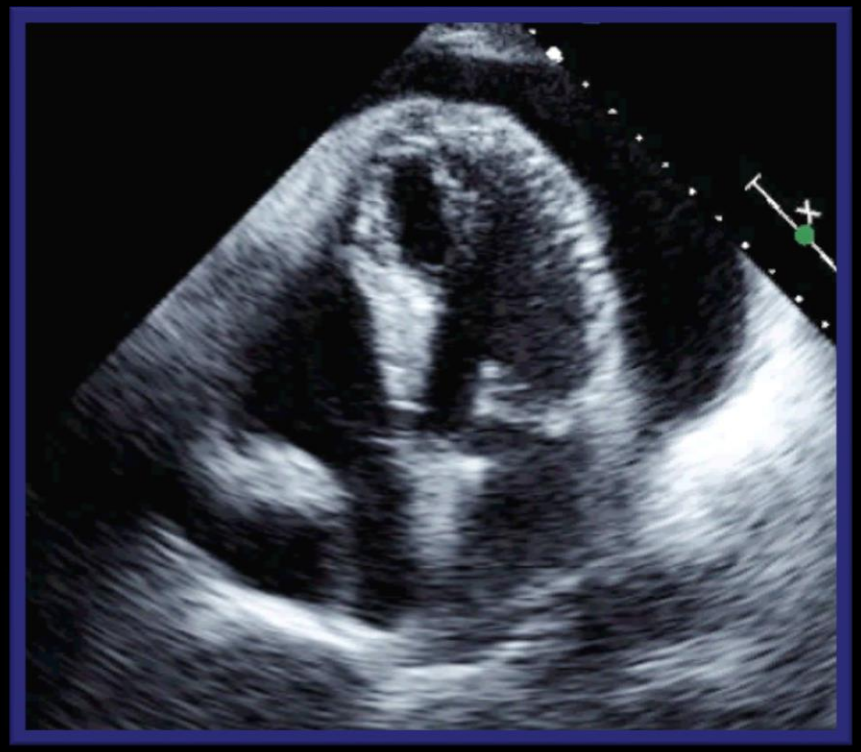
Echo Evaluation of Hemodynamics in Pericardial Disease



Natesa G. Pandian

Disclosure - None

Pre-Presentation Question 1

In cardiac tamponade, the pressure gradient between pulmonary venous system and left atrium

1. Increases during inspiration
2. Decreases during inspiration
3. Decreases during expiration
4. Shows no change

Pre-Presentation Question 2

In established constrictive pericarditis, septal bounce is recognized

1. In every heart beat
2. With breath hold
3. During regular breathing
4. Only during premature beats

Pre-Presentation Question 3

For tamponade to occur, pericardial effusion should be at least

1. 200 ml
2. 500 ml
3. 1000 ml
4. None applicable

Pre-Presentation Question 4

The following annular or septal velocity (tissue Doppler) is useful in recognizing constriction (in contrast to restrictive CMP)

1. e’ 3-5
2. e’ > 7
3. e’ > 27

The Pericardium

Visceral pericardium: single cell layer

Parietal : <2mm thick (collagen)

Pericardial fluid volume: ~ 50 cc

Normal Intrapericardial Pressure (mm Hg):

a) - 3

b) 0

c) + 2

d) + 5

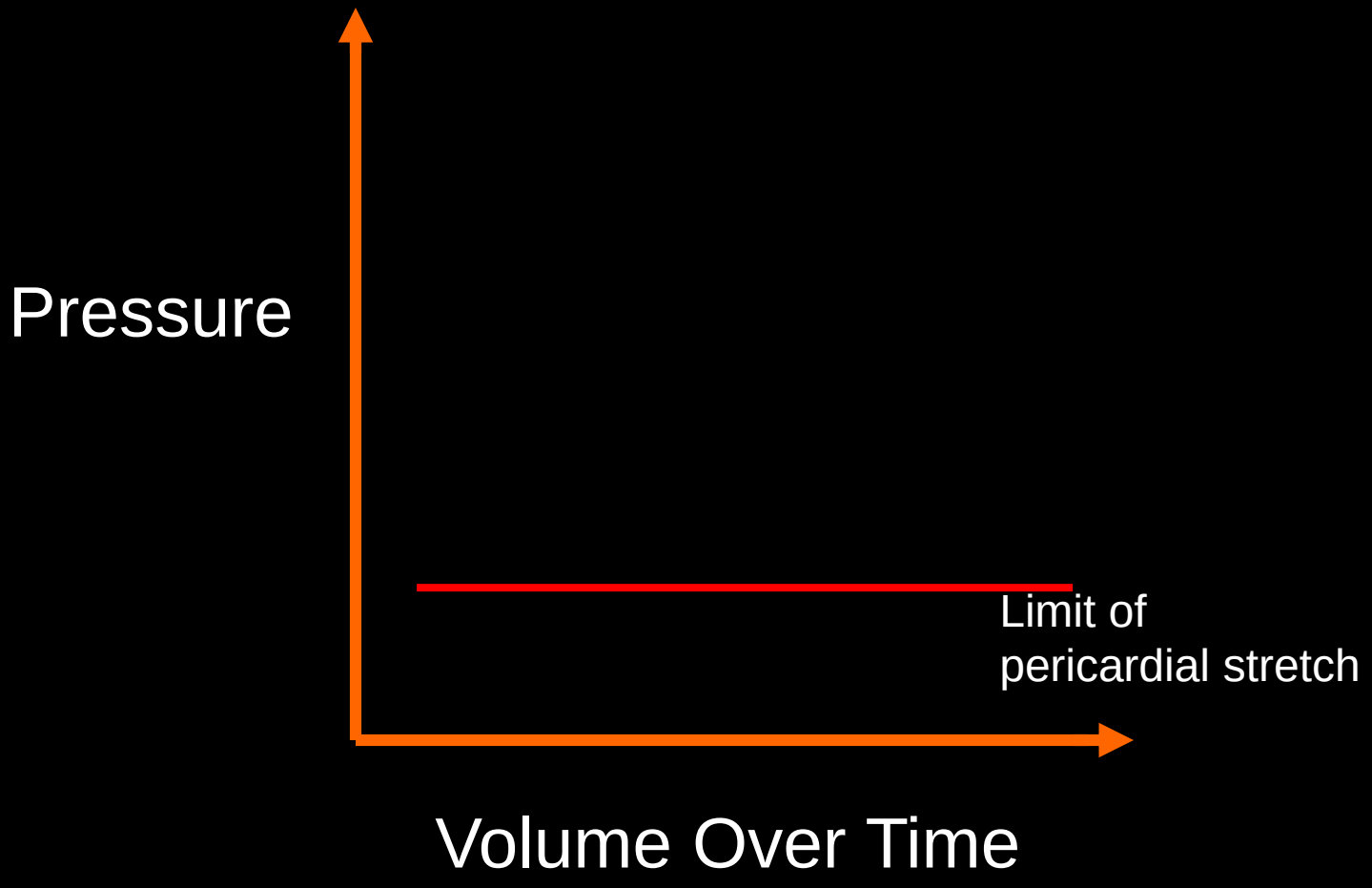
The Pericardium

Intrapericardial pressure

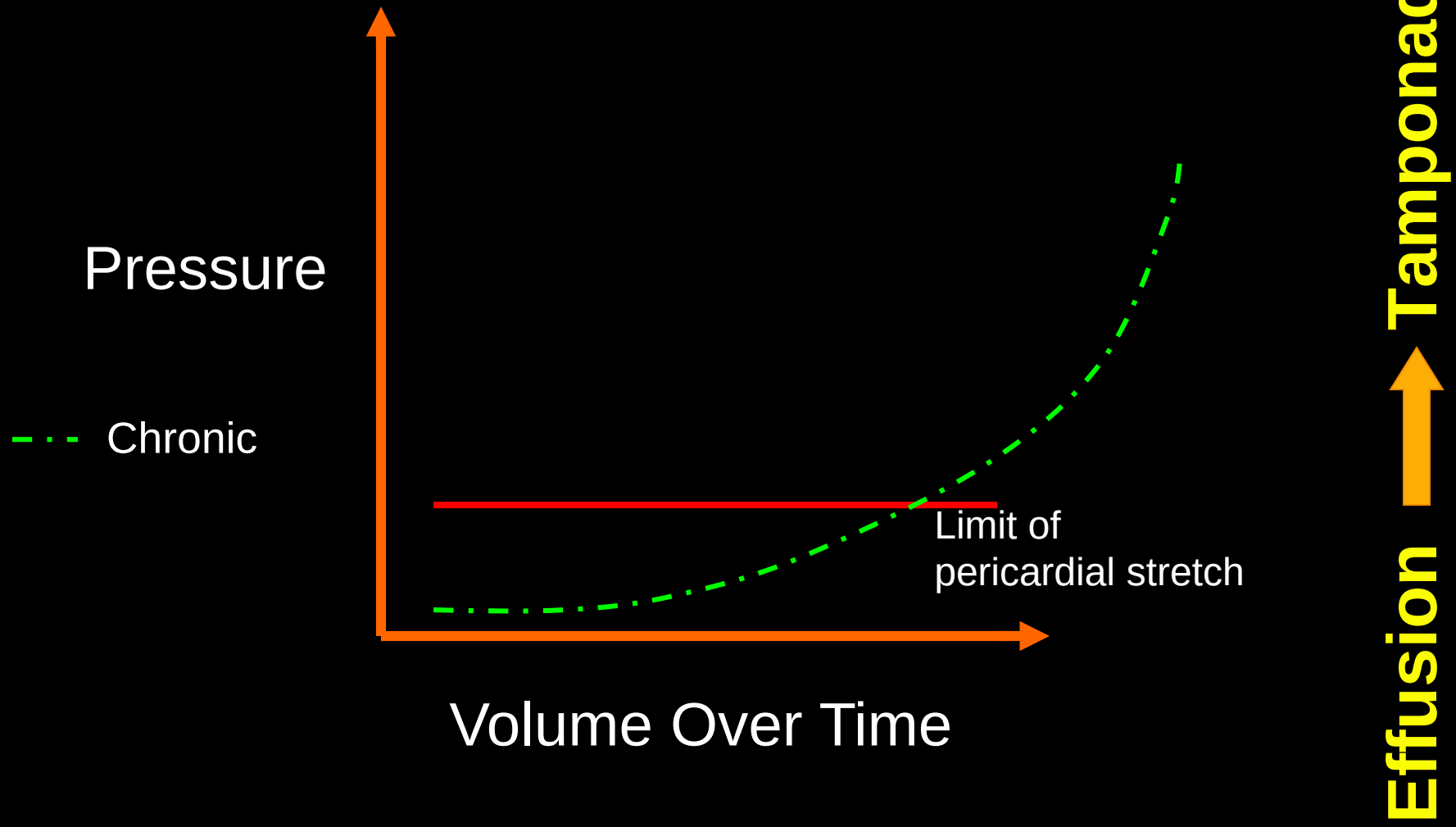
end-inspiration - 6 mmHg

end-expiration - 3 mmHg

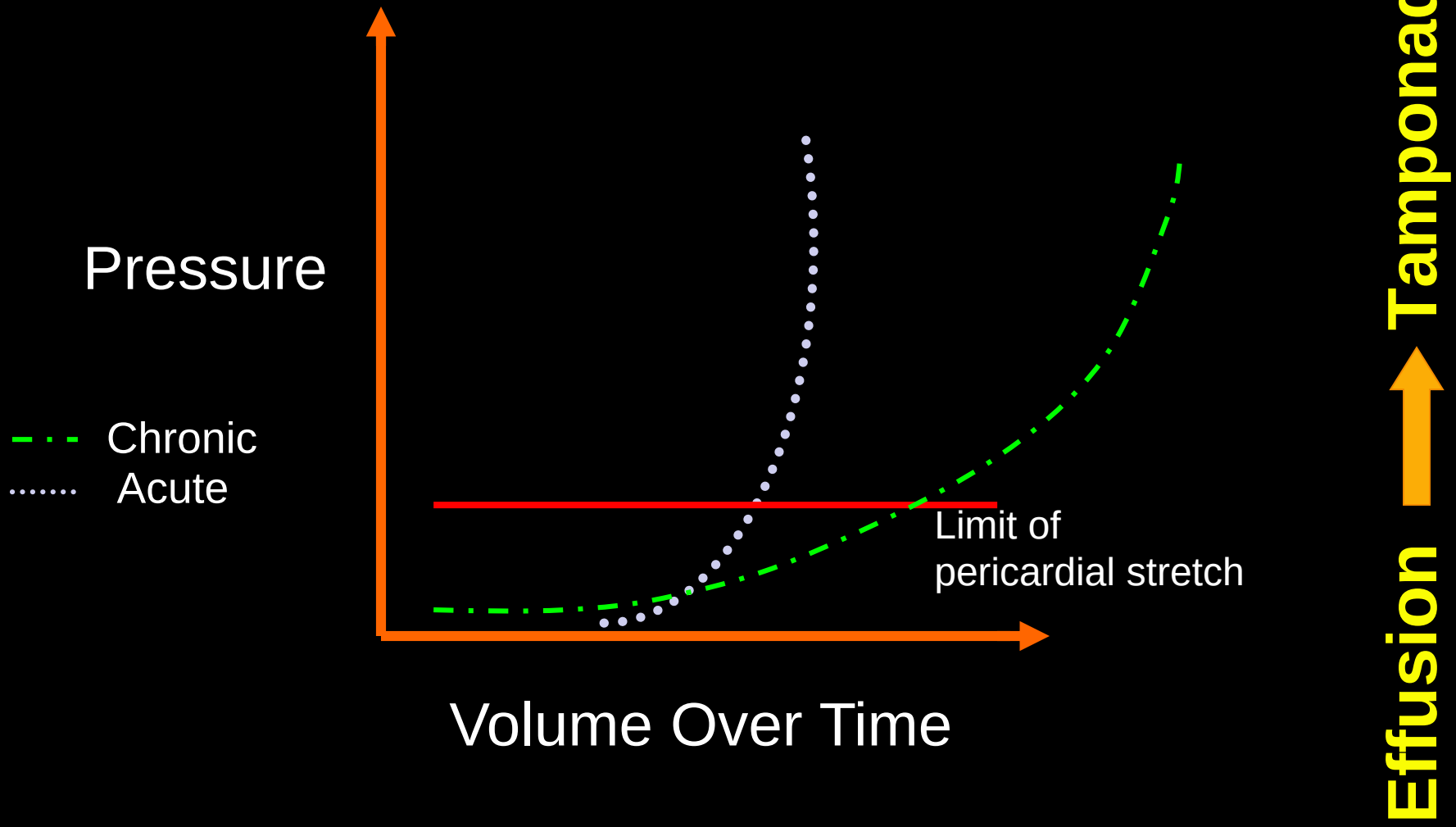
Pericardial Pr-Vol Relationship



Pericardial Pr-Vol Relationship



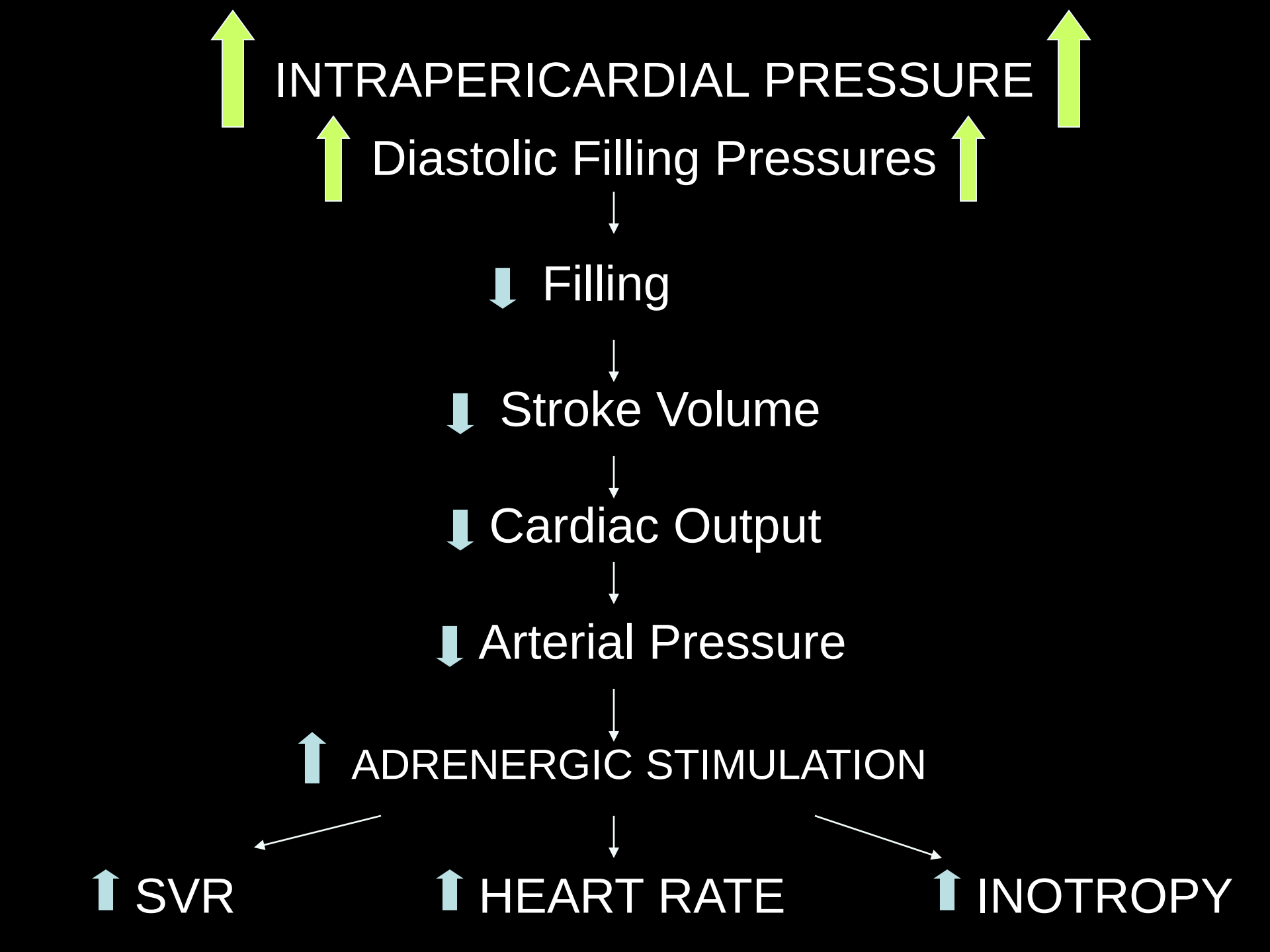
Pericardial Pr-Vol Relationship

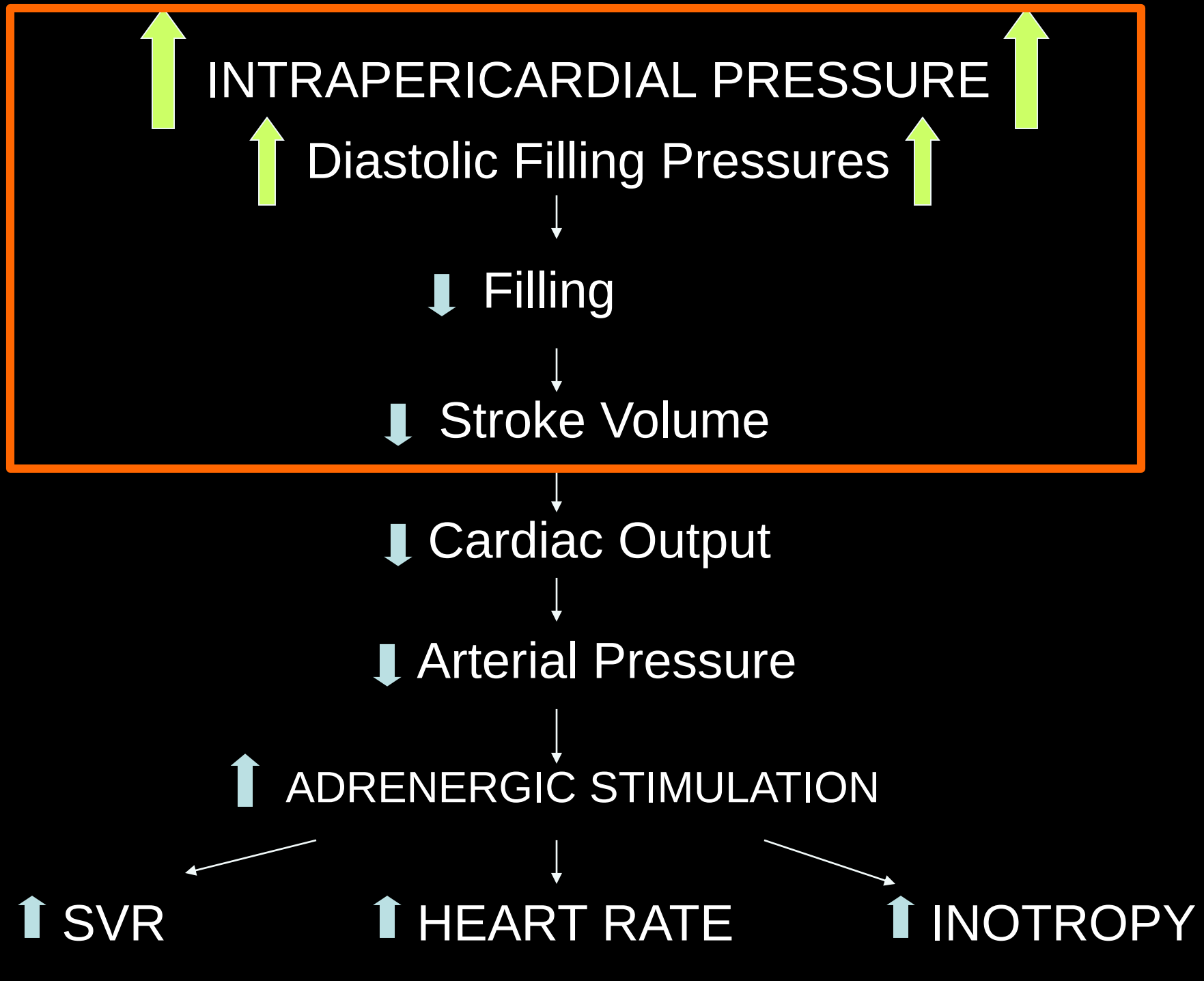


INTRAPERICARDIAL PRESSURE

INTRAPERICARDIAL PRESSURE

Diastolic Filling Pressures


INTRAPERICARDIAL PRESSURE
Diastolic Filling Pressures
Filling
Stroke Volume
Cardiac Output
Arterial Pressure
ADRENERGIC STIMULATION
SVR
HEART RATE
INOTROPY


