Hocus POCUS
The ICU Experience

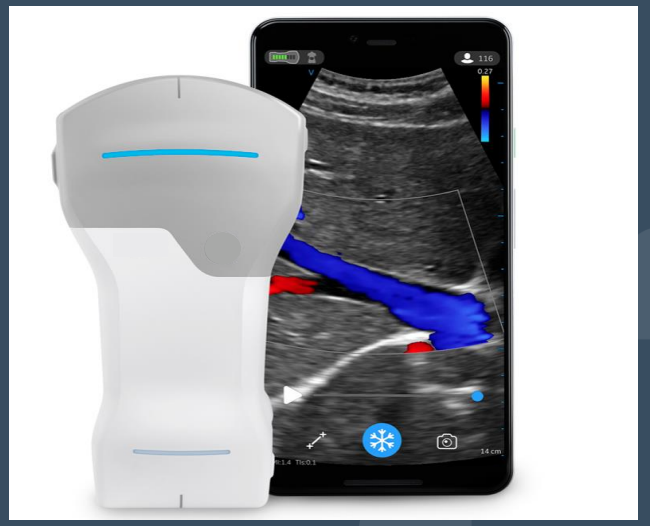
Jinesh P Mehta, MD
Director, MICU
Pulmonary & Critical Care Medicine
Cleveland Clinic Florida, Weston

Hocus Pocus - meaningless talk or activity, often designed to draw attention away from and disguise what is actually happening.

Learning Objectives

Upon completion of this learning activity, participants should be able to recognize the utility of Point Of Care Ultrasound (POCUS) at the bedside in Critical Care and integrate POCUS algorithms in the management of critically ill patients.

Ultrasound machines over time



Case - Dyspnea

66 yo woman, h/o COPD, HTN, POD #3 (femur fracture) develops worsening dyspnea and hypoxemia. Exam reveals diminished breath sounds at bases and lower extremity pitting edema.

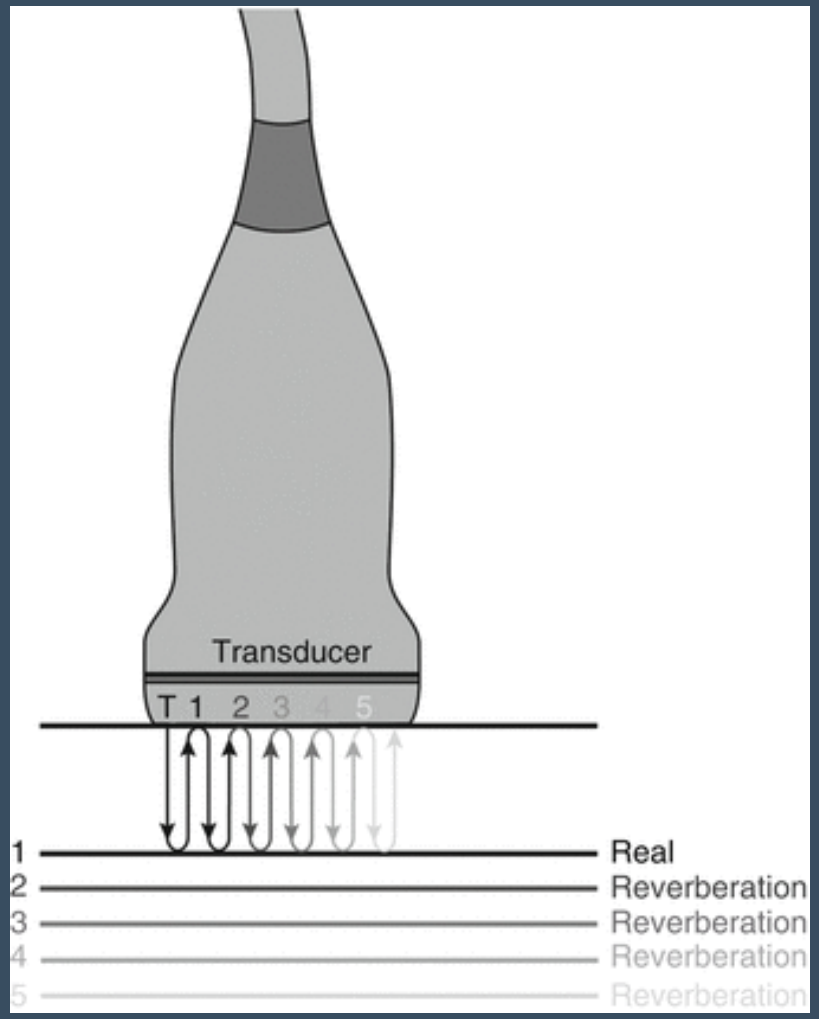
CXR - Bibasilar opacities, suggestive of atelectasis and effusions.

Labs pertinent for creatinine 2.5. Transferred to ICU.

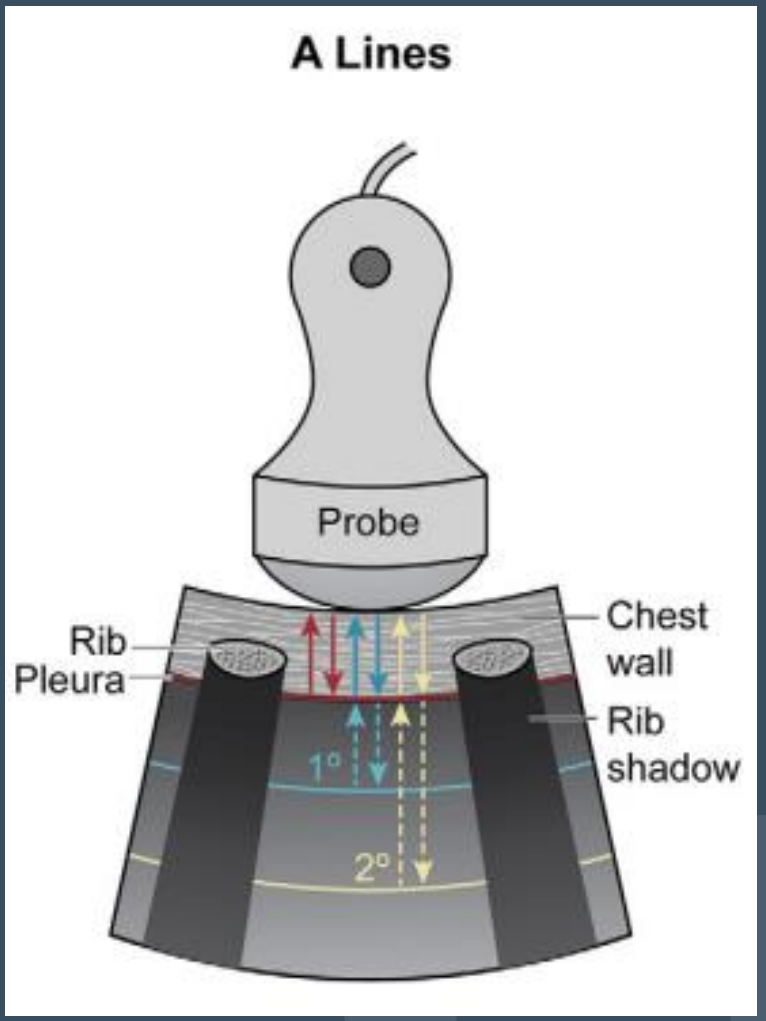
Differential diagnosis – Acute hypoxemic respiratory failure

Atelectasis / Effusion, Pulm Embolism, Pneumonia, COPD exacerbation

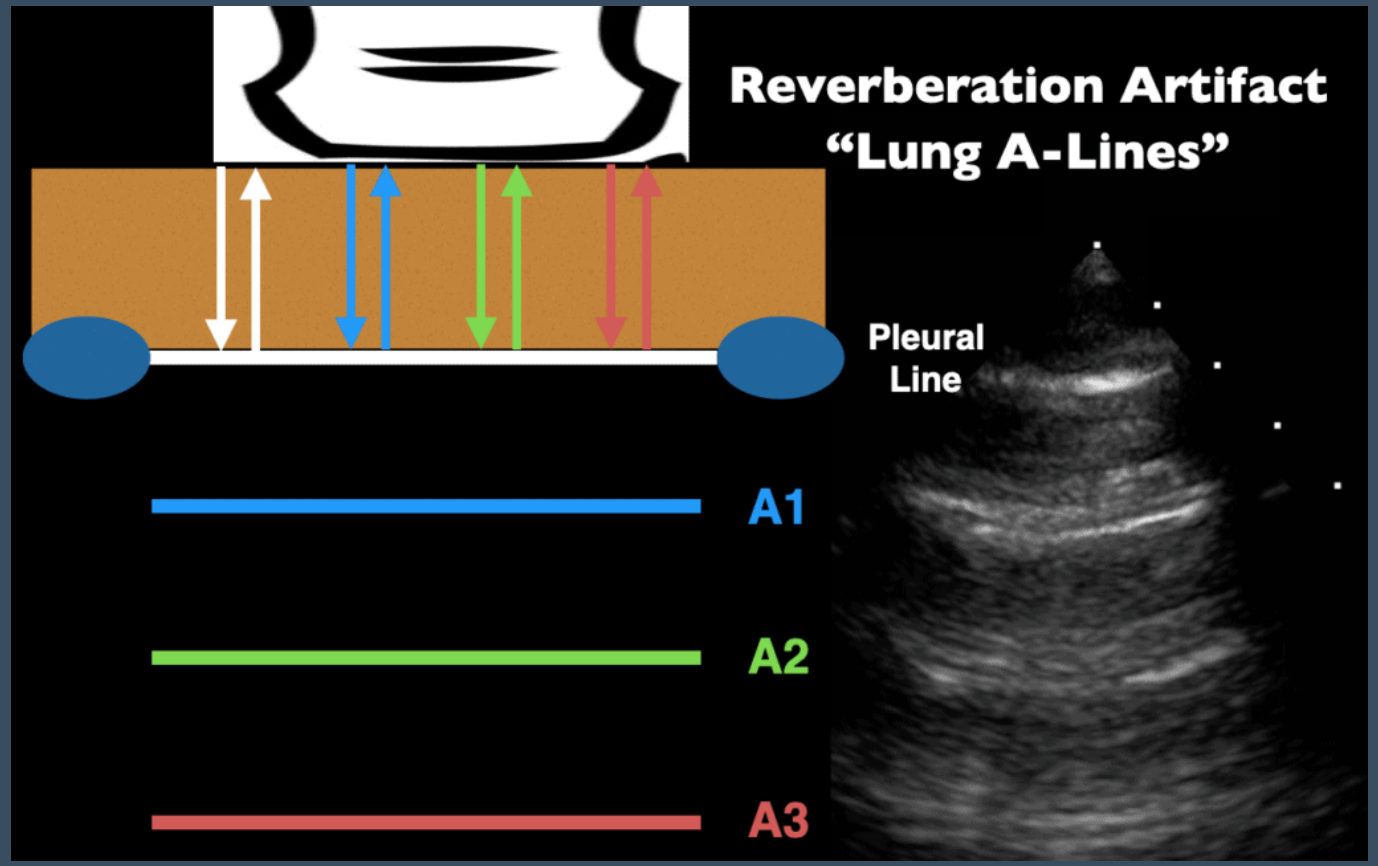
Lung - A lines

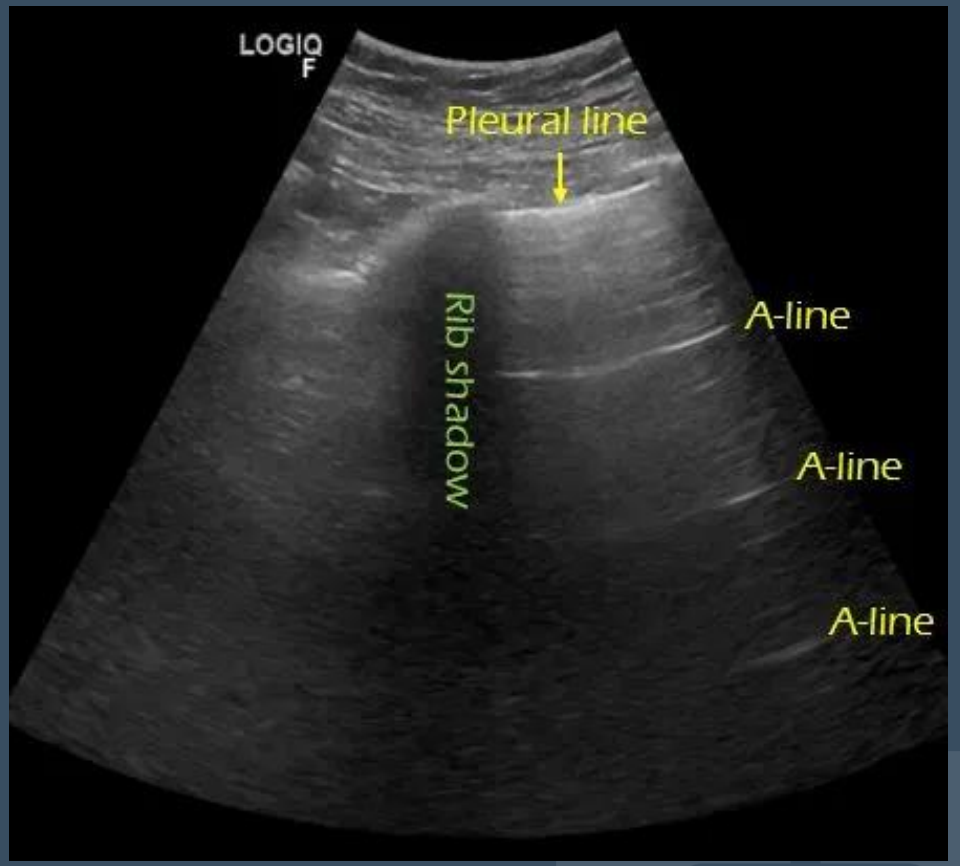


Most ultrasound waves are reflected at the pleura in an air-filled lung owing to the acoustic impedance mismatch at the air and soft-tissue interface.



