Pericardial Diseases: Image Guided Approach
A New Renaissance in Multimodality Imaging

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* No Conflicts to Declare

Introduction
Case presentations
Clinical perspective
Hemodynamics
Multimodality Imaging
Pitfalls

Constriction vs Restriction
Khandaker et al., Mayo Clin Proc 2010;85:572-93

Clinical Cardiology
“Look at the neck.”

The Pericardium
Courtesy of Drs. Yingchoncharoen and Phelan

A New Renaissance in Pericardial Diseases
Edema/Inflammation
T2W STIR LGE

“Rip-Roaring” Transient Constrictive Pericarditis
Effect of Pericarditis on Pathology

- Uremia
- Neoplastic
- Radiation


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Hypothetical Framework of Constriction

- NYHA Class
- MRI and Echo findings
- Inflammatory cascade
- CP inducing
- Time
- PPS

Constriction Pericarditis Syndromes

- Chronic Constriction
- Permanent constriction after 6 months
- Transient Constriction
- Reversible after medical therapy
- Effusive Constriction
- Failure of RAP to fall after pericardiocentesis
- Non-invasive imaging

ESC 2013 Guidelines

Constrictive Pericarditis Syndromes

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- Reversible after medical therapy
- Effusive Constriction
- Failure of RAP to fall after pericardiocentesis
- Non-invasive imaging

Case 1: 57 Year old Man from California with Abdominal bloating, Shortness of Breath

- History of Present Illness:
  - Abdominal bloating + abdominal CT
  - Incidentally found to have small pericardial effusion, pericardial thickening
  - Treated with prednisone, colchicine

- Past Medical/Surgical History:
  - Viral meningitis
  - Hyperlipidemia
  - GERD
- Social History:
  - Former tobacco, no EIOH, no IVDU
- Family History: None
- Physical Exam:
  - HR 102, BP 98/62, BMI 26
  - Cardiac: JVD 10 cm H20, regular, no murmur, no rub, 1+ edema
- Medications: None
- Labs: ESR 2, CRP 2.7

Californian lawyer who cannot enjoy the beach
- Russian basketball player with TB and calcium
- Constriction that disappears with medicine
- Caution is needed during surgery

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ESC 2013 Guidelines
**Echocardiogram**

- **IVC - Subcostal**
- **TV Inflow**
- **Split Diastole**
- **Medial Tissue Doppler**
- **Lateral Tissue Doppler**

**Cardiac MRI**

- **4 Chamber Cine**
- **Free Breathing**
- **Delayed Enhancement**
- **Black Blood SSFP**

**Surgical Pathology**

- Normal pericardium
- Thickened Pericardium

**Case 1: 57 Year Old Man From California**

- **Abdominal Bloating, Shortness of Breath**

  **Further Work-up:**
  - Right & Left Heart Catheterization:
    - Normal coronary arteries
    - Low-normal cardiac output
    - Interventricular Interdependence
  - **DIAGNOSIS: CONSTRUCTIVE PERICARDITIS**

  **Management:**
  - Trial of medical management ➔ Worsening symptoms
  - Pericardiectomy

  **Follow-up:**
  - Asymptomatic. Discontinued diuretics.

**Resting Echocardiogram**

- **Parasternal Long Axis**
- **Apical 4 Chamber**
- **Medial Tissue Doppler**
- **Lateral Tissue Doppler**

**Case 2: 39 Year Old Russian Basketball Player**

- **Sharp Chest Pain**

  **History of Present Illness:**
  - Viral illness, lower extremity edema
  - Sharp pleuritic chest pain
  - CXR/CT with pericardial calcification
  - Treated with furosemide

  **Past Medical/Surgical History:**
  - Positive PPD
  - Social History:
    - Immigrated from Russia
    - Former tobacco, no EtOH, no IVDU
  - Family History:
    - Father: cardiomyopathy

