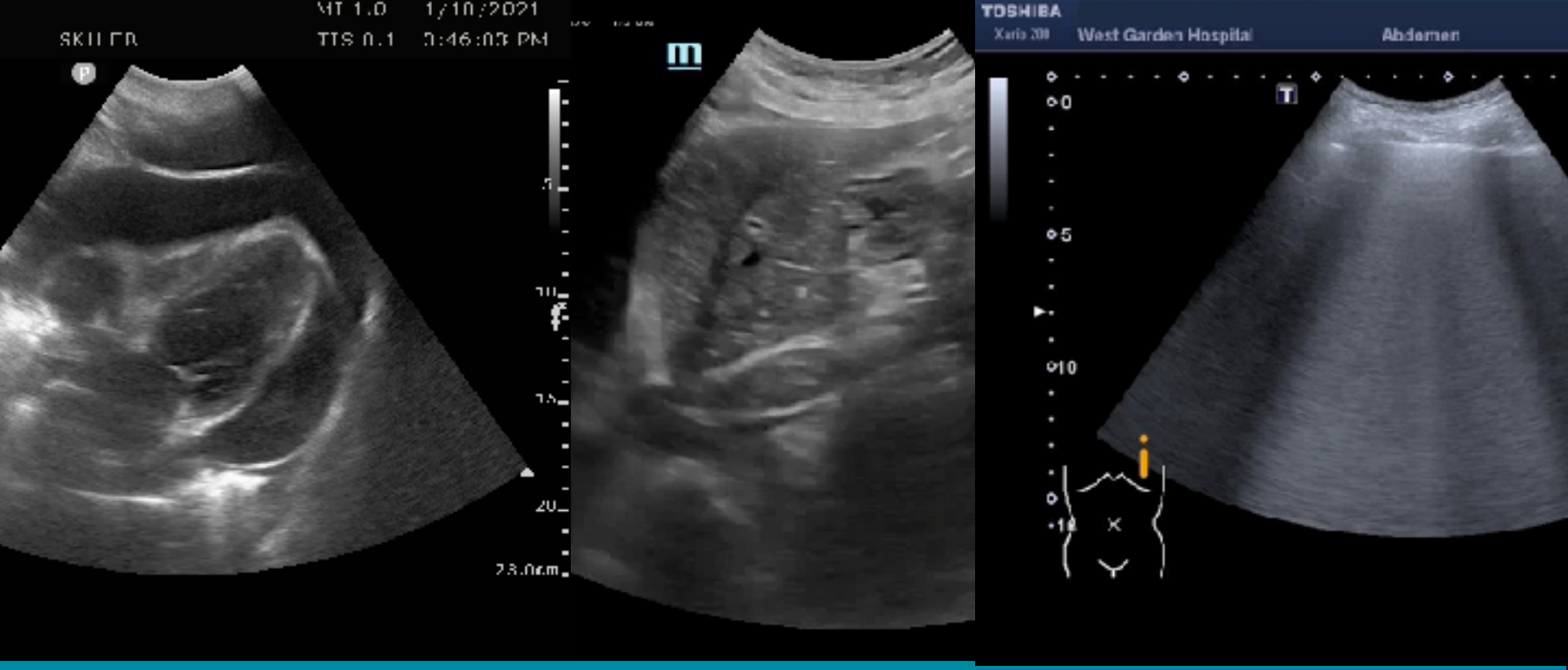


POCUS IN SHOCK MANAGEMENT

陳國智醫師 雙和醫院急診醫學科

juice119@gmail.com

POCUSacademy.com

Core Applications (2023 ACEP Emergency Ultrasound Guidelines)
15項急診超音波核心應用

陳國智醫師

- Aorta
- DVT
- Trauma
- Thoracic/Airway
- Cardia/HD assessment

- Procedural Guidance
- US-guided NB
- Testicular
- Ocular
- Skin & Soft tissue

- Hepatobiliary
- Urinary tract
- Pregnancy
- Bowel
- MSK

Journal of
Clinical Medicine

MDPI

Review

Critical Care Ultrasound in Shock: A Comprehensive Review of Ultrasound Protocol for Hemodynamic Assessment in the Intensive Care Unit

Camilo Pérez [1,2,*], Diana Diaz-Caicedo [1,2], David Fernando Almanza Hernández [1,2], Lorena Moreno-Araque [1,2], Andrés Felipe Yepes [1,2] and Jorge Armando Carrizosa Gonzalez [1,2]

Shock Subtype	CI	SVR	CVP	PAOP
Cardiogenic	Low	High	High	High
Hypovolemic	Low	High	Low	Low
Obstructive	Low	High	High	High
Distributive	High	Low	Low	Low

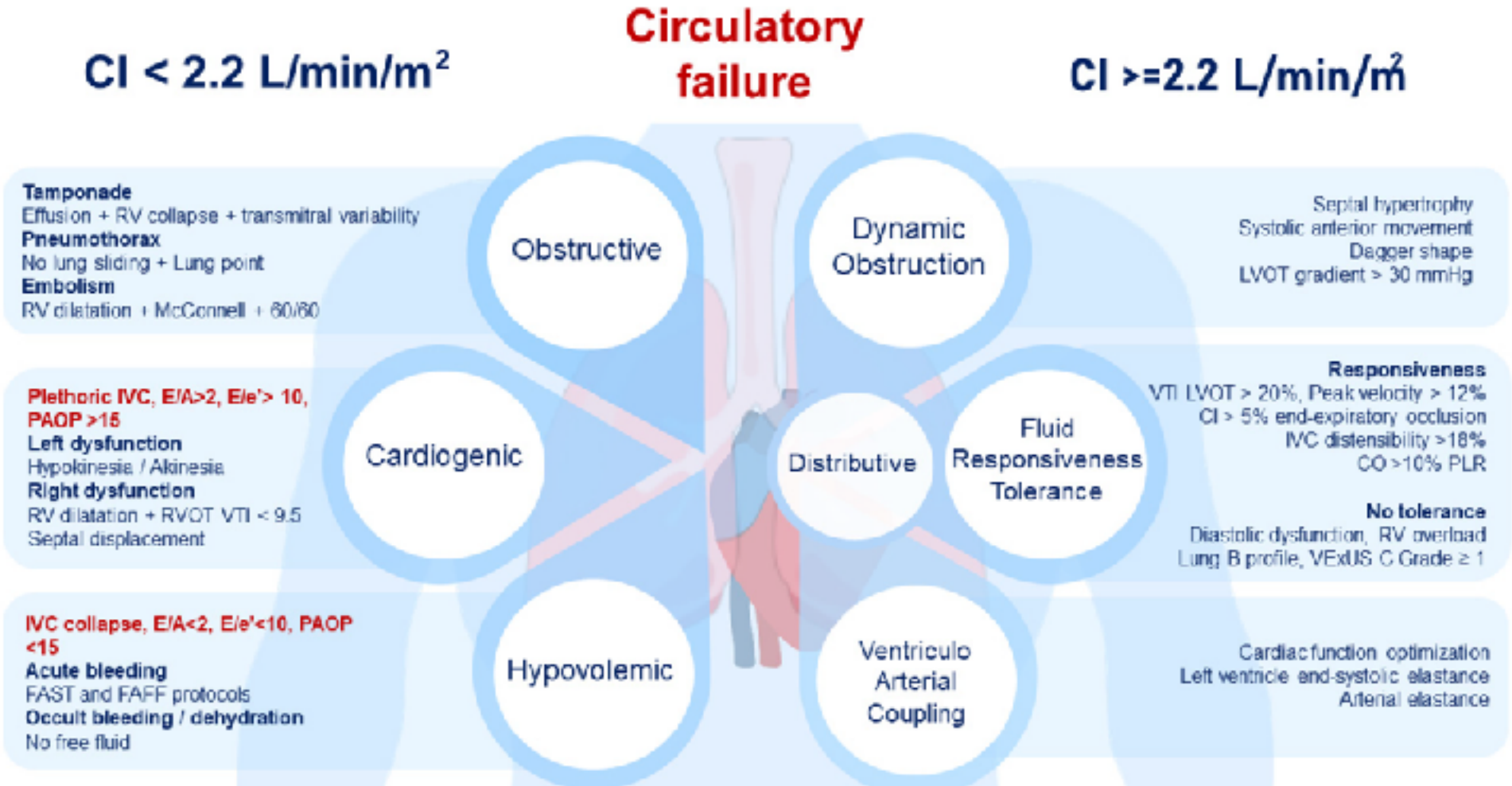
J. Clin. Med. 2024, 13, 5344

Journal of Clinical Medicine

J. Clin. Med. 2024, 13, 5344 MDPI

Review

Critical Care Ultrasound in Shock: A Comprehensive Review of Ultrasound Protocol for Hemodynamic Assessment in the Intensive Care Unit



Journal of *Clinical Medicine*

J. Clin. Med. 2024, 13, 5344

MDPI

Review

Critical Care Ultrasound in Shock: A Comprehensive Review of Ultrasound Protocol for Hemodynamic Assessment in the Intensive Care Unit

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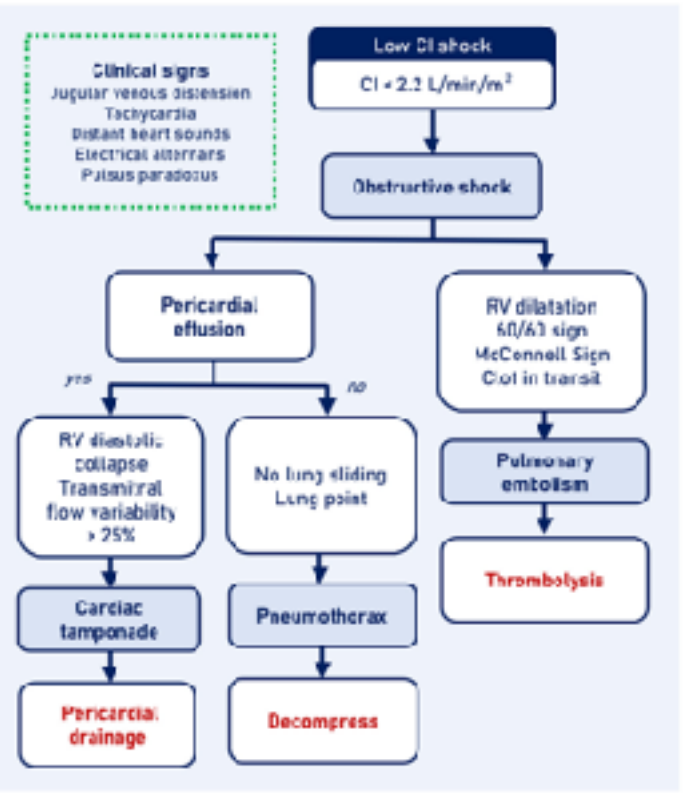
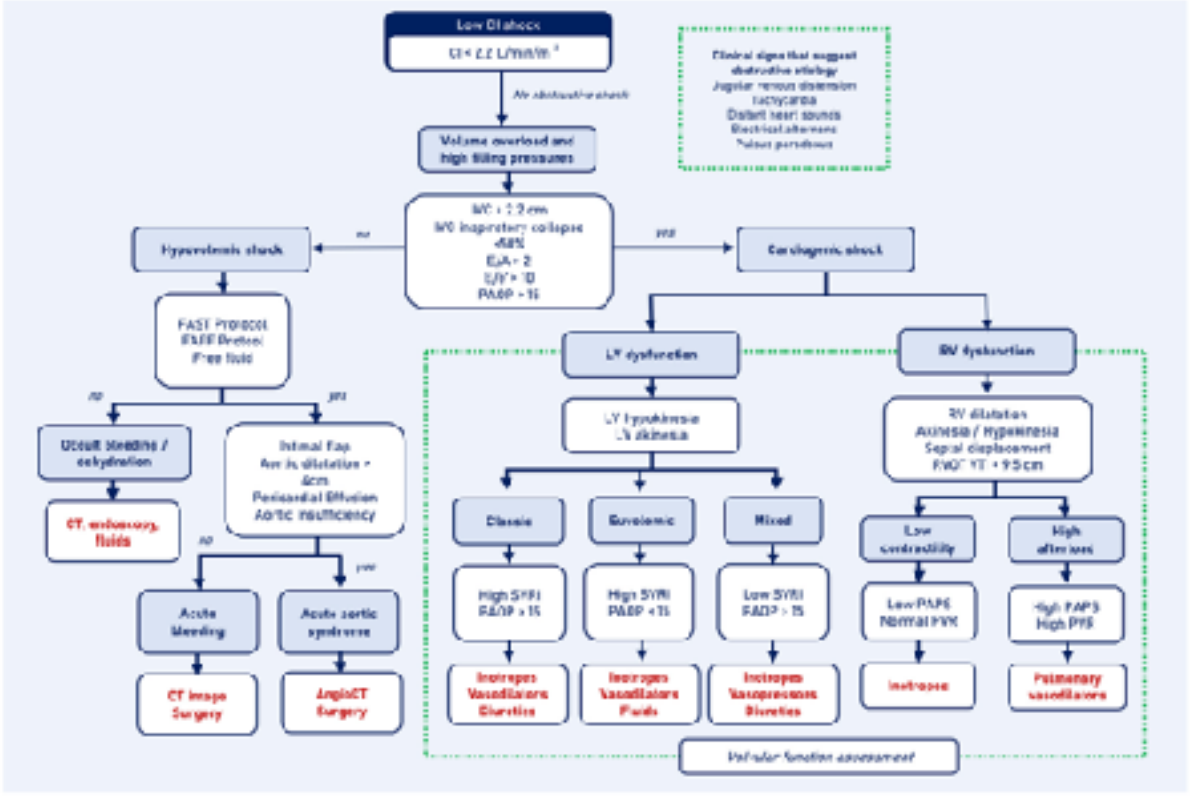
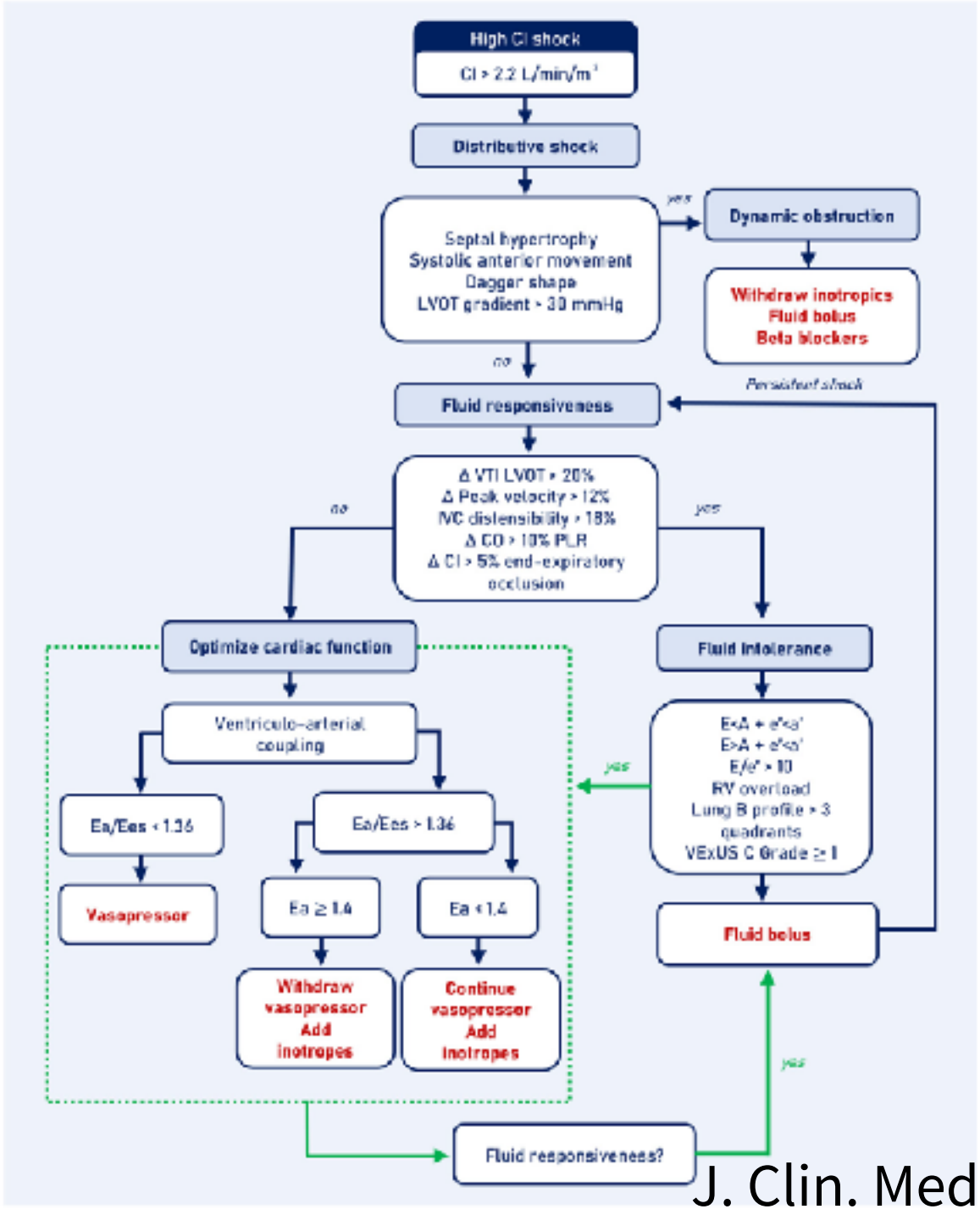
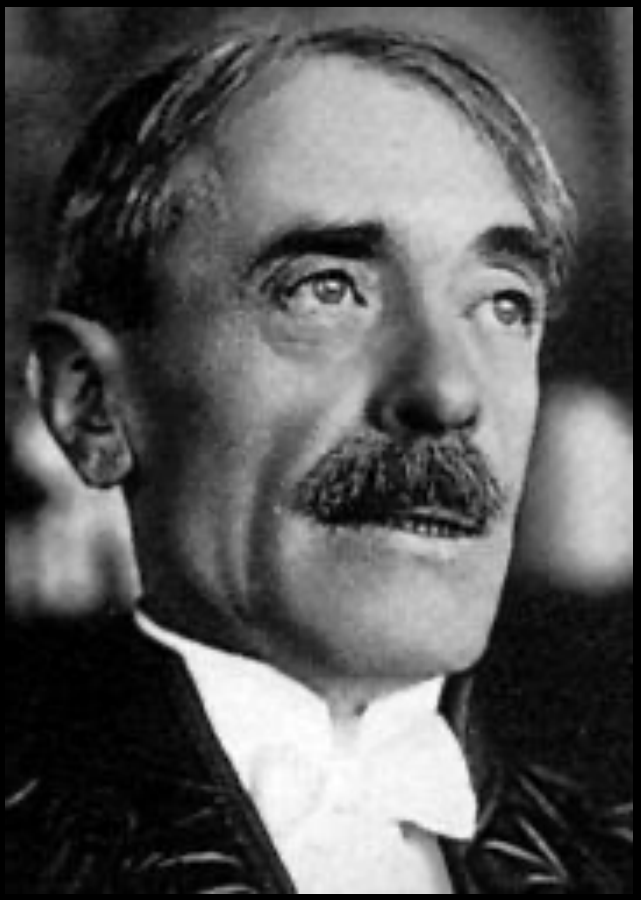






J. Clin. Med. 2024, 13, 5344



Paul Valéry

~ French poet, essayist, philosopher

"Everything simple is false.
Everything complex is unusable."

