

PEARLS: *A Pocket Guide to Basic Bedside Ultrasound*

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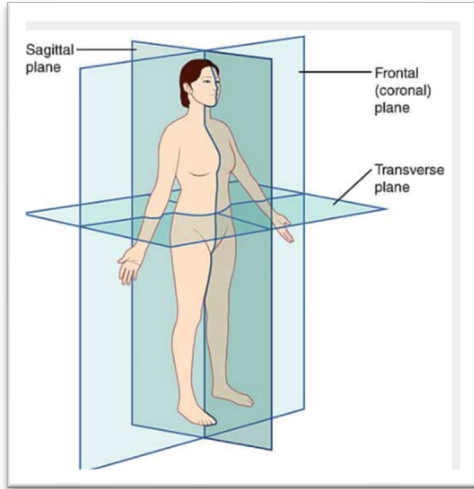
Based on the PEARLS method taught on the ACP POCUS website and the article "*PEARLS for an Ultrasound Physical and Its Routine Use as Part of the Clinical Examination.*"
Michael Wagner, MD and Janice Boughton, MD.

Table of Contents

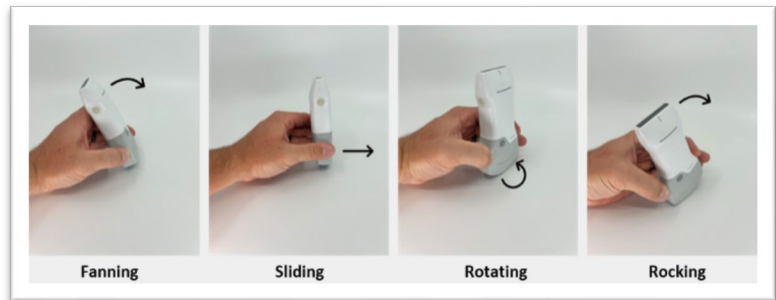
Basics	2	LUQ.....	16
Orientation	2	Kidneys.....	18
Echogenicity	2	Suprapubic.....	18
Knobology	3	Transverse	19
Probes.....	3	Longitudinal.....	20
Modes.....	4	Image gallery.....	22
PARASTERNAL	4	Parasternal.....	22
Long Axis (PLAX).....	4	Epigastric.....	23
Short Axis (PSAX)	5	Lung.....	24
Subxiphoid (SubX).....	6	RUQ	25
Apical	7	Gallbladder.....	26
Epigastric	8	LUQ.....	26
IVC/ Aorta Transverse View	8	Kidneys.....	27
IVC Longitudinal View.....	10	Suprapubic.....	27
Aorta Longitudinal View	11	Notes.....	28
Anterior Lung.....	12	Logbook.....	31
RUQ.....	15		
Gallbladder	15		

Basics

Orientation



Imaging planes to the left of page, cardinal movements of the probe depicted below.



Imaging planes adapted from Wikimedia

https://commons.wikimedia.org/w/index.php?title=File:Planes_of_Body.jpg&oldid=692147168

Echogenicity

- Anechoic – Transmit all sound waves without reflection. Appears black.
- Hypoechoic – Reflect fewer sound waves than surrounding structures. Darker than surrounding structures.
- Isoechoic – Reflect sound waves similar to surrounding structures.
- Hyperechoic – Reflect most sound waves. Appears lighter than surrounding structures.

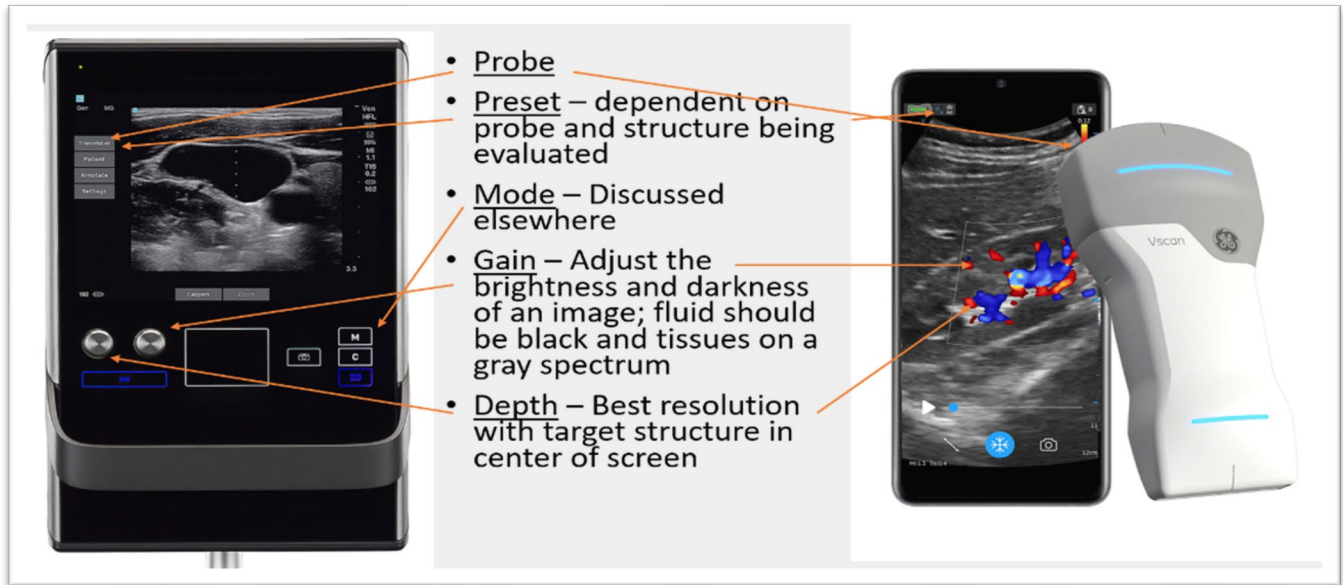


Fluid (blood, bile, urine)




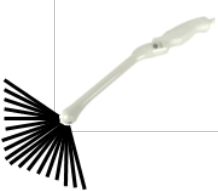
Solid organs, soft tissue,
muscle

Bone, metal, air, dense/
fibrous structures

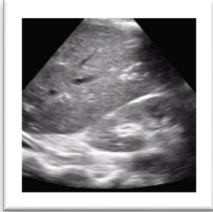
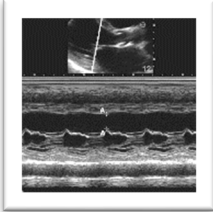
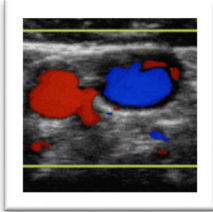
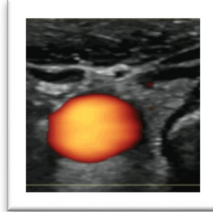
Knobology



Probes

	LINEAR	CURVILINEAR	PHASED ARRAY/ SECTOR PROBE	INTRACAVITARY
FREQUENCY	5 – 15 MHz (high)	2 – 5 MHz (low)	1 – 5 MHz (Low)	5 – 8 MHz (low)
DEPTH (MAX)	6 – 9 cm	30 cm	35 cm	13 cm
PROBE/ FOOTPRINT				
APPLICATIONS	Superficial structures, procedures, arteries/veins, MSK, eyes, thyroid, nerves	Intrabdominal organs, Abdominal aorta, LP, bladder	Heart, IVC, lungs, pleura, intraabdominal organs, transcranial doppler	Uterus/ ovaries, pharynx

Modes

	B-MODE	M-MODE	COLOR DOPPLER	POWER DOPPLER
IMAGE				
DESCRIPTION	“Brightness” mode; The echogenicity of observed structures depends on reflected signals.	Motion mode; Movements of all tissues in a given plane or axis are plotted over time.	Measures directional blood flow.	Measure magnitude of non-directional flow. 3-5 times more sensitive than doppler imaging.
USES	Standard mode for bedside US.	Size of cardiac chambers, movements of valves, measurement of respiratory variation of the IVC, eval for pneumothorax	Eval of vasculature. Affected by angle of insonation.	Advantages over color doppler include less reliance on angle of insonation and higher sensitivity in low flow states or tissues (e.g. testicles).

