



Cardiac Tamponade

DR Bigdelu

Associate professor of cardiology

Fellowship of echocardiography

MUSM

Pericardial effusion

- wide variety of conditions, broadly divided into inflammatory, neoplastic, endocrine, and traumatic, can lead to an increase in the normal volume of pericardial fluid.

- ☐ Physiologic/trivial: < 5mm
- ☐ Small : <10mm
- ☐ Moderate: 10-20mm
- ☐ Large: >20mm

Pericardial effusing versus pleural effusion

1. Pericardial fluid will track anterior to the proximal descending thoracic aorta, whereas pleural effusions will not.
2. Pericardial effusion is circumferential.
3. Pericardial effusion can be seen in front of RVOT but pleural seen posterior to LV.
4. Pericardial effusion is circumferential but it is less over LA.
5. Exaggerated cardiac motion in Pericardial effusion.
6. Pericardial effusion is $< 4\text{cm}$
7. Pericardial effusion is seen between cardiac and diaphragm in sub costal view .

Tamponade physiology

- corresponds to the hemodynamic compromise from increased intra-pericardial pressure precluding the cardiac chambers filling.

Types of tamponade

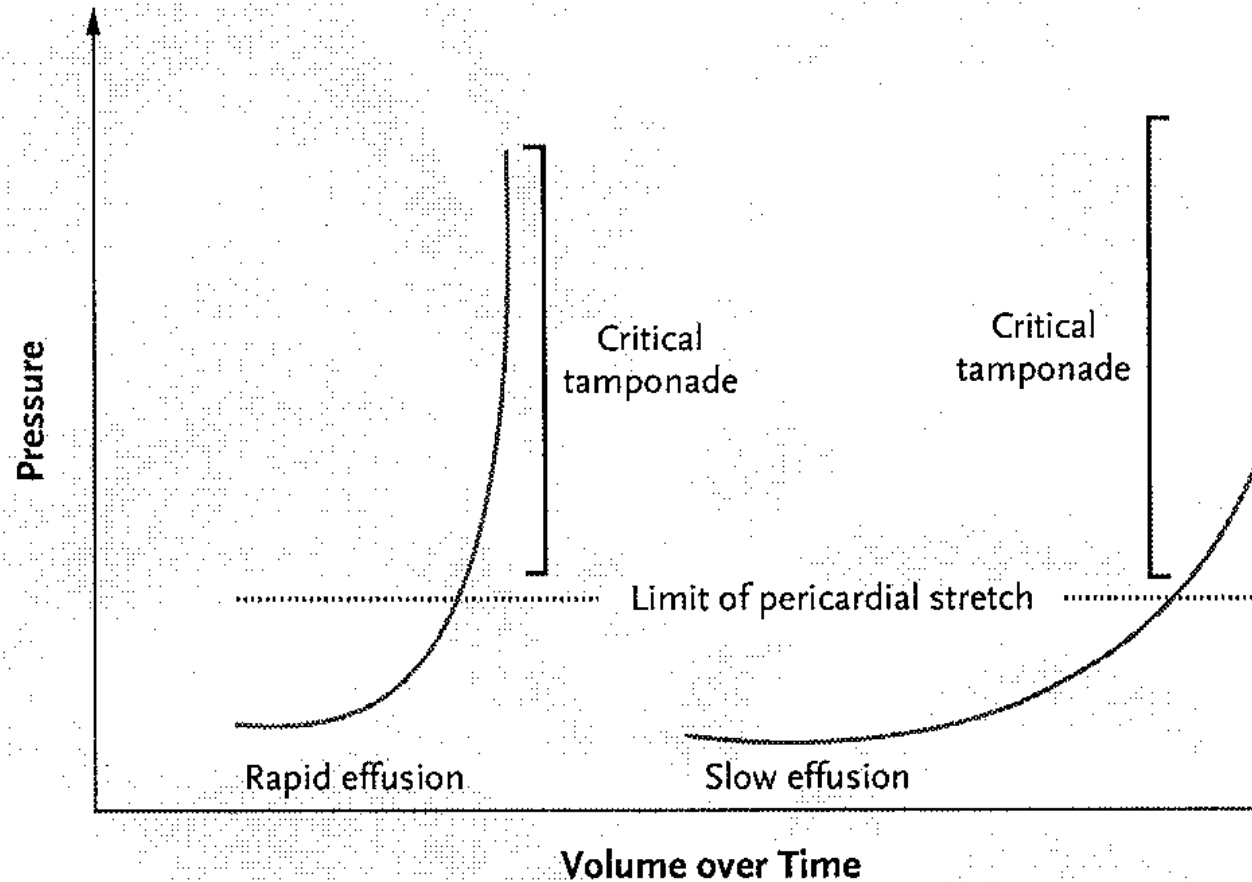
- Acute tamponade

- Due to trauma, rupture of the heart or aorta or complication of an invasive diagnostic or therapeutic intervention
- Sudden in onset
- Hypotension common

- Subacute tamponade

- Pericardial fluid accumulates slowly
- Hypotension with a narrow pulse pressure, reflecting limited stroke volume. However, patients with preexisting hypertension may remain hypertensive due to increased sympathetic activity

Acute vs chronic tamponade



Types of tamponade

- Low pressure tamponade

- Severely hypovolemic pts (*hemorrhage, hemodialysis, or overdiuresis*) → intracardiac and pericardial diastolic pressures are only 6 to 12 mmHg → fluid challenge usually elicits typical tamponade hemodynamics

- Regional tamponade

- caused by a loculated, eccentric effusion
 - typical physical, hemodynamic, and echocardiographic signs of tamponade may be absent

Echocardiography

- **2D and M-mode**
 - RV diastolic collapse
 - RA collapse/inversion
 - IVC plethora
- **Doppler**
 - Exaggerated respiratory variation in mitral and tricuspid inflow velocities
 - Phasic variation in right ventricular outflow tract/left ventricular outflow tract flow
 - Exaggerated respiratory variation in inferior vena cava flow