  **Physical Exam:**
  - HR 63, BP 107/79, BMI 29
  - Cardiac: JVD 14 cm H20, regular, no murmur, no rub, trace edema

  **Medications:**
  - Furosemide

  **Labs:**
  - ESR 2, CRP 3, + quantiferon

**Further Work-up:**

- **Right & Left Heart Catheterization:**
  - Normal coronary arteries
  - Low-normal cardiac output
  - Interventricular Interdependence

**Diagnosis:** CONSTRUCTIVE PERICARDITIS

**Management:**

- Trial of medical management ➔ Worsening symptoms
- Pericardiectomy

**Follow-up:**

- Asymptomatic. Discontinued diuretics.
Case 2: 39 Year Old Russian Basketball Player
Sharp Chest Pain

- **Further Work-up:**
  - Infectious Disease Consult: TB effusive constrictive pericarditis → interferon, rifampin, Vitamin B6 x 3 months
  - **DIAGNOSIS:** CALCIFIC TB PERICARDITIS
- **Management:**
  - Pericardiectomy
- **Follow-up:**
  - Continued TB therapy x 6 months
  - Asymptomatic, no heart failure symptoms

Case 3: 73 Year Old Man with Shortness of Breath after VT Ablation

- **History of Present Illness:**
  - OSH VT ablation → ramus injury → pericardial effusion
  - Medically managed, no drainage
  - Abdominal swelling, shortness of breath, weight gain, edema
  - Steroids, colchicine
- **Past Medical/Surgical History:**
  - VT, OSA, AFib, prostate ca
- **Social History:**
  - Former tobacco, social EtOH, no IVDU
- **Family History:** None
- **Physical Exam:**
  - HR 80, BP 114/76, BMI 26
  - Cardiac: JVD to the jaw, regular, no murmur, no rub, 3+ edema
- **Meds:** sotalol, clopidogrel, ASA
- **Labs:** ESR 32, BNP 656

- **DIAGNOSIS:** TRANSIENT EFFUSIVE CONSTRICITION
- **Management:**
  - Prednisone, aspirin, colchicine
- **Follow-up:**
  - Tapered off of steroids and colchicine
  - Resolving cardiac MRI inflammatory findings
Case 4: 48-Year-Old Male Presented with Dyspnea, Chest pain, Weight Gain and Edema
Recent Myectomy for HCM and PVI

CRP 7.3
WSR 49

Histopathology
- Histopathology showed
  - Marked fibrosis and granulation tissue with organizing hemorrhage.
  - Fibrotic with thickened pericardium
- Started on prednisone, NSAID and colchicine.
- Discharged home

Surgical Findings...“Mine Field”
- Pericardial window attempted
- Operation converted to sternotomy
- Surgical field showed, intense inflammation
- Pericardial stripping of the right side performed
- On attempting left side pericardiectomy, LAD was nicked
- Because of intense inflammatory reaction, further pericardiectomy of the left side was aborted.

Presentation
- Shortness of breath, abdominal swelling
- Chest pain, sharp in nature, increased with exertion
- WSR 45 (0 - 15 mm/H)
- CRP 8.1 (0.0 - 1.0 mg/dL)
- Prednisone was increased to 60 mg daily

A month later on anti-inflammatory medications...
Significant respiratory variation of Doppler flow (MV 40%) 
E/e' = 9

Echocardiogram Apical Views

5 months later

- Patient remained chest pain-free
- Remains on diuretics and mild heart failure symptoms
- Inflammatory markers normalized
- Prednisone was tapered off
- Remained on colchicine and NSAID and stopped 1 year later

Complete pericardiectomy

- Through a left anterior thoracotomy
- Histopathology showed:
  - Pericardium is markedly thickened
  - Organized hemorrhage
  - Mild chronic inflammation.
- Discharged on:
  - Prednisone 50 mg PO daily
  - Ibuprofen 400 TID
  - Colchicine 0.6 mg BID
- Referred to heart failure clinic and started on diuretics

Take Home Points

- Caution is needed when sending patient for pericardiectomy in setting of inflammation
- Multimodality imaging is useful tool in evaluating effusive constrictive pericardial disease
- CMR is an important tool to assess the severity and distribution of pericardial inflammation
- An adequate trial of anti-inflammatories is recommended in the setting of active inflammation and constrictive findings before proceeding to pericardiectomy
Constrictive Pericarditis

