What is your comfort level with making the diagnosis of cardiac tamponade in a patient with a pericardial effusion?

A. Low
B. Medium
C. High
Which part of pericardial effusion/cardiac tamponade evaluation do you find to be most challenging?

A. Recognizing pertinent symptoms
B. Recognizing pertinent physical exam findings
C. Reviewing imaging studies (echo)
D. Reviewing hemodynamics (cath)
E. Deciding whether to perform pericardiocentesis
What is the most sensitive physical exam sign in the diagnosis of cardiac tamponade?

A. Diminished heart sounds
B. Pulsus paradoxus >10 mm Hg
C. Hypotension
D. Elevated JVP
E. Tachycardia
What is the hemodynamic hallmark of cardiac tamponade when measured in the cath lab?

A. Elevated LVEDP
B. Aortic hypotension
C. Dip and plateau or “square root” sign
D. Diastolic equalization of chamber pressures
Which method of pericardiocentesis is preferable in terms of risk/benefits?

A. Subxiphoid
B. Parasternal
C. Apical
D. It depends…
Objectives

- Briefly review pericardial structure and function
- Describe hemodynamic pathophysiology
- Discuss physical examination data
- Outline a method to approach echocardiographic evaluation of effusion
- Decide between options for therapy in tamponade
Pericardial Anatomy - Layers

**Fibrosa**
- Adherent to parietal serosal layer
- Not a true sac

**Serosa**
- Reflects to form visceral (epicardium) and parietal pericardium
Pericardial Anatomy - Histology

- Serosal layer (both visceral and parietal pericardium)
  - Monocellular layer
  - Lined with mesothelial cells – microvilli
    - Bear friction, facilitate fluid/ion exchange
    - Actin filaments
    - Cytoskeletal filaments

Serosal Layers of the Pericardium

A. Full thickness parietal pericardium

B. Blood vessels within parietal pericardium

C. Visceral pericardium with microvilli and epicardial adipose

D. Visceral pericardium with thin layer of mesothelial cells separating myocardium
Pericardial Anatomy - Histology

- **Fibrosal layer**
  - Fibrocollagenous tissue
  - Elastin
  - Approximately 1-3 mm thick

Pericardial Anatomy – Parietal Sac
Pericardial Anatomy – Reflections/Sinuses
<table>
<thead>
<tr>
<th>Functions of the pericardium</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mechanical</strong></td>
</tr>
<tr>
<td>Effects on chambers</td>
</tr>
<tr>
<td>Limits short-term cardiac distention</td>
</tr>
<tr>
<td>Facilitates cardiac chamber coupling and interaction</td>
</tr>
<tr>
<td>Maintains pressure-volume relation of the cardiac chambers and output from them</td>
</tr>
<tr>
<td>Maintains LV geometry</td>
</tr>
<tr>
<td><strong>Effects on whole heart</strong></td>
</tr>
<tr>
<td>Lubricates, minimizes friction</td>
</tr>
<tr>
<td>Equalizes gravitation and inertial, hydrostatic forces</td>
</tr>
<tr>
<td>Mechanical barrier to infection</td>
</tr>
<tr>
<td><strong>Immunologic</strong></td>
</tr>
<tr>
<td><strong>Vasomotor</strong></td>
</tr>
<tr>
<td><strong>Fibrinolytic</strong></td>
</tr>
</tbody>
</table>
Etiologies of Pericardial Effusions

- Idiopathic
- Infectious
  - Viral
  - Bacterial
- Inflammatory/CTD
- Post MI
  - Acute after STEMI
  - Delayed – Dressler’s
- Systemic disease
  - Uremia
  - Hypothyroidism
- Malignancy
- Miscellaneous
  - Trauma
  - Surgery
  - Pacemaker placement
Objectives

- Briefly review pericardial structure and function
- Describe hemodynamic pathophysiology
- Discuss physical examination data
- Outline a method to approach echocardiographic evaluation of effusion
- Decide between options for therapy in tamponade
Cardiac Tamponade Hemodynamics

- Increased Intrapericardial pressures
- Reduced cardiac output
- Increased atrial pressure
- Increased systemic venous congestion
- Increased impedance of venous return
Increasing Pericardial Effusion Volume

Pressure

Left Heart Filling Pressure
Right Heart Filling Pressure
Intrapercardial Pressure