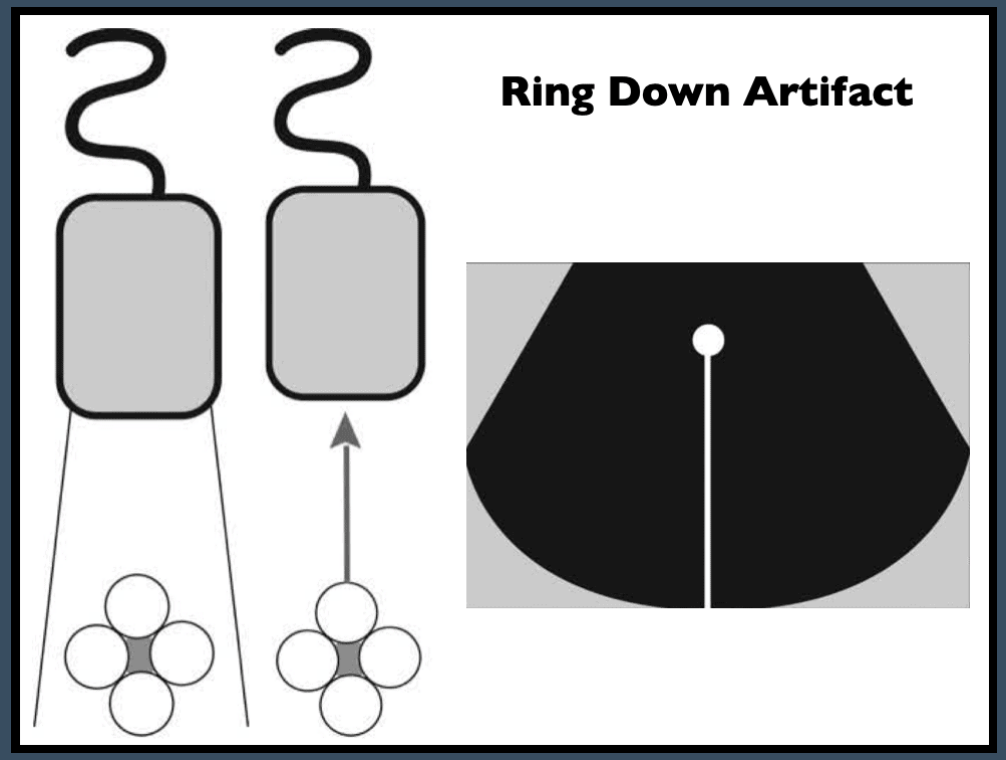
Lung - A lines

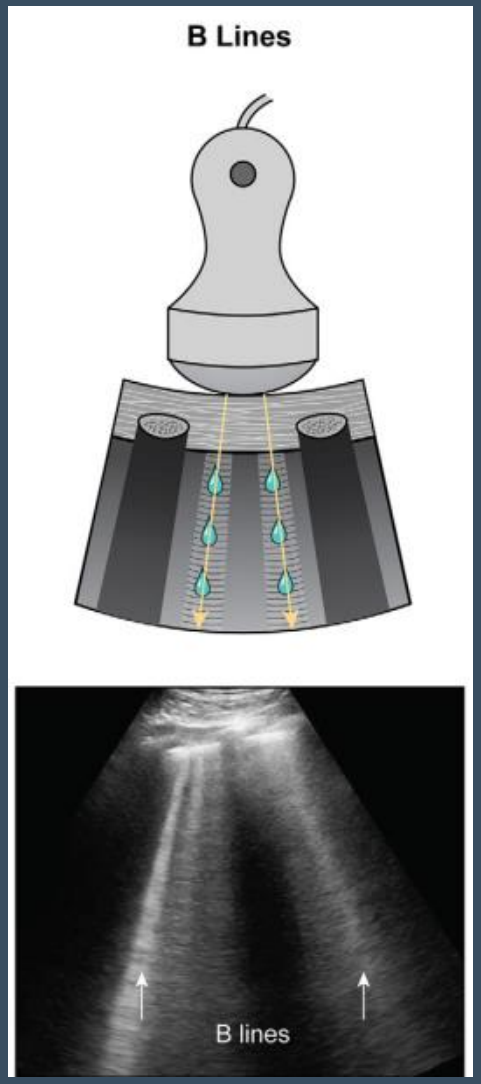




A lines - Normal air-filled lungs

Lung - B lines





Lung - B lines

3 B-lines in an intercostal space represent a “positive” region of the lung.

Represent increased water in an area of the lung

Pulmonary edema

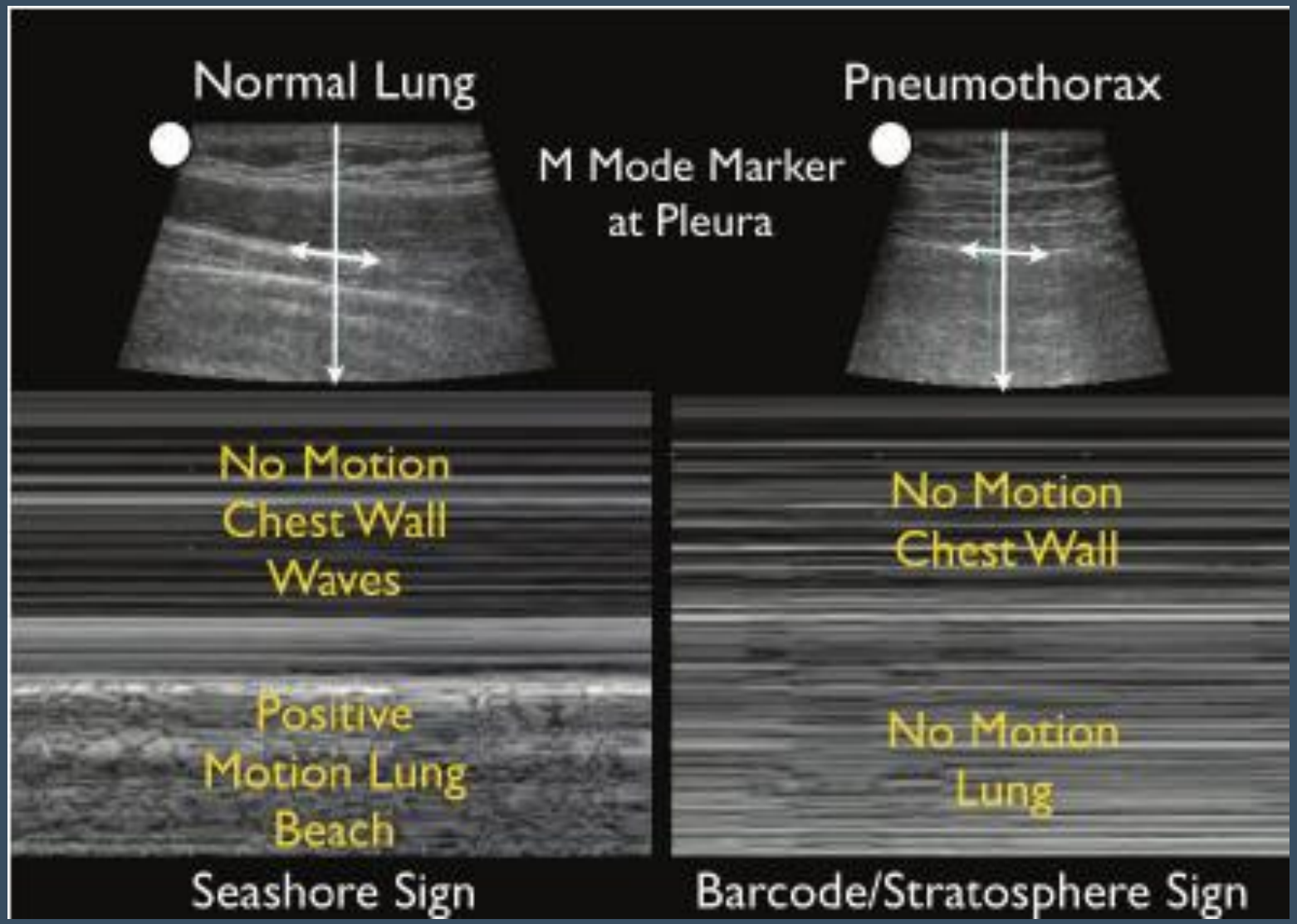
Also seen in consolidation / contusion

Lung Sliding

Present

Absent

Lung - Pneumothorax



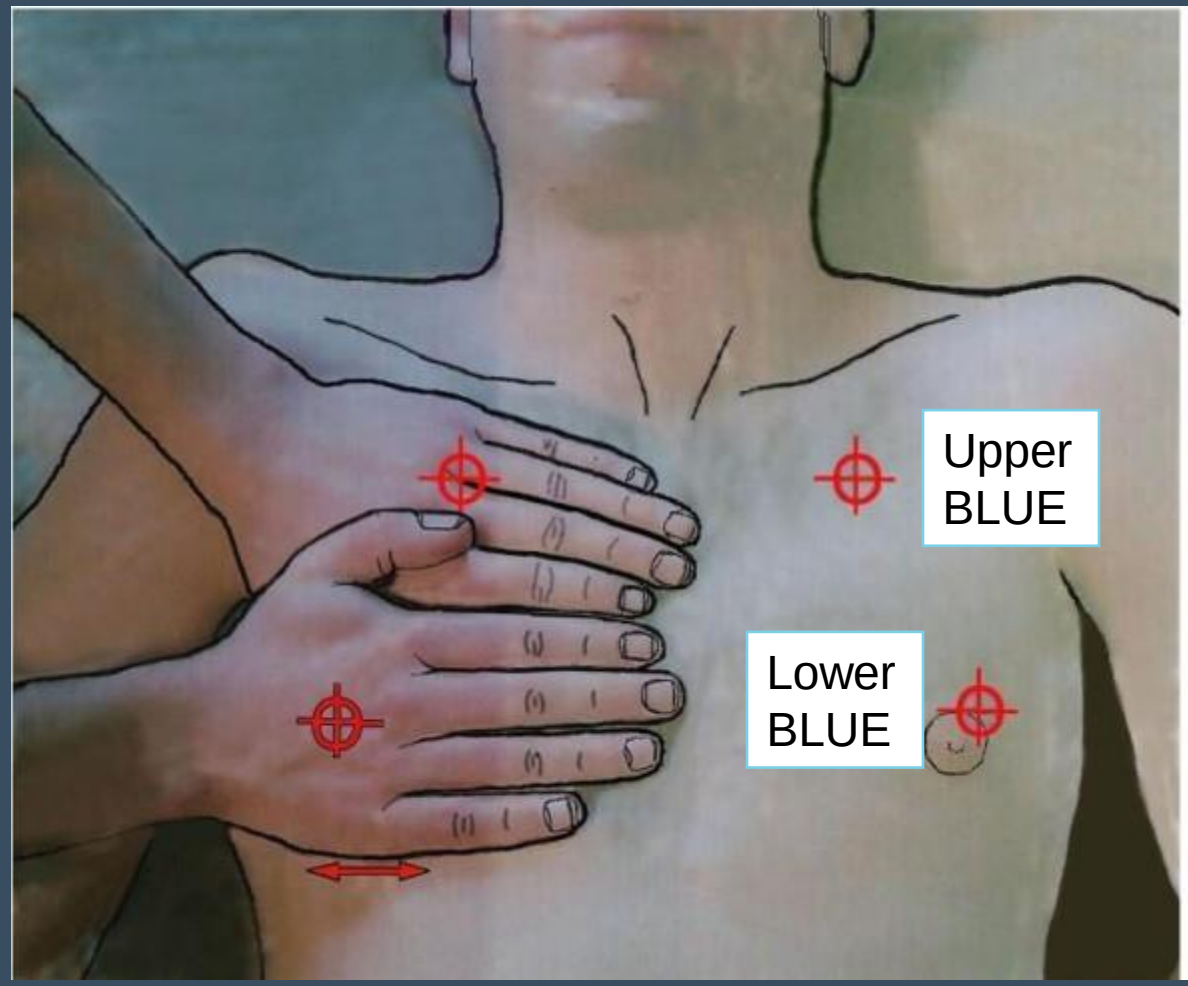
Lung - Effusion

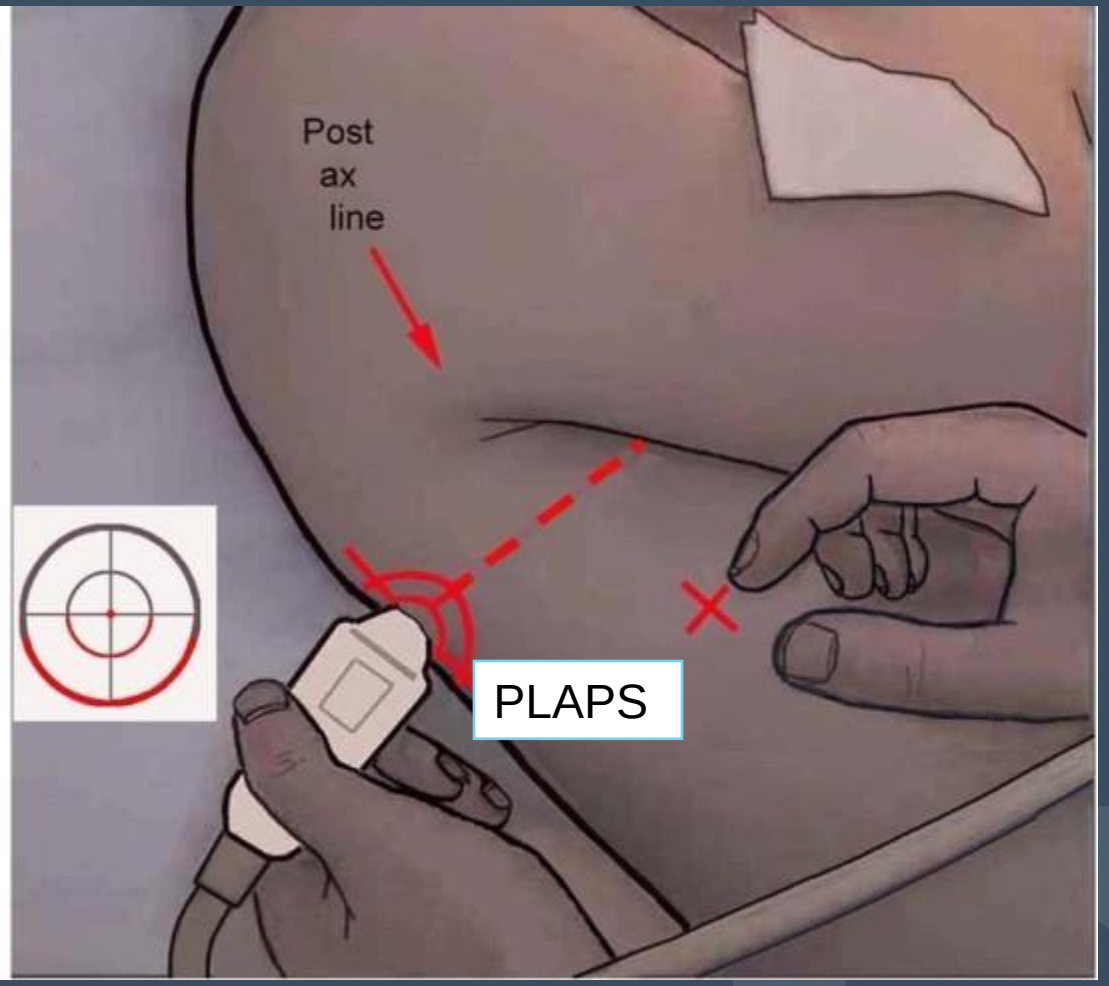