INTRAPERICARDIAL PRESSURE
Diastolic Filling Pressures
Filling
Stroke Volume
Cardiac Output
Arterial Pressure
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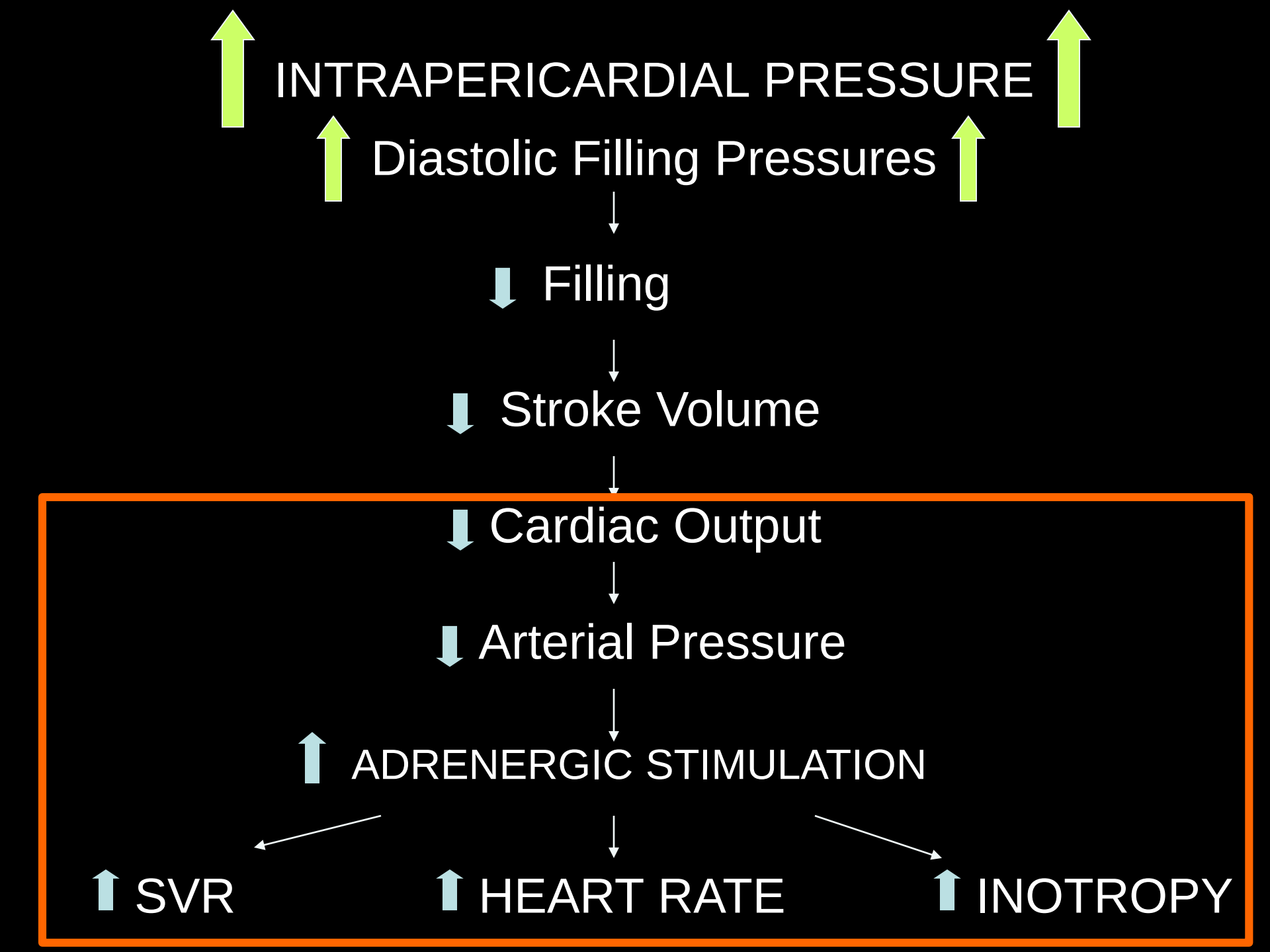
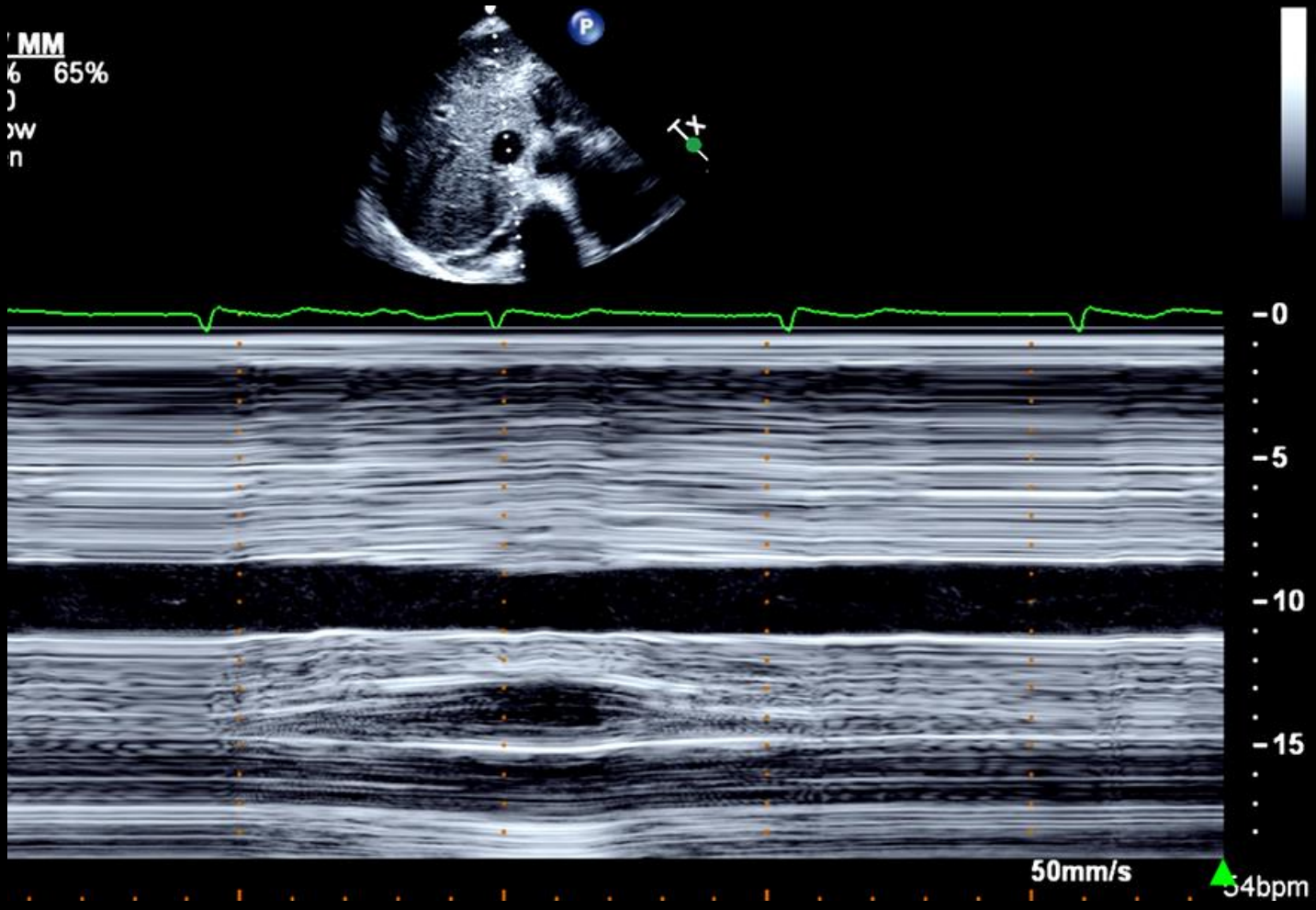
HEART RATE
INOTROPY


INTRAPERICARDIAL PRESSURE
Diastolic Filling Pressures
Filling
Stroke Volume
Cardiac Output
Arterial Pressure
ADRENERGIC STIMULATION
SVR
HEART RATE
INOTROPY


MM
65%
P
0
5
10
15
50mm/s
54bpm

INTRAPERICARDIAL PRESSURE

Diastolic Filling Pressures

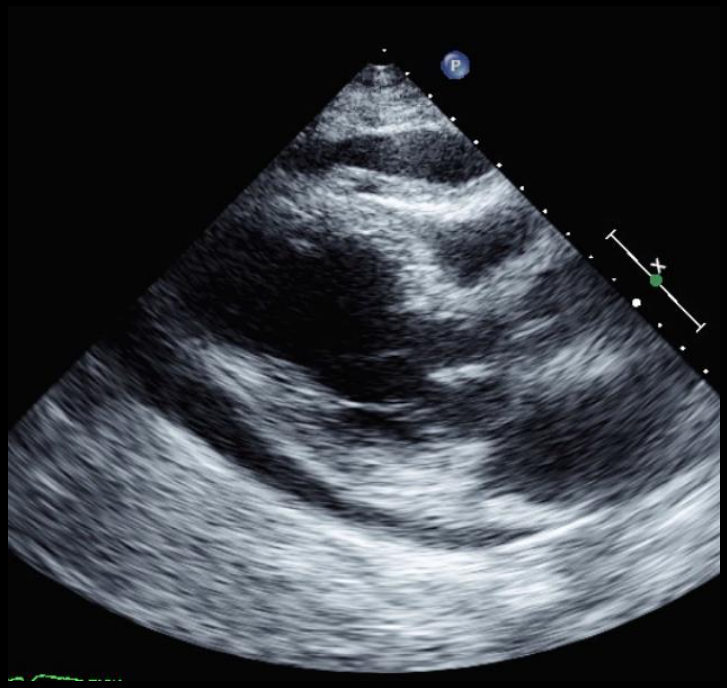
At certain times during the cardiac cycle, intrapericardial pressure may exceed chamber pressures

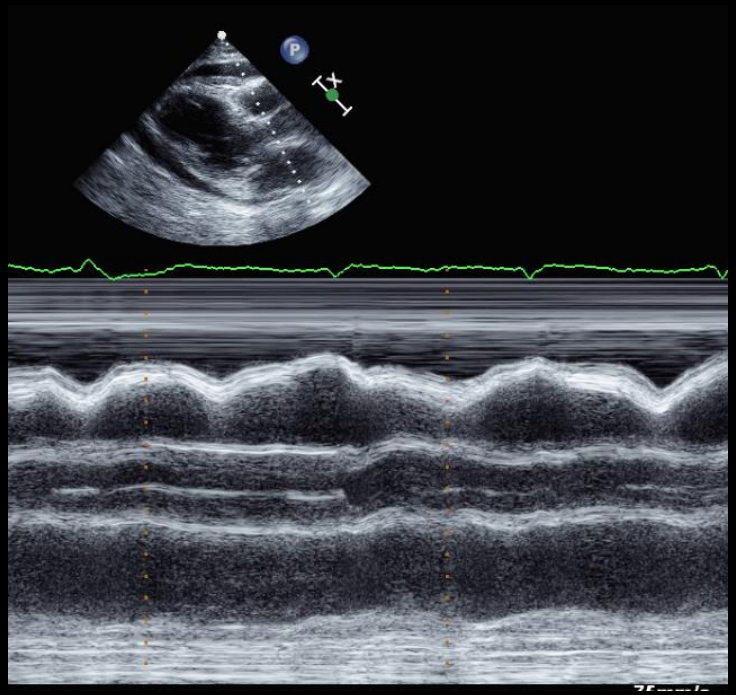
Case

RV diastolic collapse appears

a) Early RV diastole
b) Mid RV diastole
c) Late RV diastole
d) Early RV systole
e) Late RV systole

RV Diastolic Collapse





RV diastolic collapse could be absent In tamponade in the presence of

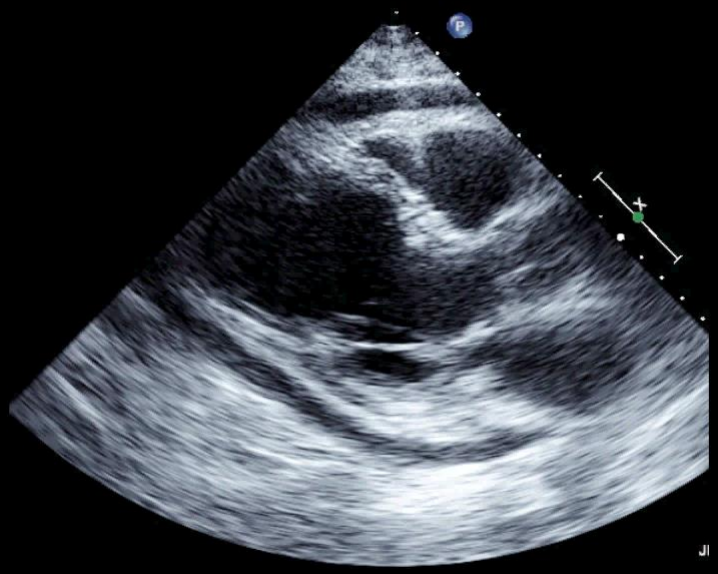
a) RV Hypertrophy
b) Pulmonary hypertension
c) RV volume overload
d) COPD
e) All of the above

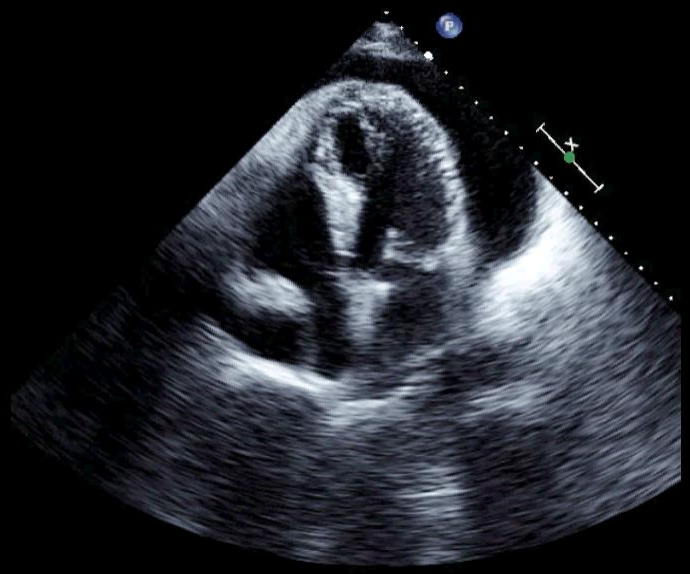
Case

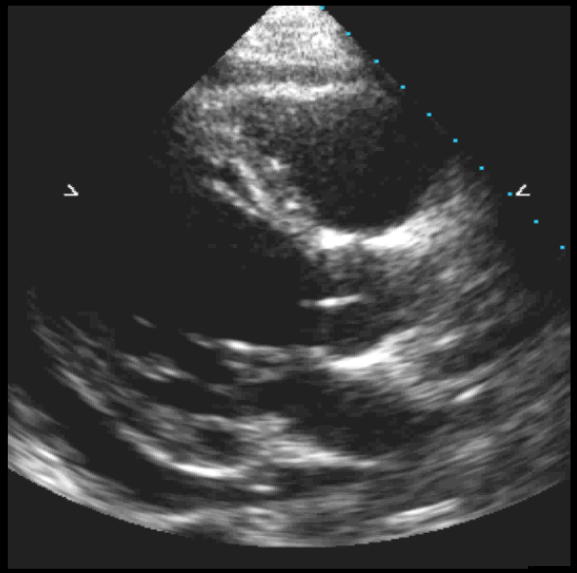
RA collapse appears during:

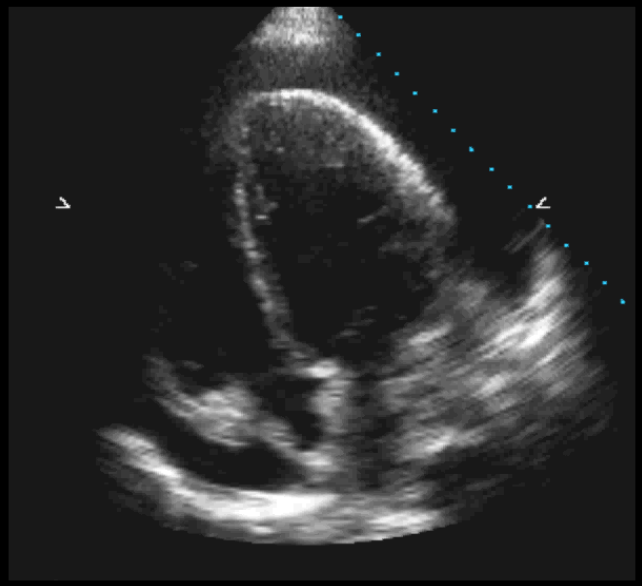
a) Early RV diastole
b) Mid RV diastole
c) Late RV diastole
d) Late RV systole

