ECHOCARDIOGRAPHY IN ICU SETTING

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DR LEE KOK TONG

CONFLICT OF INTEREST : NONE

OVERVIEW

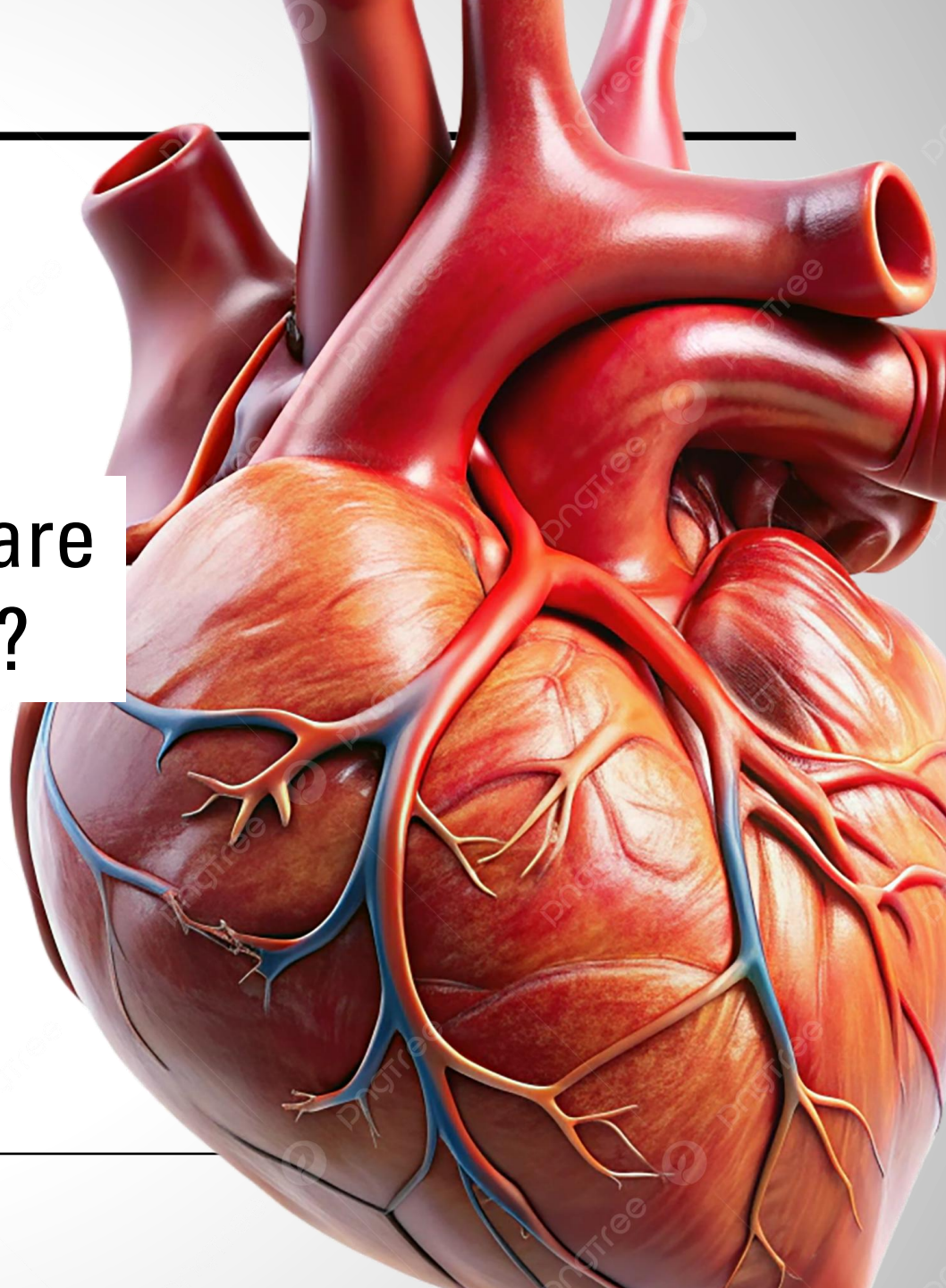
Role of bedside Echo?

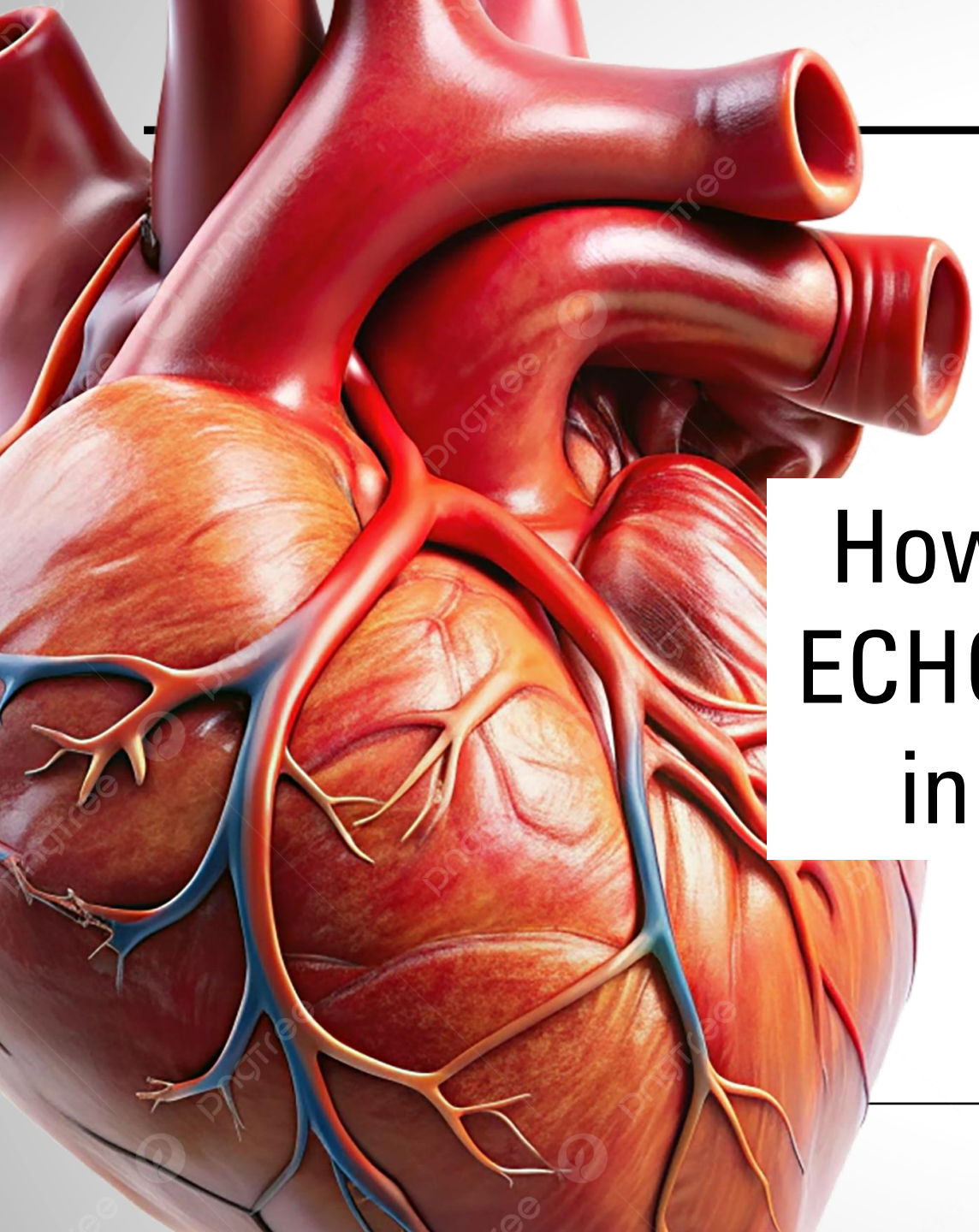
Advantages compared to invasive hemodynamic monitor?

Limitations in critical ill patients?

Key Indications to perform ECHO?

What are the..?





How does ECHO helps in…..?

- Role in sepsis?
- Types of shock
- Obstructive shock
- Traumatic valvular
- Predict fluid responsiveness

Role of bedside Echo?

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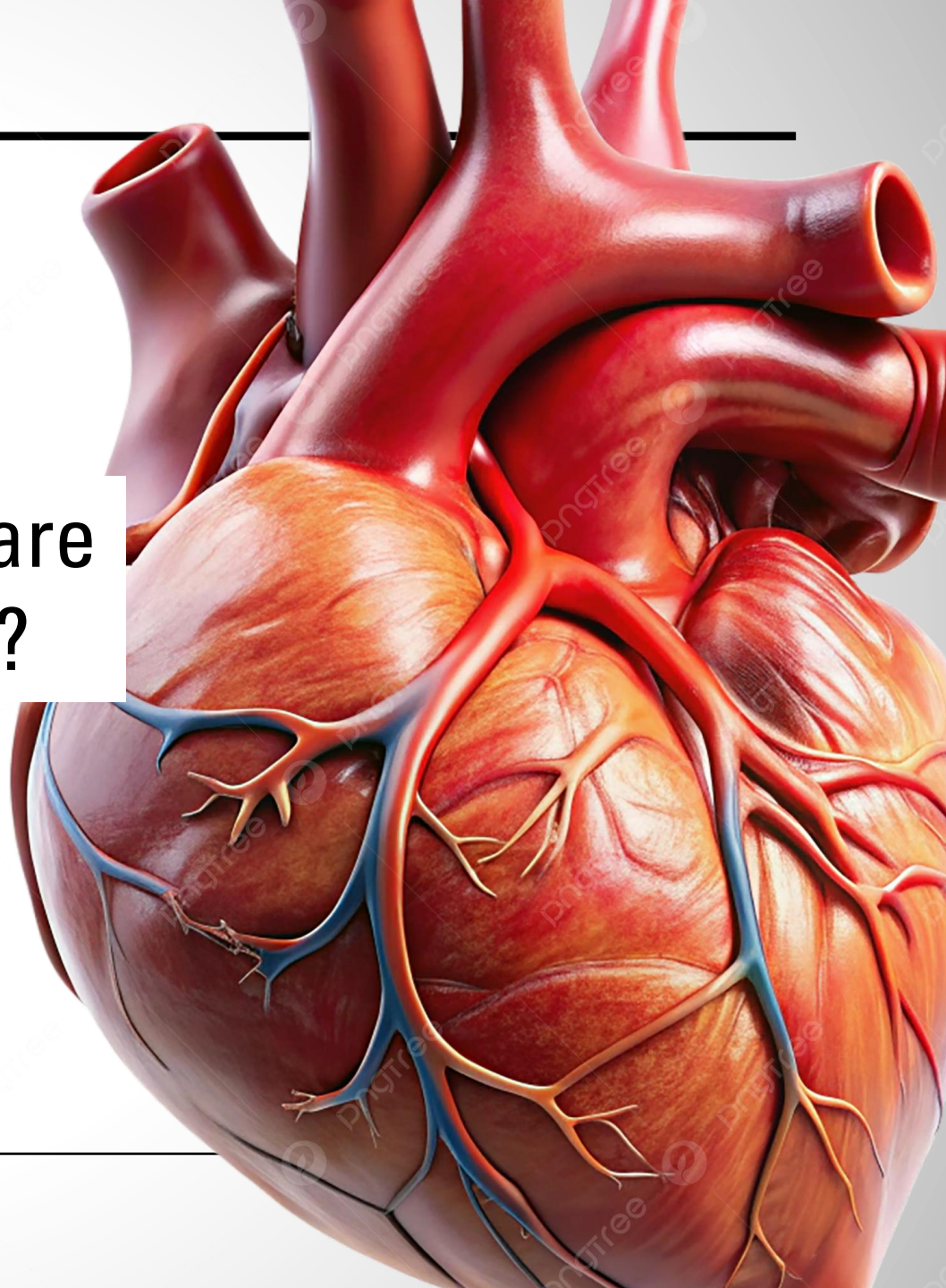
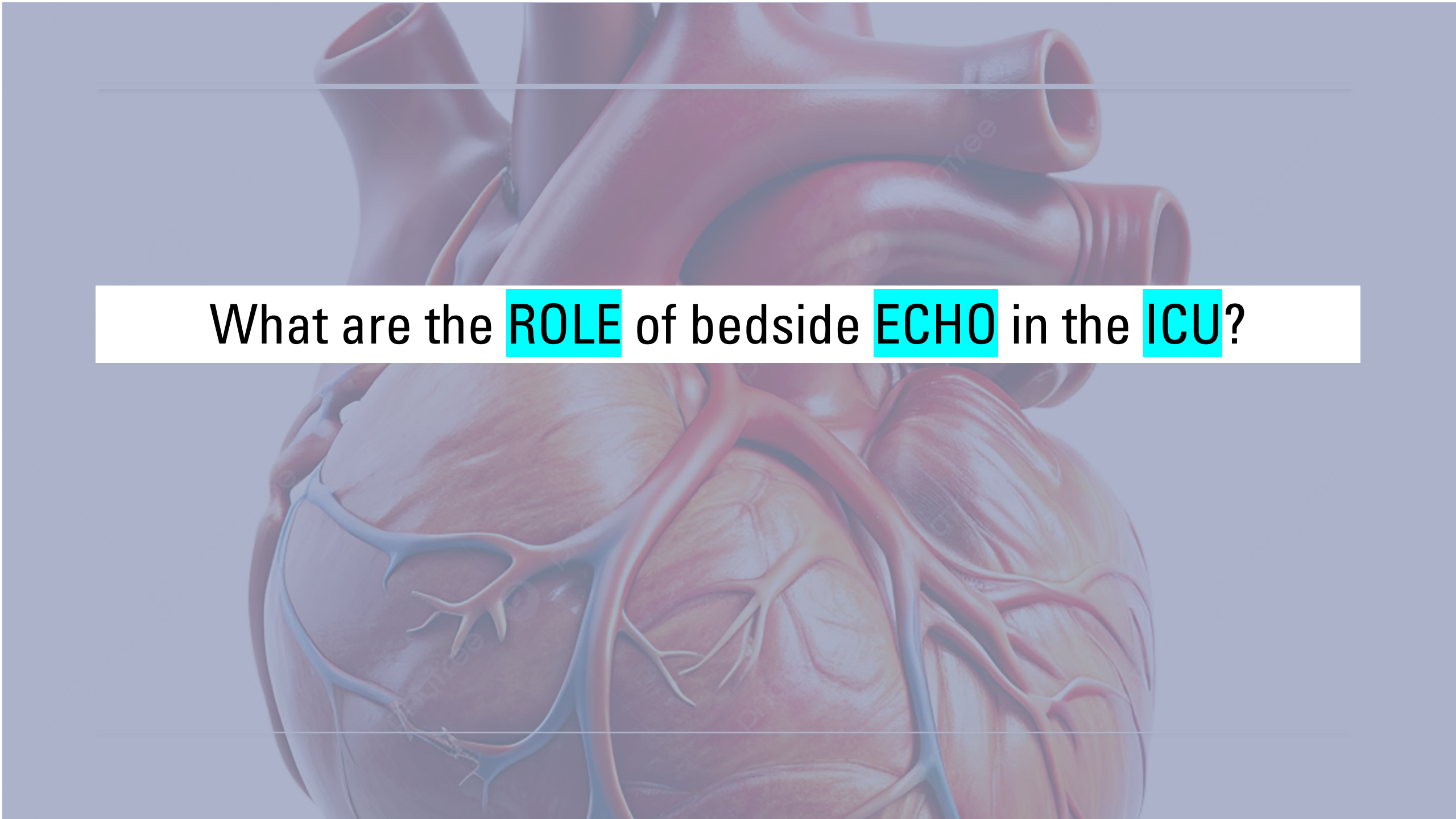




What are the ROLE of bedside ECHO in the ICU?

- Safe
- Portable
- Non-Invasive

Assessment of cardiac function and structure

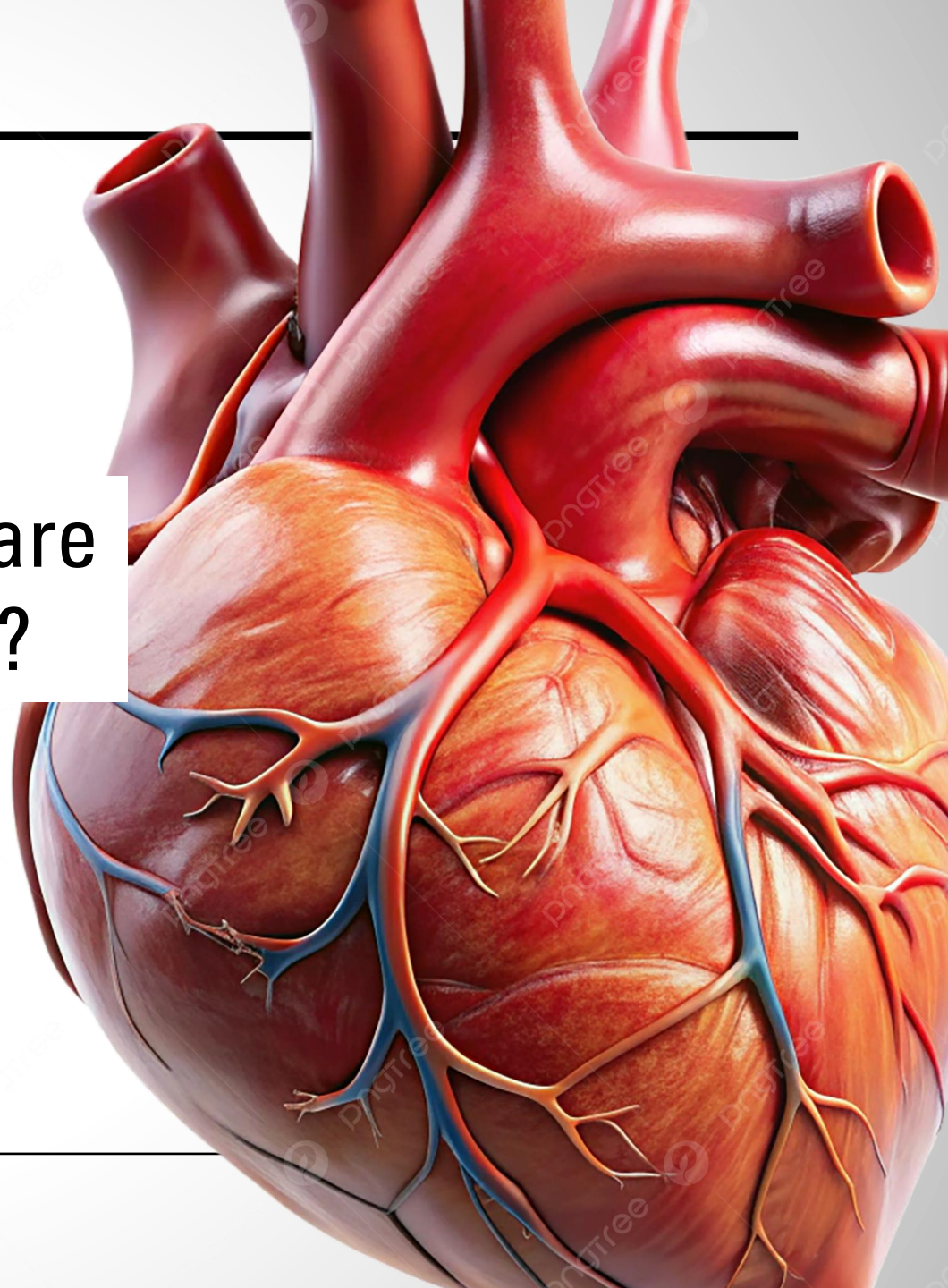
Providing immediate diagnostic information not always obtained through physical examination alone

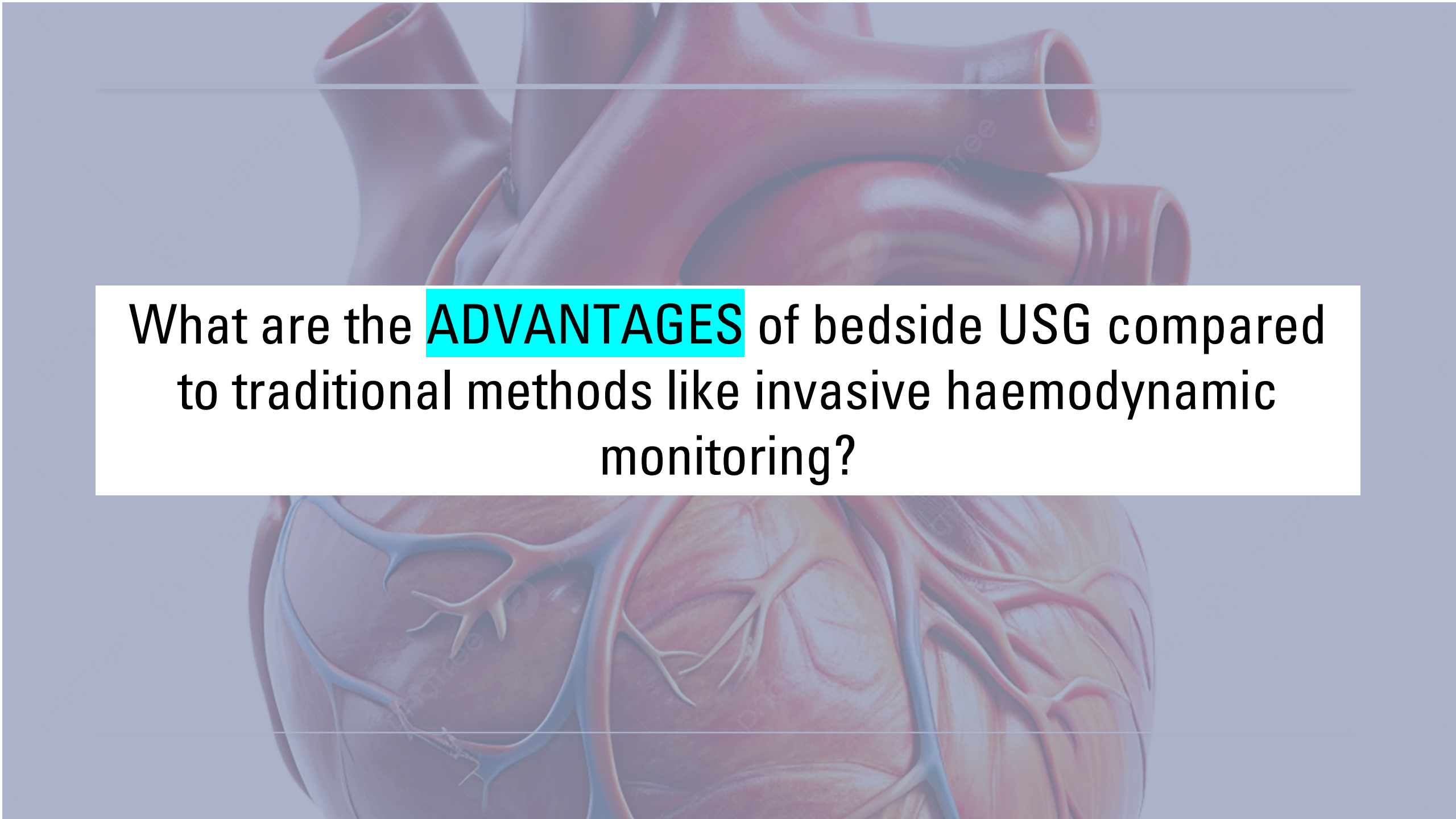
Avoiding risks associated in transporting unstable patient

Role of bedside Echo?

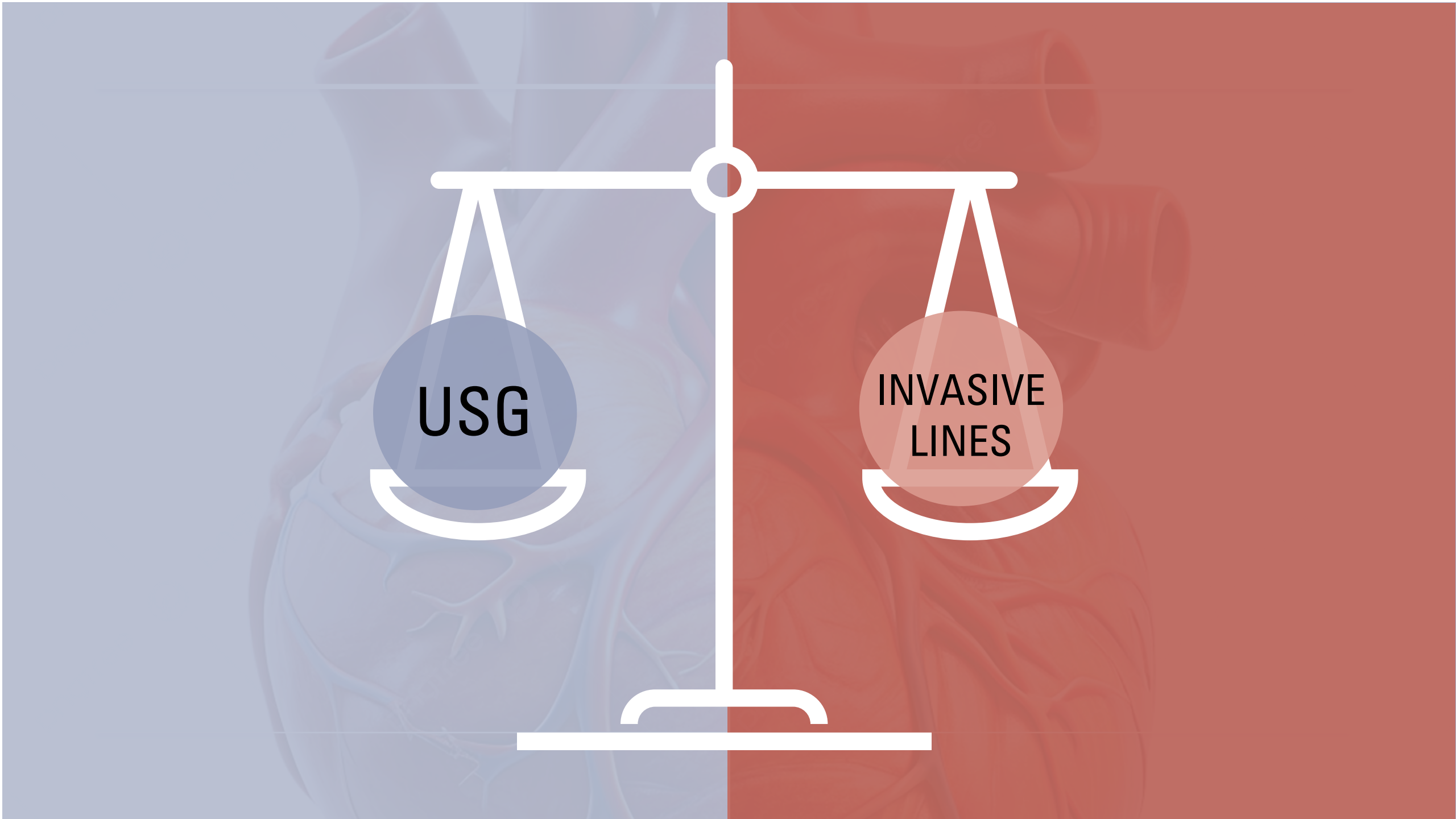
Advantages compared to invasive hemodynamic monitor?

What are the..?





What are the ADVANTAGES of bedside USG compared to traditional methods like invasive haemodynamic monitoring?


USG
INVASIVE LINES

TTE non-invasive while TEE minimally invasive with low risk of complications

Portability and allow bedside rapid assessment without the need of transporting ill patients

Risk of placing and maintaining invasive lines such as PA catheter. Eg knot formation, PA rupture, infection

Unable to provide visual info on heart structure, function, fluid, vascular access

Role of bedside Echo?

Advantages compared to invasive hemodynamic monitor?

Limitations in critical ill patients?

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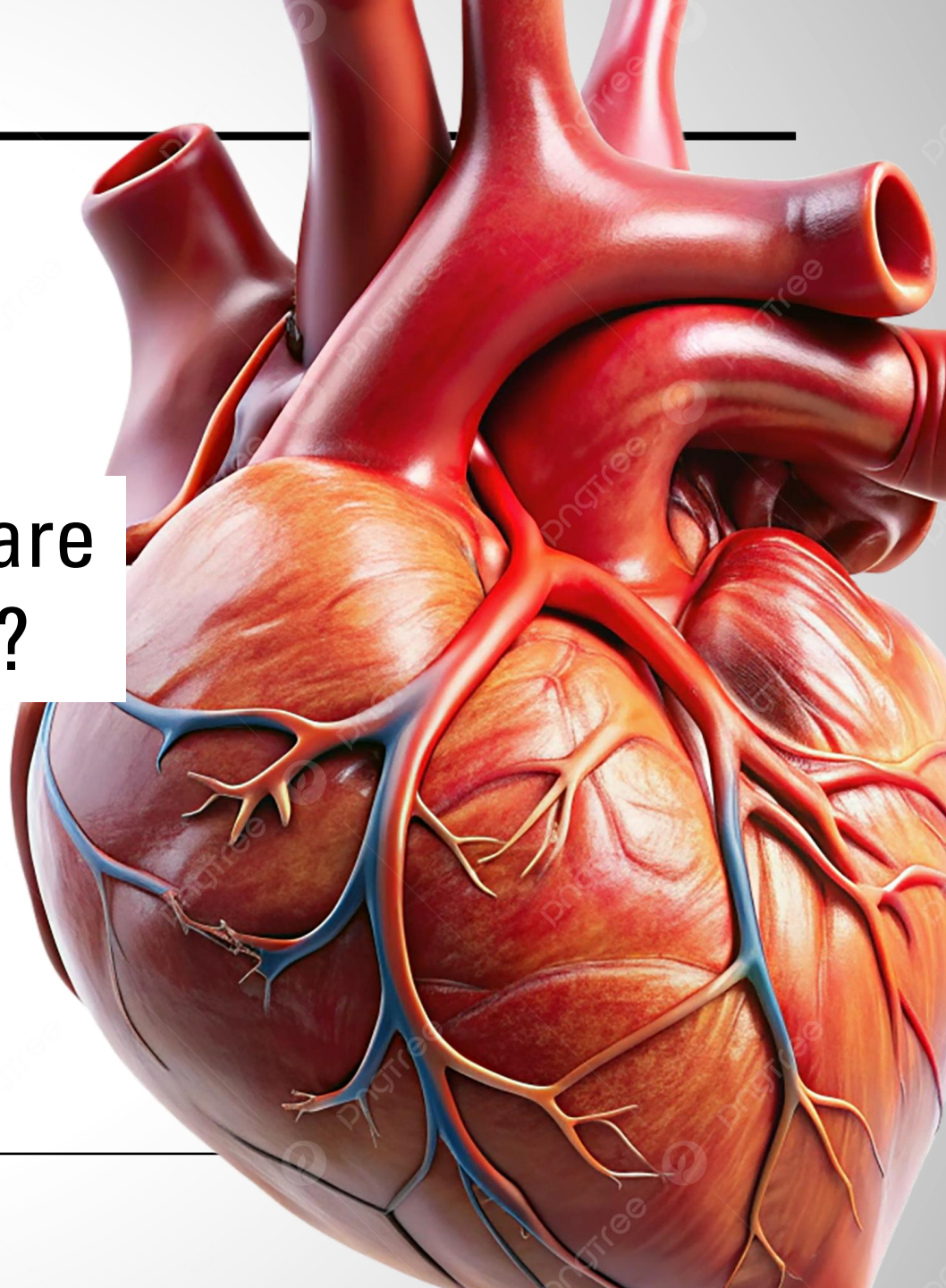
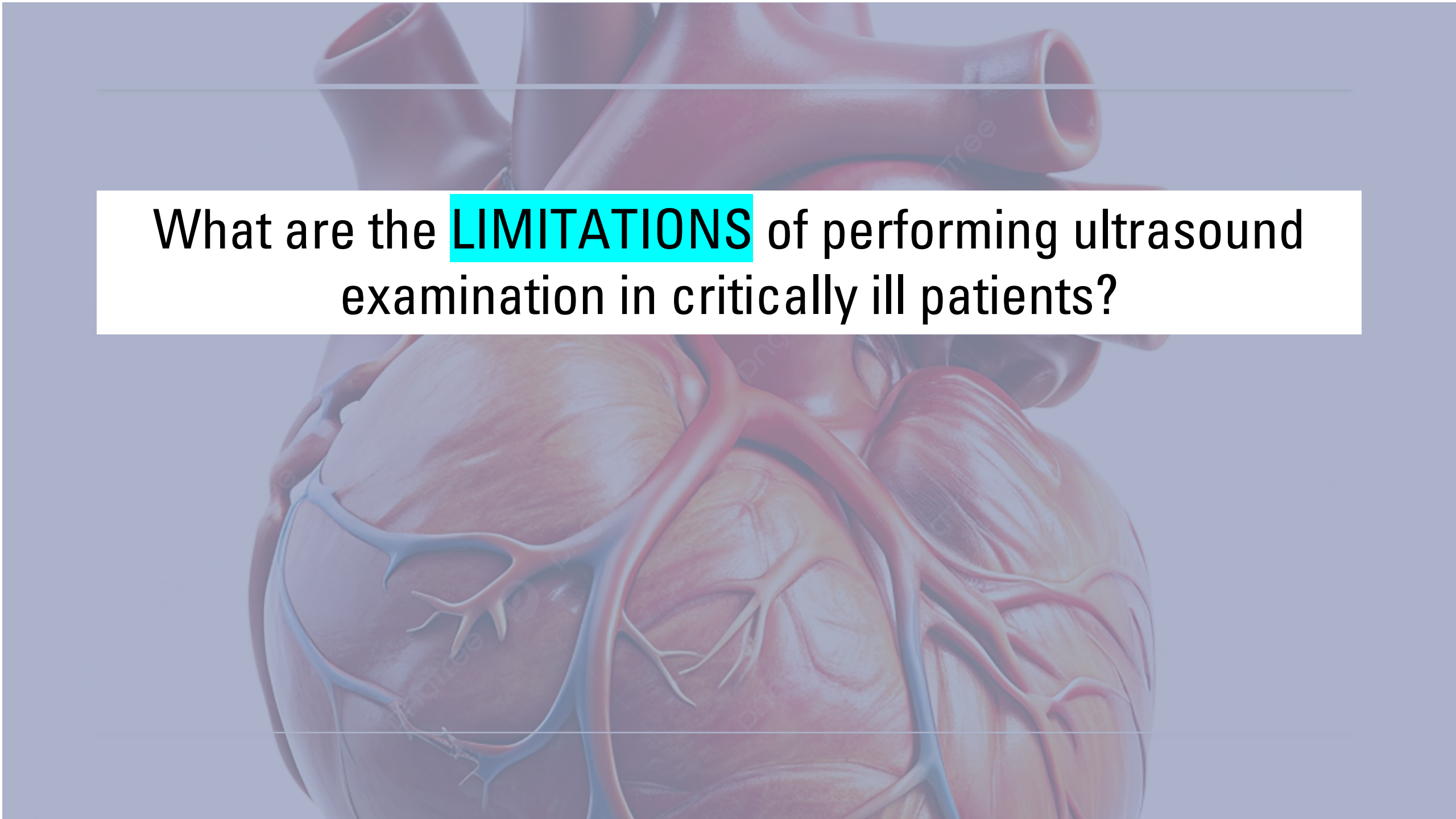




What are the LIMITATIONS of performing ultrasound examination in critically ill patients?