Large Effusion + Atelectasis

Loculated Effusion

Lung - Consolidation

BLUE Protocol

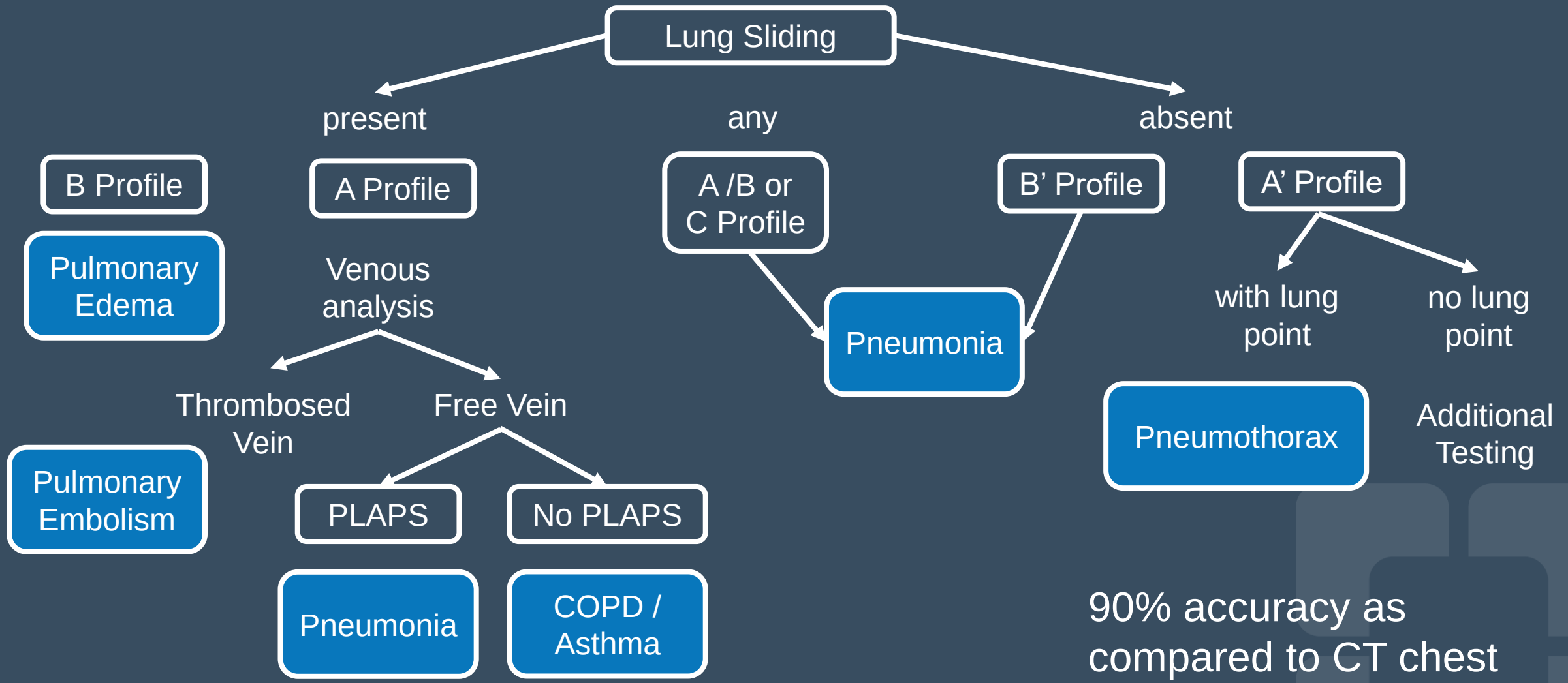




Whole Body Ultrasonography in Critically Ill (2010) Chapter 14

BLUE Protocol

Bedside Lung Ultrasound in Emergency



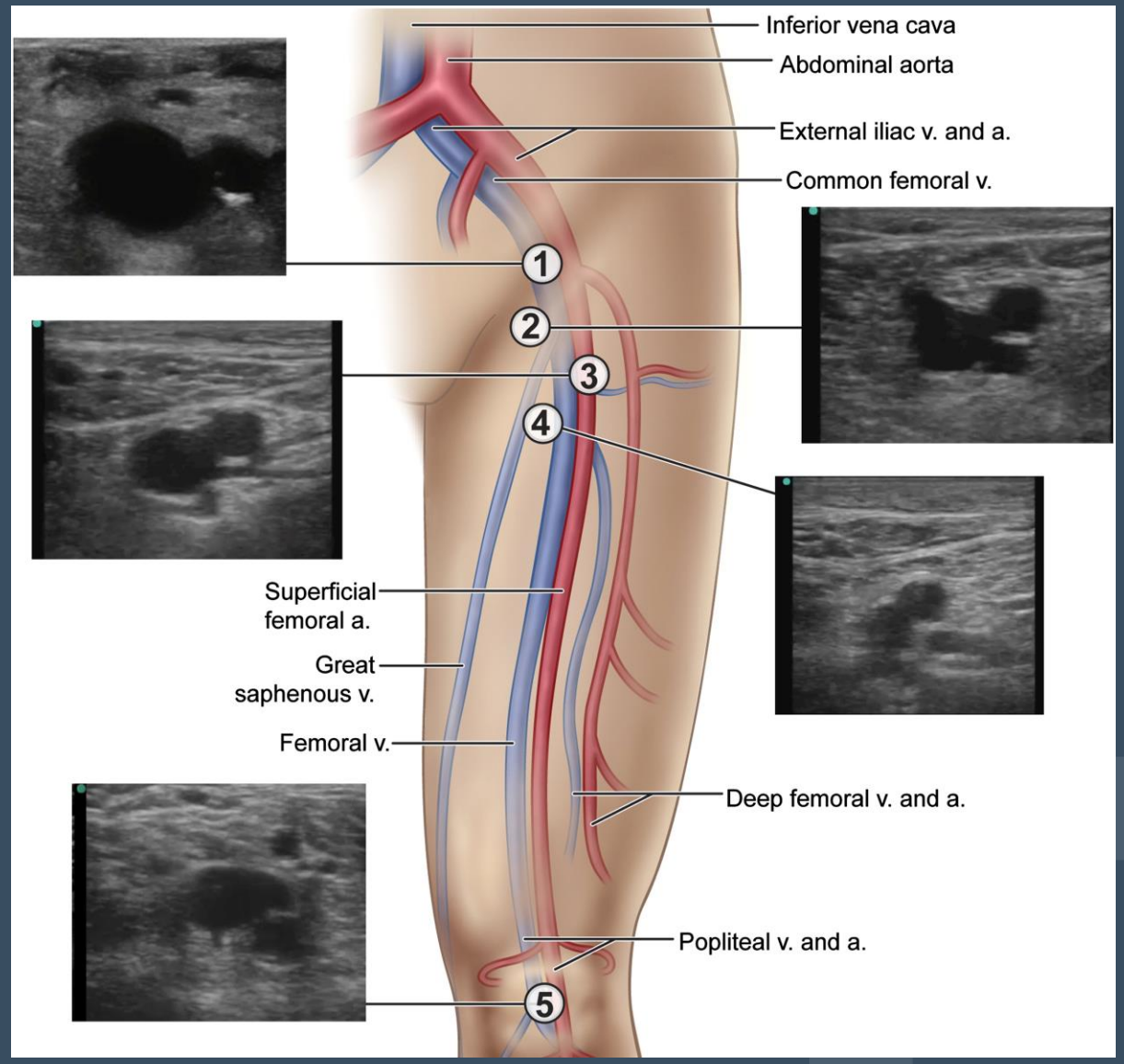
90% accuracy as compared to CT chest

Chest 2008;134:117–125

Vascular - Limited Lower Extremity Exam

Venous anatomy of the left lower extremity.

The numbered points denote the minimum sites of compression for a limited examination.

