

THE  
Point of Care  
**ULTRASOUND**  
**HANDBOOK**

Bowman | Boitnott | Miesemer



**The RUSH Exam:  
FOAMed edition**





EMSPOCUS

**THE**

Point of Care

**ULTRASOUND**

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# The RUSH Exam:

## FOAMed edition



EMSPOCUS LLC. | [www.emspocus.com](http://www.emspocus.com) | @emspocus

## Rapid Ultrasound for Shock and Hypotension (RUSH)

Patients who have unexplained tachycardia, tachypnea, hypotension or are in cardiac arrest may benefit from the RUSH exam to identify potentially treatable causes such as: **AAA, pulmonary embolism, CHF, sepsis, ruptured ectopic pregnancy, hypovolemia, pneumothorax, hemothorax, and hemoperitoneum.**

**Tip:** The complete RUSH exam is a standardized diagnostic approach for the truly undifferentiated shock patient. Use more focused exams such as the serial fluid status assessment or other individual exams when possible.

**H**EART

**I**VC

**M**(FAST Exam)  
**O**RISON'S

**A**ORTA

**P**ULMONARY

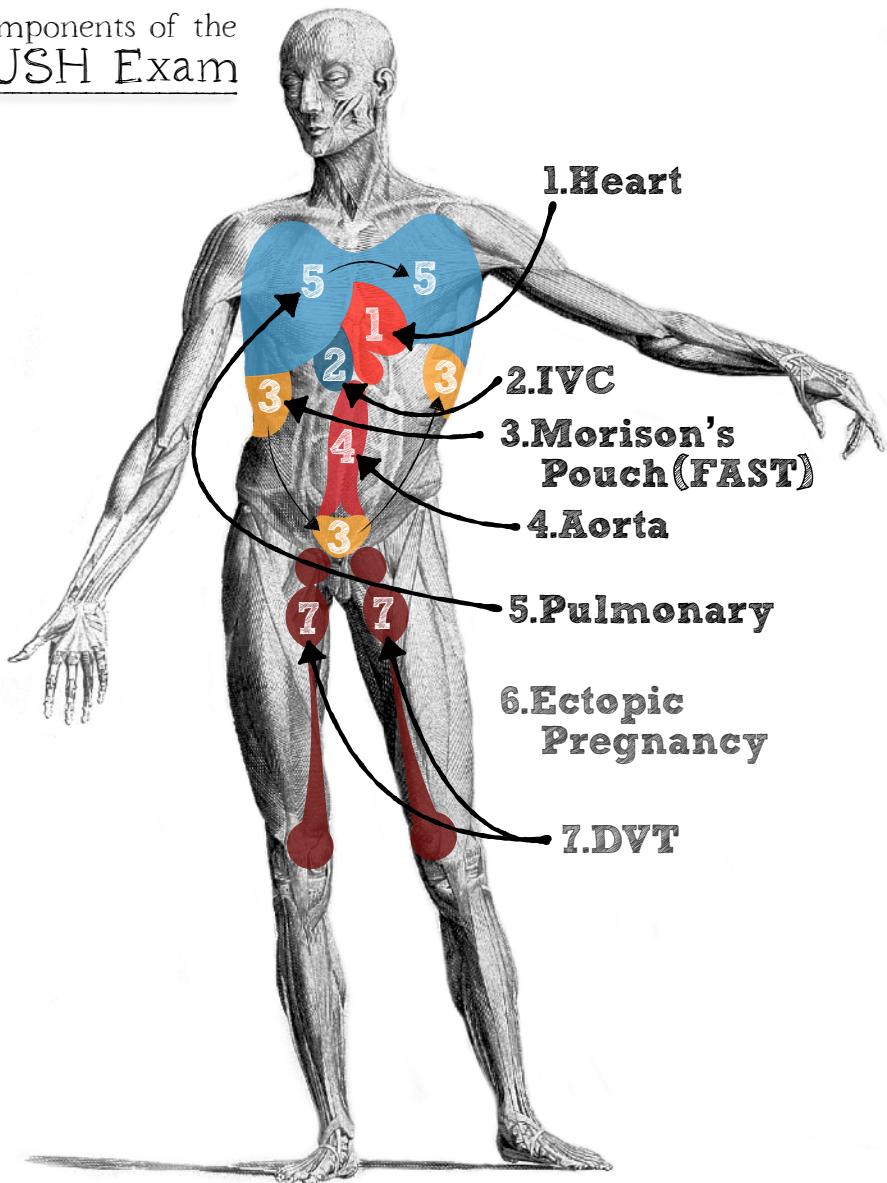
**E**(Pregnancy)  
**E**CTOPIC

Optional  
**D**VT

USE THE MNEMONIC "HIMAP-ED" TO  
REMEMBER THE STEPS OF THE RUSH EXAM

## Rapid Ultrasound for Shock and Hypotension (RUSH)

### Components of the RUSH Exam



**Cardiac****Probe**

Phased

**Exam Mode**

Cardiac or FAST

**Starting Depth**

16 cm

The point-of-care cardiac ultrasound exam is used to identify cardiac tamponade, look for causes of shock, and to assess overall cardiac function in the undifferentiated sick patient. When combined with the lung and IVC exam the cardiac exam can help guide initial treatment.

**Approach to the Exam:****1** Look for Tamponade**2** Assess global cardiac function**3** Compare the size of the ventricles**TAMPONADE**

- Evaluate for free fluid around the heart. Be careful not to mistake the anterior fat pad for free fluid. If fluid is found, evaluate the right heart for signs of tamponade.

**CARDIAC FUNCTION**

- Evaluate overall cardiac function. Good mitral valve motion in the parasternal long axis view can be a helpful indicator of good cardiac output.

