Emergency Ultrasound Educational Objectives

1) Basics of Technique

A) Machine Operation – Administrative
- Demonstrate basic workflow – ordering, performing, reporting studies
- Explain how to enter pt info if the Modality Worklist function is not working (if server down or bad wireless connection)

B) Machine Operation - Technical
- Transducer Selection: What are differences between the transducers, how are they named (what do the numbers and letters mean?), and when do you use which?
- B (Brightness) Mode, i.e. Standard Gray-Scale Images: Demonstrate how to set the following: Application-specific presets (i.e. Exam Type), Depth, Gain, Timed-Gain Compensation, Frequency, Tissue Harmonics, "Optimize" function (Zonare only) and Dynamic Range. Explain what these mean and demonstrate how to set in order to create an optimal image on both the Zonare and Sonosite machines.
- M (Motion) Mode: Demonstrate how to acquire an M-mode trace and name 2 common applications that use this.
- Color Doppler (Color vs CPD): Explain the difference between the 2 types of color Doppler and demonstrate how to adjust the size, location, and angle of the color Doppler box (ROI, i.e. "region of interest" box) and color scale on each machine.
- Spectral Doppler: Explain the difference between pulsed-wave vs. continuous-wave Doppler; give one example of where each would be used and demonstrate how to use on each machine.
- Doppler Waveform acquisition: Using color and pulsed-wave Doppler, demonstrate the proper technique of how to acquire a waveform in the common carotid artery. Easier to do on the Zonare.

Advanced:

1) Using color and pulsed-wave Doppler to obtain a waveform of either the aorta or the SFA, measure peak systolic and end-diastolic velocities. What do you notice about the character of the waveform? What would you expect to see if you had significant upstream stenosis (e.g. severe aortic stenosis or severe upstream PVD)?

2) Using color and pulsed-wave Doppler to obtain a waveform of the intrarenal/ interlobar renal arteries or the carotid artery, measure peak systolic and end-diastolic velocities. How does this differ from the aorta or SFA above? Explain the concept of a resistive index and calculate for this vessel.

3) Use color and pulsed-wave Doppler to obtain a waveform of the CFV or SFV. How would this look if there were an upstream (iliac or IVC) thrombus?

2) FAST exam

A) Background Info

- List the indications for this study.
- What transducer should be used?
- What are the specific locations where you are likely to see intra-abdominal free fluid?
- How much blood needs to accumulate in the abdomen before it is visible on ultrasound?

B) Image acquisition

- Perform a FAST exam according to the standard protocol
- Identify the following structures in the RUQ: R lobe of liver, R kidney, R hemi-diaphragm, R pleural space, Morrison's pouch
- Identify the following structures in the LUQ: Spleen, L kidney, L hemi-diaphragm, L pleural space, spleno-renal recess
- Identify the following structures in the pelvis: bladder, uterus (if female)

C) Image interpretation

- Identify normal and abnormal (+ free fluid) findings

3) Cardiac

A) Background Info

- List the indications for this study.
- List the major findings we are interested in (according to current ACEP/ASE consensus); i.e. what main questions are we trying to answer?

- What transducer should be used?

- What is ideal patient position?

- What are the 1 view that is "switched" (i.e. mirror-images of each other) between the radiology (point-of-care) convention and the cardiology convention? Why is this the case?

B) Image acquisition

- Perform a cardiac exam according to the standard protocol

- Identify the following structures in the Left Parasternal Long Axis view (PLAX): LV (including regions – septal, anterior, lateral, posterior, inferior), LA, mitral valve (including anterior and posterior leaflets), RV, inter-ventricular septum, aortic valve (including right and non-coronary cusps), aortic root, LV outflow tract (LVOT), descending thoracic aorta.

- Identify the following structures in the Left Parasternal Short Axis view (PSAX): LV (including regions - "SALPI" = septal, anterior, lateral, posterior, inferior going clockwise around LV), LA, mitral valve (including anterior and posterior leaflets), RA, RV, tricuspid valve, inter-ventricular septum, aortic valve (including right, left and non-coronary cusps), descending thoracic aorta

- Identify the following structures in the Apical 4 chamber view: LV (including regions -), LA, mitral valve (including anterior and posterior leaflets), RA, RV, tricuspid valve, inter-ventricular septum, inter-atrial septum, descending thoracic aorta, Pulmonary Vein emptying into RA (if seen)