Case

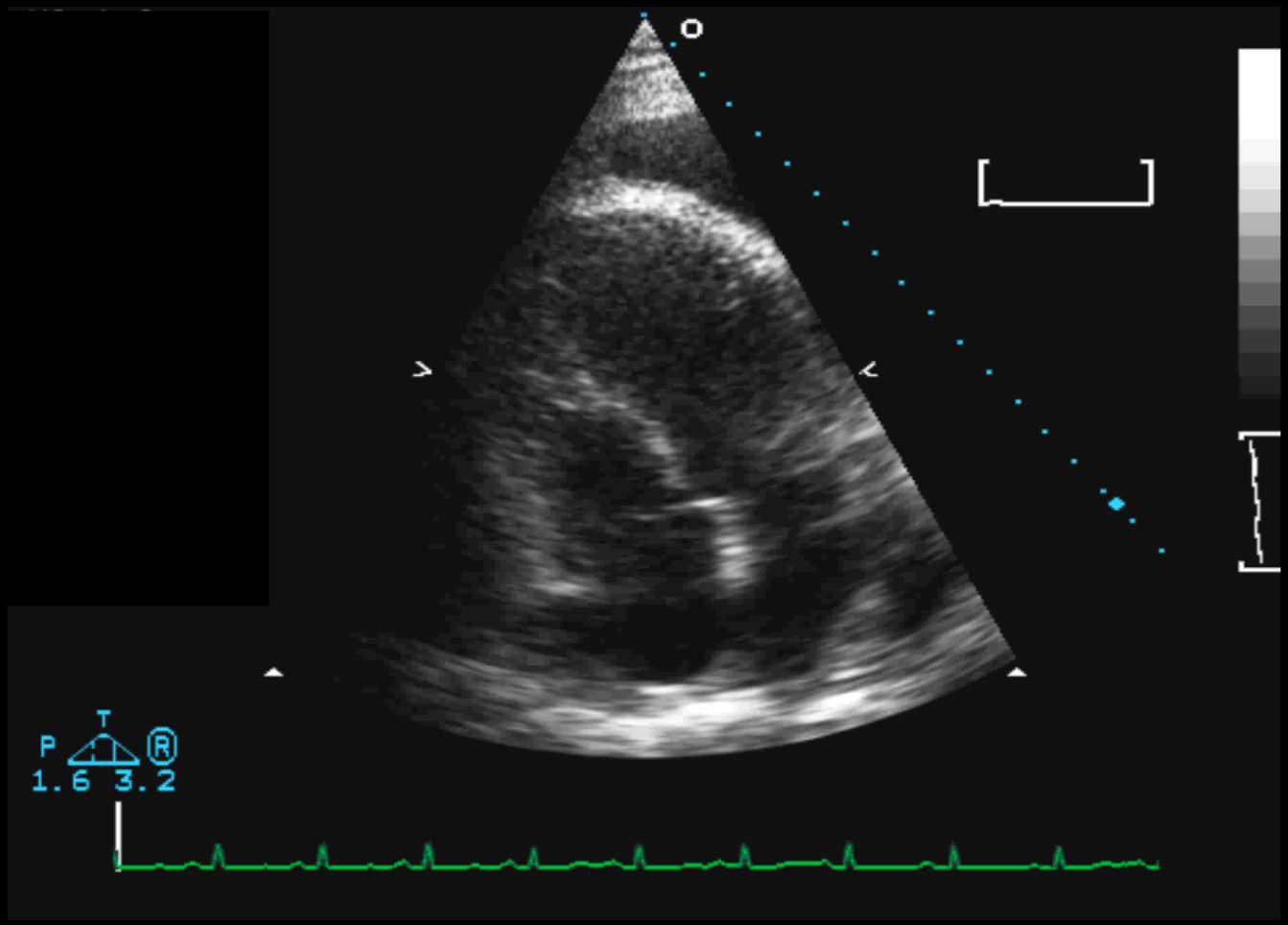




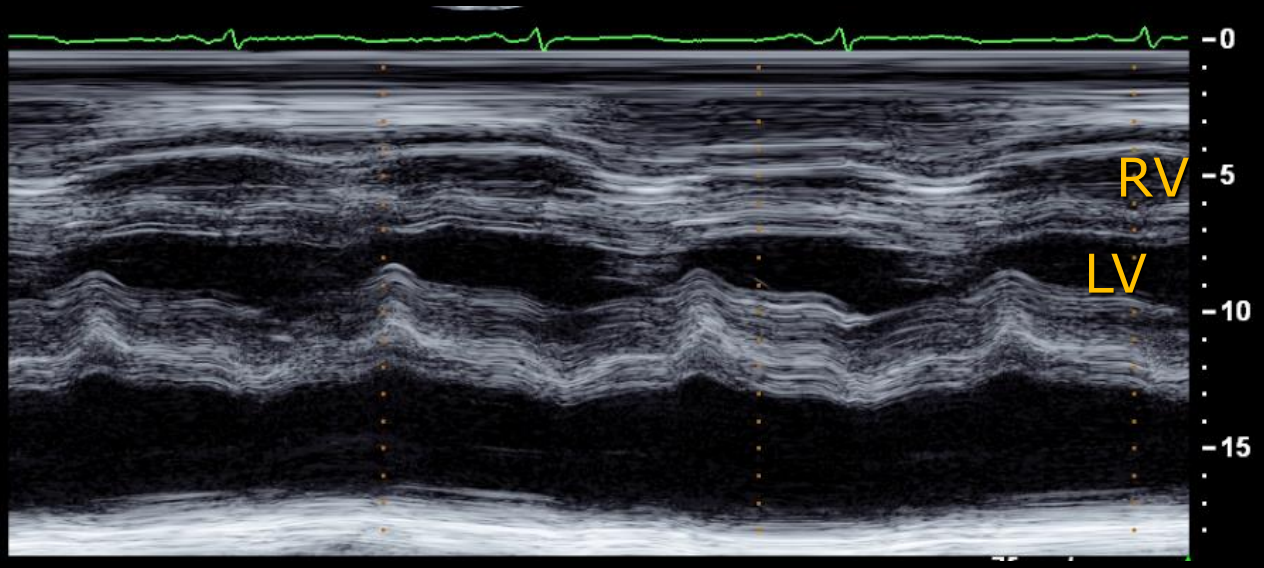




Ventricular Interaction

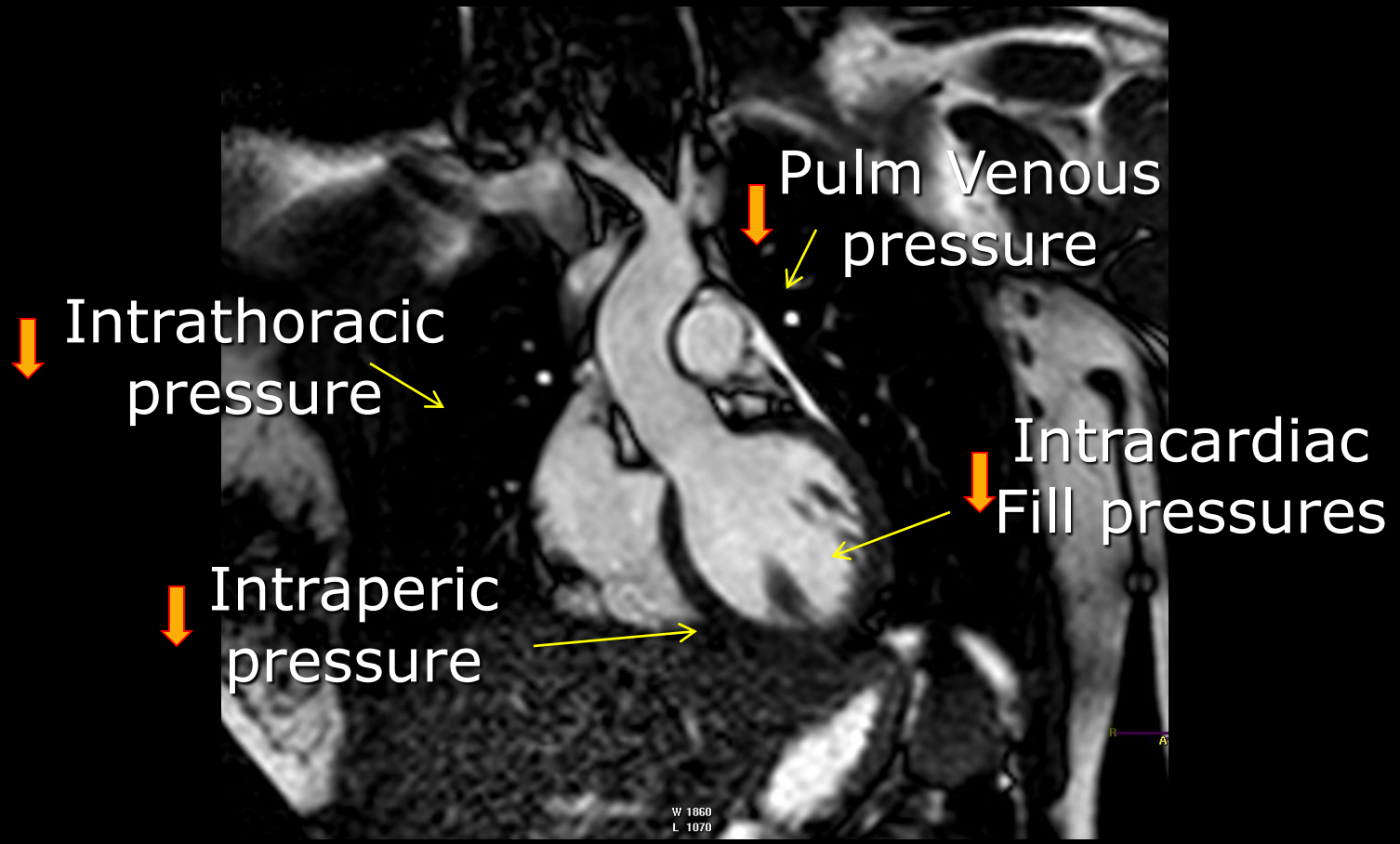


Ventricular Interaction

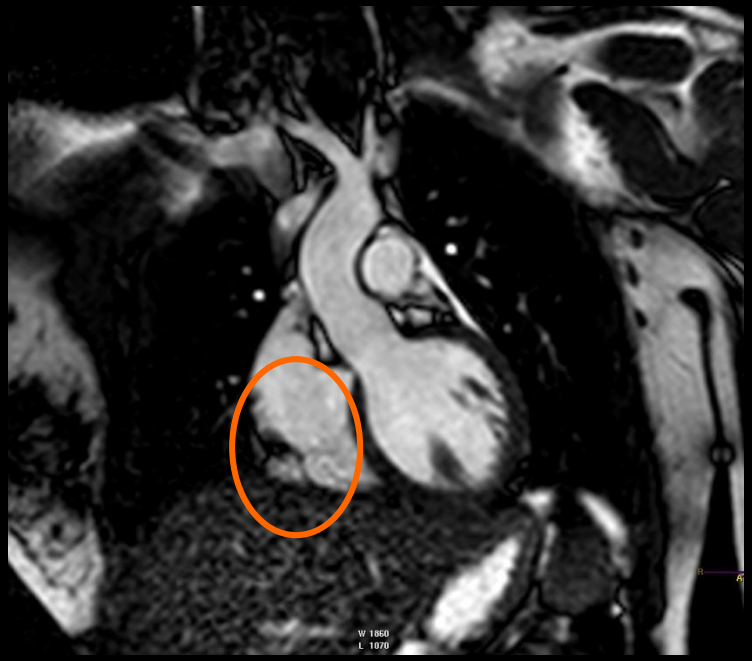


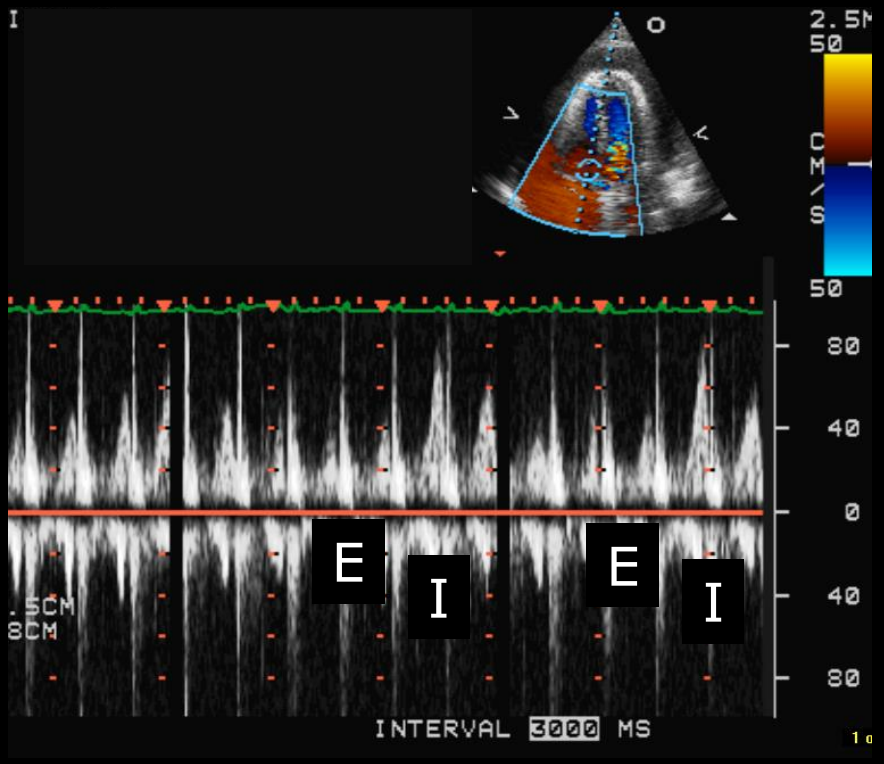
During Inspiration

During Inspiration

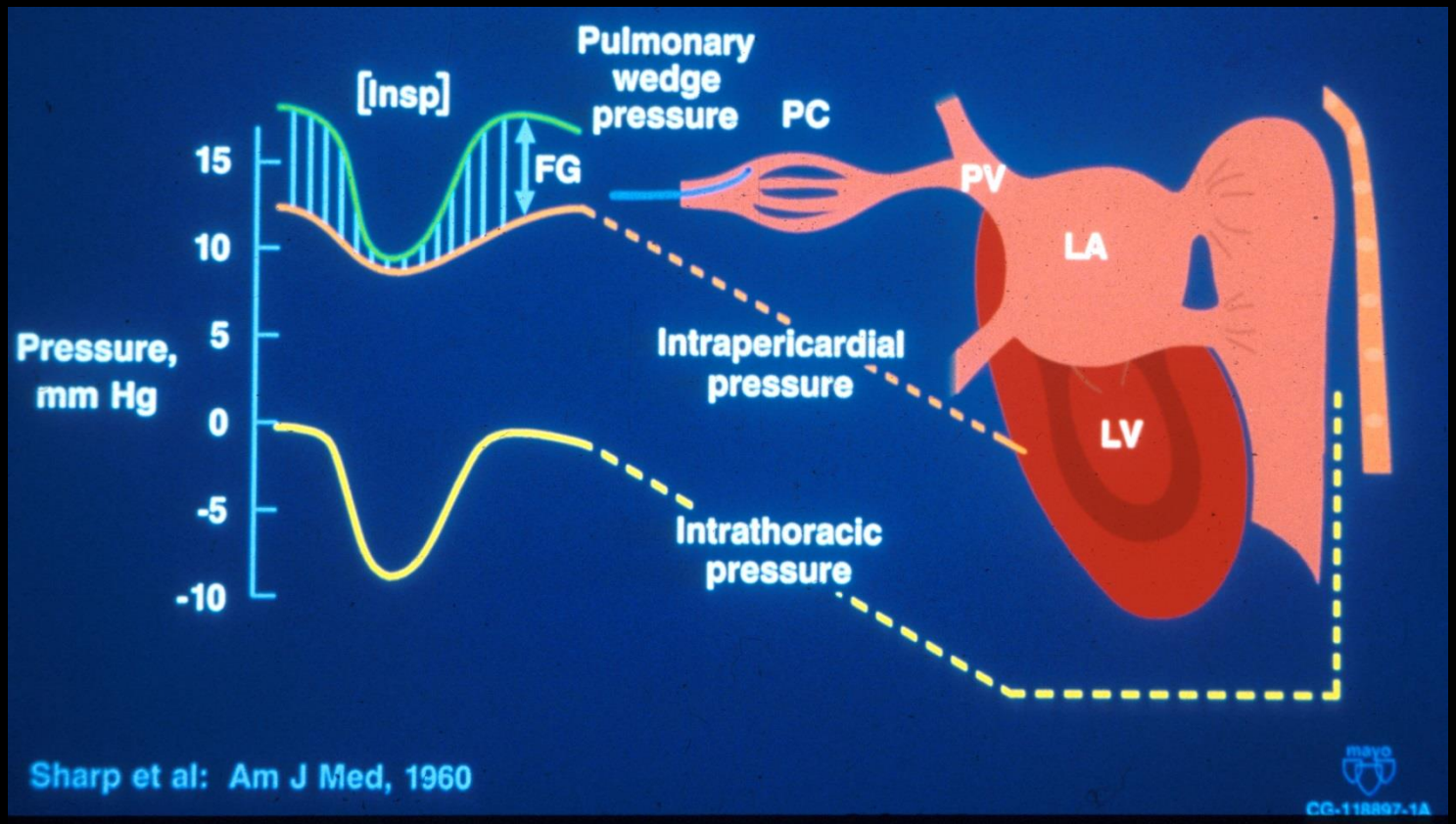


Tamponade

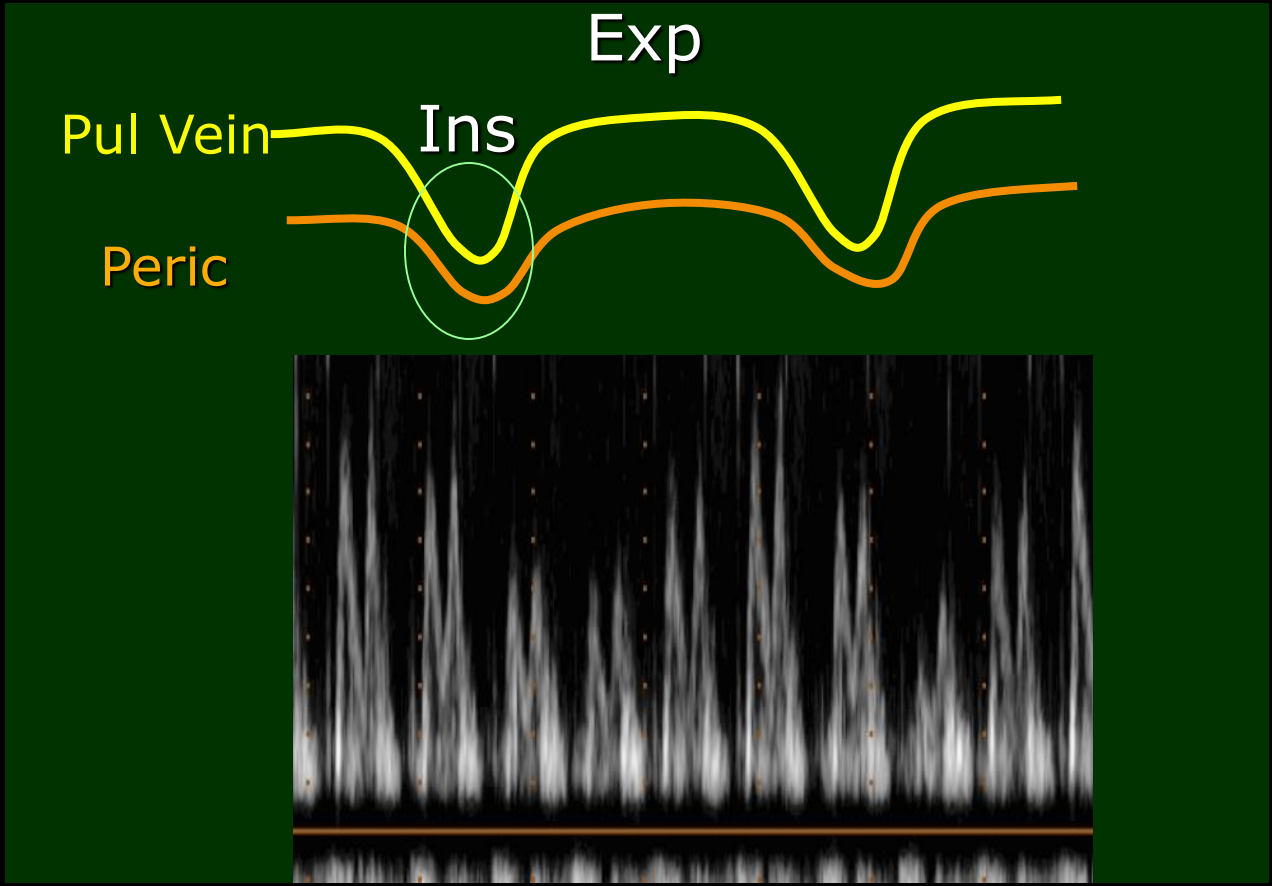




Tamponade

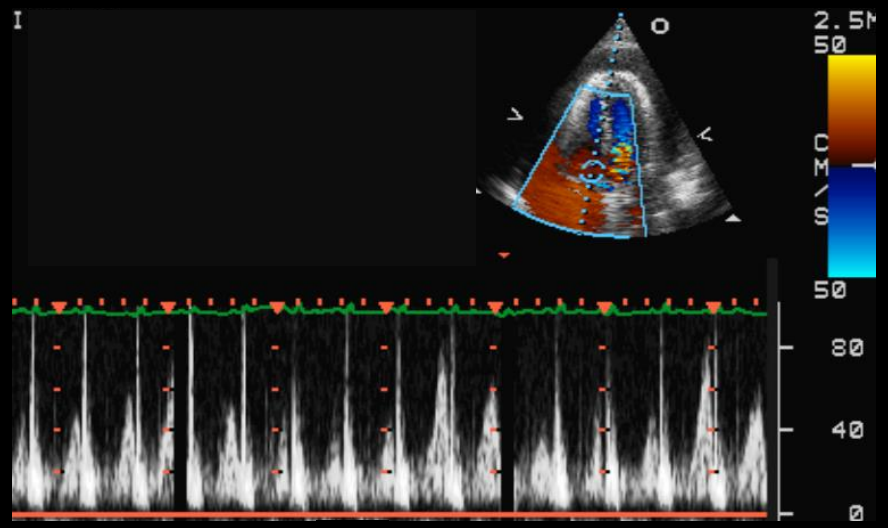

[Insp]
Pulmonary wedge pressure
PC
FG
PV
LA
LV
15
10
5
0
-5
-10
Pressure, mm Hg
Intrapericardial pressure
Intrathoracic pressure
Sharp et al: Am J Med, 1960
mayo
CG-118897-1A

Tamponade



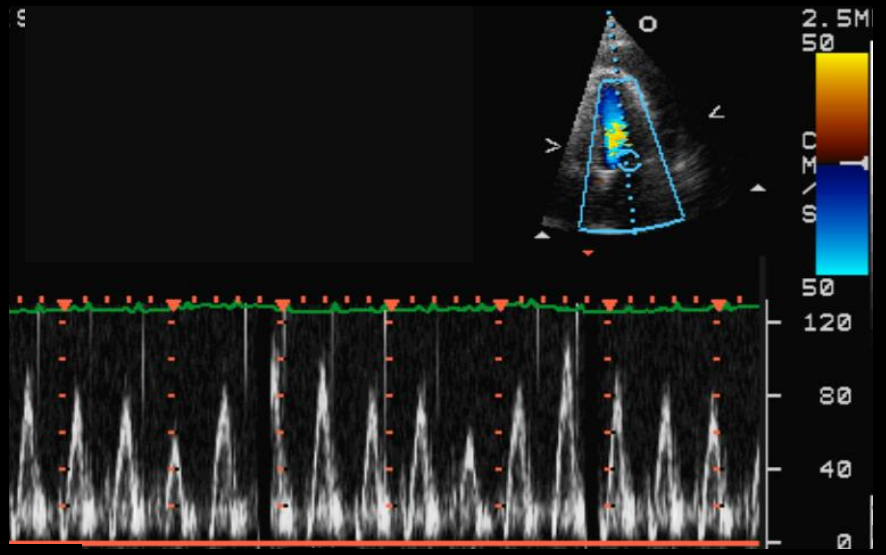
Dissociation between Intrathoracic and Intracardiac Pressures

Tricuspid Flow



E I E I

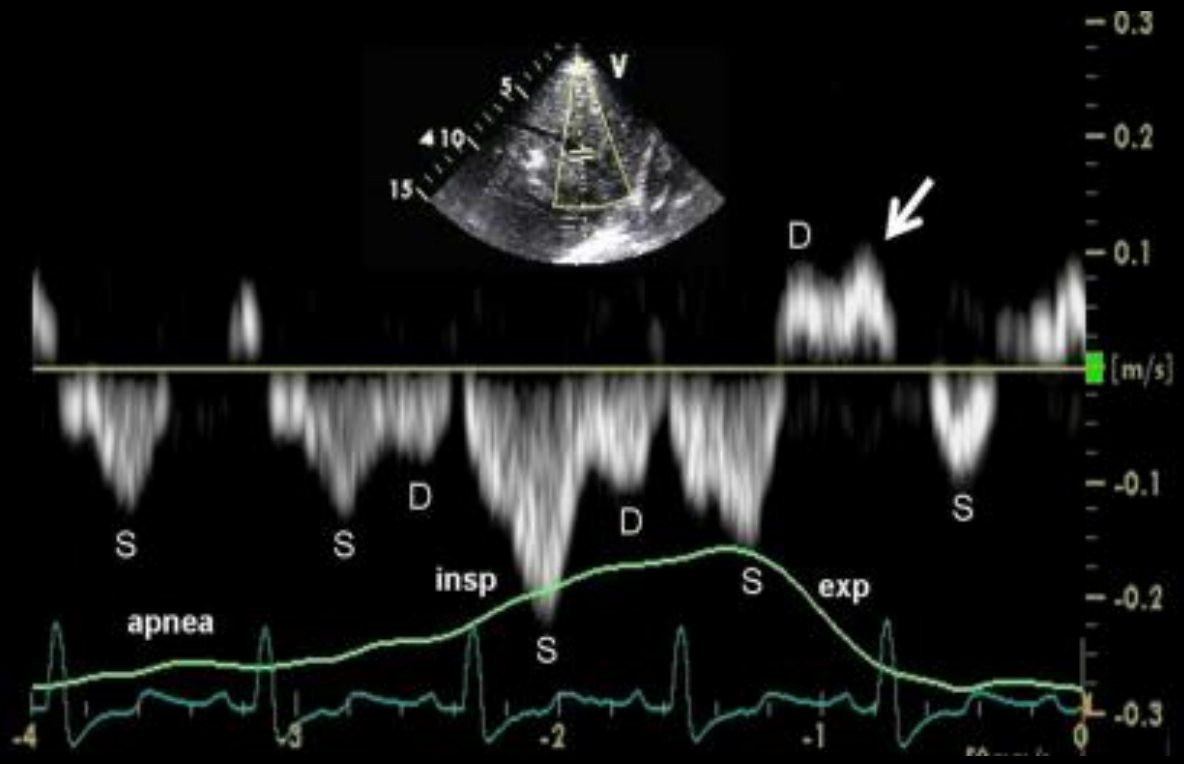
Mitral Flow



E I E I

$$\frac{\text{Exp Velocity} - \text{Insp Velocity}}{\text{Exp Velocity}}$$

Hep V/SVC Flow



Hep V/SVC Flow

- Insp Increase
- Exp Decrease
- Exp Increase in reversal flow

Pulm Vein Flow

- Insp Decrease
- Exp Increase

Hemodynamics behind Echo Findings, Symptoms and Signs

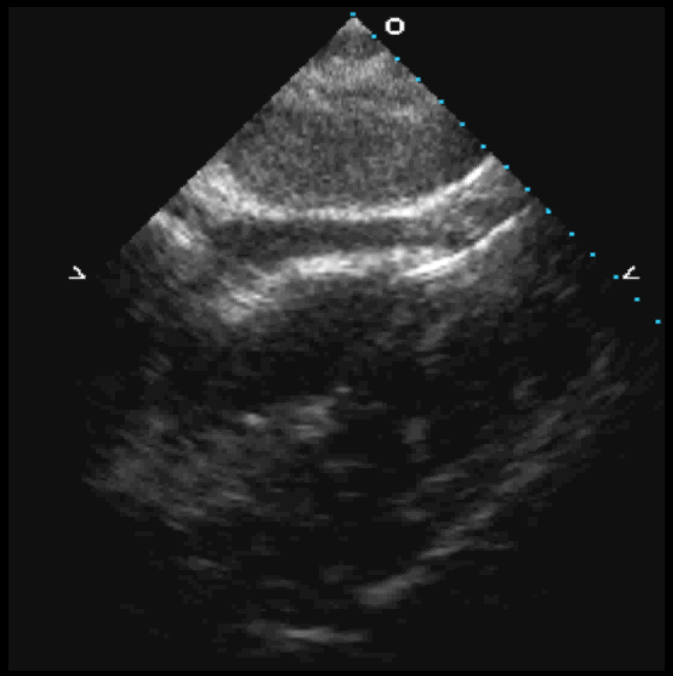
- Elevated intraperic & filling Pressures
- Intraperic pr rising above chamber pr
- Exaggerated RV-LV Interaction
- Dissociation Intrathor & Intracard Prs
- Decreased Cardiac Output

Typical Tamponade

- RV diastolic collapse
- RA collapse
- LA collapse
- Abnormal septal motion
- Resp change in LV, RV size
- Dilated IVC, Plethora
- Incr resp variation in flow

  Mitral > 25-30%, Tricuspid > 35%

Case



Etiology

1. Viral
2. Post MI
3. Traumatic
4. Post-Op

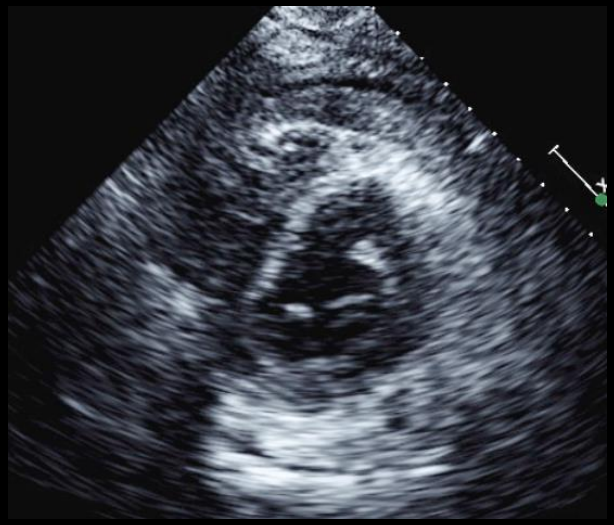
Case

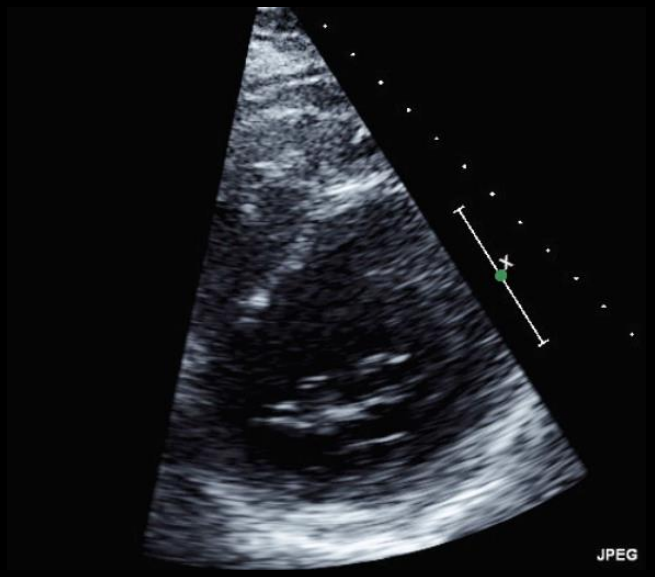
Post - CABG

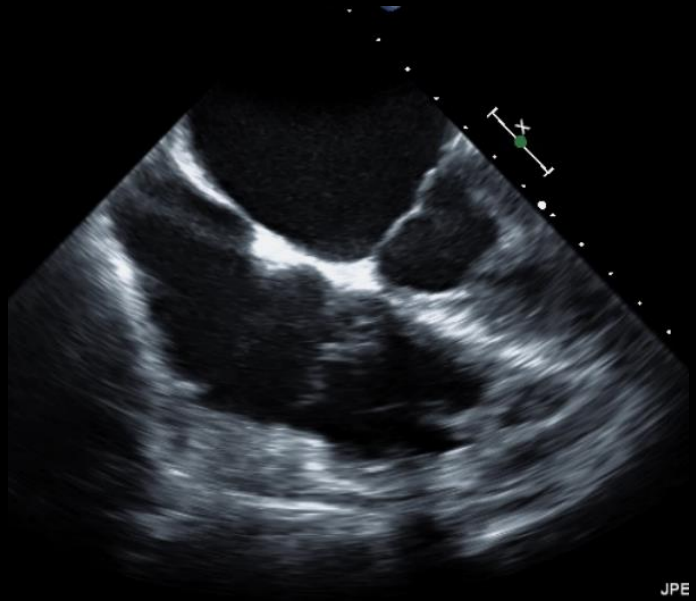
Mild Hypotension

Management

1) Percutaneous drainage
2) Surgical drainage off-pump
3) Surgical repair on pump
4) Fluids, Pressors
5) CT scan, MRI or Cath