What are the LIMITATIONS of performing ultrasound examination in critically ill patients?

mechanical ventilation (inflated lungs obscuring the heart)

surgical wounds and dressings, the presence of tubes and drains,

subcutaneous emphysema, obesity

chronic obstructive pulmonary disease

all hinder the transmission and reflection of ultrasound waves, leading to poor image quality.

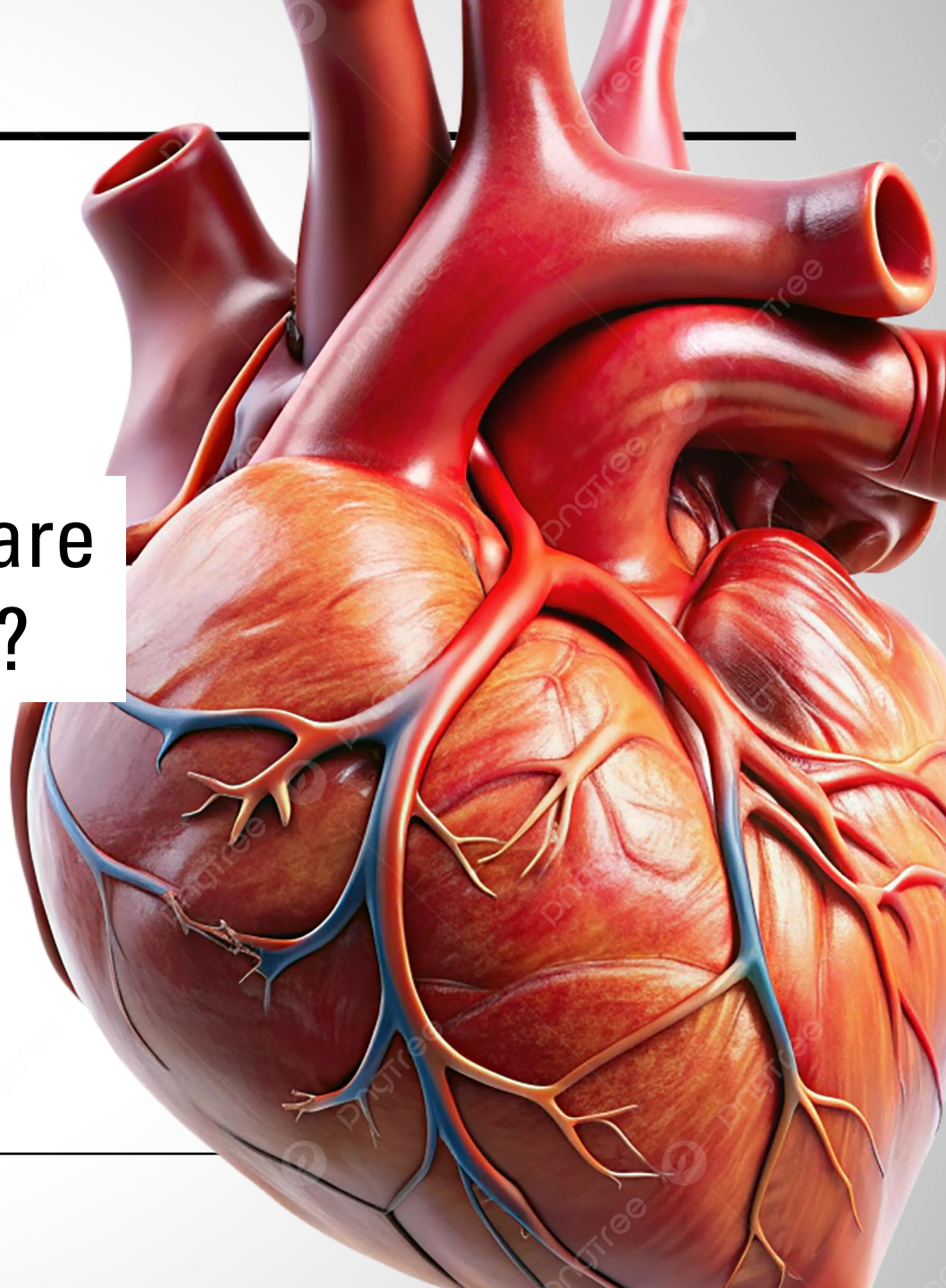
Role of bedside Echo?

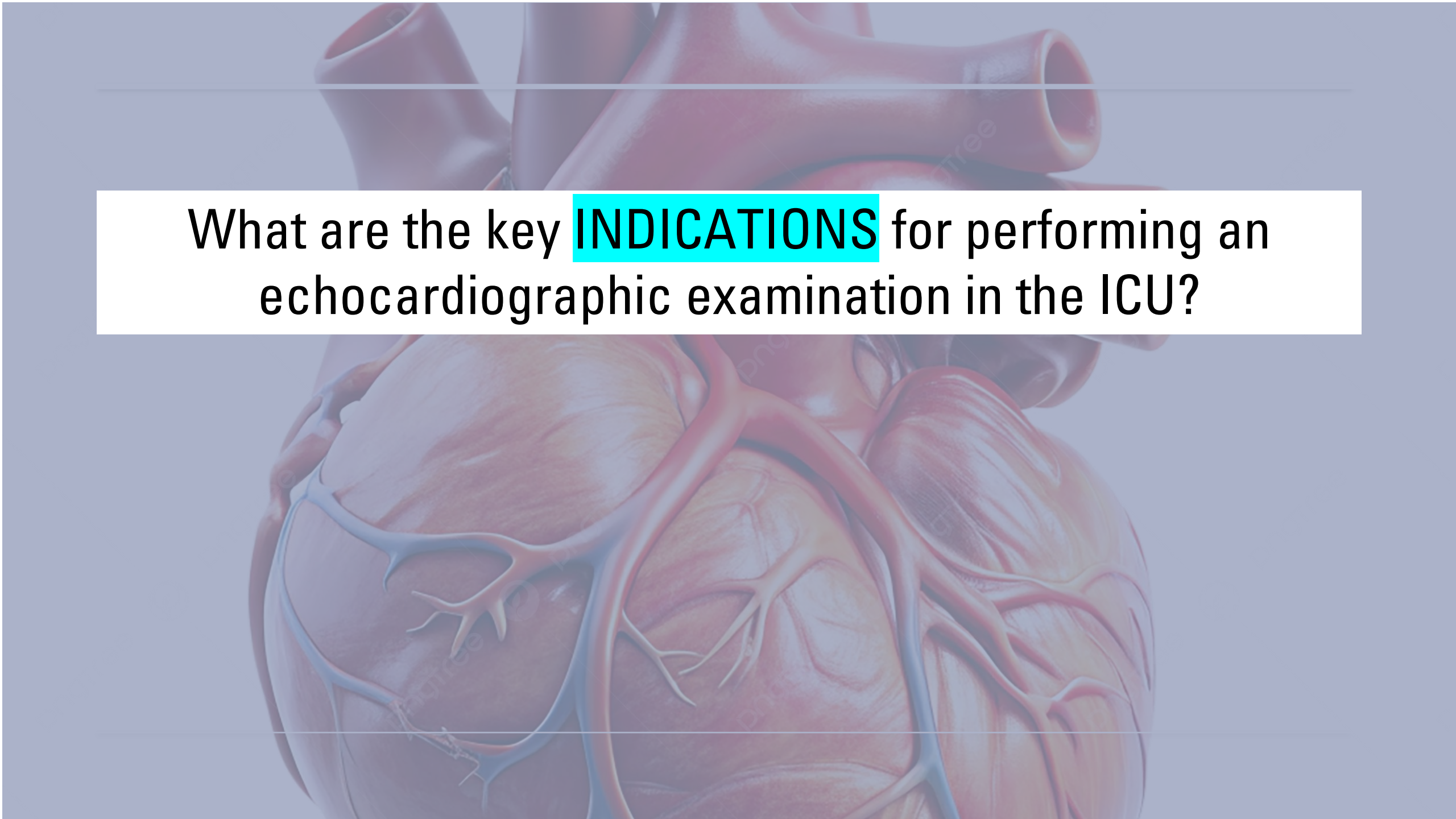
Advantages compared to invasive hemodynamic monitor?

Limitations in critical ill patients?

Key Indications to perform ECHO?

What are the..?





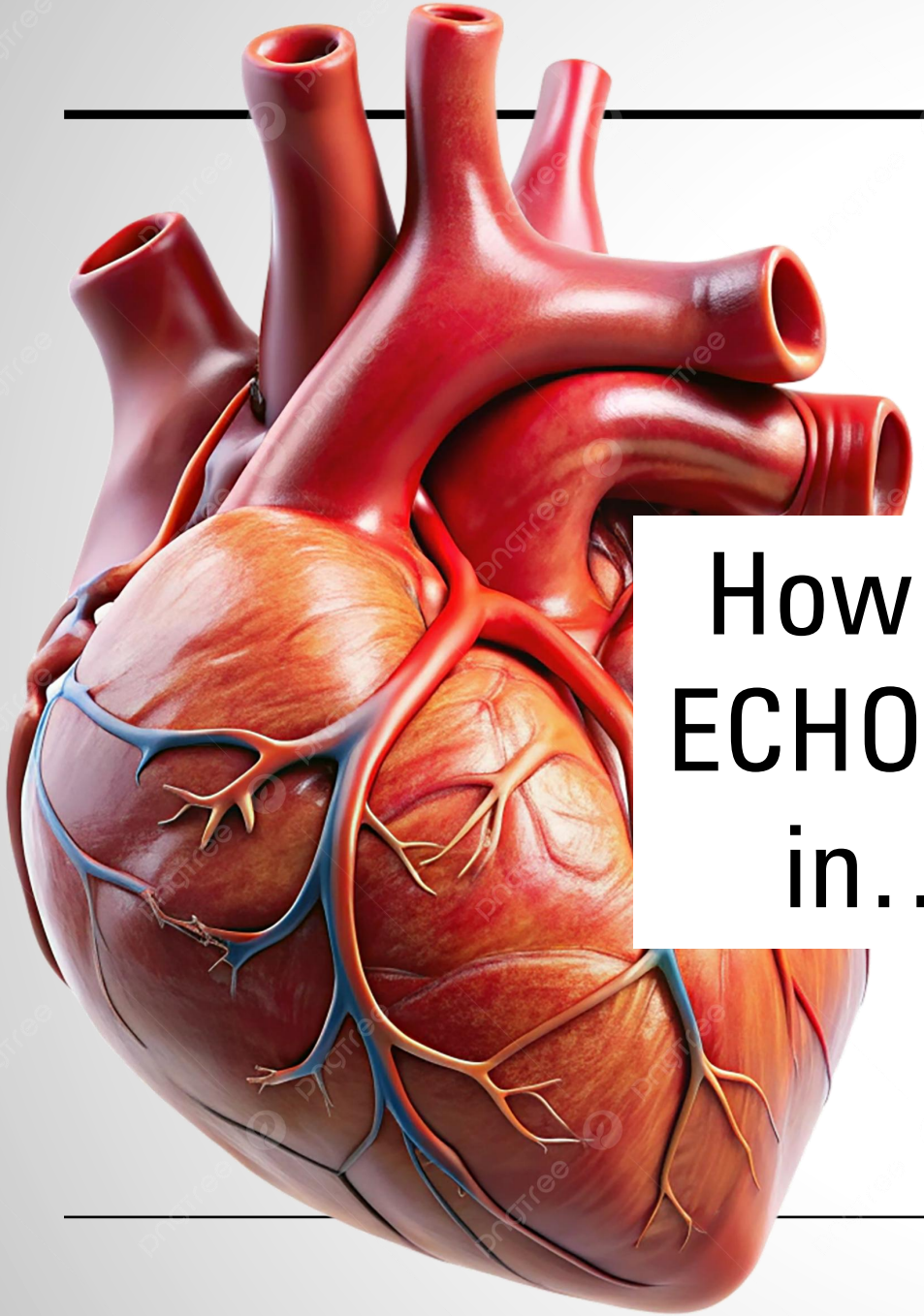
What are the key INDICATIONS for performing an echocardiographic examination in the ICU?

STRUCTURE

- Acute valvular dysfunction
- Cardiac tamponade
- Suspected infective endocarditis
- Suspected aortic dissection or rupture
- Potential source of embolus (intracardiac thrombus, left atrial appendage thrombus in AF, renal cell CA)
- Congenital heart defect ASD,VSD

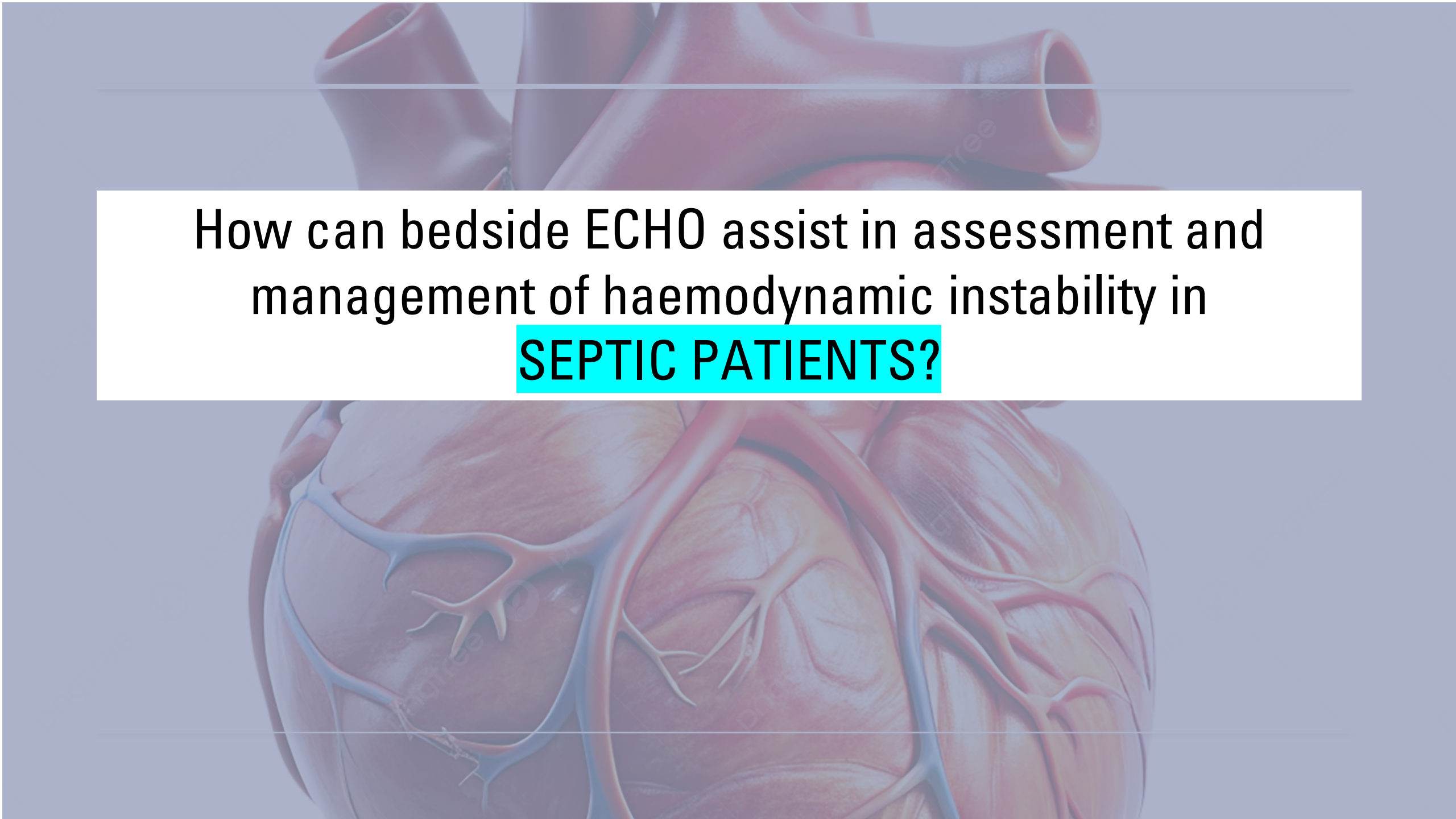
FUNCTION

- Haemodynamically instability
- Suspected ventricular failure
- Hypovolaemia
- Suspected pulmonary embolism



Role in sepsis?

How does ECHO helps in…..?

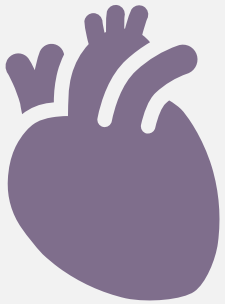


How can bedside ECHO assist in assessment and management of haemodynamic instability in SEPTIC PATIENTS?

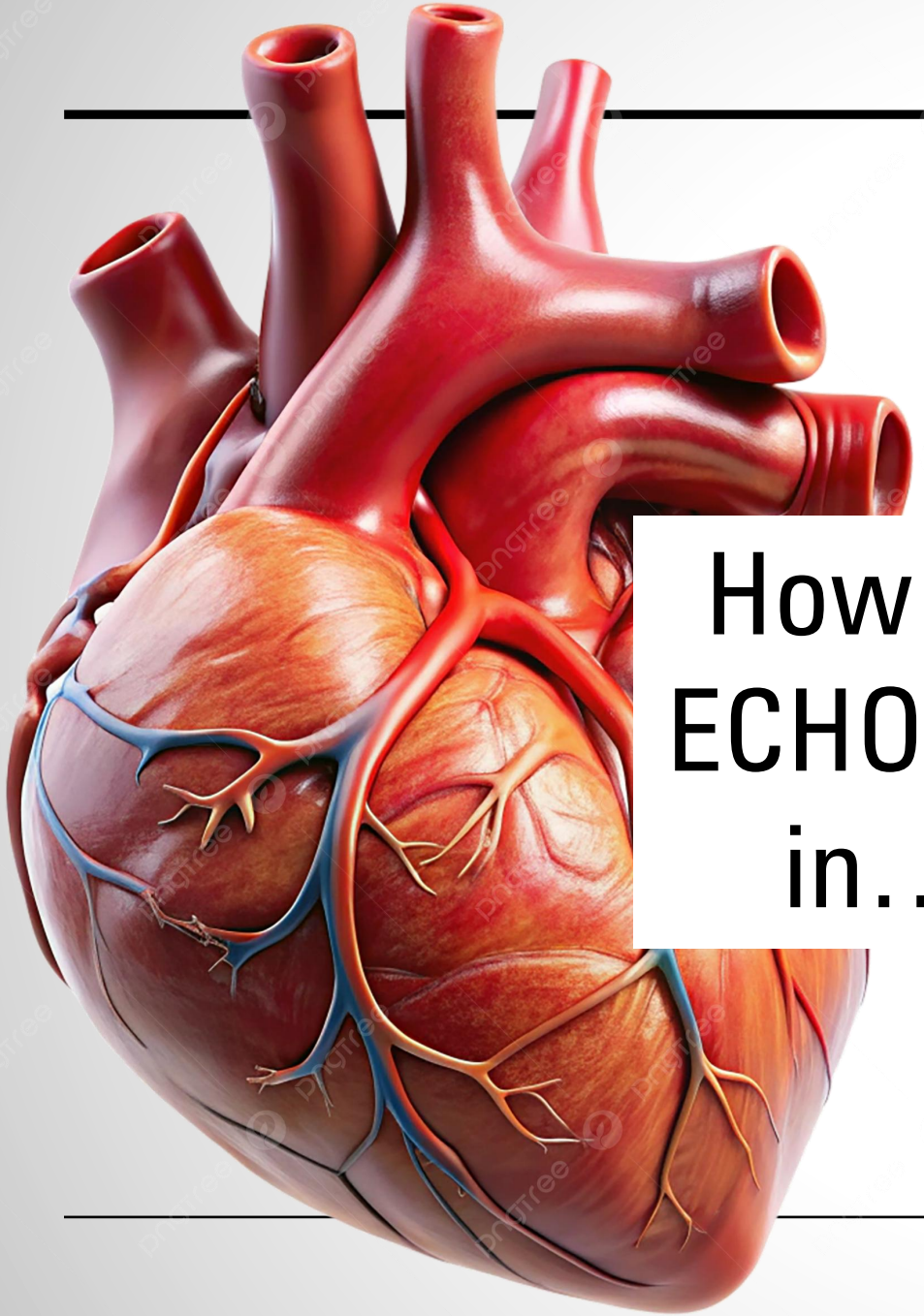
How can bedside ECHO assist in assessment and management of haemodynamic instability in SEPTIC PATIENTS?

In septic patients with haemodynamic instability, identifying the underlying cause, which may be hypovolemic, cardiogenic, or distributive in origin

repeated assessments to monitor the adequacy and efficacy of therapy, such as fluid administration and the use of inotropic or vasoconstrictor agents,



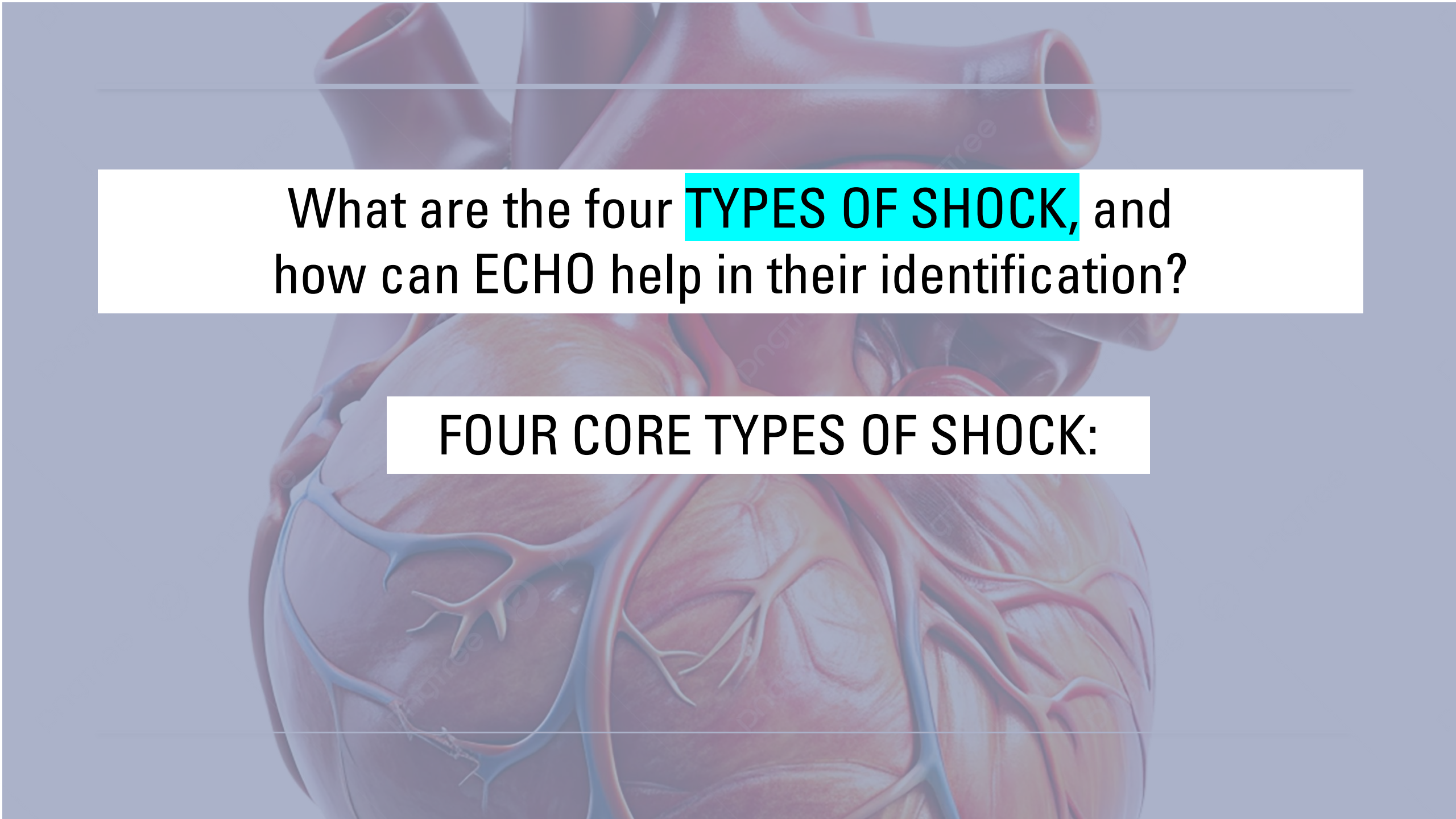
By visualising cardiac function and volumes, clinicians can better guide treatment and optimise haemodynamic parameters



How does ECHO helps in…..?

Role in sepsis?

Types of shock



What are the four TYPES OF SHOCK, and how can ECHO help in their identification?

