EMERGENCY MEDICINE CASES
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Episode 18 – Emergency Ultrasound

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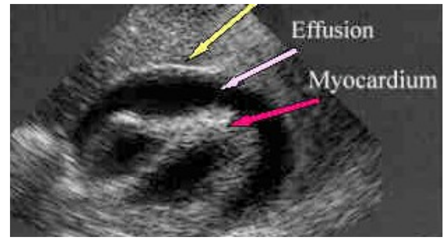
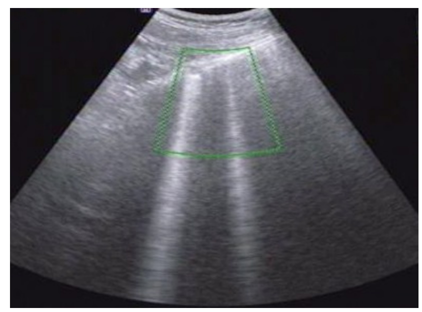


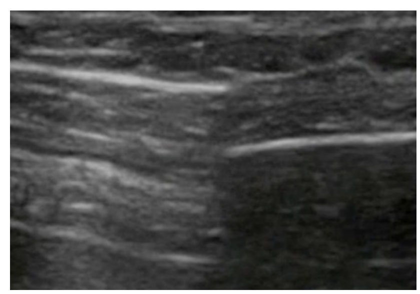
Pericardial effusion (image on right)

Technique: subxiphoid view – 96-98% sensitivity and easiest to learn: focus on the area where the inter-ventricular wall connects with the apex of the heart and sweep anteriorly and posteriorly (where blood most often pools)

Pitfalls: 1) epicardial fat pad may appear like an effusion, but is more prominent anteriorly, 2) clotted blood may be more dense and be missed, and 3) presence of effusion does NOT rule in or out cardiac tamponade, which is a clinical diagnosis

Ultrasound-guided pericardiocentesis: insert needle at the apex of the heart (as opposed to the trans-diaphragmatic approach) where there's the biggest pocket of fluid is and where there's fewer obstacles between the skin and the effusion





Pneumothorax

Sensitivity (98-99%) much better than CXR, especially in supine trauma patient where pleural air is travelling anteriorly, and faster to obtain

Technique: High-frequency linear probe placed on the most anterior portion of the chest in a supine patient, in the mid-clavicular line, and look for:

> **Lung sliding**: i.e. 'ants marching on a string', as the visceral and parietal pleura move relative to each other; if air is between the pleura, the ultrasound waves get scattered and you don't see sliding
>
> **Comet tails** (upper image): bright white beams of light going deep in the screen, caused by water droplets in the interlobular septae in the visceral pleura, and absent in pneumothorax (PTX)
>
> **Lung point** (lower image): used as confirmation tool, and located where visceral and parietal pleura are separating at the origin of the PTX, found by sliding the US probe laterally until the separation point is found – very specific for PTX

PNX Size Determination: small if no lung sliding at anterior axillary line, moderate if no lung sliding at mid-axillary line, large if no lung sliding at posterior axillary line – 95% agreement between ultrasound (US) and CT scan

False positives: bullous disease in COPD, pulmonary fibrosis, pulmonary contusions and mainstem intubation (will have no lung sliding but may have comet tails)

Undifferentiated Shock

Causes: hypovolemic (bleed, dehydration), distributive (sepsis, anaphylactic), cardiogenic (MI, cardio-myopathy, valvular), obstructive (cardiac tamponade, pneumothorax, pulmonary embolus) – US may help!

RUSH (Rapid Ultrasound in SHock) protocol[1]

To be used in undifferentiated shock, in a step-by-step algorithm to guide diagnosis and early management

1. **PUMP (i.e. the heart)**: Look at the heart for pericardial effusion (cardiac tamponade), contractility of the left ventricle (ischemia), and relative size of right and left ventricles (right heart strain in PE)

2. **TANK (i.e. intravascular volume assessment)**: IVC assessment (size, collapsibility) and 'tank compromise', i.e. PTX

3. **PIPES (i.e. major arteries and veins)**: Assessment for AAA or dissection flap, and DVT in legs

Mnemonic to remember the order: HIMAP – *H*eart, *I*VC, *M*orrison's pouch and FAST exam, *A*orta, *P*TX

Table 1
Rapid Ultrasound in SHock (RUSH) protocol: ultrasonographic findings seen with classic shock states

