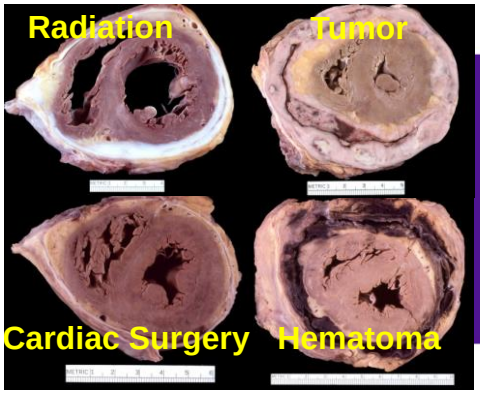
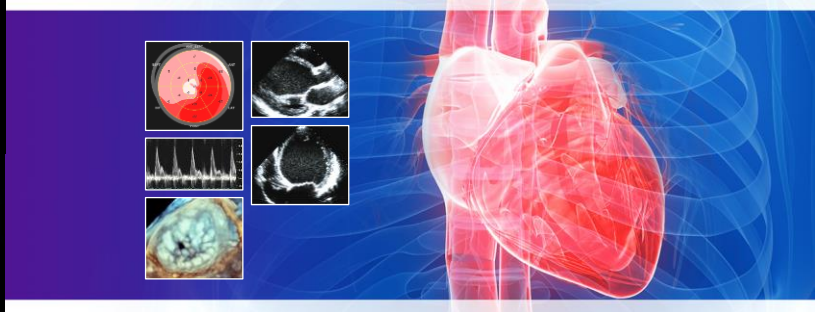
MAYO CLINIC



Pericardial Diseases

Constriction and Others



Jae K. Oh, MD

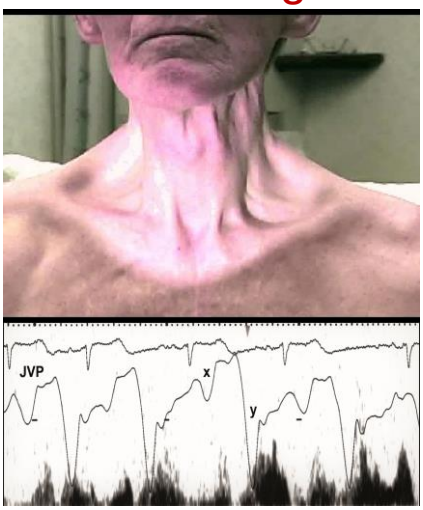
For ASE Echo Board Review 2019

Goals from this presentation

- **To learn how to diagnose constriction with Echocardiography**
- **To learn how to distinguish CP from myocardial disease**
- **To identify at least one patient with constriction which was not clinically suspected in your practice**
- **To learn Echo diagnosis of tamponade and Effusive-CP**

Constrictive Pericarditis
Symptoms/Signs & Exam Findings

- Right Heart Failure
- Ascites
- Edema
- Abdominal pain
- JVP elevation with Kussmaul
- Rapid “y” descent of JVP
- Pericardial Knock (S3)
- Pleural effusion



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Constrictive Pericarditis
Traditional Imaging and Hemodynamic Features

- Pericardial calcification (CXR and CT)
- Increased pericardial thickness (Echo, CT, and MRI)
- Hemodynamics by Cath
  - Increased RA pressure with rapid “y” descent
  - Equalization of LV/RV end-diastolic pressures
  - :Dip and Plateau (M or W pattern)
  - Pulmonary artery systolic pressure < 50 mmHg
  - High ratio between RV end-diastolic and systolic pressure

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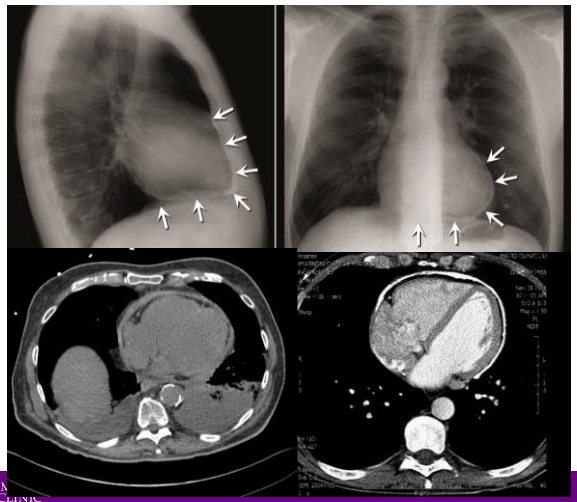
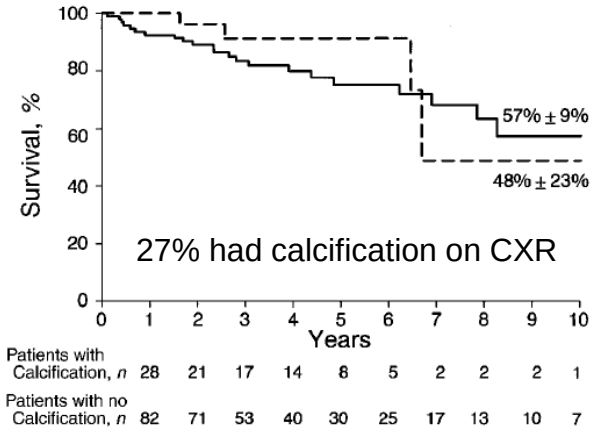
Calcific Constrictive Pericarditis: Is It Still with Us?

Lieng H. Ling, MBBS, MRCP; Jae K. Oh, MD; Jerome F. Breen, MD; Hartzell V. Schaff, MD; Gordon K. Danielson, MD; Douglas W. Mahoney, MSc; James B. Seward, MD; and A. Jamil Tajik, MD





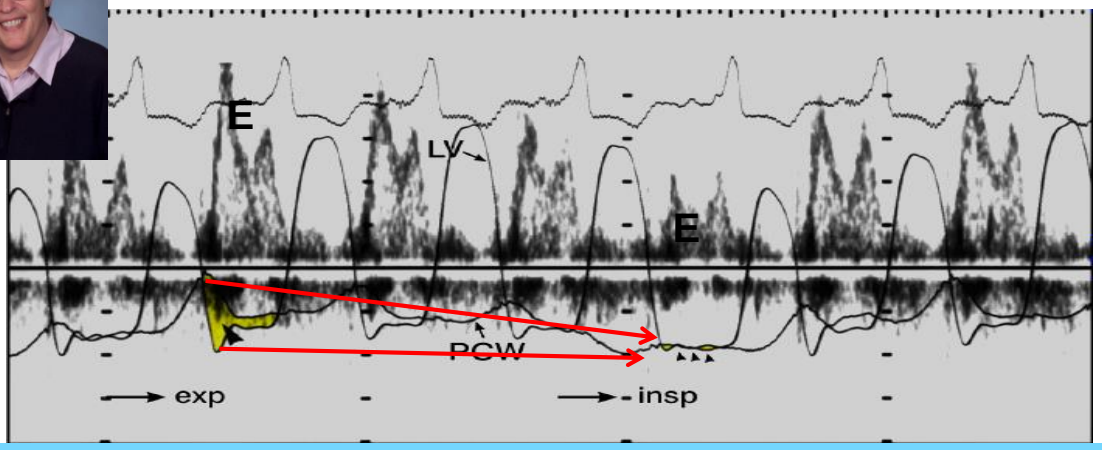
Ling et al AIM 2000

Constrictive Pericarditis :Hemodynamic Diagnosis

- **Echocardiographic Diagnostic Criteria**
  - **Pressure Dissociation (Intracardiac vs Intrathoracic)**
  - **Interventricular Dependence**
- **Restriction vs Constriction**
- **Pure vs Mixed Constrictive Pericarditis**
  - **Cardiac Cath Hemodynamics**
  - **Echo Doppler Hemodynamics**
- **Pericardiectomy Experience**

Constructive Pericarditis

Mitral Inflow vs Cath



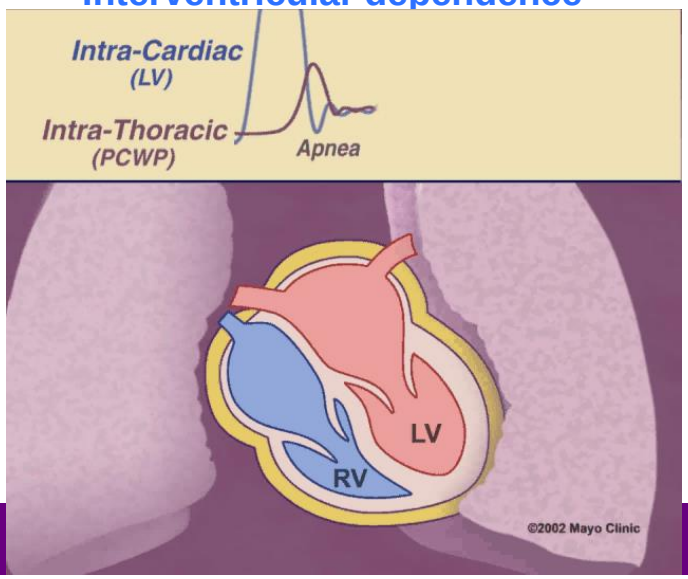
Dissociation between intrathoracic and intracardiac pressures

Differential ventricular filling with respiration

Hemodynamics in Constriction

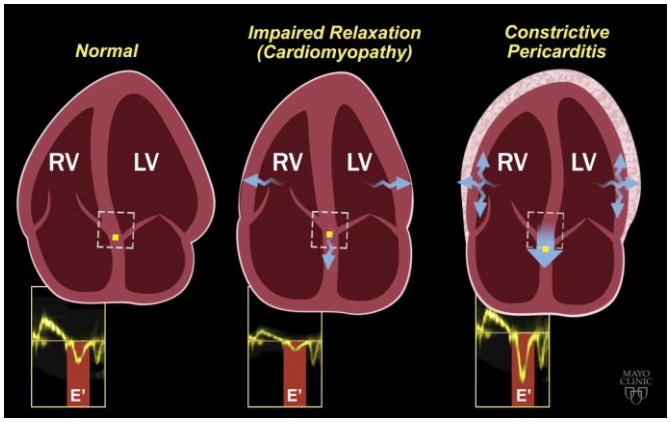
Intracardiac pressure Δ < intrathoracic pressure Δ

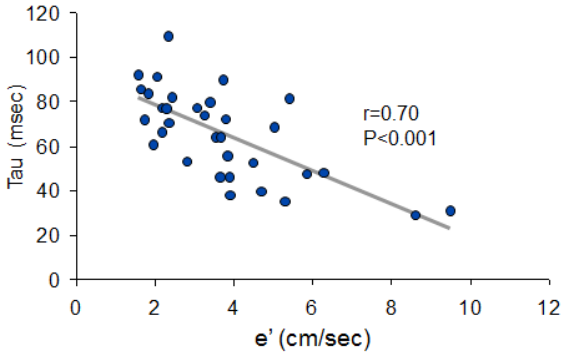
Interventricular dependence



Diastolic Function Assessment by Echo

e' velocity reflects LV relaxation



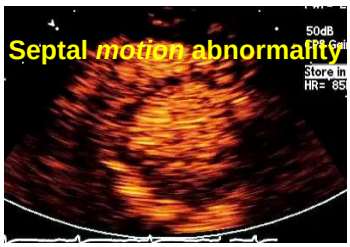


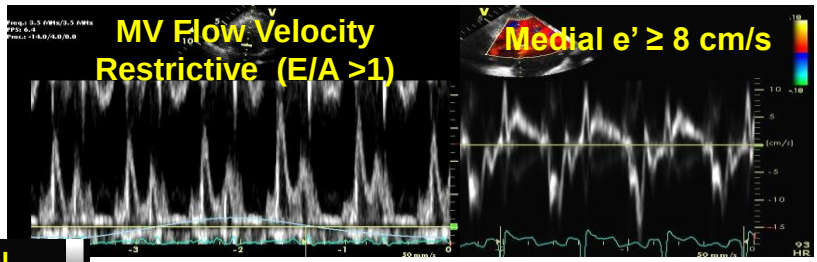
Firstenberg et al: J Appl Physiol, 2001, Nagueh et al: JACC 1997, Oki et al: AJC 1997 , Sohn et al:JACC 1997, Ommen et al: Circ 2000 Opdahl et al: Circulation 119:2578, 2009, and more

