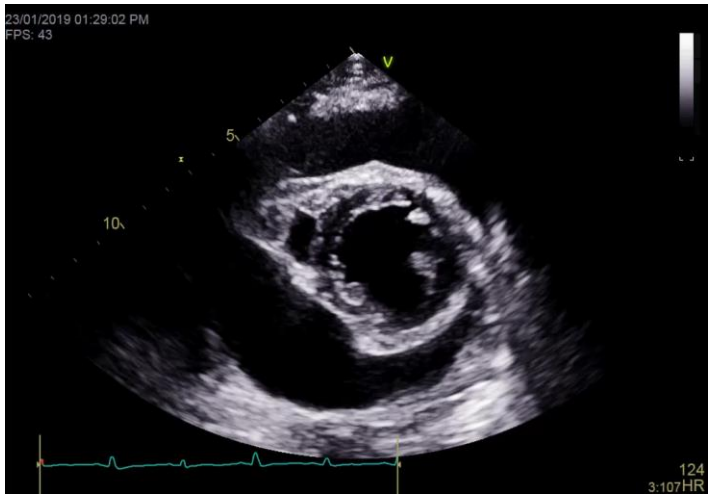
Cardiac Tamponade
Non Invasive Assessment by Echo



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Declaration of interest

- **I have nothing to declare**

Objectives

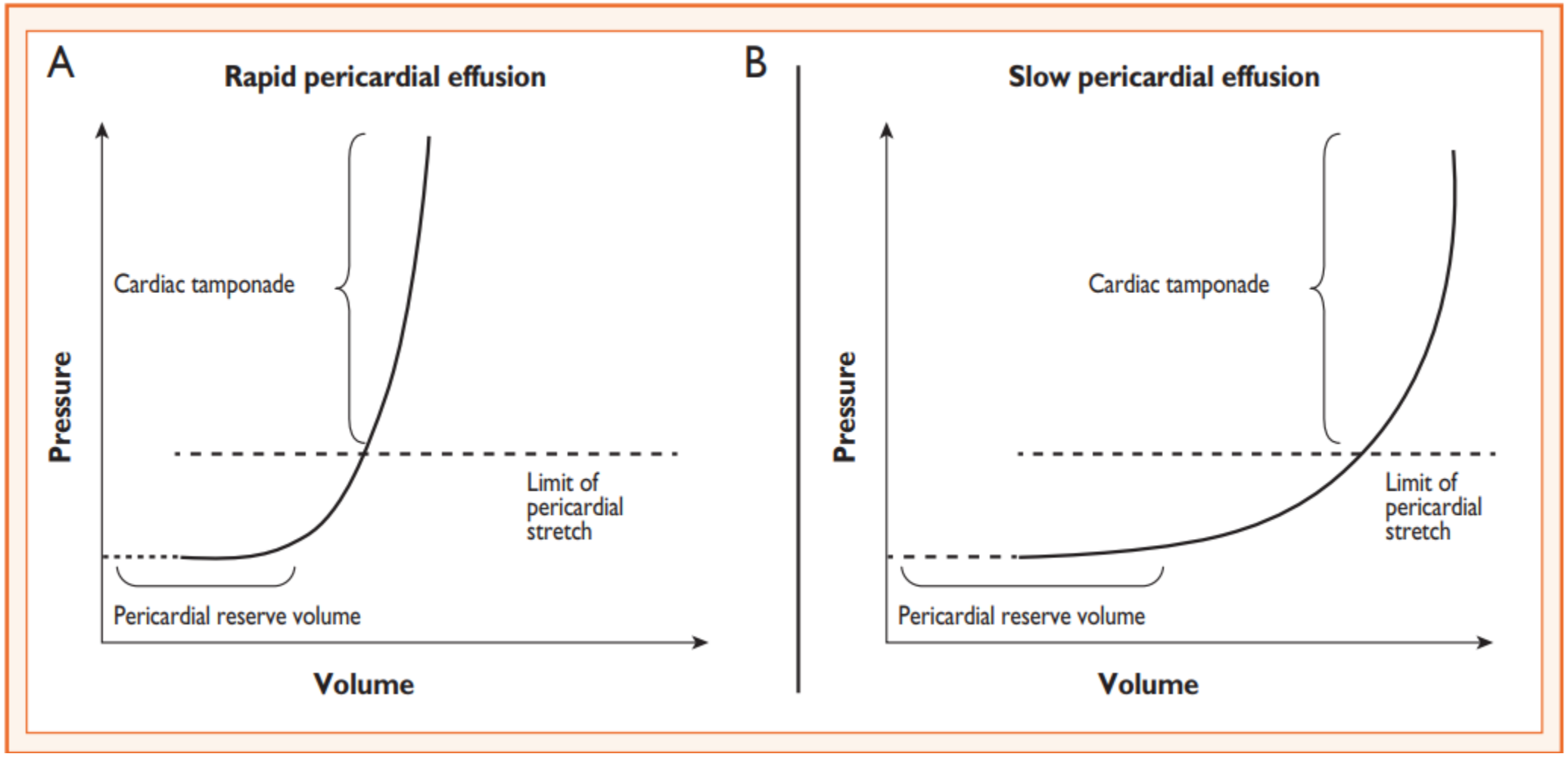
- **Introduction**
- **Why Echo is important in cardiac tamponade.**
- **Take home messages**

Introduction:

- **Cardiac tamponade is a life-threatening, slow or rapid compression of the heart due to the pericardial accumulation of fluid, pus, blood, clots or gas as a result of inflammation, trauma, rupture of the heart or aortic dissection.**

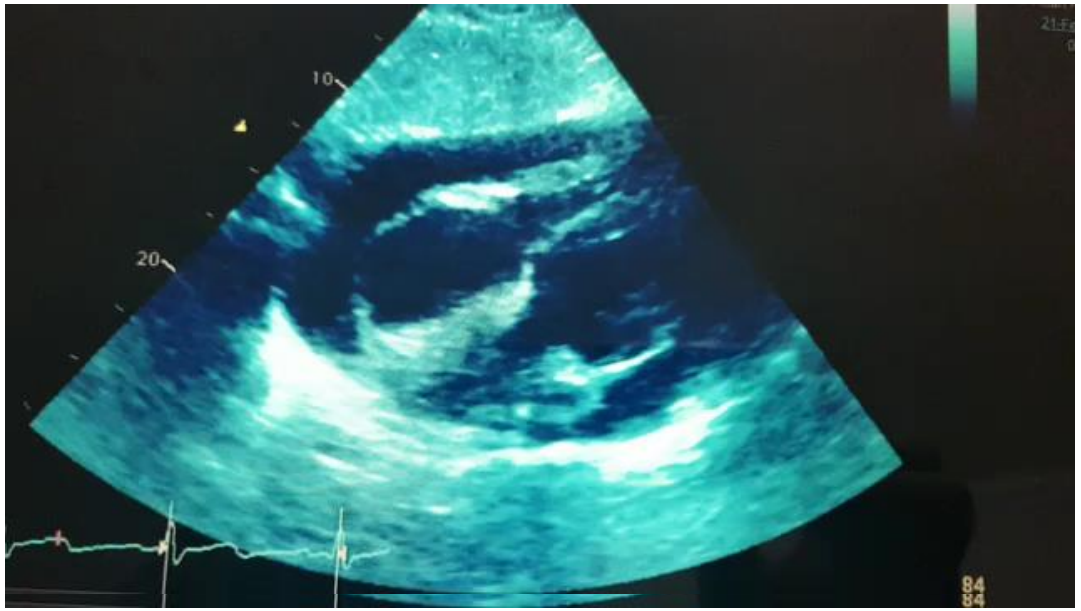
- **Can be classified based on the:**
  - **Onset to (acute, subacute) or (chronic if more than three months).**
  - **The size mild (<10 mm), moderate (10–20 mm) or large (>20 mm)**
  - **Distribution (circumferential or loculated)**

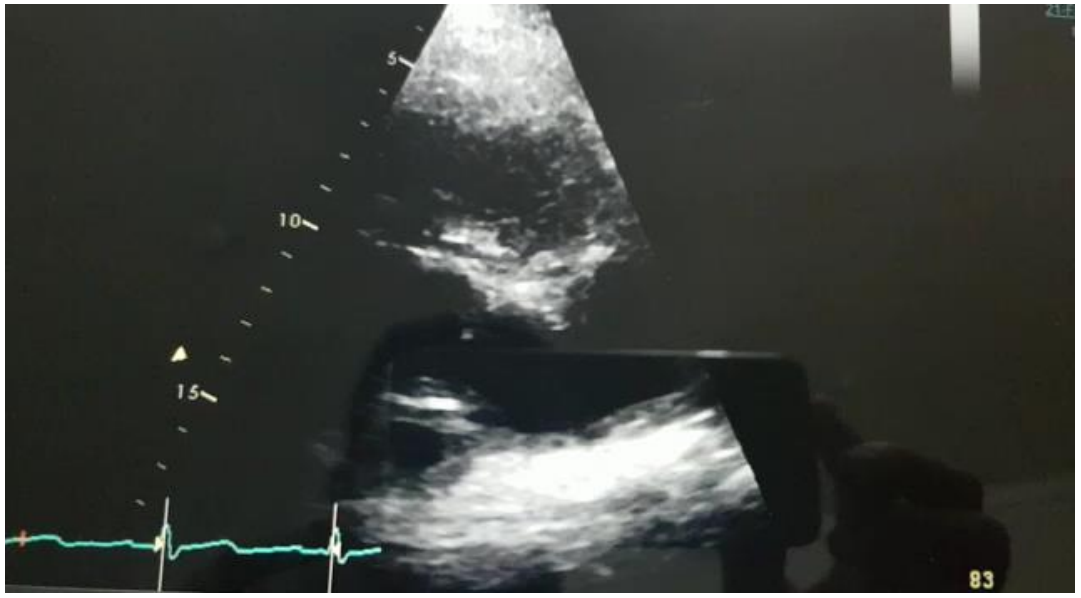
- **10-50 ml of pericardial fluid is normally present.**
- **100 ml of pericardial fluid is enough to cause circumferential effusion.**
- **300-600 ml of non hemorrhagic pericardial fluid can cause tamponade.**



Pressure/volume curve of the pericardium with fast accumulating pericardial fluid leading to cardiac tamponade with a smaller volume (A) compared with the slowly accumulating pericardial fluid reaching cardiac tamponade only after larger volumes (B

Feb 2018





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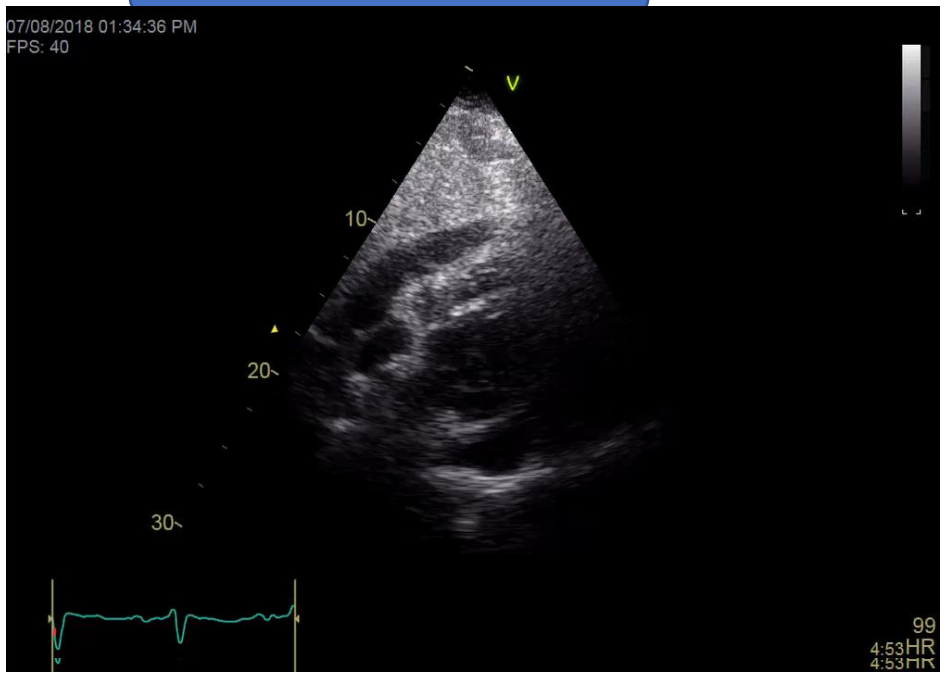
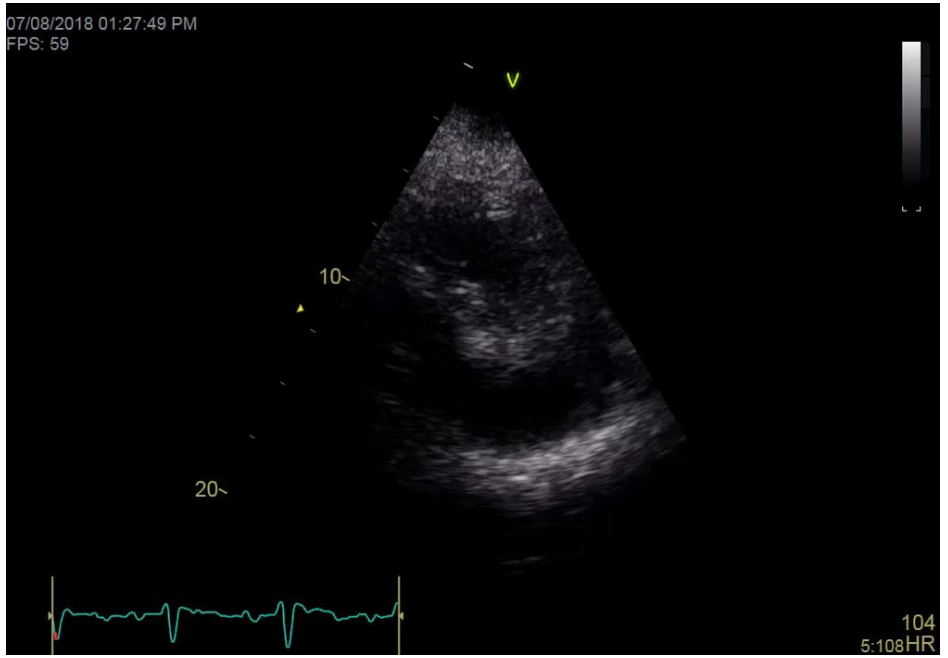




Why Echo is Important in Cardiac Tamponade?