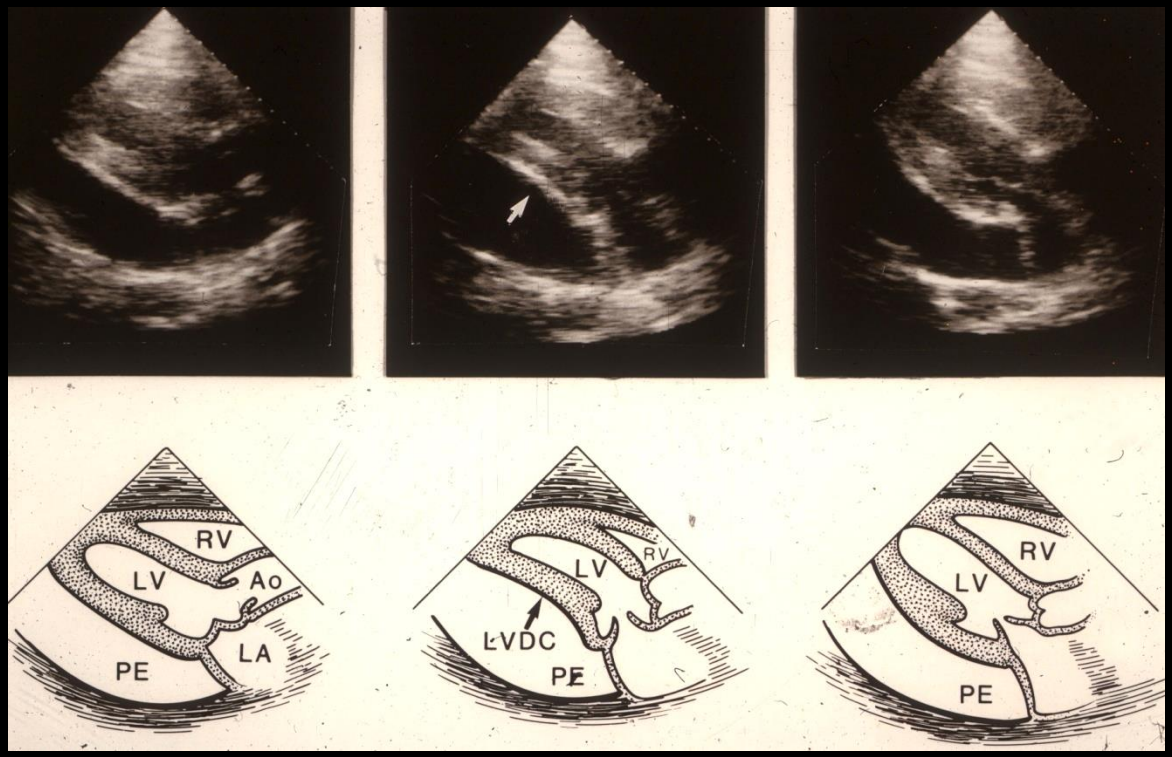



JPEG


JPE

Regional Effusion and Tamponade

Regional Tamponade



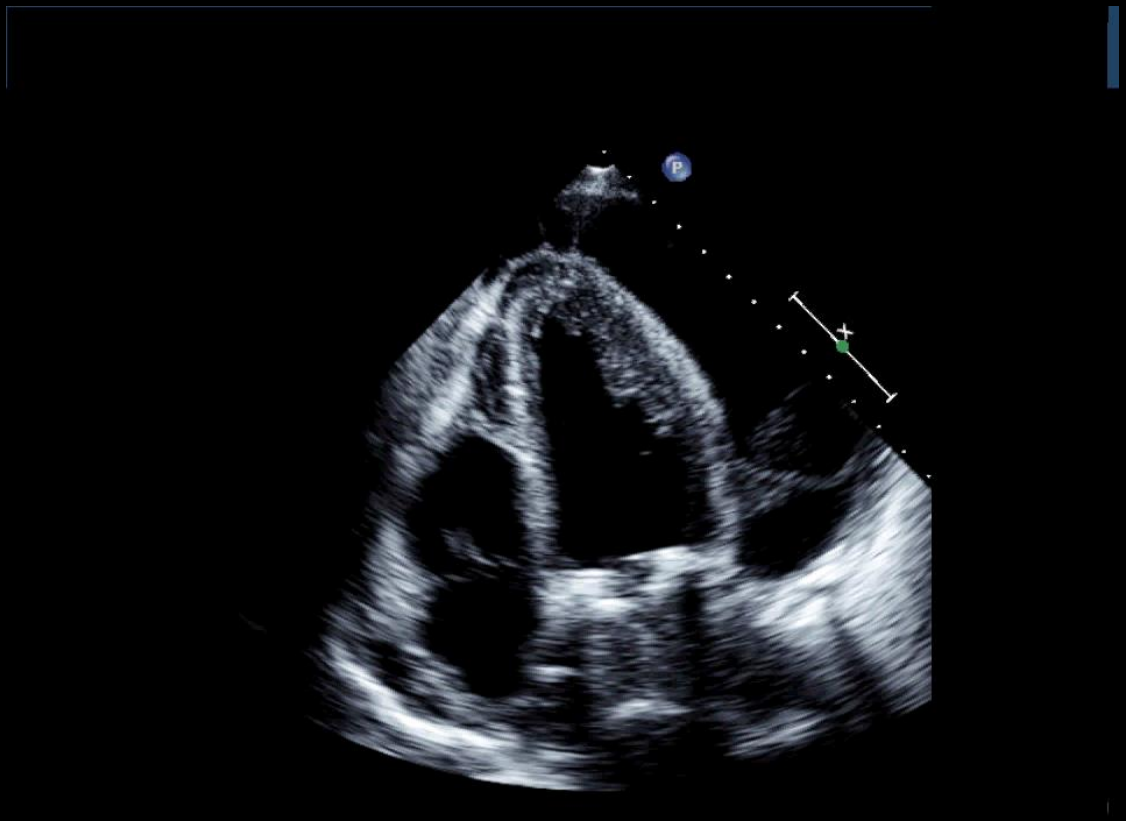
LV Diastolic Collapse

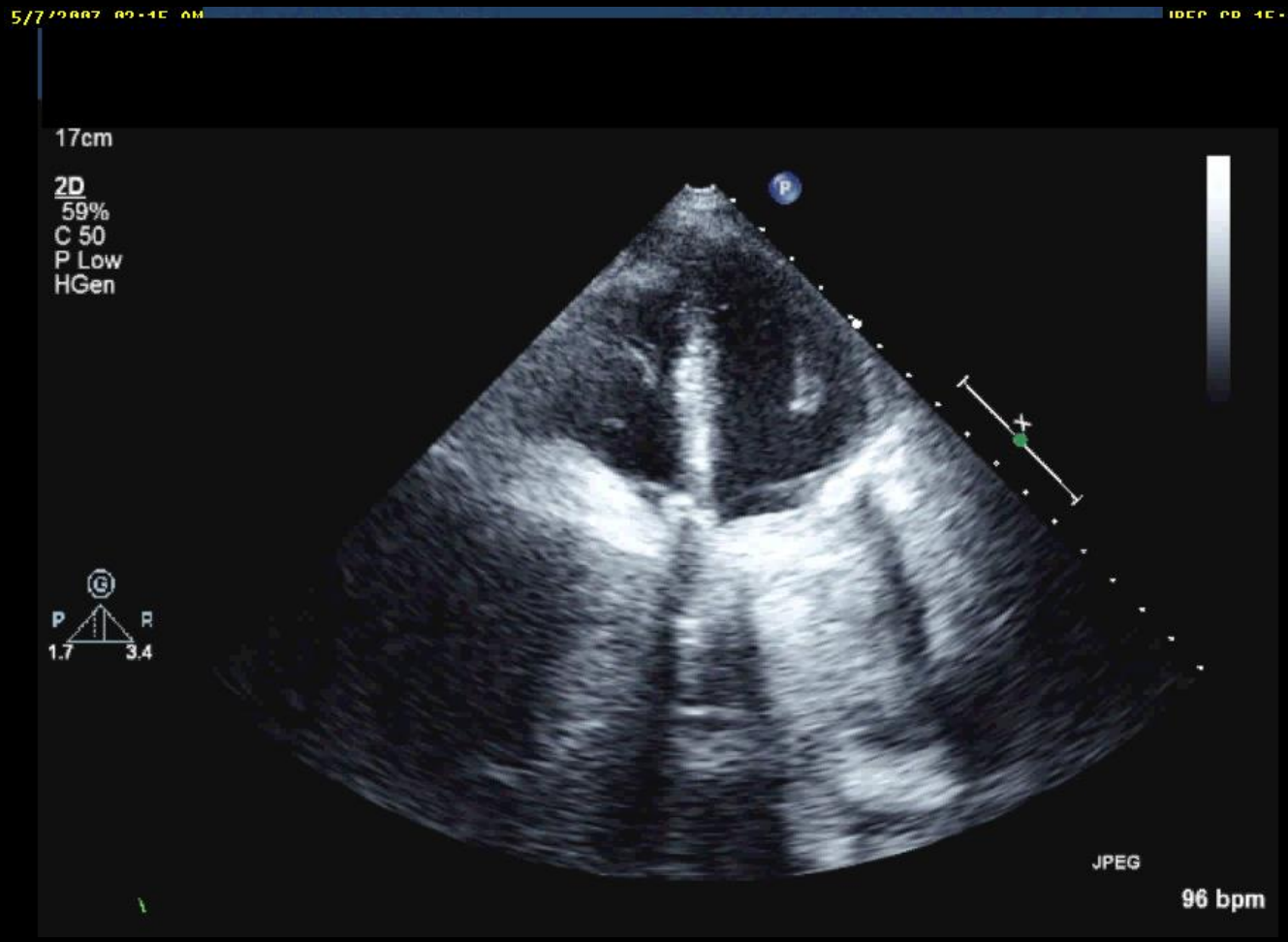
Case

Apical LVDC

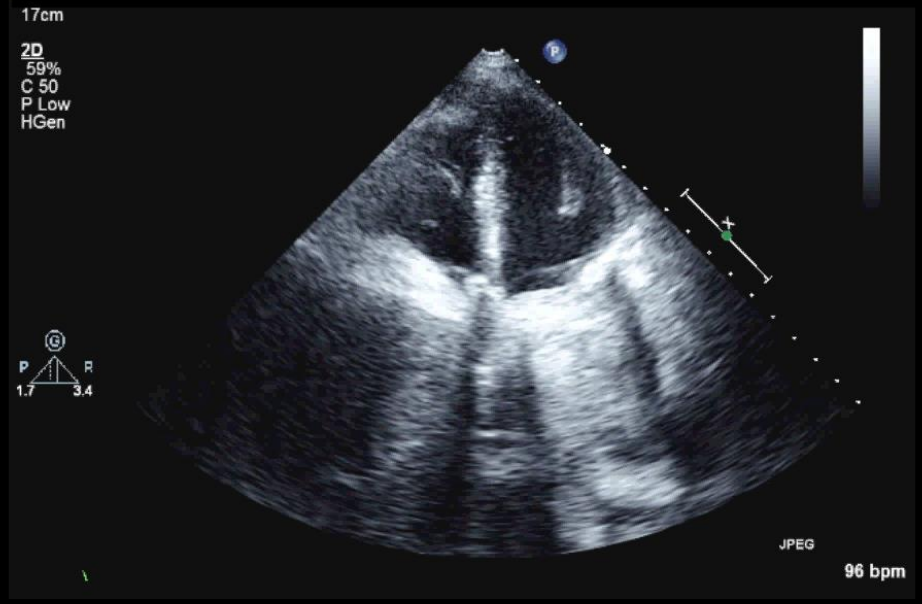
Case

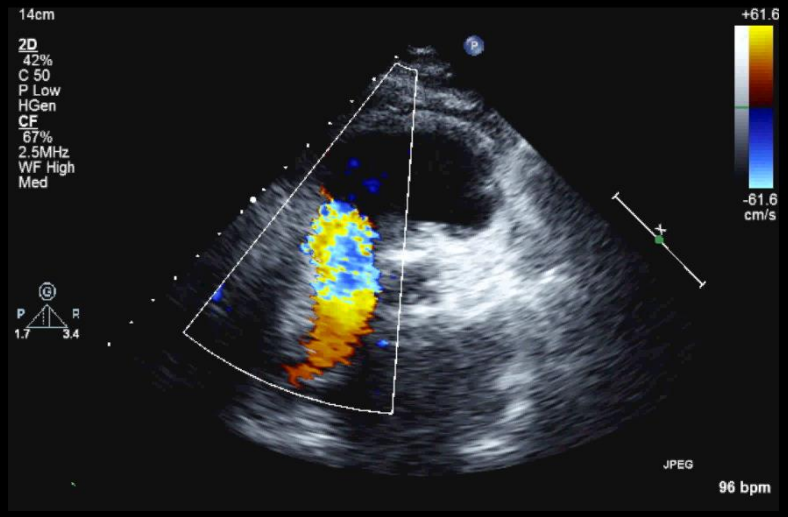
Lateral wall LVDC

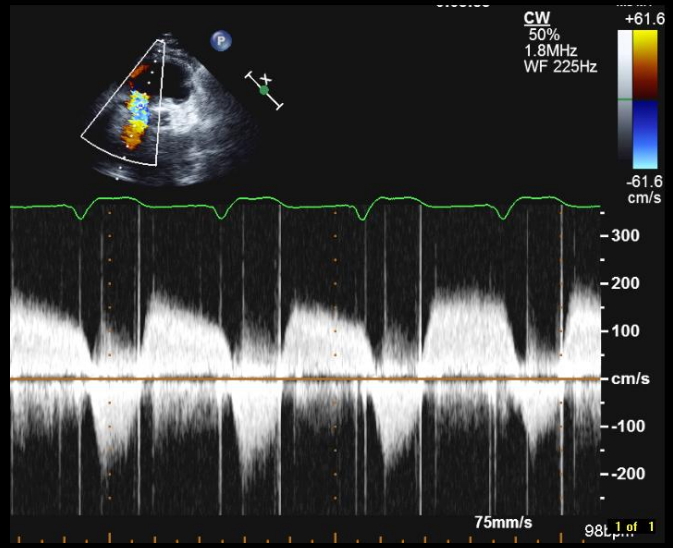




A post-op pt


17cm
2D
59%
C 50
P Low
HGen
P
R
1.7
3.4
JPEG
96 bpm


14cm
2D
42%
C 50
P Low
HGen
CF
67%
2.5MHz
WF High
Med
+61.6
-61.6
cm/s
P
R
1.7
3.4
JPEG
96 bpm


CW
50%
1.8MHz
WF 225Hz
+61.6
-61.6
cm/s
300
200
100
cm/s
-100
-200
75mm/s
1 of 1

Regional Tamponade

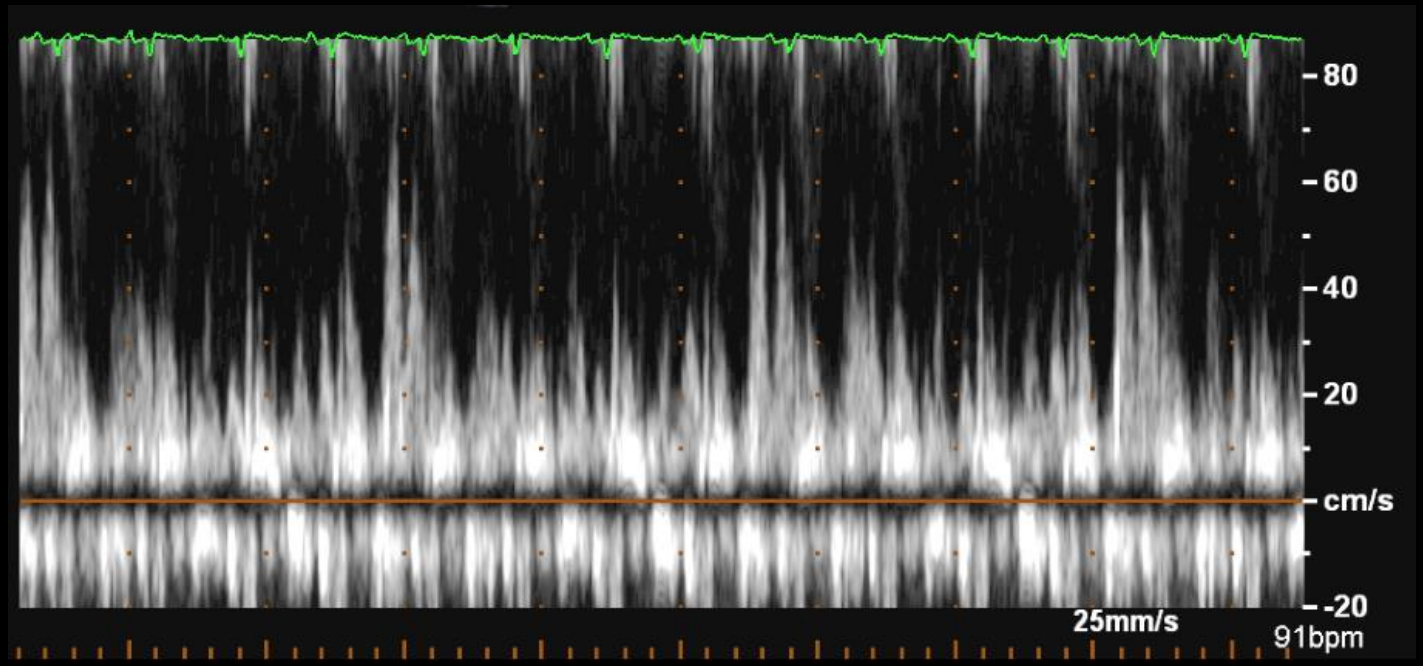
- Clinical signs not reliable
- Right sided signs may be absent
- Look for
  - LA collapse
  - LV diastolic collapse
  - Flow velocity changes