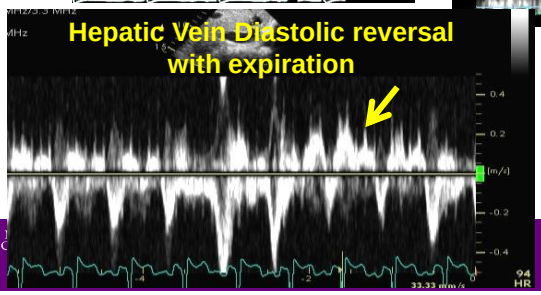
Echocardiographic Diagnosis of Constrictive Pericarditis: Mayo Clinic Criteria

Terrence D. Welch, Lieng H. Ling, Raul E. Espinosa, Nandan S. Anavekar, Heather J. Wiste, Brian D. Lahr, Hartzell V. Schaff and Jae K. Oh

Echo Diagnostic Criteria







Sensitivity	**87 %**
Specificity	**91 %**

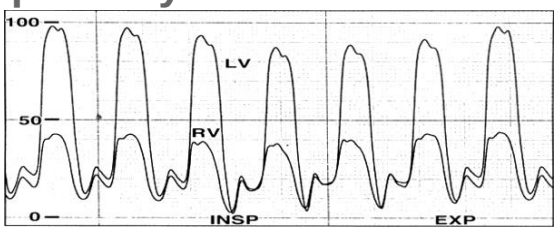
Welch et al Circ Imaging 2014

Illustrative Cases

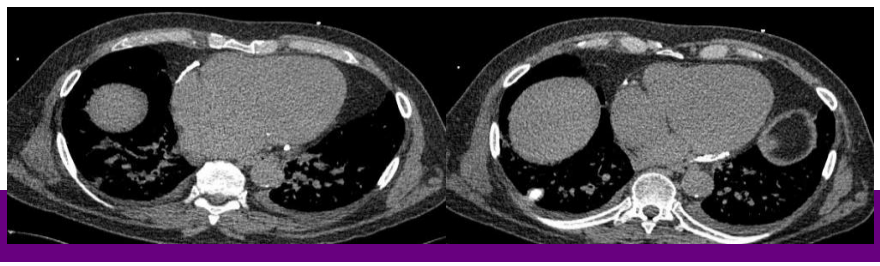
Case #1

71 yo man with worsening dyspnea 2 years after CABG

- Physical Examination
  - JVP elevation
  - Prominent S3
  - Peripheral edema

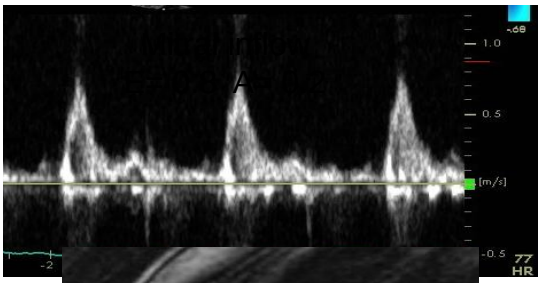


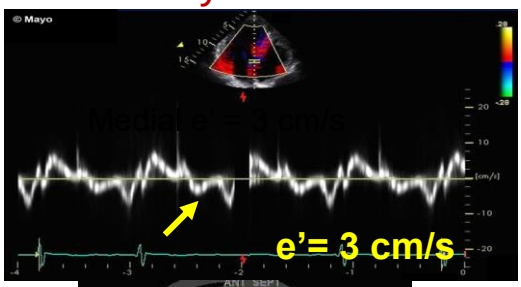
- Cardiac Cath…Equalized end-diastolic pressures
- CT was obtained: Calcified Pericardium

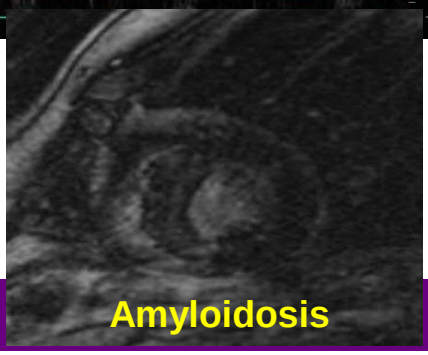


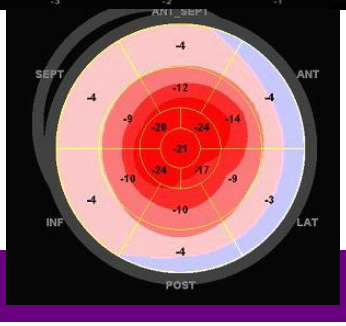
71 year old man with calcified pericardium

Referred for Pericardiectomy





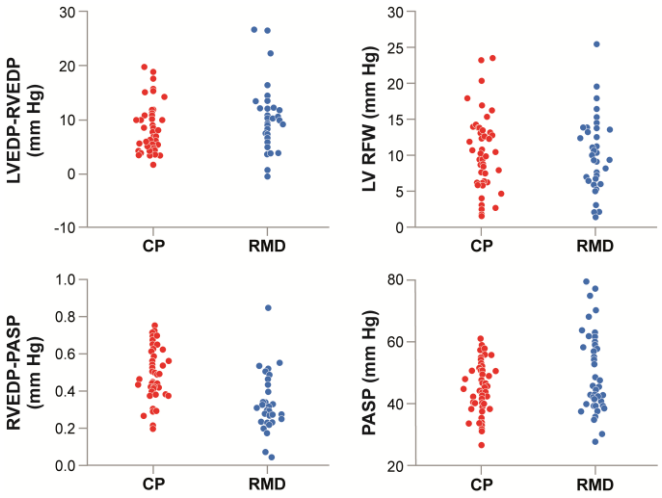




Constriction vs Restrictive Myocardial Disease

Traditional Hemodynamic Data Comparison

- Equalization LV/RV End-diastolic pressure
- Pulmonary artery systolic pressure (PASP) ≤ 50 mmHg
- RVEDP / PASP ≥ 1/3



Vaitkus and Kussmaul AHJ 1991

Talreja , Nishimura et al. JACC 2008

Case #2

70 year old man with HF referred to Cardiomyopathy Clinic

- 2 months history of increasing dyspnea and fluid retention
- Pleural effusion : Treated with thoracentesis
- Abnormal light chain with increased kappa
- Family history of Myeloma and Amyloidosis
- Cardiac catheterization : Normal coronaries
  - LVEDP = 28, PA = 41/21, PAWP = 23, RV = 38/13 , CI = 1.9

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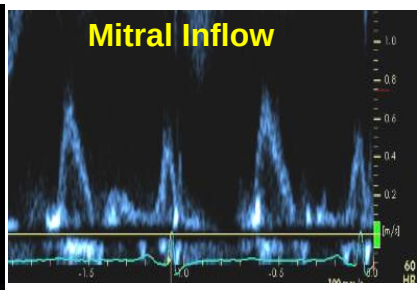
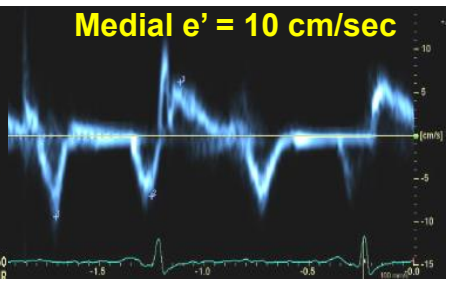
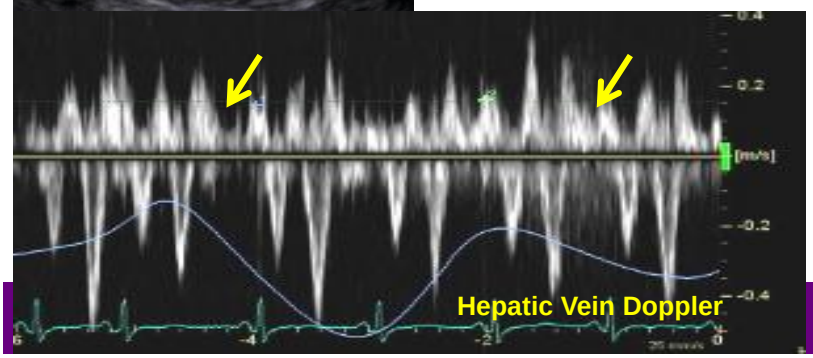
70 year old man with heart failure with preserved LVEF

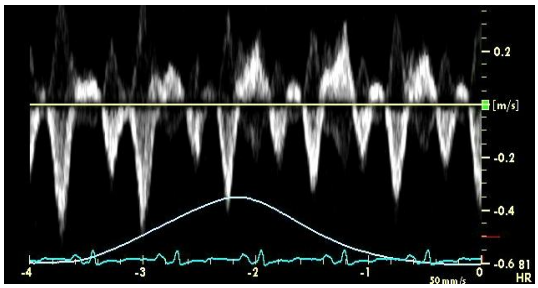




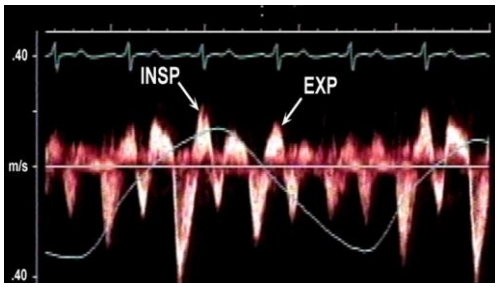


What is your next step?
1= Pyrophosphate scan
2= Tissue Biopsy
3= Cardiac MRI
4= Surgery

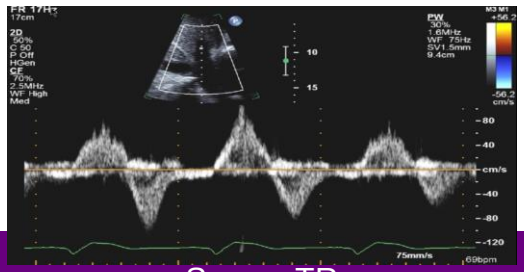
Hepatic Vein Doppler



Constriction



Myocardial Disease



Severe TR

Case #3

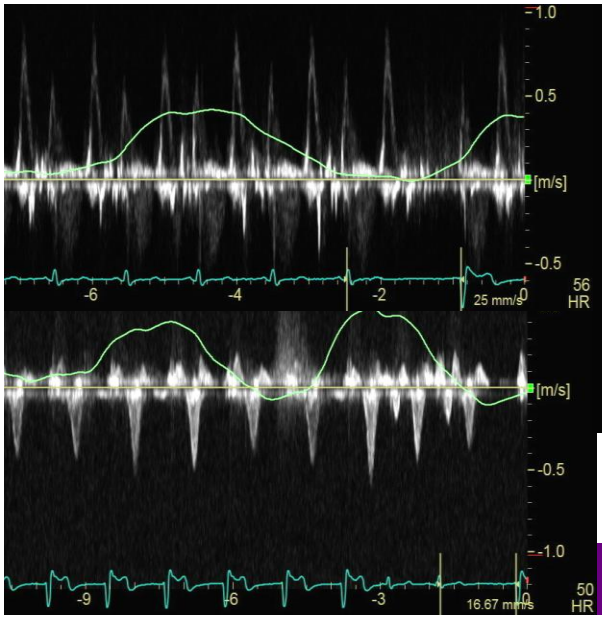
61 year old man with TOF and HF

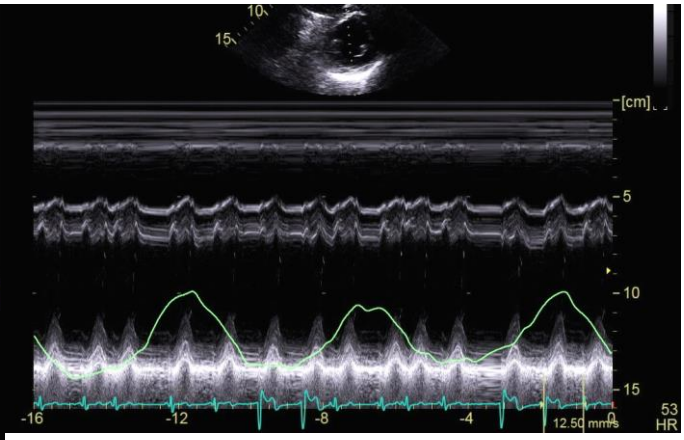
- Corrective operation at age 6
- PV replacement and TV repair at age 51
- Dyspnea and HF since his second operation
- LMD in NY city sent me an e-mail

  "I attended your EBRC in 2018, and diagnosed constriction in my patient with all Echo-Doppler findings you described"

