Emergency Department Ultrasound

For the Advanced EM Student

INTRODUCTION:

Because it can be an extremely helpful tool in diagnosing emergent conditions, Emergency Department Ultrasound (EDU) is becoming more and more commonplace. Advantages for EDU include rapid results, physical interaction with the patient, and the patient remains in the Emergency Department (ED). With EDU, you can get results, which answer your clinical question, in seconds.

Conventionally, you would have to send your patient over to Radiology to have the study performed, then wait on the radiologist reading. While this is going on. the patient often may feel neglected as he/she sits alone in their room. Instead. the patient feels that you are taking time to care for him/her directly, and something is being done about their care. Additionally, the patient may feel more involved. discussing the test while you perform the EDU.

Furthermore, if the patient does happen to decompensate, you are not faced with resuscitating the patient in the CT scanner.

The problems of implementing U/S in the ED are numerous; lack of the technical and clinical knowledge of performing and interpreting EDU; the financial cost of obtaining and maintaining an U/S machine; attributing a non-emergent finding as the

cause of the patient's symptoms while overlooking more serious causes: not recognizing a positive U/S finding.

A general caveat of EDU is that U/S is a very user and patient dependant modality. The skills and knowledge of the user can greatly alter the image quality obtained. Alternatively, the patient can affect the image by their body habitus, amount of ,,as/urine present, underlying health problems, and tenderness elicited during the exam. Without a good quality image, it is best to call the test indeterminate, rather than over/under diagnosing a potentially life-threatening condition. Without the knowledge of how to interpret an image, the quality of the image is of little importance; having an image with a clearly present AAA is useless if the physician cannot identify it.

This project is not meant to teach you everything about EDU, but merely to introduce you to EDU, understanding applications of EDU, introduction to the machine, basic Physics of U/S, and principles of obtaining an adequate image. Other topics such

as the anatomy of the different scans, interpretation of the scans, and future topics and applications are beyond the scope of this presentation.

OVERVIEW:

APPLICATIONS:

These vary from institution to institution, but most will include:

1) Trauma (FAST exam)
2) Limited Cardiac (mainly for effusions; NOT for wall motion abnormalities)
3) Undifferentiated Hypotension
4) Procedural (eg vascular access)

5) Non-emergent uses
    - Gall bladder
    - Transabdominal pelvic (fetal HR/activity)
    - Renal

Other applications that are a little more controversial include transvaginal U/S, peripheral vascular (DNIT), testicular, and ocular.

BASICS:

The machine, the probe, the interface. and the body.

The machine:

U/S machines transmit sound waves, and then "listen" for any reflected sound waves. Several factors allow for different reflections back to the probe. Included in these are the differences **between tissue interfaces**, the ability of a media **to transmit or reflect** U/S. the **power** of the U/S wave, the **frequency** of the U/S, the **depth** of the U/S penetration, sound wave **refraction** or **absorption**.

U/S does NOT transmit well through air or bone. These media will absorb. refract, diffuse. scatter, and reflect, the U/S and therefore NOT allow visualization of deeper structures. Bone reflects basically all sound waves and therefore appears **WHITE** (high intensity of reflected waves received back) on U/S. Conversely, water transmits U/S VERY well, and returns few/no echoes and therefore appears **BLACK** on U/S. Soft tissue transmits and reflects sound waves, and therefore appears **GRAY**.

WHITE = Bone (or Highly reflective media)

BLACK = water/ fluid .(transmitting nearly all the sound wave)

GRAY= soft tissue

Utilizing these concepts, images are created on a white-gray-black continuum, and can allow us to infer useful information. Even though an image that appears white on the U/S is blocking the transmission of any waves deeper, this may still prove useful. Such an image may signify a gallstone, contrasted to the black surrounding bile of the gall bladder, and supported by the "shadowing" (lack of transmission of U/S) deep to the stone.

To start, don't be afraid of the machine. U/S is a user-dependant modality. Skills (and therefore images and decision making) improve the more you use it. There are a few knobs and buttons to understand before beginning though. First, learn where the on/off switch is located. Seems basic enough, but more common a problem than you would think. Other knobs and buttons you should know about, include the

Gain

Time Gain Controls/Sliders (if present),

Probe **Frequency button** (Resolution vs. Penetration)

Freeze button

Print button

Depth button (s)

Focal Zone button (may be controlled by controlling Depth)

Power button (not present on all)

Tissue Harmonic Imaging button (on the latest models)

These are common knobs that you need to know where they are (if at all) on the machine that you are using. All machines differ in their layout, so get to know the one at your institution.

The probe:

Each probe (or transducer) contains piezoelectric crystals, but may vary in how they are oriented or used. Different types include linear array, mechanical sector, curvilinear, and sequential array. Don't worry about these for now. Basically, they all work along the same principal. These crystals can send out the U/S waves when stimulated. Alternatively, when a sound wave strikes the crystal, a small electric charge is generated, and this is how the probe receives the echo, which in turn allows the formation of an image.

More importantly for our use, the probe contains an indicator, which you should identify and know where it is located in relation to the patient's body as you scan. An indicator is shown on the U/S screen, which corresponds to the probe's indicator. By understanding this relationship, you can orient the patient's body to the image, and thus understand the anatomy.

