Cardiac Tamponade
Non Invasive Assessment by Echo

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Cardiology Consultant
Non-invasive lab, Heart hospital, Hamad Medical Corporation
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)
Why Echo is Important in Cardiac Tamponade?

• To make the diagnosis
• For triage
• To guide and monitor the pericardiocentesis
Diagnosis

The **diagnosis of cardiac tamponade** is a clinical diagnosis that may be confirmed by echocardiographic examination. A definitive confirmation test for tamponade is pericardiocentesis, which can provide clinical and hemodynamic improvement after the procedure.
Signs

Classical Beck triad

(Beck 1935)

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

## Symptoms Of Cardiac Tamponade

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Dyspnea</td>
<td>88</td>
<td>87</td>
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<tr>
<td>Fever</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Chest pain</td>
<td>20</td>
<td></td>
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<tr>
<td>Cough</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Lethargy</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Palpitations</td>
<td>3</td>
<td>3</td>
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</tbody>
</table>

*JAMA. 2007;297:1810-1818*
Sensitivity of the physical examination in the diagnosis of cardiac tamponade

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</thead>
<tbody>
<tr>
<td>Pulsus paradoxus &gt;10 mm Hg</td>
<td>71†‡</td>
<td>77§</td>
<td>75§</td>
<td>98‡</td>
<td>86</td>
<td></td>
<td></td>
<td>56</td>
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<tr>
<td>Tachycardia</td>
<td></td>
<td>77</td>
<td></td>
<td>74</td>
<td></td>
<td>65</td>
<td>87</td>
<td>77 (69-85)</td>
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<tr>
<td>Hypotension</td>
<td></td>
<td>35</td>
<td>14</td>
<td>30</td>
<td>24</td>
<td>26</td>
<td>(16-36)</td>
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<tr>
<td>Hypertension†</td>
<td></td>
<td>80</td>
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<tr>
<td>Tachypnea</td>
<td></td>
<td>34</td>
<td>24</td>
<td>24</td>
<td></td>
<td></td>
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<tr>
<td>Diminished heart sounds</td>
<td></td>
<td>88</td>
<td>74</td>
<td>53</td>
<td>87</td>
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<tr>
<td>Elevated JVP</td>
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<tr>
<td>Peripheral edema</td>
<td>21</td>
<td>28</td>
<td></td>
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<tr>
<td>Pericardial rub</td>
<td>29</td>
<td>19</td>
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<tr>
<td>Hepatomegaly</td>
<td>55</td>
<td>28</td>
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<tr>
<td>Kussmaul sign</td>
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<tr>
<td>Pulse pressure, mm Hg</td>
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<tr>
<td>&gt;0</td>
<td>54</td>
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<tr>
<td>&gt;100</td>
<td>12</td>
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<tr>
<td>Total paradox</td>
<td>23</td>
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</tbody>
</table>

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.
<table>
<thead>
<tr>
<th>Pulsus Paradoxus, mm Hg†</th>
<th>&gt;12</th>
<th>&gt;10</th>
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</thead>
<tbody>
<tr>
<td><strong>Sensitivity, %</strong></td>
<td>98</td>
<td>98</td>
</tr>
<tr>
<td><strong>Specificity, %</strong></td>
<td>83</td>
<td>70</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>LR (95% CI)</th>
<th>Positive</th>
<th>Negative</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Positive</strong></td>
<td>5.9 (2.4-14)</td>
<td>0.03 (0-0.21)</td>
</tr>
<tr>
<td><strong>Negative</strong></td>
<td>3.3 (1.8-6.3)</td>
<td>0.03 (0.01-0.24)</td>
</tr>
</tbody>
</table>

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

First Korotkoff Sounds → Korotkoff Sounds → No Korotkoff Sounds

Intermittent Korotkoff Sounds → Continuous Korotkoff Sounds

Systolic Blood Pressure (Esp) = 110mmHg
Pulsus Paradoxus = 15mmHg
Systolic Blood Pressure (Insp) = 95mmHg
Diastolic Blood Pressure = 80mmHg

Arterial Pressure

Imazio M. Myopericardial Diseases 2016; Springer
Sensitivity Of The ECG In The Diagnosis Of Cardiac Tamponade

![ECG Image](image1)

![Echocardiogram Image](image2)

**Table**

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Low voltage</td>
<td>40</td>
<td>50</td>
<td>56</td>
<td>22</td>
<td>39</td>
<td>42 (32-53)</td>
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<tr>
<td>Atrial arrhythmia</td>
<td>0</td>
<td>9</td>
<td>5</td>
<td>4</td>
<td>39</td>
<td>6 (1-11)</td>
<td></td>
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<tr>
<td>Electrical alternans</td>
<td>21</td>
<td>18</td>
<td>16</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ST-segment elevation</td>
<td>30</td>
<td>18</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PR-segment depression</td>
<td>18</td>
<td></td>
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</tr>
</tbody>
</table>

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

**References**

JAMA. 2007;297:1810-1818

*Imazio M. Myopericardial Diseases 2016; Springer*
Sensitivity Of The Chest Radiograph In The Diagnosis Of Cardiac Tamponade

