Anesthesia POCUS Pocket Reference

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By collaborators & with support from multiple institutions, including:

Open Critical Care.org | USAID | STAR | UCSF | CHESA | Association of Anesthesiologists of Uganda

Cardiac ultrasound images courtesy of: http://sites.austincc.edu/sonography-resources/
Cardiac illustrations courtesy of Dr. Atif Qasim: echocardiographer.org
Lung ultrasound images courtesy of: Picano et al. "Lung Ultrasound for the cardiologist", JACC Cardiovascular Imaging, Vol 11, No 11, 2018

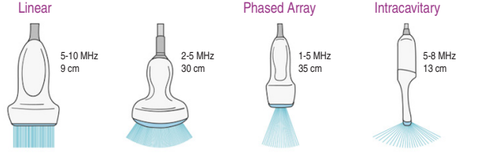
Echo Modalities

2D	gross anatomy, ventricular and valvular movement, positioning for M-mode and doppler
M-mode	2D movement along straight line, plotted over time. Used for chamber dimensions, timing of cardiac events
PWD	PWD = pulsed wave doppler, measures velocity at set point Valvular flow velocities <2 m/s LV diastolic function Stroke volume and cardiac output
CWD	CWD = continuous wave doppler, measures highest velocity along path Valvular flow velocities >2 m/s Velocity of flow in shunts
Color	gross assessment of regurgitant flows and shunts

Standard sequence for basic TTE assessment

PLAX	standard, RV inflow, RV outflow
PSAX	aortic valve, mitral valve, mid-papillary, apex
Apical	4-chamber view, 5-chamber view
Subcostal	4-chamber, IVC

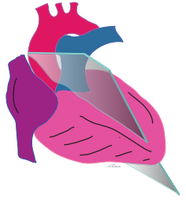
Transducer Types

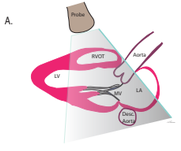


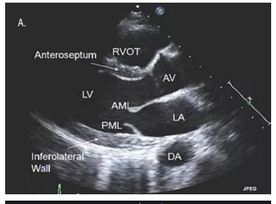
Disclaimer: This card is intended to be educational in nature and is not a substitute for clinical decision making based on the medical condition presented. It is intended to serve as an introduction to terminology. It is the responsibility of the user to ensure all information contained herein is current and accurate by using published references. This card is a collaborative effort by representatives of multiple academic medical centers.

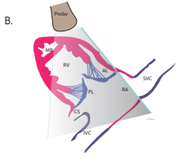
Parasternal Long Axis (PLAX) Basic

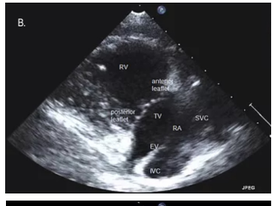
Position	Patient: slight left lateral, left arm above head, HOB @15° can help open intercostal spaces, consider end-expiratory breath hold Transducer: 2nd- 4th intercostal space left of sternum; notch toward right shoulder
Views	a) Standard PLAX: center MV and AV leaflets in the middle of the screen, IVS and LVPW should be parallel to each other, should not see LV apex, RV is closest to the chest wall/probe b) RV inflow: from PLAX view, tilt transducer to aim toward patients right hip c) RV outflow: from PLAX view, aim transducer toward patient's left shoulder (look up), may see PA bifurcate

