

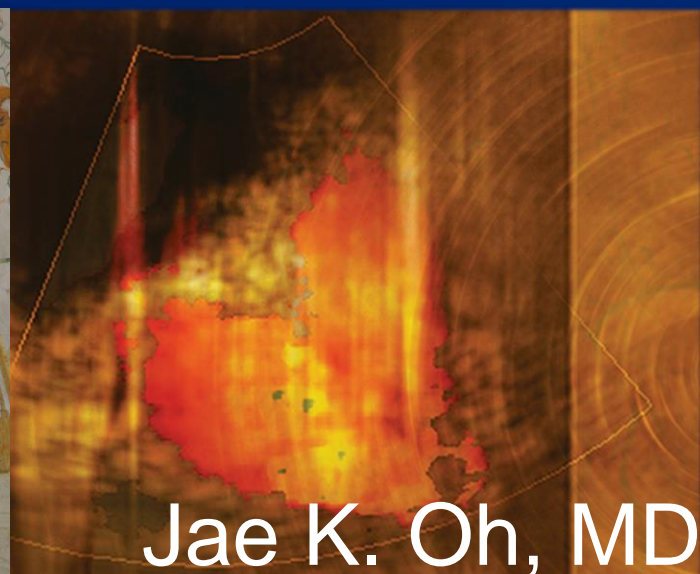


Sfide

In Cardiologia Clinica

# Constriction vs Restriction

*Is it still a big deal?*

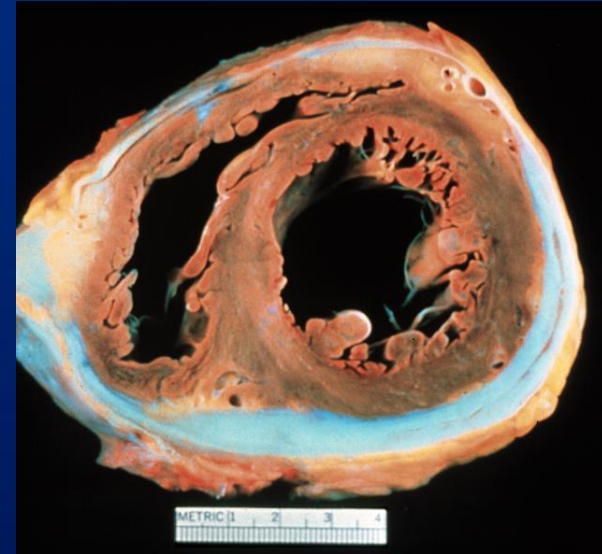
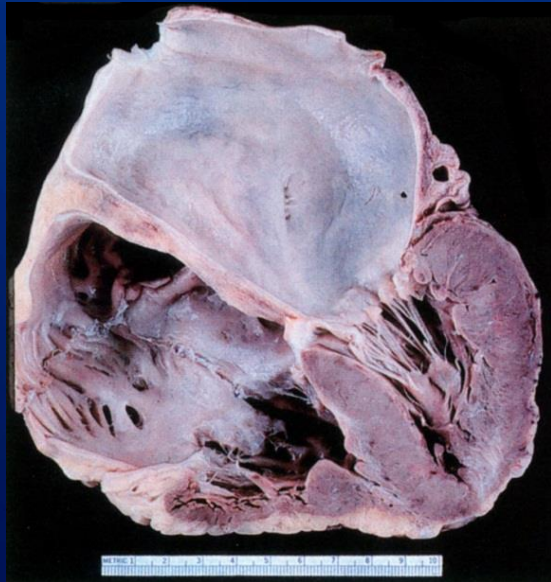


Jae K. Oh, MD

Samsung Professor of CV Diseases  
Director, Pericardial Disease Clinic  
Co-Director, Multimodality Imaging  
Mantova in Marzo 2017

# Restriction vs Constriction

## *Paradoxical DHF or HFpEF*



No paradoxical  
No variation  
Decreased ↓  
Inspiration  
Concordant

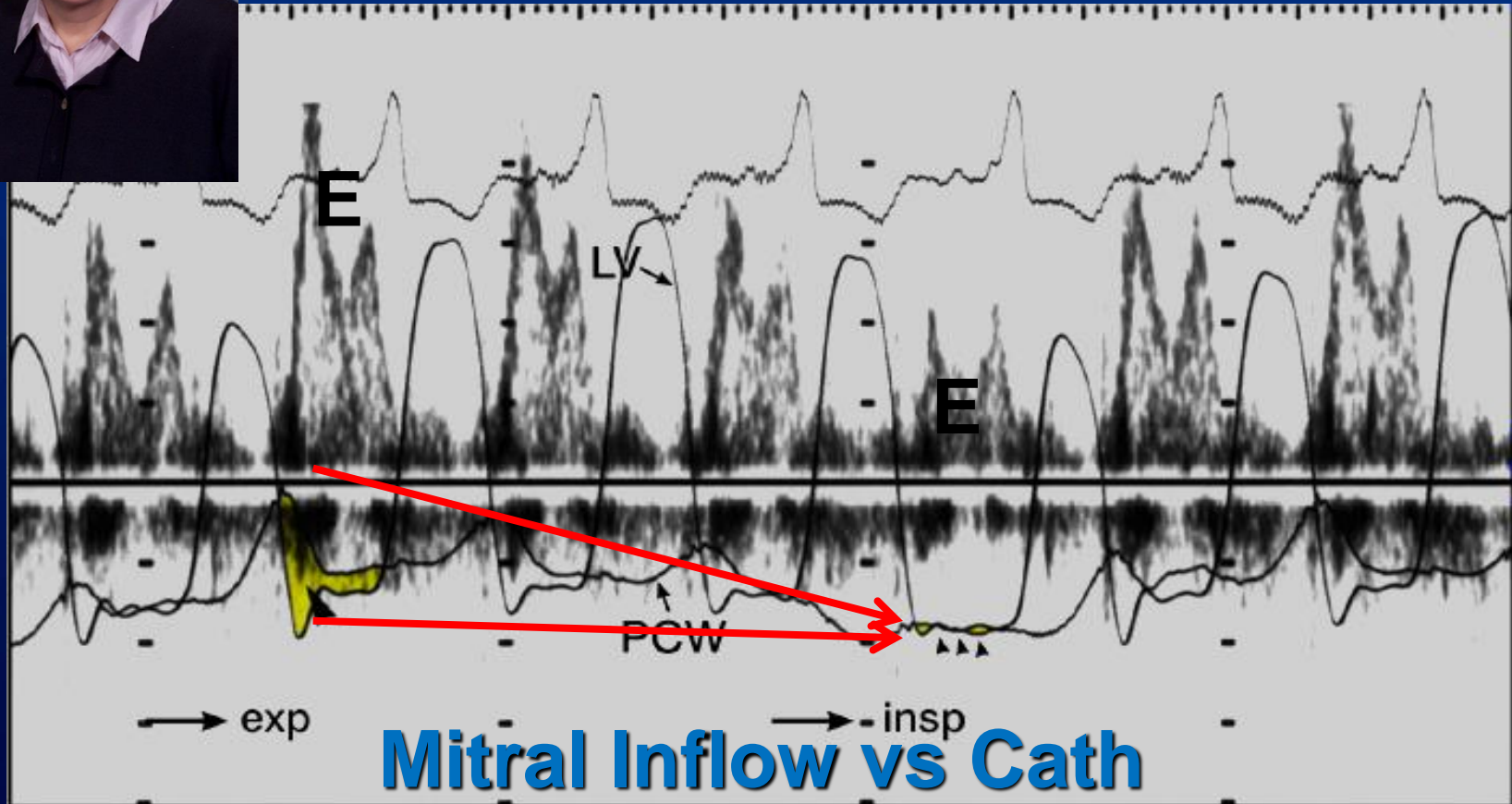
**Pulse**  
**Diastolic Filling**  
**Relaxation (e')** ↑  
**HV reversal**  
**LV/RV SP**

Paradoxical  
Variation  
Paradoxical ↑  
Expiration  
Discordant

Diagnosis should be based on their characteristic  
**HEMODYNAMICS**



# Constrictive Pericarditis

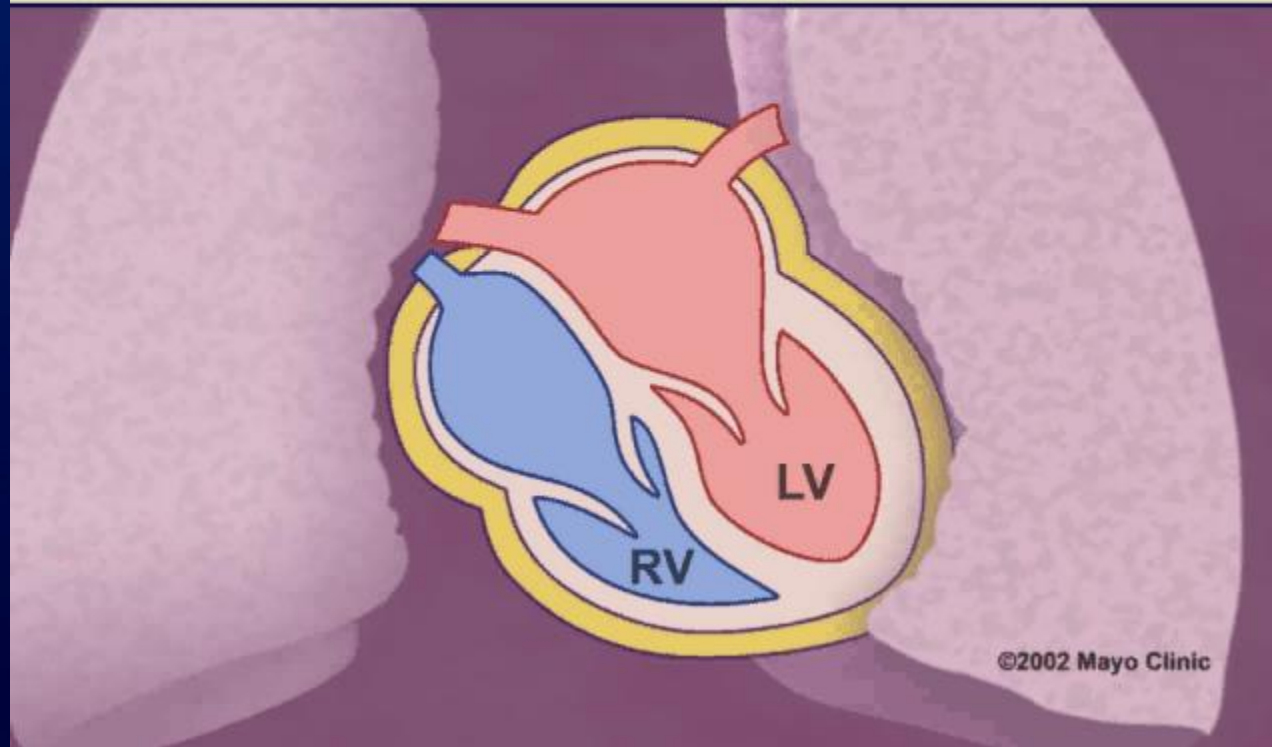
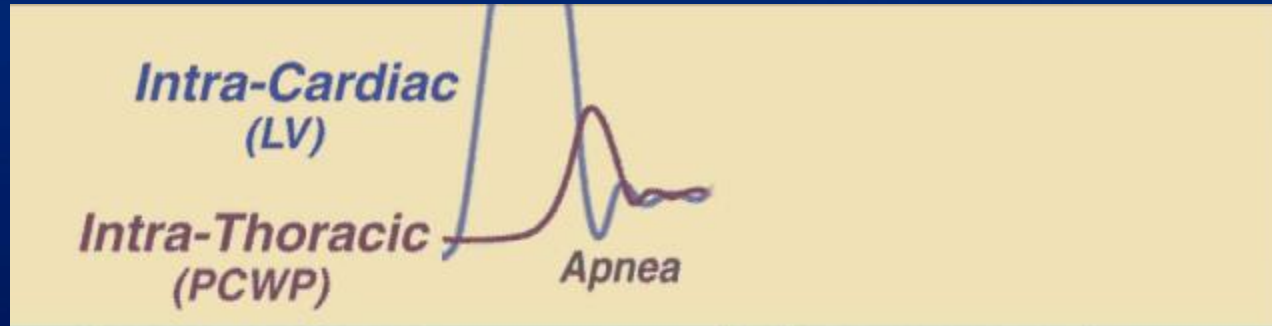


1. Dissociation between intrathoracic and intracardiac pressures
2. Interventricular Dependence

# Hemodynamics in Constriction

Intracardiac pressure  $\Delta$  < intrathoracic pressure  $\Delta$

Interventricular dependence



©2002 Mayo Clinic

CP1051850-19

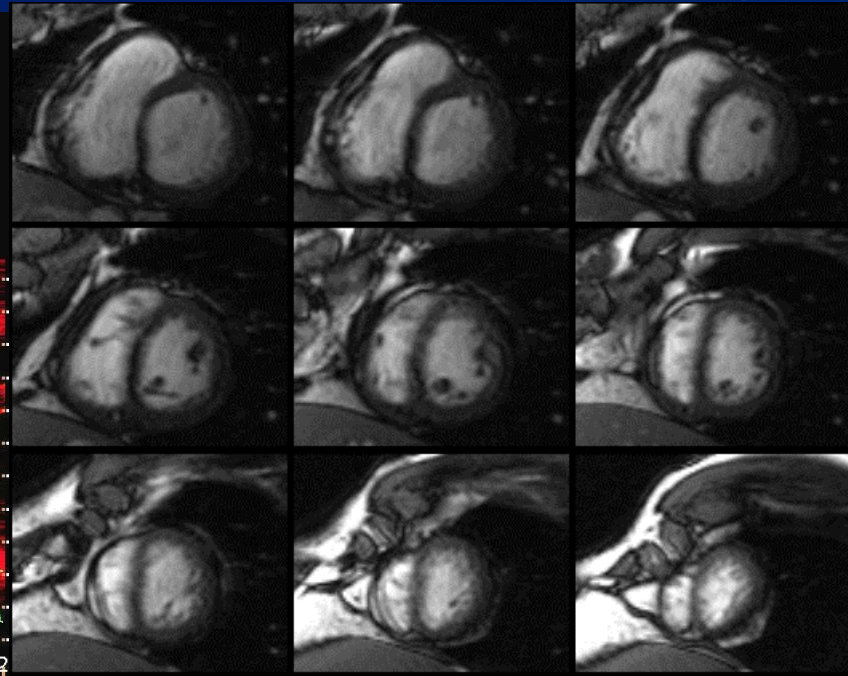
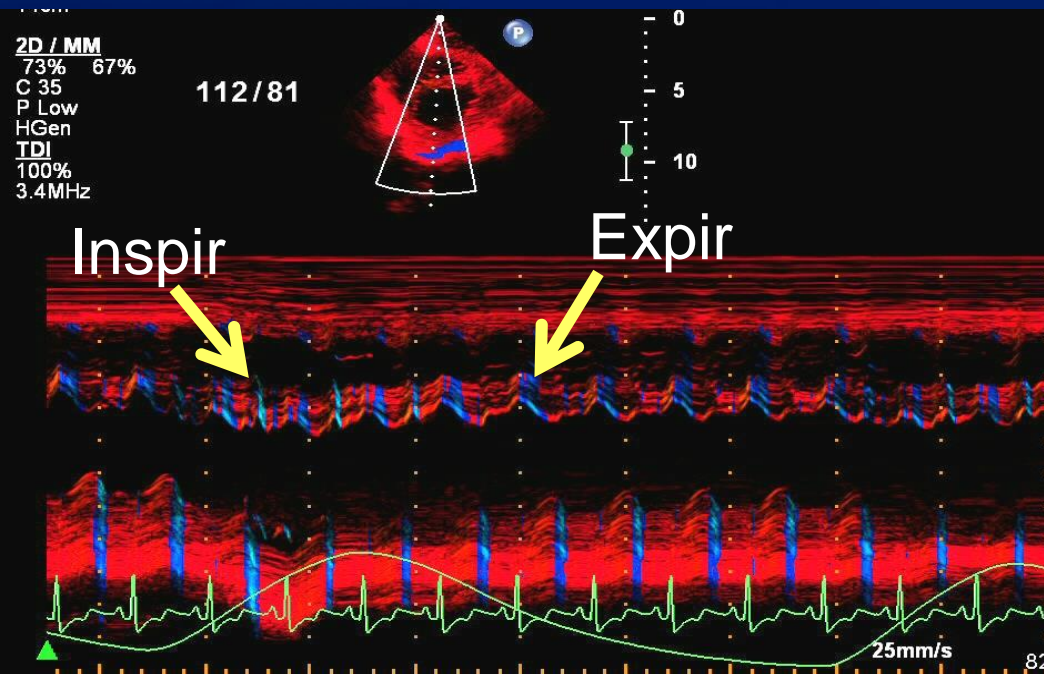
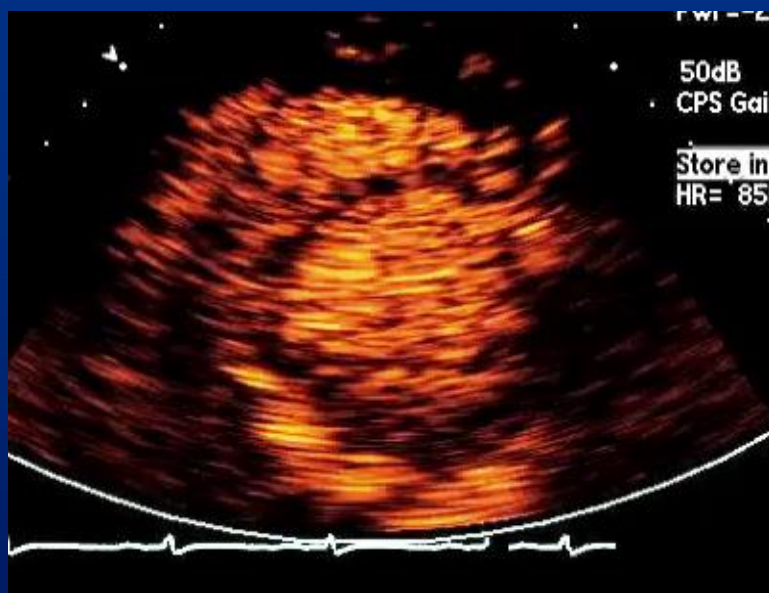
©2016 MFMR | slide-4

# Constriction

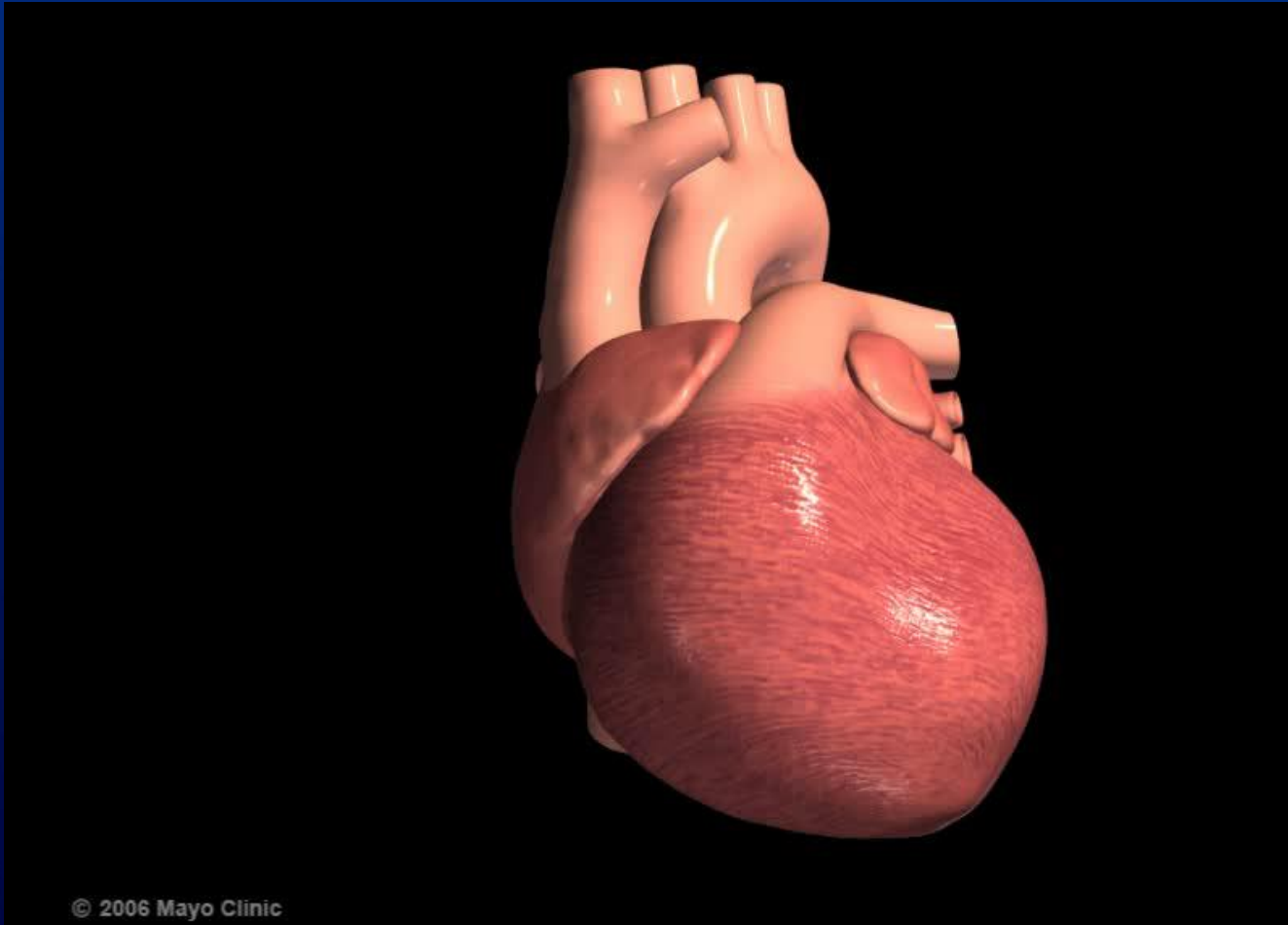
## *Abnormal septal motion*

### Interventricular Dependence

“Consider constriction if there is septal motion abnormality in patients with HF and preserved EF (HFpEF)”



