Pericardial Disease: Pathophysiology, Differentials, Treatment

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Pericardial Anatomy

- Fibrous Pericardium
- Serous Pericardium
  - Parietal Pericardium
  - Visceral Pericardium
    - Epicardium = visceral layer contacts heart (not great vessels)
- Normal fluid volume
  - 0.25 mL/kg

Pericardial Function

- Non-essential for normal CV function
- Fix heart anatomically and maintain optimal shape
- Barrier to infection
- Pericardial fluid
  - Reduces friction
  - Helps maintain transmural cardiac pressures
  - Lubrication
  - Likely role in transmission of pericardial pain
- Related to innervation and secretion of PG and other related substances that modulate neural traffic and coronary tone

Classification of Pericardial Disease

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<tr>
<th>Type</th>
<th>Cause</th>
<th>Notes</th>
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<td>PPDH</td>
<td>Pericardial cyst</td>
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<td>Congenital Absence</td>
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<td>Acquired Pericardial Effusion</td>
<td>Hydropericardium</td>
<td>CHF, Hypo-Alb, PPDH</td>
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<td>Pericarditis</td>
<td>Exudates</td>
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<td>Metabolic</td>
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<td>Cholesterol, CKD, hypo/hyperT4, Amyloidosis</td>
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<td>Neoplasia</td>
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</table>
| Cardiac rupture (LA rupture; dissect Ao aneurysm) | Idiopathic (sterile) | Pericardial abscess
| Constrictive Pericardial Disease |                       | Autoimmune (connective tissue disorders) Uremia
| Post-trauma           |                                |                                                                       |

Objectives

- Pericardial anatomy and physiology
- Causes of pericardial effusion
- Pathophysiology cardiac tamponade and constrictive pericarditis
- Diagnosis of pericardial effusion
- Treatment options and prognosis
Cardiac Tamponade: What is it?

• = elevation of diastolic pressures with progressive limitation of filling leading to reduced SV and CO
  – Acute → low CO and shock predominate
  – Chronic → R-CHF predominates

• Development of increased pericardial pressure depends on
  – Volume of effusate
  – Rate of accumulation
  – Physical nature of pericardium

Cardiac Tamponade: What is normal?

• Normal pericardial pressure ~0 mmHg
• Transmural Pressure
  – Intracavitary pressure – extracavitary pressure (pericardium)
  – Done during diastole • Normally, filling pressures equal ventricular diastolic mean pressure

Cardiac Tamponade: Pathophysiology (cont.)

• As PE accumulates → RA/RV/LA/LV diastolic pressures rise
• Severe tamponade, pressures equilibrate to that in pericardial sac (~15-20 mmHg)
• Results in low transmural filling pressures of cardiac chambers
  – Small end-diastolic ventricular volume (decreased preload) mainly accounts for small SV
  – Compensatory increase in contractility leads to decreased end-systolic ventricular volume
  – Not enough to normalize SV, therefore HR increases too
  • CO = HR x SV

Cardiac Tamponade: Pathophysiology

• R-sided filling pressures < L-sided filling pressures
  – As fluid accumulates → filling pressures increase more rapidly in the right heart
• Intrapericardial pressure equilibrates with RA/RV diastolic pressures, transmural pressure is zero and tamponade begins
• Venous pressure increased to maintain cardiac filling
  – Systemic capillaries
    • Leaky at 15-20 mmHg → R-CHF with chronic tamponade
  – Pulmonary capillaries
    • Leaky at 25-30 mmHg

Normal Influence of Breathing on Cardiac Filling

• Inspiration
  – Chest wall expands and diaphragm descends → intrapleural pressure falls → expansion of lungs, RA, RV, thoracic Cr/CdVC → decrease in intravascular and intracardiac pressures → increased venous return to RA and increased PG from RA to RV
  – Expansion of lungs/pulmonary vasculature → increased pulmonary blood volume → transiently decreased venous return to L heart
•Expiration
  – Intrapleural pressures increase → blood forced out of pulmonary vasculature → increased venous return to LA