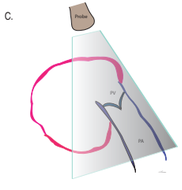










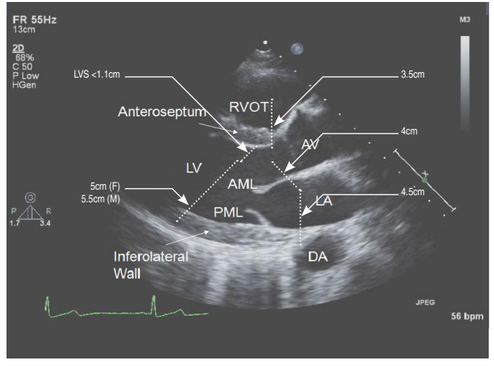


Parasternal Long Axis (PLAX) Advanced

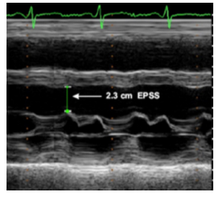
2D M-mode	Left Ventricle: 2D: gross systolic function, LVOT diameter, LV septum thickness M-mode: LV and aortic root measurements, LA dimensions Valves: 2D: gross AV and MV leaflet anatomy and function RV inflow/outflow: 2D: gross appearance of RA, TV, RV, PV, PA. RVOT PA > Aorta suggests pulm vascular pressure overload.

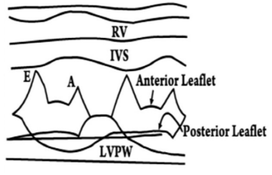
Parasternal Long Axis (PLAX) Expert

Doppler	Standard PLAX: Color doppler: gross evaluation for AR, MR, VSD RV inflow/outflow: CWD across TV to estimate PASP (see A4C section) PWD across PV to estimate pulmonary VTI (see PSAX section)
Disease	Pericardial effusion: fluid between epicardium and desc. aorta that terminates at AV groove Pleural effusion: posterior to descending aorta (visible throughout cardiac cycle) EPSS: M-mode across distal tip of anterior mitral leaflet to measure distance from IVS during early diastole. EPSS >7mm suggests LVEF <50%



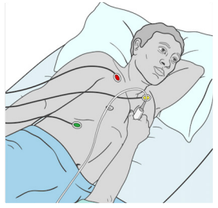
E-Point Septal Separation (EPSS):

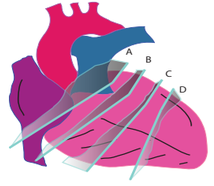


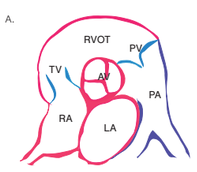


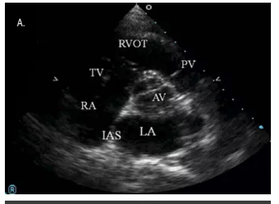
Parasternal Short Axis (PSAX) Basic

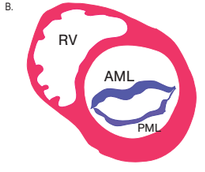
Position	Patient: same as PLAX view Transducer: from PLAX, rotate transducer 90° clockwise until notch is pointing toward left shoulder
Views	Tilt (more than slide) probe from base to apex to obtain short axis views of (A) aortic/tricuspid/pulmonic valve level, (B) mitral valve level ('fish mouth'), (C) LV mid-papillary muscle level (should see completely around muscle), (D) apex view (not shown) Optimize view: exhalation (decrease overlying lung volume), move transducer toward pt's right shoulder

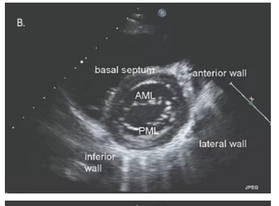


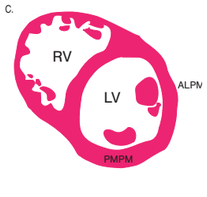


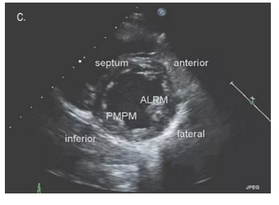












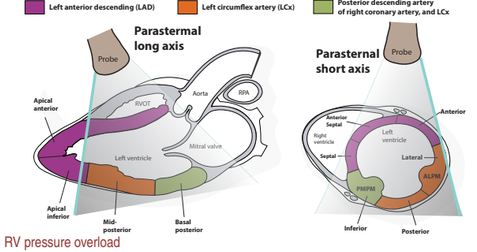
Parasternal Short Axis (PSAX) Advanced

2D M-mode	Aortic valve level: 2D: AV cusps, RA, TV, RV, PV, RVOT, PA diameter Mitral valve level: 2D: MV, mobility, and commissural apparatus LV papillary muscle level: 2D: LV wall thickness (<= 1.6/1.5 Male/Female), IVSd, RV M-mode: LVEDD (<= 5.8/5.2 Male/Female), LVESD, IVSd