Diastolic RA and RV collapse

Pericardial effusion



Intrapericardial pressure > intracardiac pressure



Intra-pericardial
pressure > RA diastolic
pressure

Intra-pericardial
pressure > RV diastolic
pressure



Late diastolic RA inversion



Early diastolic RV collapse

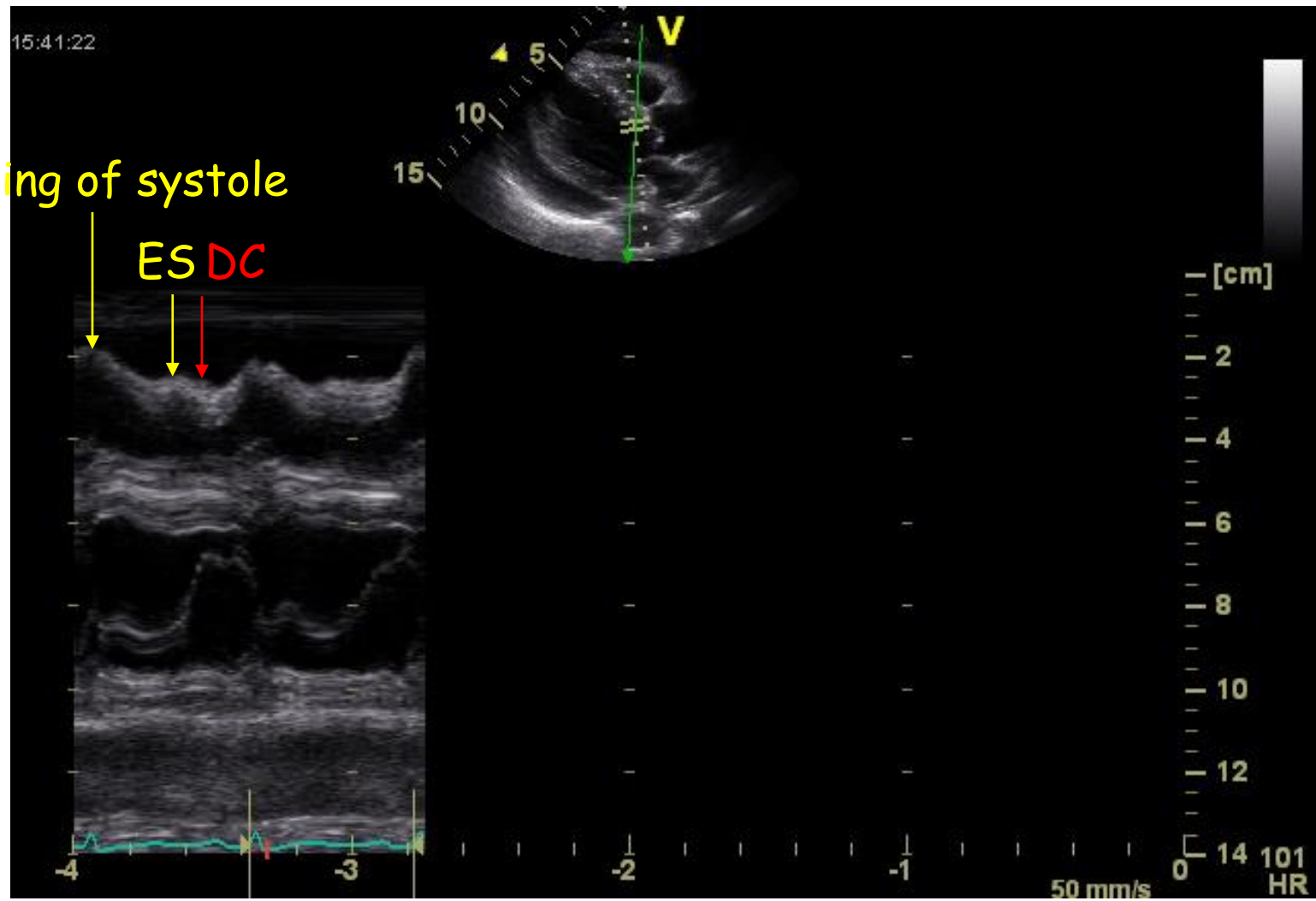
Echocardiogram: Right Ventricular Diastolic Collapse

- Most commonly(First) involves the RV outflow tract (more compressible area of RV)
- Occurs in early diastole, immediately after closure of the pulmonary valve, at the time of opening of the tricuspid valve
- When collapse extends form outflow tract to the body of the right ventricle, this is *evidence that intrapericardial pressure is elevated more substantially*