Review Article

TRANSLATIONAL
CRITICAL CARE MEDICINE

OPEN

Point of care ultrasound and shock: The value in bedside diagnosis and hemodynamic assessment in undifferentiated shock patients

Catherine Nguyen[1], Dominic Parfianowicz[1], Courtney Bennett[2,*]

Form	Etiology	Cardiac output	Systemic vascular resistance	Central venous pressure
Cardiogenic	Cardiomyopathy, STEMI, valvular disease, arrhythmia	↓	↑	↑
Distributive	Sepsis, anaphylaxis	↑	↓	↓
Hypovolemic	Hemorrhage	↑	↑	↓
Obstructive	Pulmonary Embolism Tamponade	↓	↑	↑

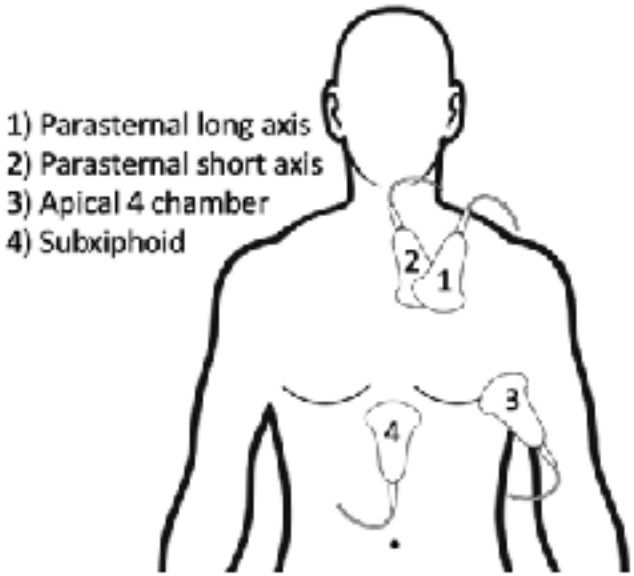
J Transl Crit Care Med 2024;6:e24-00010

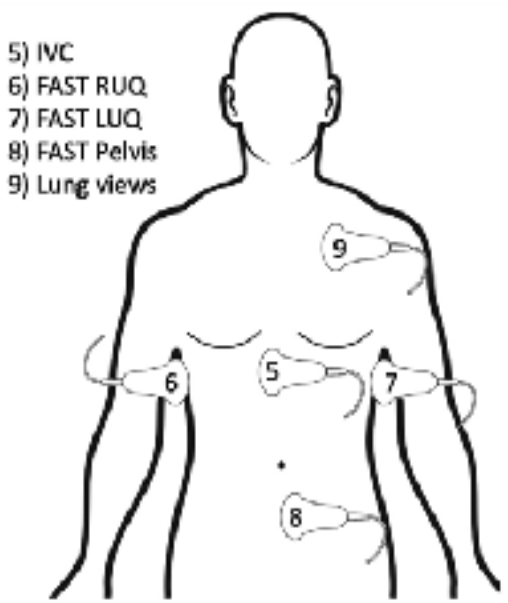
Resuscitative Ultrasound and Protocols

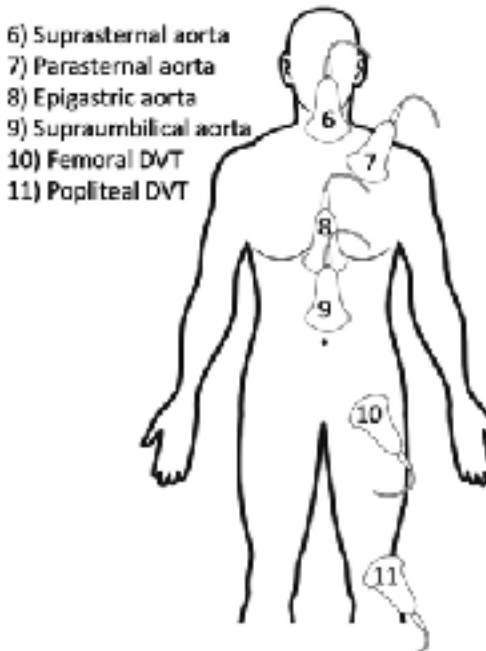
Emerg Med Clin N Am 42 (2024) 947–966

Judy Lin, MD[a,*], Javier Rosario, MD[b], Nicholas Saltarelli, MD[c]

RUSH protocol (rapid ultrasound in shock)







Transducers

表面　　頻率　　深度

Resuscitative Ultrasound and Protocols

Emerg Med Clin N Am 42 (2024) 947–966

Judy Lin, MD[a,*], Javier Rosario, MD[b], Nicholas Saltarelli, MD[c]

RUSH Component	Assessment	What to Look for	Shock Types
The Pump	Cardiac	Left ventricular function	Cardiogenic
		Left ventricle/right ventricle size	Obstructive
		Pericardial effusion	Distributive
		RV strain	
	Lungs	B-lines	
		Consolidation	
		Effusion	
		Pneumothorax	
The Tank	Abdomen	Free fluid	Hypovolemic
	Inferior vena cava	IVC respiratory variation	Distributive
The Pipes	Aorta	Aneurysm	Cardiogenic
		Dissection	Hypovolemic
			Obstructive

Resuscitative Ultrasound and Protocols

Emerg Med Clin N Am 42 (2024) 947–966

Judy Lin, MD[a,*], Javier Rosario, MD[b], Nicholas Saltarelli, MD[c]

Sonography in hypotension and cardiac arrest in the emergency department, cardiac arrest protocol

Tiers	Views	Assessment
Core	Subxiphoid Parasternal long axis	Pericardial effusion, right heart strain, LVEF
Supplemental	Lung bases IVC	Pleural fluid Size and collapse
Additional	Leg veins Aorta Pelvis	DVT AAA Free fluid

Resuscitative Ultrasound and Protocols

Emerg Med Clin N Am 42 (2024) 947–966

Judy Lin, MD[a,*], Javier Rosario, MD[b], Nicholas Saltarelli, MD[c]

Sonography in hypotension and cardiac arrest in the emergency department, hypotension protocol

Tiers	Views	Assessment
Core	Subxiphoid	Pericardial effusion, right heart strain, left ventricular ejection fraction (LVEF)
	Parasternal long axis	
	Lung bases	Pleural fluid, B-lines
	IVC	Size and collapse
Supplemental	Additional cardiac windows	
Additional	Leg veins	Deep venous thrombosis (DVT)
	Aorta	AAA
	Pelvis	Free fluid, intrauterine pregnancy (IUP)

Resuscitative Ultrasound and Protocols

Emerg Med Clin N Am 42 (2024) 947–966

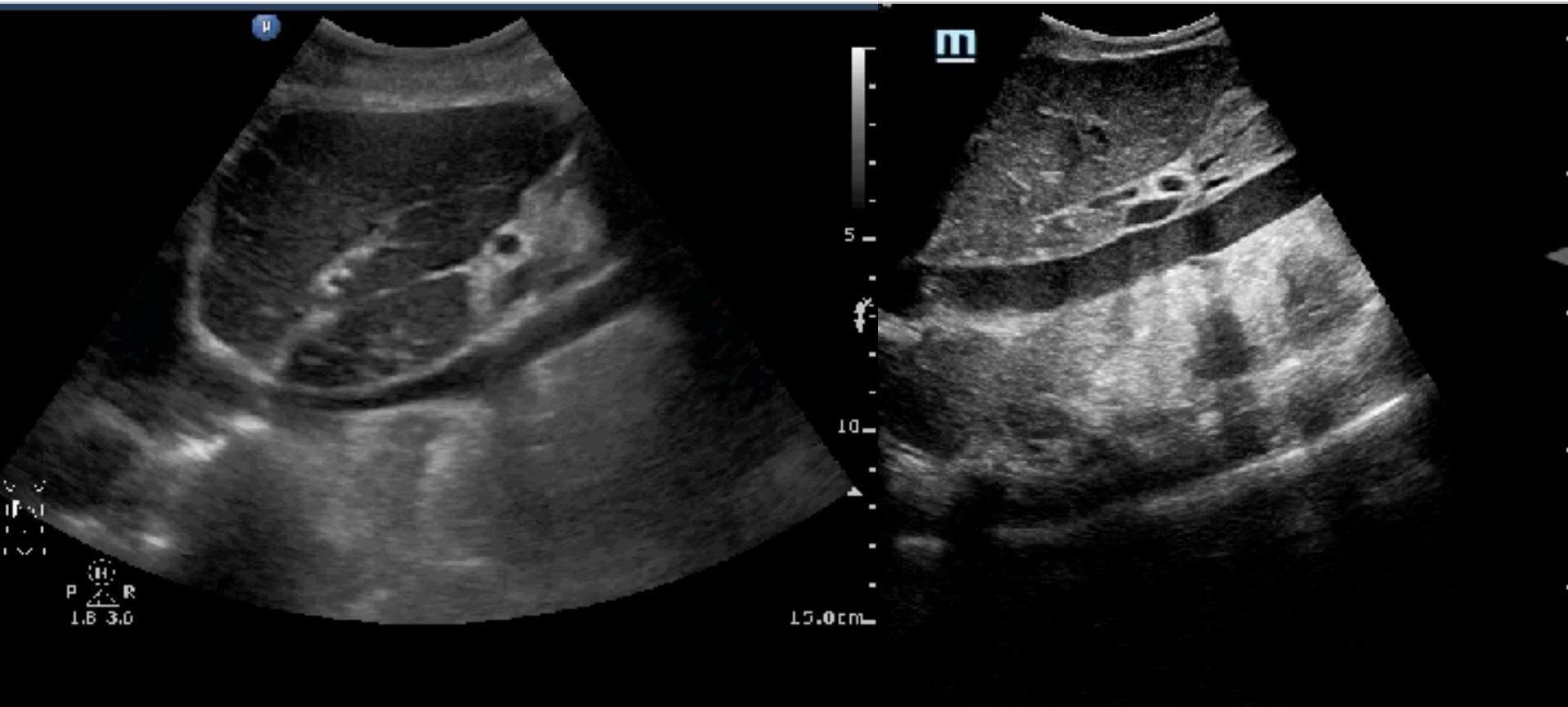
Judy Lin, MD[a,*], Javier Rosario, MD[b], Nicholas Saltarelli, MD[c]

CVP	IVC Diameter	% Collapse	RAP
Low	<2.1 cm	>50%	3 mm Hg
Intermediate	<2.1 cm	<50%	8 mm Hg
	>2.1 cm	>50%	8 mm Hg
High	>2.1 cm	<50%	15 mm Hg

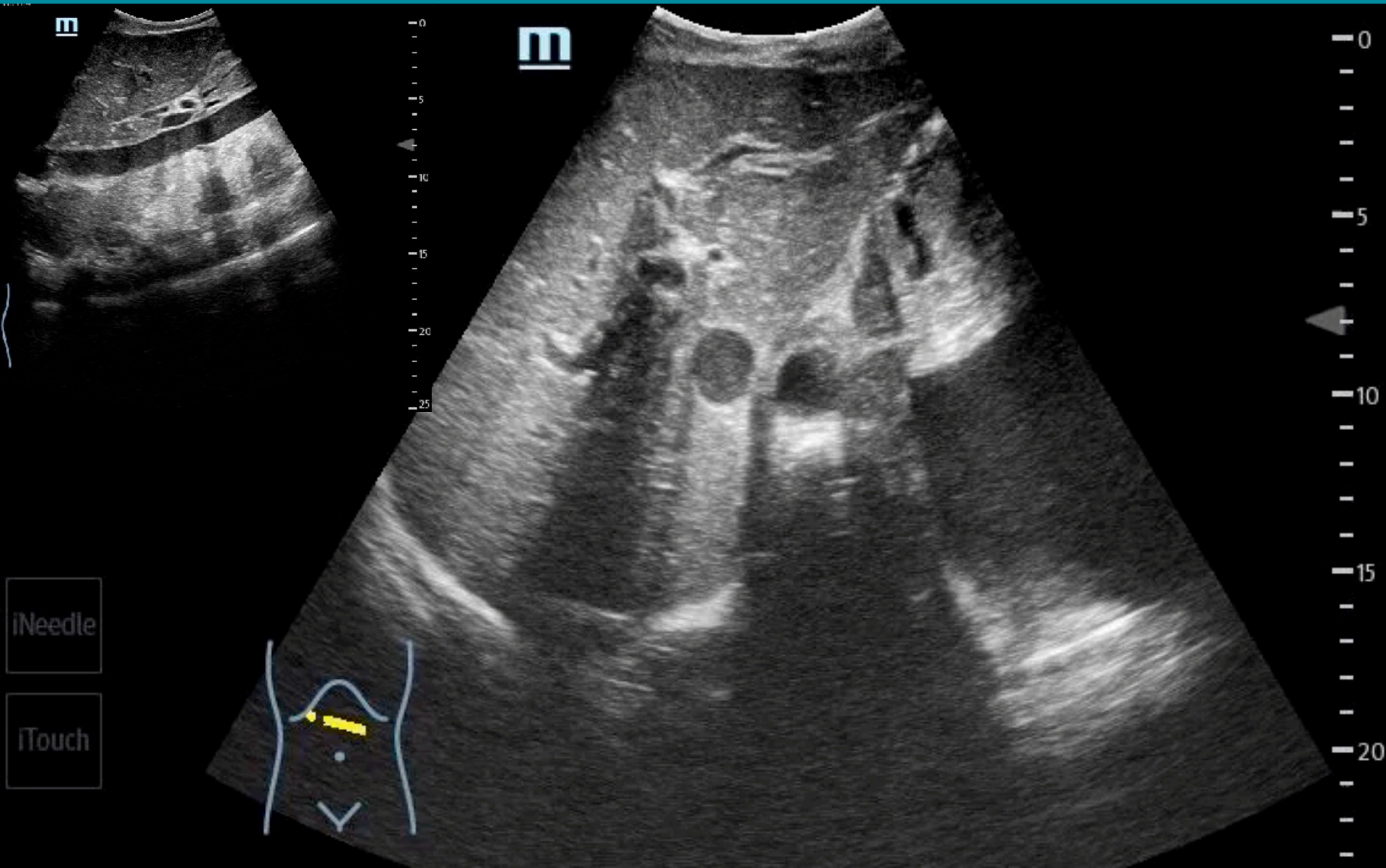
Index	Equation	Application
Collapsibility Index (%)	% [(Dmax – Dmin)]/Dmax × 100 (Dmax = maximum IVC diameter at end *expiration*; Dmin = minimum IVC diameter at end *inspiration*)	Used in spontaneously breathing patients
Distensibility Index (%)	% [(Dmax – Dmin)]/Dmin ×100 (Dmax = maximum IVC diameter at end *inspiration*; Dmin = minimum IVC diameter at end *expiration*)	Used in mechanically ventilated patients

To fill or not to fill ?

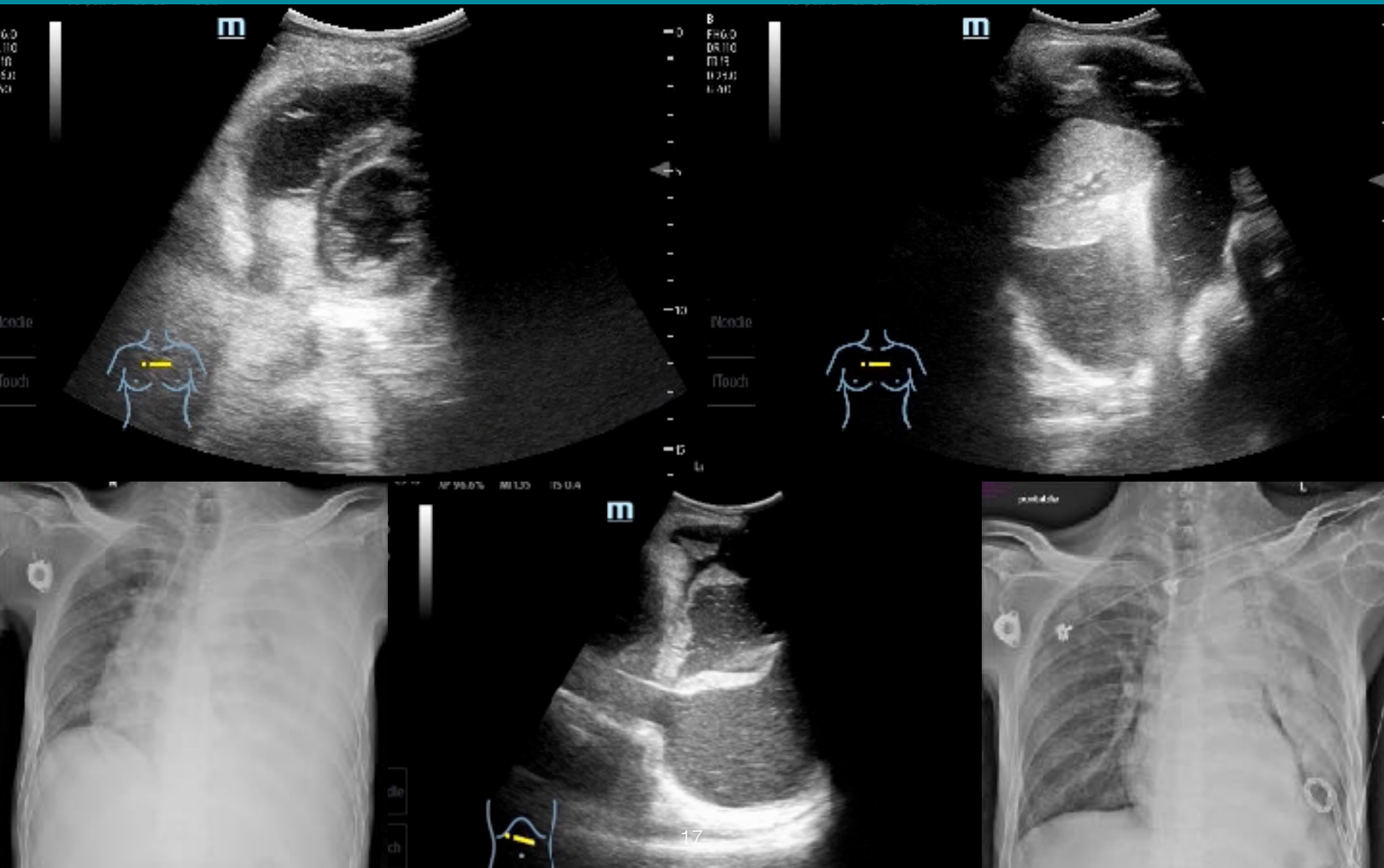
CVP	IVC Diameter	% Collapse	RAP
Low	<2.1 cm	>50%	3 mm Hg
Intermediate	<2.1 cm	<50%	8 mm Hg
	>2.1 cm	>50%	8 mm Hg
High	>2.1 cm	<50%	15 mm Hg



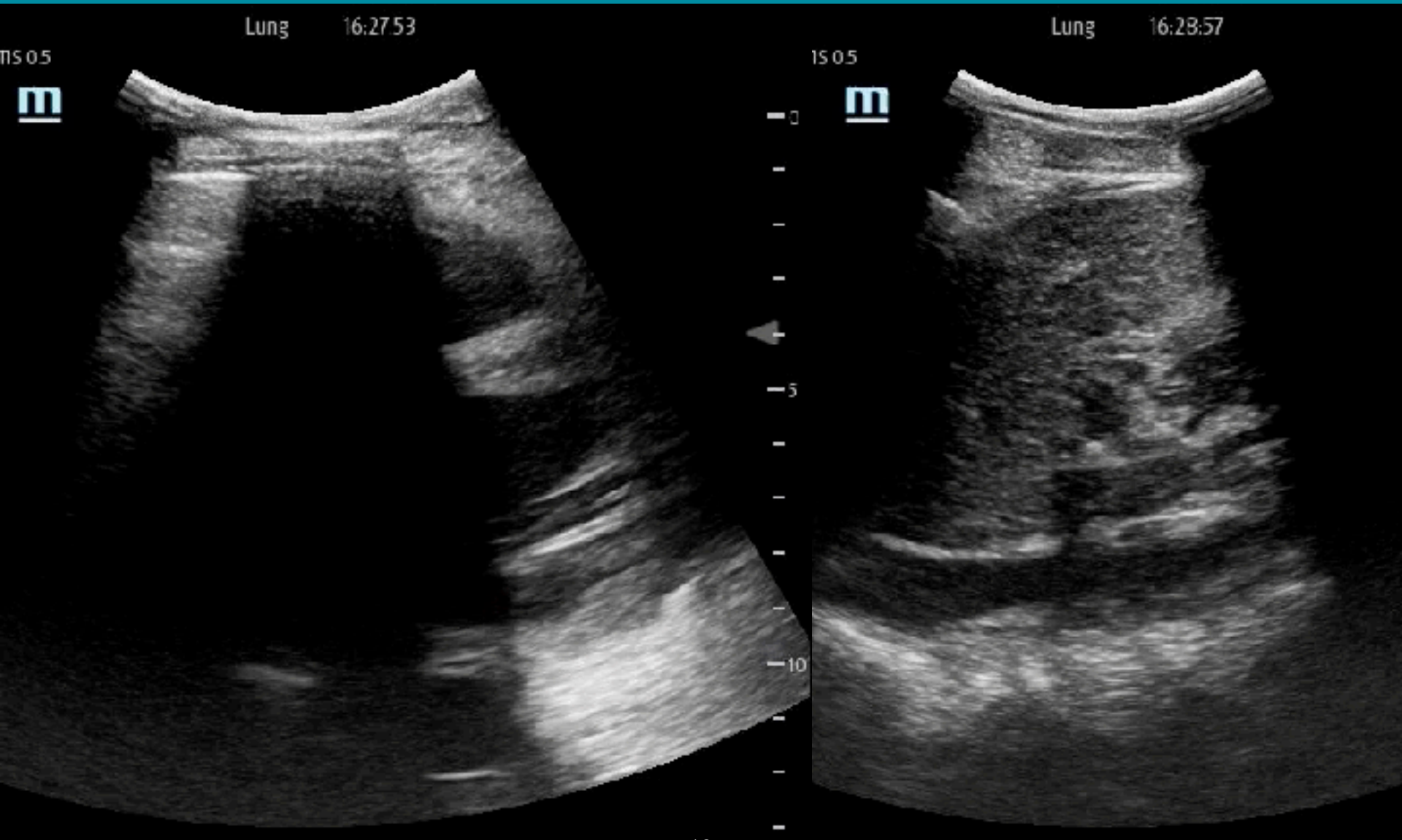
Shock type ? Fill or not to fill ?