PARASTERNAL

Probe: Phased Array, can use curvilinear but not the best choice as phased array can better peer between rib spaces and tight windows.

Preset: Cardiac

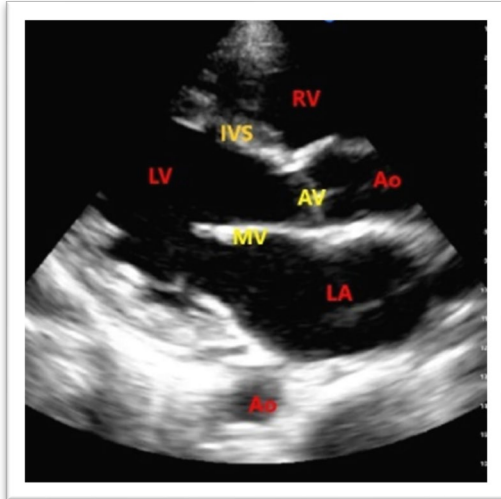
Patient position: Supine, left lateral decubitus to aid with difficult windows, especially apical view.

Long Axis (PLAX)

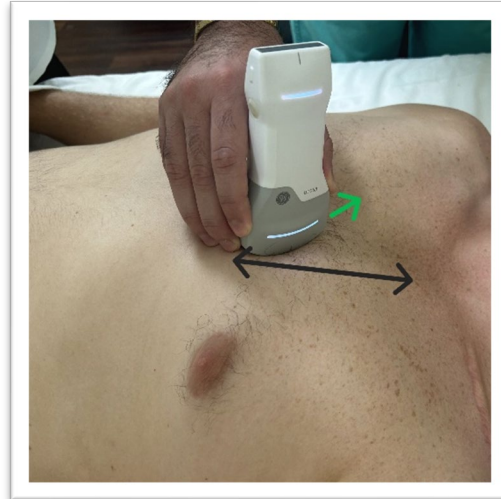
Probe marker: Towards patient’s right shoulder

Probe location: Approximately left 4th intercostal space.

Window shopping: Navigate each individual rib space, starting just under the clavicle on the left parasternal border, until you find an adequate window. Always look one space above and below “best” window to ensure you are in the actual best position. Picture below.



A.



B.

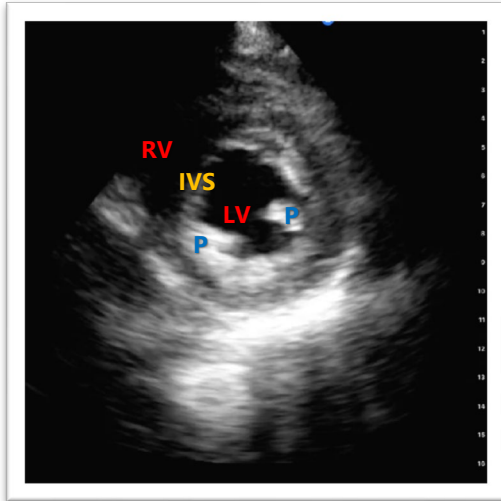
A: Should visualize right ventricle (RV), Aorta (Ao), Left atrium (LA), Left ventricle (LV), Aortic valve (AV), Mitral valve (MV), and the Interventricular septum (IVS). Deepest visualized structure should be the descending aorta (Ao). B: green arrow indicates probe marker towards right shoulder, black arrow indicates area for “window shopping.”

Evaluate **endpoint septal separation (EPSS)** which is how close the MV leaflet gets to the IVS. Should be < 1 cm typically and if greater can indicate LV dysfunction. Also evaluate “**rule of thirds.**” The RV, Ao, and LA should all approach approximately the same size and be 1/3 of the whole.

Short Axis (PSAX)

Probe marker: Rotate probe marker clockwise approximately 90 degrees toward patient’s left shoulder from a good PLAX window. Helps if you center MV on PLAX view first.

Probe location: Approximately left 4th intercostal space (where best PLAX view is obtained). Oftentimes, you will see “**fish mouth**” sign initially, which is the MV leading into the LV. Simply fan toward the apex of the heart to get the PSAX view picture below.



A.



B.

A: Should visualize right ventricle (RV), Left ventricle (LV), the papillary muscles (P) and the Interventricular septum (IVS). B: green arrow indicates probe marker towards left shoulder.

Evaluate LV squeeze and for any evidence of RV strain (**RV dilation; D sign** – see example in image gallery in back of book).

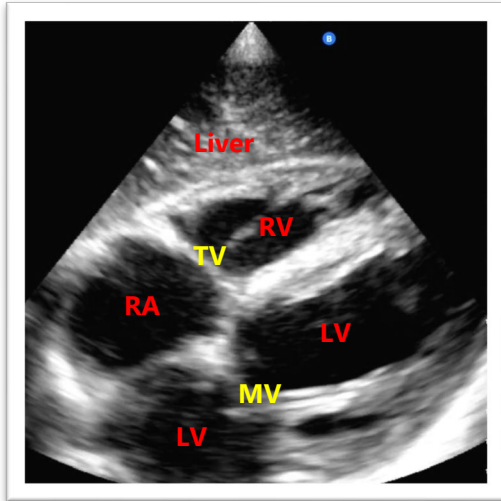
Subxiphoid (SubX)

Probe marker: Pointing towards the patient's left.

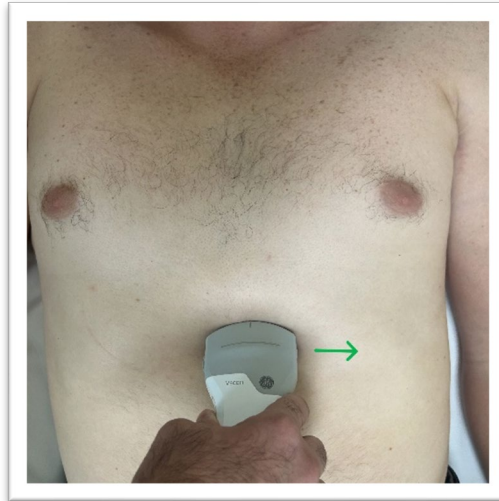
Probe location: Position the probe beneath the xiphoid process. Liver is your window so will need to get a good look through the liver in order to get a good cardiac view.

Note: Since the plane of the heart is superficial, you need to use an **overhand grip** on the probe to navigate under intercostal space and fan anteriorly until adequate view is obtained.