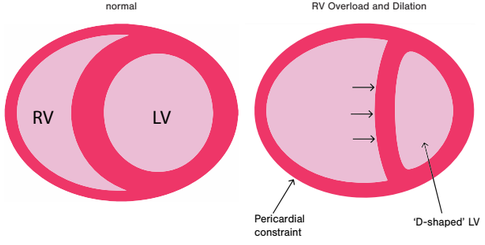
Parasternal Short Axis (PSAX) Expert

Doppler	Color doppler: gross assessment for TR, PR, VSD PASP based on TR velocity: CWD across TV (see A4C section) Pulmonary velocity time integral (VTI): PWD proximal to PV (estimate of cardiac output)
Disease	**Coronary ischemia:** regional wall motion abnormalities **RV pressure overload:** dilated PA and RV, IVS flattening, "D-shaped LV **Volume status:** "kissing" papillary muscles at end-systole suggests LV underfilling **PFO:** color mixing between RA and LA

Coronary Territories



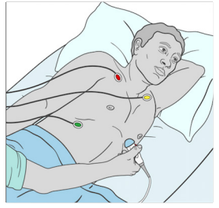
RV pressure overload

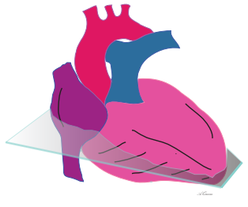


AL/PMPM: anterolateral/posteromedial papillary muscle
AML/PML: anterior/posterior mitral leaflet
AV: aortic valve
DA : descending aorta
DVT: deep-vein thrombosis
EPSS: end-point septal separation
FAST: focused assessment with sonography for trauma
LV - left ventricle
LA: left atrium
MAPSE: mitral annular plane systolic excursion
MV: mitral valve
IAS: interatrial septum
PA/PV: pulmonary artery/vein
RV – right ventricle
RVOT: right ventricular outflow tract
SVC/IVC: superior/inferior vena cava
TAPSE: tricuspid annular plane systolic excursion
TV: tricuspid valve
VTI: velocity time integral

Apical Basic

Position	Patient: left lateral decubitus, left arm up, gentle inspiratory hold Transducer: find the cardiac apex from PMI palpation (inferior to nipple, mid-clavicular line) or from observation from PSAX apical view, notch towards left shoulder and angled medially.
Views	A) Apical 4 chamber: center apex in the middle of the screen, with septum parallel to beam. Should see LV, RV, LA, RA B) Apical 5 chamber: tilt up towards patient's right shoulder until LVOT and AV comes into view





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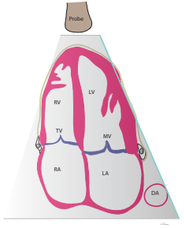

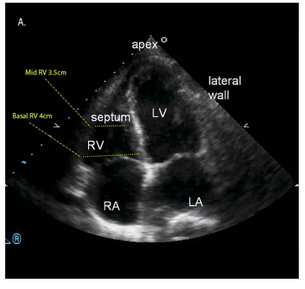

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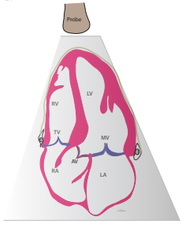
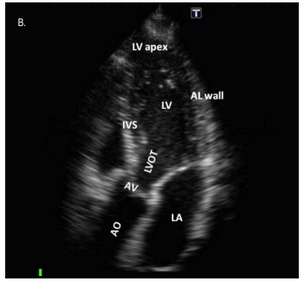
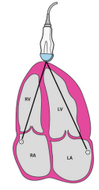