- **To make the diagnosis**
- **For triage**
- **To guide and monitor the pericardiocentesis**

Diagnosis

The **diagnosis of cardi**
clinical dia

A

ographic confirmation

The definite confirmation test for tamponade is clinical and hemodynamic improvement after pericardiocentesis

Signs
Classical Beck triad
(Beck 1935)

TWO CARDIAC COMPRESSION TRIADS

CLAUDE S. BECK, M.D.
CLEVELAND

Lesions of the pericardium are generally difficult problems in diagnosis. Auenbrugger, Corvisart and Laennec early recognized these difficulties. Osler not infrequently lamented his failure to recognize a lesion of the pericardium and it would seem that these problems in diagnosis still exist. The chief reason for failure in the diagnosis of pericardial lesions is the fact that the physiologic concept of acute and chronic compression of the heart has not found the place in applied medicine that it deserves. Clinically, almost all of the intrapericardial lesions express themselves, if they express themselves at all, by producing either acute or chronic compression of the heart. Some lesions of the pericardium are entirely silent; they produce no clinical signs whatever and clinical recognition of these silent lesions is not to be expected.[1] However, the important group of lesions—important because treatment is effective—produces either acute or chronic compression of the heart. In this respect the intrapericardial lesion producing compression of the heart is exactly similar to the intracranial lesion producing either acute or chronic pressure on the brain. The intrapericardial lesion, like the intracranial lesion, produces clear and distinctive earmarks for recognition. In the case of the heart the earmarks for both acute

From the Department of Surgery of the Western Reserve University School of Medicine and the Lakeside Hospital.

1. In this group of silent lesions are the cases of adhesions between the parietal pericardium and the heart. Intrapericardial adhesions, per se, do not disturb the circulation. The circulation is disturbed if the parietal pericardium is thickened by the formation of scar tissue, but the presence or absence of adhesions in this condition is entirely incidental. The thickened parietal pericardium produces chronic compression of the heart. Intrapericardial adhesions per se do not disturb the circulation and these also are silent lesions. However, extrapericardial and intrapericardial adhesions combined are not silent. In this condition the work load of the heart is increased and hypertrophy takes place.

- Hypotension
- Increasing jugular venous pressure
- small, quiet heart

J Am Med Assoc. 1935;104:714-716.

Symptoms Of Cardiac Tamponade

Sign/ Symptom	Levine et al,[6] 1991 (N = 50)	Cooper et al,[46] 1995 (N = 30)
Dyspnea	88	87
Fever		25
Chest pain		20
Cough	10	7
Lethargy		3
Palpitations		3

JAMA. 2007;297:1810-1818

Sensitivity of the physical examination in the diagnosis of cardiac tamponade

Sign	Reddy et al,[34] 1978 (N = 19)	Guberman et al,[25] 1981 (N = 56)	Singh et al,[8] 1984 (N = 16)	Curtiss et al,[33] 1988 (N = 65)	Levine et al,[6] 1991 (N = 50)	Brown et al,[26] 1992 (N = 18)	Cooper et al,[46] 1995 (N = 25)*	Gibbs et al,[47] 2000 (N = 46)	Pooled Sensitivity (95% CI)
Pulsus paradoxus >10 mm Hg	71†‡	77§	75§	98‡	86‖		56‖	80‖	82 (72-92)
Tachycardia		77			74		65	87	77 (69-85)
Hypotension		35			14		30	24	26 (16-36)
Hypertension ¶						33			
Tachypnea		80							
Diminished heart sounds		34			24			24	28 (21-35)
Elevated JVP			88		74		53	87	76 (62-90)
Peripheral edema		21			28				
Pericardial rub		29	19						
Hepatomegaly		55			28				
Kussmaul sign							26		
Pulse pressure, mm Hg									
>0		54							
>100		12							
Total paradox		23							

Abbreviations: CI, confidence interval; JVP, jugular venous pressure.
*Not all patients had documentation of clinical findings.
†Defined pulsus paradoxus as expiratory systolic pressure-inspiratory systolic pressure/expiratory systolic pressure >10%.
‡Pulsus paradoxus measured with intra-arterial transducer.
§Pulsus paradoxus measured with sphygmomanometer or intra-arterial transducer.
‖Pulsus paradoxus measured with sphygmomanometer.
¶Systolic blood pressure >140 mm Hg.

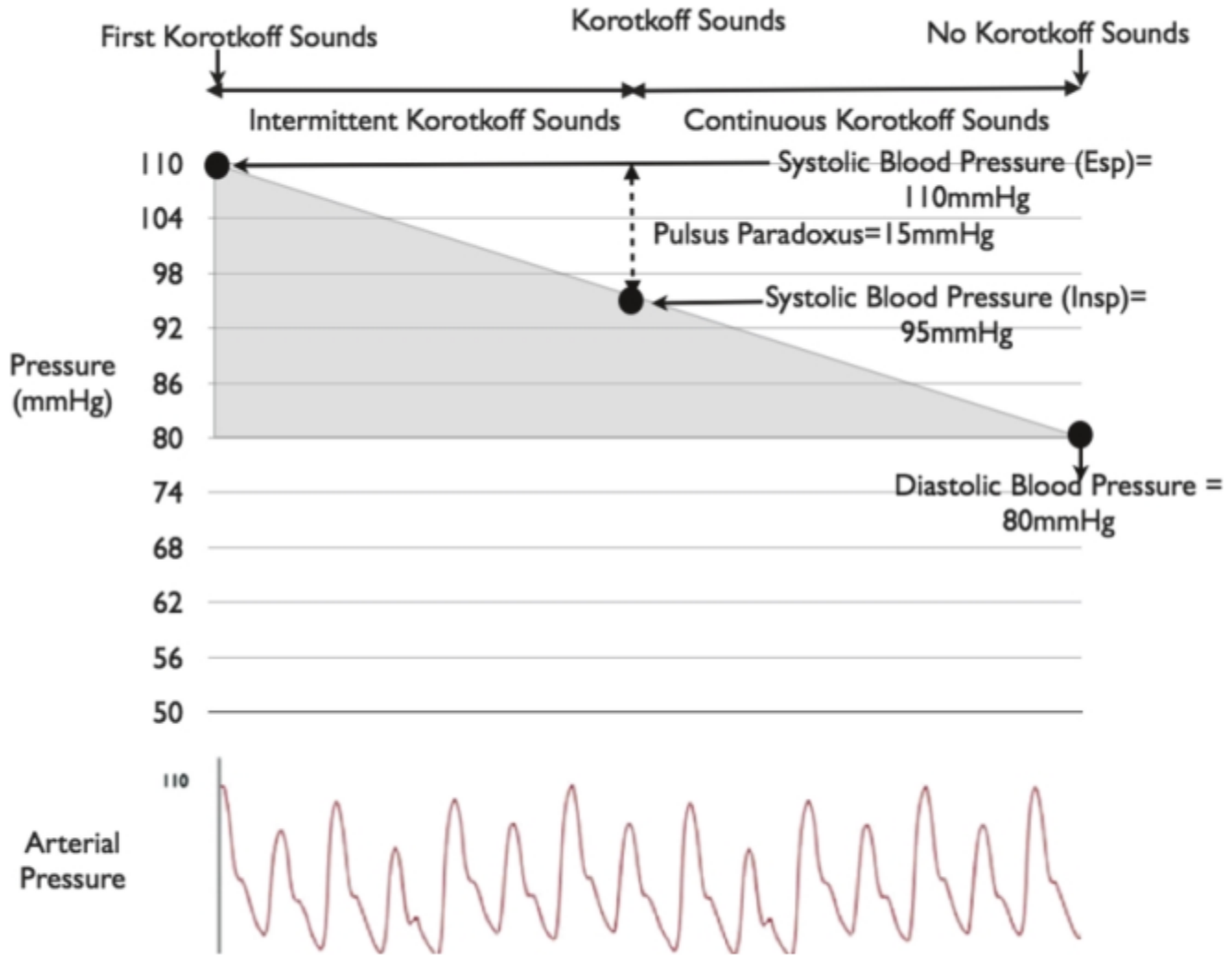
Signs of cardiac tamponade
Pulsus paradoxus

	Pulsus Paradoxus, mm Hg†	
	>12	>10
Sensitivity, %	98	98
Specificity, %	83	70
LR (95% CI)		
Positive	5.9 (2.4-14)	3.3 (1.8-6.3)
Negative	0.03 (0-0.21)	0.03 (0.01-0.24)

Abbreviation: CI, confidence interval.
*All data from Curtiss et al (N = 65).[33]
†Measured using an intra-arterial transducer.

Pulsus paradoxus

Inspiratory decrease of systolic blood pressure > 10mmHg



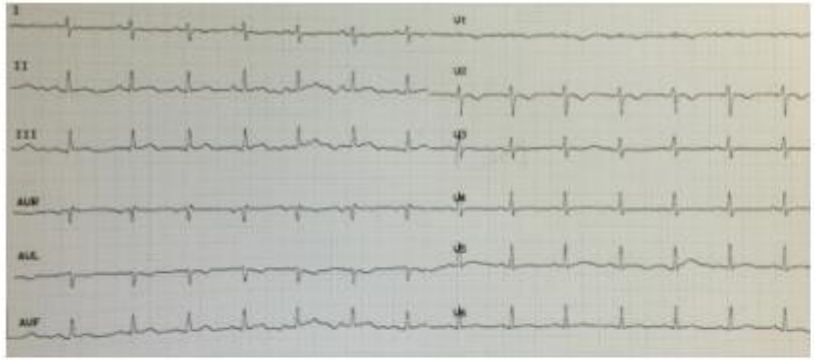
Imazio M. Myopericardial Diseases 2016; Springer

Sensitivity Of The ECG In The Diagnosis Of Cardiac Tamponade

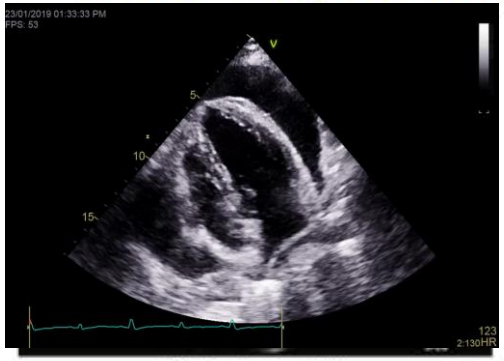
	%						
	Reddy et al,[34] 1978 (N = 19)	Guberman et al,[25] 1981 (N = 53)*	Singh et al,[8] 1984 (N = 16)	Levine et al,[6] 1991 (N = 50)	Cooper et al,[46] 1995 (N = 23)	Gibbs et al,[47] 2000 (N = 46)*	Pooled Sensitivity (95% CI)
Low voltage		40	50	56	22	39	42 (32-53)
Atrial arrhythmia	0	9		4			6 (1-11)
Electrical alternans		21		16			
ST-segment elevation		30	18				
PR-segment depression				18			

Abbreviation: CI, confidence interval.
*Not all patients had documentation of clinical findings.

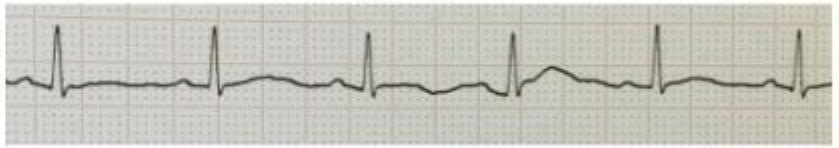
JAMA. 2007;297:1810-1818



Low voltages



"Swinging heart"



Electrical alternans= beat to beat alternation of QRS complex amplitude

Imazio M. Myopericardial Diseases 2016; Springer

Sensitivity Of The Chest Radiograph In The Diagnosis Of Cardiac Tamponade

Source	Patients, No.	Cardiomegaly, %
Guberman et al,[25] 1981	53	95
Singh et al,[8] 1984	16	94
Levine et al,[6] 1991	50	68
Gibbs et al,[47] 2000	46	100
Pooled sensitivity (95% CI)		89 (73-100)

Abbreviation: CI, confidence interval.

A pericardial effusion of >300 mL is responsible for an enlargement of cardiac silhouette on chest x-ray.