Additionally, if liver and heart are too cephalad, can have patient **hold an inspiratory breath** to lower diaphragm and subsequently lower the liver and heart.



A.



B.

A: Should visualize right ventricle (RV), Left ventricle (LV), Left atrium (LA), Right atrium (RA), Aortic valve (AV), Mitral valve (MV), the interatrial septum (IAS), and the liver through which your window lies. B: Green arrow represents probe marker pointing towards patient's left.

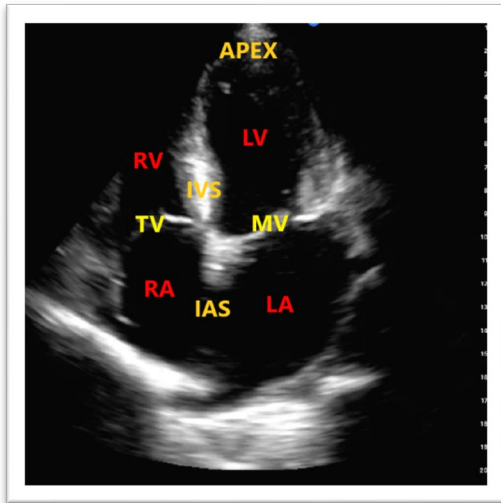
The liver is your window for this view and is therefore visualized at the top of the screen.

Great view for evaluating for pericardial effusions and similar to PLAX/PSAX. Is very helpful when PLAX/ PSAX are difficult to obtain secondary to COPD, mechanical ventilation, etc.

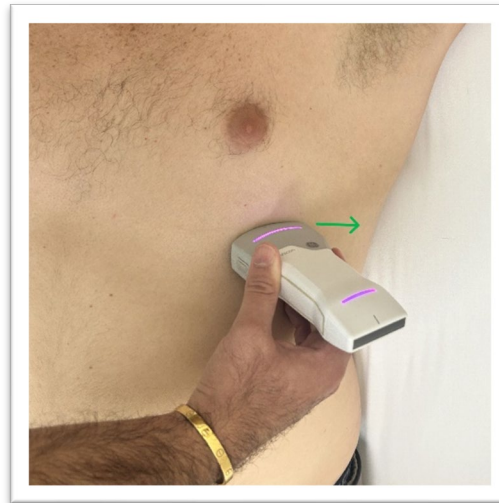
Apical

Probe marker: Toward patient's left/ towards the bed. Can often follow LV from PSAX by sliding down towards the heart or find the point of maximal impulse and start there.

Probe location: Between fourth or fifth ICS, midclavicular line (have patient lie on left side to obtain better view).



A.



B.

A: Should visualize right ventricle (RV), Left ventricle (LV), Left atrium (LA), Right atrium (RA), Aortic valve (AV), Mitral valve (MV), the interatrial septum (IAS), and the Interventricular septum (IVS). B: Green arrow represents probe marker pointing towards the bed/ patient's left.

Can visualize many abnormalities from this view but very helpful in assessing R sided heart dysfunction and valvular abnormalities. **McConnell's sign** also seen from this view.

Epigastric

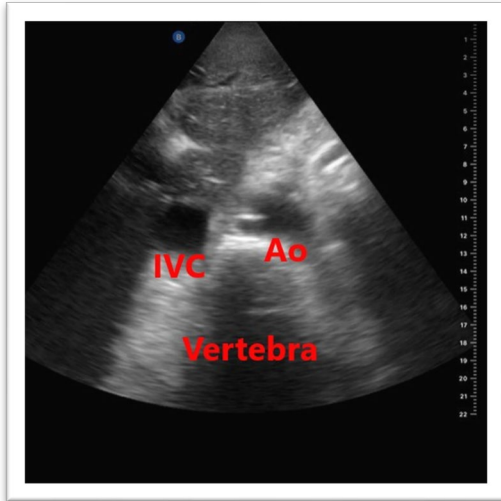
Probe: Phased-Array or Curvilinear

Preset: Cardiac or Abdominal (abdominal view is general convention, though some prefer cardiac convention. Know that the probe screen indicators change and therefore the probe marker side changes. When using bedside POCUS devices, it is often beneficial to use the cardiac preset because the frame rate and ability to capture the heart is less distorted when it enters the screen.

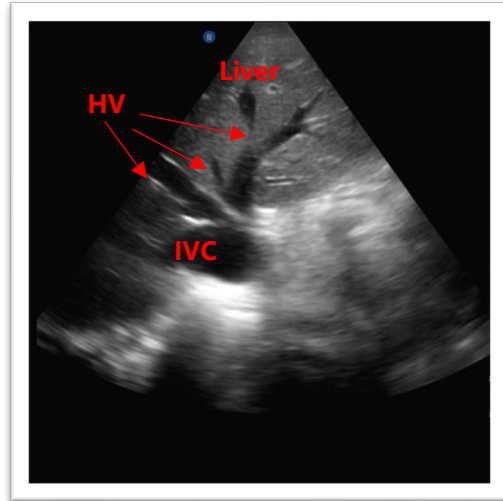
IVC/ Aorta Transverse View

Probe marker: Towards the patient's right if in abdominal preset, may need to reverse if using cardiac preset.

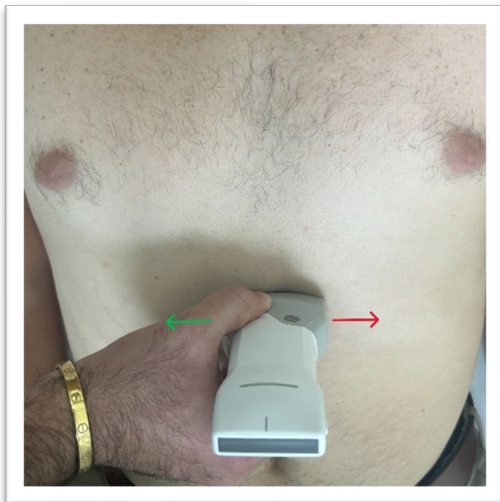
Probe location: Position the probe in the mid-epigastric region. Must visualize the liver well to best visualize the vasculature.



A.



B.



C.

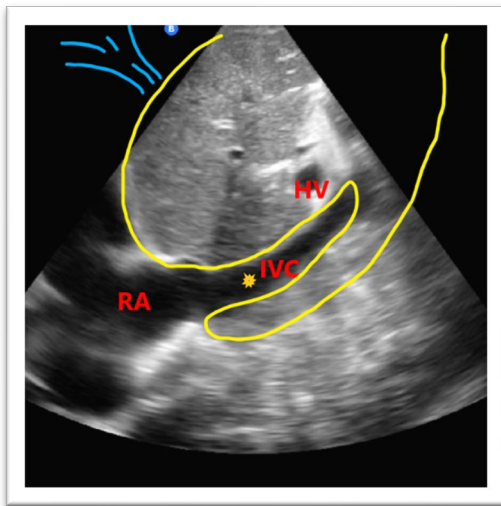
A: Should visualize inferior vena cava (IVC), aorta (Ao), and vertebrae. The Vertebrae should be the deepest structure on your screen and is oftentimes the easiest to visualize initially. B: Demonstrates following the IVC towards the heart and watching hepatic veins (HV) communicate into the IVC. C: Green arrow represent probe marker in traditional abdominal preset. Red arrow represents probe marker if in cardiac preset.