Cardiac Tamponade & Pulsus Paradoxus

• An abnormally large decline in systemic arterial pressure during inspiration (> 10 mmHg)
  – Normal = slight decline (< 10 mmHg)
HX/PE Findings

- Vague Clinical Signs
  - Lethargy, weakness, retching, coughing, weakness, anorexia, abdominal enlargement, collapse/syncope
- Beck's Triad
  - Jugular venous distension/pulsation (↑ systemic venous pressure)
  - Hypotension
  - Muffled heart sounds / ↓ precordial impulse
- Other Findings
  - Pale MM, Delayed CRT
  - Weak, variable pulse quality +/- pulsus alternans
  - Tachypnea to Dyspnea
  - Variable abdominal distension and cranial organomegaly

Possible Lab Abnormalities

- Elevated liver enzyme
  - Passive hepatic congestion
- Azotemia
  - Pre-renal
- Stress/inflammatory leukogram
- Coagulopathy
- Coccidioides serology
- Cardiac troponin I elevation

ECG Findings

- Diminished QRS complexes
- Electrical alternans
  - Produced by swinging heart within fluid-filled pericardium
  - Rate-dependent, more common at normal HR (90-140 bpm)
- Sinus tachycardia
- Non-specific ST segment deviations
- Ventricular ectopy

Radiographic Findings

- Globoid cardiomegaly, “Sharp” cardiac margins
- Distension of CdVC
- Hepatomegaly
- +/- Thoracic and abdominal effusion

PCE DDx

- Dogs
  - Neoplasia (HBT, HSA, pericardial mesothelioma, LSA, metastatic), idiopathic, LA rupture, CHF, coagulopathy, vasculitis, PPDH
  - Pericardiocentesis CAUTION
    - Acute collapse + hypotension + previously loud murmur no longer auscultable → concern for LA rupture
- Cat
  - FIP, CHF, systemic infection, vasculitis, ARF/CRF, neoplasia, pancreatitis, volume overload
  - Pericardiocentesis CAUTION
    - CHF – sudden increase in venous return and volume overload resulting in acute (often fulminant) pulmonary edema

Suspected Idiopathic PCE
Heart Base Tumor
(Chemodectoma vs Thyroid Carcinoma vs HSA vs LSA vs Other)

Normal heart/pulmonary vessels, diffuse bronchointerstitial pattern, dorsal deviation of tracheal cranial to carina with no obvious mass; Skin masses

Right Atrial Mass

Pericardial Mass
LA Rupture

T-FAST / Echo
- Confirm PCE and tamponade
- User-Dependent
  - High Se/Sp for detection for diagnosis and differentiation of RA mass vs HBT (Cardiologist) (JAVMA 2009;235(12):1456-1461)
    - 82% Se/100% Sp for cardiac mass
    - 82% Se/99% Sp for RA mass
    - 74% Se/98% Sp for heart base mass
- Presumptive Echo Dx of Cardiac Tumor (JAVMA 2013;27;1090-1096)
  - HBT (CD, ETC, LSA) – 78% Accurate
  - RA Mass (HSA) – 50% Accurate

PCE Analysis & Cytology
- JAVMA 2009;235(12):1456-1461
  - 13% - Cause identified
    - 5 infective pericarditis, 1 LSA
  - 85% - Classified as hemorrhagic
    - Suppurative inflammation > Pyogranulomatous inflammation > Modified transudate > Chylous effusion
  - 53% - mesothelial reactivity identified
- JVIM 2014;28:66-71
  - Diagnostic Cytology – 8%
    - Neoplastic - round cell neoplasia (LSA, histiocytic, undetermined), carcinoma, atypical epitheloid, hemic neoplasia
    - Infectious – bacterial and fungal
  - Non-diagnostic Cytology – 92%