FOUR CORE TYPES OF SHOCK:

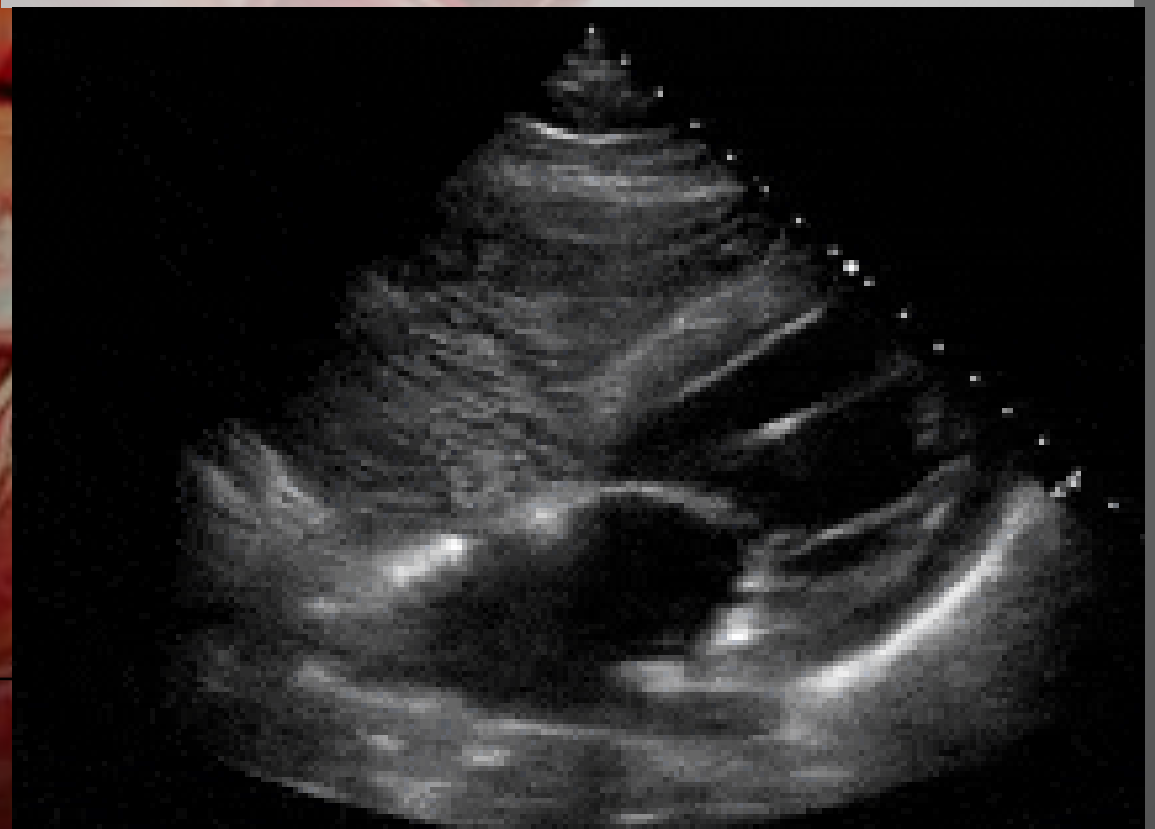
OBSTRUCTIVE SHOCK

CARDIOGENIC SHOCK

HYPOVOLEMIC SHOCK

CARDIOGENIC SHOCK

- Inadequate pump function
- Cardiac function:
  - Contractility
  - Ejection Fraction



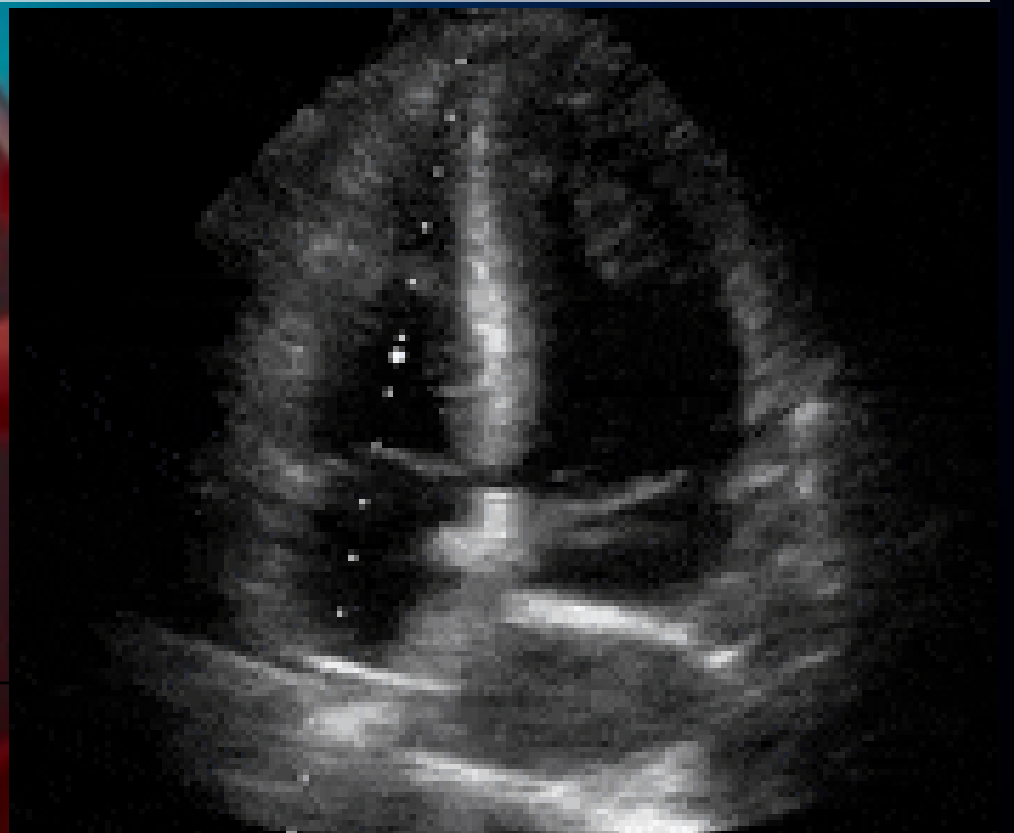
CARDIOGENIC SHOCK

HYPOVOLEMIC SHOCK

VASOPLEGIC SHOCK

HYPOVOLEMIC

- Inadequate circulating volume
- Fluid status assessment
  - IVC size, variability
  - LV “kissing” walls



Capillaries

HYPOVOLEMIC SHOCK

VASOPLEGIC SHOCK

OBSTRUCTIVE SHOCK

Artery

Capillaries

VASOPLEGIC

- Loss of vascular tone
- Clues to vasoplegia
  - Hyperdynamic
  - Well-filled LV

VASOPLEGIC SHOCK

OBSTRUCTIVE SHOCK

CARDIOGENIC SHOCK

Obstruction

OBSTRUCTIVE

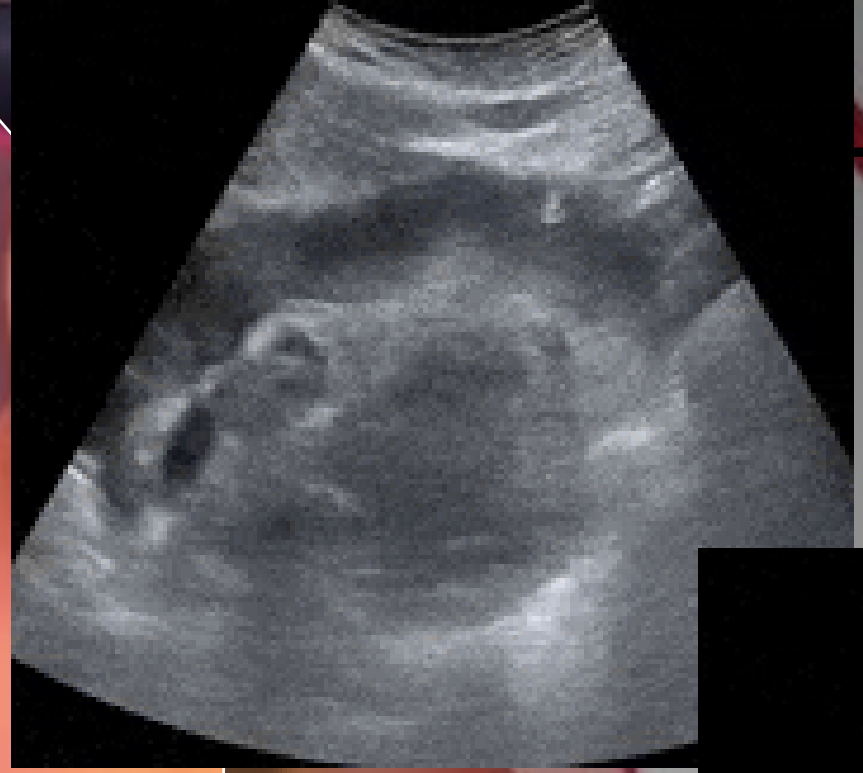
- Obstruction to blood flow
- Eg pulmonary embolism, cardiac tamponade

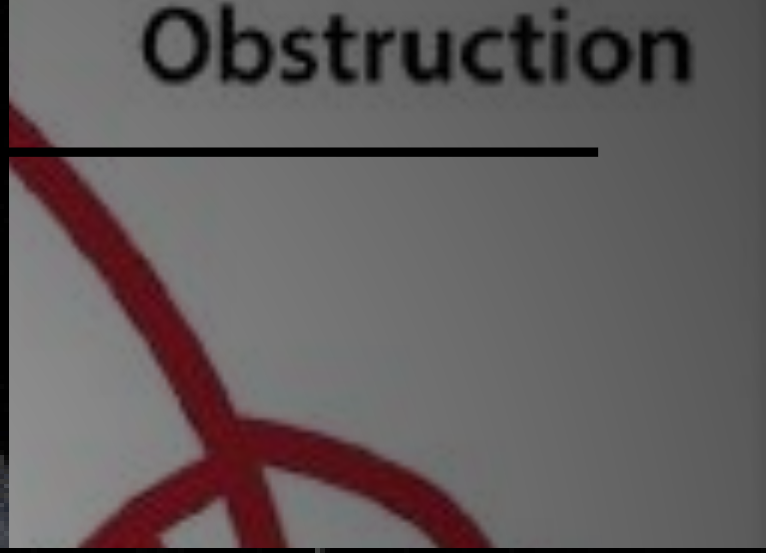
Pericardial

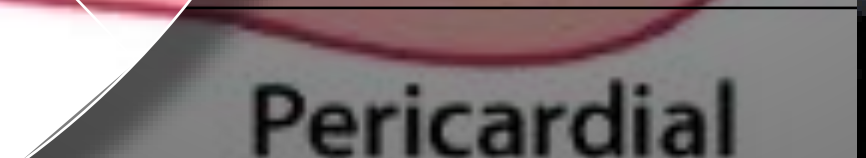
VASOPLEGIC SHOCK

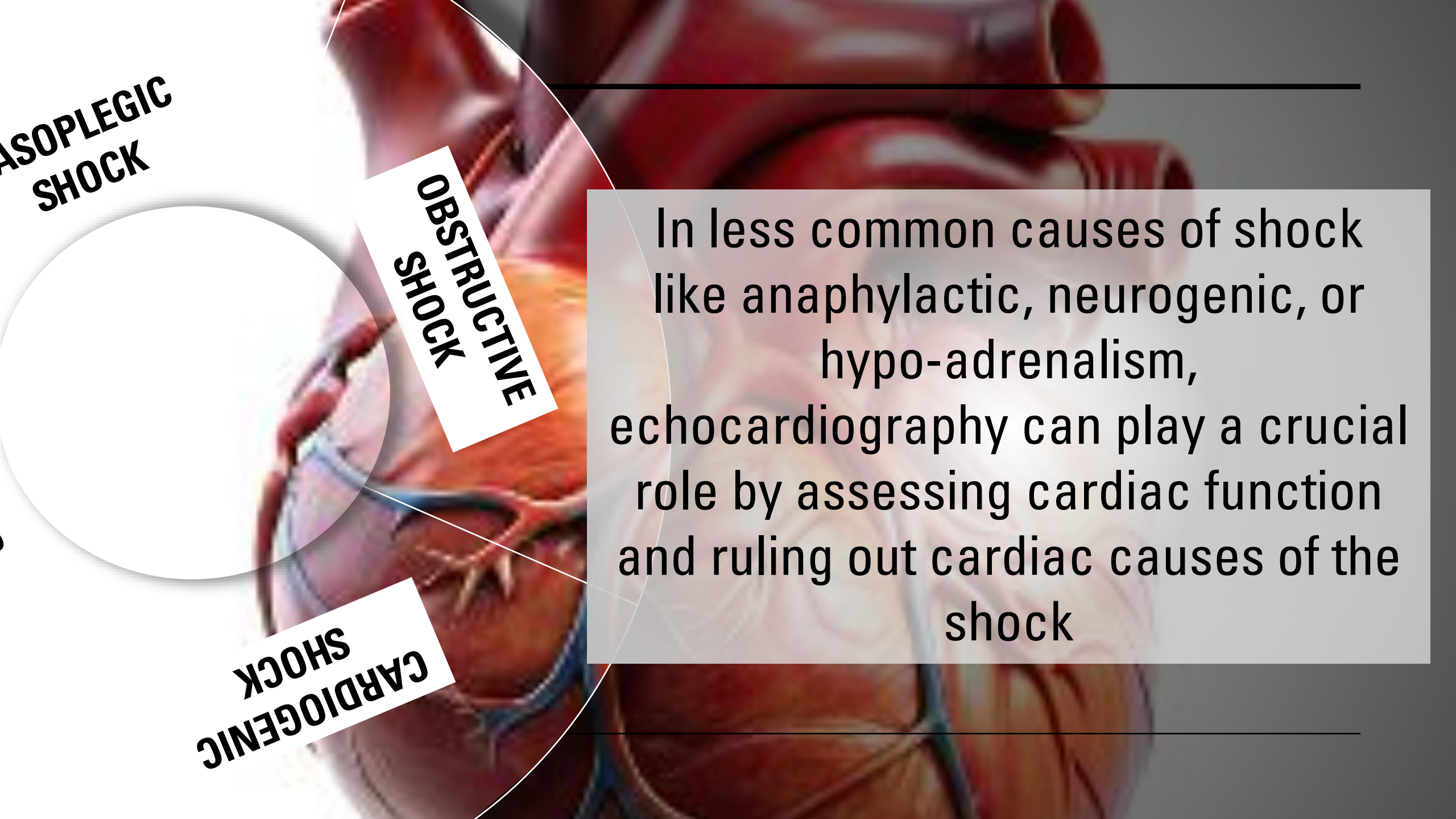
OBSTRUCTIVE SHOCK

CARDIOGENIC SHOCK

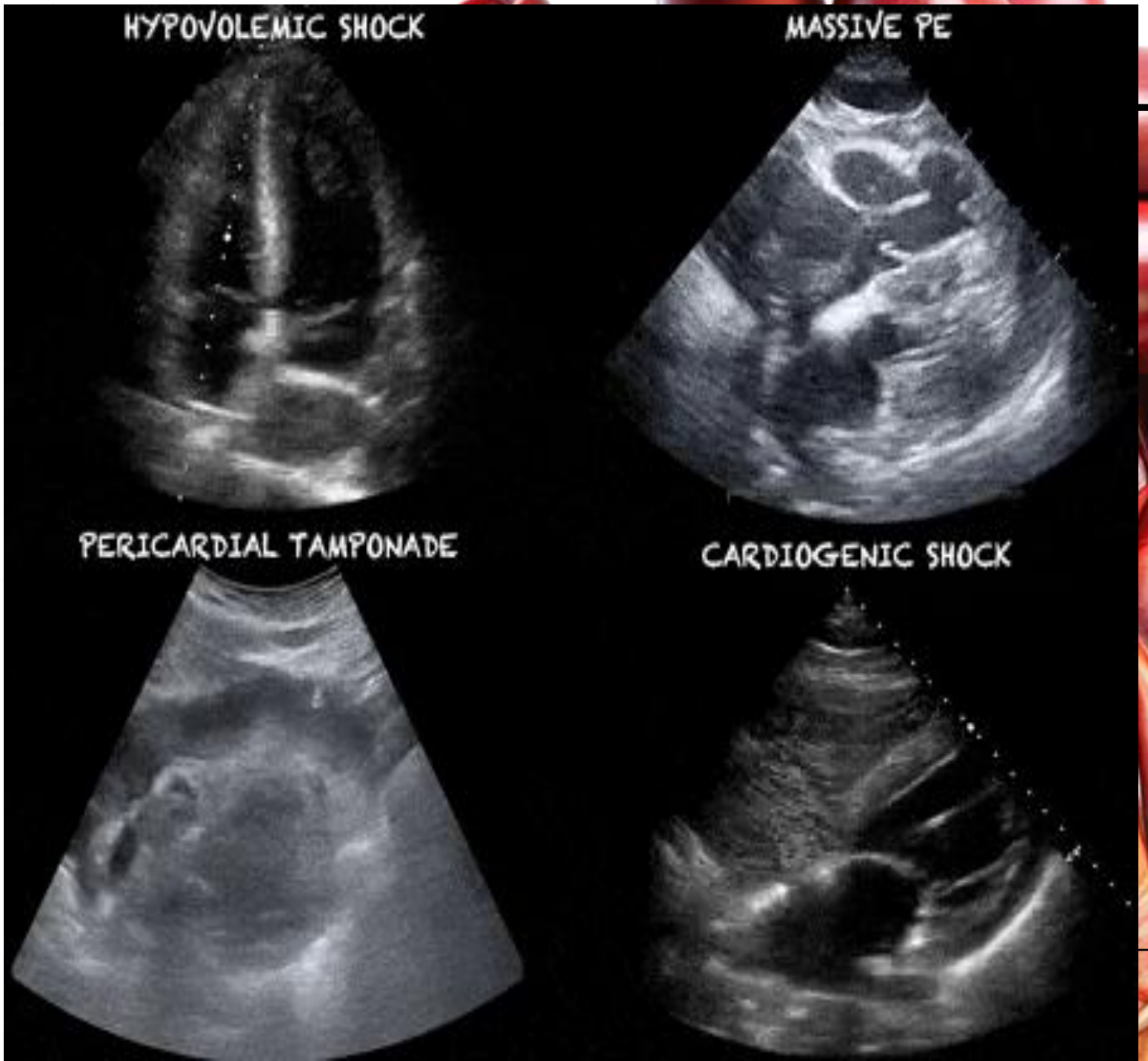




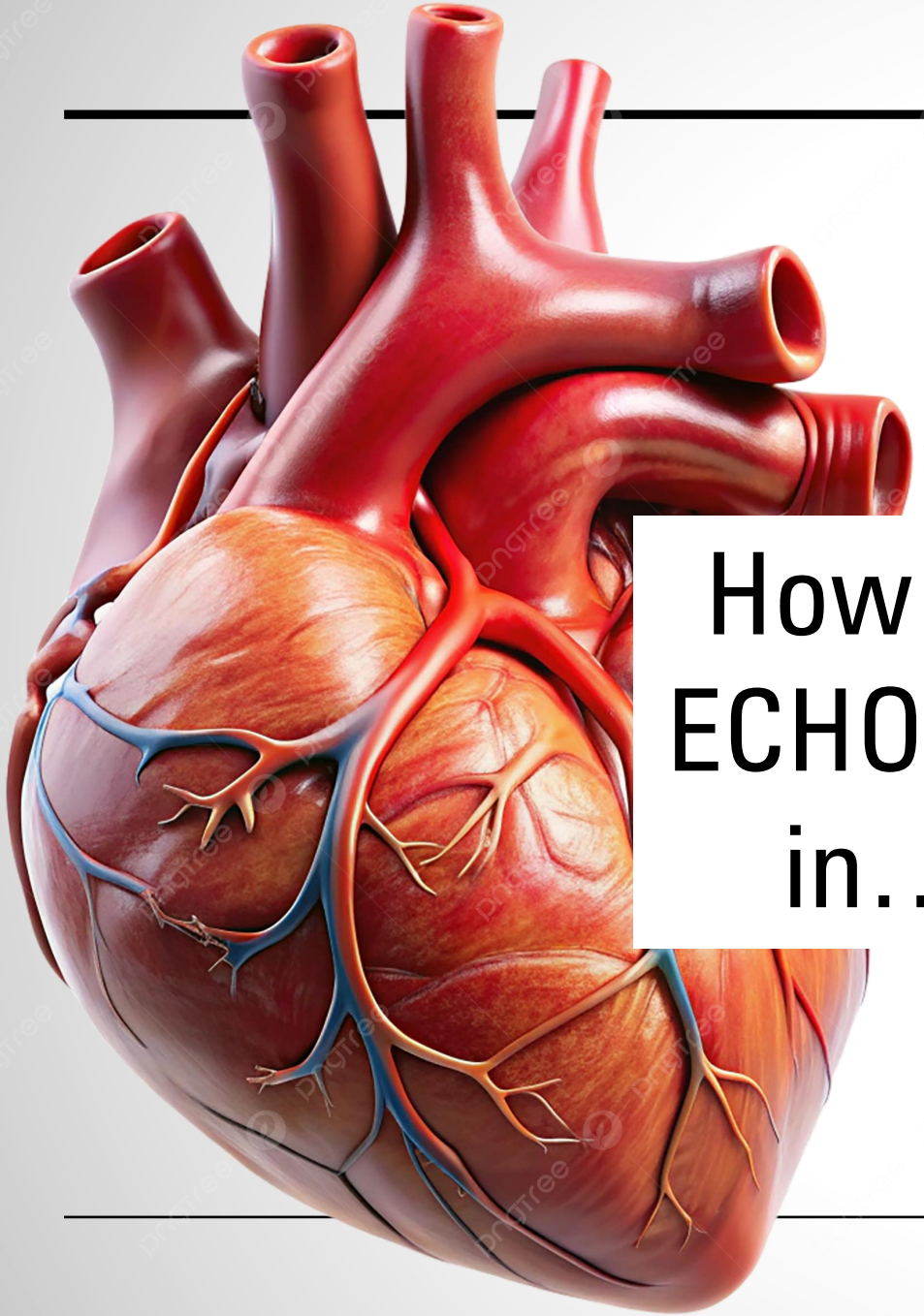




In less common causes of shock like anaphylactic, neurogenic, or hypo-adrenalism, echocardiography can play a crucial role by assessing cardiac function and ruling out cardiac causes of the shock



HYPERDYNAMIC



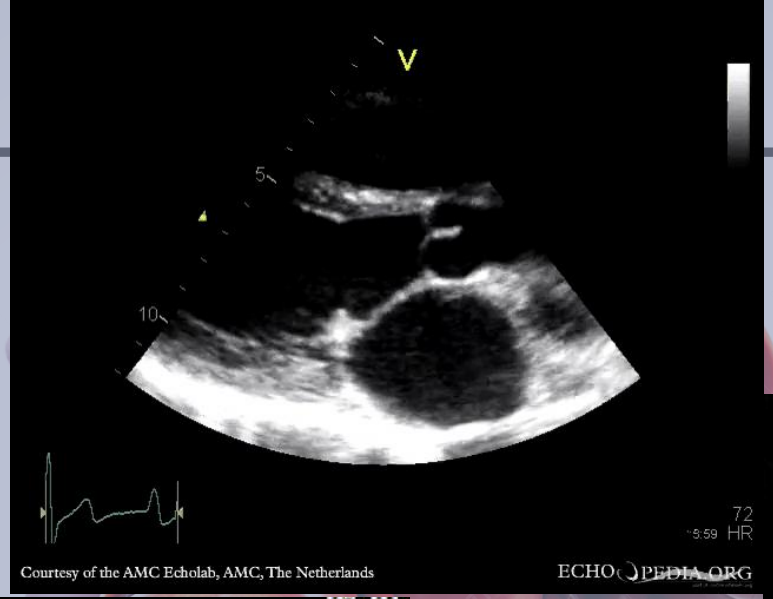
How does ECHO helps in…..?

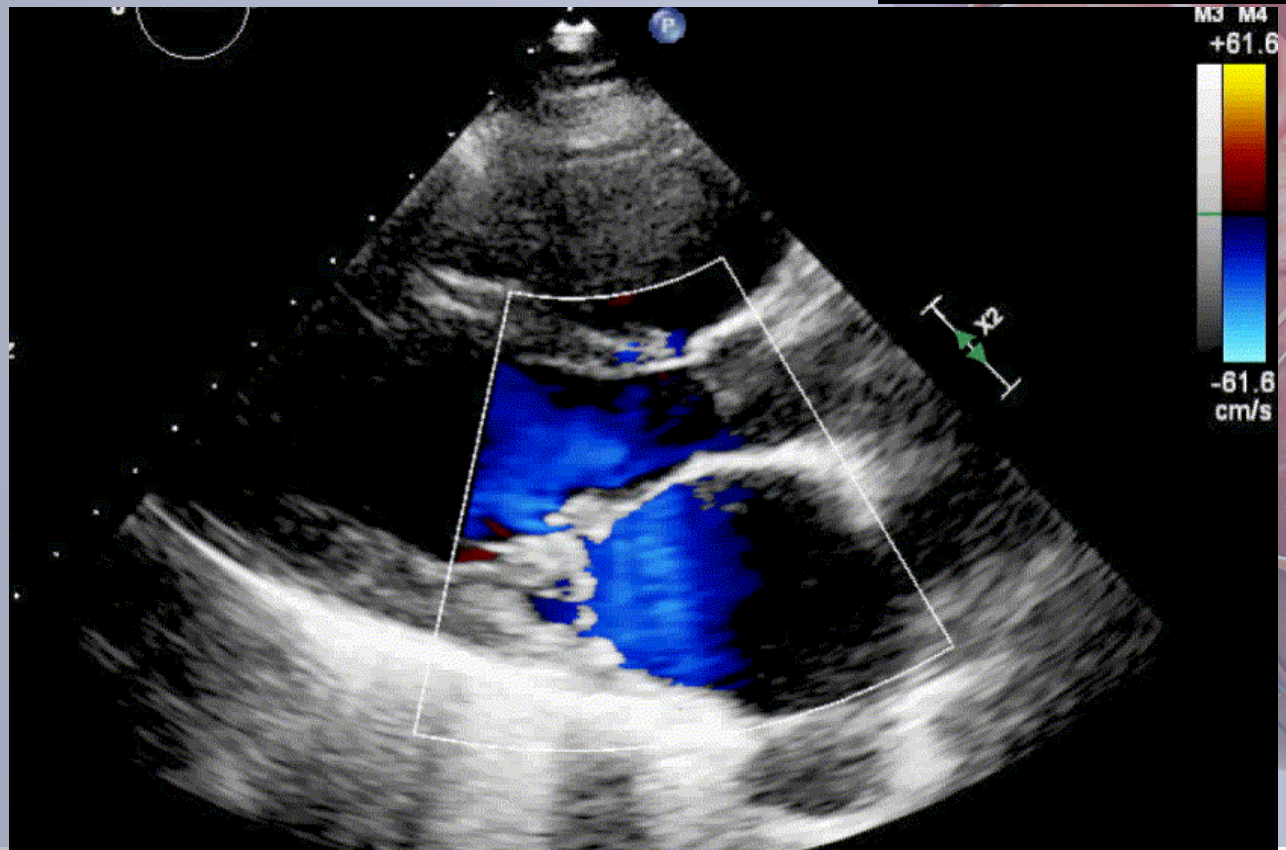
- Role in sepsis?
- Types of shock
- Traumatic valvular

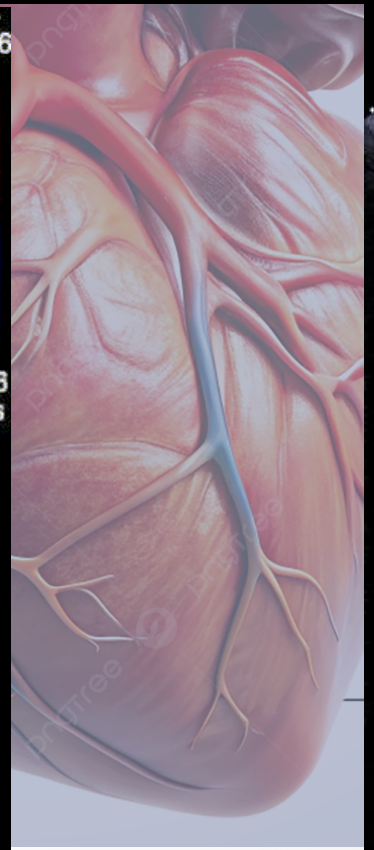
What is the role of bedside ECHO in evaluating VALVULAR function and detecting TRAUMATIC VALVULAR INJURIES in the ICU?

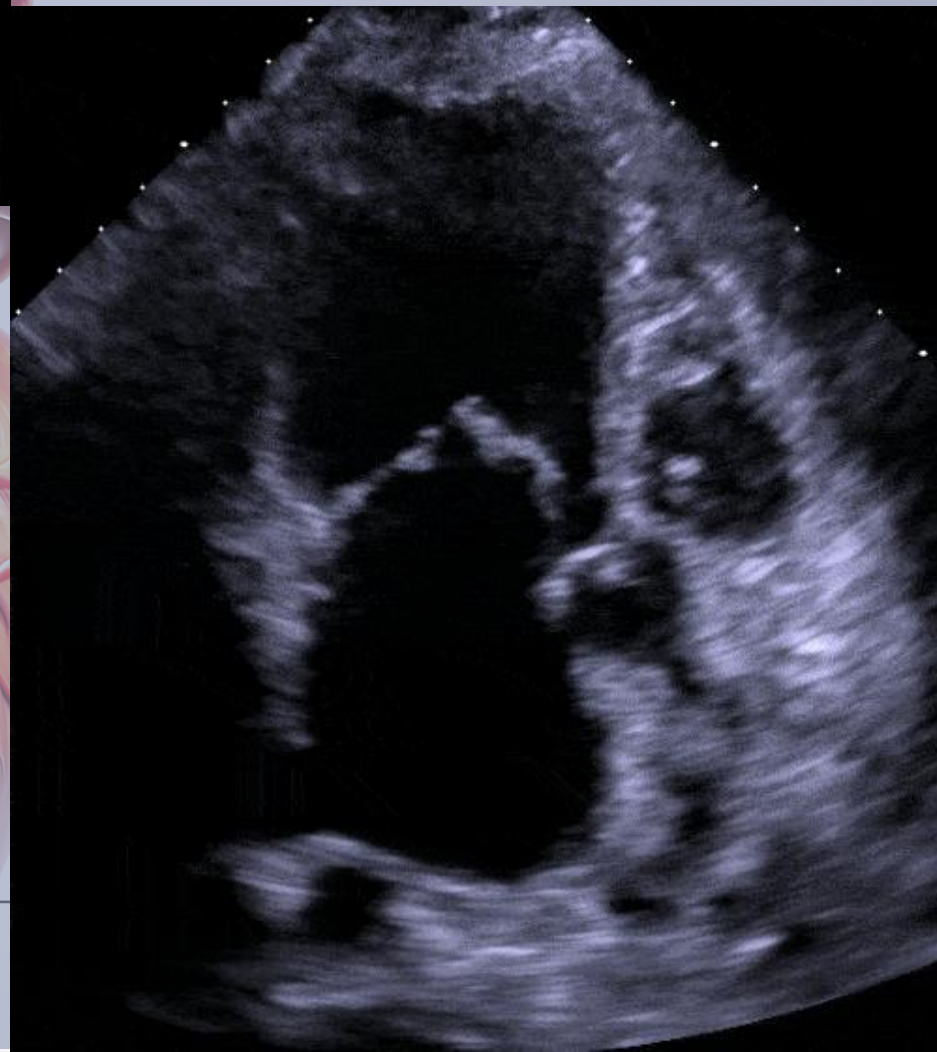
- Detection of acute aortic or mitral regurgitation, and prosthetic valve dysfunction.
- Provides information on aetiology and severity of valvular lesions.
- In patients with chest trauma, TEE is the preferred bedside modality for detecting traumatic valvular injuries such as leaflet tears or papillary muscle rupture, which may present as acute regurgitation.