Imazio M. Myopericardial Diseases 2016; Springer

Echocardiographic Signs Of Cardiac Tamponade

Echocardiographic feature	Sensitivity	Specificity
Large pericardial effusion with swinging heart	n.a.	n.a.
Diastolic collapse of the right atrium (RA)	50–100 %	33–100 %
Duration of diastolic collapse of the RA as ratio on the cardiac cycle length >0.34	>90 %	100 %
Diastolic collapse of the right ventricle	48–100 %	72–100 %
Respiratory changes of the mitral E velocity >25 %, tricuspid E velocity >40 %	n.a.	n.a.
Inferior vena cava plethora (dilatation >20 mm and <50 % reduction of diameter with respiratory phases)	97 %	40 %

n.a. not available

Echocardiography in Cardiac Tam

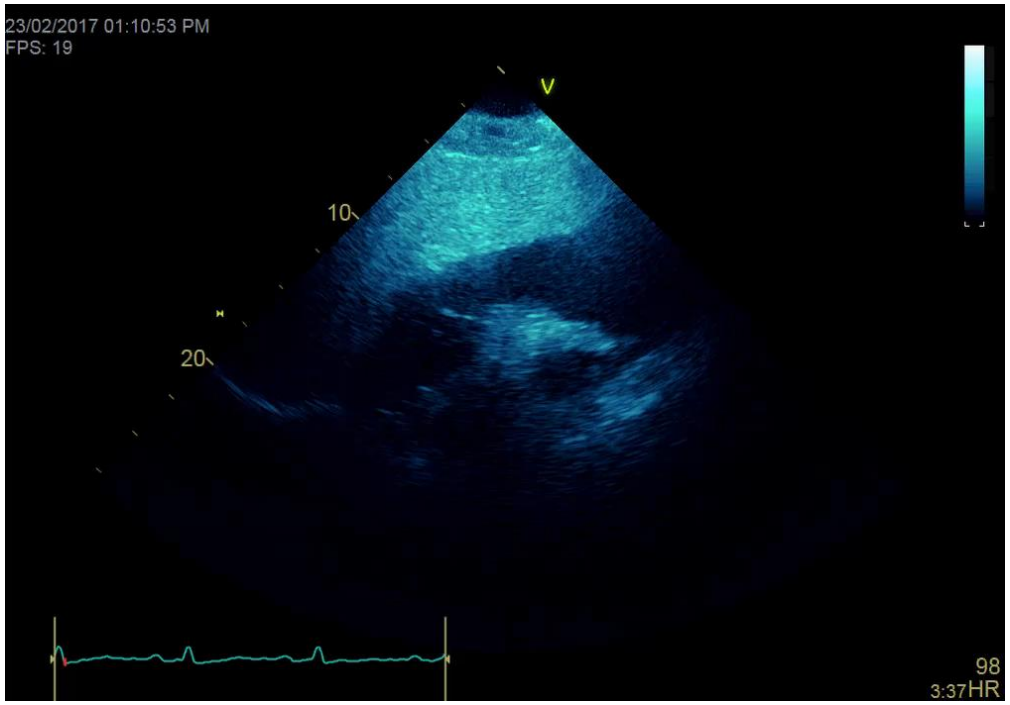
- **Chamber collapse**
- **Doppler Signs of Inc endence**
- **Inferior**

In any individual patient case, the number of abnormal echo/Doppler signs of cardiac tamponade present will increase as the hemodynamic and clinical severity of the pericardial effusion progresses.

Chamber collapse

- The lower pressure cardiac chambers (atria) are affected before the higher pressure cardiac chambers (ventricles).

- Compressive effect is more likely to be seen in the phase of cardiac cycle when filling pressure within a cavity is lower, as occurs during **systole for the atria** and during **diastole for the ventricles**.



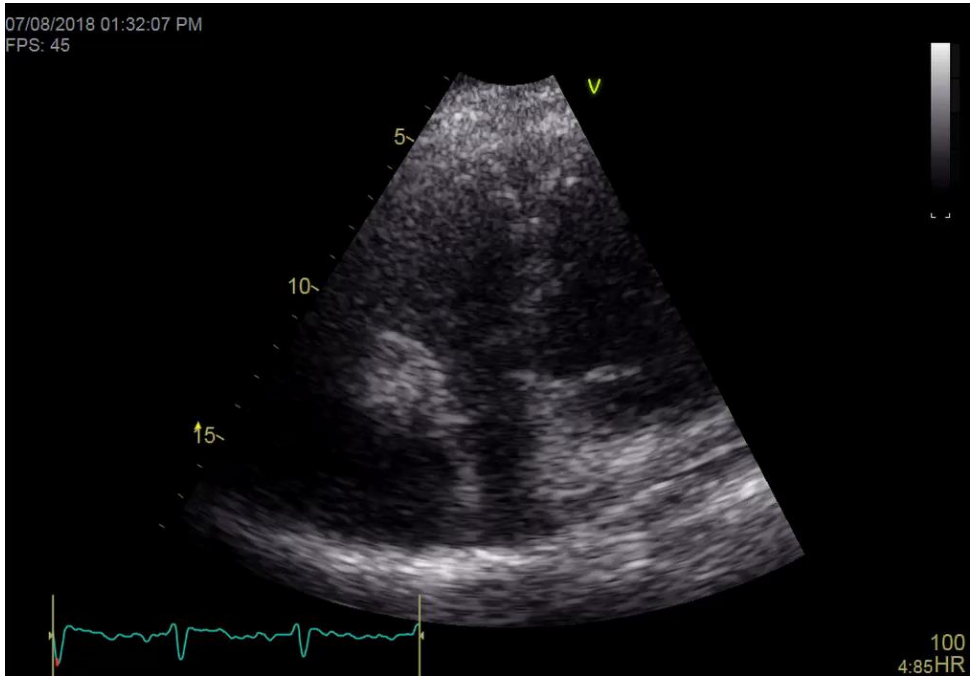
Chamber collapse

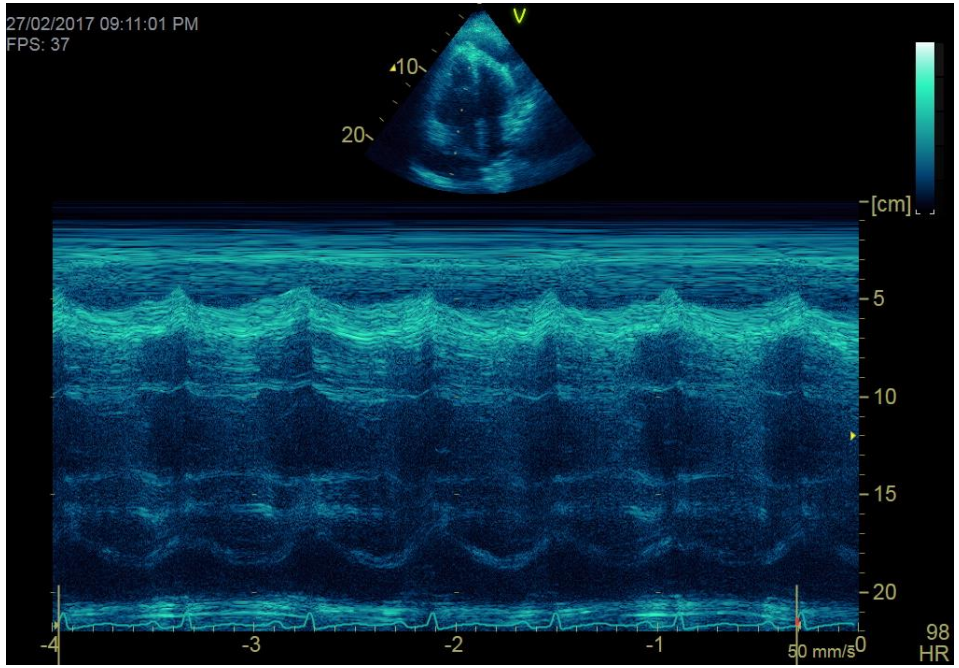
- **Right atrial chamber collapse (inversion)**

- **Right atrial chamber collapse begins first in late diastole.**
- **Commonly preceding typical clinical signs.**

- **It is sensitive but not specific sign of cardiac tamponade.**

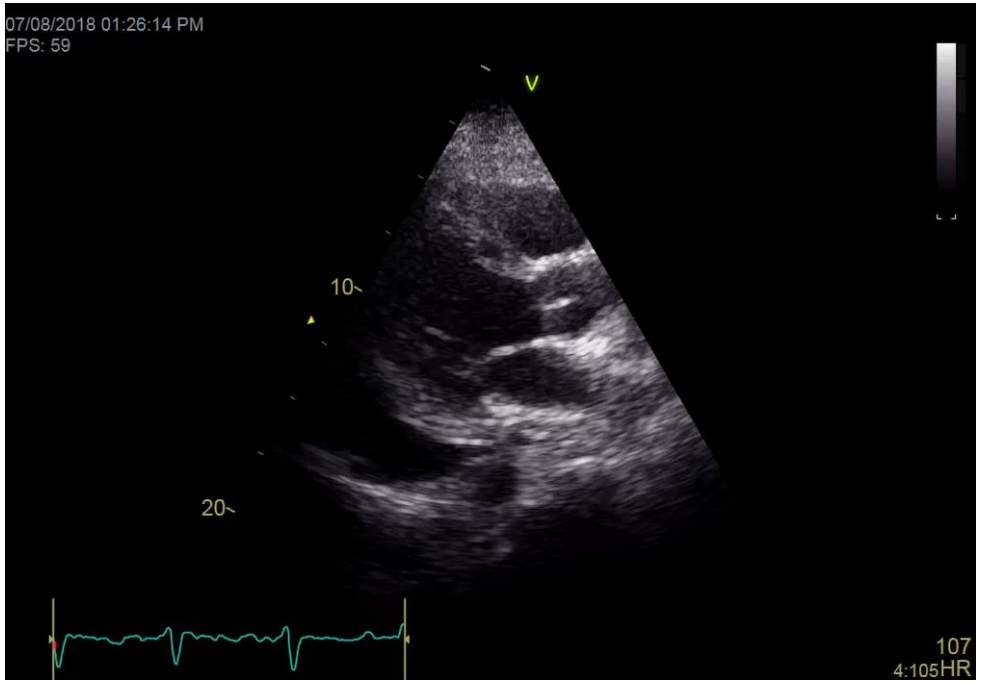
- **However, the specificity of this sign improves if the duration of right atrial collapse exceeds 30% of the cardiac cycle.**

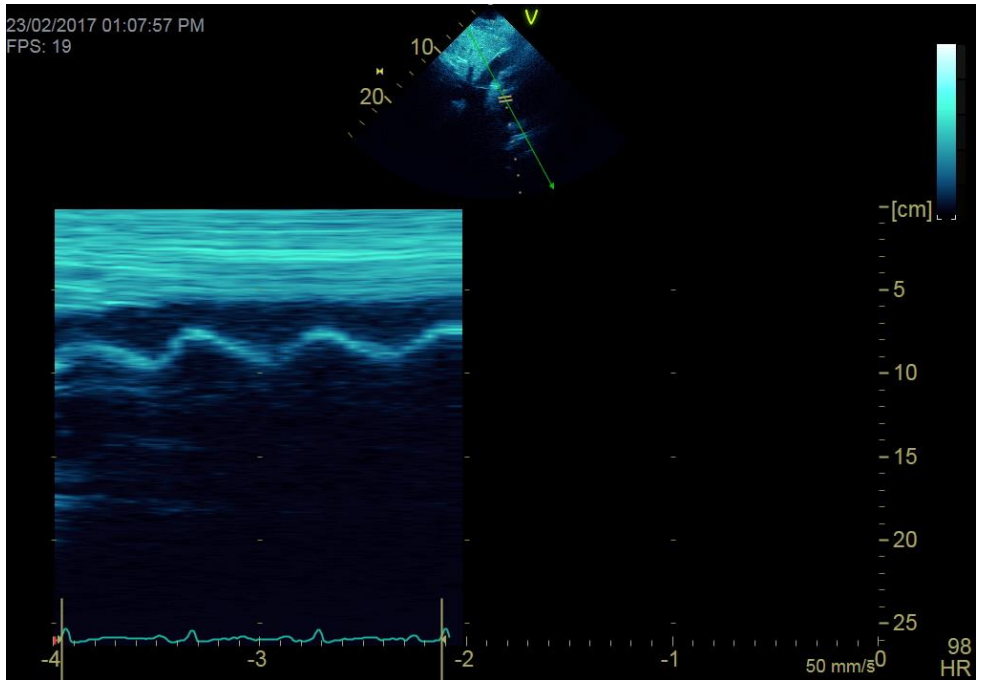




Chamber collapse

- **Right ventricular chamber collapse (inversion).**
- **Right ventricular wall inversion occurs typically in early diastole, when intracavitary RV pressure/volume is at a nadir**
- **As in right atrial wall collapse, the right-ventricular wall inversion will extend further into diastole (longer duration) as the hemodynamics of tamponade worsen.**
- **This echo finding is often best seen in the parasternal long-axis view, with transient “dimpling” of the right ventricular outflow tract anterior wall noted when the mitral valve opens.**



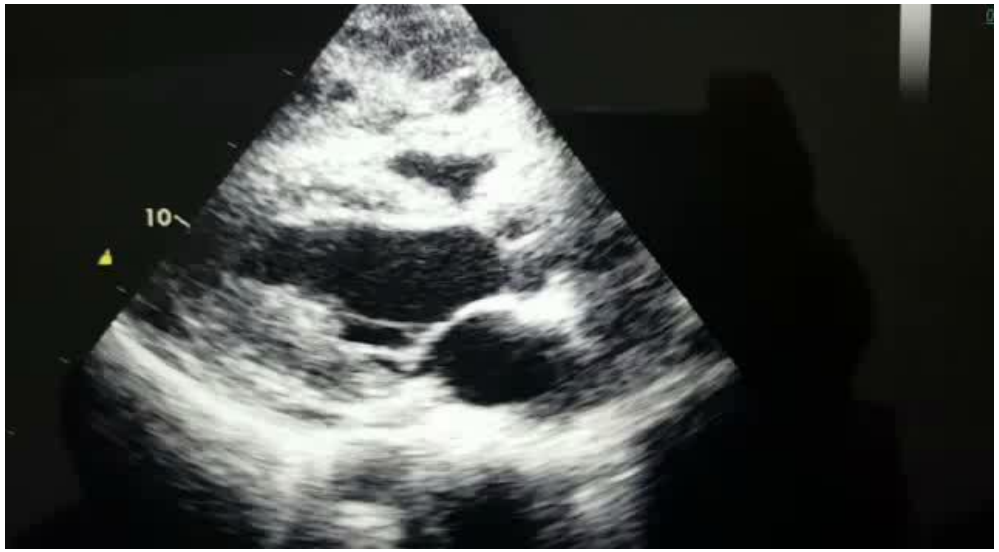


Chamber collapse

- **Left atrial and left ventricular chamber compression**

- Exclusively been described related to loculated collections occurring post cardiac surgery.