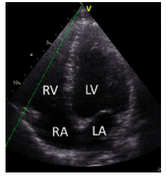


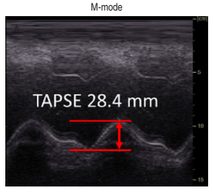
Apical 4 Chamber (A4C) Advanced

2D M-mode	2D: LV/RV size and gross systolic function M-mode MAPSE (lateral): <12mm = LVEF reduced <6mm = LVEF <30% A) M-mode TAPSE: <17mm = reduced RV systolic fxn
Doppler	B) Color doppler: assessment for MR, TR, ASD, VSD C) CWD across TV: use TR jet to estimate PASP PASP = RVSP = 4V(TR velocity)^2 + RAP D) PWD across MV: assess LV diastolic function E = early LV filling, A = late filling (atrial kick) Normal: E > A, Mild: E < A, Moderate: E > A, Severe: E >> A

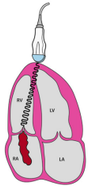
Annular Plane Systolic Excursion:

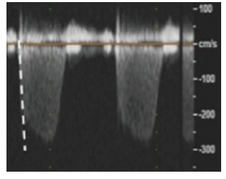




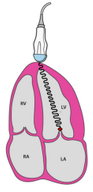


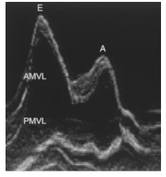
Tricuspid Regurgitation: estimating PASP

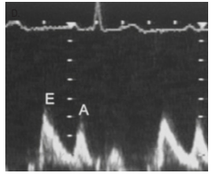




Mitral inflow: evaluating LV diastolic function



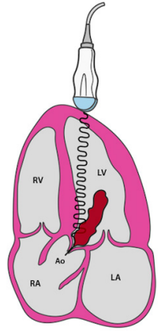


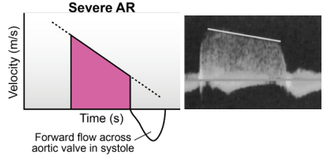


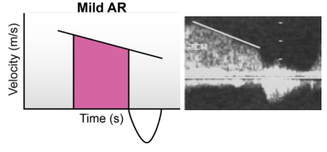
Apical 5 Chamber (A5C) Expert

2D M-mode	2D: AV, LV, LVOT appearance M-mode: LVOT and aortic root dimensions
Doppler	Color doppler: gross assessment for AR CWD: evaluate severity of AR and AS
Disease	Aortic Regurgitation: CWD across AV to measure jet deceleration rate (msec) Mild: >500, Moderate: 500-200, Severe: <200 Aortic Stenosis: CWD across AV to measure Vmax Bernoulli equation: peak gradient (mmHg) ΔP = 4(Vmax^2 Mild: <20, Moderate: 20-40, Severe: >40 Continuity equation: use velocity time integral (VTI) and LVOT diameter (D) to measure aortic valve area (cm^2) AVA = (0.785 * D_{LVOT}^2 x VTI_{LVOT})/VTI_{Aorta} Mild: >1.5, Moderate: 1.0-1.5, Severe: <1.0

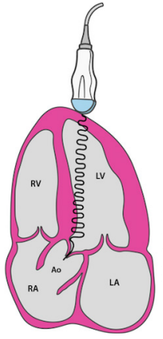
Aortic Regurgitation

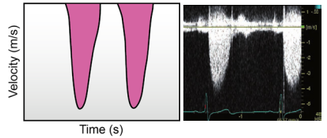


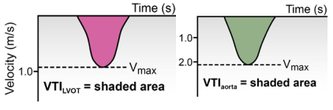




Aortic Stenosis

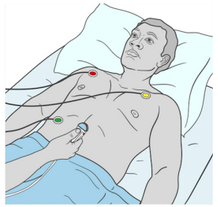


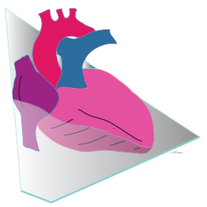




Subcostal Basic

Position	Patient: supine, legs bent to relax abdomen, deep end-inspiratory hold Transducer: probe below xiphoid and flat on the abdomen
Views	A) Subcostal 4 chamber: point notch toward right shoulder, angle cephalad to visualize cardiac chambers (often only cardiac CPR and for patients with pulmonary disease) B) Subcostal IVC: probe perpendicular to abdomen, notch pointing toward head, angle lateral for IVC and medial for aorta