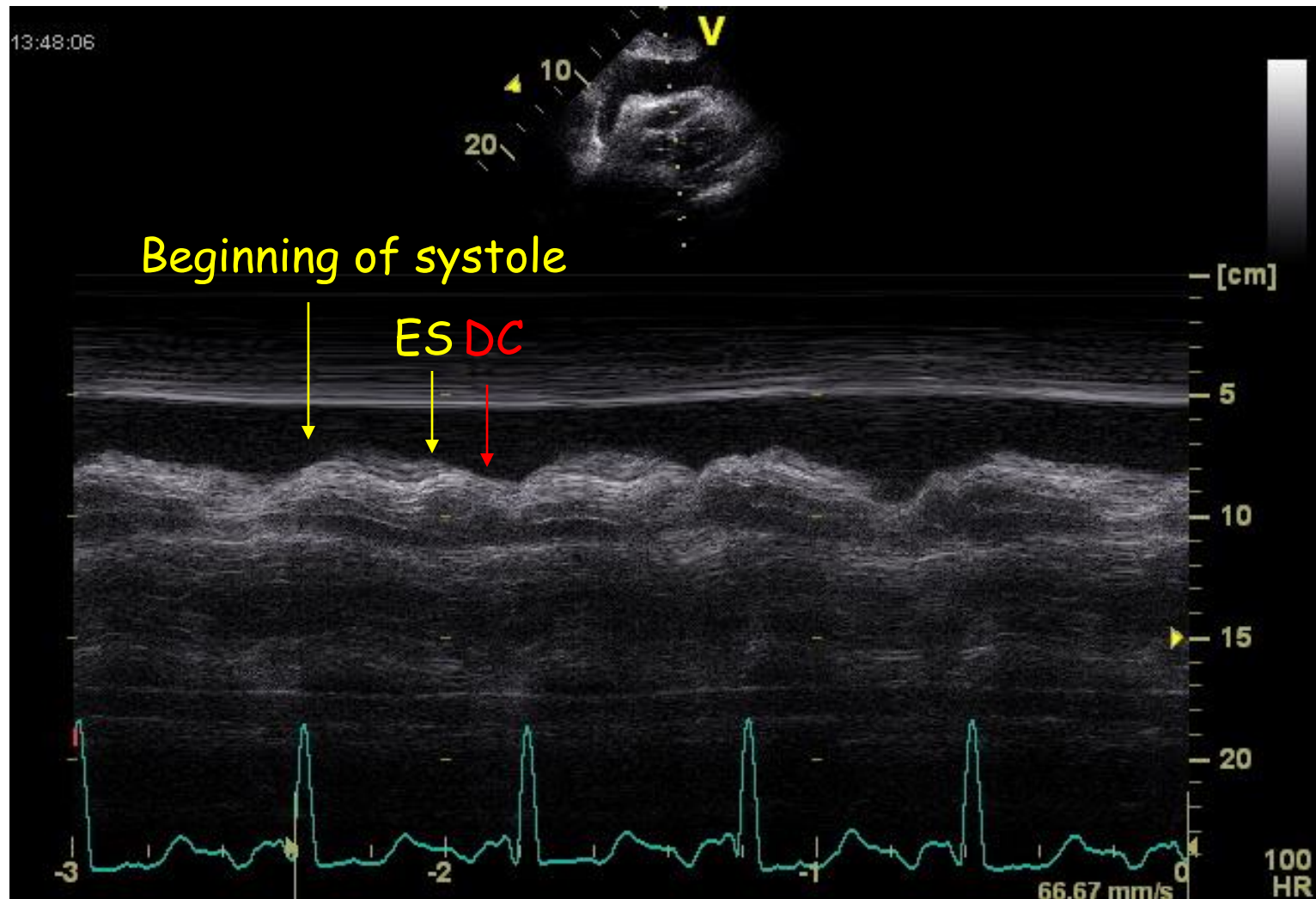


M-mode

Beginning of systole

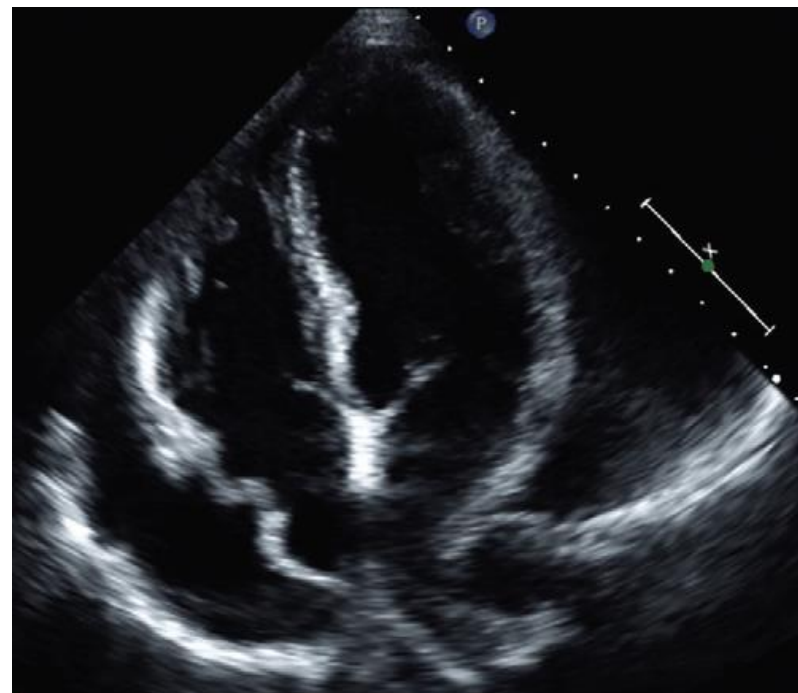
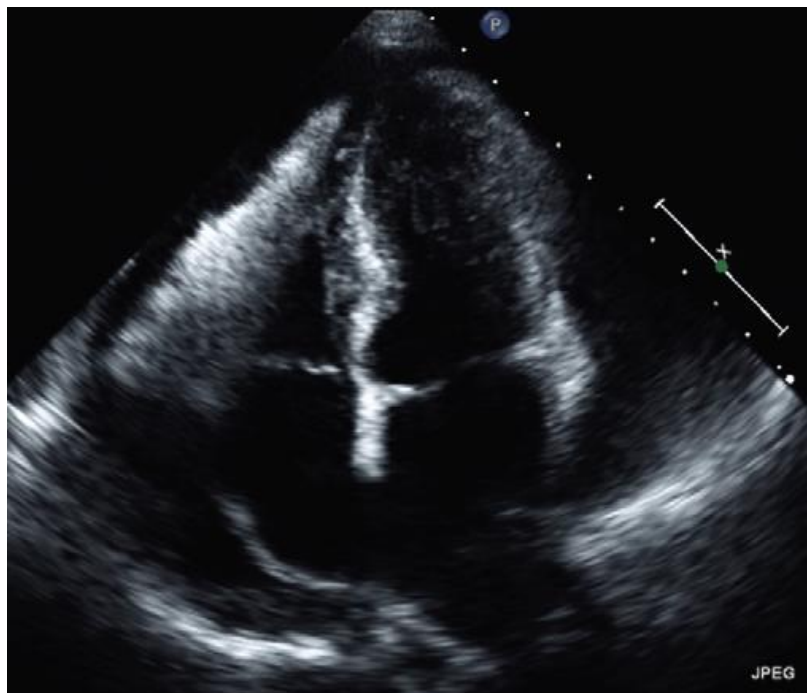