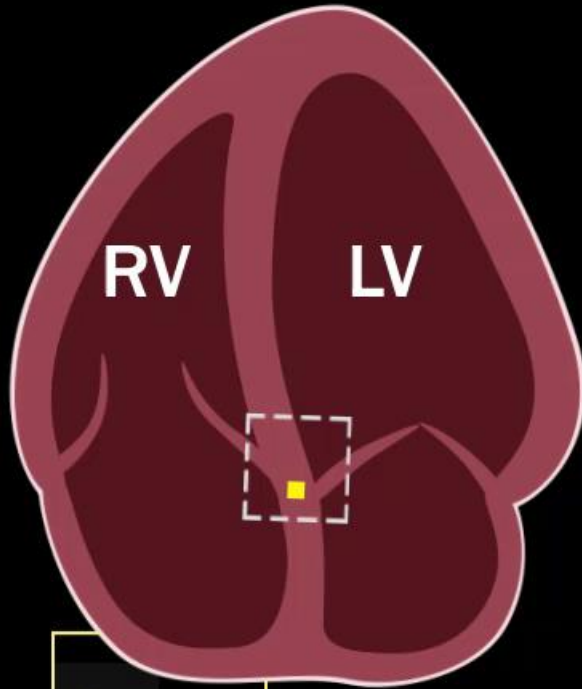
# Mitral Annulus Motion by Tissue Doppler $e'$ is noninvasive tau (relaxation)



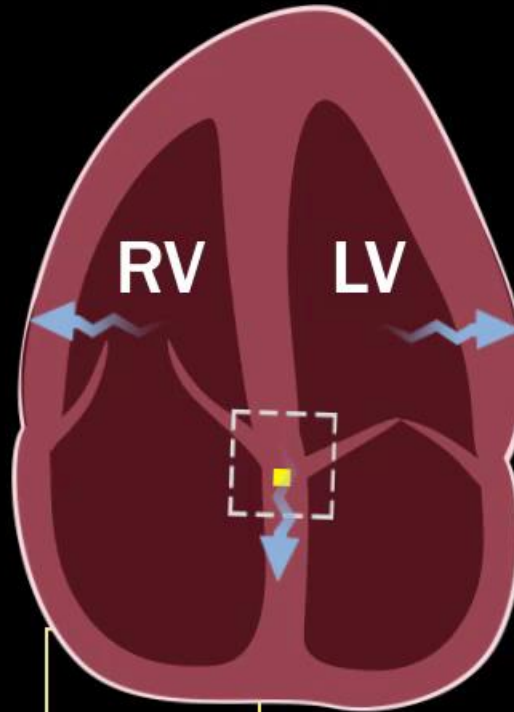
Myocardial relaxation ( $e'$ ) is reduced in all forms of myopathies

# Tissue Doppler in Constriction vs Restriction

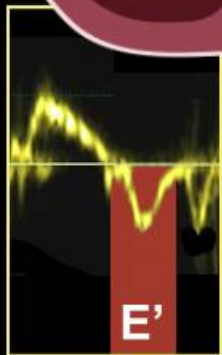
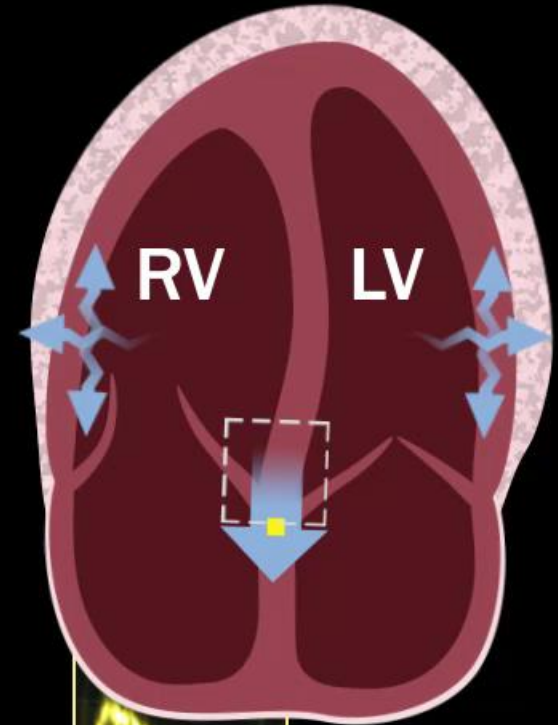
**Normal**



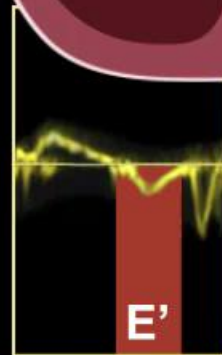
**Impaired Relaxation  
(Cardiomyopathy)**



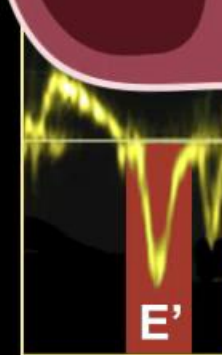
**Constrictive  
Pericarditis**



$E' > 8$  cm/sec



$E' < 7$  cm/sec



$E' > 8$  cm/sec

**$E'$  normal to high in constriction, low in myocardial disease**

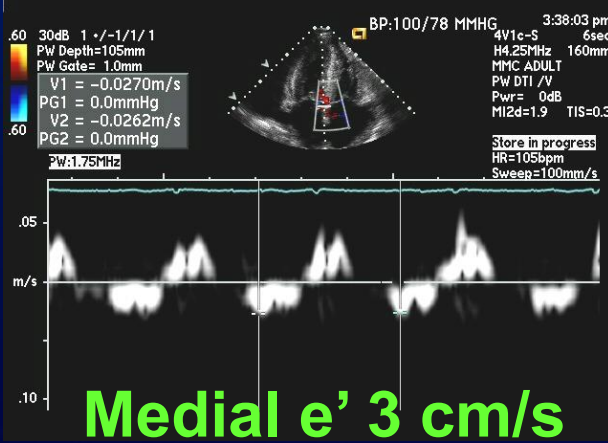
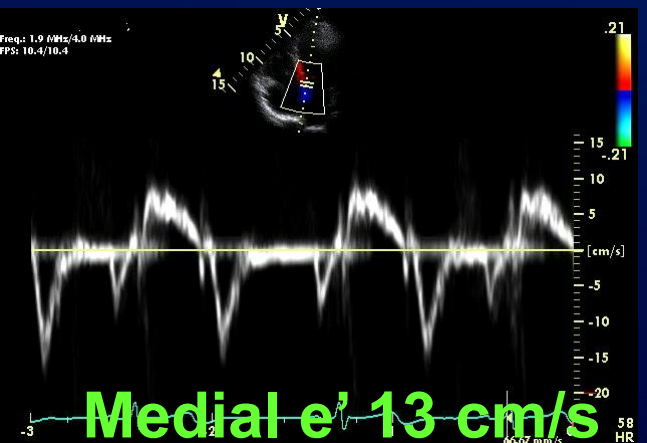
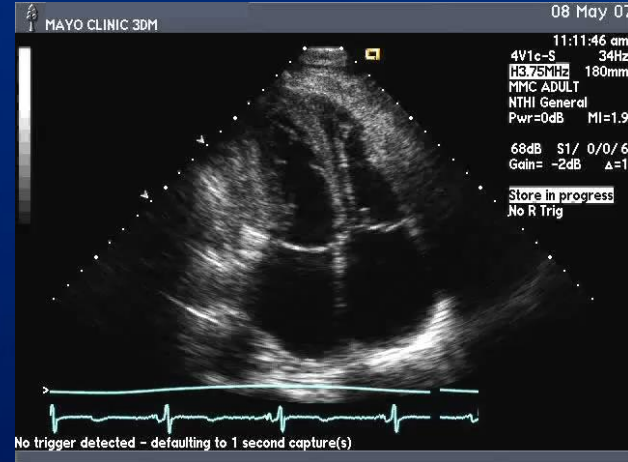
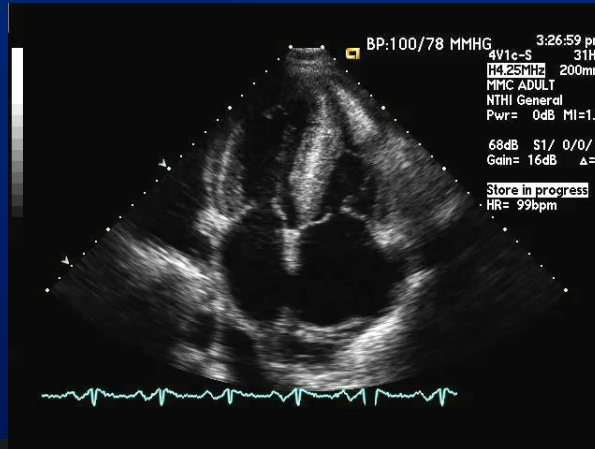
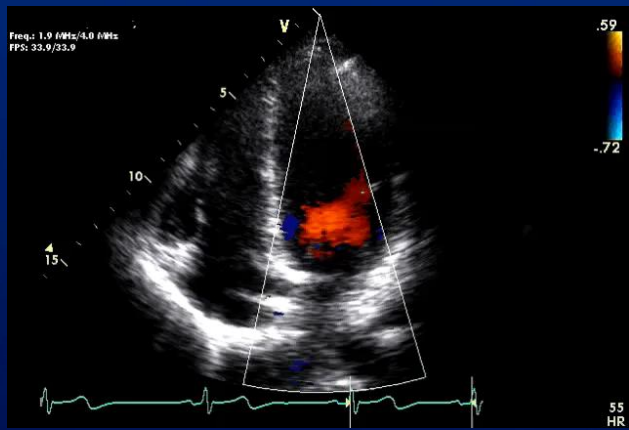
# Normal vs RCM vs CP

## Medial Mitral e' velocity (LV Relaxation)

Normal

RCM

CP



Usually > Lateral e'  
(Annulus Reversus)



# Echocardiographic Diagnosis of Constrictive Pericarditis: Mayo Clinic Criteria

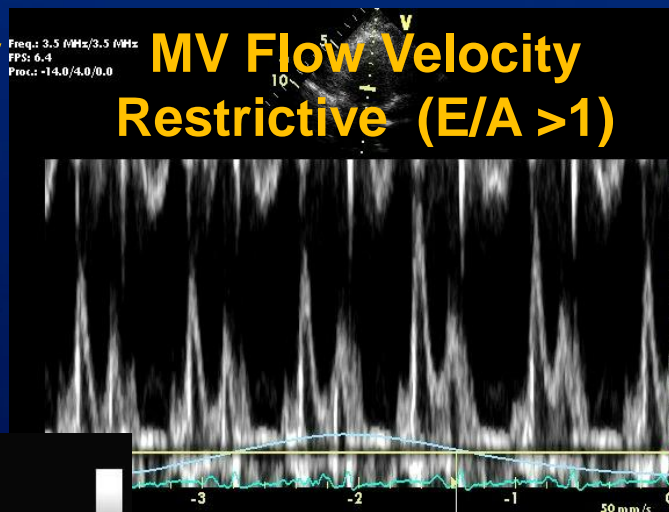
Terrence D. Welch, Lieng H. Ling, Raul E. Espinosa, Nandan S. Anavekar, Heather J. Wiste, Brian D. Lahr, Hartzell V. Schaff and Jae K. Oh

## Mayo Echo Diagnostic Criteria

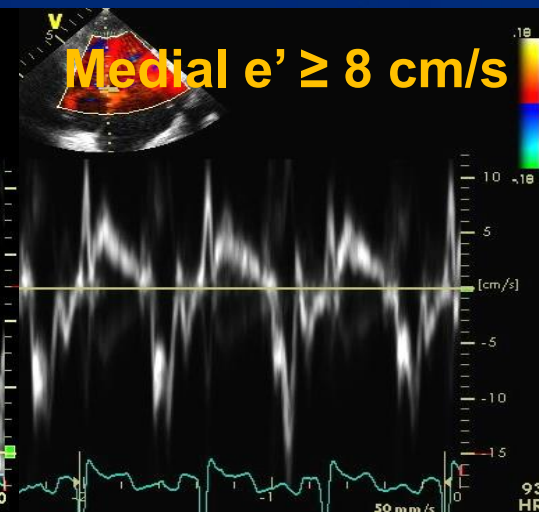
**Septal motion abnormality**



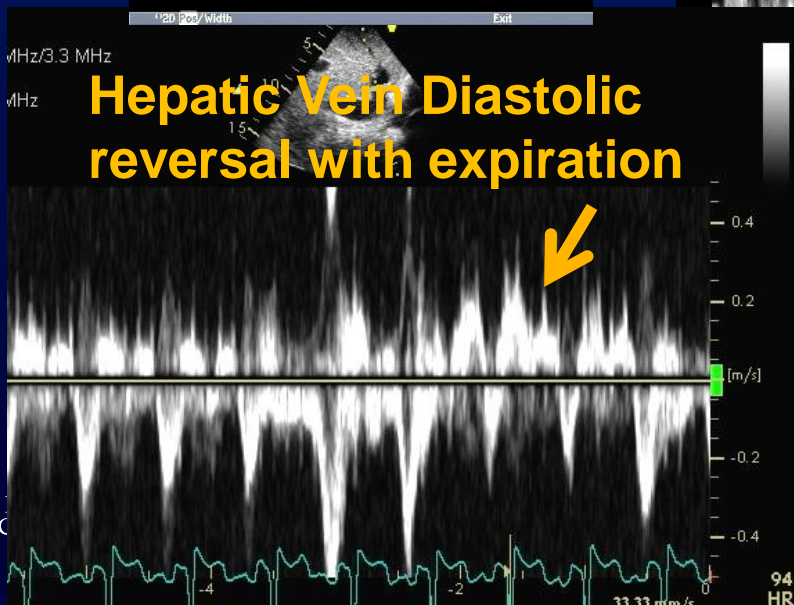
**MV Flow Velocity Restrictive (E/A >1)**



**Medial e' ≥ 8 cm/s**



**Hepatic Vein Diastolic reversal with expiration**



Sensitivity 87 %  
Specificity 91 %

Welch et al Circ Imaging 2014

# Illustrative Cases

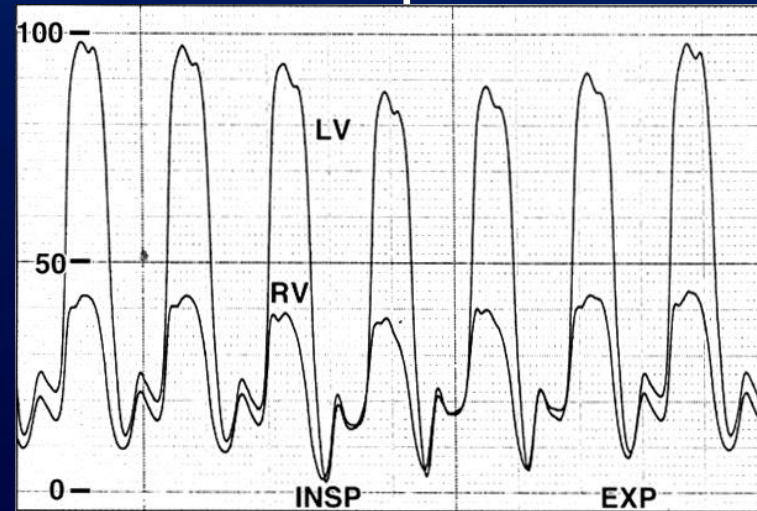
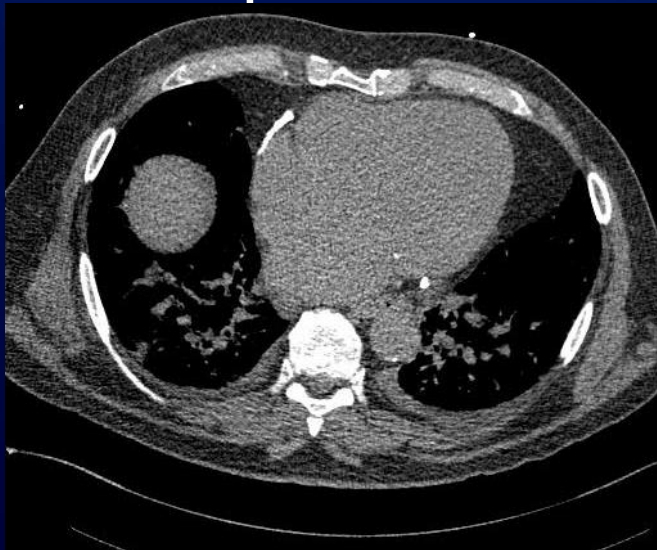
Is it a still big deal to separate CP from RCM?

Transient or Effusive CP

Role of Multi-modality Imaging

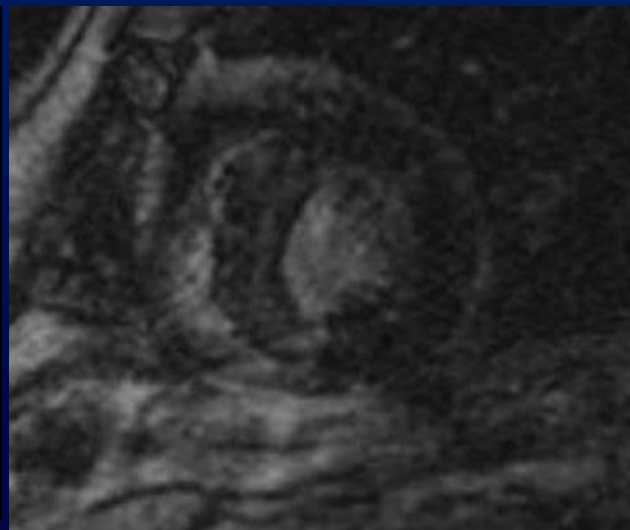
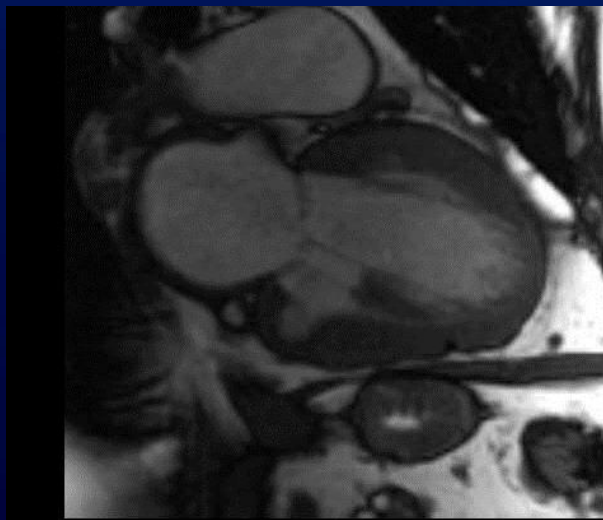
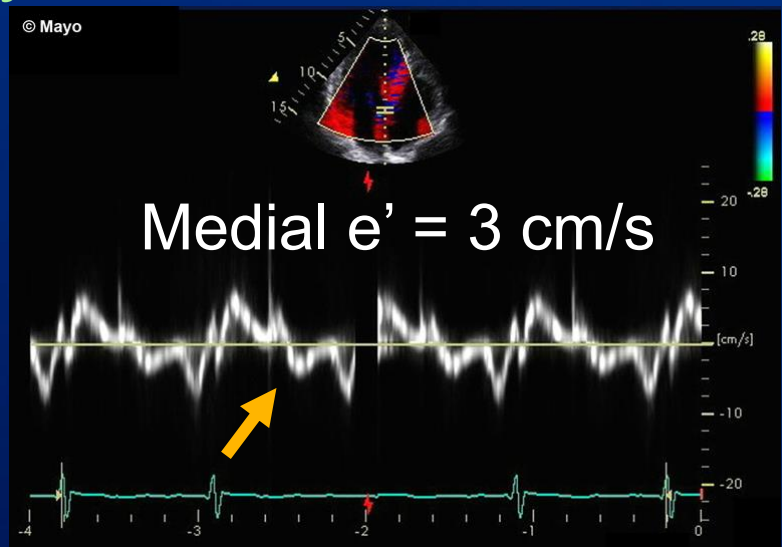
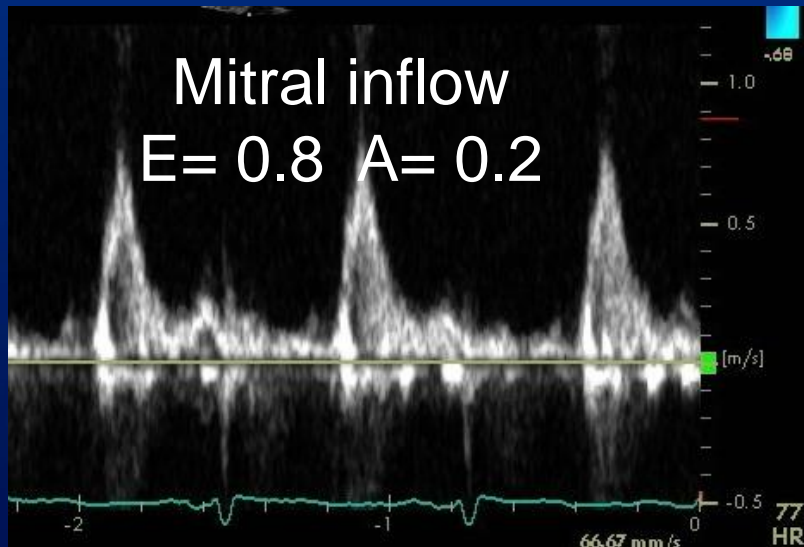
# 71 yo man with Heart Failure 2 yrs after CABG Referred for Pericardiectomy

- Physical Examination
  - JVP elevation
  - Prominent S3
  - Peripheral edema
- CT was obtained: Calcified Pericardium
- Cath : Equalization of End-diastolic pressures



