Recommendations for Multimodality Imaging of Patients with Pericardial Diseases

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Sunday, October 8, 2017

DISCLOSURE

I have **N O** relevant financial relationships

Introduction

European Heart Journal – Cardiovascular Imaging (2015) **16**, 12–31
doi:10.1093/ehjci/jeu128

POSITION PAPER

European Association of Cardiovascular Imaging (EACVI) position paper: multimodality imaging in pericardial disease

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Eur Heart J – Cardiovasc Imaging 2015;16:12-31

European Heart Journal
doi:10.1093/eurheartj/ehv318

ESC GUIDELINES

2015 ESC Guidelines for the diagnosis and management of pericardial diseases

The Task Force for the Diagnosis and Management of Pericardial Diseases of the European Society of Cardiology (ESC)

Endorsed by: The European Association for Cardio-Thoracic Surgery (EACTS)

Authors/Task Force Members: Yehuda Adler* (Chairperson) (Israel), Philippe Charron* (Chairperson) (France), Massimo Imazio† (Italy), Luigi Badano (Italy), Gonzalo Barón-Esquivias (Spain), Jan Bogaert (Belgium), Antonio Brucato (Italy), Pascal Gueret (France), Karin Klingel (Germany), Christos Lionis (Greece), Bernhard Maisch (Germany), Bongani Mayosi (South Africa), Alain Pavie (France), Arsen D. Ristić (Serbia), Manel Sabaté Tenas (Spain), Petar Seferovic (Serbia), Karl Swedberg (Sweden) and Witold Tomkowski (Poland)

Adler European Heart Journal 2015;36:2921-2964

ASE EXPERT CONSENSUS STATEMENT

American Society of Echocardiography Clinical Recommendations for Multimodality Cardiovascular Imaging of Patients with Pericardial Disease

Endorsed by the Society for Cardiovascular Magnetic Resonance and Society of Cardiovascular Computed Tomography

Allan L. Klein, MD, FASE, Chair, Suhny Abbara, MD, Deborah A. Agler, RCT, RDCS, FASE, Christopher P. Appleton, MD, FASE, Craig R. Asher, MD, Brian Hoit, MD, FASE, Judy Hung, MD, FASE, Mario J. Garcia, MD, Itzhak Kronzon, MD, FASE, Jae K. Oh, MD, FASE, E. Rene Rodriguez, MD, Hartzell V. Schaff, MD, Paul Schoenhagen, MD, Carmela D. Tan, MD, and Richard D. White, MD, *Cleveland and Columbus, Ohio; Boston, Massachusetts; Weston, Florida; Scottsdale, Arizona; Rochester, Minnesota; Bronx and New York, New York*

Klein J Am Soc Echocardiogr 2013;26:965-1012

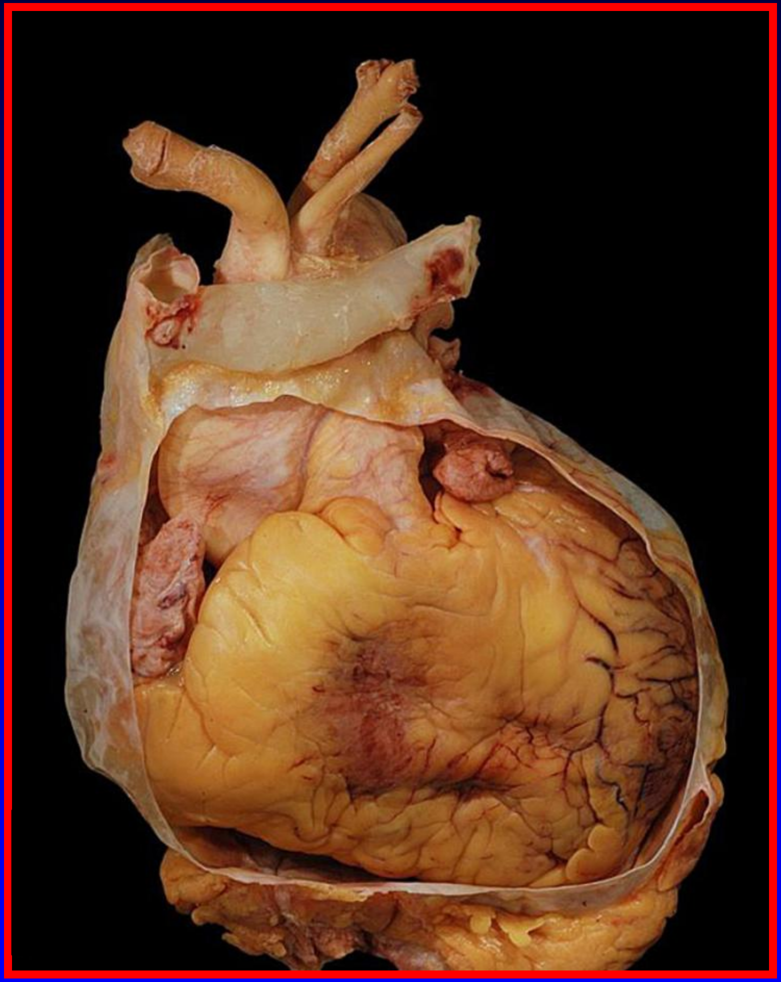
Normal Pericardium

- Fibroserous sac
- Visceral and parietal layers
- Normally contains ≈ 25 ml fluid
- Normal pericardium ≤ 2 mm thick
- Abnormal → ≥ 4 mm thick

Pericardium is a 2-layered sac

- **Parietal** → outer, thicker, fibrous layer
- **Visceral** → thin, inner, serous layer

Anterior Portion of Pericardial Sac Removed



Note: Proximal portions of great vessels are intrapericardial

modified from Klein J Am Soc Echocardiogr 2013;26:965-1012

CT "Pericardiogram"

Iodinated contrast inadvertantly injected into pericardial space during an attempted pulmonary angiogram

Wann and Passen J Am Soc Echocardiogr 2008;21:7-13

Pericardial Syndromes

- **Pericarditis**
  - Acute pericarditis
  - Recurrent pericarditis
  - Incessant and chronic pericarditis
  - Myopericarditis
- **Pericardial effusion**
- **Cardiac tamponade**
- **Constrictive pericarditis**
  - Chronic constrictive pericarditis
  - Effusive-constrictive pericarditis
  - Transient pericarditis

Specific Etiologies of Pericardial Syndromes

- Viral pericarditis
- Bacterial pericarditis (purulent pericarditis and Tbc)
- Pericarditis in renal failure
- Pericardial involvement in autoimmune and autoinflammatory disease
- Post-cardiac injury syndromes
- Traumatic pericardial effusion and hemopericardium
- Pericardial involvement in neoplastic diseases
- Misc:
  - Radiation pericarditis
  - Drug-related pericarditis and pericardial effusion
  - Pericardial effusion in pulmonary hypertension

Initial Assessment

- Careful history
- Physical exam
- ECG
- Chest X-ray

Imaging

- Echo (first-line)
- CT-scan
- CMR

Pericardial Diseases

- Wide spectrum or pericardial diseases
- Imaging essential for dx, complications, mgt
- 3 main techniques: Echo, CT, MRI
- Each has strengths and limitations
- Often complementary: may need 1 or multiple
- **TTE is first-line imaging modality**

Why Echo is Firstline Imaging Test

- Readily, widely available, portable
- Low cost, safe
- Can be performed at bedside
- Can be performed in urgent situations
- Can be performed with respirometer
- Comprehensive → anatomy and physiology

Limitations of TTE

- Dependence on good windows
- Inability to image entire pericardium
- Limited tissue characterization
- Not accurate for pericardial thickness
  (CT and MRI superior for thickness)

Strengths of CT-scan

- Measurement of pericardial thickness
- Evaluation of associated/extracardiac disease
  (pleural effusions, postradiation fibrosis, malignancy, cirrhosis, ascites)
- Detection of pericardial calcification
- Pre-operative planning

CT-Scan for Pericardial Disease

- CT attenuation of peric. similar to myocardium
- Pericardium can only be seen when surroundedby fat
- Appears as thin line on anterior surface
- Esp. useful for detecting calcification

continued . . . .

CT-Scan for Pericardial Disease

- Useful for size of atria and vena cavae
- Character of pericardial fluid:

Pericardial effusion	→	0-20 Hounsfield units
Hemorrhagic effusion	→	≥ 30 Hounsfield units
Purulent effusion	→	≥ 50 Hounsfield units

Limitations of CT-scan

- Ionizing radiation; iodinated contrast
- Functional evaluation
  (only possible with retrospective-gated studies)
- Difficult in cases of arrhythmias
- Need for breath hold
- Hemodynamically stable patients only

Cardiac MRI for Pericardial Effusion

- More detailed visualization than TTE
  (especially loculated or regional)

- May help differentiate transudate vs exudate

- Useful in myopericarditis
  - Myocardial edema
  - Hyperremia (capillary leak)
  - Myocardial fibrosis

Limitations of MRI

- Time consuming, high cost
- Difficult in cases with arrhythmias
- Calcifications not well-visualized
- Gadolinium (not recommended if GFR < 30 mL/min)
- Need for breath hold
- Hemodynamically stable patients only

Table 1 Comparison of multimodality imaging modalities in the evaluation of pericardial diseases

	Echocardiography	CT	CMR
Main strengths	• First-line imaging test in the diagnostic evaluation of pericardial disease • Readily available • Low cost • Safe • Can be performed at bedside or urgent situations • Portable • TEE available for better evaluation • High frame rate • Can be performed with respirometer	• Second-line for better anatomic delineation • Evaluation of associated/ extracardiac disease • Preoperative planning • Evaluation of pericardial calcification	• Second-line for better anatomic delineation • Superior tissue characterization • Evaluation of inflammation
Main weaknesses	• Limited windows, narrow field of view • Technically limited with obesity, COPD, or postoperative setting • Relatively operator dependent • Low signal-to-noise ratio of the pericardium • Limited tissue characterization	• Use of ionizing radiation • Use of iodinated contrast • Functional evaluation only possible with retrospective gated studies (higher radiation dose, suboptimal temporal resolution) • Difficulties in case of tachycardia or unstable heart rhythm (particularly for prospective gated studies) • Need for breath-hold • Hemodynamically stable patients only	• Time-consuming, high cost • Preferably stable heart rhythms • Relatively contraindicated in case of pacemaker or ICD • Lung tissue less well visualized • Calcifications not well seen • Use of gadolinium contrast contraindicated in case of advanced renal dysfunction (glomerular filtration rate <30 mL/min) • Use of some breath-hold sequences • Hemodynamically stable patients only

Klein ASE Consensus Statement J Am Soc Echocardiogr 2013;26:965-1012

Cardiac MRI for the Pericardium

TABLE 1: MRI Sequences and Planes Used to Evaluate the Pericardium

Sequence	Planes	Information
Scouts	Axial, sagittal, coronal	Localizing
HASTE FSE	Axial	Define anatomy and plan subsequent views
Cine SSFP	Vertical long-axis, horizontal long-axis, short-axis, four-chamber, LVOT	Evaluate function, volumes, masses
Myocardial tagging	LV short-axis × 3 (i.e., base, mid, distal), vertical long-axis, four-chamber, LVOT	Evaluate pericardial movement
T1 and T2 FSE	Vertical long-axis, short-axis, four-chamber, LVOT	Assess pericardial morphology
T2 FSE STIR	Vertical long-axis, short-axis, four-chamber, LVOT	Evaluate for pericardial edema due to inflammation
Velocity-encoded[a] phase-contrast	Mid ascending aorta	Assess aortic flow and flow pattern of SVC and pulmonary vein
Early contrast-enhanced T1-weighted FSE	Vertical long-axis, short-axis, four-chamber, LVOT	Evaluate for inflammation, masses
Delayed enhancement	vertical long-axis, short-axis, four-chamber, LVOT	Evaluate for pericardial inflammation and fibrosis, masses
Real-time imaging	Short axis, mid ventricle	Evaluate for ventricular interdependence

Note—FSE = fast spin-echo, SSFP = steady-state free precession, LVOT = left ventricular outflow tract, SPAMM = spatial modulation of magnetization, LV = left ventricular, SVC = superior vena cava.
[a]Velocity encoding = 200 cm/s.

Rajiah AJR 2011;197-Oct:W621-W634

Cardiac MRI for the Pericardium

Features that Differentiate Thickening and Effusion

TABLE 3: MRI Features That Differentiate Thickening and Effusion

Features	Effusion	Thickening
Signal in T1- and T2-weighted images	Signal void	Gray (except in calcification)
Signal in SSFP and GRE	High	Low
Margins	Smooth	Irregular or nodular
Location	Follows distribution typical of effusion	Does not follow typical distribution of effusion
Decubitus position	Change in configuration	No change in configuration
Tagging	Loss of tags with cardiac cycle	Persistent lines throughout cardiac cycle
Contrast enhancement	None	May be present if associated with inflamation

Rajiah AJR 2011;197-Oct:W621-W634

What Do CT and MRI Add ?

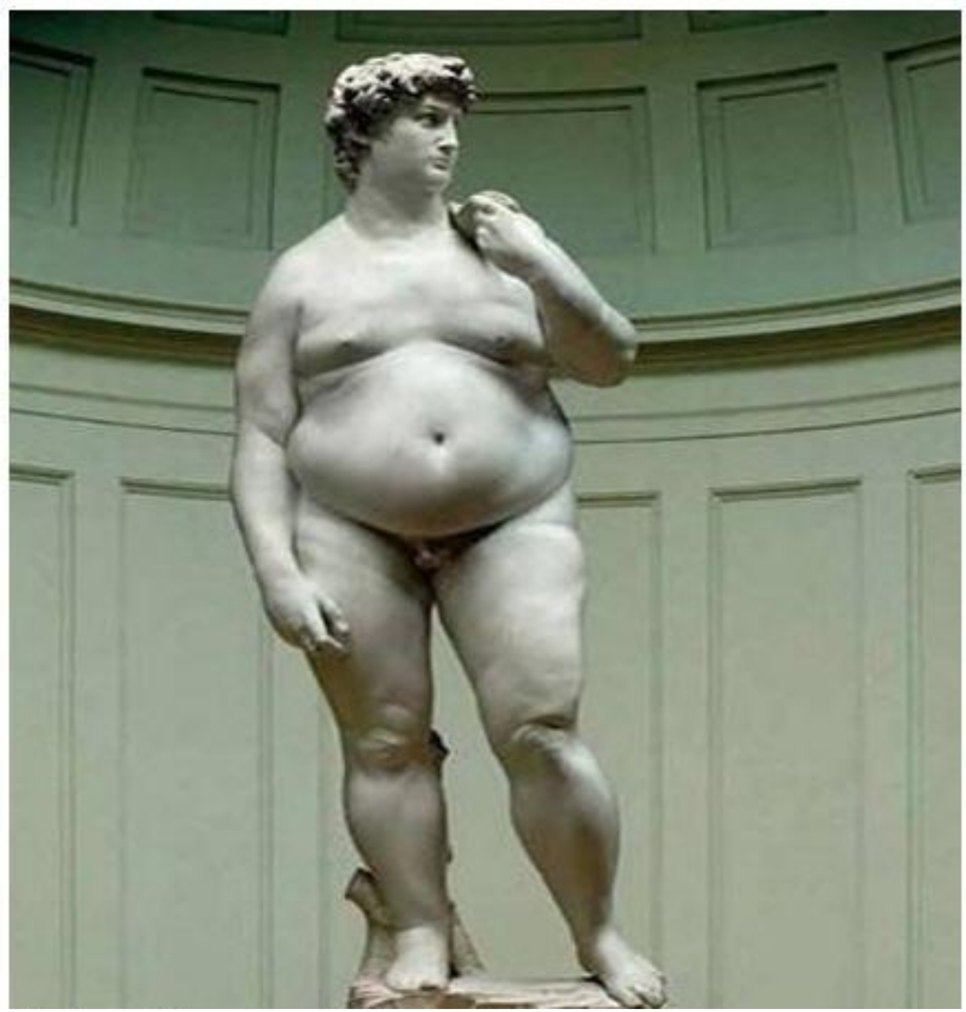
- Measurement of pericardial thickness
- Distribution of pericardial calcium
- Evaluation of pericardial inflammation
- Functional effects of the constrictive process

When to Utilize CT and/or MRI

- Inconclusive TTE and ongoing clinical concern
- Failure to respond promply to anti-inflammatory rx
- Prior to pericardiectomy (pre-op planning)
- Search for a specific cause
- Suspicion of constrictive pericarditis
- Concern for transient constriction
- Acute pericarditis in the setting of acute MI, neoplasm, lung or infection, or pancreatitis

Fat

After a two year loan to the United States, Michelangelo’s David is being returned to Italy.



