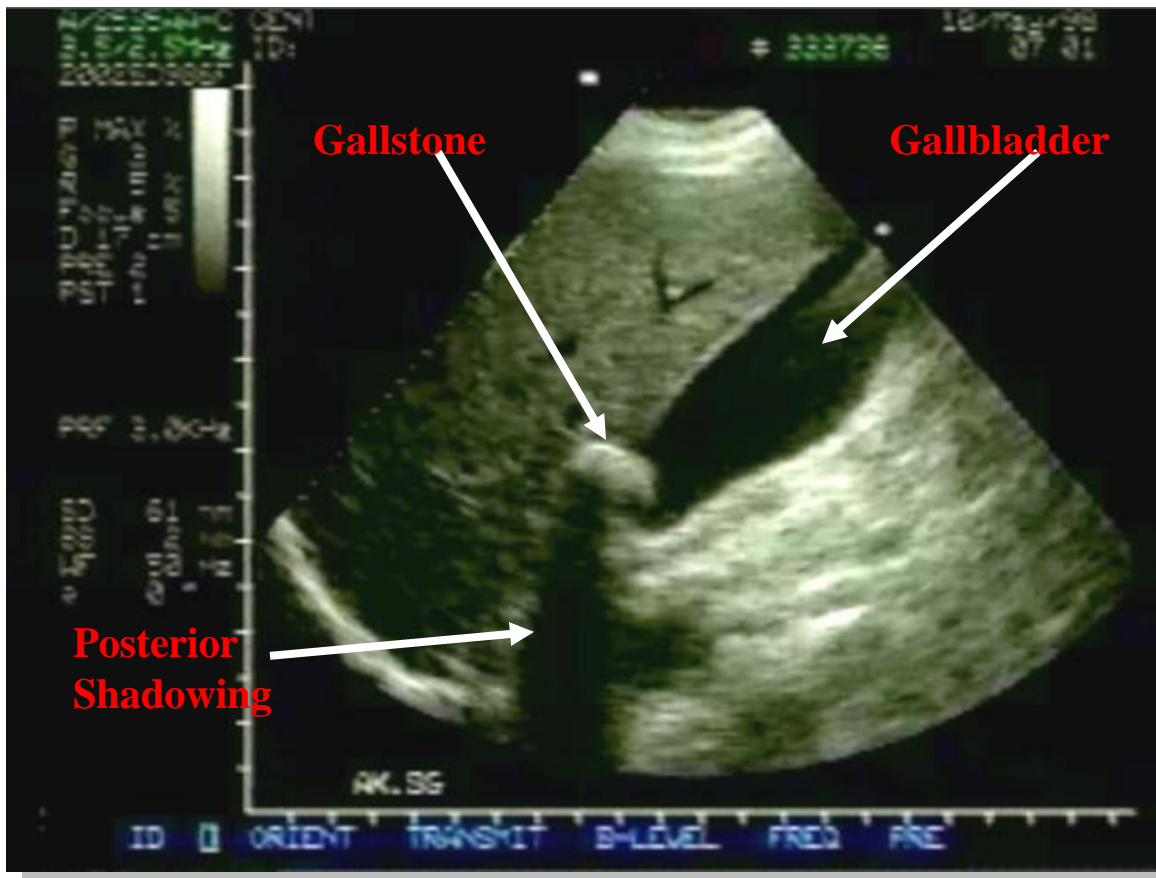
More Biliary EDU Images



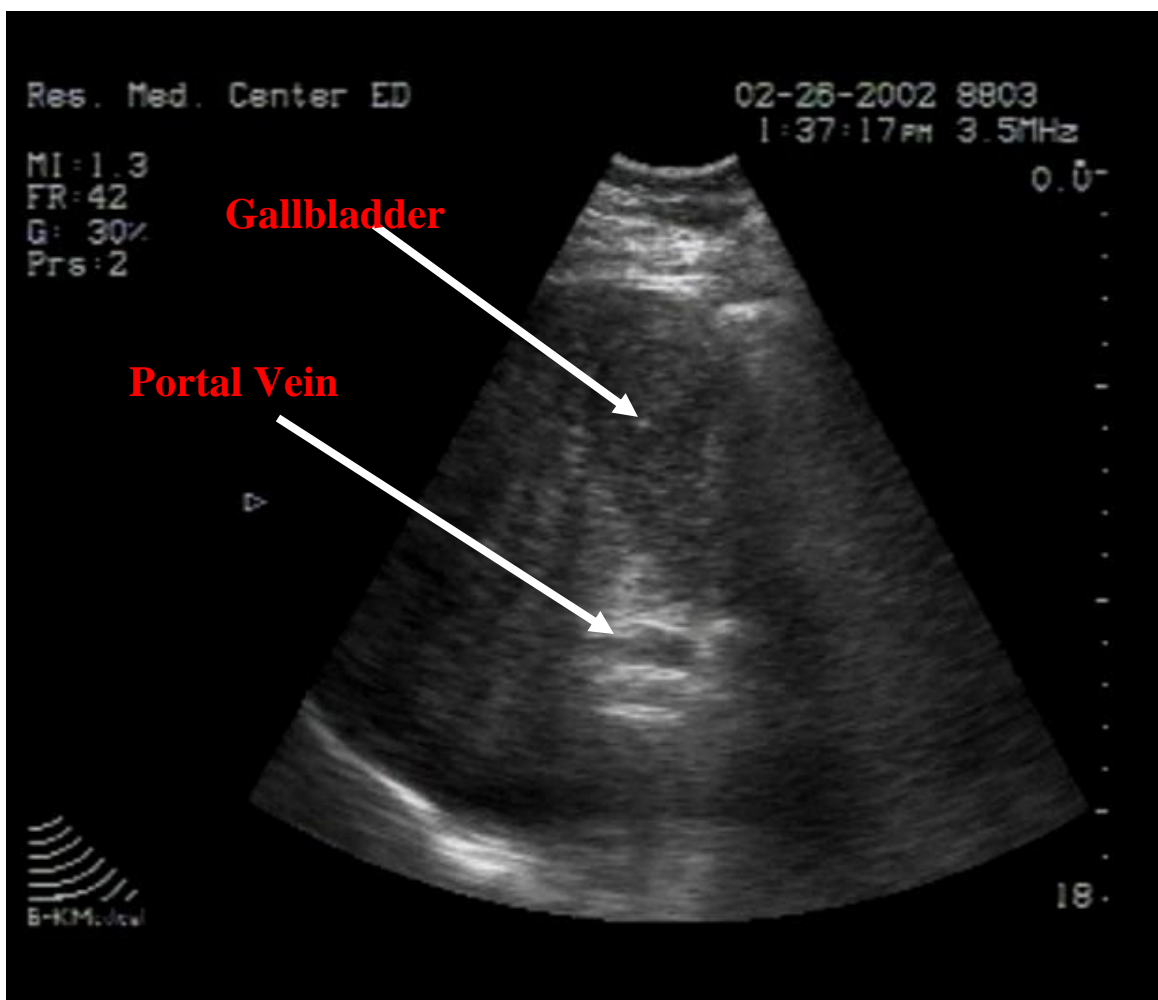
This is an image of the portal triad: the common bile duct, the common hepatic artery, the portal vein. The gallbladder is seen in its typical position anterior to the portal triad.



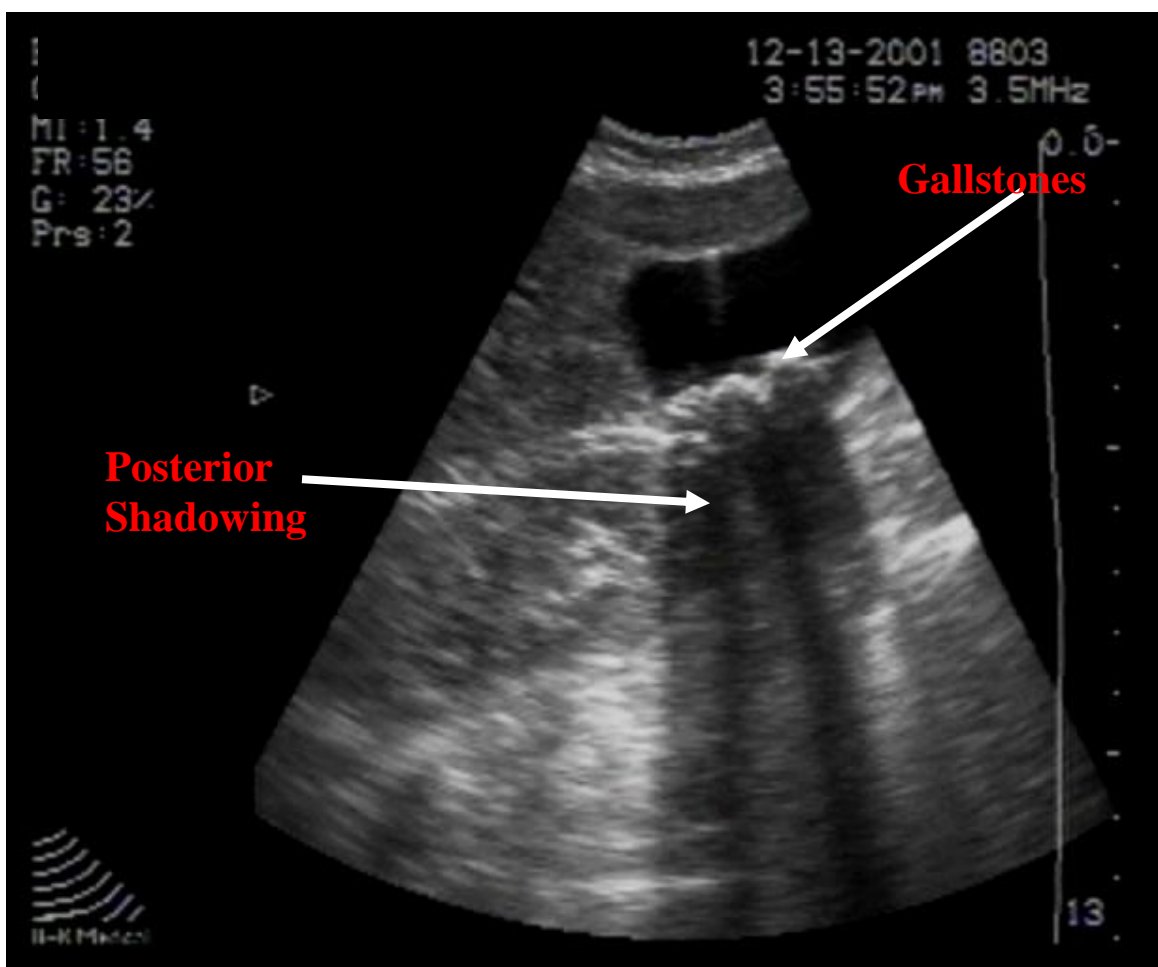
This image depicts the gallbladder in transverse view, obtained with the probe marker oriented towards the patient's right side.



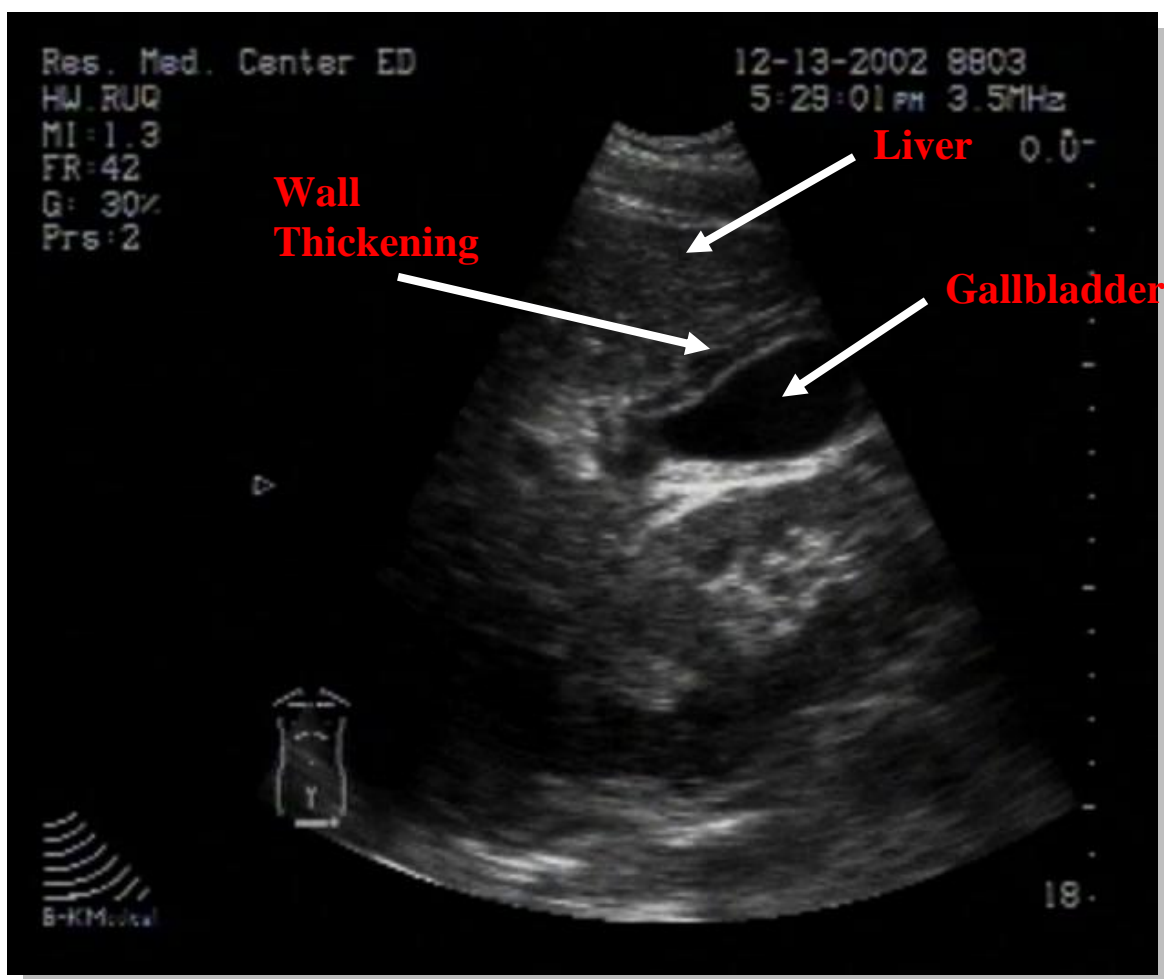
A large gallstone is seen towards the neck of the gallbladder, with shadowing posteriorly. No gallbladder wall thickening or pericholecystic fluid is seen.



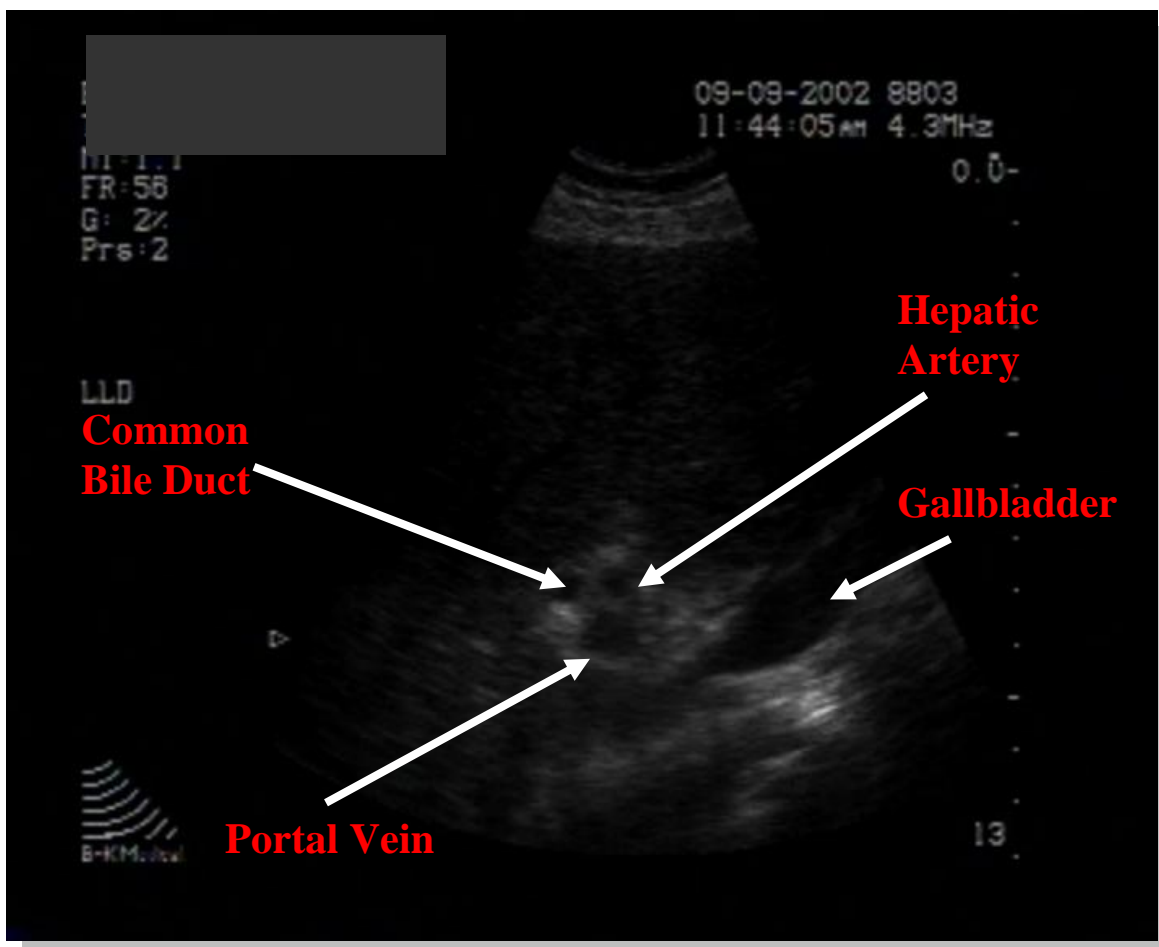
The gallbladder is seen in the top center of the image. Although not the classic anechoic image, we know that this structure is reliably the gallbladder as it is in close approximation and just anterior to the portal vein. Individual stones are not seen, but the gallbladder is filled with “sludge.” No definite wall thickening or pericholecystic fluid is visualized in this image, although additional views are necessary to make this determination.



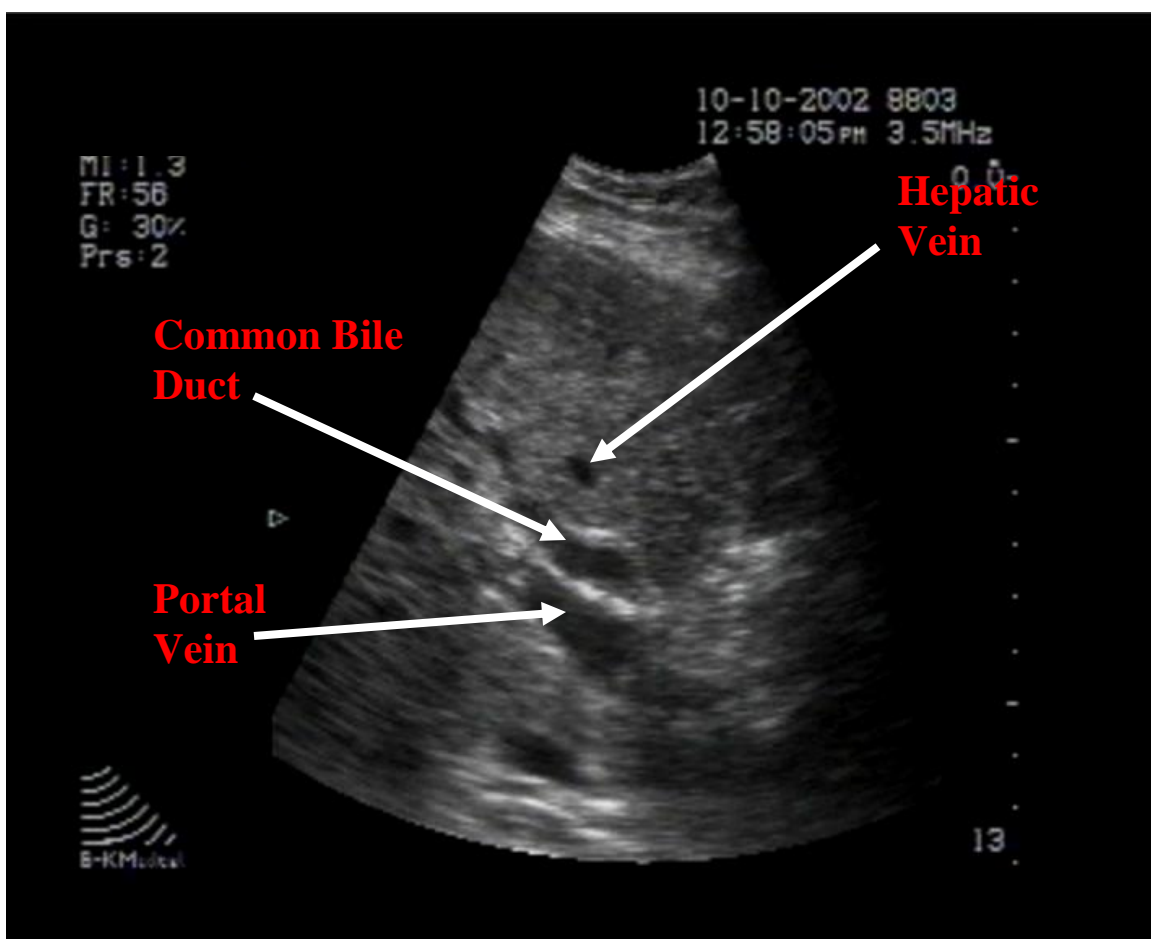
Multiple gallstones are seen layering out on the posterior wall of the gallbladder. Acoustic shadowing is visualized, and is often helpful in identifying small stones. No gallbladder wall thickening or pericholecystic fluid is noted.



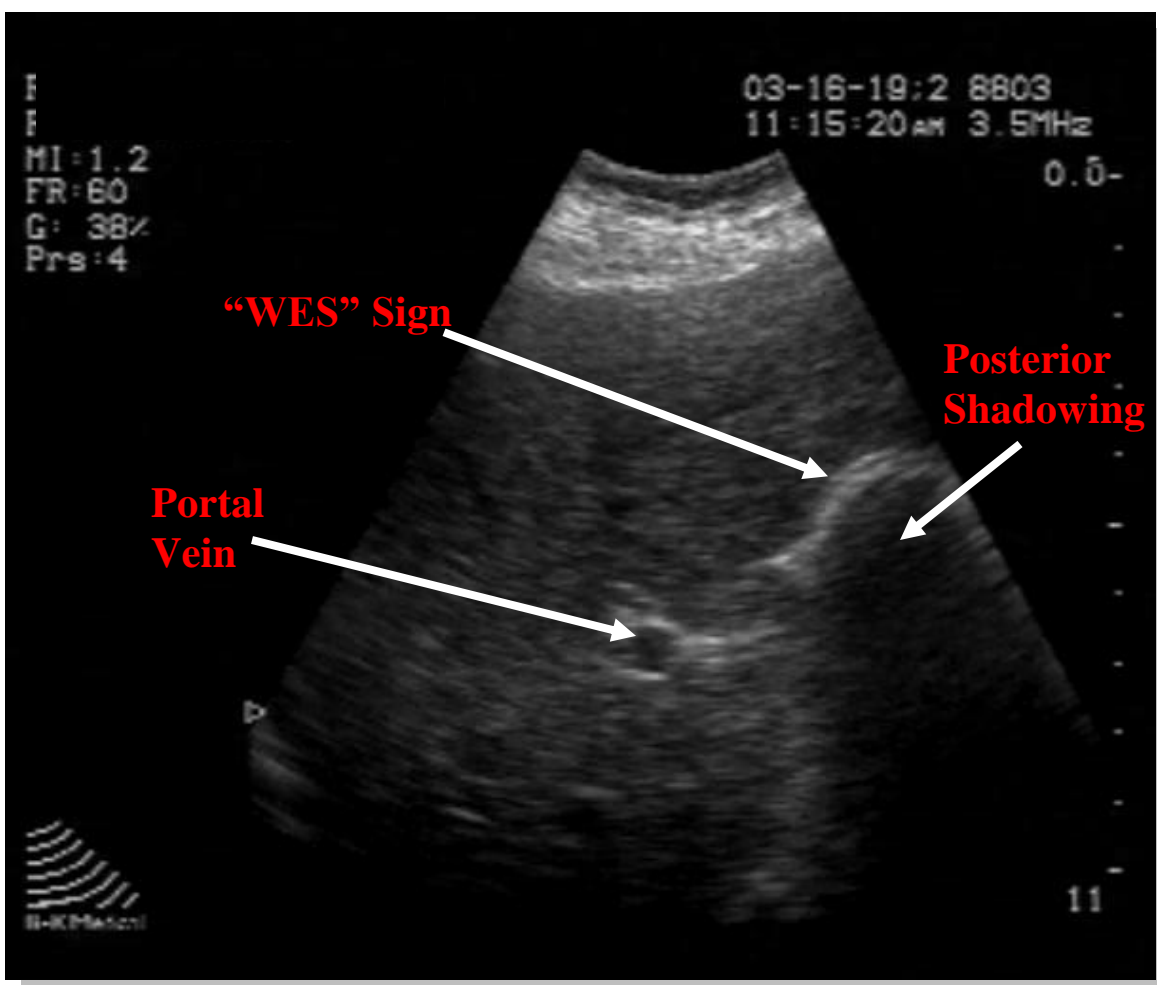
The liver and gallbladder are visualized in this image. Although the gallbladder wall appears quite thickened, this may be seen in the setting of free abdominal fluid (ascites), or with a small contracted gallbladder (e.g., post-prandial). No stones are seen in this image. Normal gallbladder wall thickness is less than 3mm.