Window is the liver, a good image cannot be obtained without first getting a good window through patient's liver. Oftentimes, may be competing with bowel gas or gastric bubble. Can reposition probe or have patient hold on inspiration to improve window.

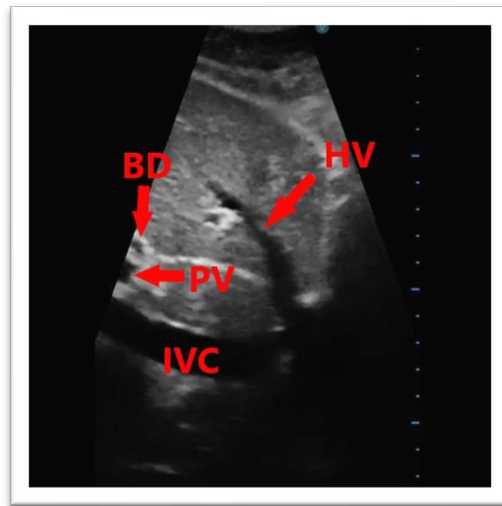
IVC Longitudinal View

Probe marker: Towards the patient's head. Keeping the right atrium in view, fan the probe to the right to locate the largest diameter of the IVC. Measurement of the IVC should be 2-3cm from the RA-IVC junction.

Probe location: Position the probe beneath the xiphoid process.



A.



B.



C.

A: Happy whale sign. A/ B: Should visualize the right atrium (RA), inferior vena cava (IVC), hepatic veins/ portal veins (HV/ PV), bile duct (BD). Measurement (burst) of IVC should be performed approximately 2 cm from cavoatrial junction. C: Green arrow represents probe marker pointing cephalad in longitudinal view.

Identify the IVC (vs. aorta) by watching it drain into the right atrium, visualizing hepatic veins drain into the IVC, and fanning to patient's left to visualize the aorta separately. This

epigastric view is often referred to as the “Happy Whale Sign.” See depiction above. Sometimes, IVC can appear to be pulsatile secondary to referred pulsations from heart and/or Ao so do not rely on pulsations alone to delineate from aorta.

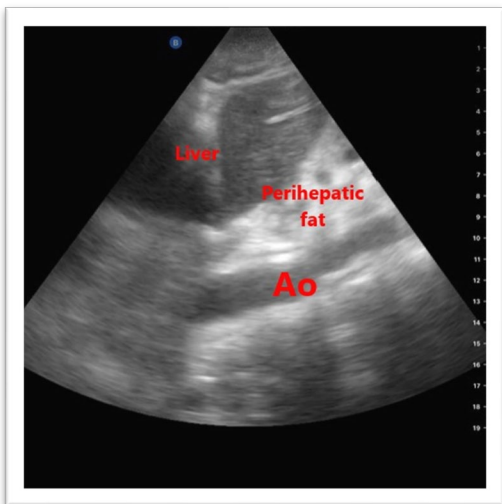
IVC diameter	IVC collapse (%)	CVP (mmHg)
<2.1	>50	0-5
<2.1	<50	5-10
>2.1	>50	5-10
>2.1	<50	10-20

Chart above is basic generalization of IVC findings correlated with CVP, though this is helpful, know that it is not a hard rule and there can be significant variation between findings and true CVP.

Aorta Longitudinal View

Probe marker: Obtain your transverse view, rotate your probe 90° clockwise, with the indicator towards the patient’s head.

Probe location: Place your probe below the xiphoid process, slightly left of midline to the patient. Fan to the patient’s left side from looking at longitudinal IVC. See image C above.



A.

A: Should visualize liver, perihepatic fat (oftentimes, though sometimes absent in smaller patients), and aorta (Ao).

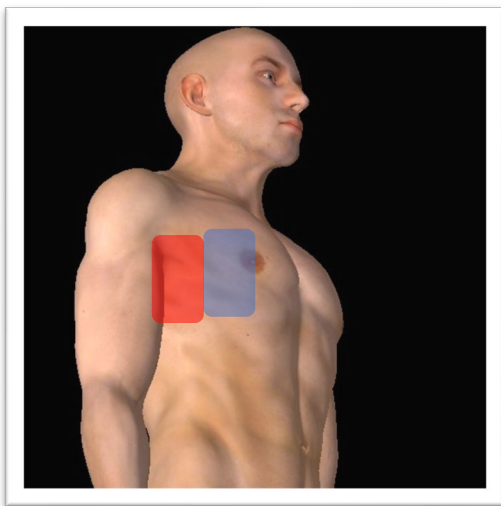
Anterior Lung

Probe: Phased array, linear for lung sliding

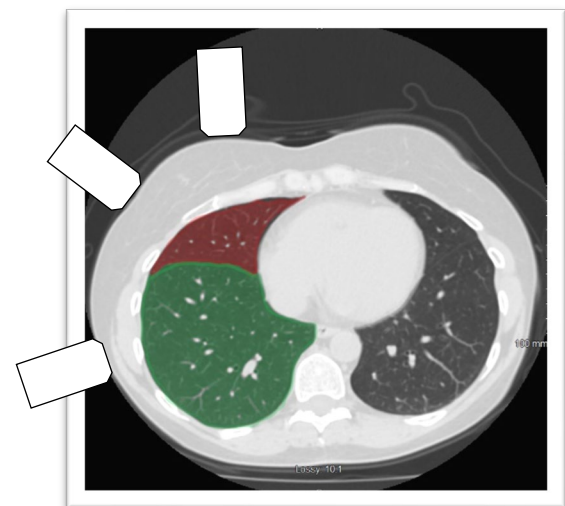
Preset: Lung

Probe marker: Cephalad

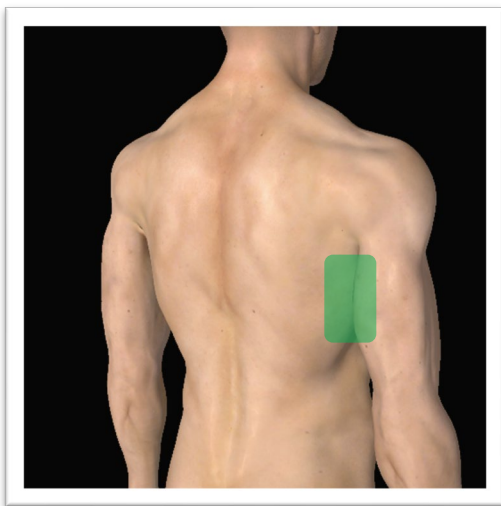
Probe location: Assess each of 6 zones pictured below (3 per hemithorax). Can increase from 6- point lung US to 12- point lung US by visualizing two intercostal spaces in each zone. General convention is to have probe longitudinal and span two separate rib spaces.



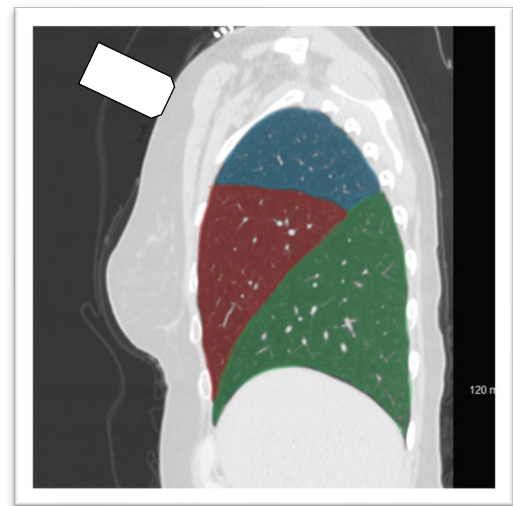
A.