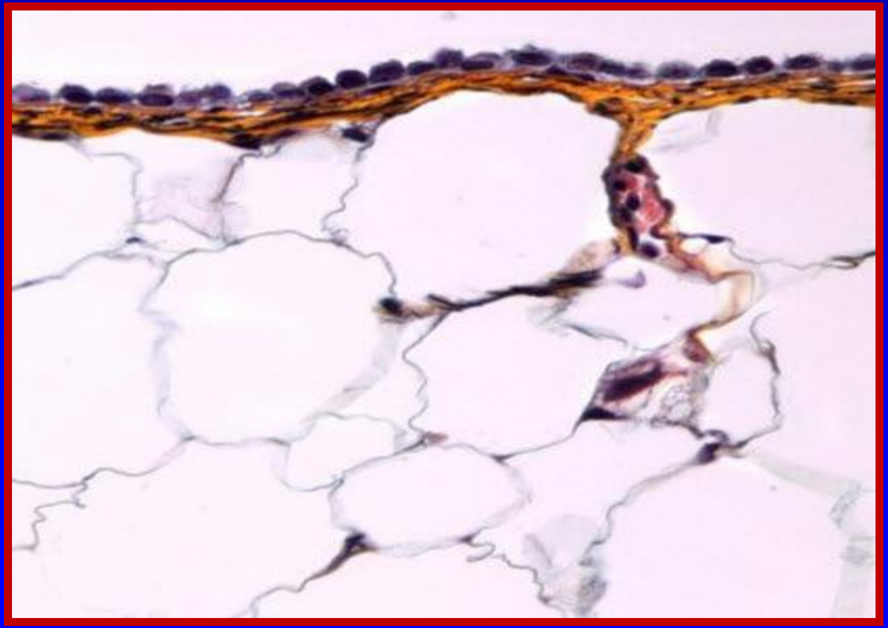
His proud sponsors were:

i'm lovin' it

STARBUCKS COFFEE

BURGER KING

Fat



Pericardial Effusion vs Fat

Epicardial Fat

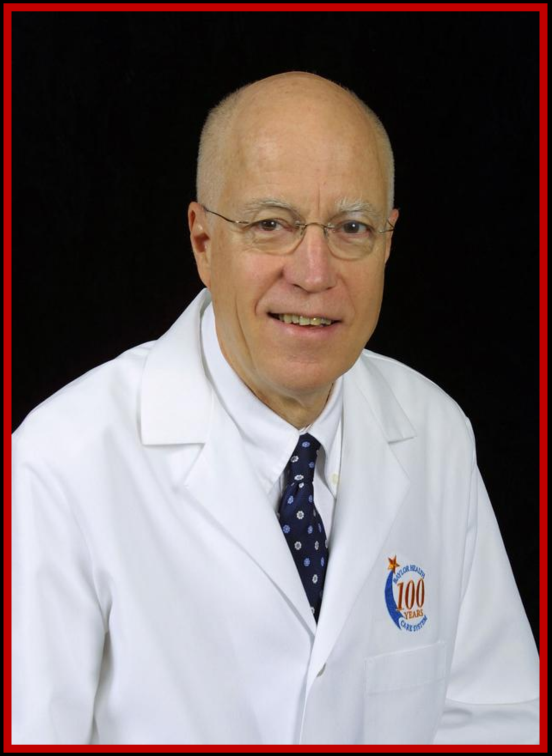
- Increases with age and obesity
- Usually present only anteriorly
- Slightly higher echo-density than effusion
- CT is more definitive

Parietal Pericardium

Parapericardial fat

Epicardial fat
over RV

modified from Klein J Am Soc Echocardiogr 2013;26:965-1012



Wm. C. Roberts | Chief Editor | Formaldehyde

1983 → 5% hearts floated

2016 → 52% hearts floated

Case

62 year-old obese male
STEMI

Epicardial and paracardial fat

Case

VW - 71 year-old woman

64” 186 lbs

BP 170/88

Epicardial fat within pericardial fluid

Pericarditis

Acute Pericarditis

Note: Pericardial effusion present in only ≈ 50% of patients

Acute Pericarditis with Small or No Effusion (non-complicated effusion)

TTE to confirm clinical diagnosis	Recommended
CMR to confirm clinical diagnosis if clinical context of myocarditis	Recommended
CT/CMR to confirm clinical diagnosis if echo inconclusive	Not recommended
TEE if poor TTE quality of imaging	Not recommended
TTE for follow-up	Not recommended

Cosyns EACVI Position Paper Eur Heart F – CV Img 2015;16:12-31

Acute Pericarditis with Complicated Course and/or Moderate-to-Severe Effusion and No Tamponade

TTE to confirm clinical diagnosis	Recommended
TEE if poor TTE quality	Recommended
TTE to indicate, contraindicate pericardiocentesis	Recommended
TTE to guide and for f/u of pericardiocentesis	Recommended
CT/CMR to confirm clinical diagnosis in case of high suspicion of aortic dissection	Reasonable
CT/CMR to confirm clinical diagnosis in case of trauma or associated disorders	Reasonable
CT/MRI to confirm clinical diagnosis if echo inconclusive	Reasonable
CMR to confirm clinical diagnosis of myocarditis	Recommended
CMR for f/u of pericardiocentesis	Reasonable
TTE for follow-up	Reasonable

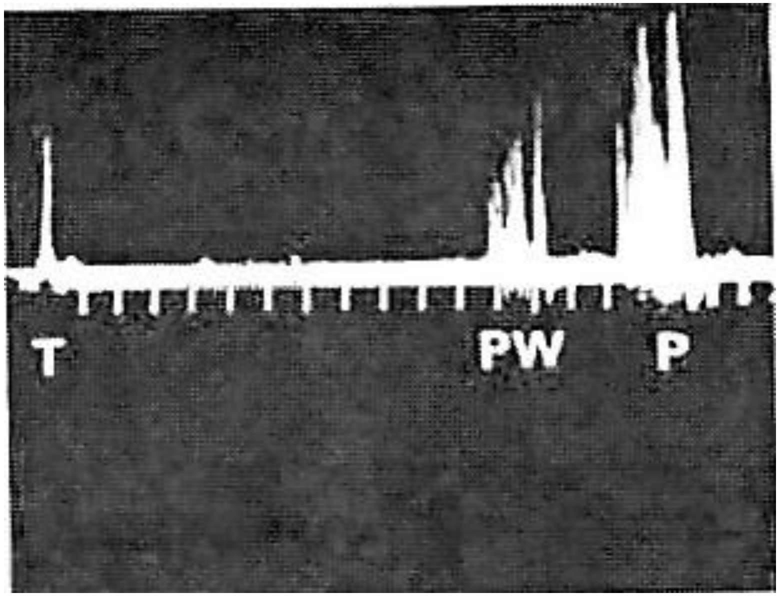
Cosyns EACVI Position Paper Eur Heart F – CV Img 2015;16:12-31

Effusion

Ultrasound Diagnosis of Pericardial Effusion

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

The differentiation between a large, dilated heart and pericardial effusion is essential but frequently difficult. The clinician must often resort to diagnostic procedures which offer some hazard to the patient. The use of reflected ultrasound was found to be a highly effective and simple method of making this differential diagnosis. In five dogs with artificially produced pericardial effusion it was noted that without pericardial fluid only one ultrasound echo was produced in the vicinity of the posterior heart wall. When fluid was introduced, one detected two echoes, one which moved with cardiac action, the posterior heart wall, and another which moved only with respiration, the pericardium. The space between the two signals represented the pericardial fluid. Subsequent clinical studies confirmed the accuracy, reliability, and simplicity of this diagnostic procedure.



JAMA, March 1, 1965 • Vol 191, No 9

Pericardial Effusion
Role of Echocardiogram

- Detection of pericardial effusion
- Semiquantitation of pericardial effusion
- Determine hemodynamic significance of pericardial effusion
- Determine best site for pericardiocentesis

Estimation of Amount of Pericardial Effusion

(perpendicular to ventricular walls in diastole)

Minimal pericardial effusion	→	Seen only in systole
< 1 cm	→	~ 300 mL
1 – 2 cm	→	~ 500 Ml
> 2 cm	→	typically > 700 mL

Cosyns EACVI Position Paper Eur Heart J – CV Img 2015;16:12-31

Size of Pericardial Effusions

Semiquantitative Grading

Grade	**Echo-free space** (end-diastole)
Trivial	only in systole
Small	< 1 cm
Moderate	1 to 2 cm
Large	> 2 cm
Very large	> 2.5 cm

Klein ASE Consensus Statement J Am Soc Echocardiogr 2013;26:965-1012

Size of Pericardial Effusions

Arbitrary Partitions

Small	50 – 100 mL
Moderate	100 – 500 mL
Large	> 500 mL

Klein ASE Consensus Statement J Am Soc Echocardiogr 2013;26:965-1012

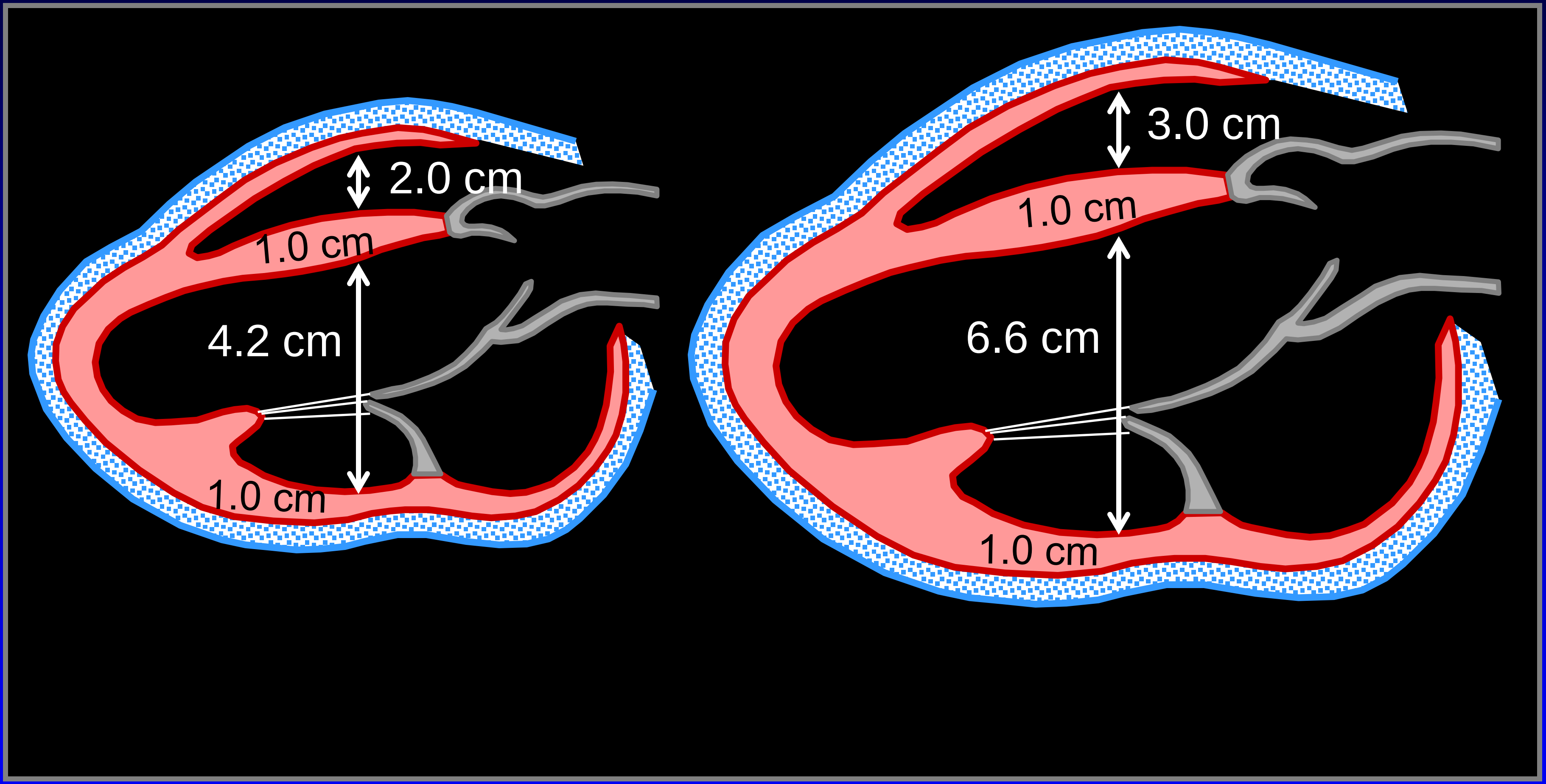
Classification of Pericardial Effusion

2015 ESC Guidelines

Onset	Acute Subacute Chronic (> 3 months)
Size	Mild < 10 mm Moderate 10-20 mm Large > 20 mm
Distribution	Circumferential Loculated

Adler 2015 ESC Guidelines Eur Heart J 2015;36:2921-2964

1 cm circumferential rim of pericardial effusion



285 cc **525 cc**

$$V = \frac{4}{3} \pi r^3$$

Case

SM - 51year-old woman

Pericardial and pleural effusion

Case

RC - 69 year-old woman

Pericardial effusion and thickened pericardium

Case

MLD - 74 year-old woman

Small pericardial effusion and RA collapse

No tamponade

Case

RD - 77 year-old man

Massive pericardial effusion

Case

GR - 53 year-old man

"Swinging Heart"

GR - 53 year-old man, longtime cigarette smoker

July, 2011 → pain in “neck muscles”

PMD → Chest X-ray → suspicious mass

Chest CT →bilat. nodules & hilar lymphadenopathy

Fine needle aspiration supraclavic node → cancer

Squamous cell lung cancer

Began cisplaten/pemetrexed chemotherapy

2D-echo performed

Case

LD - 70 year-old woman

Fluid around LA-appendage

Case

LAA surrounded by fluid

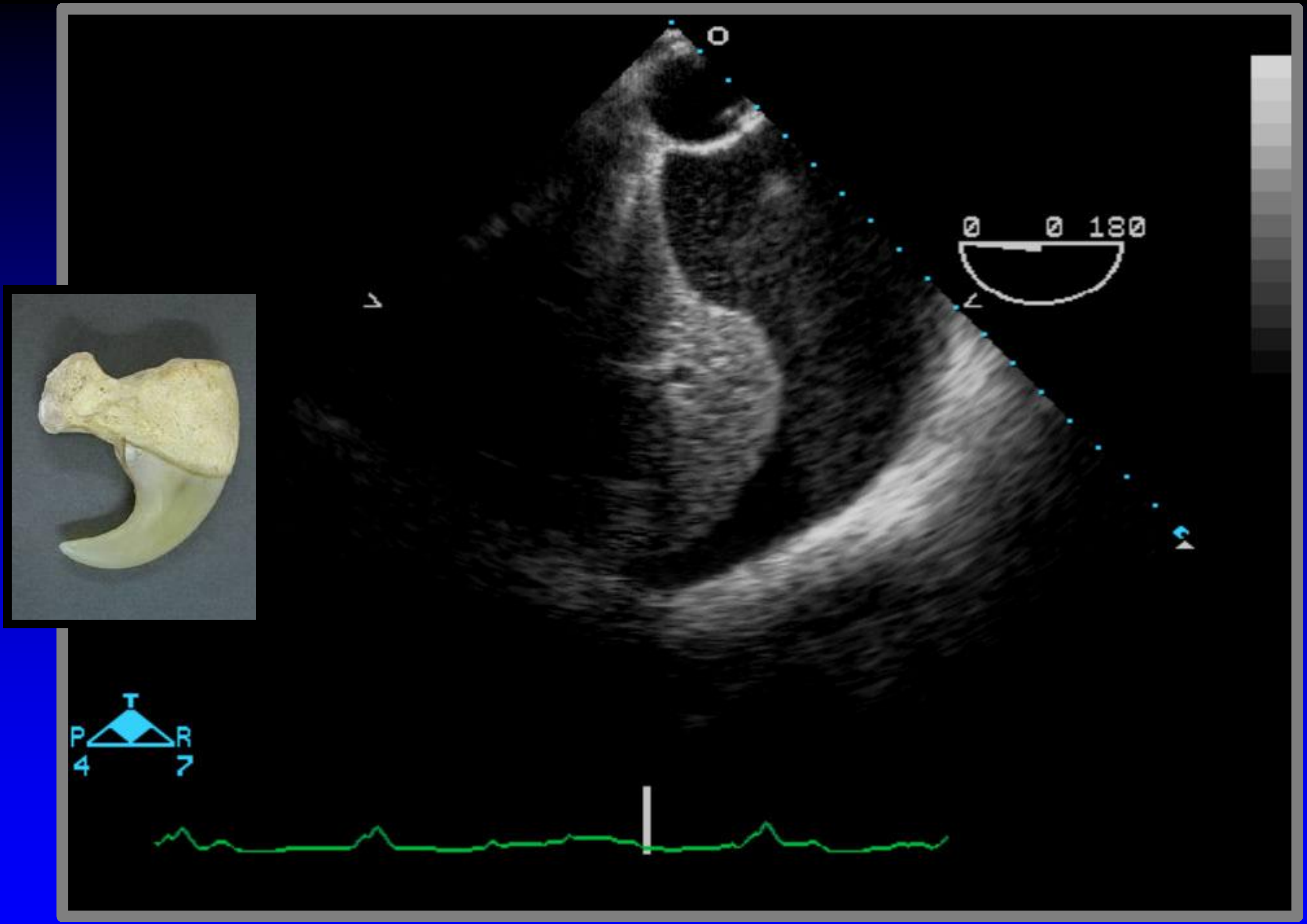
Case

Moderate size effusion

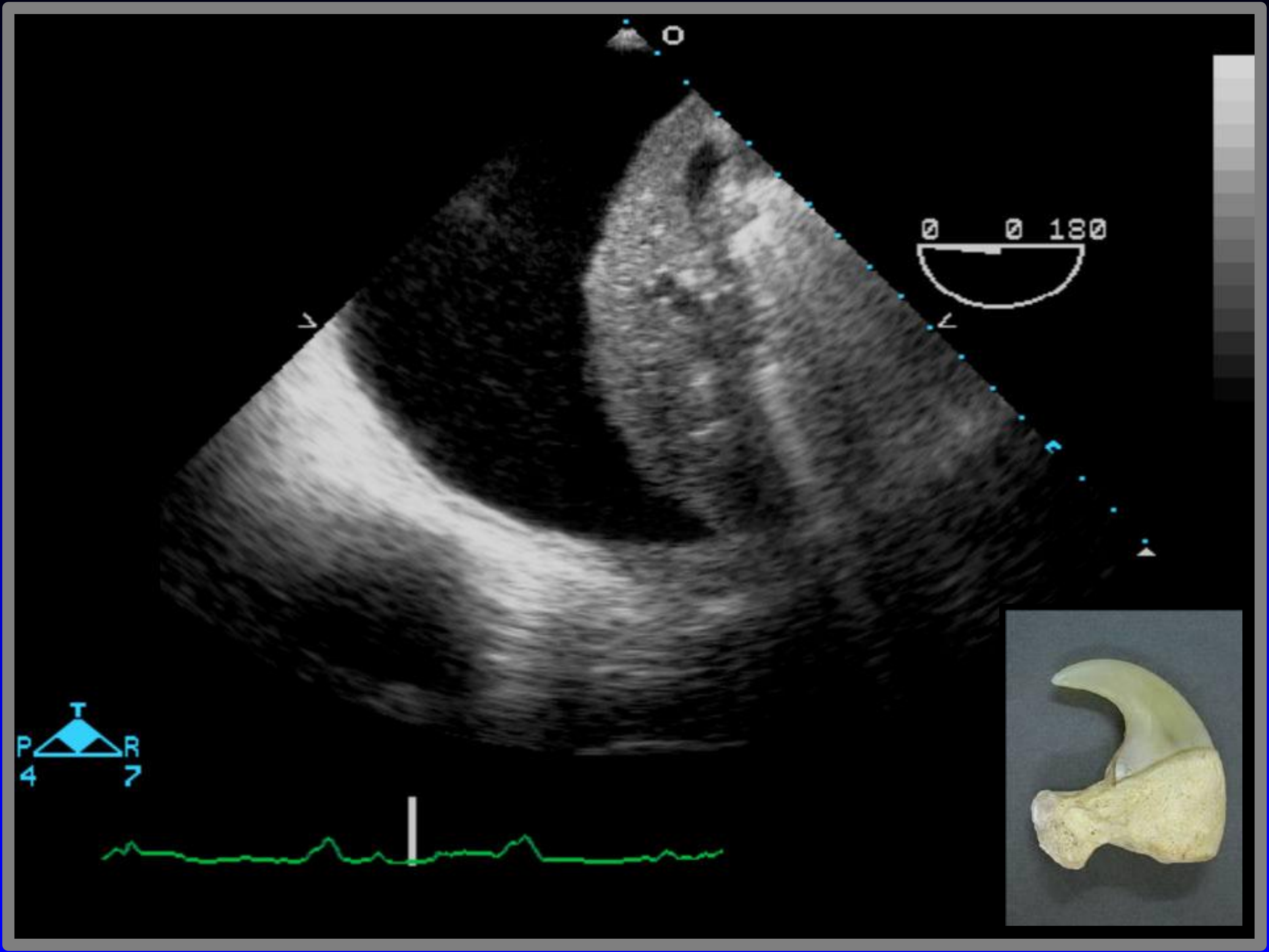
RA invagination relatively short

Case

TEE



Left pleural effusion - Tiger claw left



Right pleural effusion - Tiger claw right

Case

Which of the following is the best explanation for this echo-free space ?