# 71 year old man with calcified pericardium

## Cardiac Amyloidosis



# Constrictive Pericarditis

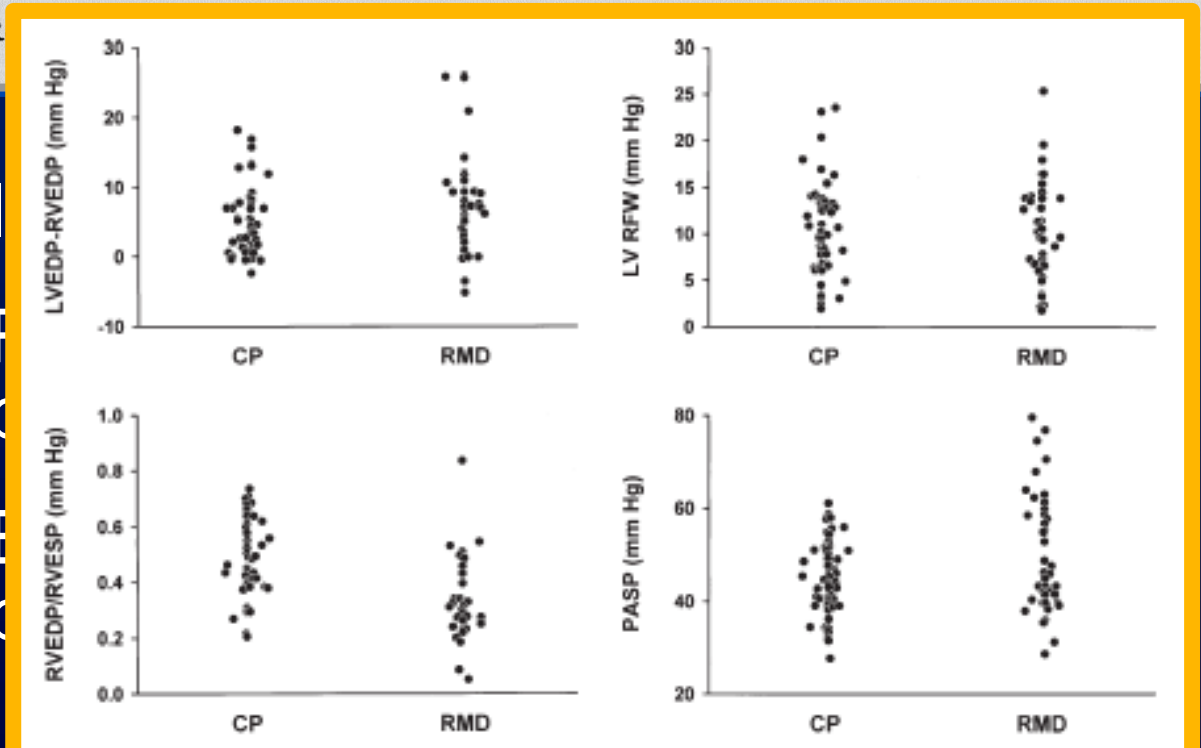
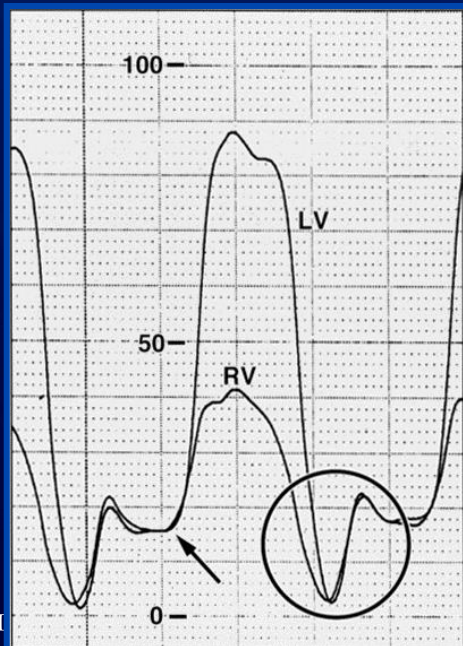
## Cath Hemodynamic Criteria

RECORDING OF RIGHT HEART PRESSURES IN NORMAL SUBJECTS AND IN PATIENTS WITH CHRONIC PULMONARY DISEASE AND VARIOUS TYPES OF CARDIO-CIRCULATORY DISEASE<sup>1</sup>

By RICHARD A. BLOOMFIELD, HENRY D. LAUSON, ANDRE COURNAND, ERNEST S. BREED, AND DICKINSON W. RICHARDS, JR.

(From the Department of Physiology of New York University College of Medicine, and the Department of Medicine of Columbia University, College of Physicians and Surgeons, and the Chest Service (Columbia University Division), Bellevue Hospital, New York City)

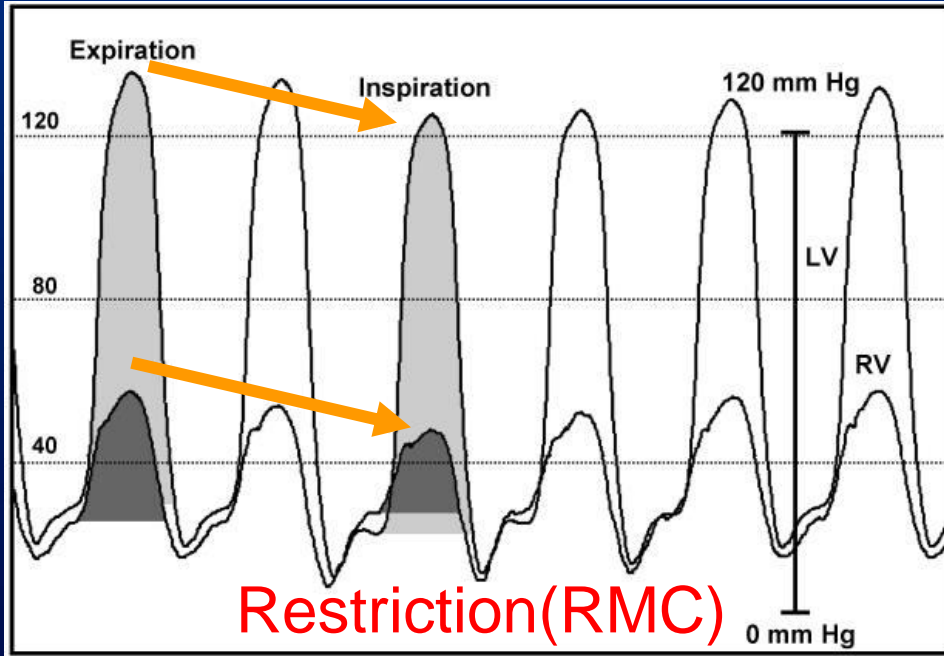
(R



Bloomfield and Cournand et al: JCI, 1946

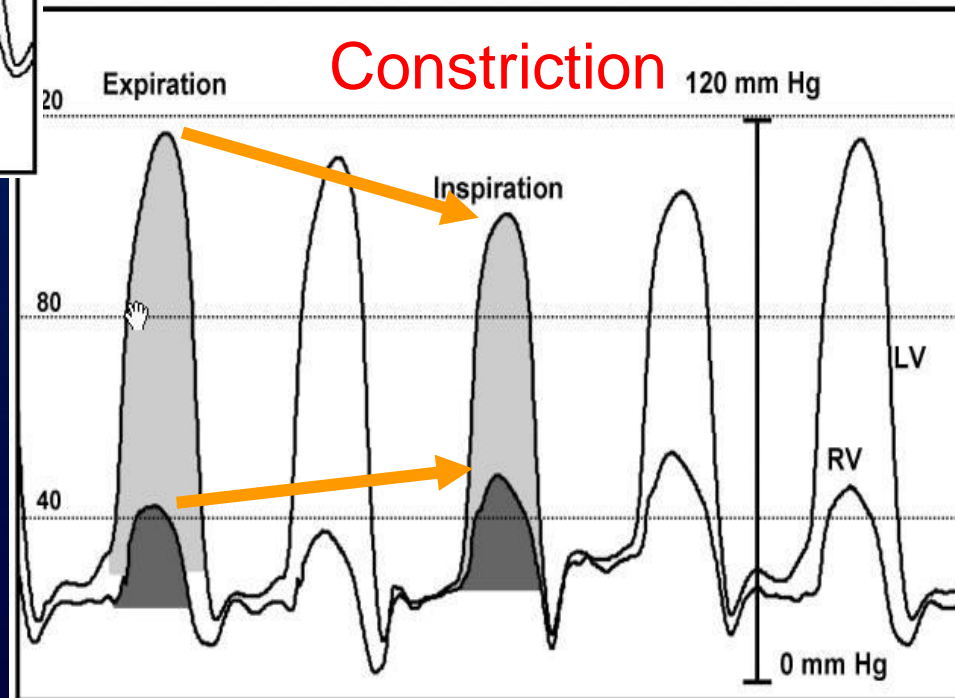
# Constrictive Pericarditis in the Modern Era

Novel Criteria for Diagnosis in the Cardiac Cath Laboratory  
(Talreja, Nishimura, Oh, Holmes. Jan. 2008 JACC)

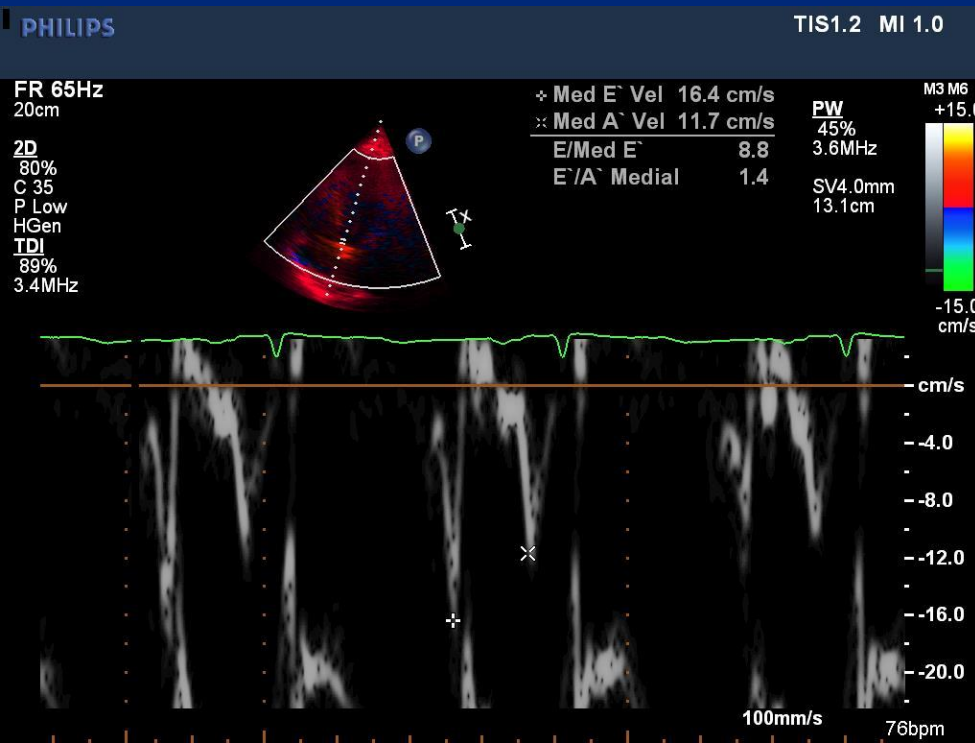


Concordant change

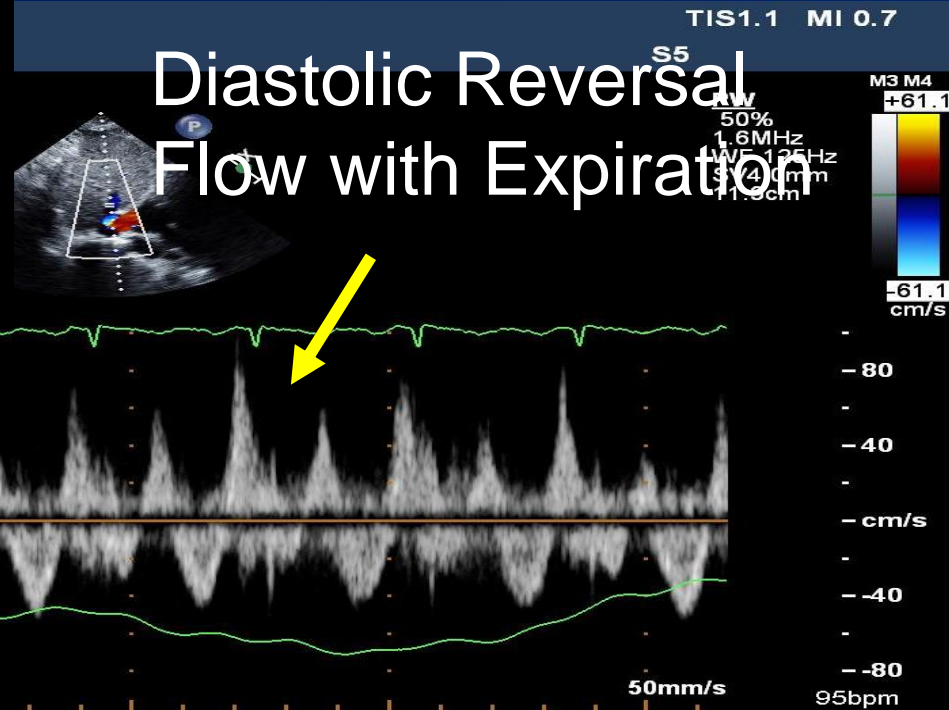
Discordant change



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



**Dx= RCM**



Medial e' = 20 cm/sec

What would you recommend?

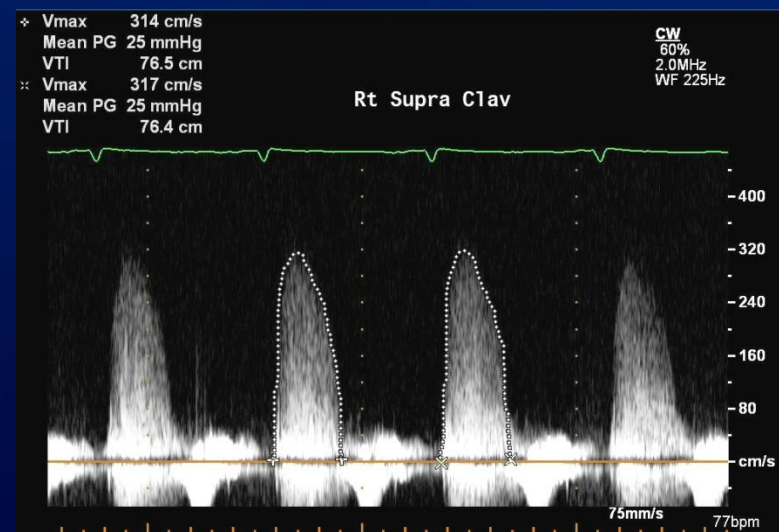
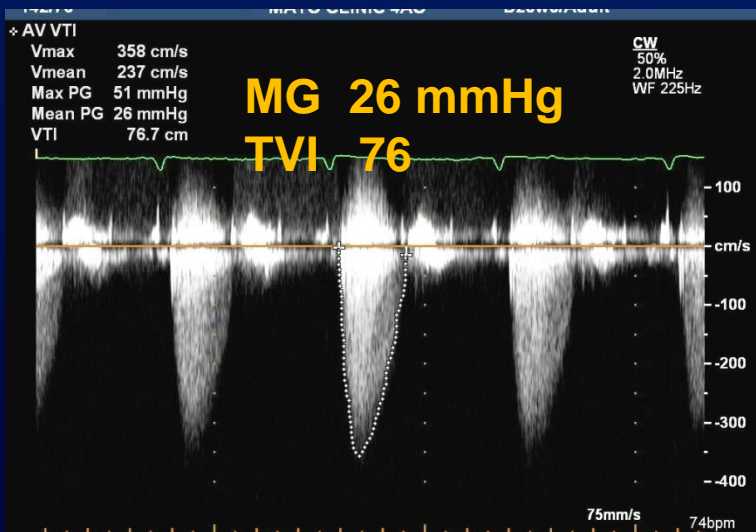
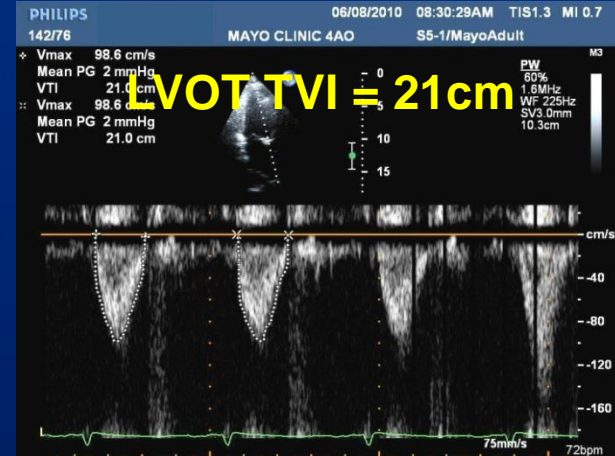
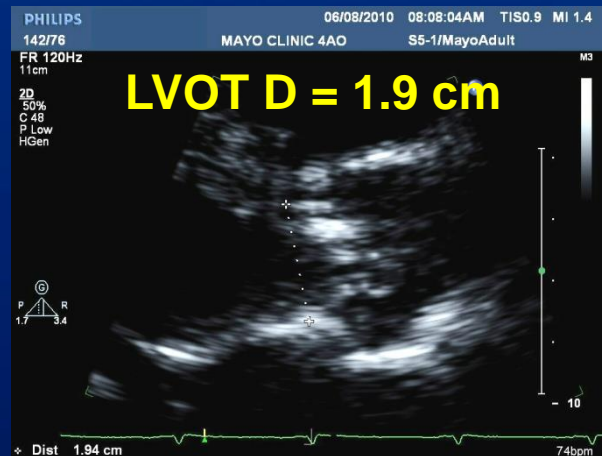
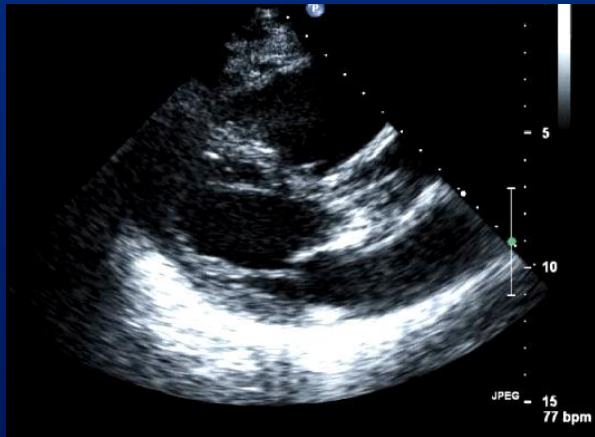
1. Being a junior staff, keep quiet
2. Believing in Echo-Doppler, un-list him and further evaluation
3. Proceed with transplantation



# Explanted Heart



# 67 yo man with severe aortic stenosis and HF Came to Valve Clinic for AVR (LFLG Severe AS)

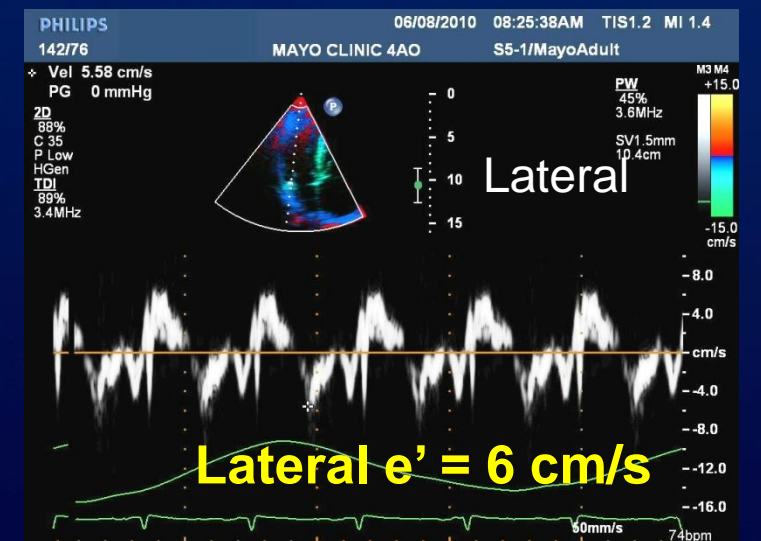
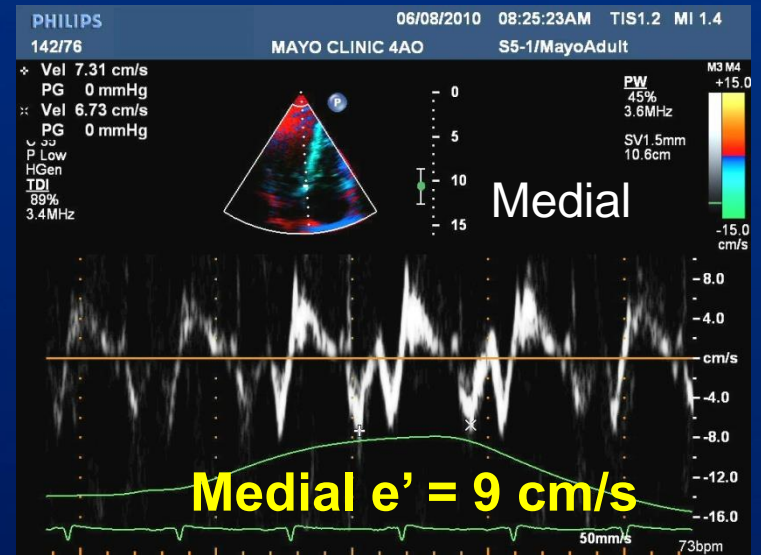
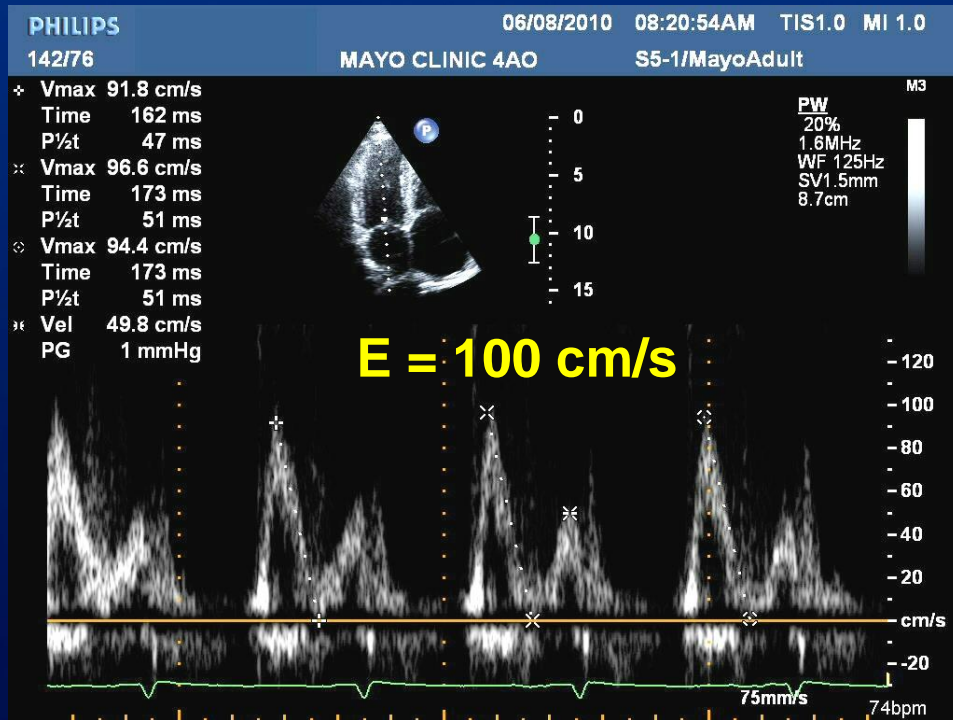