- However, circumferential pericardial effusion leading to left ventricular diastolic compression has rarely been reported in the setting of severe pulmonary hypertension

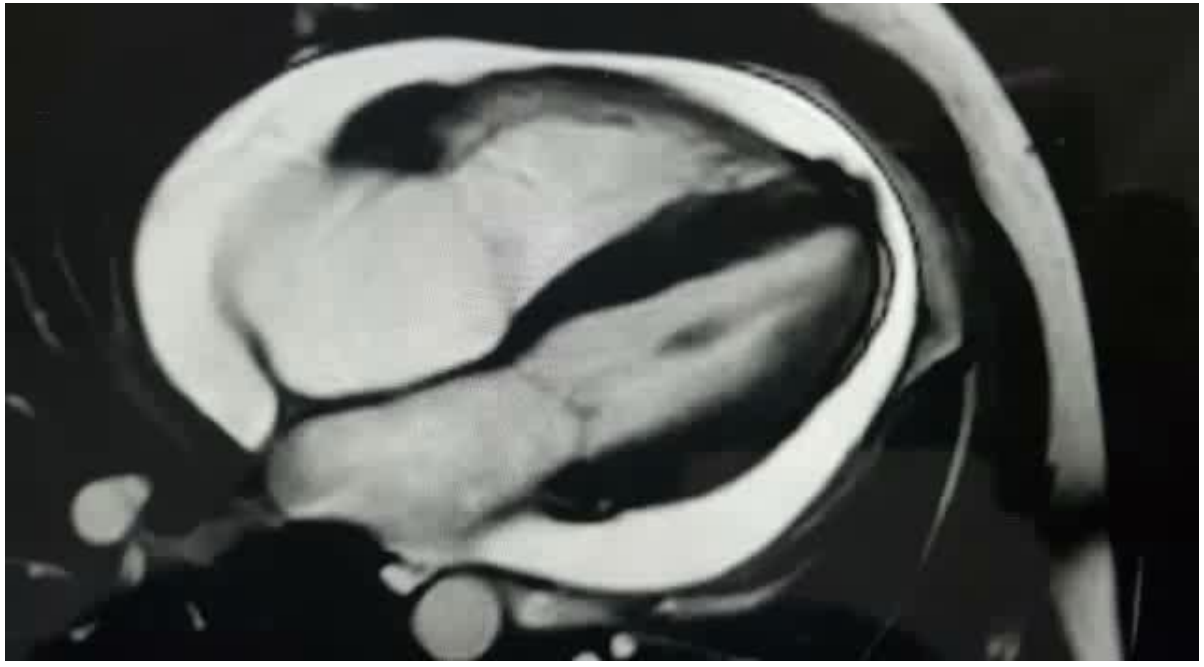


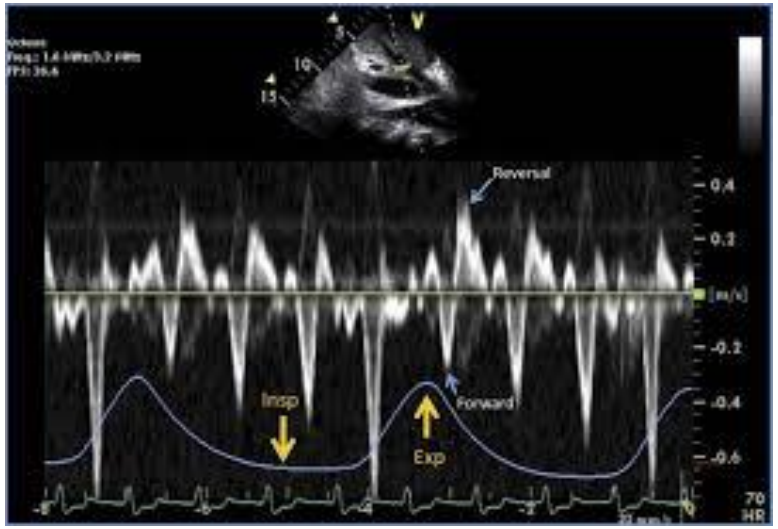
Caveats

Tamponade in patients with high intracardiac pressure

Ventricular interdependence doppler signs can be helpful in some cases.

Hepatic vein expiratory diastolic flow reversal.





Inferior Vena Cava Plethora (IVC)

- A dilated (>2.1 cm) with (<50%) respiratory ch
  size has >97% sensitivity of cardiac tampo
  physiology reflecting the elevated intr
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- It is considered
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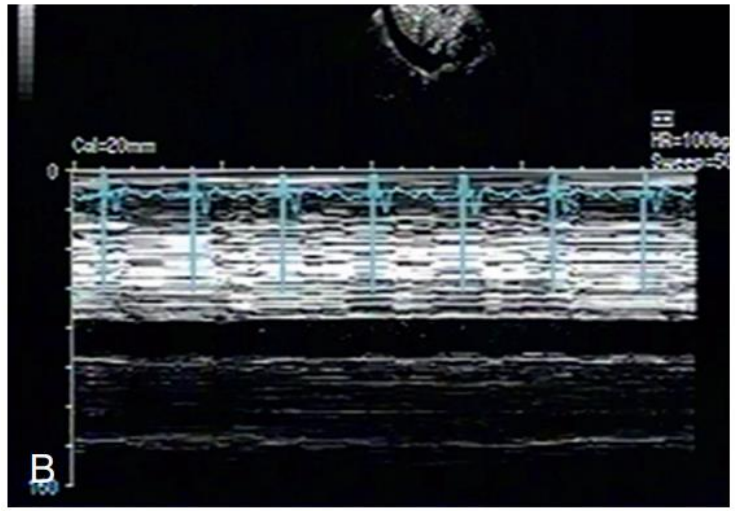

When IVC plethora does not present and there is Loculated effusion, post surgery or trauma, or in tamponade think about: hypovolemic patient

Echocardiographic or Doppler Signs of Increased Ventricular Interdependence

Echocardiographic or Doppler Sig
Increased Ventricular Interd

- As increasing pericardial fluid leads the cardiac chambers compete for less and less space.
- Thus
  - ease in
  - other
  - ie.
- Dopple
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  inflow ve
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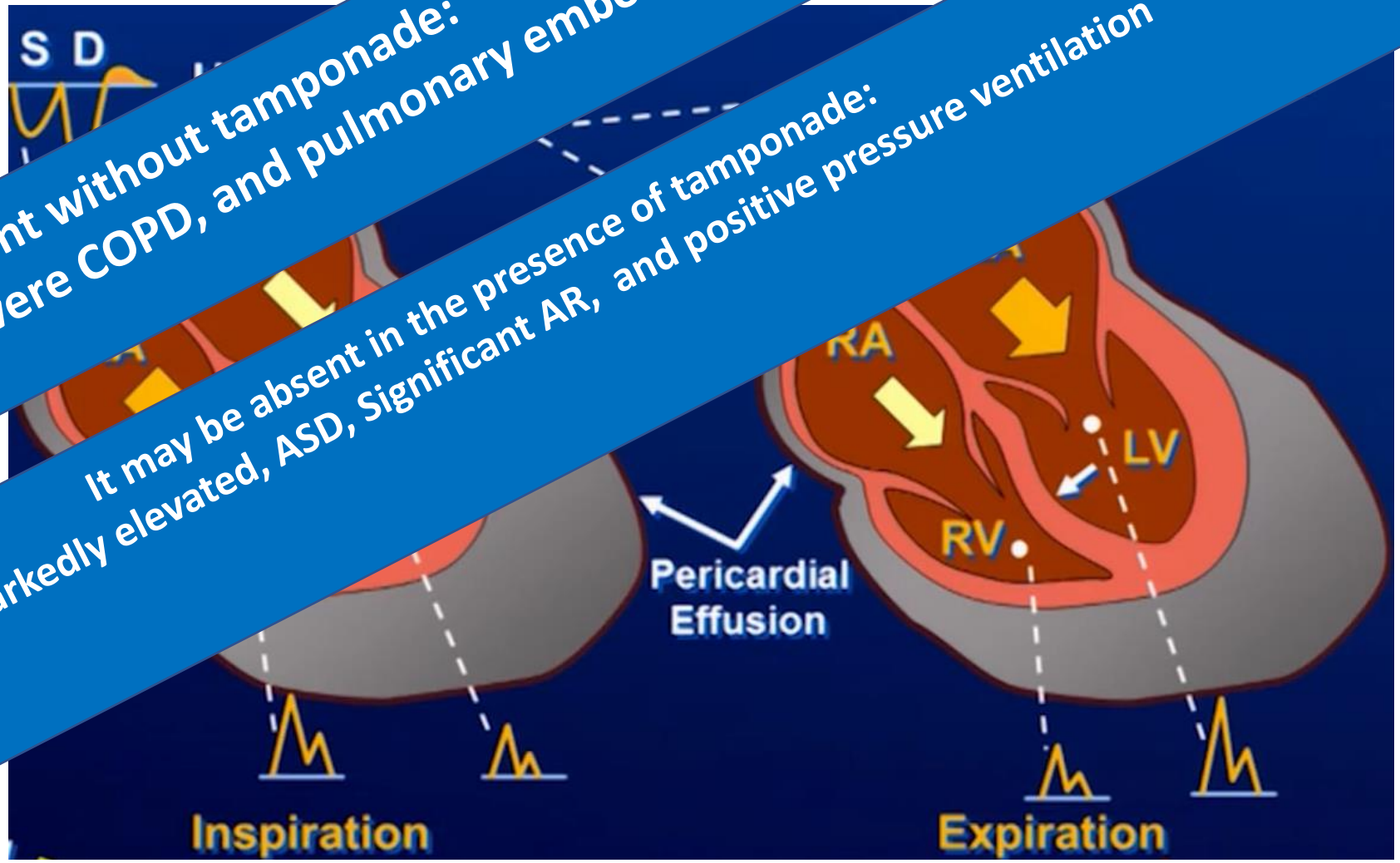
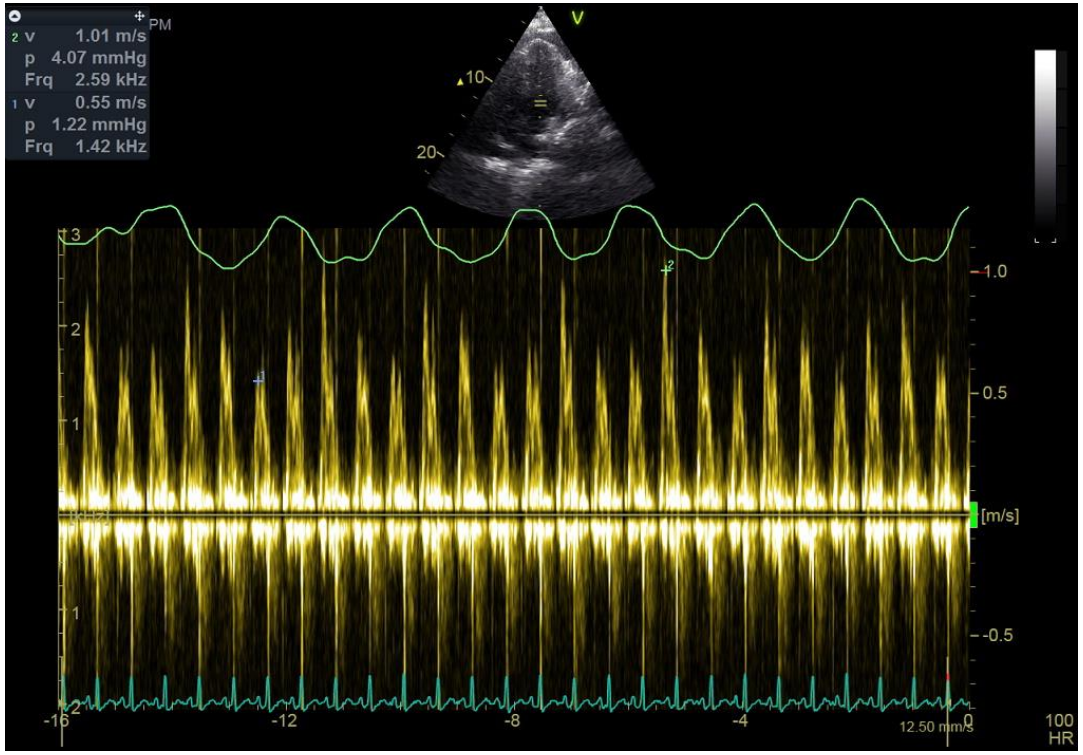
It is present without tamponade:
Marked dyspnea, severe COPD, and pulmonary embolism.