A. Pericardial effusion

B. Pleural effusion

C. Ascites

D. Mediastinal fluid

E. Pericardial cyst

The Falciform Ligament in the Echocardiographic Diagnosis of Ascites

Frank Patrick Cardello, MD, Dong-Hi Anthony Yoon, MD, Robert E. Halligan Jr, MD, and Herschel Richter, MD, *Phoenix, Arizona*

Objective: **The purpose of this study was to show that the falciform ligament (FL) is an important finding on transthoracic echocardiography (TTE) in patients with ascites.**

Background: **It is difficult to determine the cause of echo-free spaces around the heart. When an echo-free space is seen anterior to the right ventricle, the identification of the FL helps to distinguish ascites from pericardial effusions, pleural effusions, and pericardial cysts.**

Methods: **TTE was performed with a 3-MHz multiplane transducer connected to an ultrasound system. Standard TTE and Doppler flow measurements were performed following the American Society of Echocardiography guidelines. A total of 32 patients with ascites were studied.**

Results: **In all 32 patients with ascites noted on clinical examination and documented with abdominal ultrasound, magnetic resonance imaging, computerized tomography, paracentesis, or a combination of these, the FL was identified in the subdiaphragmatic view on TTE examination.**

Conclusion: **The FL can be readily visualized on TTE in the subdiaphragmatic view and can aid in the differential diagnoses of translucent space around the right heart border and the liver. The presence of the FL in this echolucent space denotes ascites.** (J Am Soc Echocardiogr 2006;19: 1074.e3-e4.)

The Falciform Ligament in the Echocardiographic Diagnosis of Ascites

Conclusions: The FL can be readily visualized on TTE in the subdiaphragmatic view and can aid in the differential diagnoses of translucent space around the right heart border and the liver. The presence of the FL in this echolucent space denotes ascites.

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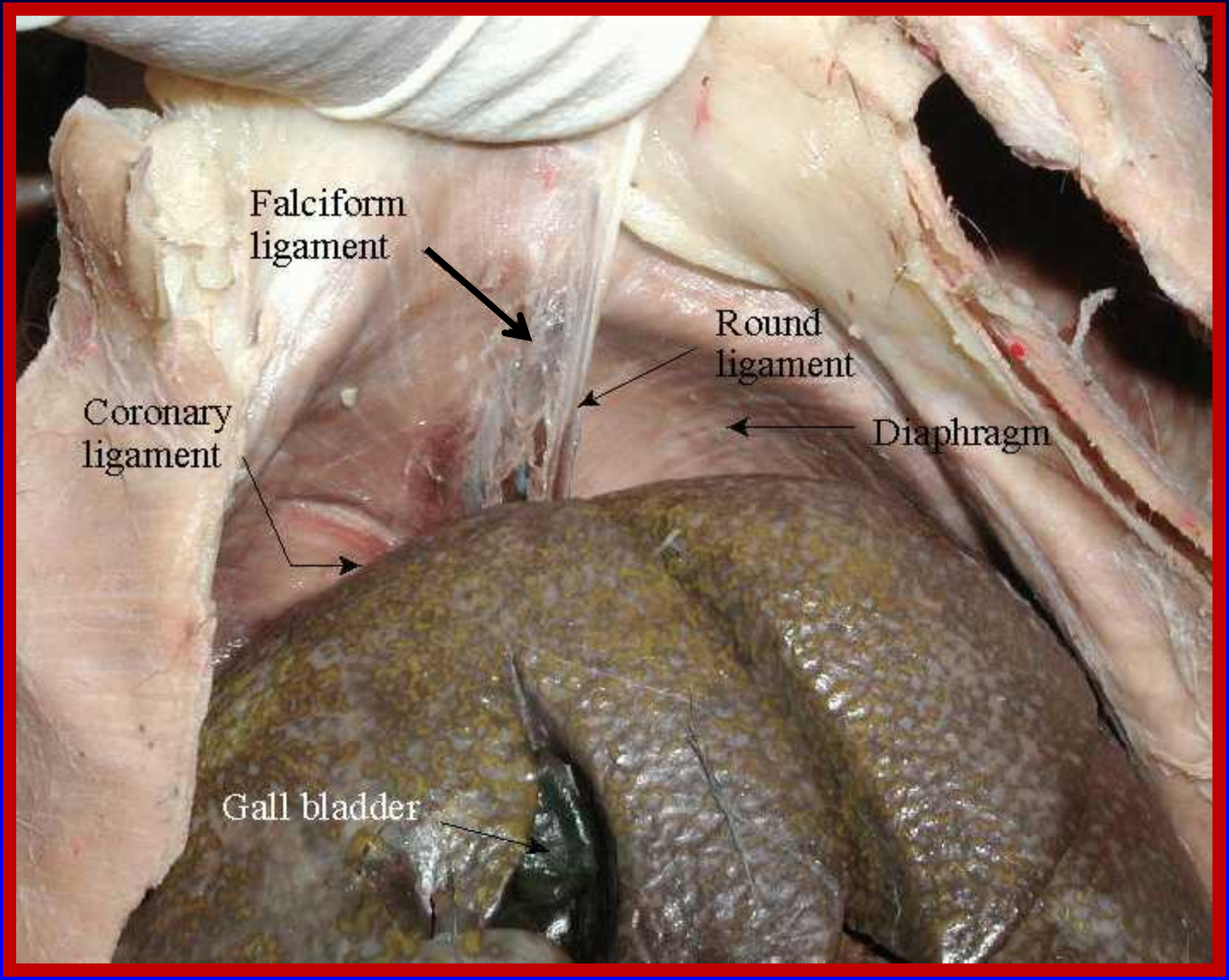
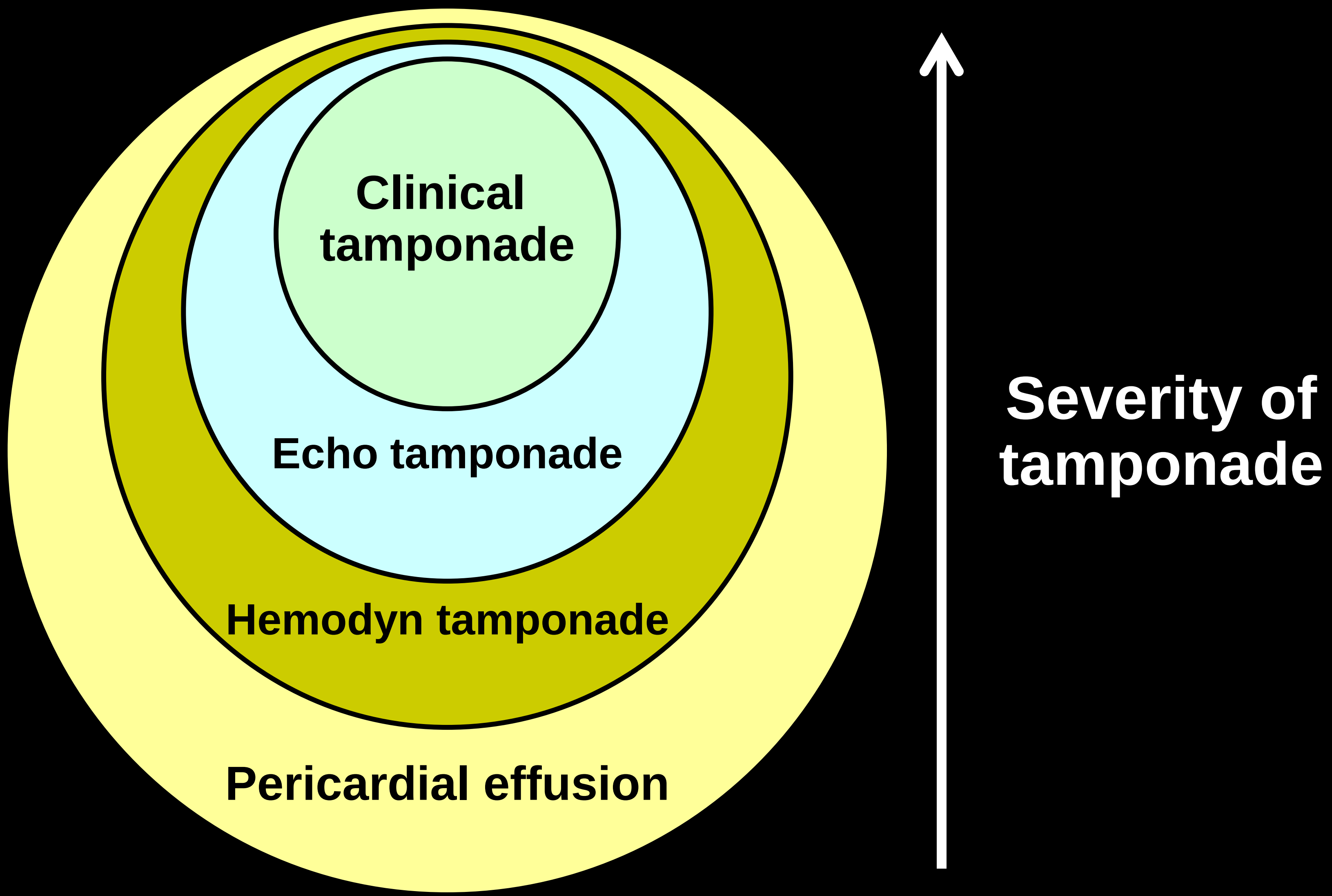
J Am Soc Echocardiogr 2006;19:1074

Falciform Ligament



Tamponade

Tamponade not all-or-none phenomenon


Clinical tamponade
Echo tamponade
Hemodyn tamponade
Pericardial effusion
Severity of tamponade

Tamponade

Cardiac Tamponade
Defintion

Accumulation of fluid in the pericardium in an amount sufficient to cause restriction to filling

Pathophysiology of Tamponade

Accumulation of fluid in pericardial sac

↓

Rise in intrapericardial pressure

↓

Increase in ventricular filling pressures

Pathophysiology of Tamponade

Greater interdependence of ventricles when heart constrained by fluid

↓

Filling of one ventricle influences filling of the other

Pathophysiology of Tamponade

Inspiratory increase in RV volume occurs at expense of LV cavity

↓

Septum shifts toward LV

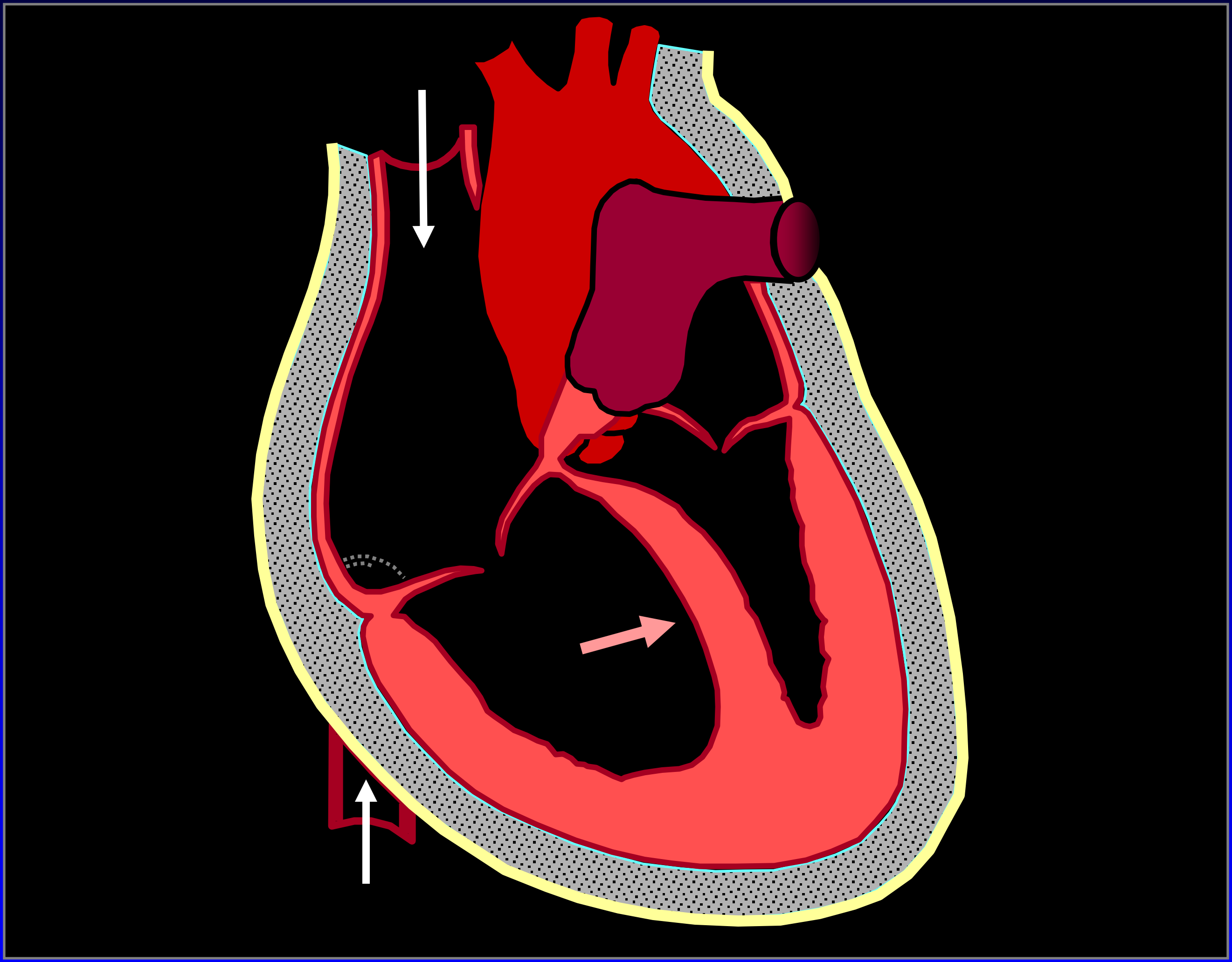
↓

Reduces LV filling

↓

Reduces stroke volume

Tamponade (in inspiration)



Inspiration: pericardial pressure falls from 20 to 18 mmHg
venous return increases (arrows)
right heart volume increases (septal bulging)

Pathophysiology of Tamponade

Extrapericardial venous pressure falls more than intracardiac pressure during inspiration

↓

Reduces LV filling

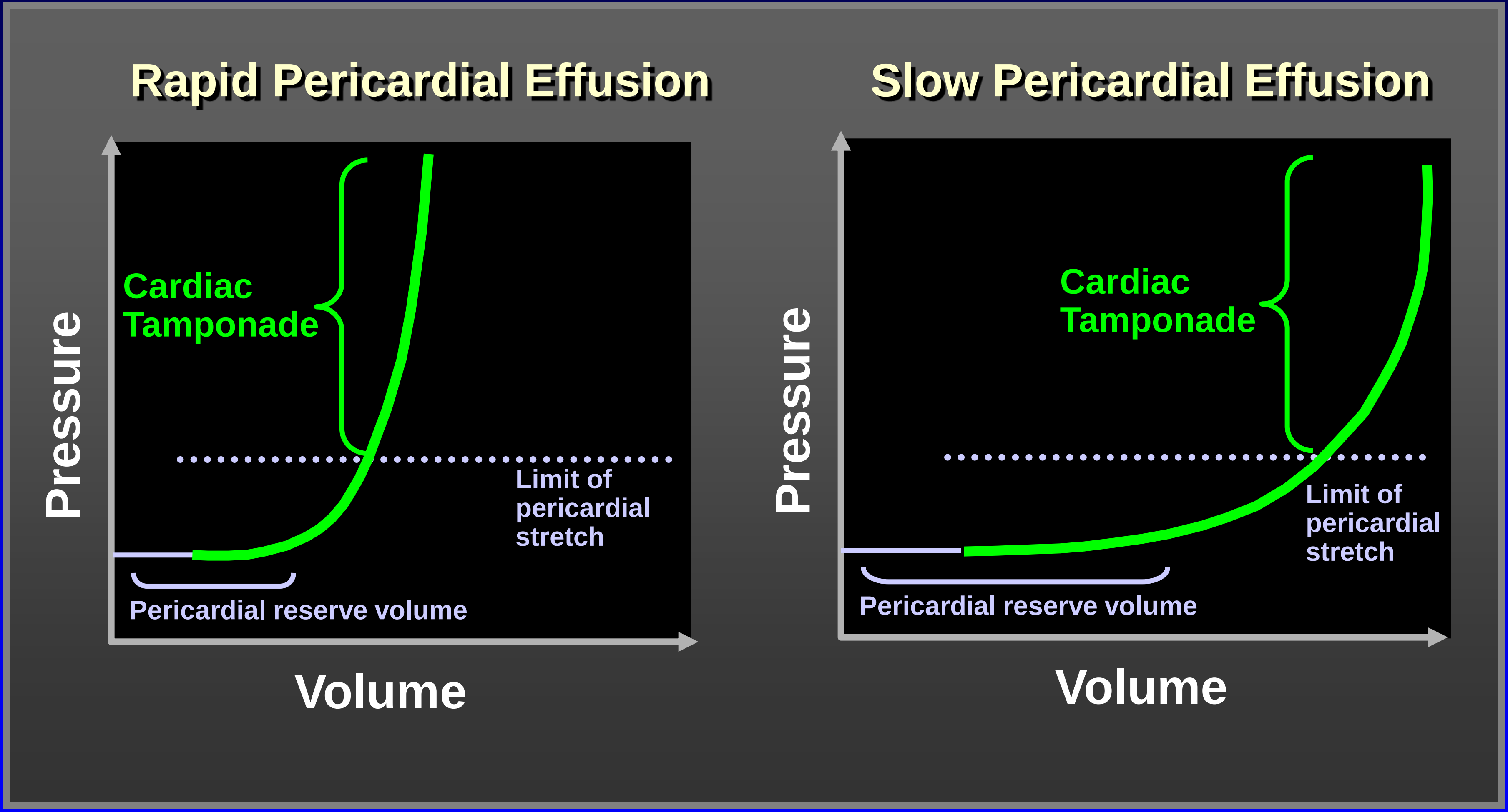
↓

Reduces stroke volume

Development of Tamponade Depends On:

- Distensibility of the pericardium
- Amount of fluid
- Speed of fluid accumulation

Pericardial Pressure-Volume Curves



Cardiac Tamponade
2D-Echo Features

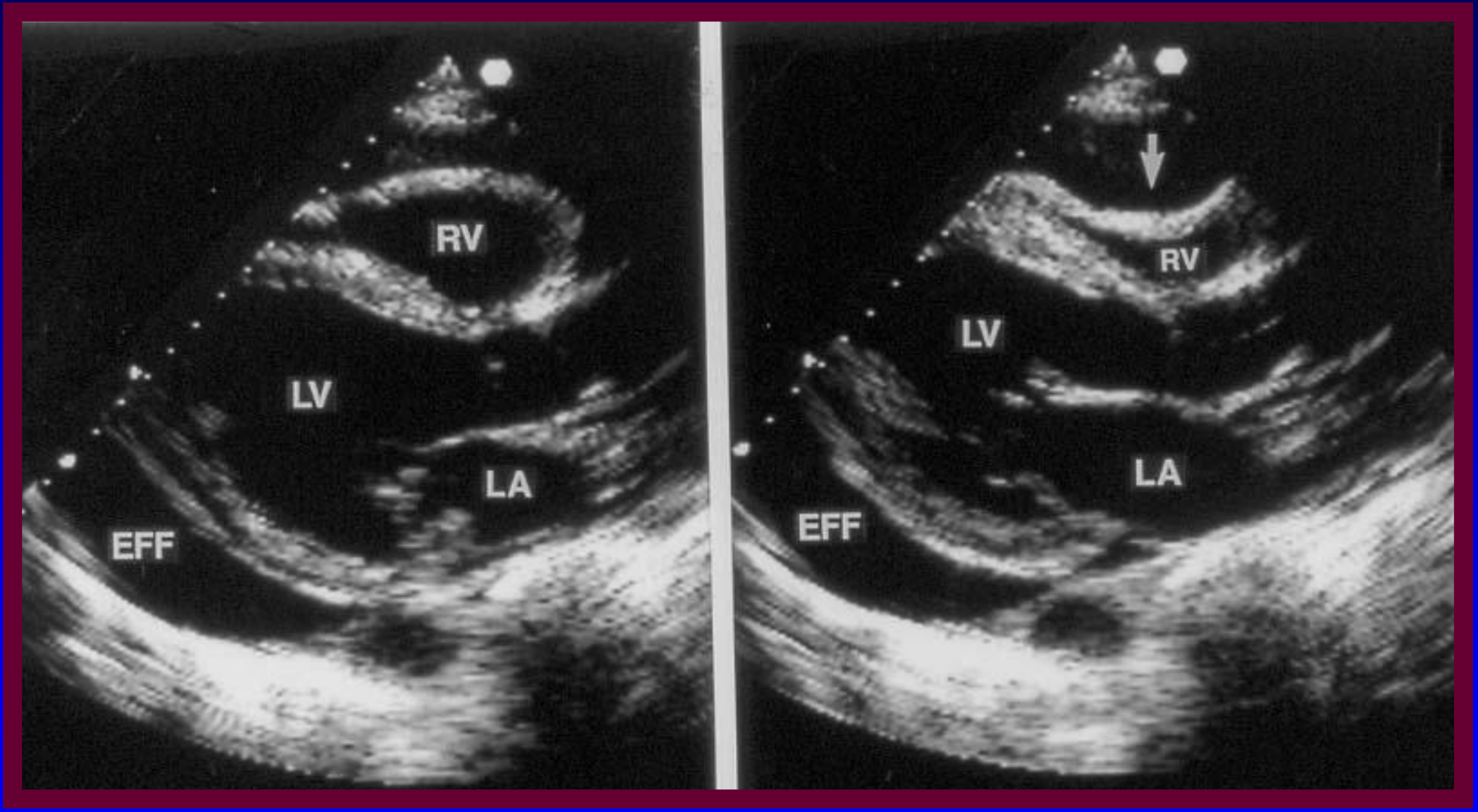
- RA diastolic collapse
- RV diastolic collapse
- Reciprocal variation in ventricular chamber size throughout respiratory cycle
- LA end-diastolic collapse
- Lack of IVC inspiratory collapse
- Swinging heart
- LV pseudohypertrophy

RA Systolic Collapse

- Inversion/collapse RA free wall
- Longer duration of inversion likely tamponade
- Inversion>1/3 systole —

94% Sensitive
100% Specific

Cardiac Tamponade
Diastolic Collapse of Right Ventricle



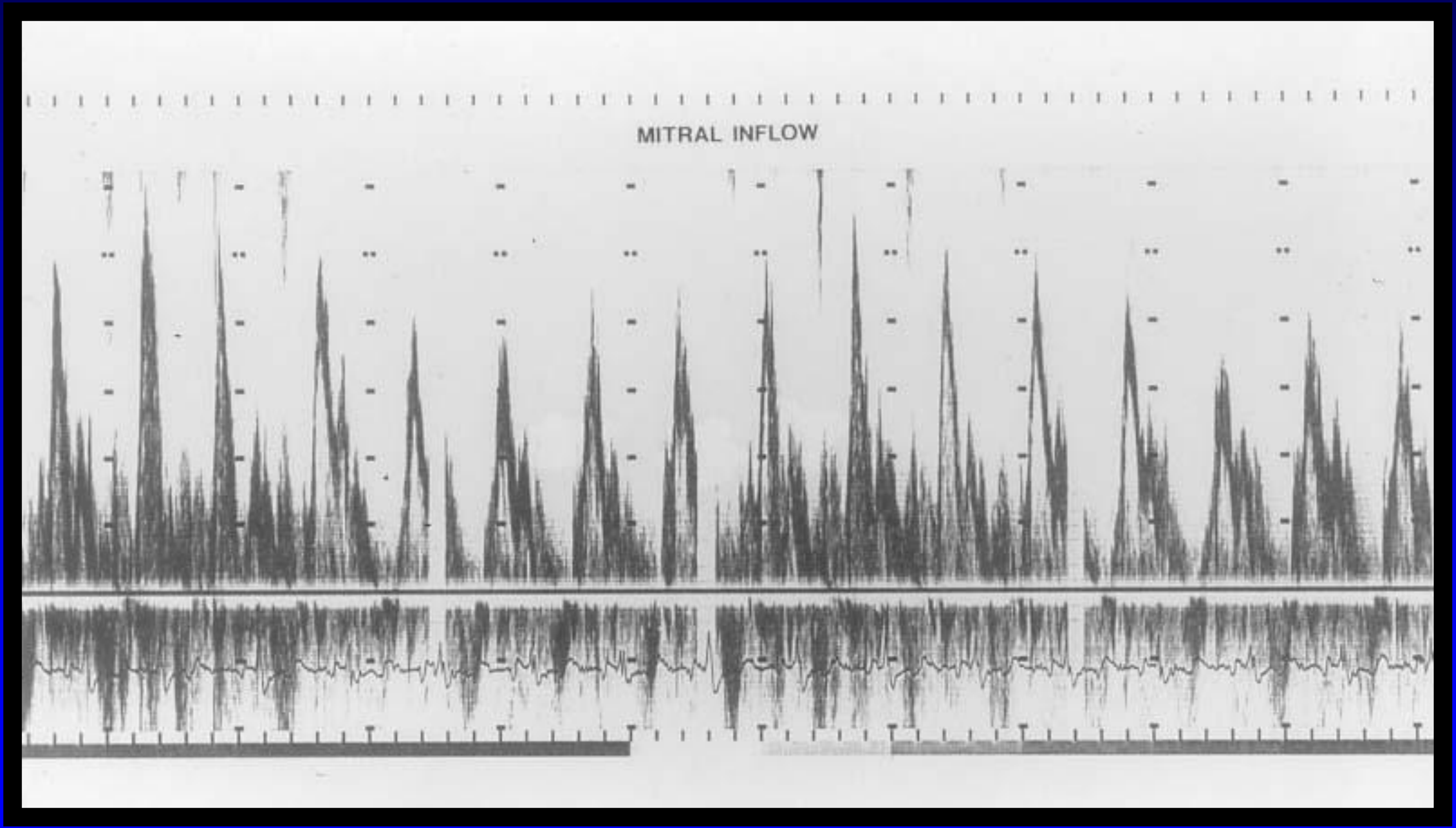
RV Diastolic Collapse

- Intrapericardial pressure>RV diastolic pressure
- Sensitivity — 60-90%
- Specificity — 85-100%

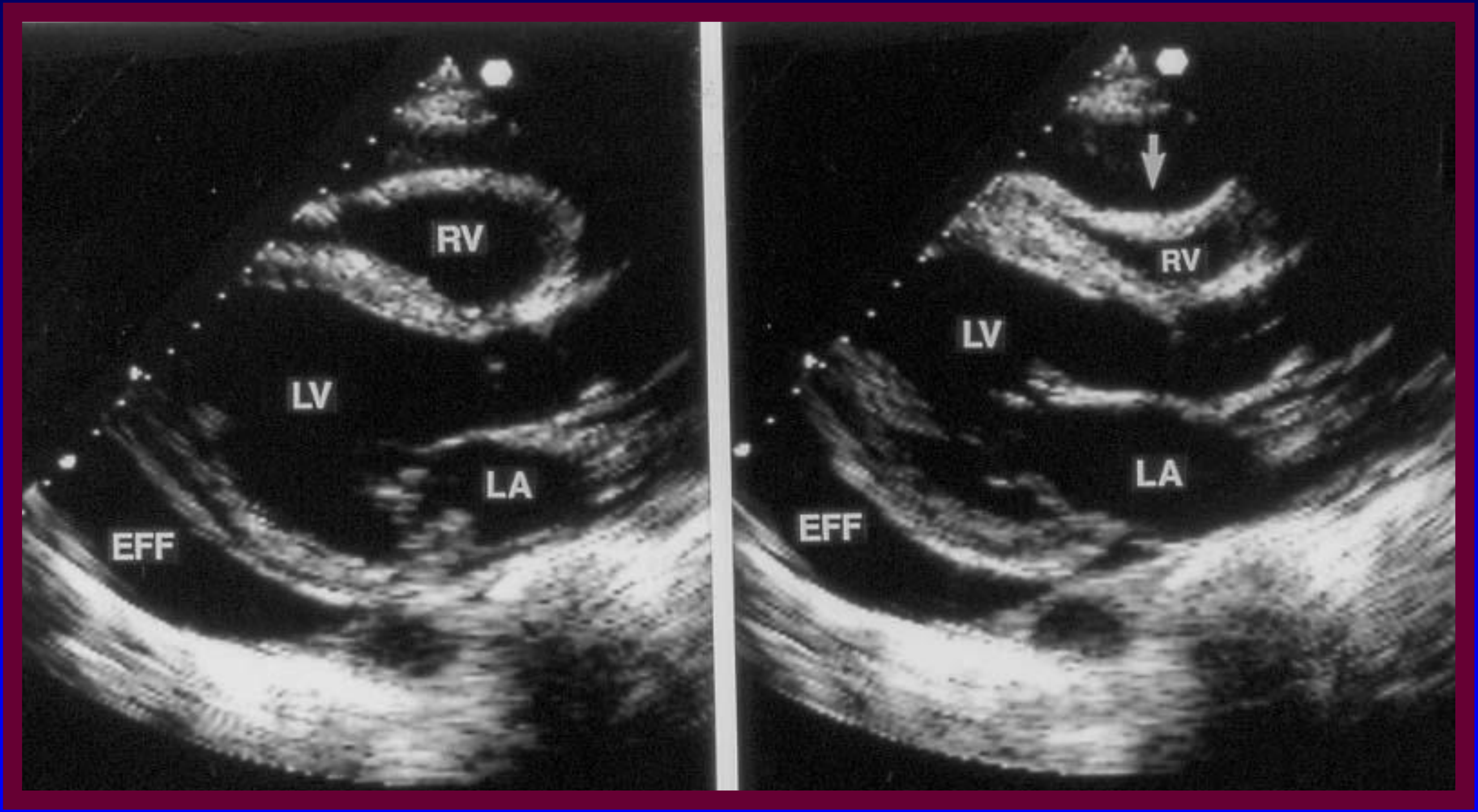
Cardiac Tamponade
Doppler Features

- Exaggerated inspiratory decrease in mitral inflow velocity
- Exaggerated inspiratory increase in tricuspid inflow velocity
- IVC/SVC: decrease in flow velocity with exp'n

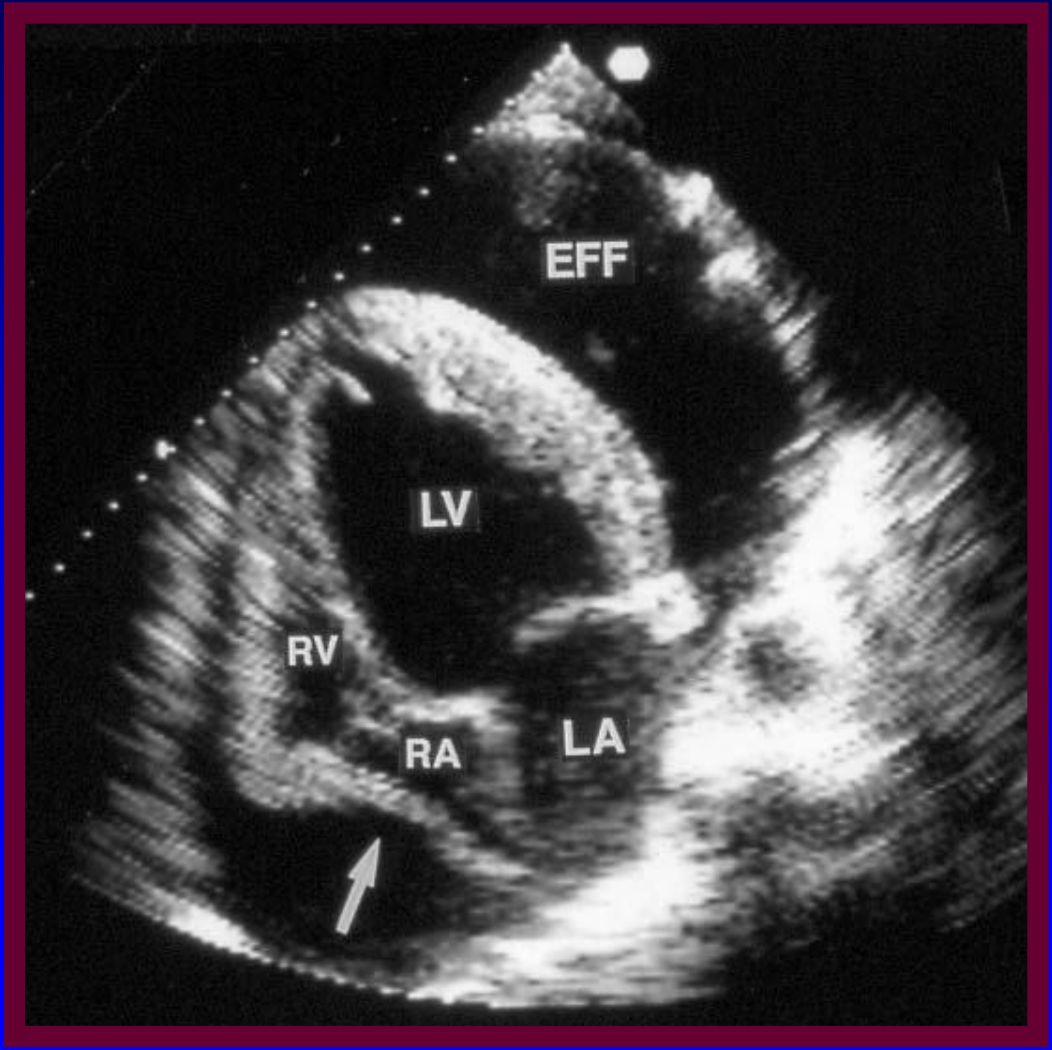
Cardiac Tamponade
Mitral Inflow Pattern



Cardiac Tamponade
Diastolic Collapse of Right Ventricle



Cardiac Tamponade
Right Atrial Collapse



Hydrodynamic compression of the right atrium: a new echocardiographic sign of cardiac tamponade

LINDA D. GILLAM, M.D., DAVID E. GUYER, M.D., THOMAS C. GIBSON, M.D., MARY ETTA KING, M.D., JANE E. MARSHALL, B.S., AND ARTHUR E. WEYMAN, M.D.