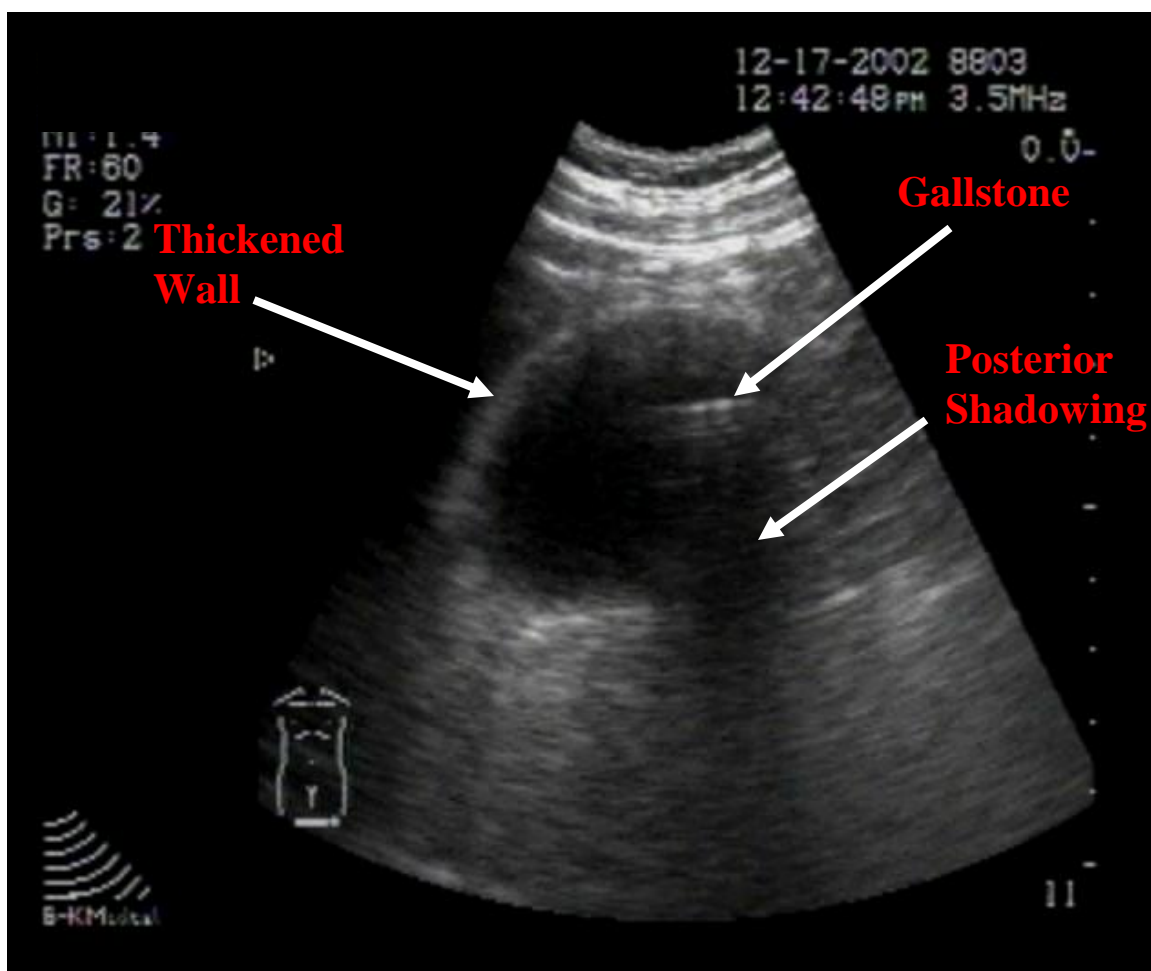
The portal triad is seen in cross section at the center of the image, with the gallbladder at the right side of the image. The triad is made up of the portal vein, common bile duct, and hepatic artery. This is a normal scan.



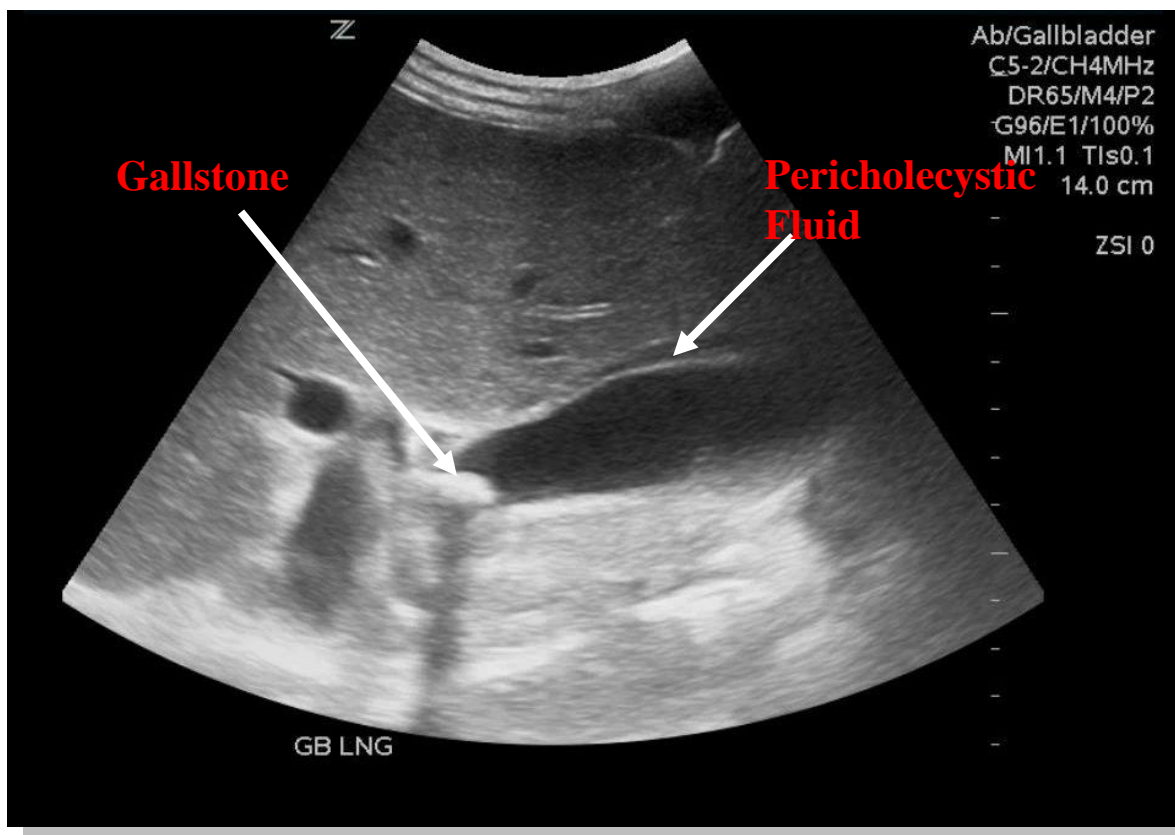
The liver is visualized with multiple normal thin-walled hepatic veins. The portal triad is visualized longitudinally here. Unlike the hepatic veins, the portal vein has hyperechoic (white) walls. The common bile duct runs directly anterior to the portal vein. Although stated normal ranges for the CBD vary significantly with age, in this image the duct is clearly dilated at approximately 1 cm, forming a “railroad track” appearance.



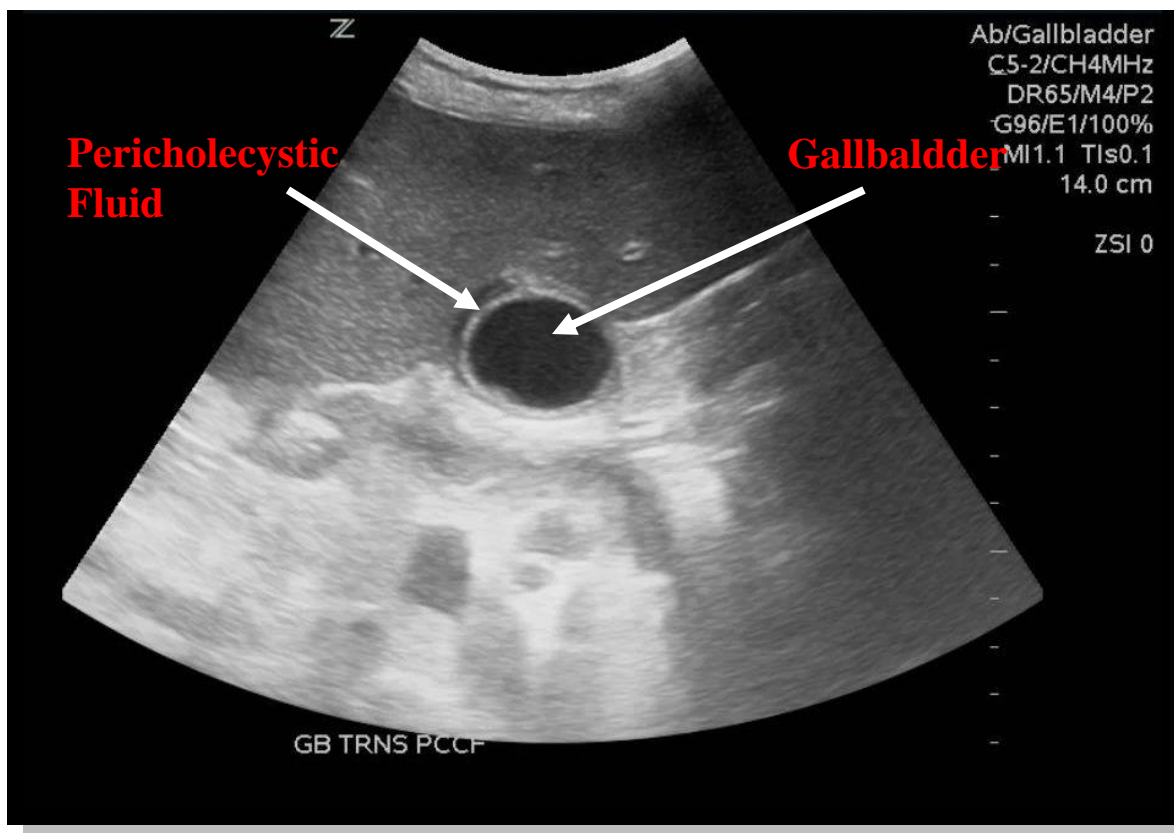
The liver is visualized with the hyperechoic (white)-walled portal vein in the center of the image. The gallbladder is not visualized in its usual position anterior to the portal vein, but a dense rim of gallstones is seen with associated acoustic shadowing. The gallbladder here is full of stones and completely contracted, referred to as the wall echo shadow (or “WES”) sign.



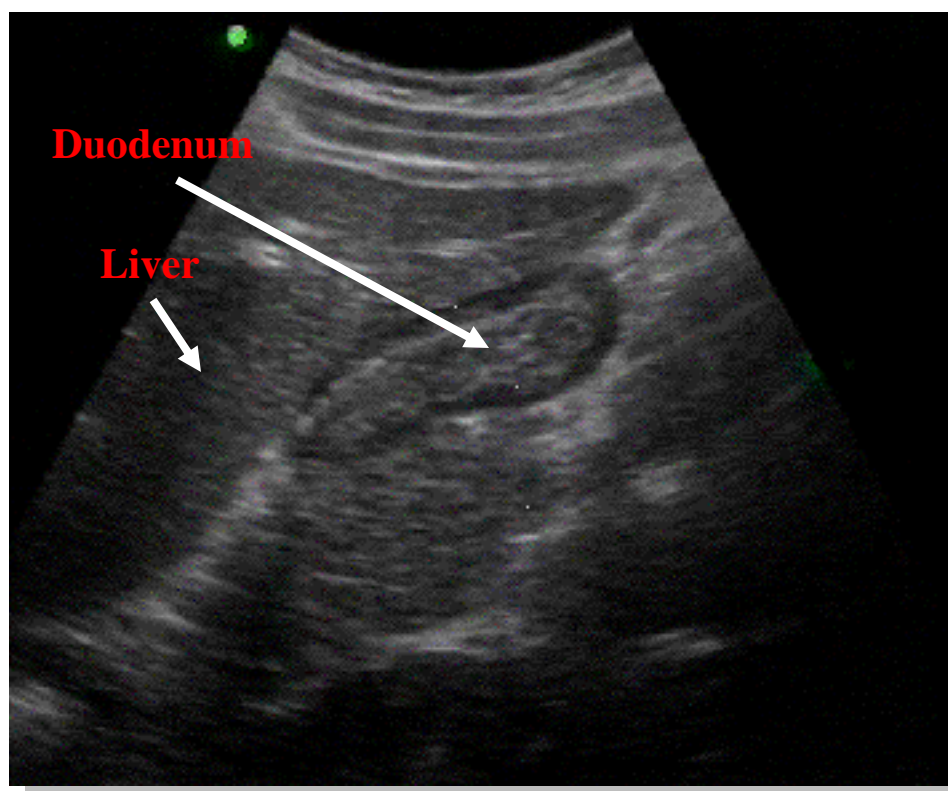
The gallbladder exhibits a large gallstone towards the fundus with acoustic shadowing. Note that the wall is quite thickened, clearly more than the normal allowed thickness of 3mm or less. Wall thickening and pericholecystic fluid (not present), taken together with a sonographic Murphy's sign are very highly sensitive for cholecystitis.



This longitudinal view of the gallbladder shows a large gallstone near the neck. Also note the pericholecystic fluid concerning for acute cholecystitis.



This transverse image of the gallbladder was taken from the same patient on the previous page. Although no gallstones are observed in this particular view of the gallbladder, the large amount of pericholecystic fluid continues to be seen.



While this structure may appear to be a gallbladder filled with sludge, this structure is actually the duodenum. The gallbladder should be anterior to the portal vein, which is important to identify as a landmark to avoid this common pitfall. Other small bowel loops may also have a similar appearance. The liver is evident on the left side of the image.

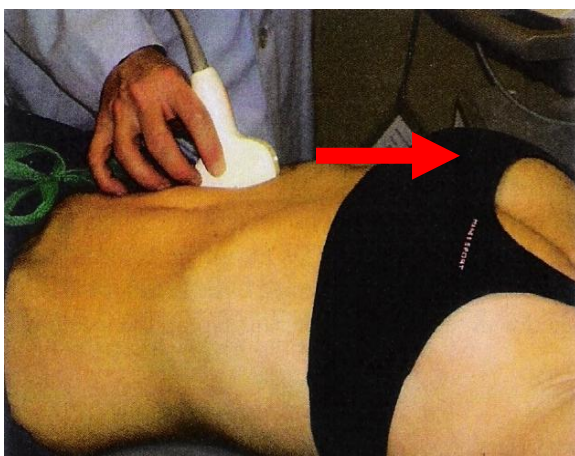
Renal EDU

Introduction

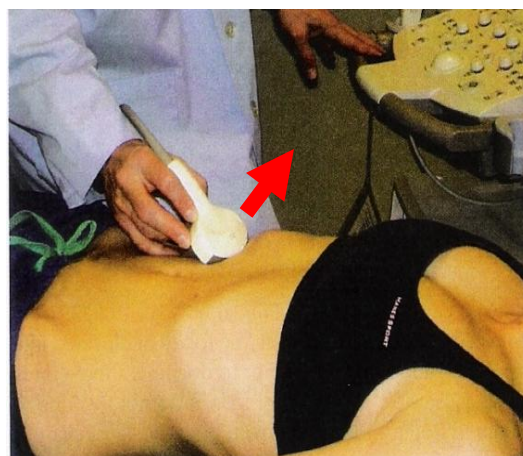
The main application of renal EDU is to determine the presence or absence of hydronephrosis. More specifically, the presence of unilateral hydronephrosis in the context of acute flank pain and hematuria is very sensitive for the diagnosis of ureterolithiasis. Further, the degree of hydronephrosis seen with EDU can help determine the need for urgent urology consultation; i.e., mild or moderate hydronephrosis is typically managed on an outpatient basis.

Technique

The basic technique for identifying the kidneys is similar to the RUQ and LUQ scans described in the FAST section of this text. The right kidney is usually imaged with the patient supine, with the probe placed longitudinally (indicator toward the patient's head) at a position inferior to the costal margin at the anterior-to-mid axillary line. From here, the probe is moved inferiorly and laterally until the kidney is visualized. Once the image of the kidney is obtained, scan through the parenchyma and sinus of the kidney. Then, rotate the probe 90° counterclockwise (indicator toward the patient's right) to obtain a transverse view. Once visualized in a transverse view, scan through the entire kidney from superior to inferior pole.



Longitudinal Plane

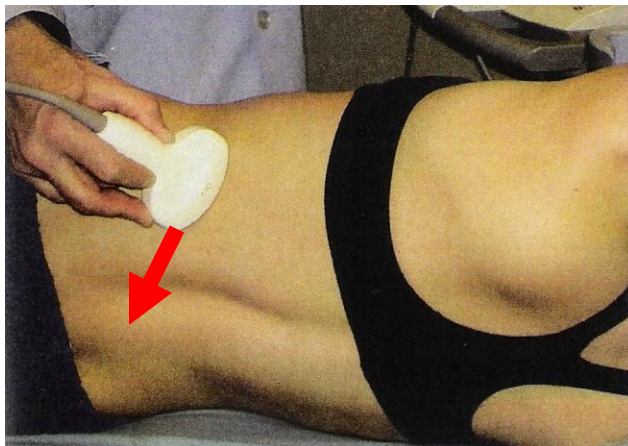


Transverse Plane

The left kidney can also be imaged while the patient is in a supine position as described above for the right kidney; however, unlike the right kidney, the left kidney can frequently be obscured by air in the stomach and/or intestine. This interference can be avoided by having the patient lie toward you in a right lateral decubitus position²⁰. In this position, the

²⁰ You may also have to place a patient in a left lateral decubitus position when scanning the right kidney if good images are not obtainable while the patient is supine.

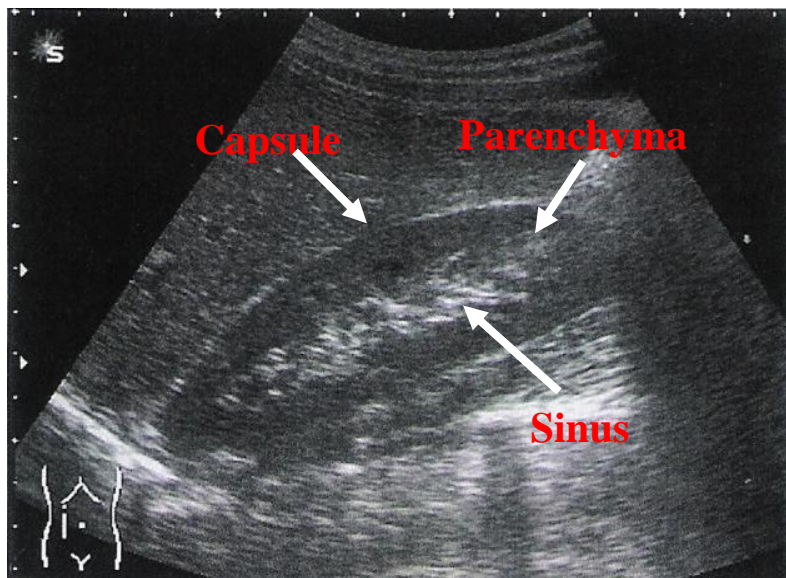
probe is placed longitudinally (indicator toward the patient's head) between the costal margin and iliac crest in line with the scapular tip. From here, the probe may have to be moved either laterally or medially to obtain good images of the left kidney. As with the right kidney, define the margins of the left kidney first by scanning through the entire left kidney first in a longitudinal, then transverse (indicator toward the patient's right) plane.



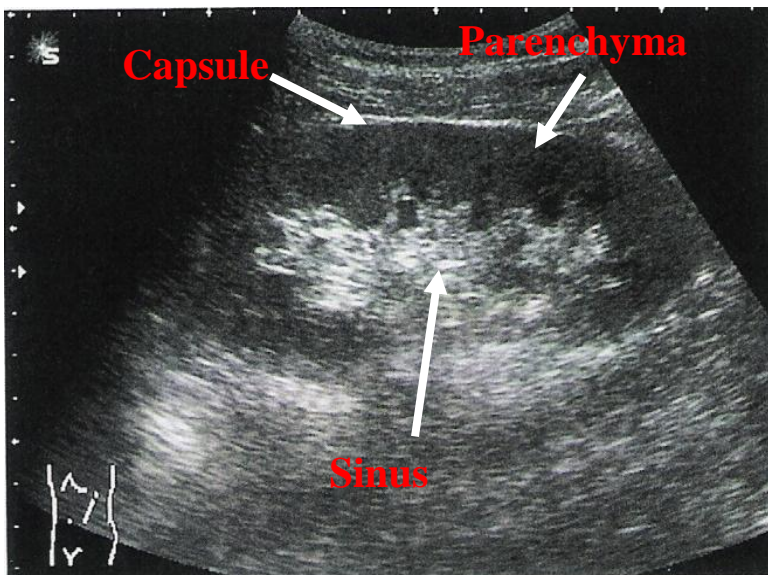
Right Lateral Decubitus Position

Identifying Pathology

Each kidney is clearly outlined by a hyperechoic (white) capsule. The parenchyma appears slightly less echogenic (not as bright as) than the liver. The renal sinus lies deep within the parenchyma and is typically hyperechoic (white) due to its high fat content. Some pockets of anechoic (black) urine may be seen within the sinus even in well hydrated patients. However, with hydronephrosis secondary to an obstructive uropathy, large, anechoic areas can be seen within the renal sinus. The degree of hydronephrosis exists on a continuum, with severe hydronephrosis being reserved for kidneys that also demonstrate cortical wall thinning. A helpful approach to determining the amount of hydronephrosis present is to image and compare *both* kidneys, not just the “symptomatic kidney.” Stones themselves may be seen within the kidney, and have an appearance similar to gallstones; i.e., hyperechoic (white) foci with posterior acoustic shadowing.