Case

1. Hematoma
2. Fat pad
3. Pus
4. Malignant mass

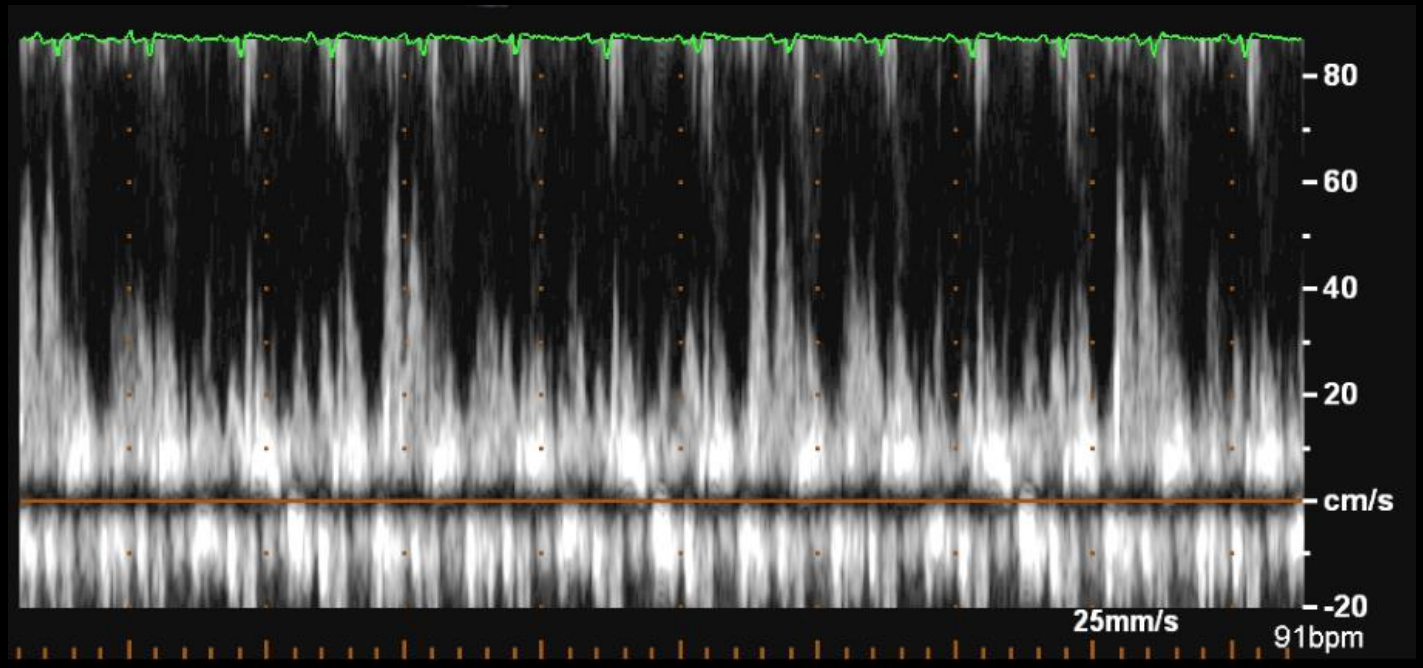
Patient with Dyspnea

Tricuspid Flow



Patient with Dyspnea

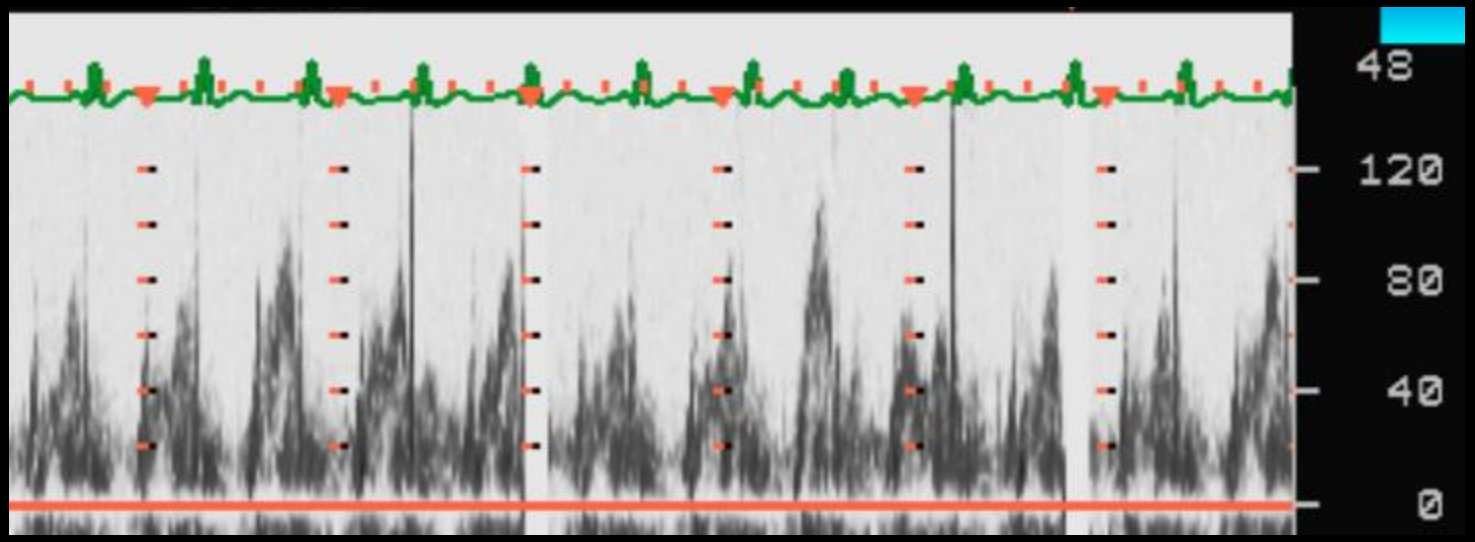
Tricuspid Flow



COPD

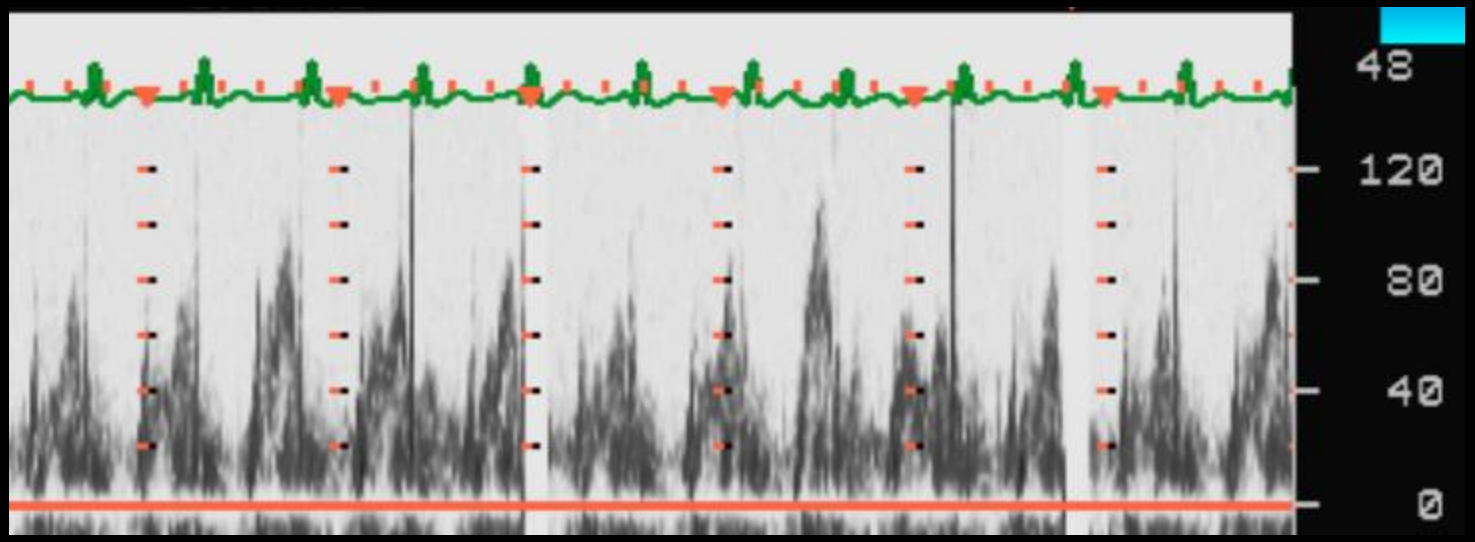
Asymptomatic Subject

Mitral Flow



Asymptomatic Subject

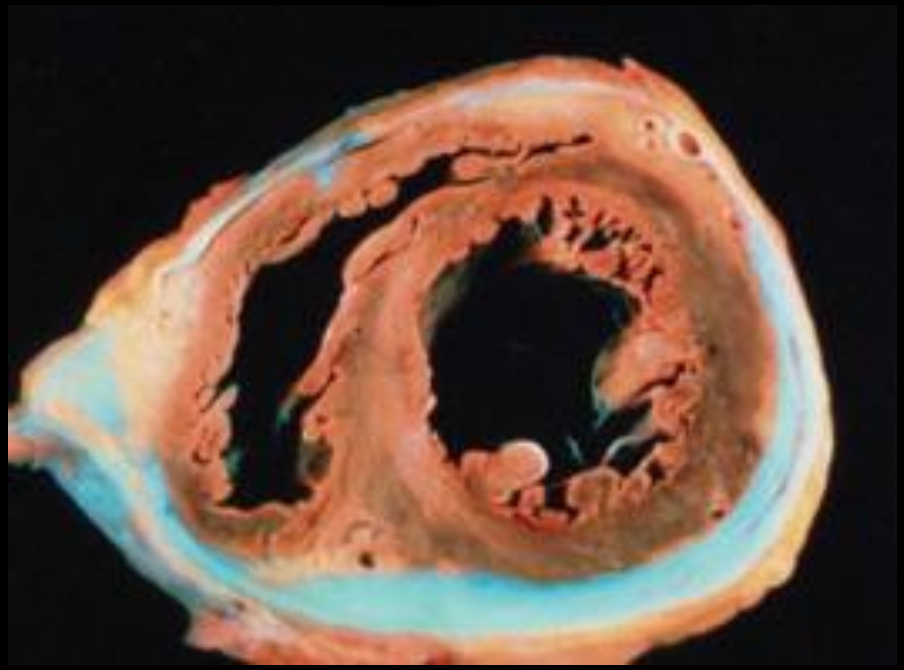
Mitral Flow

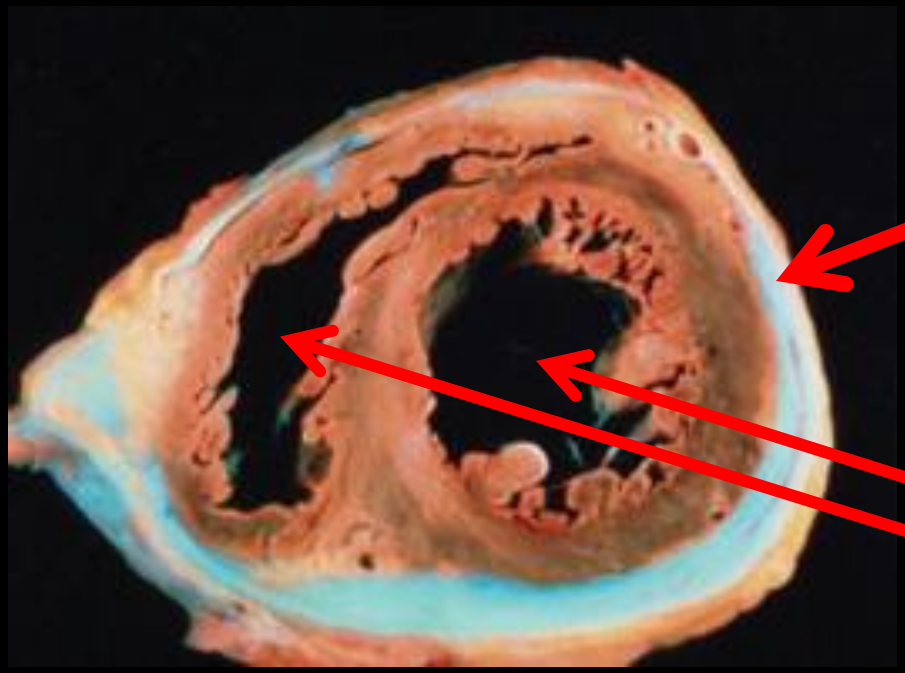


Deep Breathing

Constrictive Pericarditis

Constrictive Pericarditis

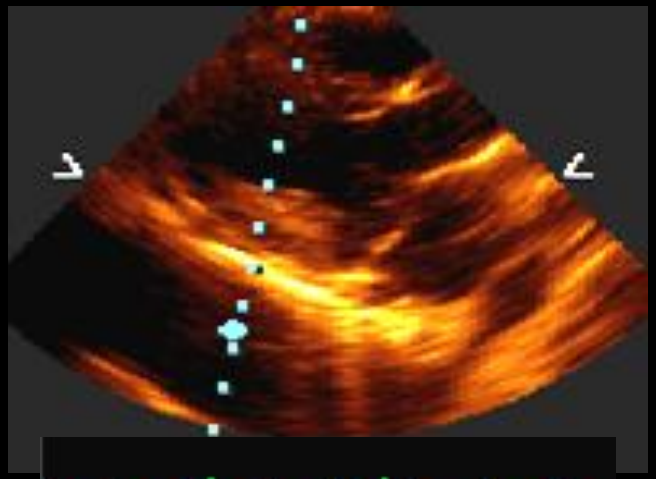


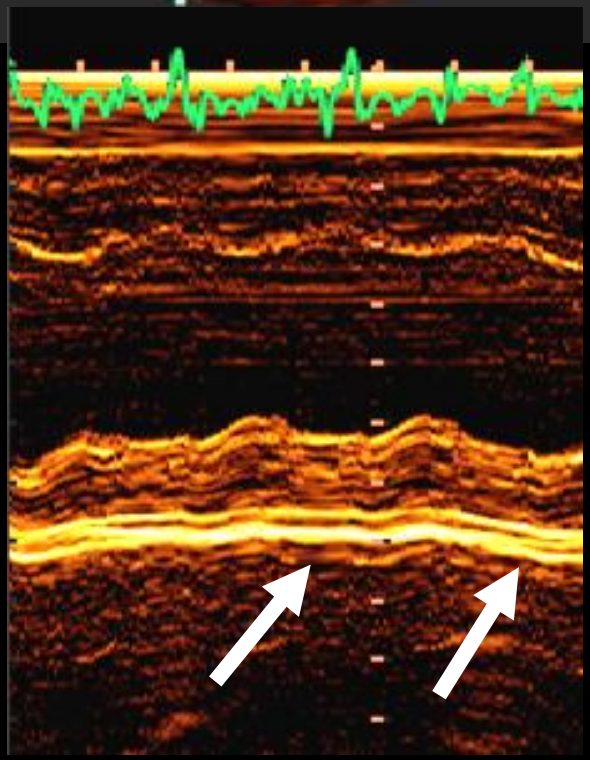


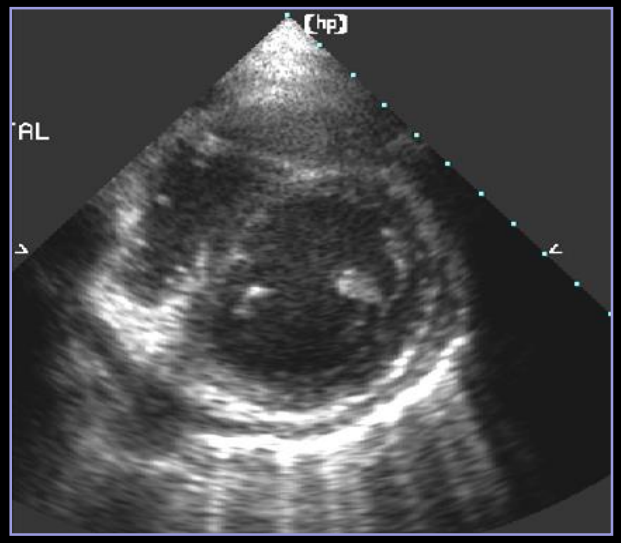
Thick Pericardium

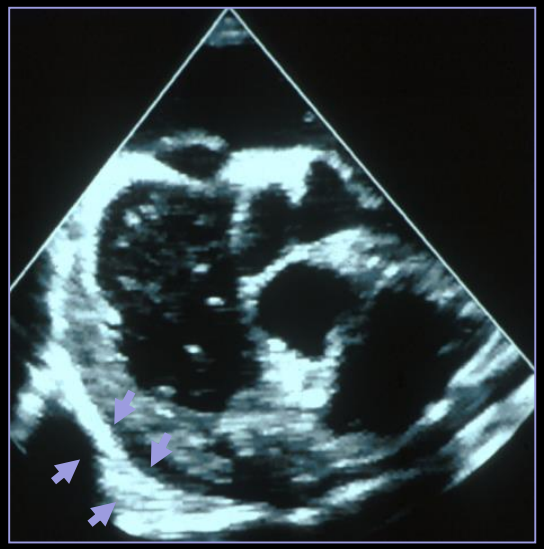
Filling Dysfunction

Pericardial Thickness



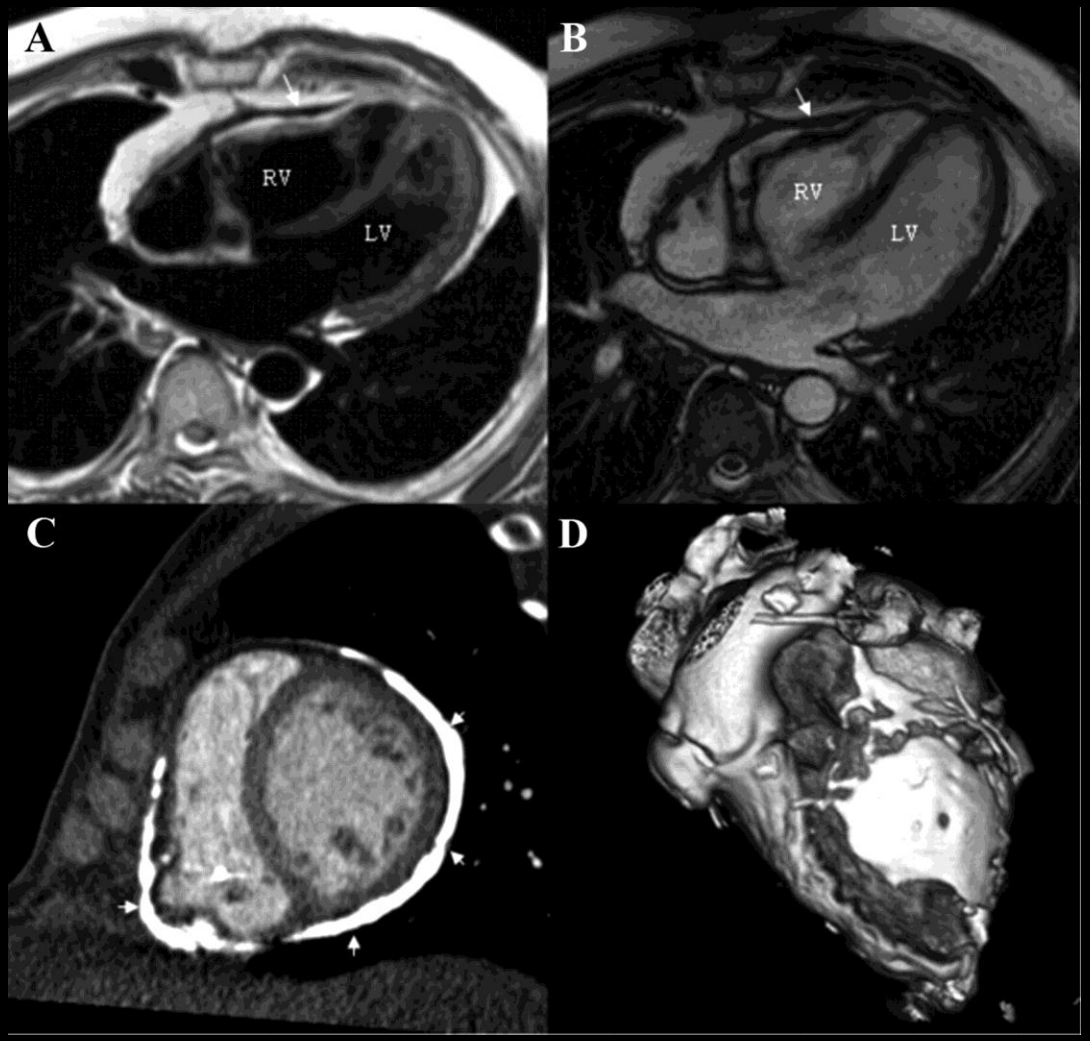






CMR

CT



Verhaert D et al. *Circ Cardiovasc Imaging*. 2010;3:333-343

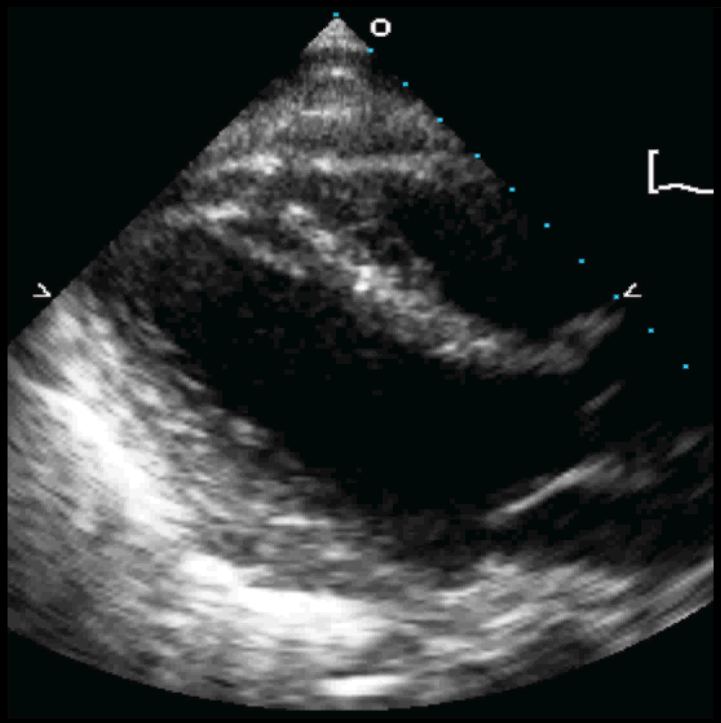
Const Pericarditis: 2DE & M-mode

- Dense rigid pericardial shell
- Normal sized LV and RV
- Septal bounce, notch
- Rapid LV expansion with abrupt halt
- Premature pul valve opening
- IVC dilation and plethora
- Atria normal or mildly enlarged

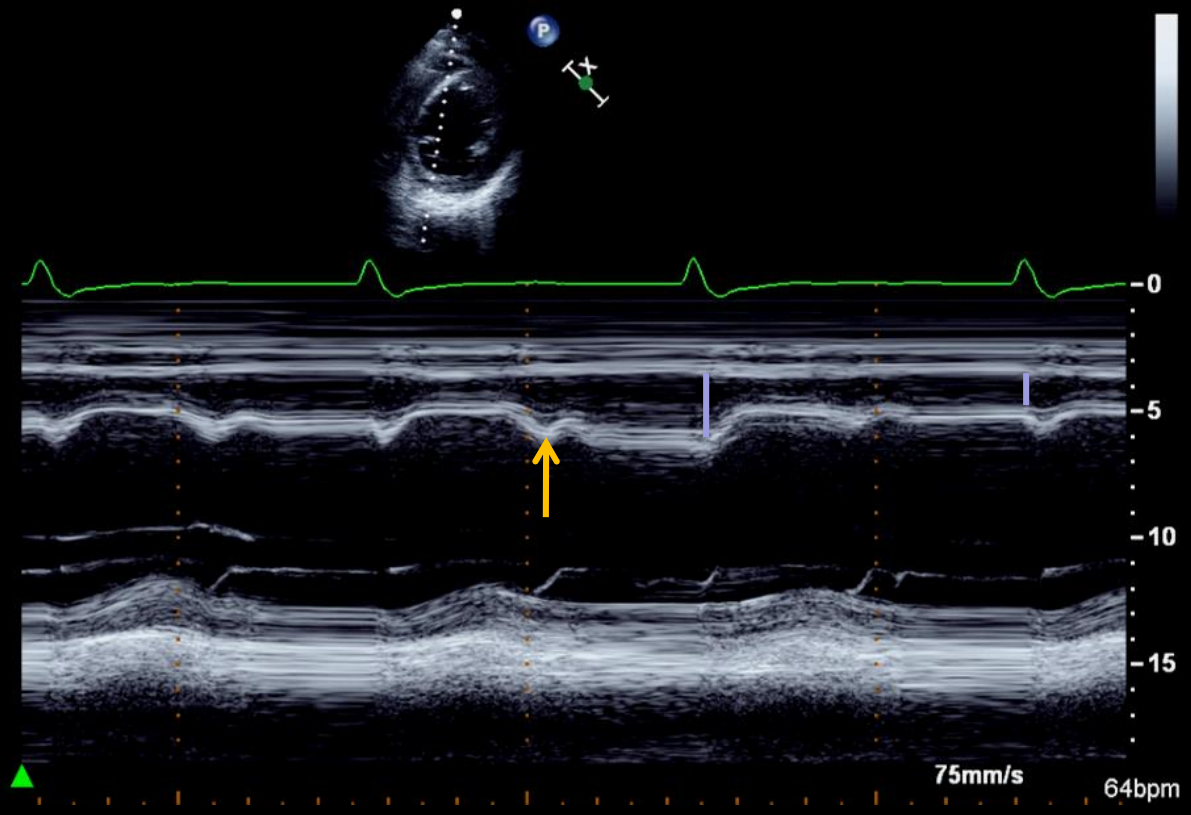
Filling Dysfunction

- Elevated filling pressures
- Ventricular interdependance
- Dissociation between intrathoracic and intracard prs