RUSH Evaluation	Hypovolemic Shock	Cardiogenic Shock	Obstructive Shock	Distributive Shock
Pump	Hypercontractile heart Small chamber size	Hypocontractile heart Dilated heart	Hypercontractile heart Pericardial effusion Cardiac tamponade RV strain Cardiac thrombus	Hypercontractile heart (early sepsis) Hypocontractile heart (late sepsis)
Tank	Flat IVC Flat jugular veins Peritoneal fluid (fluid loss) Pleural fluid (fluid loss)	Distended IVC Distended jugular veins Lung rockets (pulmonary edema) Pleural fluid Peritoneal fluid (ascites)	Distended IVC Distended jugular veins Absent lung sliding (pneumothorax)	Normal or small IVC (early sepsis) Peritoneal fluid (sepsis source) Pleural fluid (sepsis source)
Pipes	Abdominal aneurysm Aortic dissection	Normal	DVT	Normal

[1]*From Perera et al. The RUSH Exam: Rapid Ultrasound in Shock in the Evaluation of the Critically Ill. Emerg Med Clin N Am 28 (2010) 29–56*

Pulmonary embolus

Ultrasound is neither sensitive nor specific for PE but may help in 1. thrombolysis and 2. disposition decisions

1. **Submassive PE & thrombolysis**: While there is clear evidence for benefit of thrombolysis in ***massive*** PE, in ***submassive*** PE where the patient is NOT in shock, but has evidence of right heart dysfunction on US or ECG, or who has positive troponin or BNP biomarkers – controversy exists regarding thrombolysis given that bleeding risks may outweigh potential benefits. In deciding which patients with submassive PE should receive thrombolysis, some experts suggest lysis if severe right-heart strain on US, which may indicate a pre-shock state.

2. **Dispostion**: Compare right and left ventricular sizes in apical view (right ventricle is on the left in the image below), and consider it in right-heart strain – if right heart strain present, consider inpatient therapy even if patient appears well

Hypodynamic vs. hyperdynamic left ventricle

Hyperdynamic, i.e. small ventricle with >70% (on gestalt) change in diameter of ventricle in systole (or if the walls touch) – 94% specific for failure in non-traumatic shock patient

ICV diameter (i.e. intravascular volume assessment)

In long axis (longitudinal plane) view, assess anterior-posterior diameter of IVC:

Size: if <1cm, patient likely volume depleted; if >2cm, unlikely volume depleted

Variability: If no variation of size with respiration, likely not hypovolemic; if IVC collapses with respiration, likely hypovolemic

Intubated patient: IVC will increase with respiration due to positive pressure ventilation (as opposed to usual negative pressure)

Pediatric hydration status: Compare IVC to aorta; normal ratio 1.2:1, and can help to guide fluid therapy

PEARL from the experts: use US for intra-osseus needle placement confirmation: high-frequency probe placed next to IO to see flow beneath cortex in Doppler mode

Cardiac Arrest Resuscitation

US may be used as an adjunct to stop resuscitative efforts, but there's no absolute criteria

Early phase of cardiac arrest: US may help with the H's and T's, i.e. tamponade, PTX, AAA, PE and volume resuscitation

Later phases: assess for cardiac standstill, i.e. patient very unlikely to survive code (except in pediatric hypoxic arrest and hypothermic arrest), and may be useful for family members to see that the heart has stopped beating – survival is <<1% (likely close to 0%)

Do not interrupt chest compressions to use US! Rather, use US at the 2min intervals when checking for pulse

Confirmation of ETT placement

Quantitative capnography still the gold standard, but if lung sliding is only seen unilaterally on the right, consider right mainstem bronchus intubation and pull on the ETT until lung sliding is seen bilaterally

Deep vein thrombosis (DVT)

2-point compression testing is reliable in select patients (no chronic or recurrent DVTs, no obese patients)

Most useful in situations where you are considering giving LMWH 'on spec' and arranging outpatient radiology department ultrasound. If emergency bedside ultrasound is negative, consider not treating with LMWH until the confirmatory US is obtained.

May also be useful in undifferentiated shock patient to help rule in pulmonary embolism.

Interpreting the emergency ultrasound literature

There is a huge body of literature for emergency ultrasound, which can be overwhelming to interpret for the practicing clinician, and with results that appear very impressive at first glance. However, these studies must be interpreted with 'a grain of salt' as most have at least one of the following limitations:

Generalizability: clinician-ultrasonographers in studies are often few and very experienced, which doesn't mean that most clinicians would obtain the same levels of sensitivity and specificity

Biases: on top of the inherent biases of the authors themselves, there is 'destiny bias' – if seeing cardiac standstill on the US influences your decision to stop the resuscitative efforts, the study results will obviously be influenced by this

Convenience sampling: young, slim and healthy volunteers (or patients) are often chosen by 'convenience' because they are much easier to scan than the real life patients who are older and bigger

Publishing bias: negative studies probably don't get published as much

Outcomes: studies often compare imaging outcomes (PTX on CXR and US vs. CT scan), but not clinically-relevant outcomes (eg, are those occult PTX found by US clinically significant?)

Ethics: for some indication for which US is now the standard of care (eg, FAST), it is not ethical to randomize patients to FAST vs. no-FAST, and therefore we might never get grade I evidence for certain modalities that we already use