M-mode

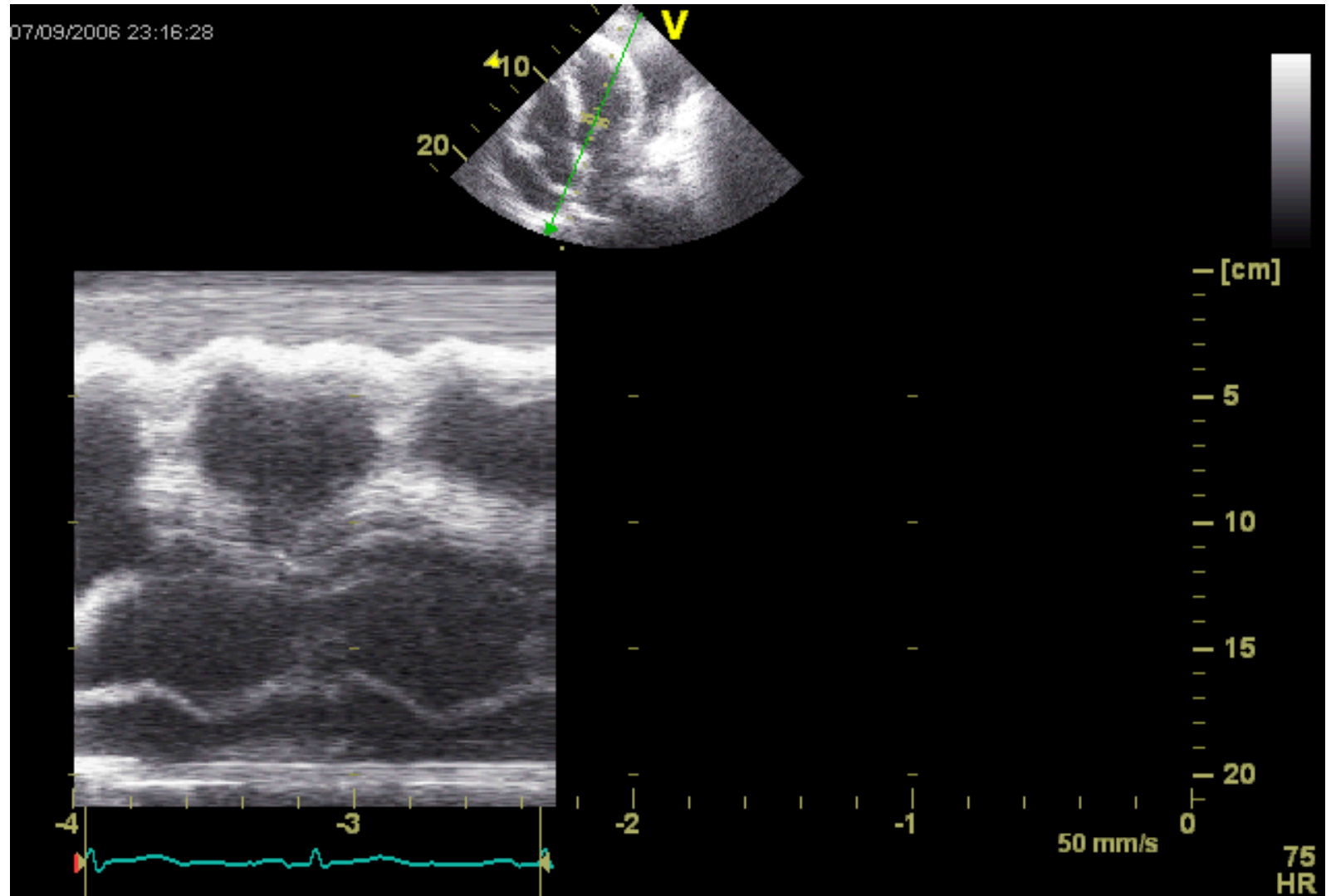


Echocardiogram: RA Inversion

- Right atrium normally contracts in volume with atrial systole
- In the presence of marked elevation of intrapericardial pressure, RA wall will remain collapsed throughout atrial diastole (early ventricular systole)
- Isolated RA inversion occurs during late diastole
 - Very sensitive but specificity = 86%
 - Positive predictive value = 50%
- RA Inversion Time Index (RAITI)
 - Calculated by dividing
 - Using 33% as the threshold
 - Specificity = 100%
 - Sensitivity = 94%



M-mode across RA



RA late diastolic collapse



**Expiratory early RVOT
diastolic collapse**



**Inspiratory and expiratory early
RVOT diastolic collapse**



RV free wall collapse

Left sided collapse

- Posterior loculated effusions after **cardiac surgery** and **severe pulmonary arterial hypertension** may produce LA and LV diastolic collapse.
- As indicated earlier, establishing the diagnosis of regional tamponade is challenging and may require nontraditional echo views, TEE, CT, or CMR.

Table 68.3: Sensitivity and Specificity of Right Heart Chamber Collapses in Cardiac Tamponade

	<i>Sensitivity (%)</i>	<i>Specificity (%)</i>
Any chamber	90	65
Right atrium	68	66
Right ventricle	60	90
Simultaneous right atrium/ right ventricle (RA/RV)	45	92

Source: Modified from Reference 24.

- Although the sensitivity and specificity of collapses are variable (Table), the absence of any cardiac chamber collapse *has > 90% negative predictive value for clinical cardiac tamponade.*

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Reduction of right heart diastolic collapse

1. Right heart chamber pressures over load *RV hypertrophy and severe pulmonary hypertension.*
2. Right heart chamber volume over load (*ASD*)
3. Reduction of right ventricular compliance (*RV MI*)

Respiratory bulge or “bounce” of the interventricular septum

- interventricular septum inspiratory bulge into the LV.
- It should be recognized that an inspiratory septal bulge or “bounce” is not specific for cardiac tamponade but may be seen in other conditions associated with pulsus paradoxus, such as chronic obstructive pulmonary disease and pulmonary embolism.

absent inspiratory septal bulge:

1. may be in cardiac tamponade when there is LV hypertrophy
2. Marked preexisting elevated LV filling pressures.