Normal Right Kidney

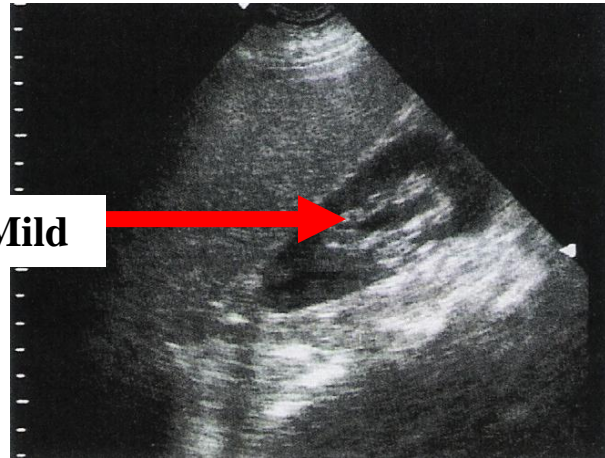


Normal Left Kidney

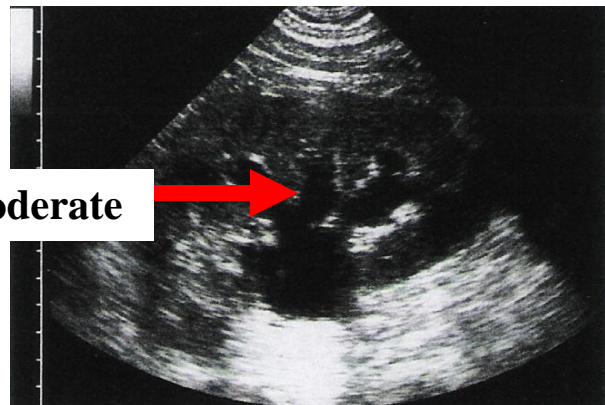
Degrees of Hydronephrosis



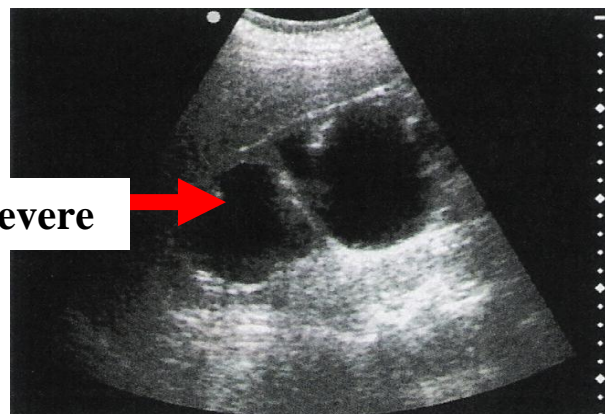
Mild



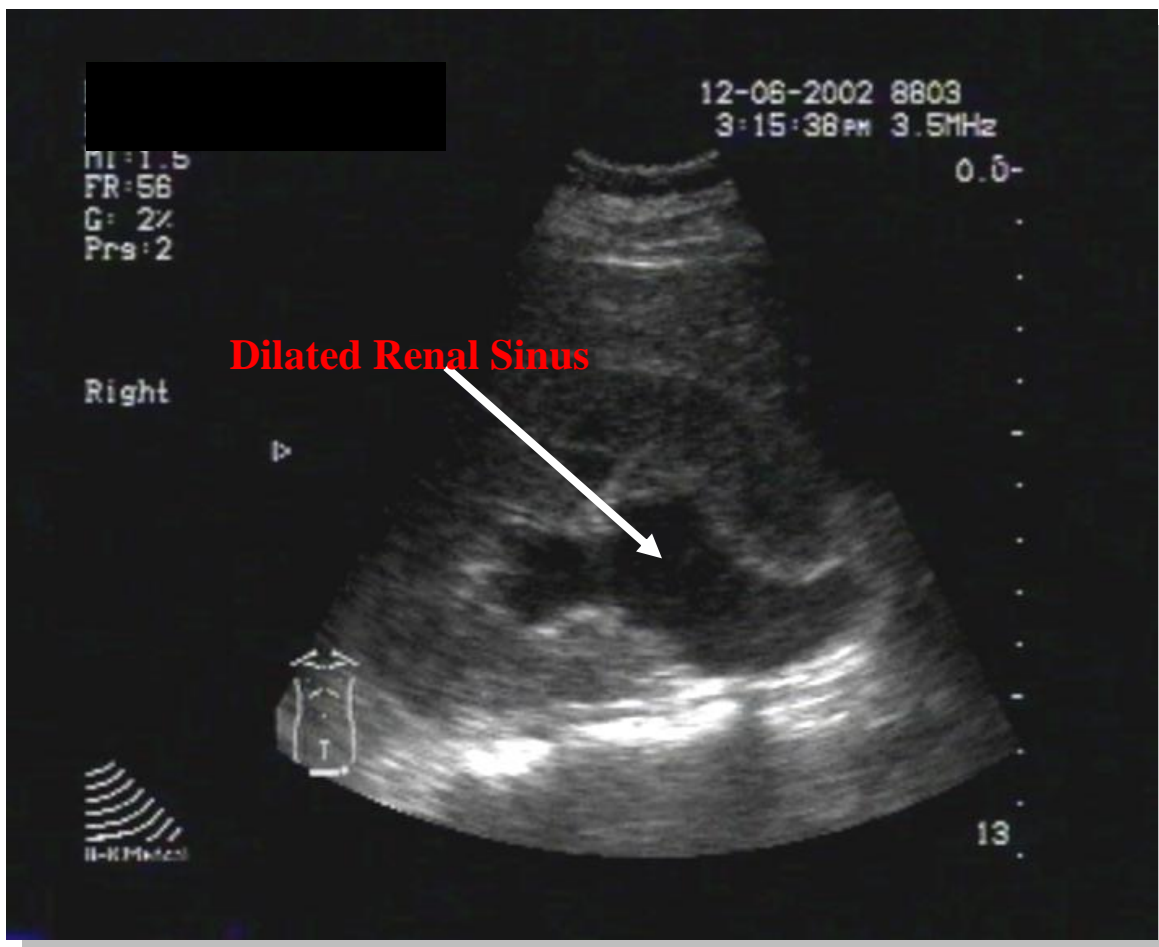
Moderate



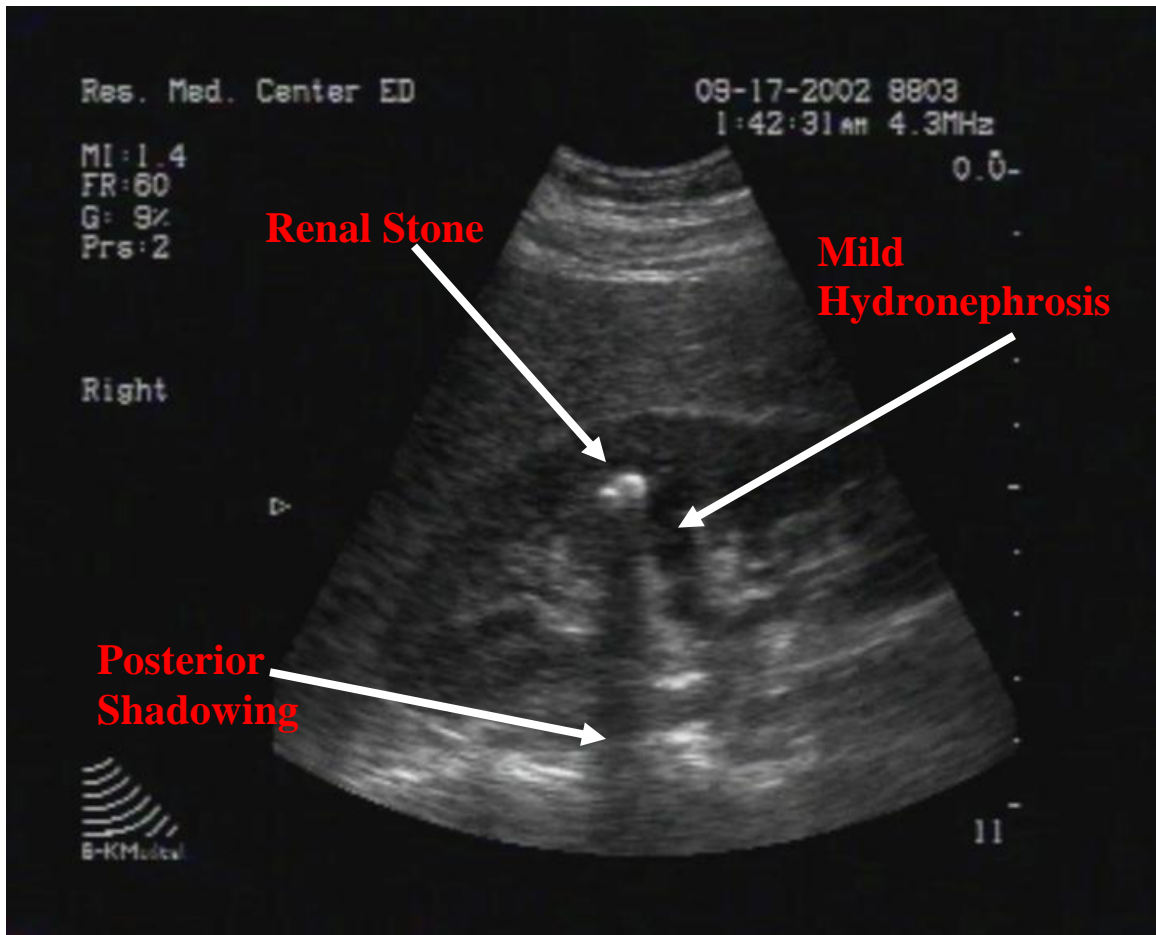
Severe



More Renal EDU Images



Moderate hydronephrosis is apparent in this image of the right kidney. Note the dilated renal sinus.



This image of the right kidney, shows a hyperechoic stone associated with acoustic shadowing posteriorly. Also note the mild anechoic (black) areas representing mild hydronephrosis.

Obstetrical EDU

Introduction

Obstetrical EDU differs from all the other indications previously discussed because it seeks to *rule-in a benign condition* - intrauterine pregnancy (IUP) - rather than rule-out a malignant one – ectopic pregnancy²¹. By its very presence, an IUP dramatically decreases the probability of ectopic pregnancy. While the detection of ectopic pregnancy by ultrasound is quite difficult, the detection of an IUP is quite straightforward, making it an appropriate goal for EDU.

The diagnosis of ectopic pregnancy is one that, as a group, emergency physicians must learn to make more accurately. Current data suggests that over 40% of women with this condition are misdiagnosed at first contact. You will recall how previous chapters have stressed the primacy of clinical skills and their superiority over labs and imaging. Ectopic pregnancy is the exception to this rule. We all know how unreliable history is for date of LMP and pregnancy symptoms, and the “classic triad” of delayed menses, vaginal bleeding and pain is incomplete in up to a quarter of ectopic pregnancies. As for physical exam ... the most skilful obstetricians are unable to detect more than half of ectopic pregnancy masses on physical, even under general anaesthesia.²²

Luckily, in this area where our primary tools are unreliable, we have a lab test - β -HCG - that is extraordinarily sensitive and specific, and an imaging modality - EDU - that is readily available and highly accurate.

²¹ The word “malignant” is particularly apt here. Ectopic pregnancy remains the second-leading cause of maternal death, accounting for 10% of all such mortality.

²² In fact, when an adnexal mass is felt, it is often the corpus luteum of pregnancy. Not infrequently, this mass is not on the same side as the ectopic.

Ectopic Pregnancy – Epidemiology

Clinical experience has shown that a good rule to follow in Emergency Medicine is to **assume that every woman who comes to your department with a pelvic or abdominal complaint has an ectopic pregnancy until proven otherwise**. A negative β -HCG will rule this out in most cases. For the remainder who have a positive β -HCG, obstetrical EDU can greatly improve our diagnostic accuracy and accelerate disposition by detecting the presence of an IUP. While the incidence of ectopic pregnancy is 19.7 per 1000 reported pregnancies, the rate of heterotopic pregnancy (a twin gestation where one embryo is in the uterus and the other one is elsewhere) is 1 in 30,000²³. By detecting an IUP, therefore, the risk of ectopic pregnancy is vastly reduced.

Anatomical Approach

There are two anatomical approaches by which Obstetrical EDU can be performed: transabdominal (TA) and transvaginal (TV).

TA Obstetrical EDU is done with the same 3.5 MHz probe as for the other indications we have seen. The bladder must be full for this scan to be performed, which can be inconvenient.

The TV probe allows for earlier detection of an IUP, which can represent a significant clinical advantage. The exam should always be performed with the bladder empty. On the other hand, a TV probe will add roughly \$10,000 to the purchase price of your EDU machine.

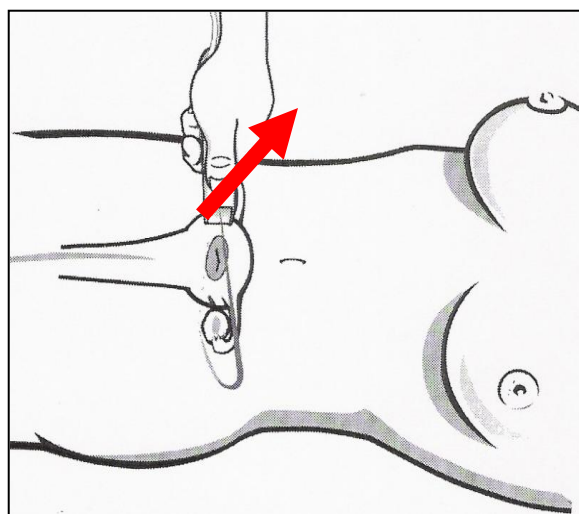
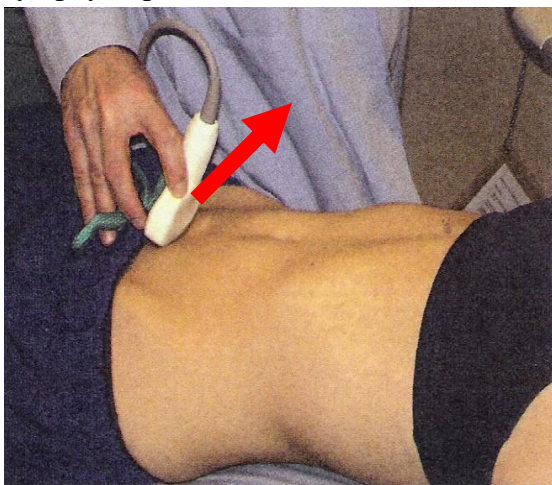
In these days of political correctness, it is worth mentioning that every time women who have been scanned via both approaches are asked which one they preferred, the responses are overwhelmingly in favour of the TV approach. Modesty seems to go out the window when someone is pushing on an overfilled bladder.

²³ It is worth noting that both these number are trending downwards as chlamydia and fertility treatments become more widespread.

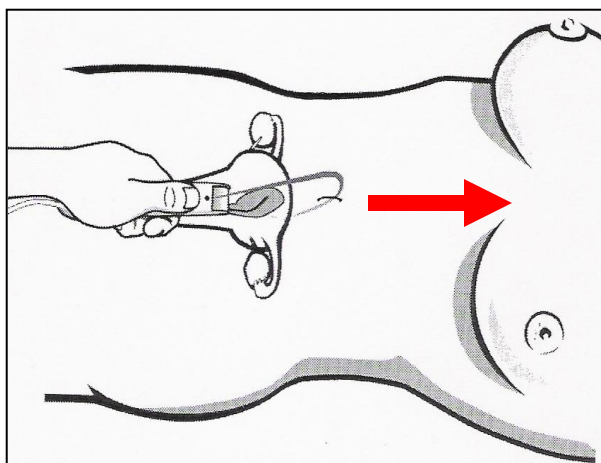
Transabdominal Obstetrical EDU

Proper visualization of the uterus by TA EDU requires the acoustic window provided by the full bladder. This can be accomplished by the IV or Foley route, depending on the urgency of the situation.

Begin the scan as per the pelvis in trauma: place the probe in the transverse plane immediately superior (cephalad) to the symphysis pubis and scan from true transverse to 30° caudal (see illustration in “Suprapubic” section of FAST chapter). The scan is then continued by placing the probe in the midline longitudinally and sweeping from 45° left to 45° right. Note that the longitudinal sweep will have to be done with 10-20° of caudal angulation, depending on the gestational age. Since the uterus is a pelvic organ until 12 weeks gestation, it is necessary to angle the beam somewhat inferiorly to look under the symphysis pubis.



Transverse Transabdominal Position

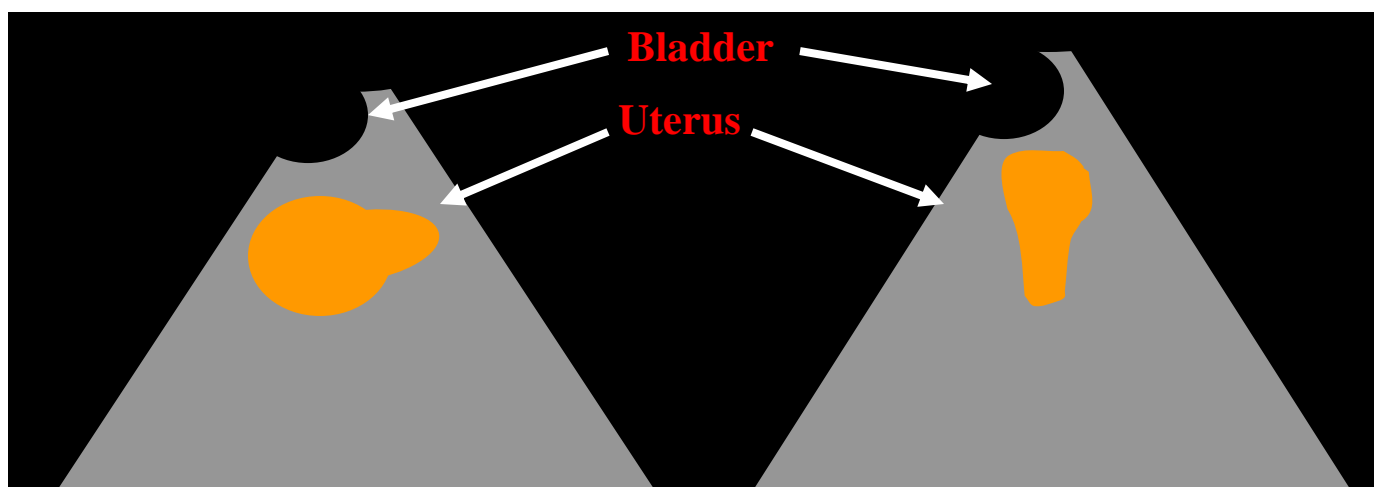


Longitudinal Transabdominal Position

In the longitudinal view the uterus will look like an elongated pear, while on the transverse view it will look like a circle. It is a homogenous structure that, in terms of echogenicity, resembles the liver. In both cases, it should appear below the bladder (the anechoic “black” structure which is at the top of the screen).

Note that the degree of anteversion or retroflexion of the uterus can dramatically alter the plane in which the organ lies.

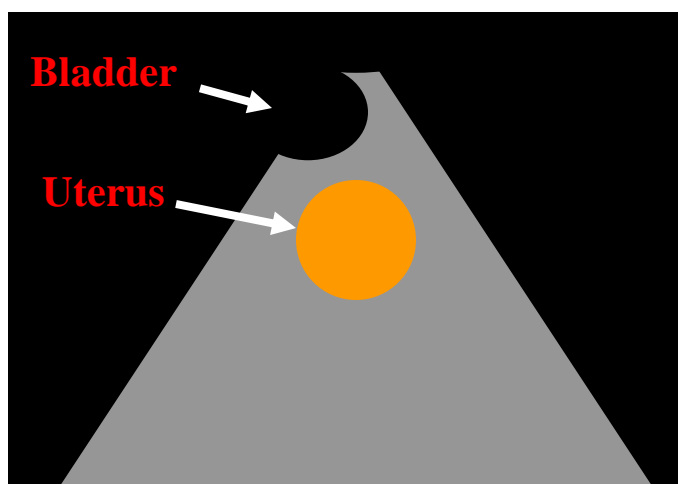
Longitudinal View



Uterus in usual
anteverted position

Uterus in extreme
anteversion

Transverse View



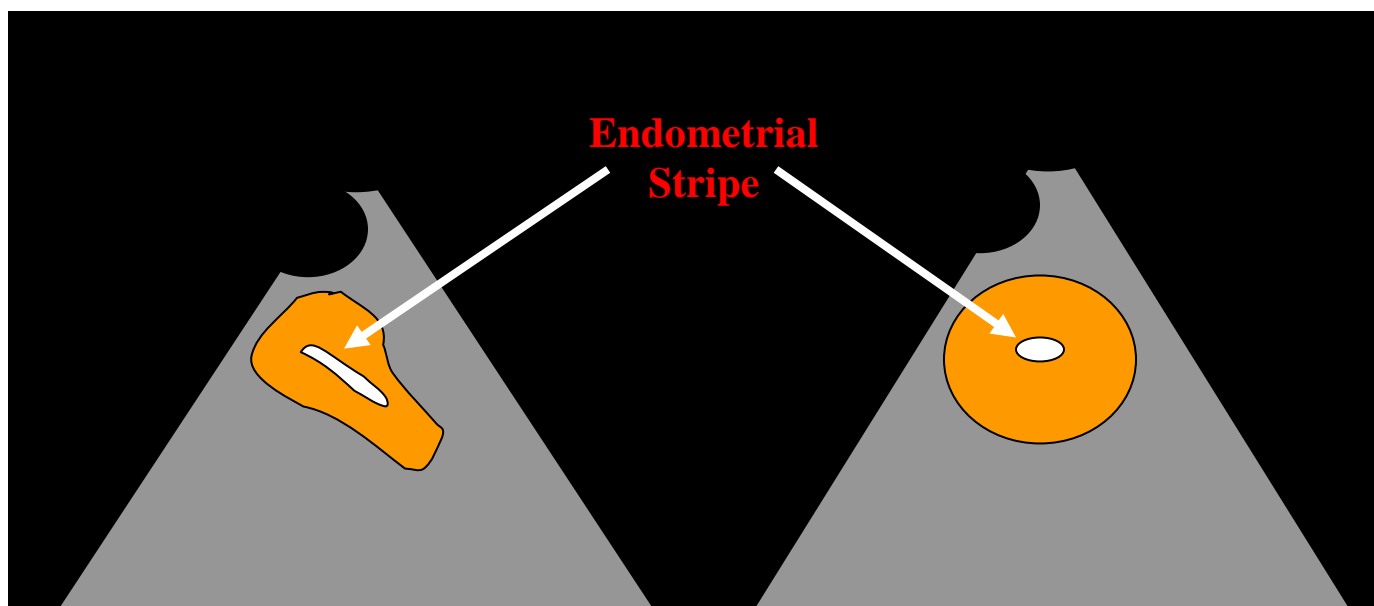
Note that, regardless of the view, it is *essential to identify the bladder* with certainty before making any decisions about the uterine contents. Many novices have been fooled by urine masquerading as something else.

The Endometrial Stripe

In the center of the non-gravid uterus is the *endometrial stripe*, which shows up as an echogenic (white) line.²⁴ This structure is the **key Area of Interest** and must be visualized in its entirety, from left to right in the longitudinal view and from the cervix to the fundus in the transverse view.

Longitudinal View

Transverse View



Centering the Area of Interest

Remember that in the longitudinal view, the *left* side of the screen corresponds to the *cephalic* direction on the patient while, in the transverse view, the *left* side of the screen corresponds to the *right* side of the patient. Centering the **Area of Interest**, therefore, is done in the same manner as we have seen in the transverse and longitudinal planes in the abdomen:

In the Longitudinal view

To move the Area of Interest to the *right*, move the probe *cephalad*.

To move the Area of Interest to the *left*, move the probe *caudad*.

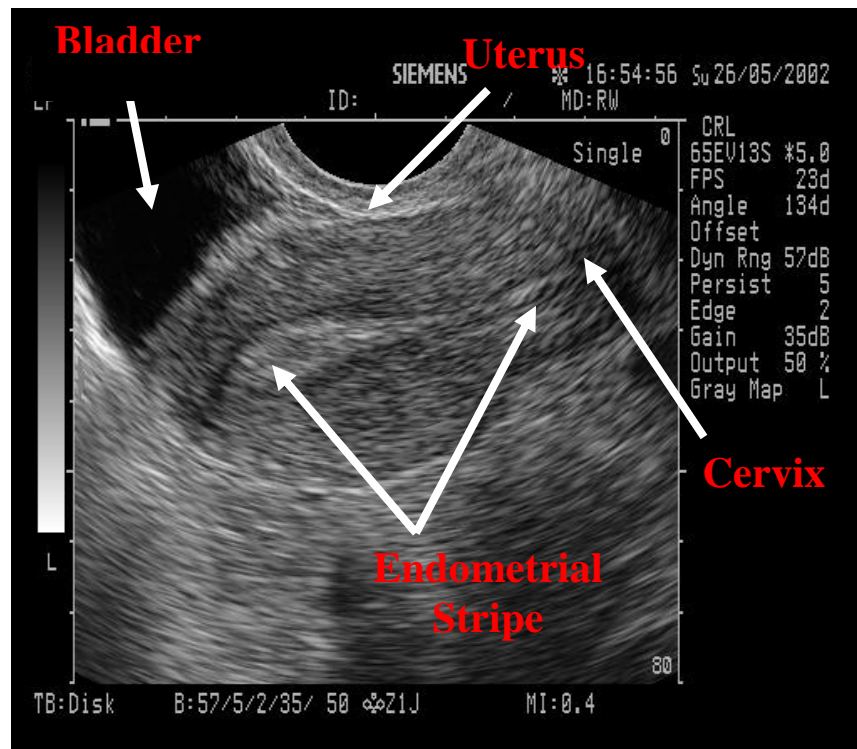
In the Transverse view

To move the Area of Interest to the *right*, move the probe to the *patient's right*.