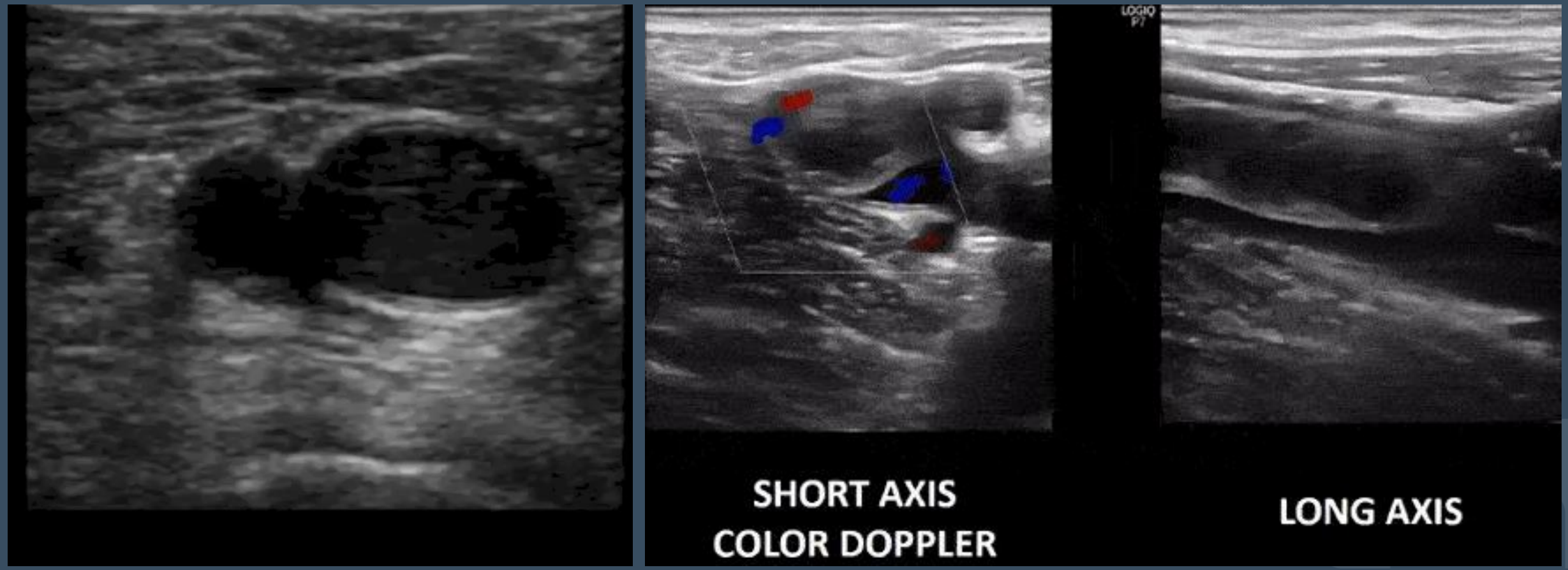


Vascular - Venous Exam showing DVT

Common Femoral Vein

Normal

DVT



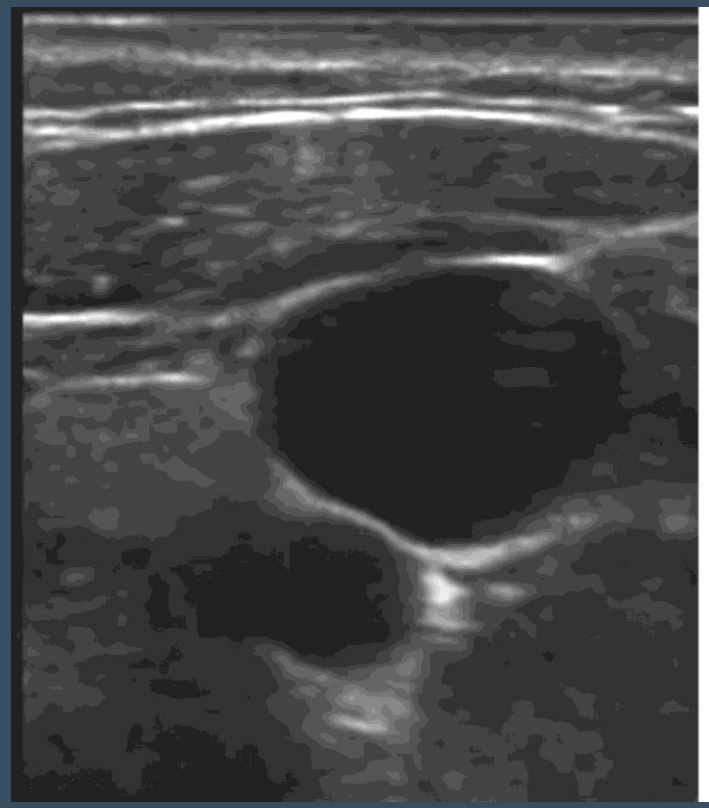
Case - Dyspnea

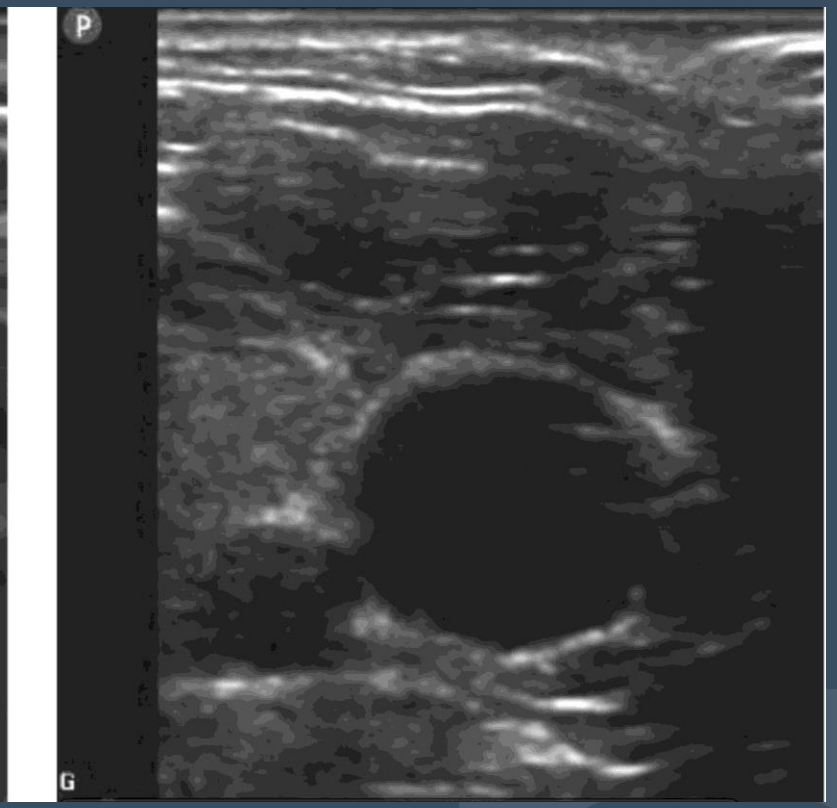
After admission to ICU, started on antibiotics and high flow nasal canula oxygen supplementation with improvement in oxygenation.

A few hours later, she develops hypotension with mean arterial pressure ranging in the mid 50s.

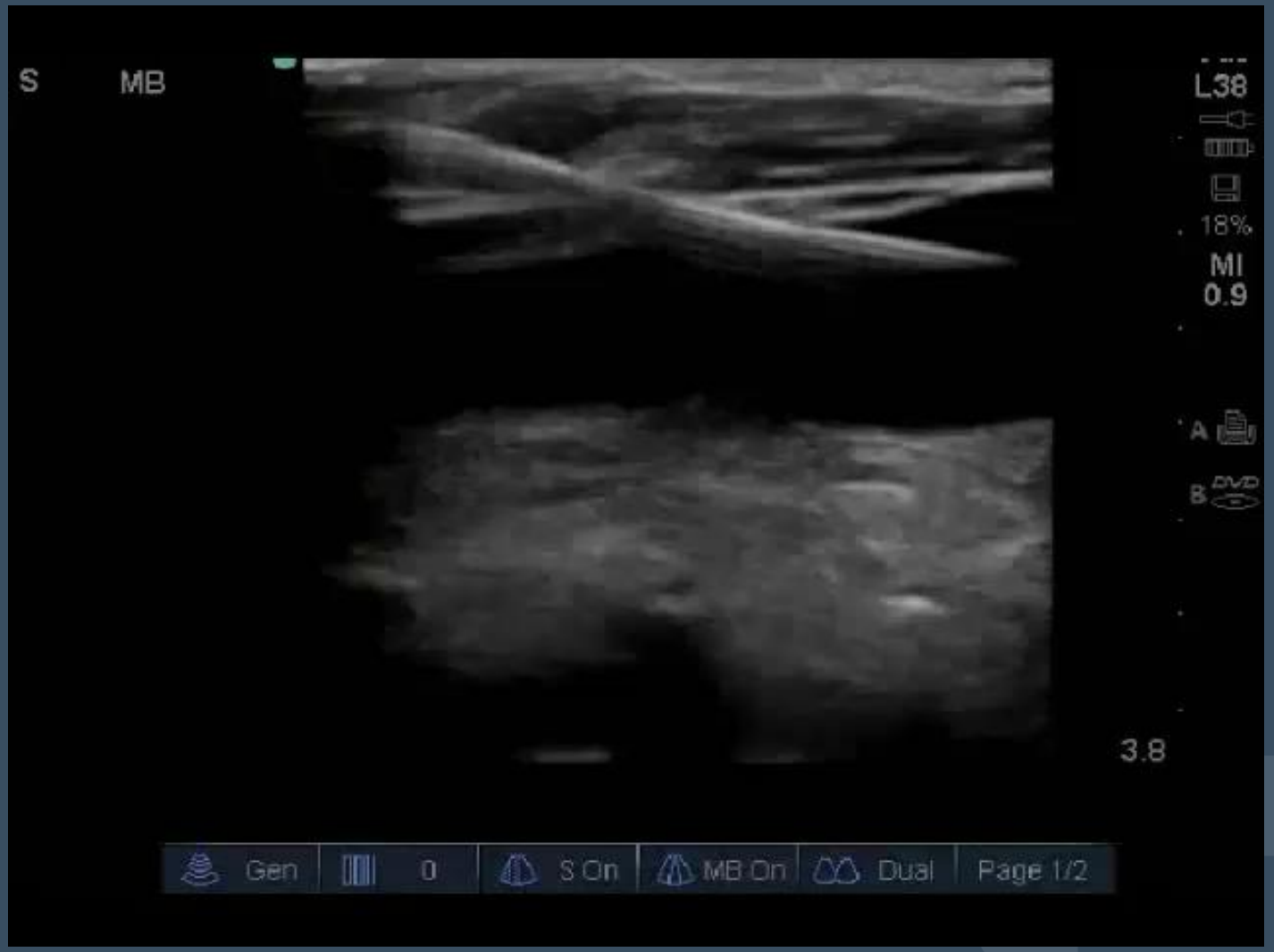
Norepinephrine is started, and MAP remains above 65. She has increasing vasopressor requirements, and a decision to place a central line is made.