Cardiac Output
Normal

Increasing Pericardial Effusion Volume
Normal IVS Interdependence
“Pulsus Normalus”

Expiration

Inspiration

Expiration

Right Ventricle

Left Ventricle
Exaggerated IVS Interdependence
Pulsus Paradoxus
I feel comfortable assessing for pulsus paradoxus

A. True
B. False
Measurement of Pulsus Paradoxicus
Objectives

- Briefly review pericardial structure and function
- Describe hemodynamic pathophysiology
- Discuss physical examination data
- Outline a method to approach echocardiographic evaluation of effusion
- Decide between options for therapy in tamponade
Does This Patient With a Pericardial Effusion Have Cardiac Tamponade?

Christopher L. Roy, MD
Melissa A. Minor, MD
M. Alan Brookhart, PhD
Niteesh K. Choudhry, MD, PhD

CLINICAL SCENARIOS

Case 1
A 55-year-old woman with chronic obstructive pulmonary disease presents to your office with 2 weeks of progressive dyspnea. She had breast cancer diagnosed and treated more than 10 years ago and has had no evidence of recurrence. She was seen in the emergency department 1 week ago, where her evaluation included an echocardiogram that demonstrated a moderate-sized (15 mm in maximum width), circumferential pericardial effusion without echocardiographic evidence of cardiac tamponade. During your examination, you note tachycardia and faint heart sounds. A pulsus paradoxus is 6 mm Hg with a blood pressure of 100/60 mm Hg, the jugular venous pressure is not elevated, and auscultation of her lungs reveals diminished breath sounds. You obtain a chest radiograph that is unchanged from previous films and that shows hyperinflated, clear lung fields and no enlargement of the cardiac silhouette. You

Context Cardiac tamponade is a state of hemodynamic compromise resulting from cardiac compression by fluid trapped in the pericardial space. The clinical examination may assist in the decision to perform pericardiocentesis in patients with cardiac tamponade diagnosed by echocardiography.

Objective To systematically review the accuracy of the history, physical examination, and basic diagnostic tests for the diagnosis of cardiac tamponade.

Data Sources MEDLINE search of English-language articles published between 1966 and 2006, reference lists of these articles, and reference lists of relevant textbooks.

Study Selection We included articles that compared aspects of the clinical examination to a reference standard for the diagnosis of cardiac tamponade. We excluded studies with fewer than 15 patients. Of 787 studies identified by our search strategy, 8 were included in our final analysis.

Data Extraction Two authors independently reviewed articles for study results and quality. A third reviewer resolved disagreements.

Data Synthesis All studies evaluated patients with known tamponade or those referred for pericardiocentesis with known effusion. Five features occur in the majority of patients with tamponade: dyspnea (sensitivity range, 87%-89%), tachycardia (pooled sensitivity, 77%; 95% confidence interval [CI], 69%-85%), pulsus paradoxus (pooled sensitivity, 82%; 95% CI, 72%-92%), elevated jugular venous pressure (pooled sensitivity, 76%; 95% CI, 62%-90%), and cardiomegaly on chest radiograph (pooled sensitivity, 89%; 95% CI, 73%-100%). Based on 1 study, the presence of pulsus paradoxus greater than 10 mm Hg in a patient with a pericardial effusion increases the likelihood of tamponade (likelihood ratio, 3.3; 95% CI, 1.8-6.3), while a pulsus paradoxus of 10 mm Hg or less greatly lowers the likelihood (likelihood ratio, 0.03; 95% CI, 0.01-0.24).

Conclusions Among patients with cardiac tamponade, a minority will not have dyspnea, tachycardia, elevated jugular venous pressure, or cardiomegaly on chest radiograph. A pulsus paradoxus greater than 10 mm Hg among patients with a pericardial effusion helps distinguish those with cardiac tamponade from those without. Diagnostic certainty of the presence of tamponade requires additional testing.