FR 25Hz

18cm

0:42:08

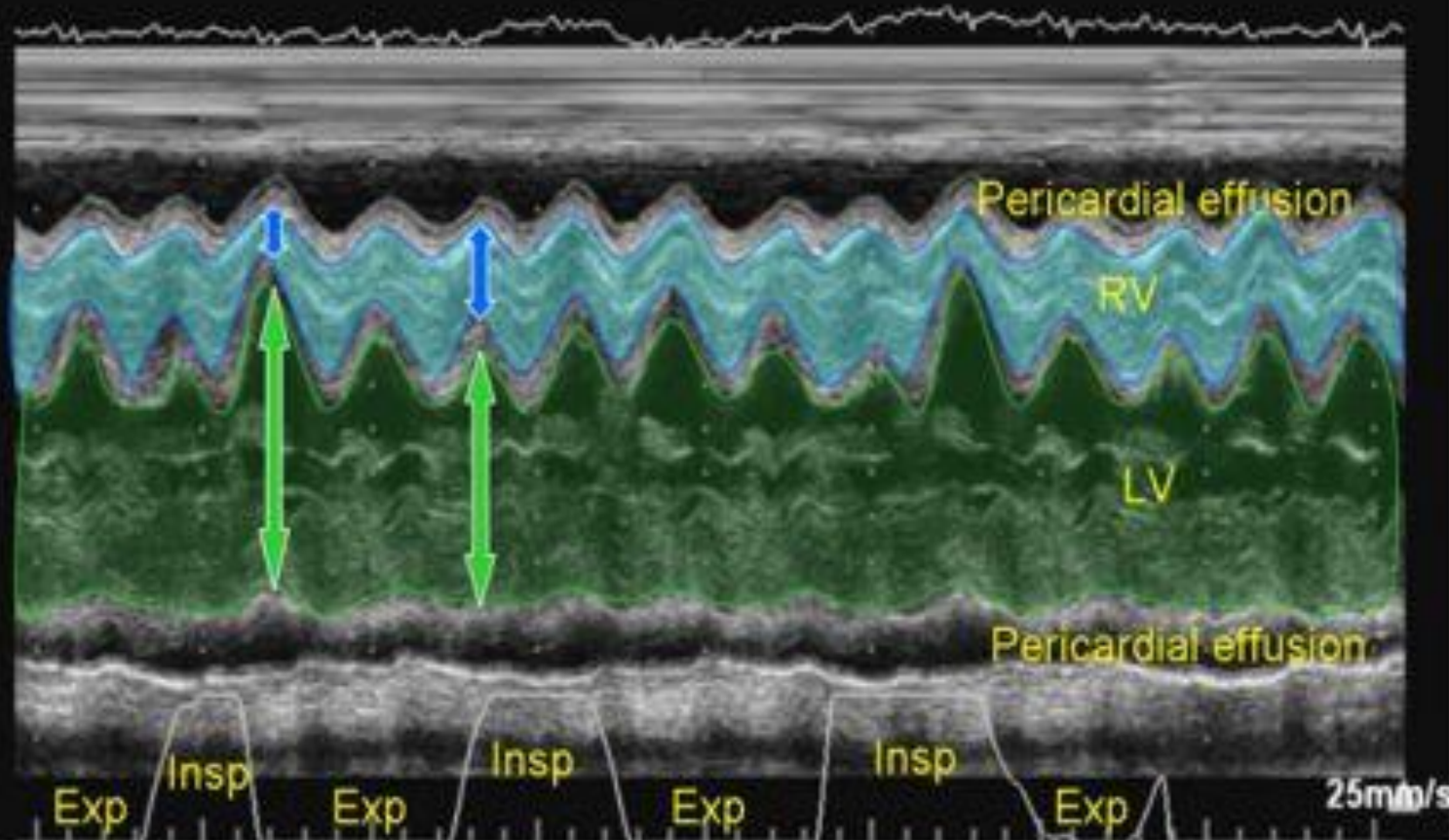
2D / MM

67% 63%

C 50

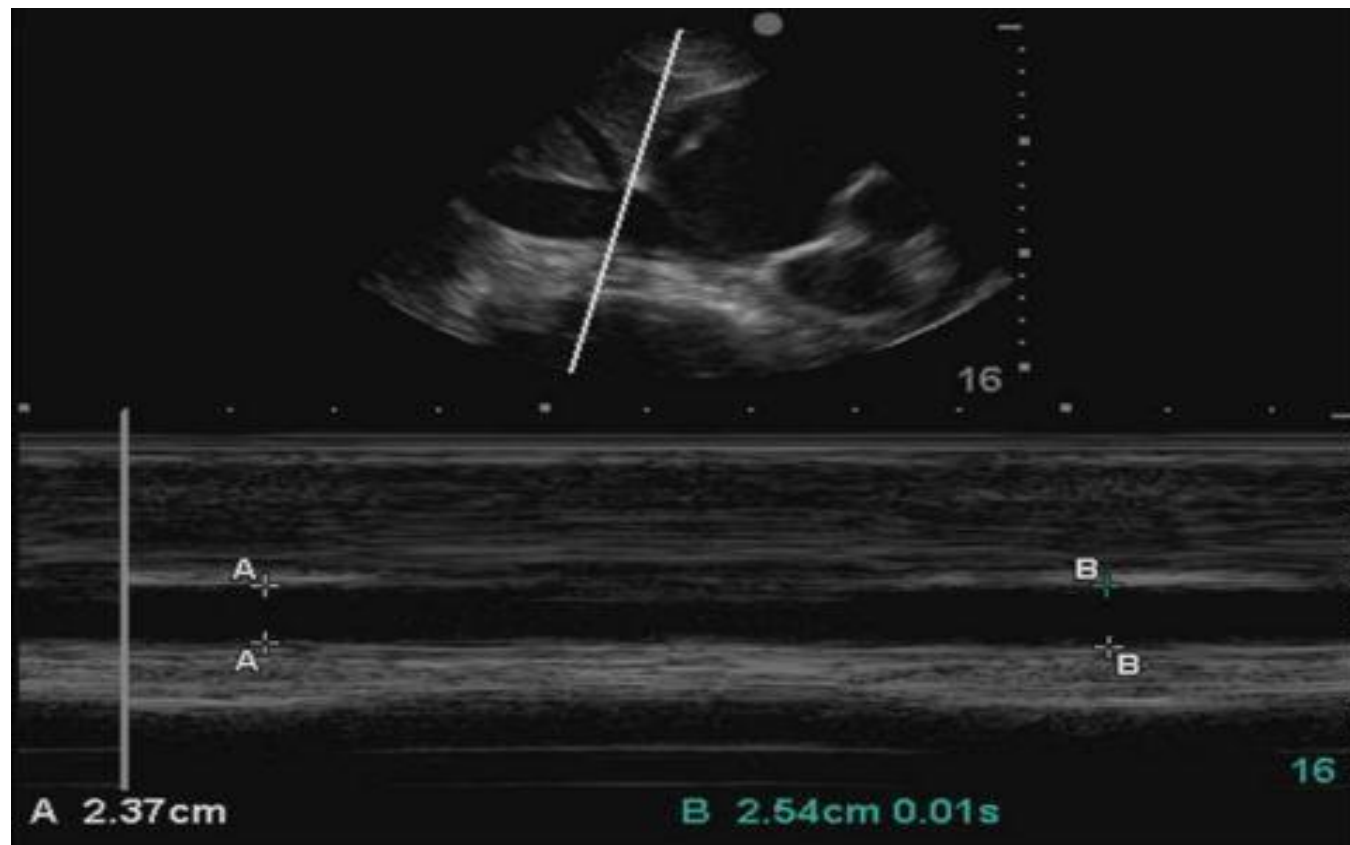
P Low

HGen



IVC dilatation and loss of respiratory variation

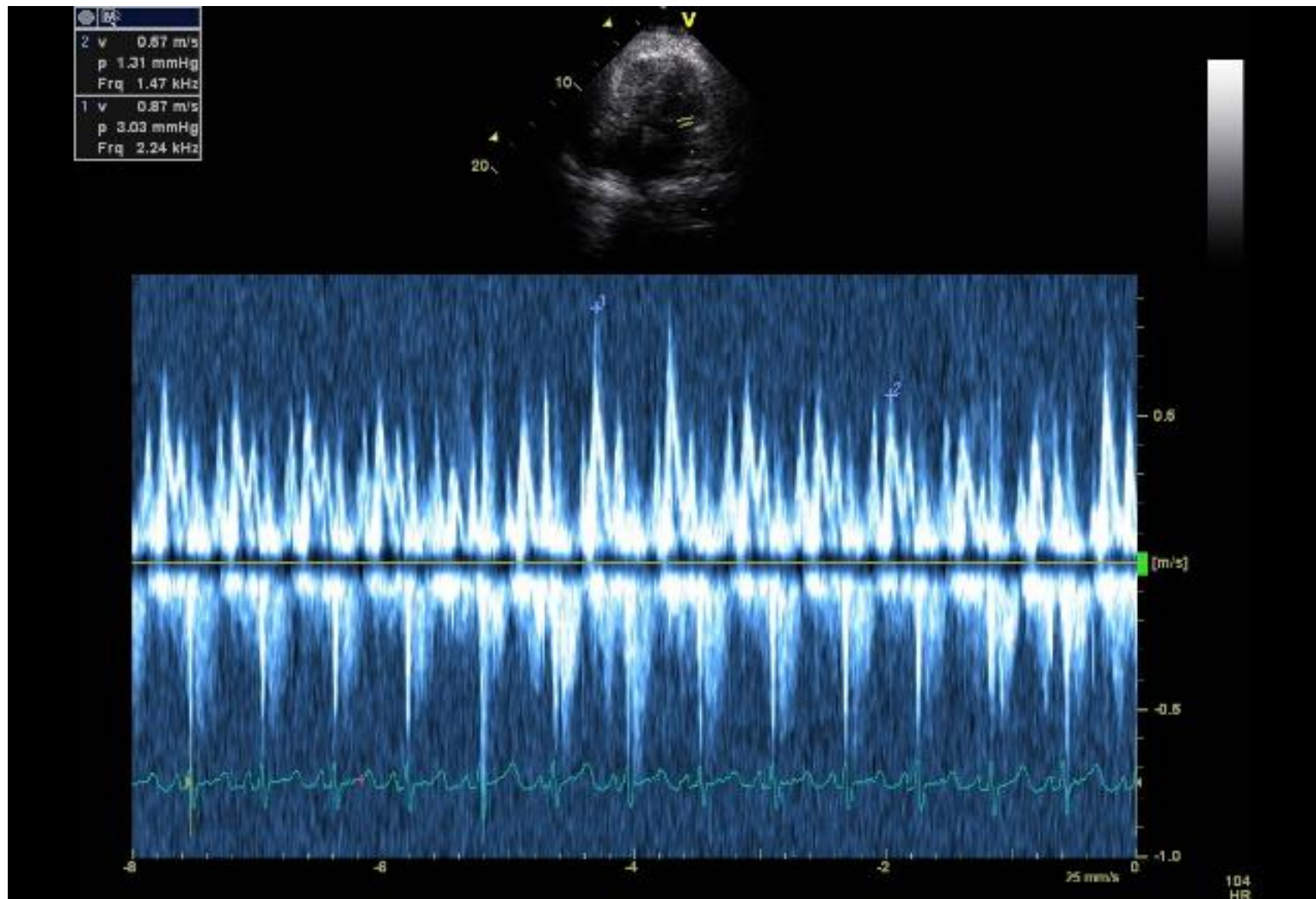
- The Dilated IVC(>21mm)
- IVC is dilated without respiratory variations, reflecting the elevated right atrium pressure
- Absent of these finding in low pressure tamponade



Doppler Flow Velocity Recordings

- Tricuspid and pulmonary flow velocities increase with inspiration while simultaneously mitral and aortic valve flow velocities decrease.
- Normally change in MV E velocity.....15%.....25%
- Normally change in TV E velocity.....25%.....50%
- Normally change in IVRT.....3%.....46%

- The changes are greatest on the **first** beat of inspiration and expiration (a point which helps differentiate the respiratory variation seen in COPD, obesity, pleural effusion(seen in **2 or third beat**)).
- Respiratory variation in the isovolumic relaxation and ejection times are also seen.
- The effect of respiration may be absent in the ventilated patients.