MITRAL VALVE PATHOLOGY

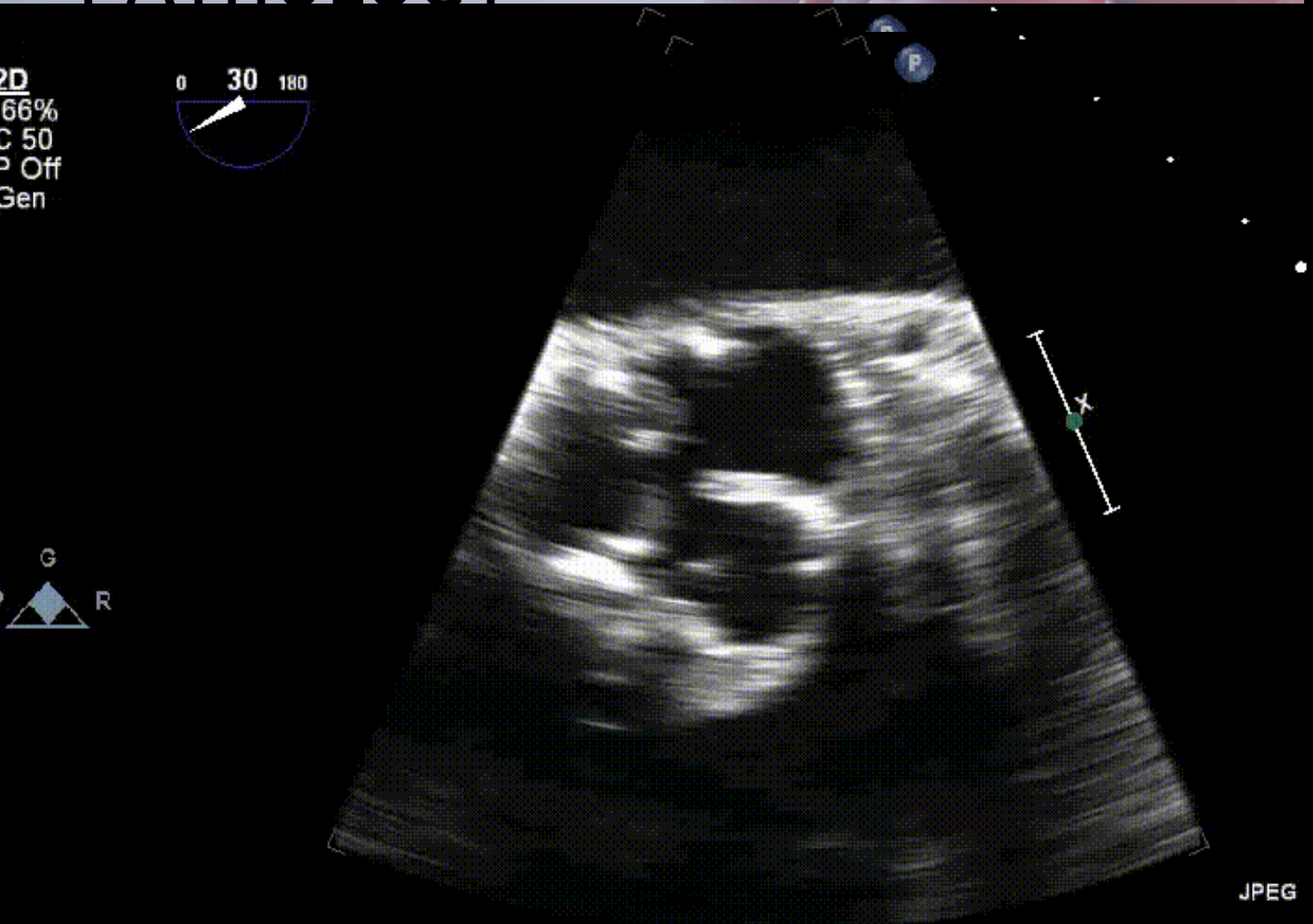


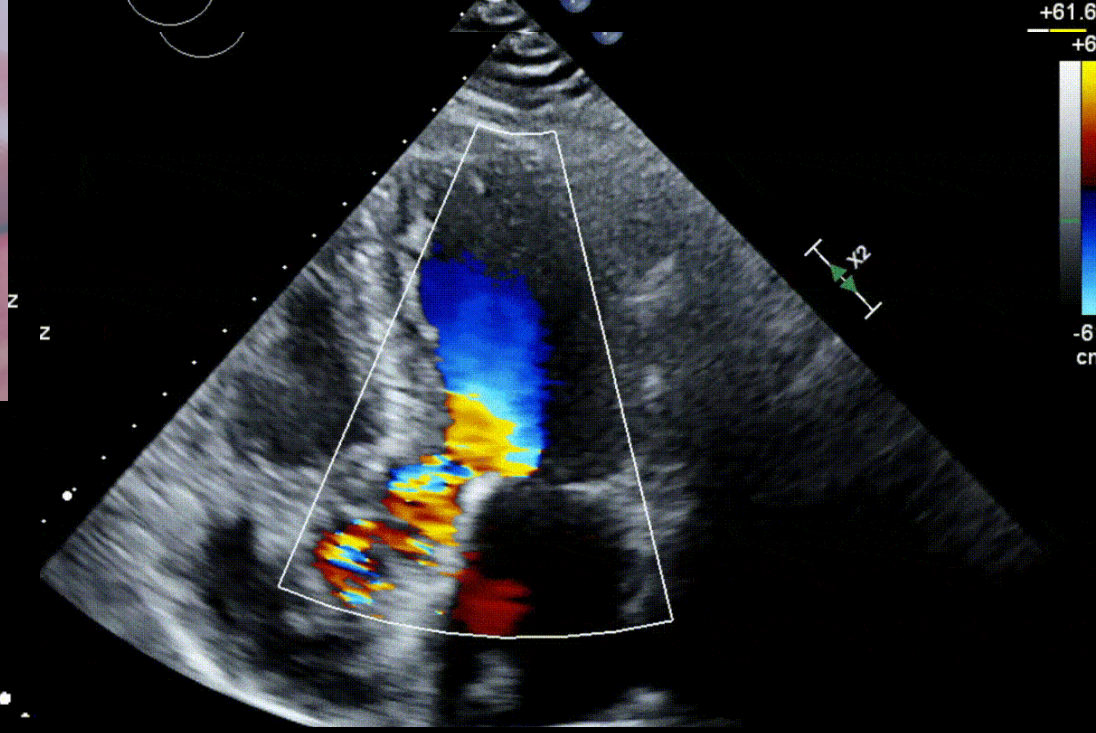


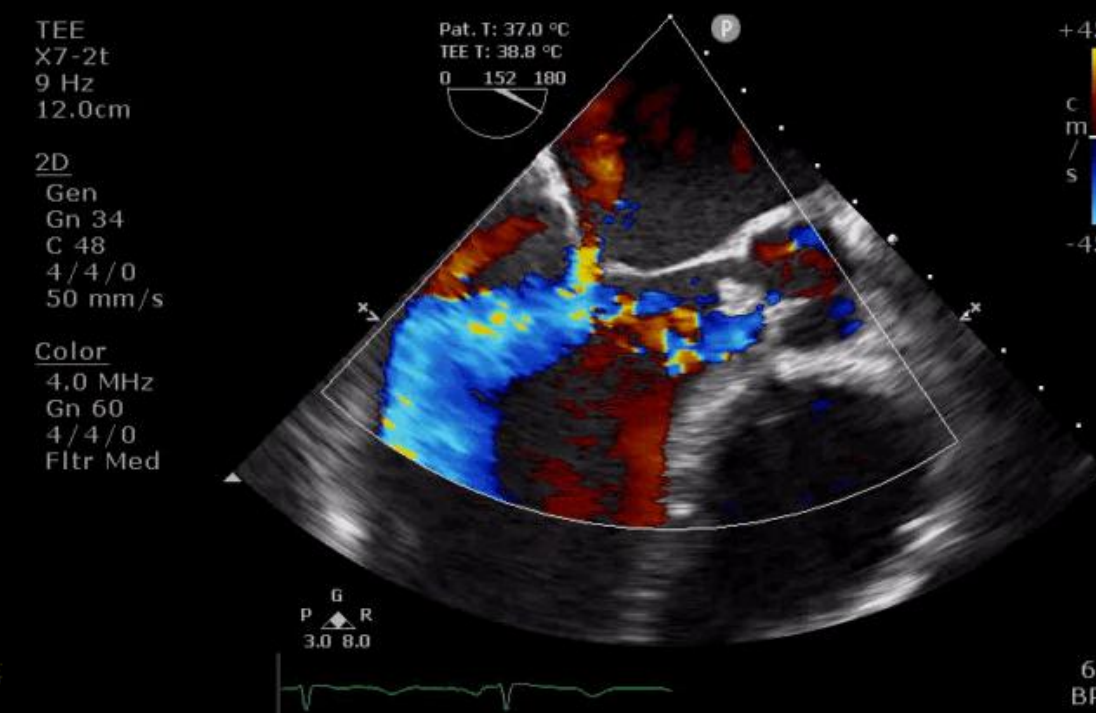




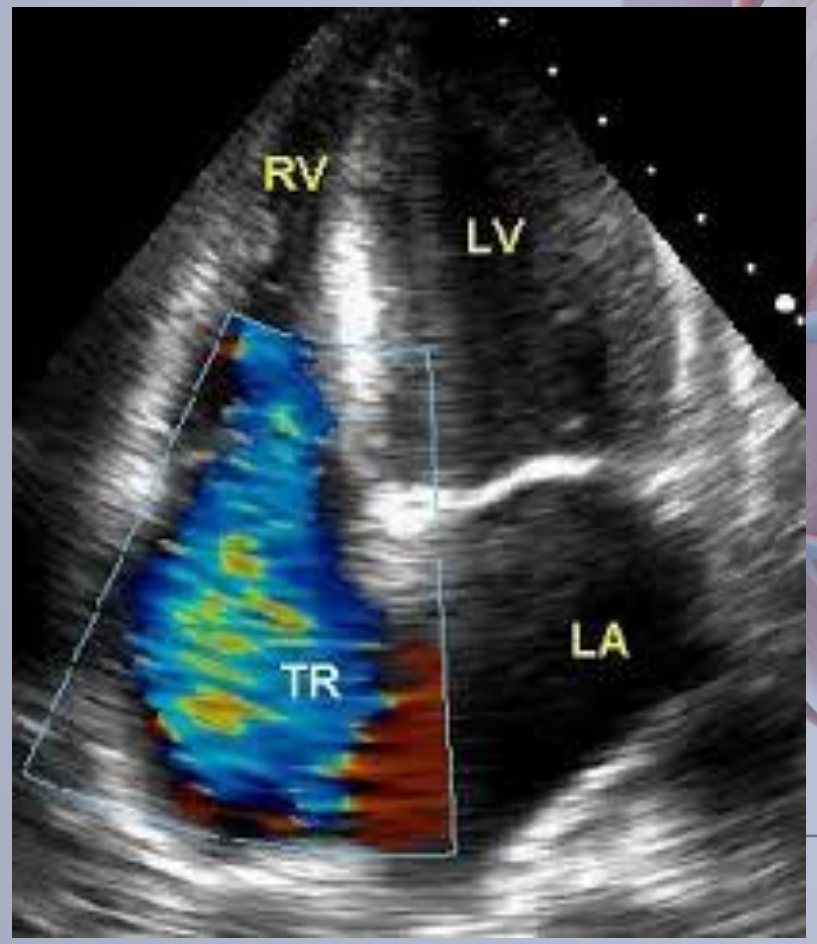
AORTIC VALVE PATHOLOGY

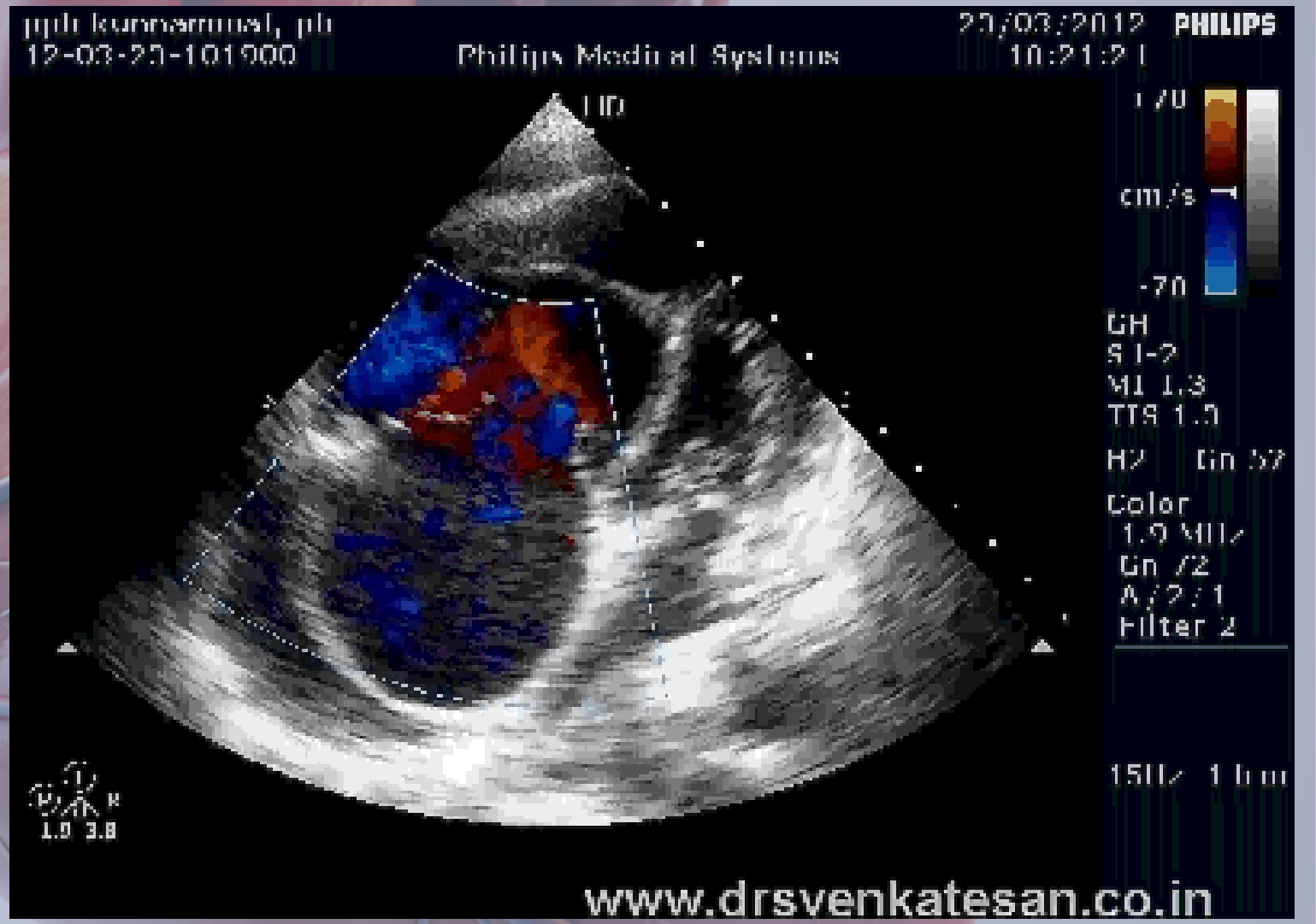


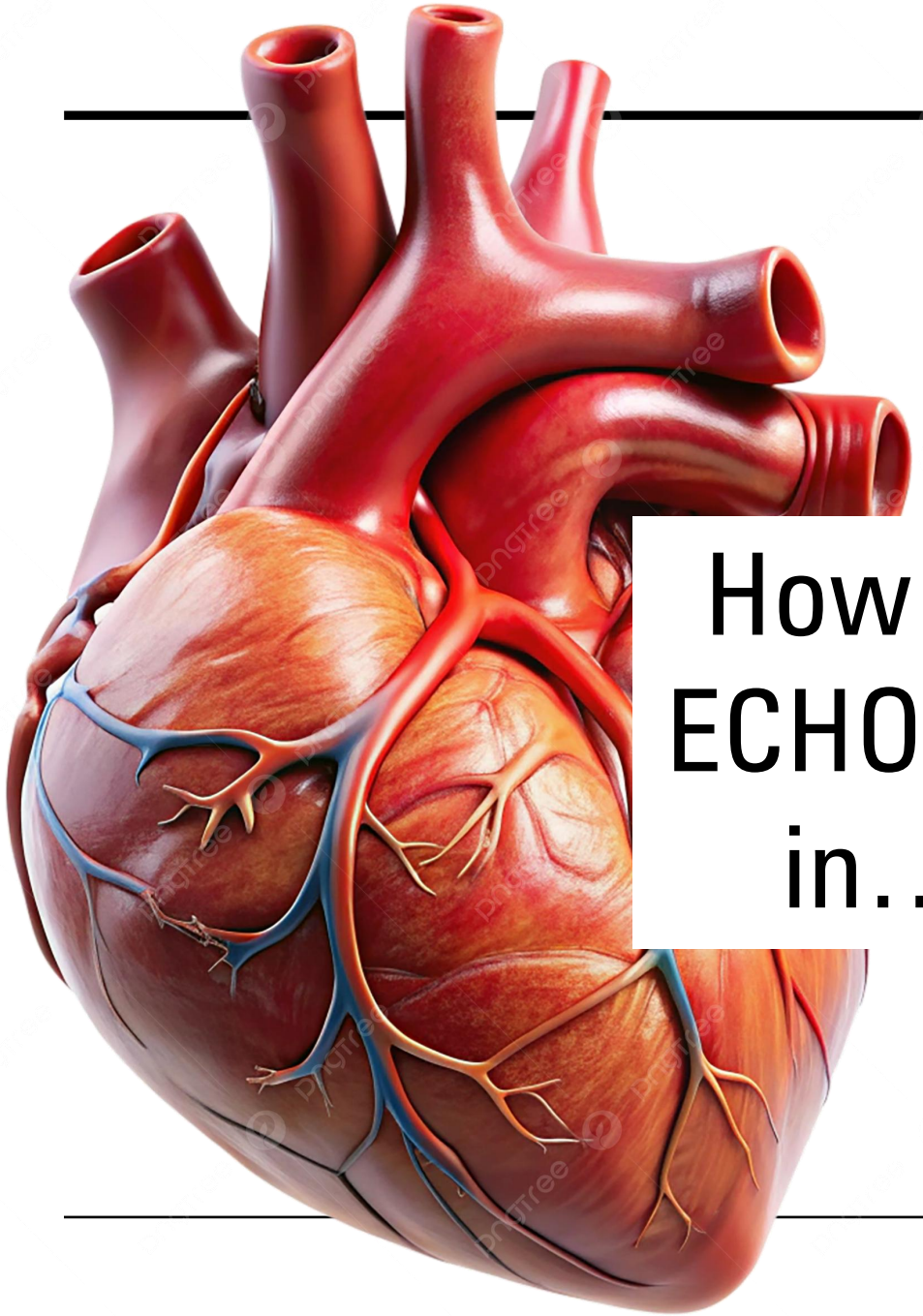




TRICUSPID VALVE PATHOLOGY







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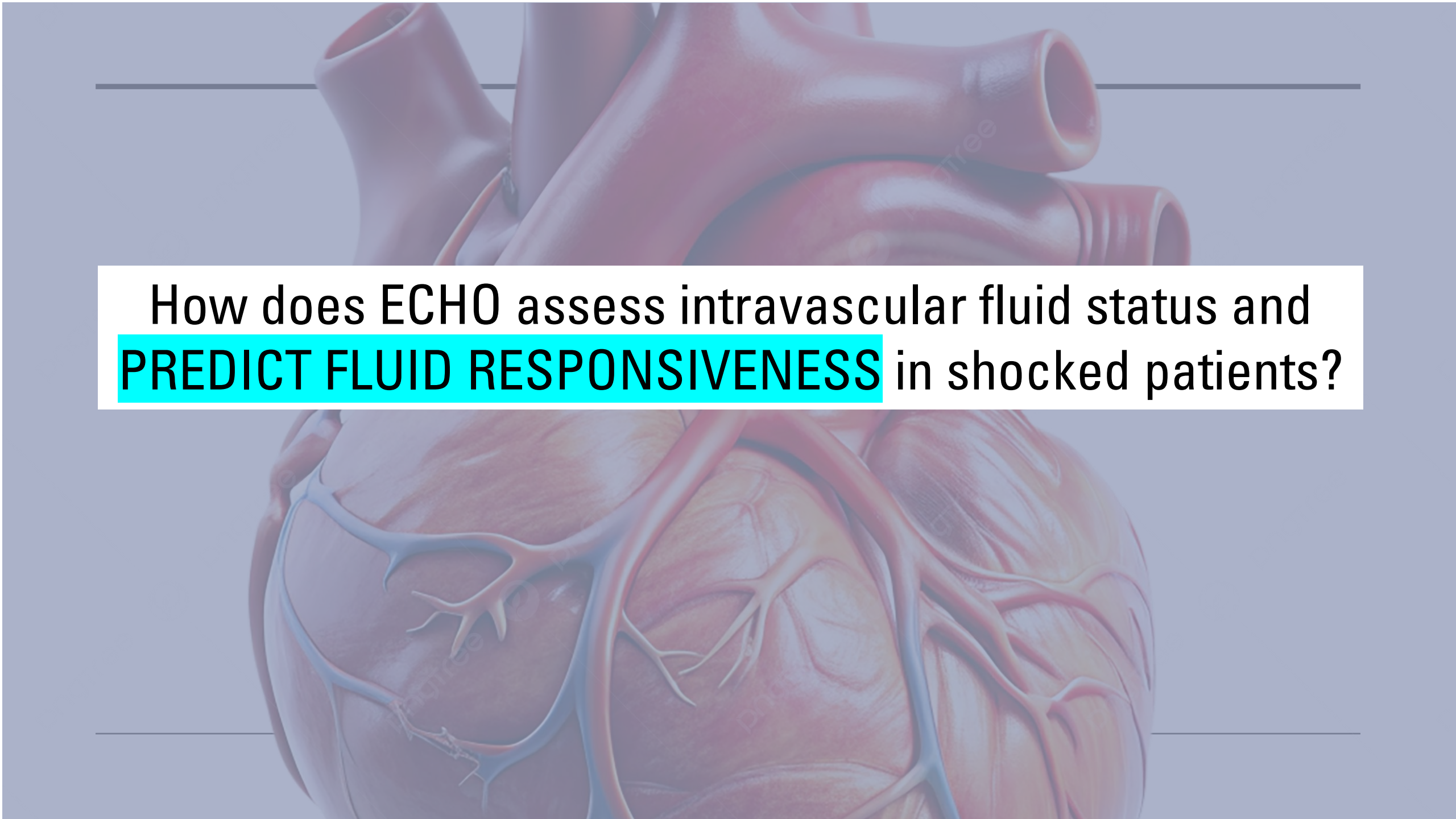
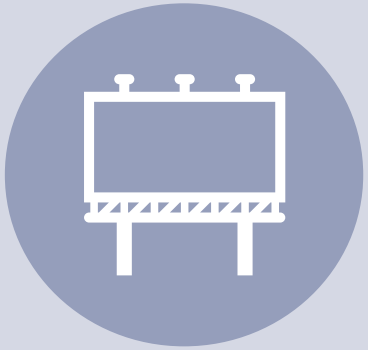
- Role in sepsis?
- Types of shock
- Traumatic valvular
- Predict fluid responsiveness



How does ECHO assess intravascular fluid status and PREDICT FLUID RESPONSIVENESS in shocked patients?

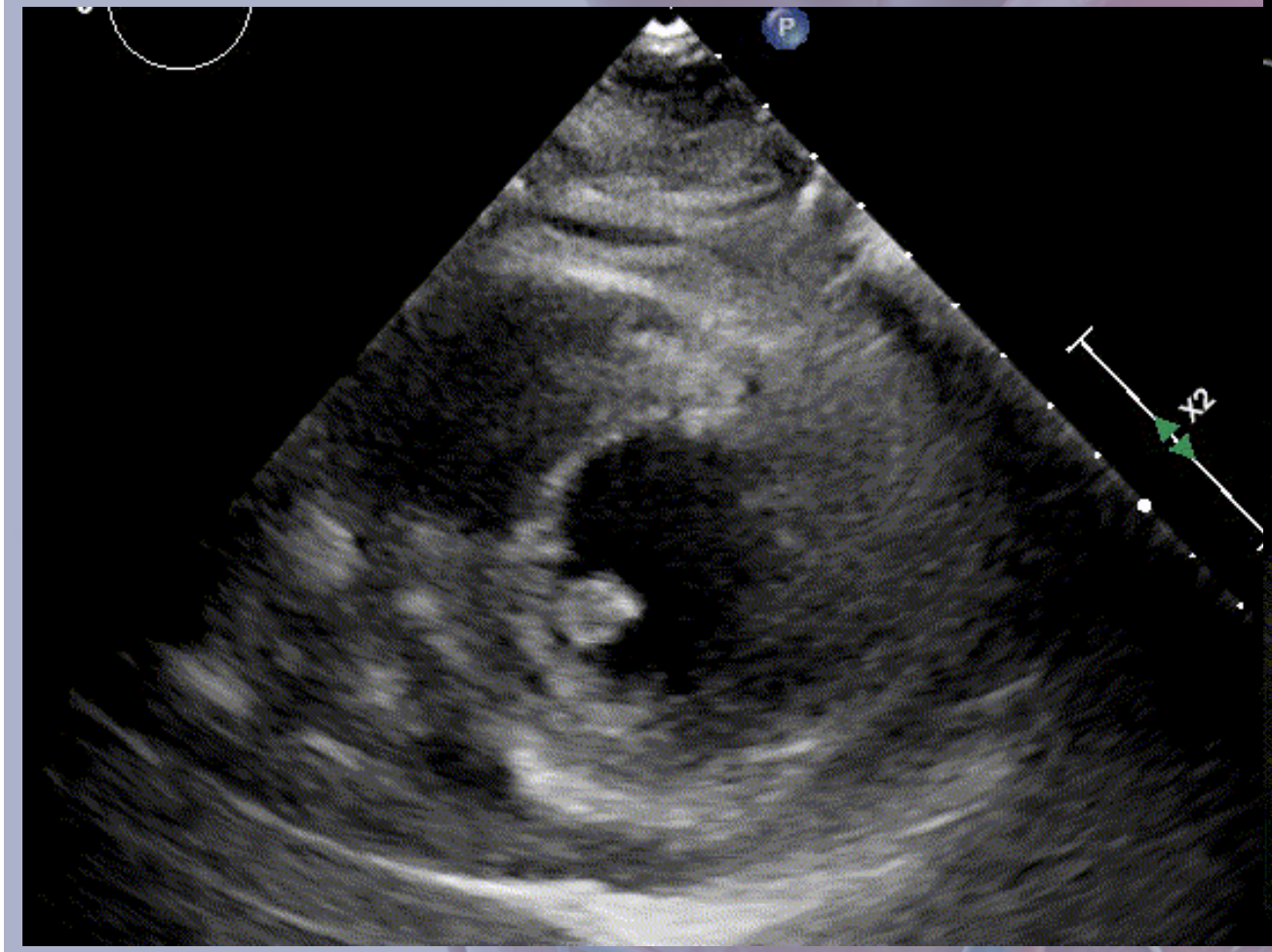


Parameters like IVC diameter and respiratory variation

Spontaneous breathing; small & highly collapsible IVC suggest low right atrial pressure and likely fluid responsiveness

Ventilated patients, IVC distensibility index is used.

Dynamic assessments of changes in SV or CO (ECHO: LVOT VTI &CSA) in response to passive leg raising/fluid bolus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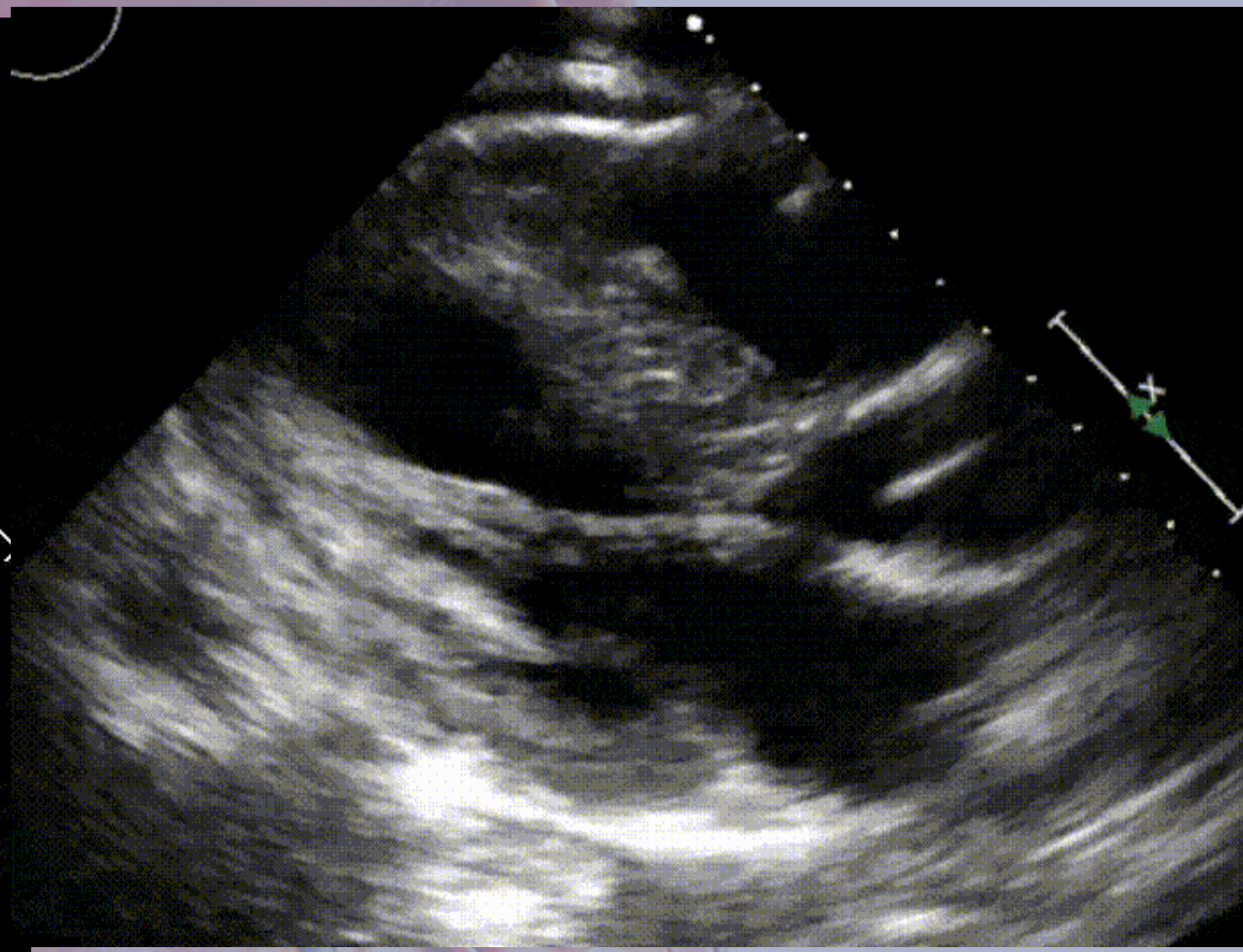
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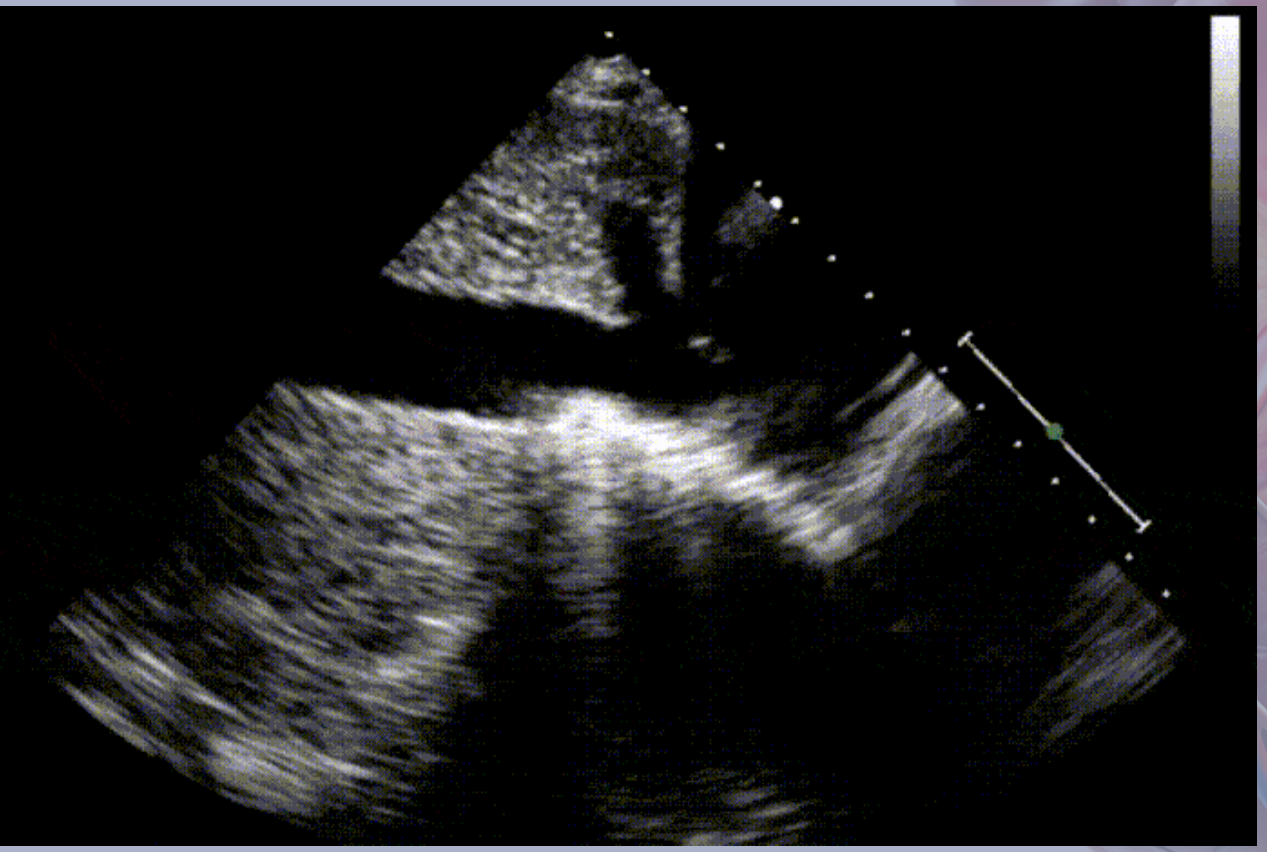
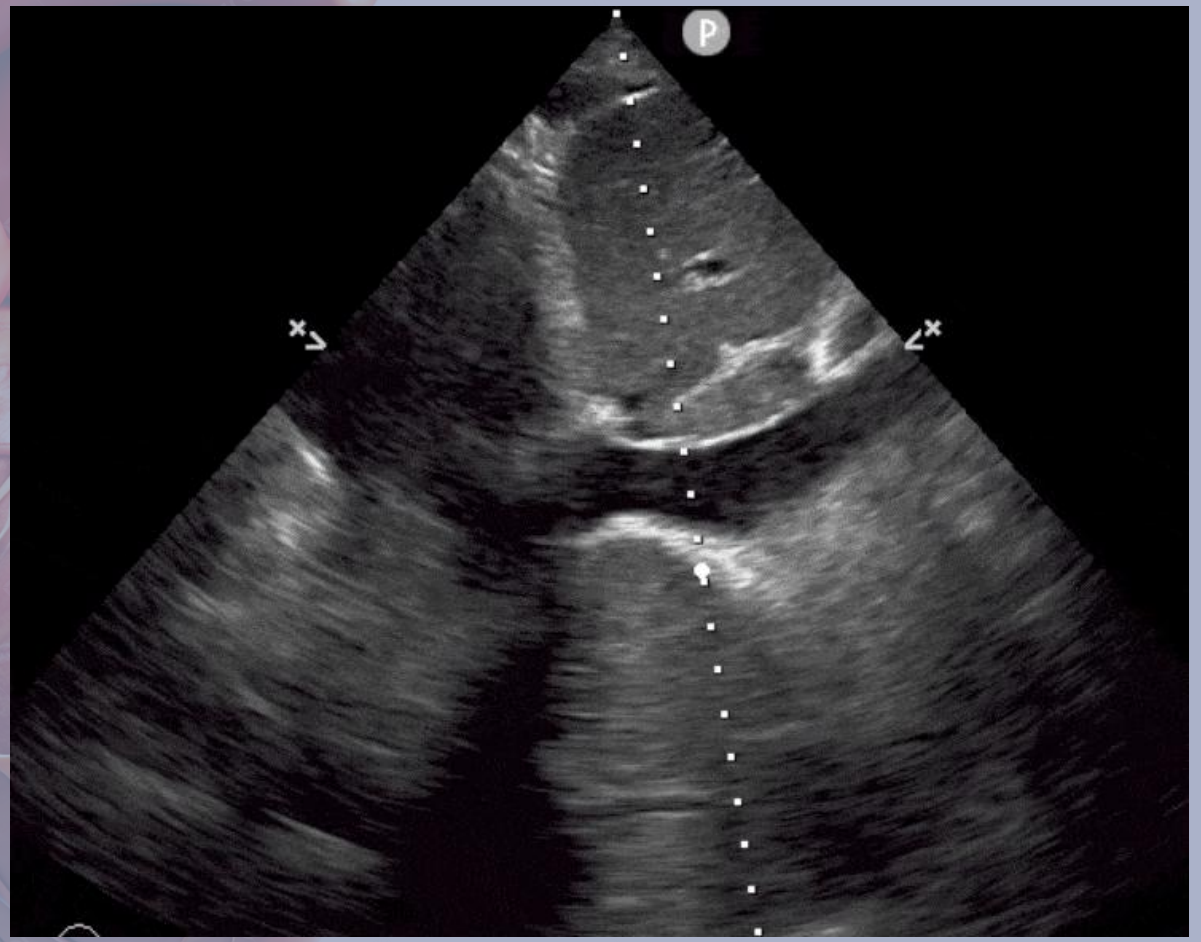
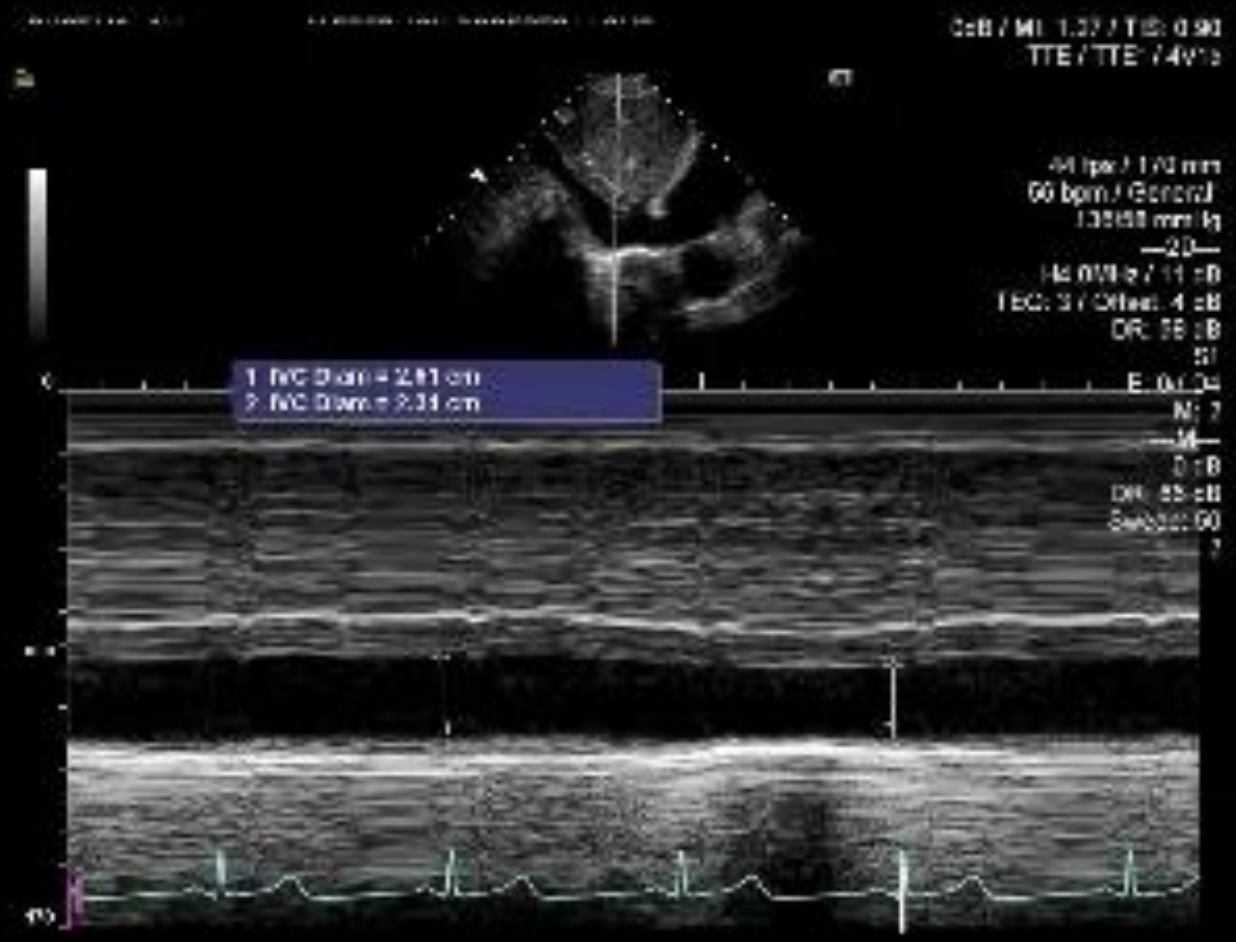
IVC