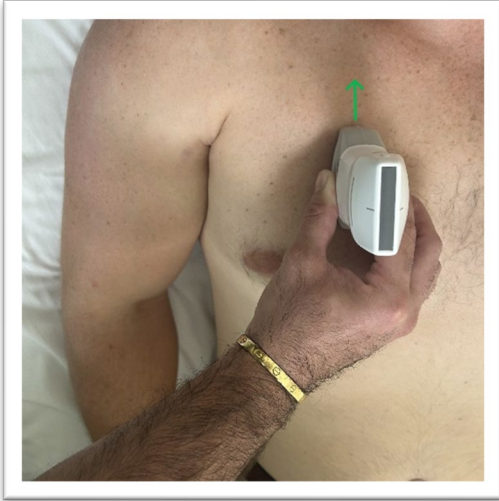
C.



B.



D.



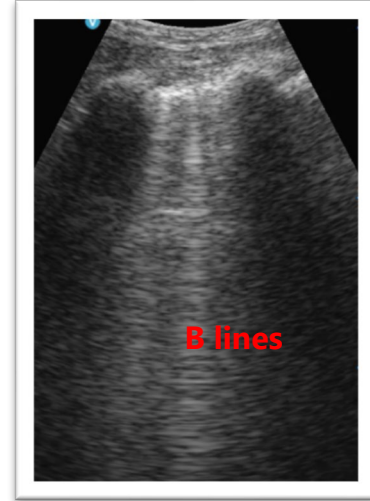
E.



H.



F.



I.



G.

A/B/C/D: 3 lung zones on hemithorax that, if performed bilaterally, create a 6 zone lung US exam. Each zone should be scan at multiple points. The zones will cover all three lung lobes as indicated by the accompanying CT scans. E. Anterior lung ultrasound, green arrow represents probe marker pointing cephalad. F. Zone 2 of lung US over anterior axillary line (black line). Green arrow represents probe marker pointing cephalad. Red line is posterior axillary line. G. PLAPS point, green arrow represents probe marker pointing cephalad. H. Should visualize pleural lining and A lines. Keep in mind, must be perpendicular to lung tissue and this is often not the same as being perpendicular to chest wall. I. B lines if present (requires three or more B lines for positive result).

Evaluate for lung sliding, AKA “ants on a log.” Presence of lung sliding can approach **100% sensitivity** for absence of pneumothorax and presence of **lung point** is **100% specific** for presence of pneumothorax.

6 zone approach is validated in literature and used in simplified BLUE protocol.

PLAPS (posterolateral alveolar and/or pleural syndrome) point is often your highest yield view. Demonstrated below and for our purposes, more often visualized in RUQ/LUQ views:

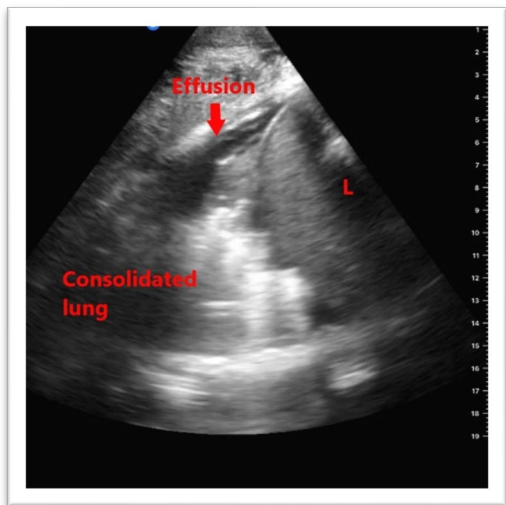


Image above is PLAPS point with consolidated lung and air bronchograms. Liver (L) noted on right side of screen.

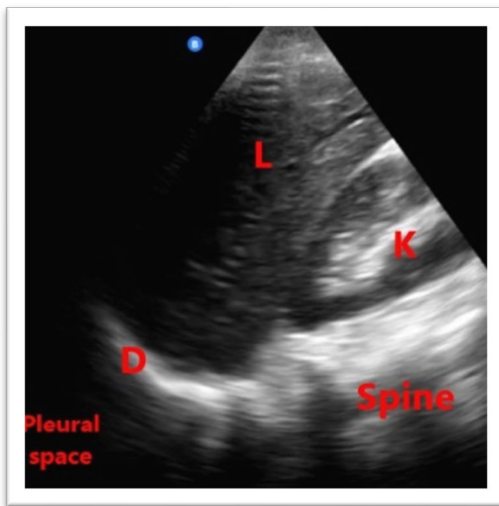
RUQ

Probe: Curvilinear (preferred), Phased-Array

Preset: Abdomen

Probe marker: Cephalad for longitudinal view, posteriorly for transverse view (to better assess the right kidney cross section)

Probe location: On the patient's right in the mid-axillary line at the 10th and 11th intercostal space.



A.



B.

A: Should visualize liver (L), kidney (K), diaphragm (D), pleural space, and spine in RUQ “home screen.” B: Probe location with green arrow representing probe marker pointing cephalad.

Potential space between liver and kidney is **Morrison's pouch** and is the location that fluid is most likely to accumulate in this view.

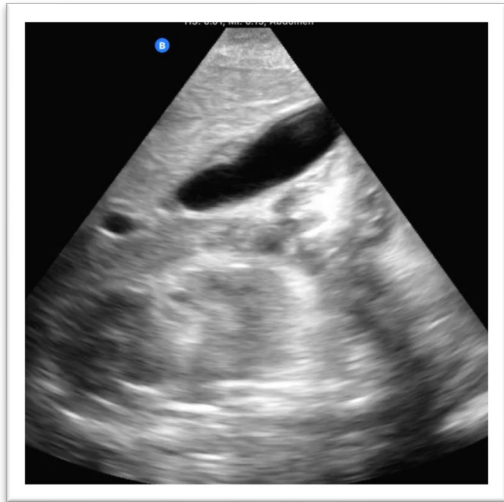
Gallbladder

Probe: Curvilinear, Phased-Array

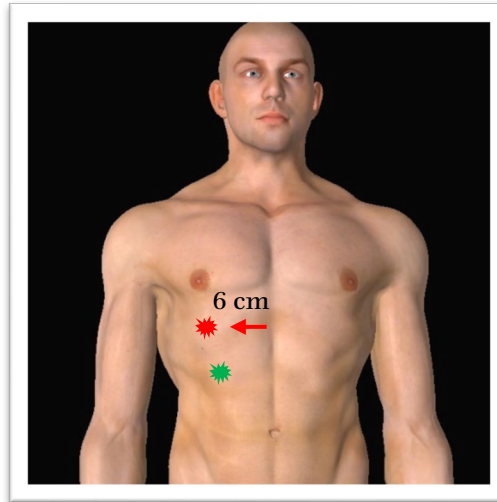
Preset: Abdomen

Probe marker: Start with probe marker towards patient' right side

Probe location: Can vary. Estimate approximately 6 cm left of sternal border and place probe in this area, under the lowest rib space. Find hypoechoic structure and slowly rotate and adjust image to achieve exclamation point sign



A.