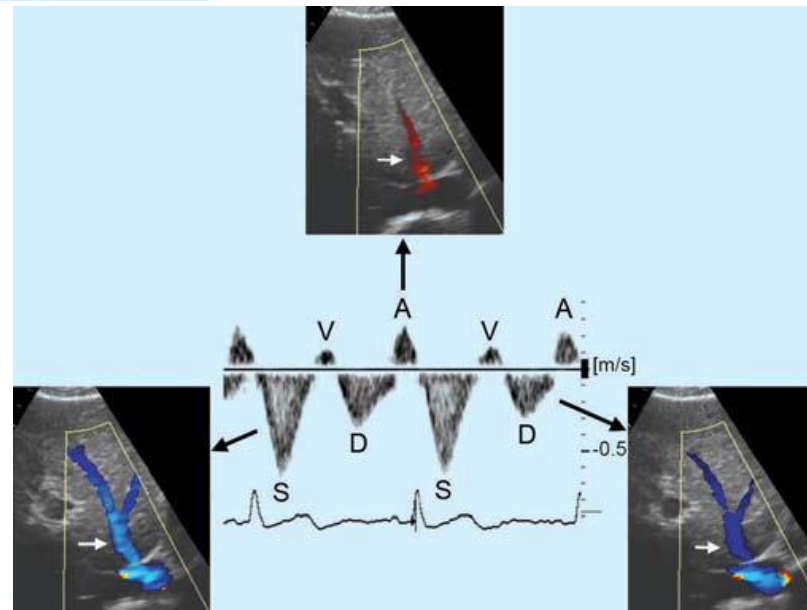
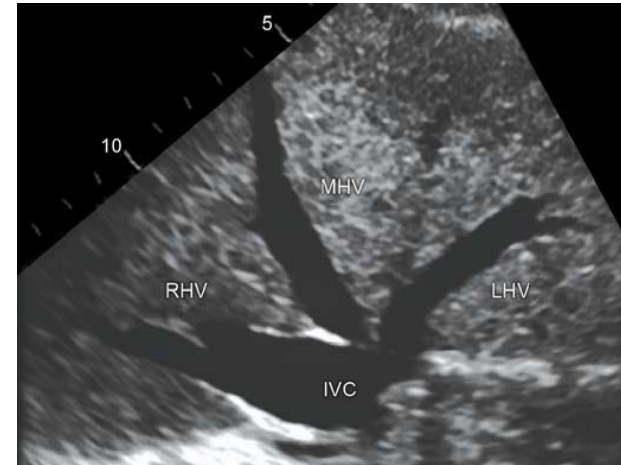
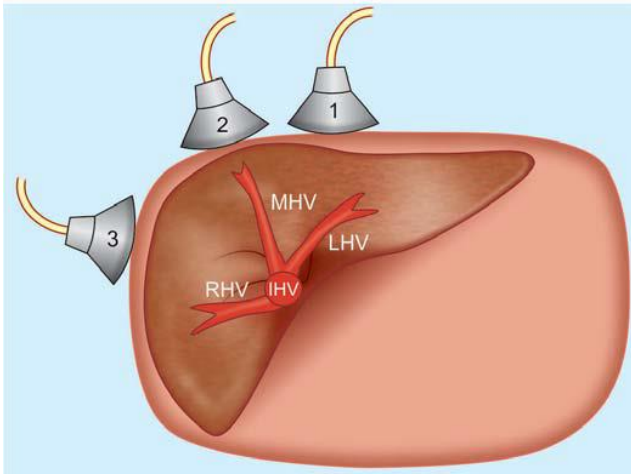


Peak velocity of mitral inflow varies > 15%
with respiration

hepatic venous flow

- Normal is biphasic, with systolic velocity greater than diastolic velocity, and atrial contraction resulting in reversals flow

Hepatic venous flow



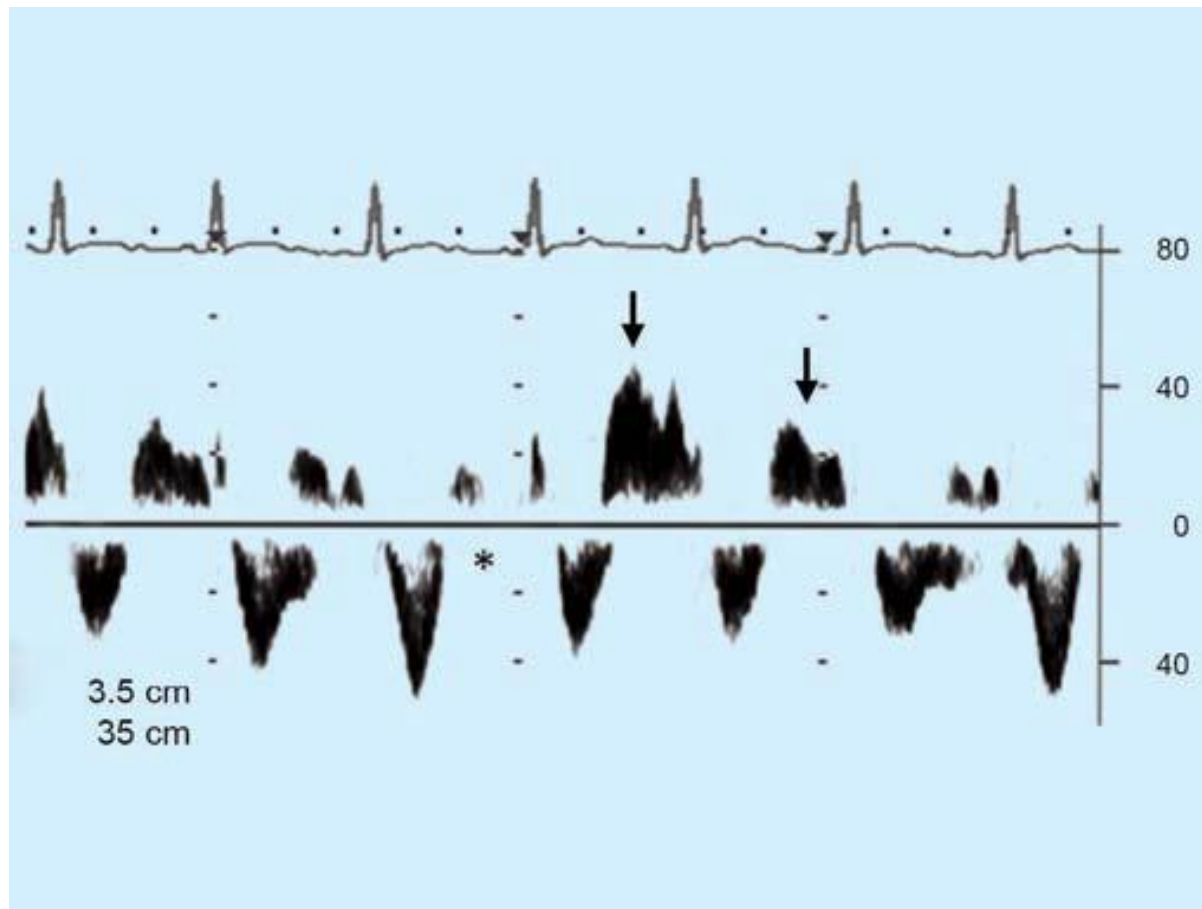
Hepatic venous flow in Tamponade

- Early diastolic flow is markedly reduced or ceases leading to significant decrease or loss of the HV D velocity together with prominent expiratory diastolic reversals
- Systolic predominance
- Diastolic flow reversal or >25% respiratory changes of D wave indicative for cardiac tamponade.