Pyopneumothorax



Fill or not to fill ?



Yoshida et al. Critical Care (2023) 27:200
https://doi.org/10.1186/s13054-023-04495-6

Critical Care

REVIEW Open Access

Diagnostic accuracy of point-of-care ultrasound for shock: a systematic review and meta-analysis

Takuo Yoshida[1,2], Takuya Yoshida[1], Hisashi Noma[3], Takeshi Nomura[4], Akihiro Suzuki[5] and Takahiro Mihara[1,6*]

Shock type	No. of patients (study)	Sensitivity	Specificity	Area under the ROC curve	Positive likelihood ratio	Negative likelihood ratio
Obstructive	810 (9)	0.82 (0.68–0.91)	0.98 (0.92–0.99)	0.95 (0.78–0.97)	40 (11–105)	0.20 (0.10–0.33)
Cardiogenic	828 (9)	0.78 (0.56–0.91)	0.96 (0.92–0.98)	0.96 (0.86–0.97)	19 (7.1–40)	0.24 (0.09–0.47)
Hypovolemic	688 (9)	0.90 (0.84–0.94)	0.92 (0.88–0.95)	0.96 (0.87–0.96)	12 (7.3–18)	0.11 (0.07–0.17)
Distributive	594 (8)	0.79 (0.71–0.85)	0.96 (0.91–0.98)	0.86 (0.75–0.96)	23 (9.3–49)	0.22 (0.16–0.30)
Mixed	291 (4)	0.80 (0.61–0.91)	0.96 (0.89–0.99)	0.95 (0.76–0.97)	20 (7.9–49)	0.21 (0.10–0.40)

CEEM Clinical and Experimental Emergency Medicine
Clin Exp Emerg Med 2023;10(4):363-381
https://doi.org/10.15441/ceem.23.101

Role of point-of-care ultrasound in critical care and emergency medicine:

eISSN: 2383-4625

Exam	Hypovolemic	Cardiogenic	Obstructive	Distributive
Cardiac exam				
Left ventricle	Hyperdynamic function	Decreased function Dilated chamber Valve abnormality?	Hyperdynamic function Pericardial effusion+chamber collapse → Tamponade?	Hyperdynamic or hypocontractile or normal function?
Right ventricle	Normal or small size	Dilated chamber? Valve abnormality?	Dilated, strained RV D-shaped septum → Pulmonary embolism?	Normal or small size
Pulmonary exam				
Lungs	A-line predominance	B-lines	Absent lung sliding? → Pneumothorax?	Consolidation pattern or focal B- lines → Pneumonia
Pleura	Pleural effusion (–)	Bilateral pleural effusions?	Pleural effusion (±) Subpleural consolidations → Pulmonary embolism?	Pleural effusion (±) → Pneumonia? Empyema?
IVC exam	Collapsed IVC	Distended IVC	Distended IVC	Normal or collapsed IVC
Supplementary exam				
Abdomen	Aortic aneurysm Aortic dissection Intra-abdominal hemorrhage	Peritoneal fluid in chronic right or left heart failure (±)		Peritoneal fluid (±)
Vascular	Collapsed veins	-	Distended internal jugular vein → Tamponade? Femoral, popliteal vein thrombus?	

RUSH protocol (rapid ultrasound in shock)

Pump (cardiac)	Pericardial effusion	Left ventricular contractility	Right ventricular strain
	Effusion? Tamponade?	Hyperdynamic? Normal? Decreased?	Right ventricle size? Septal displacement?

Tank (intravascular volume)	Tank volume	Tank leakiness	Tank compromise	Tank overload
	Inferior vena cava Internal jugular veins → Size or inspiratory collapse?	Free fluid abdomen or pelvis? Free fluid thoracic cavity?	Absent lung sliding? Absent comet tails? → Tension pneumothorax?	Lung rockets? → Pulmonary edema

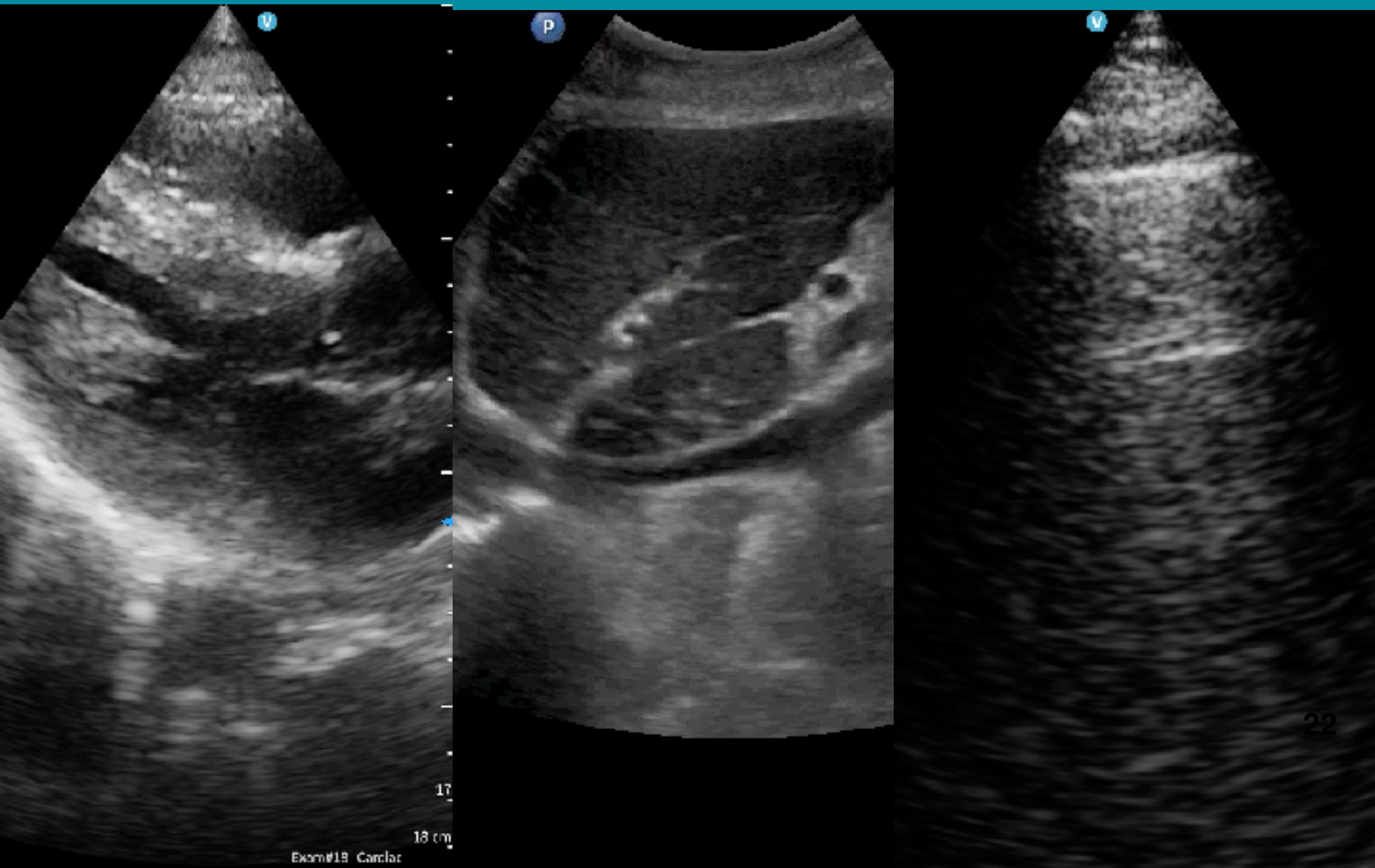
Pipes (vessel)	Rupture of the pipes	Clogging of the pipes
	Aorta aneurysm Aortic dissection	Femoral vein? Popliteal vein? → Thrombosis?

SHoC protocol (sonography in hypotension & cardiac arrest)

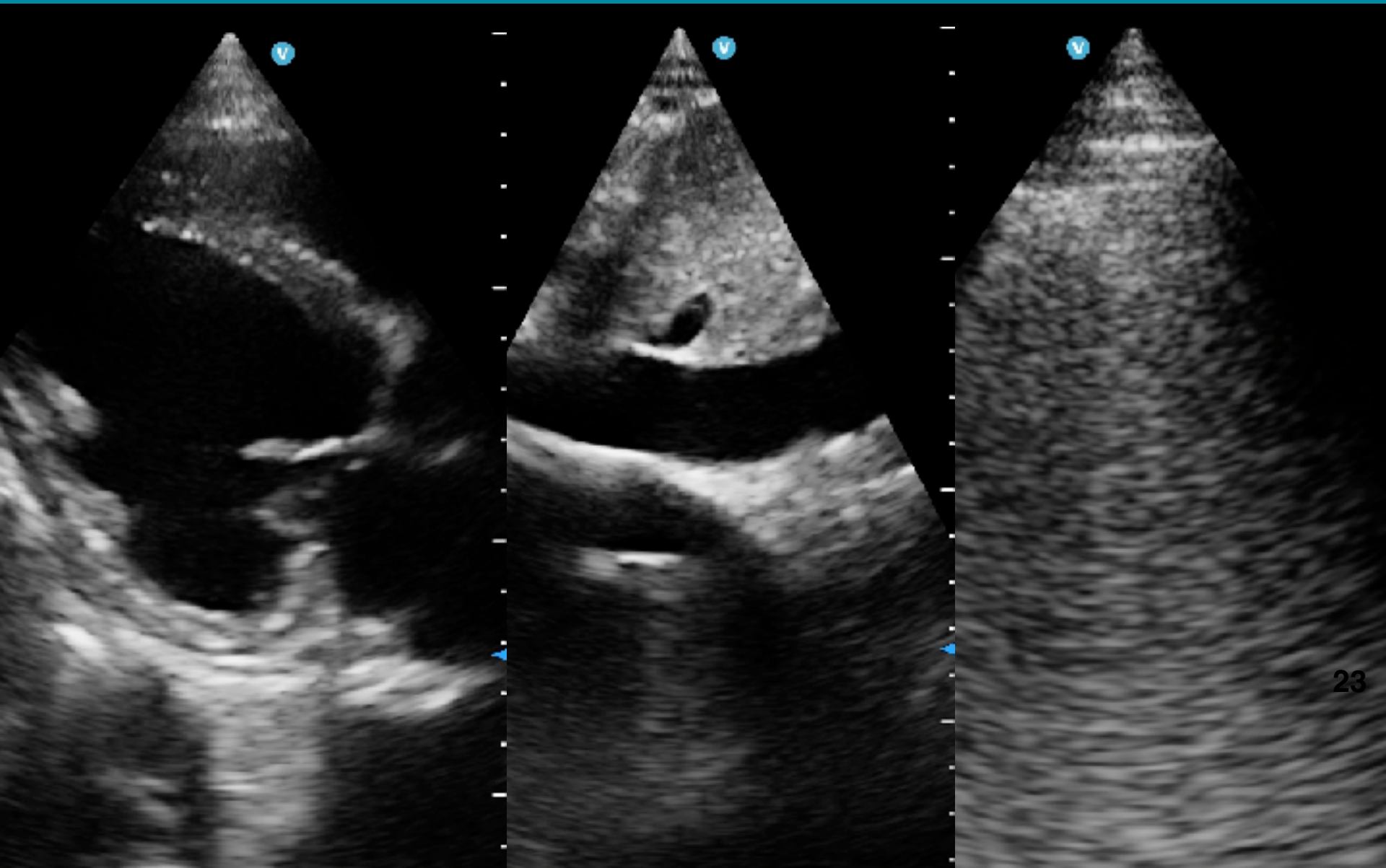
1. Core view: should be completed
Cardiac view (subxiphoid and parasternal long axis): pericardial fluid, gross cardiac size, shape and ventricular function Lung view (bilateral anterior and lateral chest views): pleural fluid and B-lines Inferior vena cava view (subxiphoid or transhepatic view): overall diameter, respiratory variation in size
2. Supplementary view: if more cardiac information is required
Other cardiac views (parasternal short axis and apical views): pericardial fluid or cardiac form or function
3. Additional view: when clinically indicated
Abdomen-pelvic view: peritoneal fluid Aortic view: abdominal aortic aneurysm Deep vein thrombosis view