Vascular - Central Line Placement

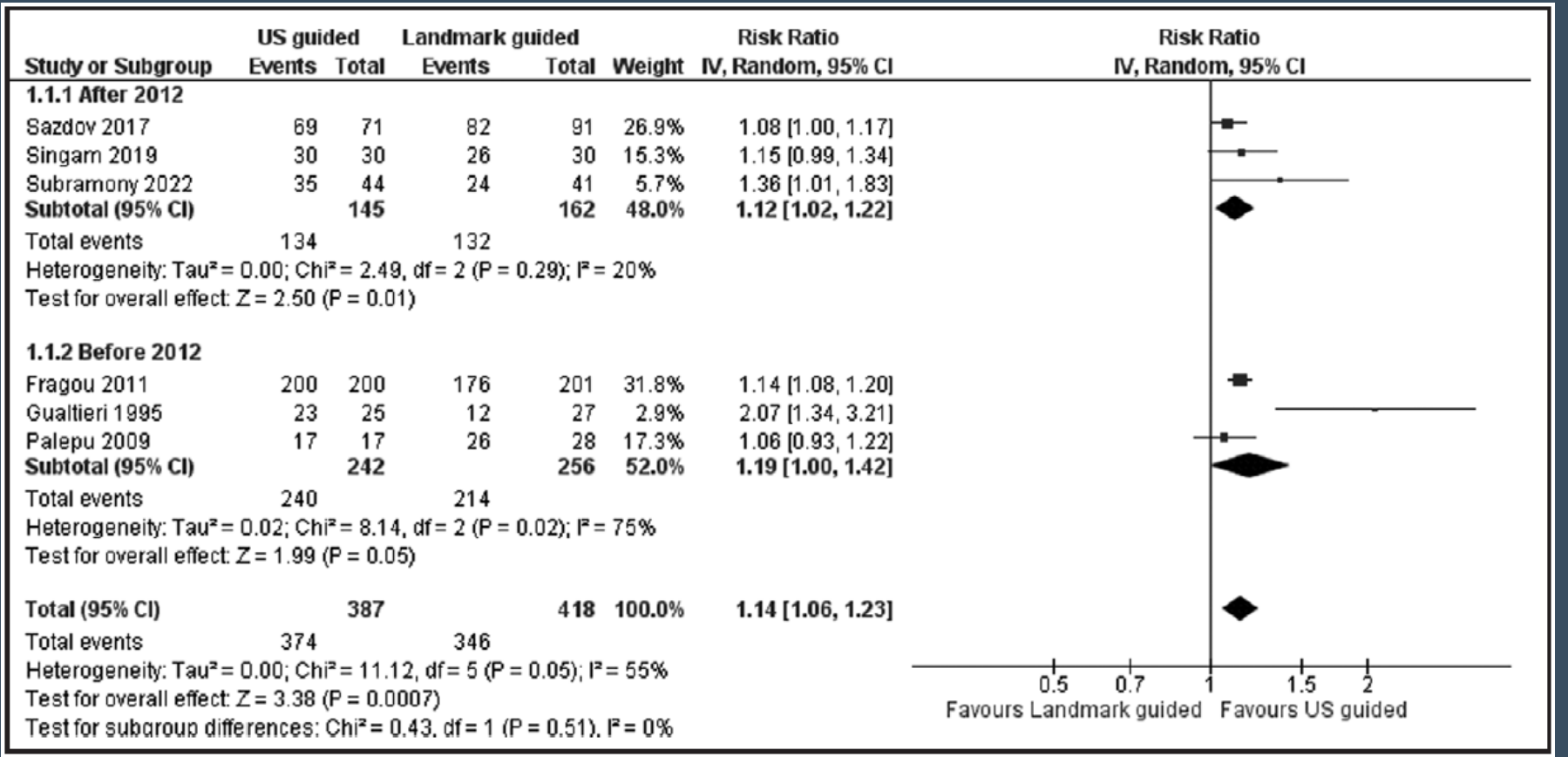




Vascular - Central Line Placement



Landmark vs. Ultrasound Guided Subclavian Line



Study or Subgroup	US guided Events	Total	Landmark guided Events	Total	Weight	Risk Ratio IV, Random, 95% CI
1.1.1 After 2012						
Sazdov 2017	69	71	82	91	26.9%	1.08 [1.00, 1.17]
Singam 2019	30	30	26	30	15.3%	1.15 [0.99, 1.34]
Subramony 2022	35	44	24	41	5.7%	1.36 [1.01, 1.83]
Subtotal (95% CI)		**145**		**162**	**48.0%**	**1.12 [1.02, 1.22]**
Total events	134		132			
Heterogeneity: Tau² = 0.00; Chi² = 2.49, df = 2 (P = 0.29); I² = 20%						
Test for overall effect: Z = 2.50 (P = 0.01)						
1.1.2 Before 2012						
Fragou 2011	200	200	176	201	31.8%	1.14 [1.08, 1.20]
Gualtieri 1995	23	25	12	27	2.9%	2.07 [1.34, 3.21]
Palepu 2009	17	17	26	28	17.3%	1.06 [0.93, 1.22]
Subtotal (95% CI)		**242**		**256**	**52.0%**	**1.19 [1.00, 1.42]**
Total events	240		214			
Heterogeneity: Tau² = 0.02; Chi² = 8.14, df = 2 (P = 0.02); I² = 75%						
Test for overall effect: Z = 1.99 (P = 0.05)						
Total (95% CI)		**387**		**418**	**100.0%**	**1.14 [1.06, 1.23]**
Total events	374		346			
Heterogeneity: Tau² = 0.00; Chi² = 11.12, df = 5 (P = 0.05); I² = 55%						
Test for overall effect: Z = 3.38 (P = 0.0007)						
Test for subgroup differences: Chi² = 0.43, df = 1 (P = 0.51), I² = 0%						

Figure 1. Forest plot of overall success rate. Comparison is made between patients according to the use of ultrasound (US)–guided subclavian cannulation versus landmark technique. *df* = degrees of freedom, IV = inverse variance.

Favor US guided

Number of attempts

Access Time

Complication Rate

Lung Ultrasound vs. Chest Radiography

Sensitivity and Specificity of Lung US versus Chest Radiography

			Lung US		Chest Radiography	
Indication	Study Type	No. of Patients	Sensitivity (%)	Specificity (%)	Sensitivity (%)	Specificity (%)
Pleural effusion (5)	Prospective	32	92	93	39	85
Pneumonia (7)	Systematic review with meta-analysis	742	95	90	77	91
Pneumothorax (4)	Systematic review with meta-analysis	5314	87	99	46	100
Pulmonary edema (6)	Systematic review with meta-analysis	1827	88	90	73	90

Note.—Sensitivity and specificity values vary slightly from study to study. The pleural effusion statistics are drawn from a sample of critically ill patients.

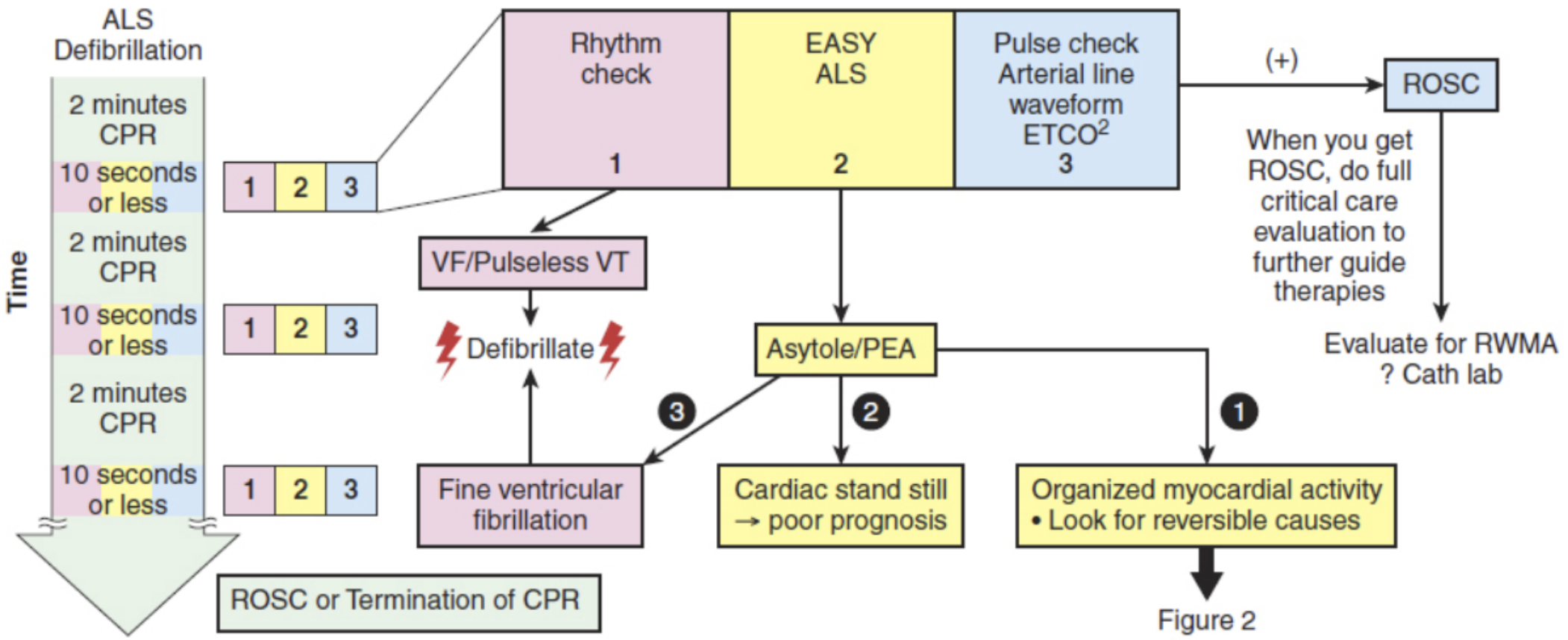
Case - Dyspnea

Despite prompt initiation of antibiotics, fluid resuscitation and vasopressor support, her clinical condition continues to worsen, and you are called to her room as she was noted to have PEA cardiac arrest.

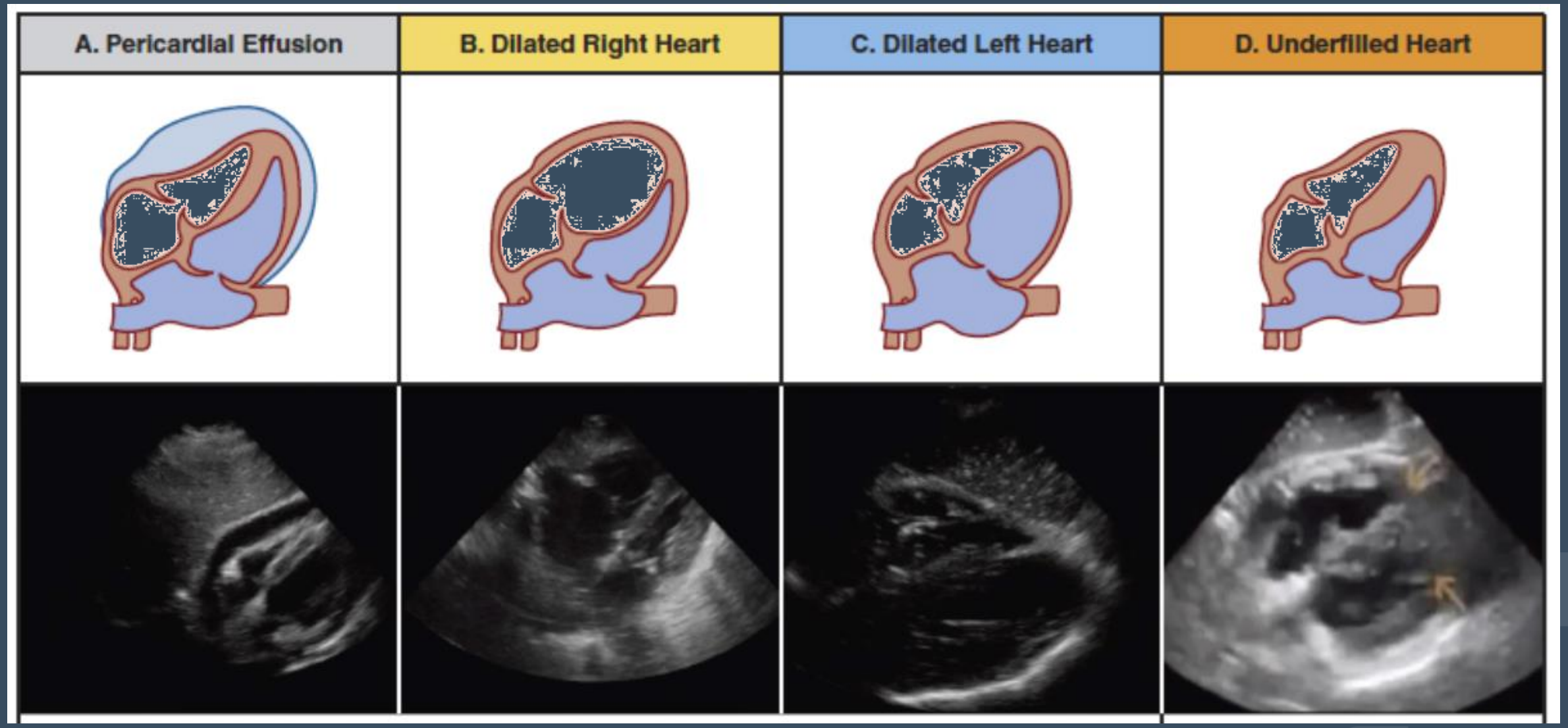
ACLS is initiated

EASY ALS during Cardiac Arrest

Figure 1. Algorithm for the integration of EASY-ALS (echocardiographic assessment using subcostal-only view in Advanced Life Support)



EASY ALS during Cardiac Arrest



EASY ALS during Cardiac Arrest

Condition	Asystole	PEA	Pseudo PEA
Palpable pulse	-	-	-
Electrical Activity	-	+	+/-
Coordinated Cardiac Activity on US	-	-	+
Prognosis	Poor	Poor	Better

Predicting RoSC (Return of Spontaneous Circulation)
Sensitivity – 95%
Specificity – 80%

International Liaison Committee on Resuscitation (ILCOR)
Cautions on prognostication using POCUS during ACLS due to lack of robust evidence

Resuscitation 2017;114:92-99

Case - Heart Failure

55 yo man, h/o Pulmonary hypertension and RV failure, on IV epoprostenol, oral macitentan and sildenafil, admitted to the ICU for signs and symptoms of worsening heart failure and fluid overload.