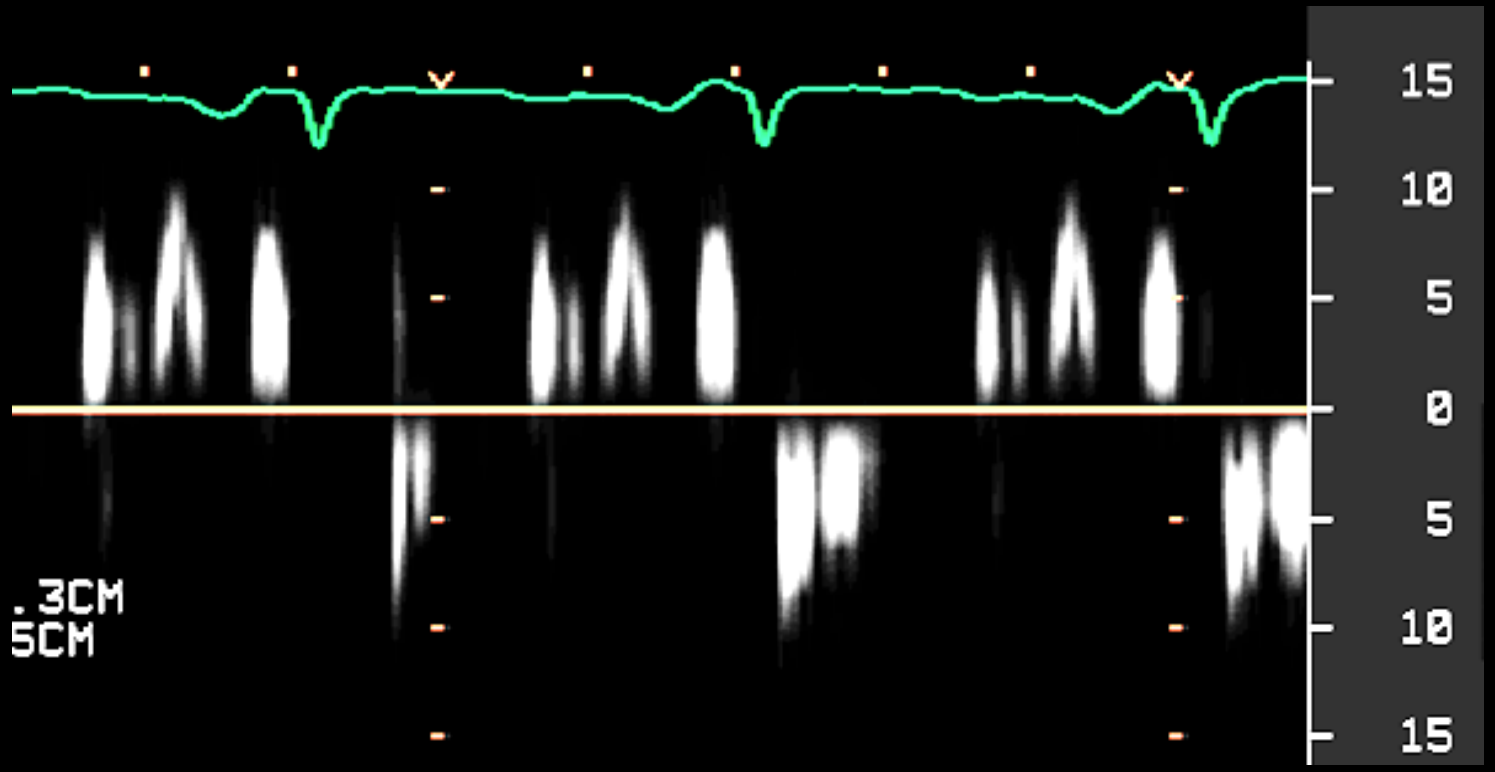
Septal bounce

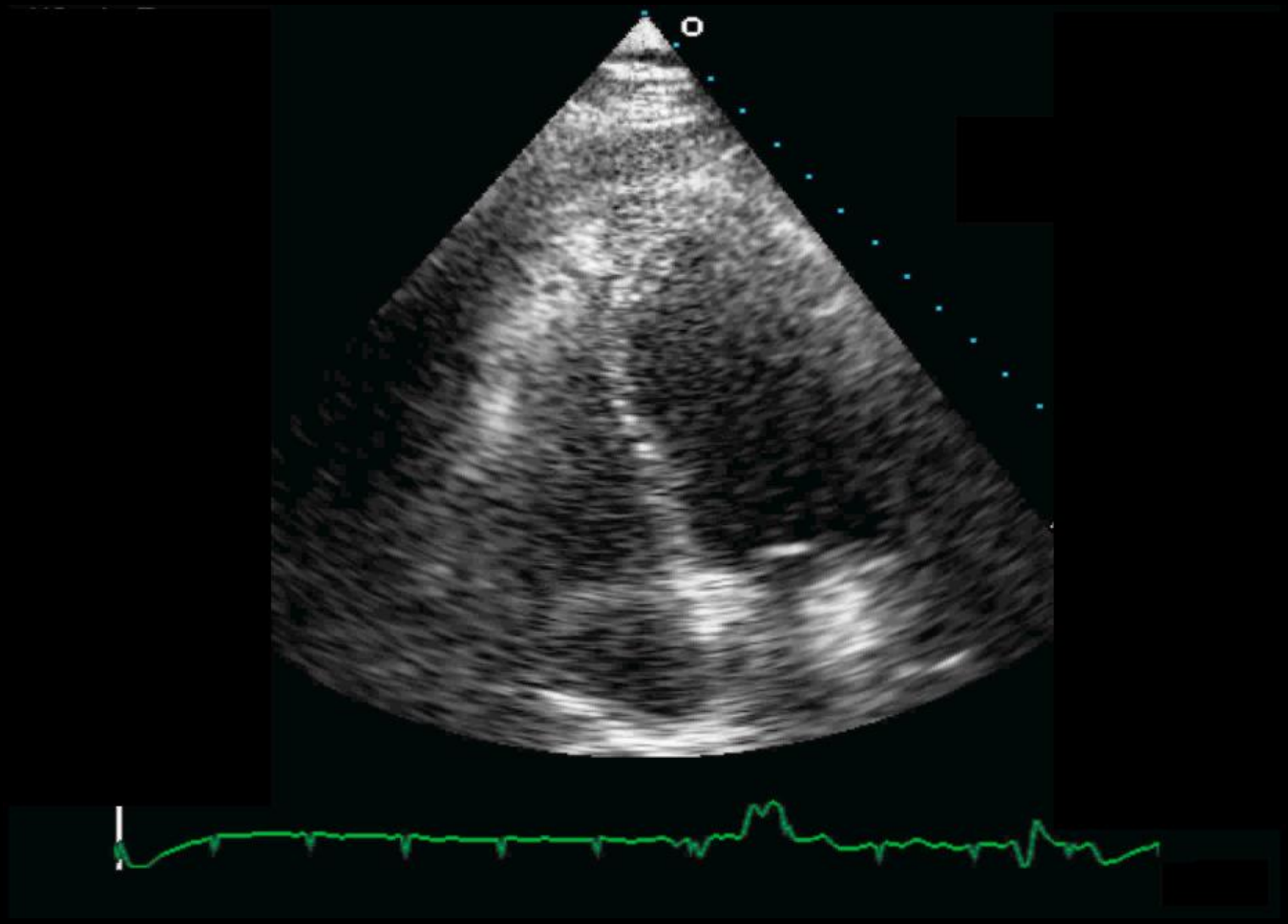


Septal Bounce, Diastolic notch

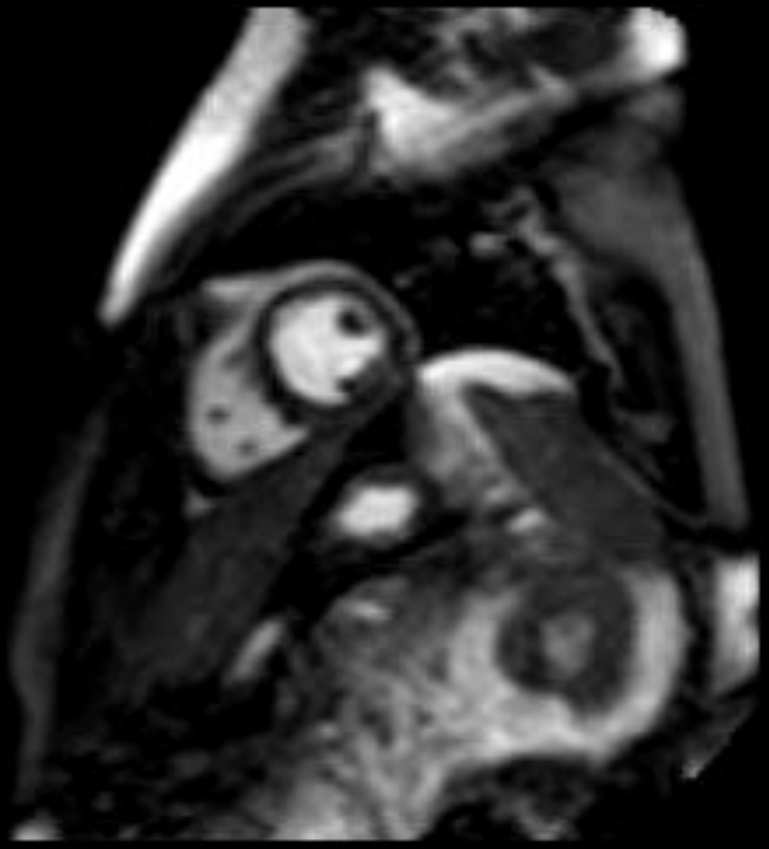


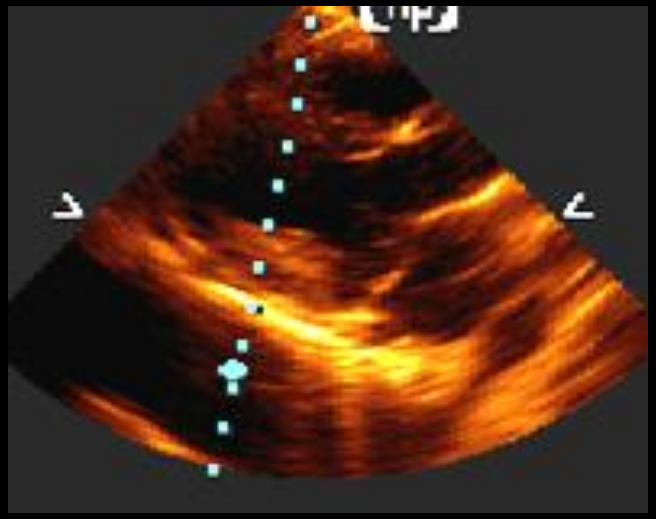
TVI: septal dynamics

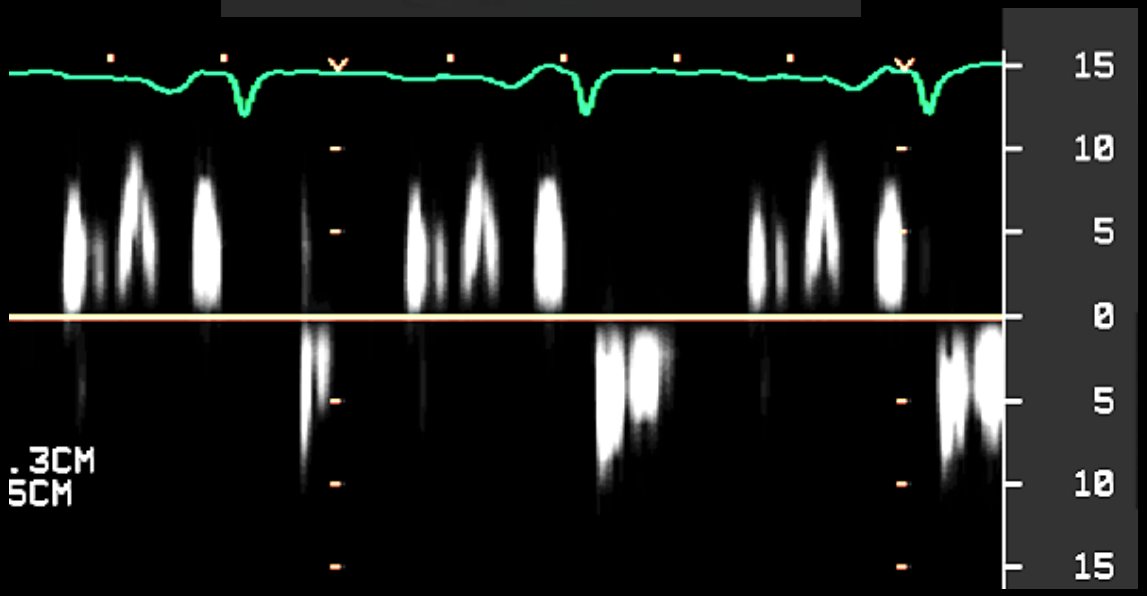




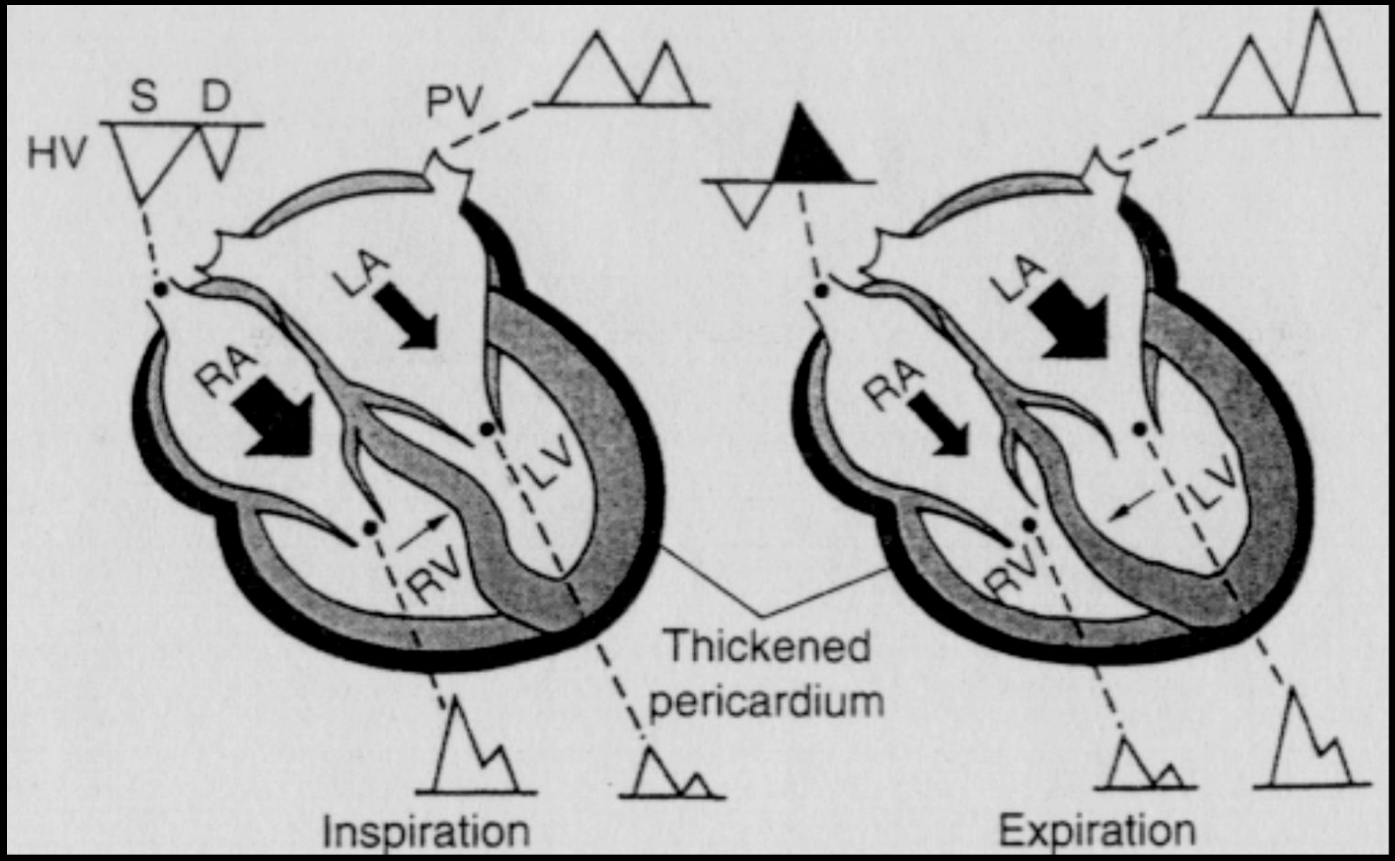
Septal bounce



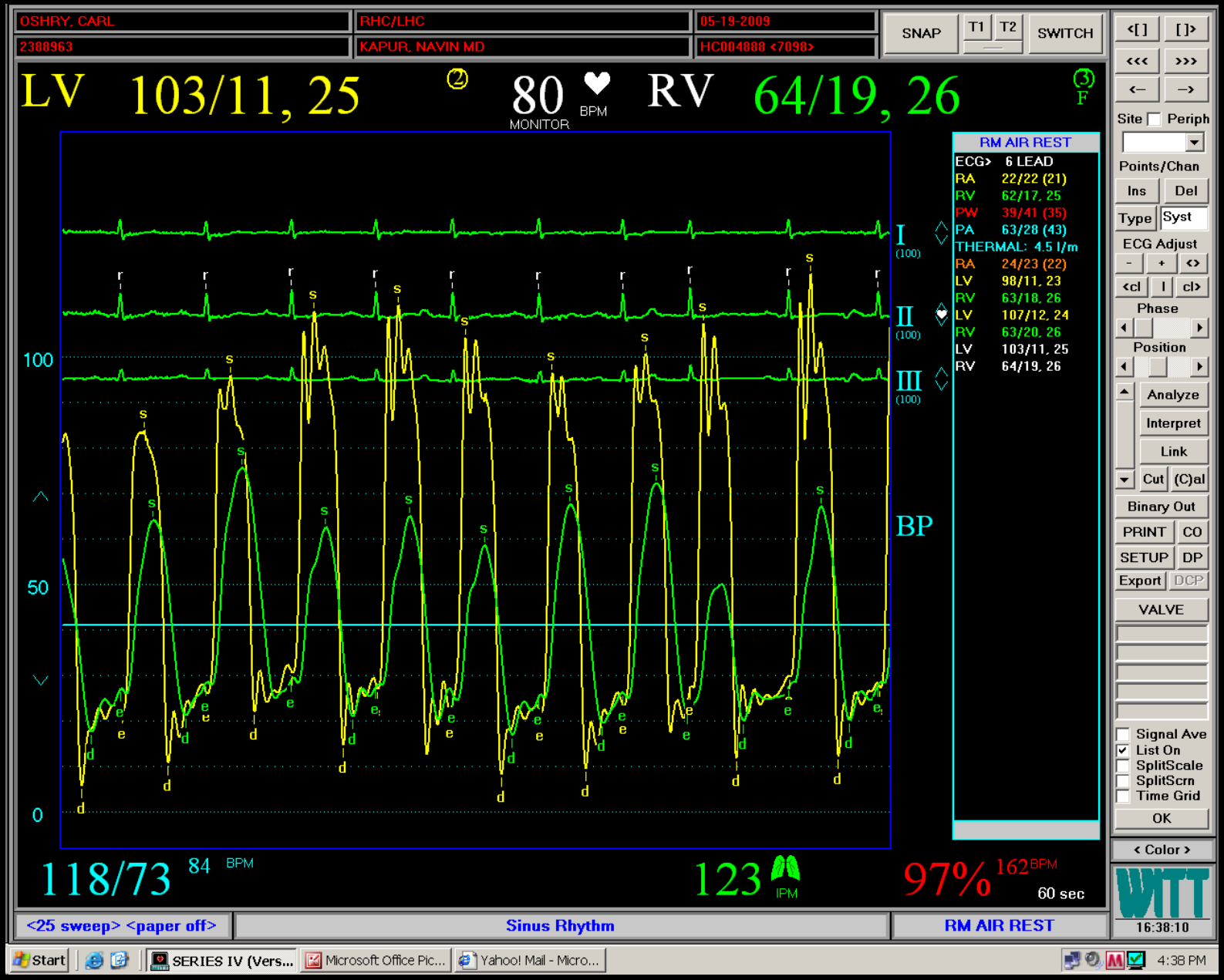



15
10
5
0
5
10
15
.3CM
5CM

Respiratory Flow Variation



Mayo Publications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RHC/LHC
05-19-2009
2388963
KAPUR, NAVIN MD
HC004888 <7098>
SNAP
T1
T2
SWITCH
LV 103/11, 25
80 BPM
MONITOR
RV 64/19, 26
RM AIR REST
ECG> 6 LEAD
RA 22/22 (21)
RV 62/17, 25
PW 39/41 (35)
PA 63/28 (43)
THERMAL: 4.5 l/m
RA 24/23 (22)
LV 98/11, 23
RV 63/18, 26
LV 107/12, 24
RV 63/20, 26
LV 103/11, 25
RV 64/19, 26
I (100)
II (100)
III (100)
BP
100
50
0
118/73 84 BPM
123 IPM
97% 162 BPM
60 sec
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Sinus Rhythm
RM AIR REST
Site
Periph
Points/Chan
Ins
Del
Type
Syst
ECG Adjust
Phase
Position
Analyze
Interpret
Link
Cut
(C)al
Binary Out
PRINT
CO
SETUP
DP
Export
DCP
VALVE
Signal Ave
List On
SplitScale
SplitScrn
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Start
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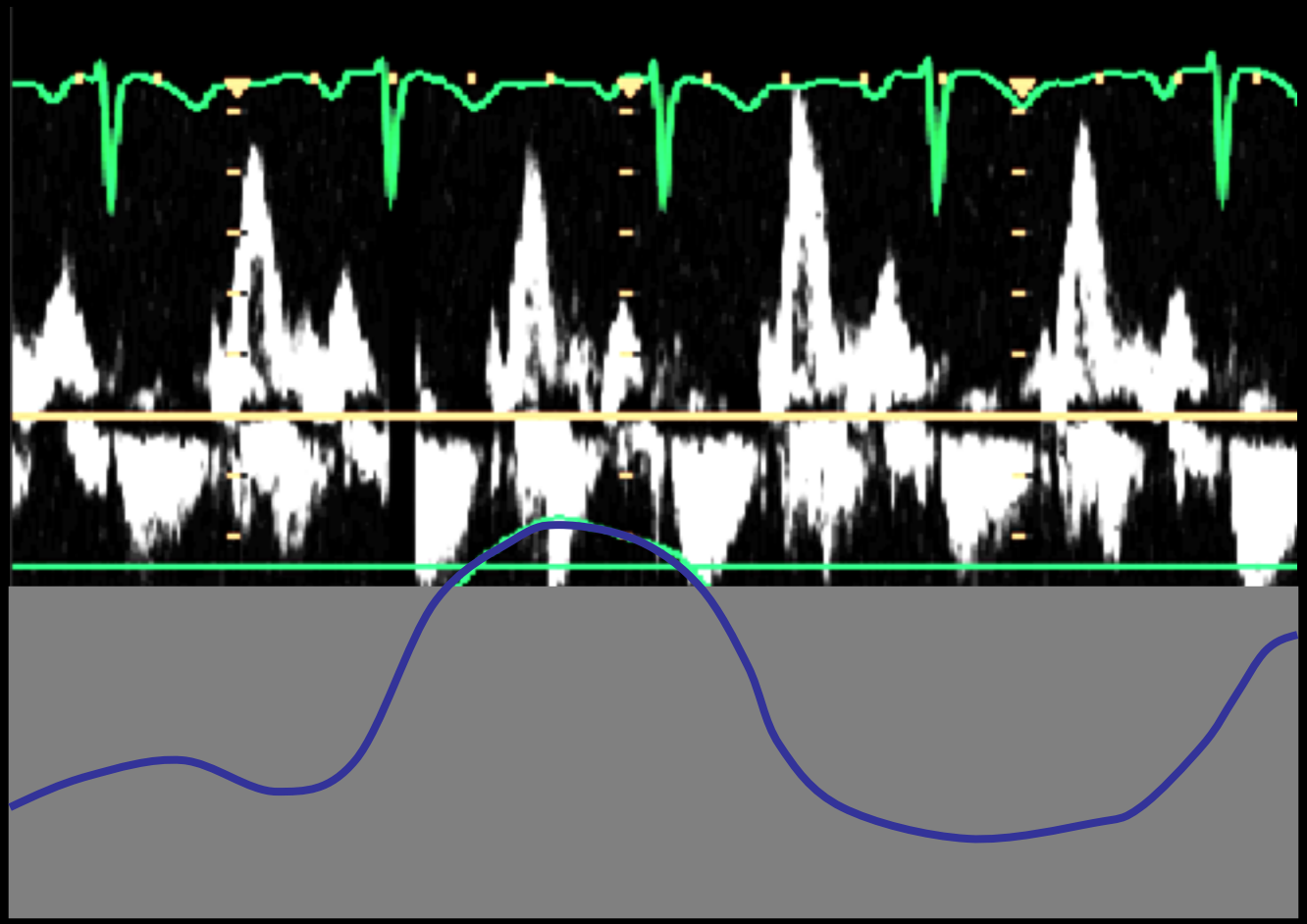
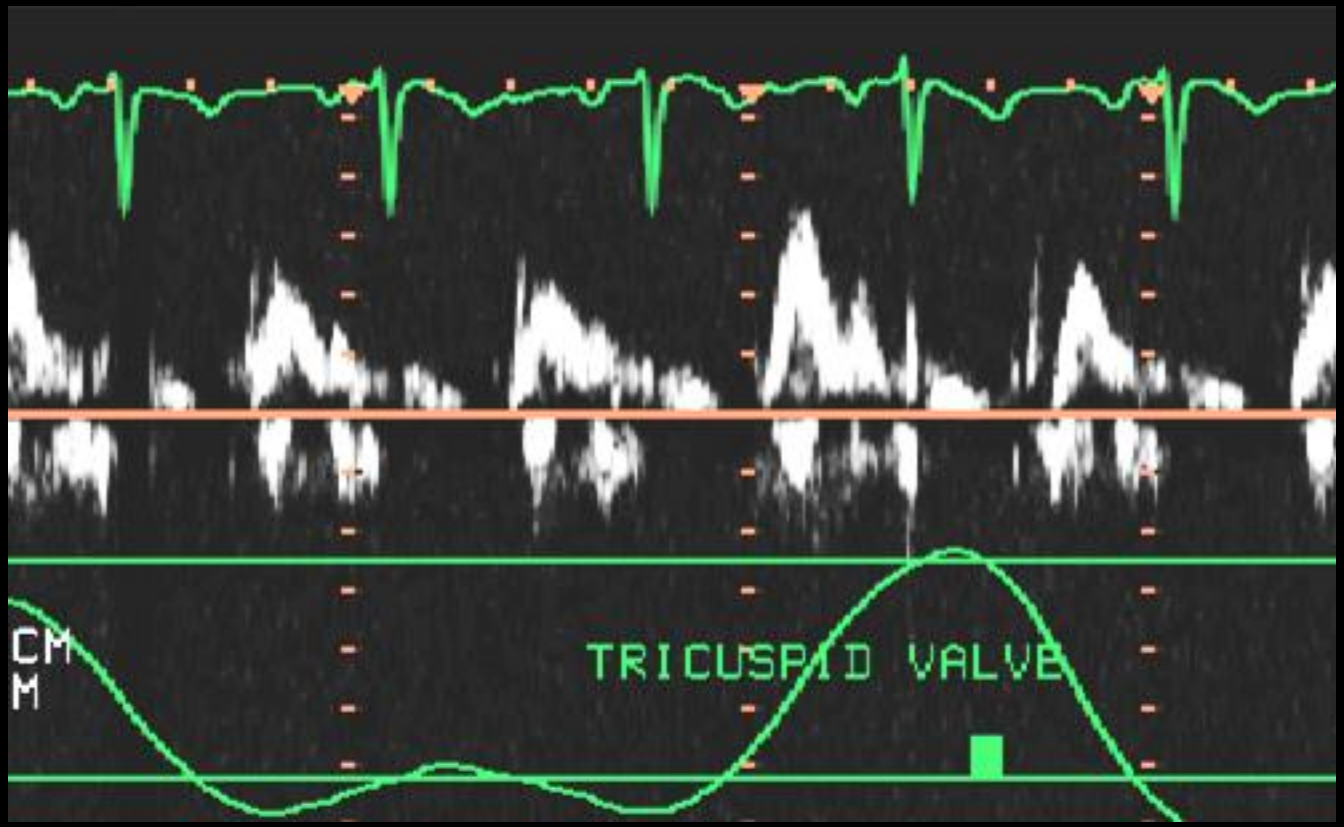
Microsoft Office Pic...
Yahoo! Mail - Micro...
4:38 PM