- Came to Mayo for Pericardiectomy

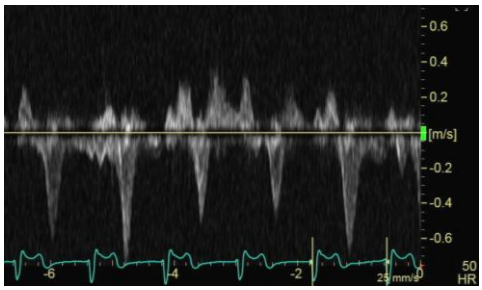
61 year old male with TOF : No constriction ! By Echo Edema and JVP elevation

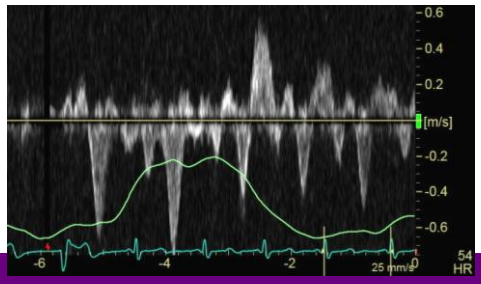




1= Repeat Echo 2= Cardiac Cath
3= Cardiac MRI 4= Pericardiectomy

61 yo with TOF and HF : Constriction





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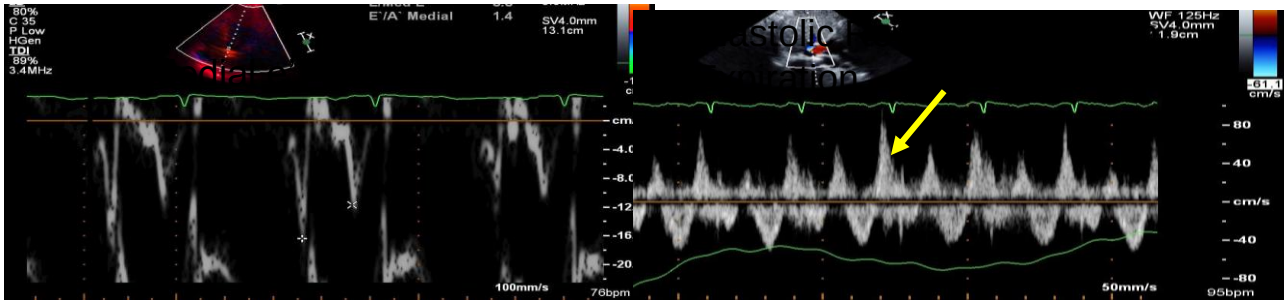
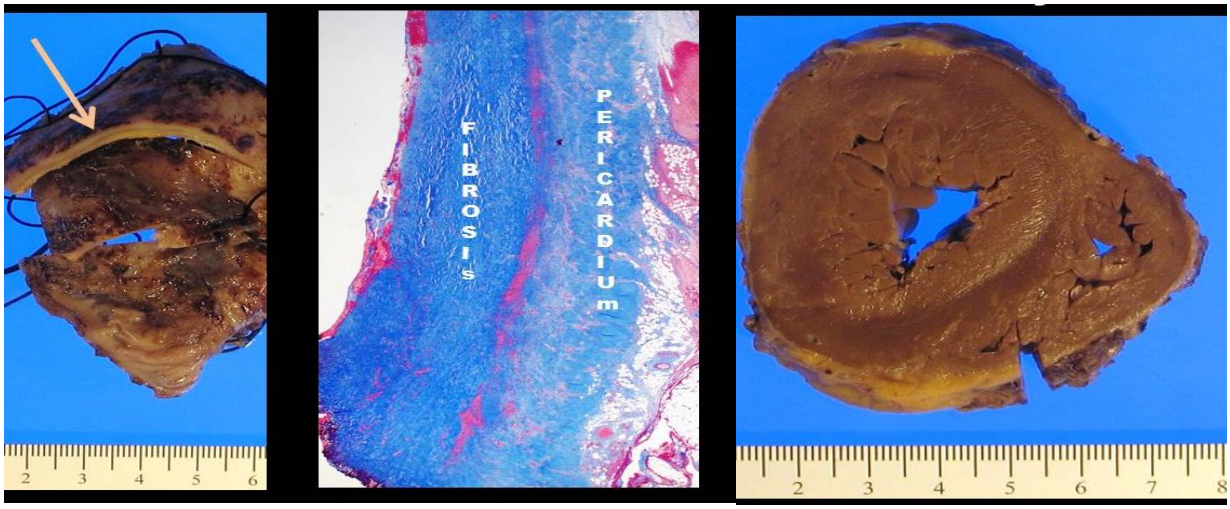
An e-mail from a junior staff at a major MC
52 year old man with RCM waiting for heart transplantation
(Had Echo, MRI, and cardiac cath performed)

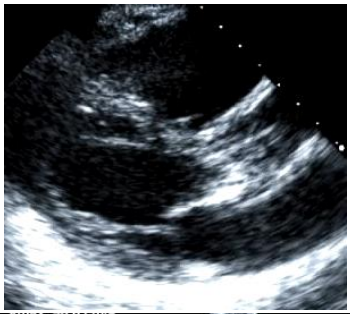


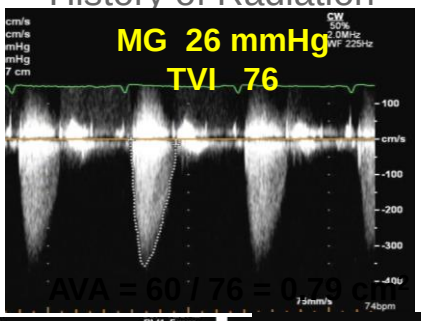
Explanted Heart

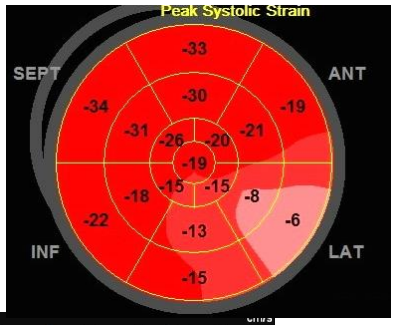


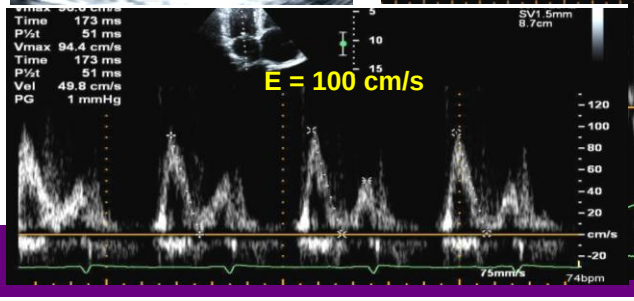
67 yo man with severe aortic stenosis and HF

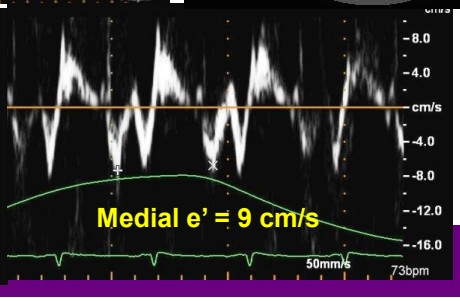
Came to Valve Clinic for AVR (LFLG Severe AS)
History of Radiation



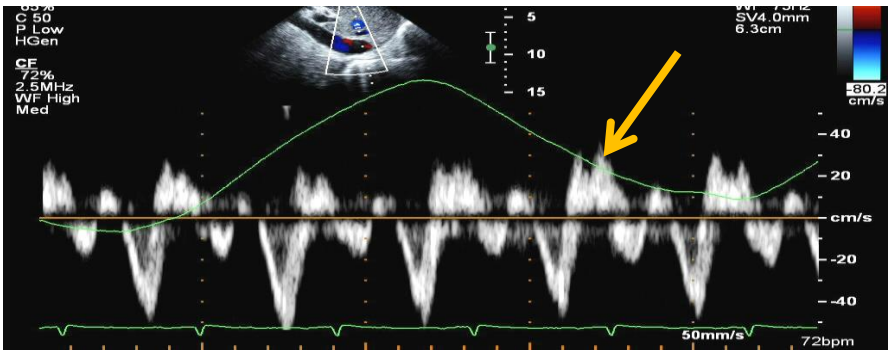








67 year old man with AS and Constriction Hepatic Vein Doppler c/w constriction



Radiation Heart Disease

Valvular Heart Disease

Circulation CV Imaging 2015

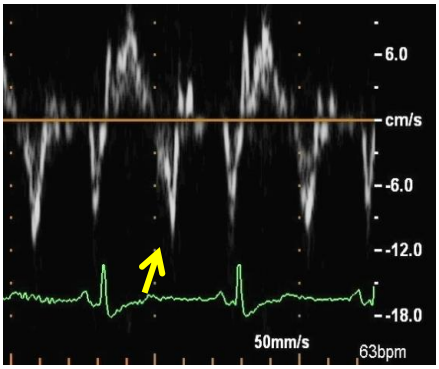
Low-Flow, Low-Gradient Severe Aortic Stenosis in the Setting of Constrictive Pericarditis

Clinical Characteristics, Echocardiographic Features, and Outcomes

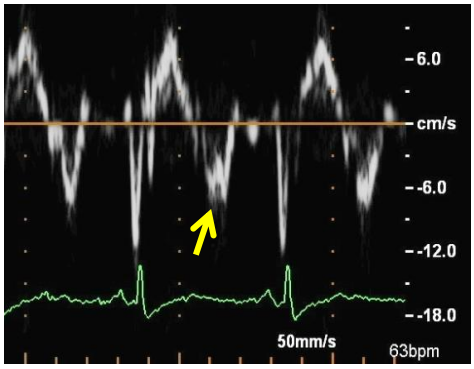
Michael Y.C. Tsang, MD; Jin-Oh Choi, MD, PhD; Barry A. Borlaug, MD; Kevin L. Greason, MD; Stephen S. Cha, MSc; Rick A. Nishimura, MD; Jae K. Oh, MD

Using mitral 'annulus reversus' to diagnose constrictive pericarditis

Christina S. Reuss[1], Susan M. Wilansky[1], Steven J. Lester[1], Joan L. Lusk[1], Diane E. Grill[2], Jae K. Oh[3], and A. Jamil Tajik[1]*



Medial e'= 12 cm/s



Lateral e' = 8 cm/s

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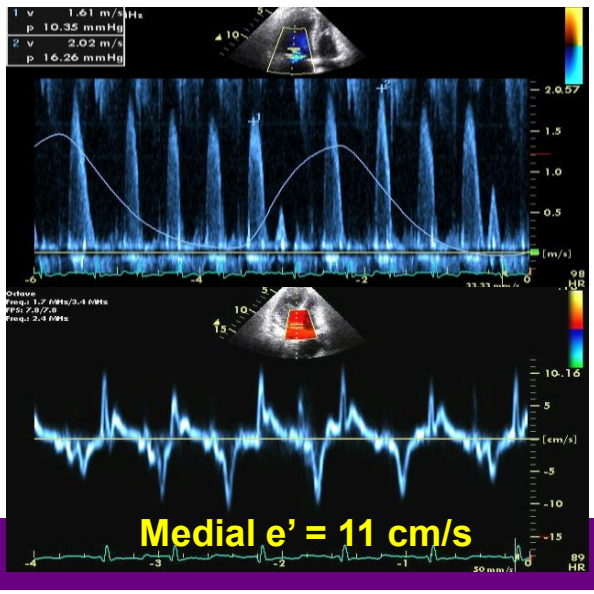
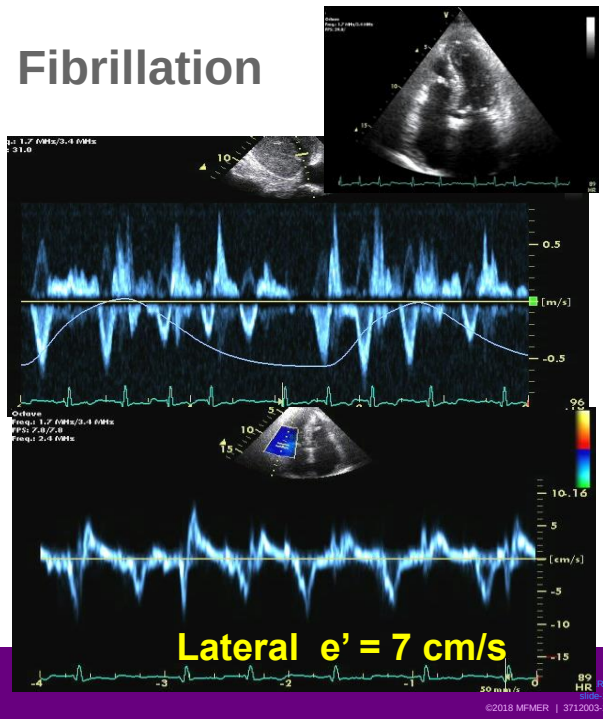
Reuss et al, EHJ Imaging June 2008