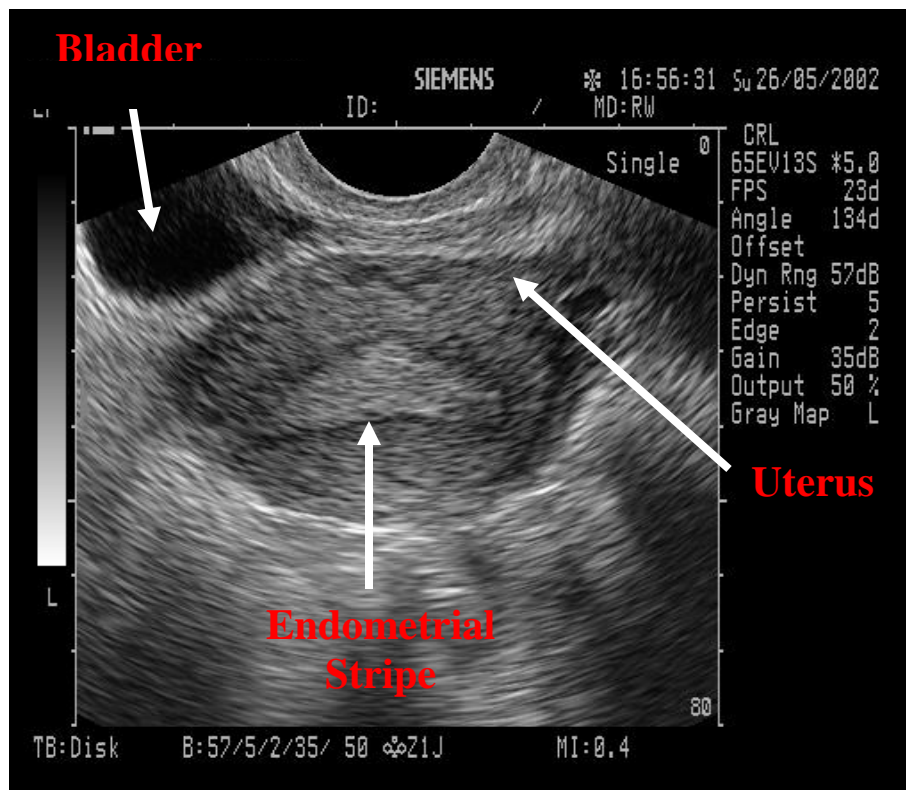
To move the Area of Interest to the *left*, move the probe to the *patient's left*.

²⁴ In the immediate post-menstrual period, this stripe may be less echogenic for a day or two. This is unlikely to be a source of confusion precisely because of where it falls in the menstrual cycle – immediately post-menstrual women are unlikely to present with vaginal bleeding and a positive β -HCG.

Transabdominal Approach – Longitudinal View



Transabdominal Approach – Transverse View



Transvaginal Obstetrical EDU

Transvaginal EDU is performed with a special probe. Properly called an “*endocavitary*” probe²⁵, this device will be of a higher frequency than the standard EDU probe. Usually these probes are 5.0 MHz, though some authors use 6.5-7.5 MHz. You will recall that as frequency increases, penetration decreases. This is not a problem, as the endocavitary probe can be placed directly against the structure of interest. No resistance problems, no need for acoustic windows. The higher frequency therefore provides greater axial resolution at no real cost in probe efficiency in terms of penetration.



An Endocavitary Probe

In exact contradistinction to TA EDU, the patient must first void or have her bladder emptied by catheterization. Optimally, the patient is then placed in stirrups in a proper obstetrical stretcher. If the OB/GYN exam table is unavailable, or if patient instability precludes movement to the OB/GYN room, an adequate MacGyver²⁶ is to place pillows or an upside down bedpan under the patient’s hips. This is essential, as it will be difficult, to perform the scan without dropping the handle of the probe beneath the level of the patient.



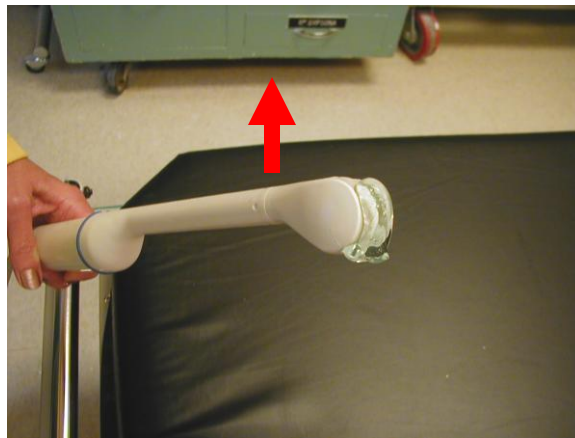
²⁵ The same probe is also used for transrectal U/S, mostly to image the prostate.

²⁶ For those of you without a thorough grounding in popular North American culture, a “MacGyver” is an ingenious improvised solution using common materials readily at hand. From the eponymous 1980’s television show of the same name.

Preparing the probe

The next step is to prepare the probe, with an eye to a) patient safety and b) making sure the U/S waves get to where they need to go. Patient safety is assured by covering the probe with a latex condom (if the patient is not allergic), which is then securely fastened to the probe by use of an elastic band. Placing gel on the probe both *before and after* the condom is placed optimizes acoustic transmission. Without gel on both sides of the condom, air may distort the passage of the U/S waves, leaving part of the screen black. Particular care must be taken immediately after the condom has been placed over the first layer of gel to ensure that no small air bubbles have been trapped. If any are seen, they should be gently pushed off to the side before the second layer of gel is placed (over the condom). To assuage the patient's concerns, always describe the use of the condom for their protection.

Goo...



...Condom...



... Goo.



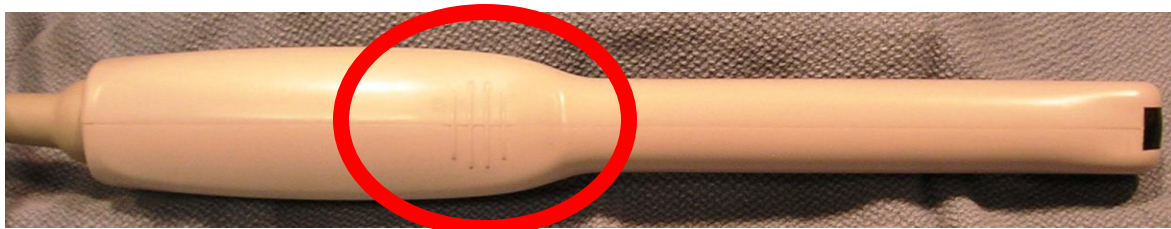
Transvaginal EDU – Contraindication

The only contraindication to TV EDU is recent gynecological surgery, a rather rare occurrence in the first trimester.

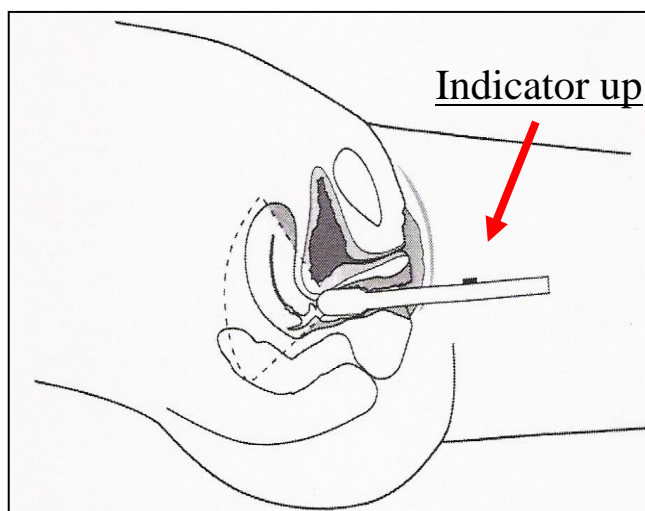
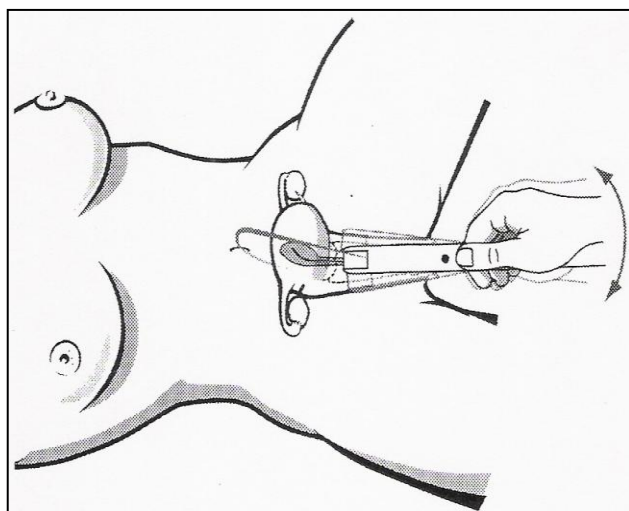
Transvaginal EDU - Technique

As with all other probes, an endocavitary probe will have a tactile reference mark to enable the user to orient the instrument in the dark.

Endocavitary Probe Reference Mark



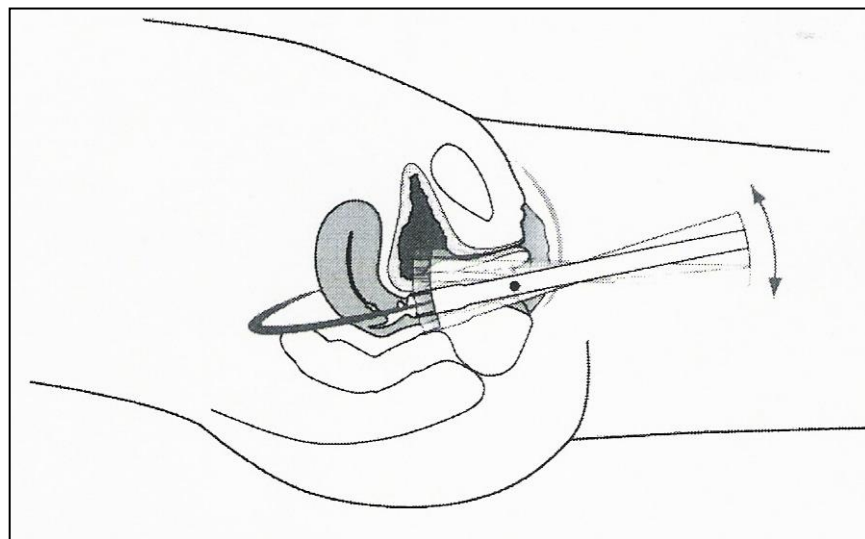
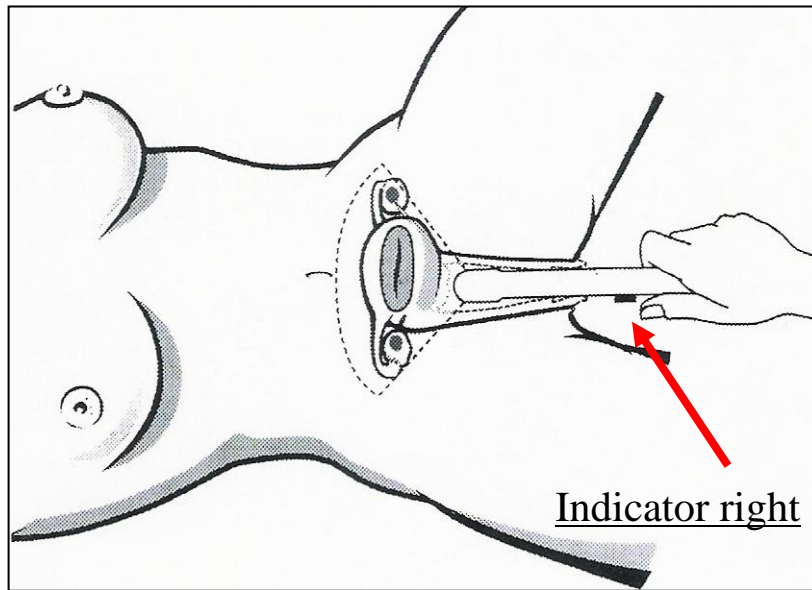
The scan is begun by placing the probe with the reference mark towards the ceiling and inserting it 2-3 cm into the vagina²⁷. This places the probe in a true *sagittal* orientation (body divided into left and right mirror images). The uterus should appear as a roughly oval homogenous structure, though it can be somewhat *pear-shaped* (like the longitudinal transabdominal view seen on page 132). As with TA EDU, the endometrial stripe is the key **Area of Interest**. Once it has been identified, a slo-o-o-ow sweep is performed to the left by moving the probe toward the patient's left until the beam passes entirely out of the uterus. The scan is then repeated to the right, again until the uterus disappears.



Longitudinal Transvaginal Position

The probe is then brought back to center and turned 90° counterclockwise. This places the probe in a true *coronal* plane, dividing the body into anterior and posterior halves. The same procedure is repeated – the probe is swept anteriorly and posteriorly until the uterus disappears, always passing through (and returning to) the endometrial stripe. In the coronal view the uterus appears in cross-section and is therefore more consistently *circular* (mimicking the image seen transabdominal transverse view).

²⁷ Some women, particularly if they have had TV U/S before, may prefer to insert the probe themselves.

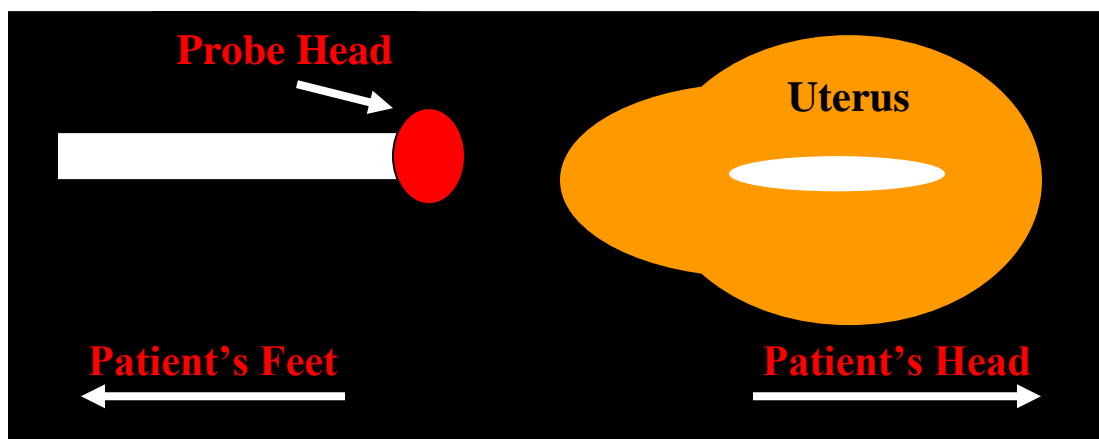


Transverse Transvaginal Position

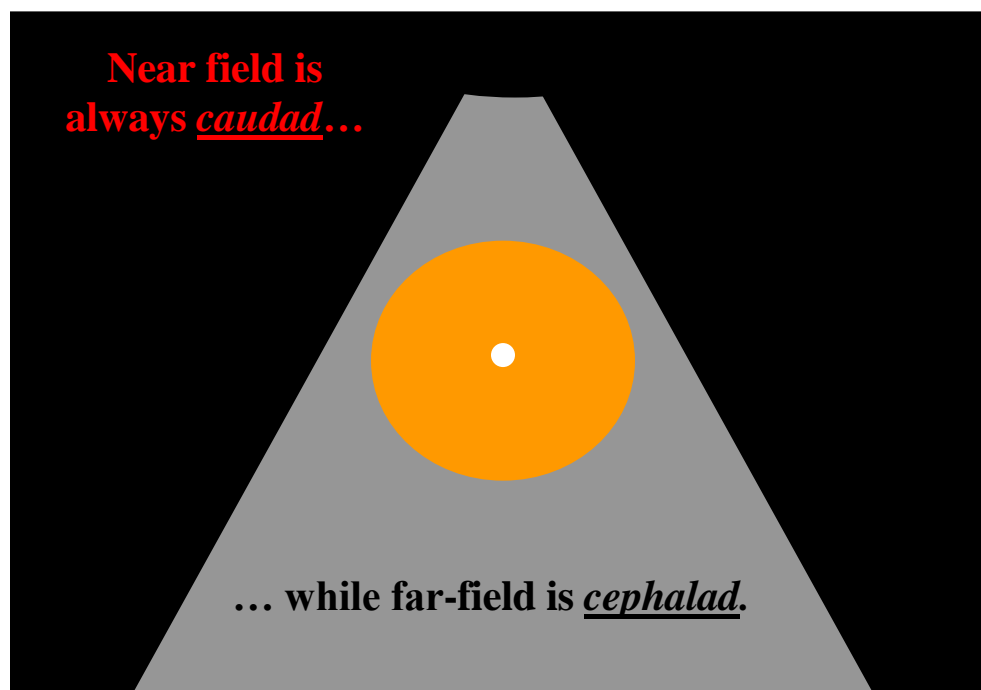
Transvaginal EDU- Spatial Orientation

Spatial orientation is more difficult in TV EDU than any other scan. The diagrams on the next four pages will take you through the basic concepts, but it takes a while to really integrate this. Don't panic!

The probe head is placed against the cervix...



... therefore it follows that...

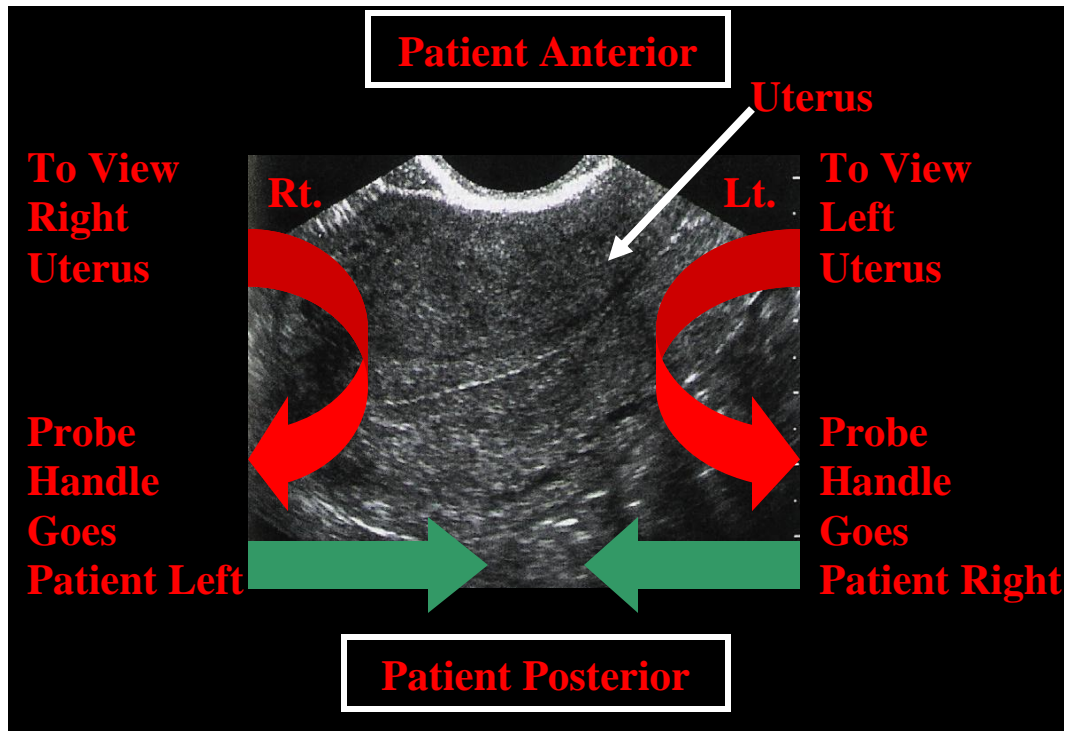


But this is far from obvious when you try to picture where the structures lie in the pelvis.

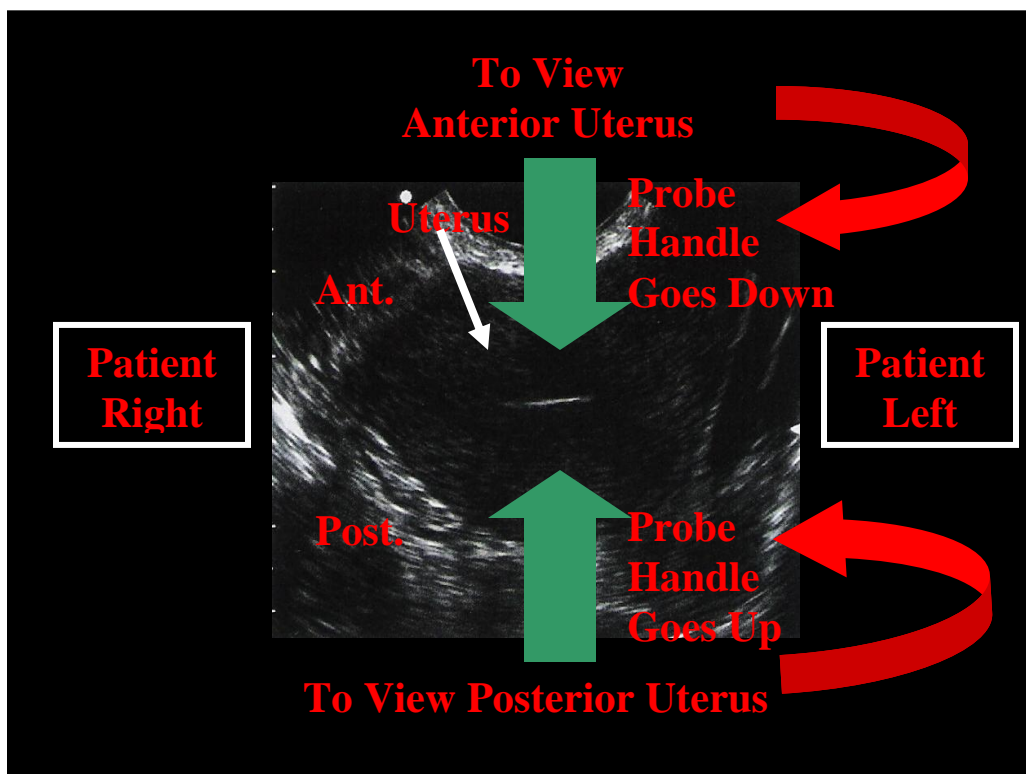
Transvaginal EDU – Probe Manipulation

With transvaginal EDU, the probe handle moves *opposite* the desired direction of view:

Probe in Longitudinal Position (indicator up)



Probe in Transverse Position (indicator patient right)

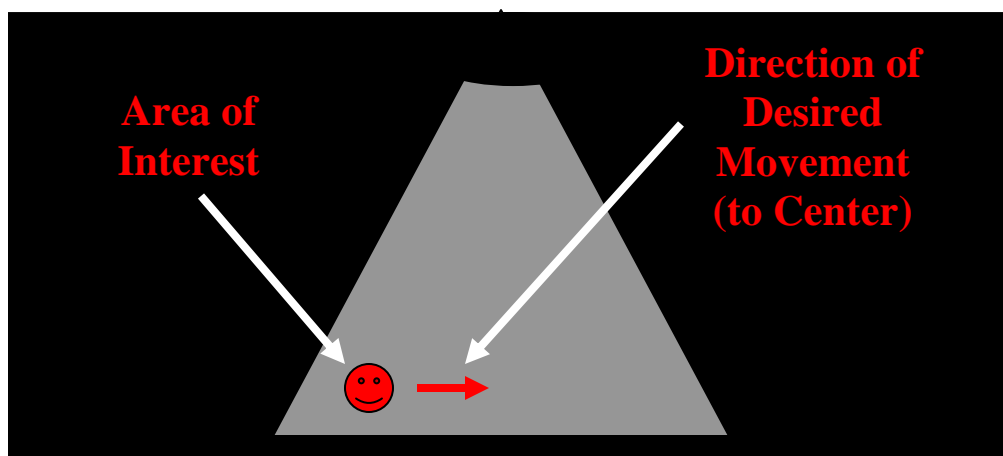


Transvaginal EDU - Probe Manipulation cont...

Don't be dismayed if the diagrams on the preceding pages leave you scratching your head. Remember that, with EDU, complicated things either *don't matter* or can be circumvented. In this case, it will suffice (at first) to get the uterus on the screen and then to center the **Area of Interest**.