B.

A: "Exclamation point sign." Gallbladder is line and the point is the portal vein. Often, you can see a "Mickey Mouse" sign at the point. The two additional, smaller, circles that can arise around the portal vein include the common bile duct and hepatic artery (these three vessels make up the portal triad). B: Two options for initiating view. Start by placing probe approximately 6 cm to patients right xiphoid in the intercostal space (red burst). My preferred location is subcostal, mid axillary line as a starting point (green burst). From here, using you 4 cardinal probe maneuvers to image and elongate the GB (subcostal sweep).

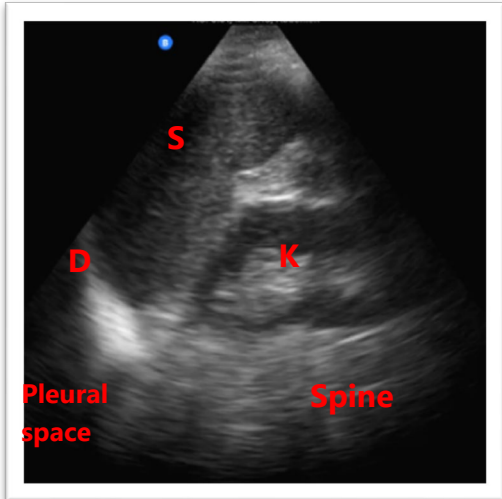
LUQ

Probe: Curvilinear, Phased-Array

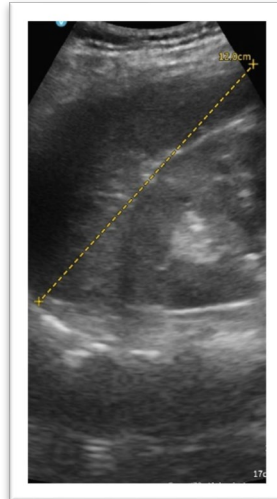
Preset: Abdomen

Probe marker: Cephalad for longitudinal view, anteriorly for transverse view (to better assess the left kidney)

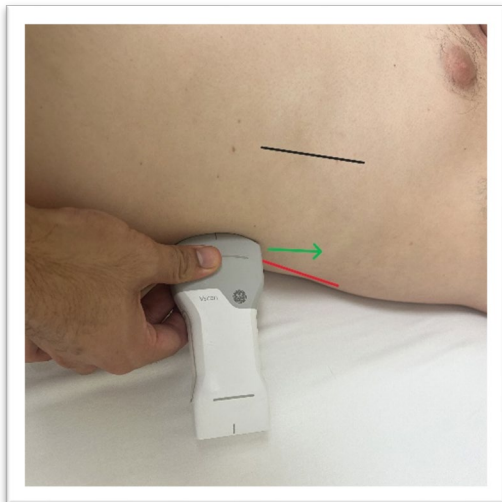
Probe location: Anchor your probe in the posterior axillary line around the 8th – 10th intercostal space



A.



B.



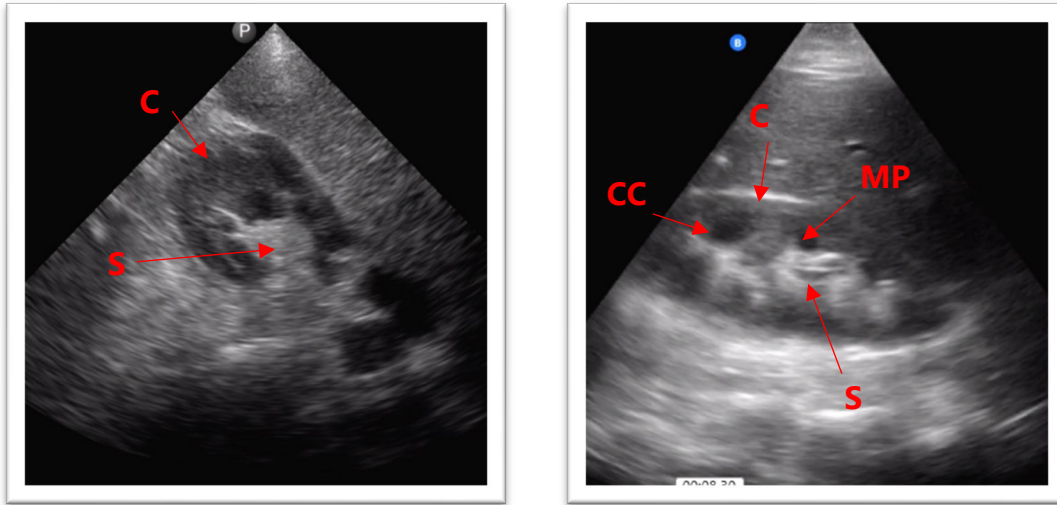
C.

A: Visualize the spleen (S), kidney (K), diaphragm (D), pleural space, and spine. B: Measurement of the spleen craniocaudally. Should be < 12 -14 cm. C: Probe placement with green arrow representing probe marker pointing cephalad.

Fluid is most likely to accumulate in the potential space between the spleen and the diaphragm.

Kidneys

Preset, probe marker and probe location similar to the RUQ and LUQ windows.



A/B: Should visualize the cortex (C), sinus (S), medullary pyramids (MP), and note cortical cyst (CC) when present as well.

Renal sinus is hyperechoic secondary to fatty content.

Suprapubic

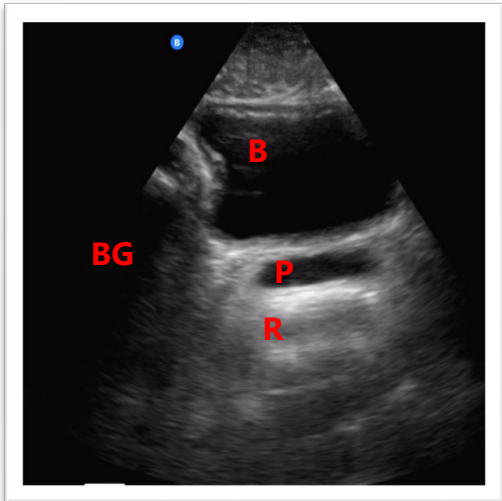
Probe: Curvilinear (Phased-Array)

Preset: Abdomen

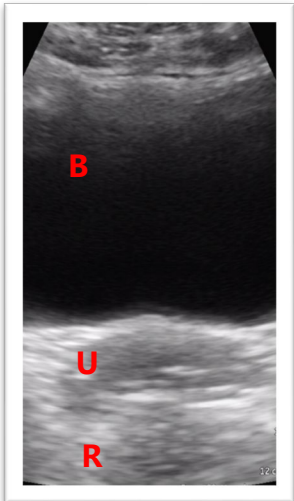
Probe marker: Cephalad for long-axis (longitudinal plane); patient's right for short-axis (transverse plane)

Probe location: Above pubic symphysis

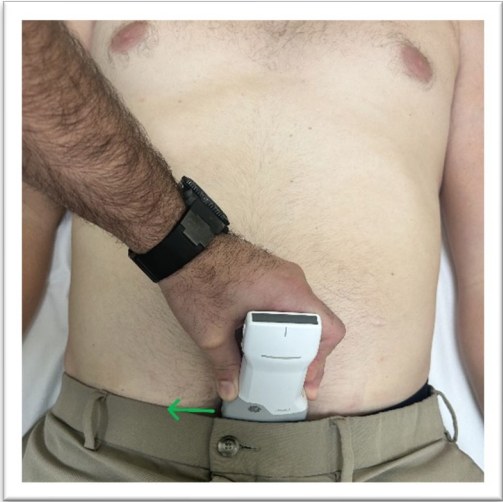
Transverse



A.