Definition

- Impaired diastolic filling due to pericardial disease
- Signs and symptoms of RHF with preserved RV and LV function
- Absence of previous or ongoing myocardial disease

Syed et al. Nat Rev Cardiol 2014;11: 530-544

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Calcific Constriction

Syed et al. Nat Rev Cardiol 2014;11: 530-544

Constrictive Pericarditis

Etiologies


Pathophysiology

Constrictive Pericarditis

Restrictive Cardiomyopathy

Appleton CP et al. 1990
Elevated Jugular venous Pressure

Edema and Ascites Requiring Paracentesis

Constrictive Pericarditis

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Constrictive Pericarditis

LV - diastolic filling volume (%)


Constrictive Pericarditis

Square Root Sign

LV pressure
LV/RV Interdependence

Talreja et al. JACC 2008

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Radical Pericardiectomy

Syed et al Nat Rev Cardiol 2014;11: 530-544

Which is Better for Detecting Constriction?
Echo vs CT/CMR

Survival Curves After Pericardiectomy by Etiology of Constriction

Berting et al. J Am Coll Cardiol. 2004;8:1445-52

Strengths and Limitations of Various Imaging Modalities in the Evaluation of Pericardial Disease

CONSTRUCTION STUDY

Ventricular Interdependence

Syed et al Nat Rev Cardiol 2014;11: 530-544

Constriction

IVC Plethora

HV Flow

Mitral Inflow

Tricuspid Inflow

TDI septal

E insp
e
E exp
S
d
C
e'
a'
s'
**Tissue Doppler Echo Velocities**

**Constrictive Pericarditis**

**Restrictive Cardiomyopathy**

Rajagopalan et al. Am J Cardiol 2001;87:86-94

**Mitral Annular Velocity in Constriction**

**Annulus Paradoxus**

Ha JW et al. Circulation 2001;104:976-978

**Diagnosis of Constriction Algorithm**

Nagueh et al. JASE 2016

**Tissue Doppler Imaging**

**Annulus Reversus**

- Lateral/septal e’ ratio is significantly reduced in CP compared to normal control and RCM
- Reduced lateral e’ are correlated with the pericardial thickness on their respective side

Choi et al. JACC Imaging 2011

**Constrictive Pericarditis Cardiac Mechanics**

Thickened, fused and calcified pericardial shell tethers the epi-myocardium
**Constrictive Pericarditis vs Restriction**

**Cardiac Mechanics**

- **Constriction**
  - Epicardial tethering and pericardial constraint in fibrotic or inflamed pericardium
  - LV filling limited in circumferential direction (sub-epicardial dysfunction)

- **Restriction**
  - Intrinsic myocardial disease with sub-endocardial dysfunction
  - LV filling limited in longitudinal direction (sub-endocardial dysfunction)

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**Regional Mechanics**

Aim: To compare the longitudinal LV and RV regional mechanics.

**Constriction**

CT

CMR

Interventricular Dependence CMR

Free breathing sequence

**Interventricular Dependence CMR**

Free breathing sequence

Pre and Post Pericardiectomy

Regional Strain

“LV Strain Reversus”

Pericardiectomy leads to systolic strain improvement. It is more pronounced in left and right ventricular free walls.

**CONCLUSIONS:**

Regional longitudinal systolic strain ratios are robust novel diagnostic tools for CP. Regional myocardial mechanics inversely correlate with adjacent pericardial segment thickness detected by CMR and pericardiectomy leads to systolic strain improvement, which is more pronounced in RV and LV free walls. (Circ Cardiovasc Imaging 2013;6:2399-406)
Calcium and CP

Calcium band Encircling the Heart in Yellow and ‘Relatively Spared’ Segments are in Red

Histology of Pericardial Inflammation

Incremental Prognostic Value of Quantitative Pericardial DHE to Predict Clinical Improvement

Pericardial Diseases: Image Guided Approach
Mixed Constriction/Restriction
“Mixed Bag”


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Multimodality Imaging
Exciting Times


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