It may be absent in the presence of tamponade:
LVDP markedly elevated, ASD, Significant AR, and positive pressure ventilation



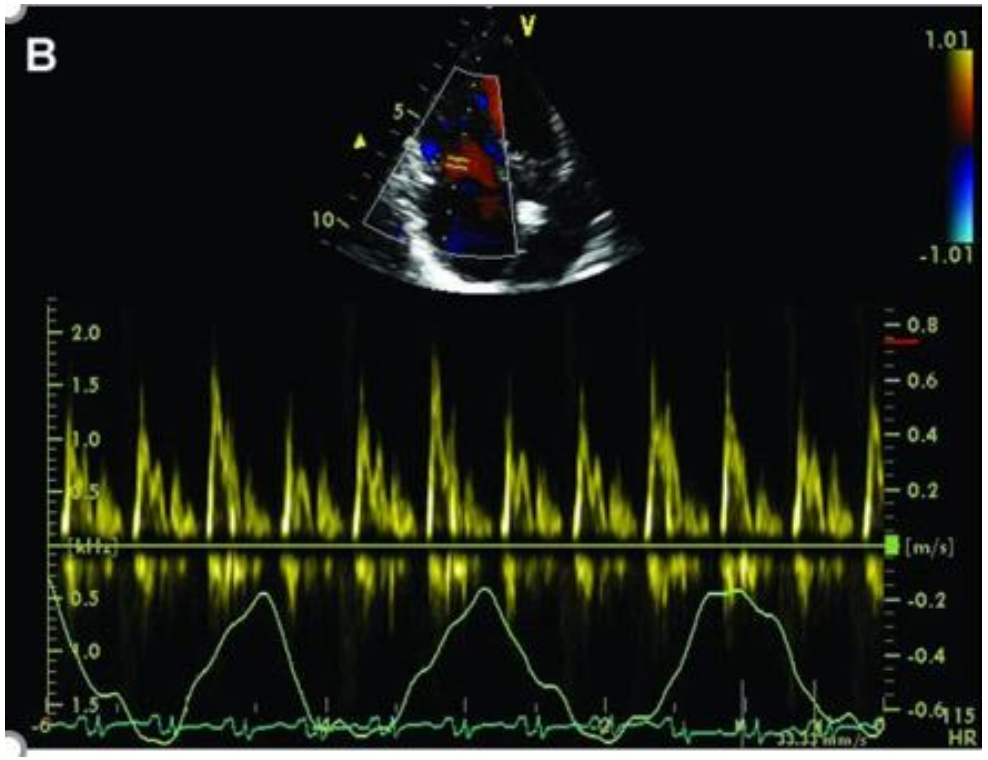
Echocardiographic or Doppler Signs of Increased Ventricular Interdependence

- **Mitral flow velocities:**
- **Mitral inflow E velocity will decrease significantly with inspiration (vs. expiration)**
- **A drop of more than 25% is considered consistent with significant tamponade physiology.**



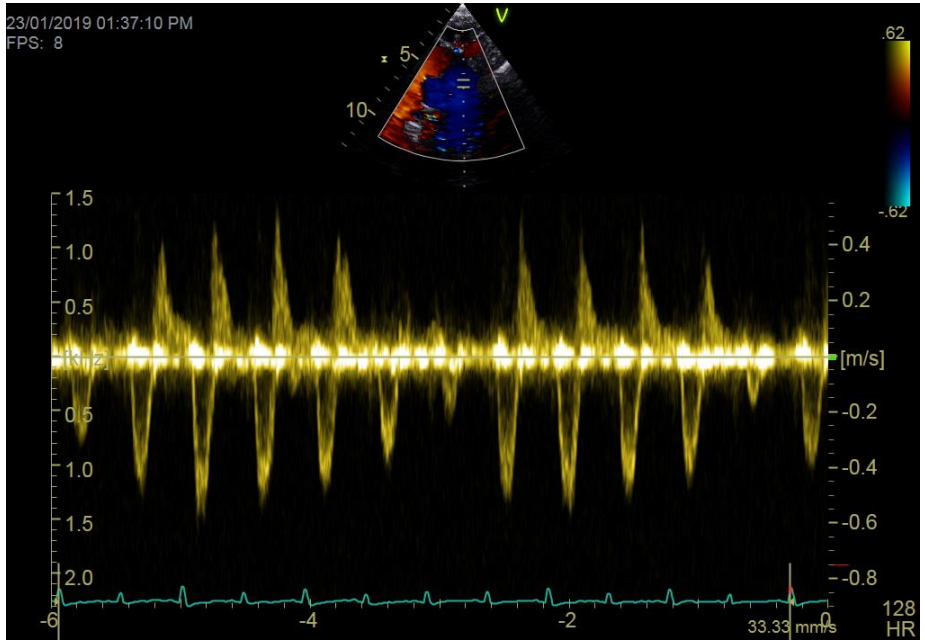
Echocardiographic or Doppler Signs of Increased Ventricular Interdependence

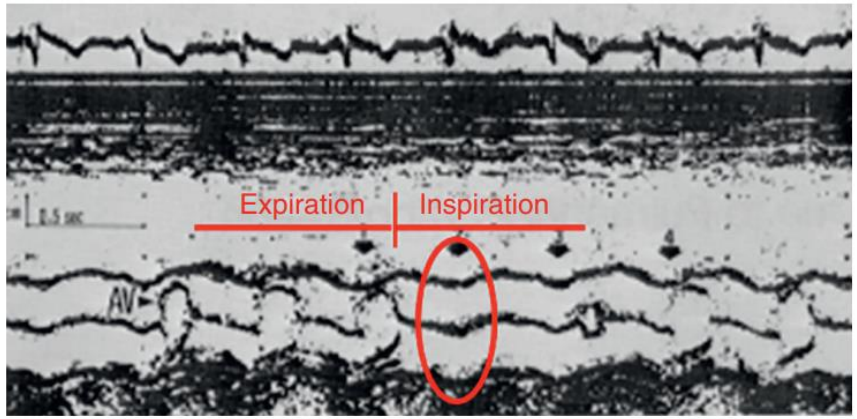
- **Tricuspid flow velocities:**
- **Tricuspid inflow E velocity will decrease significantly with expiration (vs. inspiration)**
- **A drop of more than 40% is considered consistent with significant tamponade physiology.**
- **This change should be noted on the first beat with expiration versus the first beat with inspiration**



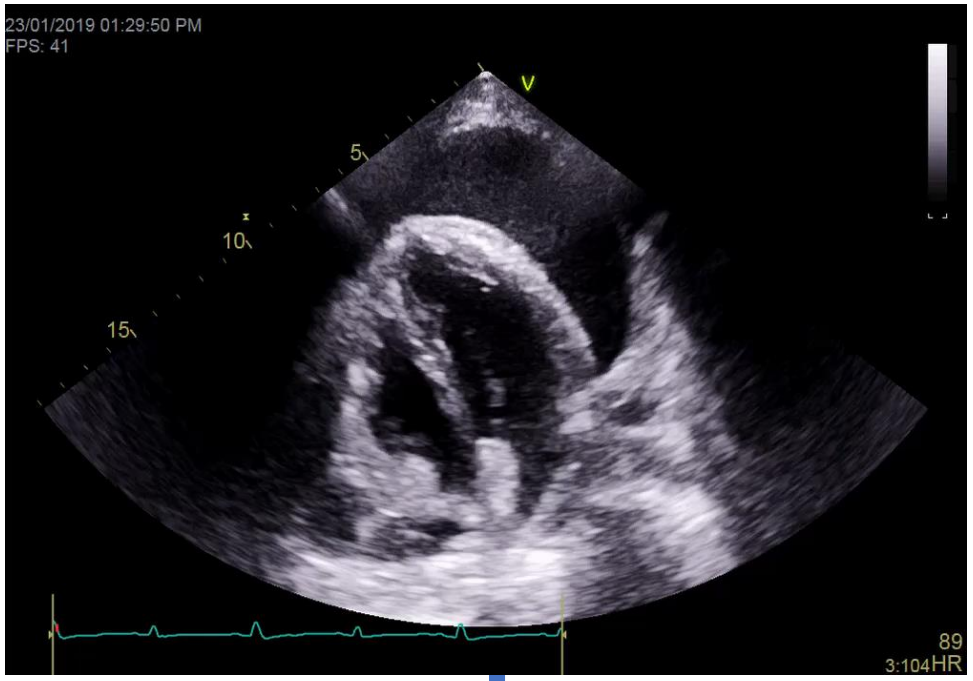
Echocardiographic or Doppler Signs of Increased Ventricular Interdependence

Aortic flow velocities:






Triage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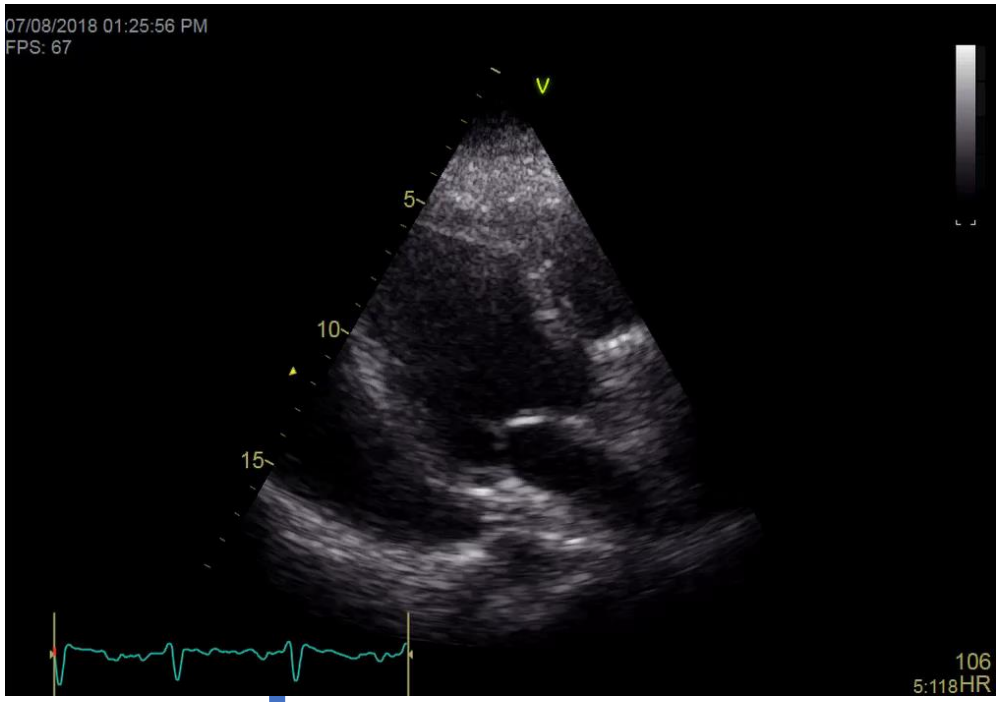
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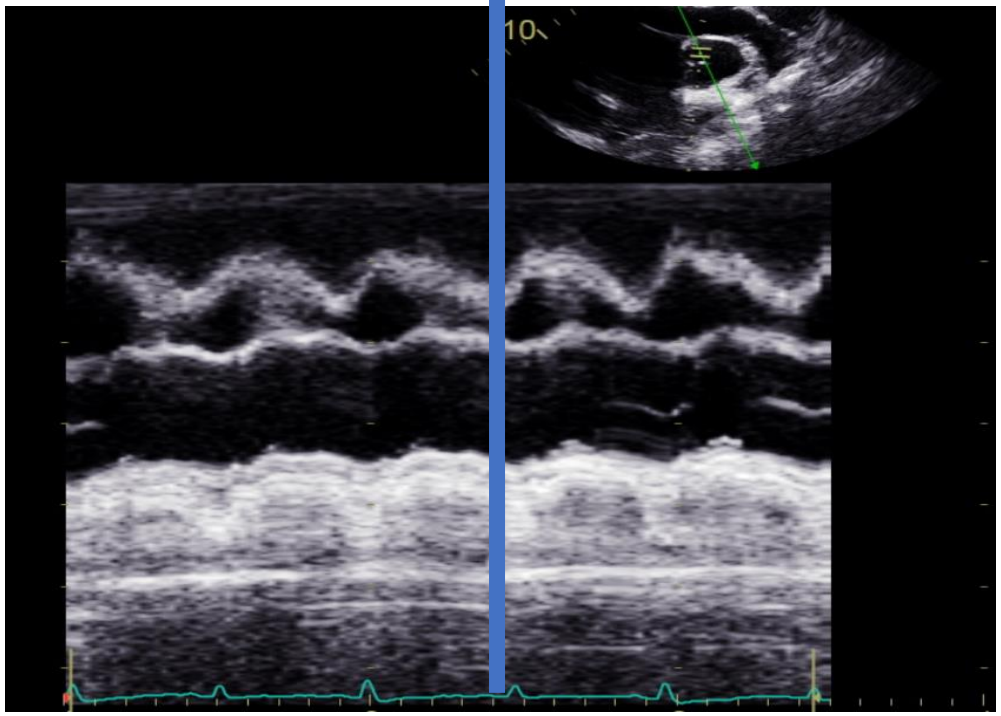
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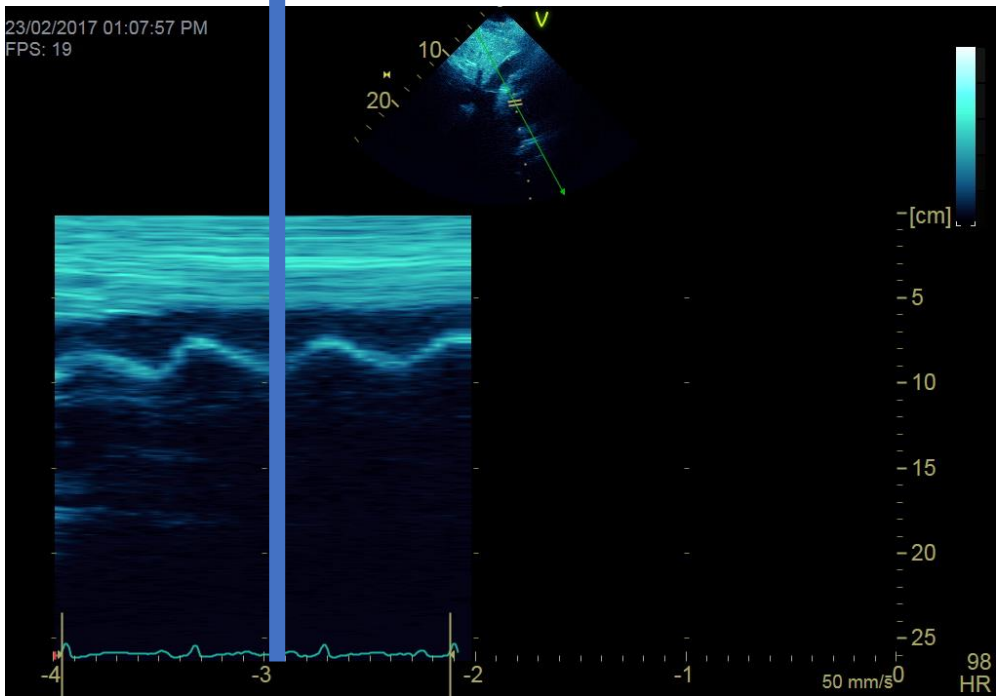
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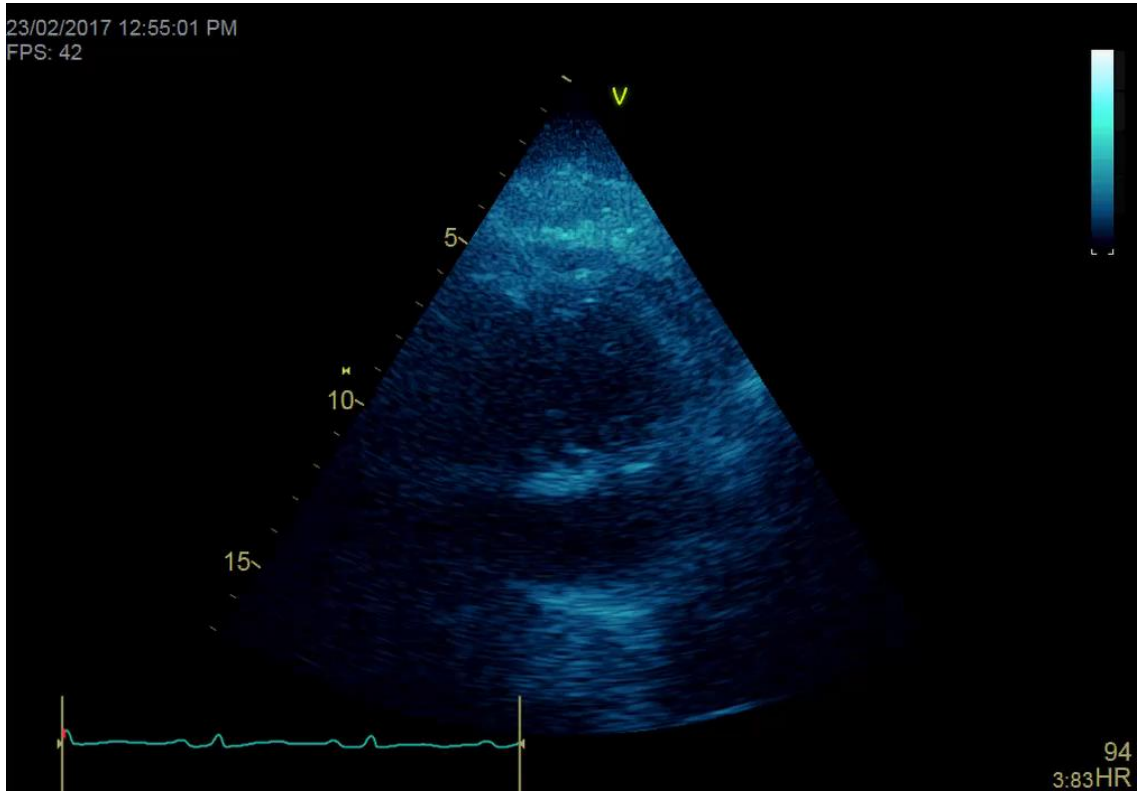
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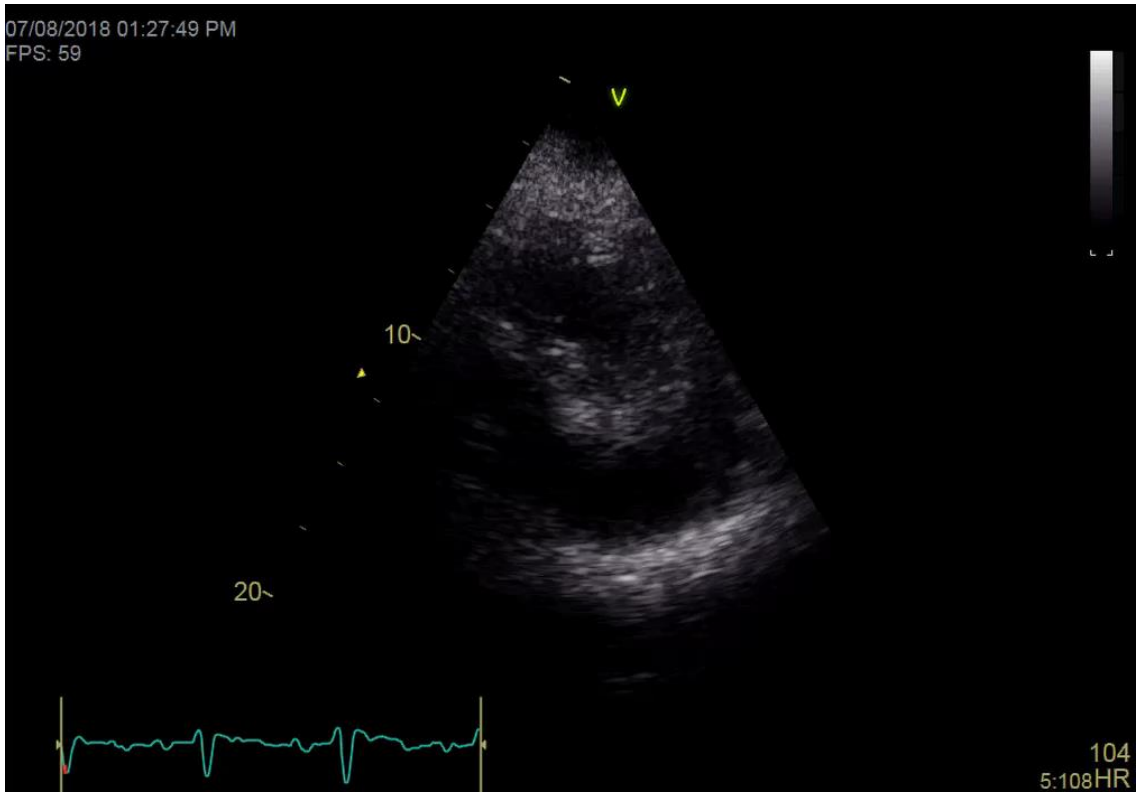
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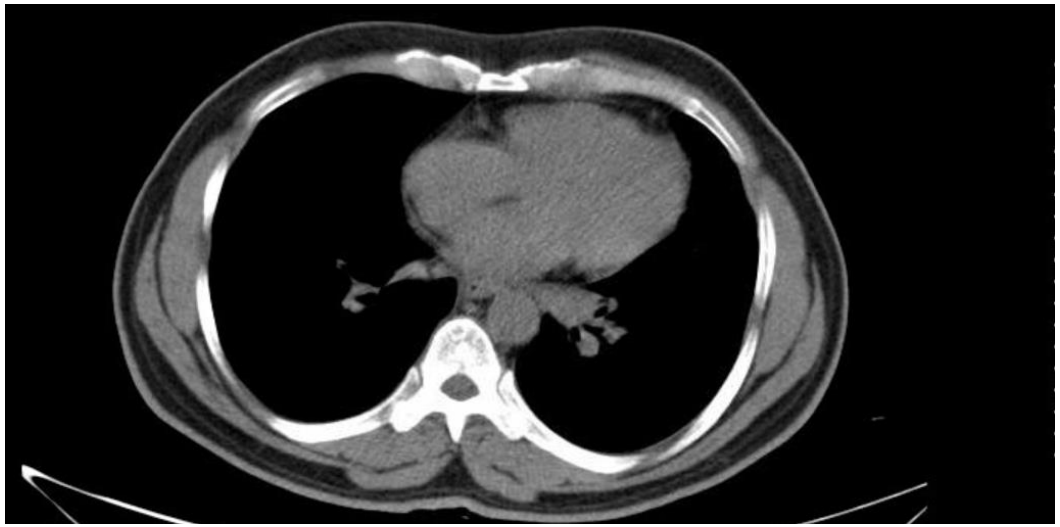


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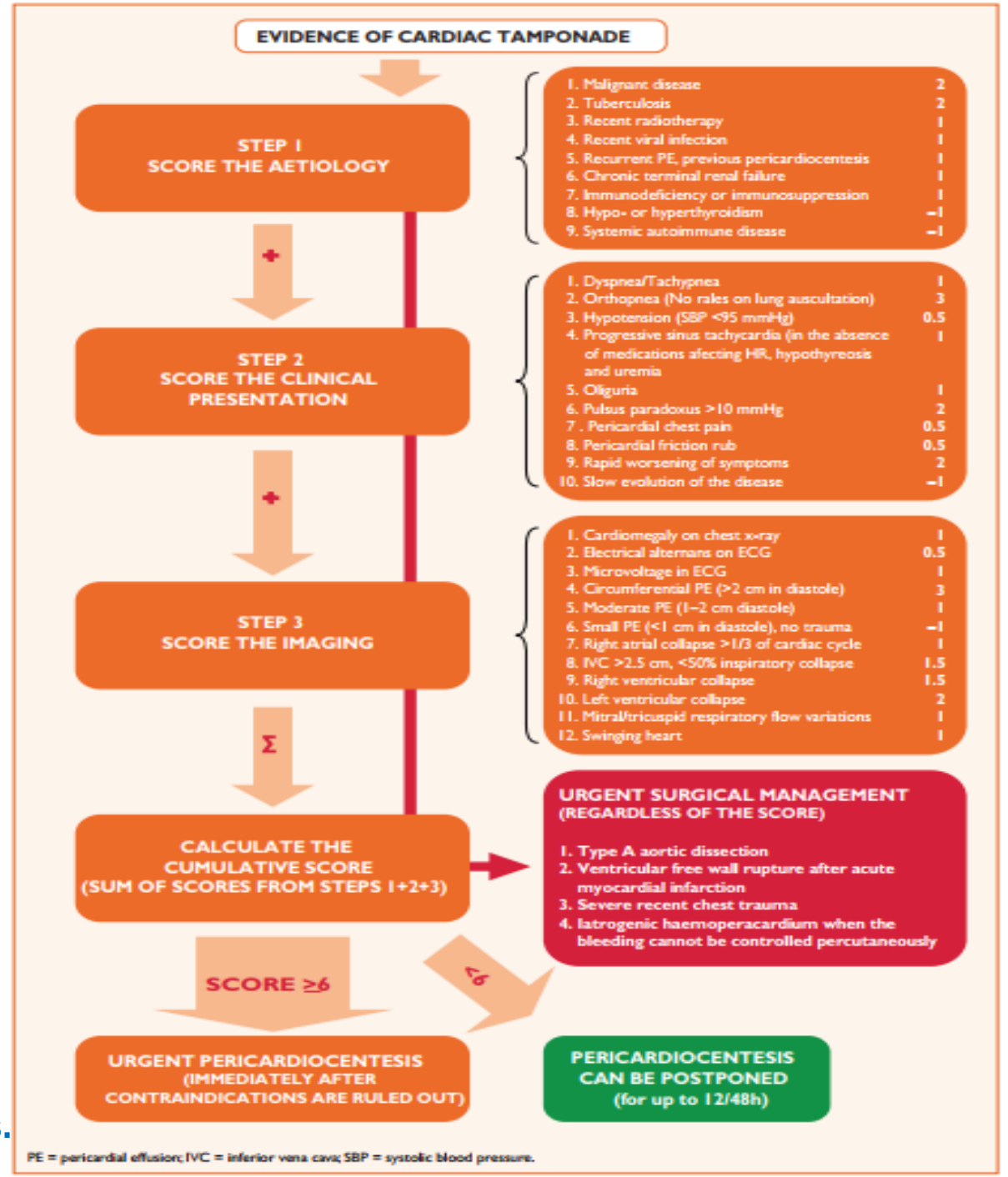
Triage cardiac tamponade proposed by the European Society of Cardiology Working Group on myocardial and pericardial diseases.