The instructions below are meant to simplify things by telling you how to move the probe to center the image on the screen. Note that the movements refer to the direction you move the probe *handle*. The probe head, therefore, will move in the opposite direction inside the patient's vagina.

Let's try to see how this works. In the *longitudinal* view, the plane of the beam runs anterior-posterior. You know that the probe reference mark is pointed *up*, or towards the anterior side and that, by convention, *the side the probe marker points to appears on the left of the screen*. So, if you want to move an **Area of Interest** more to the *right* of the screen, thusly:



You would have to move the beam *anteriorly*. The probe head, therefore, has to move *up*. This can only be done by *dropping the probe handle*. Alternatively, to move an **Area of Interest** more to the *left* of the screen, you must move the beam *posteriorly*, by moving the probe head *down*. This is accomplished by *raising the probe handle up*. Once centered, the **Area of Interest** is “swept through” from right to left by moving the probe handle opposite the direction of desired view; i.e, to “sweep” through the right half of the uterus, the probe handle must be moved toward the patient's left and vice versa as illustrated on the previous page.

In the *transverse* view, the plane of the beam runs left-to-right. You know that the probe marker is oriented towards the patient's *right side*, which will be the side which appears on the *left* of the screen. It follows, then, that to move an **Area of Interest** more towards the right of the screen, you would have to move the beam more towards the *right of the patient*. The only way to do this is to move the head of the probe towards the *patient's right*, which means the handle of the probe must be moved toward the *patient's left*. Once centered, the Area of Interest is “swept through” from anterior to posterior by moving the probe handle again opposite the direction of desired view; i.e, to “sweep” through the anterior half of the uterus, the probe handle must be moved toward the patient's posterior and vice versa as illustrated on the previous page.

This concept seems to give a lot of people a hard time. It might be better if, for now, you just memorize the following directions:

In the *Longitudinal* view

The beam divides the body into two symmetrical halves, left and right.

The scan is done by sweeping to one side and then to the other.

To move the Area of Interest to the *right*, move the probe handle *down*.

To move the Area of Interest to the *left*, move the probe handle *up*.

To view the *right* half of the Area of Interest, move the probe handle *left*.

To view the *left* half of the Area of Interest, move the probe handle *right*.

In the *Transverse* view

The beam divides the body into anterior and posterior halves.

The scan is done by sweeping anteriorly and posteriorly.

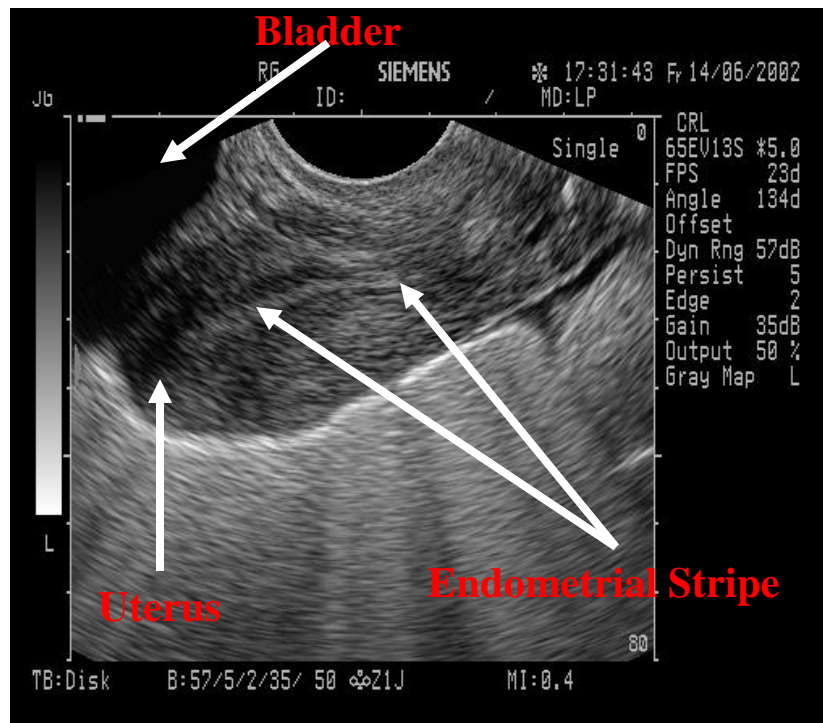
To move the Area of Interest to the *right*, move the probe handle to *your right*.

To move the Area of Interest to the *left*, move the probe handle to *your left*.

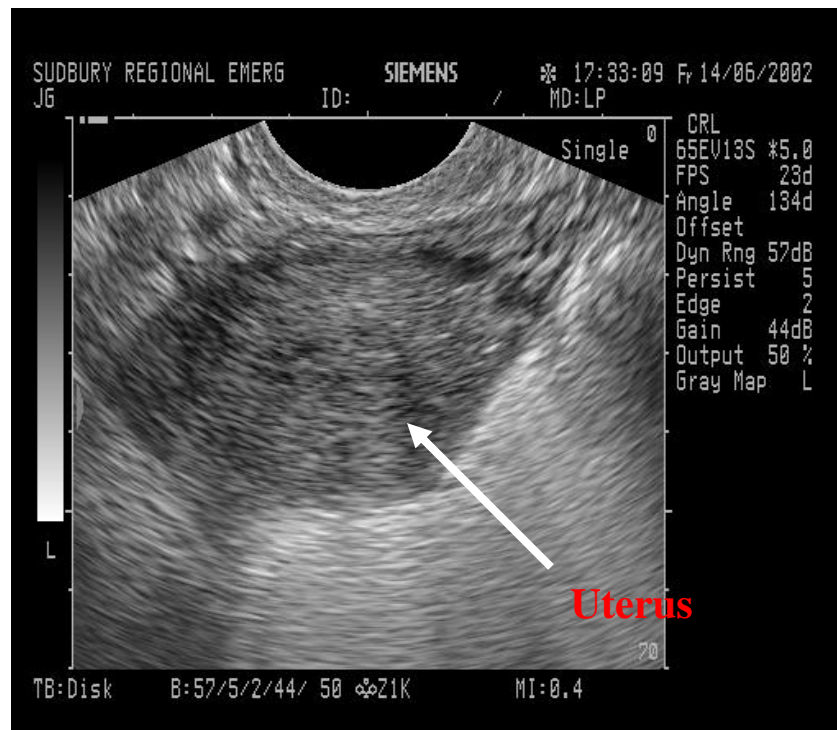
To view the *anterior* half of the Area of Interest, move the probe handle *down*.

To view the *posterior* half of the Area of Interest, move the probe handle *up*.

Transvaginal Approach – Longitudinal View



Transvaginal Approach - Transverse View



As mentioned earlier, it is *important to locate and identify the bladder* to ensure that it is not confused with the gestational sac. The bladder will appear at the top left of the screen in the longitudinal view and across the entire top of the screen in the transverse view.

Diagnosing an IUP

The aim of this exercise, whether in TA or TV, is to follow the endometrial stripe along its entire course, looking for evidence of pregnancy. Because of the potentially devastating consequences of a false negative in this setting, the criteria for diagnosing pregnancy by EDU are quite strict. No fewer than **three** ultrasonographic findings **must** be present:

1) Decidual reaction.

Around the 14th post-fertilization day, the endometrium begins to undergo the decidual reaction. This will lead to the formation of a strongly echogenic (white) lining.²⁸

2) Gestational sac

What we are looking for is an anechoic (black) area contained in the decidual reaction. This is the growing pocket of amniotic fluid wherein the fetus will reside, and can be clearly identified by ~ 5 weeks gestational age.

Unfortunately, some sources use the term “gestational sac” when they are really referring to the **amnion**, which leads to no end of confusion. The amnion is a **thin** echogenic sac **contained** in the gestational sac (see illustration on pg# 148). It divides the gestational sac into two cavities – the amniotic and the chorionic - and fuses with the deciduas between the 12th and 14th week. While it is possible to visualize it as a separate structure until that point, in reality this is a) quite difficult and b) not clinically useful. If you see fluid (black) inside the uterus, proceed with your EDU.

The real challenge of Obstetrical EDU is to detect the...

3) Yolk sac

This is another **thick echogenic layer** found within the gestational sac, but **much smaller** than said sac. The “**double ring sign**” of the yolk sac within the gestational sac is the earliest sign of a viable IUP. It becomes visible when the gestational sac is 10 mm by TV and 20 mm by TA. It can be detected as early as 5 weeks gestation by TV EDU and 6 weeks gestation by TA EDU.

Therefore, to confirm the presence of an IUP, you must visualize:

- a strongly echogenic layer, which is **white** (the decidual reaction), within which you find...
- a **black** area (the gestational sac), in which you must find...
- another **white** layer (the yolk sac)

These three structures form the “**double ring sign**”.

²⁸ The decidua is made up of the decidua capsularis and the decidua vera, which can form separate echogenic layers, sometimes partially separated by a further layer of fluid. Regretably, this is sometimes referred to as a “double decidual reaction” which is often confused with the “double ring sign”. Examples of both are provided further.

With the above findings confirmed, the probability of ectopic pregnancy is greatly reduced, as detailed in “Epidemiology”. The EDU is documented in the chart as an intrauterine pregnancy (*IUP*). *Any other result* is documented as “No definitive intrauterine pregnancy” (*NDIUP*) and the work-up proceeds as detailed in the flow chart at the end of this chapter.

Fetal Pole

Embryologically, the fetal pole begins to develop roughly at the same time as the yolk sac. Realistically, EDU can only pick it up approximately one week later (i.e. at six weeks gestation for TV and seven weeks for TA). It should be seen within the gestational sac, once the gestational sac reaches a diameter of 16mm. While not essential to the diagnosis of an IUP, it is useful to know that fetal cardiac activity should always be detectable if the fetal pole exceeds 5 mm in length. Absence of cardiac activity beyond this length is almost certain to result in a miscarriage.

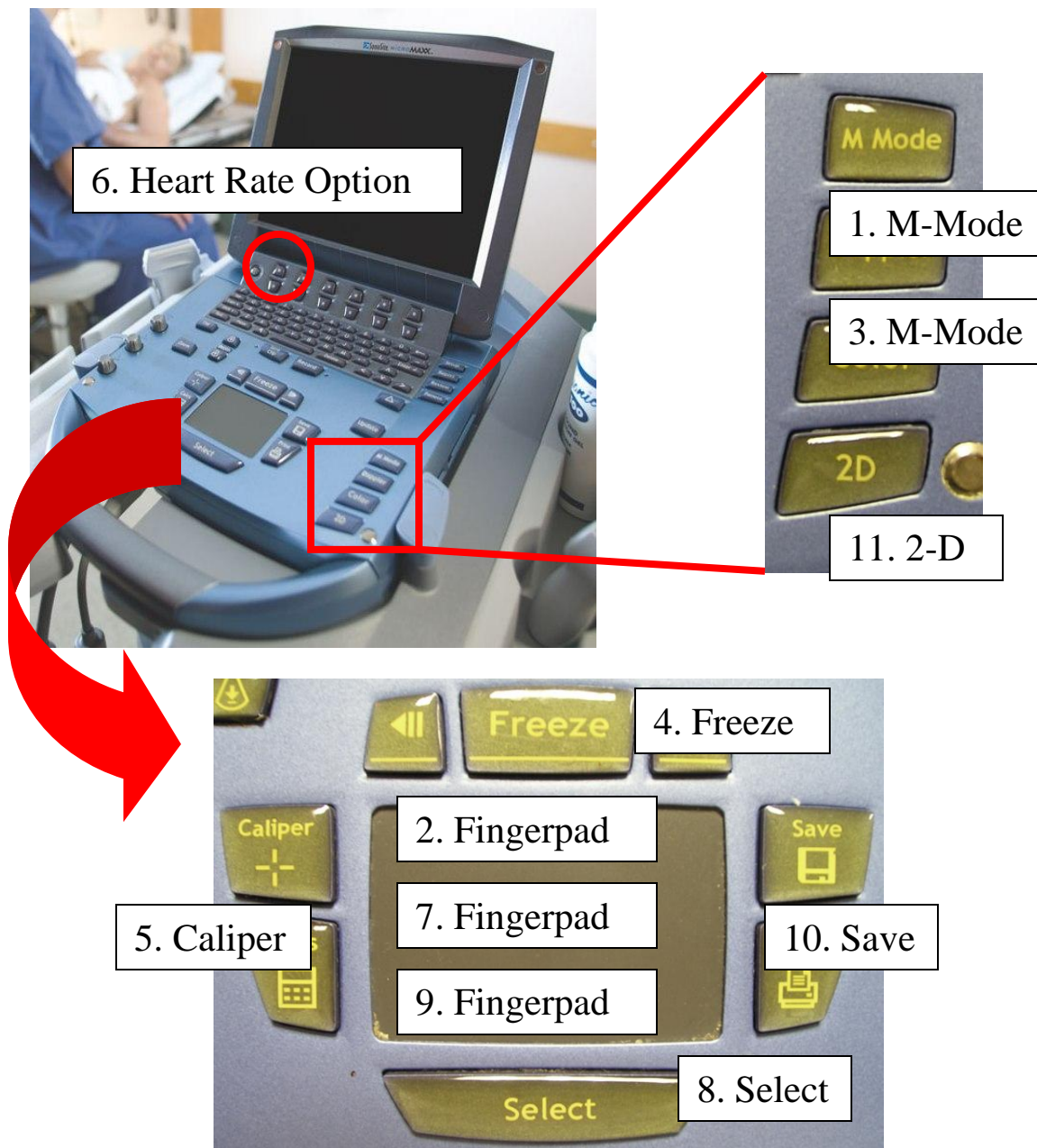
Fetal Cardiac Activity

Proof positive of a *live* IUP (LIUP), but may be hard to detect in early gestations. It can be reliably detected from approximately the sixth week onwards by TV EDU, and roughly a week later by TA EDU. The normal heart rate for an embryo longer than 5 mm is greater than 120bpm. The lower the heart rate is below 120bpm, the lower the survival rate. Embryos longer than 5mm with heart rates less than 100bpm have a survival rate of ~6%. Cardiac activity must *never* be tested by Doppler (transmits a higher amount of energy and risks later malformation) but can be tested by “M” (“Movement”) mode.

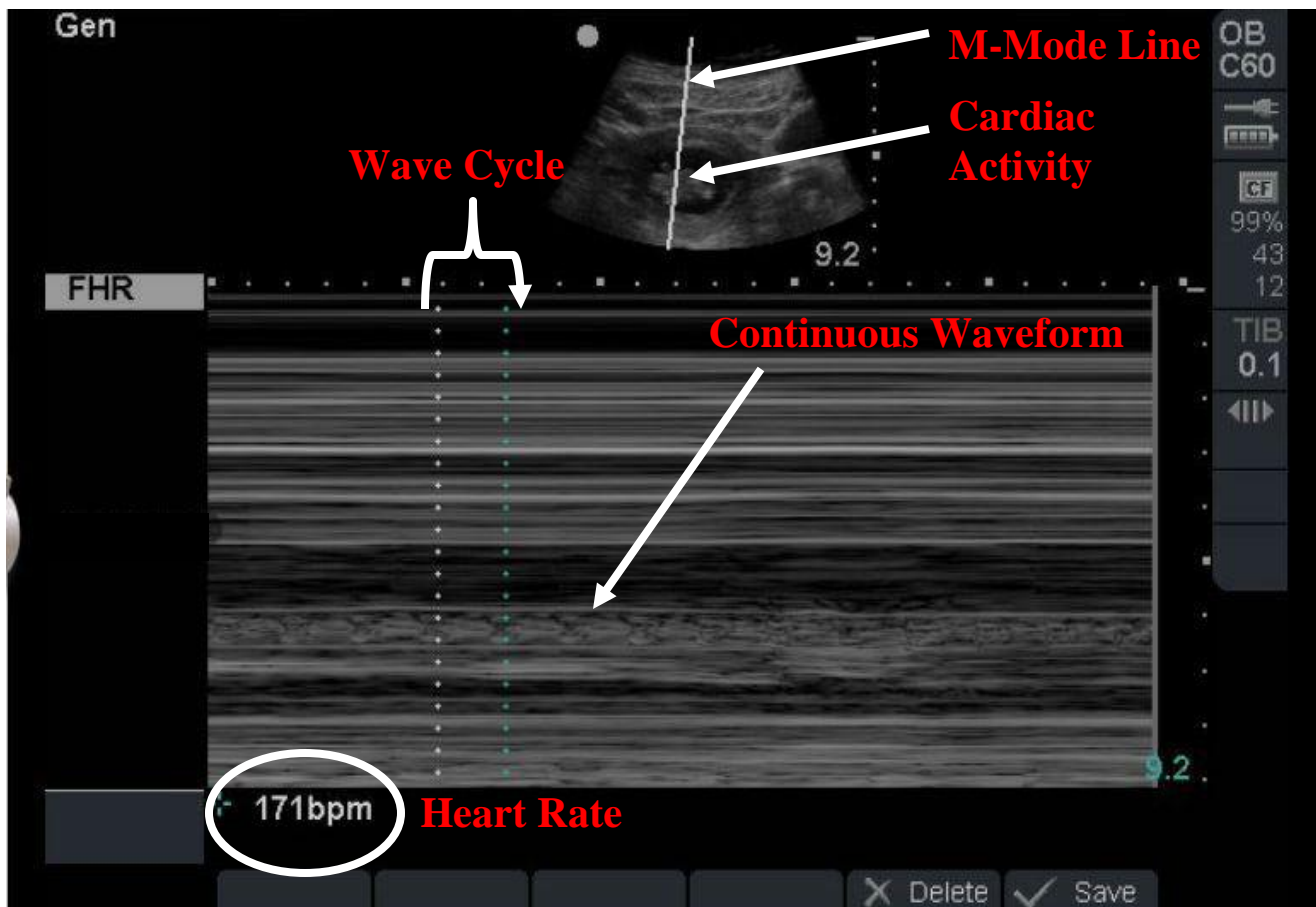
The process used to measure fetal cardiac activity is the same in either TV or TA EDU. When using the Sonosite, first make sure that the machine is set to an obstetrics setting after you enter the patient’s identification information. Next, obtain a clear, centered image of the fetus, and its rhythmic, oscillating cardiac activity. Press the “M” mode button at the right lower corner of the machine’s face. “M” mode is a graphic, one dimensional time display that represents the motion of structures along a single line penetrated by a single ultrasound beam. Once selecting “M” mode, you will see a narrow line positioned vertically on the monitor. Using the fingerpad, position the “M” mode line so that it passes through the fetal heart, and press the “M” mode button a second time. The monitor will now display a split screen with the EDU image of the fetal pole at the top, and a graphic characterization of the ultrasound echoes along the single “M” mode line at the screen’s bottom. Each horizontal line across the graph represents a structure’s movement over time. On the “M” mode graph, fetal cardiac activity appears as a continuous horizontal waveform. The waveform representing fetal cardiac activity is generally found at a distance from the top of the “M” mode graph that is the same as the distance of the fetal heart from the top of the EDU image at the upper screen; i.e, if the fetal heart is observed to be half-way from the top of your ultrasound image, the waveform representing fetal cardiac activity will be half-way from the top of the “M” mode graph. Once you have identified the fetal cardiac activity on the “M” mode graph, freeze the image, and press the caliper button located to the left of the fingerpad.

The monitor will now display an option at the lower left screen to measure the fetal heart. You must select this option by pressing the unlabelled button just underneath the fetal heart rate option. A vertical line will now appear on the “M” mode graph. Using the fingerpad, position this line at either a “peak” or “depression” at a single wave along the waveform. Press the select button underneath the fingerpad. The initial vertical line that you just placed along the waveform will now be “locked,” and a second vertical line will appear on the “M” mode graph. Using the fingerpad, position this second line at either the “peak” or “depression” of the very next wave along the waveform. Keep in mind, that each line should be at *either* a “peak” *or* a “depression” so that you are measuring the length of one wave cycle from “peak” to “peak” or “depression” to “depression.” After you have positioned both vertical lines on the “M” mode graph, the fetal heart rate will appear in beats per minute at the left lower corner of the monitor. Save the image, then press the 2-D button at the right lower corner of the machine’s face to exit “M” mode.