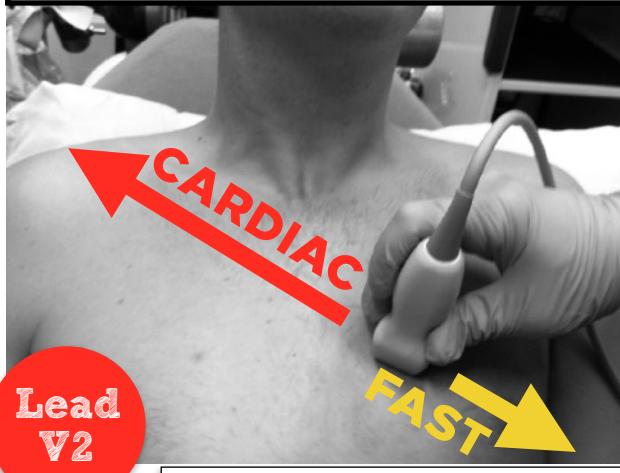
**RIGHT VS LEFT**

- The right ventricle should be visibly smaller than the left ventricle. If it is not consider the patient history. If long standing COPD or pulmonary HTN, this is likely chronic. If they have new onset SOB this may be signs of an acute pulmonary embolism. Evaluate as such. Consider a DVT exam.

## Cardiac - Parasternal Long Axis (PLAX or PSL)

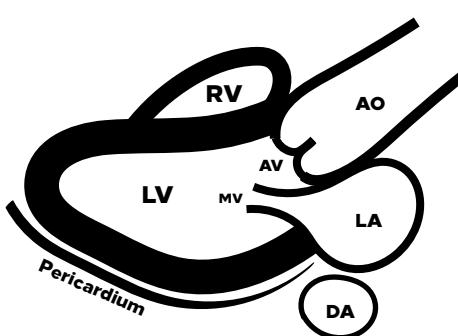
The parasternal long axis view (PLAX) is a great starting point for cardiac POCUS. Use the location of ECG lead V2 to place the probe. The PLAX view is great for identifying cardiac function, but be sure not to confuse an anterior fat pad for an effusion.

### Parasternal Long Axis (PLAX)

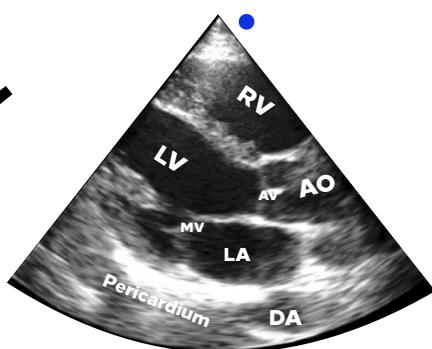


**The Orientation Dilemma:** One of the most confusing aspects of the PLAX view is the orientation marker. Radiologists and cardiologists use different imaging conventions. Therefore when the machine goes into cardiac mode it flips the image. This means to maintain the same image orientation, the probe needs to be pointed in different directions depending on if you're in cardiac mode or any other mode. Hence the two orientation directions.

ORIENT THE PROBE TOWARDS THE RIGHT SHOULDER IN CARDIAC MODE AND TOWARDS THE LEFT HIP IN ALL OTHER MODES



THE MITRAL VALVE "SLAPPING"  
THE SEPTUM IS A SIGN OF  
GOOD CARDIAC FUNCTION



NOTICE THE RIGHT VENTRICLE IS  
ALWAYS ON TOP AND IS SMALLER  
THAN THE LEFT VENTRICLE

## Cardiac - Subxiphoid View (SUBX)

The subxiphoid view is the other mainstay of cardiac POCUS. This view is commonly used in the FAST exam as it is more sensitive for pericardial fluid. It can also be easier to obtain in COPD patients whose lungs may obscure the PLAX view. Be comfortable with both views.

**Subxiphoid (SUBX)**

USE A SCOOPING MOTION TO GET UNDER THE XIPHOID. NO FINGERS UNDER THE PROBE AS IT SHOULD BE NEARLY FLAT

**How much fluid is bad?:**

The SUBX view is the most sensitive for picking up PCE. It is so sensitive that it can pick up a physiologic amount of fluid. So how much free fluid is bad? Knowing the anatomy can help. The top of the image in SUBX is the lowest part of the heart, where fluid will collect first. Pathologic free fluid will then collect and move around the apex of the heart. Beware, loculations can limit this. Also, the area near the atria has many vessels that can mimic free fluid accumulations to the novice sonographer.

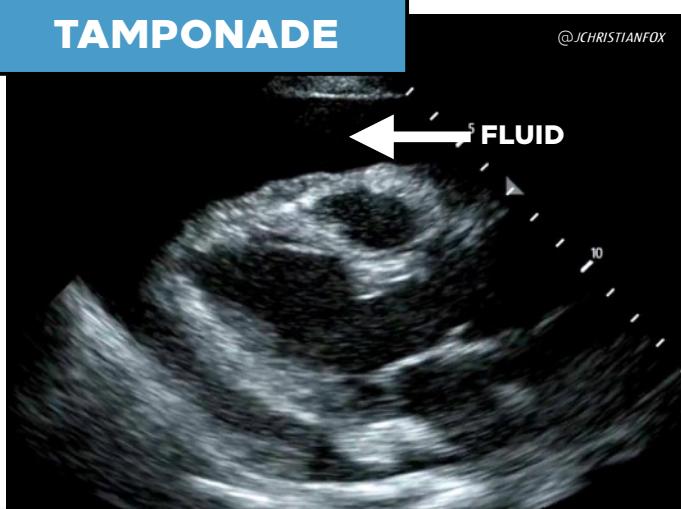
THE SUBXIPHOID VIEW IS THE MOST SENSITIVE FOR PICKING UP TAMPONADE

NOTICE THE RIGHT VENTRICLE IS ALWAYS ON TOP AND IS SMALLER THAN THE LEFT VENTRICLE

## Cardiac - Tamponade

Identifying cardiac tamponade is one of the most valuable uses of POCUS. While a full echo is required to truly quantify compartment pressures in some borderline cases, there are some basic and easy to spot signs that should not be missed.