Each transducer (probe) has a specific Frequency(-ies). The different frequencies penetrate differently, and in general have a reverse correlation to image resolution (ie. the deeper they penetrate, the worse the resolution, and vice versa)

The Interface:

U/S needs some form of conducting medium to transmit the sound waves from the probe to the tissues. U/S gel is used for this purpose, and insufficient gel will create distorted, or poor images. In short, be liberal with the use of the gel to ensure a good contact.

The Body: NOT Jesse.

Now you are ready to start using the U/S.

OBTAINING THE IMAGE:

1) Use a window. U/S needs to have some structure that is a good transmitter of sound waves to obtain an image. Typically, this will be a solid organ (such as the liver), or a fluid filled on (e.g. the bladder). - Gas filled bowel is NOT a good window. Move around freely in the region of interest (e.g. RUQ) to locate a good window.
2) Once you have found a good window, orient yourself An indicator on the image correlates with a notch on the probe, allowing orientation of the image with anatomic structures of the body.

"TWEAKKING" THE IMAGE.

1) Move the probe to allow for the best image. Don't be scared to move around A LOT!
2) **Lower the GAIN** as much as possible. Gain is an amplification of the echo, but it will also amplify any artifact.
3) Change the **Frequency/Image Quality Button**. **High** frequency (eg 7.5MHz) allows good resolution, but poor penetration. **Low** frequency penetrates well, but has poor resolution (think of the booming bass of the car a couple blocks away - you can hear it from distance, but not very distinctly)
4) Change your **depth**. Get the point of interest closest to the focal zone (typically somewhere near the middle of the image). This allows maximal resolution.

INTERPRET THE IMAGE.

1) Orient yourself.
   - Objects at the **top** of the image = **closest to the probe**.

- **Bottom** of the image = **deep to the probe**.
- On side of the **Image Marker** = on side of **Probe Marker**.

2) Identify soft tissue, bone/calcification/dense structures, fluid filled structures. (remember **black, white, gray**)
3) Correlate with anatomy.
4) Correlate with normals.
5) Determine if it is a positive, negative or INDETERMINANT study.

HELPFUL/DISTRACTING ARTIFACTS and PROBLEMS:

Acoustic Shadowing. An acoustic shadow may be present deep to any highly reflective structure, such as a gallstone. This is seen as a dark image directly deep to the stone. At the same depth, on either side of the shadow, the sound waves are transmitted better, and results in a higher echogenicity (brighter image). This looks very much like a shining a light on an object and the resulting shadow directly behind it. Seeing an acoustic shadow helps identify and verify the presence of stones.

Acoustic shadows may not always be seen, even behind a stone. This will often relate to lateral resolution and proximity (in terms of depth) to the probes focal zone.

Acoustic Enhancement. On the reverse side of shadowing is enhancement. When U/S travels through a medium that transmits sound very well (such as the call bladder), it diffuses and attenuates the sound waves less than other tissue. As a result, the tissue deep to these structures often appears brighter than surrounding tissue.

Tangential Shadowing. Occurs tangentially along the border of cystic structures, in the axis of the U/S beam. A shadow is cast deep to the border of the structure. This finding can be helpful to identify the structure as cystic, but can be misleading if interpreted as the presence of a stone.

Mirror Effect. When scanning the liver or spleen and reflections at the diaphragm (which appears bright white) make it appear that hepatic or splenic tissue is above the diaphragm. This is a normal finding, but it's absence, may signal pathology. Particularly if the region opposite the diaphragm appears anechoic (black) then the presence of fluid (effusion or blood) is diagnosed.

Resolution. Resolution applies to the ability to distinguish to points/objects that are close together. The higher the resolution, the greater the ability to distinguish the points/objects as separate, even when close together. Multiple factors affect both **AXIAL** and **LATERAL RESOLUTION**.

OTHER HINTS:

Remember to use **LOTS OF GEL**.

Use the highest frequency possible. This results in better resolutions (but remember, this comes at the cost of decreased penetration).

Find your window. If you are using adequate gel, but still not seeing things, **MOVE AROUND**. Alternatively, you may want to just **CHANGE THE ANGLE** of the probe on the patient's skin.

Rotate the probe. This will allow visualization of the structure in a different plane, and may help to further define the structure (is it the gall bladder, or an oblique view of a vessel?)

Apply Pressure. Gently pressure can improve tissue contact, push gas out of the way, compress overlying tissue. All of which may improve imaging.

Look at relationships of different structures (in terms of echogenicity) to help determine if you need to change the **GAIN**. If you know that the gall bladder is there, is it black. or is it gray and grainy? If so, turn down the gain. How does the liver look? Is it black/very dark? Turn UP the gain.

Where is the area of interest? Do you need to move it up/down in the image? Change the **DEPTH**. This will also allow you to bring it into the focal zone for best image and resolution.

The image is a 2D image, but the body is 3D. Scan back in forth in the direction of the third dimension (ie perpendicular to the plane of the image). You may have to stop to orient yourself with the probe/image/body at first, but this will become second nature.

Move the patient. Roll them on their side if needed. This may shift some of the intraabdominal organs to allow for better viewing.

Have the patient **VALSALVA**. Look at structures as the breath and how they change (eg the IVC collapses with sniffing).