Sonosite - The Steps

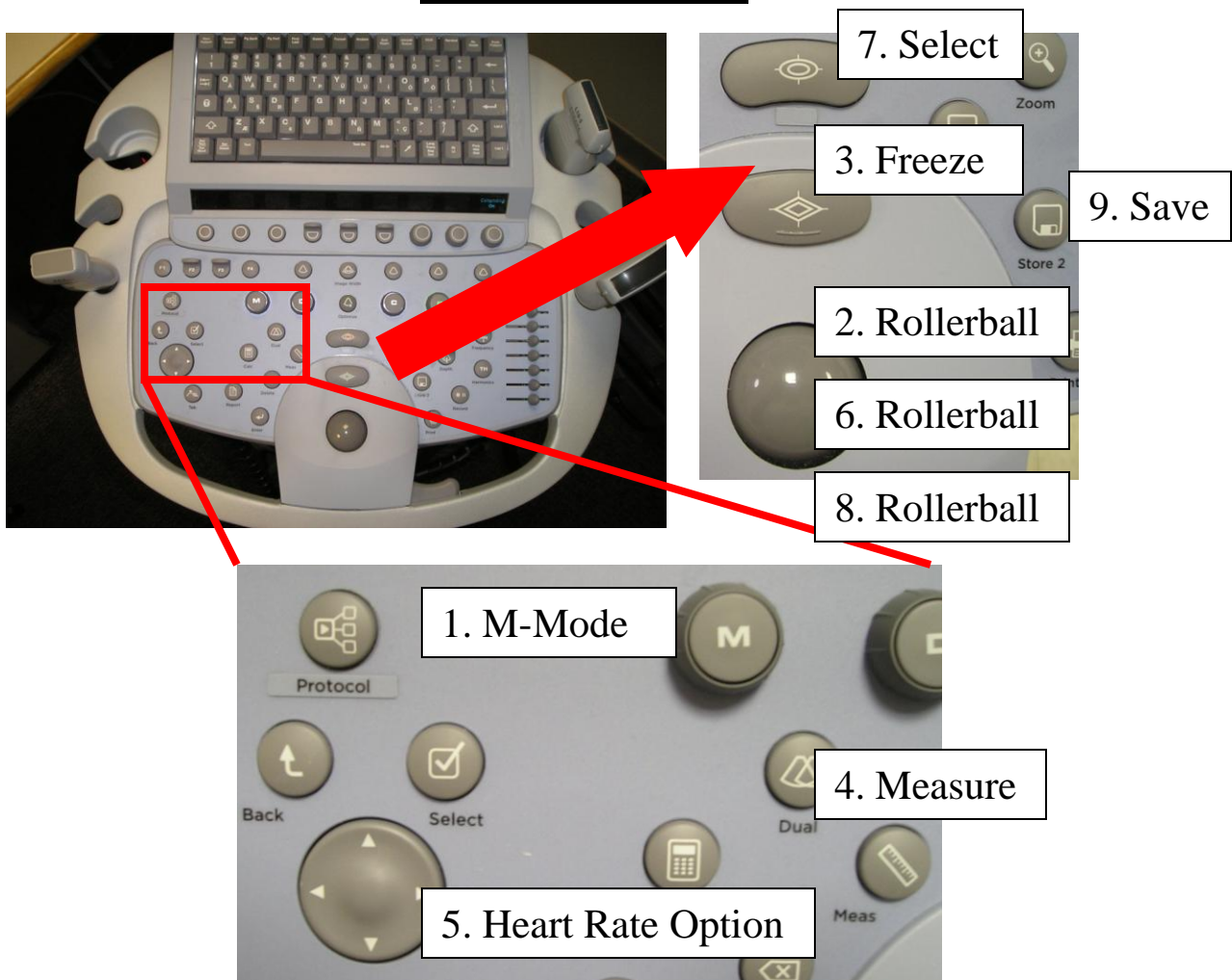


Sonosite - The Final Image

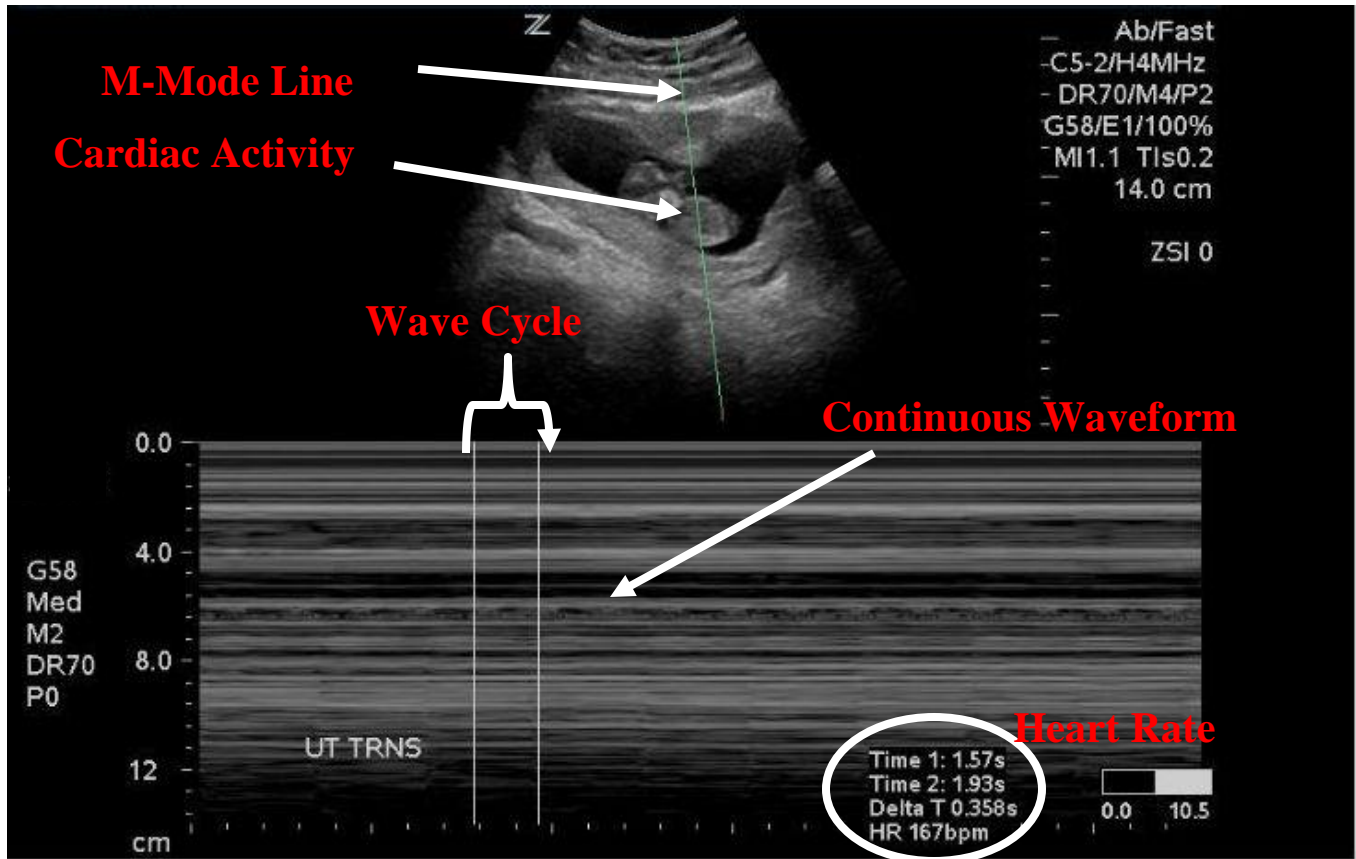


When using the Zonare, again make sure that you have selected the obstetrics getting and general preset after entering the patient's identification information. Obtain a clear, centered image of the fetus and its rhythmic, oscillating cardiac activity. Select the "M" mode by pressing the M-labelled button at the left mid-face of the machine. The monitor will now display a split screen with your EDU image at the top, and the "M" mode graph at the bottom. A vertically oriented line will now appear on the EDU image. Use the rollerball to position this line across the oscillating fetal heart. Once in the correct position, you will observe the continuous waveform representing fetal cardiac activity on the lower "M" mode graph. Press the freeze button labelled with two diamonds just above the rollerball. Press the measure button just to the left of the freeze button. On the machine's monitor, you will now be given the option to measure the fetal heart rate. Highlight that option by pressing the down arrow of the circular arrow-pad at the far left of the machine's face. A vertical line will appear on the "M" mode graph. Use the rollerball to position this line at *either* a "peak" *or* "depression" of a single wave along the waveform. Press the select button labelled with two ovals just above the diamond-labelled freeze button. The initial vertical line placed on the "M" mode graph is now locked in place, and a second vertical line will appear. Use the rollerball to position this second vertical line at either the "peak" or "depression" of the very next wave along the waveform. Again, you are essentially measuring the length of one wave cycle. Once the second line is in position, the fetal heart rate will appear in beats per minue at the right lower corner of the monitor. Save the image. Then unfreeze the image and press the M button to exit "M" mode.

Zonare - The Steps



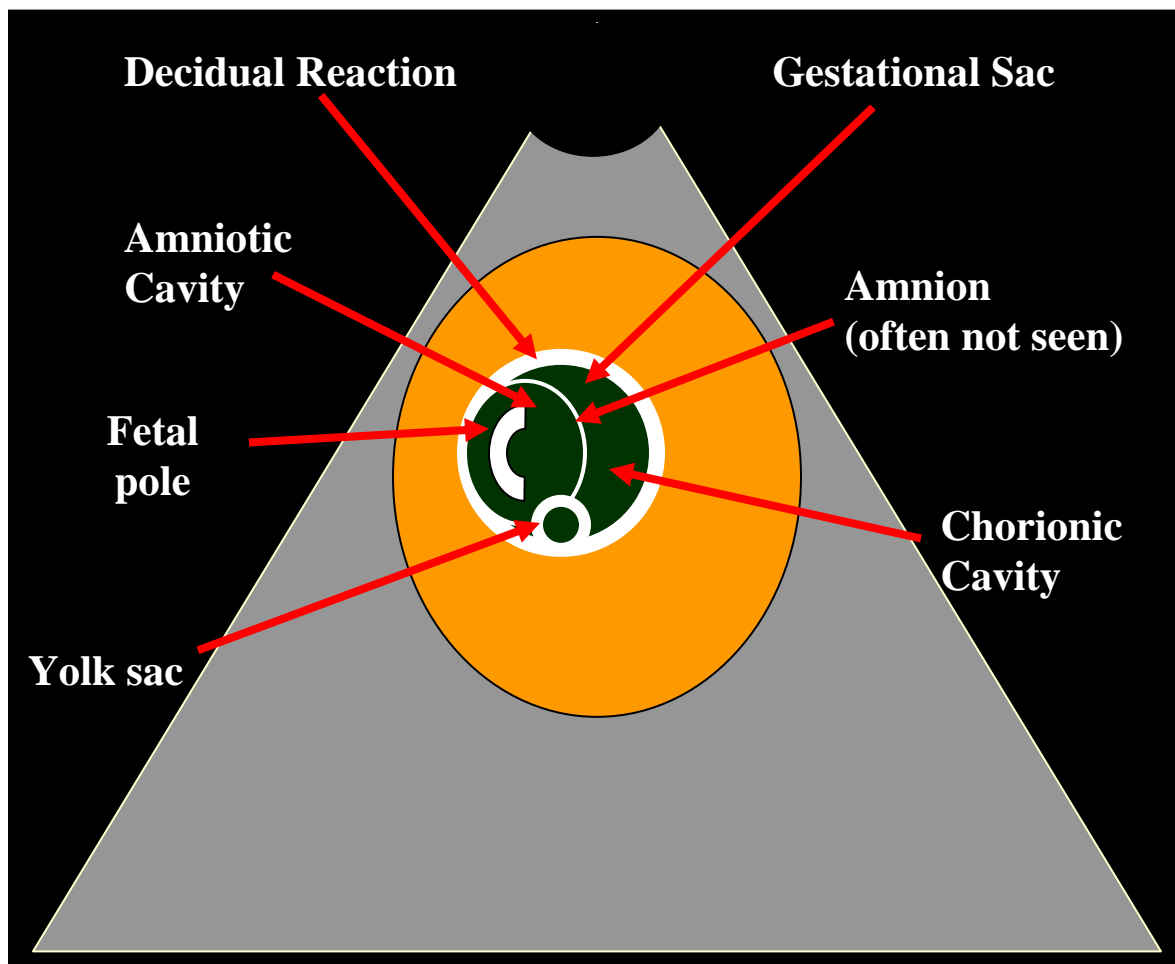
The Final Image



Keep in mind that it is ***very*** important to make sure the rhythmic activity you are watching is ***within*** the gestational sac. It is surprisingly easy to be fooled by blood vessels coursing near there. It can be helpful to compare the observed pulsations to the maternal heart rate in these cases.

It is important, however, to always bear in mind that the fact that an IUP is actually an ***L***IUP falls into the “nice-to-know” category, rather than “need-to-know”. Even an IUP which is determined to have expired rules out ectopic pregnancy.

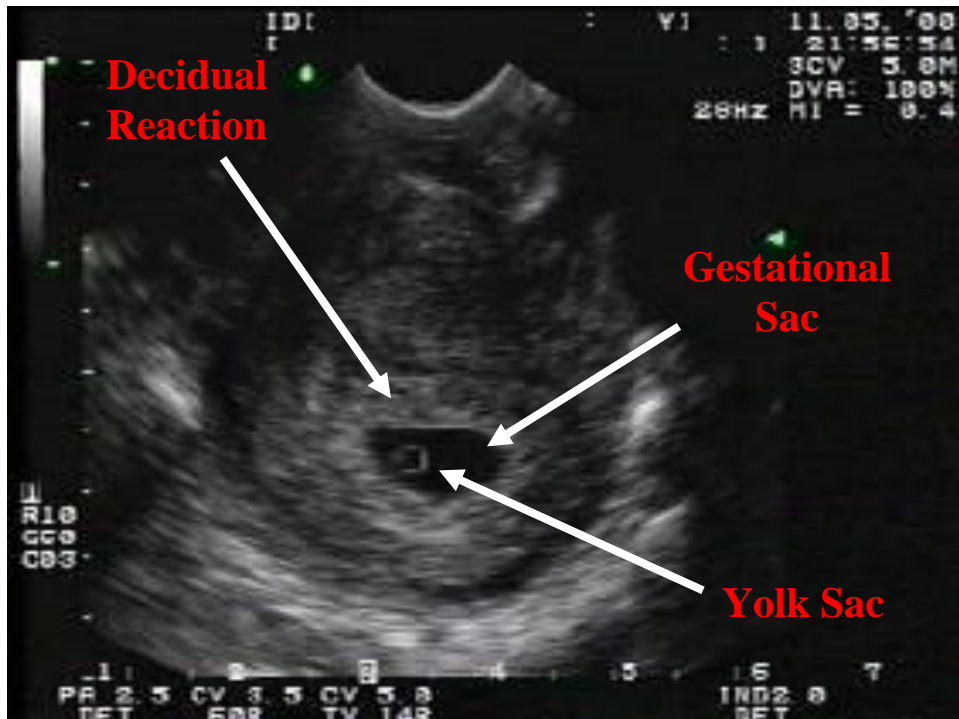
Normal IUP



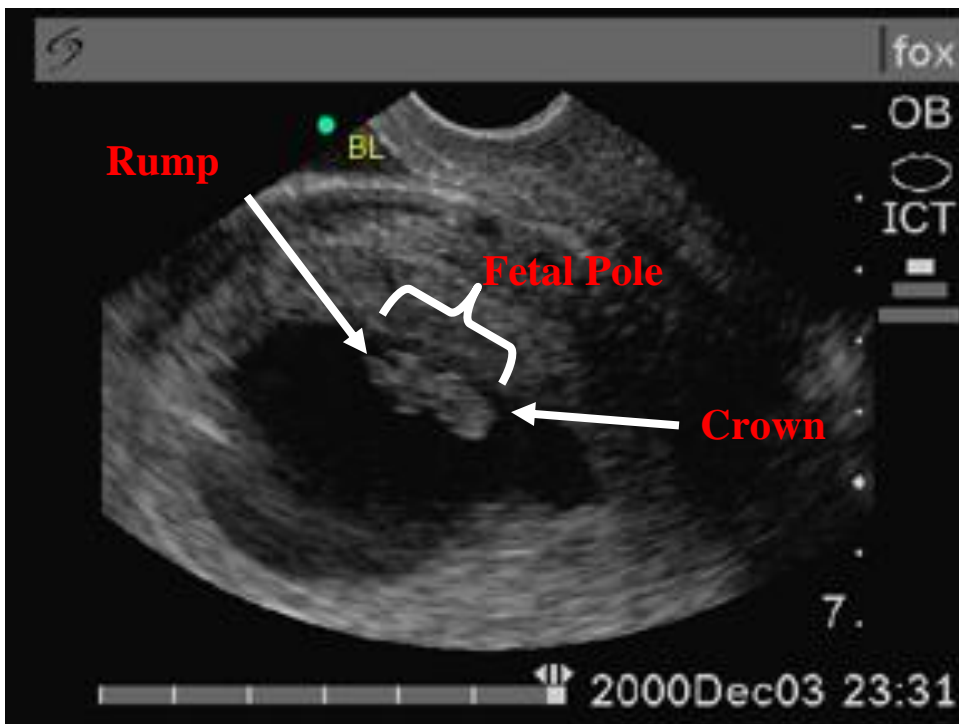
The ***gestational sac*** is made up of the chorionic cavity and the amniotic cavity. As mentioned above, it is common to be unable to visualize the amnion.

The yolk sac is found in the chorionic cavity and is obliterated after the twelfth week, when the above-mentioned amnion fuses with the ***chorion*** (the inner lining of the decidual reaction).

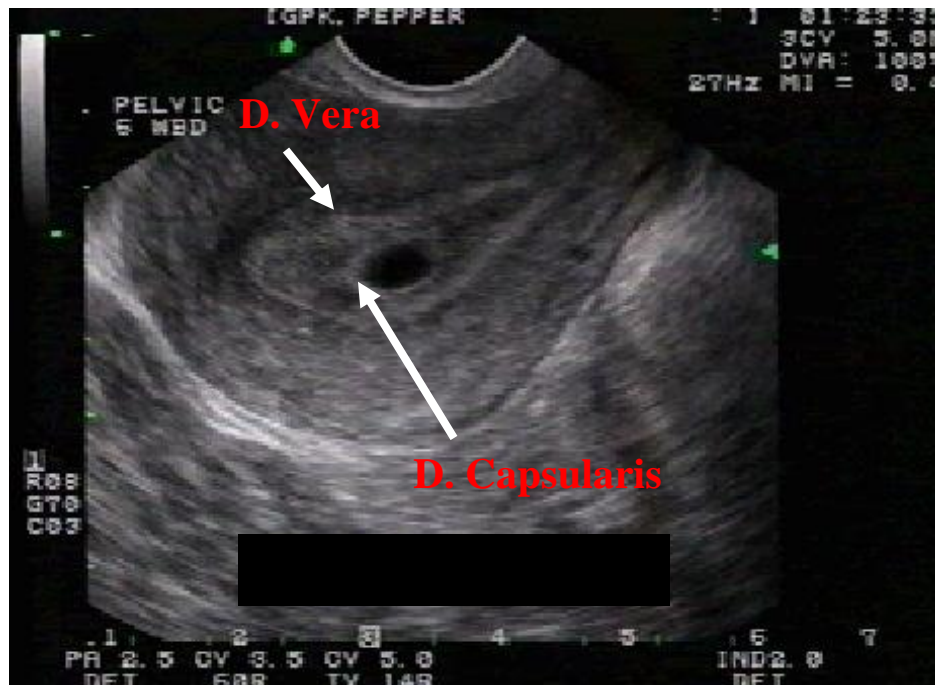
IUP – Double Ring Sign



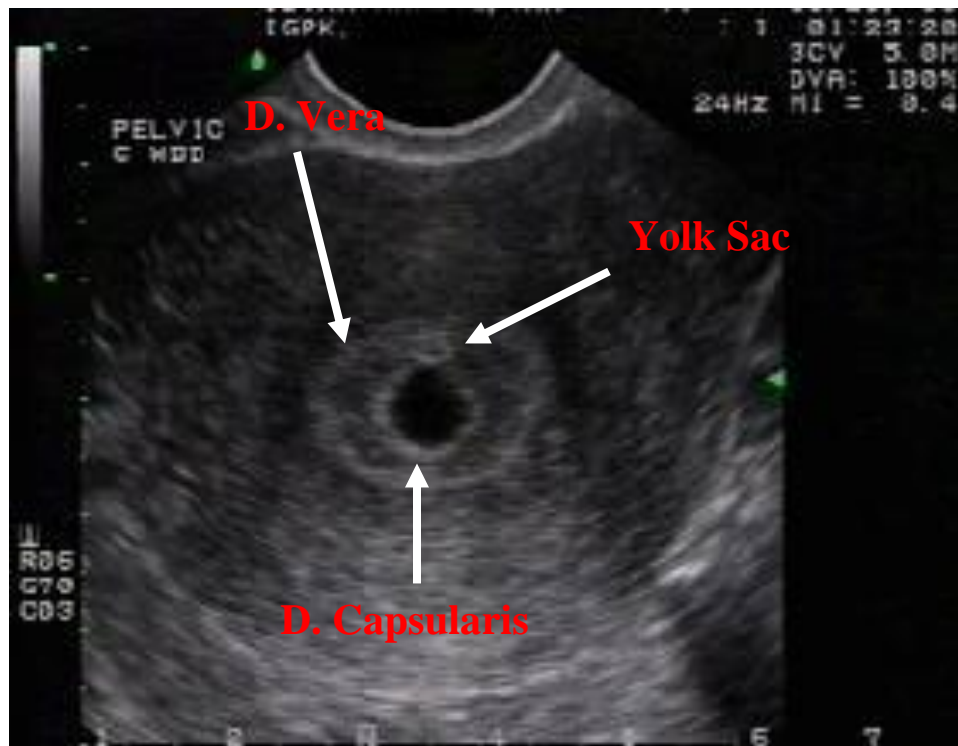
IUP – Fetal Pole



NDIUP - “Double Decidual Sign”, NO Yolk Sac



IUP - “Double Decidual Sign” AND Yolk Sac



Sources of Error

The most *dangerous* error in obstetrical EDU would be to conclude that an empty gestational sac within a decidual reaction represents an early pregnancy. While this is certainly possible, it is also found in ectopic pregnancy, where it is termed the “*pseudogestational* sac”. Provoked by the natural increase in pregnancy hormones that accompanies the growth of the ectopic pregnancy, the pseudogestational sac is identical to the real thing but it contains *no yolk sac*. It can be tempting, especially early in pregnancy with a stable patient, to assume that the yolk sac is merely poorly seen. Statistically, you are likely to be right. But this is like playing Russian Roulette. When things do go wrong, the result can be catastrophic. Unless *all three* criteria are present, the patient must be referred for a formal ultrasound at the earliest opportunity.

A more unusual source of error is the extrauterine fetal heart, found in certain advanced tubal (or, more rarely, intramyometrial or intra-abdominal) pregnancies. These can be identified by their “off-center” position. While this anatomic relationship can be more easily determined on TA EDU, TV EDU is much less likely to be misleading in the first place as its field of view is so focused that it is difficult for the beam to “wander” into the adnexae.

The Empty Uterus

In the case of the *unstable* patient, the finding of an empty uterus (*normal endometrial line*) in a patient with a positive β -HCG completes the workup. The patient must go directly to the OR, the diagnosis of ectopic pregnancy being essentially confirmed. An abdominal EDU can be performed to detect the presence of free fluid in the abdomen, although free fluid can often be visualized in the pelvis with either TA or TV EDU. This would make the presumptive diagnosis even more likely but should not delay the patient’s movement towards surgery.

If the patient is *stable*, an abdominal EDU should again be performed to look for free fluid. If the abdominal EDU is *positive*, obstetrical consultation should be obtained promptly. If there is no intra-abdominal free fluid, obtain a *formal ultrasound* to attempt to identify the location of the pregnancy. However, one must realize that the most common formal ultrasound report in this setting, even when done by experienced U/S techs using expensive machines is “*uterus empty, normal pelvis*”. But whatever the result, obstetrical consultation should be obtained, so that close follow-up (or possibly immediate medical management with methotrexate) can be organized.

Other Possibilities

Abortion: If the abortion is *incomplete*, virtually anything can be seen on the screen, ranging from debris remnants all the way to a normal-looking embryo whose cardiac activity seems undetectable. This is a good time to re-emphasize the importance of your clinical skills – the sine qua non of incomplete abortion is the *open os*, confirmed on physical exam. If you find this, the diagnosis of incomplete abortion can be made with confidence²⁹. The presence of abnormal uterine contents merely confirms the diagnosis.

A *complete* abortion (total evacuation of the uterine contents) has the same sonographic appearance as an ectopic pregnancy (empty uterus), a positive β -HCG and, if enough time had passed, a closed os. The patient would obviously be stable in this case, leaving the diagnosis to be confirmed by a formal U/S and serial quantitative β -HCG testing. If the history is strongly suggestive of this diagnosis³⁰, these tests can safely be delayed 24-48 hours.

Blighted Ovum (a fertilized egg that did not develop or whose development ceased at an early stage): These can be frustrating for the EDU beginner because the β -HCG level can be extremely high (i.e. at a level where uterine contents should almost certainly be visualized) and yet there is nothing to be seen in the gestational sac. A blighted ovum, therefore, gives you the same image as a pseudogestational sac, but the sac is *much bigger*. The *length* of the gestational sac is the key element which will enable you to differentiate between these two entities. If it is over 20 mm without a yolk sac visible a blighted ovum should be suspected. If it is over *25 mm without a yolk sac* visible a blighted ovum is virtually *confirmed*.

Molar pregnancies: A molar pregnancy (or hydatidiform mole) is a grossly abnormal pregnancy. It is described as looking like a “snowstorm” on U/S. A molar pregnancy is actually a mass of small cysts. What you see on U/S is a fairly homogenous echogenic mass inside the uterus full of small, hypoechoic vesicles filled with fluid (anechoic or black holes). This has been described as taking the appearance of a snowstorm, a cluster of grapes, an anthill in cross-section, or possibly a cut through a particularly “holy” piece of Swiss cheese.

Remember that patients with molar pregnancies will present with:

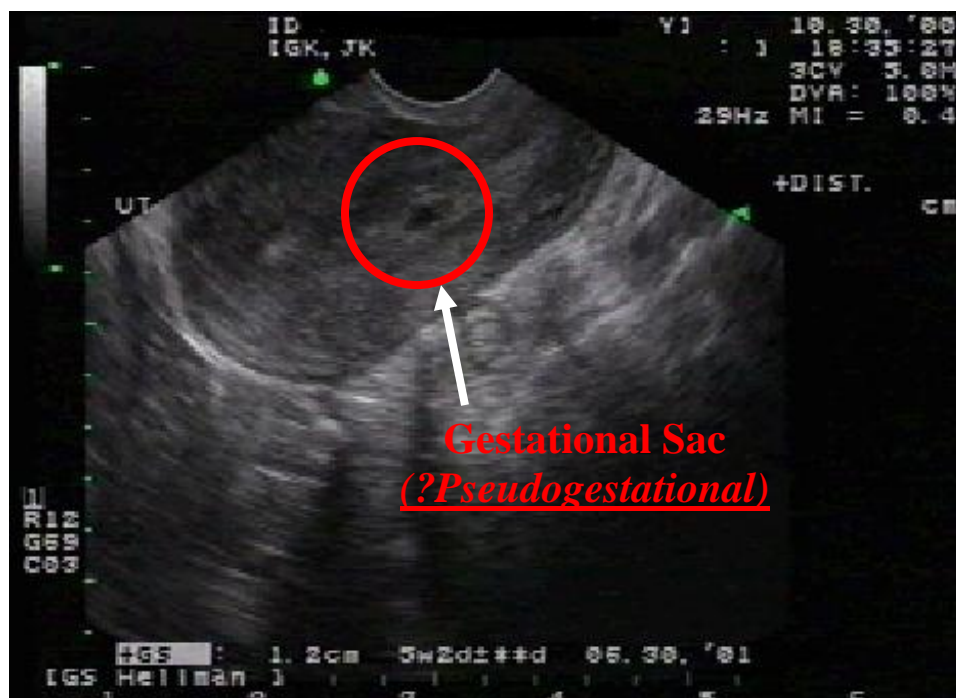
- Astronomical β -HCG levels,
- Hyperemesis and signs of hyperthyroidism (caused by the β -HCG),
- A uterus which is larger than expected, and
- Anemia.

As well, it is extremely rare for a normal pregnancy to co-exist with a mole. There should therefore not be any detectable fetal cardiac activity.

²⁹ An ectopic pregnancy will present with bleeding and abnormal uterine contents but **VERY RARELY** an open os.

³⁰ Bleeding *before* pain, significant bleeding now *tapering off*, passage of *tissue*.