Clin Exp Emerg Med 2023;10(4):363-381

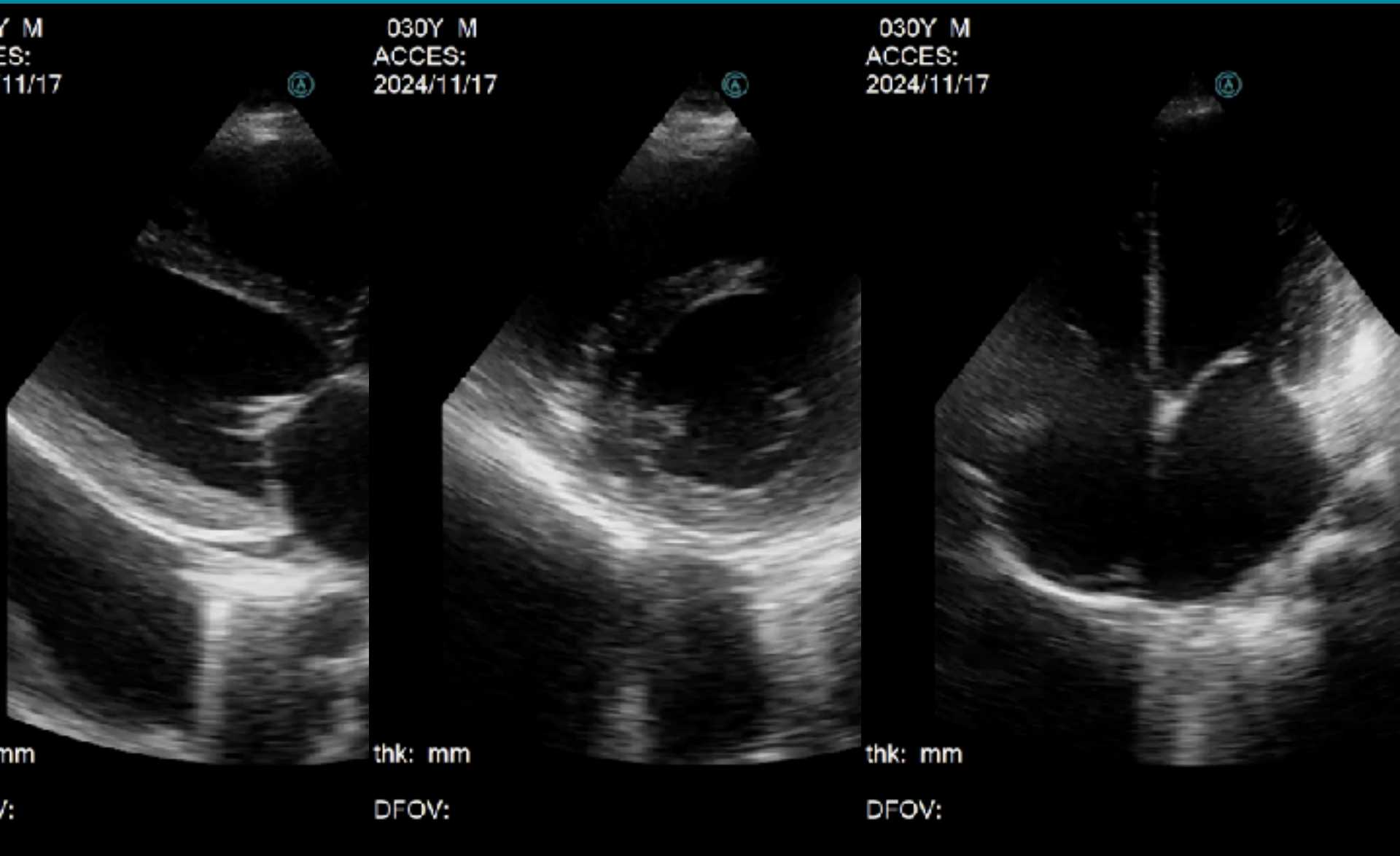
In shock >> to fill



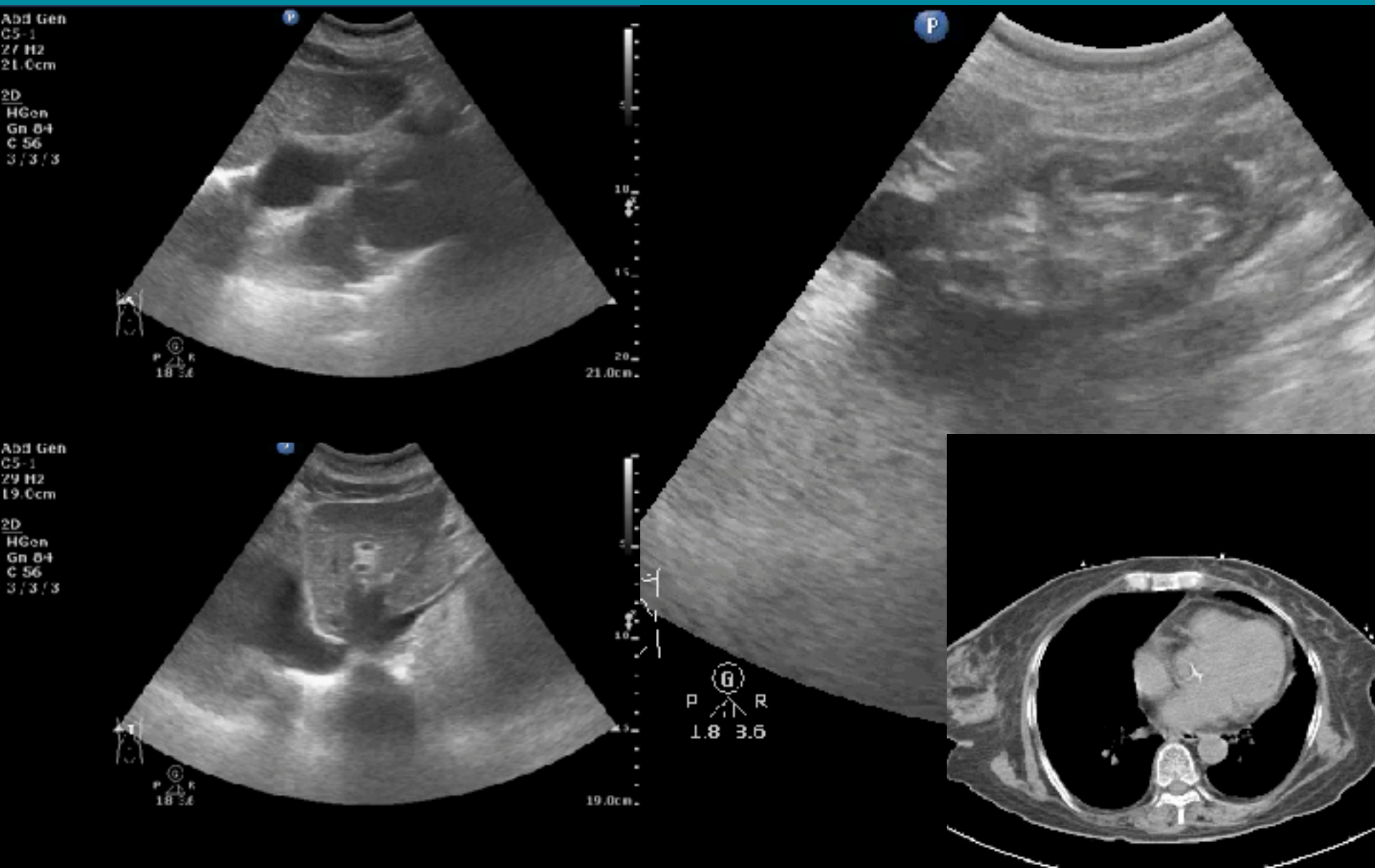
In shock >> not to fill



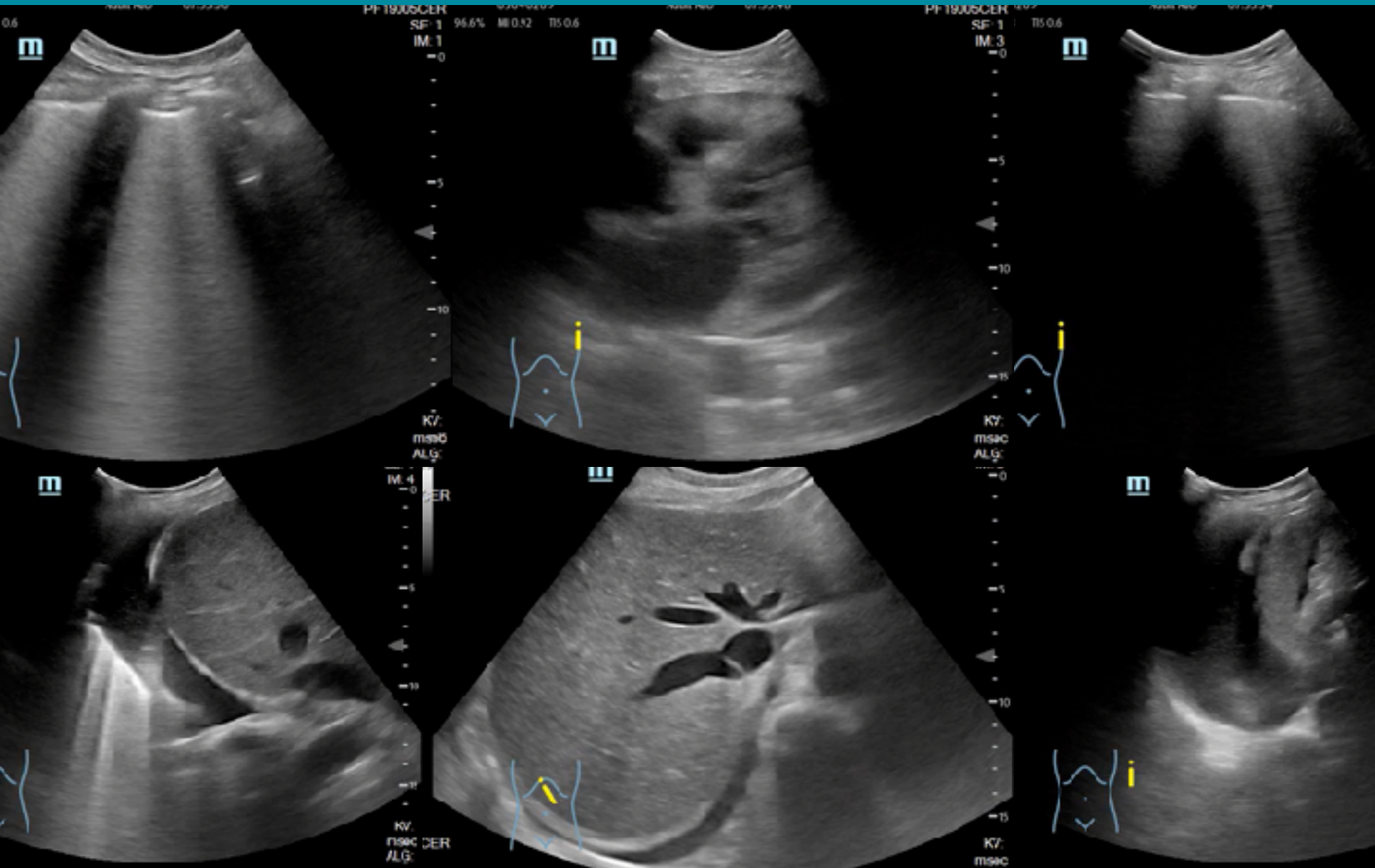
Heart - Lung - IVC



Heart - Lung - IVC



Heart - Lung - IVC



Fluid accumulation syndrome in sepsis and septic shock: pathophysiology, relevance and treatment—a comprehensive review

Carmen Andrea Pfortmueller[1*], Wojciech Dabrowski[2], Rob Wise[3,4,5], Niels van Regenmortel[6,7] and Manu L. N. G. Malbrain[2,8,9]

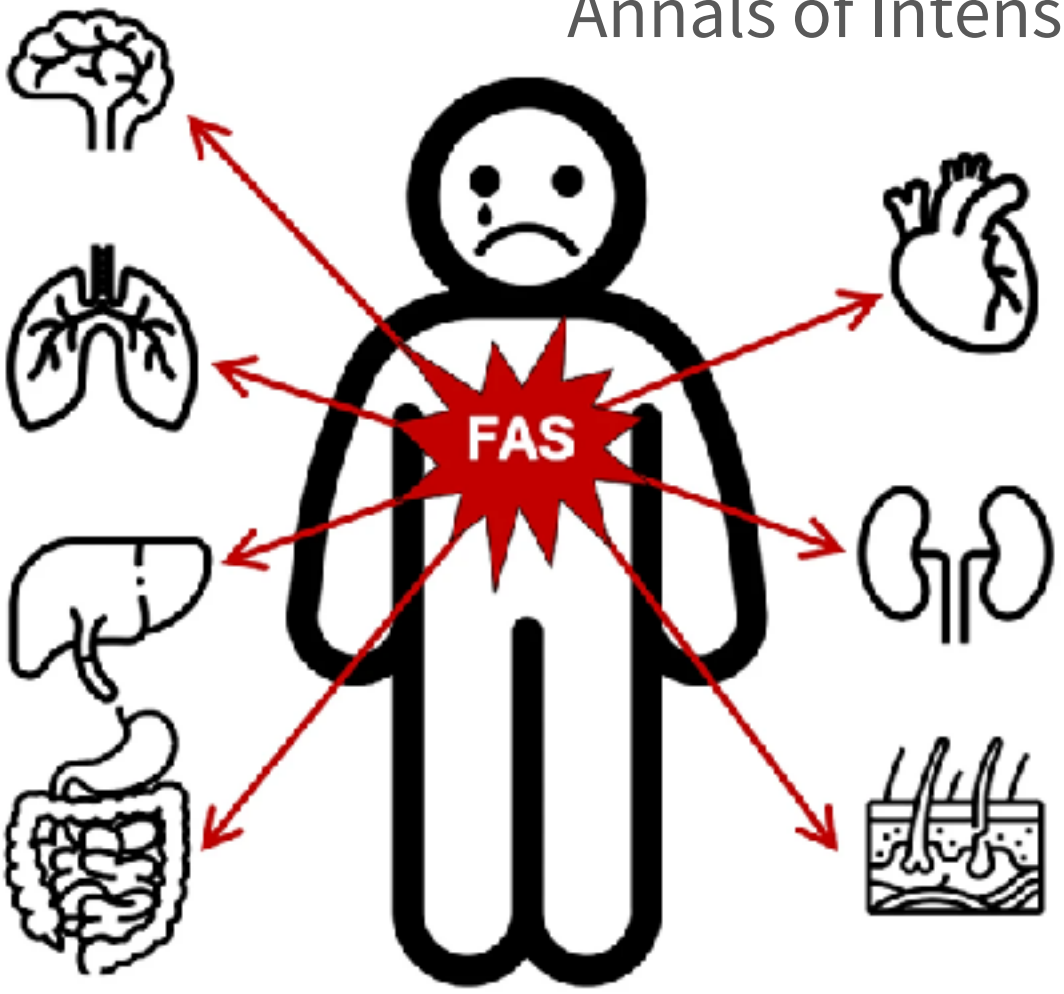
Annals of Intensive care 2024

Central Nervous
- Cerebral edema ↑
- Impaired cognition
- Delirium ↑

Respiratory
- Pulmonary edema ↑
- Altered pulmonary and chest wall elastance
- Oxygenation index ↓
- Lung volumes ↓
- Work of breathing ↑
- Time on ventilator ↑
- Difficulty in weaning ↑
- Pleural effusions ↑
- Extravascular lung water ↑

Hepatic
- Hepatic congestion ↑
- Hepatic Compartment Syndrome
- Impaired synthetic function
- Cholestatis ↑
- Cytochrome P450 activity ↓

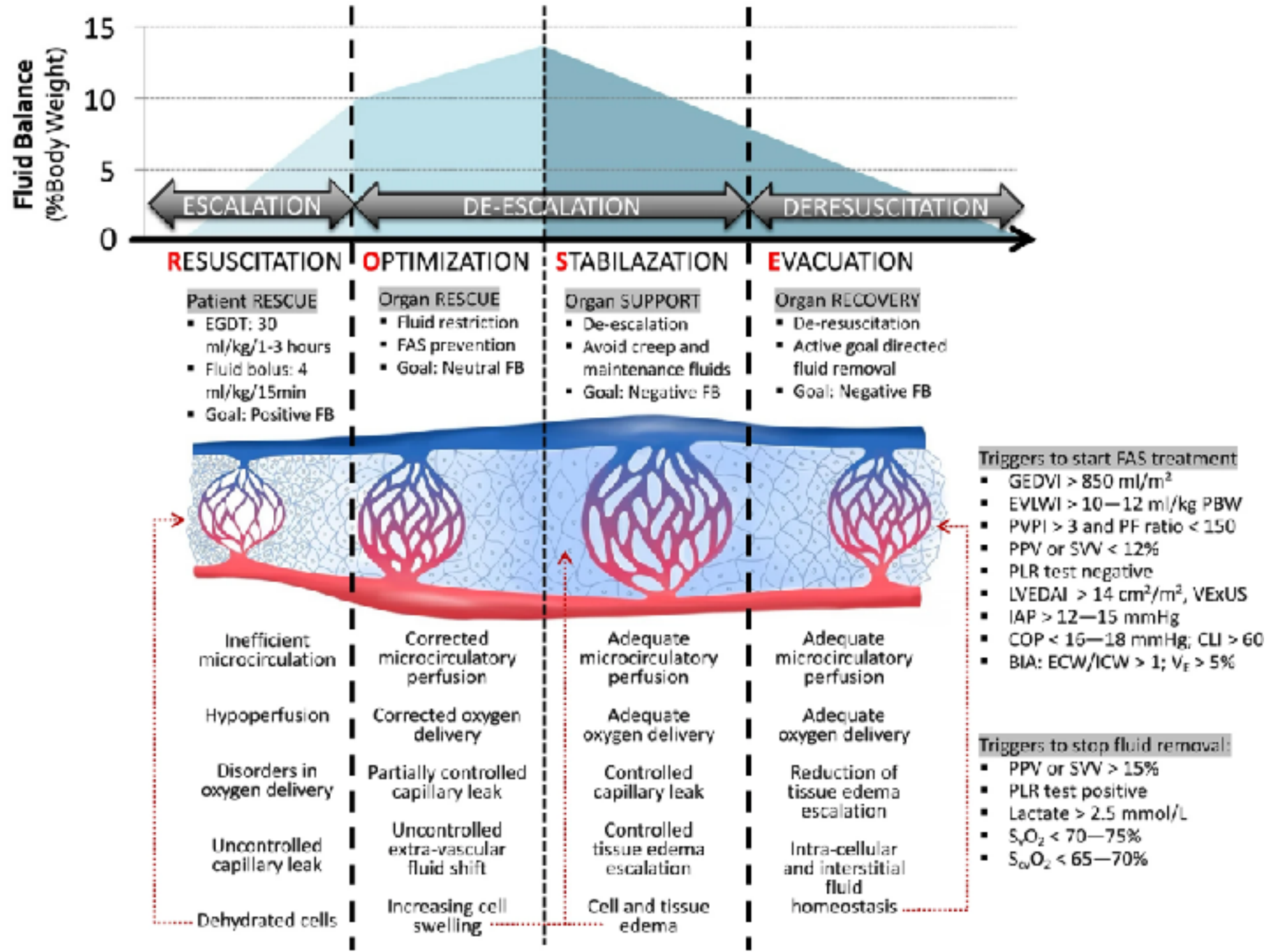
Gastrointestinal/Visceral
- Gut and bowel edema ↑
- Ascites formation ↑
- Bowel contractility ↓
- Intra-abdominal pressure ↑
- Success enteral feeding ↓
- Bacterial translocation ↑
- Splanchnic microcirculation ↓



Cardiovascular
- Myocardial edema ↑
- Impaired contractility
- Diastolic dysfunction
- Myocardial depression
- Conduction disturbance
- Filling pressures ↑
- Altered venous return
- Pericardial effusion ↑

Renal
- Renal interstitial edema
- Renal venous pressure ↑
- Renal blood flow ↓
- Interstitial pressure ↑
- Salt retention
- Water retention
- Glomerular filtration rate ↓
- Renal Compartment Syndrome
- Altered RAAS

Skin/Soft Tissue
- Tissue edema ↑
- Poor wound healing
- Risk wound infection ↑
- Risk pressure ulcers ↑
- Abdominal wall compliance ↓


Fluid Balance
(%Body Weight)
15
10
5
0
ESCALATION
DE-ESCALATION
DERESUSCITATION
RESUSCITATION
OPTIMIZATION
STABILAZATION
EVACUATION
Patient RESCUE
EGDT: 30 ml/kg/1-3 hours
Fluid bolus: 4 ml/kg/15min
Goal: Positive FB
Organ RESCUE
Fluid restriction
FAS prevention
Goal: Neutral FB
Organ SUPPORT
De-escalation
Avoid creep and maintenance fluids
Goal: Negative FB
Organ RECOVERY
De-resuscitation
Active goal directed fluid removal
Goal: Negative FB
Inefficient microcirculation
Hypoperfusion
Disorders in oxygen delivery
Uncontrolled capillary leak
Dehydrated cells
Corrected microcirculatory perfusion
Corrected oxygen delivery
Partially controlled capillary leak
Uncontrolled extra-vascular fluid shift
Increasing cell swelling
Adequate microcirculatory perfusion
Adequate oxygen delivery
Controlled capillary leak
Controlled tissue edema escalation
Cell and tissue edema
Adequate microcirculatory perfusion
Adequate oxygen delivery
Reduction of tissue edema escalation
Intra-cellular and interstitial fluid homeostasis
Triggers to start FAS treatment
GEDVI > 850 ml/m²
EVLWI > 10—12 ml/kg PBW
PVPI > 3 and PF ratio < 150
PPV or SVV < 12%
PLR test negative
LVEDAI > 14 cm²/m², VExUS
IAP > 12—15 mmHg
COP < 16—18 mmHg; CLI > 60
BIA: ECW/ICW > 1; VE > 5%
Triggers to stop fluid removal:
PPV or SVV > 15%
PLR test positive
Lactate > 2.5 mmol/L
SvO2 < 70—75%
ScvO2 < 65—70%

Journal of Critical Care 71 (2022) 154070

Contents lists available at ScienceDirect

Journal of Critical Care

journal homepage: www.journals.elsevier.com/journal-of-critical-care

The emerging concept of fluid tolerance: A position paper

Eduardo Kattan [a], Ricardo Castro [a], Francisco Miralles-Aguiar [b], Glenn Hernández [a], Philippe Rola [c,*]

[a] Departamento de Medicina Intensiva, Facultad de Medicina, Pontificia Universidad Católica de Chile, Chile
[b] Anesthesia & Surgery Critical Care Service, Hospital Universitario Puerta del Mar, Cádiz, Spain
[c] Chief of Service, Intensive Care Unit, Hopital Santa Cabrini, CIUSSS EMTL, Montreal, Canada

Characteristic	Fluid responsiveness	Fluid tolerance	Fluid overload
Definition	Increase on cardiac output ≥10% after preload incrementation by manipulation of venous return in a dynamic test context.	Fluid tolerance is the degree to which a patient can tolerate administration of fluids without causation of organ dysfunction.	A state of global body accumulation of fluids after resuscitation with a deleterious impact on organ function.
When to use	During resuscitation	During resuscitation	After resuscitation
Adequate use	Increase CO through a fluid challenge in FR + patients to resolve hypoperfusion	Modify resuscitation strategy (vasopressors, other types of fluids, etc.)	Prompt de-resuscitation
Inadequate use	Consider fluid responsiveness as a mandatory trigger for fluid administration, irrespective of tissue perfusion status	Assume that fluid intolerance only occurs in fluid unresponsive patients	Inadequate timing or intensity of de-resuscitation
Limitations	Not assessable in all patients and technical challenges	Theoretical construct, not clinically validated yet	Retrospective diagnosis; still lack of evidence on how to best de-resuscitate

biomedicines

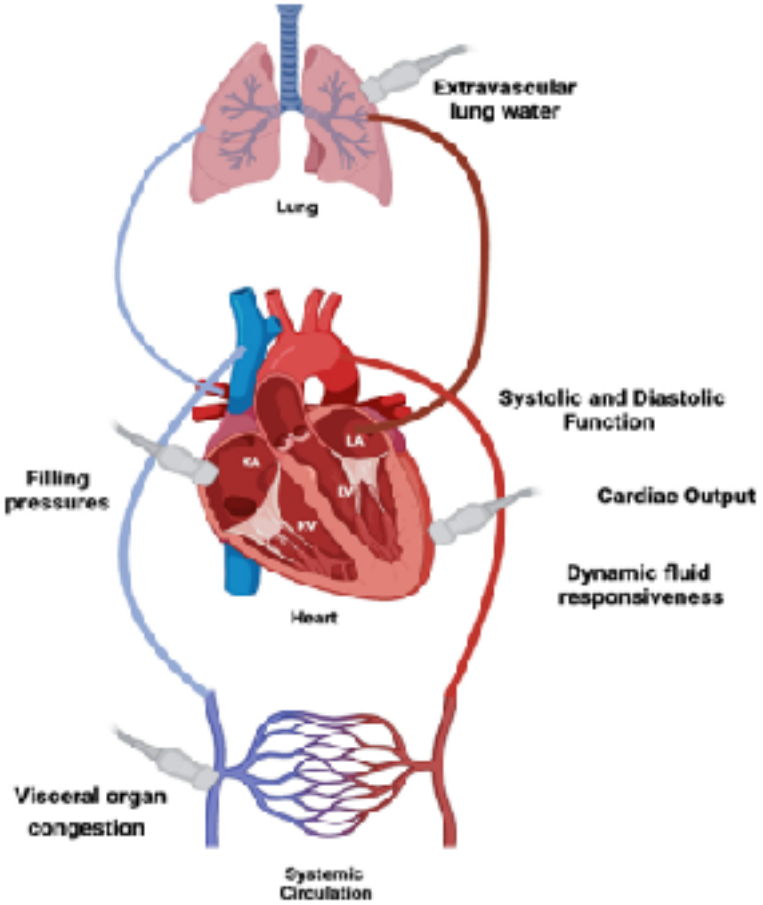
Biomedicines 2025, 13, 1426

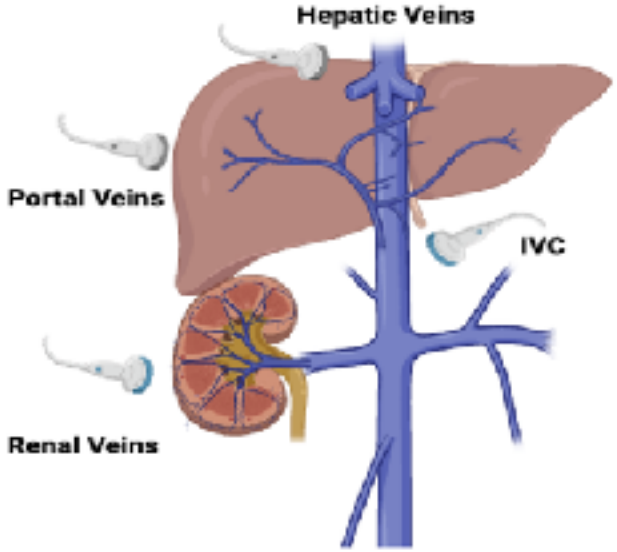
MDPI

Review

Point-of-Care Ultrasound Use in Hemodynamic Assessment

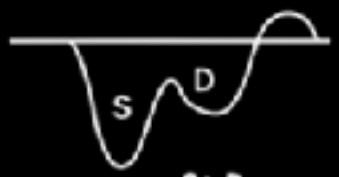
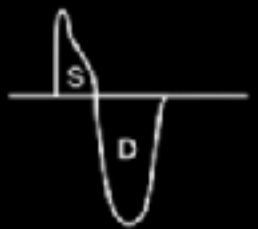
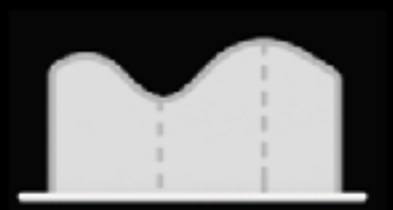
Ahmed Noor [1,†], Margaret Liu [1,†], Alan Jarman [2], Travis Yamanaka [3] and Malvika Kaul [4,*]