$$\text{Stroke volume} = (1.9)^2 \times 0.785 \times 21 = 60 \text{ cc}$$

$$\text{AVA} = 60 / 76 = 0.79 \text{ cm}^2$$

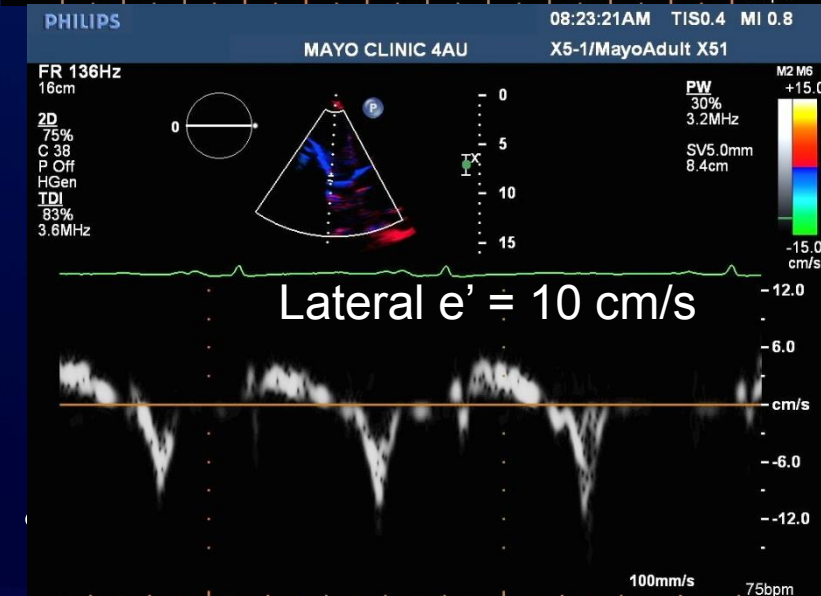
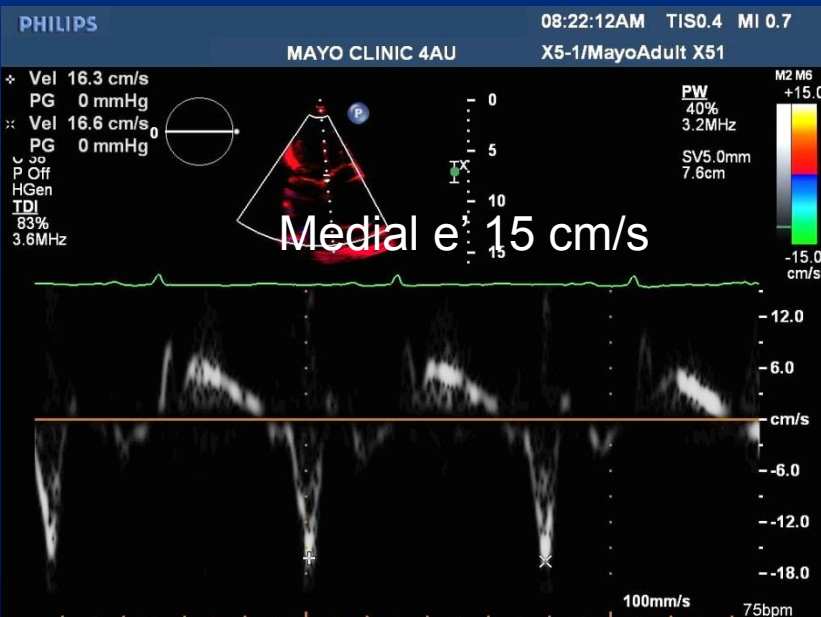
# 67 year old man with AS and heart failure

## Mitral Annulus Tissue Doppler E' Velocity

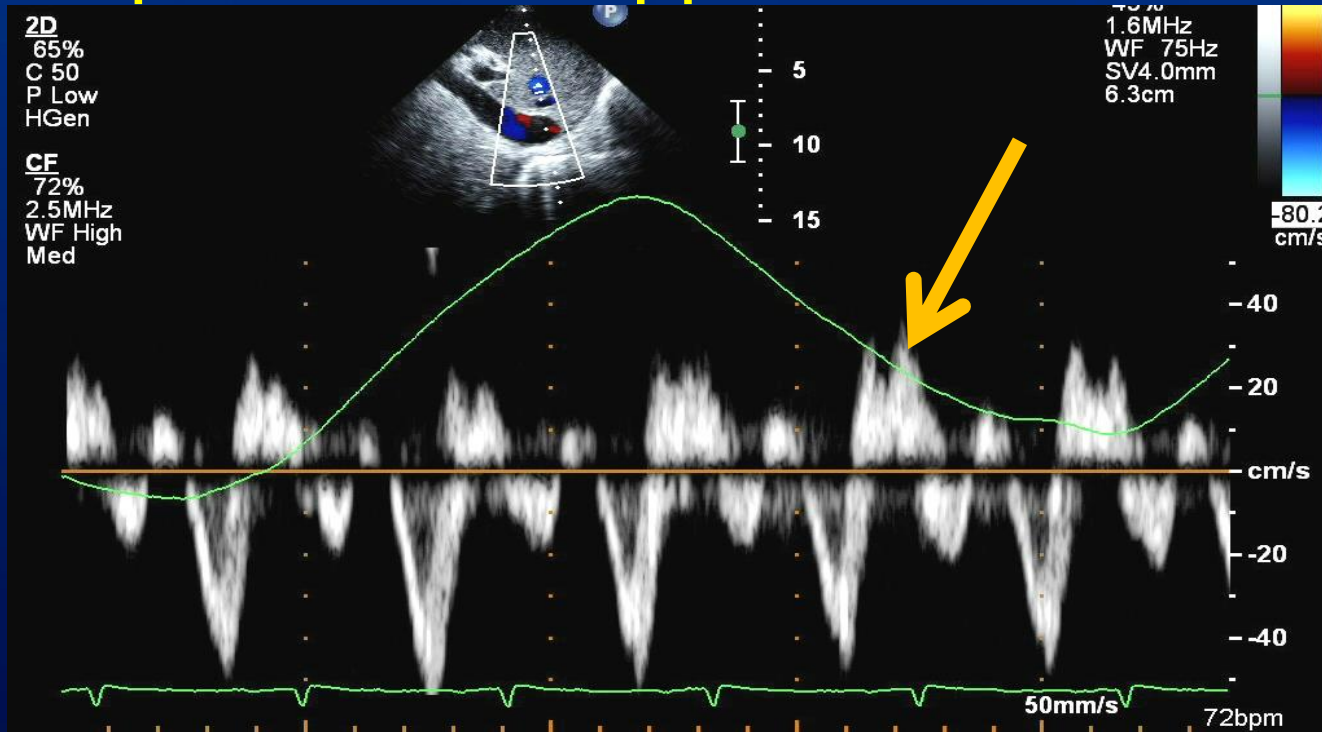


1. OK for aortic stenosis
2. Not OK for AS
3. Does not matter

# Tissue Doppler and Strain Imaging in Constriction (Annulus Reversus)



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



## Radiation Heart Disease

### Valvular Heart Disease

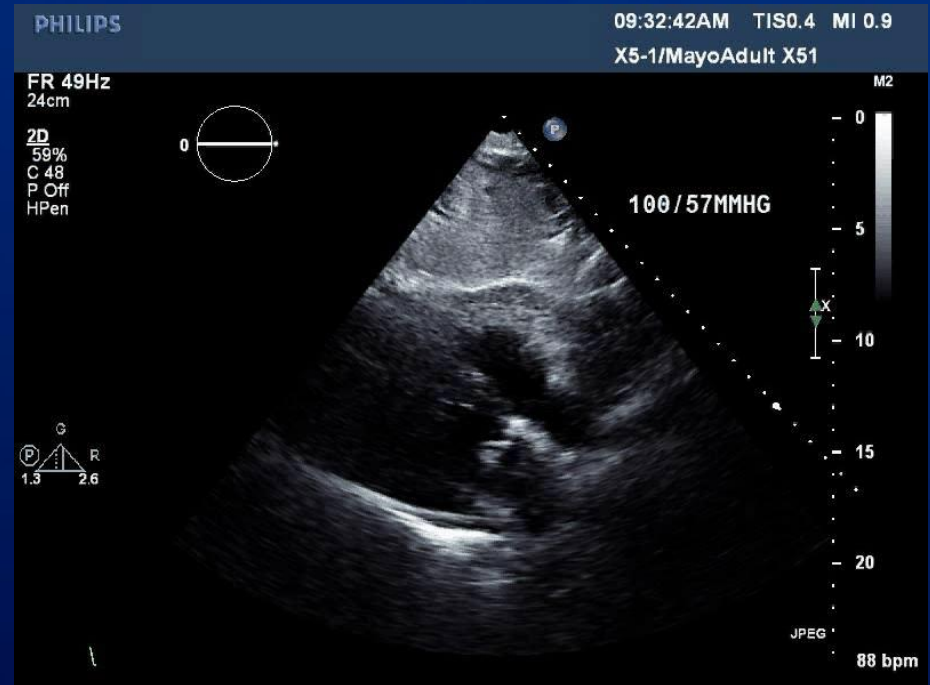
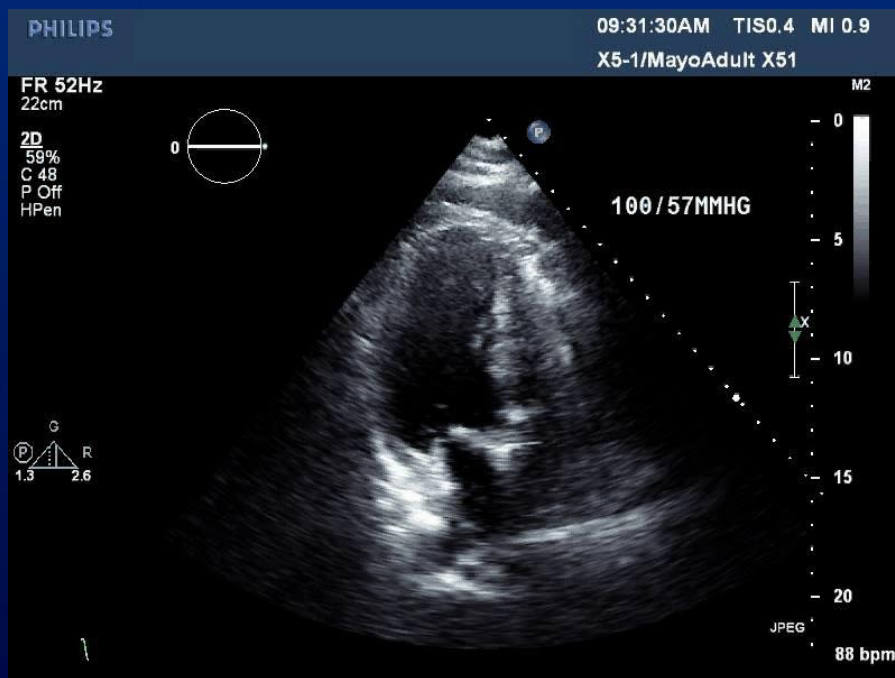
Circulation CV Imaging 2015

#### 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

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



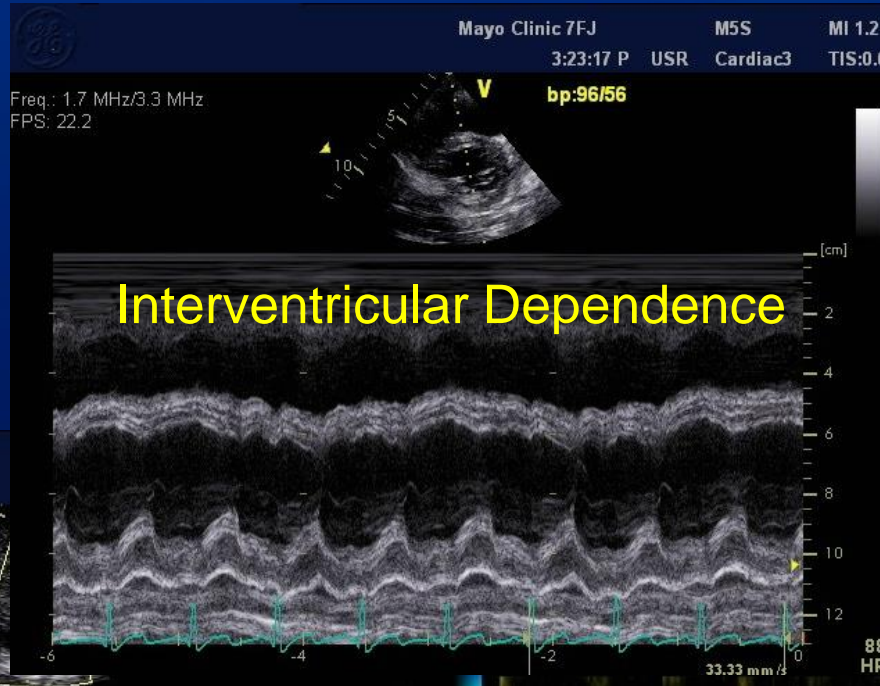
Pericardiocentesis yielded 125 cc of  
bloody fluid

# 77 yo man with severe aortic stenosis

## Increasing dyspnea 2 months after pericardiocentesis

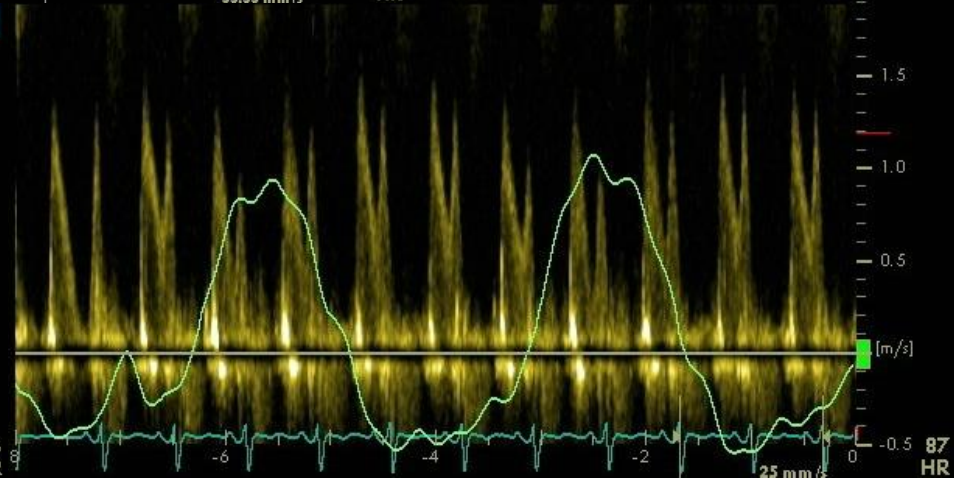


# Effusive-Constrictive Pericarditis



GE

Freq.: 1.7 MHz/3.3 MHz  
Proc.: 2.0/14.0/20.0/6.0/0.7  
Power: 0 dB  
FPS: 8.6/8.6  
Depth: 12.9 cm  
Freq.: 2.4 MHz  
SV: 3.0 mm

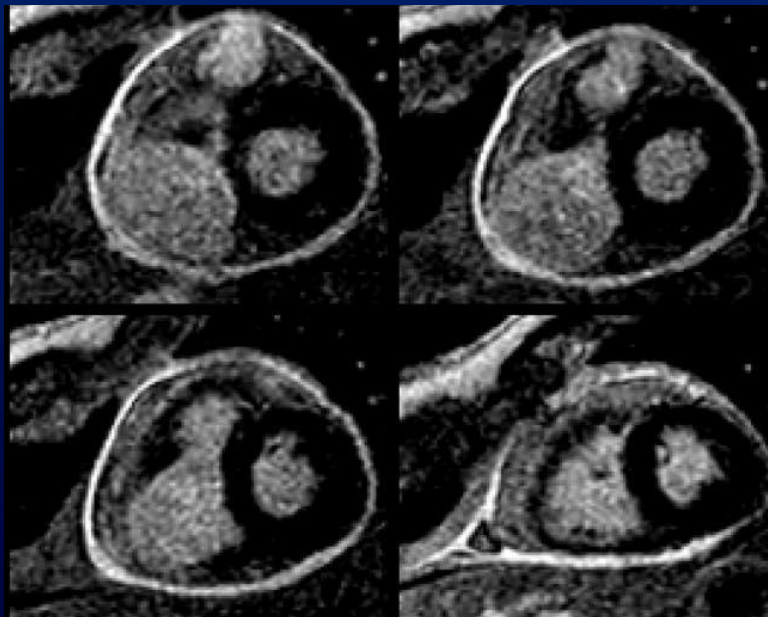




# Cardiac Magnetic Resonance Imaging Pericardial Late Gadolinium Enhancement and Elevated Inflammatory Markers Can Predict the Reversibility of Constrictive Pericarditis After Antiinflammatory Medical Therapy

## A Pilot Study

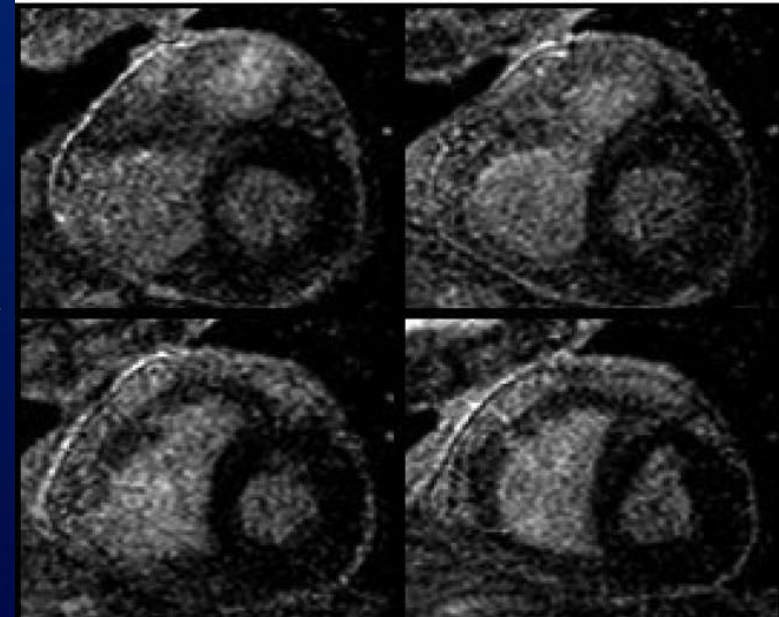
DaLi Feng, MD; James Glockner, MD, PhD; Kye-hun Kim, MD; Matthew Martinez, MD; Imran S. Syed, MD; Philip Araoz, MD; Jerome Breen, MD; Raul E. Espinosa, MD; Thoralf Sundt, MD; Hartzell V. Schaff, MD; Jae K. Oh, MD



Baseline



Medical  
RX



3 Months

Circulation Oct 3<sup>rd</sup> 2011

# Transient Constriction



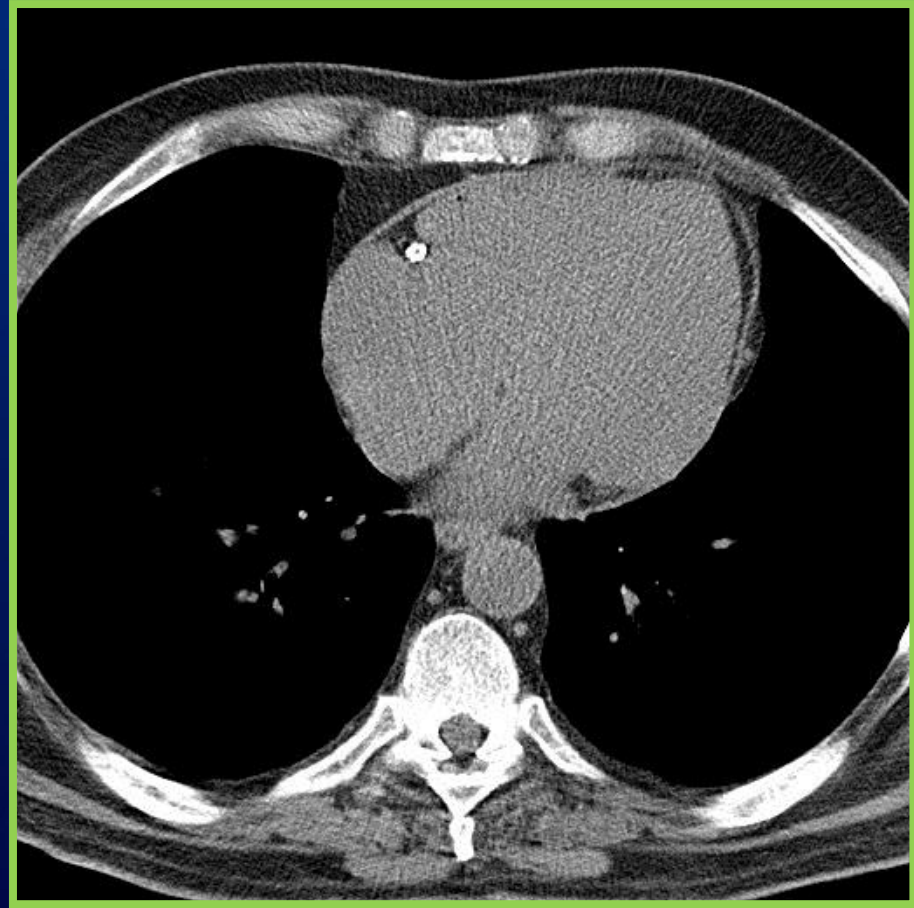
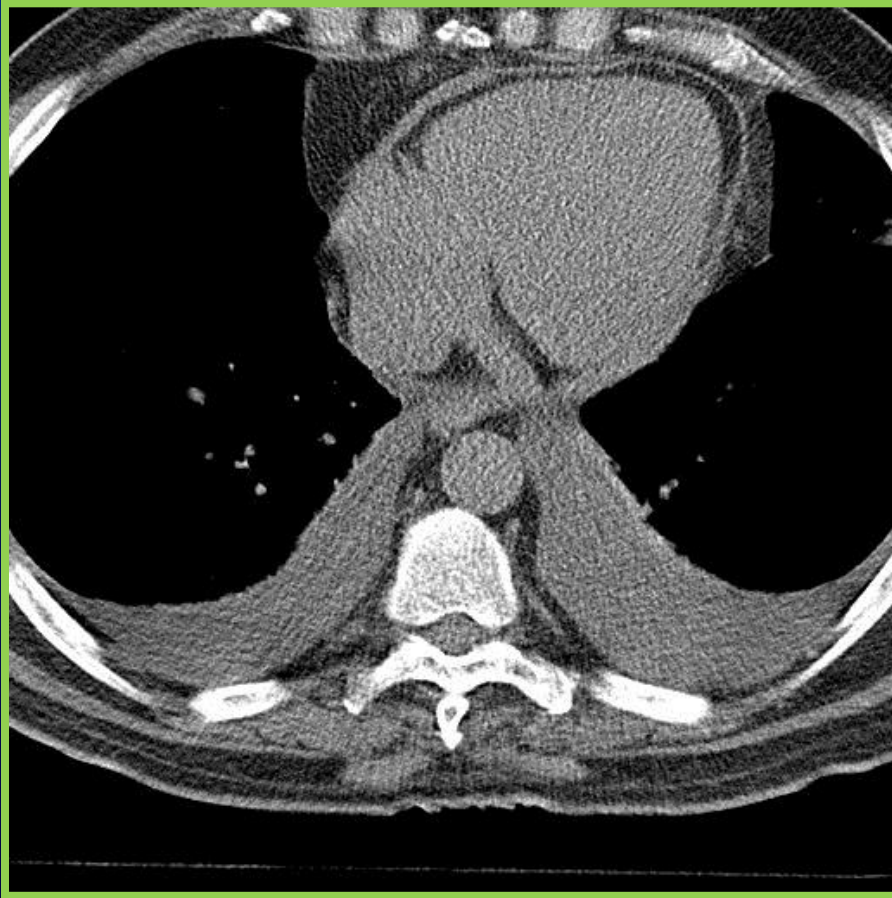
Reversible (N=14)