### TAMPONADE

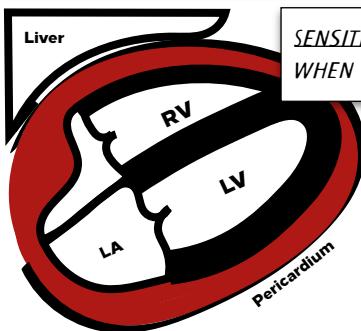


@JCHRISTIANFOX

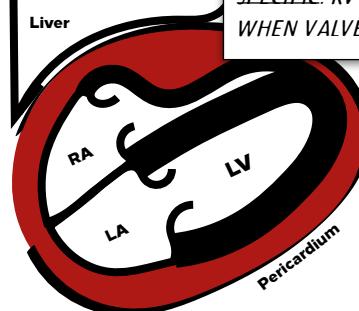
3.19.14 PM  
Made In Oscar

THESE ULTRASOUND FINDINGS IN AN UNSTABLE PATIENT ARE INDICATIONS FOR AN EMERGENCY PERICARDIOCENTESIS.

**The big ones:** Very large effusions are rarely a cause of acute tamponade. Often the large effusions have taken months to develop, by this time the pericardium has stretched to accommodate them. Medium sized effusions are much more likely to be a problem as they have likely accumulated over hours to days, not enough time for the pericardium to adapt to them.



**Diastole**



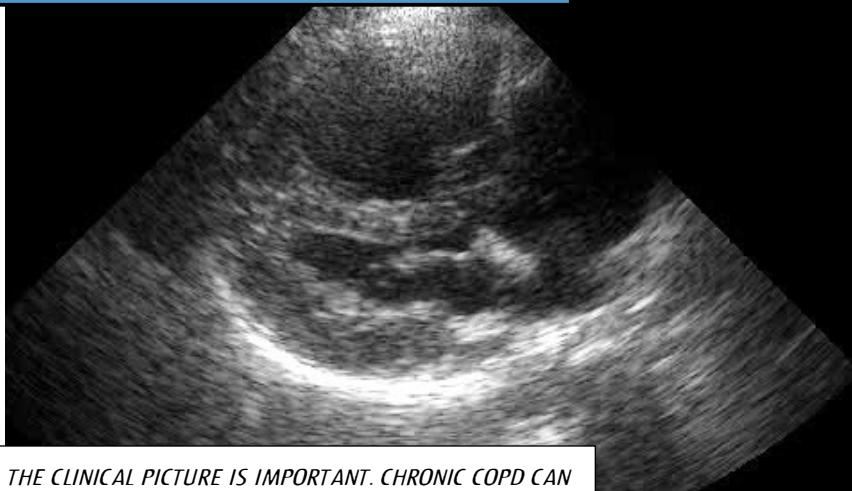
**Systole**

## Cardiac - Pulmonary Embolism

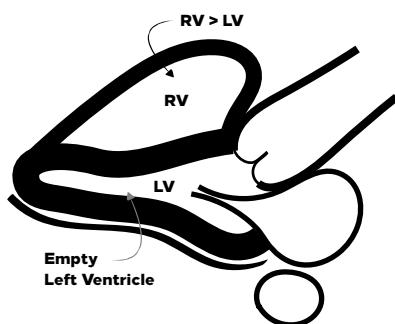
Pulmonary embolism identification on echo hinges upon determining acute vs chronic pulmonary hypertension and the signs thereof (cor pulmonale). This can be difficult, but with the easy ability to clinically correlate your findings provided by POCUS, it is possible to do.

### PULMONARY EMBOLISM

DAVE SPEAR MD



THE CLINICAL PICTURE IS IMPORTANT. CHRONIC COPD CAN ALSO CAUSE THE RV TO BECOME LARGER THAN THE LV.

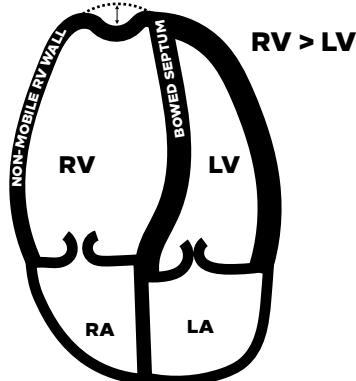


CONSIDER CHECKING FOR D-SIGN  
IN THE PARASTERNAL SHORT VIEW

FOR THE DIAGNOSIS OF ACUTE PE  
THE IVC MUST ALSO BE ENLARGED

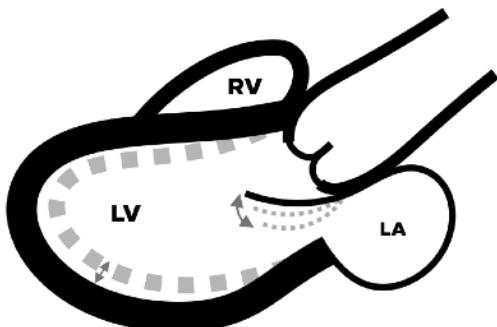
SUGGESTIVE FOR ACUTE RV STRAIN

McConnell's Sign



## Cardiac - Visually Estimating EF%

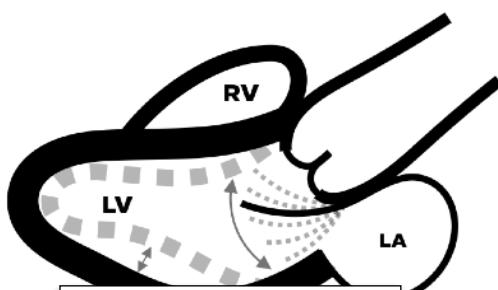
There are many ways to estimate ejection fraction (EF%) using ultrasound. While not nearly as accurate as actually measuring it, it is possible to pick out the extremes of cardiac function by nothing more than eyeballing it.