IVC distensibility index



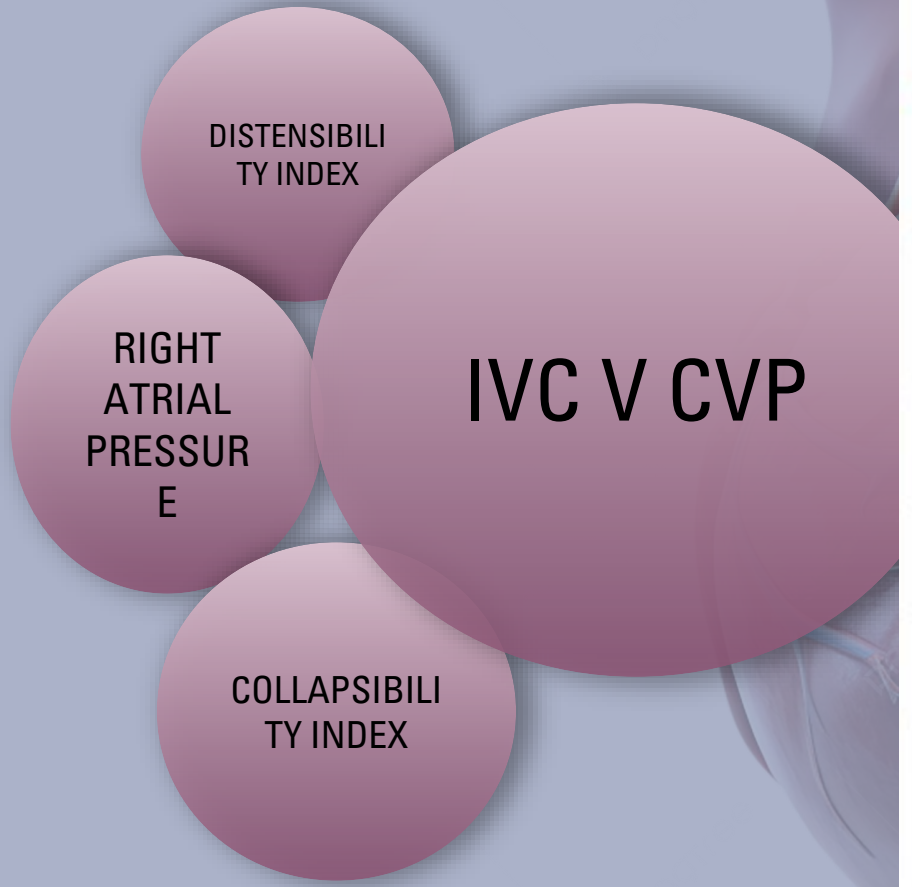
Change in IVC with positive pressure

> 18% significant

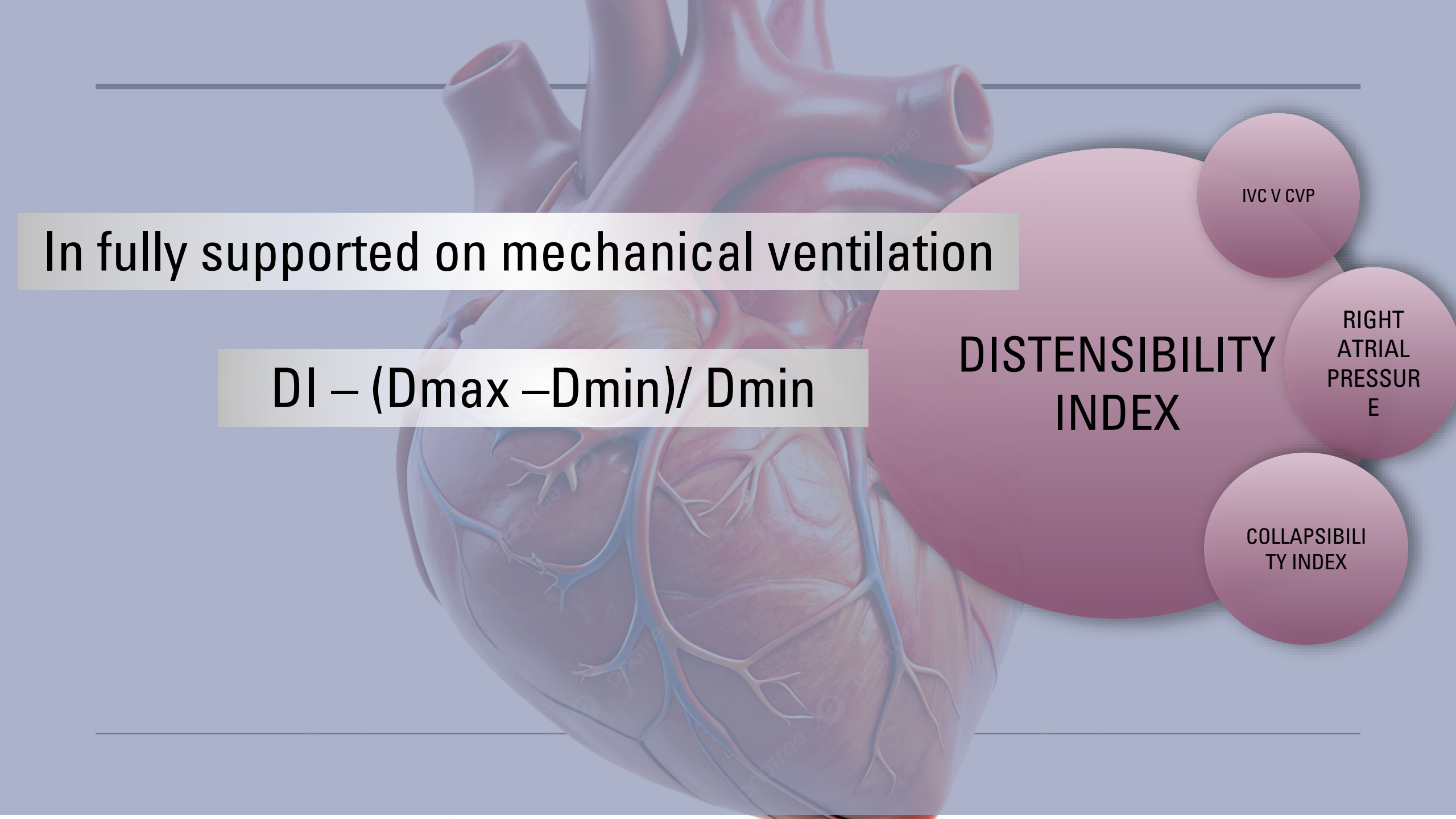
Sensitivity 90%
Specificity 100%

Max IVC D-min IVC D/ Mean IVC D

Feissel et al ICM 2004



Correlation Between IVC Diameter Plus CI and CVP		
IVC Max Diameter (cm)	**CI**	**CVP (mmHg)**
< 1.5	100% (total collapse)	0-5
1.5-2.5	> 50%	6-10
1.5-2.5	< 50%	11-15
> 2.5	< 50%	16-20
> 2.5	0% (no collapse)	>20


In fully supported on mechanical ventilation
DI – (Dmax –Dmin)/ Dmin
DISTENSIBILITY INDEX
IVC V CVP
RIGHT ATRIAL PRESSUR E
COLLAPSIBILI TY INDEX

In fully supported on mechanical ventilation

DI – (Dmax –Dmin)/ Dmin

DISTENSIBILITY INDEX

IVC V CVP

COLLAPSIBILITY INDEX

RIGHT ATRIAL PRESSUR E

In spontaneously breathing patient

CI = (Dmax- Dmin) / Dmax – 100%

DISTENSIBILITY INDEX

RIGHT ATRIAL PRESSURE

IVC V CVP

COLLAPSIBILITY INDEX

Ultrasonographic Indices for estimation of right atrial pressure (RAP)

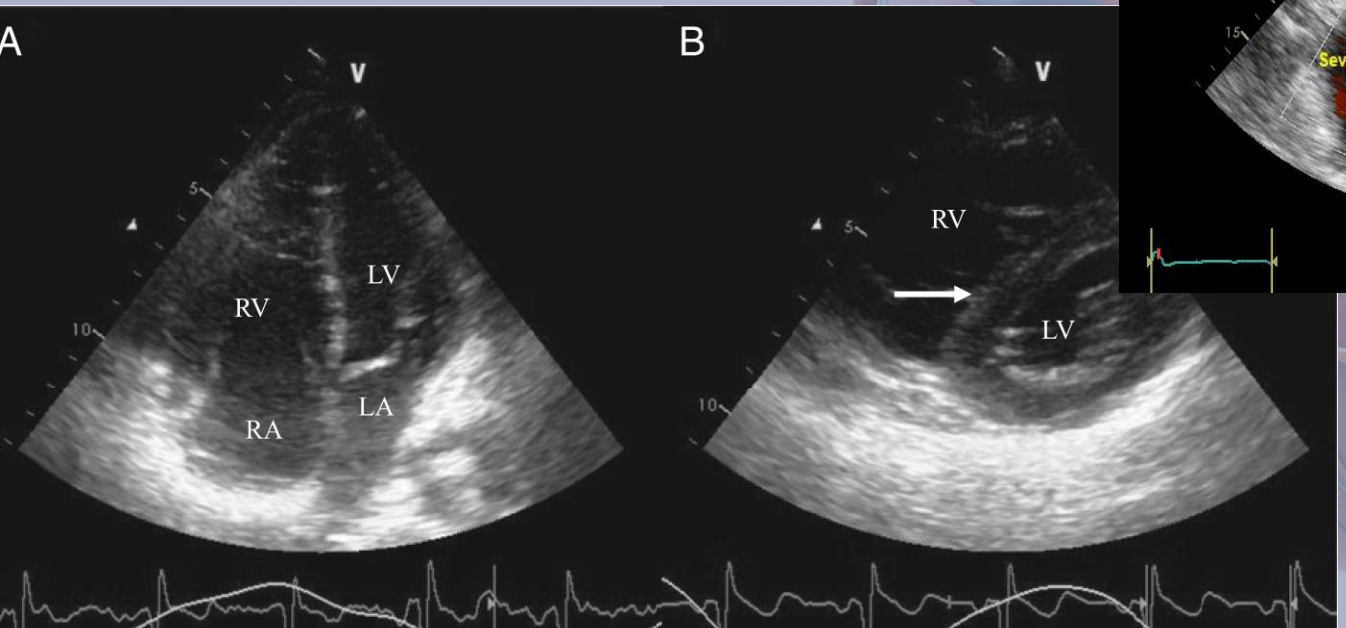
Variables	Normal 0-5mmHg (3mmHg)	Intermediate 5-10mmHg (8mmHg)		High 10-20 mmHg (15mmHg)
☐ IVC diameter (cm)	≤ 2.1	≤ 2.1	> 2.1	> 2.1
☐ Collapse with sniff (%)	>50	<50	>50	<50
☐ Secondary indices of ↑RAP				- RAE - RVH - Hepatic vein Flow S/D<1 - Tricuspid E/e' >6 - Restrictive filling - Other indices*

These indices yield more accurate results when estimating low or high RAP. The guidelines recommend using mid-range values of (3 mmHg) for normal and (8 mmHg) for intermediate RAP. Intermediate RAP may be downgraded to normal if no secondary indices of elevated RAP are present, or upgraded to high if minimal collapse with sniff (<35 %) and secondary indices of elevated RAP are present, or left at 8 mmHg if uncertain.

*Other indices of increased RAP on Doppler evaluation are non-continious portal vein, non-continious renal paranchymal vein flow, renal artery resistive index (RI) ≥ 0.80.

RAE, right atrial enlragement; RVH, right ventricle hypertrophy;

ARDS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RV
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RA
B
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RV
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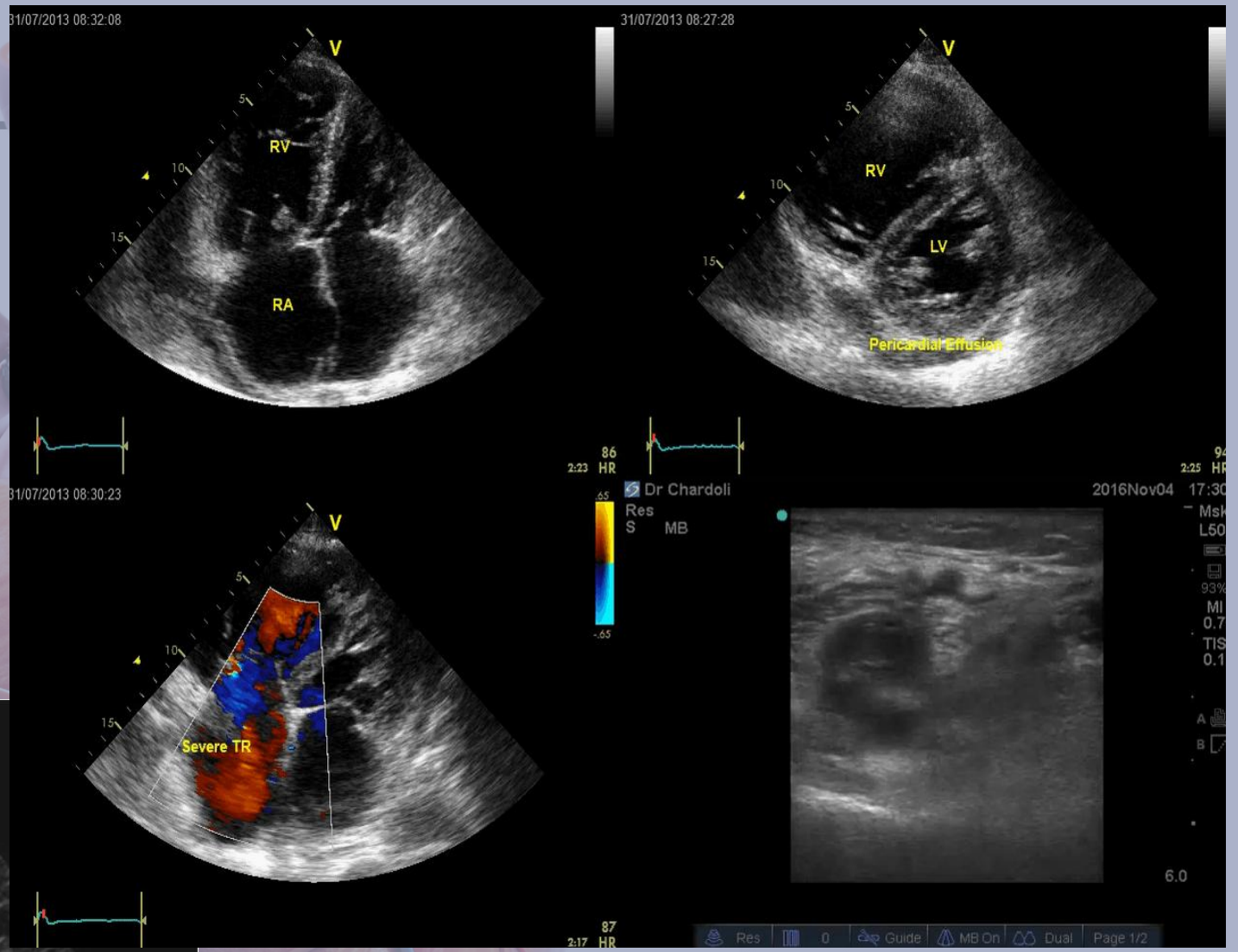
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RV
RA
31/07/2013 08:27:28
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LV
Pericardial Effusion
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Severe TR
Dr Chardoli
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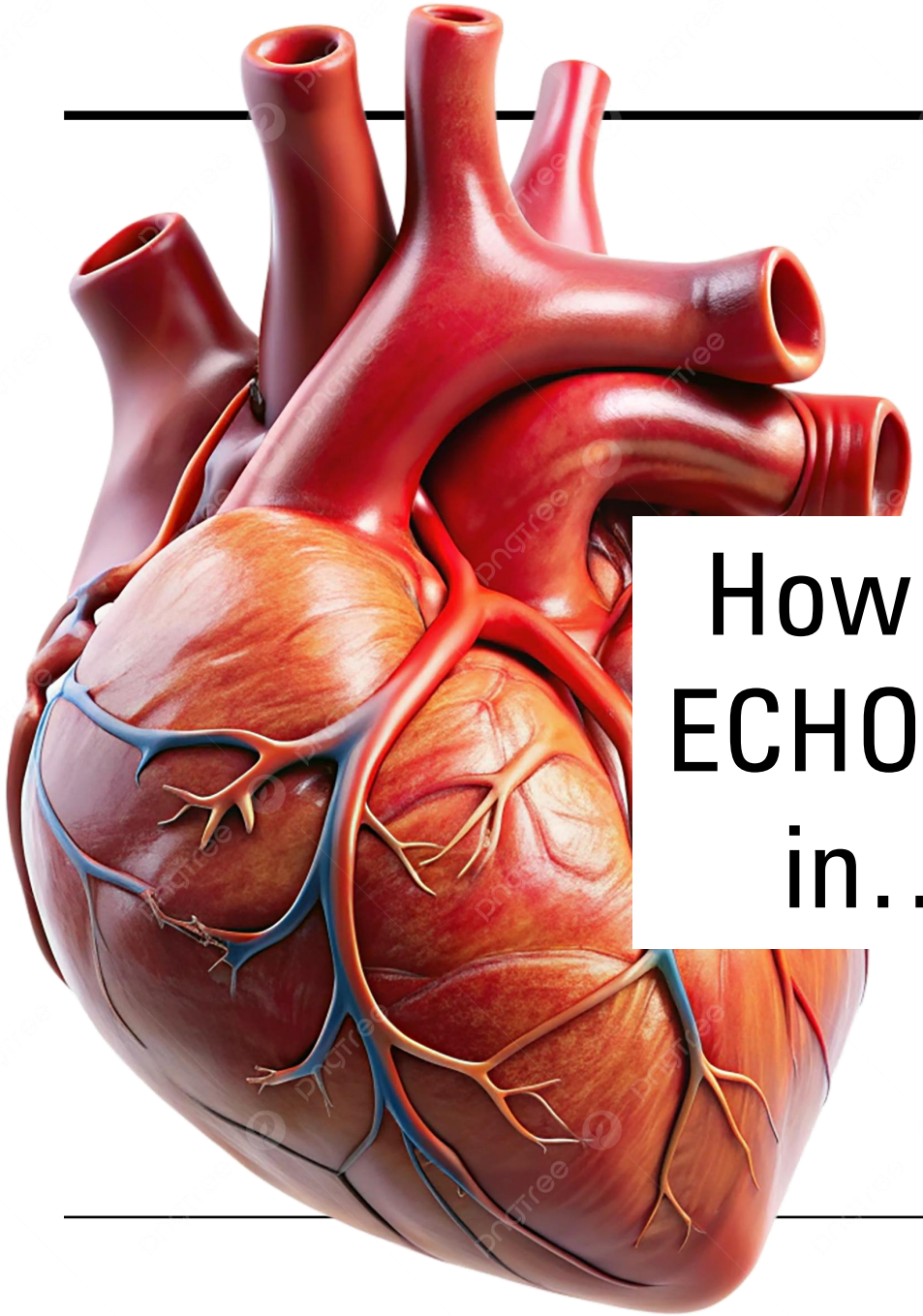
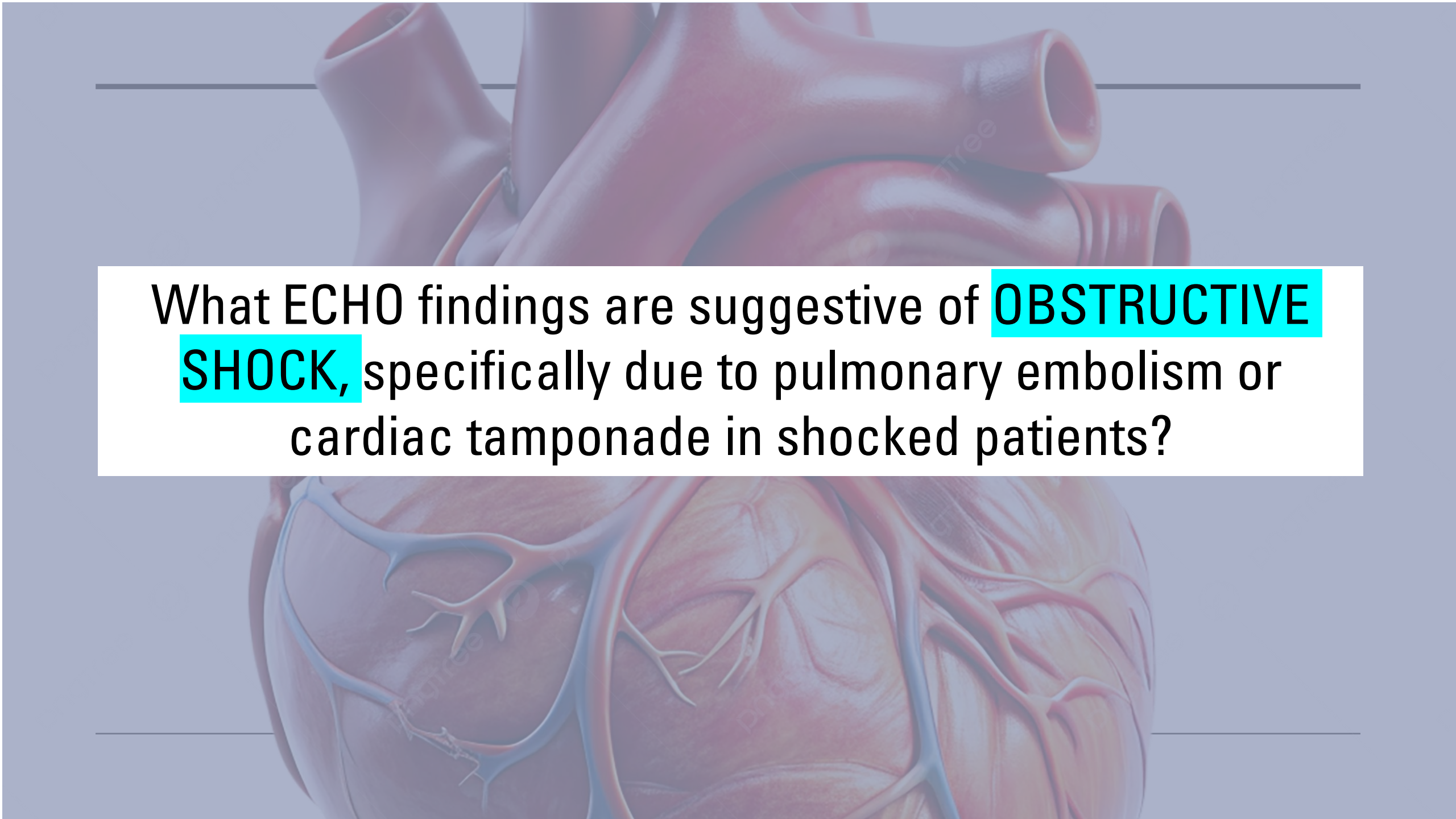
Dual
Page 1/2

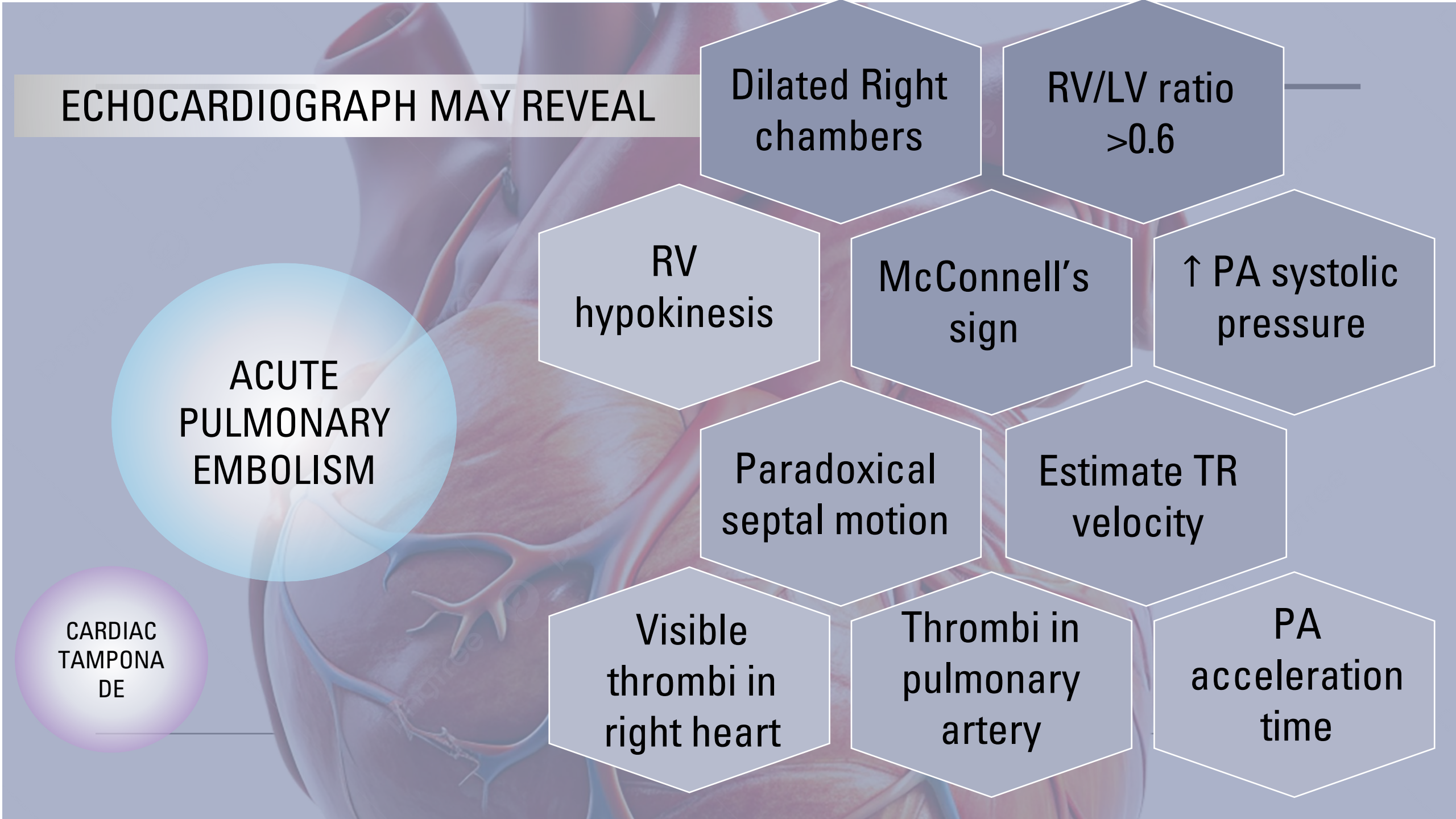


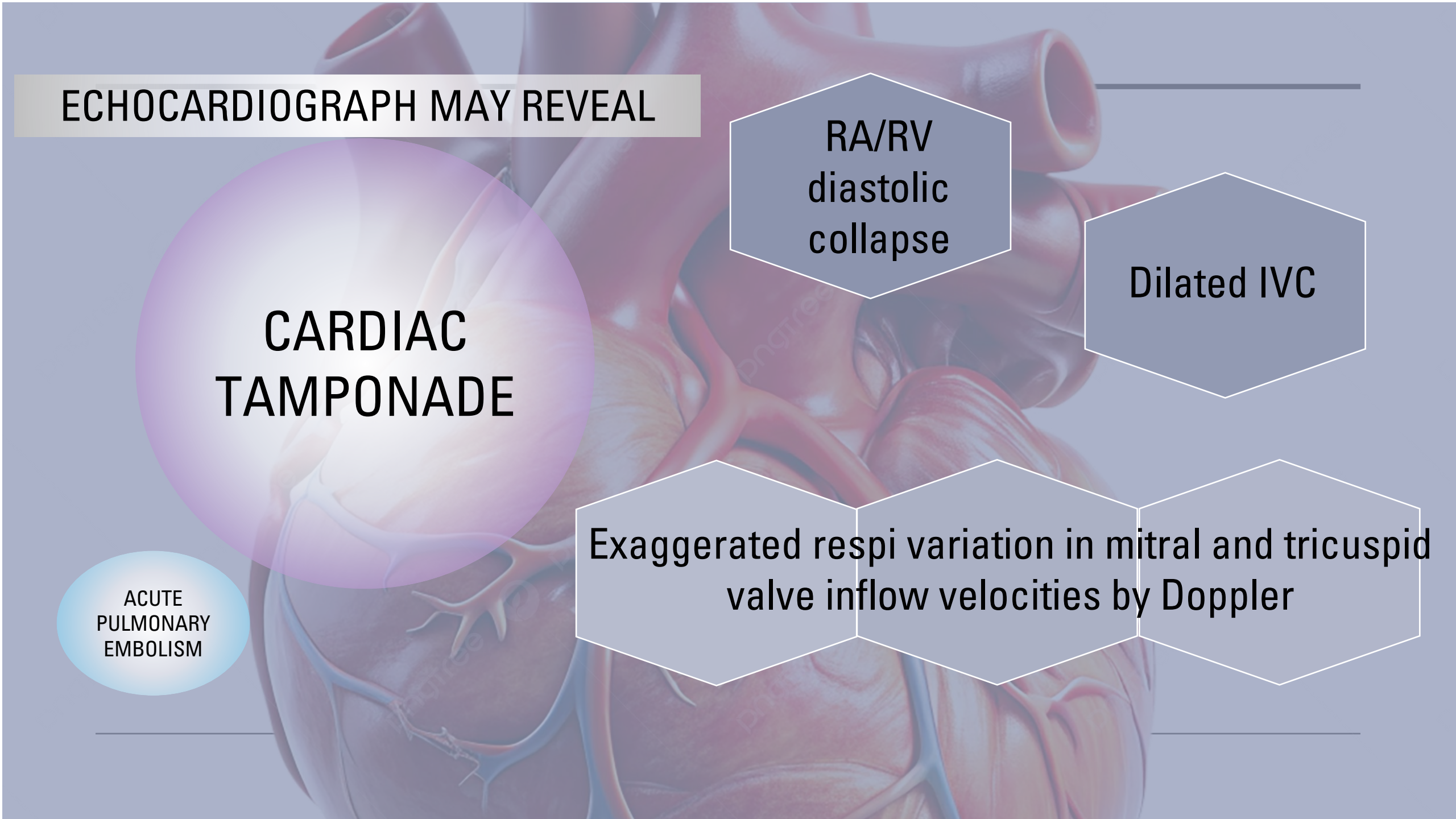
How does ECHO helps in…..?