Persistent (N=15)

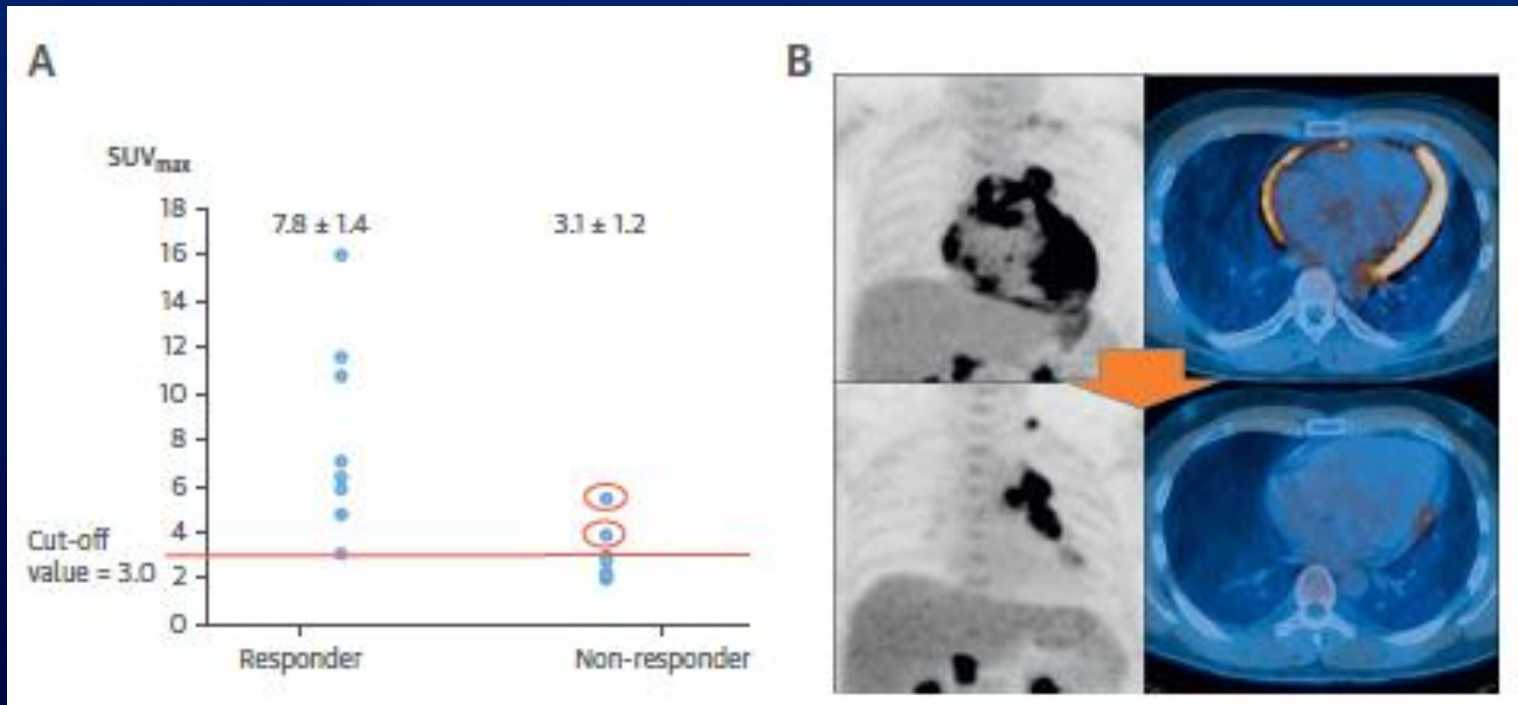
Age	54 ± 17	59 ± 16
LVEF	57 ± 3	60 ± 3
E' (cm/sec)	12 ± 1	11 ± 1
Steroid Rx	71 %	53 %
Pericardium	3.8 ± 0.6 mm	4.0 ± 0.6 mm
DE Pericardium	4.4 ± 0.4 mm	2.1 ± 0.4mm
Grade 3-4/4 DE	93 %	33 %
Sed rate	45 to 4	25 to 20
CRP	75 to 2	14 to 15

# Transient Constrictive Pericarditis

## One week of Steroid Rx



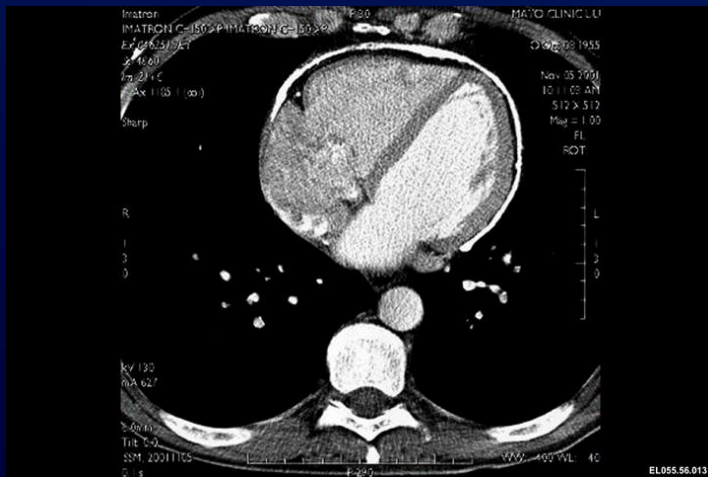
# [<sup>18</sup>F]Fluorodeoxyglucose PET/CT Predicts Response to Steroid Therapy in Constrictive Pericarditis



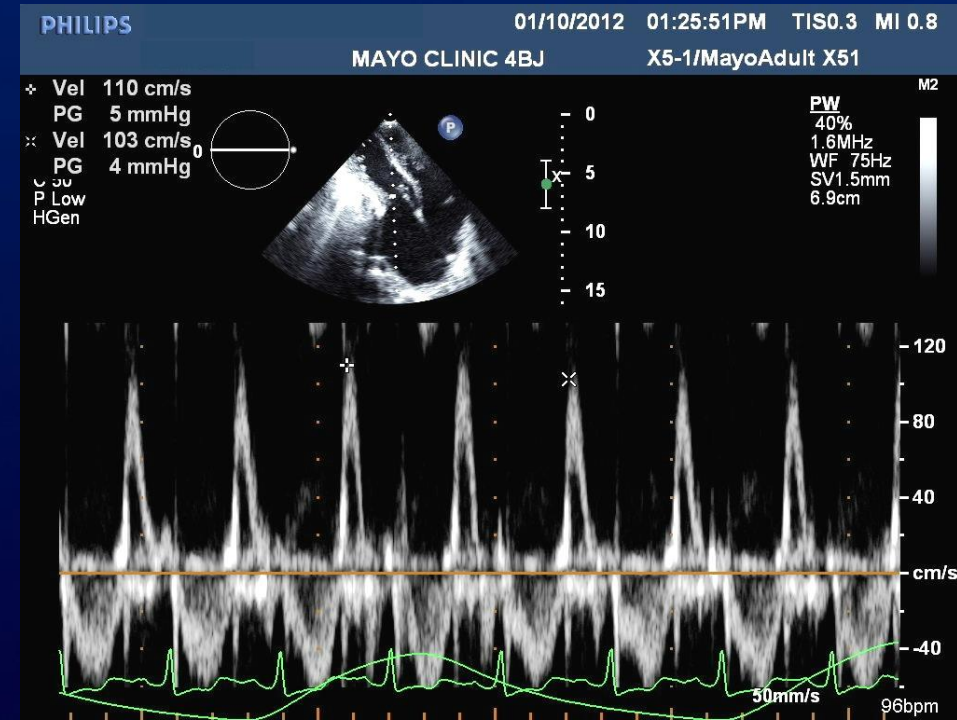
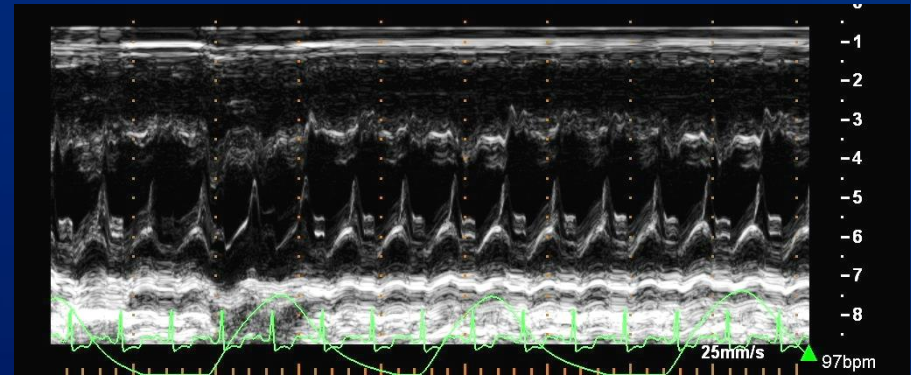
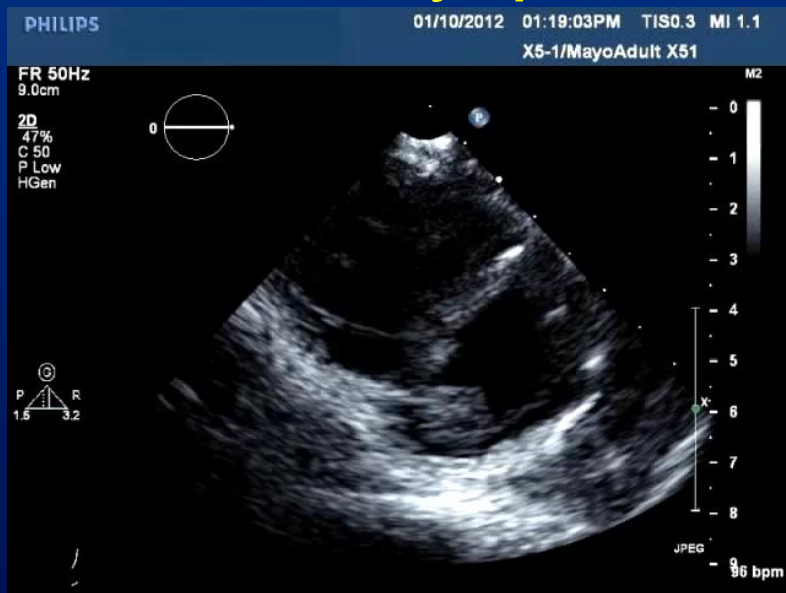
SA Chang, JK Oh et al JACC Feb 2017

# Constrictive Pericarditis

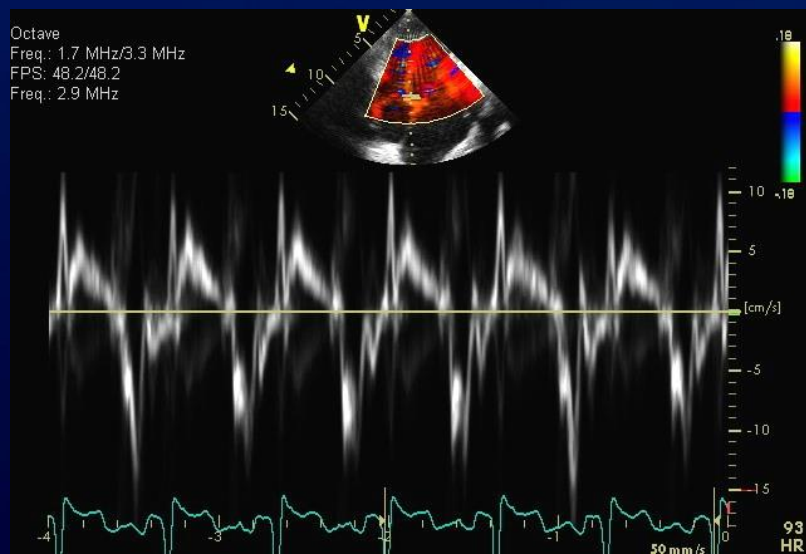
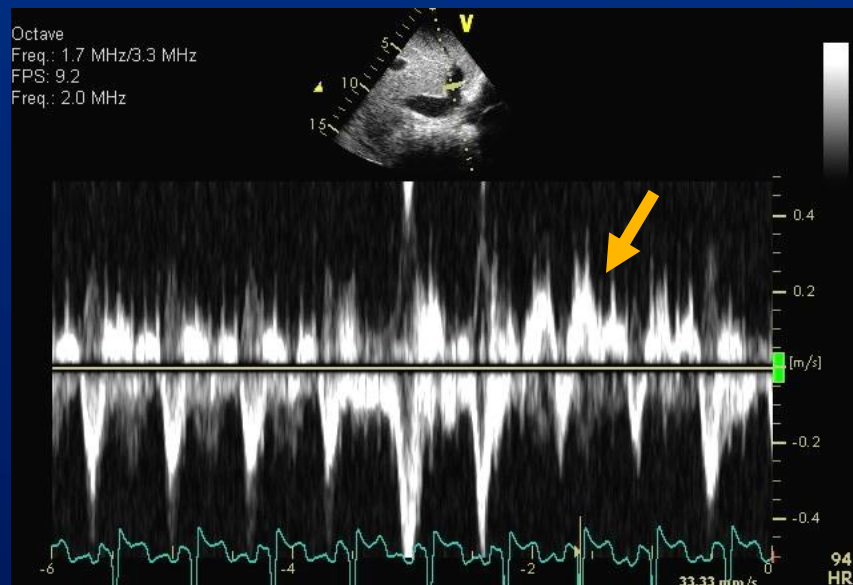
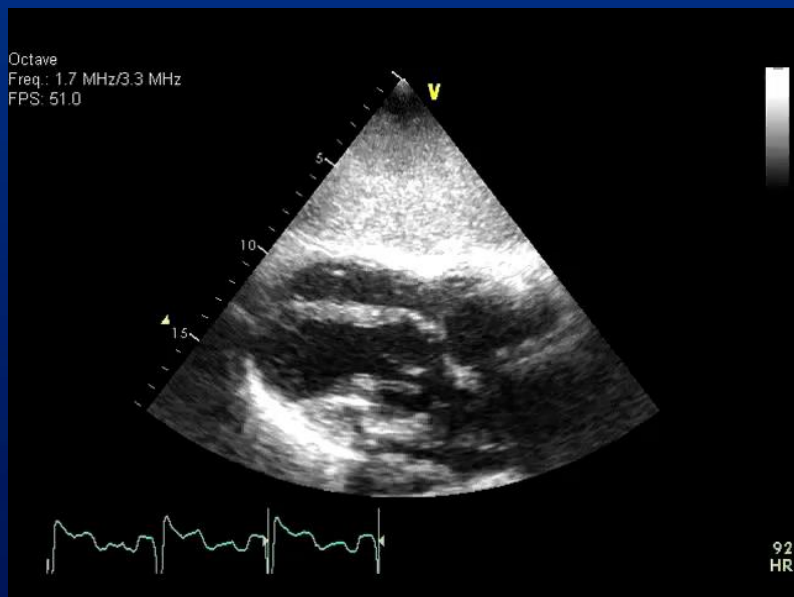
## CT for anatomy and calcification



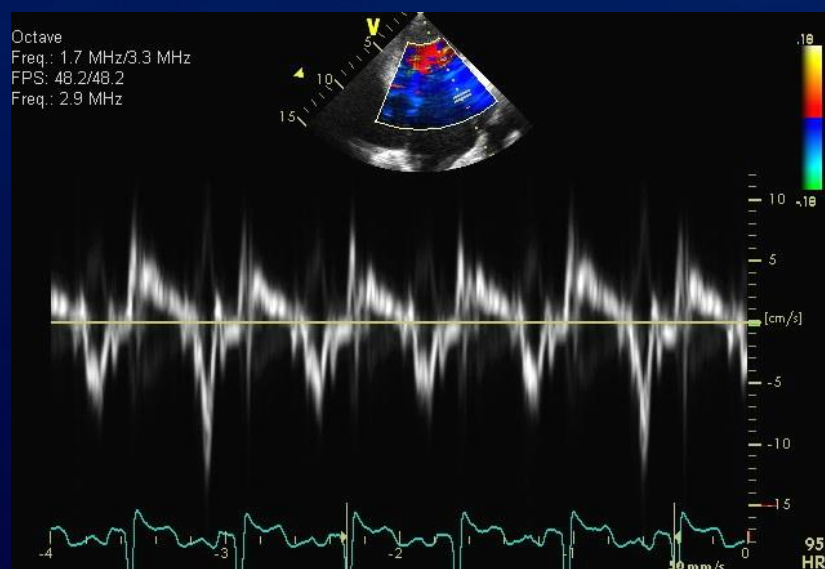
# A 26 year old woman with a previous pericardiectomy, presenting with edema



# Hepatic Vein Doppler and TDI



Medial e' 12 cm/s



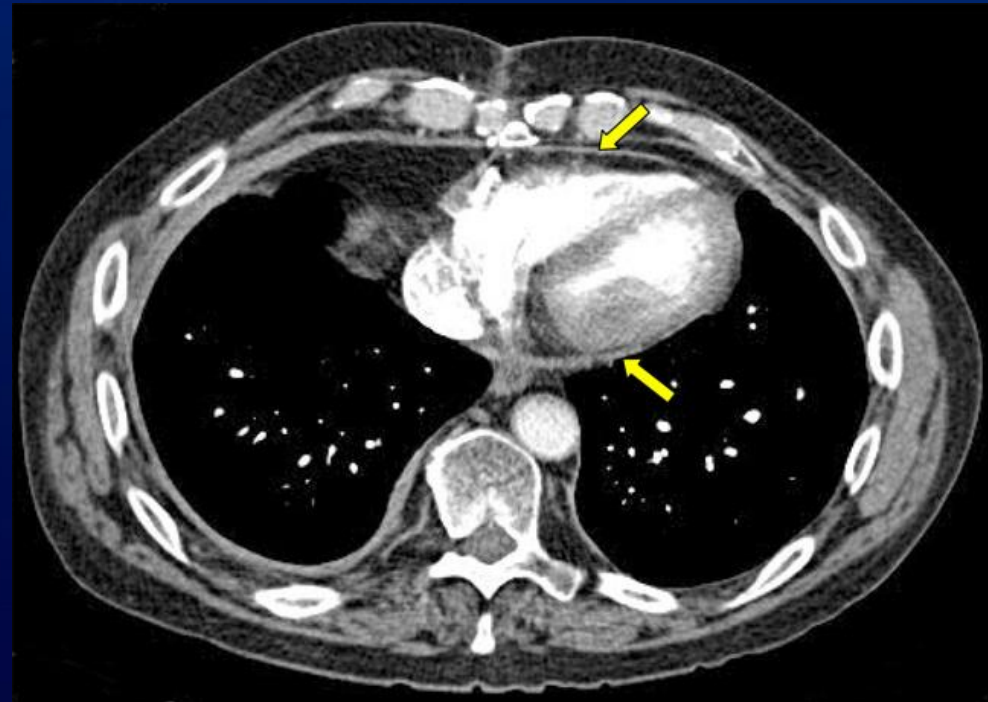
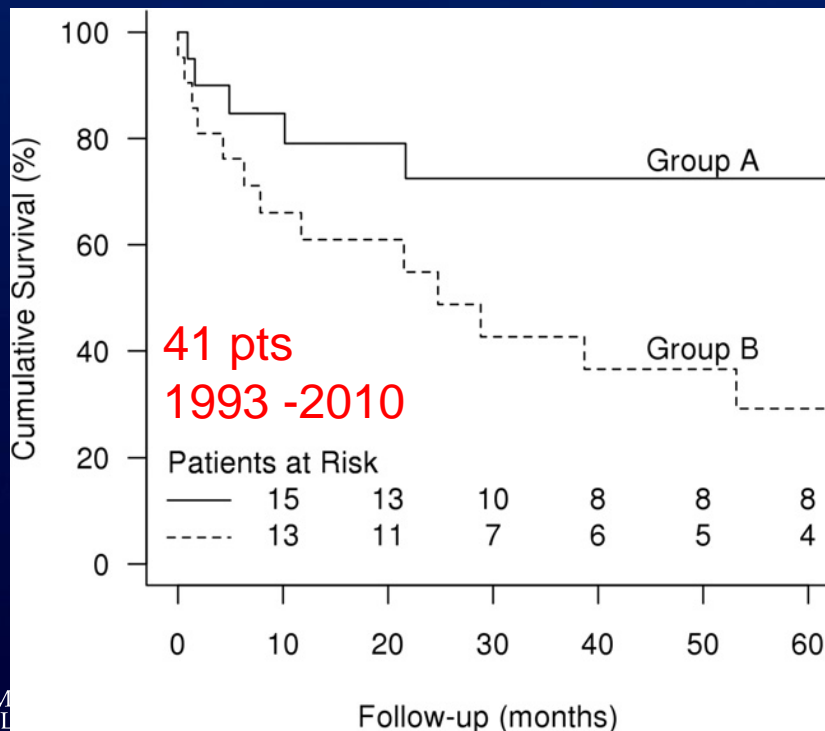
Lateral 2' = 8 cm/s