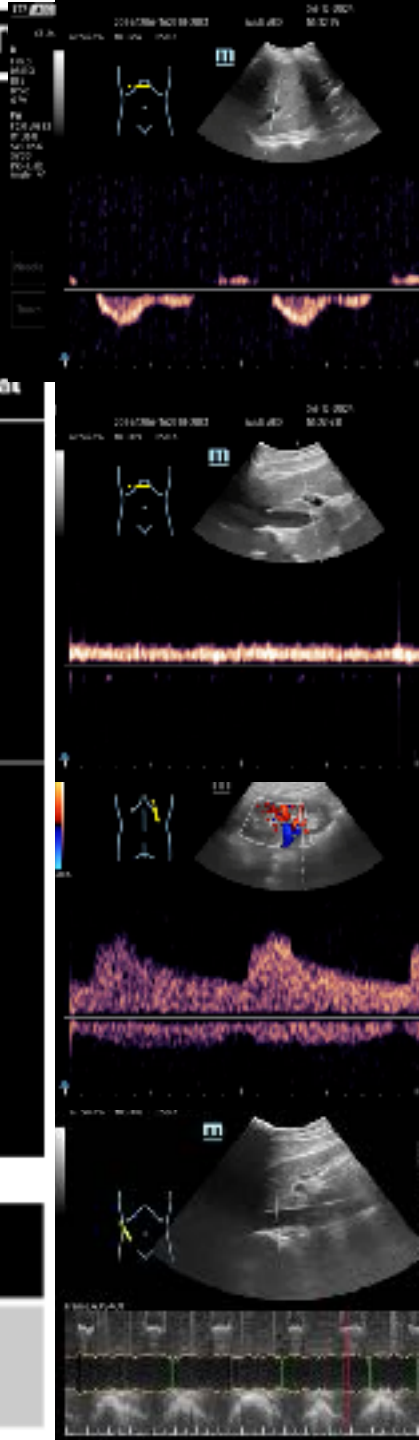




VExUS protocol:

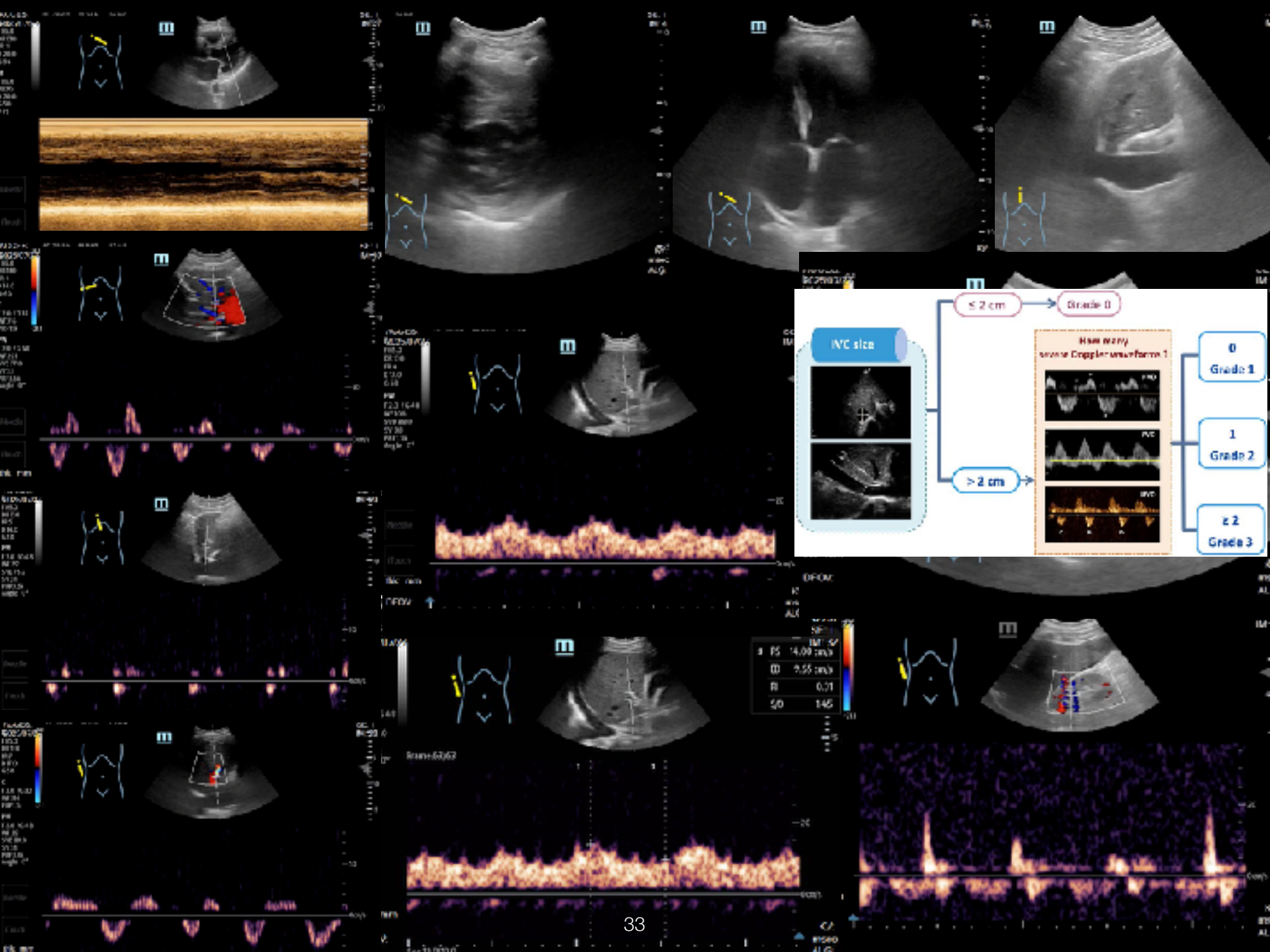
Step 1: Inferior vena cava diameter: If ≥2, proceed with next steps.
Step 2: Hepatic vein Doppler.
Step 3: Portal vein Doppler.
Step 4: Renal vein Doppler.

VEIN	NORMAL	MILD ABNORMALITY	SEVERE ABNORMALIT.
Hepatic	S: Systolic wave D: Diastolic wave  S > D	 S < D	 S wave reversa
Portal	 Pulsatility < 30%	 Pulsatility 30% -50%	 Pulsatility > 50%
Renal	 Continuous Monophasic Flow	 Discontinuous Biphasic flow with Systolic/Diastolic Phases	 Discontinuous Monophasic flow with only diastolic phase



Grade 0	Grade 1 (mild congestion)	Grade 2 (moderate congestion)	Grade 3 (severe congestion
IVC < 2 cm	IVC ≥ 2cm + any combination of normal or mildly abnormal patterns	IVC ≥ 2cm and only severely abnormal pattern	IVC ≥ 2cm and ≥ 2 severely abnormal patterns

48M, SOB w/ general edema


INC size
≤ 2 cm
Grade 0
> 2 cm
0
Grade 1
1
Grade 2
≥ 2
Grade 3

Review Article

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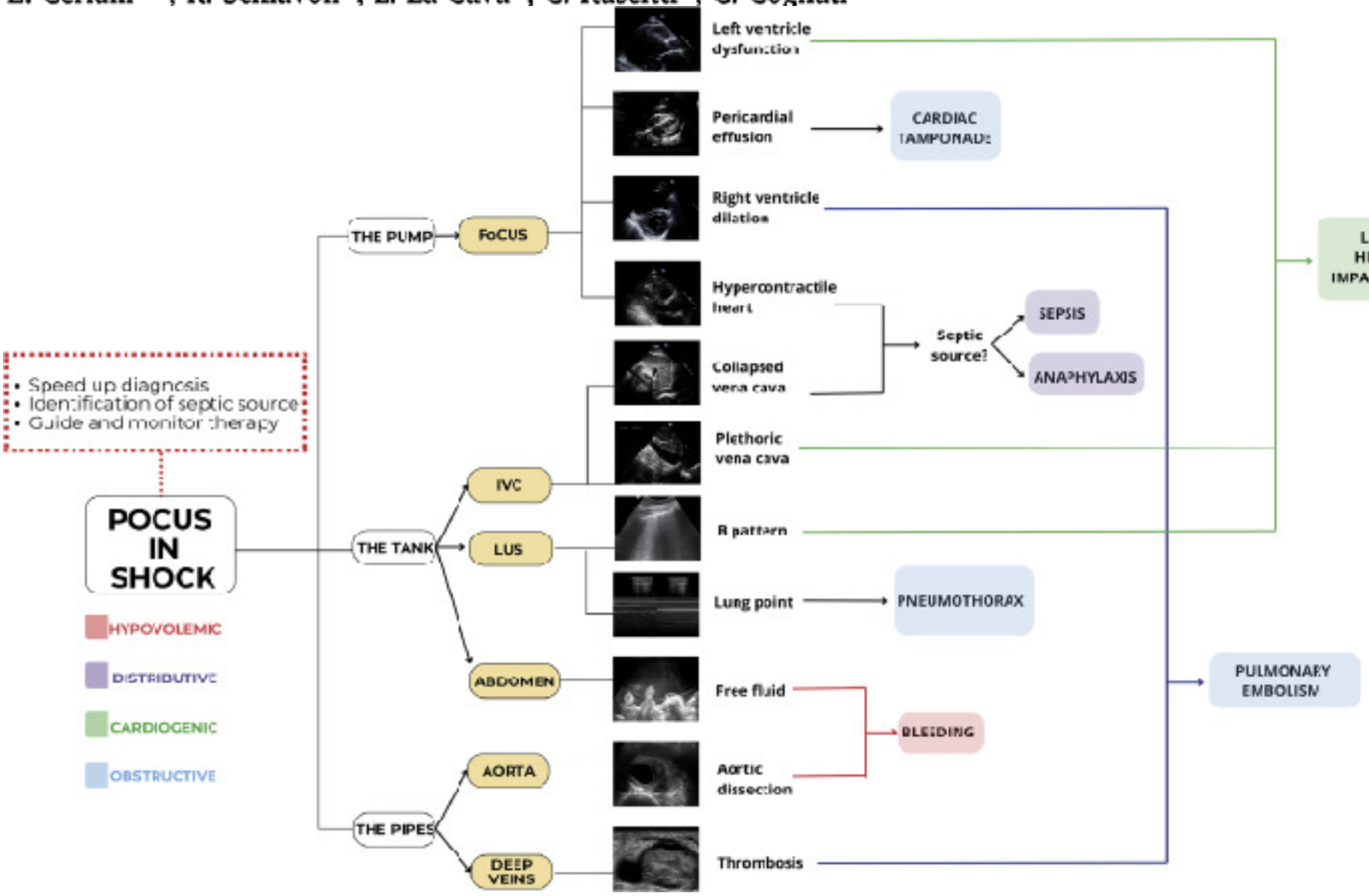
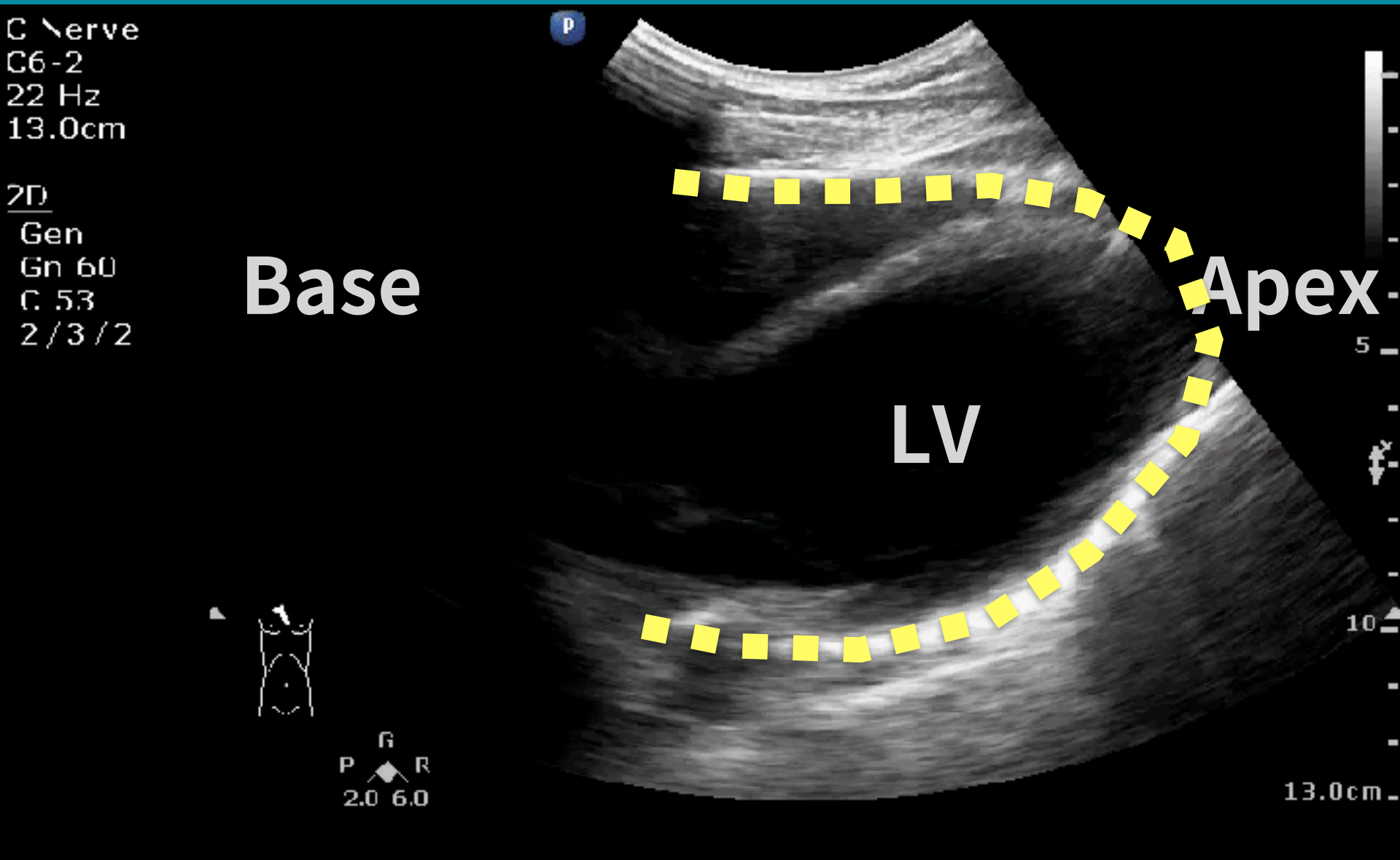
Point of care ultrasound: focus on evidence for a critical appraisal

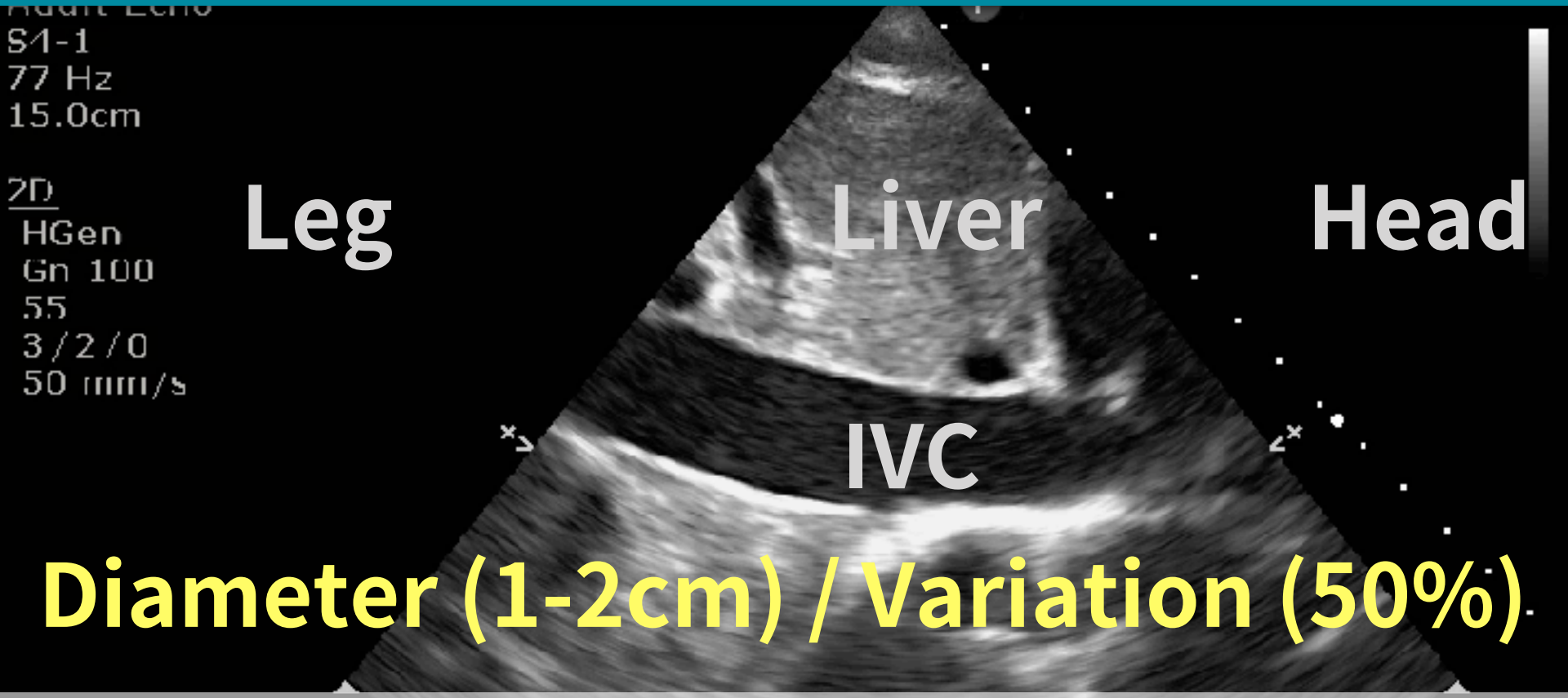
E. Ceriani [a,*], R. Schiavon [a], L. La Cava [a], C. Ruscitti [a], C. Cogliati [a,b]



UAPE-Quick check for shock



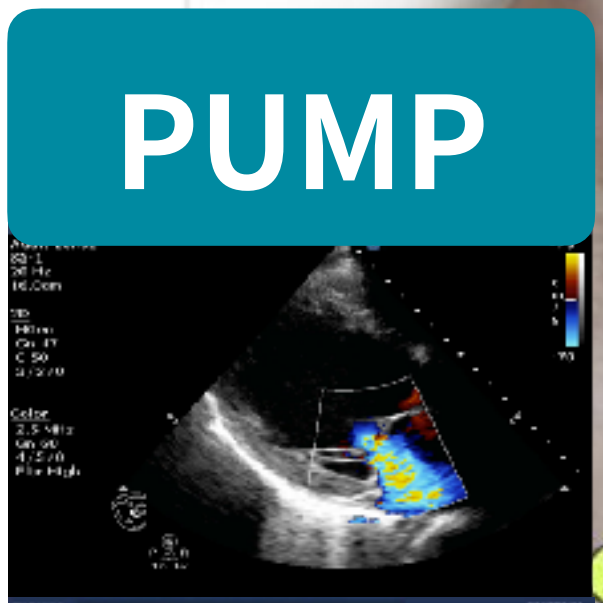
UAPE-Quick check for shock

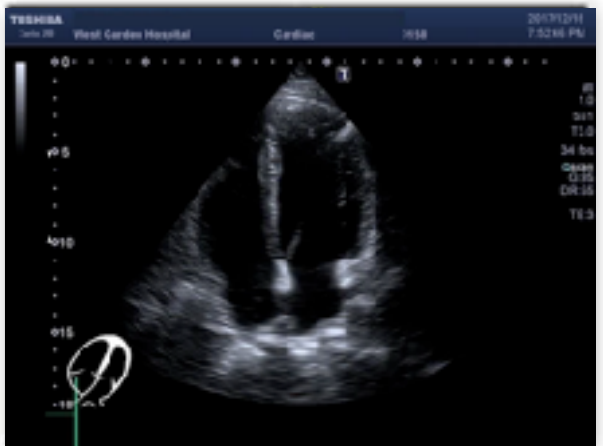


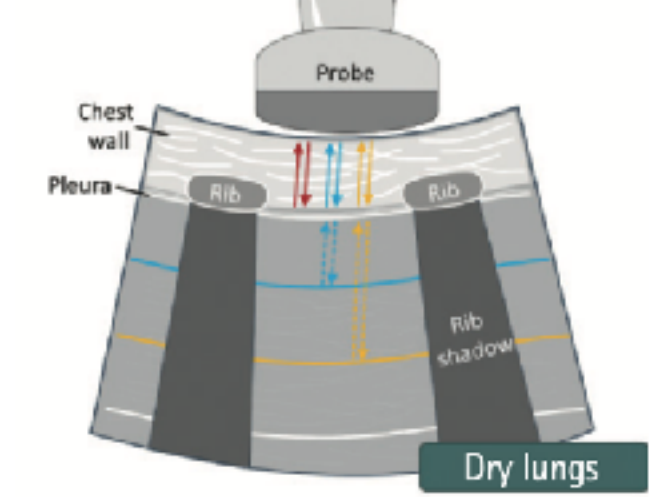
Diameter (1-2cm) / Variation (50%)

