Cardiology Consults: Symptomatic Severe Aortic Stenosis & Cardiac Tamponade

Milena A. Gebska M.D., Ph.D., MME, FACC

December 5, 2020
Disclosures

- None
Consult #1
Consult #1 - Objectives

In relation to severe aortic stenosis (AS) at the conclusion of this activity, participants will be able to:

1. Be able to diagnose severe AS based on physical exam

2. Understand natural history and pathophysiology of AS

3. Learn the basics of echocardiographic assessment and how to interpret Echo report/measurements
A 78 yo M with no significant past medical history, now presents with syncope.

Physical Exam:

- BP 131/63 | Pulse 55 | Ht 5' 4’ | Wt 70.3 kg (154 lb 15.7 oz) | SpO2 96% | BMI 26.59 kg/m²

- Loud 3/6 systolic ejection murmur at the apex, R clavicle and 2nd ISC radiating to the neck (LR+/95% CI: 9-154; Etchells E et al. JAMA 1997;277(7):564-571)

- Usually peaks in early- or mid-systole; if absent or soft S2 = severe AS
- Apical murmur due to Galliverdin phenomenon
- Carotid pulse is *parvus et tardus*, delayed carotid upstroke
Consult #1 - Transthoracic echo images obtained, pending report

Reference Values:

LVEF: 50-70%
SV: 80-120 ml
SVi: >35 ml/m^2
LVOT VTI: 18-22 cm
IVSd: <1.0 cm
LVPWd: <1.0 cm
Ao V2 max: ≤2.5 m/sec
Ao V2 mean gr: <20 mmHg
AVA: 2.0-2.5 cm^2
DI (V1/V2): >0.5
Grading AS Severity

Table 3  Recommendations for grading of AS severity

<table>
<thead>
<tr>
<th>Aortic sclerosis</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak velocity (m/s)</td>
<td>≤2.5 m/s</td>
<td>2.6–2.9</td>
<td>3.0–4.0</td>
</tr>
<tr>
<td>Mean gradient (mmHg)</td>
<td>–</td>
<td>&lt;20</td>
<td>20–40</td>
</tr>
<tr>
<td>AVA (cm²)</td>
<td>–</td>
<td>&gt; 1.5</td>
<td>1.0–1.5</td>
</tr>
<tr>
<td>Indexed AVA (cm²/m²)</td>
<td>–</td>
<td>&gt;0.85</td>
<td>0.60–0.85</td>
</tr>
<tr>
<td>Velocity ratio (or DI)</td>
<td>–</td>
<td>&gt; 0.50</td>
<td>0.25–0.50</td>
</tr>
</tbody>
</table>

Echo Doppler can NOT overestimate the gradient (unless Hb <8), so AV gr ≥40 mmHg = SEVERE AS

Normal LVEF *
1. LV systolic function

- Preserved (EF ≥40%)
- Decreased (EF <40%)

Ejection Fraction

- X5-1
  - 47Hz
  - 22cm

- LV Length 5.49 cm
- LV Area 13.7 cm²
- LV Vol 29.7 ml
- ESV (A2C) 29.7 ml
- EF (A2C) 61.2 %
- ESV (BP) 35.7 ml
- EF (BP) 64.0 %
2. LV hypertrophy

The Laplace’s law:

\[ \text{Wall stress} = \frac{\text{Pressure} \times \text{Radius}}{\text{Wall Thickness}} \]

Severe aortic stenosis without left ventricular hypertrophy: prevalence, predictors, and short-term follow up after aortic valve replacement

194 pts: 90% - LVH, 10% no LVH, 4% had no macroscopically detectable hypertrophic adaptation

*small body size was an independent risk
3. Aortic Valve hemodynamics

Severe AS: Peak AV vel \( \geq 4.0 \text{ m/sec} \)

Severe AS: Mean AV gradient \( \geq 40 \text{ mmHg} \)

\[ \text{LV V1 VTI: 22.8 cm} \]

\[ \text{Ao V2 VTI: 104 cm} \]

\[ \text{Ao mean PG: 43 mmHg} \]
2. Aortic valve hemodynamics

LV V1 max: 92.4 cm/sec = 0.9 m/sec
LV V1 VTI: 22.8 cm

LV V1 VTI = LVOT VTI

LVOT VTI: 22.8 cm

AO V2 max: 430 cm/sec = 4.3 m/sec
AO V2 VTI: 104 cm
AO mean PG: 43 mmHg

Dimensionless Index (Velocity Ratio) = \frac{V1}{V2} \times \frac{V1}{V1_{LVOT}} = \frac{V1_{LVOT}}{V1_{AV}}