# Chronic constriction requires Complete Pericardiectomy

## Completion Pericardiectomy for Recurrent Constrictive Pericarditis: Importance of Timing of Recurrence on Late Clinical Outcome of Operation

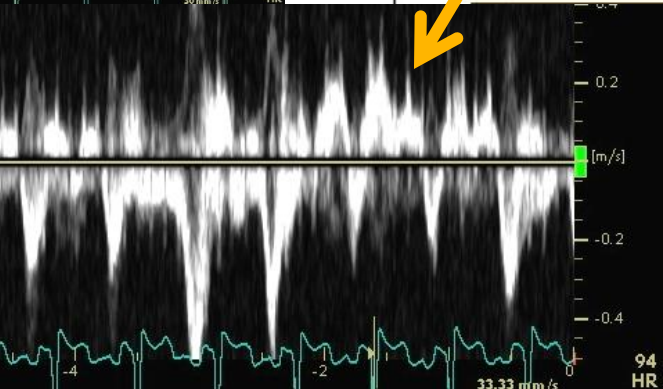
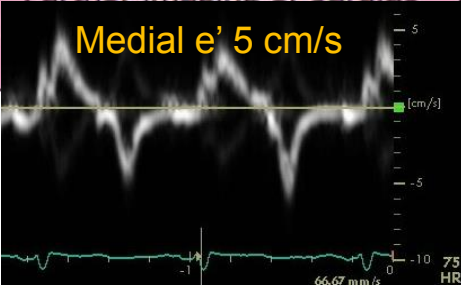
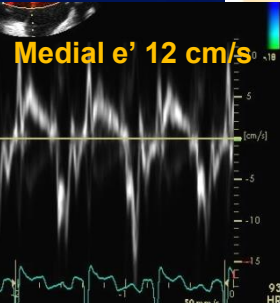
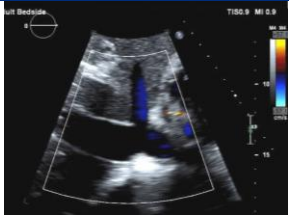
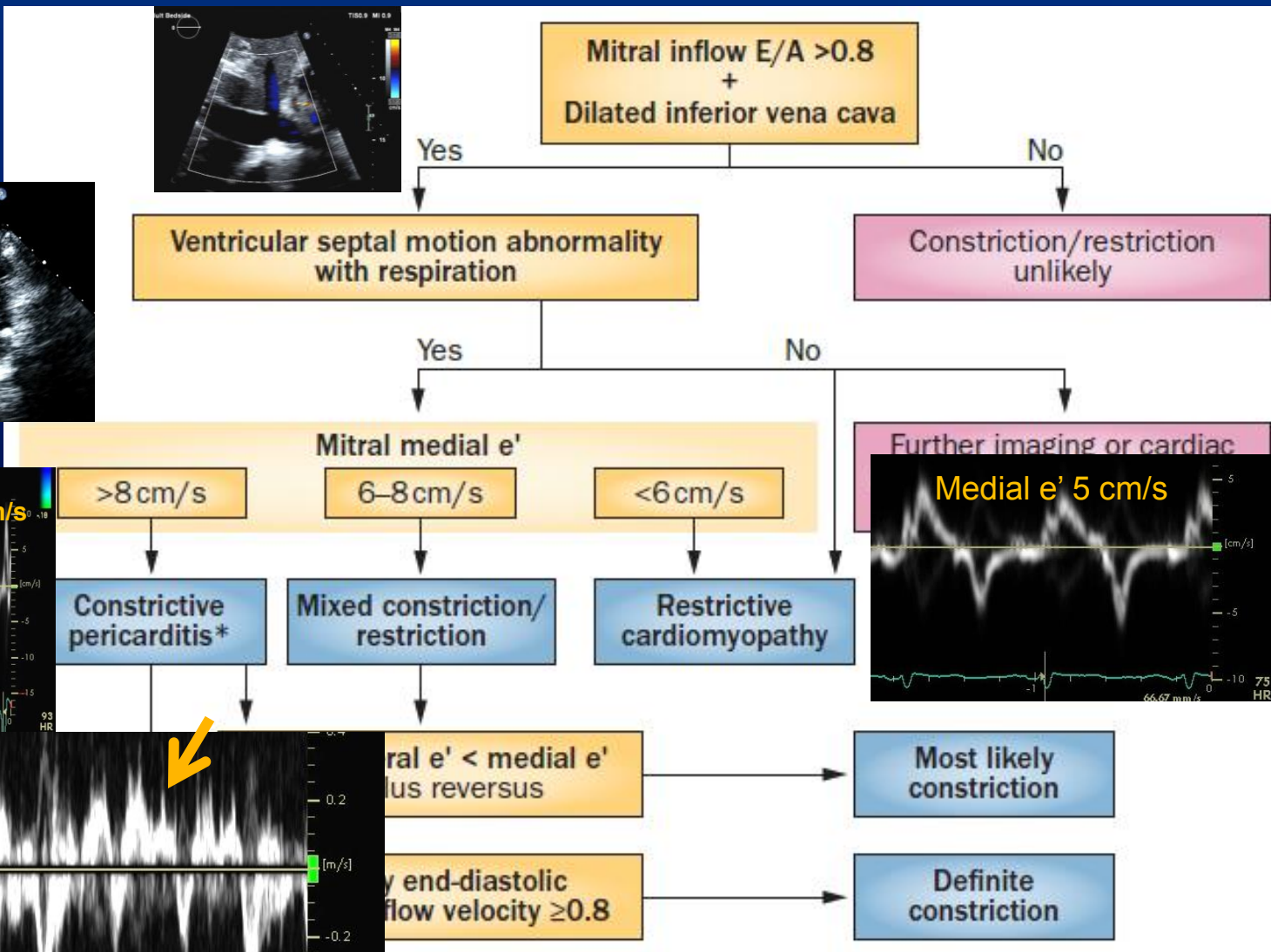
Yang Hyun Cho, MD, Hartzell V. Schaff, MD, Joseph A. Dearani, MD, Richard C. Daly, MD, Soon J. Park, MD, Zhuo Li, MS, and Jae K. Oh, MD

Division of Cardiovascular Surgery, Division of Biomedical Statistics and Informatics, and Division of Cardiovascular Disease, Mayo Clinic, Rochester, Minnesota





# Constriction or Myocardial Disease ? Diagnostic Algorithm



ed, Schaff, Oh Nature Review Sep 2014

Do not let a quick look fool you !



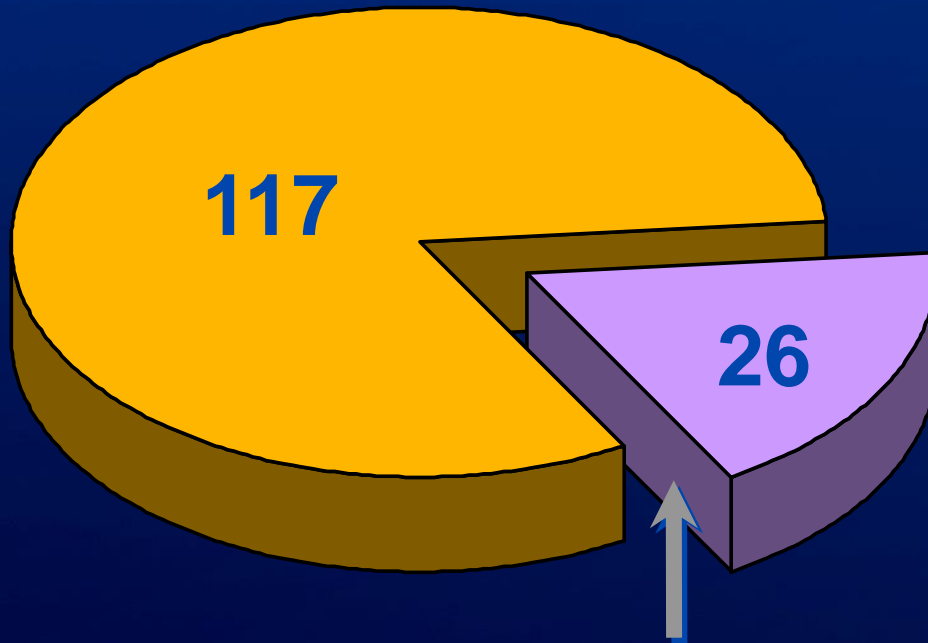


Thanks for listening!  
oh.jae@mayo.edu

# Constrictive Pericarditis

## Pericardial Thickness by Surgical Pathology

143 cases (1993-1999)



**18% of all cases of  
constriction**

- Constriction with thick pericardium**
- Constriction with normal thickness ( $\leq 2$  mm)**

# 27 yo man with fatigue and dyspnea



- Sep. 2015...Flu-like symptoms, treated with inhaler
- Oct. 2015...Pre-syncopy and palpitation
  - Pericardial rub
  - Pericardial effusion on Echo
  - Treated with Ibuprofen 2400 mg/d, Colchicine 0.6 mg BID
- Not feeling better and CRP 60
- Underwent pericardial window

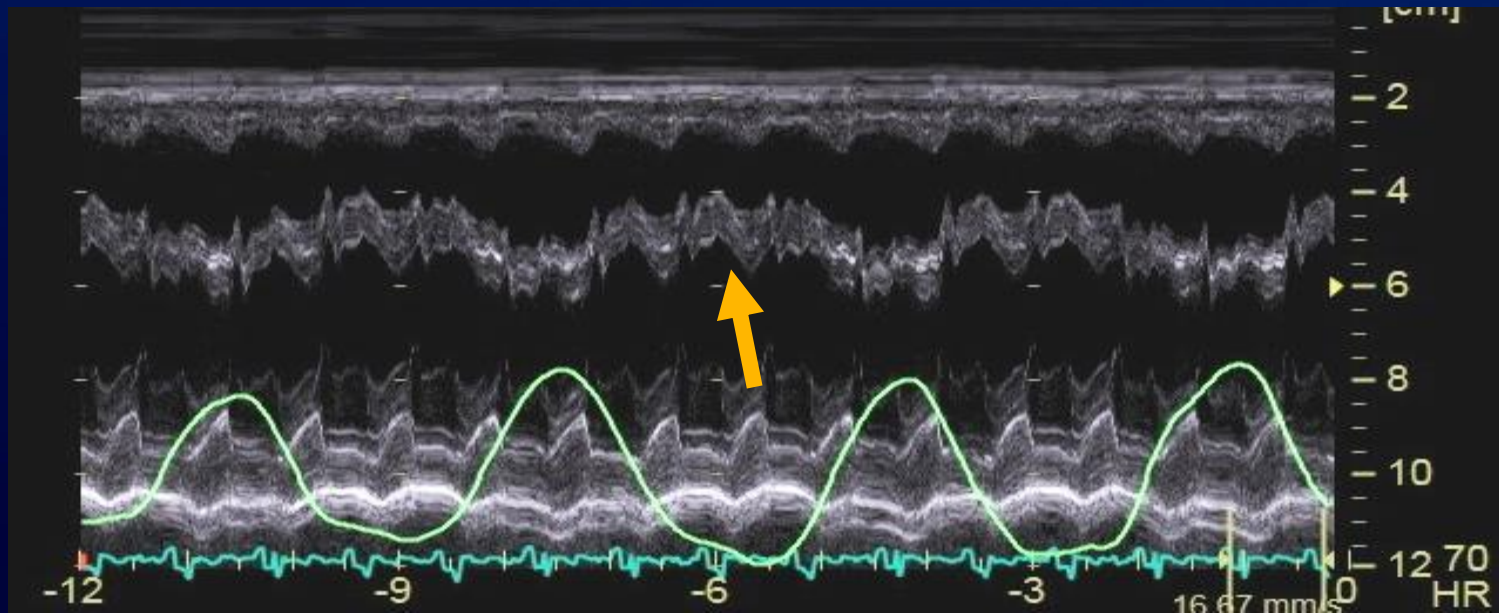
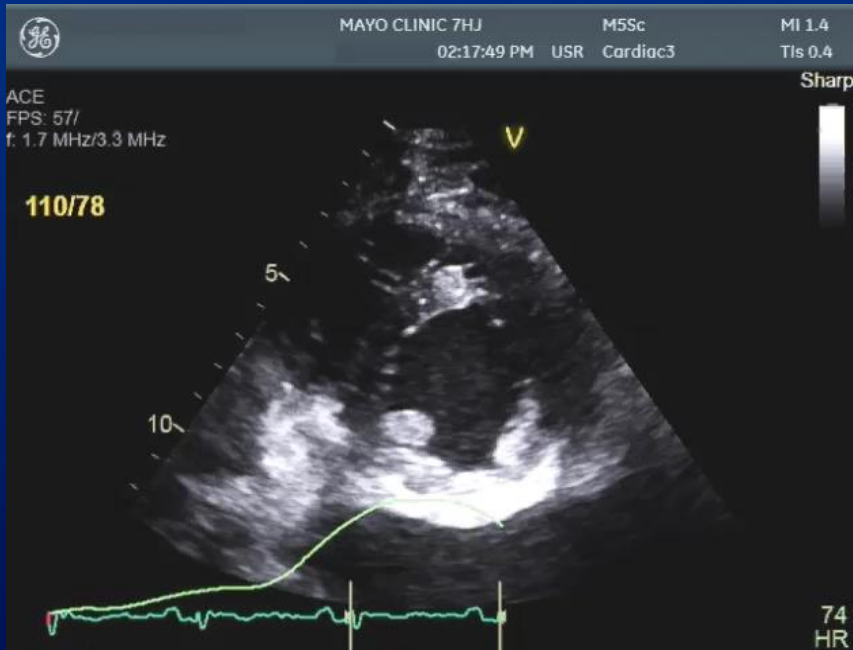


# 27 year old man underwent a window

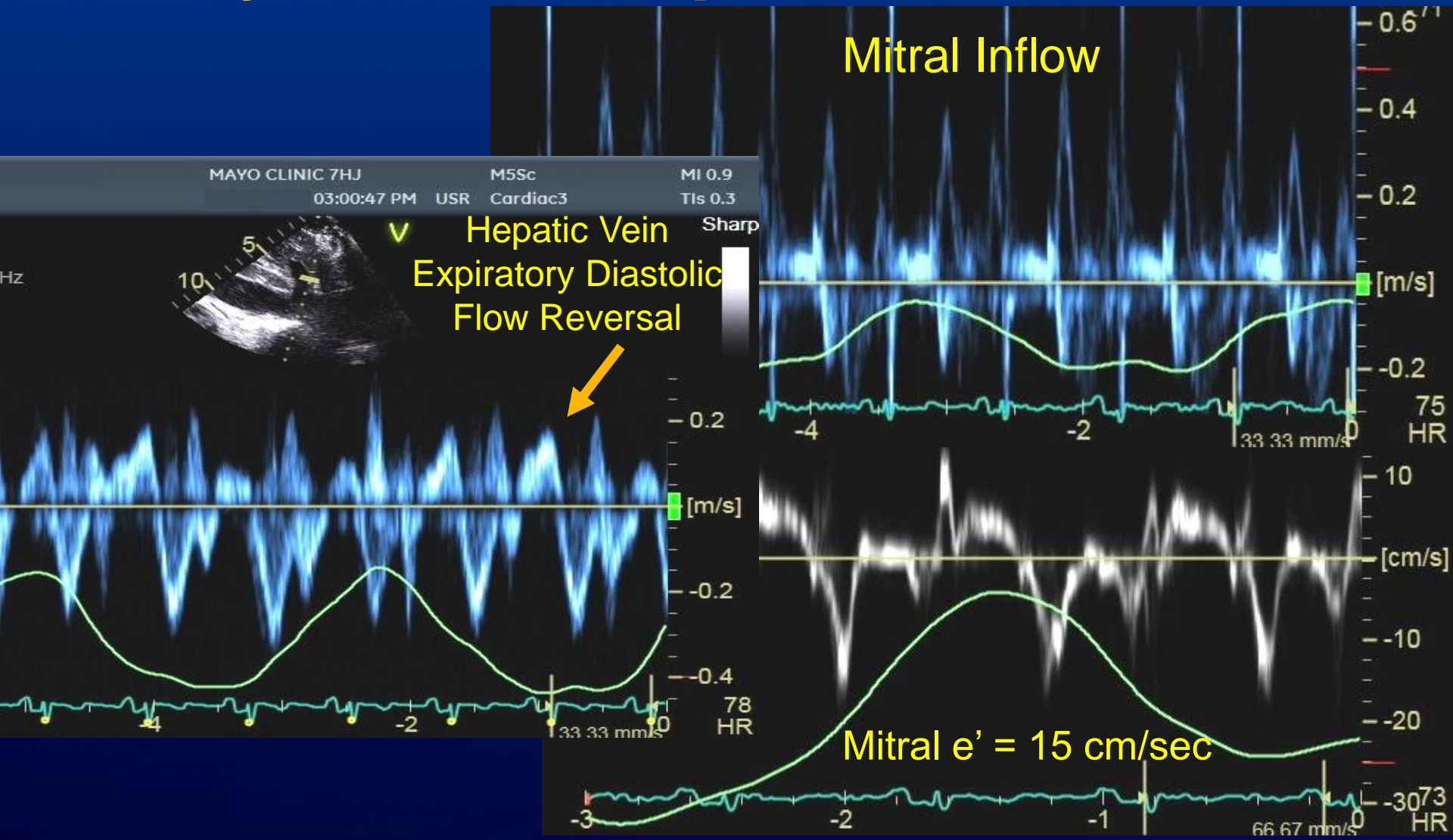
## Referred to Mayo

- Pericardial fluid ...studies were *negative*
- Not feeling better
- RUQ abdominal pain and fatigue
- U/S...Enlarged gallbladder and liver





# 27 yo man after pericardial window



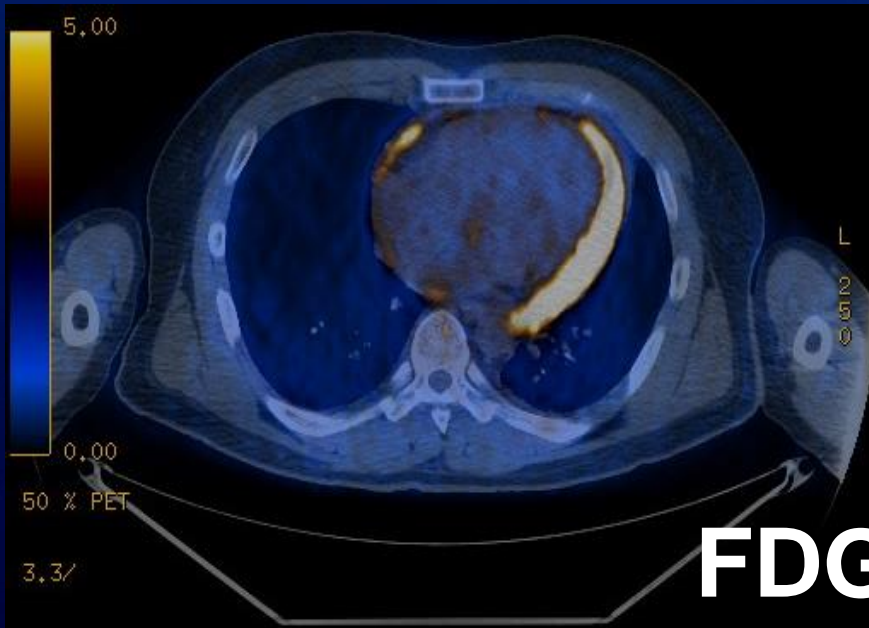
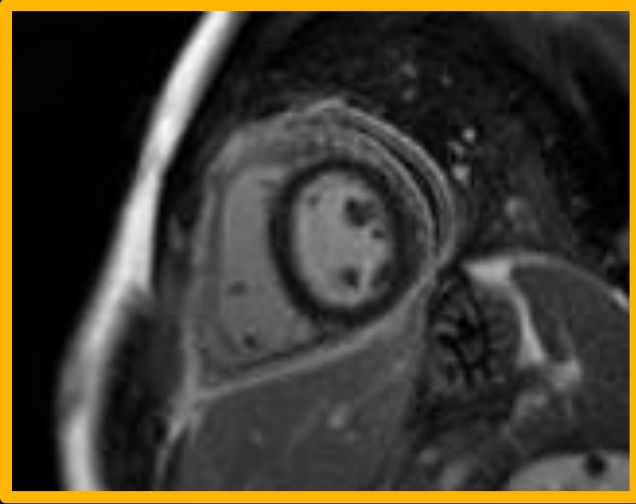
1= CT 2= MRI 3= Cath 4= Pericardiectomy