ABSTRACT The relationship of right atrial inversion, a previously undescribed cross-sectional echocardiographic sign, to the presence of cardiac tamponade was examined. We studied 127 patients with moderate or large pericardial effusions. Cardiac tamponade was present in 19 and absent in 104. Four patients with equivocal tamponade were excluded from analysis. Right atrial inversion was present in 19 of 19 patients with cardiac tamponade and 19 of 104 without cardiac tamponade (sensitivity, 100%; specificity, 82%; predictive value, 50%). The degree of inversion as quantitated by the area-corrected curvature did not improve the ability to discriminate between patients with and without cardiac tamponade. However, consideration of the duration of inversion by the right atrial inversion time index (duration of inversion/cardiac cycle length) and an empirically derived cut-off of 0.34 did improve the specificity and predictive value (100% and 100%, respectively) without a significant loss of sensitivity (94%). We conclude that right atrial inversion, particularly if prolonged, is a useful echocardiographic marker of cardiac tamponade that may be of particular diagnostic value when the clinical picture is unclear.

***Circulation* 68, No. 2, 294–301, 1983.**

Circulation 68, No. 2, 294-301, 1983

Right Atrial Inversion

	Cardiac tamponade	No cardiac tamponade
RA inversion	19	19
No RA inversion	0	85

Sensitivity 100%

Specificity 82%

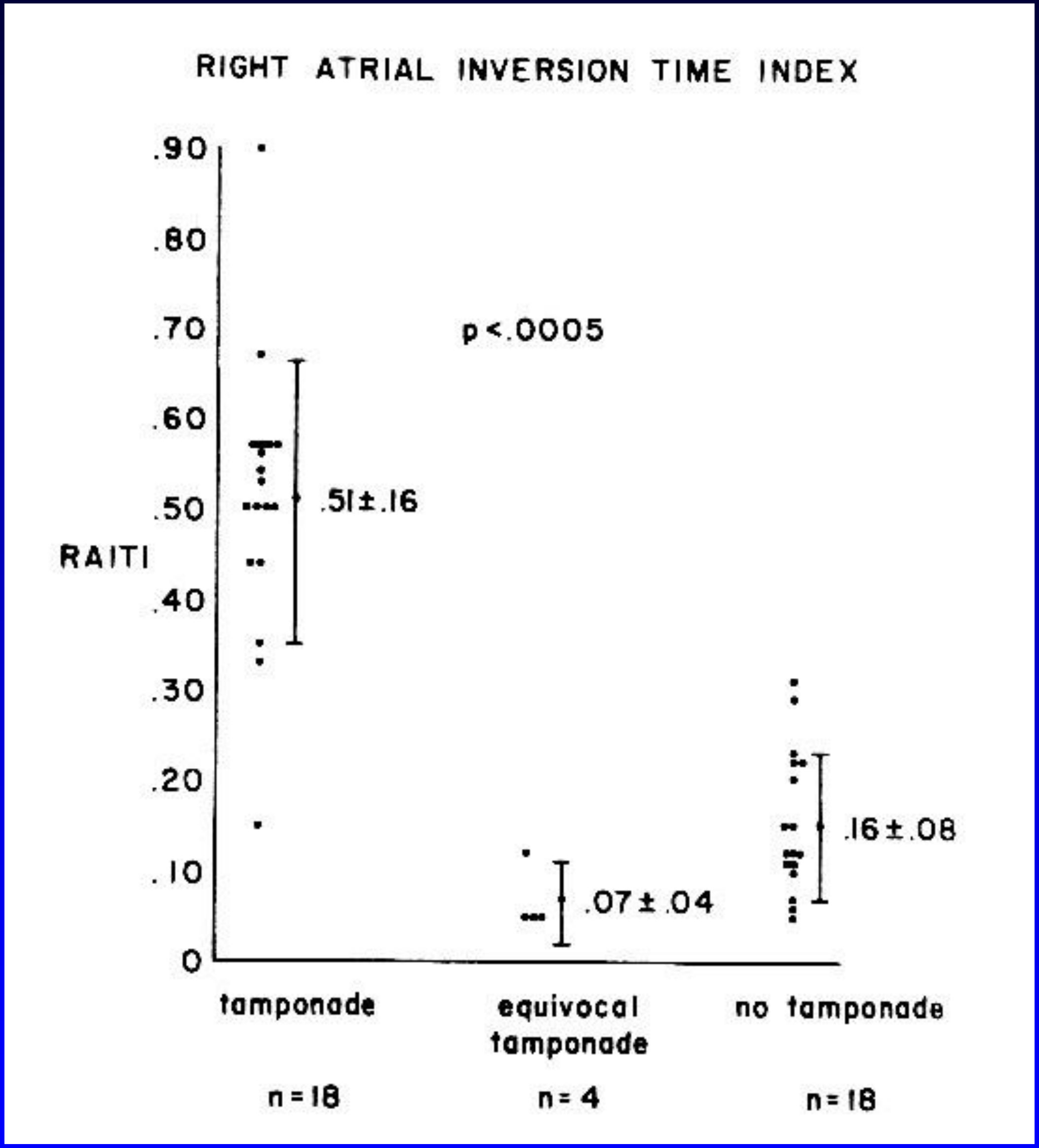
Pred Value 50%

Accuracy 85%

Gillam Circulation 1983;68:294-301

$P < 0.001$

Duration of RA Collapse



Gillam Circulation 1983;68:294-301

Separation of Groups by RA Inversion Time Index

	Cardiac tamponade	No cardiac tamponade
RAITI >0.34	17	0
RAITI <0.34	1	18

Sensitivity 94%

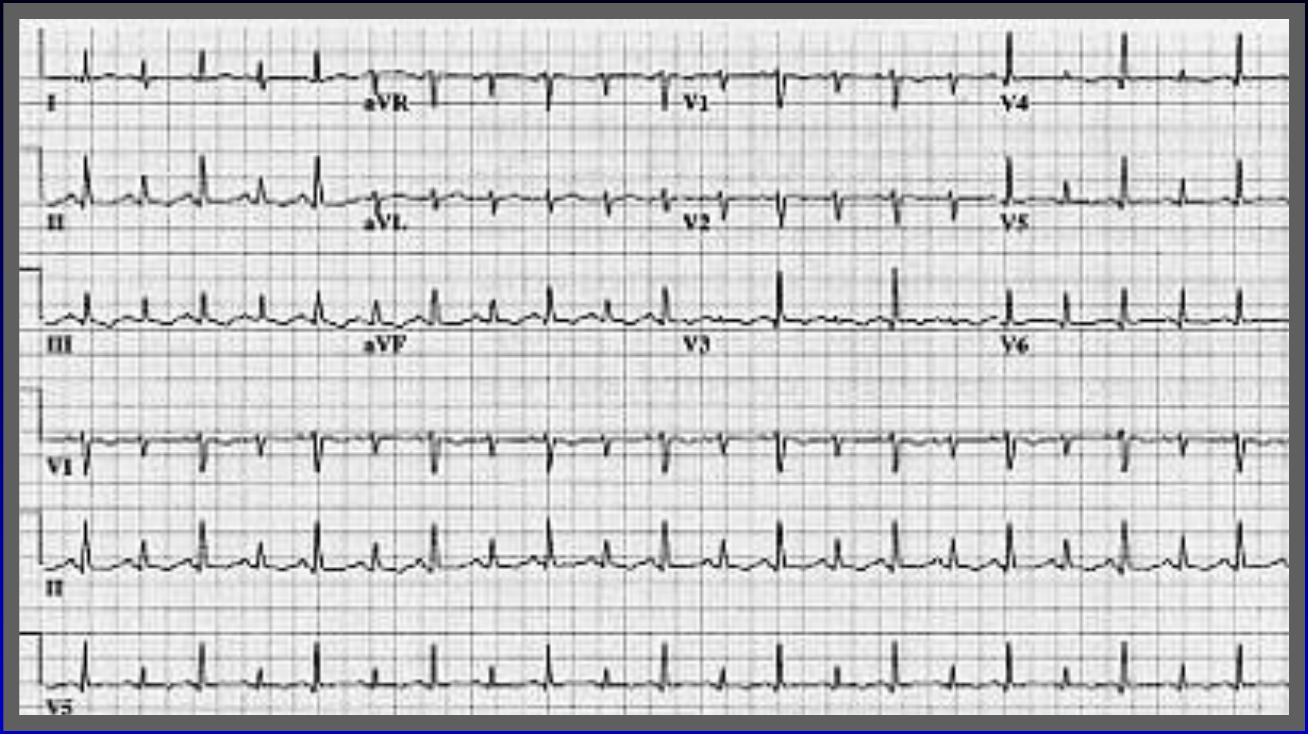
Specificity 100%

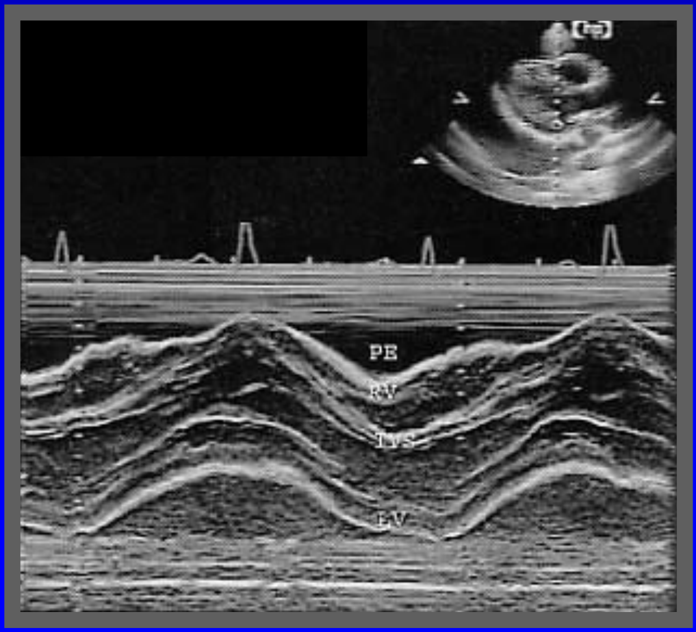
Pred Value 100%

Accuracy 97%

Gillam Circulation 1983;68:294-301

$P < 0.0005$


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
V1
II


PE
RV
IVS
LV

Case

Tamponade

Case

AR - 24 year-old woman

Tamponade

Cardiac Tamponade after Cardiac Procedures

Coronary interventions	0.2%
EP procedures	0.2 – 0.5%
Cardiac surgery	1.5 – 2.0%

Constriction

Echocardiographic Diagnosis of Constrictive Pericarditis

Mayo Clinic Criteria

Terrence D. Welch, MD; Lieng H. Ling, MBBS, MD; Raul E. Espinosa, MD; Nandan S. Anavekar, MBBCh; Heather J. Wiste, BA; Brian D. Lahr, MS; Hartzell V. Schaff, MD; Jae K. Oh, MD

Background**—**Constrictive pericarditis is a potentially reversible cause of heart failure that may be difficult to differentiate from restrictive myocardial disease and severe tricuspid regurgitation. Echocardiography provides an important opportunity to evaluate for constrictive pericarditis, and definite diagnostic criteria are needed.

Methods and Results**—**Patients with surgically confirmed constrictive pericarditis (n=130) at Mayo Clinic (2008–2010) were compared with patients (n=36) diagnosed with restrictive myocardial disease or severe tricuspid regurgitation after constrictive pericarditis was considered but ruled out. Comprehensive echocardiograms were reviewed in blinded fashion. Five principal echocardiographic variables were selected based on prior studies and potential for clinical use: (1) respiration-related ventricular septal shift, (2) variation in mitral inflow E velocity, (3) medial mitral annular e' velocity, (4) ratio of medial mitral annular e' to lateral e', and (5) hepatic vein expiratory diastolic reversal ratio. All 5 principal variables differed significantly between the groups. In patients with atrial fibrillation or flutter (n=29), all but mitral inflow velocity remained significantly different. Three variables were independently associated with constrictive pericarditis: (1) ventricular septal shift, (2) medial mitral e', and (3) hepatic vein expiratory diastolic reversal ratio. The presence of ventricular septal shift in combination with either medial e'≥9 cm/s or hepatic vein expiratory diastolic reversal ratio ≥0.79 corresponded to a desirable combination of sensitivity (87%) and specificity (91%). The specificity increased to 97% when all 3 factors were present, but the sensitivity decreased to 64%.

Conclusions**—**Echocardiography allows differentiation of constrictive pericarditis from restrictive myocardial disease and severe tricuspid regurgitation. Respiration-related ventricular septal shift, preserved or increased medial mitral annular e' velocity, and prominent hepatic vein expiratory diastolic flow reversals are independently associated with the diagnosis of constrictive pericarditis. **(*Circ Cardiovasc Imaging*. 2014;7:526-534.)**

Circ Cardiovasc Imaging 2014;7:526-534

Constrictive Pericarditis

Definition

An abnormally thickened* and rigid pericardium which causes restriction to diastolic filling

* note: up to 20% of pts have normal pericardial thickness

Constrictive Pericarditis

Pathophysiology

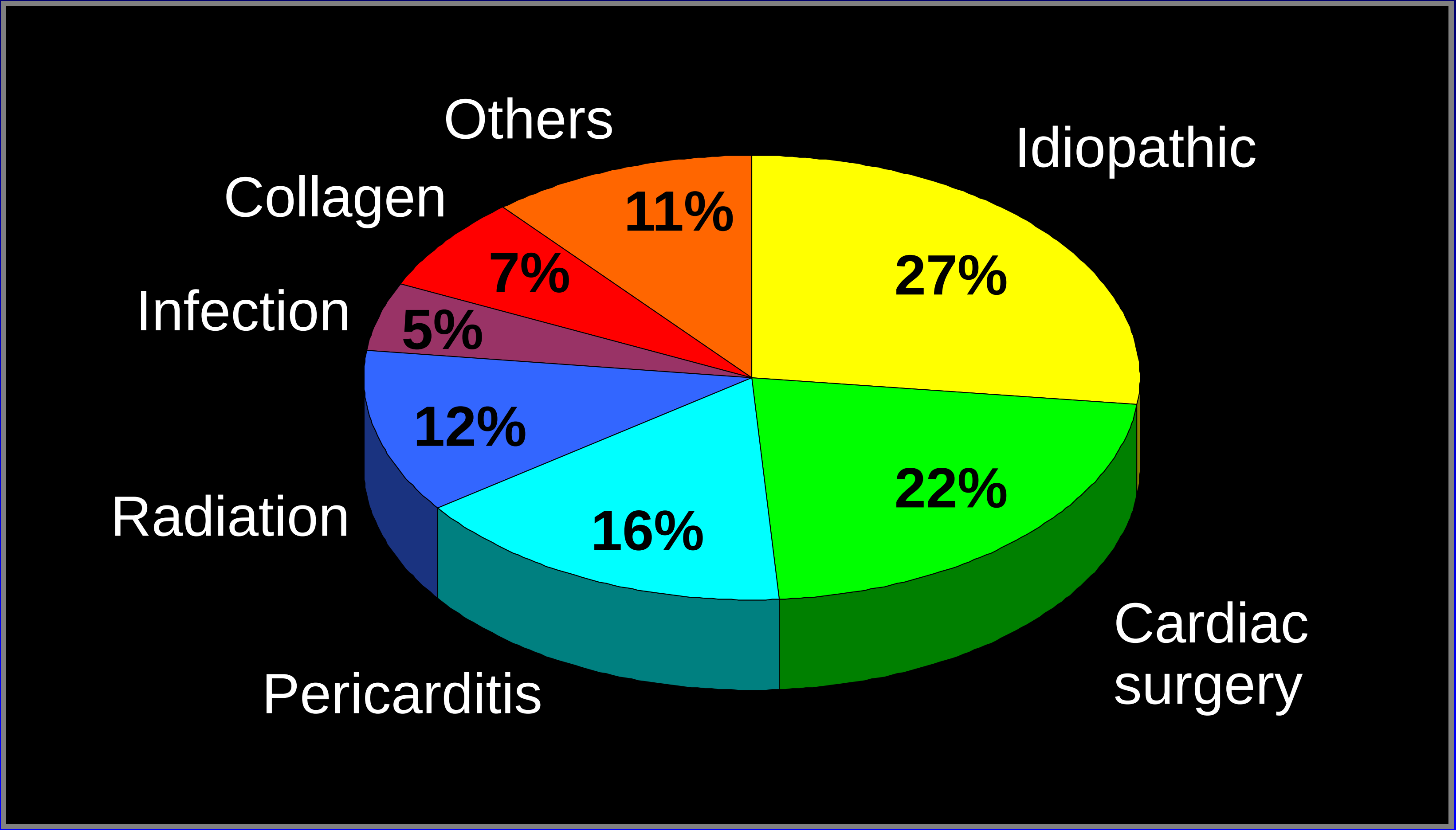
- Thickened, scarred, and sometimes calcified pericardium
- Impairs diastolic filling of heart ("imprisons" the heart)
- Elevated and equal diastolic pressures in all 4 chambers
- RA and JVP may increase with inspiration (Kussmaul's sign)

Constrictive Pericarditis
Hemodynamic Characteristics

- Pericardial resistance in later 2/3 diastole
- Elevation and equalization of diastolic pressures
- Venous return biphasic: prominent "X" and "Y"
  ↓ intracardiac volume, SV, CO
- Insp augmentation of venous return blunted
- Kussmaul's sign
- Pulsus paradoxus uncommon (33%)
- Ventricular discordance

Constructive Pericarditis Etiologies (1985 to 1998)