NDIUP – No Yolk Sac (Early IUP or *Ectopic*)



Abnormal Gestational Sac



This gestational sac is over 25 mm in diameter, yet no yolk sac is visible. This almost certainly represents a *blighted ovum*.

Role of Quantitative β -HCG Testing

The role of quantitative β -HCG testing is often misunderstood. It is generally recognized that it will be impossible to see an *IUP* if the β -HCG level is below 1500 mIU/ml by the TV approach or below 3000 mIU/ml by the TA approach. However, it does *NOT* follow that EDU should be deferred until such time as the β -HCG level reaches these thresholds, as the *gestational sac* should be visible *far earlier*. Therefore, *ANY* positive β -HCG combined with an *empty* uterus should be treated as an ectopic³¹ - stat referral to Ob/Gyn if *unstable, formal* ultrasound at the earliest opportunity if stable. Having identified that the uterus is empty (again, assuming the patient is stable), it is useful to do a *quantitative* β -HCG while awaiting the formal to allow the Ob/Gyn to better interpret the results.

Measuring Crown-Rump Length

While not one of the formal objectives of EDU, measuring crown-rump length (CRL – the distance from the top of the skull to the base of the pelvis) can enable you to prognosticate more accurately: a CRL of greater than 5 mm without a visible fetal heart is unlikely to proceed to viability.

Most U/S machines with transvaginal capability allow the physician to automatically convert CRL into gestational age (between 7 and 12 weeks). However, this is of no clinical interest to EDU, other than as a friendly service to our patients.

Viewing the Ovaries

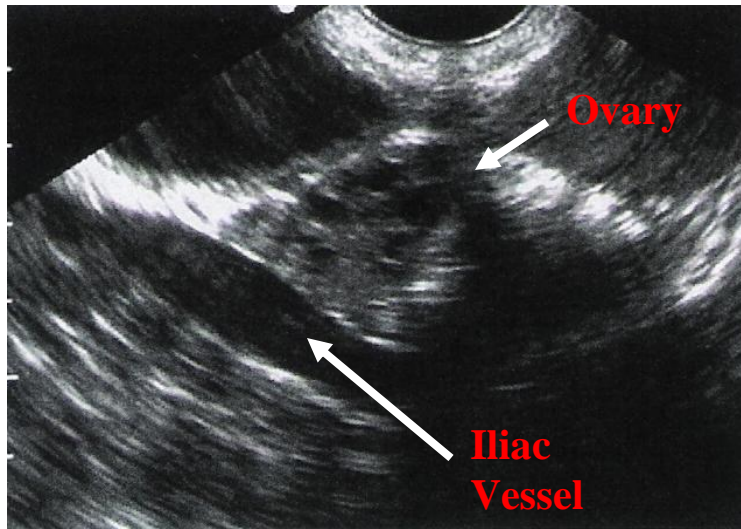
Although it is not essential to image the ovaries in order to make the diagnosis of an ectopic pregnancy, views of the ovaries may help to “cement” the diagnosis as the presence of a complex ovarian mass can be commonly found in ectopic pregnancy.

Ovaries are best imaged via a longitudinal transvaginal position. Ovaries are identified by the presence of multiple, circular anechoic (black) follicles contained within an echogenic ovoid structure. This appearance of the ovaries is often described as a “chocolate-chip cookie.” To find the left ovary, start with the probe in a midline position and sweep toward the patient’s left side until the anechoic iliac vessels are seen to stretch across the monitor in their long axis. The ovary should be found just adjacent to these vessels. The right ovary is similarly identified, except the probe is swept toward the patient’s right.

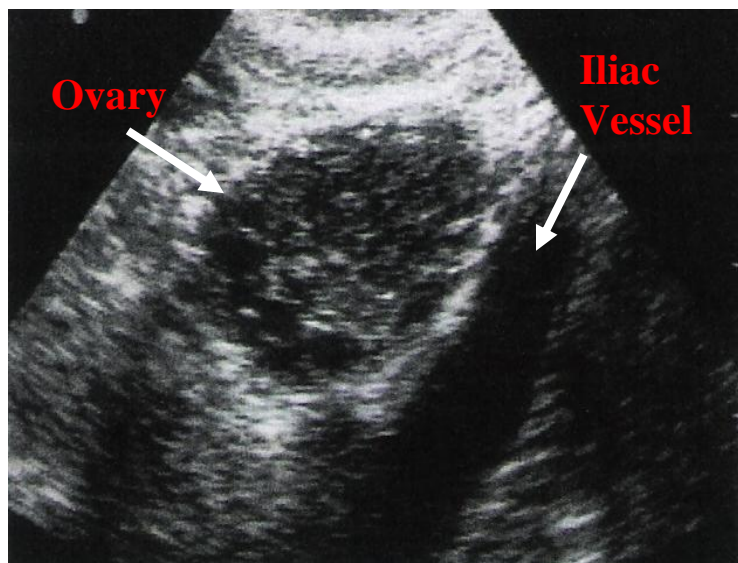
A complex ovarian mass contains a mixture of cystic and solid components, and may represent the contents of an ectopic gestational sac, ectopic trophoblastic tissue, or a tubal hematoma. Any distortion of the regular “chocolate-chip cookie” appearance of the ovary should raise a suspicion for a complex ovarian mass.

³¹ Ectopic pregnancies have been documented with a quantitative β -HCG as low as 10.

Normal Right Ovary



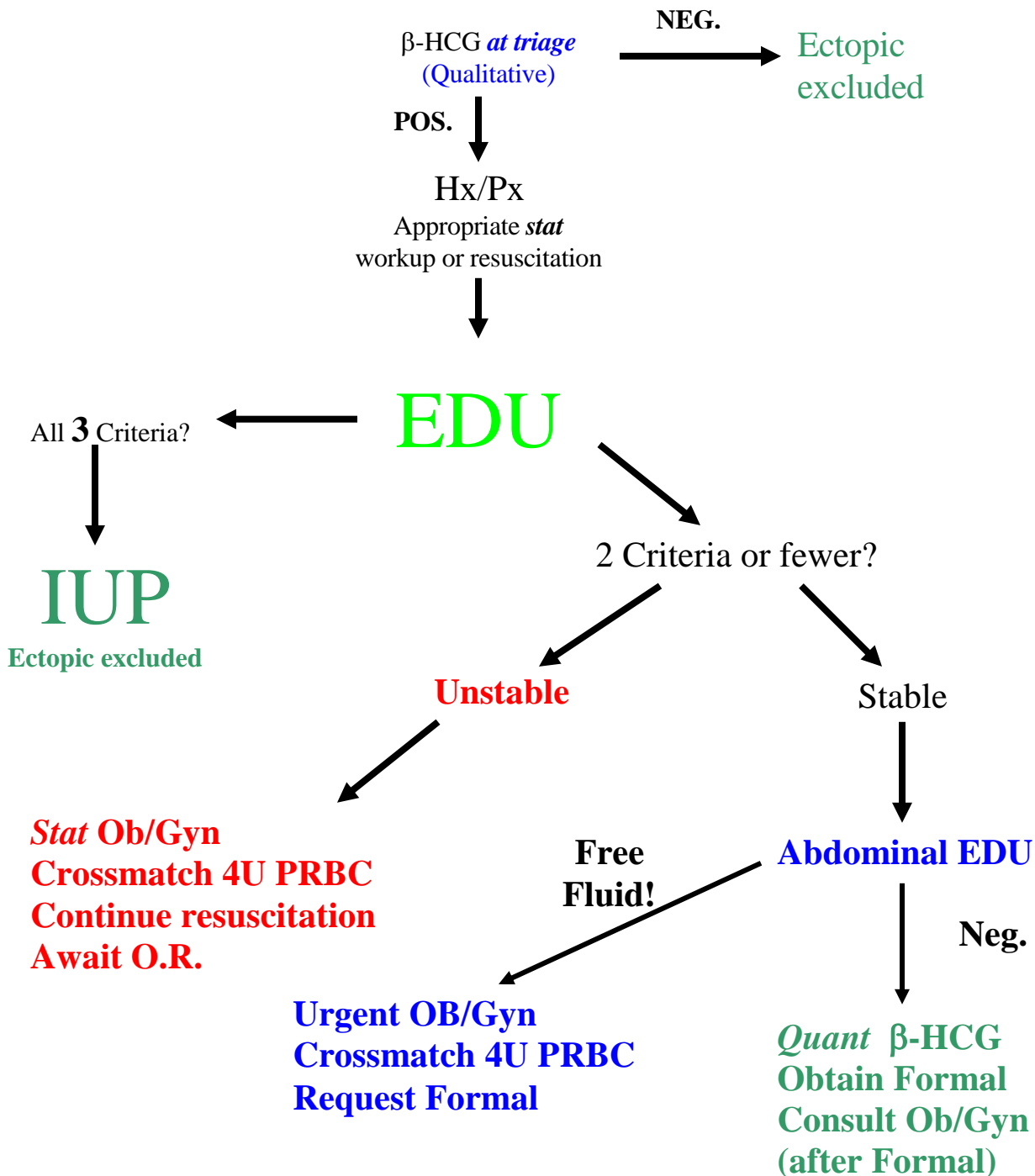
Normal Left Ovary



Obstetrical EDU Algorithm

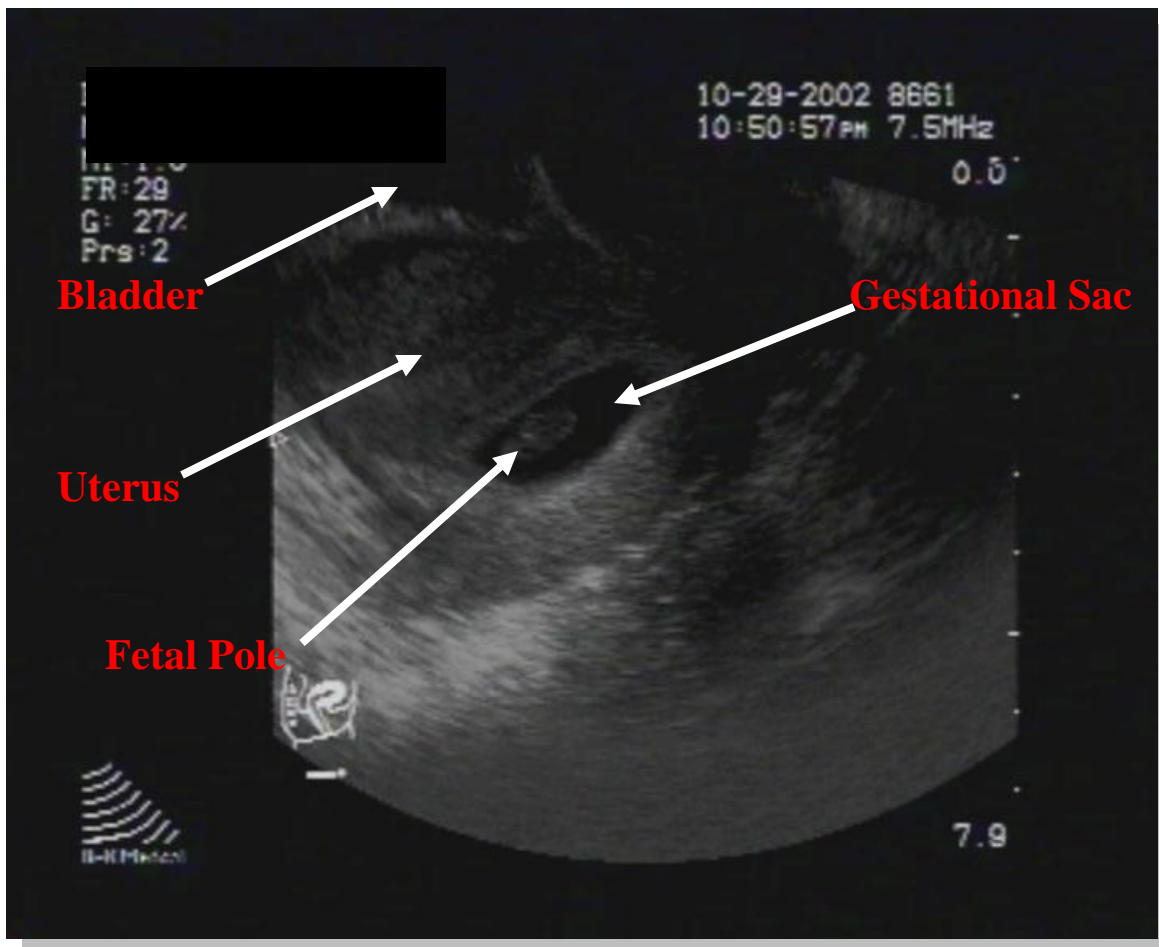
Woman of childbearing age presents with *any one* of:

Pelvic pain Abdominal pain Vaginal bleeding Unexplained hypotension

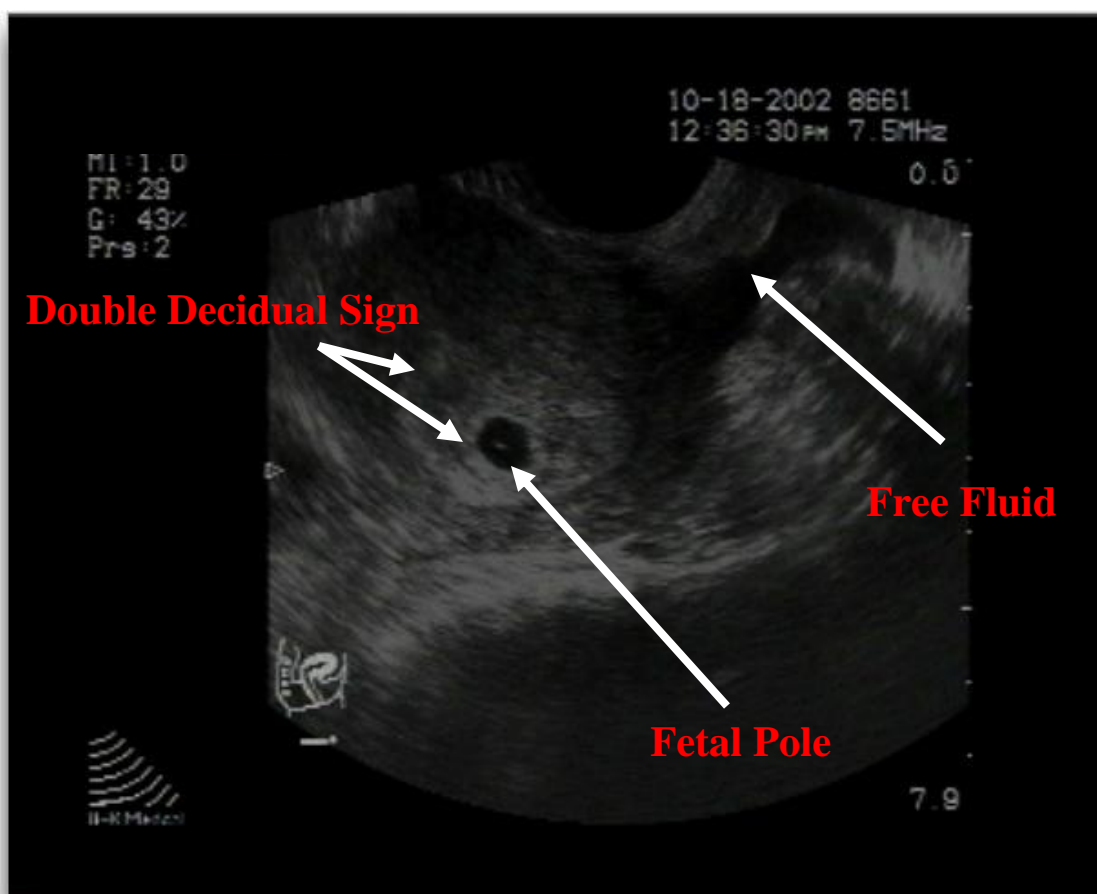


Note: it is *not* necessary for the patient to c/o delayed menses.

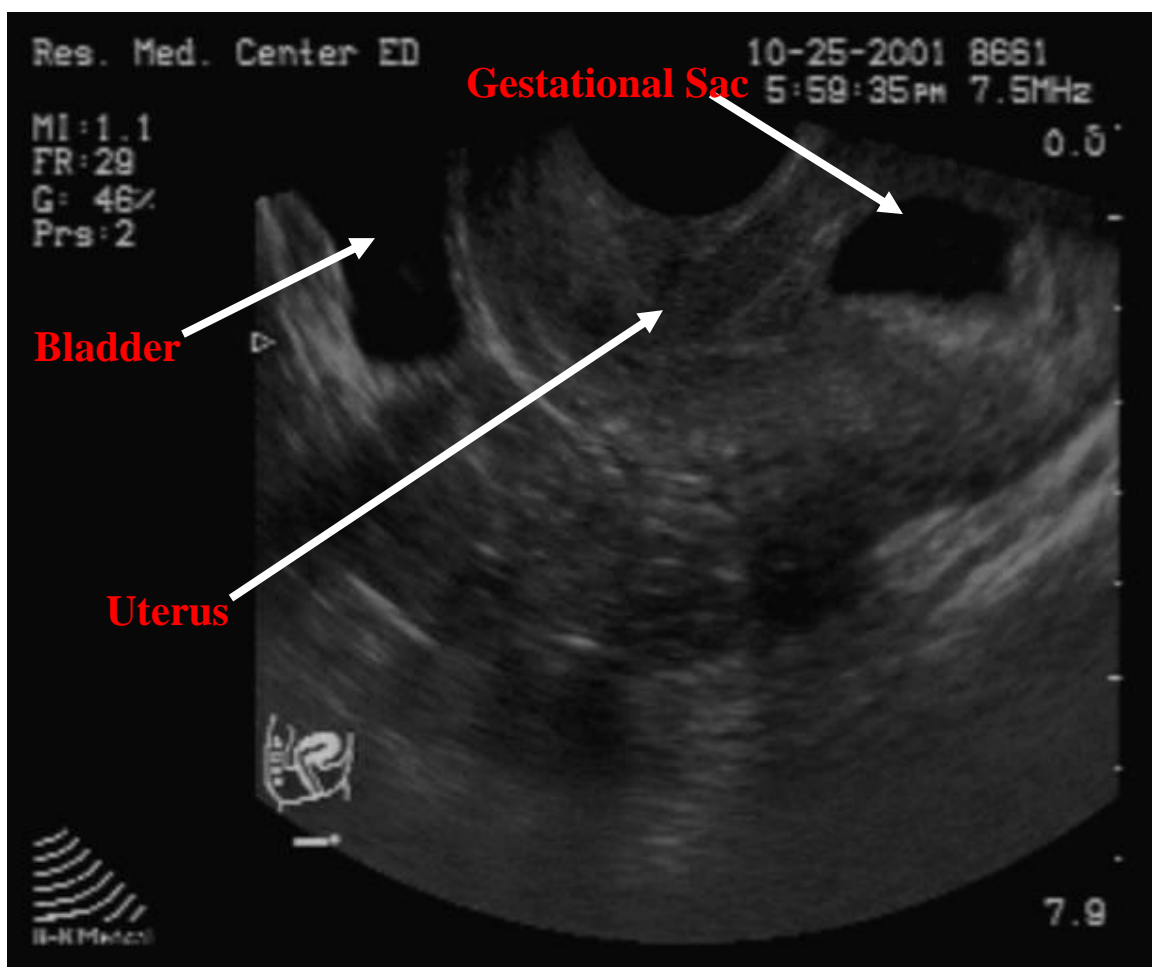
More Obstetrical EDU Images



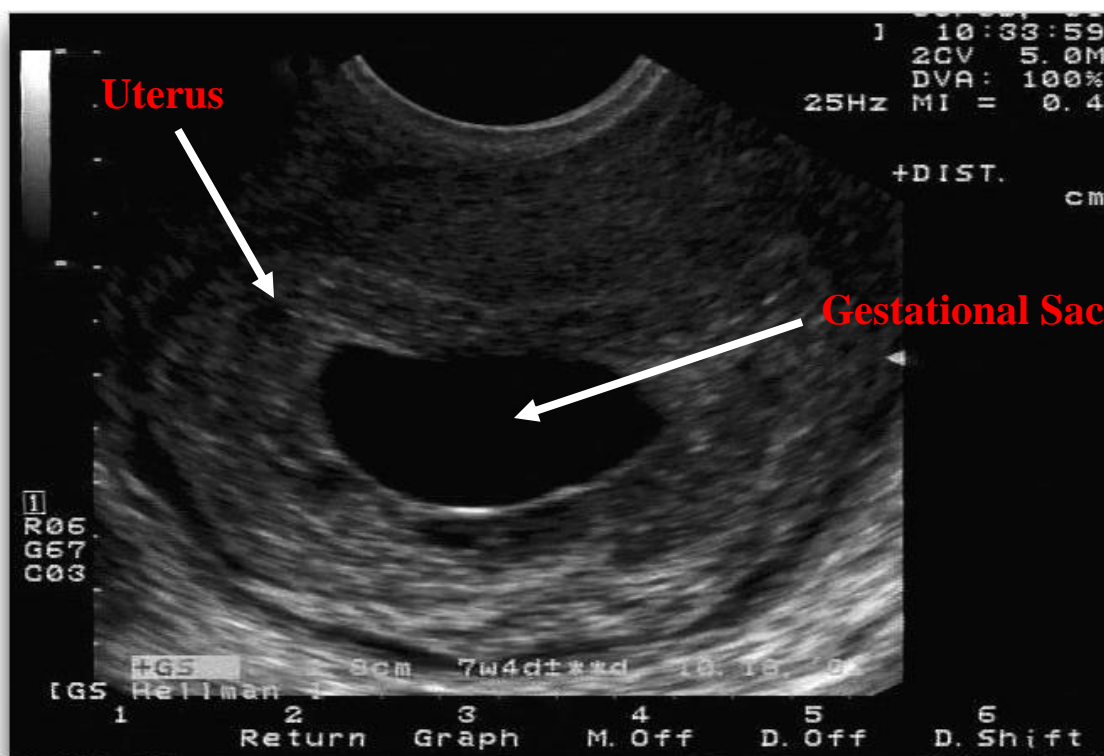
This endovaginal pelvic image demonstrates the usual orientation with the bladder in the left corner. A clear fetal pole is seen in the uterus. If a heartbeat is visualized, this image represents an early live intrauterine pregnancy. However, if no heartbeat is visualized, this image represents an abnormal intrauterine pregnancy. The heartbeat should be easily visualized by endovaginal ultrasound if the fetal pole is already visible.



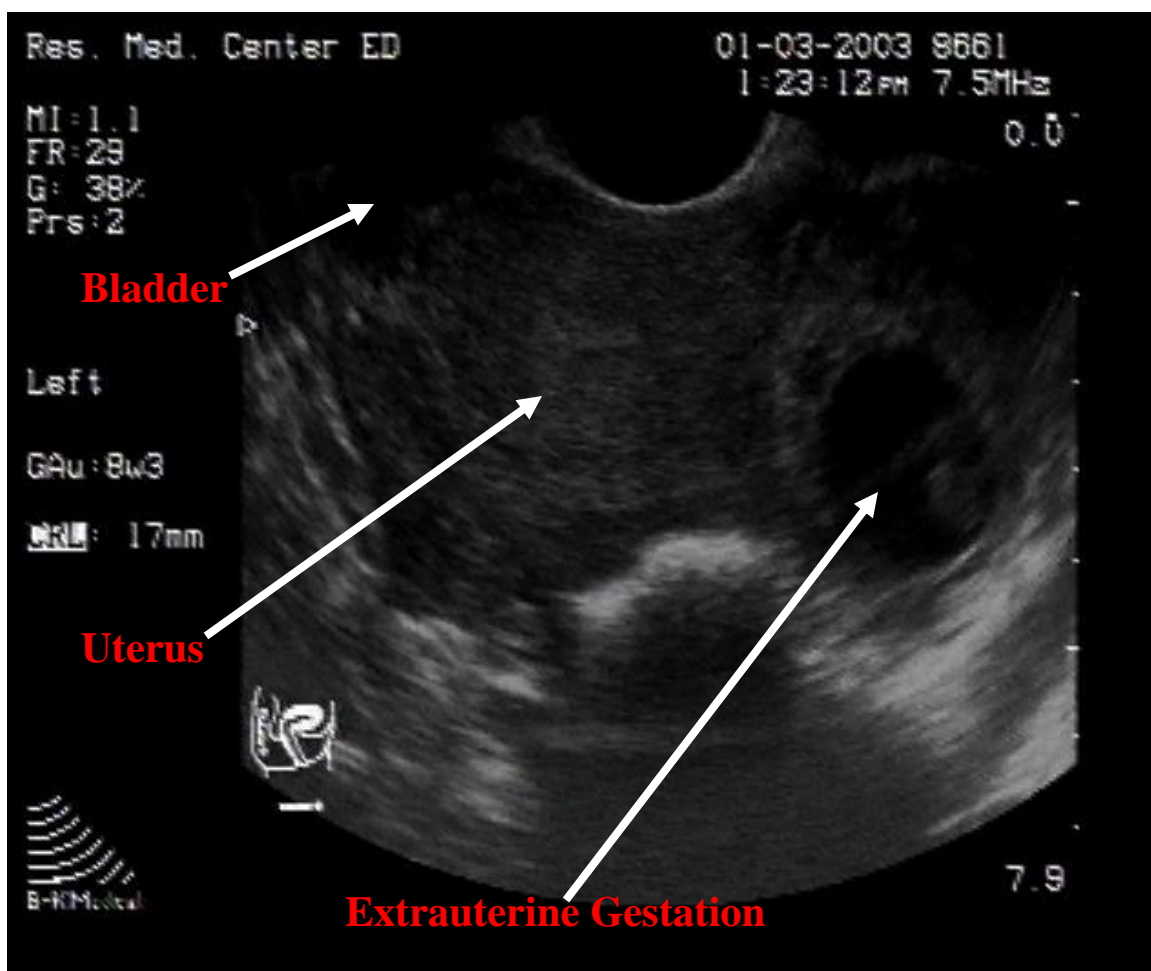
This image of a normal early intrauterine pregnancy is taken from an endovaginal position. A “double decidual sac” within the uterus is visualized. A fetal pole is just visible, and cardiac motion should be apparent in real-time. Note the moderate free fluid which may have resulted from a ruptured corpus luteal cyst.