- Identify the following structures in the Apical 5 chamber view: LV (including regions -), LA, mitral valve (including anterior and posterior leaflets), RA, RV, tricuspid valuve, inter-ventricular septum, inter-atrial septum, aortic valve, LV outflow tract (LVOT), descending thoracic aorta, Pulmonary Vein emptying into RA (if seen)

- Identify the following structures in the Subcostal (Subxiphoid) 4 chamber view: LV, LA, mitral valve (including anterior and posterior leaflets), RA, RV, tricuspid valuve, inter-ventricular septum, inter-atrial septum, aortic valve, descending thoracic aorta

- Identify the following structures in the Subcostal (Subxiphoid) IVC view: IVC, hepatic vein(s), cavo-atrial junction, RA, liver, portal vein, R hemi-diaphragm

C) Image interpretation

- Estimate global LV systolic function as normal, hyperdynamic, moderately diminished, or severely diminished using 1) Subjective Visual Estimation and 2) Mitral E-point septal separation, 3) Subjective Assessment of decent of base
- Identify a pericardial effusion and subjectively grade as trace, small, moderate, or large. Assess whether the effusion is loculated or free-flowing.
- Subjectively assess chamber sizes and comment on LV or RV dilation, LAE, RAE
- For IVC assessment, measure 1) maximum IVC diameter using correct technique (just proximal to hepatic vein in sagital view), 2) % collapse with passive breathing (caval index), 3) % collapse with "sniff" test

Questions:

What is the most common fake-out for pericardial effusion, and how do you tell the difference?

How will a traumatic hemopericardium differ in appearance relative to a pericardial effusion from another cause (e.g. cancer, pericarditis)?

What are the echocardiographic signs of impending tamponade physiology?

What is the optimal position for needle insertion when performing an emergent pericardiocentesis? What equipment should be used for this?

What is the upper limit of normal for mitral E-point septal separation?

What are the 5 major signs of increased R sided pressures?

How can RV enlargement be assessed quantitatively?

How is RV function assessed quantitatively?

What are the current American Society of Echocardiography guidelines re: IVC measurements and CVP?

What is the definition of "volume responsiveness?" How is this concept related to CVP?

Advanced:

What is the upper limit of normal for myocardial thickness and where do you measure?

What is the upper limit of normal for Ao root diameter and where do you measure?

How is diastolic function assessed? Demonstrate how to use pulsed-Doppler to obtain E and A wave velocities and how to use tissue Doppler to obtain E` velocity.

Demonstrate how to use color Doppler to identify MR, TR and AI.

Demonstrate how to measure tricuspid jet velocity to estimate pulmonary artery systolic pressure. What is the formula that is used for this?

Demonstrate how to estimate LV EF using the summation of discs method (Simpson's method).

Demonstrate how to estimate RV function using TAPSE.

Demonstrate how to estimate cardiac output using the LVOT VTI and LVOT diameter. How would this allow you to assess "volume responsiveness?"

Be able to identify and describe the appearance of mitral annular calcification.

Be able to identify and describe the appearance of a vegetation.

4) Lower Extremity Venous for DVT

A) Background Info

- List the indications for this study.
- What transducer should be used? What is minimum depth that should be used for femoral and popliteal regions?
- What is ideal patient positioning?

B) Image acquisition

- Perform a DVT exam according to the standard protocol
- Identify the following structures in the groin: CFA, CFV, GSV, saphno-femoral junction (SFJ), SFA, Profunda Femoris artery (PFA), SFV, DFV. Identify lateral femoral circumflex vein if visible (runs lateral off of CFV and bisects SFA and PFA).
- Identify the following structures in the proximal-mid thigh: SFA, SFV
- Identify the following structures in the proximal-mid thigh: popliteal vein, popliteal artery, tibial branch of sciatic nerve, muscular calf veins (if visible)

C) Image Interpretation

- Demonstrate proper compression technique at each level. How is an acute thrombus identified?
- If a patient has had a prior DVT, how will the vessel often appear?

Questions:

What is the rationale for the "2-point" technique? What are its limitations (i.e. why do we recommend looking at several additional points along the SFV)?

Why do some (including our radiology - but not vascular – sonographers) call the SFV the "Femoral Vein?"

What are 2 common fake-outs that can mimic a DVT?

Advanced:

Demonstrate how to obtain a Doppler waveform of the CFV, proximal SFV, or popliteal vein. What are the characteristics of a normal venous waveform? What does an abnormal waveform suggest?

Demonstrate how to perform augmentation. What does abnormal augmentation suggest? When should you NEVER perform augmentation?