Severe AS: DI ≤ 0.25

\frac{23}{104} = 0.22

3. Aortic Valve Area (AVA)

Continuity Equation:

Concept: LVOT flow (SV) = AV flow (SV)

\[ \text{AVA} \times \text{VTI}_{\text{AV}} = \text{CSA}_{\text{LVOT}} \times \text{VTI}_{\text{LVOT}} \]

\[ A2 \times V2 = A1 \times V1 \]

\[ \text{AVA (A2)} = \frac{\text{CSA}_{\text{LVOT}} \times V1}{V2} \]

Dimensionless Index (DI) or Velocity Ratio (VR)

Severe AS: AVA < 1cm\(^2\)
AVA < 0.6 cm\(^2\)/m\(^2\)

*J Am Soc Echocardiogr 2017;30:372-92*
Natural History of Aortic Stenosis

Stages:

A. At risk of AS

B. Progressive AS

C. Asymptomatic severe AS

D. Symptomatic severe AS

Ross J Jr. and Braunwald E, 1968; Circ 38; Suppl 5:61

2014 ASE/ACC Valvular Heart Disease Guideline, Nishimura et al, JACC 63:e57
Severe AS - Treatment

- Operate at the ONSET of symptoms

2017

Severe AS Symptomatic (Stage D)
- Class I
- Class IIa

- Low surgical risk
  - Surgical AVR (Class I)
  - Intermediate surgical risk
  - TAVR (Class IIa)
- High surgical risk
  - Surgical AVR or TAVR (Class I)
- Prohibitive surgical risk
  - TAVR (Class I)

2014 ASE/ACC Valvular Heart Disease Guideline, Nishimura et al, JACC 63:e57

Circulation. 2017;135:e1159–e1195
1. Severe AS can be recognized on physical exam (soft S2)

2. AS severity should be assessed by Transthoracic Echocardiography:
   - AV max velocity ≥ 4.0 m/sec
   - AV mean gradient ≥ 40 mmHg
   - Dimensionless index/VR ≤ 0.25
   - AVA < 1.0 cm² (<0.6 cm²/m²)
   - LV hypertrophy +/-

3. Operate at the ONSET of symptoms, irrespective of LV function (surgical AVR or TAVR)

4. Severe asymptomatic AS remains a clinical challenge
Consult #2
Consult #2 - Objectives

At the conclusion of this activity, participants will be able to:

1. Be able to differentiate between pleural and pericardial effusion on transthoracic echocardiogram

2. Understand pathophysiology of cardiac tamponade

3. Recognize echocardiographic features of cardiac tamponade
Curbside Consult

A 62 yo M with SOB and a large pericardial effusion on POCUS. Does he need emergent pericardiocentesis?
Questions:

1. Is this pericardial effusion or pleural effusion?

2. Is hemodynamic compromise present?

3. Can it be drained percutaneously?
**PLEURAL vs PERICRDIRAL effusion?**

**STEP 1:** Obtain Parasternal Long Axis view

**STEP 2:** Find descending thoracic Aorta

If effusion is **POSTERIOR** to Aorta

If effusion is **ANTERIOR** to Aorta
A 62 yo M with SOB and a large pericardial effusion on POCUS. Does he need emergent pericardiocentesis?

Large pleural effusion, small to moderate pericardial effusion
A 59-yr F with Hx of breast cancer presents to the ER with worsening shortness of breath. HR 120 bpm, BP 95/72 mmHg, RR 20/min. On exam her extremities are cool, neck veins are distended, and heart sounds are distant:
A 59-yr F with Hx of breast cancer presents to the ER with worsening shortness of breath. HR 120 bpm, BP 95/72 mmHg, RR 20/min. On exam her extremities are cool, neck veins are distended, and heart sounds are distant:

STAT CONSULT

Parasternal long axis view

Parasternal short axis view

RV Ao LA LV
Subcostal view

Subcostal IVC view

RA, RV, LA, LV, IVC

UNIVERSITY OF IOWA
PW Doppler through MV with Respirometer
Questions:

1. Is this pericardial effusion or pleural effusion?

2. Is hemodynamic compromise present?

3. Can it be drained percutaneously?
Cardiac Tamponade
Cardiac Tamponade

- Clinical diagnosis; Not diagnosed by Echo
- Clinical syndrome of:
  - Hypotension
  - Tachycardia

Symptoms due to higher intrapericardial pressure than intrathoracic pressure; Pulsus paradoxus:

https://www.youtube.com/watch?v=d4aCDhMvb0M
Cardiac Tamponade

Symptoms: dyspnea, chest pain, and/or non-specific sense of discomfort

Physical exam:

- Pulsus paradoxus (an inspiratory decline >10 mmHg in SBP)
- Beck’s triad: hypotension, muffled heart sounds, and elevated JVP
- EKG: low voltage and electric alternans
- CXR: flask-like or “boot-shaped” appearance of cardiac silhouette
As fluid accumulates in the pericardial sac, pericardial pressure rises, and systemic and pulmonary venous pressures must increase to maintain cardiac filling. When compensatory mechanisms are exhausted, preload becomes insufficient to sustain cardiac filling and coronary and systemic perfusion.
Lower-pressure chambers (atria) are affected before higher-pressure chambers (ventricles)

The compressive effect of the pericardial fluid is seen most clearly in the phase of the cardiac cycle when pressure is lowest in that chamber—systole for the atrium, diastole for the ventricles
Cardiac Tamponade - Pathophysiology

INSPIRATION

Pulsus paradoxus: SBP drop (>10 mmHg)

EXPIRATION

Ventricular Interdependence
The size of the effusion, its rate of accumulation, and any pathology altering the pressure-volume relation of the pericardium determine the extent of hemodynamic compromise.
**Pericardium - Pressure Volume Curves**

**CHRONICALLY**
- slowly developing effusions are safer
- pericardium stretches
- tamponade / large volume effusion

**ACUTELY**
- rapidly developing effusion
- pericardium has no time to stretch
- tamponade may occur with small volume

* The flat initial segments of the curves represent the pericardial reserve volume that once exceeded, causes a steep increase in pressure.
Echocardiographic features of Cardiac Tamponade
Cardiac Tamponade - Echocardiographic features

Physiologic changes evident on echocardiographic and Doppler examination include:

1. RA systolic collapse for greater than 1/3 of systole
2. RV diastolic collapse
3. Reciprocal respiratory changes in RV and LV volumes (septal shifting)
4. Reciprocal respiratory changes (>25%) in RV and LV filling
5. Severe dilation of the inferior vena cava/”plethoric IVC”
1. RA systolic collapse for greater than 1/3 of systole
2. RV Diastolic Collapse
Patients with pulmonary hypertension may NOT have Right sided chambers compression
3. Reciprocal respiratory changes in RV and LV volumes (septal shifting)

**Cardiac Tamponade - Echocardiographic features**

- Inspiratory septal bulge / "bounce"
  - Cardiac tamponade
  - COPD
  - Pulmonary embolism

**Echocardiographic features**

- Cardiac Tamponade
  - Echocardiographic features

*J Am Soc Echocardiogr 2013;26:965-1012*
Cardiac Tamponade - Echocardiographic features

4. Reciprocal respiratory changes (>25%) in RV and LV filling

**PW Doppler** of TV and MV inflow with a **respirometer** during cardiac tamponade
Cardiac Tamponade - Echocardiographic features

PW Doppler recording of LV outflow tract velocity and respirometer in a patient with cardiac tamponade and pulsus paradoxus

Cardiac Tamponade - Echocardiographic features

5. Severe dilation of the inferior vena cava/"plethoric IVC"

ASE Clinical Recommendations for Multimodality Cardiovascular Imaging of Patients with Pericardial Disease.
J Am Soc Echocardiogr 2013;26:965-1012
Pericardial effusion - Etiology

Bloody coagulum = EMERGENCY: acute MI, aortic dissection, catheter manipulation, pacemaker, cardiac surgery

- Neoplastic
- Inflammation (infection, autoimmune, radiation)
- Metabolic (hypothyroid, renal failure)
- CHF
Take home points

1. Cardiac tamponade is a clinical diagnosis and “echocardiographic features of tamponade” are not by themselves an indication for pericardiocentesis

2. Coagulum = Emergency
Thank you!

milena-gebska@uiowa.edu