- Role in sepsis?
- Types of shock
- Traumatic valvular
- Predict fluid responsiveness
- Obstructive shock



What ECHO findings are suggestive of OBSTRUCTIVE SHOCK, specifically due to pulmonary embolism or cardiac tamponade in shocked patients?


ECHOCARDIOGRAPH MAY REVEAL
Dilated Right chambers
RV/LV ratio >0.6
RV hypokinesis
McConnell's sign
↑ PA systolic pressure
ACUTE PULMONARY EMBOLISM
Paradoxical septal motion
Estimate TR velocity
CARDIAC TAMPONA DE
Visible thrombi in right heart
Thrombi in pulmonary artery
PA acceleration time



ECHOCARDIOGRAPH MAY REVEAL

CARDIAC TAMPONADE

RA/RV diastolic collapse

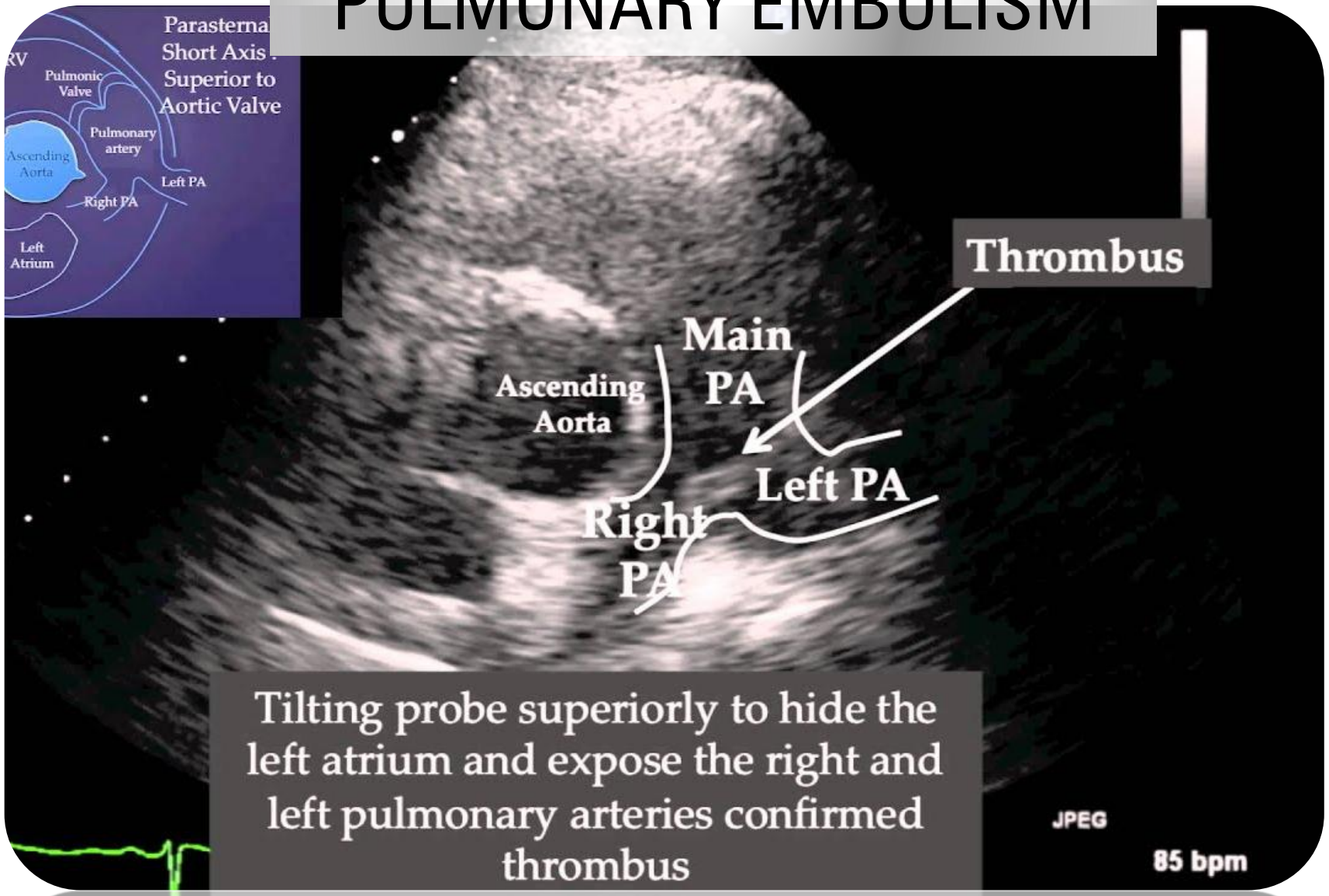
Dilated IVC

Exaggerated respi variation in mitral and tricuspid valve inflow velocities by Doppler

ACUTE PULMONARY EMBOLISM

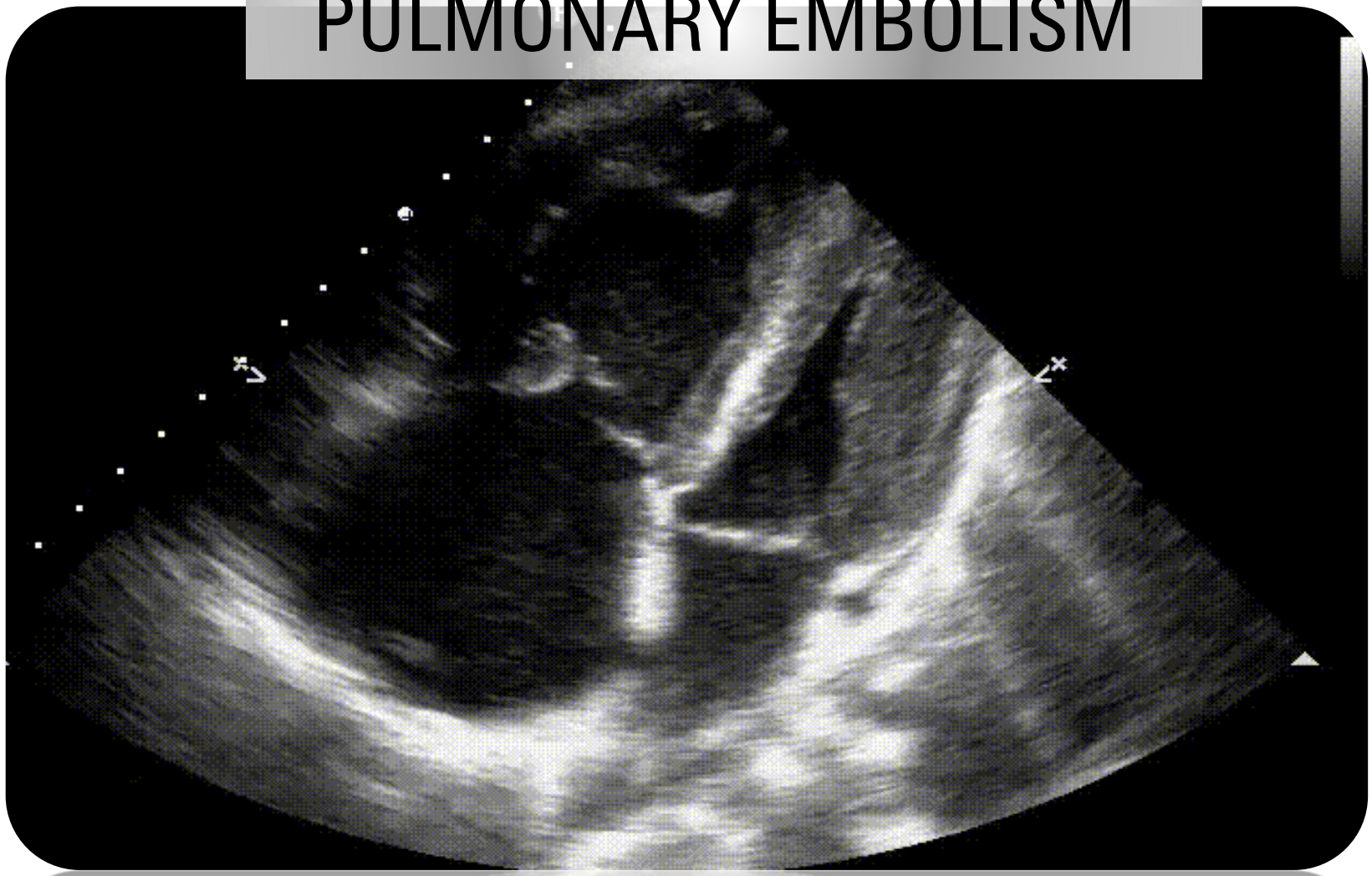
PULMONARY EMBOLISM

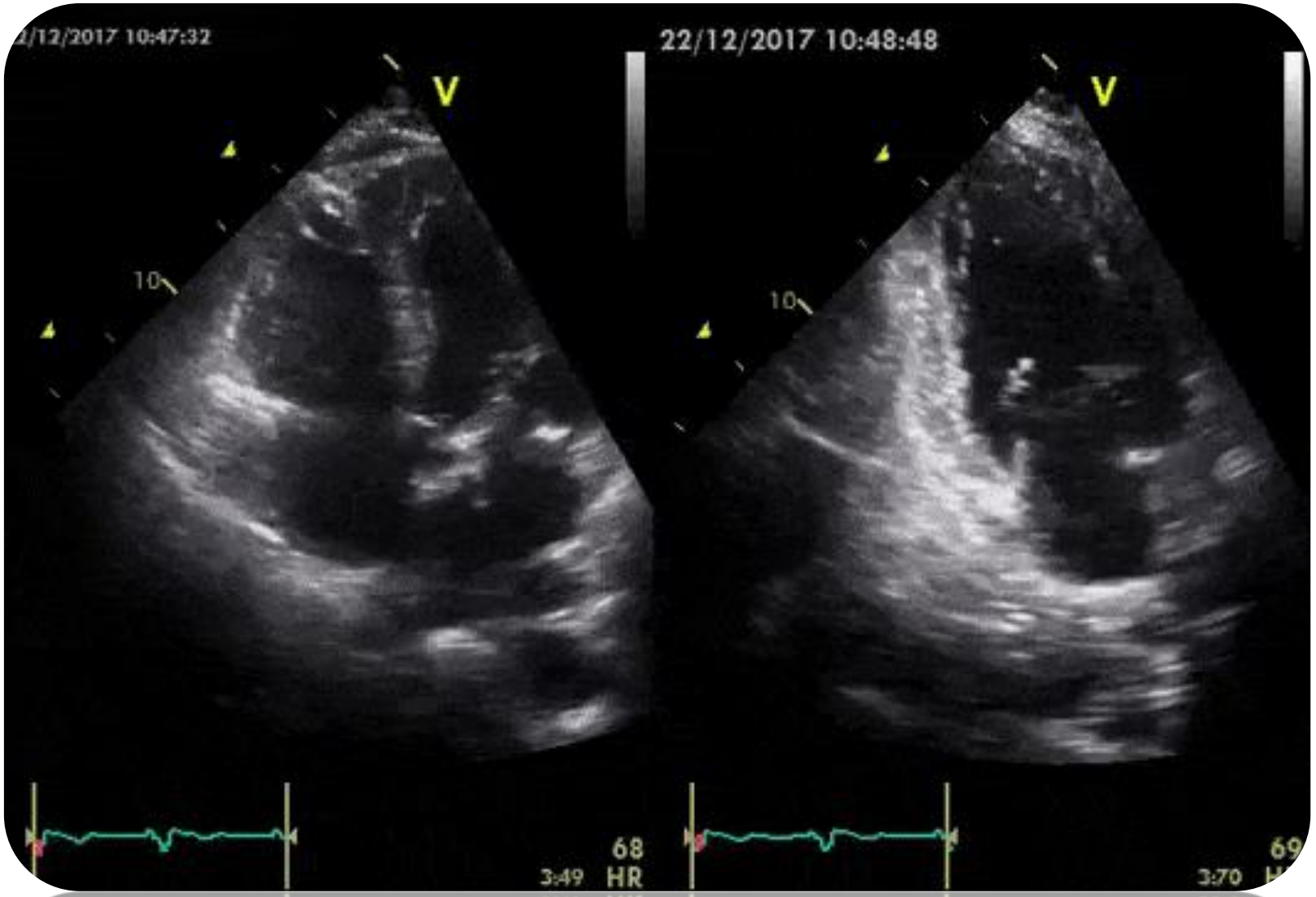
PULMONARY EMBOLISM



Tilting probe superiorly to hide the left atrium and expose the right and left pulmonary arteries confirmed thrombus

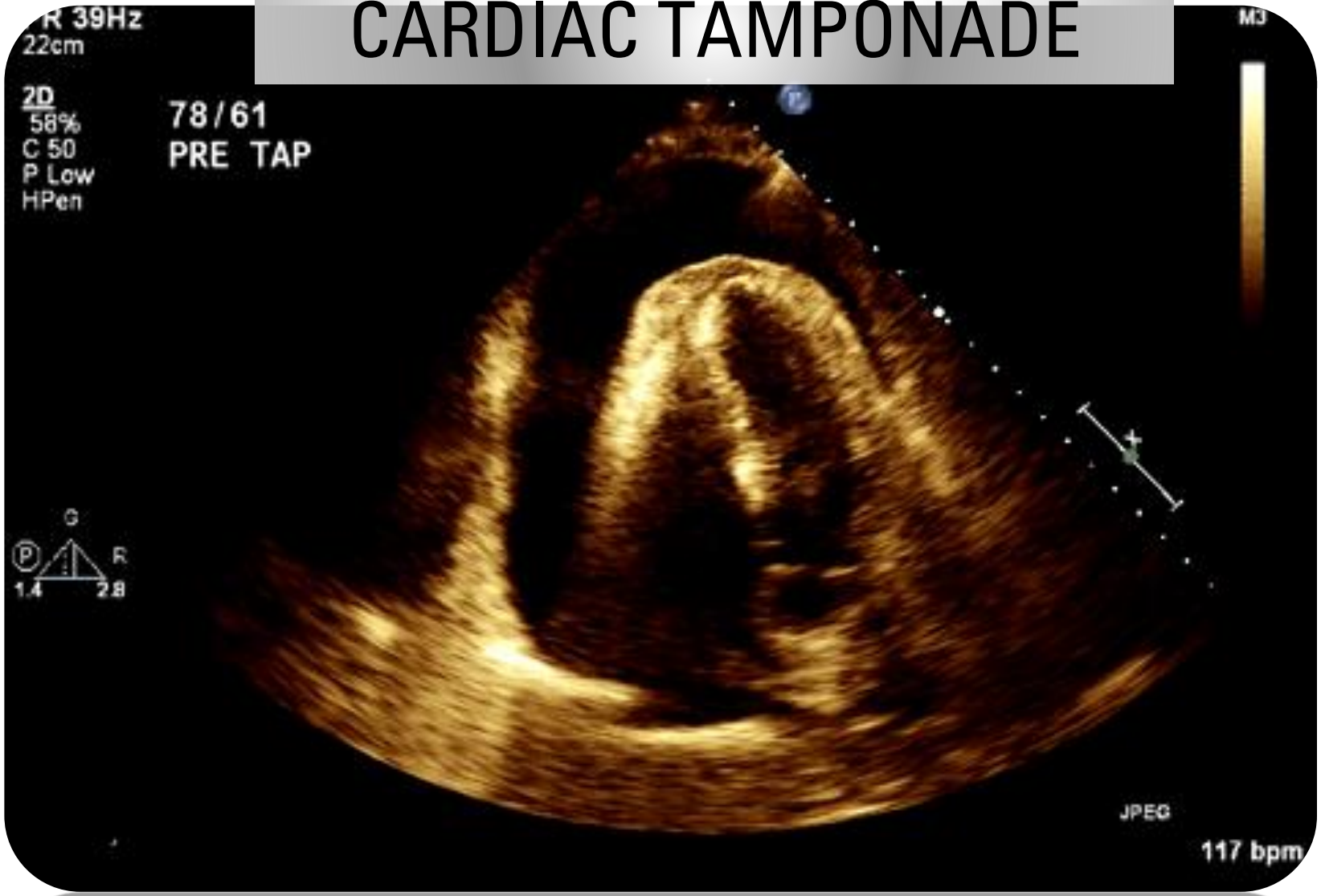
PULMONARY EMBOLISM



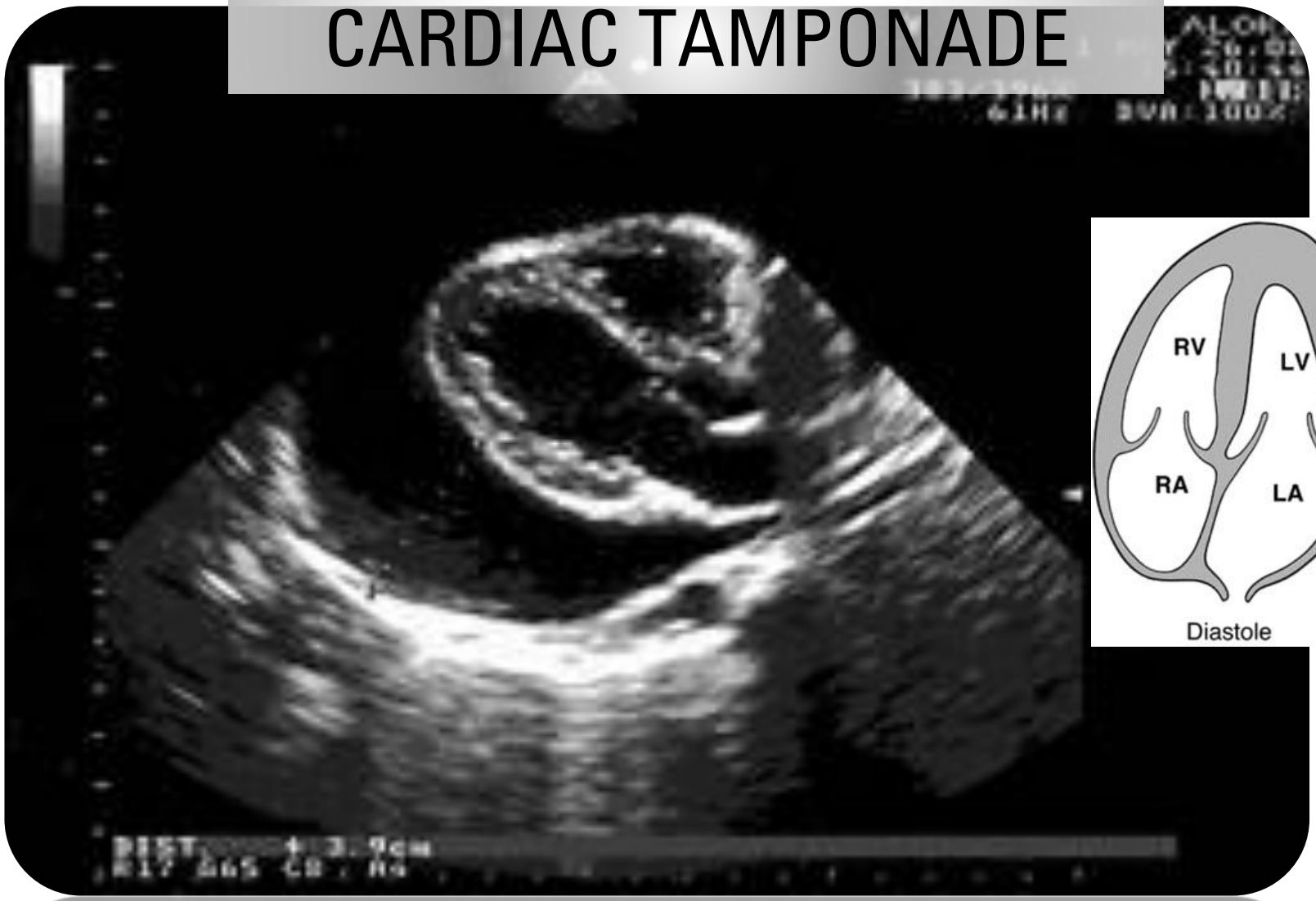

22/12/2017 10:48:48
V
10
68
3:49 HR

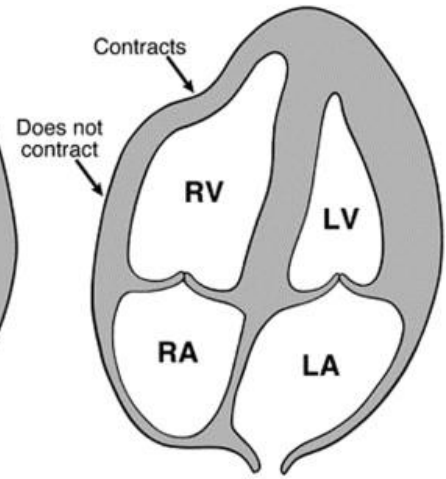

FR 39
22cm
2D
58%
C 50
P Low
HPen

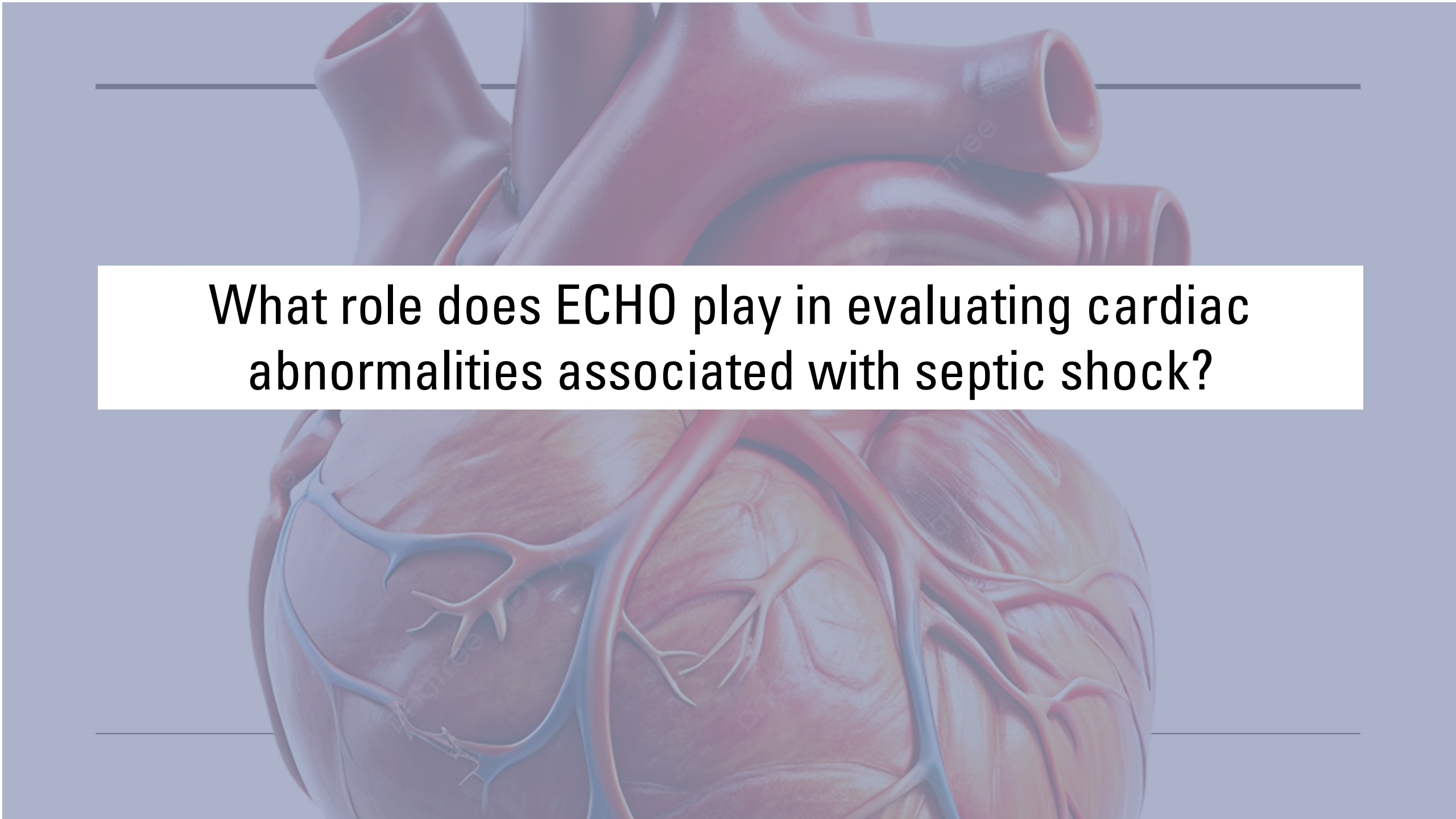
CARDIAC TAMPONADE



CARDIAC TAMPONADE



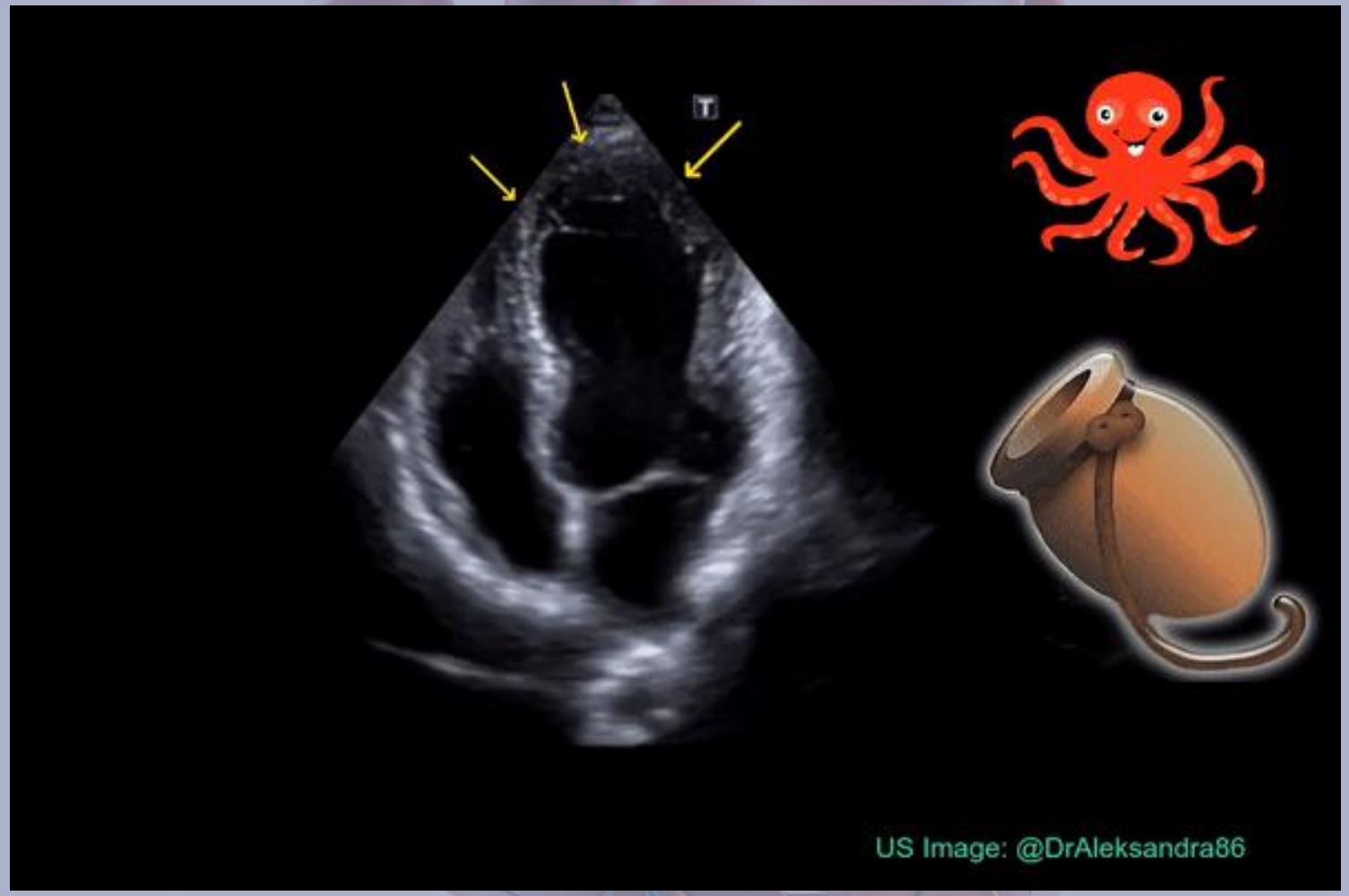


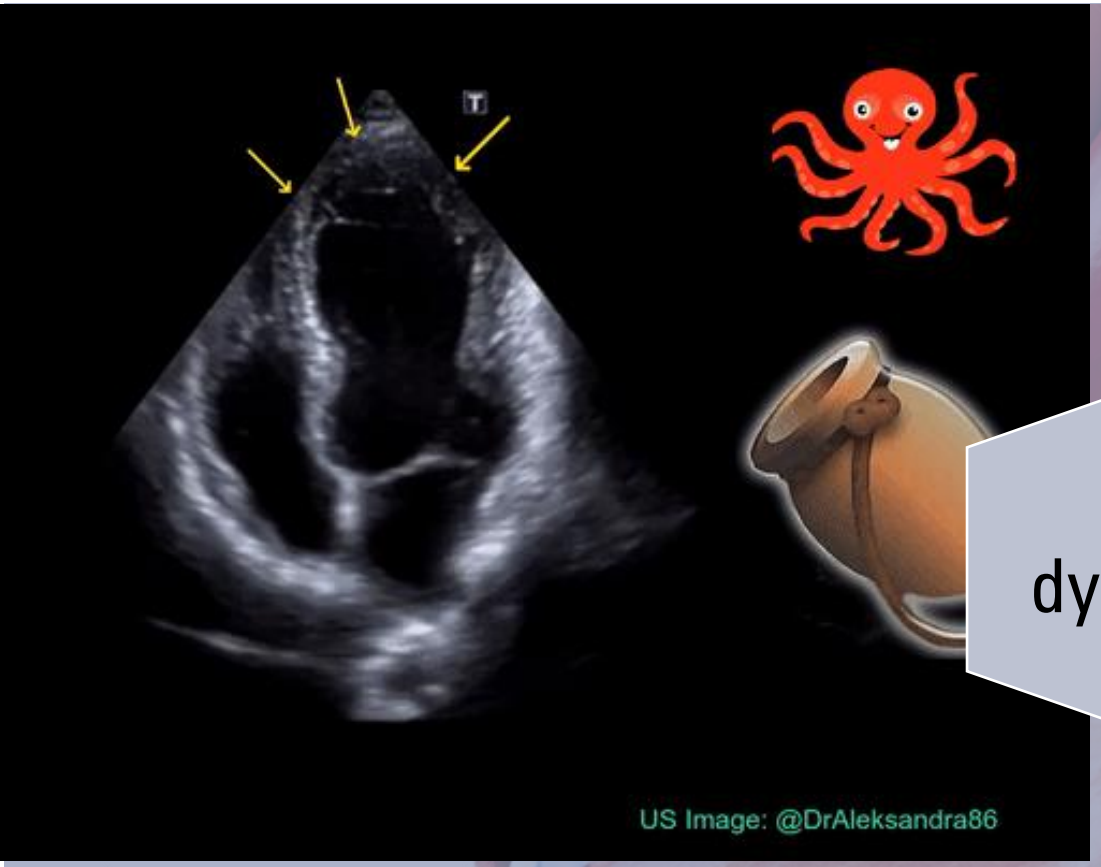


What role does ECHO play in evaluating cardiac abnormalities associated with septic shock?