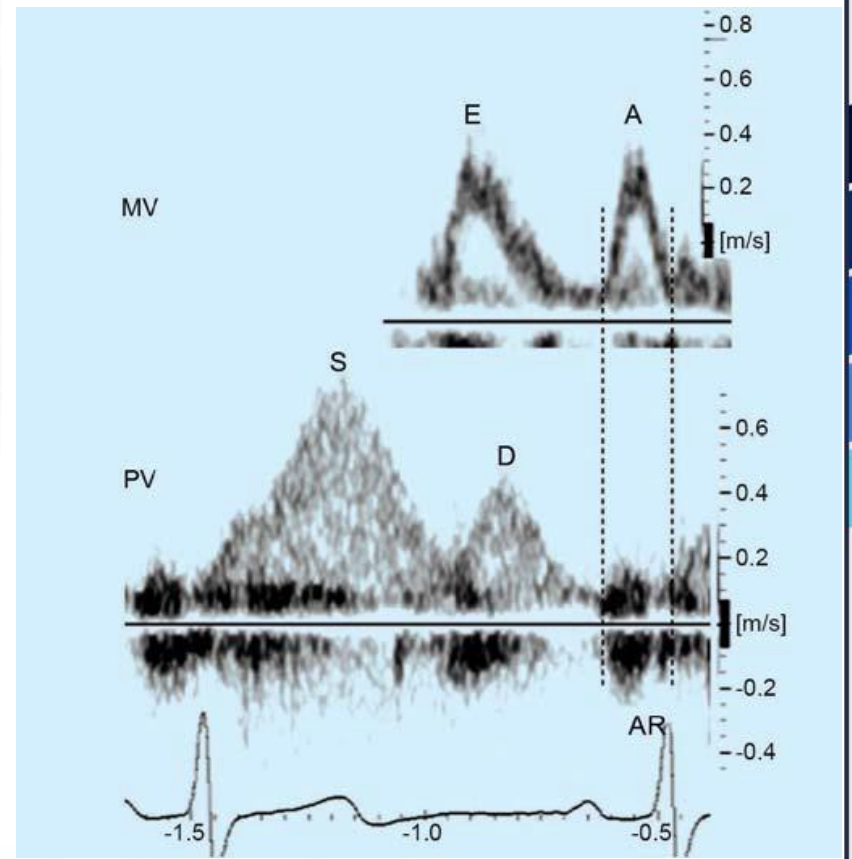
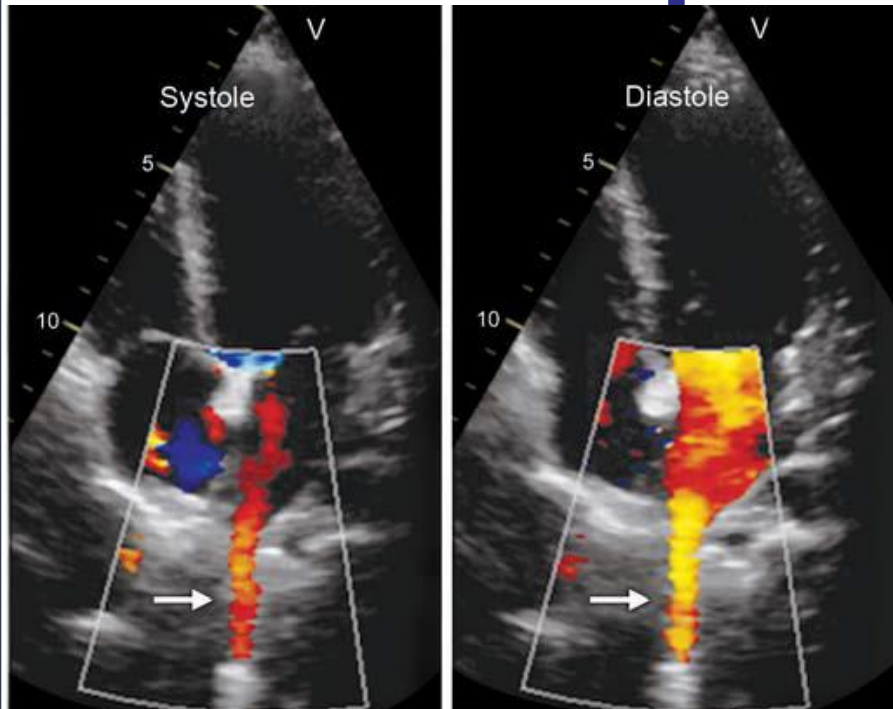
- In **mild cardiac tamponade**, forward flow velocities decrease and venous flow during systole predominates because intra pericardial pressure decreases significantly only during ventricular ejection.
- In **moderate tamponade**, diastolic flow velocity is markedly reduced but still augments with inspiration.

- When tamponade is **severe**, forward flow occurs only during systole, and when hepatic forward flow is observed only during inspiration, systemic venous and intra cardiac pressures are markedly elevated and equalized at which time cardiac arrest is imminent

Hepatic venous flow in Tomponade



Normal pulmonary vein



Pulmonary vein in tamponade

- The marked impairment of cardiac filling in early diastole in cardiac tamponade.
- It demonstrates significant inspiratory decrease and expiratory increase in PV-D velocity and TVI that parallel the changes in the transmitral wave.
- The PV-D waveform may completely disappear during inspiration due to impairment in early diastolic filling.

Post cardiac surgery tamponade

- May be seen as local hematoma.
- TEE is preferred to TTE.
- May be absent classic finding of cardiac tamponade.
- May be need evaluated with off axis view.
- But abnormal hepatic flow pattern may be commonly seen.

How to describe pericardial effusion

1. No diastolic collapse, No respiratory variation.....**Pericardial effusion without compressive effect.**
2. RV and RA diastolic collapse, Respiratory variation($MV > 25\%$, $TV > 50\%$).....**Pericardial effusion with echocardiographic tamponade.**
3. Neither of the aforementioned categories as having "echocardiographic indicators of elevated pericardial pressure without echocardiographic features of 'tamponade.'"

Predictable hierarchy of events

Exaggerated respiratory variation of tricuspid inflow



Exaggerated respiratory variation of mitral inflow



Abnormal right atrial collapse



Right ventricular free wall collapse