Constriction with Atrial Fibrillation





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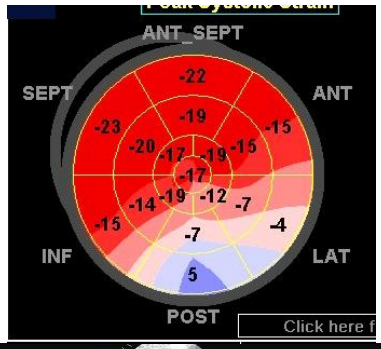
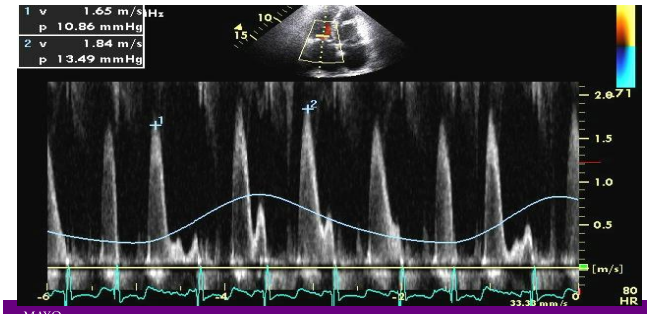
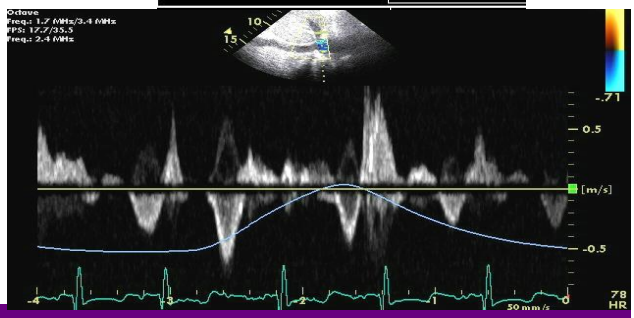
Constriction with A. Fibrillation After Cardioversion

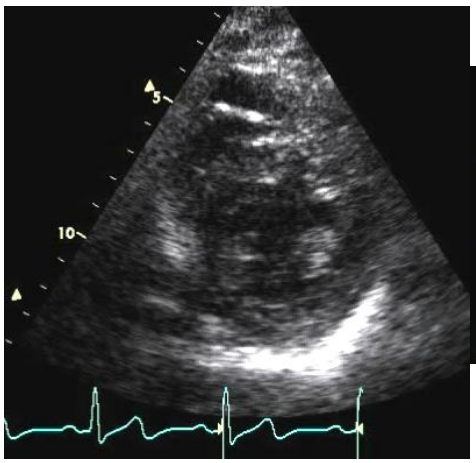


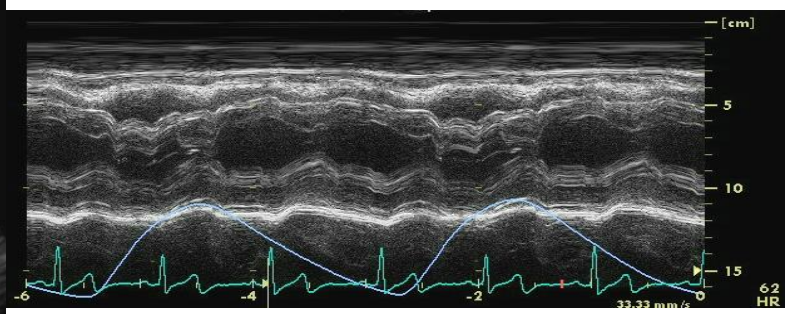




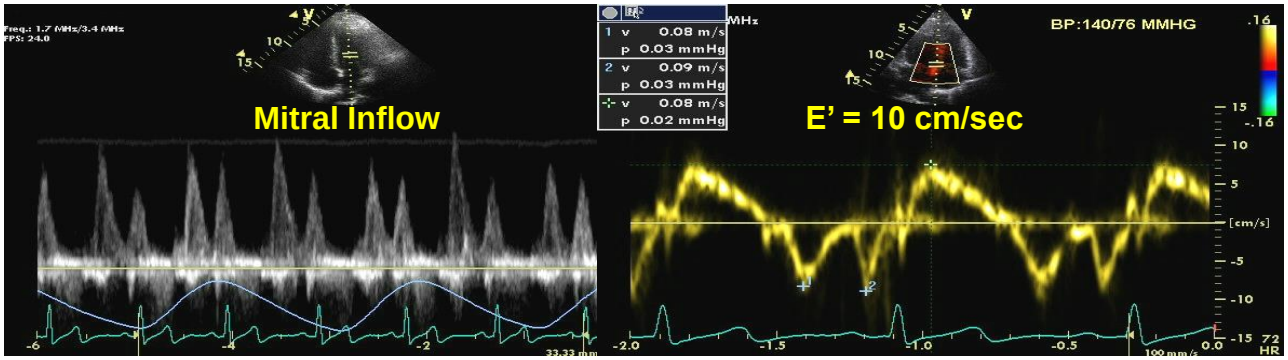
A 27 yo woman with Asthma

Marked Septal Motion Abnormality

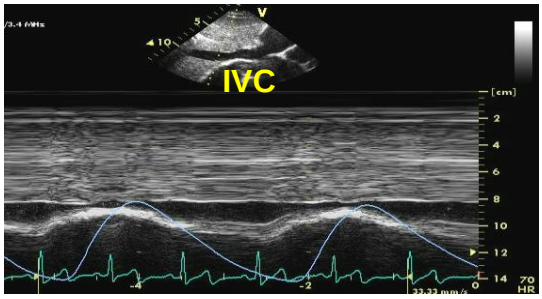


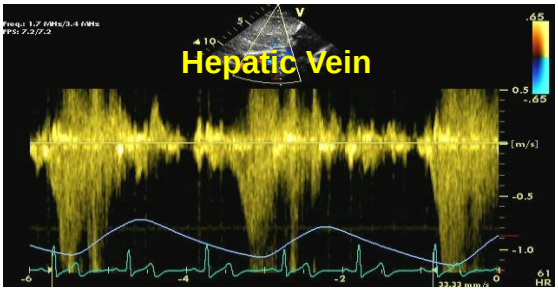


A 27 yo woman with dyspnea
Constrictive Pericarditis?



A 27 yo woman with dyspnea
Pulsus Paradoxus with Asthma

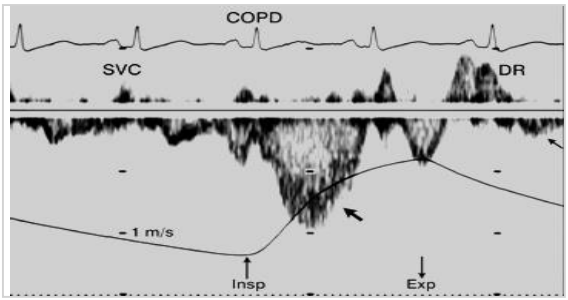




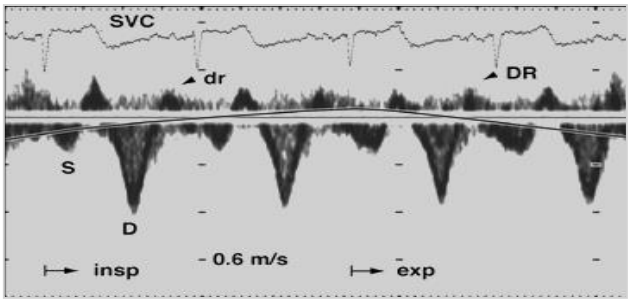
Constrictive vs COPD/Asthma

SVC Flow Velocities

COPD



Constriction



MAYO CLINIC

Boonyaratavej S, et al. J Am Coll Cardiol 1998 Dec; 32 : 2043-8

Annulus Reversus and Annulus Paradoxus

Pure vs Mixed Constrictive Pericarditis

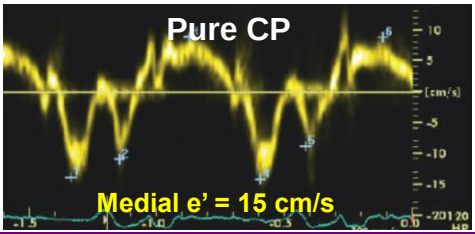
MAYO CLINIC

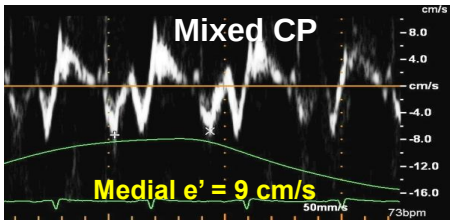
Mitral and Tricuspid Annular Velocities Before and After Pericardiectomy in Patients With Constrictive Pericarditis

Gabriella Veress, MD; Lieng H. Ling, MD; Kye-Hun Kim, MD, PhD; Jacob P. Dal-Bianco, MD; Hartzell V. Schaff, MD; Raul E. Espinosa, MD; Rowlens M. Melduni, MD; Jamil A. Tajik, MD; Thoralf M. Sundt, III, MD; Jae K. Oh, MD

Annulus Reversus

	Pure CP	Mixed CP
Medial e'	14.6 ± 3.2	10.3 ± 3.5
Lateral e'	12.8 ± 3.8	9.3 ± 2.8



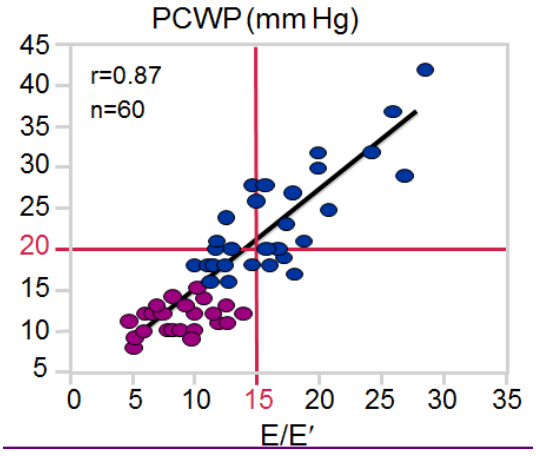


Veress et al. Circulation CV Imaging July 2011

Annulus Paradoxus

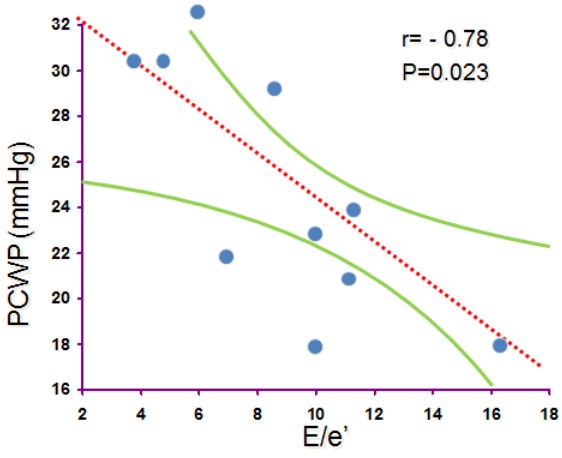
Transmitral Flow Velocity to Mitral Annular Velocity Ratio Is Inversely Proportional to Pulmonary Capillary Wedge Pressure in Patients With Constrictive Pericarditis

Jong-Won Ha, MD, PhD; Jae K. Oh, MD; Lieng H. Ling, MD; Rick A. Nishimura, MD; James B. Seward, MD; A. Jamil Tajik, MD