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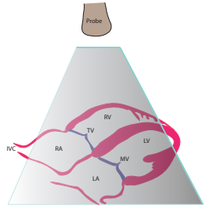

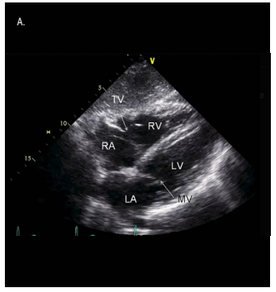

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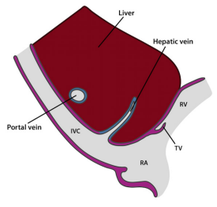
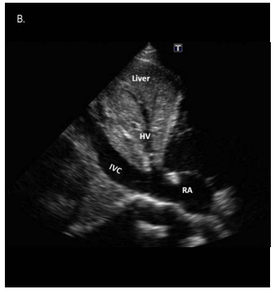




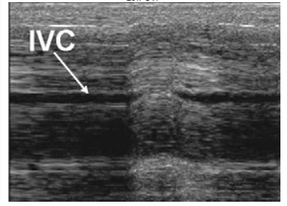
Subcostal Advanced

2D M-mode	2D: similar to other 4-chamber views; only available view during CPR M-mode: IVC view assess intravascular volume status *during spontaneous breathing* RAP 0-5mmHg: <2.1cm + collapses >50% w/ sniff RAP 10-20mmHg: >2.1cm + collapses <50% w/ sniff

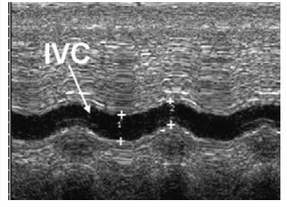
Subcostal Expert

Doppler	Color doppler: assessment for MR, TR, ASD, VSD PWD: hepatic vein systolic flow reversal >0.3-0.4m/s suggestive of RV pressure/volume overload

Low CVP

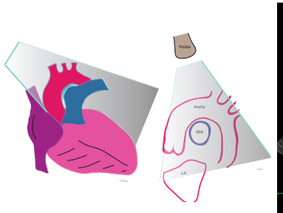


High CVP



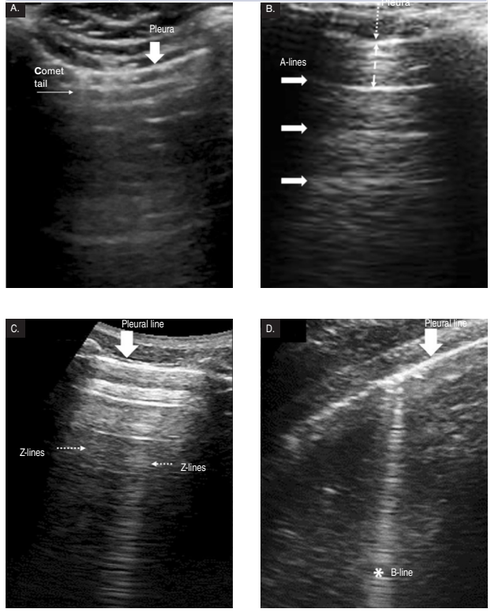
Suprasternal Expert

Position	Patient: have pt look up and left Transducer: place in suprasternal notch with indicator pointed to 14:00; tilt probe up and down
Disease	Aortic arch dissection: gross visualization Pulmonary hypertension: if RPA is smaller than aorta, filling pressures likely normal



