Pericardial Anatomy

- Two serous surfaces
  - Visceral: adherent to epicardial surface of heart
  - Parietal: denser more fibrous surface apposed to the pleural surfaces
  - Creates potential space: <15-50 ml

Restricts the anatomic position of the heart
Retards spread of infections from pleural space
Pericardial Reflections Create Sinus’

- **Transverse**: surrounds the great arteries
- **Oblique**: surrounds pulmonary veins
Pericardial Disease

- Congenitally absent pericardium
- Pericardial cyst
- Pericarditis
- Pericardial effusion
- Tamponade
- Constrictive physiology
Congenital Absence of Pericardium

• Moves the heart to the left chest
• 1/14000 births, more common in males
• Usually incidental and asymptomatic
• Can rarely cause strangulation of LAA, torsion of great vessel or coronary artery
• EXCESSIVE cardiac motion on echo
• Interpostion of lung between L PA and aorta is diagnostic
Pericardial Effusion

• Identified by
  – Enlarged cardiac silhouette by CXR
  – 2 D echo best diagnostic choice
  – CT scan

• Usually diffuse and symmetric
  – Small: <0.5 cm
  – Medium: >0.5 cm <2 cm
  – Large: >2 cm

• Loculated (adhesions)
  – Post-op, history of pericardial disease
  – Hemodynamic compromise can occur with a small amount of fluid rapidly growing or properly placed
Pericardial Effusion: Discriminate from pleural effusion
Pericardial Effusion
Evidence of hemodynamic compromise

- Clinical syndrome: obstruction to LV filling, high filling pressures, low cardiac output
- Tamponade physiology: pericardial pressure exceeds cardiac chamber pressures and filling is impaired.
- Hemodynamic compromise is related to the rate of accumulation/volume status NOT just effusion size
Clinical Features of Tamponade

Physiology

- Low BP
- Pulsus Paradox >10 mmHg inspiratory decline SBP
- Increased HR
- Low peripheral perfusion, mottled
- High CVP
- Faint heart sounds
- Prominent x descent in JVP/CVP
- No Y descent
Tamponade by 2D Echo
Ventricular Interdependence and Respiratory Variation to Filling

- Inspiration augments right heart filling and diminishes left heart filling
  
  *Pulsus paradox*

- Septal shifting by 2 D/M-mode

- Respirophasic changes in Doppler velocities
  - Mitral/Tricuspid Inflow
  - Aortic/Pulmonic Outflow
  - Hepatic and Pulmonary Veins
Mitral Inflow Variation

Lossy compression - not intended for diagnosis

45dB 3 +/-1/1/2
PW Depth = 108mm
PW Gate = 5.0mm
PW Gain = 15dB

PW: 1.75MHz

HR = 93bpm
Sweep = 25mm/s
Mitral and Tricuspid Doppler Velocities in Tamponade

A

Mitral valve

-1 m/s

Effusion, Tamponade

Tricuspid

0.6 m/s

B

Insp

Exp
Pulmonary and Hepatic Venous Doppler Velocities in Tamponade

![Diagram showing Doppler velocities in pulmonary and hepatic veins]

- Pulmonary vein
  - 0.4 m/s
- Hepatic vein
  - DR
  - S, D
- Inspect (Insp)
- Expiratory (Exp)
2D/ M-mode Evidence of Hemodynamic Compromise

- Echo findings often precede clinical symptoms
- Diastolic chamber collapse
  - late atrial $>1/3$ PR interval (sens 94%, spec 100%)
  - early right ventricular collapse (sens 60-90%, spec 85-90%)

RVH, decreased RV compliance limit the sensitivity

- Plethoric IVC and hepatic veins
M-mode RV Diastolic Collapse
Clinical and Physical Findings of Pericardial Constriction

- Insidious and chronic symptoms of systemic venous congestion (edema, ascites, Kussmaul’s sign) or reduced cardiac output (malaise, fatigue).
- Looks like cirrhosis with elevated JVP
- Dyspnea (no acute CHF)
- Atrial fibrillation (secondary to high RA/LA p)
- Quiet apical impulse, regurgitant murmurs uncommon, low-voltage ECG <50%, pulsus 1/3
- Rarely: pericardial calcification on CXR
Hemodynamic Indices of Constriction

• Equalization of diastolic ventricular filling:
  LVEDP-RVEDP <5 mmHg *
• PASP < 55 mmHg
• RVEDP/RVSP > 1/3
• dip and plateau diastolic ventricular filling
• lack of respiratory variation in the mean RA p