Myocardial Diseases

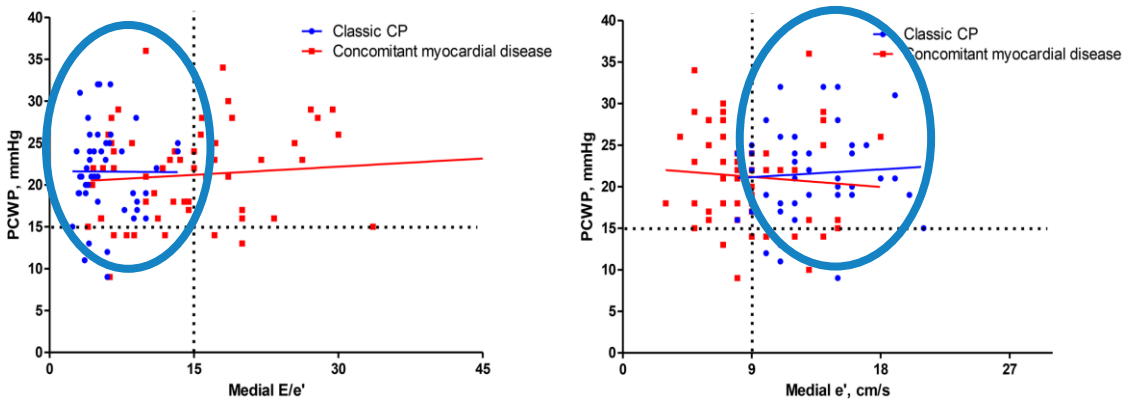
Nagueh et al JACC 1997



Constrictive Pericarditis

Ha et al Circulation 2001

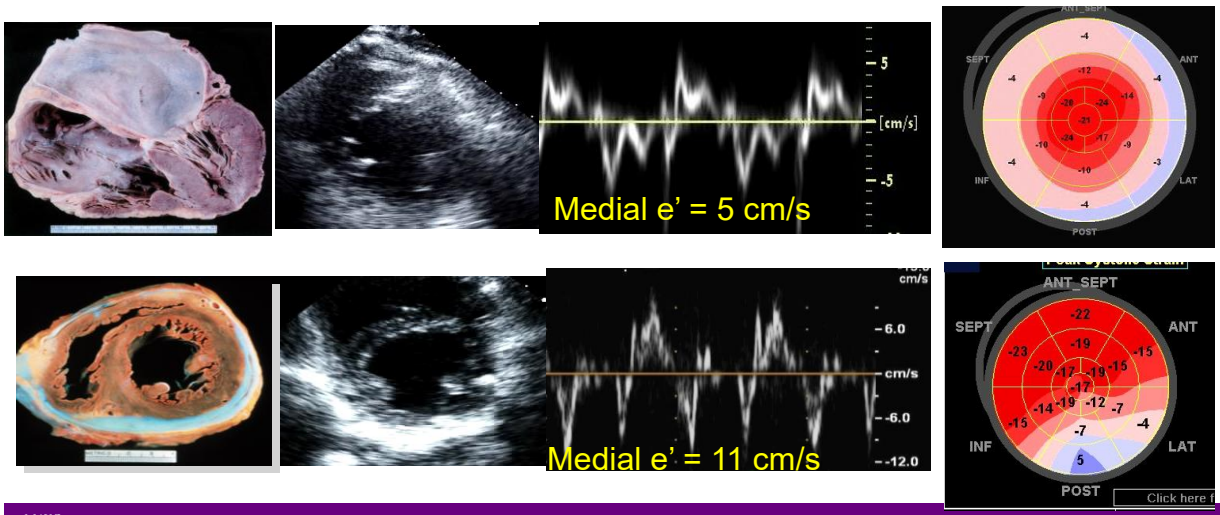
Pure vs Mixed (with CM) Constrictive Pericarditis
Annulus Paradoxus?



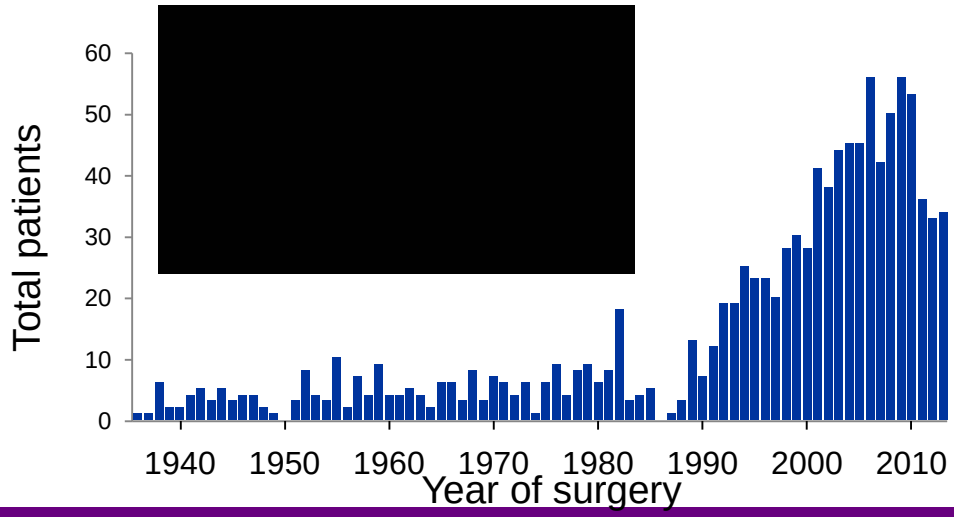
Mitral medial e' velocity is ≥ 9 cm/s and E/e' ratio is < 15 in almost all patients with pure constrictive pericarditis

Yang, Miranda, Oh et al. JACC Accepted

Restriction or Constriction?
Diagnosis based on 2-D , e' and strain imaging



Pericardiectomy for Constrictive Pericarditis
Mayo Clinic (n=1,066)



Murashita, Schaff, Greason et al Ann Thorac Surg 2017

Constrictive Pericarditis

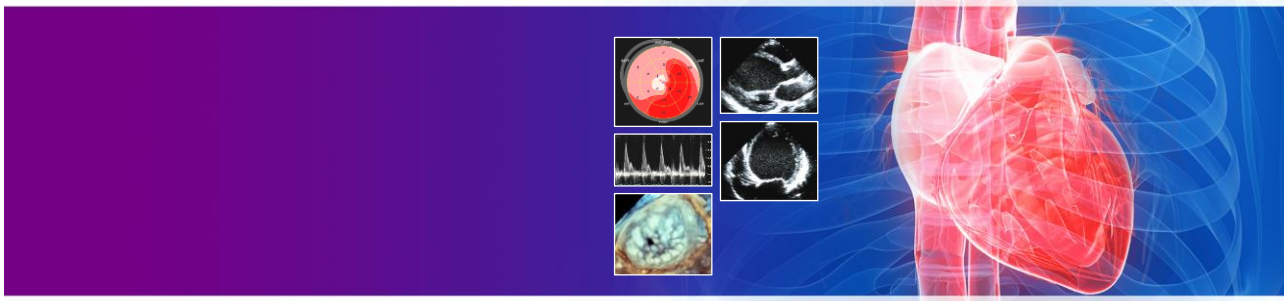
Take home Message : Curable Paradoxical DHF

- Constriction is a Hemodynamic Diagnosis
- Echo – Doppler can be diagnostic for constriction with
  - **Septal motion abnormality : Interventricular Dependence**
  - **Increased medial e' velocity > 8 cm/s**
  - **Mitral inflow restrictive pattern with or without respiratory variation**
  - **Hepatic Vein Doppler diastolic flow reversal with expiration**
- Very different from Restrictive Myocardial Disease

MAYO CLINIC

Tamponade and Effusive Constriction

for ASE Board Review 2019

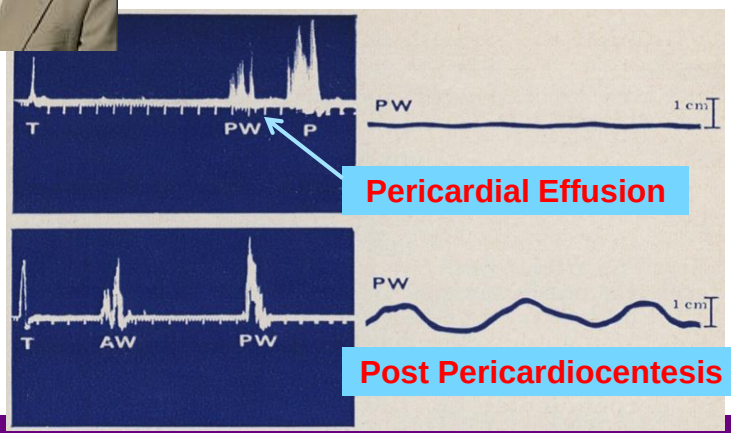


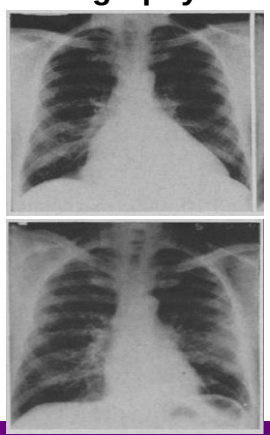
Jae K. Oh, MD

Ultrasound Diagnosis of Pericardial Effusion

Harvey Feigenbaum, MD, John A. Waldhausen, MD, and Lloyd P. Hyde, MD

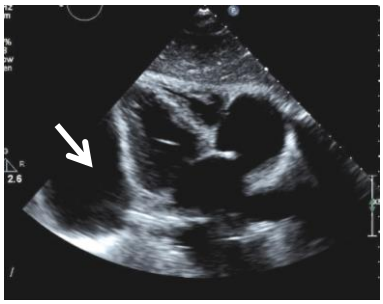
A (Amplitude) Mode Echocardiography

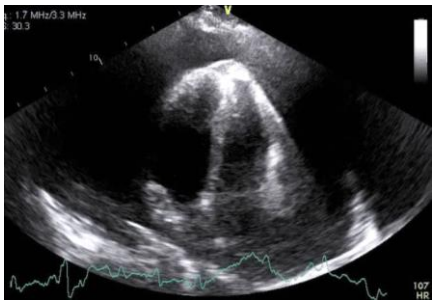


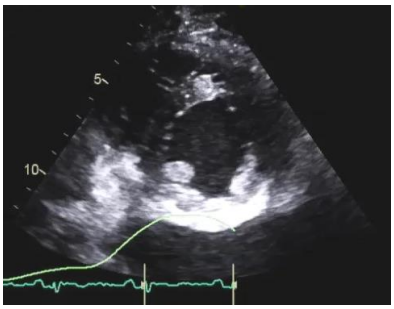


H. Feigenbaum JAMA 1965

Echocardiography for Pericardial Diseases Structure and Function with 2-D





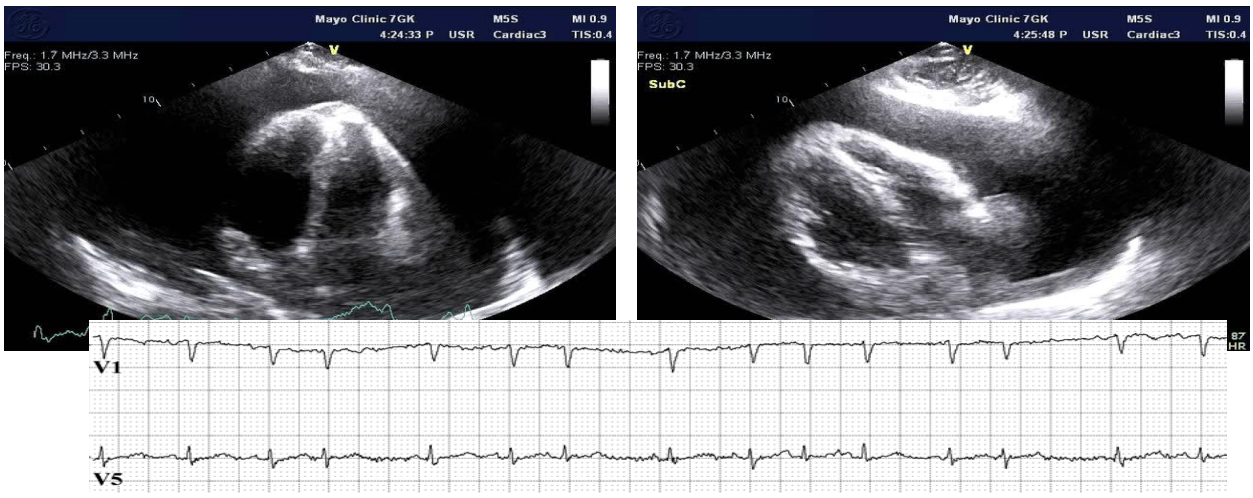


Cyst **Tamponade** **Constriction**

Case # 1

51 yo with SLE and BP 150/115 mmHg

Dyspnea and RUQ discomfort



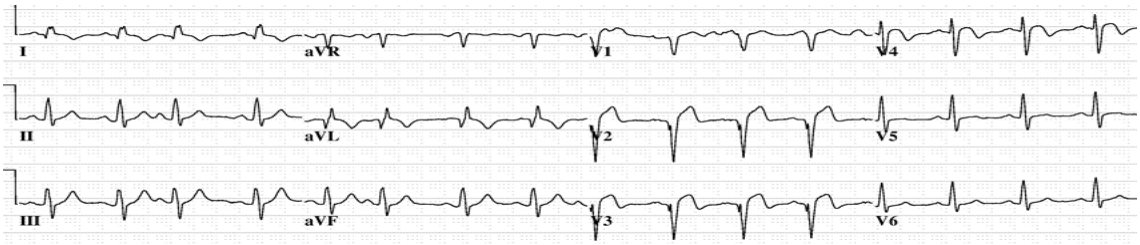
4 liters of pericardial effusion

Case # 2

57 year old man with STEMI

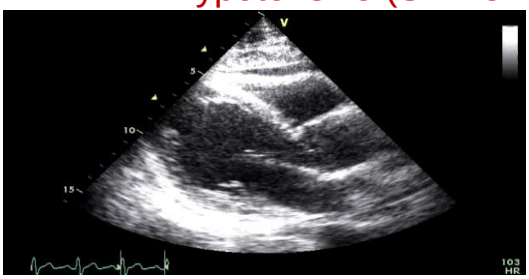
Transferred to CCU after PCI/LAD stent

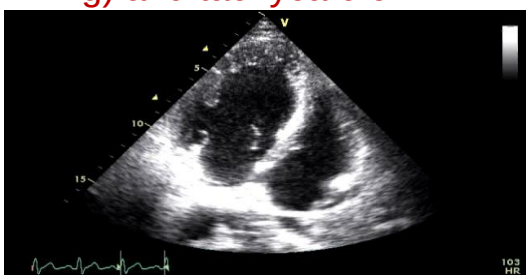
- Blood pressure 84 /60 mmHg
- HR 105 BPM
- Lungs are clear and no heart murmur