### Poor Heart Failure?

Compared to cardiologists, emergency physicians were able to visually identify low EF% with a sensitivity of 98.7% and specificity of 87.9%

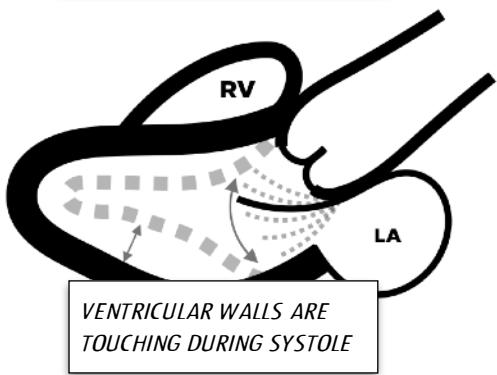
-Unluer et al, 2014, WJEM



**USE MITRAL VALVE MOTION TO ESTIMATE CARDIAC FUNCTION.**

### Normal Non-contributory

Mitral valve motion can be a good marker of cardiac function. Measuring this is called the E-Point Septal Separation (EPSS). Informally seeing good mitral motion is an indicator of good EF%.



**VENTRICULAR WALLS ARE TOUCHING DURING SYSTOLE**

### Hyperdynamic Sepsis? Hypovolemia?

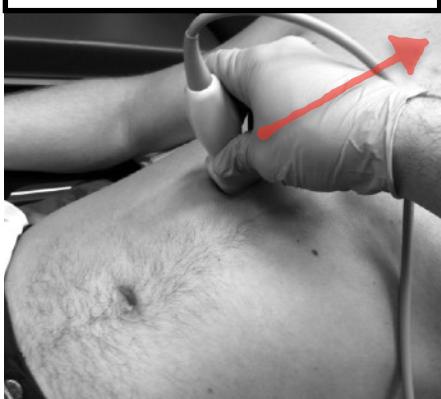
While only 33% sensitive, a hyperdynamic EF% on initial presentation to the emergency department was 94% specific for sepsis.

- Jones et al, 2005, Shock

## Inferior Vena Cava (IVC)

Examining the IVC gives an estimate of central venous, right atrial and right ventricular end diastolic pressures. The IVC provides information on fluid status, as well as right ventricular and cardiac function.

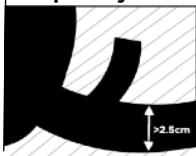
### IVC Exam



- 1 Place probe to the right of midline with the marker towards the head.
- 2 Identify the IVC and align the probe along it lengthwise
- 3 If spontaneously breathing, let the patient breath normally
- 4 If IVC is large, have patient sniff 3 times to assess for complete loss of collapsibility

### Large

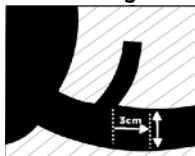
No respiratory variation



PE? CHF? Tamponade?

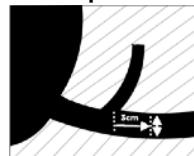
### Normal

Resting



Reversed with positive pressure ventilation

Inhalation



### Collapsed

Collapsed



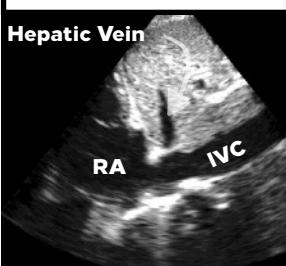
Sepsis? Hypovolemia?

IVC MEASUREMENT IS MOST USEFUL AT THE EXTREMES AND SHOULD NOT BE USED TO CALCULATE A QUANTITATIVE CVP NUMBER

CLINICAL JUDGEMENT COMBINED WITH SERIAL IVC ASSESSMENTS IS THE BEST APPROACH

### Normal IVC

Hepatic Vein



IDENTIFYING THE IVC:

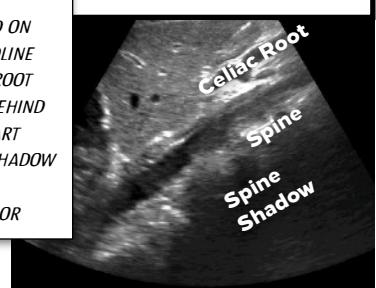
- LOCATED TO THE RIGHT OF MIDLINE
- HEPATIC VEIN
- GOES INTO THE RIGHT ATRIUM
- CAN VISUALIZE TISSUE POSTERIOR

IDENTIFYING THE AORTA:

- LOCATED ON THE MIDLINE
- CELIAC ROOT
- DIVES BEHIND THE HEART
- SPINE SHADOW BLOCKS POSTERIOR

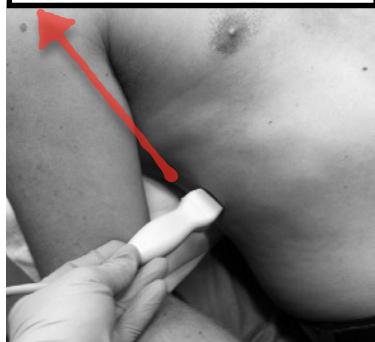
### Normal Aorta

Celiac Root  
Spine  
Spine Shadow



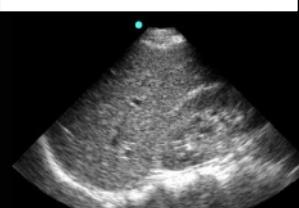
The RUQ (Morison's Pouch) window is relatively easy to obtain. Be sure to visualize the kidney and obtain clips/images from the diaphragm, down through Morison's Pouch, and through to the caudal tip of the liver.