Exam lower extremity pitting edema.

CXR - clear.

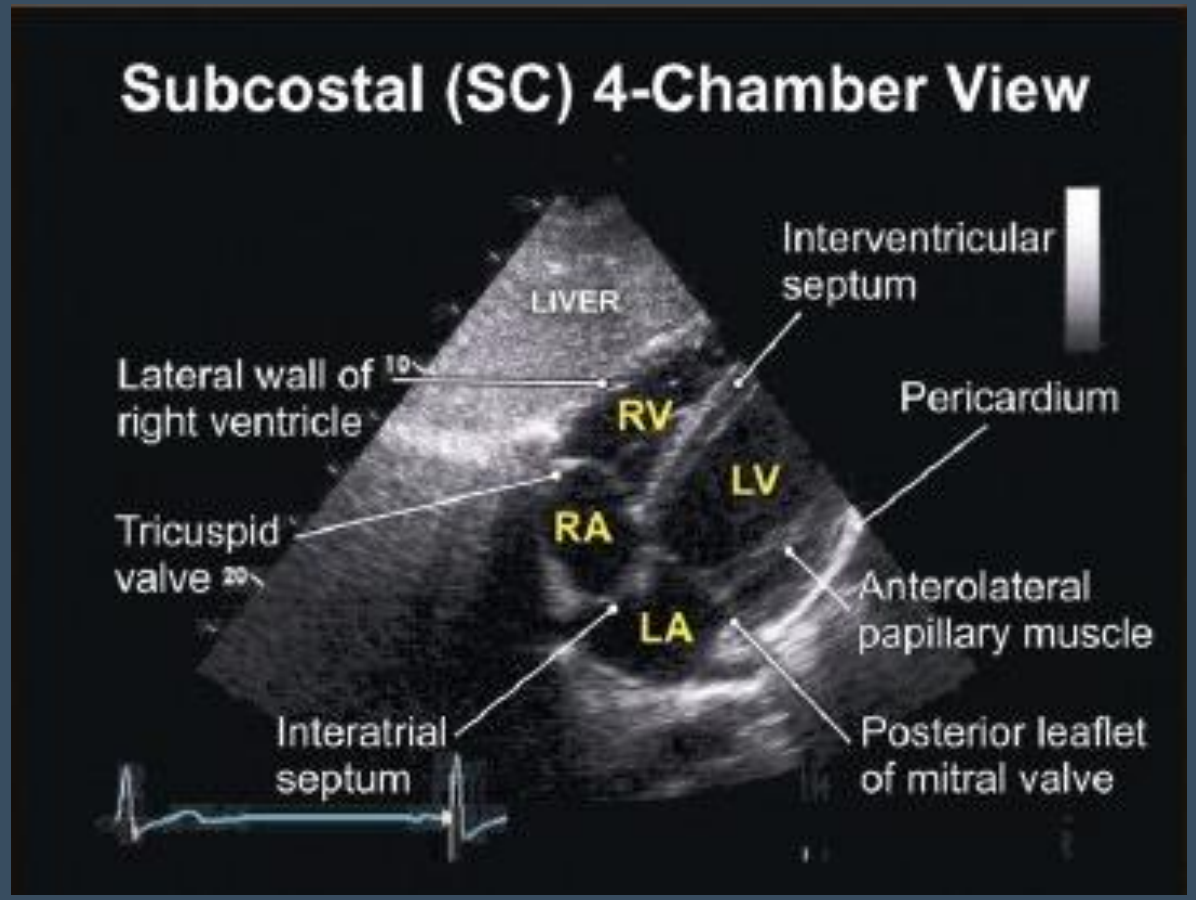
Started on diuretics, minimal UOP. BP now lower, requiring norepinephrine to keep MAP > 65