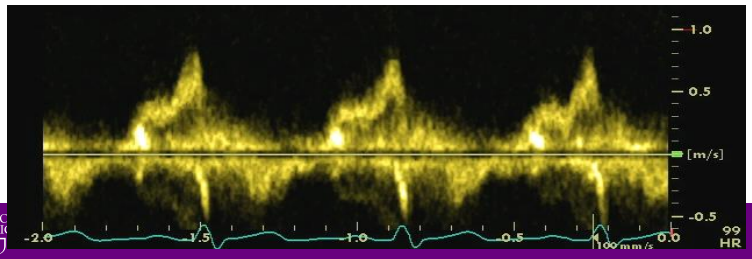


57 year old male with STEMI

Thrombolysis and Stent
Hypotensive (SBP 84 mmHg) and tachycardic

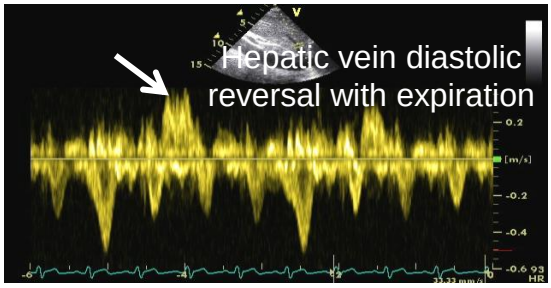


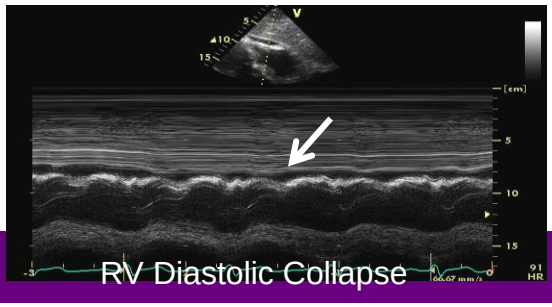


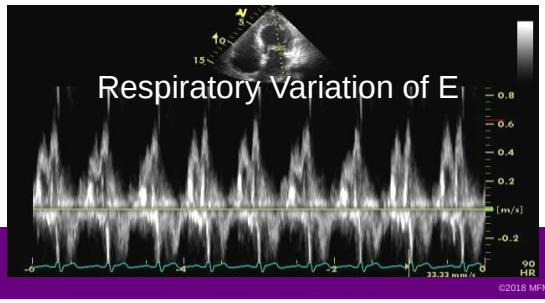


1. LV systolic Dysfunction
2. Hypovolemia
3. Tamponade
4. Pulmonary Edema

57 year old man with STEMI and Tamponade







Tamponade Physiology

NEJM 349: 684, 2003

How often all Beck's Triad are present in patients with cardiac tamponade ?

1. Hypotension
2. Increased JVP
3. Quiet heart

1. 40 %
2. 60 %
3. 80%
4. 100%

1. Beck CS. Two cardiac compression triads. JAMA 1935; 104:714-716
2. Hurst JM. Common Problems in Trauma. Chicago: Year Book Medical Publishers, 1987, p. 161
3. Wilson RF, Bassett JS. Penetrating wounds of the pericardium or its contents. JAMA 1966; 195:513-18

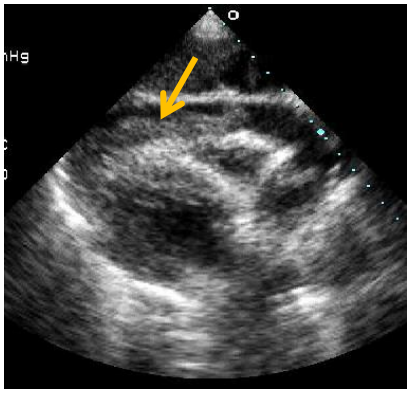
MAYO CLINIC

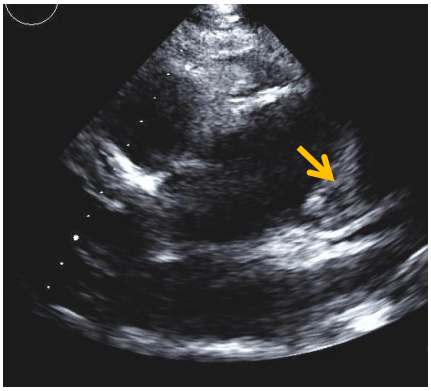
Tamponade is a clinical diagnosis !

Tamponade is an Echo Diagnosis !

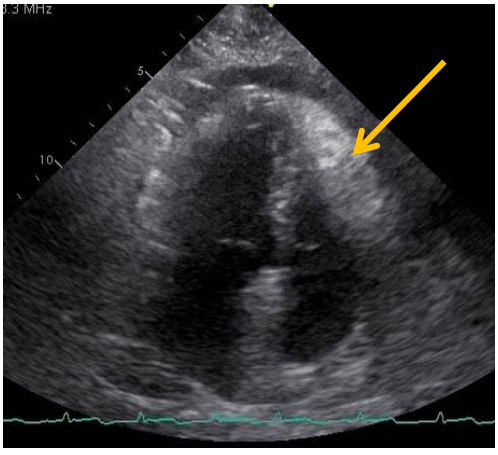
MAYO CLINIC

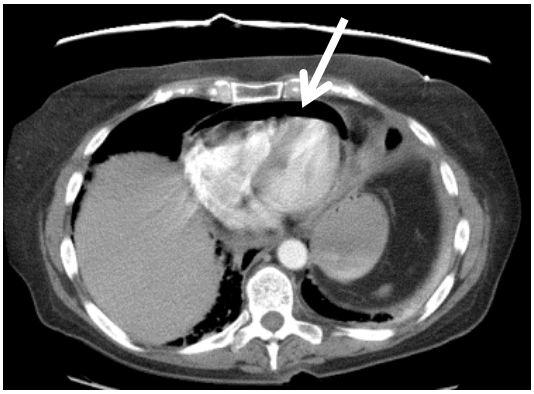
Hemo-pericardium due to Aortic Dissection





66 year old woman with dyspnea
Gastro-pericardial fistula





Pneumo-pericardium

ORIGINAL ARTICLE

Incidence and Management of Hemopericardium: Impact of Changing Trends in Invasive Cardiology

Annop Lekhakul, MD; Eric R. Fenstad, MD; Chalailak Assawakawintip, MD; Sorin V. Pislaru, MD, PhD; Assefa M. Ayalew, MD; Joseph F. Maalouf, MD; Vuyisile T. Nkomo, MD, MPH; Jeremy Thaden, MD; Jae K. Oh, MD; Larry J. Sinak, MD; and Garvan C. Kane, MD, PhD

Abstract

Objective: As invasive cardiovascular care has become increasingly complex, cardiac perforation leading to hemopericardium is a progressively prevalent complication. We sought to assess the frequency, etiology, and outcomes of hemorrhagic pericardial effusions managed through a nonsurgical echo-guided percutaneous strategy.

Patients and Methods: Over a 10-year period (January 1, 2007, to December 31, 2016), 1097 unique patients required pericardiocentesis for clinically important pericardial effusions. Of these 41[illegible] drainage of hemorrhagic effusions (defined as a pericardial hemoglobin level >50% of serum hemo[illegible] or frank blood in the setting of cardiac perforation). Clinical characteristics, echocardiographic data[illegible] of the procedure, and outcomes were determined.

Results: Median patient age was 67 years (interquartile range, 56-76 years), and 60% were [illegible] procedure was emergent in 83% and elective in 17%. The site of pericardiocentesis was deter[illegible] echo-guidance in all: 68% from the left para-apical region, 18% from the left or right parasternal [illegible] 14% were subxyphoid. Half (n=215 [52%]) occurred after cardiac perforation with percutan[illegible] ventional procedure (ablation, n=94; device lead implantation, n=65; percutaneous coronar[illegible] tion, n=22; other, n=34), whereas 30% followed cardiac or thoracic surgery. Pericardial [illegible] drained was 546±440 mL. In 94% of cases, echo-guided pericardiocentesis was the only trea[illegible] effusion needed, whereas definitive surgery was required in 25 (6%) cases for persistent blee[illegible] management of the underlying etiology. There was no procedural mortality. Late mortality [illegible] hemorrhagic effusions compared with a contemporary cohort with nonhemorrhagic effusi[illegible]

Conclusion: Echocardiographic guidance allows rapid successful pericardiocentesis in [illegible] hemopericardium related to microperforation with interventional procedures, malignancy, [illegible] with most not requiring surgical intervention. Surgery should remain the first-line ap[illegible] dissection or myocardial rupture.

Small historical studies suggested that pericardial effusions accounted for [illegible] of the pericardiocenteses also occur in the setting of [illegible] lar surgery[1-3,13] Rarely, [illegible] develops as a complication of acute [illegible] or myocardial rupture after a [illegible] dissection or [illegible] develops, 3 [illegible]

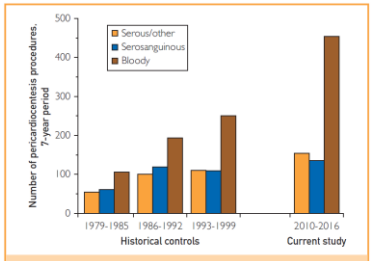
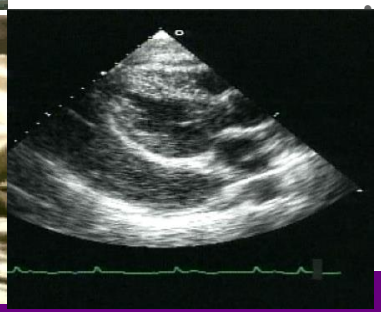


FIGURE 1. Temporal trends in pericardiocentesis. Compared with institutional historical data,[1] there has been a significant rise in the need for pericardiocentesis over the past 3 decades, with the difference related predominantly to a major rise in the incidence of hemorrhagic pericardial

Setting of hemopericardium, n (%)	
Interventional procedure	215 (52)
Cardiac ablation	94 (23)
Device lead implantation	65 (16)
PCI	22 (5)
Other	34 (8)
Postoperative, n (%)	123 (30)
Cardiac surgery	117 (28)
Esophageal surgery	3 (1)
Lung/other mediastinal	3 (1)
Malignancy	36 (9)
Idiopathic/other	35 (9)
Spontaneous rupture/dissection	2 (0.5)