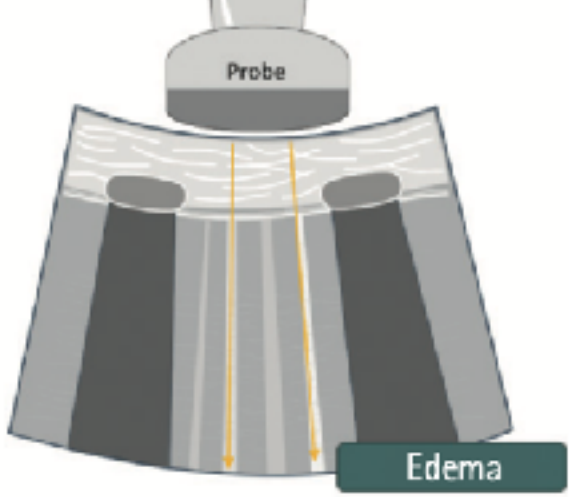
CVP	IVC Diameter	% Collapse	RAP
Low	<2.1 cm	>50%	3 mm Hg
Intermediate	<2.1 cm	<50%	8 mm Hg
	>2.1 cm	>50%	8 mm Hg
High	>2.1 cm	<50%	15 mm Hg

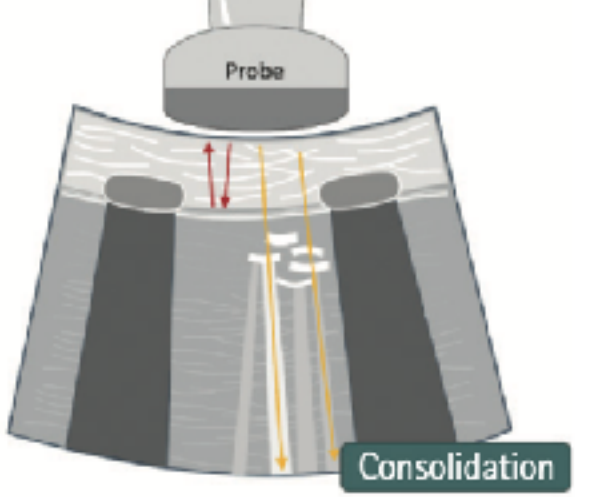
PUMP

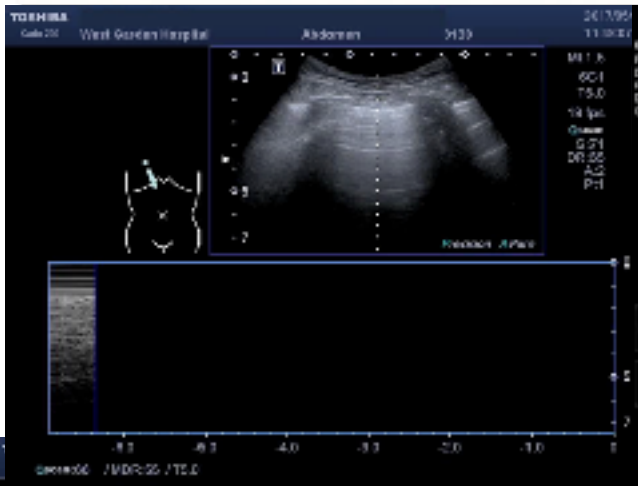


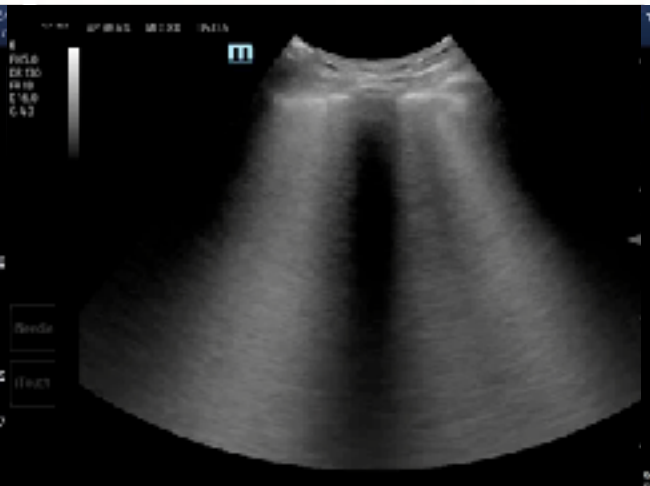


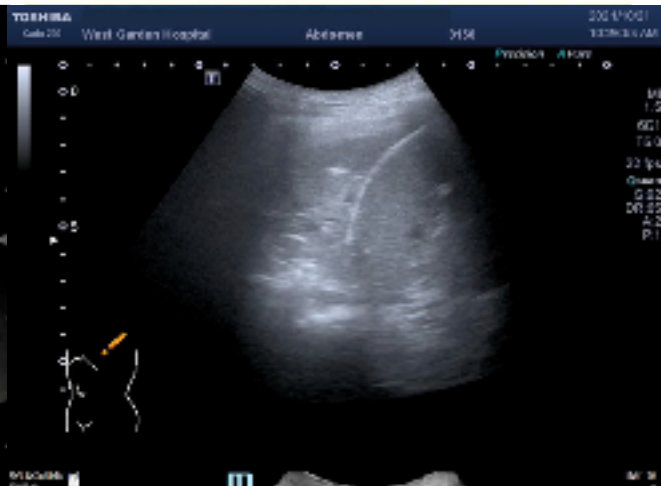

Probe
Chest wall
Pleura
Rib
Rib
Rib shadow
Dry lungs

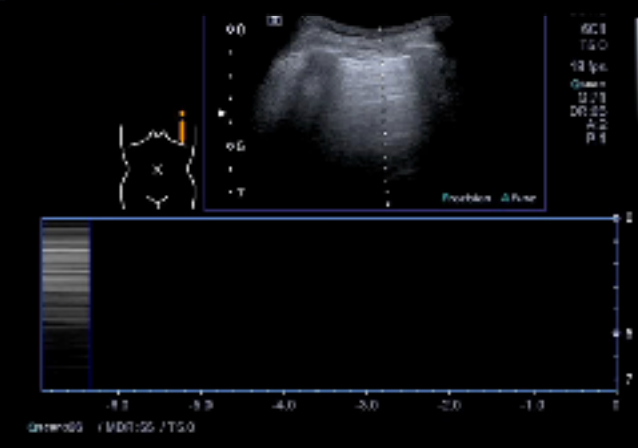

Probe
Edema

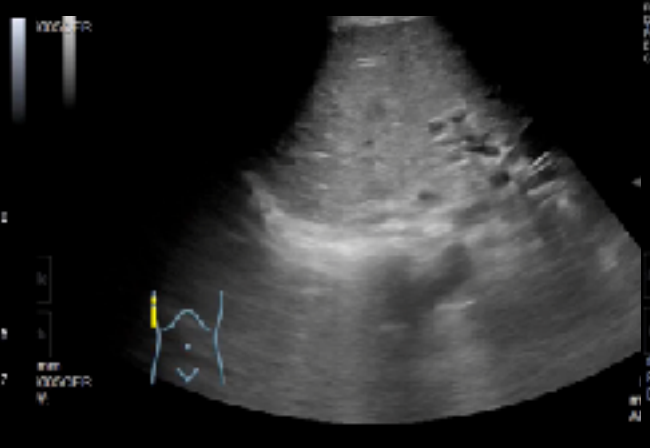

Probe
Consolidation

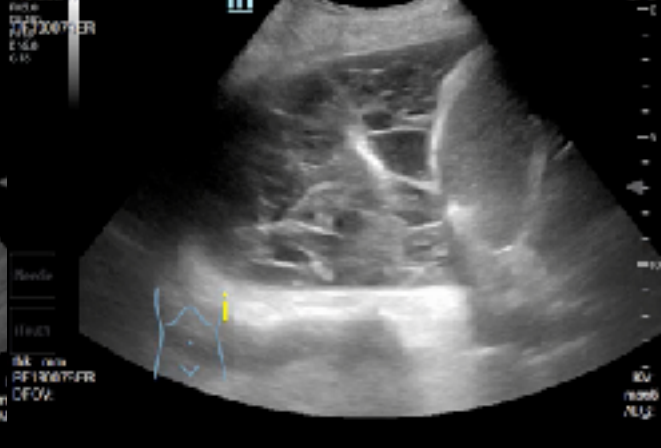




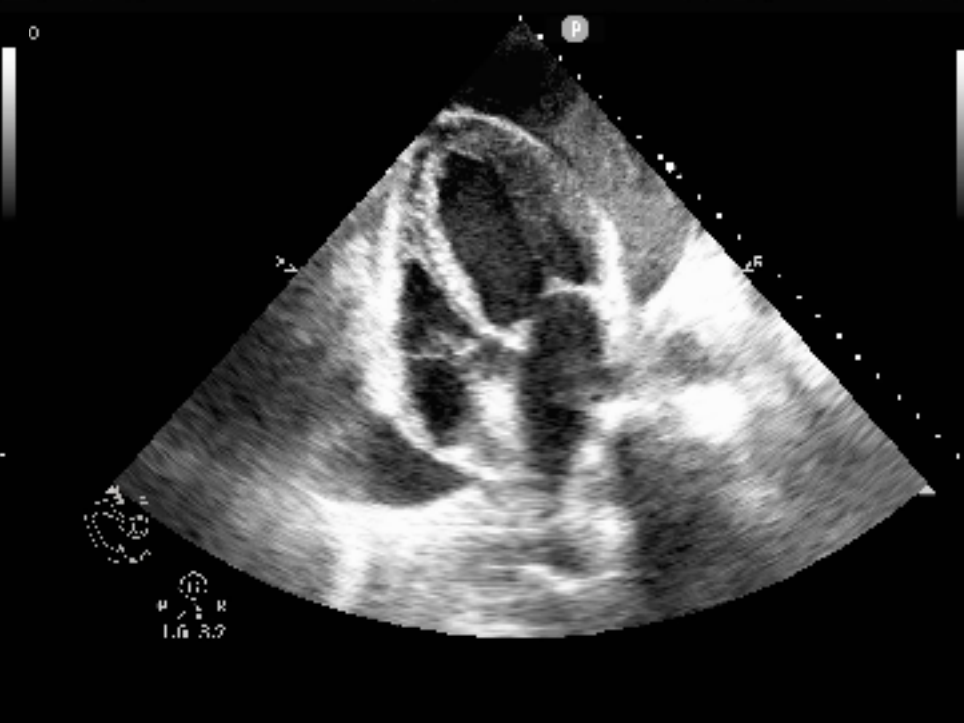


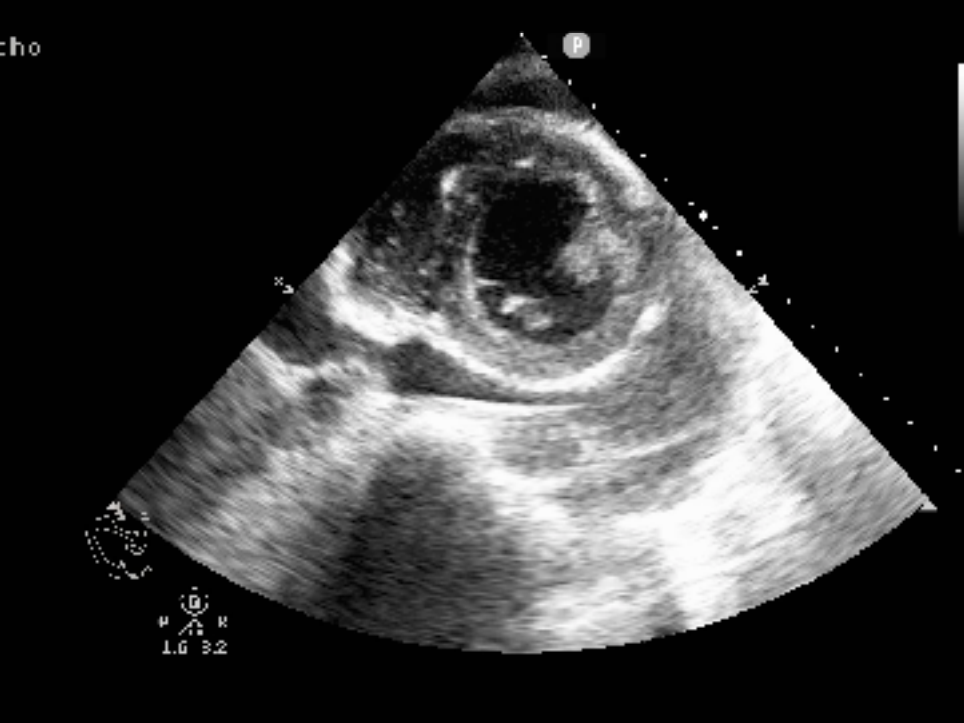


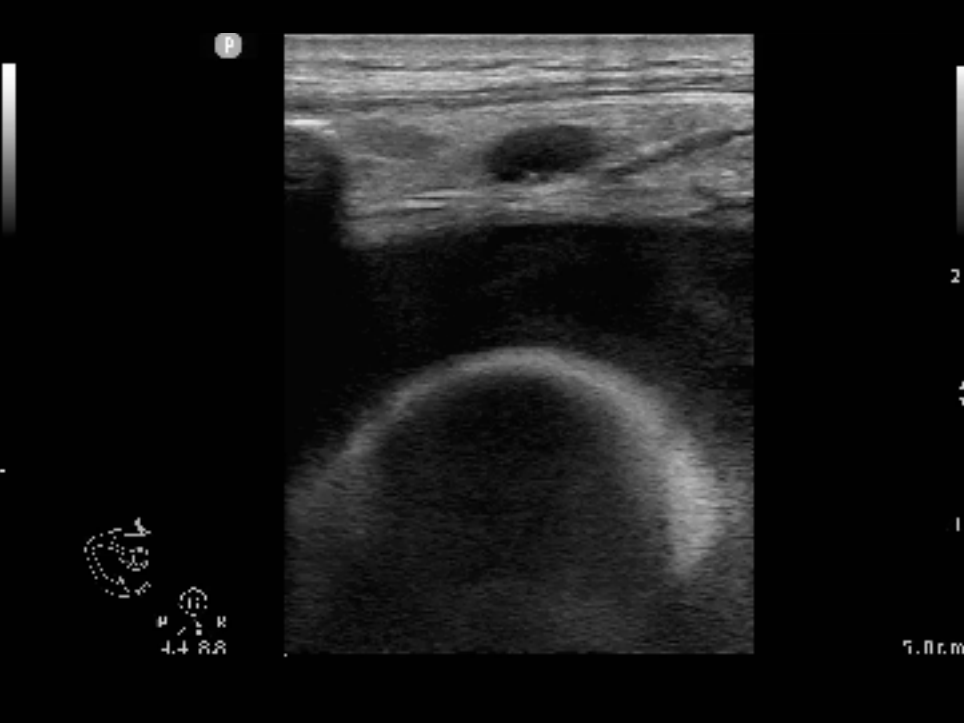




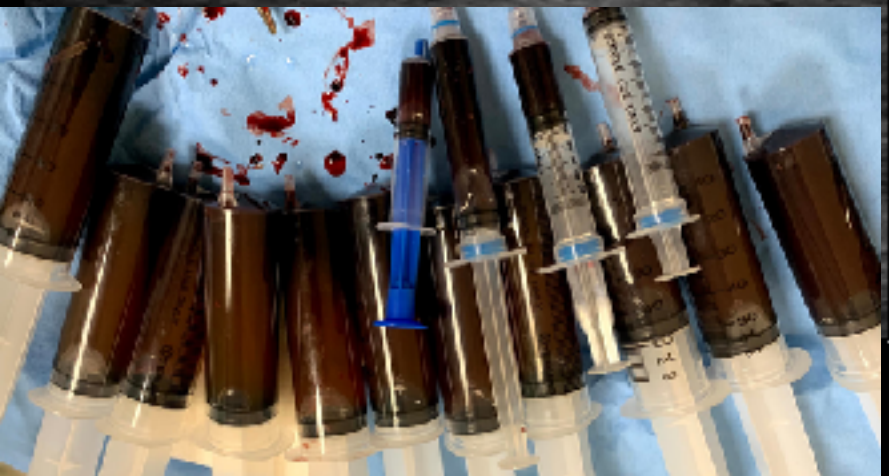
CARDIAC TAMPONADE

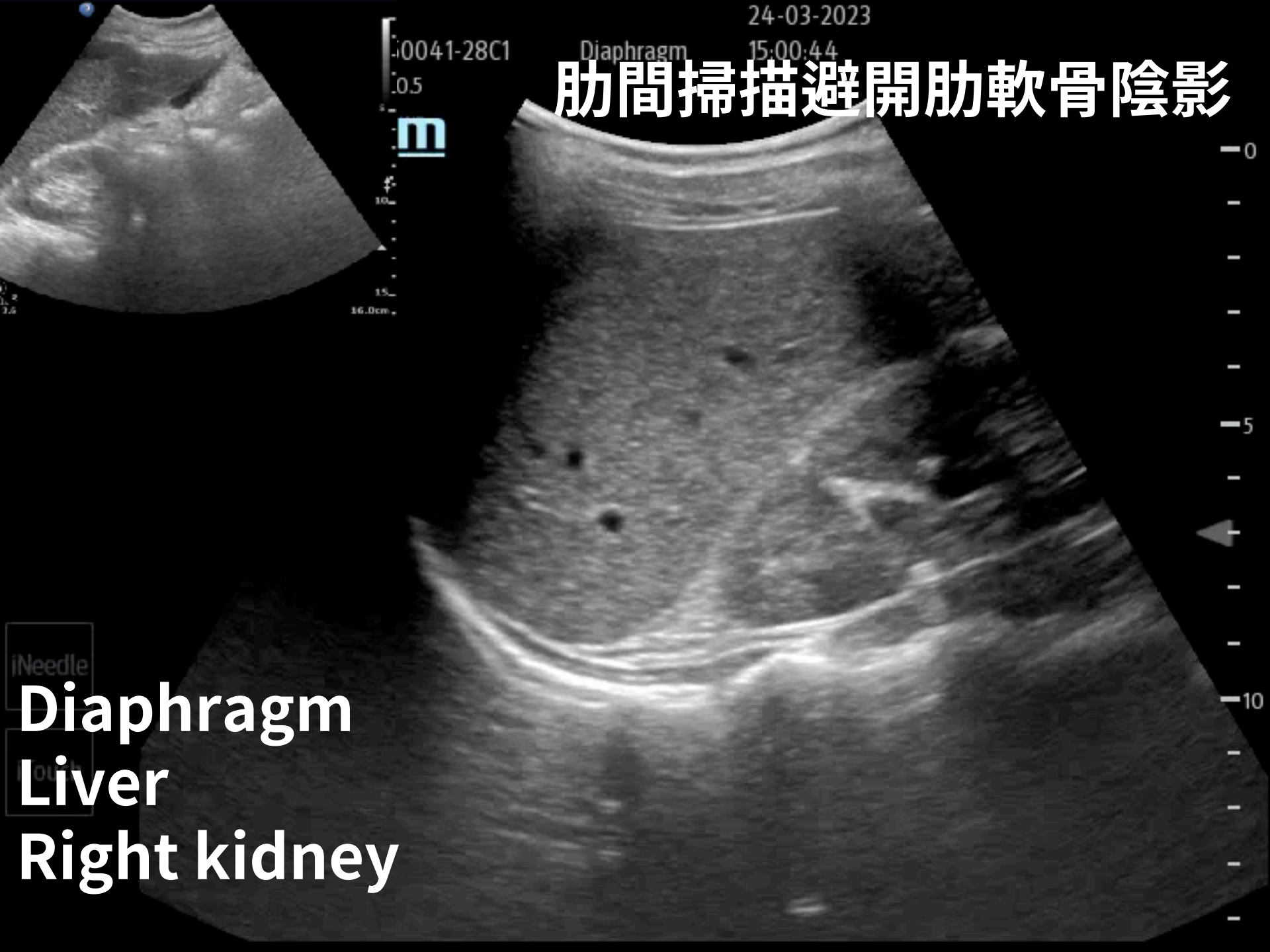