SEPTIC SHOCK

SEPTIC SHOCK





SEPTIC SHOCK

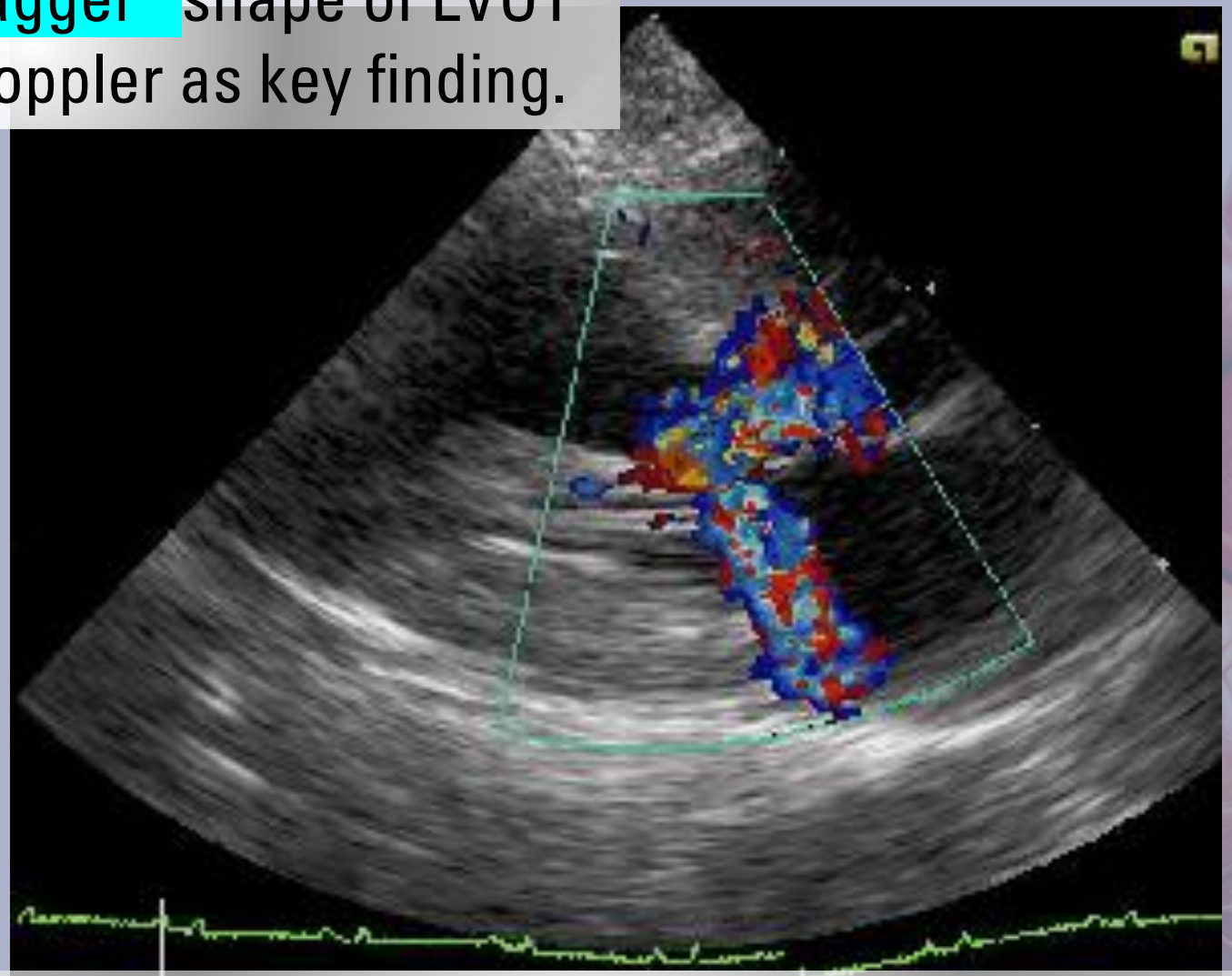
- LV systolic and diastolic dysfunction
- Global or regional dysfunction
- RV dysfunction
- LVOT obstruction
- Takotsubo syndrome
- Hyperdynamic heart
- Well-filled LV as indirect evidence
- TEE evaluate valvular function
- Detecting endocarditis
- Peri-valvular abscesses

LVOT obstruction

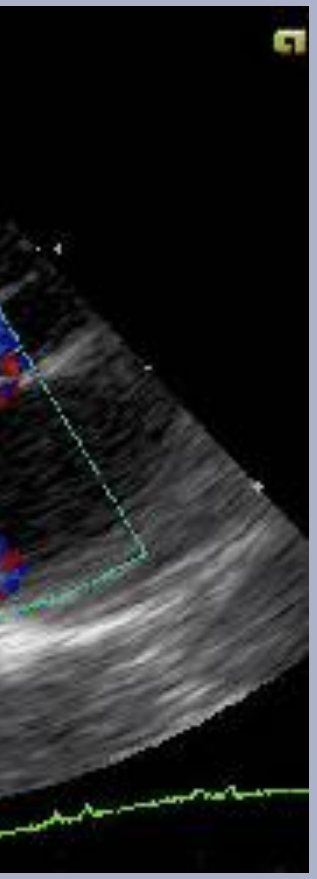
How can ECHO detect DYNAMIC left ventricular outflow tract (LVOT) OBSTRUCTION in critically ill patients?

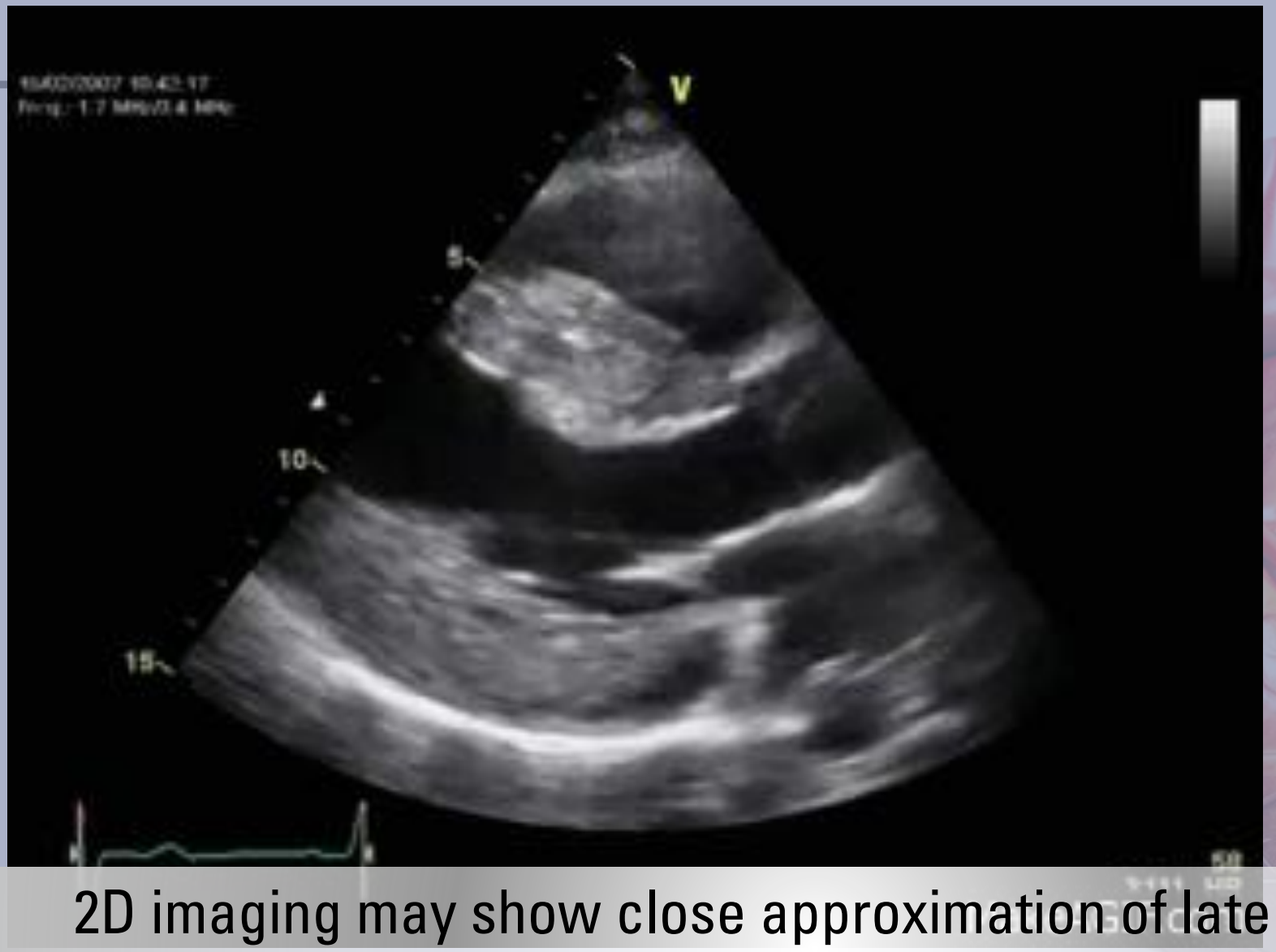
Dynamic LVOT obstruction often underrecognized, can be identified using advanced echocardiography with Doppler.

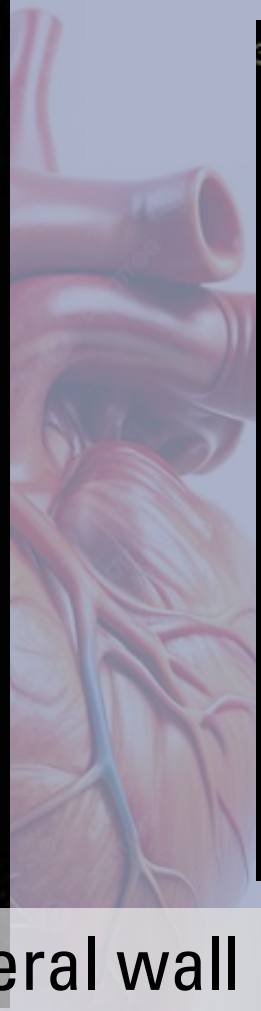
Characteristic “dragger” shape of LVOT flow on spectral Doppler as key finding.

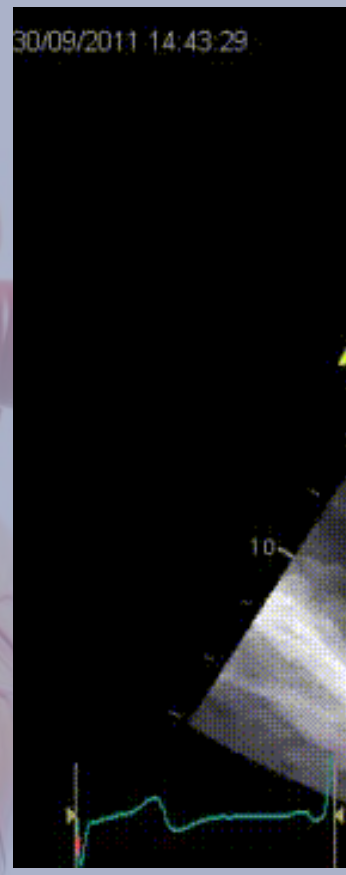


Colour doppler reveals turbulent flow in LVOT, while continuous-wave Doppler detects high velocities indicative of obstruction, and pulsed wave Doppler pinpoints the location.

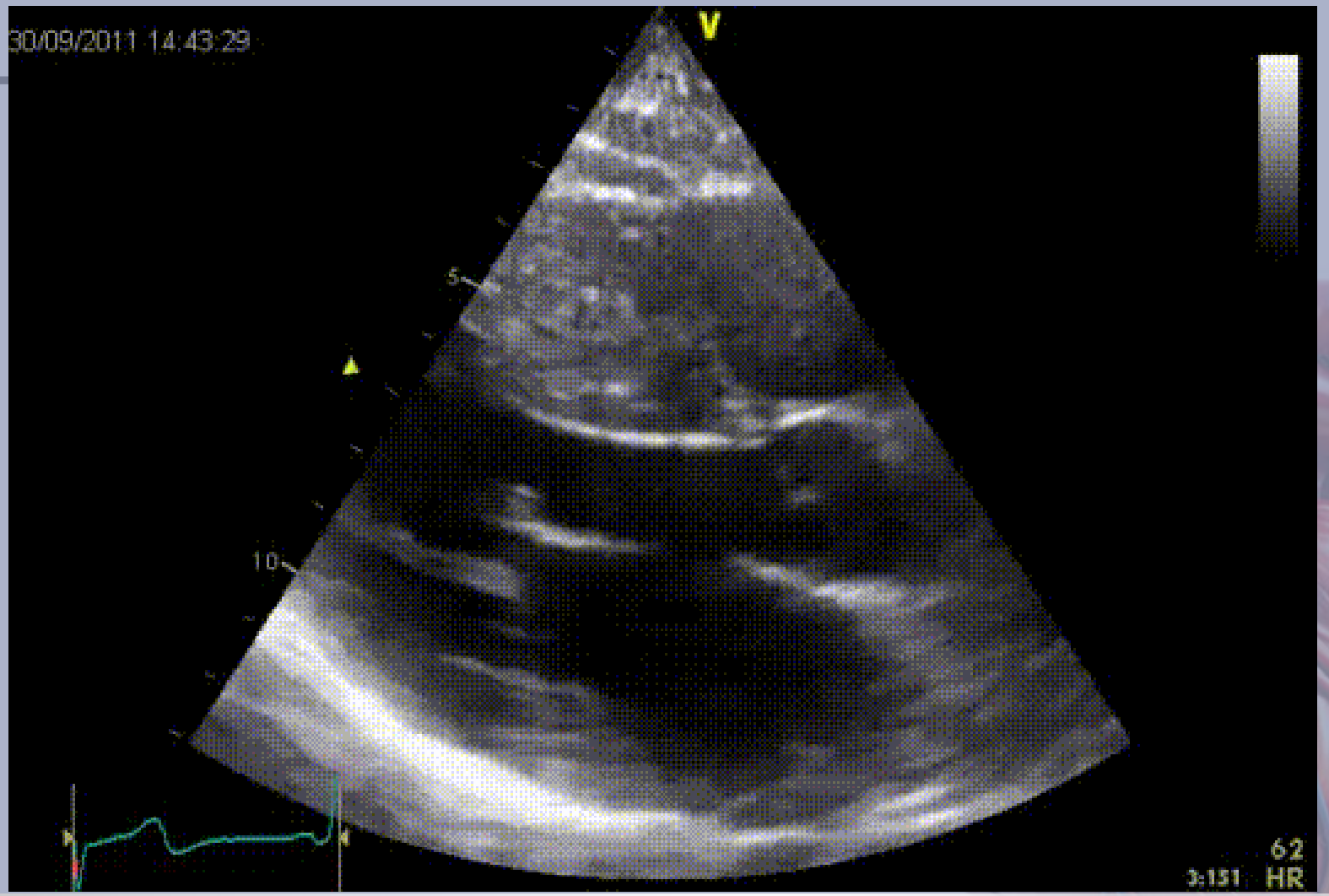






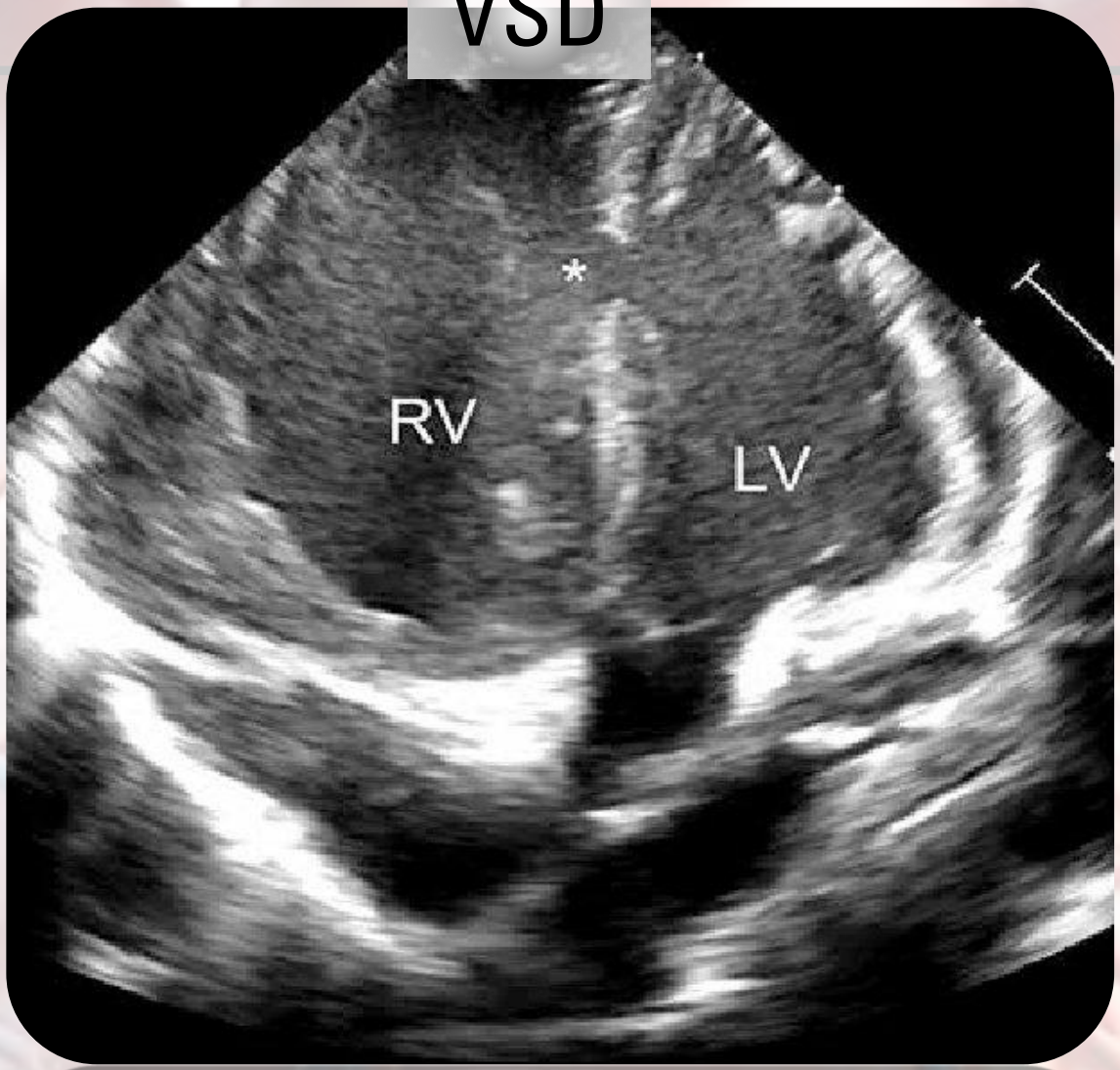


2D imaging may show close approximation of lateral wall and septum, along with systolic anterior motion of anterior mitral leaflet.



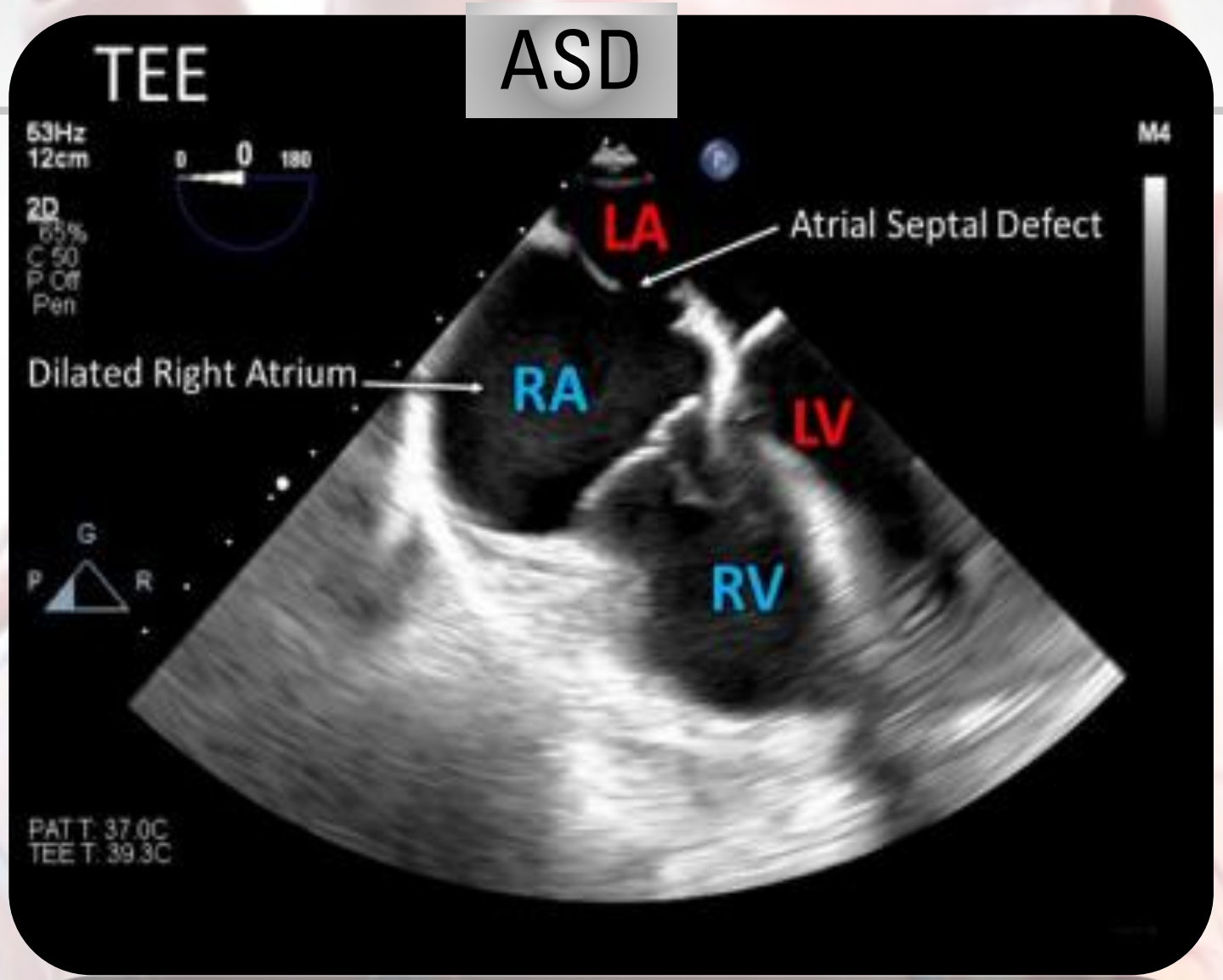
2D imaging may show close approximation of lateral wall and septum, along with systolic anterior motion of anterior mitral leaflet.

VSD

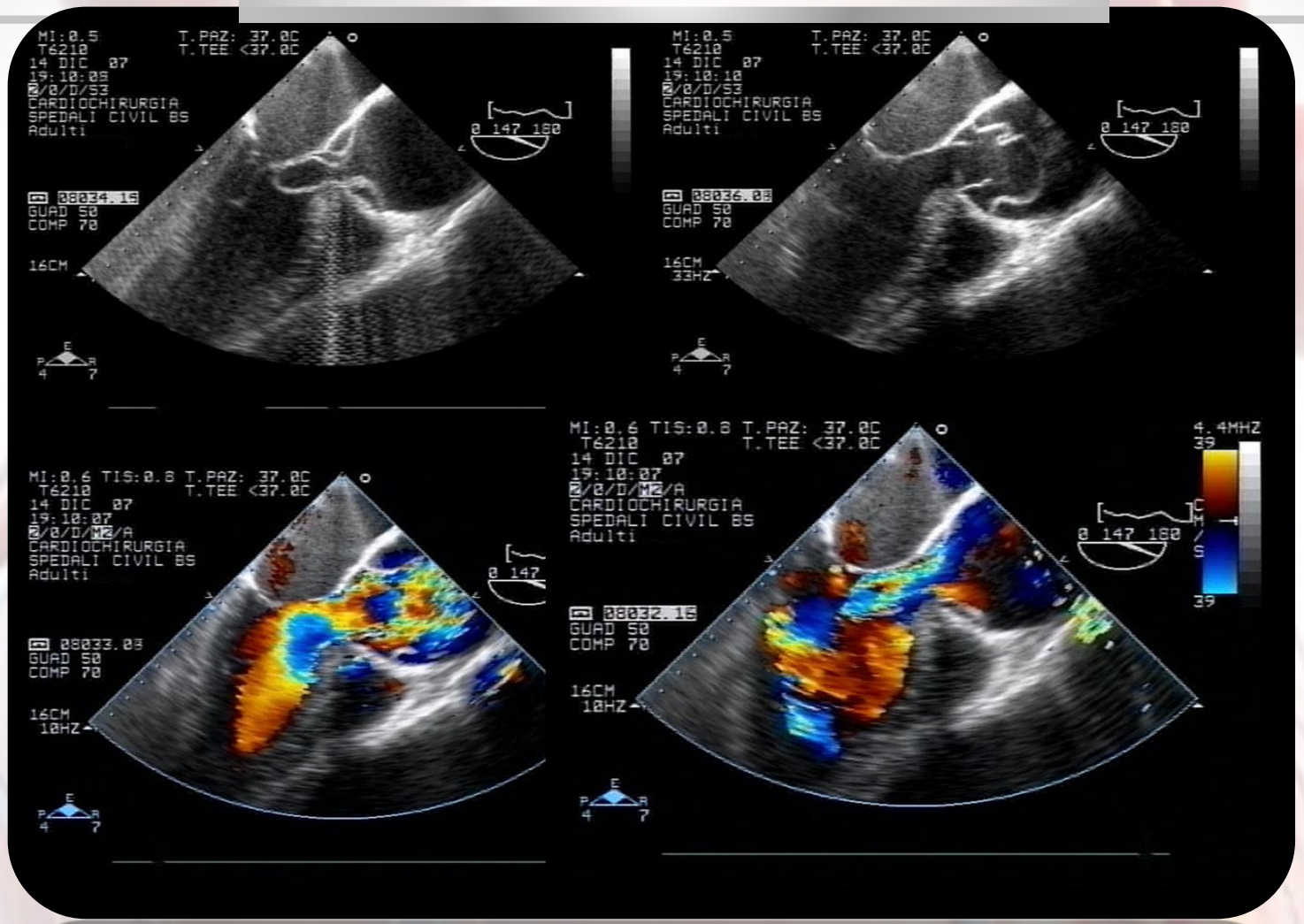

*
RV
LV


TEE
53Hz
12cm
0
0
180
2D
68%
C 50
P Off
Pen
Dilated Right Atrium
G
P
R
PAT T: 37.0C
TEE T: 39.3C

ASD

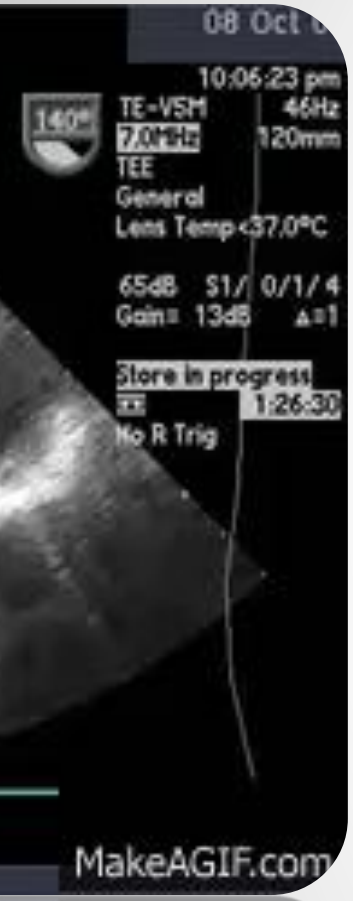

TEE
53Hz
12cm
2D
65%
C 50
P Off
Pen
M4
LA
Atrial Septal Defect
Dilated Right Atrium
RA
LV
RV
G
P
R
PAT T. 37.0C
TEE T. 39.3C