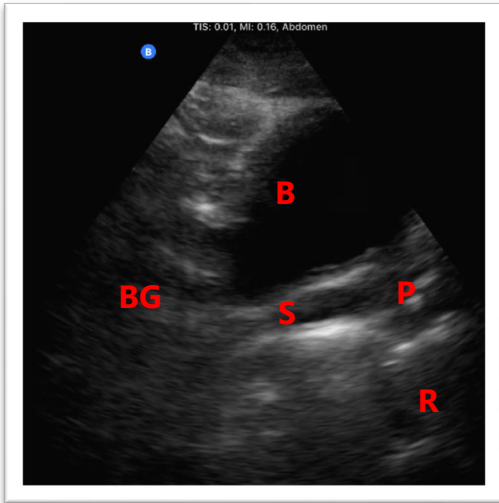


B.

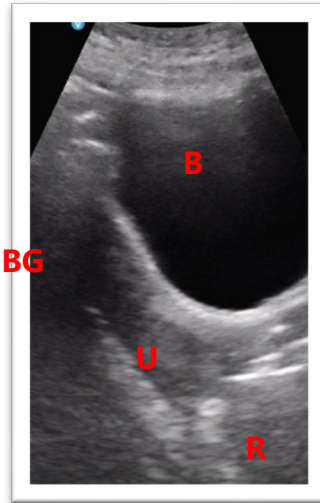


C.

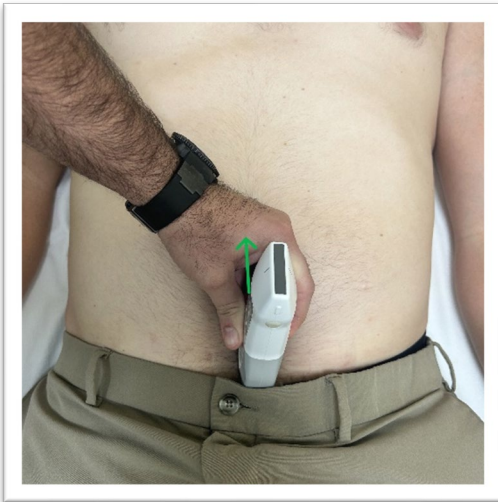
Longitudinal



D.

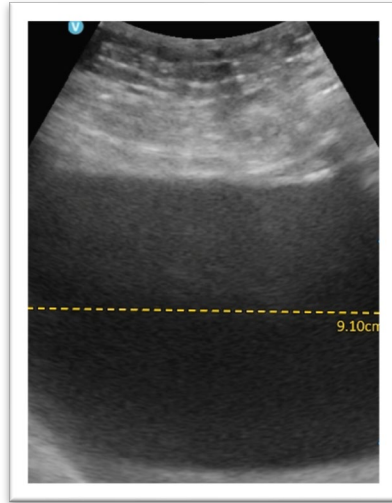
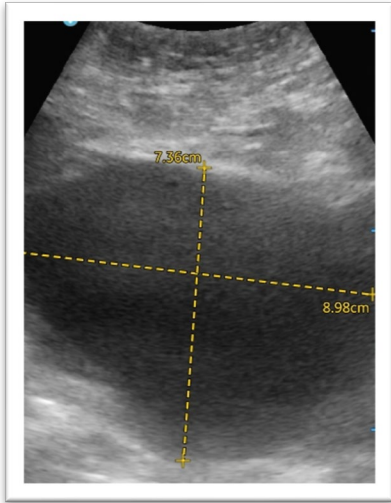


E.



F.

A/B/D/E: Visualize the hypoechoic bladder (B), uterus (U)/ prostate (P), rectum (R), bowel gas (BG), and sometimes the seminal vesicles in males (S). C: Demonstrates probe orientation with green arrow representing probe marker pointing towards patient's right. F: Demonstrates probe orientation with green arrow representing probe marker pointing cephalad.



Bladder volume: $(L \times W \times H) \times .72$ (mult. factor is variable)

Fluid is most likely to accumulate posterior to the bladder in males and posterior to the uterus in females

Artifact to be considered below is posterior acoustic enhancement. It may affect any pathology behind the bladder and can be improved on some machines by adjusting “far field” gain:

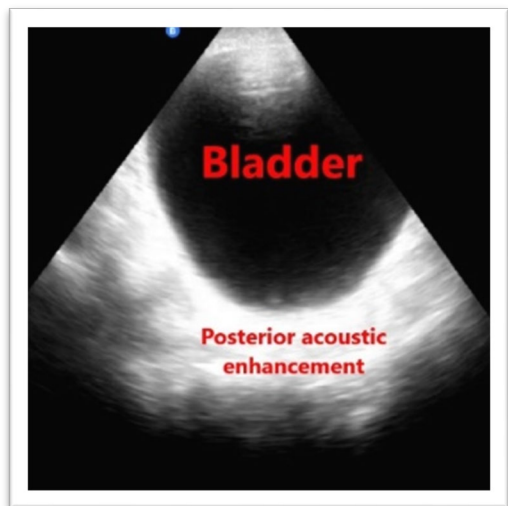


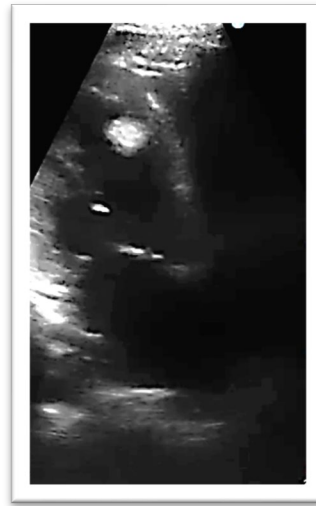
Image gallery

Keep in mind not all pathology can be adequately represented in a single snapshot of a complete scan and this gallery is certainly not complete.

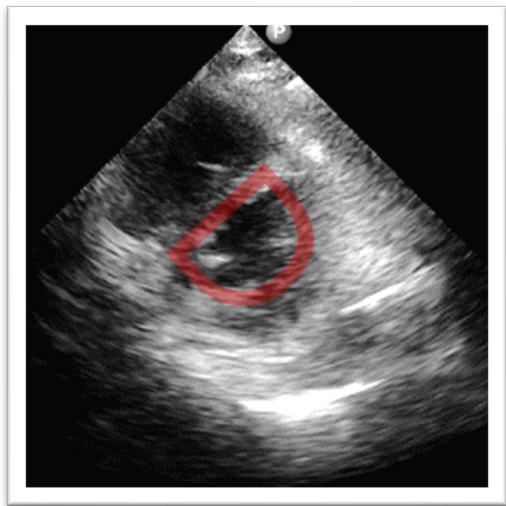
Parasternal



PLAX with reduced EPSS, severe LV dilation, and severe RA dilation.



LV thrombus. Image is reversed so the LV is on the left side of the screen.