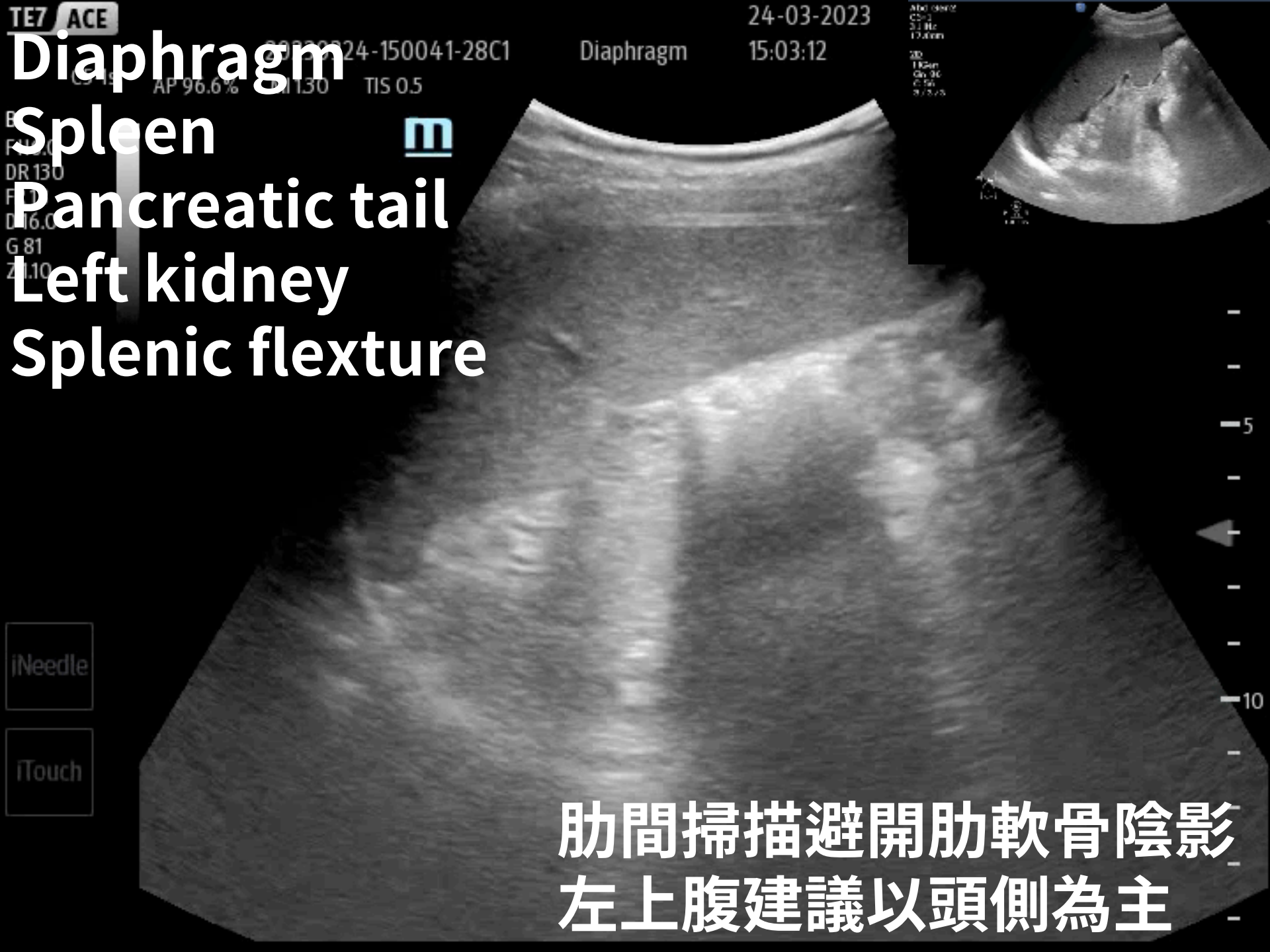
Step-by-step drainage

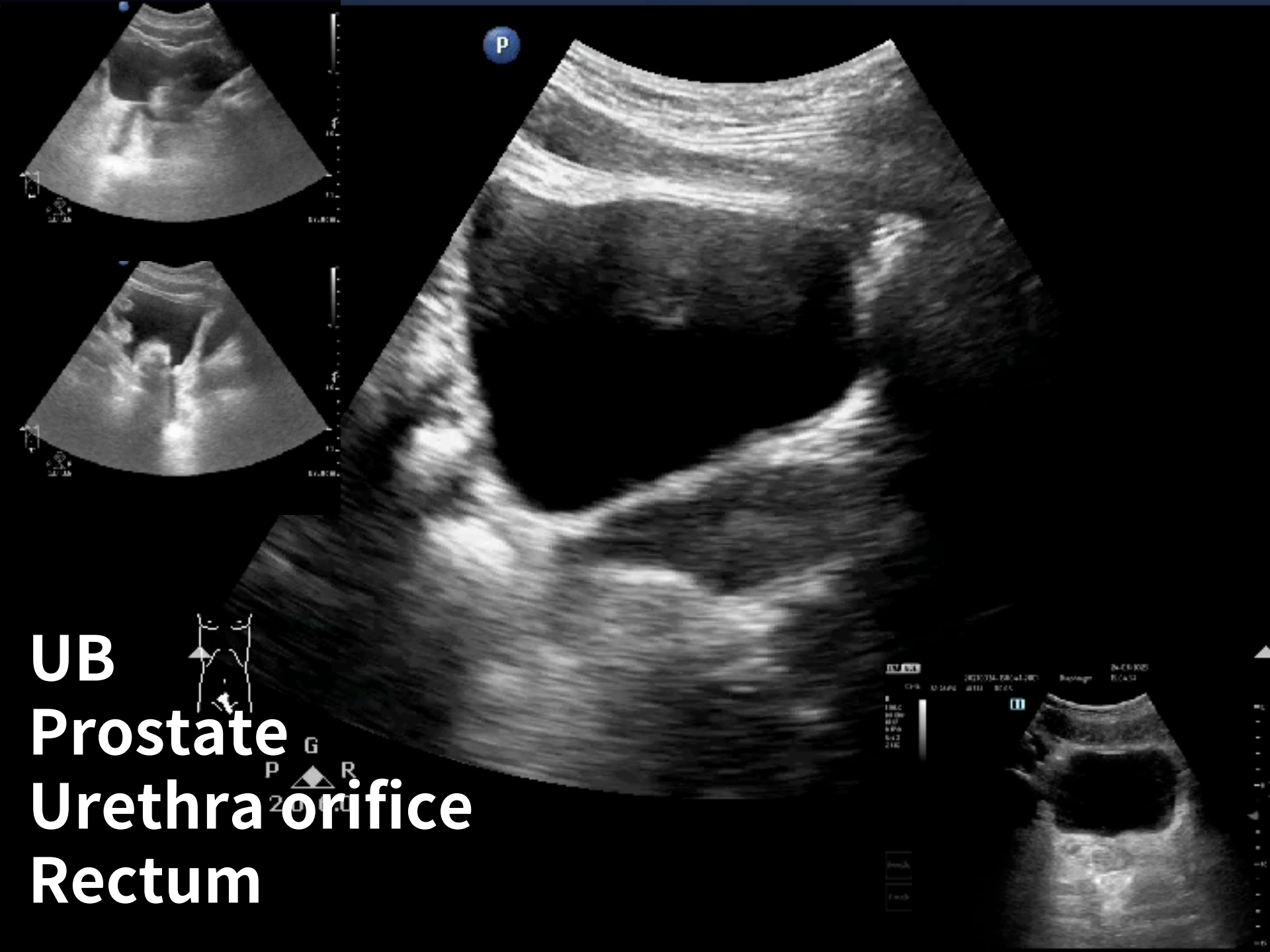


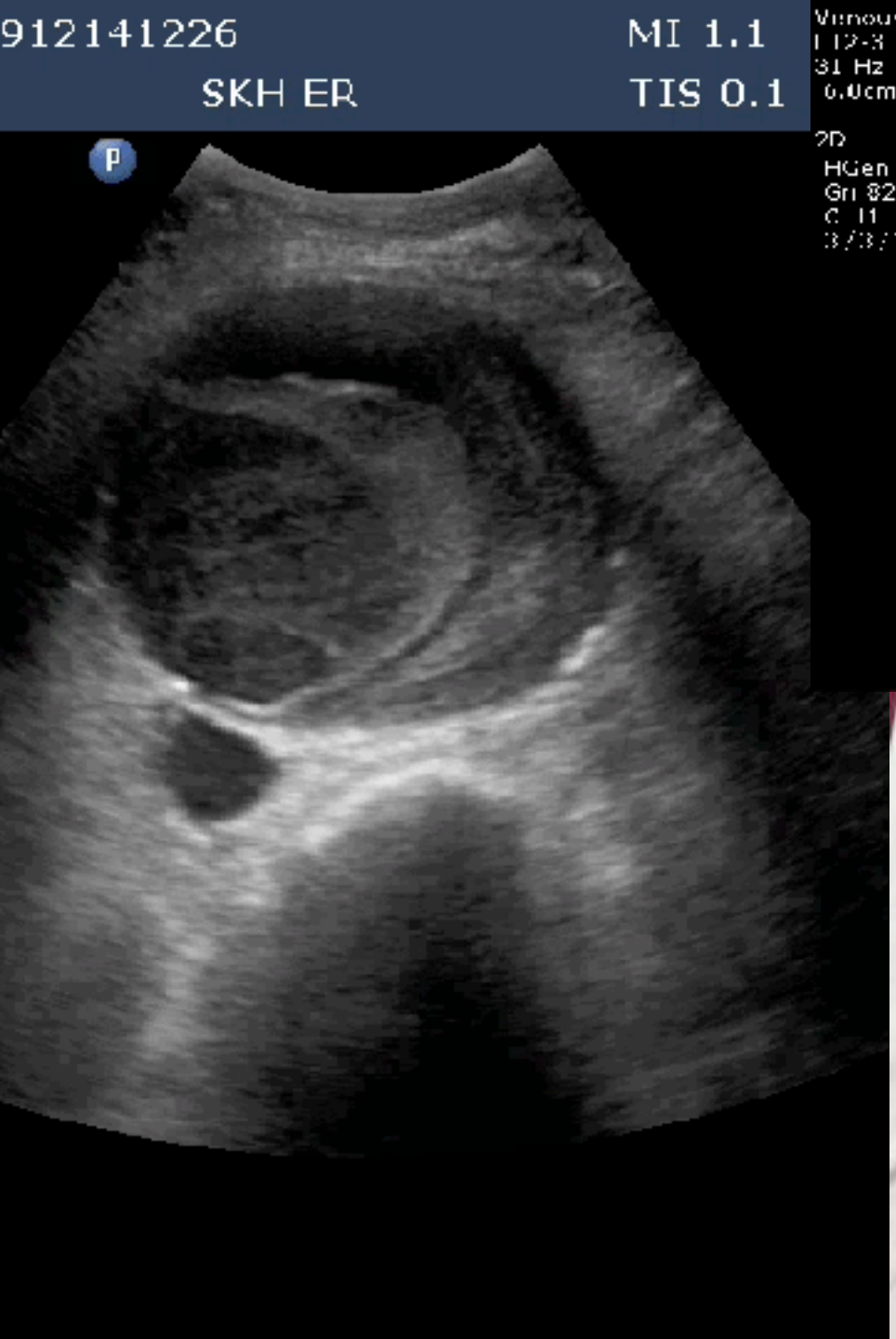

24-03-2023
0041-28C1
Diaphragm
15:00:44
肋間掃描避開肋軟骨陰影
Diaphragm
Liver
Right kidney

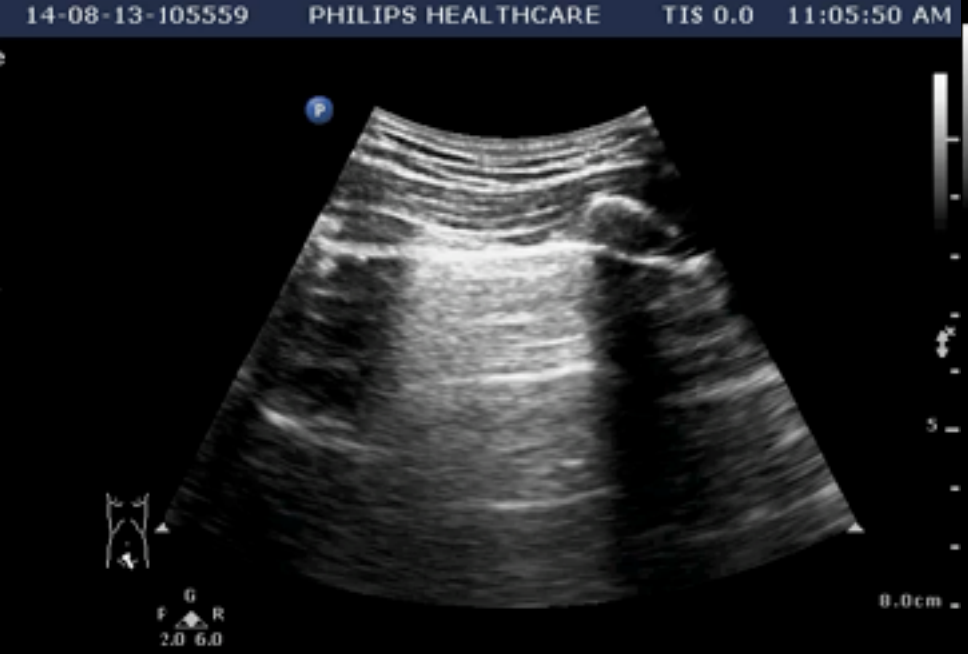

Liver
IVC / Hepatic veins
Portal veins
Biliary tree
Abdominal aorta
劍突下縱向掃描
利用肝臟當視窗
TE7 ACE
06-12-2024
20241129-180534-28C1
Adult ABD
18:29:45
C5-2s
AP 96.6%
MI 0.91
TIS 0.6
FH5.0
D 17.0
iNeedle
iTouch
5
10
15

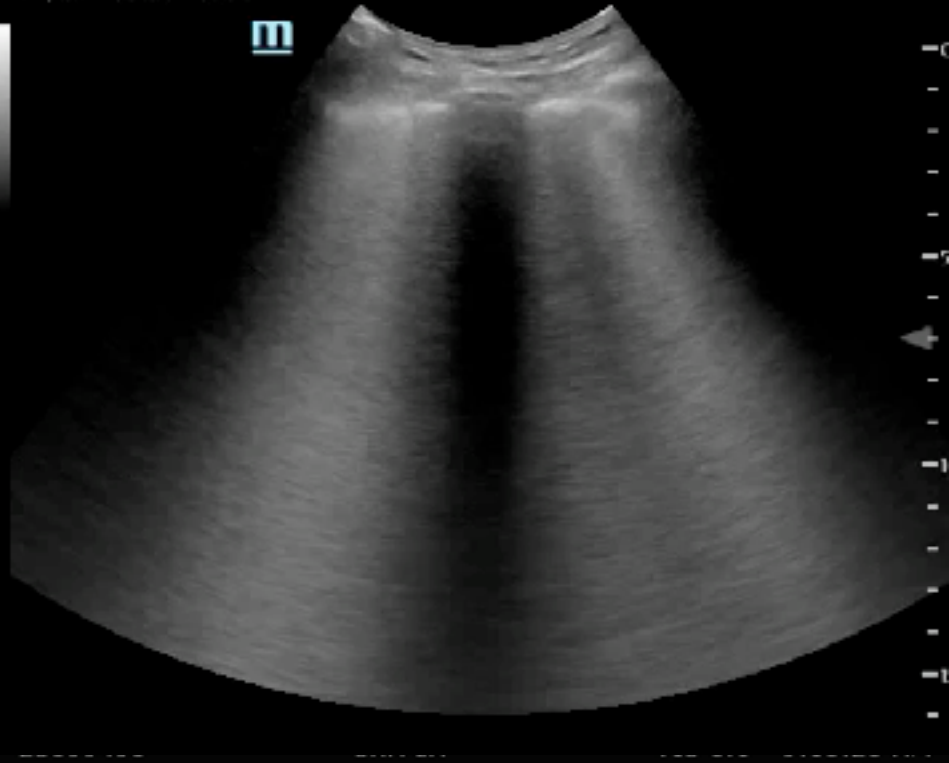

41-28C1
Diaphragm
24-03-2023
15:02:13
劍突下縱向掃描
利用肝臟當視窗
Diaphragm
Liver
EC junction
Abdominal aorta
Pancreas
Antrum

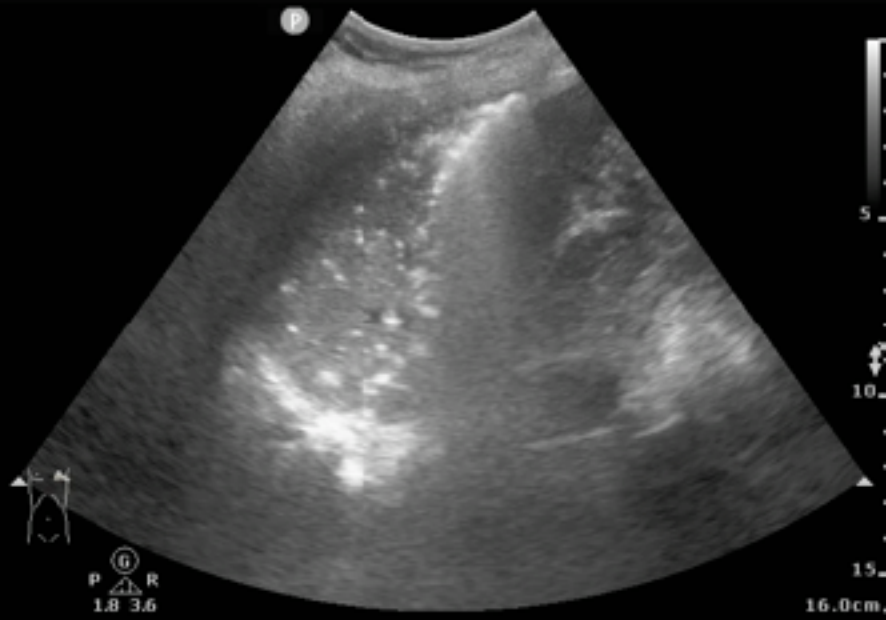

Diaphragm
Spleen
Pancreatic tail
Left kidney
Splenic flexture
TE7 ACE
24-03-2023
Diaphragm
15:03:12
肋間掃描避開肋軟骨陰影
左上腹建議以頭側為主