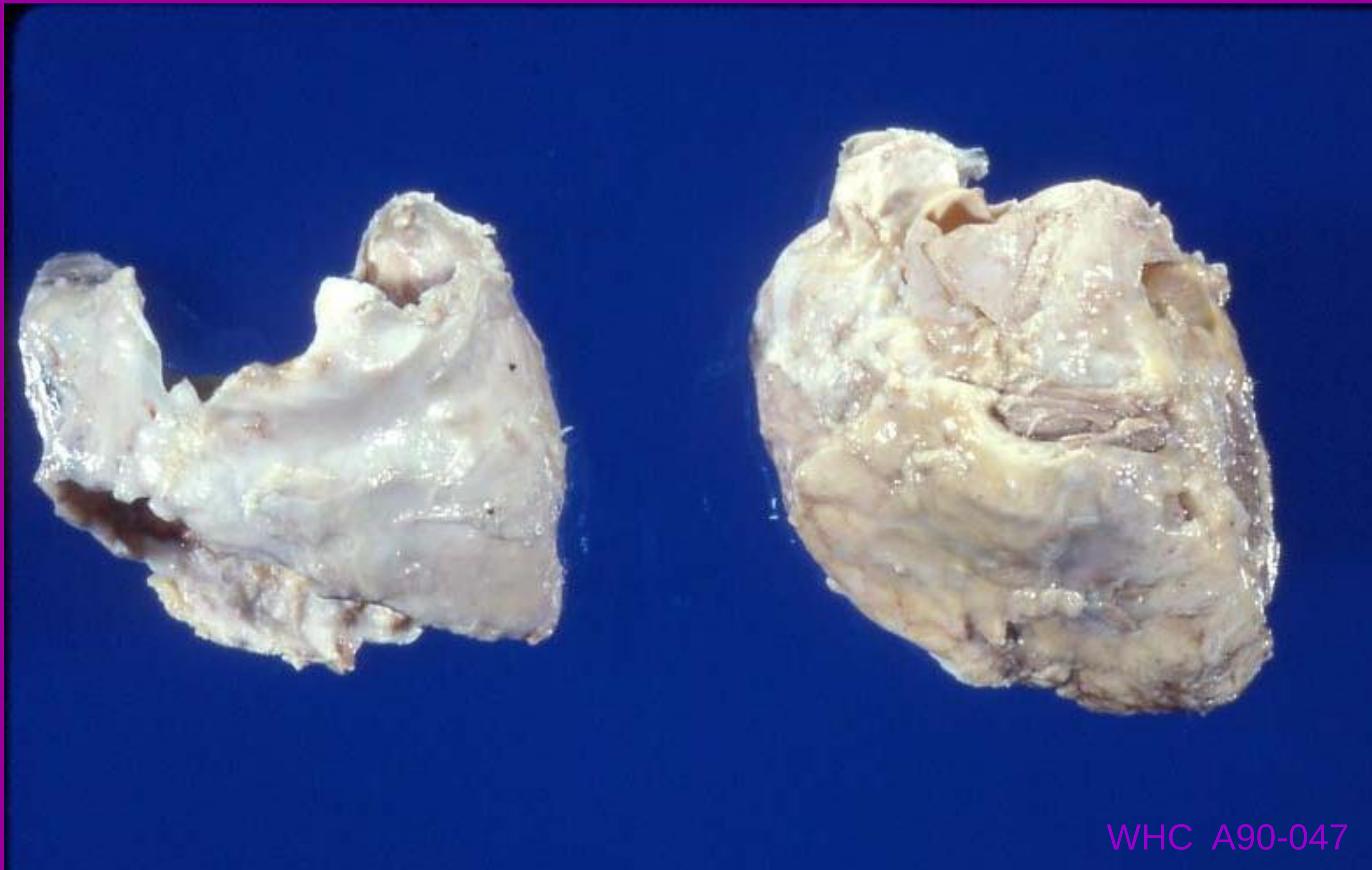
n = 212



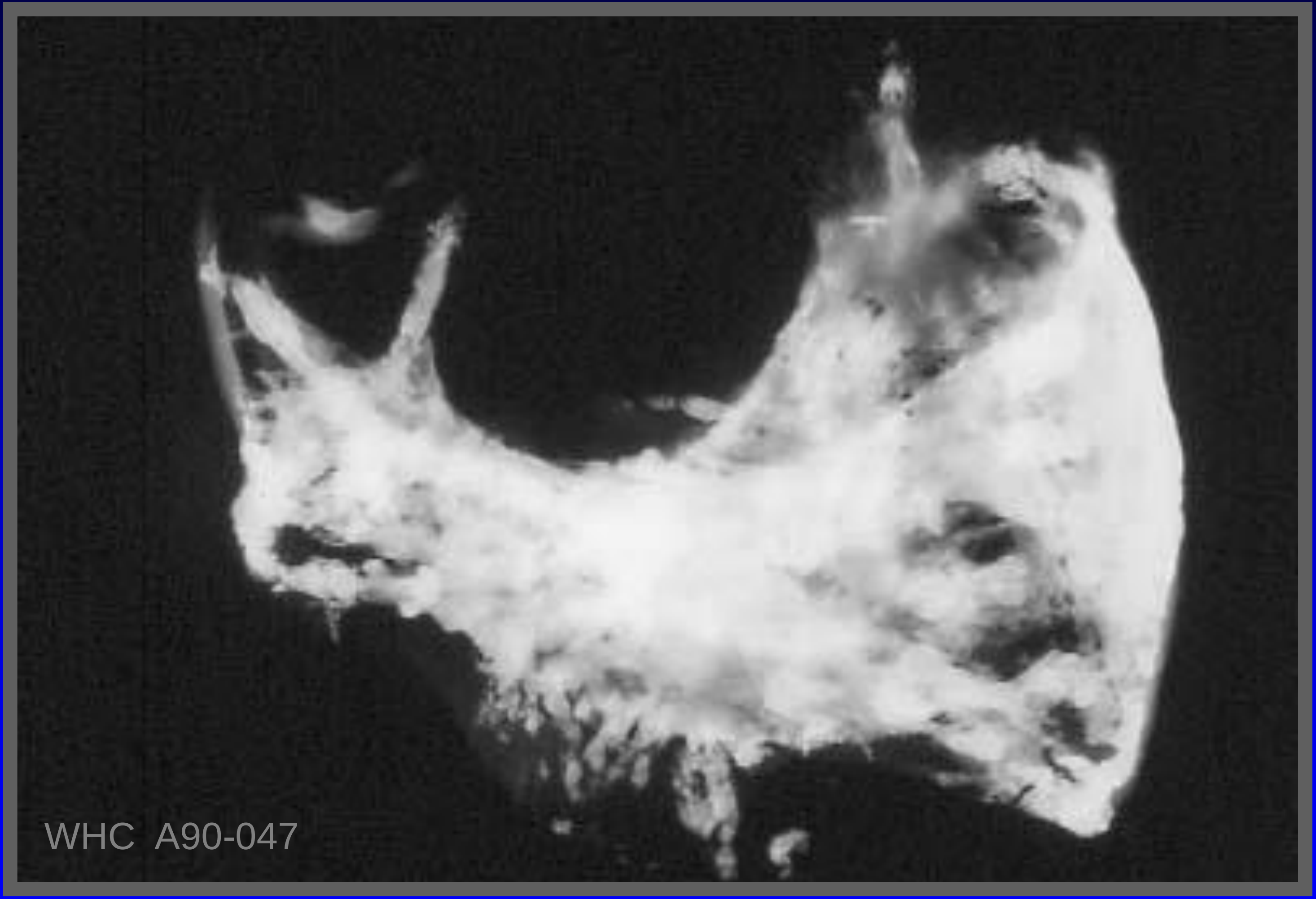
Ling Circulation 100:1380(1999)

Constrictive Pericarditis

Constrictive Pericarditis



Constrictive Pericarditis



Pathophysiology of Constrictive Pericarditis

CP results from thickening of pericardium

↓

Layers become adherent

↓

Limits diastolic distensibility

↓

Dissociation of intrathoracic and intracardiac pressures with respiration

↓

Increased LV and RV interdependence

↓

Hinders diastolic filling

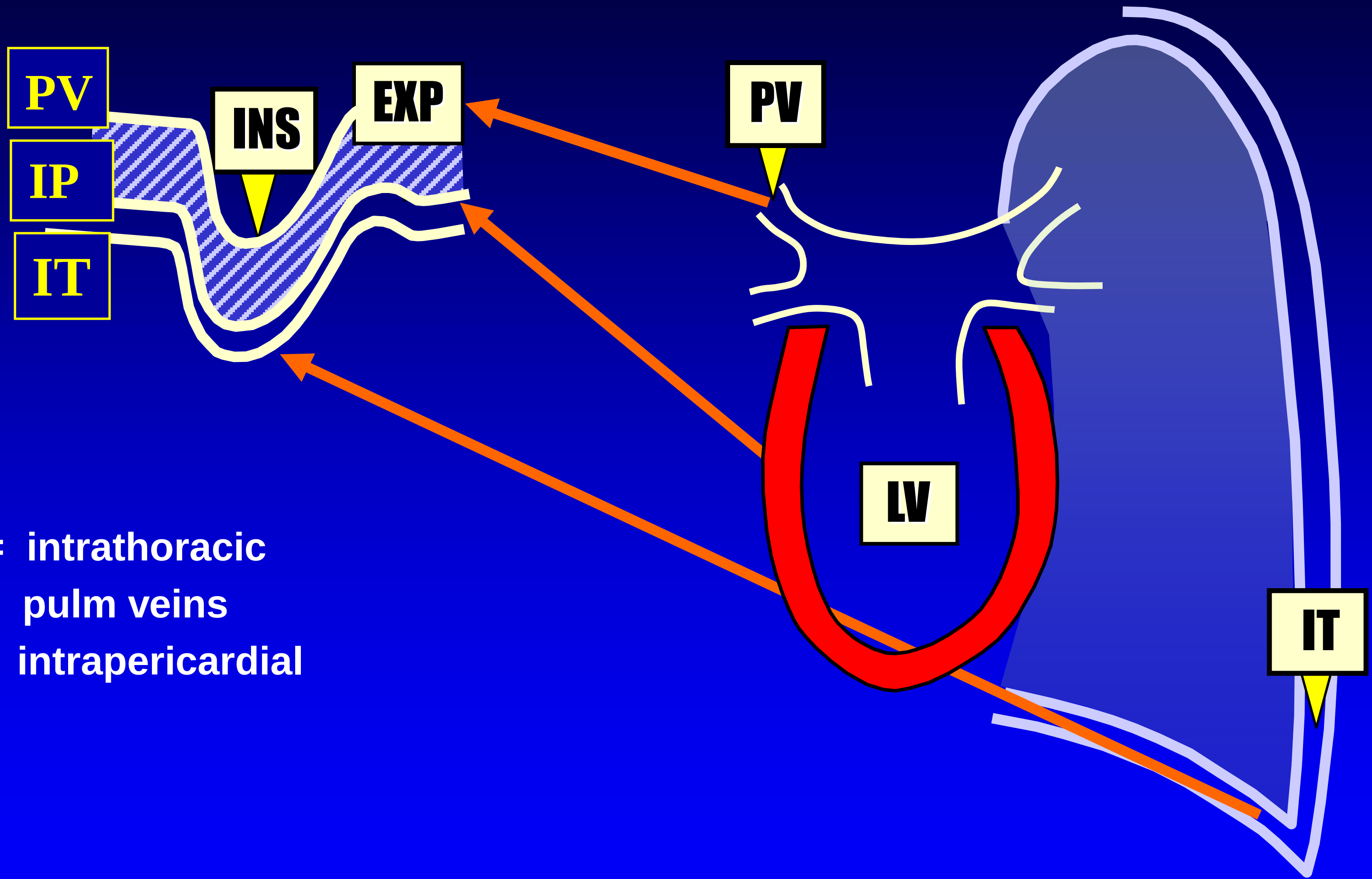
Constrictive Pericarditis Pathophysiology

2 keys

1. Dissociation of intrathoracic and intracardiac pressures

2. Enhanced ventricular interaction

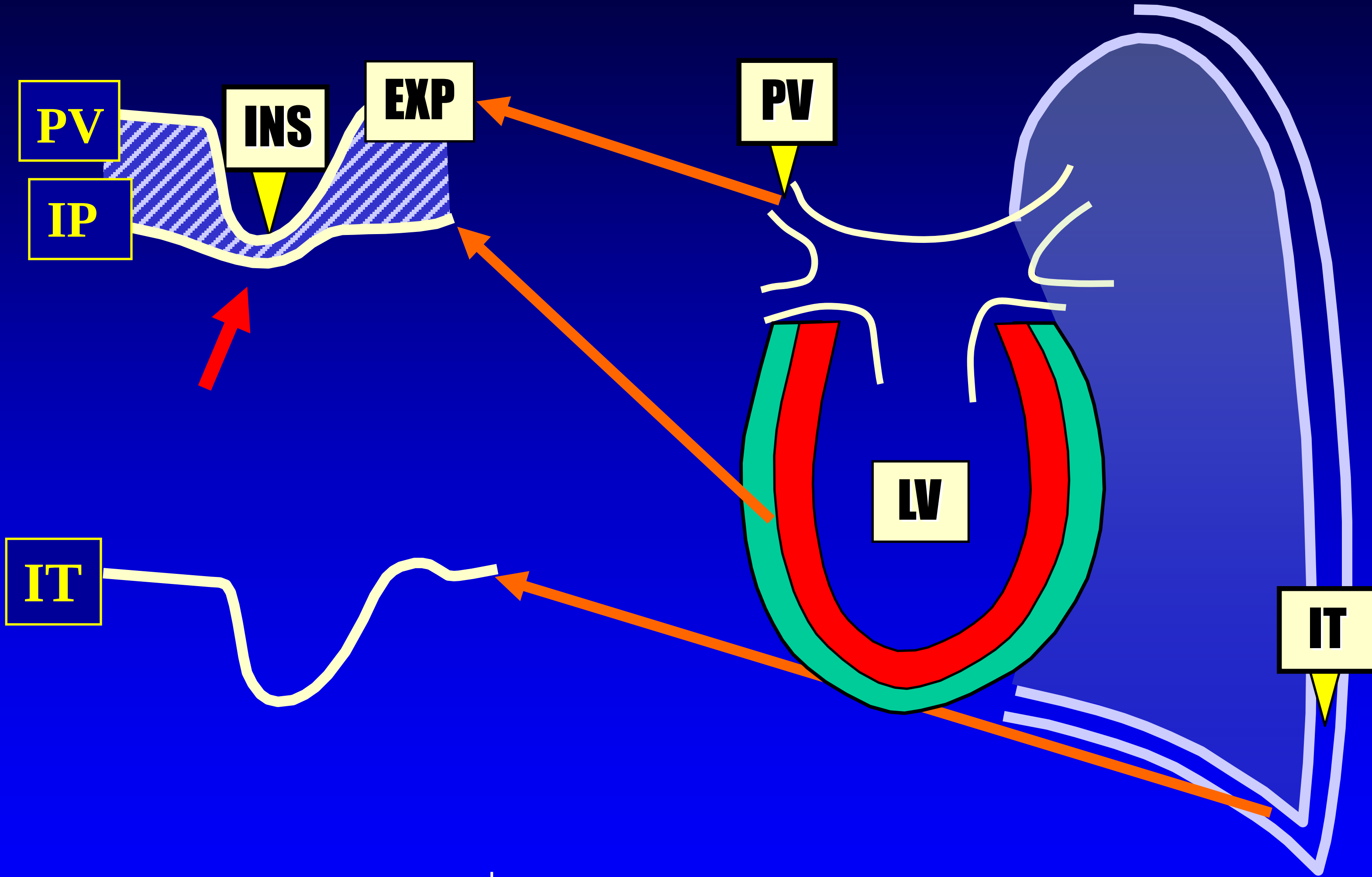
Normal Physiology



IT = intrathoracic
PV = pulm veins
IP = intrapericardial

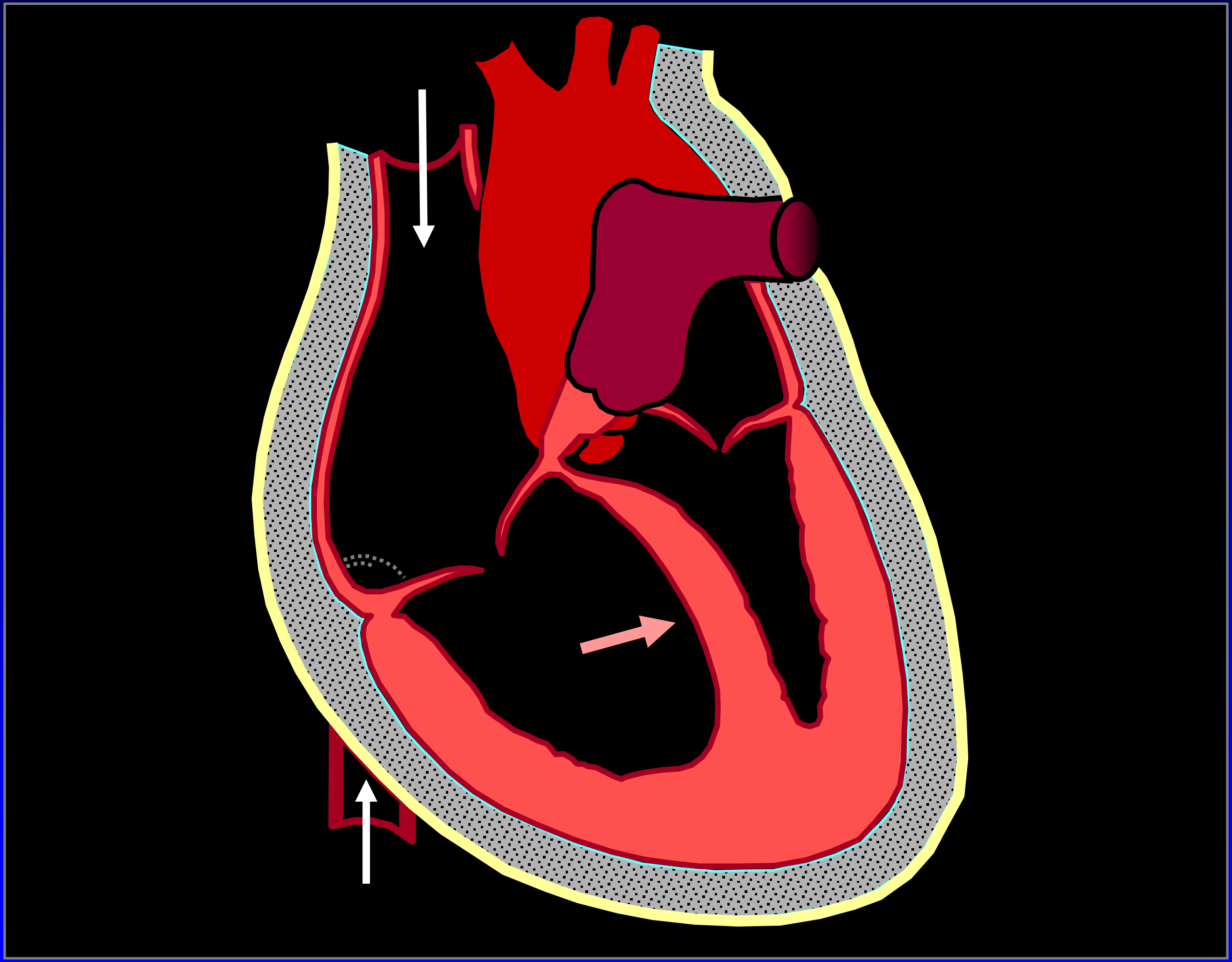
Inspiratory decrease in intrathoracic pressure is transmitted to the heart