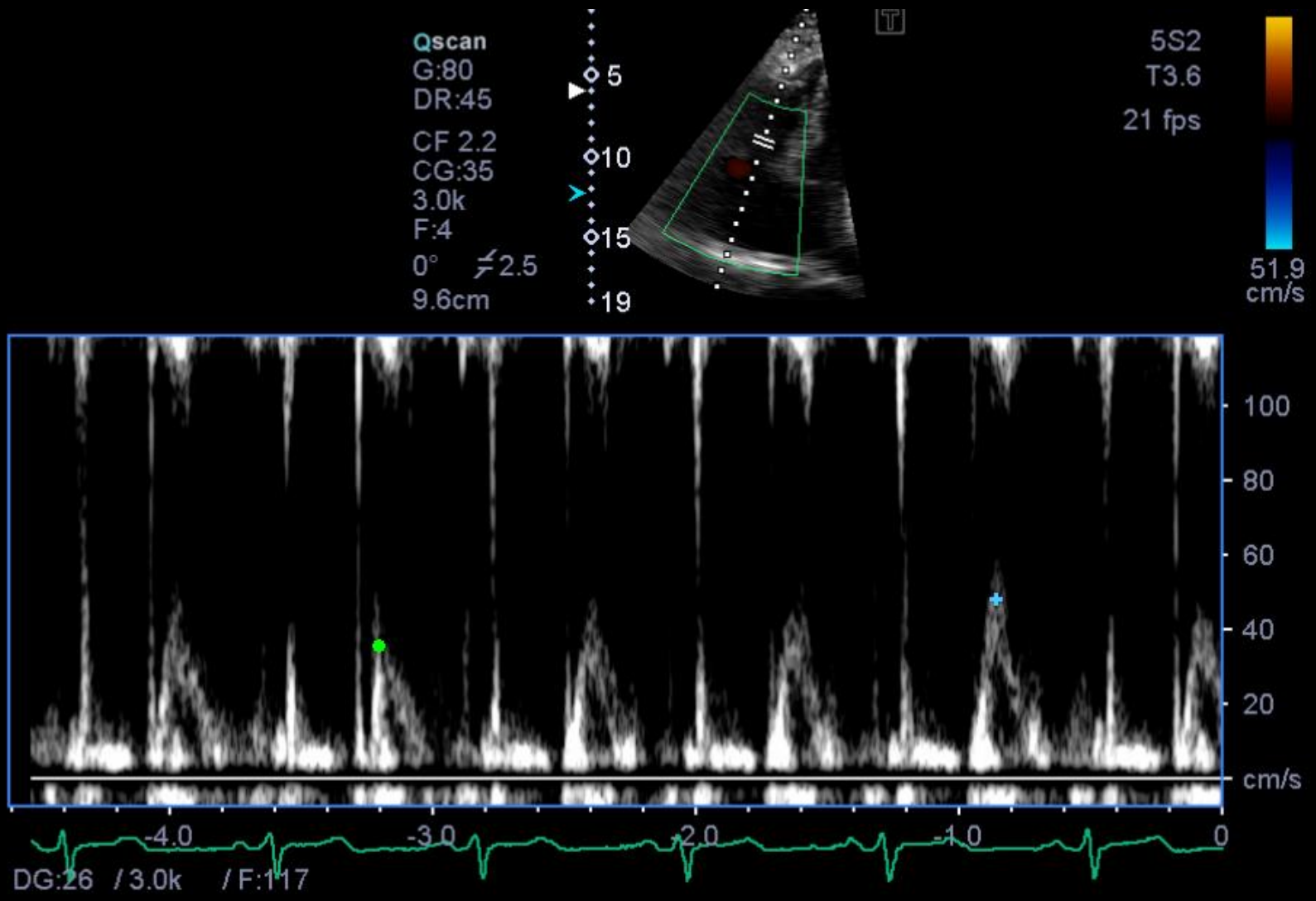
Mitral flow



Tricuspid flow

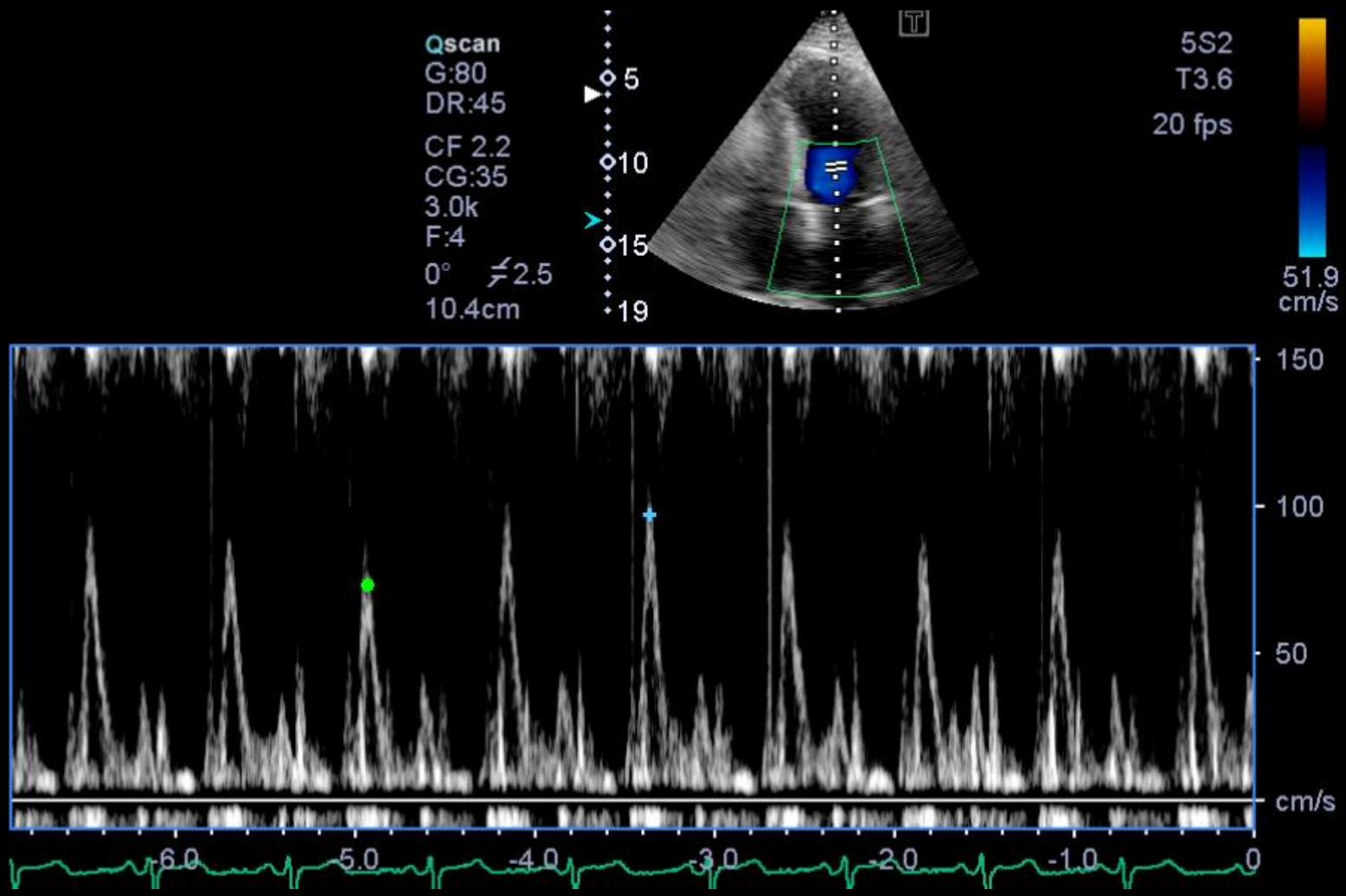


Tricuspid Flow Velocity



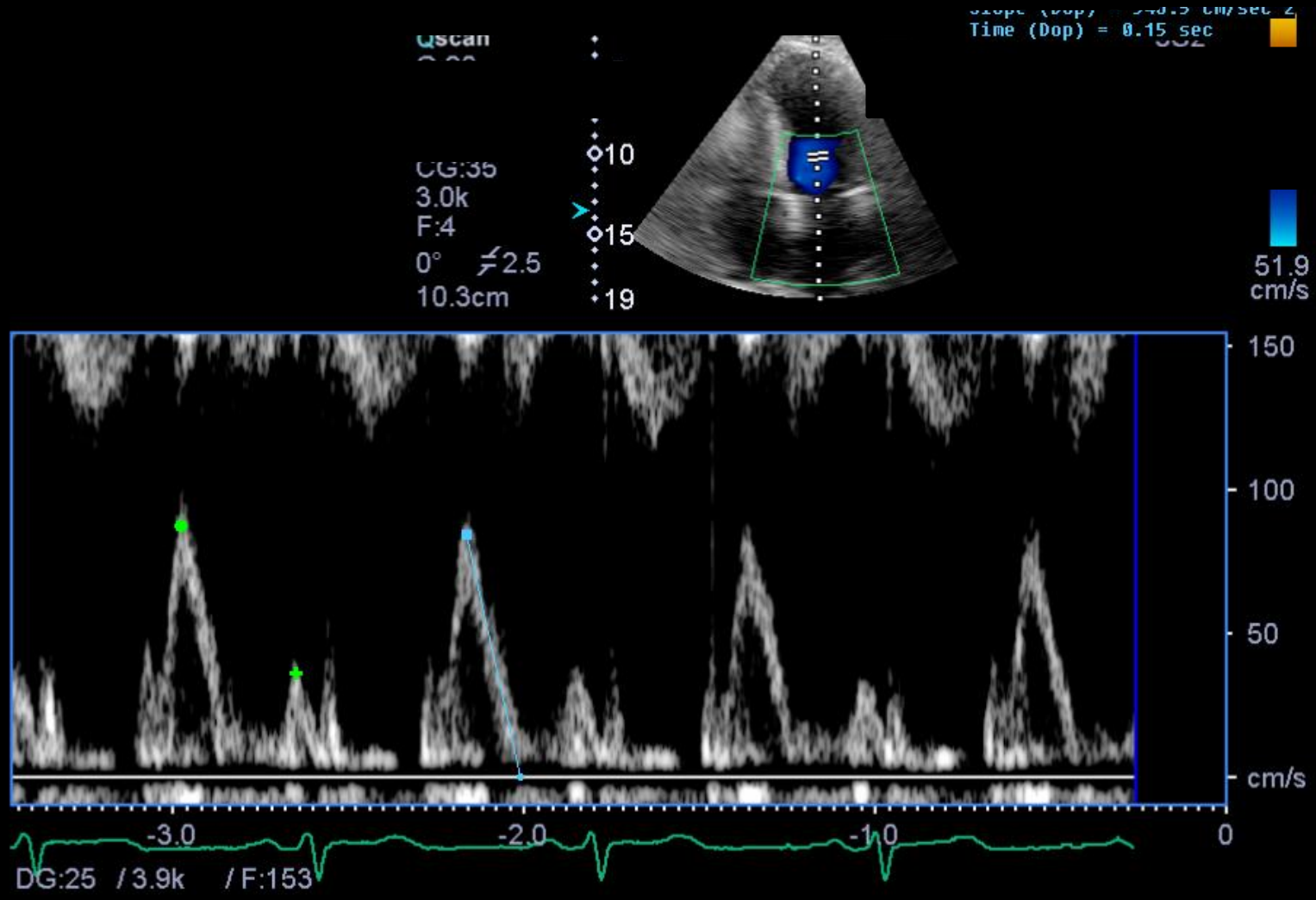
35% increase during inspiration

Mitral Flow Velocity



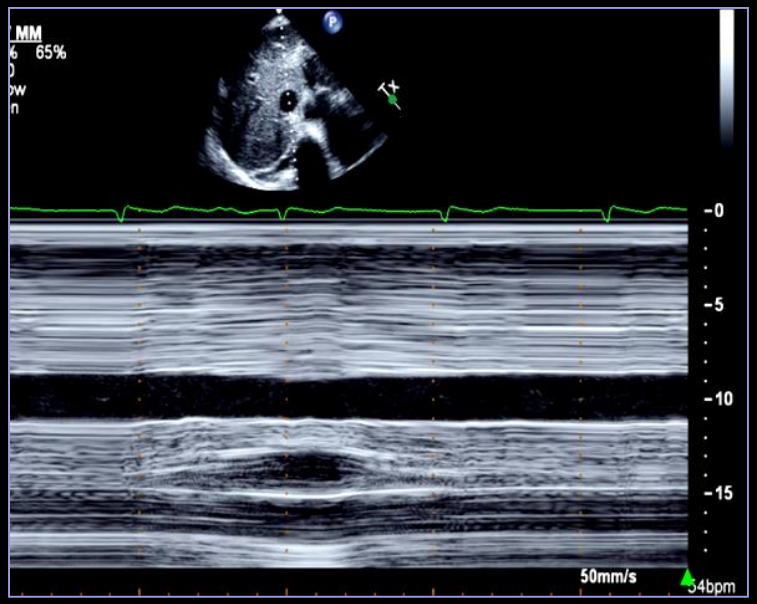
32% decrease during inspiration

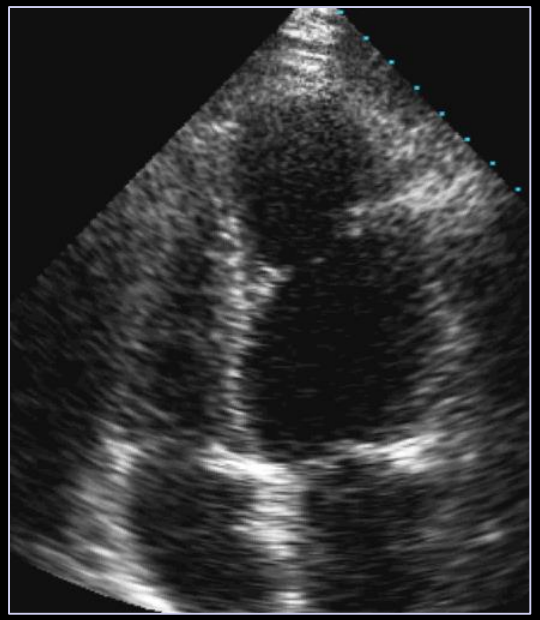
Mitral Flow Velocity

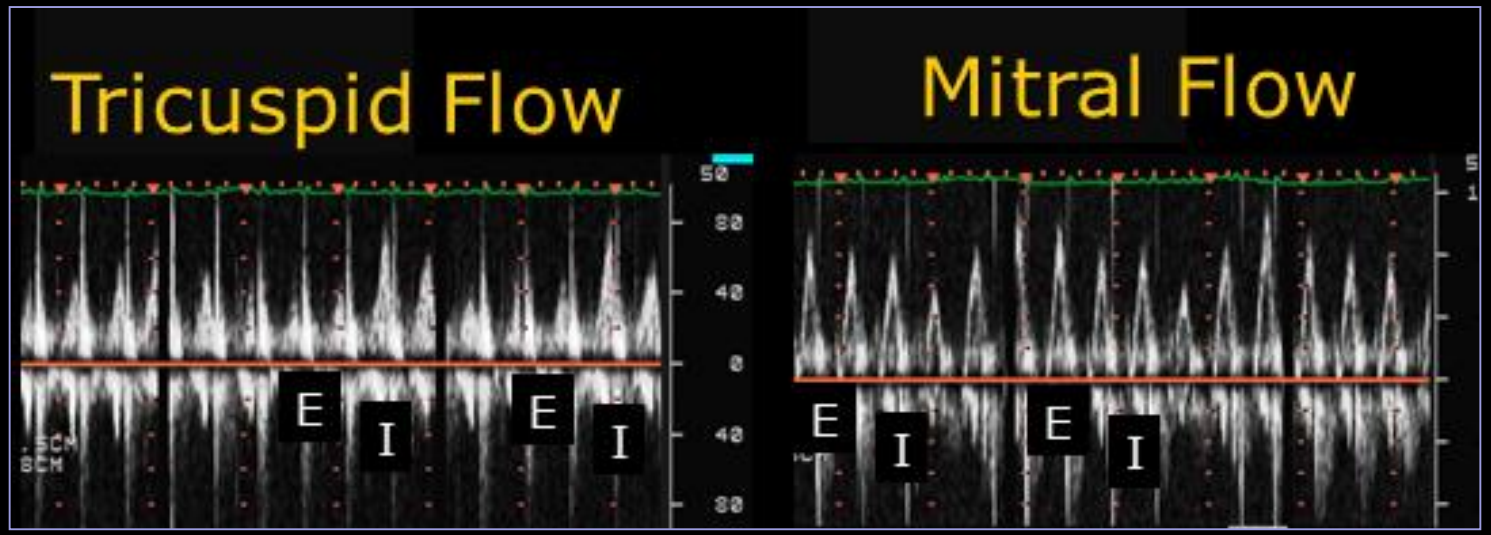


E/A ratio: 2.2 Decel Time: 150 msec

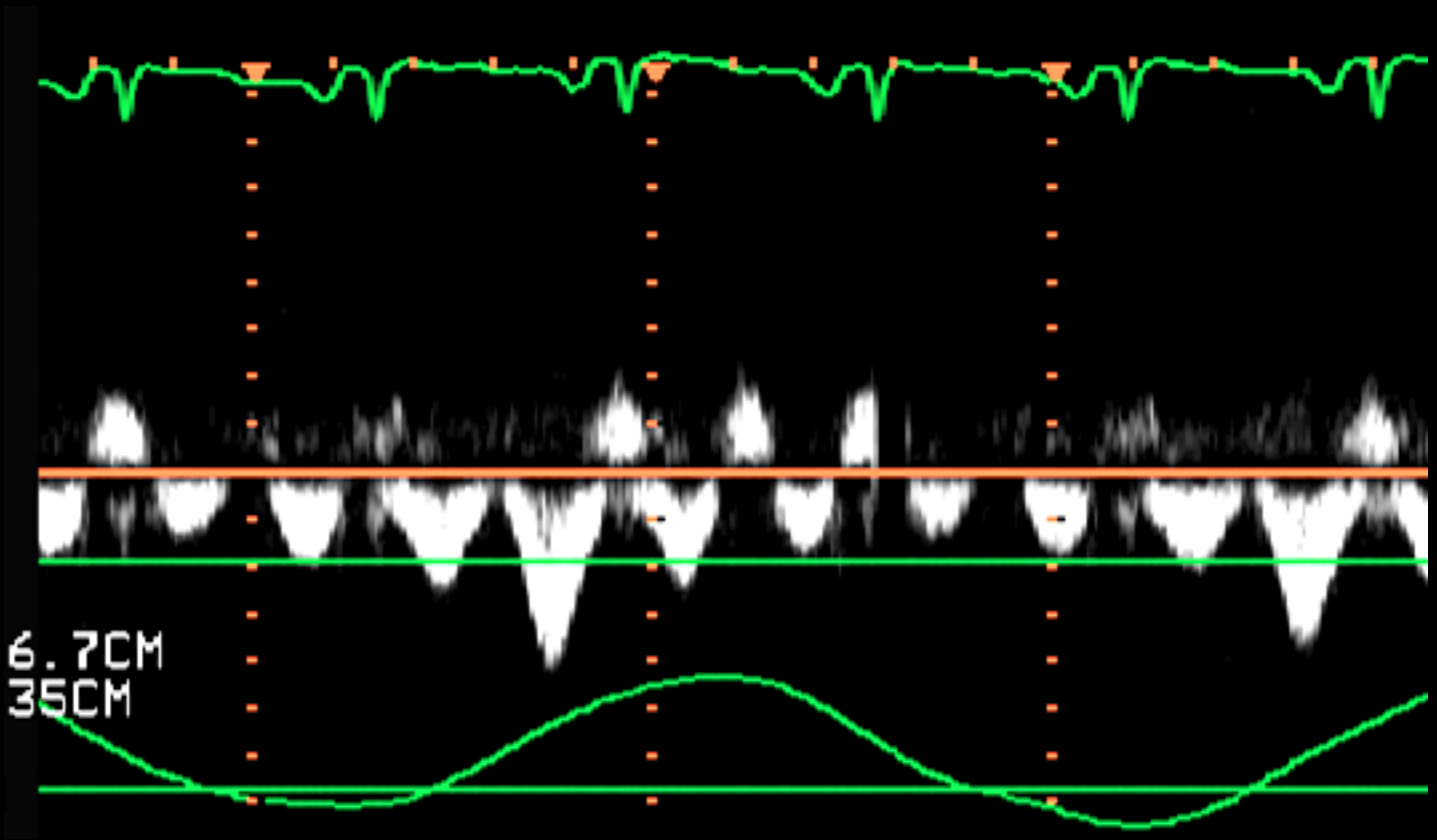
Filling Dysfunction

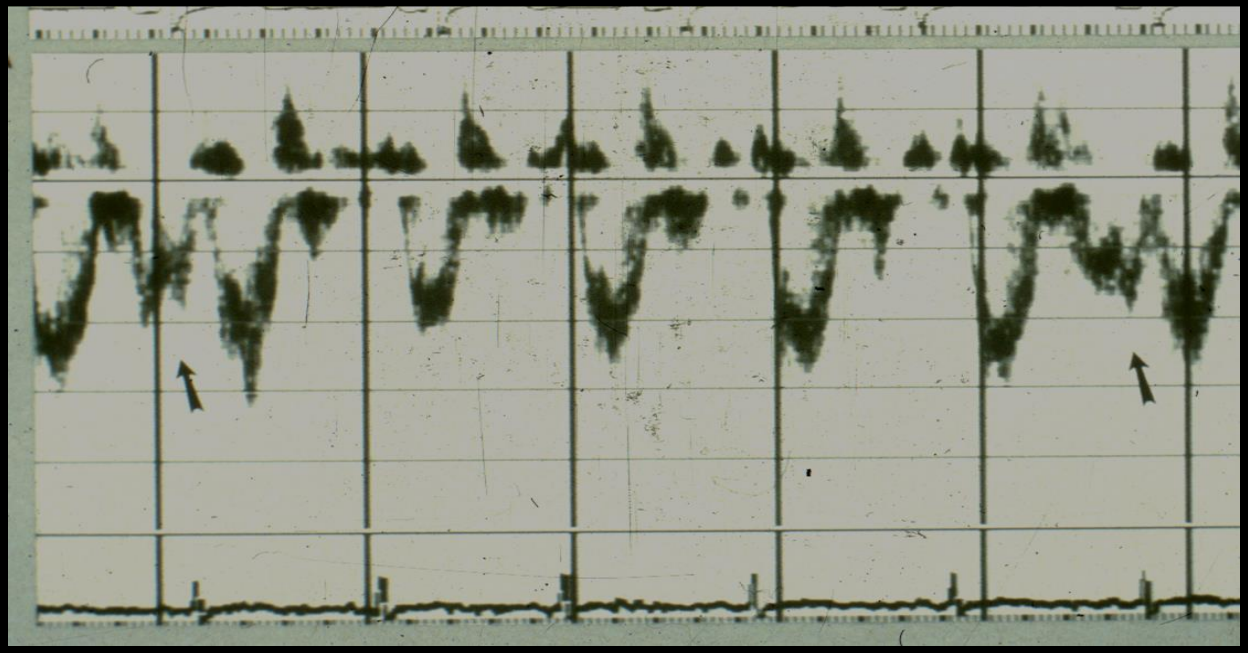


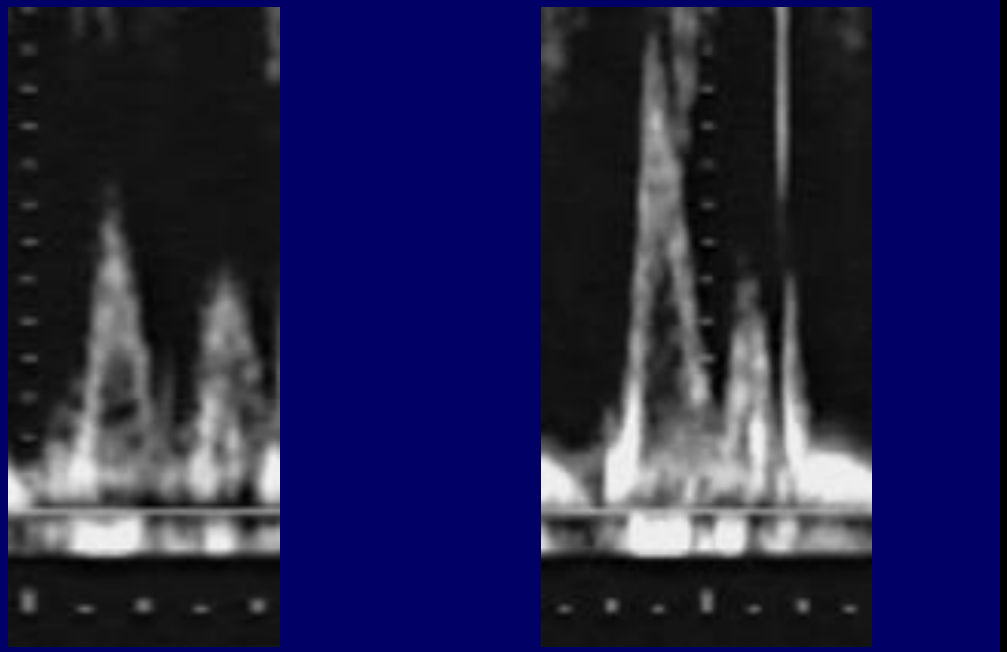




Hepatic vein flow

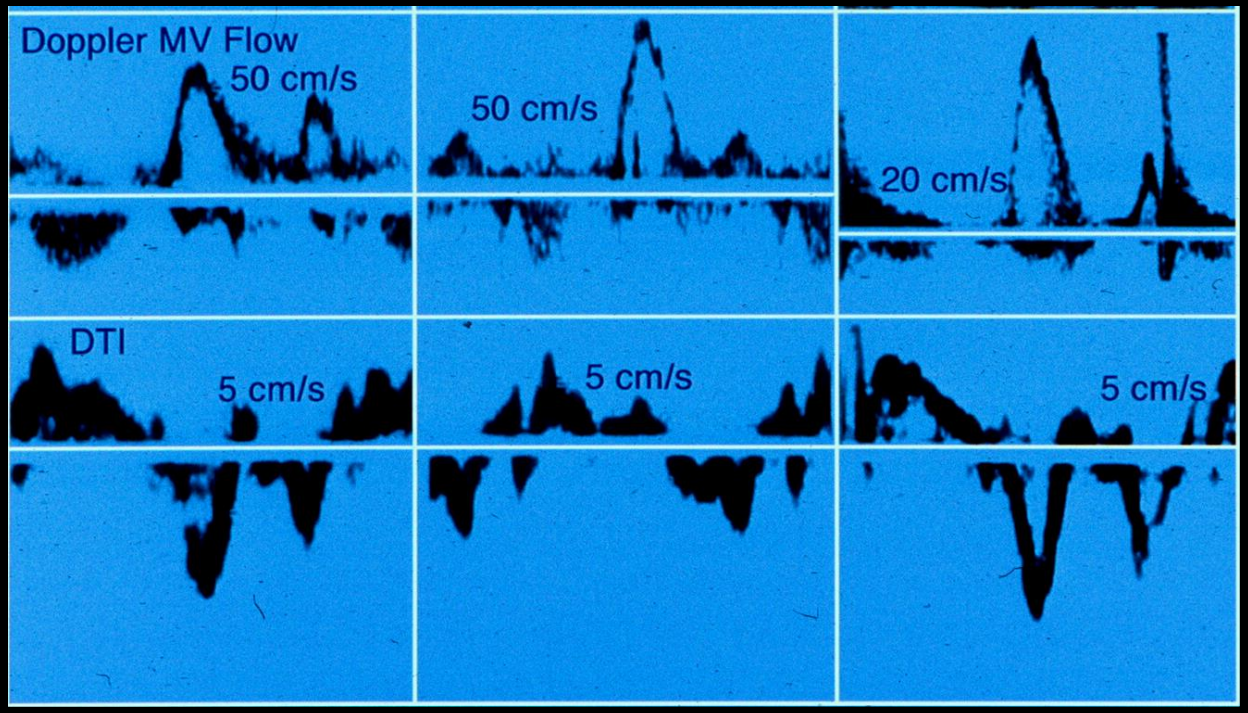






Normal Cons Pericarditis

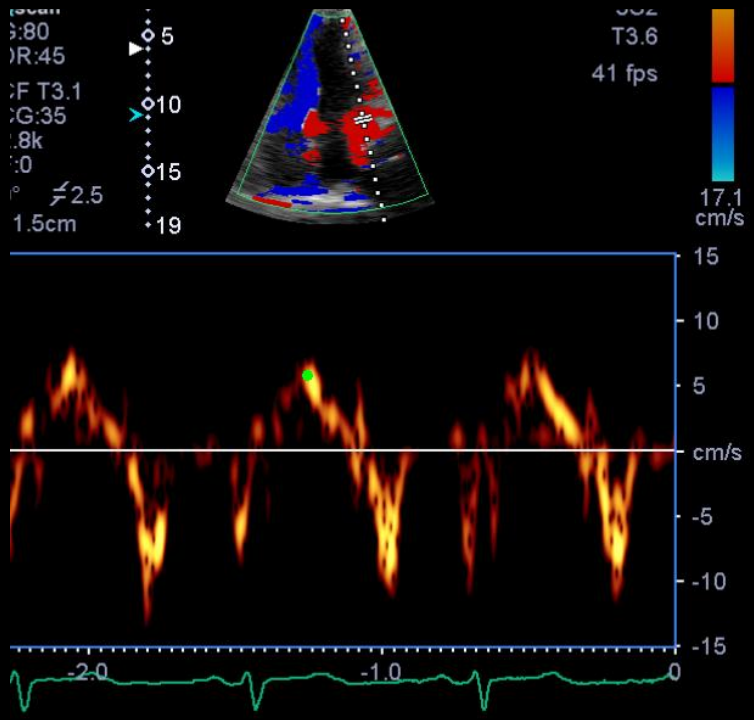
Normal Restr CMP Cons P



Garcia et al. JACC 1996

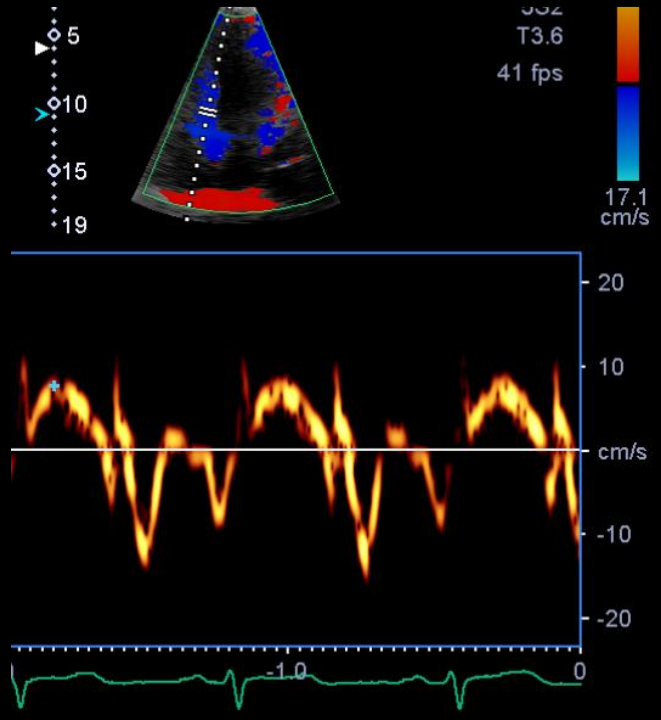
Tissue Doppler

Lateral Annulus



E/e’ 8

Septal



E/e’ 7

Systolic 7 cm/s

DIAGNOSTIC VALUE OF DOPPLER ECHOCARDIOGRAPHY

Study	Respiratory variations	n	Sn	Sp
Oh,Hatle et al.	>/- 25% in MV inflow velocity	28	88	67
Rajgopalan et al.	>/- 10% in MV inflow velocity	19	84	91
Klein et al.	PV systolic/diastolic flow ratio>/-65%	14	86	94
Rajgopalan et al.	PV peak diastolic flow velocity>/- 18%	19	79	91
Von Bibra et al.	Hepatic veins ‘W’ wavepattern	13	68	100

Dal-Bianco&Sengupta,JASE.2009;22:24-33

MITRAL ANNULAR VELOCITY

Study	n	Age(yr)	E'(cm/s)	Sn	Sp
Garcia et al	8	62+/-13	NA	NA	NA
Rajgopalan et al	19	56+/-13	>/=8	89	100
Ha et al	23	59+/-13	>/=8	95%	96%
Sohn et al	17	46+/-14	*	76%	82%
Sengupta et al	45	24+/-12	>8	89%	73%
Choi et al	17	55+/-12	>8	70%	100%
Sengupta et al	16	62+/-13	>6.6	93%	93%
Sengupta et al	26	56+/-13	>5"	92%	90%