• Limited predictive value: Constrictive Pericarditis from restrictive cardiomyopathy
Accuracy of Cath Hemodynamics  
CP vs RCM

• Marked overlap between individuals in each group
• LVEDP-RVEDP < 5mmHg
  - Sensitivity 60%  Specificity 71%
• RVEDP/RVSP > 1/3
  - Sensitivity 93%  Specificity 57%

Echocardiographic Findings of Constriction

- Ventricular interdependence
- Enlarged LA and RA
- Usually normal LV and RV size and function
- Inspiratory decline in left sided / increase in right sided Doppler velocities
- Elevated filling pressures
- Decreased stroke volume
- Annulus Paradox
Hepatic Venous Doppler and Right Atrial Pressure in Constriction
Limitations to Echo/Doppler

- Not accurate at determining pericardial thickening
- False negatives
  - Marked elevations in LA/RA pressures
- False positives
  - Severe lung disease
  - Atrial fibrillation
  - Cardiac movement around Doppler sample volume
  - RV MI, acute PE—other clues by echo to these diagnoses
Cath lab learns from Echo lab

- Cath evidence of ventricular interdependence
- RESPIROPHASIC changes in simultaneous RV and LV filling distinguishes CP from other CHF causes
- Discordance of RV and LVSP = CP
  - Sensitivity 100%, specificity 95%
  - PPV 94%, NPV 100%
- Concordance of RV and LVSP = other CHF/RHD

Dynamic Respiratory Changes in LV and RV Systolic Pressures

Hurrell et al, Circulation 1997
Reduction in Preload Unmasks Doppler Inflow Changes

A

Supine
(5% change)

E
0.98
1 m/s
1.03

Insp
Exp

Sitting
(25% change)

0.75
1 m/s
0.95

Insp
Exp

B

Baseline

Mean
0.81 ± 0.24
0.84 ± 0.21

% change
5 ± 7%

Upright Position

Mean
0.61 ± 0.13
0.78 ± 0.13

% change
32 ± 28%
Tissue Doppler

- E’ early diastolic longitudinal velocity of mitral annulus is reduced with increased LVEDP/PCWP
- E/E’, preload independent variable, has been found to correlate well with PCWP and LVEDP.
- However, E’ is not reduced in CP despite elevated filling pressures
- Annulus paradox - annulus moves excessively
- High E’ when filling pressures are obviously elevated

Ha et al, Circulation 2001, 28;976-8
Klein et al found via TEE, $E' > 8$ differentiated CP from RCM with 89% sensitivity and 100% specificity.

Am J Cardiol 2001;87:86-94
Early diastolic mitral inflow (E) and annular velocities in 2 separate patients. A, 56-year-old man with CP. Note that E is 100 cm/s and E' is 20 cm/s. PCWP was 31 mm Hg, and E/E' was 5. B, 54-year-old man with CP. PCWP was 18 mm Hg, and E/E' was 17. A indicates late filling velocity; A', late diastolic annular velocity. 

Ha et al. Circulation. 2001;104:976
Final Lesson
Consider Constriction When...

- Abnormal septal motion
- Dilated IVC and hepatic veins
- Restrictive filling pattern
- Respiratory variation
- Normal tissue Doppler in CHF
- Exp diastolic reversal in HV
Effusive-Constrictive Pericarditis

- 1184 pts w/pericarditis evaluated
- 190 with clinical tamponade had pericardiocentesis with catheterization
- 15 (1.3%, 7%) had effusive-constrictive physiology
- Definition: < 50% fall in RA pressure post tap LVEDP and RVEDP remained elevated >10 mmHg.
- 7 required pericardiectomy, 3 spontaneously resolved

NEJM 2004; 350: 469-75
Prognosis Following Pericardiectomy

- Late survival c/t age-matched controls
- For survivors >83% free of symptoms
- Independent predictors of poor long term outcome
  - Age
  - NYHA Class
  - Post XRT (most powerful)
Treatment of Constrictive Pericarditis

- Mayo: 135 CP pts with pericardiectomy 1985-95 vs historic cohort

- ↑ Freq of CP due to cardiac surgery and XRT

- ↑ Age 61 vs 45 yrs

- Perioperative mortality ↓ 6% vs 14% p<0.01

Ling et al. Circulation 1999;100:1380-6
Late Survival Following Pericardiectomy

Ling et al. Circulation. 1999;100:1380-1386
Change in NYHA functional class in 93 late survivors

Ling et al. Circulation. 1999;100:1380-1386