Lekhakul A et al. MCP 2018

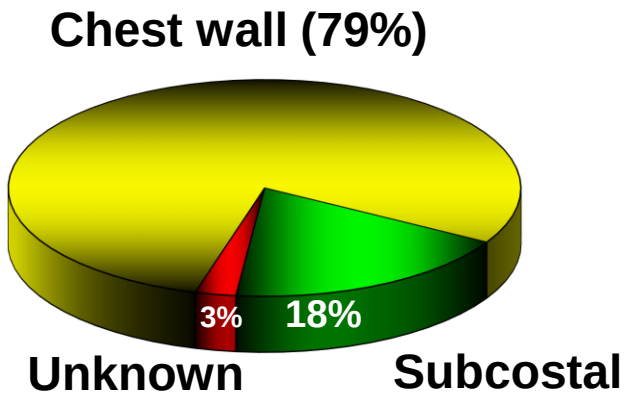
Echo-Guided Pericardiocentesis



- ***Pericardiocentesis tray***
- **Sterile prep and drape**
- **Lidocaine**
- **Midazolam/Fentanyl**
- **16 gauge angiocath**
- **Agitated saline**
- **6French introducer sheath (w/ stylet)**
- **65cm Pigtail catheter**
- **3-way stopcock**
- **Connector tubing**
- **14 gauge needle**
- **Vacuum bottle**

Echo-guided Pericardiocentesis

Paraapical	*80%*
L parasternal	*9%*
L axillary	*6%*
R parasternal	*4%*
Posterolateral	*1%*



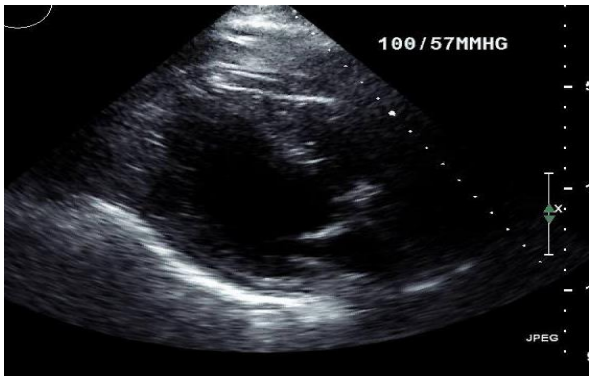
MAYO CLINIC

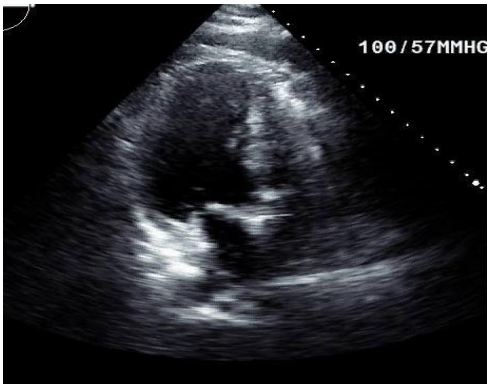
Tsang TS et al: Mayo Clin Proc 77:429, 2002

Case

77 yo man with severe aortic stenosis

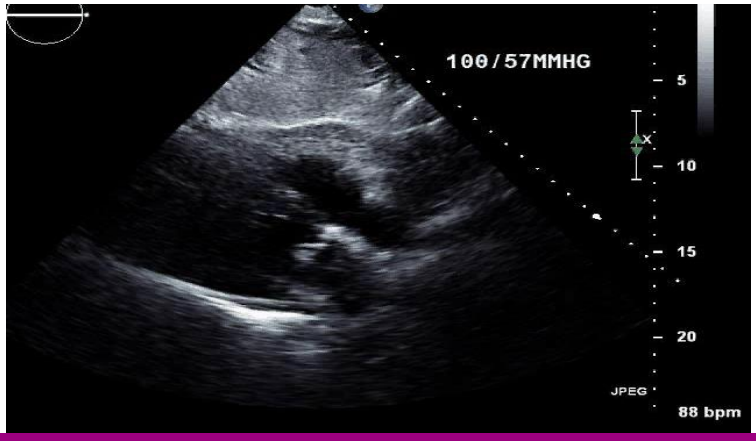
TAVR and PM implantation





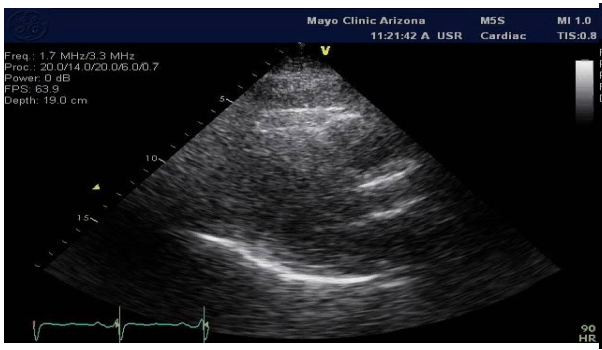
MAYO CLINIC

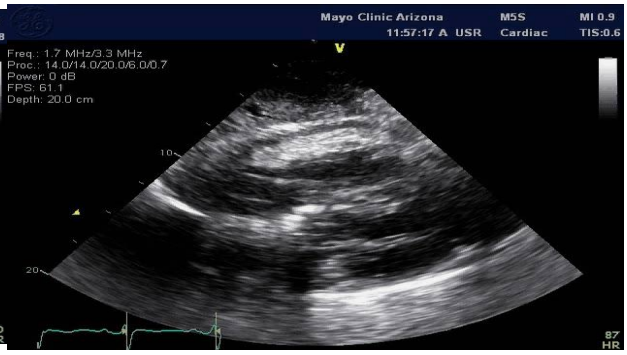
77 yo man with severe aortic stenosis
TAVR and PM implantation & RV Perforation



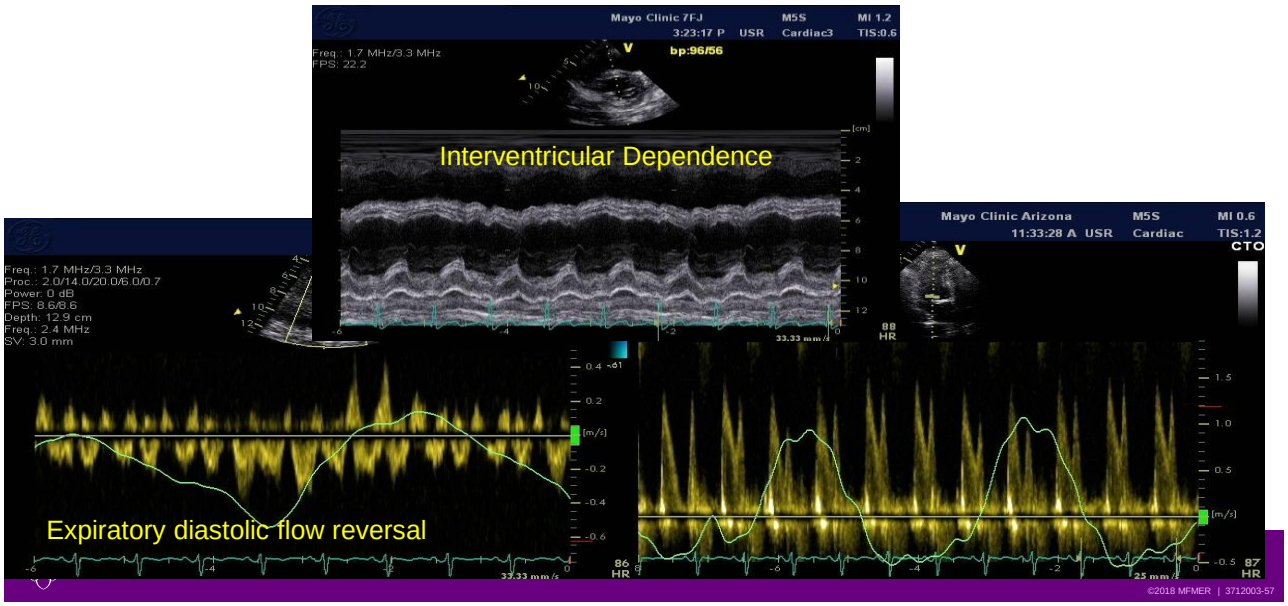
Pericardiocentesis yielded 125 cc of bloody fluid

77 yo man with severe aortic stenosis
Increasing dyspnea 2 months after pericardiocentesis





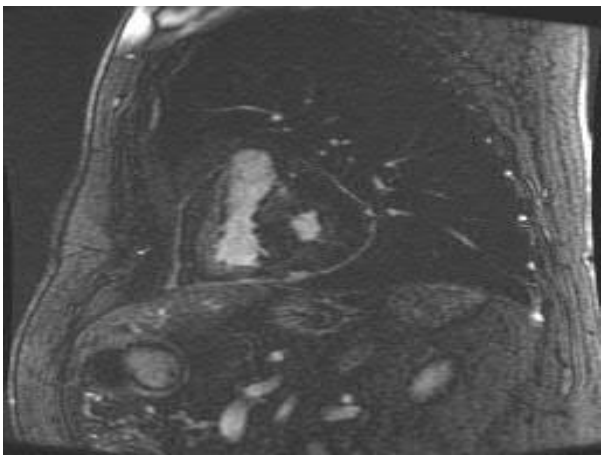
Effusive-Constrictive Pericarditis



77 yo man with effusive constrictive pericarditis

Cardiac MRI with Delayed Enhancement

How would you treat this ?



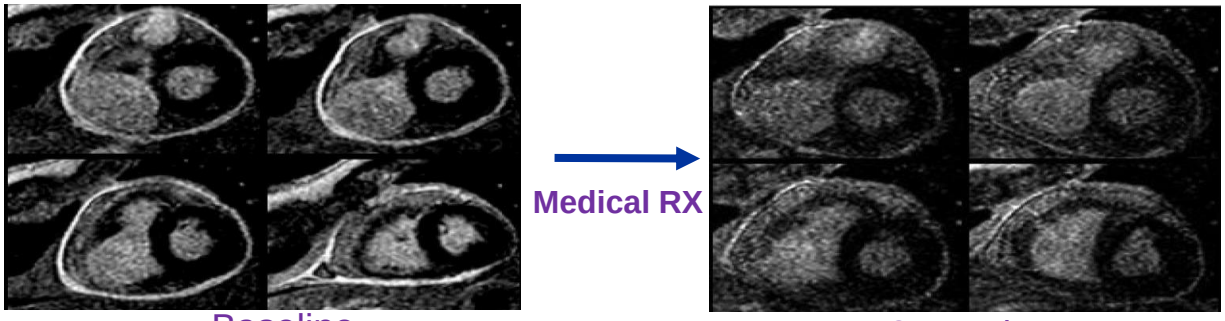
1. Observe & Wait
2. NSAID
3. Colchicine
4. Steroid
5. Pericardiectomy

MAYO CLINIC

Cardiac Magnetic Resonance Imaging Pericardial Late Gadolinium Enhancement and Elevated Inflammatory Markers Can Predict the Reversibility of Constrictive Pericarditis After Antiinflammatory Medical Therapy

A Pilot Study

DaLi Feng, MD; James Glockner, MD, PhD; Kyehun Kim, MD; Matthew Martinez, MD; Imran S. Syed, MD; Philip Araoz, MD; Jerome Breen, MD; Raul E. Espinosa, MD; Thoralf Sundt, MD; Hartzell V. Schaff, MD; Jae K. Oh, MD