Consider constriction if E' >7cm/s

Constrictive vs Restrictive CMP on 2DE

	Constriction	Restrictive CM
Systolic function	Normal	Initially NL
Atrial size	+/- mild bi-atrial enlargement	Bi-atrial enlargement
Pericardial thickness	+/- increased	NL
Wall thickness	NL	+/- “LVH”
Septal motion	Abnl- “bounce”	NL
Myocardial texture	NL	May be “sparkling” w/ amyloid

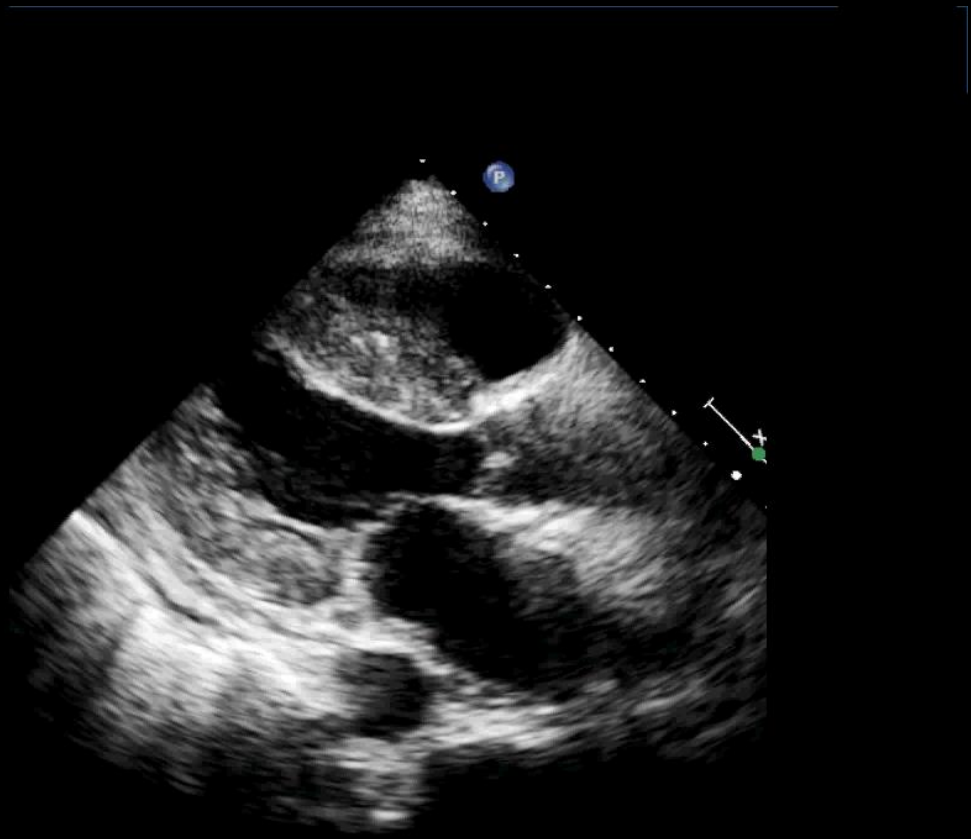
Doppler

	Constriction	Restrictive CM
Resp variation mitral inflow	Present	Absent
Pulmonary HTN	Absent	Present
Hepatic veins	Predominant forward flow-systolic	Predominant forward flow-diastolic
Hepatic veins	Increased diastolic flow reversal w/expiration	Increased diastolic flow w/inspiration
Septal mitral annular e’	Usually >/-8cm/s; higher than lateral e’	Usually <8cm/s; lower than lateral e’

Strain Parameters

	Constriction	Restrictive CM
Doppler based strain	Ventricular septal strain usually NL	Ventricular septal strain usually decr
Speckle tracking	Preserved longitudinal strain	Decreased longitudinal strain
Speckle tracking	Lateral long strain < septal	Lateral longitudinal strain >septal
Speckle tracking	Decreased circumferential strain	Preserved circumferential strain finally decr w/ progression of disease

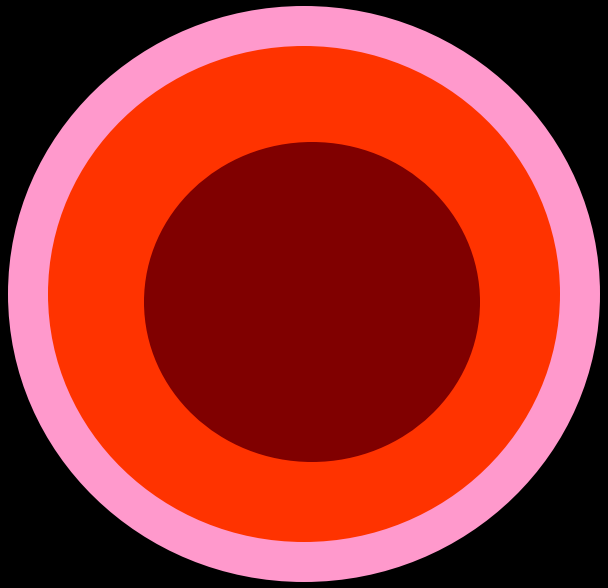
Restrictive CMP

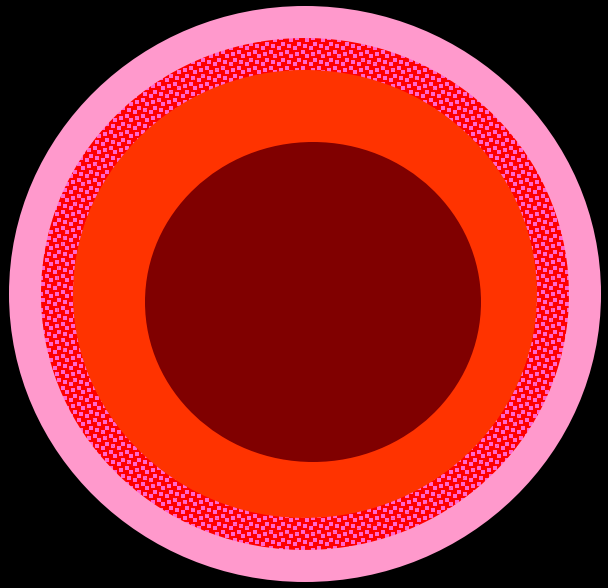


Constrictive Pericarditis

No myocardial involvement

Myocardial fibrosis





Doppler flow pattern early after pericardiectomy

Normal 40%

Restrictive 40%

Constrictive 20 %

43% abnormal flow at a mean FU of 20 months

Michele Senni et al , JACC April 1999

Doppler Flow Velocities

Limitations

False positive:

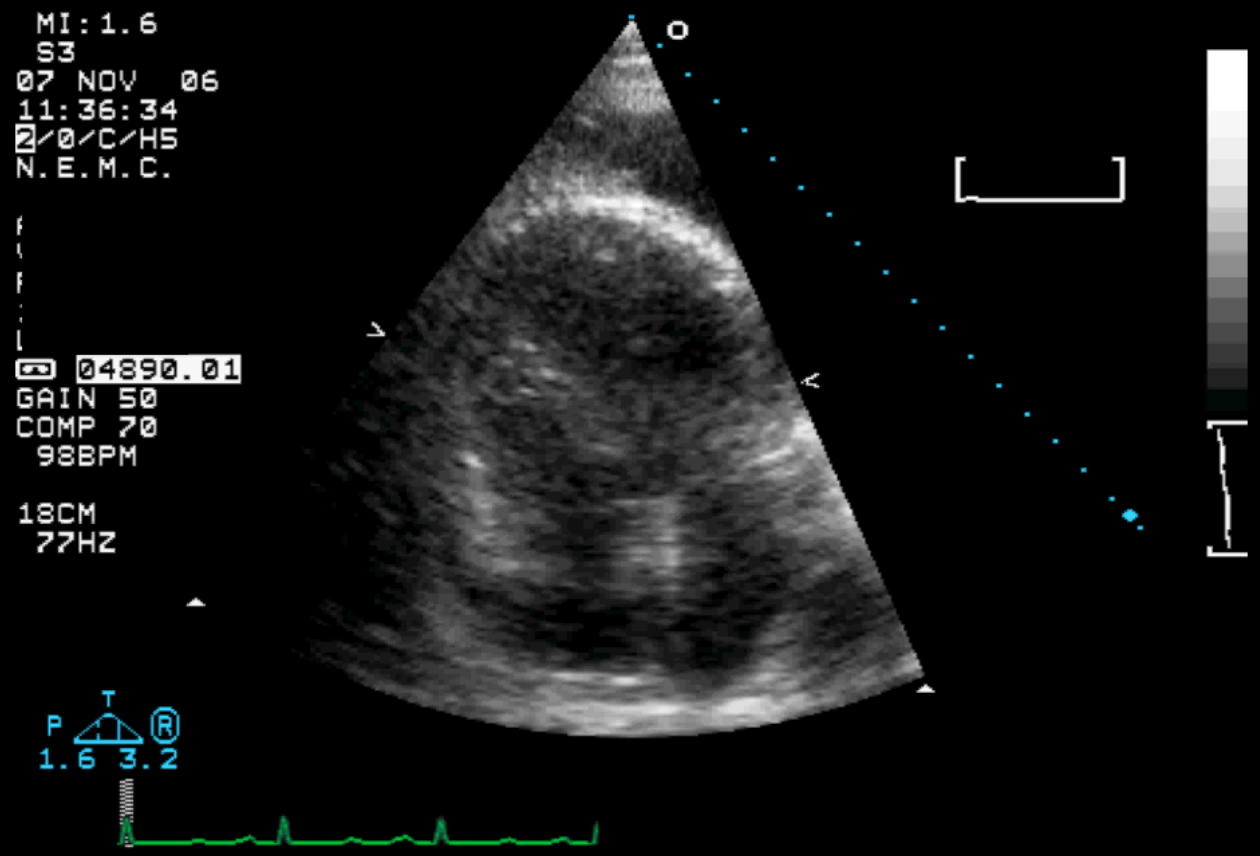
COPD, RV infarction

Obesity, massive PE

Marked increase in LA pressure

Irregular rhythm e.g. AF

Effusive – Constrictive Pericarditis



Constr Pericarditis
Atypical Scenarios

- Changing clinical spectrum
- Co-existing disease
- Effusive-constrictive pericarditis

Constrictive Pericarditis

Chronic
Subacute
Acute

Diffuse
Localized
Not thickened

Classic, Occult
Effusive-Const
Reversible

Pure Constriction
Peri-Myocardial
Disease

Occult
Constrictive Pericarditis

Hypovolumic states

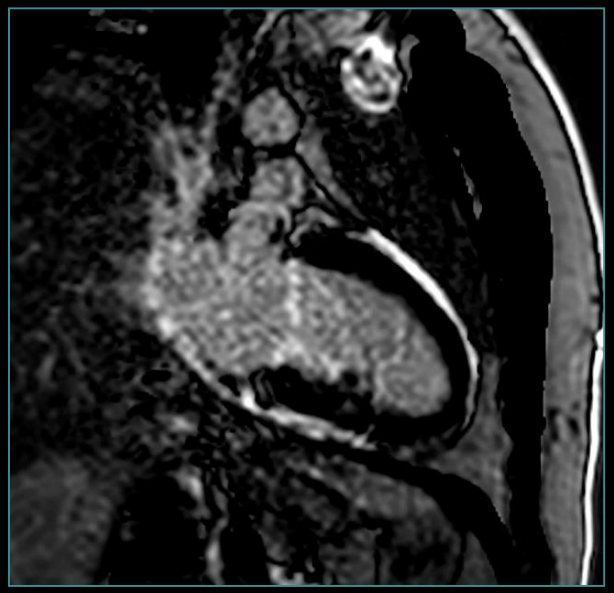
Give fluids and study

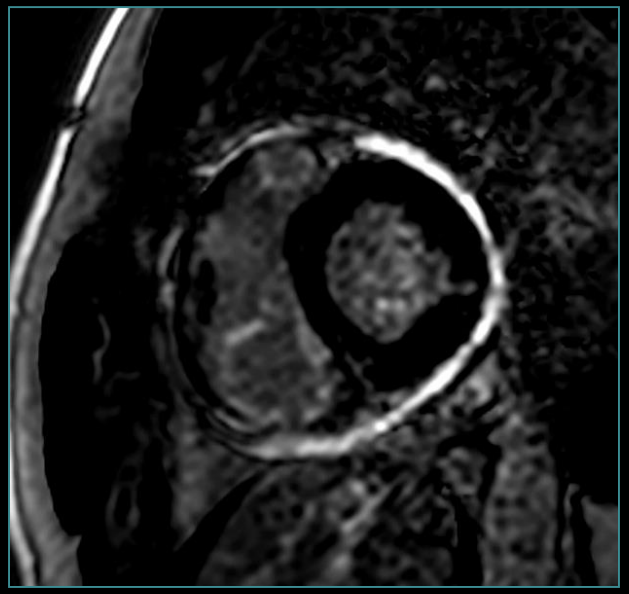
Transient
Constrictive Pericarditis

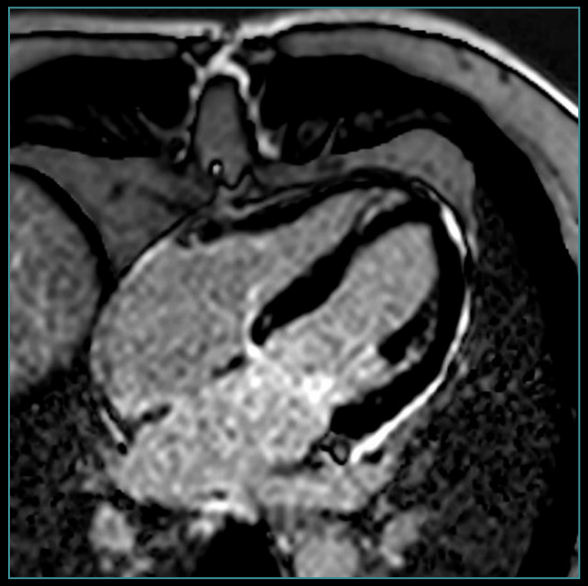
Viral, Post-op

Medical Follow-Up

CMR Delayed Enhancement







Myocardial Fibrosis in Constrictive Pericarditis

- Direct subepicardial penetration
- Throttling of coronaries by scar tissue
- Subendocardial hypoperfusion
- Concomitant pathologic process

Levine H et al, Circulation 1973

Differential Diagnosis

Any disease leading to HF

Restrictive CMP

Nephrotic syndrome

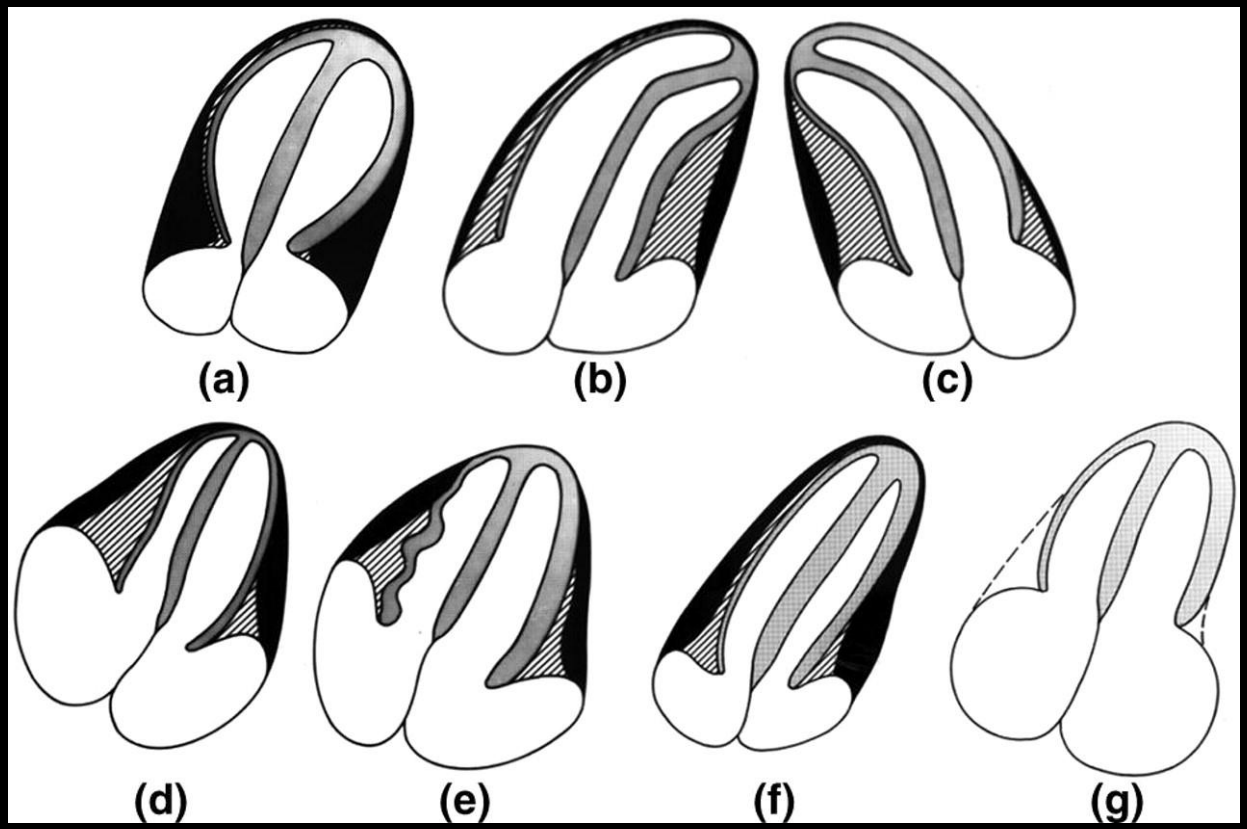
Cirrhosis of liver

Tricuspid valve disease

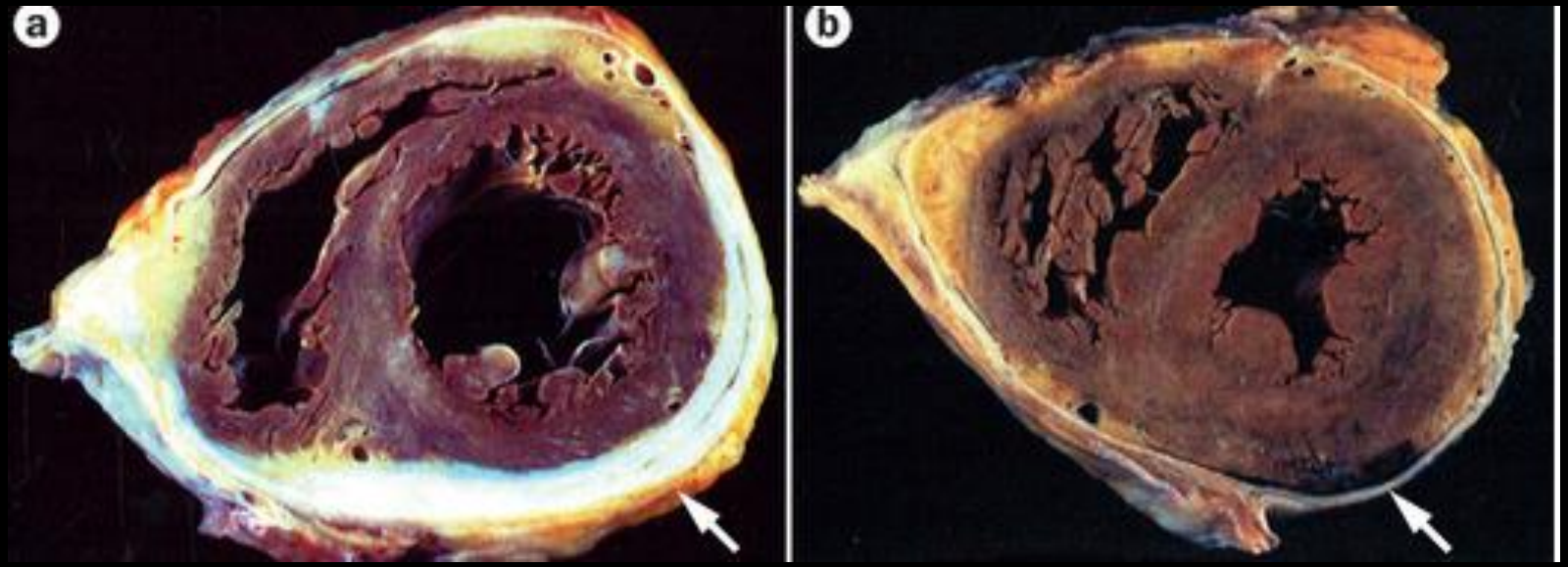
SVC syndrome

Obstructive RH tumors

Pathoanatomical forms of constrictive pericarditis



Rienmuller et al. CT and MR J Thorac Imaging 1993
Maisch B et al. Eur Heart J 2004;25:587-610



Talreja et al, Circulation 2003

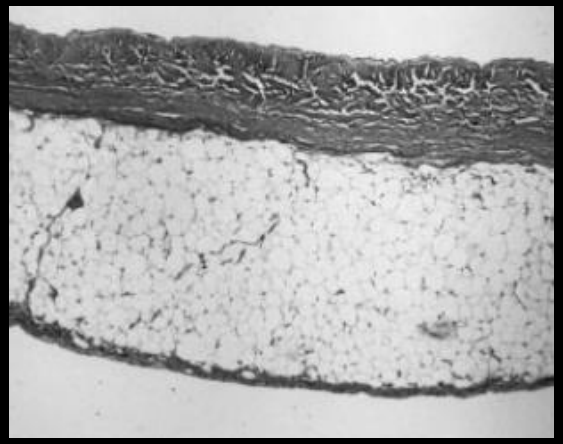
Pericardial thickening

… a constant finding?

18% of patients with pathologically proven constrictive pericarditis have **normal** pericardial thickness.

1.5 mm in depth

3 mm of fat on exterior surface of pericardium



Main etiologies:
cardiac surgery (42%), infection (20%), thoracic irradiation (19%), previous MI (12%), idiopathic (12%).

Talreja et al, Circulation 2003

- Thickened pericardium does not
- mean it is constriction

- Pericardial pathology has
- varied distribution

- Constrictive physiology can develop with normal thickness pericardium

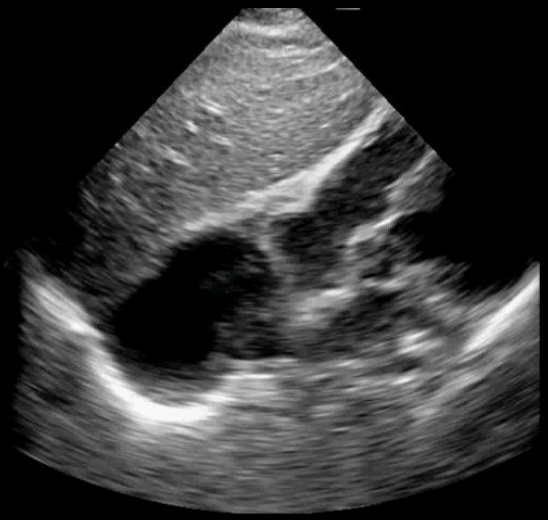
Surgical Results

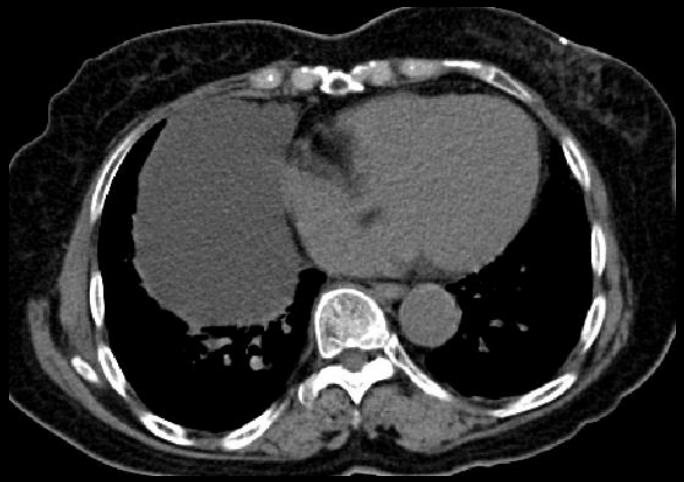
- Operative mortality in 6-19%
- Low output syndrome in 14 - 28%
- Symptoms improvement in 90% but Symptom relief in 50%
- Five year survival is 74-87%

Predictors of poor surgical response

- Poor pre-op functional class
- Severe constriction
  - presence of unresectable calcification

Pericardial Cyst





Post-Presentation Question 1

In cardiac tamponade, the pressure gradient between pulmonary venous system and left atrium

1. Increases during inspiration
2. Decreases during inspiration
3. Decreases during expiration
4. Shows no change

Post-Presentation Question 2

In established constrictive pericarditis, septal bounce is recognized

1. In every heart beat
2. With breath hold
3. During regular breathing
4. Only during premature beats

Post-Presentation Question 3

For tamponade to occur, pericardial effusion should be at least

1. 200 ml
2. 500 ml
3. 1000 ml
4. None applicable

Post-Presentation Question 4

The following annular or septal velocity (tissue Doppler) is useful in recognizing constriction (in contrast to restrictive CMP)

1. e’ 3-5
2. e’ > 7
3. e’ > 27

Thank you!