"D" sign – IVS encroaches on LV due to increase RV pressures

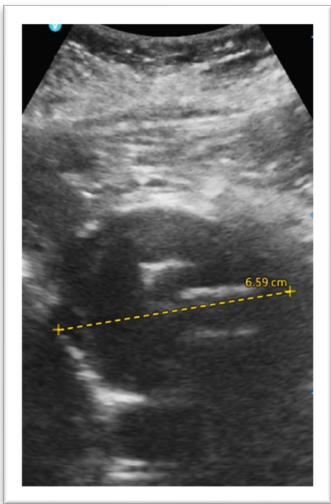


Severe LV hypertrophy



Pericardial effusion visualized in subX view

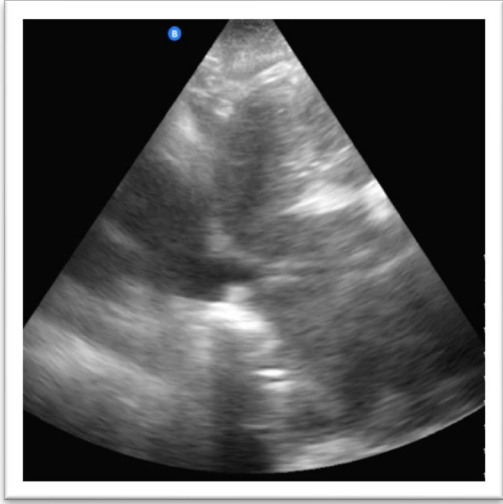
Epigastric



AAA



Abdominal aortic thrombus



"Sliver in the liver"

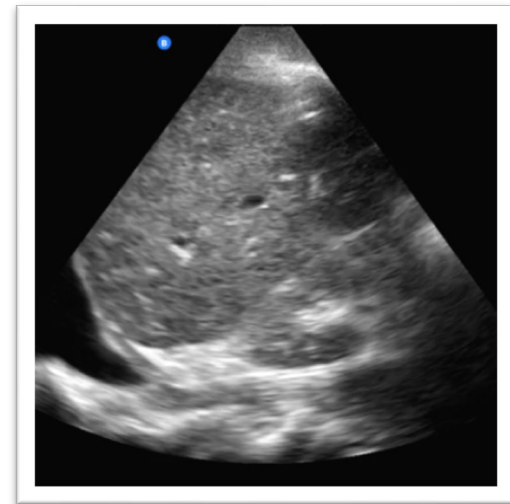


Plethoric IVC

Lung



Shred Sign



Spine sign with pleural effusion



Jelly fish sign



Fatty hernia above diaphragm

RUQ

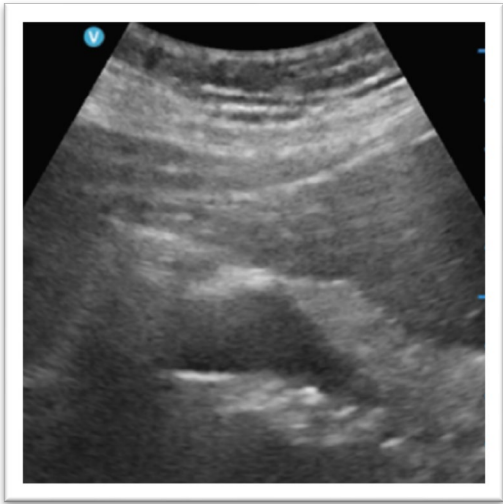


Hepatic steatosis. Note hyperechoic liver echogenicity.

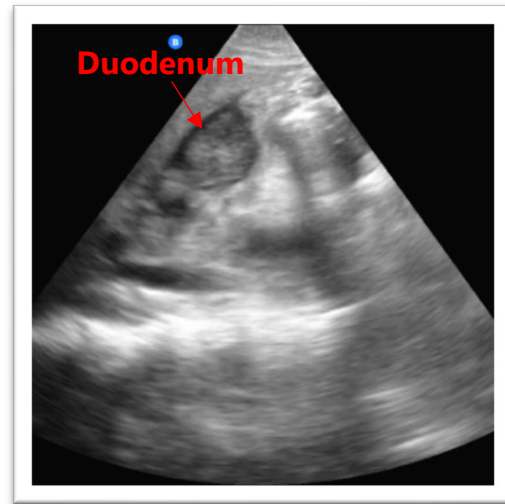


Liver cirrhosis (nodular border) with ascites fluid

Gallbladder

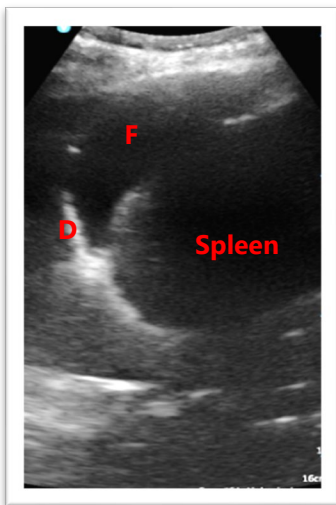


Layering of gallstones in gallbladder.



Portion of duodenum adjacent to liver that can often be mistaken for gallbladder. Note hypoechoic walls, filled isoechoic space, and you can often delineate the two by simply searching for the true gallbladder.

LUQ

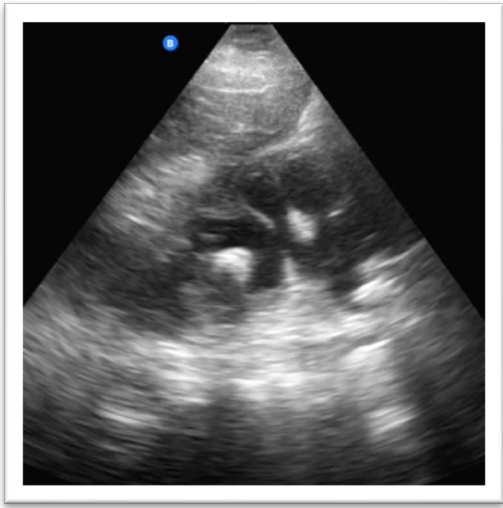


Fluid (F) accumulation between spleen (S) and diaphragm (D)



Splenomegaly with fluid accumulation, abnormal contour and echotexture.

Kidneys

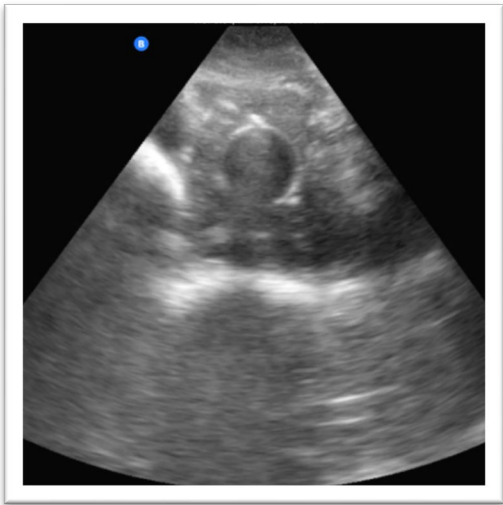


Hydronephrosis with kidney stones



PCKD

Suprapubic



Foley with decompressed bladder

Notes

Logbook

No.	Case ID	Date	Total time	Systems Viewed	Interpretation
1					
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POCUS Log



Device Check Out