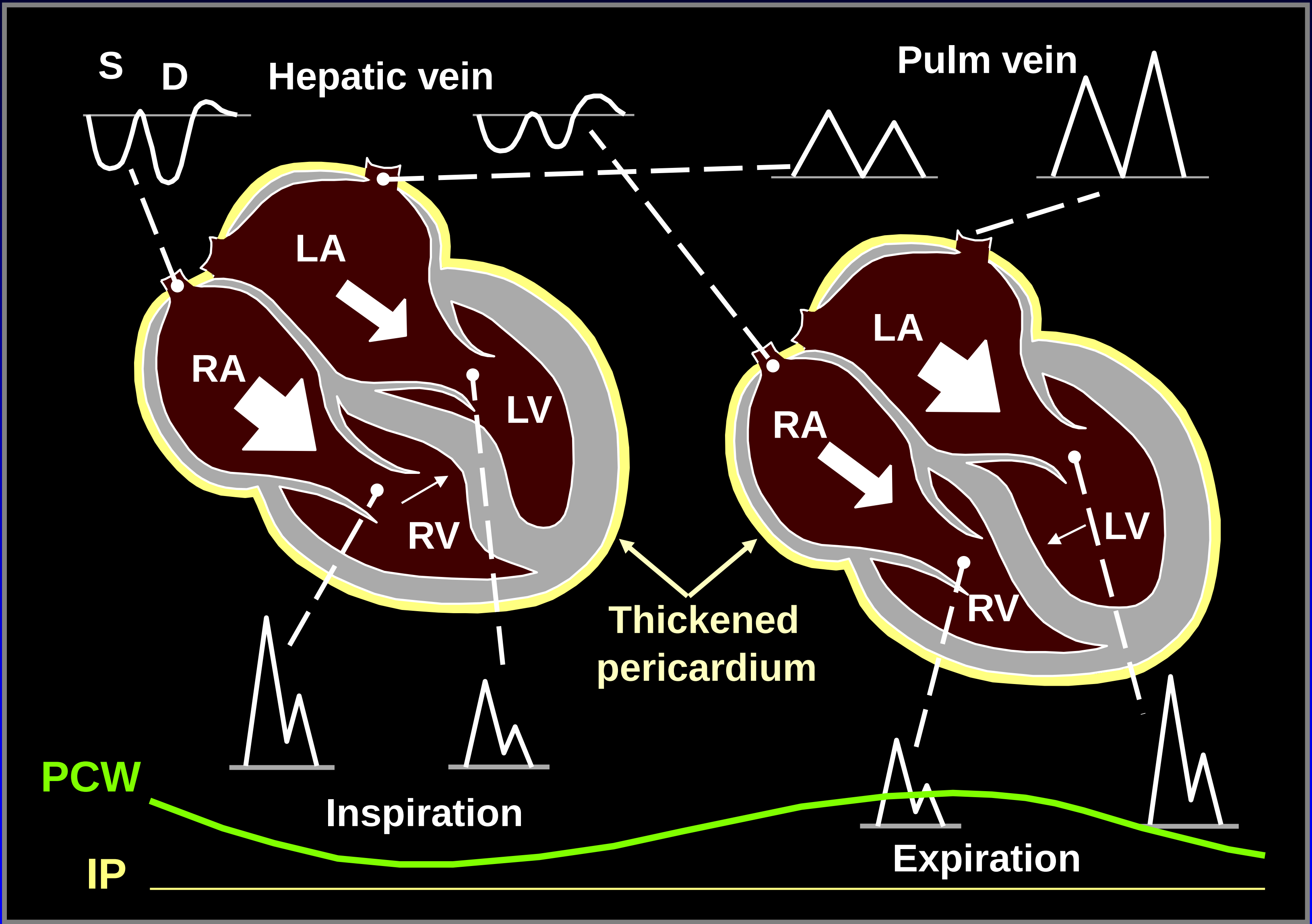
Constriction Physiology



Inspiration results in a ↓LV filling pressure gradient due to smaller pressure decrease in the pericardium and LV compared to PCWP

Constriction (in inspiration)




S
D
Hepatic vein
Pulm vein
LA
RA
LV
RV
LA
RA
LV
RV
Thickened pericardium
PCW
Inspiration
Expiration
IP

These dynamic changes can be used to diagnose constrictive pericarditis and to differentiate CP from restrictive CM

Constrictive Pericarditis
Diagnosis

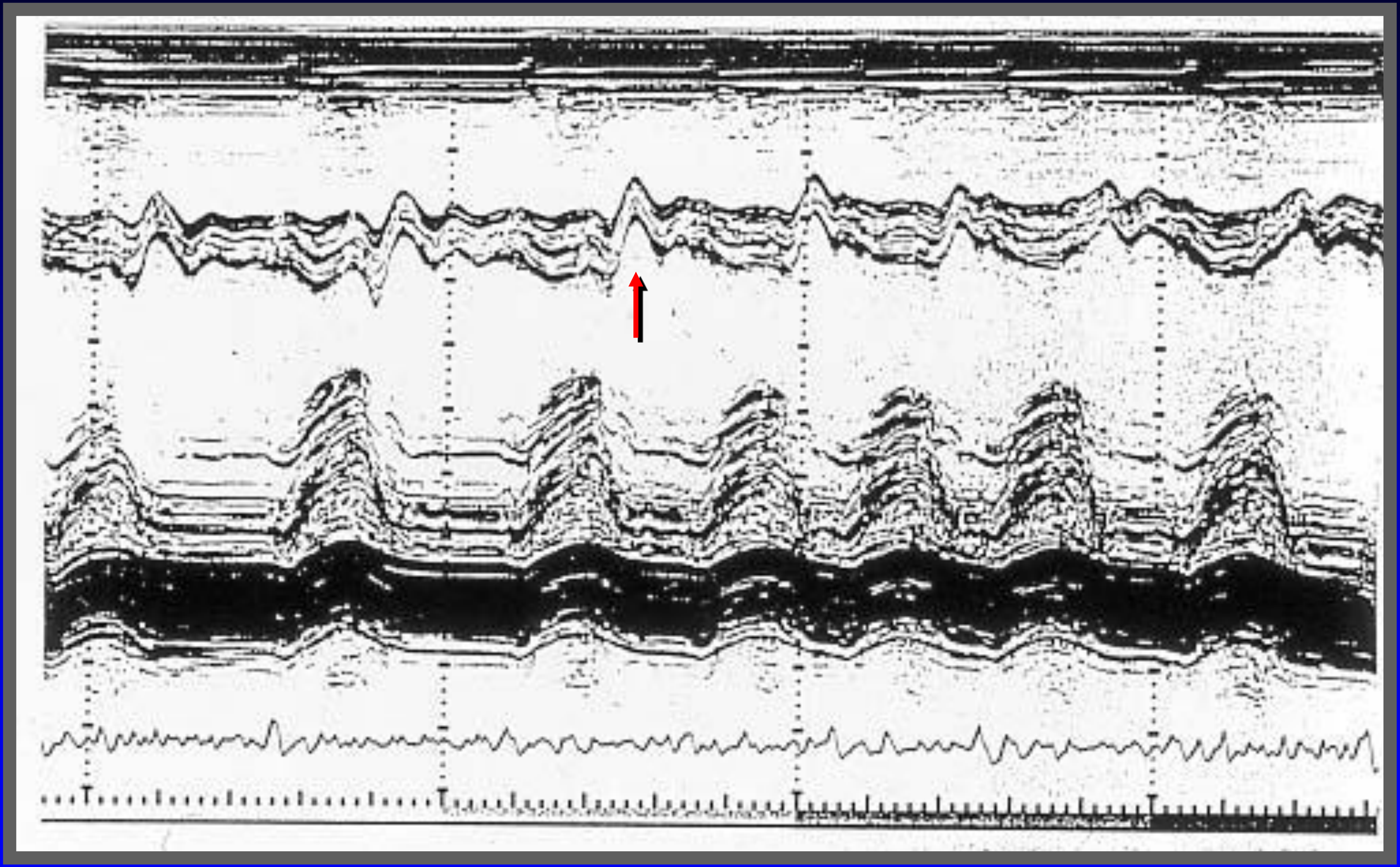
- Dx can be straightforward when clinical, hemo-dynamic, and echo-Doppler findings typical
- But dx often elusive, even after extensive evaluation
- **Echo-Doppler → initial and key test**

Constrictive Pericarditis

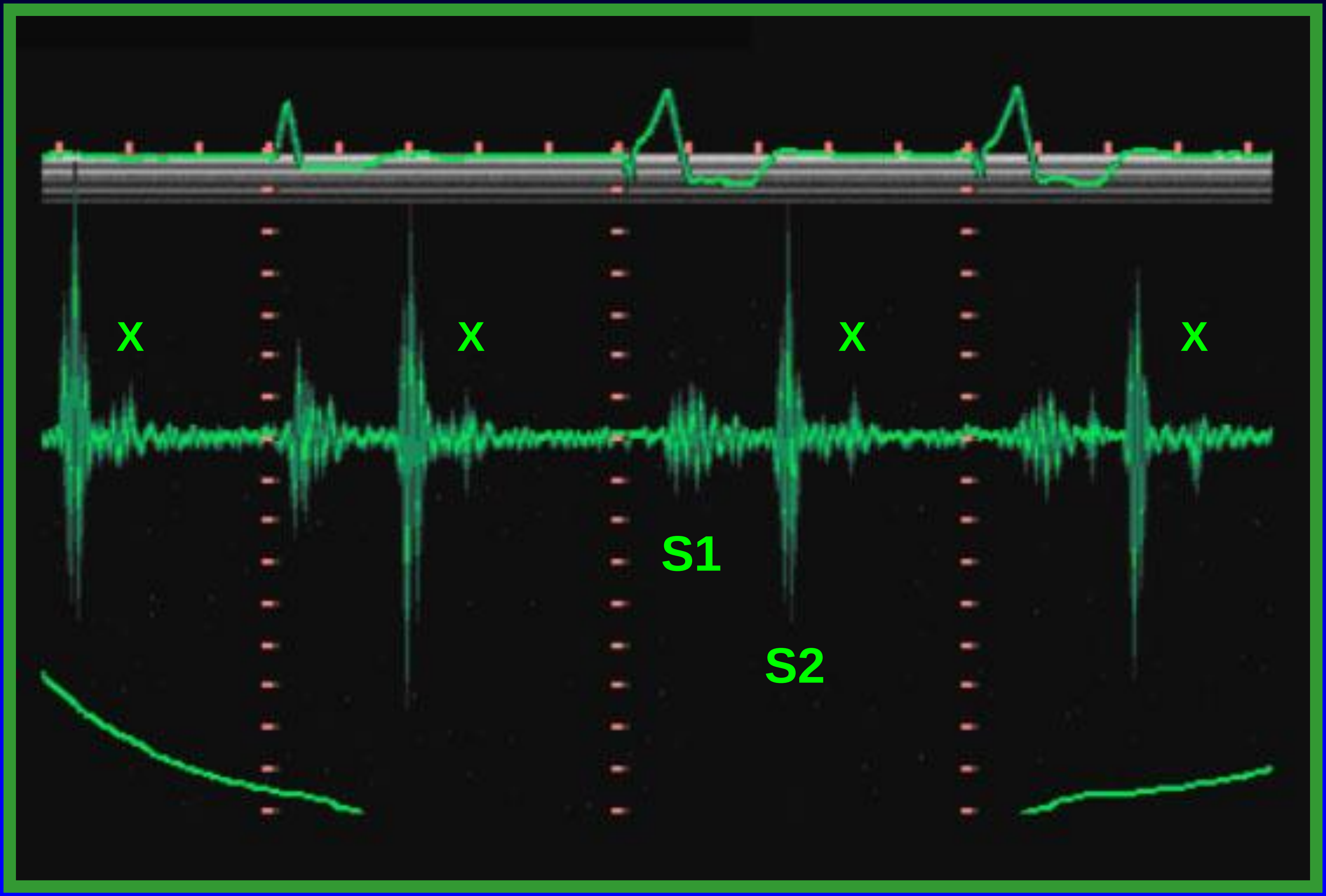
Echo-Doppler Findings

Constrictive Pericarditis
M-Mode Echo

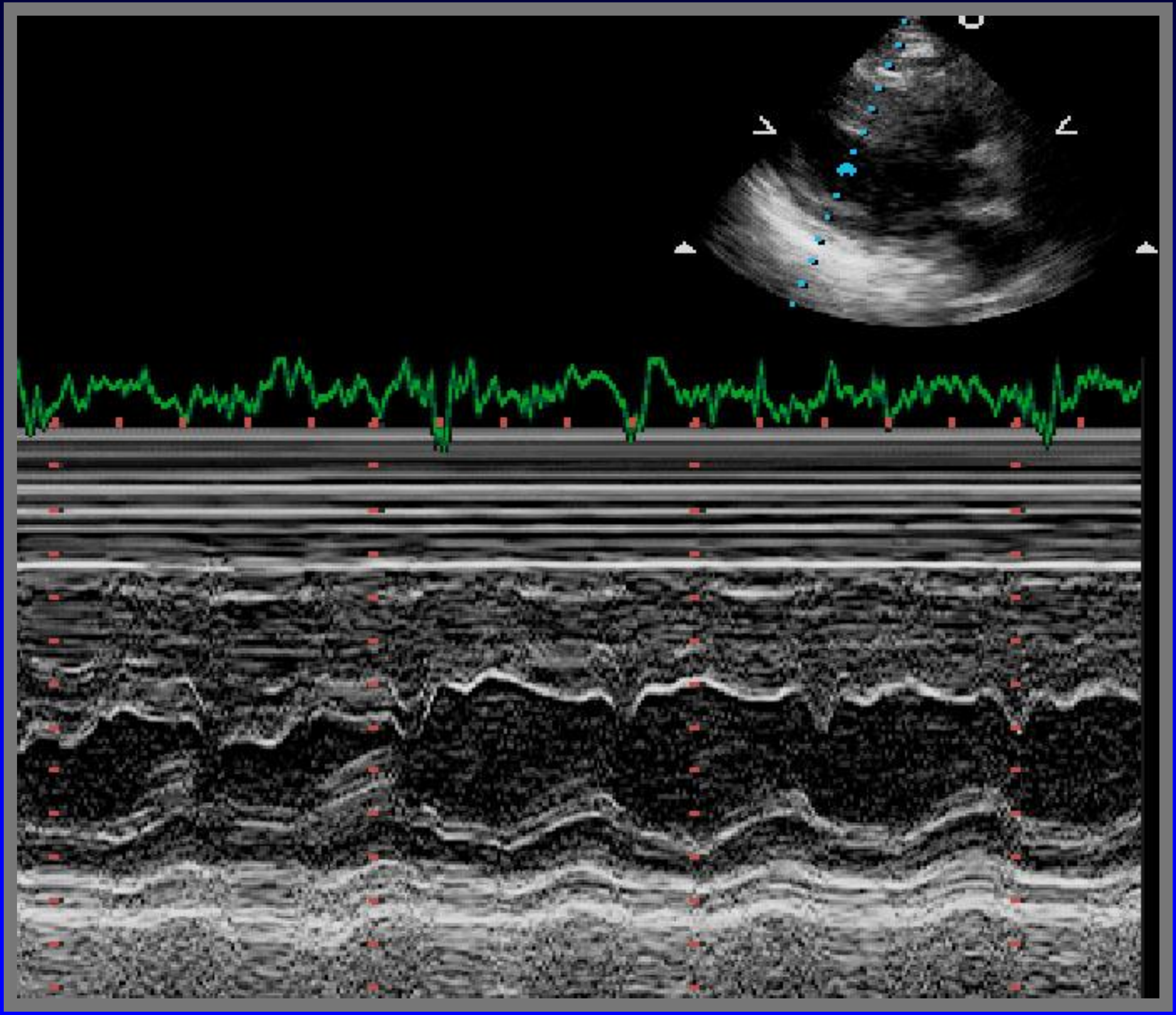
- Ventricular dimensions usually normal
- Ventricular function is preserved
- Pericardial thickening (only up to 40%) → MRI and CT superior
- Left atrial enlargement (75%)
- **Premature pulmonic valve opening (≤10%)**
- **Paradoxic septal motion - "diastolic septal bounce"**
- Diastolic flattening of LV posterior wall motion