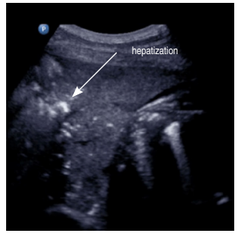
Pulmonary Ultrasound

Position	Probe selection: High frequency: better for superficial evaluation (pleura and small subpleural structures) Low frequency: better for deep structure evaluation (consolidation, pleural effusion) Probe position: point in a cranial-caudal axis with notch toward head, probe perpendicular to chest wall, evaluated multiple rib spaces in both anterior and dependent areas Patient: supine or lateral
Image findings	**Pleural-line:** thick hyperechoic horizontal line, moves with respiration ('ants marching') **Pleural effusion:** anechoic fluid in dependent lung areas **A. Comet tails (artifact)**: thin and short vertical lines, originate at intact pleural line, move with lung sliding, usually <1cm. Normal lung finding, help rule out PTX. **B. A-lines (repetition artifacts):** static equally spaced horizontal lines. No clinical significance. **C. Z-lines (reverberation artifacts)**: static vertical lines, do not originate at pleural line, do not move with lung sliding, do not obliterate A lines; Do not misinterpret for B-lines; No clinical significance. **D. B-lines (ring-down artifacts)**: thick vertical lines, originate at intact pleural line, and extend to edge of field at least 15cm, move with lung sliding, obliterate other background US artifacts; >3 per intercostal space likely pathologic; Interstitial edema = 7mm apart; Alveolar edema = 3mm apart

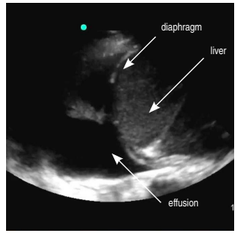


Pulmonary Ultrasound

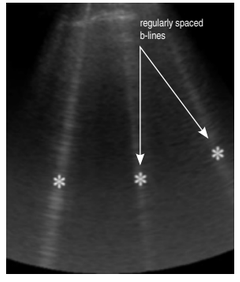
CONSOLIDATION



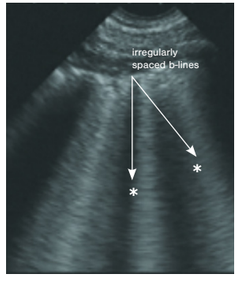
EFFUSION



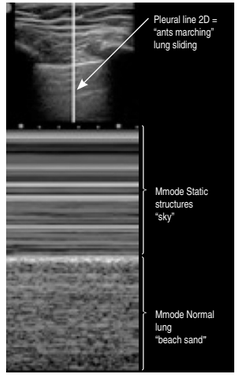
ALVEOLAR EDEMA



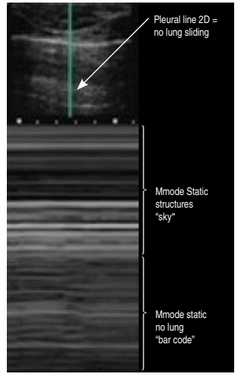
INTERSTITIAL EDEMA



NORMAL LUNG

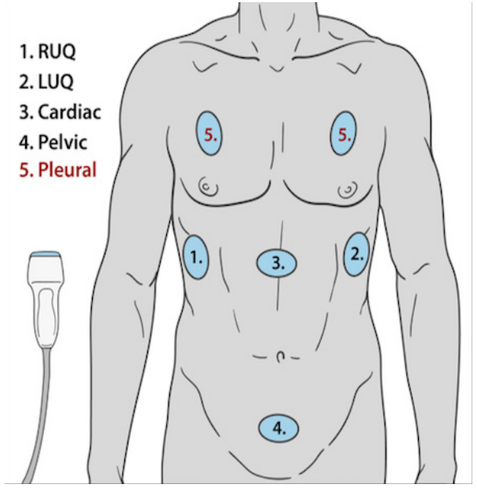


PNEUMOTHORAX

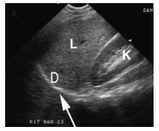
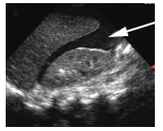
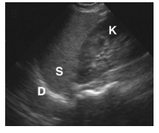
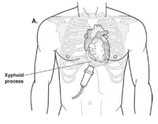
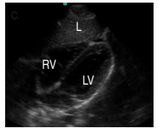
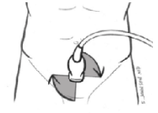
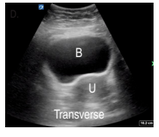
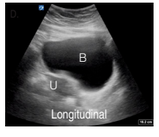