<table>
<thead>
<tr>
<th>Source</th>
<th>Patients, No.</th>
<th>Cardiomegaly, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guberman et al,25 1981</td>
<td>53</td>
<td>95</td>
</tr>
<tr>
<td>Singh et al,8 1984</td>
<td>16</td>
<td>94</td>
</tr>
<tr>
<td>Levine et al,6 1991</td>
<td>50</td>
<td>68</td>
</tr>
<tr>
<td>Gibbs et al,47 2000</td>
<td>46</td>
<td>100</td>
</tr>
<tr>
<td><strong>Pooled sensitivity (95% CI)</strong></td>
<td><strong>89 (73-100)</strong></td>
<td></td>
</tr>
</tbody>
</table>

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**

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

*n.a. not available*
Echocardiography in Cardiac Tamponade

- Chamber collapse
- Doppler Signs of Increased Ventricular Interdependence
- Inferior Vena Cava Plethora

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 change in size has >97% sensitivity of cardiac tamponade, physiology reflecting the elevated intrapericardial pressure transmitted to the right heart chambers.

- It is considered a nonspecific sign of cardiac tamponade. However, its presence in the setting of a patient with a moderate to large pericardial effusion is helpful in implying that the pericardial fluid has hemodynamic import.

- Mode recording of the IVC, which allows measurement of size and change in size with inspiration or sniff.

When IVC plethora does not present and there is tamponade think about: loculated effusion, post surgery or trauma, or in hypovolemic patient.
Echocardiographic or Doppler Signs of Increased Ventricular Interdependence
Echocardiographic or Doppler Signs of Increased Ventricular Interdependence

- As increasing pericardial fluid leads the cardiac chambers compete for less and less space.
- Thus, an increase in filling of one ventricle will cause a decrease in filling of the other ventricle.
- Doppler mitral and tricuspid diastolic inflow velocities are used to quantify these exaggerated changes.

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
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
4. Recent viral infection
5. Recurrent PE, previous pericardiocentesis
6. Chronic terminal renal failure
7. Immunodeficiency or immunosuppression
8. Hypo- or hyperthyroidism
9. Systemic autoimmune disease
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 affecting 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

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Score</th>
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</thead>
<tbody>
<tr>
<td>Cardiomegaly on chest x-ray</td>
<td>1</td>
</tr>
<tr>
<td>Electrical alternans on ECG</td>
<td>0.5</td>
</tr>
<tr>
<td>Microvoltage in ECG</td>
<td>1</td>
</tr>
<tr>
<td>Circumferential PE (&gt;2 cm in diastole)</td>
<td>3</td>
</tr>
<tr>
<td>Moderate PE (1–2 cm diastole)</td>
<td>1</td>
</tr>
<tr>
<td>Small PE (&lt;1 cm in diastole), no trauma</td>
<td>-1</td>
</tr>
<tr>
<td>Right atrial collapse &gt;1/3 of cardiac cycle</td>
<td>1</td>
</tr>
<tr>
<td>IVC &gt;2.5 cm, &lt;50% inspiratory collapse</td>
<td>1.5</td>
</tr>
<tr>
<td>Right ventricular collapse</td>
<td>1.5</td>
</tr>
<tr>
<td>Left ventricular collapse</td>
<td>2</td>
</tr>
<tr>
<td>Mitral/tricuspid respiratory flow variations</td>
<td>1</td>
</tr>
<tr>
<td>Swinging heart</td>
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</tbody>
</table>
CALCULATE THE CUMULATIVE SCORE (SUM OF SCORES FROM STEPS 1+2+3)

SCORE >6

URGENT PERICARDIOCENTESIS (IMMEDIATELY AFTER CONTRAINDICATIONS ARE RULED OUT)

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 haemopericardium when the bleeding cannot be controlled percutaneously

PERICARDIOCENTESIS CAN BE POSTPONED (for up to 12/48h)
A simplified algorithm for pericardial effusion triage and management

1. Cardiac tamponade or suspected bacterial or neoplastic aetiology?
   - Yes: Pericardiocentesis and aetiology search
   - No: Elevated inflammatory markers?
     - Yes: Empiric anti-inflammatory Therapy (treat as pericarditis)
     - No: Known associated disease?
       - Yes: Pericardial effusion probably related. Treat the disease.
       - No: Large (>20 mm) pericardial effusion?
         - Yes: Consider pericardiocentesis and drainage if chronic (>3 months)
         - No: Follow-up
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
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
2. Electrical alternans on ECG
3. Microvoltage in ECG
4. Circumferential PE (>2 cm in diastole)
5. Moderate PE (1-2 cm in diastole)
6. Small PE (<1 cm in diastole), no trauma
7. Right atrial collapse >1/3 of cardiac cycle
8. IVC >2.5 cm, <50% inspiratory collapse
9. Right ventricular collapse
10. Left atrial collapse
11. Mitral/tricuspid regurgitation
12. Swinging heart