AORTIC DISSECTION



AORTIC DISSECTION

LA MYXOMA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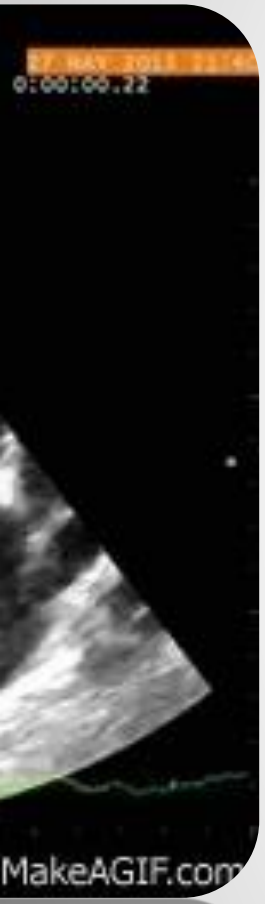
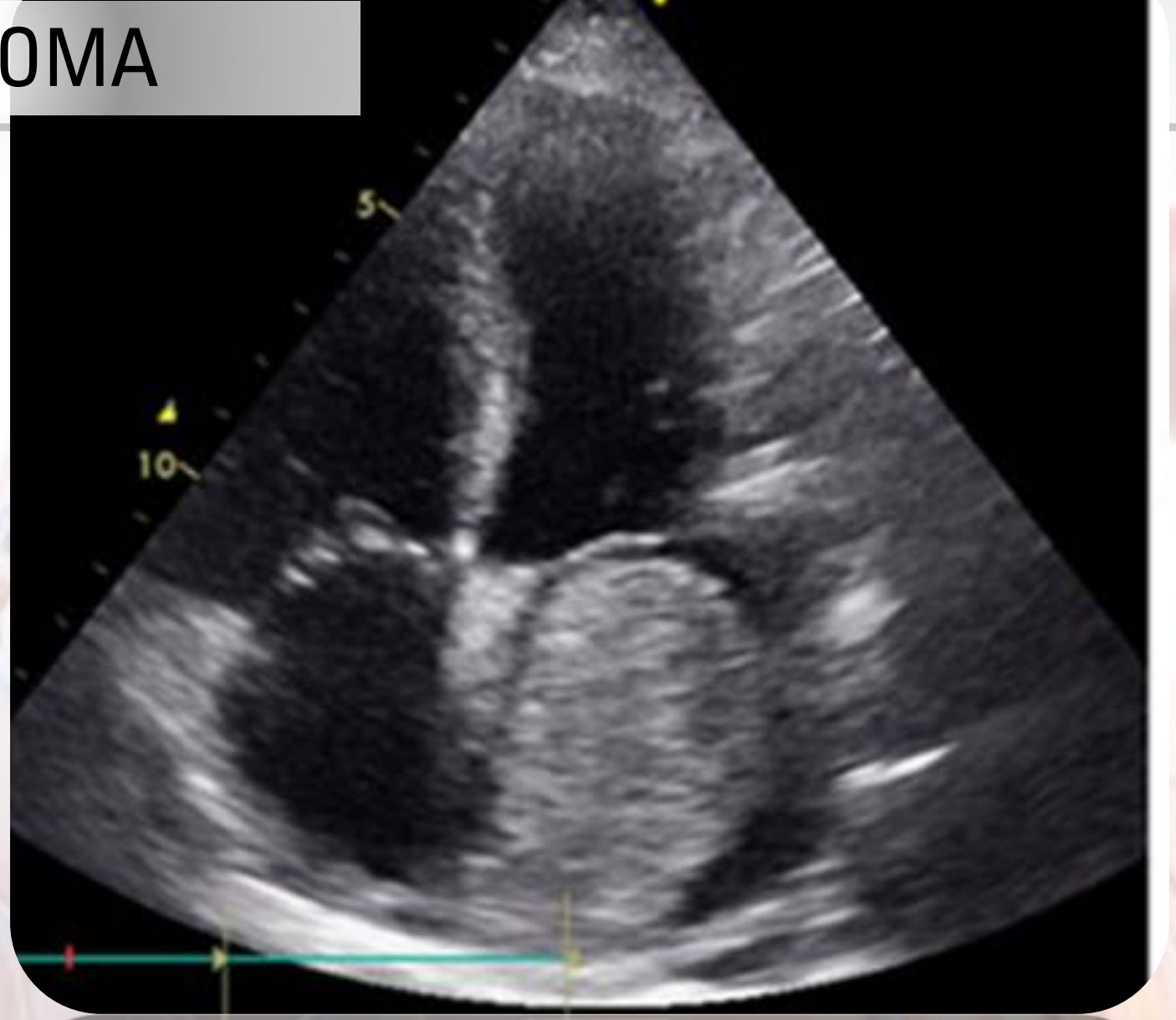
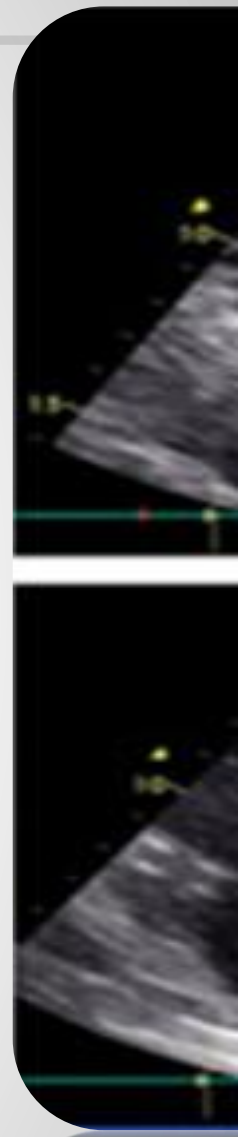
TE-V5M
46Hz
7.0MHz
120mm
TEE
General
Lens Temp<37.0°C
65dB S1/ 0/1/4
Gain= 13dB
Store in progress
1:26:30
No R Trig
MakeAGIF.com


CARDIAC1 PA210
MakeAGIF.com

LA MYXOMA







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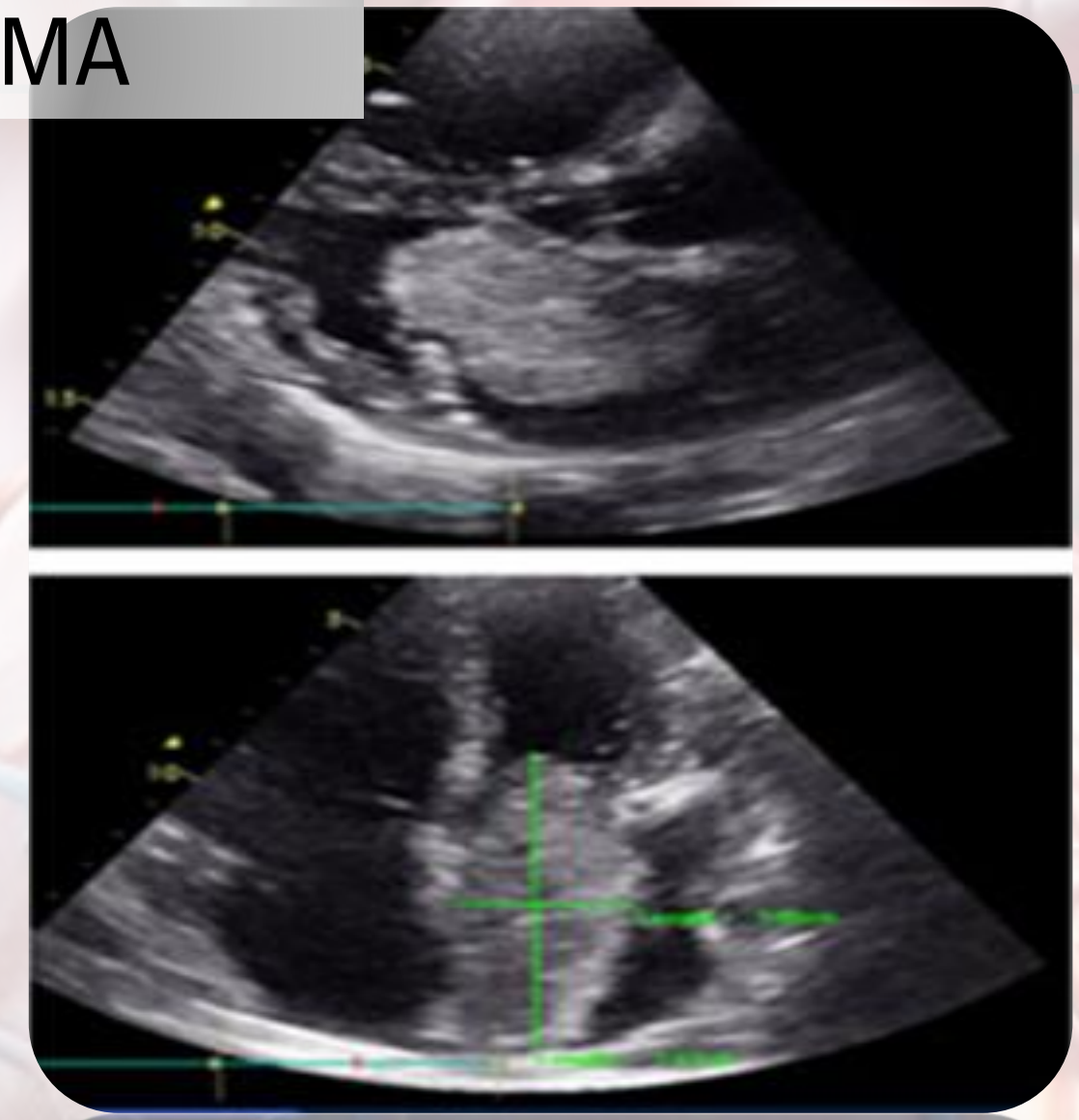
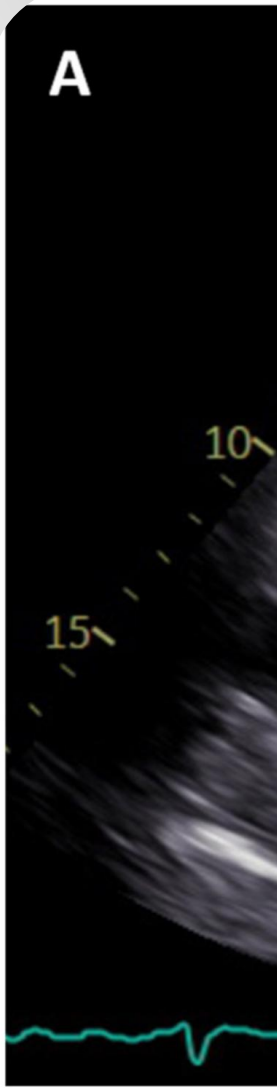
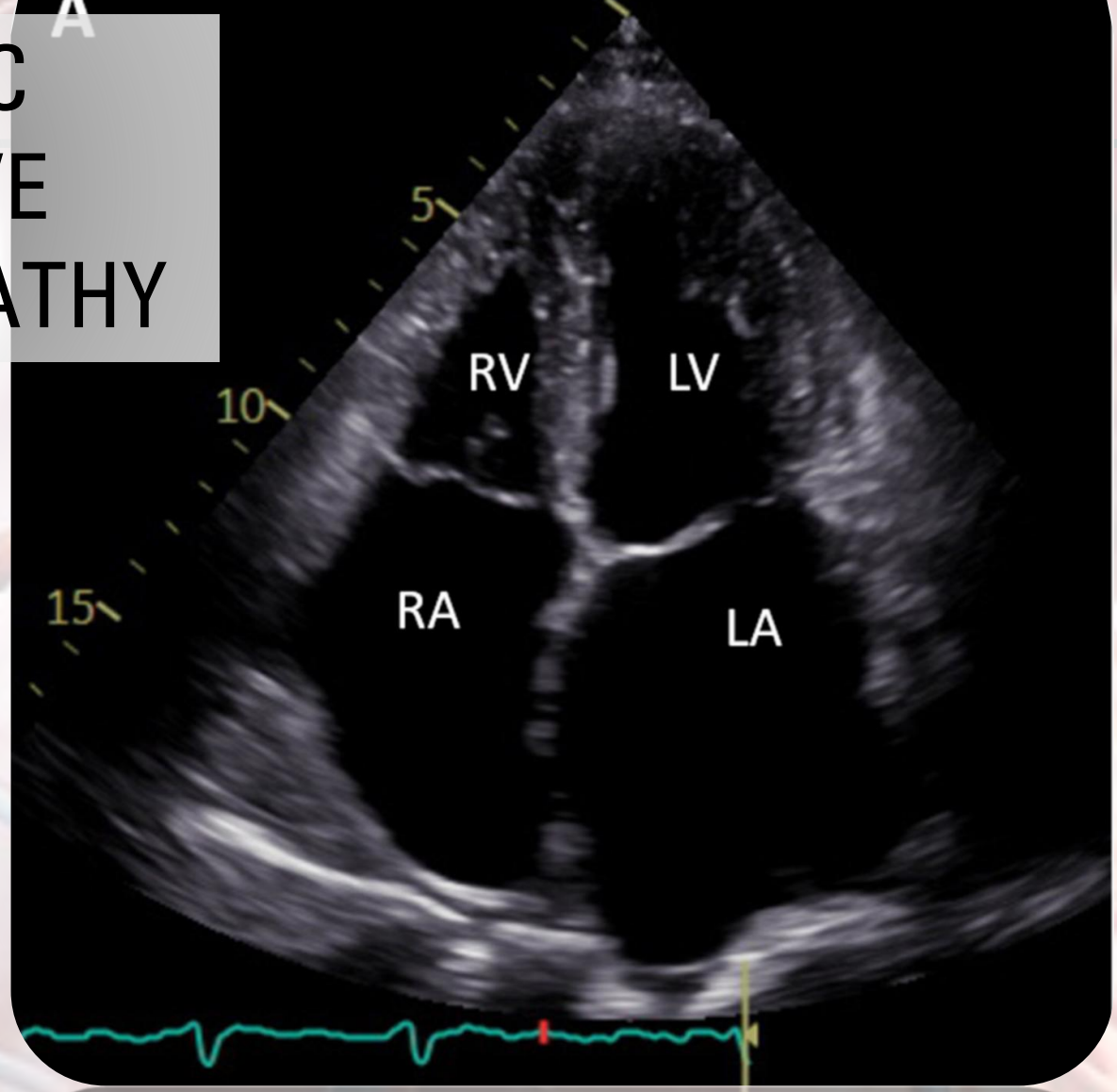
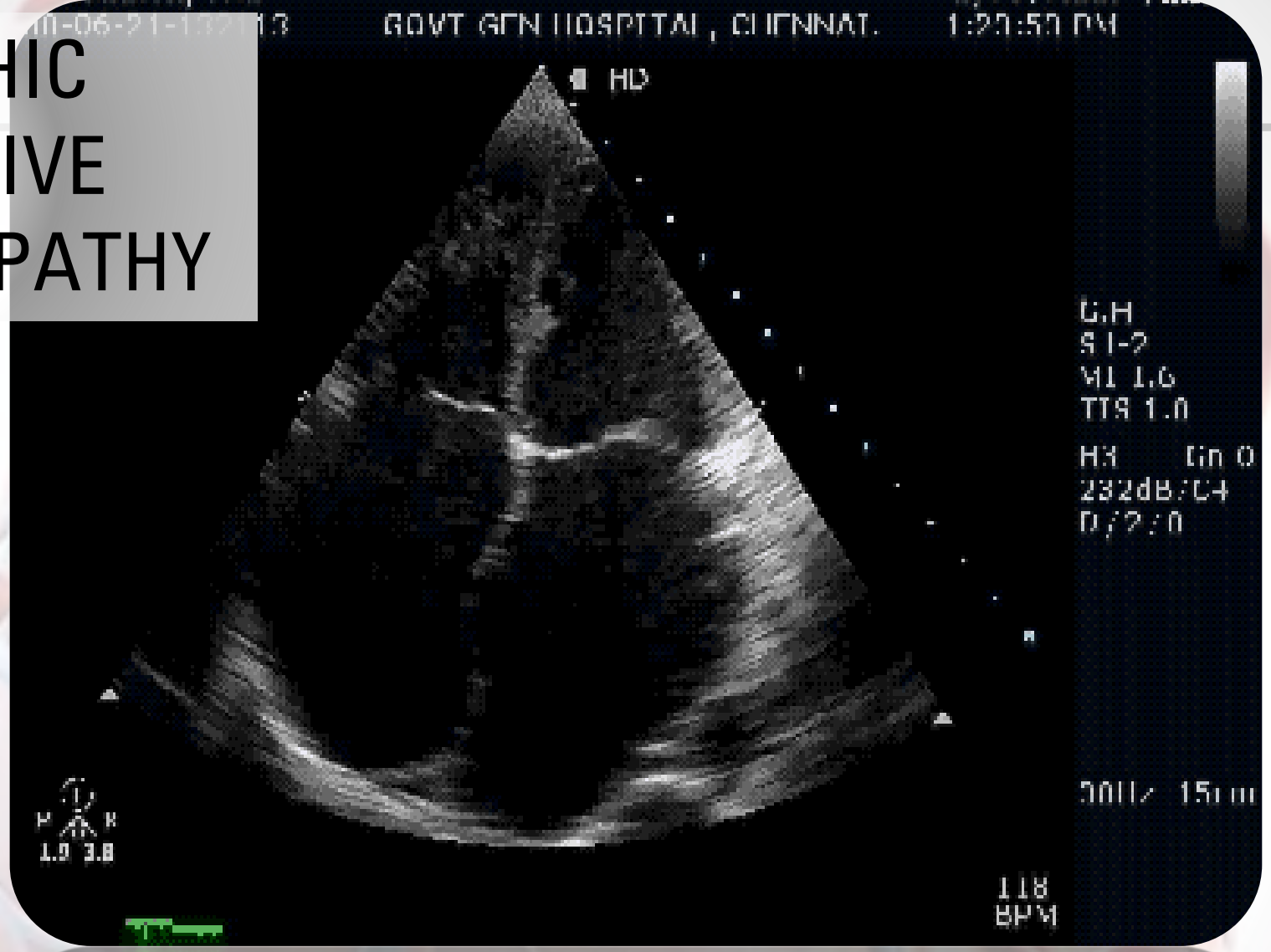


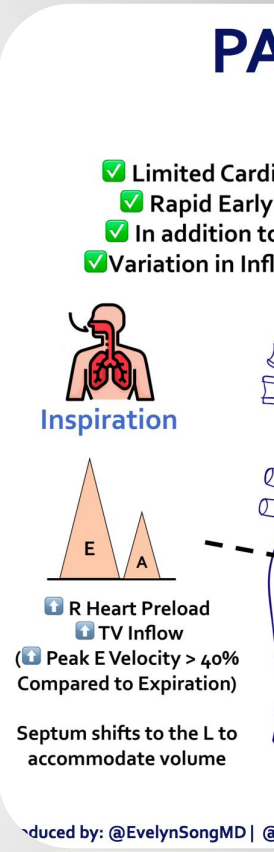


IDIOPATHIC RESTRICTIVE CARDIOMYOPATHY



IDIOPATHIC RESTRICTIVE CARDIOMYOPATHY

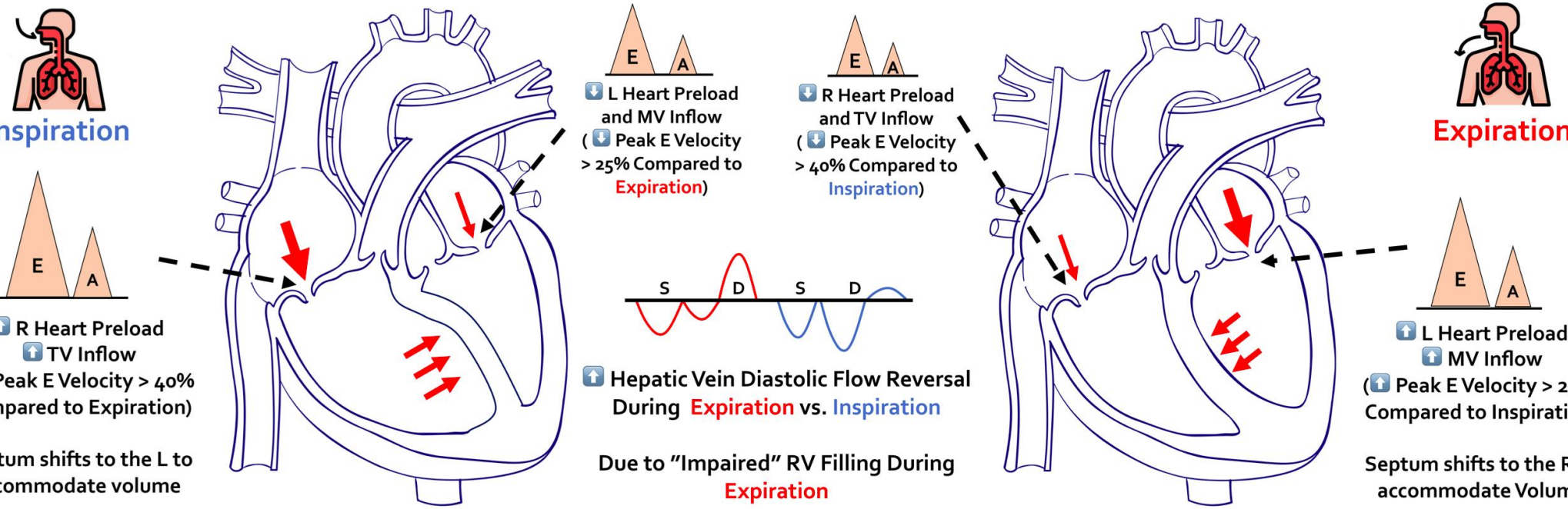




PATHOPHYSIOLOGY OF CONSTRICTION

Exaggerated Ventricular Interdependence

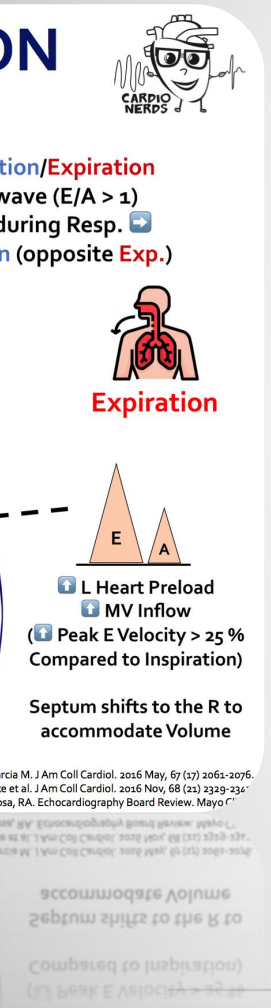
✅ Limited Cardiac Filling due to Fixed Volume ➡ Septum Shifts L/R to Accommodate RV/LV Filling During Inspiration/Expiration
✅ Rapid Early Ventricular Filling and then Abrupt Cessation due to Stiff Pericardium: ⬆ E-Wave Velocity + ⬇ A-wave (E/A > 1)
✅ In addition to Intrathoracic-Intracardiac Pressure Disassociation ➡ Exaggerated Ventricular Interdependence during Resp. ➡
✅Variation in Inflow Across A-V Valves ➡ >25% ⬇Peak MV Velocity and >40% ⬆Peak TV Velocity During Inspiration (opposite Exp.)

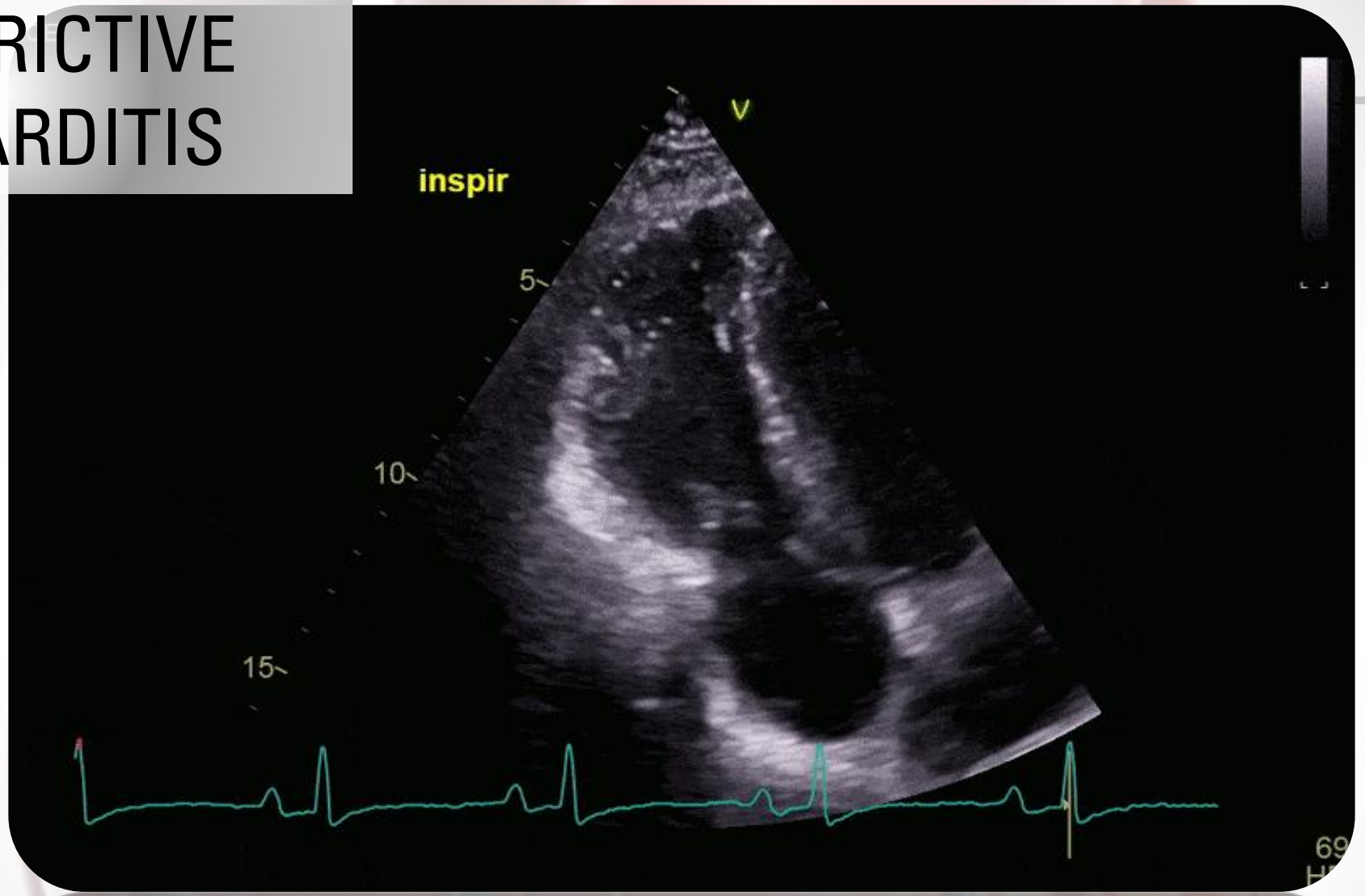


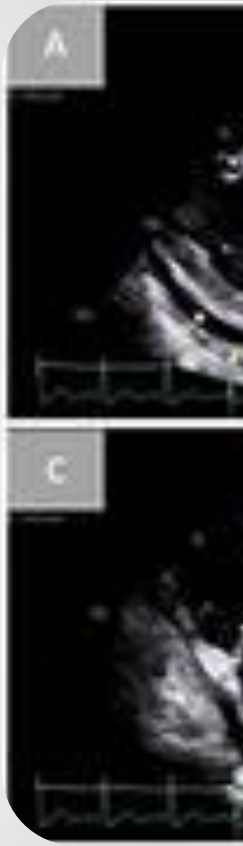
Produced by: @EvelynSongMD | @varghes_bibin | @karanpdesai

Garcia M. J Am Coll Cardiol. 2016 May, 67 (17) 2061-2076.
Geske et al. J Am Coll Cardiol. 2016 Nov, 68 (21) 2329-234
Espinosa, RA. Echocardiography Board Review. Mayo C

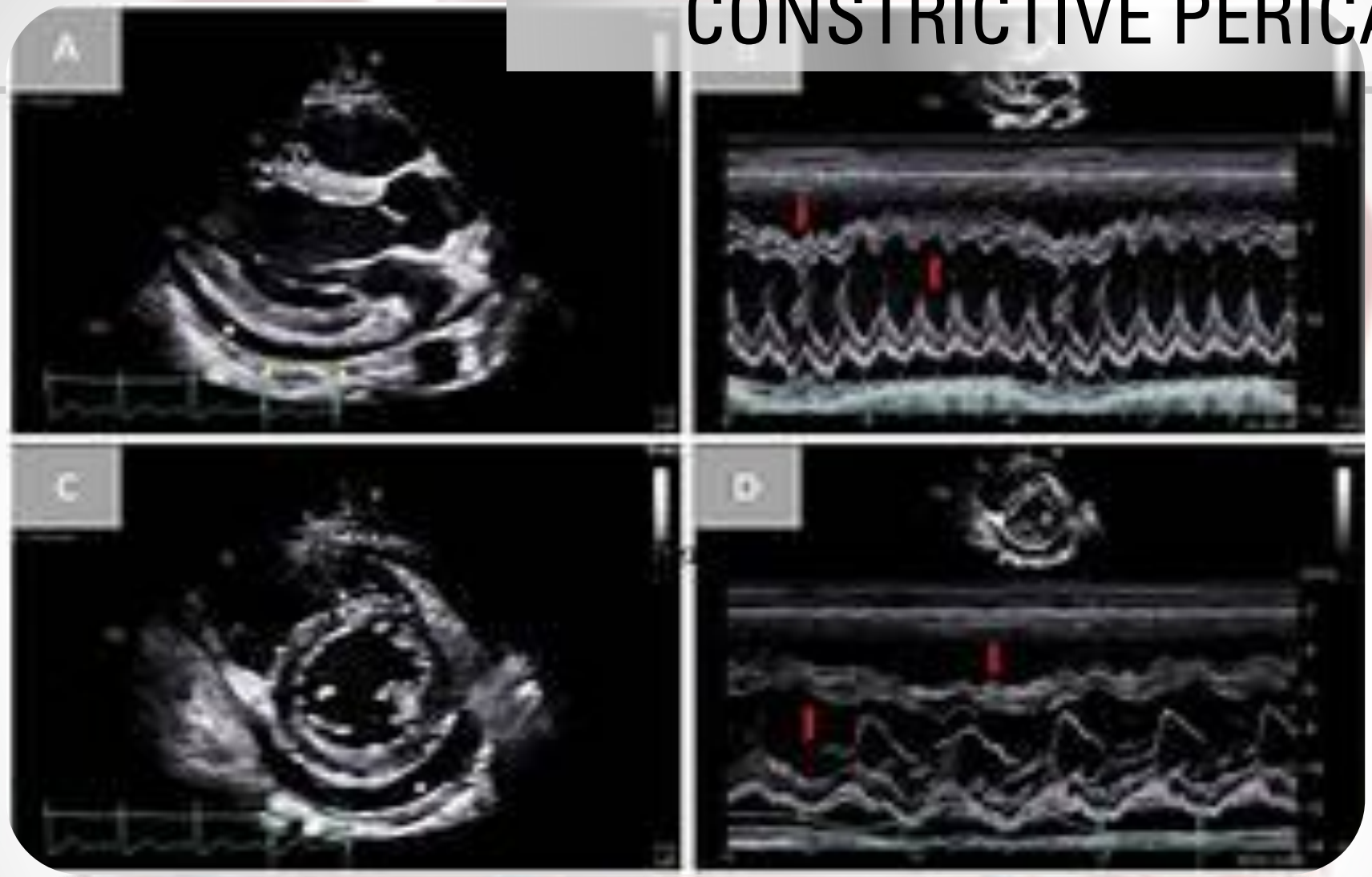
CONSTRICTIVE PERICARDITIS







CONSTRICTIVE PERICARDITIS



REFERENCE

- Bedside Ultrasonography in the ICU* Part 1 Yanick Beaulieu, MD; and Paul E. Marik, MD, FCCP
- Echocardiography in shock management Anthony S. McLean
- Ultrasonography in the Critical Care Unit Keith Guevarra1 &YonatanGreenstein
- Point-of-care ultrasound of the brain: A systematic review of competencies and training frameworks for intensivists Adrian Wong1 Nourhan Ahmed1 , Richard Cashmore1 , Nurul Liana Roslan1,2 , Mohamed Ibrahim1 and Masumi Tanaka Gutiez1

THANK YOU