Differential Diagnosis – Acute on Chronic RV failure

Cardiogenic, Hypovolemic (intravascular), Sepsis

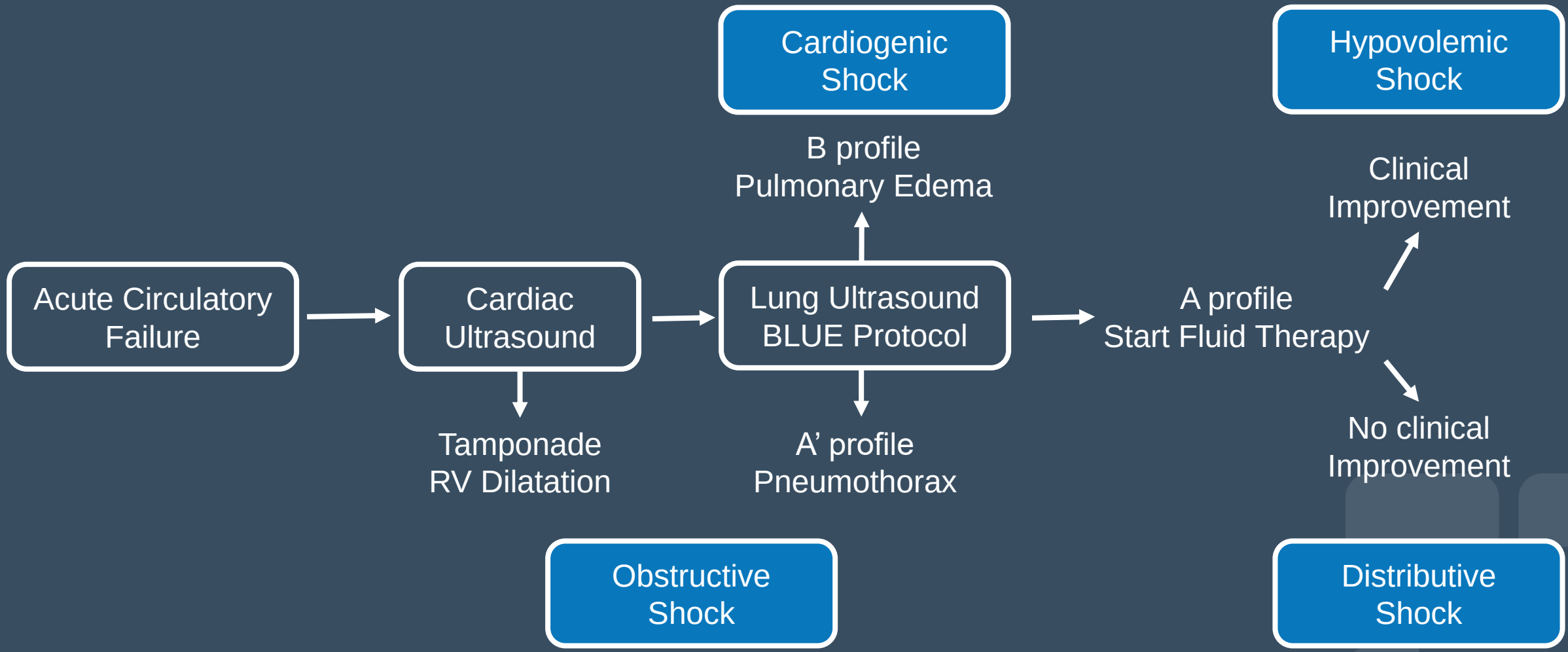
Cardiac - Bedside Echo

RV / RA dilatation, Hyperdynamic LV



FALLS Protocol

Fluid Administration Limited by Lung Sonography

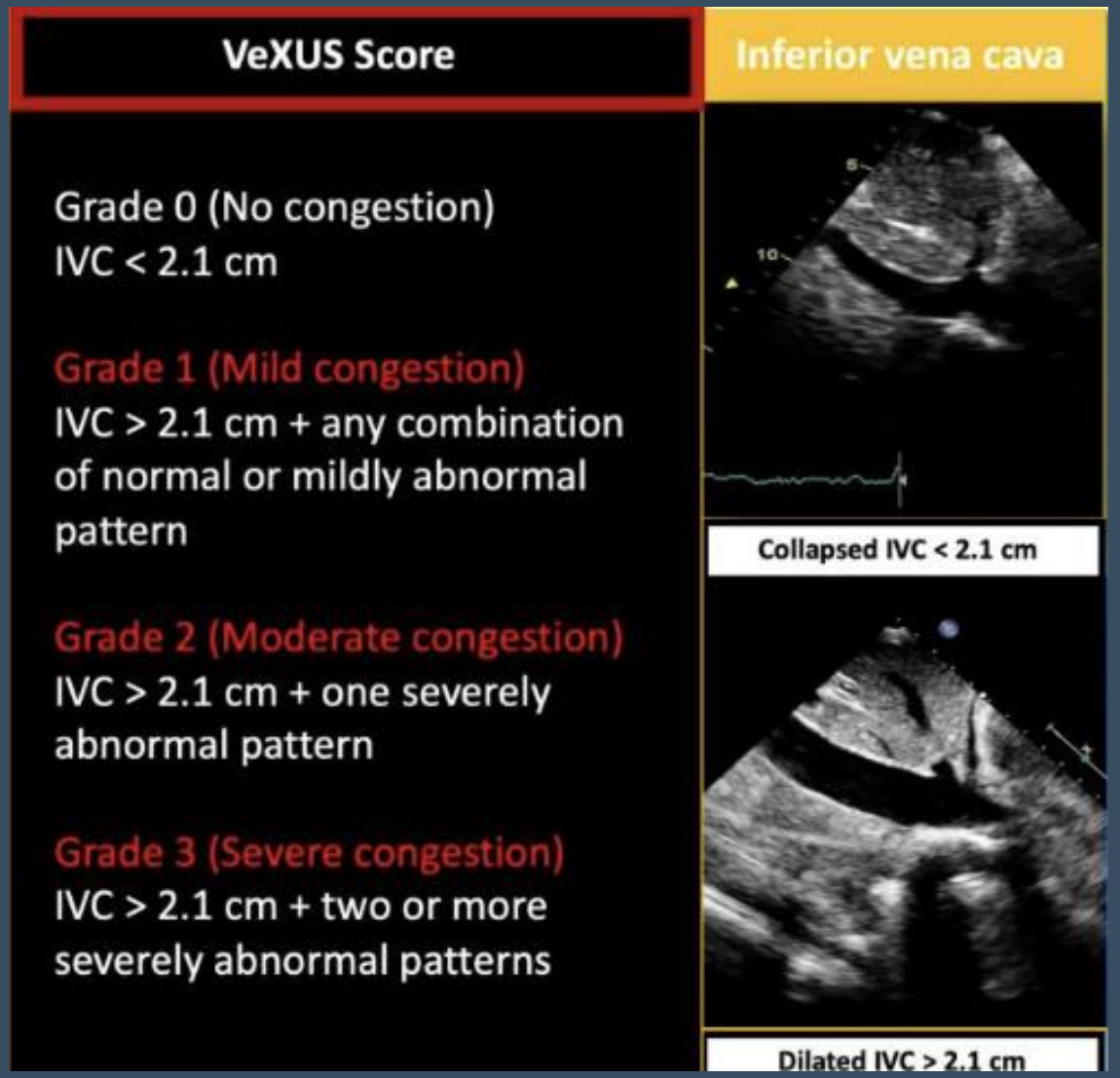


Lichtenstein - Expert Rev Resp Med 6(2):155-62

Abdomen - VeXUS Protocol

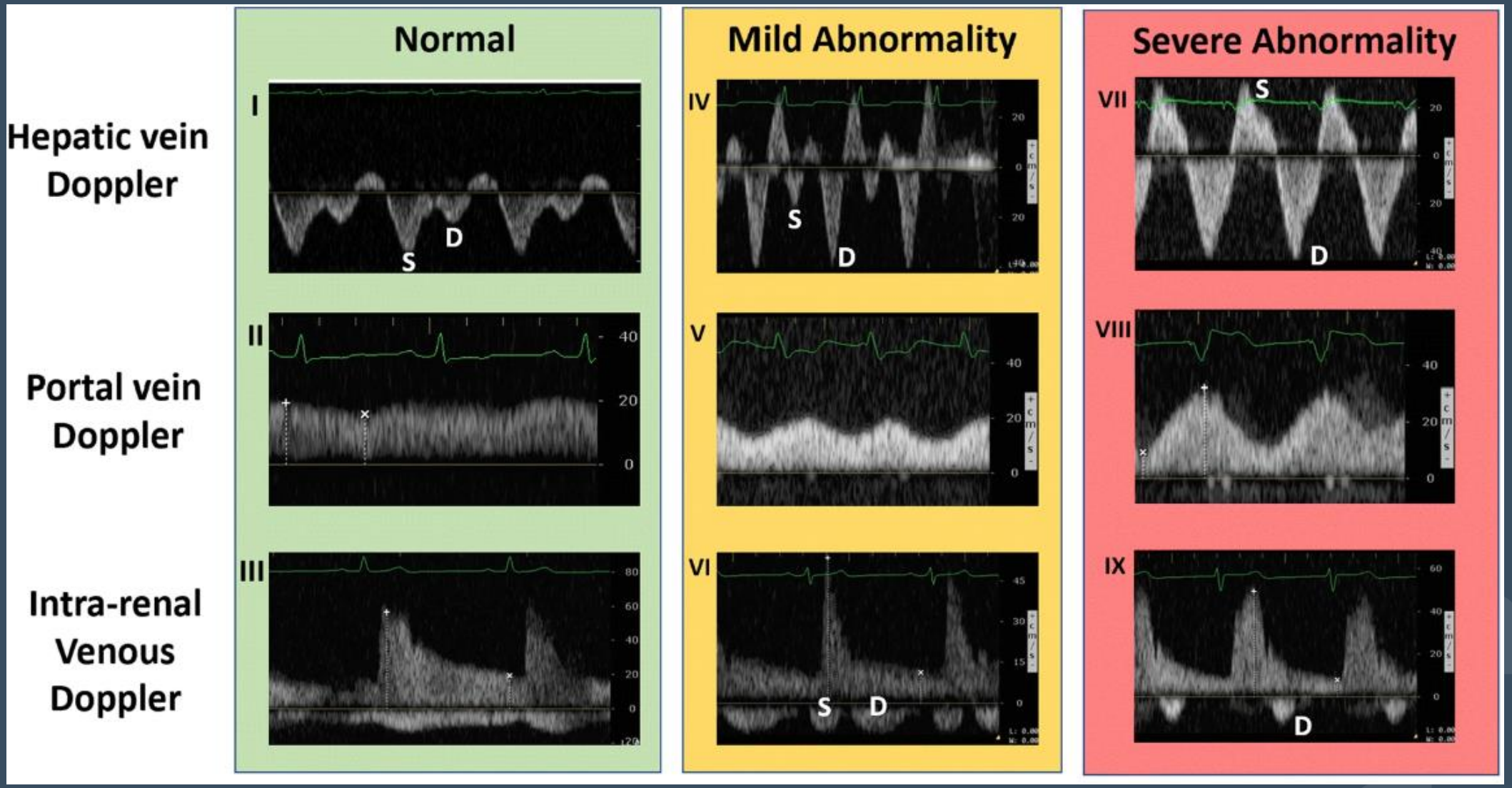
Venous Excess / Organ Congestion Score

- IVC
- Hepatic Vein
- Portal Vein
- Renal Vein



The Ultrasound Journal 2020 -12 (16)