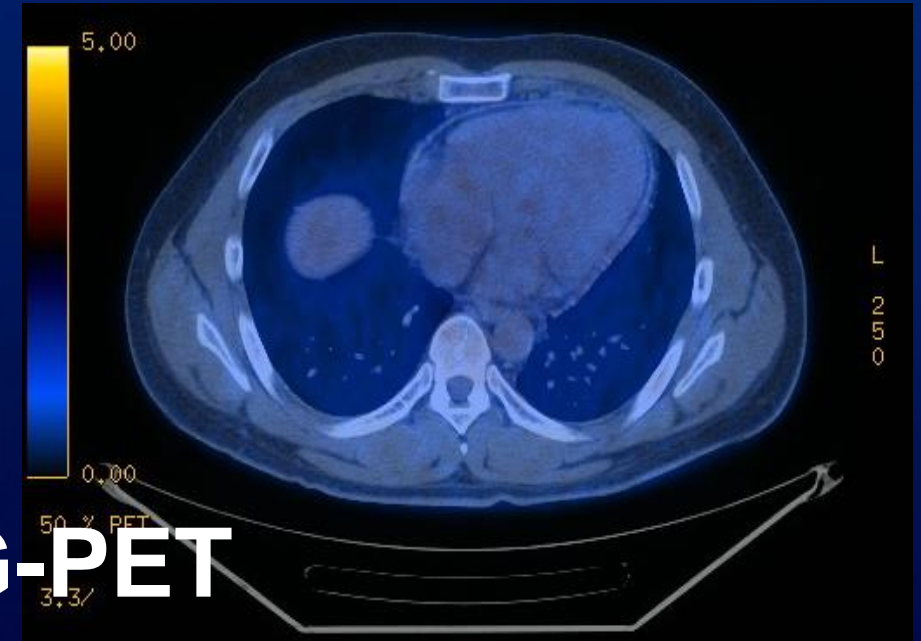




# 31 year old man with Acute Pericarditis Treated with NSAID

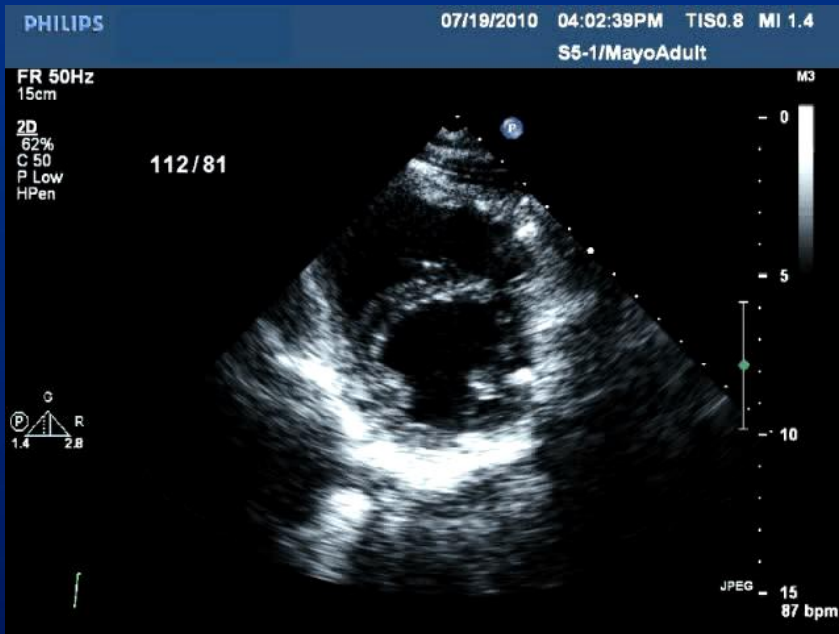


**Baseline**



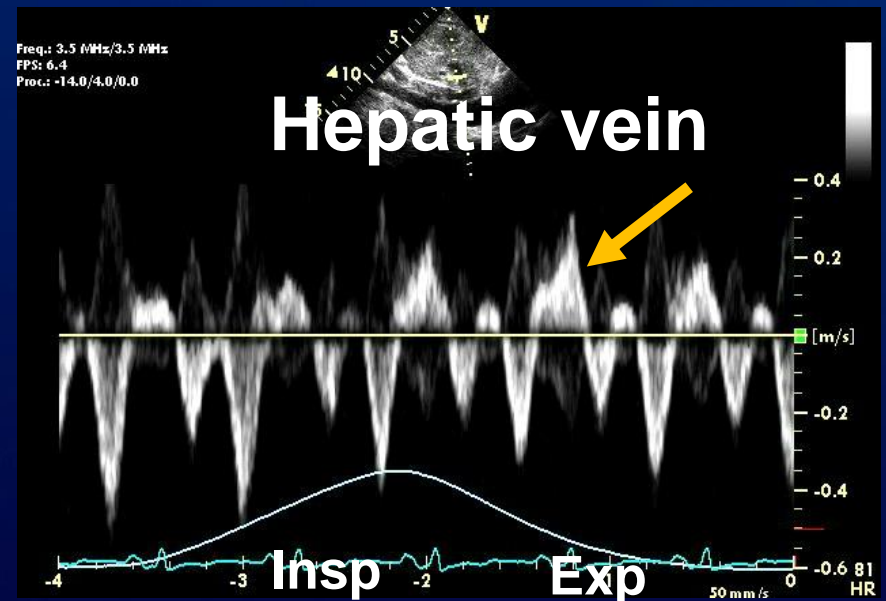
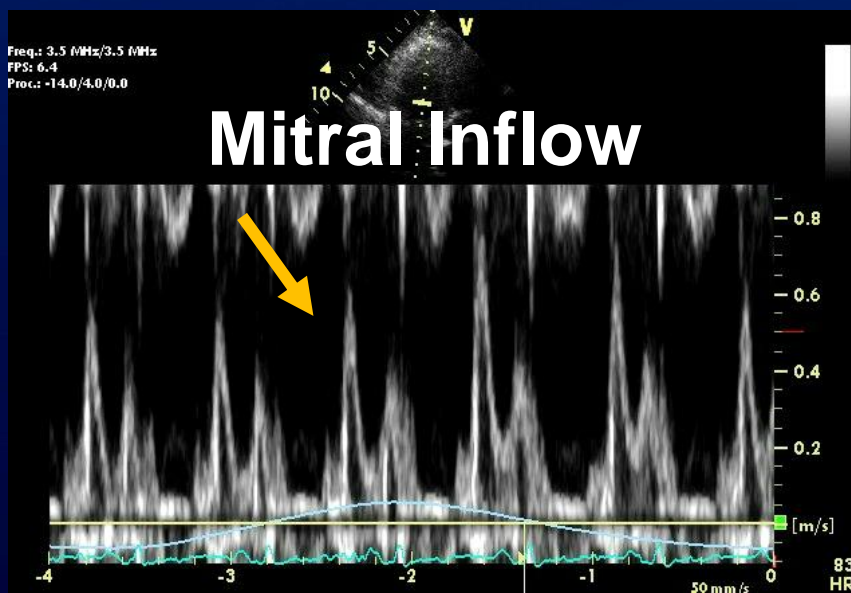
**3month later**

**FDG-PET**



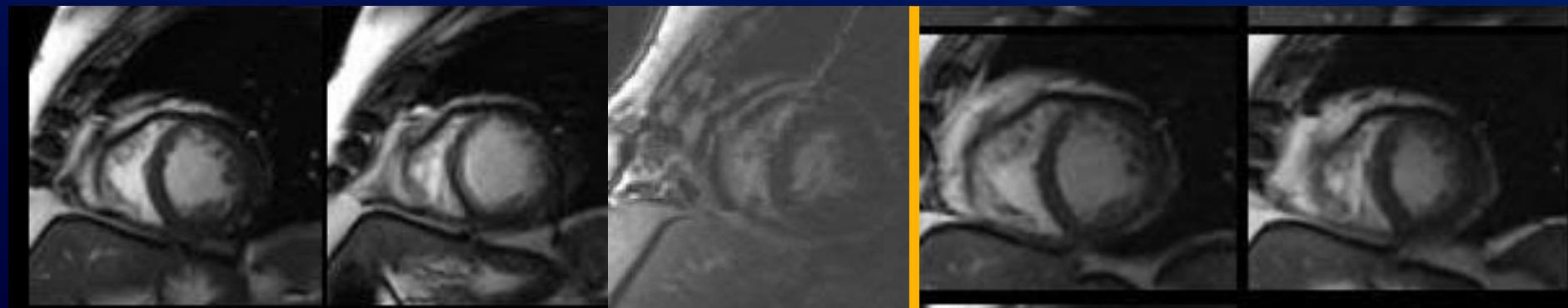
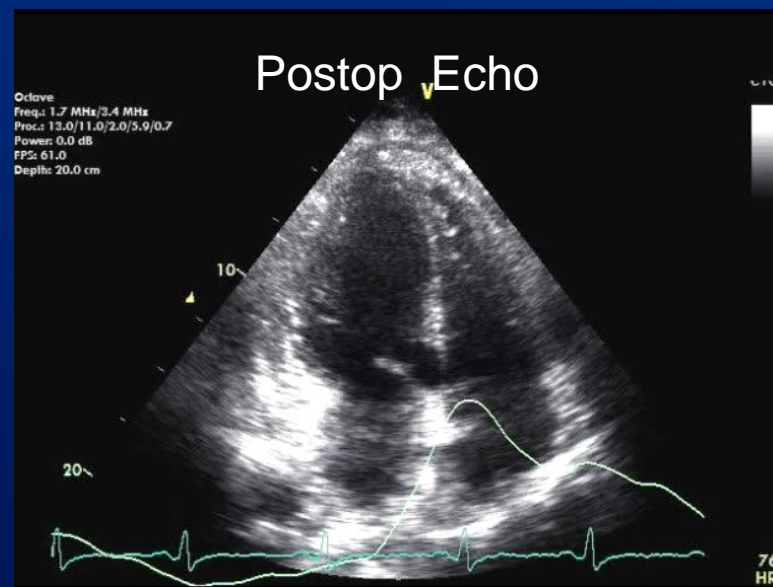
## Echo Dx of Constriction 1989-1997

1. Abnormal Septal Motion
2. Restrictive Mitral Inflow with Respiratory Variation  $> 25\%$
3. Hepatic Vein Diastolic Flow Reversals with Expiration



# Removal of LA myxoma

## Post-op transient constriction

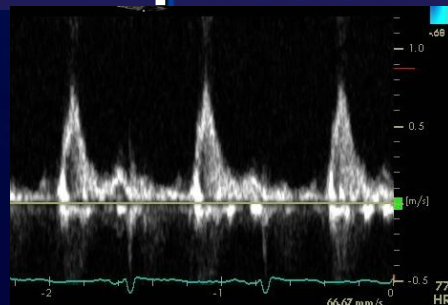
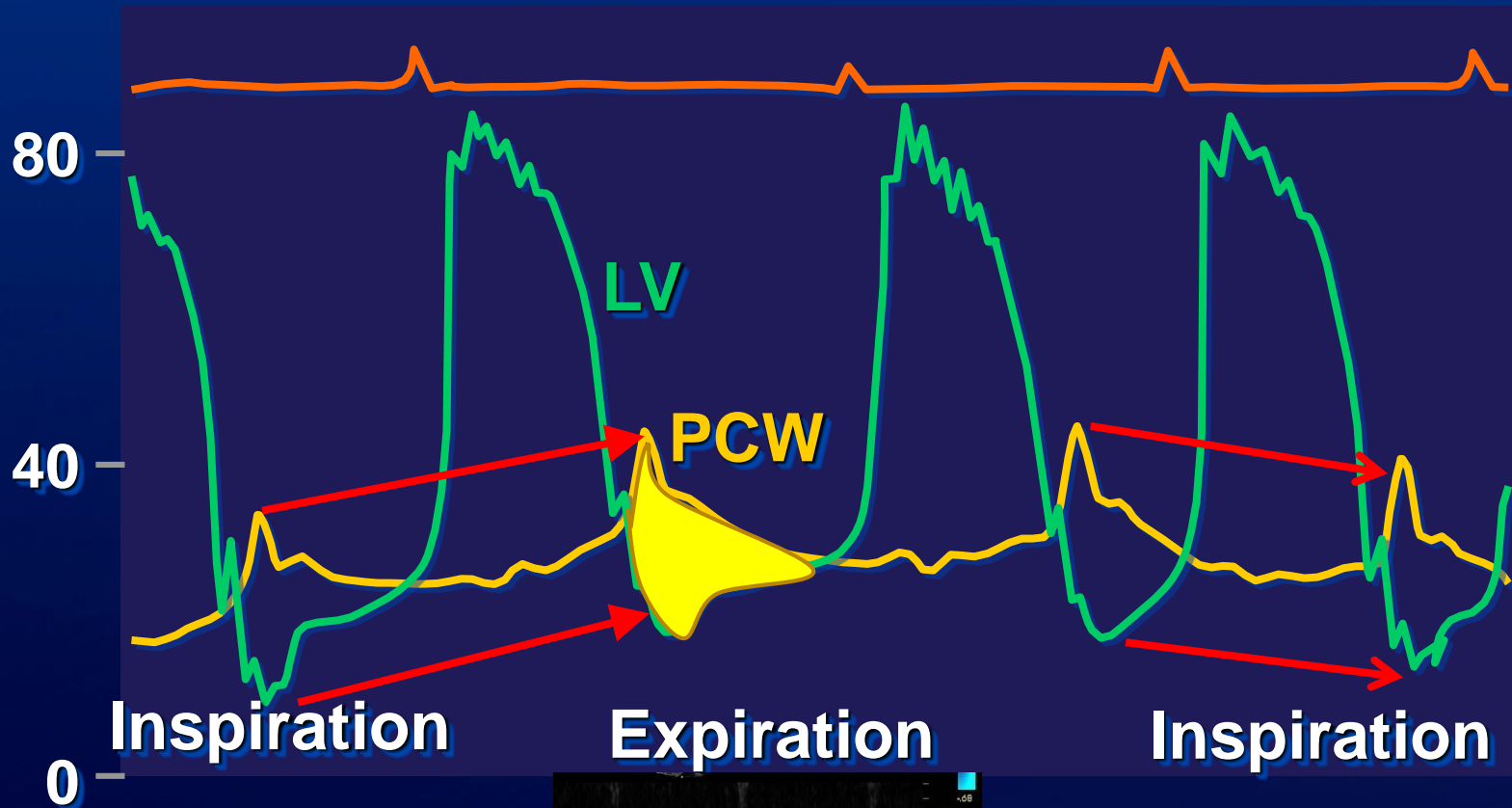


Post-op MRI

3 months later

# Hemodynamics of Myocardial Disease

## Concordant change in PCWP and LVDP



*Hatle et al. Circ 1989*

# Pericardiectomy at Mayo Clinic

## The first cardiac surgery in 1936

### FEELS HEART BEAT AGAIN

#### Melbourne Man Has Stone Casing Cut Away at Mayo Clinic

ROCHESTER, Minn., July (AP).—Alick M. Watkins, 27, who came from Melbourne for surgical aid, walked out of a hospital here today able to feel his heart beat again after Mayo Clinic surgeons had cut away a half-inch casing of stone from that organ.

When he left Melbourne, March 17, physicians gave him only six months to live.

His father, Alick W. Watkins, told how a Mayo Clinic surgeon, performing the second pericardiectomy, worked at the calcified pericardium. The heart, with its hardened casing, was exposed for two hours, and four ribs resected in the operation which took four hours.

Alternately working three minutes and covering the organ with a warm cloth for three minutes, the surgeon lifted the heart out of the

chest cavity part of the time the operation was in progress.

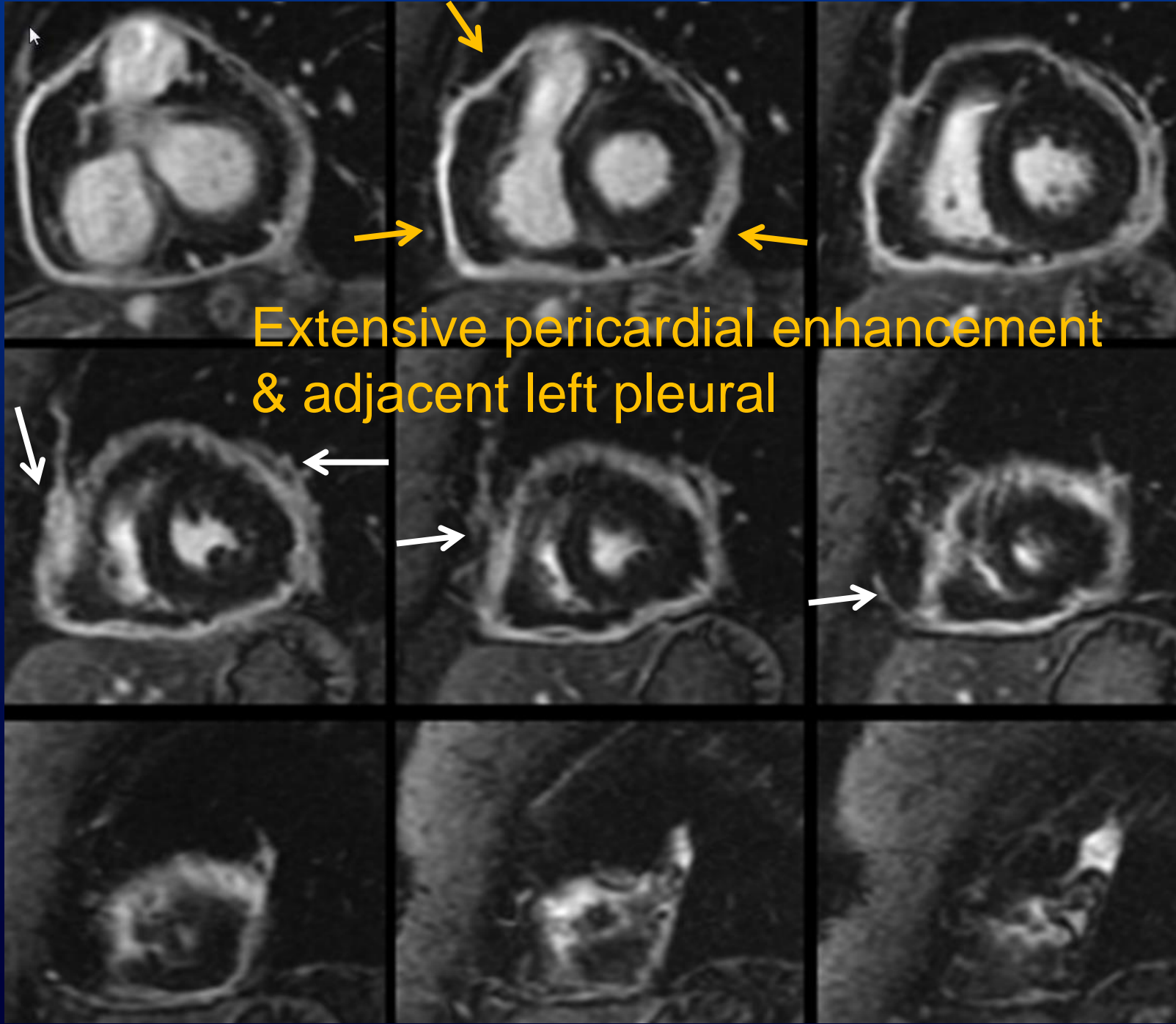
Recovery from the relatively rare operation was rapid. Father and son will leave here next month for Melbourne.



The New York Times

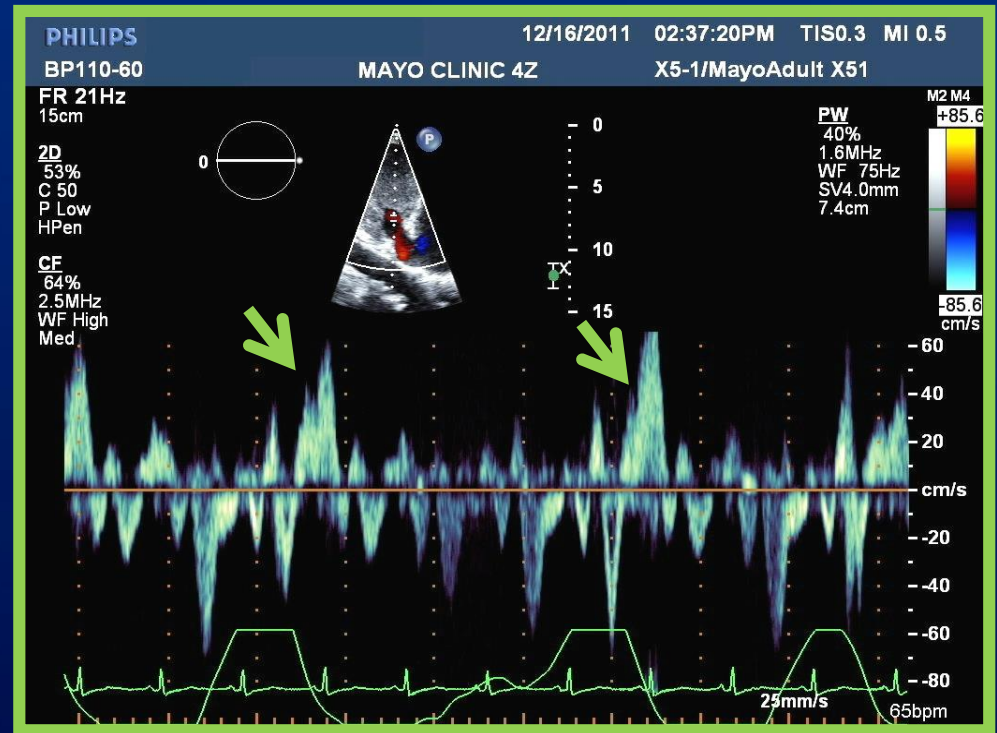
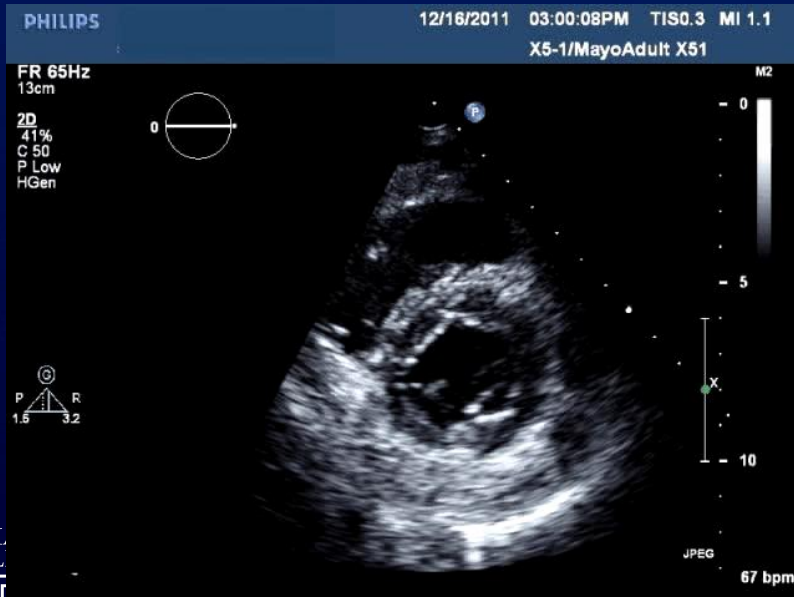
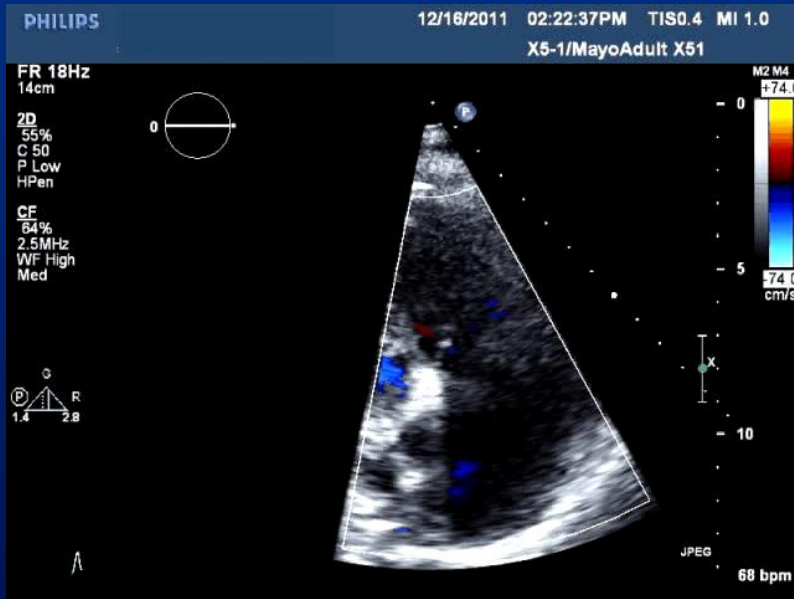
Published: July 17, 1938