JAMA. 2007;297:1810-1818
<table>
<thead>
<tr>
<th>Source</th>
<th>No. of Patients</th>
<th>Study Design/ Patient Population</th>
<th>Reference Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reddy et al, 1978</td>
<td>19</td>
<td>Retrospective chart review of patients with pericardial effusion referred for pericardiocentesis</td>
<td>Hemodynamic findings before and after pericardiocentesis</td>
</tr>
<tr>
<td>Guberman et al, 1981</td>
<td>56</td>
<td>Retrospective chart review of patients with cardiac tamponade</td>
<td>Clinical criteria including elevated jugular venous pressure, pulsus paradoxus, and documentation of pericardial effusion</td>
</tr>
<tr>
<td>Singh et al, 1984</td>
<td>16</td>
<td>Prospective cohort of patients with pericardial effusion referred for pericardiocentesis</td>
<td>Hemodynamic findings before and after pericardiocentesis</td>
</tr>
<tr>
<td>Curtiss et al, 1988</td>
<td>65</td>
<td>Prospective cohort of patients with pericardial effusion referred for pericardiocentesis</td>
<td>Hemodynamic findings before and after pericardiocentesis</td>
</tr>
<tr>
<td>Levine et al, 1991</td>
<td>50</td>
<td>Prospective cohort of patients with suspected cardiac tamponade referred for pericardiocentesis</td>
<td>Hemodynamic findings before and after pericardiocentesis</td>
</tr>
<tr>
<td>Brown et al, 1992</td>
<td>18</td>
<td>Prospective cohort of patients with cardiac tamponade referred for pericardiocentesis</td>
<td>Hemodynamic findings before and after pericardiocentesis</td>
</tr>
<tr>
<td>Cooper et al, 1995</td>
<td>30</td>
<td>Retrospective chart review of patients with pericardial effusion referred for pericardiocentesis</td>
<td>Relief of symptoms of dyspnea by pericardiocentesis</td>
</tr>
<tr>
<td>Gibbs et al, 2000</td>
<td>46</td>
<td>Retrospective chart review of patients with pericardial effusion referred for pericardiocentesis</td>
<td>Echocardiographic evidence of cardiac tamponade</td>
</tr>
</tbody>
</table>

*All studies were quality level 4.*
Table 4. Sensitivity of the Physical Examination in the Diagnosis of Cardiac Tamponade

<table>
<thead>
<tr>
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<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>
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<tr>
<td>Tachycardia</td>
<td>77</td>
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<td></td>
<td>74</td>
<td>65</td>
<td>87</td>
<td>77 (69-85)</td>
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<td>Hypotension</td>
<td>35</td>
<td></td>
<td>14</td>
<td></td>
<td>30</td>
<td>24</td>
<td>26 (16-36)</td>
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<td>Hypertension †</td>
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<td>33</td>
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<tr>
<td>Tachypnea</td>
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<tr>
<td>Diminished heart sounds</td>
<td>34</td>
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<tr>
<td>Elevated JVP</td>
<td>88</td>
<td>74</td>
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<td>Peripheral edema</td>
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<td>Pericardial rub</td>
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<td>Hepatomegaly</td>
<td>55</td>
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<tr>
<td>Kussmaul sign</td>
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<td>26</td>
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<tr>
<td>Pulse pressure, mm Hg</td>
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<td>$&gt;0$</td>
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<td>$&gt;100$</td>
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<tr>
<td>Total paradox</td>
<td>23</td>
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</tr>
</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.
Despite its sensitivity, exercise appropriate skepticism of PP

- Presence may be masked by:
  - Hypotension
  - Pericardial adhesions
  - AI
  - ASDs
  - RVH

- Can result from other conditions:
  - COPD
  - CHF
  - MS
  - Massive PE
  - Severe hypovolemic shock
  - Obesity
  - Tense ascites
Objectives

- Briefly review pericardial structure and function
- Describe hemodynamic pathophysiology
- Discuss physical examination data
- Outline a method to approach echocardiographic evaluation of effusion
- Decide between options for therapy in tamponade
1. Is There a Pericardial Effusion?
2. How Big is the Effusion?

Parasternal Long Axis

Parasternal Short Axis
2. How Big is the Effusion?

Parasternal Long Axis

Apical 4 Chamber
2. How Big is the Effusion?

Parasternal Long Axis

Parasternal Short Axis

Subcostal 4 Chamber
3. Is it Circumferential? Localized?

Apical 4 Chamber

Parasternal Short Axis
4. What Are the Characteristics of the Effusion?

Apical 4 Chamber

Parasternal Long Axis
5. How is the Right Heart Doing?
Right Atrium

Apical 4 chamber
5. How is the Right Heart Doing?

RVOT

M-mode of the Parasternal Long Axis
5. How is the Right Heart Doing?