Cardiac Troponin I (cTnl – pretap)
- Comparison of plasma cTnl among dogs w/ cardiac HSA, non-cardiac HSA, other neoplasms, PCE of non-HSA origin (JVIM 2010;237(7):806-811)
  - cTnl >0.25 ng/mL - used to ID PCE due to cardiac HSA with 81% Se and 100% Sp
- Utility of cTnl in differentiating b/w underlying etiologies of PCE in K9 patient (ACVIM Forum 2011 Abstract)
  - HSA vs HBT vs Idiopathic
    - cTnl >0.78 ng/mL
      - 67% Se/95% Sp for HSA
      - Not reliable to DDx HBT vs. Idiopathic

Advanced Imaging
- CT
  - Not superior to echo for identifying cardiac masses
  - Potentially higher sensitivity in identifying metastases
- cMRI
  - May yield more descriptive anatomic information re: masses
  - Allows for imaging of the pericardium itself

Pericardiocentesis
- Catheter (14-18 G polypropylene 3.5-5.25 inch)
- Scalpel blade
- 3-way stopcock
- IV extension set
- Appropriately large syringes
- Collection vessel
- Specimen tubes (EDTA and RTT)

Not pictured:
- Clippers
- Surgical scrub
- Sterile gloves
- 2% lidocaine
Pericardiocentesis

- Patient Prep
  - IV catheter recommended
  - 2 mg/kg lidocaine dose pre-calculated
  - +/- Sedation (benzo/opioid)
  - Monitor ECG continuously
  - Left lateral recumbency / tap from right
  - Local anesthesia with 2% lidocaine
  - U/S-guided, if available
    - If not, elbow point or 4-5 ICS over cardiac impulse

- Advance catheter toward heart – look for flash of effusion
  - Advance 5-10 mm past flash and feed catheter off needle
  - Hook up extension set & stopcock

- Remove effusion
  - Withdraw catheter if scratching against heart is felt
  - On negative pressure, remove slowly and continue to draw on syringe

- More than 1 way to perform
  - Sternal recumbency, from underneath
  - Use a flexible central line

- Indications
  - Multiple centeses fail to resolve effusion
  - Pericardial constrictive disease suspected
  - Exploration and biopsy needed

- Complications
  - Damage lung (pneumothorax)
  - Cardiac puncture
  - Hemorrhage
  - Arrhythmias
Pericardiectomy

- **Window vs. Subtotal Pericardiectomy** (JAVMA 2013;242(4):493-498)
  - Idiopathic PCE
    - Window had shorter DFI and MST compared to subtotal
      - Subtotal 3yr survival - 100% (histologic Dx - pericarditis)
        - Window MST - 13 mo
  - Neoplastic PCE
    - DFI and MST not significantly different
      - Subtotal MST - 4 mo
        - Window MST - 3 mo
- **Heart Base Tumors** (JAVMA 2001;219(4):485-487)
  - Pericardiectomy provided significantly longer MST compared to medical management
    - 661 days vs 129 days

Constrictive Pericarditis: What is it?

- Restriction of cardiac filling as a result of reduced pericardial compliance involving the parietal pericardium +/- visceral pericardium (epicardium)
- True Constrictive Pericarditis
  - Pericardial space is obliterated by complete fusion of the parietal and visceral layers
  - Pericardium constricts the chambers, resulting in increases in atrial and diastolic ventricular pressures
- Constrictive-Effusive Pericarditis
  - Small fluid space remains
  - Normal pressure-volume relationship is altered so that minimal increases in pericardial volume cause dramatic increases in pericardial pressure

Echo

Coccidiodes immitis pericarditis

Treatment/Prognosis

- HBT: Pericardiectomy with +/- chemotx and/or RT
  - Can be decent Px if chemodectoma
- HSA: Pericardiectomy, RAAu amputation with chemotx: 6 months
- Idiopathic: three taps and your "out"…
  - Pericardiectomy

Comments / Questions

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