### RUQ Exam



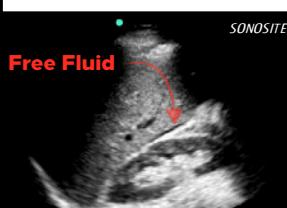
- 1 Place probe on the patients right side midaxillary with marker towards head. Touch your knuckles to the cot.
- 2 Angle the probe to identify the kidney and Morisons pouch. Save a clip.
- 3 Slide the probe towards the head to visualize the diaphragm and assess for spine sign. Save a clip.
- 4 Slide the probe towards the feet to visualize the caudal tip of the liver. Save a clip.

### Normal RUQ Exam



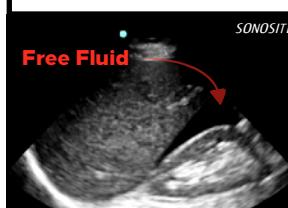
SOME MEDICAL CONDITIONS MAY MIMIC BLOOD IN THE ABDOMEN, SUCH AS ASCITES FROM LIVER FAILURE. IT IS IMPORTANT TO SCREEN YOUR PATIENTS FOR POTENTIAL MEDICAL CAUSES OF A POSITIVE FAST EXAM.

### Trace Free Fluid



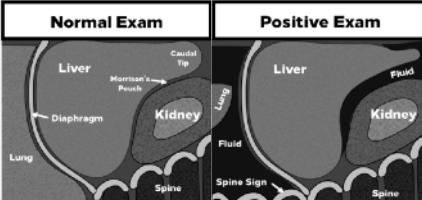
IT TAKES UP TO 500 CC OF FREE FLUID FOR THIS EXAM TO BE POSITIVE. A negative exam does not mean your patient is not bleeding!

### Free Fluid



FRESH BLOOD WILL APPEAR BLACK, WHILE CLOTTED BLOOD MAY TAKE ON A MORE GRAYISH APPEARANCE.

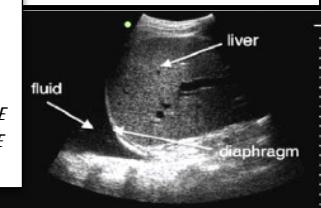
#### Normal Exam



#### Positive Exam

**SPINE SIGN:** AIR IN THE LUNGS DESTROYS THE IMAGE OF THE SPINE ABOVE THE DIAPHRAGM. IF THE SPINE IS VISIBLE ABOVE THE DIAPHRAGM THERE IS FLUID IN THE CHEST.

### Fluid in Chest



## Aorta

**Probe**

Phased/Curved

**Exam Mode**

ABD or FAST

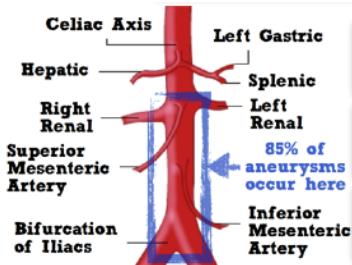
**Starting Depth**

11-16

AAA's are more common in older smokers, but some genetic conditions can predispose younger patients as well. They are often asymptomatic until rupture. Mortality goes up every hour after.



- 1 Apply a line of gel down the midline from the xiphoid to the umbilicus.
- 2 Place probe on the patients midline just below the xiphoid process with the marker towards the patients right. (Short Axis)
- 3 Identify the IVC and the aorta with spine behind it.
- 4 With firm, steady pressure, scan down the length of the aorta and through the iliac bifurcation. Apply manual traction to move the umbilicus to the right if needed. Save a clip.



YOU MUST SCAN THROUGH THE ILIAC BIFURCATION TO RULE OUT AAA

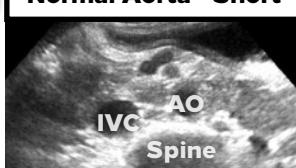
Iliac artery aneurysm: > 1.5 cm



SCROTAL ECCHYMOSIS, AKA.  
BRYANT'S SIGN, CAN BE AN EARLY  
INDICATOR OF A RUPTURED AAA.

< 3cm	Normal Aorta
3 - 5cm	requires follow up
5.5 - 7cm	surgical candidate
> 7cm	RUPTURE RISK: SURGERY!

Normal Aorta - Short



CORRECT IDENTIFICATION OF THE AORTA IS EXTREMELY IMPORTANT.  
IT IS EASY TO MISTAKE THE IVC FOR THE AORTA. LOOK FOR THE SPINE & SHADOW BEHIND IT.

AAA - Short



MEASURE FROM OUTSIDE TO OUTSIDE.  
MEASURING THE INNER LUMEN WILL GREATLY UNDERESTIMATE THE SIZE OF THE AAA DUE TO THE LARGE CLOT BURDEN COATING THE WALLS.

## Pulmonary Ultrasound

<b>Probe</b>	Any	<b>Exam Mode</b>	Lung or FAST	<b>Starting Depth</b>	6 cm
--------------	-----	------------------	--------------	-----------------------	------

The pulmonary ultrasound serves two purposes. First, to identify if the lung is ventilated and “up” via sliding lung sign (SLS). Second, to identify pulmonary pathology such as a wet lung (edema) a consolidated lung (pneumonia) or a dry lung (normal or COPD/RAD).

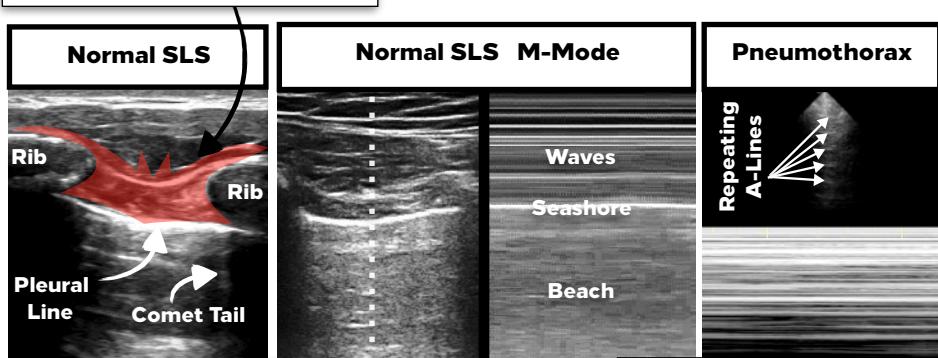


DONT GET TOO CLOSE TO THE HEART

- 1 Place probe in the 2nd to 3rd intercostal space, midclavicular, with the marker towards the head.
- 2 Identify the rib interspace “batwing sign”. Look for SLS. Label and save a clip.
- 3 Repeat the exam on the other side. Label and save a clip.
- 4 If looking for edema or pneumonia repeat exam midaxillary bilaterally. Save clips.