Copyright © The New York Times

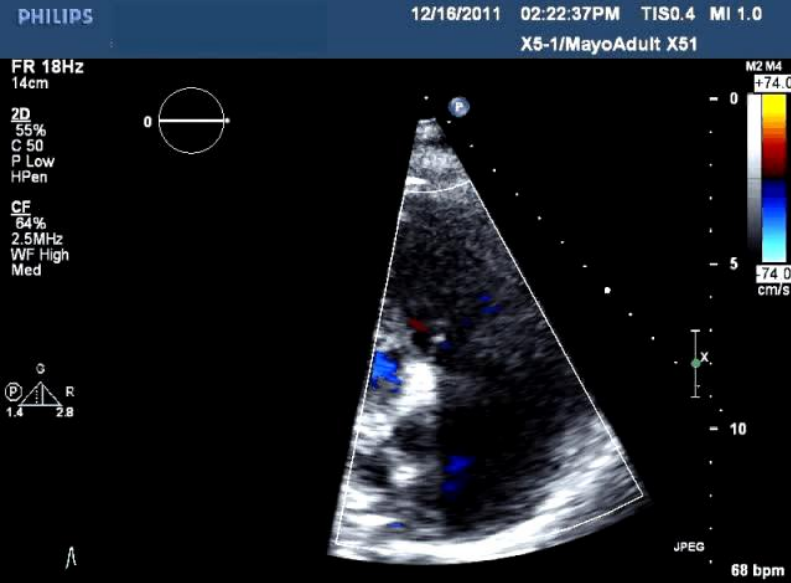


Extensive pericardial enhancement  
& adjacent left pleural

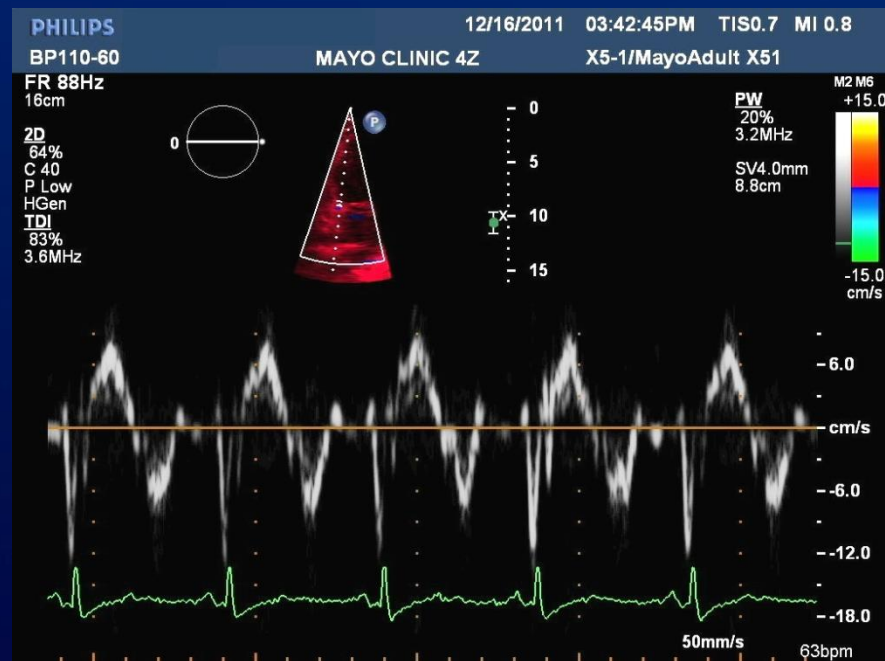
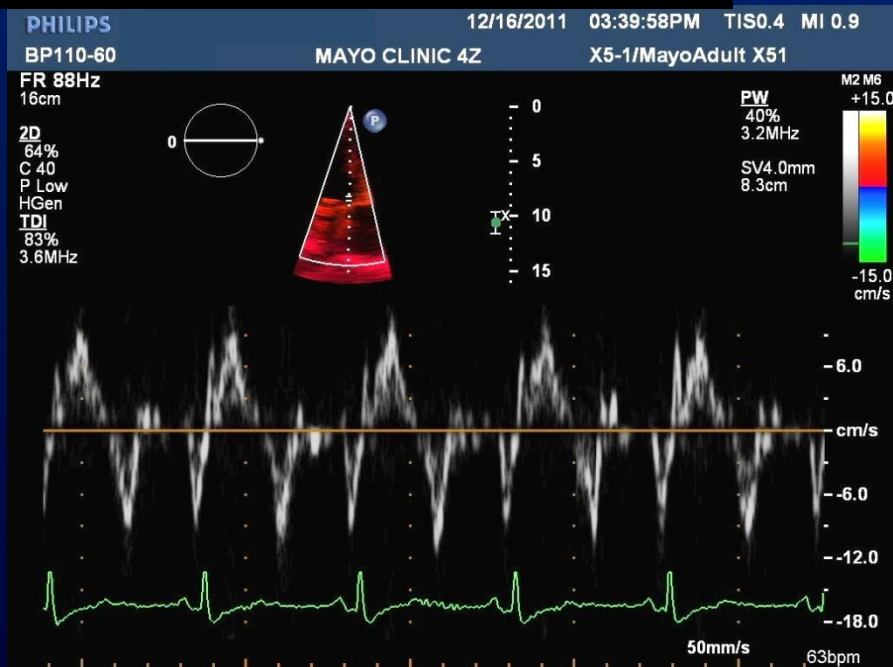
# Heart failure with ascites and leg edema



- 1= Severe TR
- 2=Constriction
- 3= TR + CP
- 4= TR and RV dysfunction



# Annulus Reversus Severe TR and CP



**Medial  $e'$  = 12 cm/sec**

**Lateral  $e'$  = 9 c/sec**



E' velocity is inversely proportional  
to pericardial thickness in the AV groove

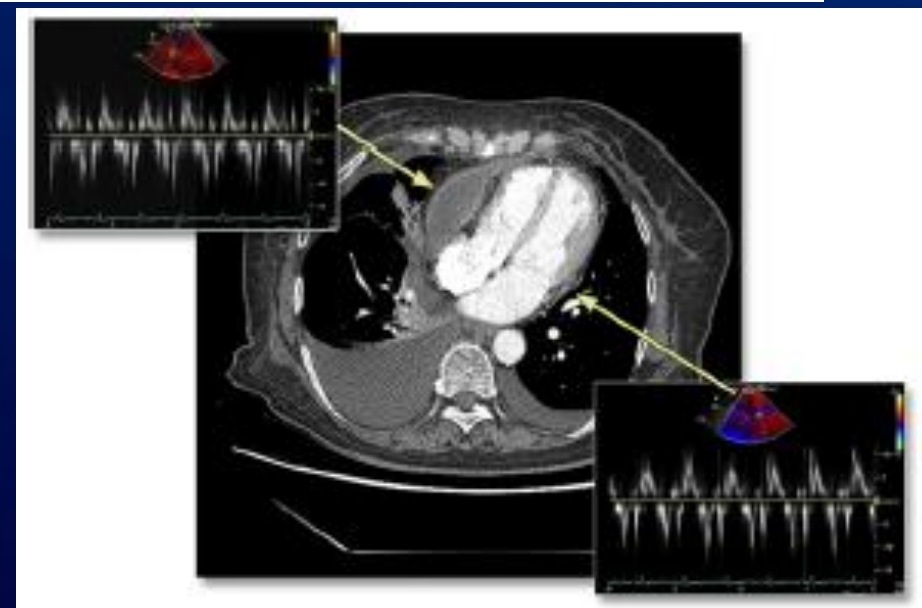
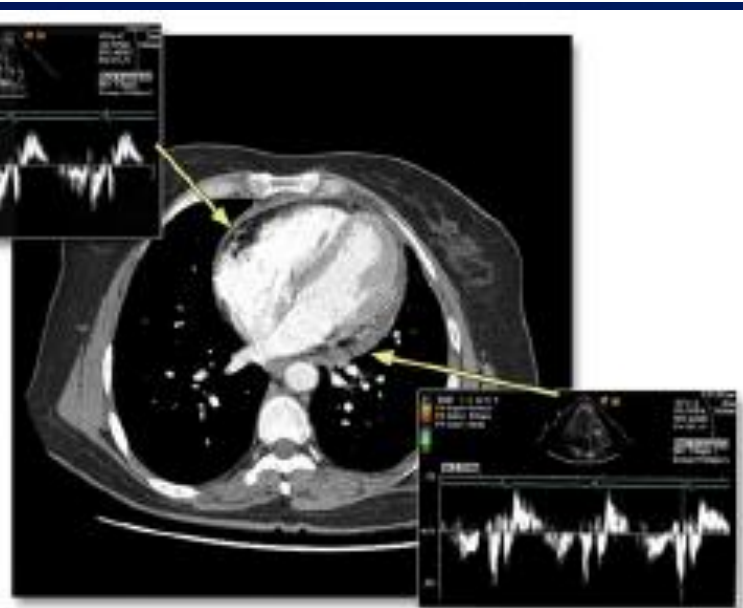
ORIGINAL RESEARCH

## Mitral and Tricuspid Annular Velocities in Constrictive Pericarditis and Restrictive Cardiomyopathy

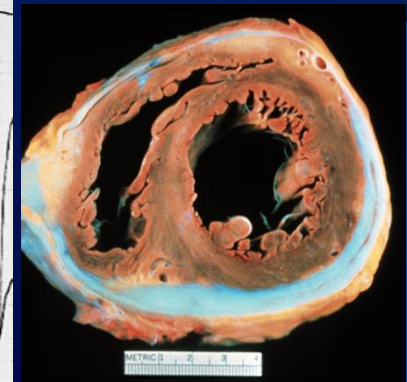
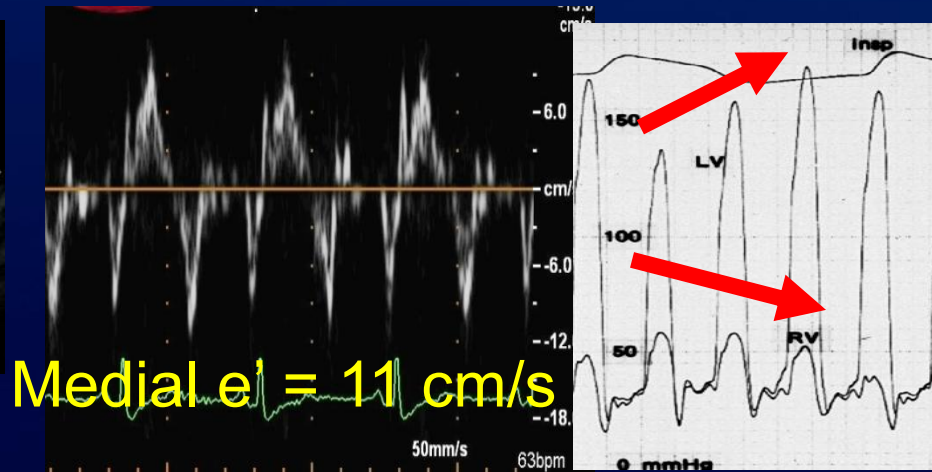
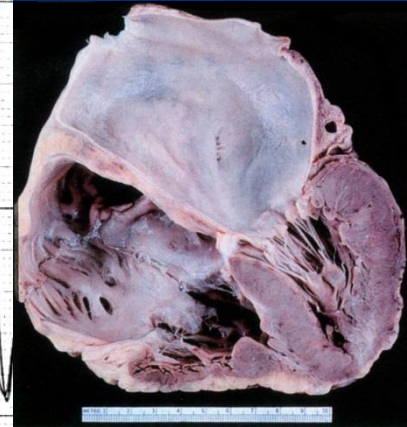
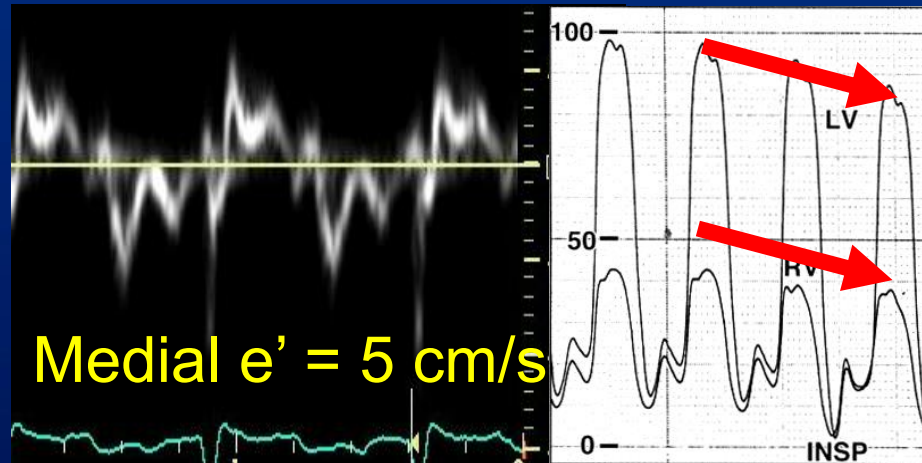
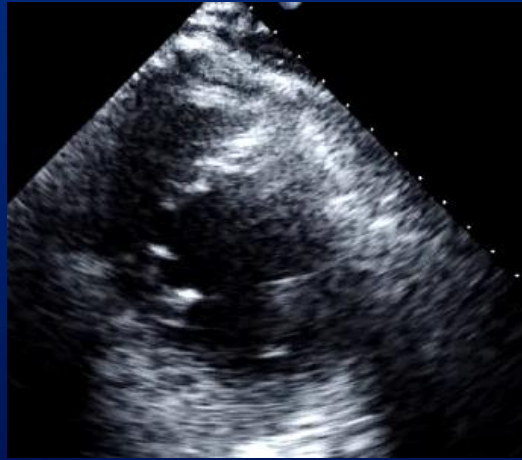
Correlation With Pericardial Thickness on Computed Tomography

Joon Hyouk Choi, MD,\* Jin-Oh Choi, MD,\* Dong Ryeol Ryu, MD,\* Sang-Chol Lee, MD,\*  
Seung Woo Park, MD,\* Yeon Hyeon Choe, MD,† Jae K. Oh, MD\*‡

Seoul, Korea; and Rochester, Minnesota



# Take Home Point :Restriction or Constriction? Diagnosis based on Hemodynamics

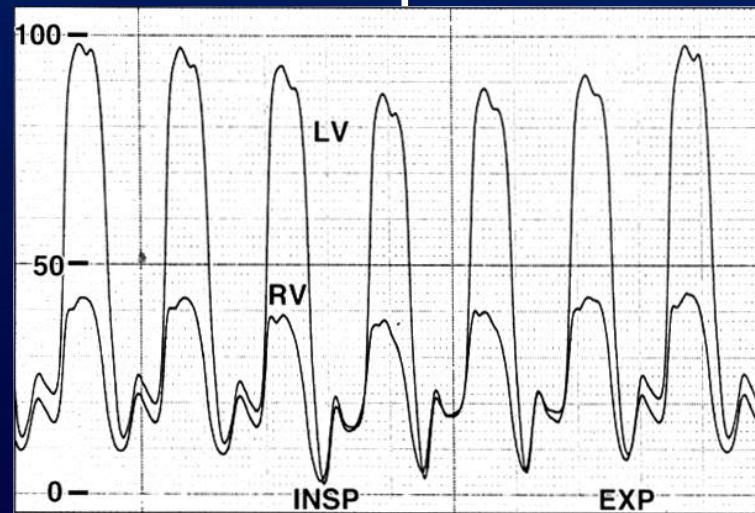


# Learning Objectives Based on Cases

- Identify constriction by 4 parameters
  - Ventricular septal motion abnormality
  - Mitral inflow velocity  $\geq$  Grade 2
  - Mitral annulus medial  $e' \geq 8$  cm/sec
  - Hepatic vein diastolic expiratory flow reversal
- Identify mimickers of constriction
  - Restrictive CM
  - Severe TR
  - Interventricular dependence of other causes

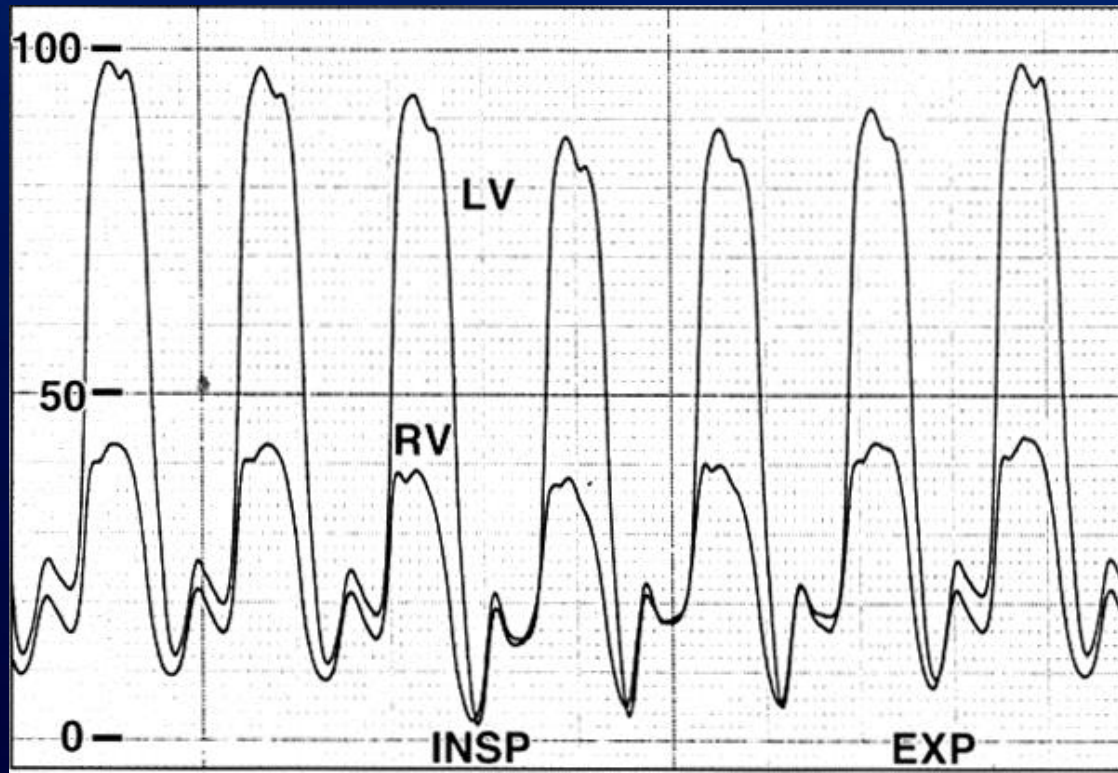
# 71 yo man with Heart Failure 2 yrs after CABG Referred for Pericardiectomy

- Physical Examination
  - JVP elevation
  - Prominent S3
  - Peripheral edema
- CT was obtained: Calcified Pericardium
- Cath : Equalization of End-diastolic pressures

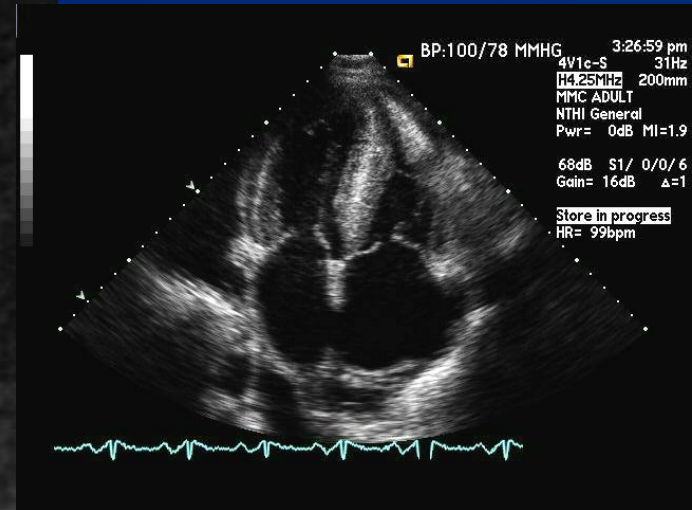
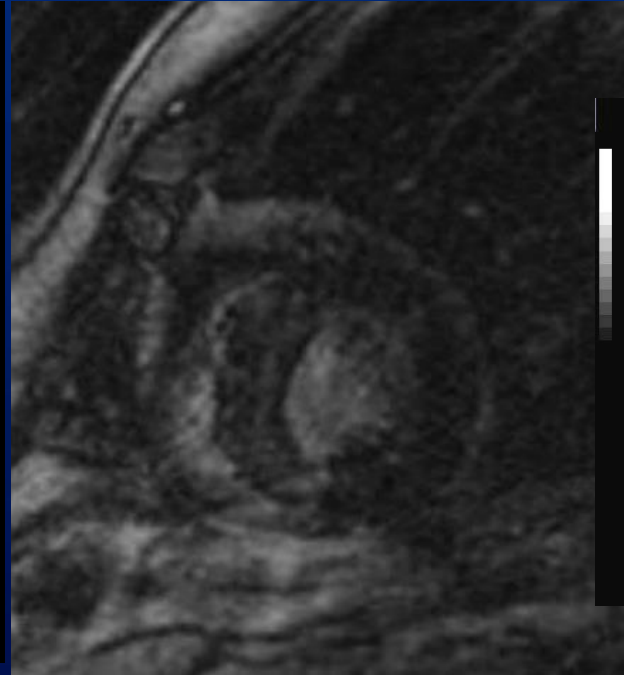


# 71 yo man with calcified pericardium Referred for Pericardiectomy

- Cardiac Cath
  - Normal Coronaries
  - Elevated RAP, RVEDP, LVEDP  
Equalized LV/RV EDP



# 71 year old man with calcified pericardium



**MRI : Patchy myocardial delayed enhancement and increased wall thickness**

**Cardiac Amyloidosis**