Abdomen - VeXUS Protocol



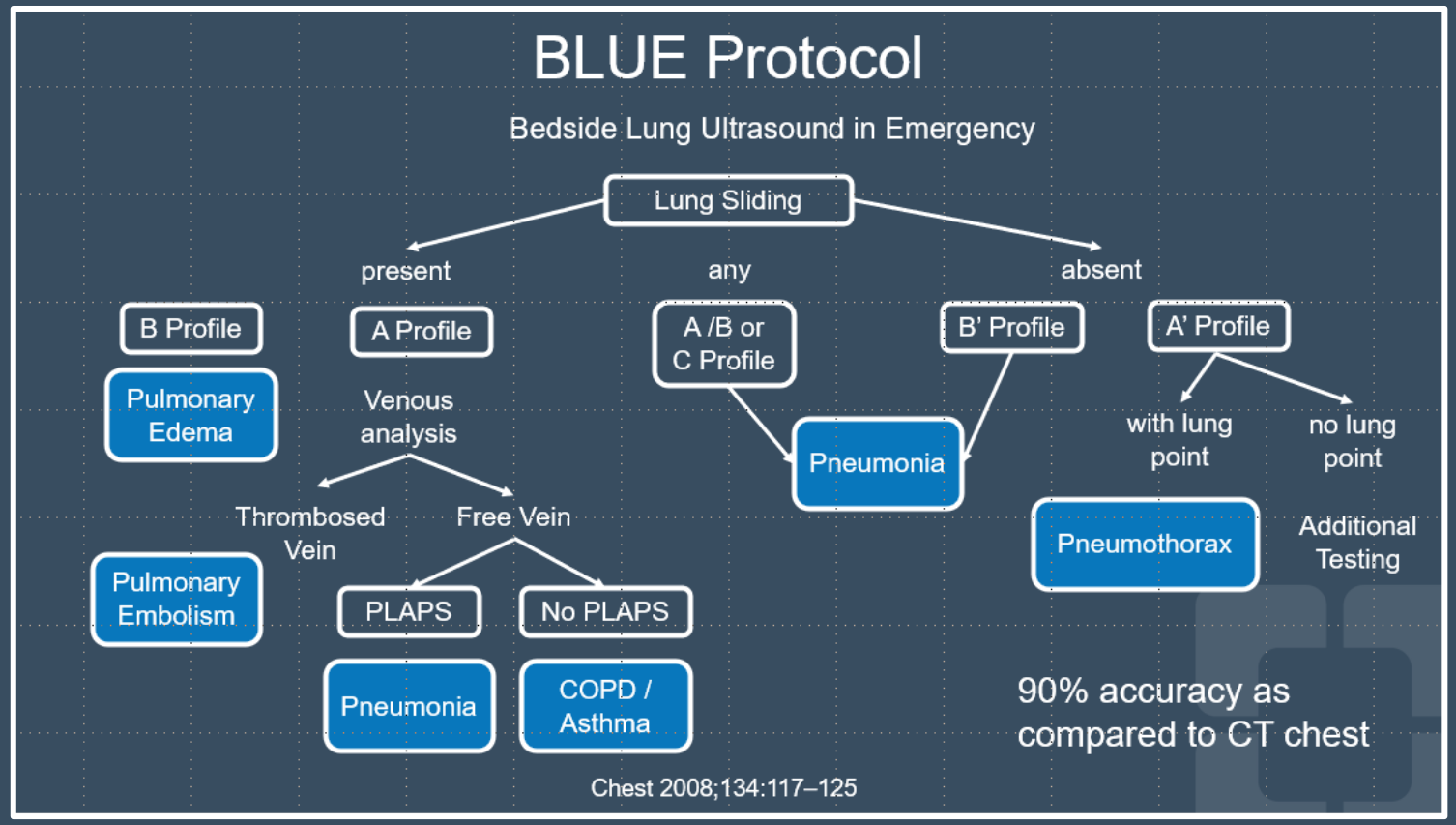
Lung Ultrasound

A lines
B lines
Effusion
Consolidation
Pneumothorax

Cardiac Ultrasound

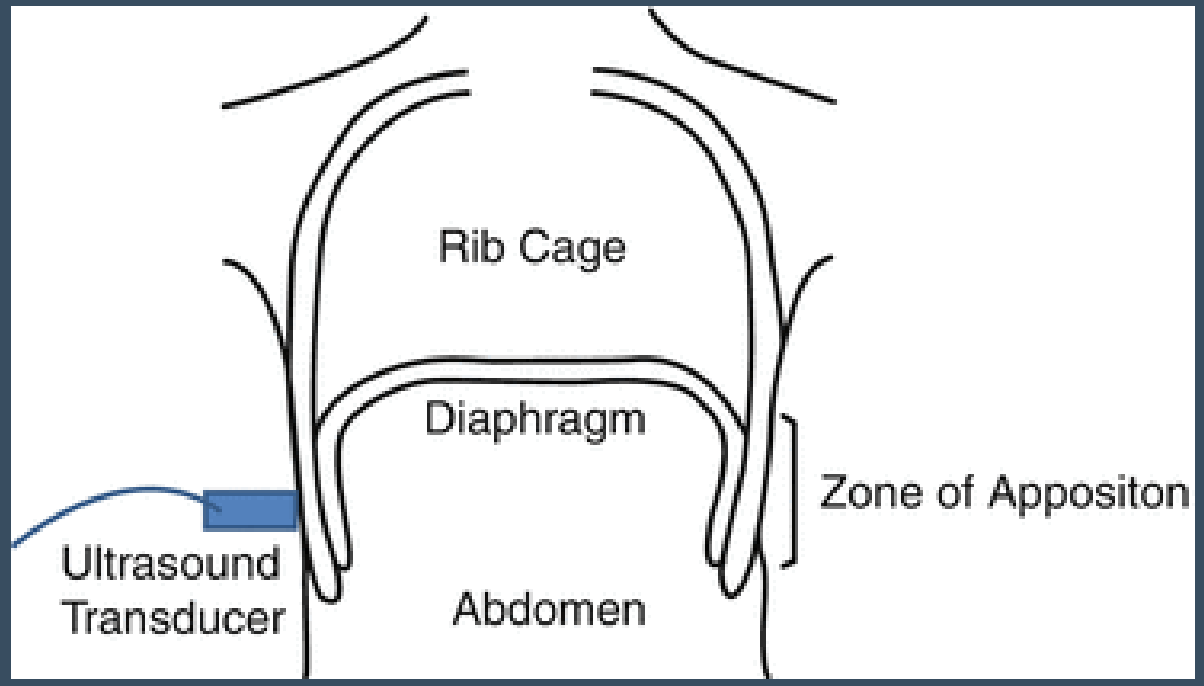
Subcostal view

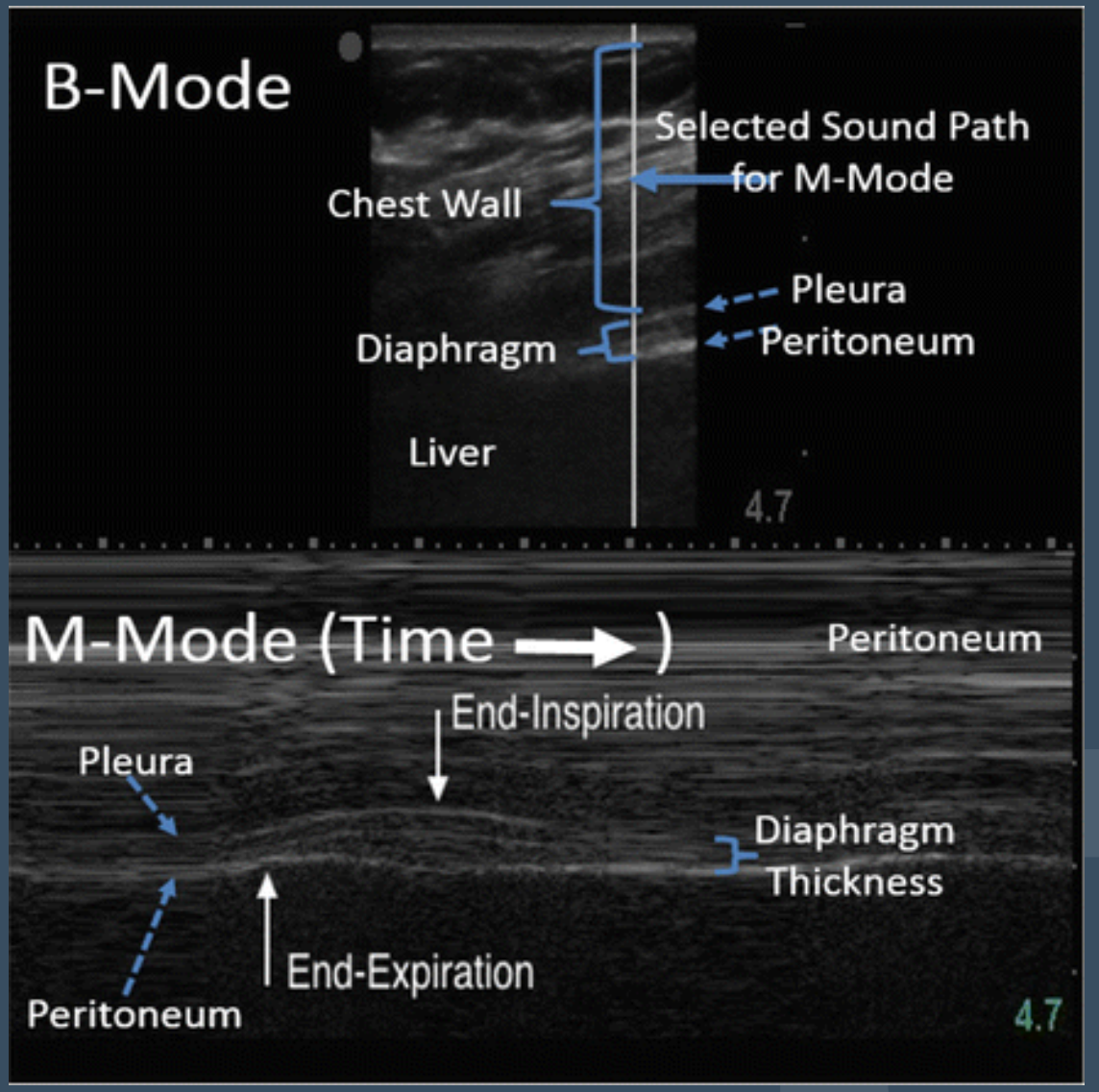
Integration into ACLS
EASY ALS



FALLS protocol
VeXUS protocol

Pulmonary - Diaphragm Thickness





Right Diaphragm easier to measure

Ant / Mid Axillary line

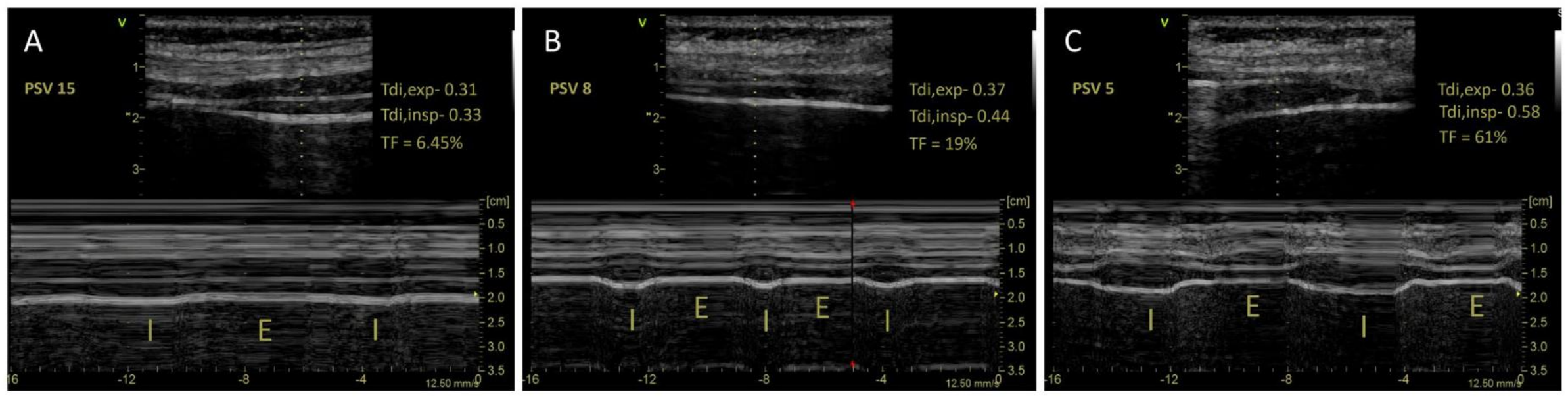
9th / 10th intercostal space

Diaphragm Thickening Fraction (TF) - Ventilation

TF < 15%

TF 15 - 30%

TF > 30%



PSV – 15 cm

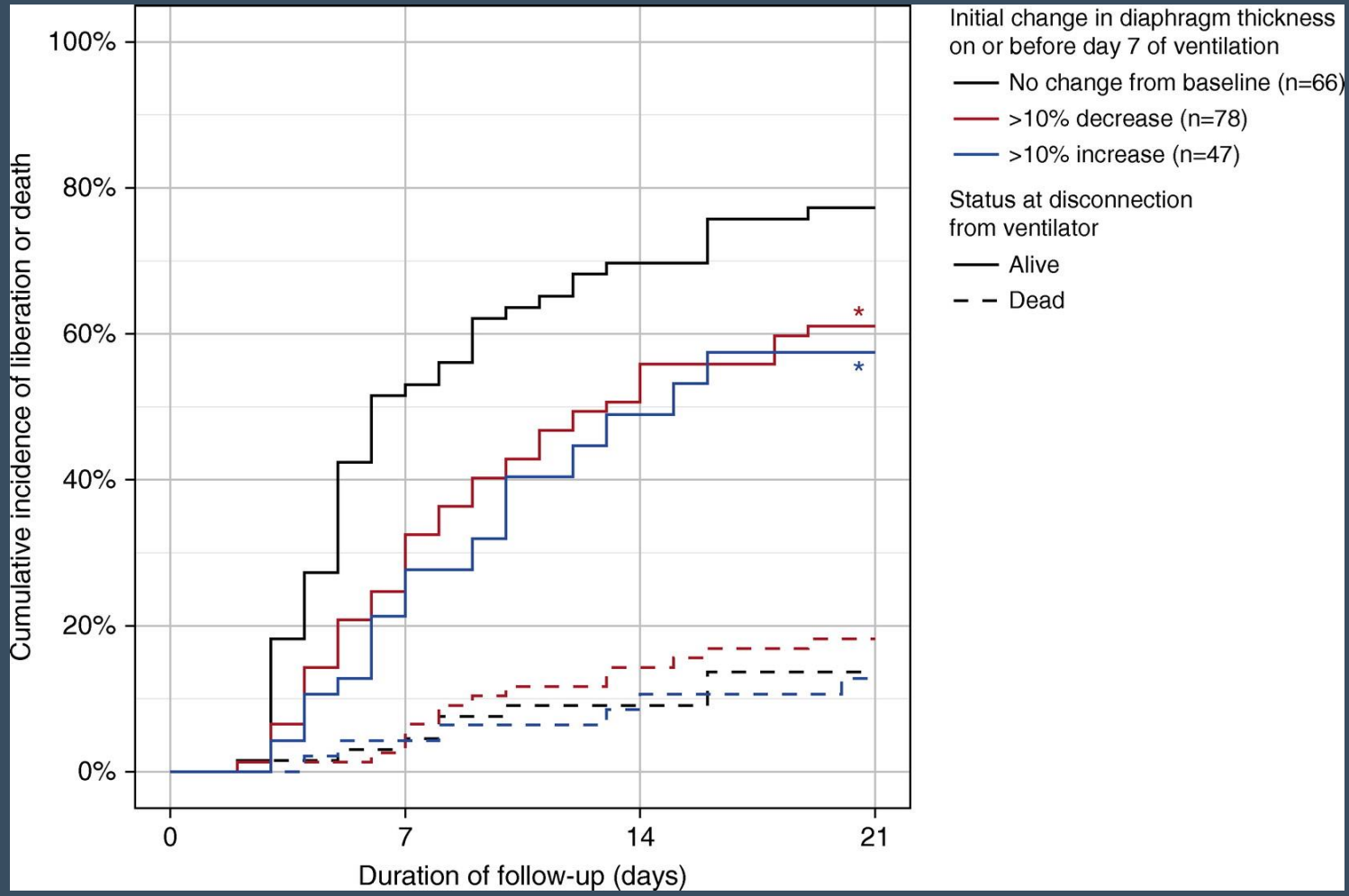
PSV – 8 cm

PSV – 5 cm

Tuinman et al: Int Care Med 2020

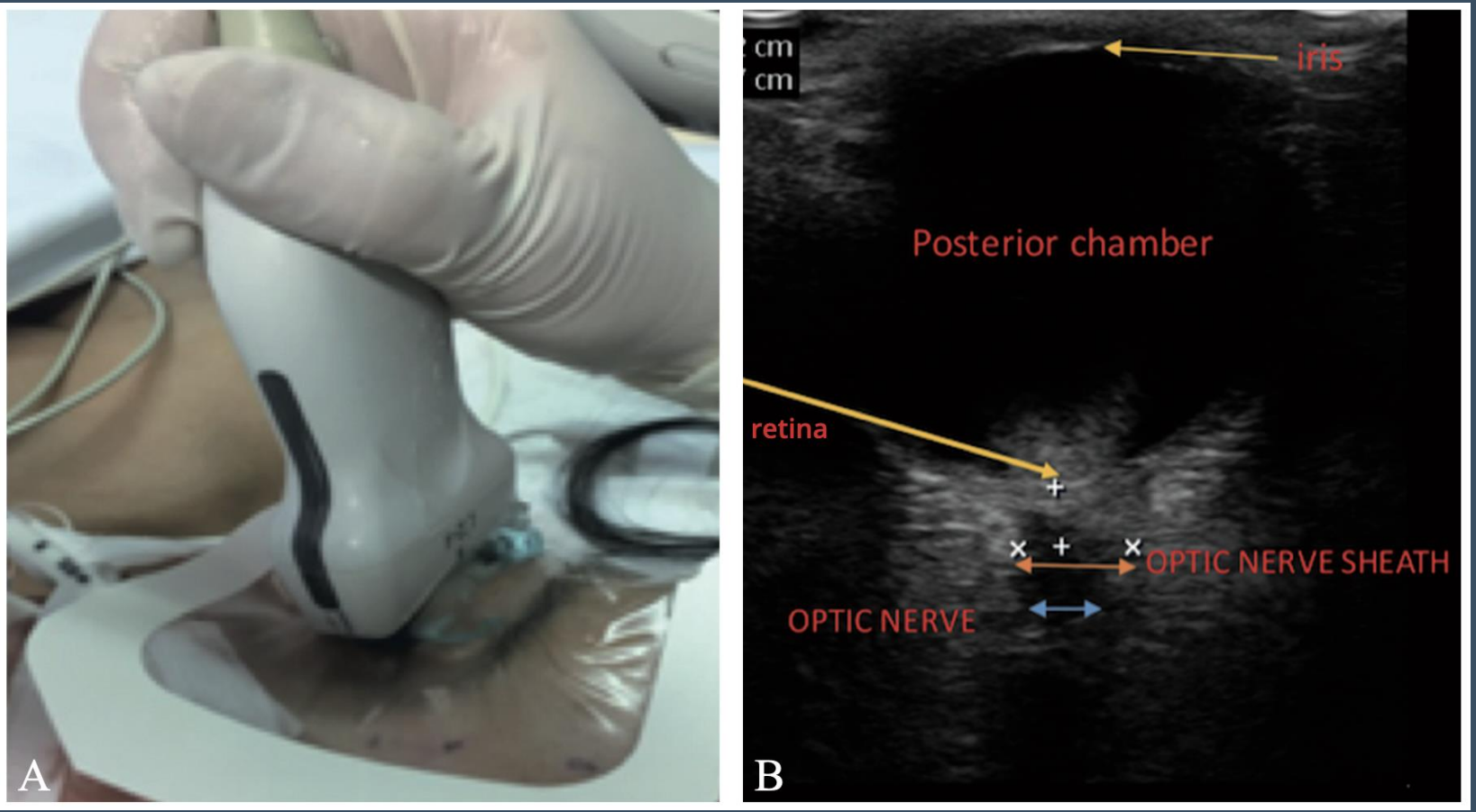
Changes in diaphragm thickness during the first week

Predict an increased risk of prolonged mechanical ventilation.



Goligher et al: AJRCCM 2017

Optic Nerve Sheath Diameter - Intra Cranial Pressure



< 5 mm - Normal ICP
> 6 mm - Increased ICP

2 measurements each eye
- Axial
- Sagittal

4 measurement total

POCUS and Artificial Intelligence (AI)

Increase utility at the bedside

Teaching tool

Increase accuracy of data

Good interclass correlation (AI vs Expert Physician) when green zone achieved

Auto EF Tool

Gohar et al: J Clin Med 2023

Outpatient Utility

Novice-performed point-of-care ultrasound for home-based imaging

Healthy volunteers, home lung ultrasonography, anterior / lateral zones

Images sent to clinician, compared to baseline

84% of clips interpretable (as compared to 87% clips expert obtained clips)

Proposed decision tree for heart failure management at home with ultrasound
Continue management, Increase diuresis, Evaluate in person

Nature Scientific Reports (2022) 12:20461

Could Ultrasound replace the Stethoscope

Physical Exam 2.0 / PE ++

US gets the ‘physical exam’ back in fashion, increases its scope / yield and potentially allows for a bedside interface for the patient / physician and AI

History

Exam

Diagnostic Testing

POCUS

Clifford Marks - New Yorker Jan 2023