BIZARRE LOOKING SET OF BATWINGS,  
BUT THAT'S WHAT THEY CALL THIS SIGN.

IF YOU'RE HAVING DIFFICULTY FINDING SLIDING LUNG SIGN  
YOU CAN USE M-MODE, BUT IT IS NOT A NECESSITY.



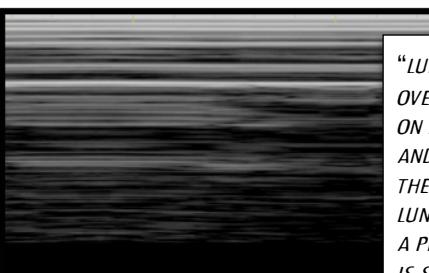
“SEASHORE” SIGN AKA “WAVES ON A BEACH”  
IS THE NORMAL SLS FINDING IN M-MODE

“BARCODE” SIGN IS INDICATIVE OF  
A PNEUMOTHORAX ON M-MODE

# **Confirming a Pneumothorax**

## **Lung Point**

Lung Air

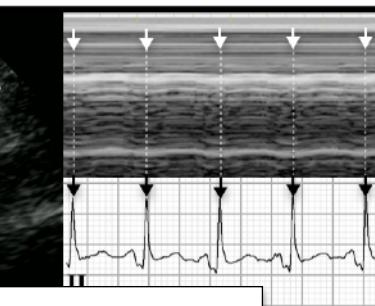


# **Specificity:**

**"LUNG POINT" - WHEN THE PROBE IS OVER THE EDGE OF A PNEUMOTHORAX. ON INSPIRATION THE LUNG EXPANDS AND TEMPORARILY TRAVERSES UNDER THE PROBE. DURING EXPIRATION THE LUNG CONTRACTS AND THE PROBE SEES A PNEUMOTHORAX AGAIN. LUNG POINT IS SPECIFIC FOR PNEUMOTHORAX.**

*LUNG POINT CAN BE A LITTLE TRICKY, SO TAKE YOUR TIME.  
BEWARE THE LEFT UPPER CHEST, THE HEART CAN MIMIC BOTH  
LUNG POINT AND LUNG PULSE IF YOU GET TO CLOSE TO IT.*

Lung Pulse



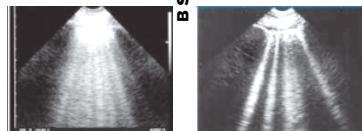
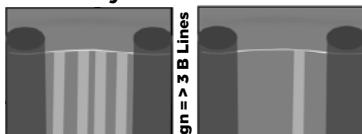
LUNG PULSE CAN ALSO BE A SIGN OF PNEUMONIA IN AREAS OF COMPLETE ATTELESTASIS

**“LUNG PULSE” IS CAUSED BY A NON-VENTILATED LUNG. INSTEAD OF LUNG SLIDING WITH RESPIRATORY RATE, THE LUNG SLIDES WITH THE HEART RATE DUE TO CARDIAC MOTION. THIS CAN BE A SIGN OF ATELECTASIS IN THE SPONTANEOUSLY BREATHING PATIENT. IN THE RECENTLY INTUBATED, IT CAN BE INDICATIVE OF A MAINSTEM BRONCHIAL INTUBATION.**

## Pulmonary Ultrasound

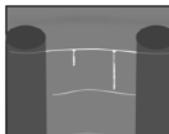
### B Sign    B Line    Comets    A Lines    C Line

Pulmonary Edema    Some Fluid

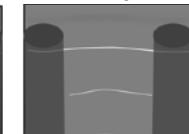


Sensitivity: 97%

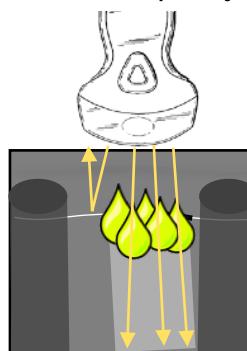
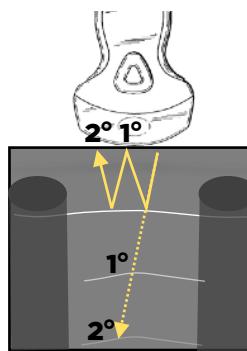
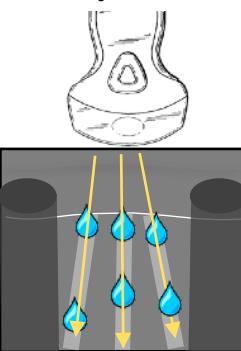
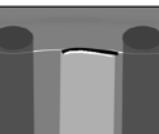
Normal