FAST/eFAST

Uses	Rapidly identify intraperitoneal free fluid or pericardial free fluid, as well as pleural free fluid or pneumothorax as part of the "extended" FAST (eFAST). Best validated for unstable blunt trauma adult patient.
Tips	- Probe Selection: low frequency curvilinear or phased array "cardiac" probe. Consider high frequency linear probe for anterior thoracic views - Patient: supine or in Trendelenberg position - A complete FAST must include sweep through entire interface between kidney and liver/spleen. Also visualize the diaphram including supradiaphragmatic space for evaluate for hemothorax.
Position	1. RUQ (hepatorenal / Morrison's pouch): midaxillary line, 9-11th intercostal space; probe marker towards patients head; visualize lung, diaphragm, liver, and kidney 2. LUQ (splenorenal): "knuckles to bed," probe marker towards patients head; 8-10th intercostal space; visualize lung, diaphragm, spleen, and kidney 3. Subxiophoid (cardiac): Hold probe in palm, probe marker toward patient's right, just below xiphoid process, aiming towards patient's left shoulder while applying gentle dowardward pressure 4. Suprapubic (bladder): Midline just above pubic bone, scan in longitudinal (probe marker toward's patient's head) and transverse (probe marker to patient's right) planes; look for fluid posterior to bladder and the prostate/uterus/rectum interface 5. eFAST: Pleural (pneumothorax): Decrease depth, probe marker towards patient's head; evaluate left and right anterior chest wall in air-dependent locations. look for normal lung sliding "ants marching" (see previous page)



FAST Views

Probe Positing	NORMAL	ABNORMAL
RUQ 	 L= Liver; K= Kidney; D= Diaphragm If no pleural effusion, will see liver reflection superior to diaphragm = 'mirror sign' (arrow) and will not see spine continue superior to diaphragm = negative spine sign	 Arrow = Free fluid in Morrison's pouch, between liver and kidney. Always include evaluation of the tip of the liver and inferior pole of the kidney.
LUQ 	 S= spleen; K= Kidney; D= Diaphragm.	 Arrow = Free fluid around spleen. In LUQ, fluid is most likely to accumulate between the diaphragm and the spleen. It is also important to also evaluate the tip of the spleen and inferior pole of the kidney.
Cardiac 	 L = Liver; RV= Right ventricle; LV = Left ventricle. For best view, place probe in palm of hand and apply pressure below xiphoid process, use liver as acoustic window	 Arrow = pericardial fluid. This appears as an anechoic stripe between the liver and the myocardium.
Bladder 	 	 B= Bladder, U=Uterus. In males, the prostate is located in a similar anatomical location as uterus. Fan the length of the bladder in both transverse and longitudinal (saggital) planes. Arrow = free fluid next to bladder in sagittal plane .

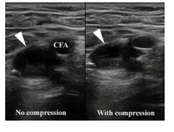
DVT US

Uses	- Suspected DVT/PE (when radiology not readily available or CTPE contra-indicated)
Tips	Probe Selection: linear/vascular probe Compression technique: Hold the transducer in a transverse position, perpendicular to the skin surface - At each point described below, apply firm, downward pressure to achieve complete collapse of the vein. Study is positive if vein does not collapse with compression; utilize doppler to confirm flow and evaluate in longitudinal plane. - Common false positives: superficial thrombosis, cysts, lymph nodes, pseudoaneurysms
Position	- Patient supine with hip slightly flexed + externally rotated. To evaluate popliteal vein compression is applied behind the knee in posterior knee crease

NORMAL CFV w/o COMPRESSION

NORMAL CFV w/ COMPRESSION

DVT OF CFV



Levels for Evaluation

Increasing # of levels = increased sensitivity

1. Common femoral vein (CFV) (proximal to greater saphenous vein)
2. At sapheno-femoral junction
3. Just below sapheno-femoral junction
4. Proximal femoral vein (FV)*
5. Mid FV
6. Distal FV
7. Proximal popliteal vein (compress in posterior crease behind knee)

* The "femoral vein" (FV) has also been referred to as "the superficial femoral vein." Clots in the FV are considered deep vein thromboses.