Baseline

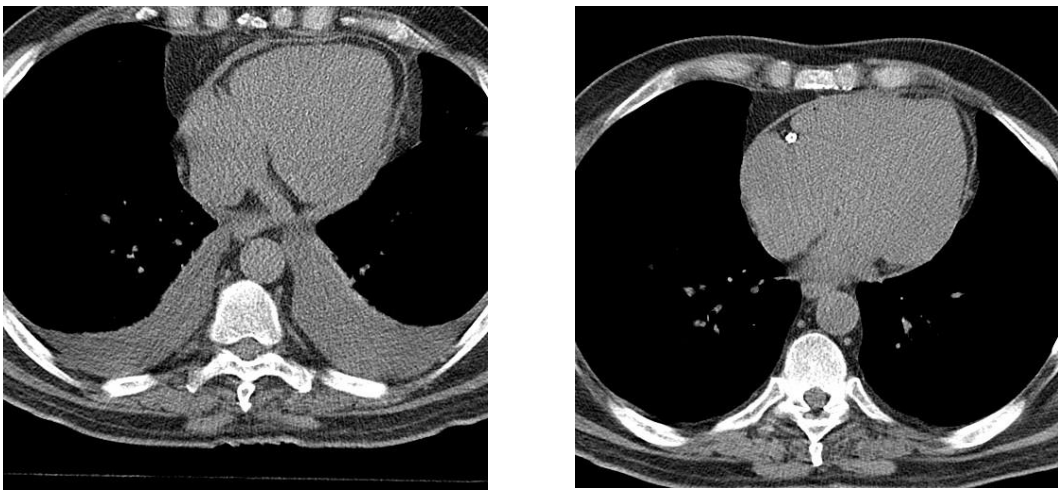
3 Months

MAYO CLINIC

Circulation Oct 3rd 2011

Transient Constrictive Pericarditis

One week of Steroid Rx

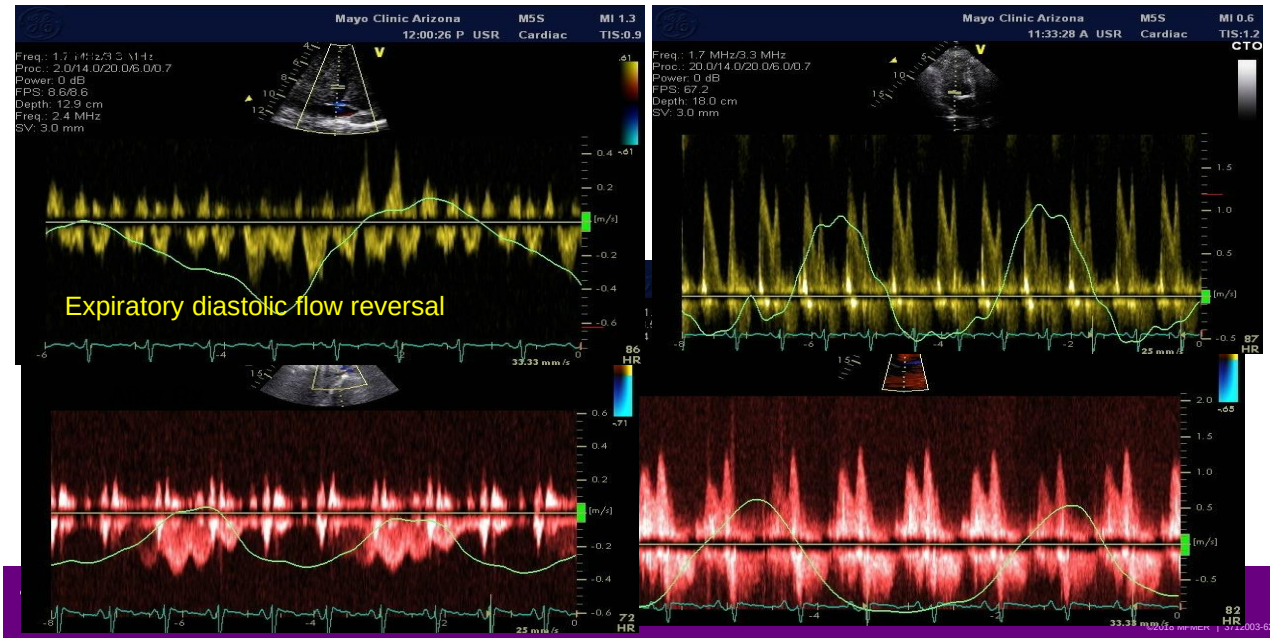


MAYO CLINIC

Transient Constriction

	Reversible (N=14)	Persistent (N=15)
Age	54 ± 17	59 ± 16
LVEF	57 ± 3	60 ± 3
E' (cm/sec)	12 ± 1	11 ± 1
Steroid Rx	71 %	53 %
Pericardium	3.8 ± 0.6 mm	4.0 ± 0.6 mm
DE Pericardium	4.4 ± 0.4 mm	2.1 ± 0.4mm
Grade 3-4/4 DE	93 %	33 %
Sed rate	45 to 4	25 to 20
CRP	75 to 2	14 to 15

After 2 months of NSAID and Colchicine



Effusive-Constrictive Pericarditis After Pericardiocentesis

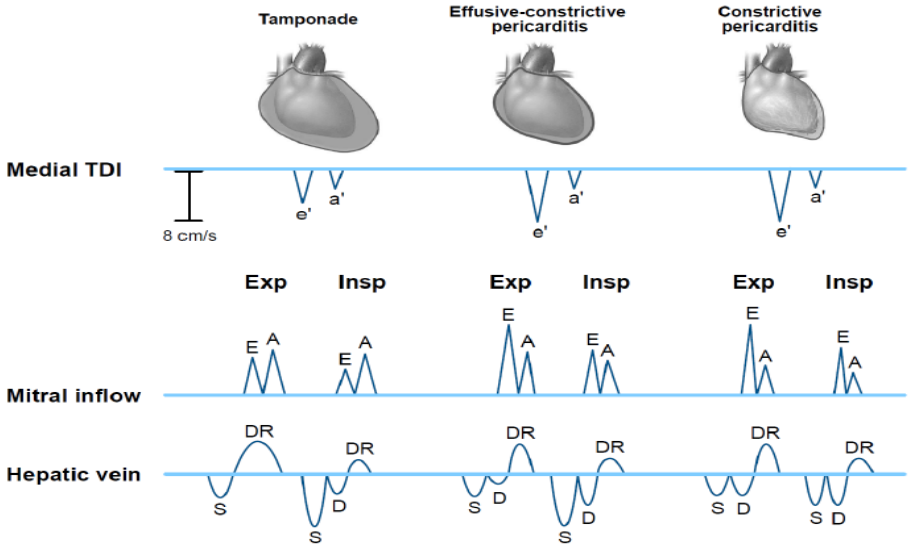
Incidence, Associated Findings, and Natural History

- 205 consecutive patients with pericardiocentesis
- ECP was diagnosed in 33 (16%)
  - More frequent hemo-pericardium (33% vs 13%)
  - Higher % of neutrophils
  - Baseline medial mitral annulus e' higher
  - Expiratory diastolic flow reversal in HV more frequent
  - 2 required pericardiectomy in 3.8 year follow-up

MAYO CLINIC

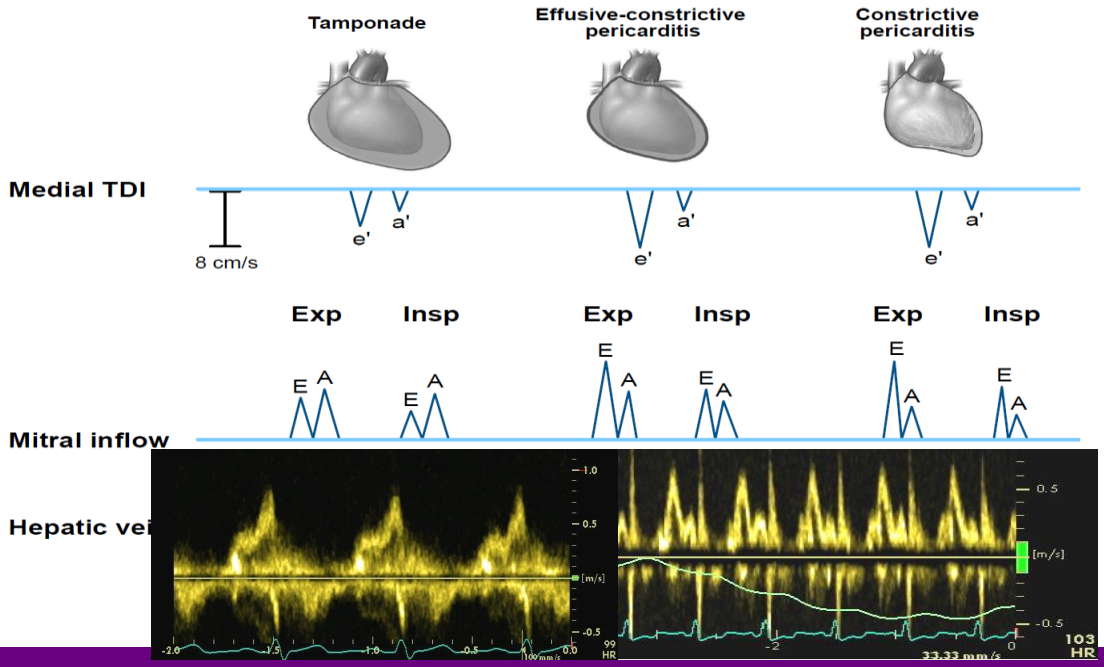
Kim KH, Miranda W et al JACC Imaging 2017

Tamponade vs Effusive CP



MAYO CLINIC

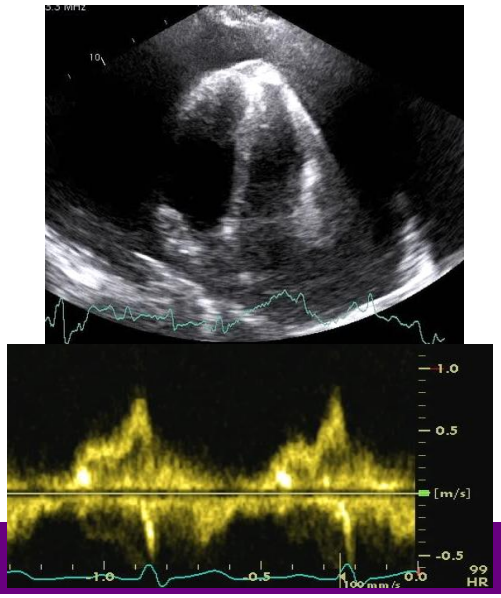
Miranda et al. EHJ Imaging 2018



Kim, Miranda, Oh et al EJCV Imaging 2018

Effusive Constrictive Pericarditis can be predicted by mitral inflow velocity pattern

1



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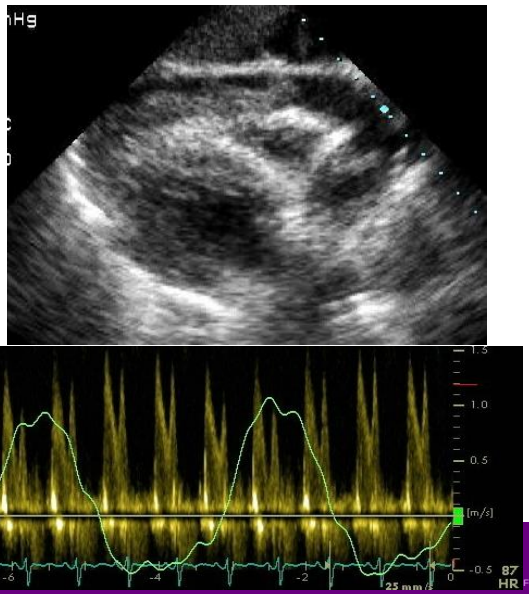
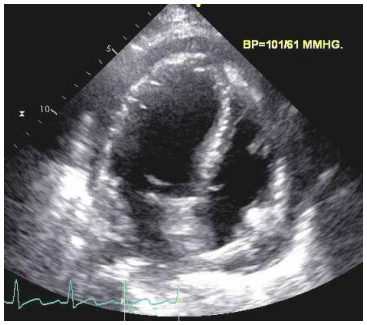
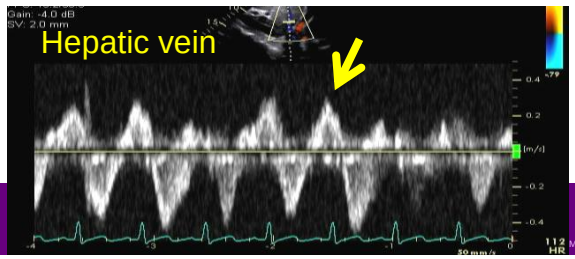


35 yo man presents with dyspnea and fever

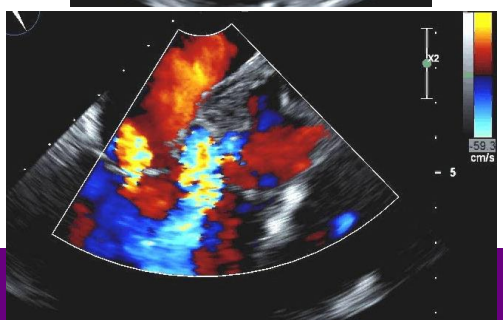
BP 80/40 mmHg

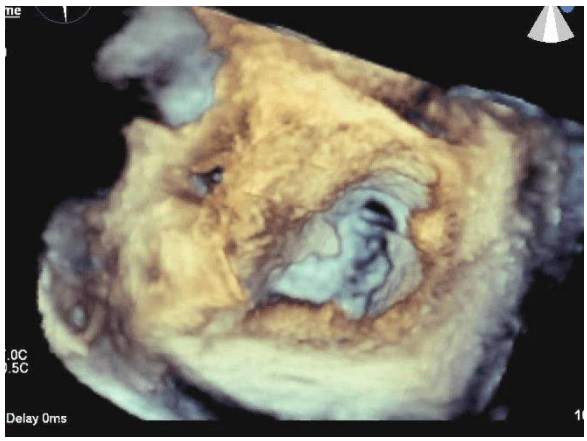




35 yo man with tamponade and fever

TEE after pericardiocentesis





Thank you for listening!
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