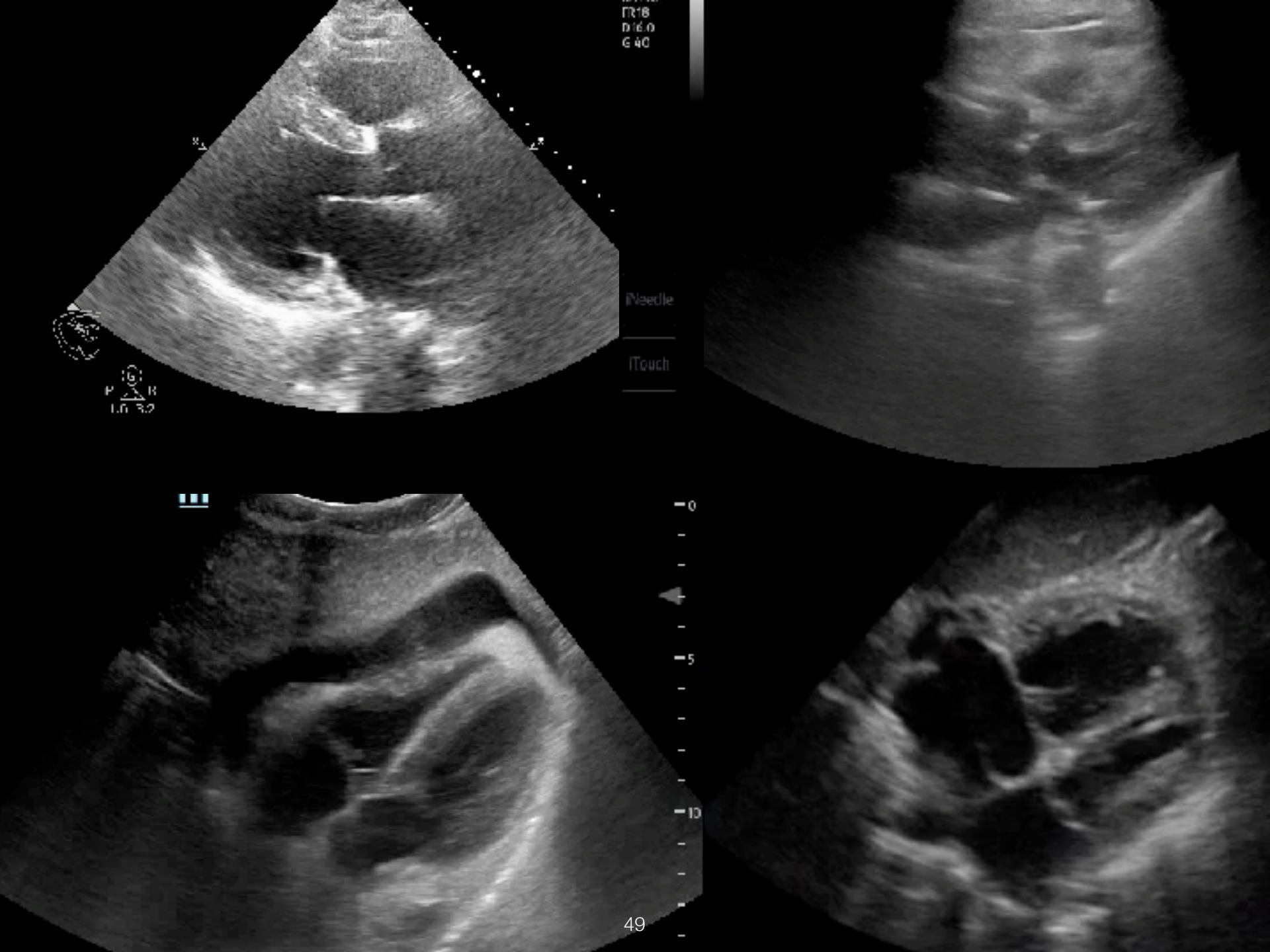

P
G
P
R
UB
Prostate
Urethra orifice
Rectum

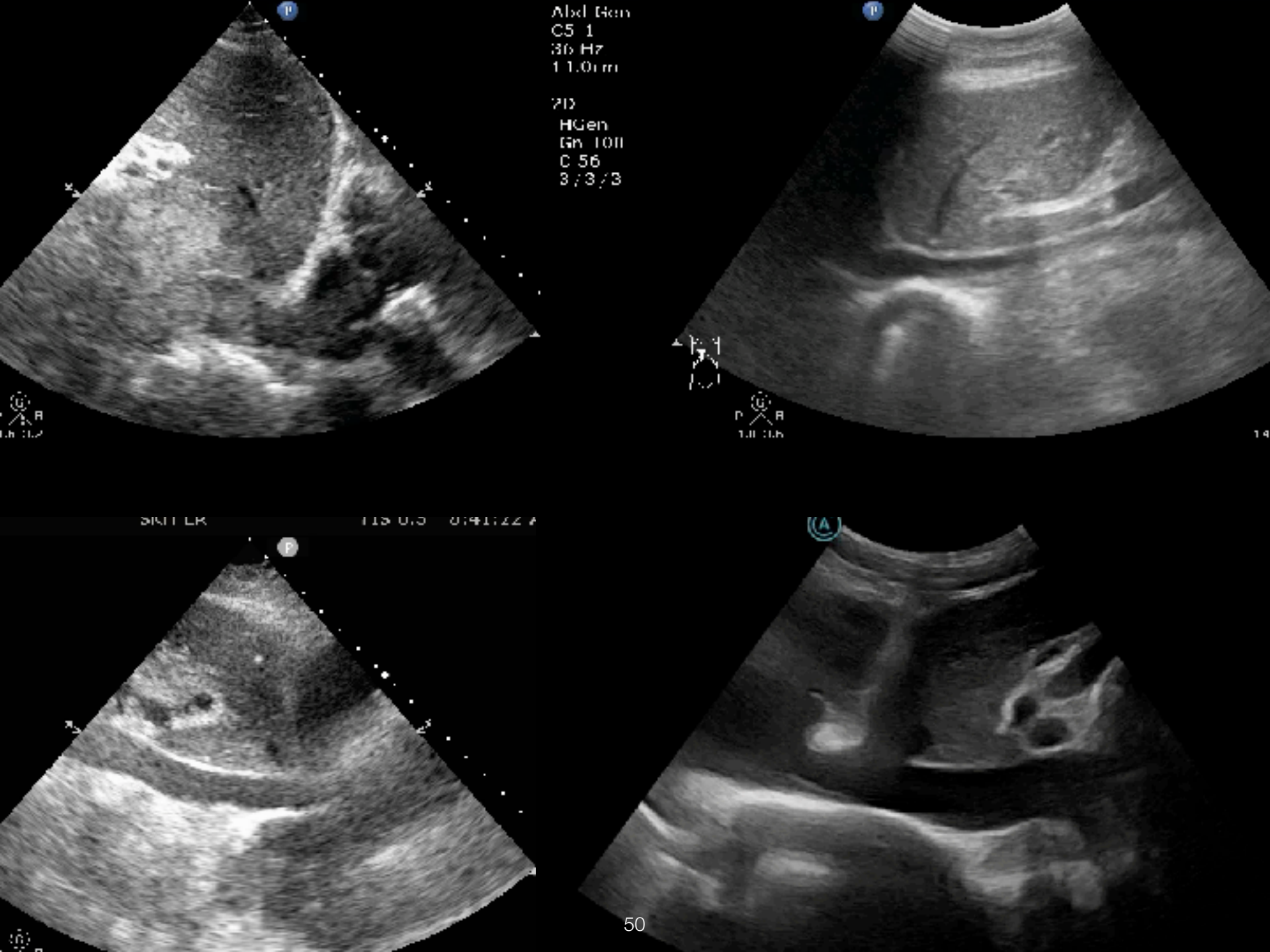

912141226
MI 1.1
SKH ER
TIS 0.1

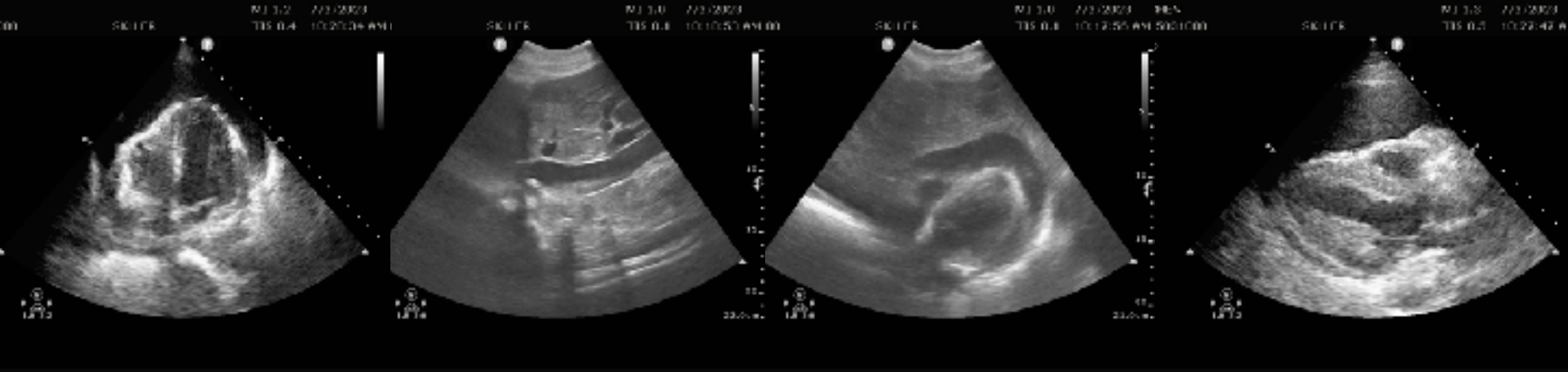

14-08-13-105559 PHILIPS HEALTHCARE TIS 0.0 11:05:50 AM
8.0cm

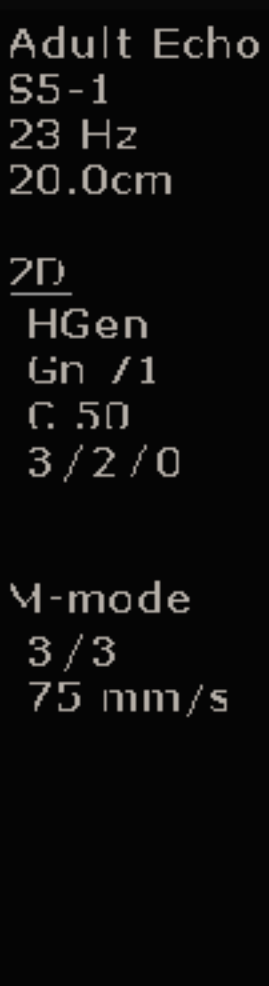



16.0cm

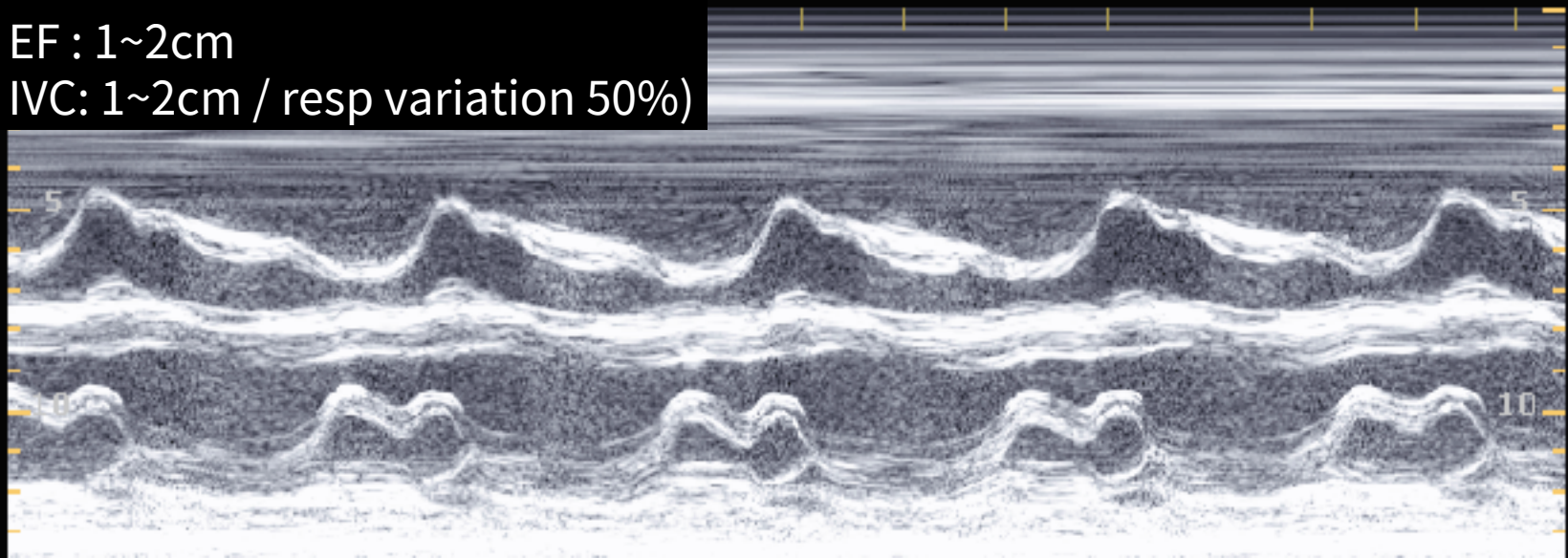

iNeedle
iTouch
0
5
10

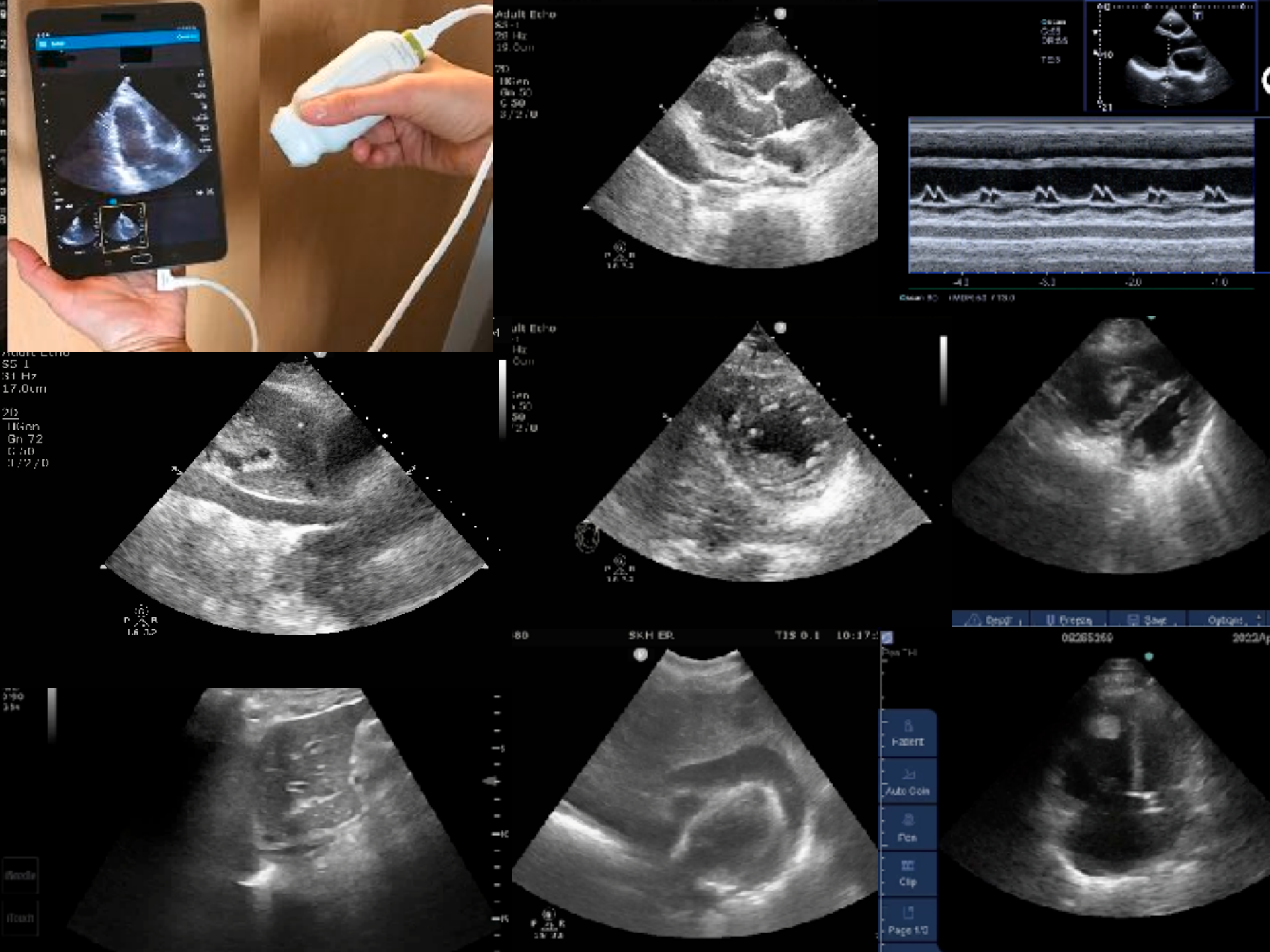

Abd Gen
C5 1
36 Hz
11.0 cm
2D
HGen
Gn 10
C 56
3/3/3

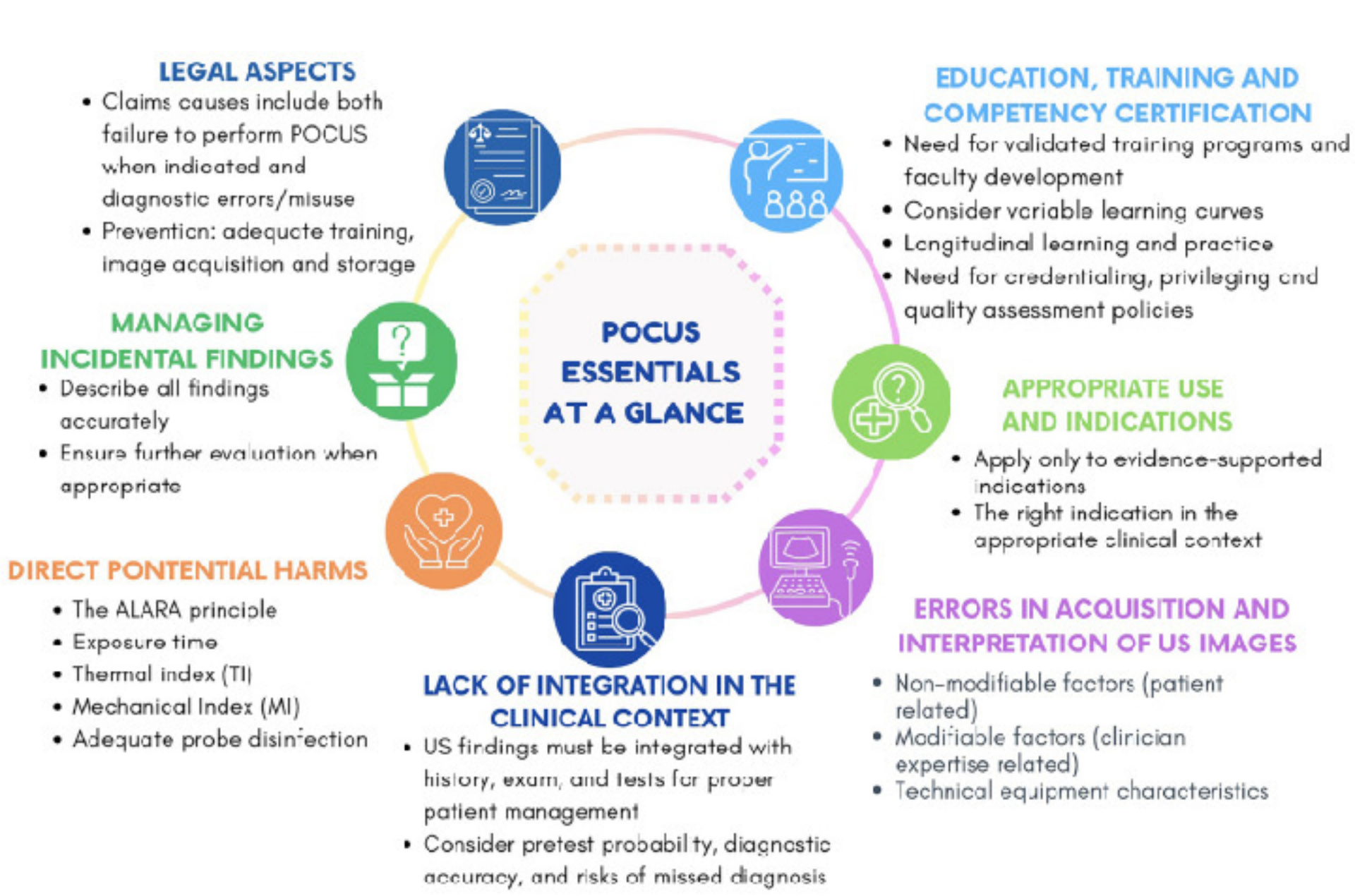




EF : 1~2cm
IVC: 1~2cm / resp variation 50%)







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biomedicines

Biomedicines 2025, 13, 1426

MDPI

Review

Point-of-Care Ultrasound Use in Hemodynamic Assessment

POCUS Exam	Hypovolemic	Cardiogenic	Obstructive	Distributive
Heart	Hyperdynamic left ventricle (LV)	Dilated chambers or reduced LV/RV function	Pulmonary embolism (PE): dilated, strained RV, with a D-shaped septum and positive McConell's sign. Tamponade: pericardial effusion with RA systolic and RV diastolic collapse	Hyperdynamic LV in early sepsis and hypodynamic in late sepsis
Lung	A-Line pattern (normal lung)	B-lines and/or pleural effusion	PE: small pleural effusion or pulmonary infarcts (subpleural consolidations) Pneumothorax: absent lung sliding	Pneumonia: consolidation and/or focal B-lines, pleural effusion
IVC	Small and collapsible	Distended, non-collapsible	Distended, non-collapsible	Normal or collapsed
Others	Abdominal exam may show abdominal aortic aneurysm, aortic dissection, or intra-abdominal hemorrhage. Vascular exam may reveal deep vein thrombosis (DVT) or collapsed vessels	Abdomen exam may show peritoneal fluid	Vascular exam may show DVT	An abdomen exam could show peritoneal fluid. Musculoskeletal ultrasound may detect a focal abscess as a fluid collection

休克型態

最佳輸液

精準處置