Normal/Dry or PTX



Pneumonia



### B Lines

Rib    Rib

↑    ↑    ↑  
B Lines

**Edema**

### A Lines

Pleura

→  
A Lines  
→  
→

**Dry Lungs**

### C Lines

Consolidation

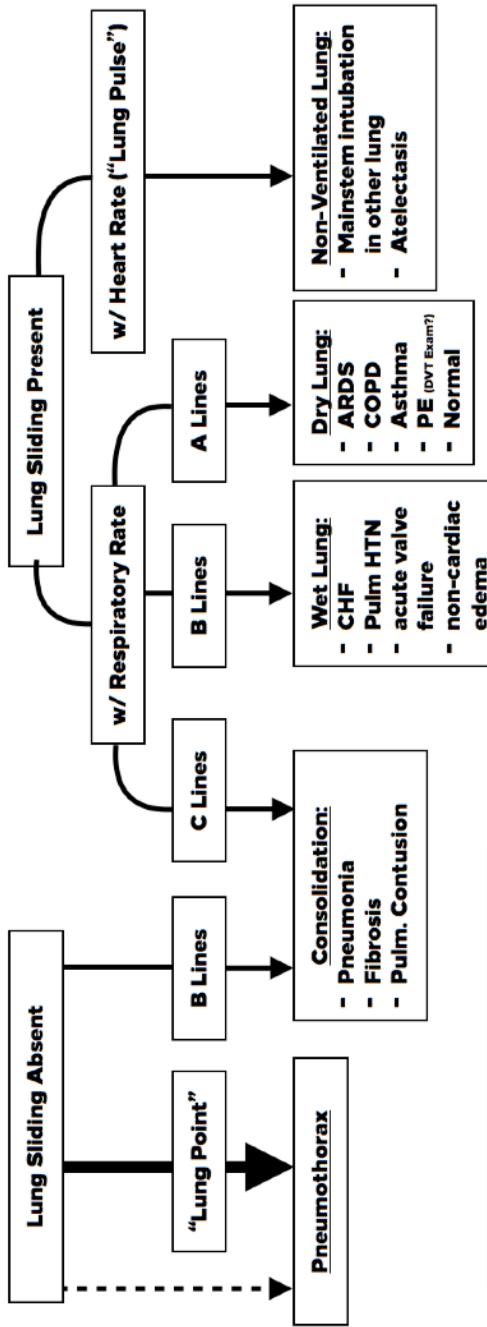
→  
→  
C Line

**Consolidation  
(Pneumonia)**

A THICK, IRREGULAR PLEURAL LINE COMBINED WITH A THICK, VERTICAL HYPER-ECHOIC STRIPE IS A C LINE. "AIR BRONCHOGRAMS" FURTHER CONFIRM THE DIAGNOSIS OF PNEUMONIA.

# Pulmonary Ultrasound

## Approach to pulmonary ultrasound:



*ALL FINDINGS REQUIRE CLINICAL CORRELATION.  
ADAPTED FROM THE BLUE PROTOCOL.*

# Intra-Uterine Pregnancy

Probe

Phased or  
Curved**Exam  
Mode**

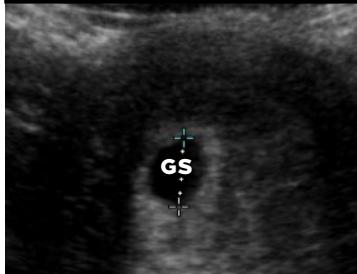
OB

**Starting  
Depth**

16 cm

Determining IUP helps rule out ectopic pregnancy (heterotopic pregnancy is extremely rare). Definition of an IUP= GS + YS or Fetal Pole, surrounded by a thick myometrium (EMM > 8 mm in 2 planes). Double decidual sign is not a reliable sign of IUP.

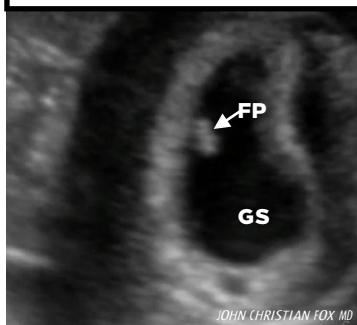
## Gestational Sac (GS)



## GS + Yolk Sac (YS)



## Fetal Pole



## Stages of an IUP

4.5 Weeks

Gestational Sac

4-6 Weeks

Double Decidual Sign

5-6 Weeks

Yolk Sac

B-Hcg  
1500 (TV)  
3000 (TA)

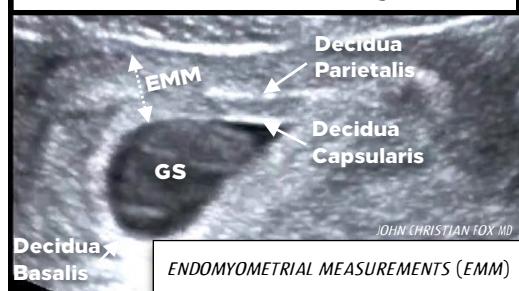
6 Weeks

Fetal Pole / FHR

B-Hcg  
>3000

FETAL POLE OF >5MM SHOULD FIND  
HEART BEAT IN TRANSGASTRIC (TV)

## Double Decidual Sign



JOHN CHRISTIAN FOX MD  
ENDOMYOMETRIAL MEASUREMENTS (EMM)  
SHOULD BE GREATER THAN 8MM IN THE  
THINNEST PLACE IN TWO PLANES.