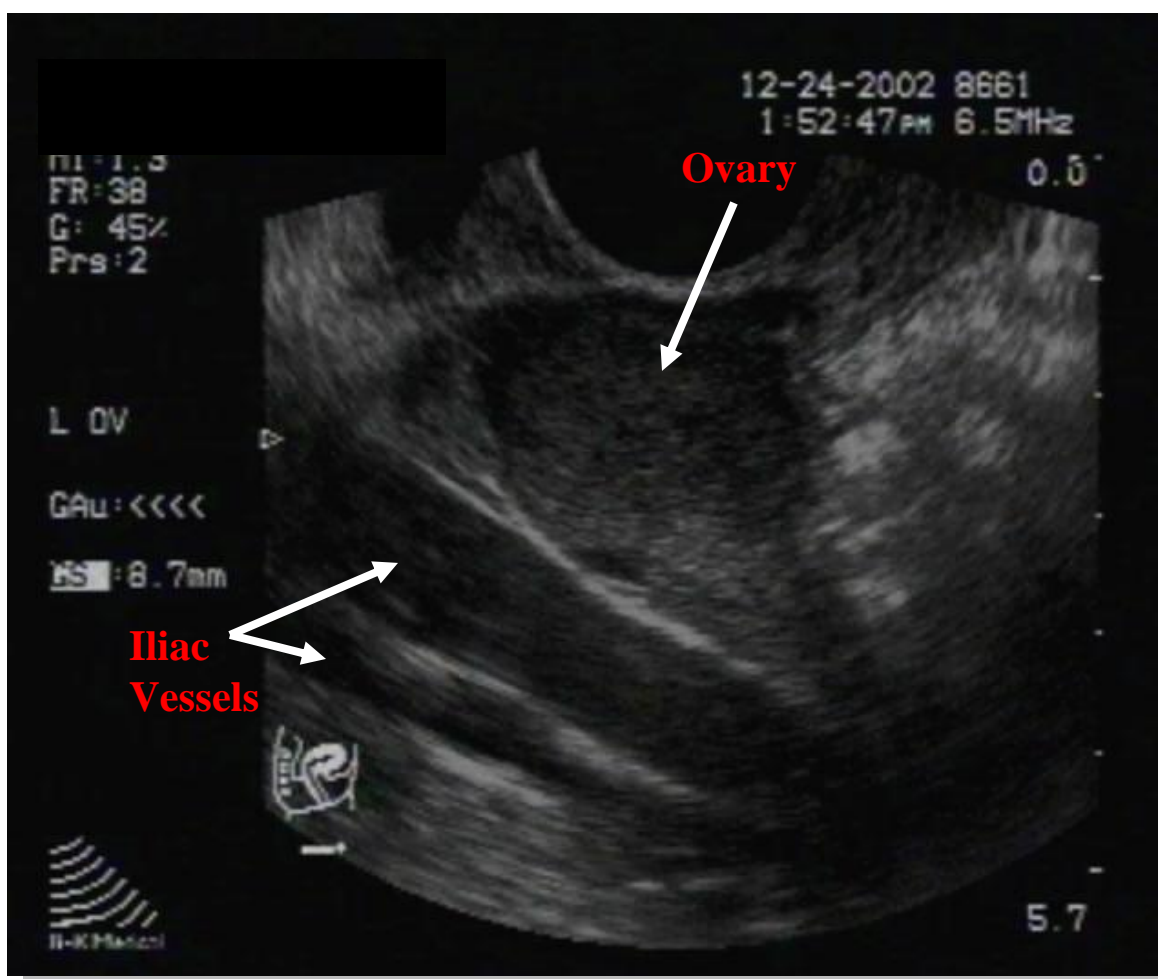
This is a longitudinal endovaginal image of the pelvis. In this view, the bladder is visualized in the left upper corner of the image, and the uterus is seen on the right side of the image (retroverted). A gestational sac is visible, without an obvious yolk sac or fetal pole. This may represent an early pregnancy, or a pseudogestational sac common in ectopic pregnancy. Either way, this scan should be documented as “no definitive intrauterine pregnancy.”



This image is taken from an endovaginal study. A anechoic gestational sac is evident within the uterus in the center of the image. Despite the large size of the gestational sac (over 60 mm in greatest dimension), no fetal pole or yolk sac is seen. Any gestational sac greater than 10 mm in length without a yolk sac, or greater than 16 mm without a fetal pole, defines an abnormal intrauterine pregnancy. Ectopic pregnancy and blighted ovum should be considered.



This image is taken from an endovaginal scan. The bladder is just visible in the usual left corner, while the uterus is in the center of the image. Note the extrauterine (ectopic) gestation at the right of the image. While ectopic pregnancies are rarely seen so clearly, the absence of an intrauterine pregnancy and free intraperitoneal fluid (not well seen in this particular image) would be concerning for an ectopic until proven otherwise.



This image is from an endovaginal scan. Again note the wide angle of view provided by the sharply curved endovaginal probe. The ovary is visualized in the center of image with a few peripheral follicles. The ovary lies in its usual position anterior and medial to the paired iliac artery and vein. This is a normal adnexal view.

One Last Thing...Endocavitary Probe Storage

Before we completely leave the Obstetrical EDU chapter, one last issue needs to be addressed, and that is the location of the endocavitary probe. For obvious sanitary reasons, the endocavitary probe is not kept on the machine next to the other probes. The endocavitary probe is found hanging in a vented "hood" attached to the south wall of the dirty utility room with the main emergency department. Here, the probe is left to soak in a disinfectant solution between uses. Before immediately using the probe, it must be 1) rinsed in a cleansing solution, 2) rinsed under running water, and 3) dried. When finished, the probe must be returned to the high level disinfectant. Use caution and the probe cord clamps when returning the probe to the disinfectant or placing the probe in the cleansing solution. **The probe's face should never come in contact with the bottom of either the disinfectant or cleansing cylinder.** Doing so can (and has in the past) damage the probe's crystals beyond repair. Use caution and the cord clamps when placing the probe in either cylinder.



Cord Clamps

Vascular Access EDU

Introduction

Invasive procedures are commonplace in the ED. Traditionally, these procedures are performed by relying on physical exam and surface landmarks. Recently, the procedural application of EDU has been shown to augment traditional approaches and decrease complication rates. Although EDU has been shown to help accomplish a variety of procedures, EDU has essentially transformed vascular access to the point where EDU-guided central venous catheters are now largely considered standard of care. Why? EDU-guidance not only results in fewer complications, but has also been shown to be more effective in time-to-cannulation and first attempt success.

Technique

The complete technique of placing a central venous catheter (CVC) is beyond the scope of this text. What follows is a description of how to identify either the internal jugular or femoral vein, and cannulate that vein with the needle provided in the CVC kit. Once cannulated, the actual placement of the catheter follows the same traditional steps of the Seldinger technique that you have already learned.

Vascular access EDU is performed with the high frequency linear array probe, as the vessels of interest are typically superficial just underneath the skin surface. The technique itself is summarized by the 4 Ps: Preparation, Pre-Scan, Poke, and Path. **Preparation** involves both preparation of the patient as well as preparation of the probe. Patient preparation refers to the standard practice of sterile technique in which the patient's skin is adequately cleansed and the patient is appropriately draped. Preparation of the probe involves ensuring its sterility for the procedure. Pre-packaged probe "kits" can be found in inventory, and consist of a sterile sleeve and gel.



Open the probe “kit” with a sterile hand, and apply a small amount of sterile gel to the probe face³².



Once the gel has been applied, the probe can be placed in the sterile sleeve. It is helpful to have an assistant hold the unsterile probe upside down, allowing you (with your sterile gloves) to unroll the probe sleeve along its length³³.



³² **DO NOT** use all of the sterile gel on the probe face. Save some of the gel to place on the outside of the sleeve and the patient.

³³ Note the above image shows the probe sleeve lengthened. When the probe kit is first opened, the sleeve is actually collapsed as demonstrated by the image on the previous page. **DO NOT** “unroll” the sleeve prior to placing it on the probe as illustrated above. This makes it nearly impossible to place the probe in the sleeve. Unroll the sleeve down the length of the probe in the same fashion that you unroll a condom down the length of the endocavitary probe when doing Obstetrical EDU.

The sterile sleeve may then be secured to the probe with elastic bands, although this step is often omitted.

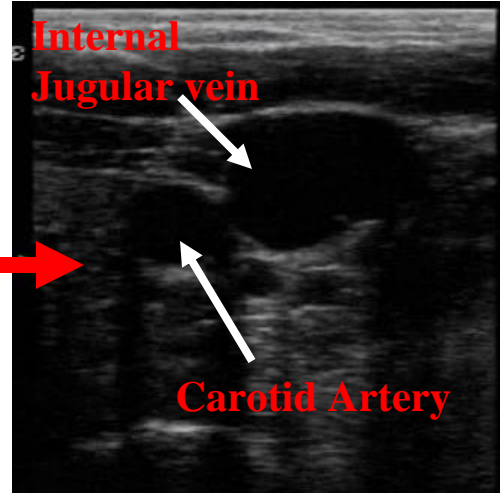
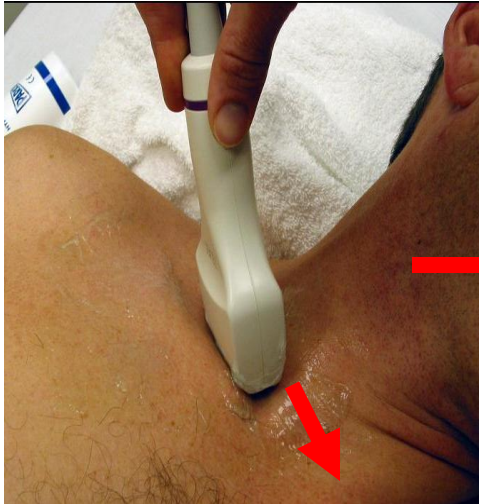


Now apply the remainder of the sterile gel to outside of the sleeve and the patient. the probe is now sterile, and you are ready to move on to the next step.

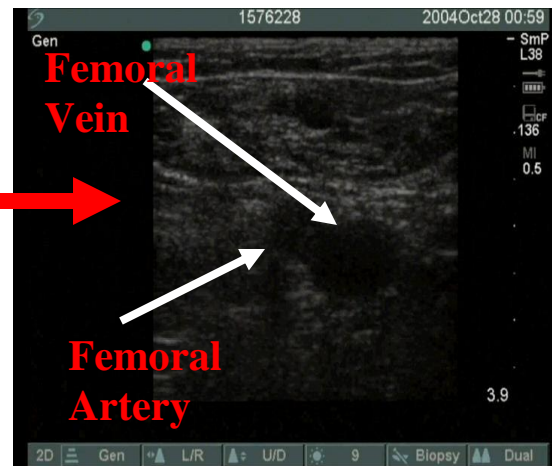
The **Pre-Scan** involves surveying and correctly targeting the appropriate vessel. EDU-guided CVC placement is done in one of two vessels: the internal jugular (IJ) or femoral vein. To cannulate the IJ, start by using the traditional landmarks: the IJ sits below the bifurcation of the sternocleidomastoid muscle (SCM). Stand at the head of the bed (above the patient), and place the probe at the SCM bifurcation in a transverse plane with the indicator pointed toward the patient's *left*. The structures that should be visualized are adjacent anechoic (black) circles: the carotid artery and IJ. By having the indicator pointed left, the image on the EDU monitor will reflect the true anatomic relationship of the carotid and IJ; i.e., when cannulating the patient's right IJ, the carotid will be on the left of the screen, and the IJ on the right. Thus, when it comes time to manipulate the needle, your physical movements will mirror the image movements on the monitor; i.e., when physically moving the needle left, it will move left on the monitor. This may be a little confusing. With the exception of echocardiography, we have always kept the indicator toward the patient's right side. Question: Can the IJ be cannulated with the indicator pointed toward the patient's right. Answer: Yes. But remember, the IJ is now on the *left* side of the monitor, and your hand movements of the needle are opposite the needle movements observed on the monitor.

When standing at the patient's feet, the femoral vein is identified by placing the probe in a transverse plane just below the midportion of the inguinal ligament. As with the IJ, you should visualize two adjacent anechoic (black) circles: the femoral artery and femoral vein. From the **NAVEL** mnemonic, we know that the femoral artery lies laterally, while the femoral vein lies medially. This anatomic relationship holds true on the monitor if the probe's indicator is pointed toward the patient's right; i.e., the femoral artery on left of the monitor and the femoral vein on the right when scanning the right leg. If the indicator is pointed toward the patient's left, the femoral artery will be on the right side of the monitor and the femoral vein of the left when scanning the right leg.

Internal Jugular Vein



Femoral Vein

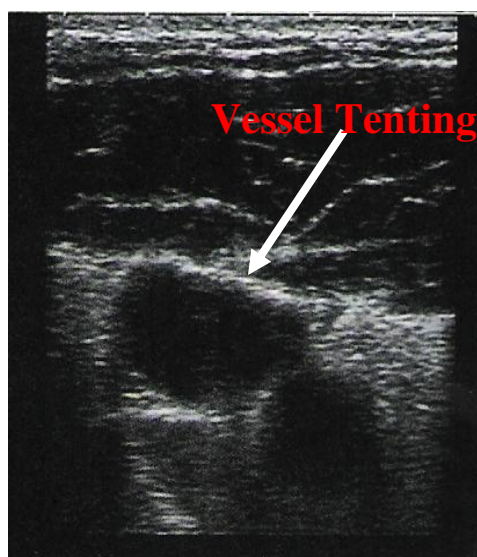
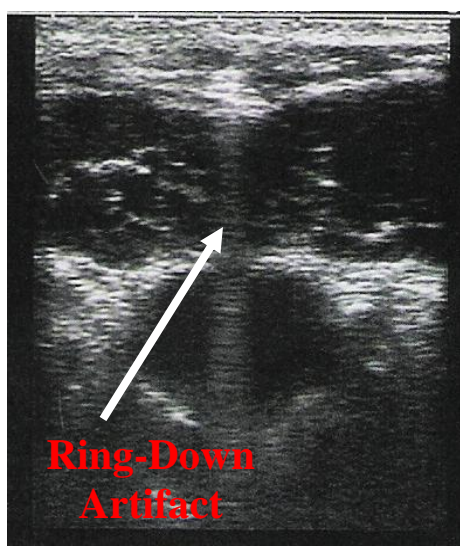


Still confused about indicator position and right versus left? No matter where the indicator is pointing, the vein should always be identified from the artery by the following features: 1) the veins have thinner walls, 2) the veins have no arterial pulsations, and most importantly, 3) the veins are more easily and completely collapsible with gentle external compression from the ultrasound probe.

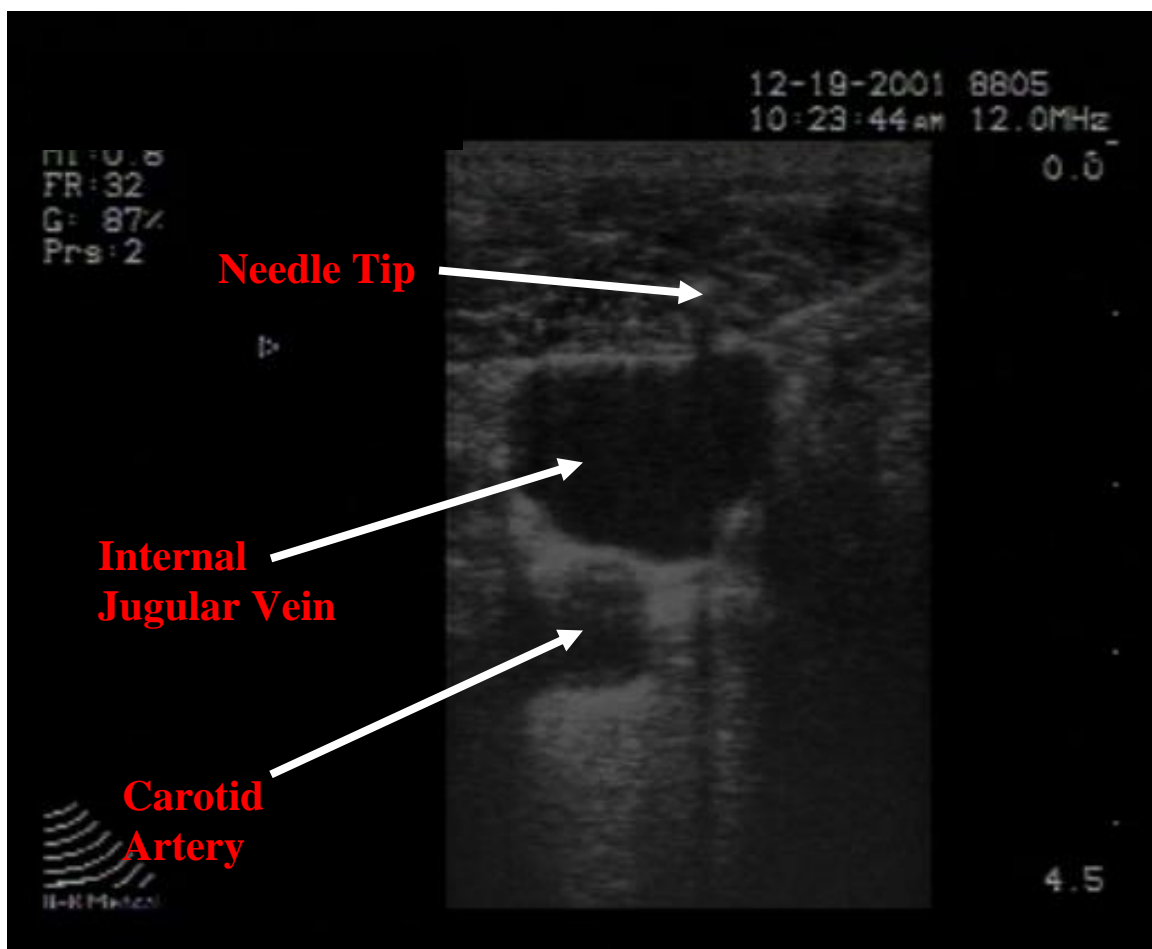
Once the correct vein has been identified on the screen, the third step or **poke** refers to the initial skin puncture which places the needle in the subcutaneous tissues where it is identified on the monitor. Proper needle position should occur at a location that is midline and 0.5cm-to-1cm behind the probe.



The needle will be detectable on the monitor through a ring-down artifact. Additionally, small back-and-forth “wiggling” movements of the needle will cause the subcutaneous tissue to also move back-and-forth, allowing for needle identification if the ring-down artifact is not immediately apparent. Once the needle and the needle *tip* have been identified, follow the **path** of the needle on the monitor as you slowly advance through the subcutaneous tissue toward the target vein. Once at the surface of the vein, pressure from the needle tip will be seen to indent or tent the vessel wall. Once this tenting is observed, a small, gentle “jab” will result in venipuncture, which is confirmed with the usual flash of venous blood into the syringe. At this point, you are done with the ultrasound, and free to place the catheter according to routine Seldinger technique.



Additional Vascular EDU Image



This image was obtained during the cannulation of the internal jugular vein. Note the needle tip with associated acoustic shadowing. The internal jugular vein is less than 2 cm from the skin surface, while the carotid artery lies deeper in this image.

Maintenance

The Emergency Department is a hostile environment for an EDU machine. Rather than being ensconced in a dark corner of the radiology department from whence it shall never budge, the EDU machine is constantly being moved around, sometimes at a high rate of speed. When one then considers the physical layout of the Emergency Department, with all its angles, turns, nooks and crannies as well as the sharp edges one finds along stretchers, crash carts and other resuscitation-area paraphernalia, it is not surprising that EDU machines quickly acquire a goodly number of battle scars. There is little one can do to minimize this other than to urge all Emergency Department personnel to be as cautious as possible when driving the EDU machine around.

The most important aspect of maintenance is preventative. It must be clearly understood that 99% of the cost of each probe lies in the crystals directly behind the plastic head cover. When probes are dropped they invariably fall headfirst into the ground. The clear “ping” that you hear when the probe hits the ground is the sound of those crystals shattering and of ten thousand dollars flying out the window. It must be an absolute rule that a probe is never left unattended. It must be in its *holster* or in someone’s *hand* at all times.

Maintenance of the actual probes is quite straightforward. In spite of this, it is remarkable how many emergency departments’ EDU probes are in a rather shabby state. The ultrasound gel, while not particularly corrosive, certainly can gum up the works if not cleaned off promptly. After each patient contact the gel (or blood or any other bodily fluid) should be wiped off with a soft, smooth cloth (the corner of the patient’s bed sheet does very nicely). After this the probe must be wiped off with a non-corrosive disinfectant. Alcohol and other corrosive substances should be avoided, as they will gradually erode the delicate covering at the probe head.

Conclusion

Emergency Department Ultrasound seeks to rule-in or rule-out conditions which can have an immediate or short term impact on patient survival: non-cardiogenic shock, pericardial tamponade, intra-abdominal hemorrhage, ruptured abdominal aortic aneurysm, ectopic pregnancy, as well as biliary and renal disease. Further, EDU has certain procedural applications such as vascular access that are changing the standard of care for patients in the ED.

But the impact of EDU is not limited to those cases where it helps to make a life threatening diagnosis in seconds and leads to a dramatic change in management. There are also the far more numerous times when it is able to reassure the clinician that such a condition does not exist. If anything, this second point is where EDU's impact is more significant: the ability to rule out significant pathology and, by doing so, reduce the stress involved in dealing with such cases.

It is the essentially perfect availability of EDU which allows this situation to occur. We no longer have to seek approval for our studies, nor wait for the arrival of the operator. This dramatically drops the threshold at which one obtains an ultrasound study.

But if EDU is to be a continued success in our practice of emergency medicine, we must use it as it was intended. Our scope of practice must remain limited to those things that we can do well. We must commit ourselves to having 100% sensitivity – ***NO FALSE NEGATIVE'S!***

The day is not far when EDU will be considered as essential a part of the Emergency Physician's armamentarium as his stethoscope – or is it here already?

The 10 Commandments of EDU

- 1) *Nothing shall replace the primacy of your clinical skills.*
- 2) Thou shalt only call a study negative when it is *incontrovertibly* so.
- 3) Thou shalt not hesitate to call a study *inconclusive*.
- 4) Thou shalt only use EDU in the *appropriate clinical situations*.
- 5) Thou shalt *rescan* patients whose initial scan is negative, should your clinical suspicion deem it necessary.
- 6) Thou shalt move your hand *slowly* and deliberately.
- 7) Thou shalt always orient the probe towards the *patient's right* or the *patient's head*.
- 8) *Thou shalt not drop the probe!*
- 9) Thou shalt use lots of gel. *Lots* of gel.
- 10) Nothing shall replace the primacy of your clinical skills. Was that mentioned already? Well, it's worth repeating.

Further Reading

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