5) Liver/Biliary

A) Background Info

- List the indications for this study.
- What transducer should be used? What are the 2 main transducer positions typically used?
- What is ideal patient positioning?
- List the major findings we are interested in, i.e. what main questions are we trying to answer?

B) Image acquisition

- Perform an exam according to the standard protocol
- Identify the following structures using the "X minus 7" transducer position: R lobe of liver, R hemidiaphragm, gallbladder, main portal vein, CBD, hepatic veins, IVC, R kidney, duodenum (2^{nd} portion)
- Identify the following structures in the sub-costal position: Gallbladder, main portal vein, extrahepatic bile duct (CBD).
- Identify body, fundus, and neck of GB.

C) Image Interpretation

- What are the sonographic characteristics of gallstones?

- What are the sonographic characteristics of sludge?
- What sonographic findings are concerning for acute cholecystitis?
- Demonstrate how to properly measure the gallbladder. Above what dimensions is the GB considered dilated?
- Demonstrate how to properly measure the gallbladder wall. What is the upper limit of normal?
- Demonstrate how to properly measure the extrahepatic bile duct. What is the upper limit of normal?

Questions:

What combination of sonographic findings is MOST sensitive for acute cholecystitis?

Other than cholecystitis, what conditions can cause gallbladder wall thickening?

Why is it critical to make sure the neck of the gallbladder is visualized?

What is a common finding that leads to a false positive call for gallstones?

How can you tell the difference between portal and hepatic veins based on their morphology?

Advanced:

What sonographic findings are consistent with cirrhosis?

Demonstrate how to obtain a Doppler waveform of the portal vein. What changes are seen in cirrhosis?

6) Renal

A) Background Info

- List the indications for this study.
- What transducer should be used?
- What is ideal patient positioning?

- List the major findings we are interested in, i.e. what main questions are we trying to answer?

B) Image acquisition

- Perform an exam according to the standard protocol.

- Identify the following structures in the kidney: Gerota's fascia, perinephric fat, renal capsule, renal parenchyma (which contains the renal cortex and medullary pyramids), renal sinus (contains major braches of the renal artery and renal vein, and the collecting system), and proximal ureter.

- Use color Doppler to identify the main and interlobar renal vessels in order to differentiate these structures from a dilated collecting system.

- Identify the following structures in/around the bladder: Urinary bladder, ureteric ridges, ureteric jets, UVJ, and ureteral stone, if present.

C) Image Interpretation

- Demonstrate how to properly measure the kidney in its long axis. What is a normal size?

- Identify hydronephrosis if present. Differentiate between the renal pelvis, major calyces, and minor calyces. What terms are used to describe dilation of each of these structures?

- Besides hydro, what sonographic findings are consistent with an acute ureteral stone?
  Presence of a perinephric fluid collection, presence of intrarenal stone (these do not typically cause pain but suggest guilt by association – i.e. could have a friend in the ureter), dilated proximal ureter (hydroureter), presence of a stone in the proximal ureter, presence of stone

Questions:

Can the collecting system be visualized in a normal kidney?

What degree of hydronephrosis is typically seen with an acute ureteral stone?

Why is the renal sinus so echogenic compared to the renal parenchyma?

What structures are commonly mistaken for dilated calyces, often causing providers to overcall hydro?

How can intrarenal vasculature be differentiated from a dilated collecting system?

What is appropriate range of color Doppler scale to use for this?

What technique can be used to illuminate a stone that may be difficult to see, especially at the UVJ?

What findings are consistent with acute pyelonephritis?

Advanced:

Is a normal kidney typically more or less echogenic than liver and spleen parenchyma? What does renal echogenicity greater than the liver suggest?

Demonstrate how to obtain a Doppler waveform of the intrarenal renal artery. What are the characteristics of a normal waveform? What would the waveform look like if there were renal artery stenosis?

7) Abdominal Aorta

A) Background Info

- List the indications for this study.
- What transducer should be used?
- What is ideal patient positioning?
  Supine. Must be patient and hold constant pressure to displace bowel gas.
- List the major findings we are interested in, i.e. what main questions are we trying to answer?

B) Image acquisition

- Perform an exam according to the standard protocol.
- Identify the following structures in both a transverse and sagittal orientation: Abdominal aorta, celiac trunk, common hepatic artery, splenic artery, SMA, splenic vein, left renal vein, IVC, pancreas, spinal column.

C) Image Interpretation

- Demonstrate how to properly measure the aorta in its long axis and short axis.

Questions:

What are normal dimensions for the abdominal aorta?

At what diameter is surgery typically recommended?