## Ruptured Ectopic Pregnancy

Probe

Phased or  
Curved**Exam  
Mode**

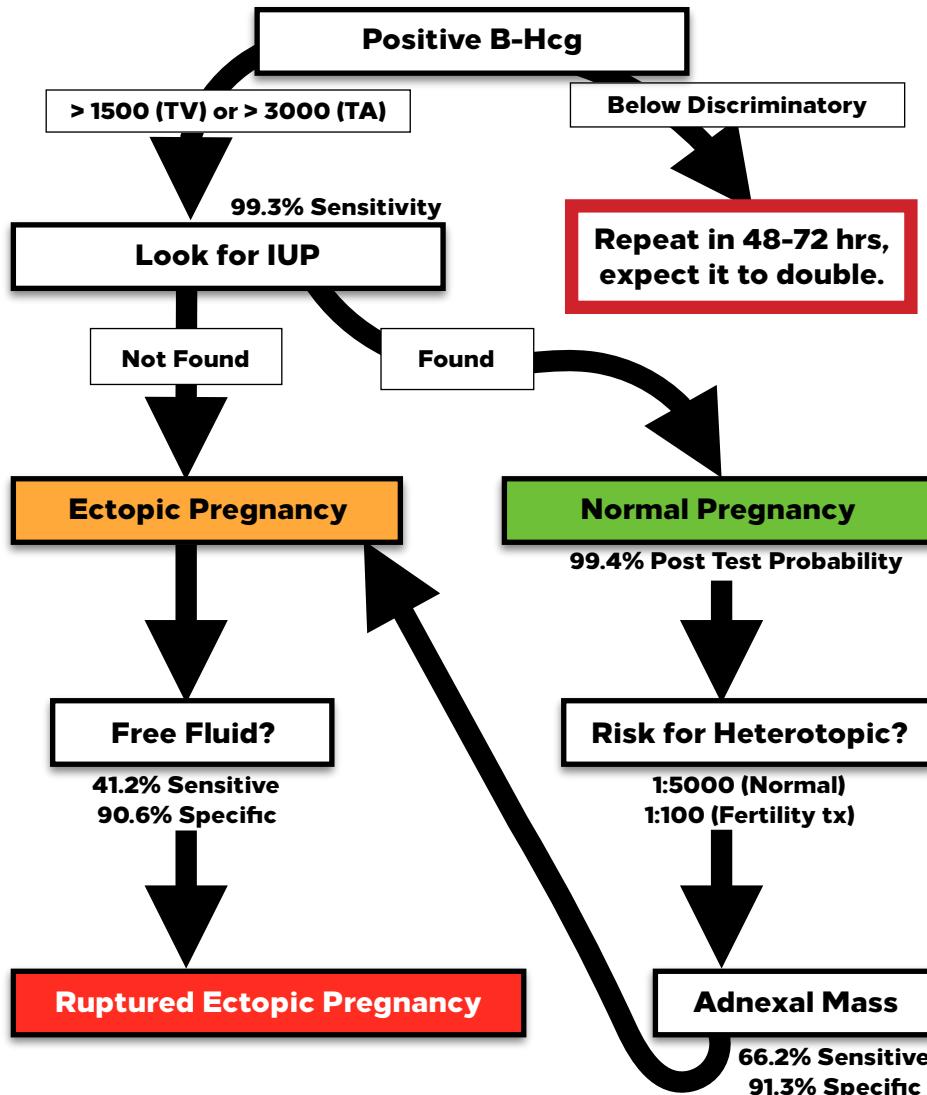
OB

**Starting  
Depth**

16 cm

Ruptured ectopic pregnancy is the leading cause of mortality in the first trimester and is responsible for ~10% of all pregnancy related deaths. Keep this diagnosis in mind.

### Ectopic Flow Chart



**DVT****Probe**

Linear

**Exam Mode**

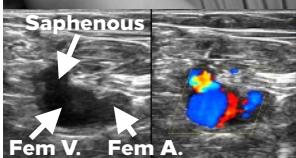
Vascular

**Starting Depth**

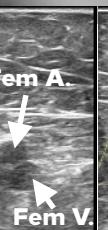
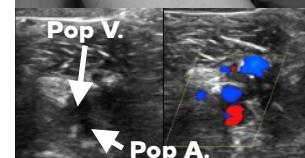
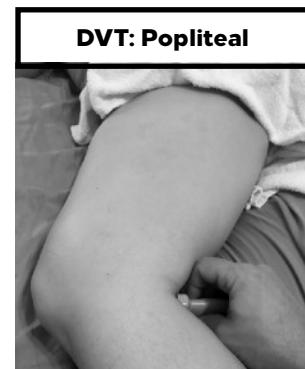
4 cm

The DVT exam can be conducted as part of the RUSH exam. If there is any concern for possible PE, the presence of DVTs should be assessed for. 50% of DVT's can go on to cause PEs.

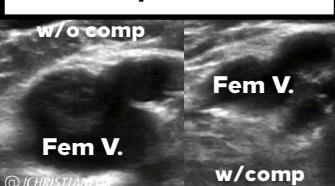
- 1 Remove the patients pants and drape for modesty. Position the legs in a frog leg position.
- 2 Label the image as left or right, place the probe in the inguinal crease with marker to right. Identify the saphenous junction.
- 3 Turn on color doppler, apply and release pressure. The goal is to compress the vein completely without compressing the artery. Save a clip.
- 4 Repeat at the femoral and popliteal arteries. Repeat on the opposite leg. Any absence of complete vein compression is considered a positive exam.

**Saphenous Junction**

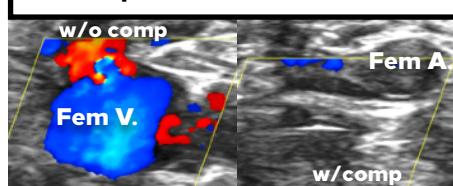
*BE SURE TO INCLUDE THE SAPHENOUS JUNCTION IN YOUR CLIP, THIS IS A COMMON SITE OF DVT.*

**Femoral****DVT: Popliteal**

*POSITIONING IS KEY TO THE POPLITEAL, IF YOU ARE STRUGGLING, TRY REPOSITIONING THE KNEE.*

**Non-compressible: DVT**

@JCHRISTIANMD

**Compressible: Normal Exam**

## About our book

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This is just a small excerpt from our new book, **The Point of Care Ultrasound Handbook**. We hope you like it! We want this effort to be something useful to carry with you for both the basic and advanced point of care ultrasound clinician. It started out as something for EMS ultrasound but has since evolved into something useful for medical students, residents, nurses, paramedics and pretty much anyone doing or interested in doing point of care ultrasound. We packed it full of greatness from the very basics of ultrasound up to advanced measurements, covering cardiac, OB, pulmonary, abdominal, and many other POCUS topics. All with plenty of tips, tricks and useful information to go around on your journey to POCUS nirvana. Please be sure to check us out at a conference or reach out to us on twitter, we would love to hear from you!

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**The Point of Care Ultrasound Handbook**

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