STEP 1
SCORE THE AETIOLOGY

1. Malignant disease	2
2. Tuberculosis	2
3. Recent radiotherapy	1
4. Recent viral infection	1
5. Recurrent PE, previous pericardiocentesis	1
6. Chronic terminal renal failure	1
7. Immunodeficiency or immunosuppression	1
8. Hypo- or hyperthyroidism	–1
9. Systemic autoimmune disease	–1

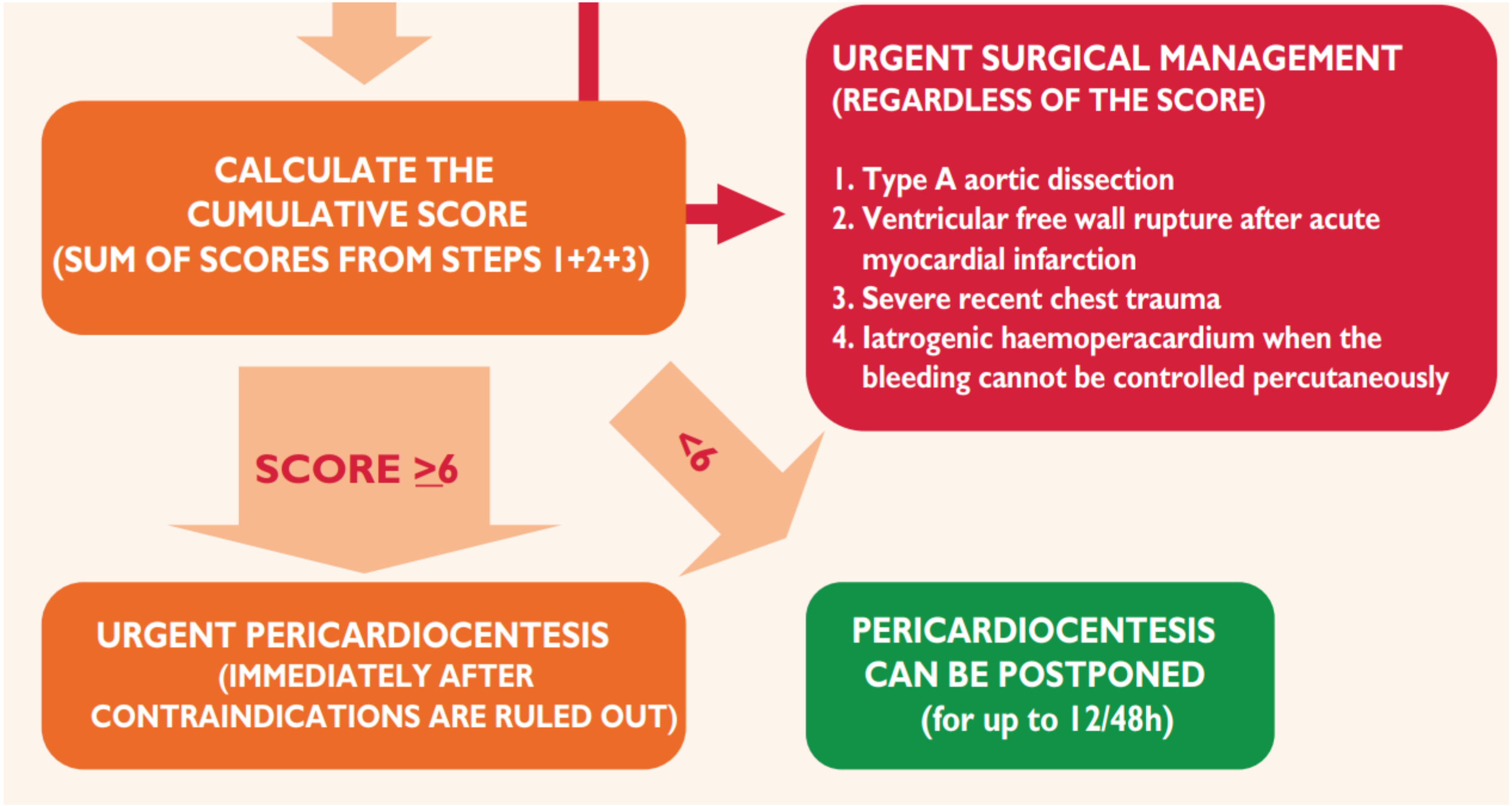
STEP 2
SCORE THE CLINICAL PRESENTATION

1. Dyspnea/Tachypnea	1
2. Orthopnea (No rales on lung auscultation)	3
3. Hypotension (SBP <95 mmHg)	0.5
4. Progressive sinus tachycardia (in the absence of medications afecting HR, hypothyreosis and uremia	1
5. Oliguria	1
6. Pulsus paradoxus >10 mmHg	2
7 . Pericardial chest pain	0.5
8. Pericardial friction rub	0.5
9. Rapid worsening of symptoms	2
10. Slow evolution of the disease	–1

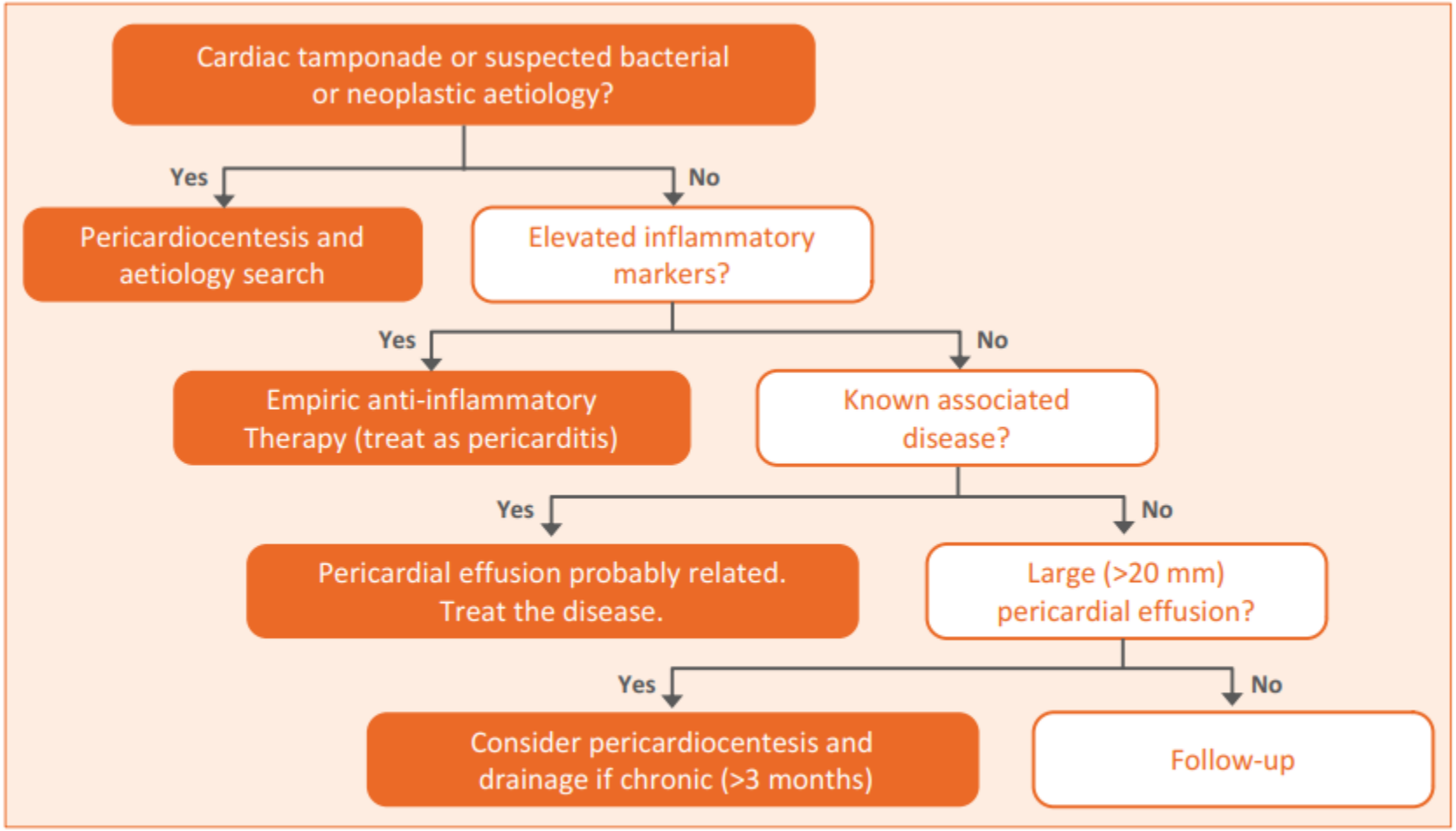
STEP 3
SCORE THE IMAGING

Σ

1. Cardiomegaly on chest x-ray	1
2. Electrical alternans on ECG	0.5
3. Microvoltage in ECG	1
4. Circumferential PE (>2 cm in diastole)	3
5. Moderate PE (1–2 cm diastole)	1
6. Small PE (<1 cm in diastole), no trauma	–1
7. Right atrial collapse >1/3 of cardiac cycle	1
8. IVC >2.5 cm, <50% inspiratory collapse	1.5
9. Right ventricular collapse	1.5
10. Left ventricular collapse	2
11. Mitral/tricuspid respiratory flow variations	1
12. Swinging heart	1


CALCULATE THE CUMULATIVE SCORE (SUM OF SCORES FROM STEPS 1+2+3)
URGENT SURGICAL MANAGEMENT (REGARDLESS OF THE SCORE)
1. Type A aortic dissection
2. Ventricular free wall rupture after acute myocardial infarction
3. Severe recent chest trauma
4. Iatrogenic haemoperacardium when the bleeding cannot be controlled percutaneously
SCORE ≥6
<6
URGENT PERICARDIOCENTESIS (IMMEDIATELY AFTER CONTRAINDICATIONS ARE RULED OUT)
PERICARDIOCENTESIS CAN BE POSTPONED (for up to 12/48h)

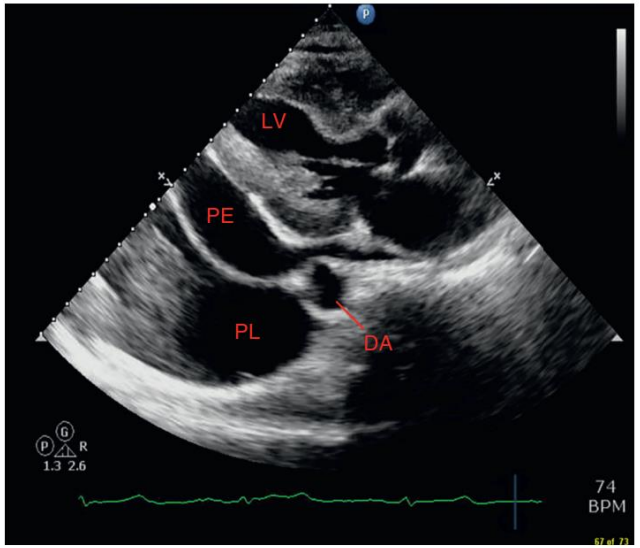
A simplified algorithm for pericardial effusion triage and management