What is the typical sonographic appearance of an acutely rupturing AAA? Would you expect to see intra-abdominal free fluid? If so, where in the abdomen are you most likely to see it?

8) First Trimester Obstetrical

A) Background Info

- List the indications for this study.
- What transducer should be used?
- What is ideal patient positioning?
- List the major findings we are interested in, i.e. what main questions are we trying to answer?

B) Image acquisition

- Perform an exam according to the standard protocol.
- Identify the following structures in both a transverse and sagittal orientation on TA and TV scans (not all will be present in some cases): uterus (body and fundus), cervix, endometrial canal, endocervical canal, ovaries (if visible), external iliac artery, external iliac vein, gestational sac, yolk sac, amnion (if visible), embryo, fetal heart

C) Image Interpretation

- Demonstrate how to properly measure the diameter of the gestational sac.
- Demonstrate how to properly measure the crown-rump length (CRL).
- Demonstrate how to properly measure the fetal heart rate.

Questions:

What is the most common cause of first trimester bleeding that is identifiable on ultrasound? Describe its appearance. What prognostic significance does this finding carry?

At what gestational age should you see heart activity on TV ultrasound?

If you see a small, intrauterine fluid collection with no yolk sac and no embryo, what are the chances that this finding represents an early IUP vs a "pseudo-gestational sac" with an ectopic pregnancy?

According to current guidelines, what discriminatory zone should be used when diagnosing a likely ectopic pregnancy?

Make sure you are familiar with the ED-GYN 1st trimester management guidelines (on website under Resources -> "Clinical Guidelines")

9) Non-Obstetrical Pelvic

A) Background Info

- List the indications for this study.
- What transducer should be used?
- What is ideal patient positioning?
- List the major findings we are interested in, i.e. what main questions are we trying to answer?

B) Image acquisition

- Perform an exam according to the standard protocol.
- Identify the following structures in both a transverse and sagittal orientation on TA and TV scans: uterus (body and fundus), cervix, endometrial canal, endocervical canal, ovaries (if visible), external iliac artery, external iliac vein.

C) Image Interpretation

- Describe any abnormalities such as pelvic free fluid. Measure both ovaries if they can be visualized.

Questions:

What are normal dimensions for ovaries?

Cysts above what diameter are prone to torsion?

What findings are commonly associated with ovarian torsion?

10) Thoracic/Lung (Non-trauma)

A) Background Info

- List the indications for this study.
- What transducer should be used?
- What is ideal patient positioning?
  Supine. Must be patient and hold constant pressure to displace bowel gas.
- List the major findings we are interested in, i.e. what main questions are we trying to answer?

B) Image acquisition

- Perform an exam according to the standard protocol.
- Identify the following structures: Skin/soft tissue, rib shadow, pleural line, A lines, B lines, Z lines

C) Image Interpretation

- Give definitions for A, B and Z lines.
- How many B lines per rib interspace are considered normal? What do lots of B lines suggest?
- Describe the appearance of a pleural effusion.
- Describe the appearance of a pneumothorax.

Questions:

What do each of these terms mean: “comet tails,” “lung rockets,” “lung comets,” “ultrasound lung rockets.”

11) Musculoskeletal/Soft tissue

A) Background Info

- List the indications for this study.
- What transducer should be used?
- What is ideal patient positioning?
- List the major findings we are interested in, i.e. what main questions are we trying to answer?

B) Image acquisition

- Perform an exam according to the standard protocol.
- Identify the following structures: skin, subcutaneous fat, fascia, muscle, tendon, lymph nodes (if present), fluid collection (if present)

C) Image Interpretation

- Describe any abnormal findings.

Questions:

Why is it essential to always put a color Doppler box over the area of interest when evaluating a possible fluid collection?

12) Bladder (for Bladder Volume)

A) Background Info

- List the indications for this study.
- What transducer should be used?
- What is ideal patient positioning?
  Supine. Must be patient and hold constant pressure to displace bowel gas.
- List the major findings we are interested in, i.e. what main questions are we trying to answer?

B) Image acquisition

- Perform an exam according to the standard protocol.

- Identify the following structures: urinary bladder, ureteric ridges, UVJ's, prostate (if male).

C) Image Interpretation

- Demonstrate how to measure the volume of the bladder.

Questions:

What is a typical PVR in a young, healthy patient?

In patients with BPH, above what PVR is a foley typically recommended?

In patients who are suspected of a myelopathy causing urinary retention (e.g. cauda equine syndrome) what PVR essentially rules out this condition?