Right Ventricle

M-mode of Parasternal Short Axis
6. Is There Evidence of Venous Congestion?

Subcostal View of IVC
7. What Are the Hemodynamic Consequences of the Effusion?

Pulsed doppler – **tricuspid valve** inflow varies with respiration by \(\geq 25\%\)

Pulsed doppler – **mitral valve** inflow varies with respiration by \(\geq 15\%\)
7. What Are the Hemodynamic Consequences of the Effusion?

Pulsed doppler – **pulmonic valve** inflow varies with respiration

Pulsed doppler – **aortic valve** inflow varies with respiration
Echo Evaluation of Effusion

1. Is there a pericardial effusion?
2. How big is the effusion?
3. Is it localized? Circumferential?
4. What are the characteristics of the effusion?
5. How is the right heart doing?
6. Is there evidence of venous congestion?
7. What are the hemodynamic consequences of the effusion?
Objectives

- Briefly review pericardial structure and function
- Describe hemodynamic pathophysiology
- Discuss physical examination data
- Outline a method to approach echocardiographic evaluation of effusion
- Decide between options for therapy in tamponade
Which type of pericardiocentesis approach have you done the most?

A. Subxiphoid
B. Parasternal
C. Apical
Pericardiocentesis: A Clinical Anatomy Review

M. Loukas, A. Walters, J.M. Boon, T.P. Welch, J.H. Meiring, and P.H. Abrahams

1Department of Anatomical Sciences, St George’s University, School of Medicine, Grenada, West Indies
2Department of Anatomy, Varmia and Mazuria Medical School, Olsztyn, Poland
3Department of Anatomy, Unit of Clinical Anatomy, School of Medicine, Faculty of Health Sciences, University of Pretoria, Pretoria, South Africa
4Queen’s College, Cambridge, United Kingdom
5Institute of Clinical Education, Warwick Medical School, Coventry, United Kingdom

The safe and successful performance of pericardiocentesis demands a working and specific knowledge of anatomy. Misunderstanding of anatomy may result in failure or serious complications. This review attempts to aid understanding of the anatomical framework, pitfalls, and complications of pericardiocentesis. Pericardiocentesis is carried out for aspiration of blood from the pericardial cavity in cases of cardiac tamponade and symptomatic pericardial effusion. In addition, this technique may be used for the diagnosis of neoplastic effusions, purulent pericarditis, and introduction of cytotoxic agents into the pericardial space. Most complications of the procedure are due to the needle penetrating the heart and surrounding structures such as coronary arteries, lungs, stomach, colon, and liver. These complications, if severe, may result in pneumothorax, hemothorax, arrhythmias, infections or arterial bleeding. Therefore, the more fluid or blood there is between the myocardium and pericardium—within the pericardial cavity—the less chance of complications. With a thorough knowledge of the complications, regional anatomy and rationale of the technique, and adequate experience, a pericardiocentesis can be carried out safely and successfully. Clin. Anat. 25:872–881, 2012.
Approaches to Pericardiocentesis
Subxiphoid
Approaches to Pericardiocentesis
Subxiphoid
Approaches to Pericardiocentesis
“Echo-Guided” – Parasternal and Apical

Korean Circ J 2012; 42:725-734
# Approaches to Pericardiocentesis

## Risks/Benefits

<table>
<thead>
<tr>
<th>Technique</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
</table>
| **Subxiphoid** | - Safest approach in emergent situation  
- Needle in direct contact with diaphragm, with less risk of injuring the pleura | - Highest rates of morbidity and mortality  
- Irritation to diaphragm and phrenic nerve.  
- Highest risk of liver injury  
- Possibility of colon or stomach perforation |
| **Parasternal** | - Cardiac notch of left lung leaves pericardium exposed | - Possible higher risk of pneumothorax than with subxiphoid  
- Internal thoracic vessels lie close to sternal margin |
| **Apical** | - Smaller sized vessels near the apex  
- L lateral position allows pericardial fluid to accumulate around the apex  
- Bare area over apex where pleura usually absent | - Piercing wall of left ventricle results in higher rate of ventricular fibrillation |
Take Home Points

- The pericardium is more than just a sac
- Pulsus paradoxus is helpful, but is often non-specific, especially in intermediate volume effusions
- Diastolic equalization = tamponade
- Cardiac tamponade is a clinical diagnosis
- Consider the anatomy when planning your intervention