*Eur Heart J 2013;**34**:1186-1197*

European Heart Journal (2015) - doi:10.1093/eurheartj/ehv318

Large pleural effusion with pericardial effusion

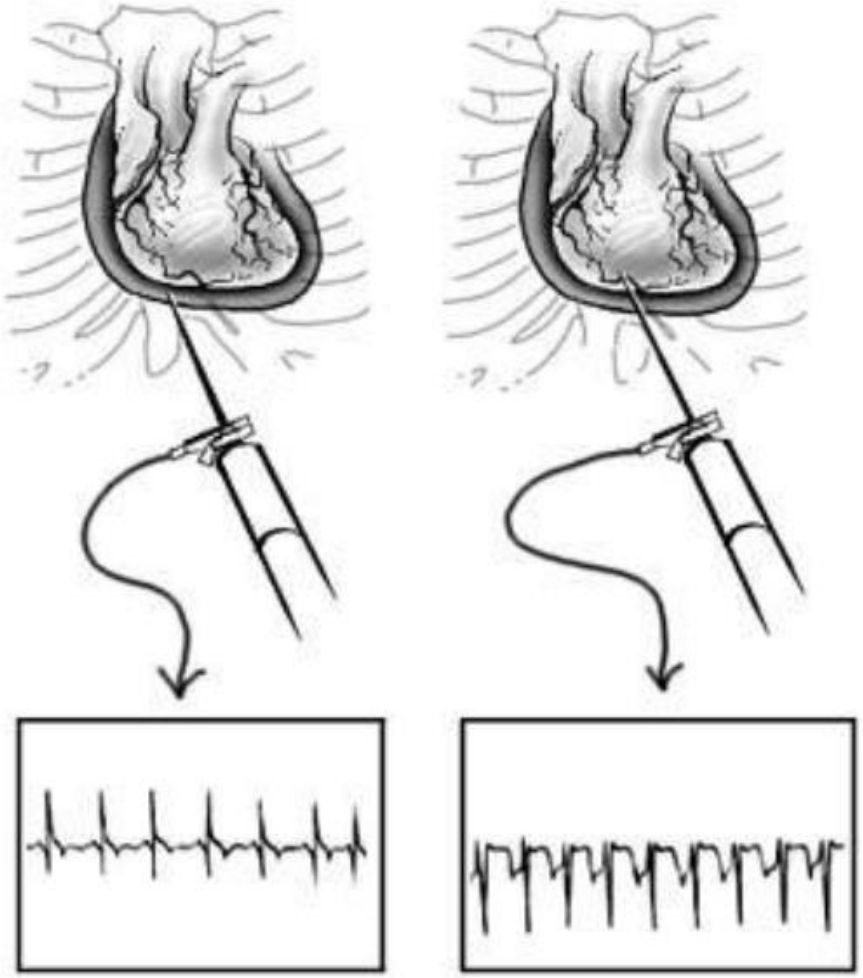


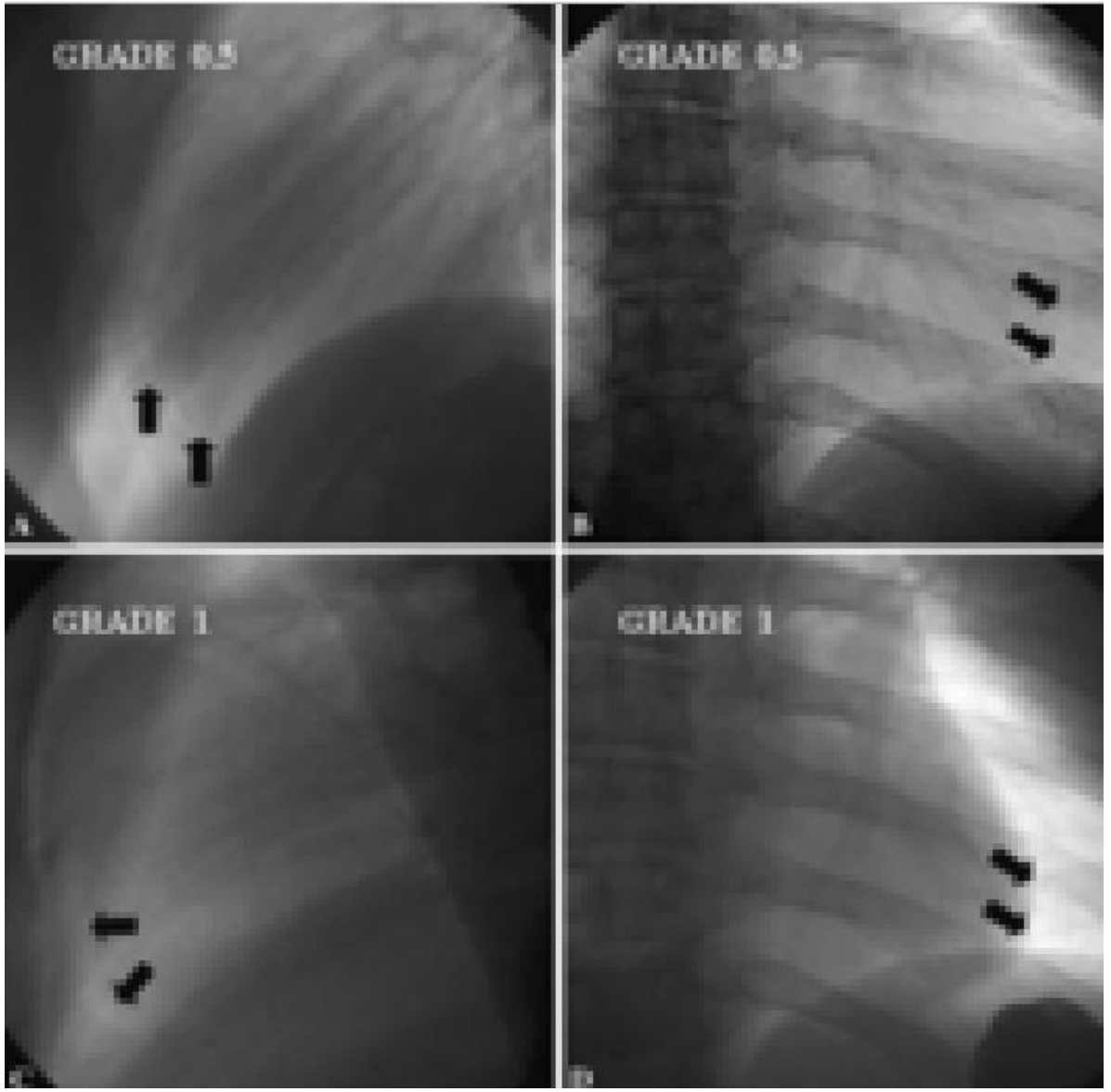
- **Large left pleural effusions:**
- **Occasionally been described as causing tamponade physiology sometimes with echo signs such as right ventricular diastolic collapse.**

- **In these situations, pericardial effusion is often present, and it can be difficult to decide which collection is more significant.**

- **Clinical experience usually favors first draining the more accessible pleural fluid, and then reassessing both clinically and by echocardiography**

Guiding the pericardiocentesis



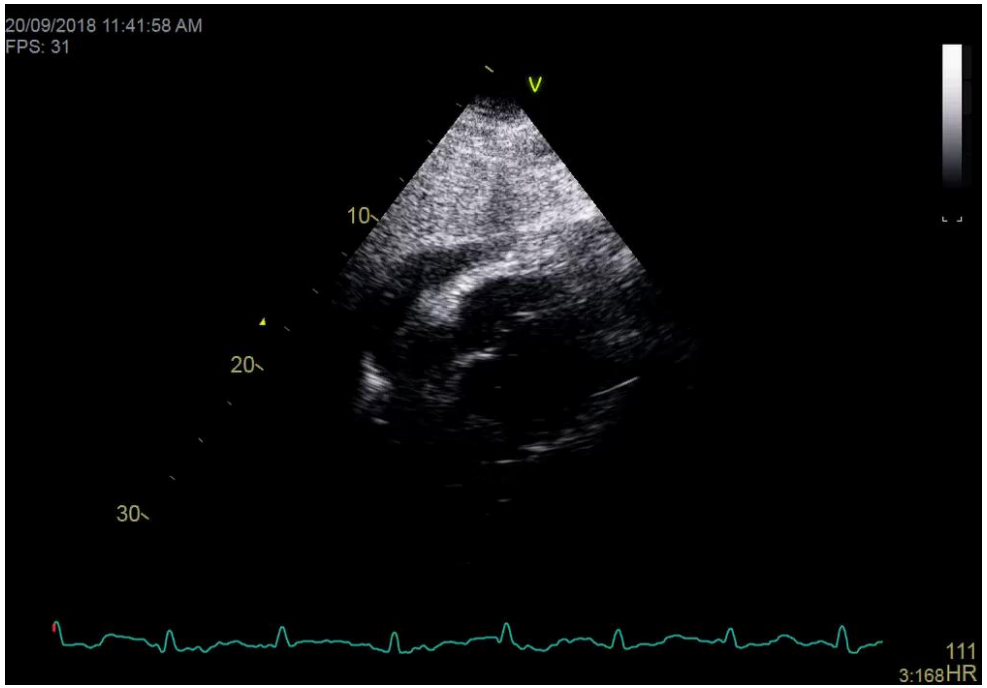


Echocardiography

- **Bedside**
- **Easy**
- **Can guide and monitor pericardiocentesis**
- **Look for the largest and nearest pocket collection.**

Echo-guided

Echo-monitored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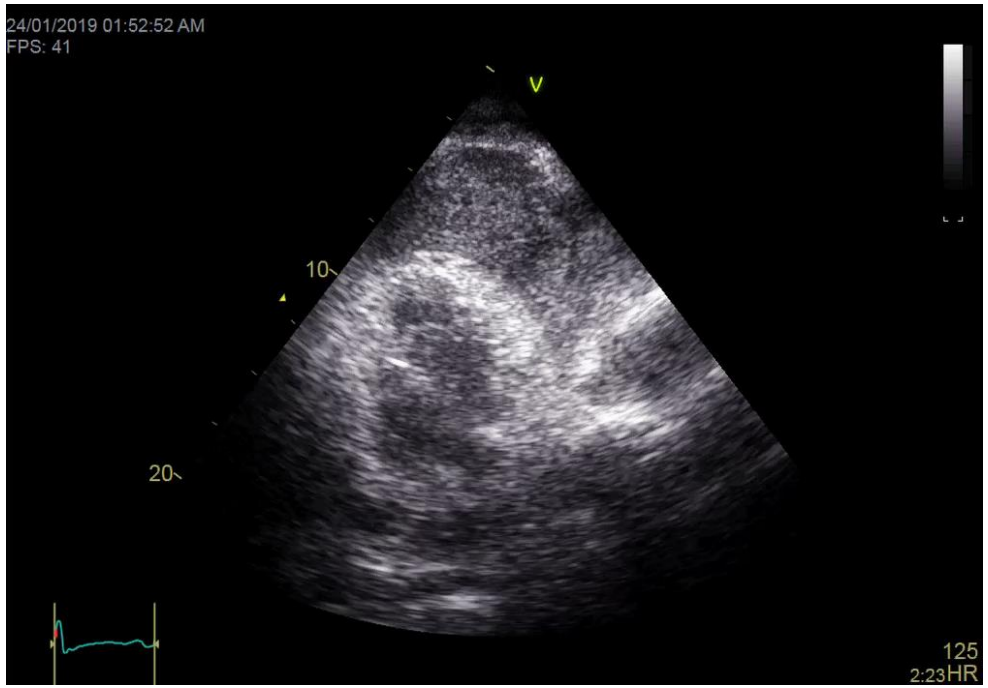
FPS: 31
10
20
30
111
3:168HR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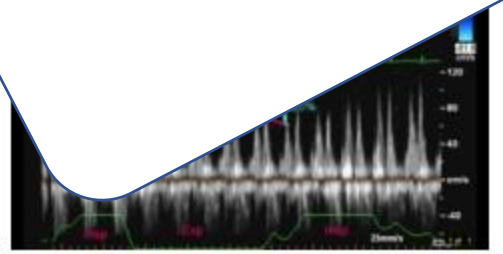
FPS: 41
10
20
125
2:23HR

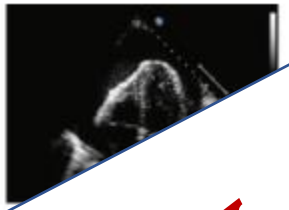
Take home messages

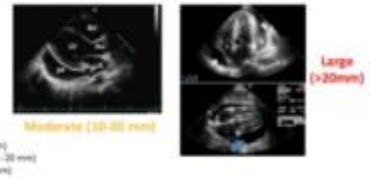
- **Tamponade is a clinical diagnosis and the use of echocardiography is for confirmation.**
- **Some echocardiographic features of tamponade may precede the clinical signs.**
- **Use the triage system for selecting the appropriate time of pericardiocentesis.**
- **The progression of tamponed varies according to the etiology.**
- **No blind pericardiocentesis in the presence of echocardiography.**

A pericardial effusion of >300 mL is responsible for an enlargement of cardiac silhouette on chest x-ray.

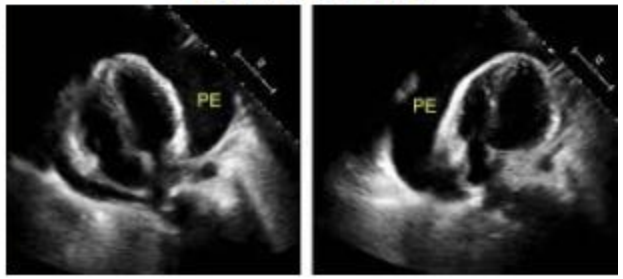
1. Cardiomegaly on chest x-ray	1
2. Electrical alternans on ECG	0.5
3. Microvoltage in ECG	1
4. Circumferential PE (>2 cm in diastole)	3
5. Moderate PE (1-2 cm in diastole)	1
6. Small PE (<1 cm in diastole), no trauma	
7. Right atrial collapse >1/3 of cardiac cy	
8. IVC >2.5 cm, <50% inspiratory c	
9. Right ventricular collapse	
10. Left atrial collapse	
11. Mitral/tricuspi	
12. Swinging	







Swinging heart



Thank you