Case 28

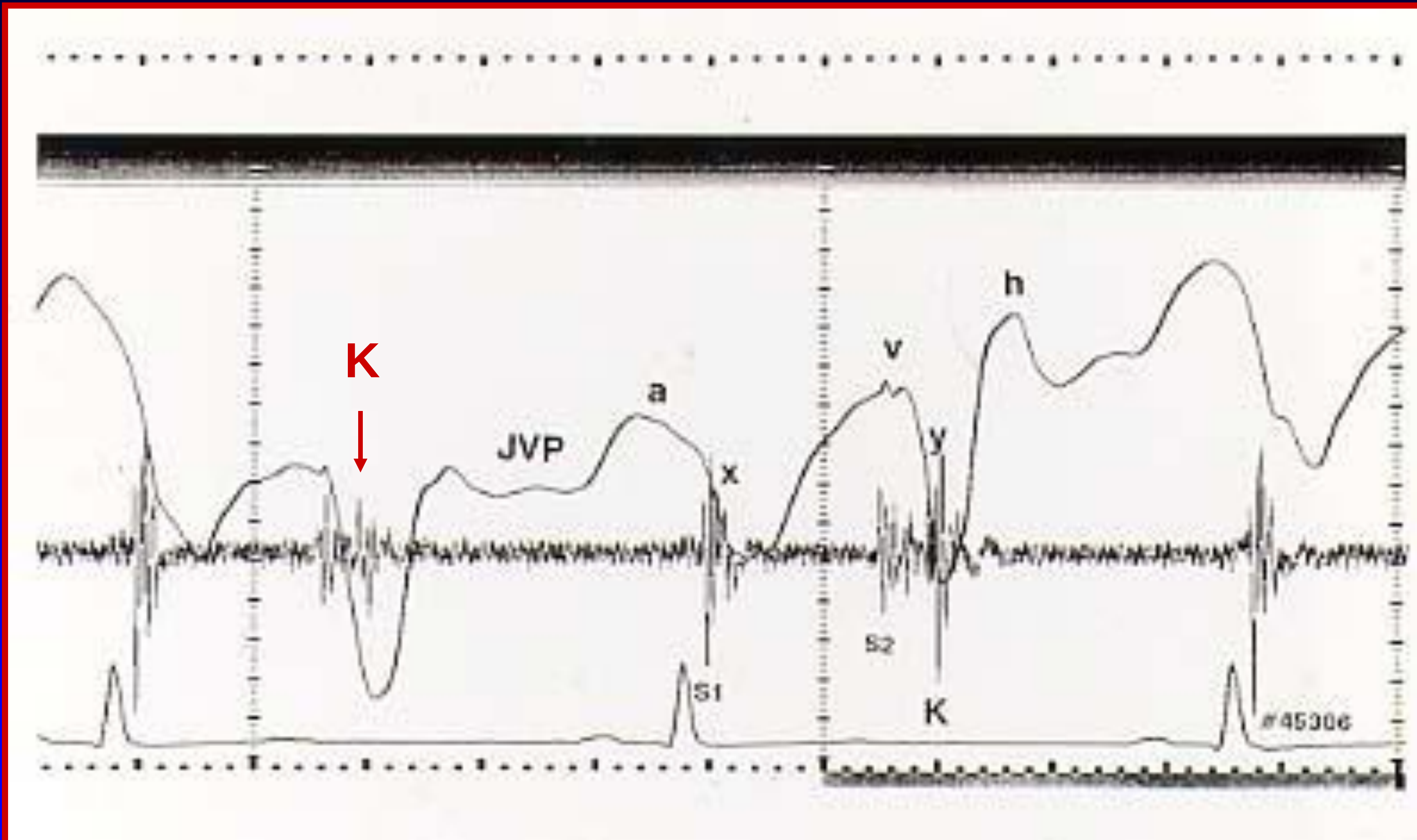


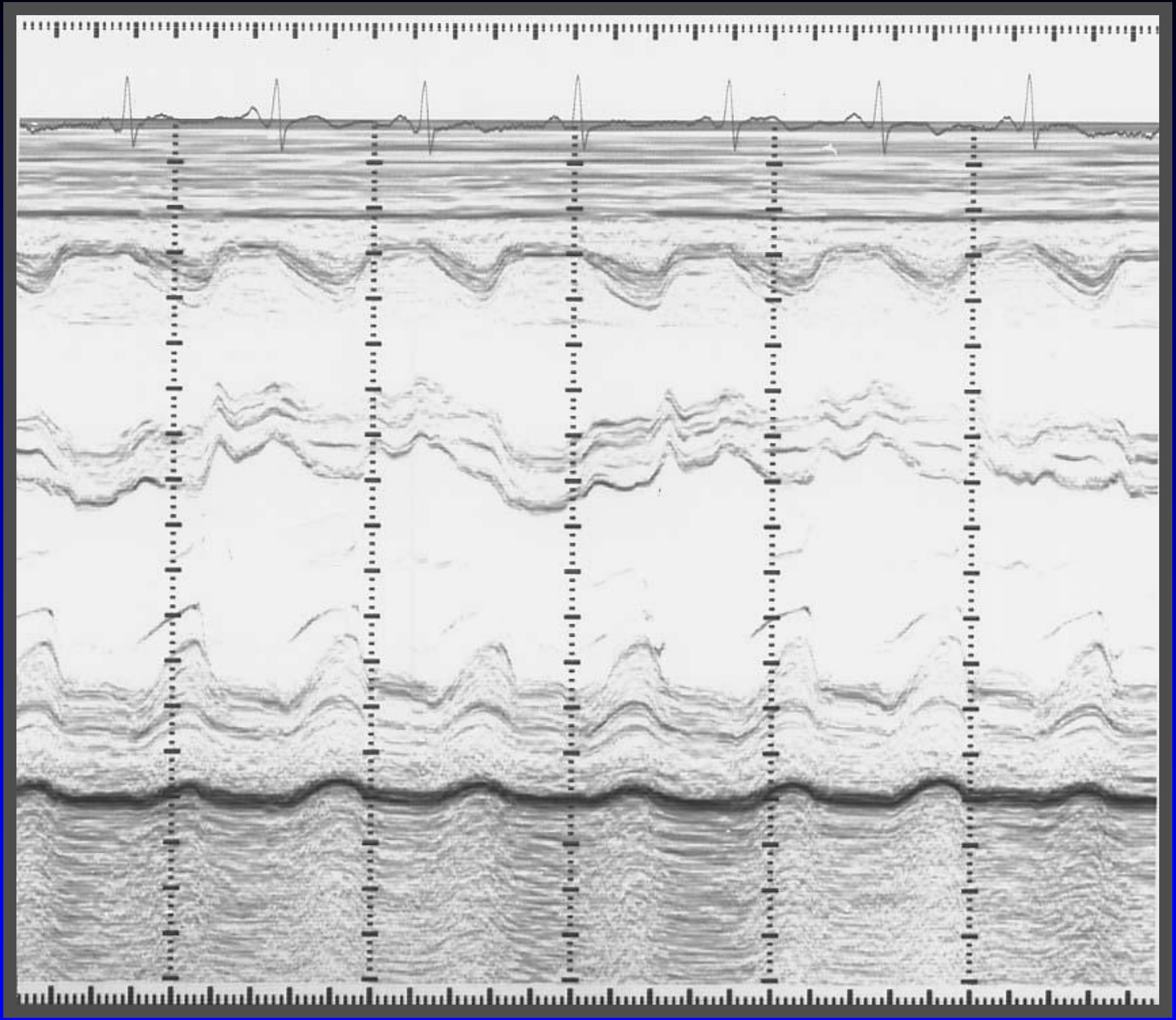
Constrictive Pericarditis

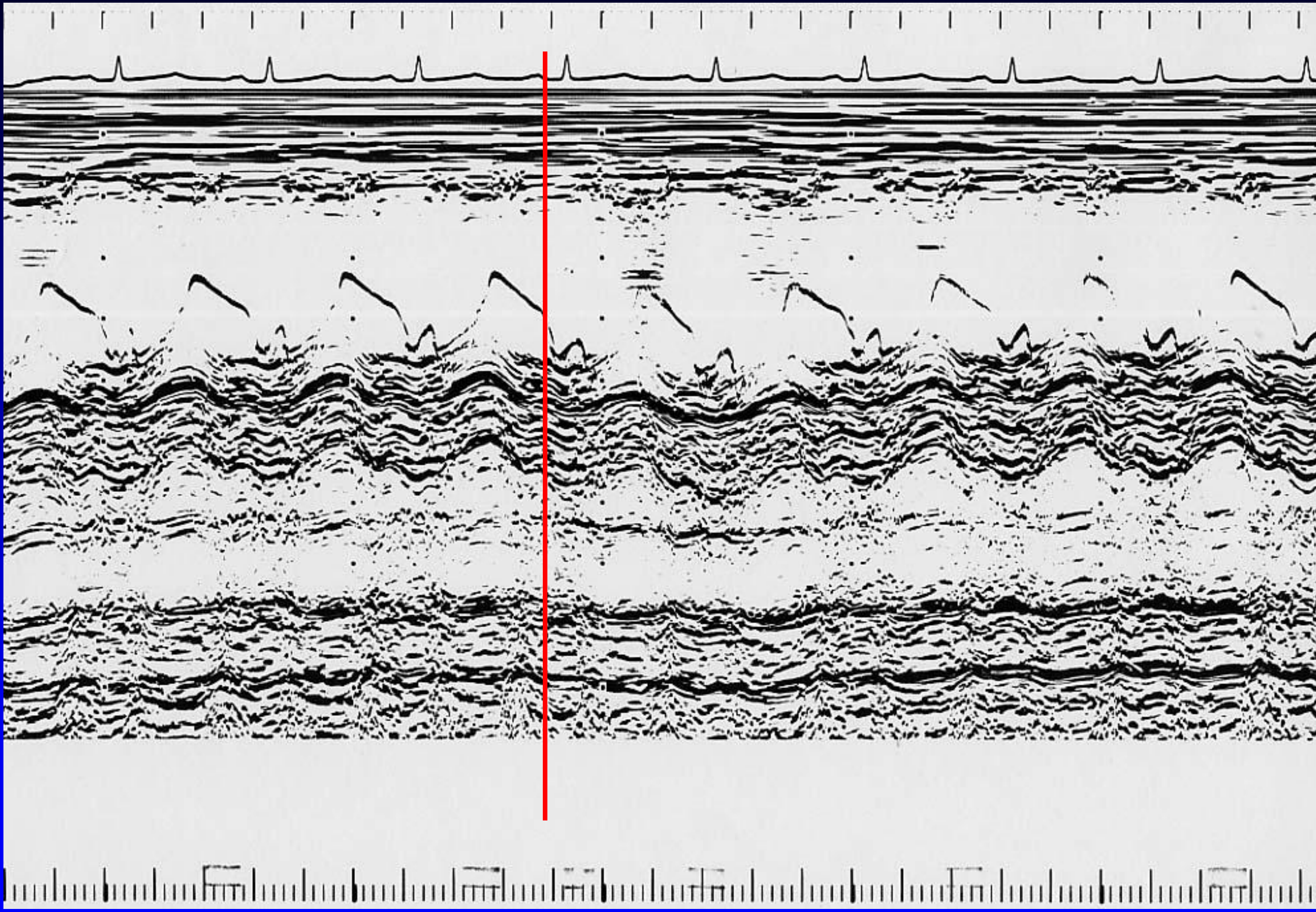


Latasha Bowser
MR 214-76-04
157655

Phonocardiogram and JVP Tracing







Early opening of pulmonic valve c/w elevated RVEDP (eg constr peri, TR)

Loretta Young
MR 107-80-94

Constrictive Pericarditis

2D-Echo

- Ventricular dimensions usually normal
- Ejection fraction usually preserved
- Biatrial enlargement
- Diastolic "septal bounce"
- IVC usually dilated

Protocol for Constrictive Pericarditis

1. More than 2-beats-per clip for all images (minimum of 6 beats/clip)

2. M-mode of LV
   a. PLAX → Obtain several strips (at 50 mm/sec and 25 mm/sec) – to look for septal bounce and for ventricular independence

3. Apical-4 → several clips with 6-10 beats per clip

4. Mitral inflow careful to look for exaggerated respiratory variation of E-wave (use respirometer); also decrease sweep speed to look for resp variation

5. Carefully done TDI of septum and lateral walls

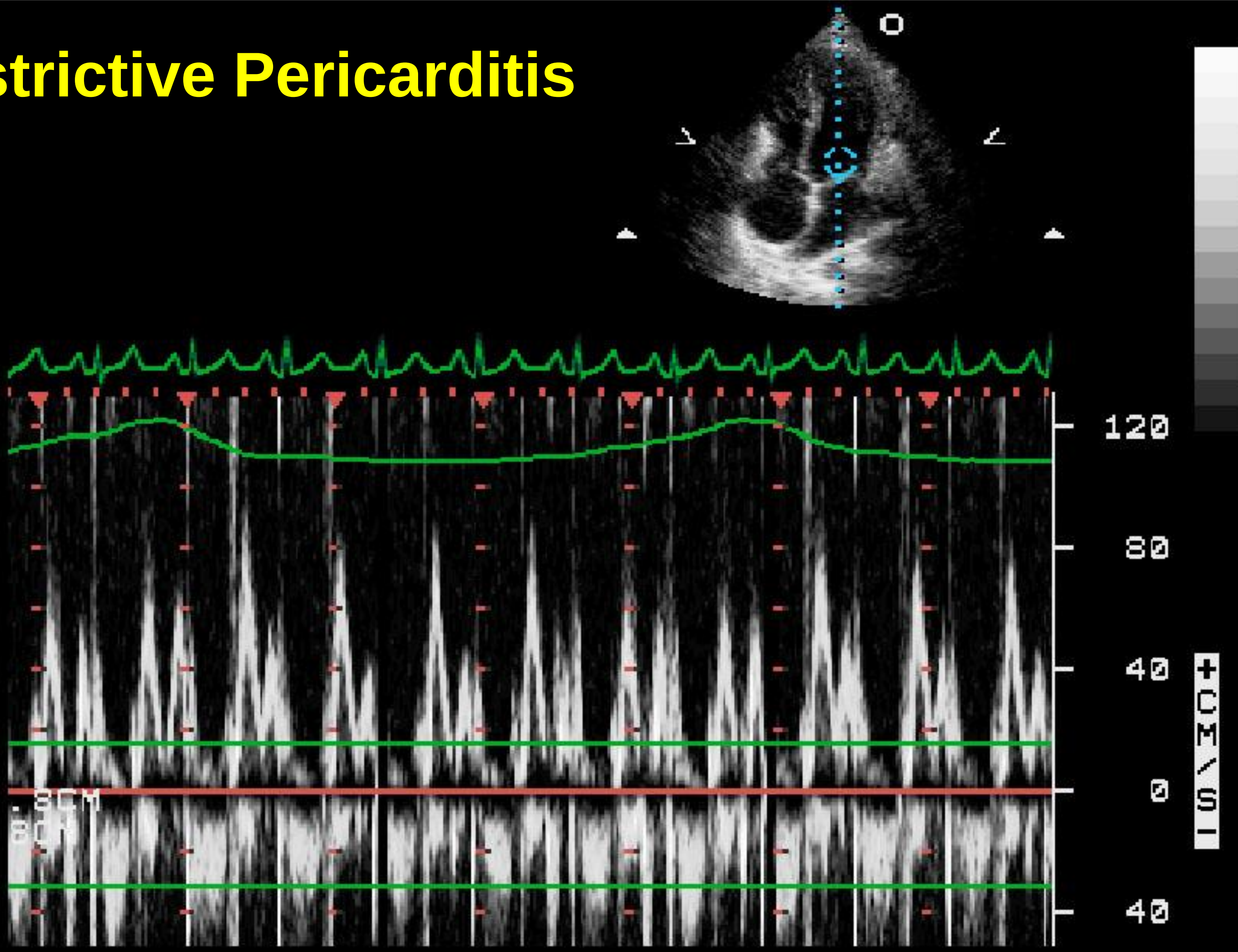
6. IVC – long clips to look for distension and inspiratory collapse

7. Hepatic vein flow with decreased sweep speed (multiple clips)

Strongly suggest that you speak to MD prior to study for instructions

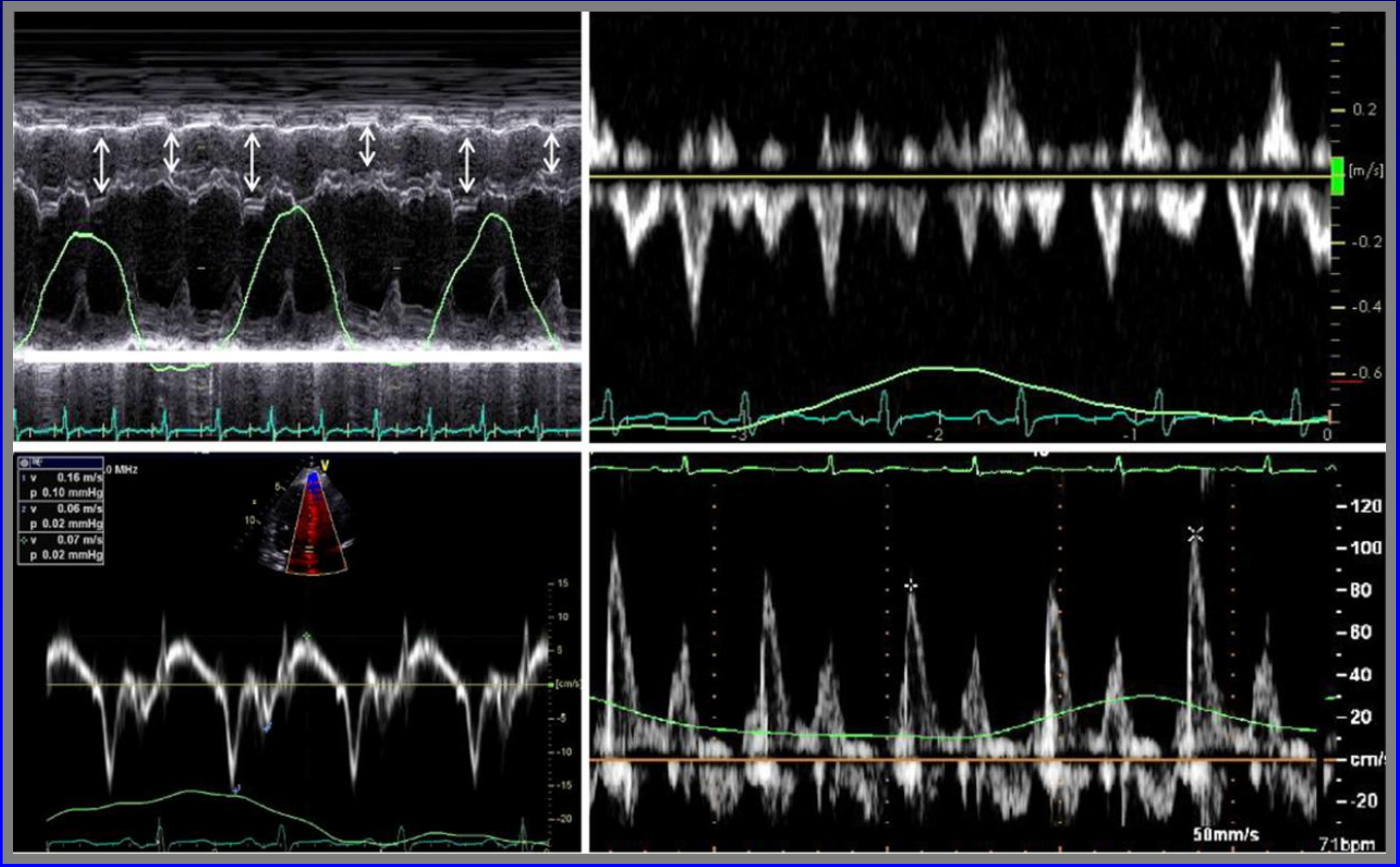
Case

Constrictive Pericarditis



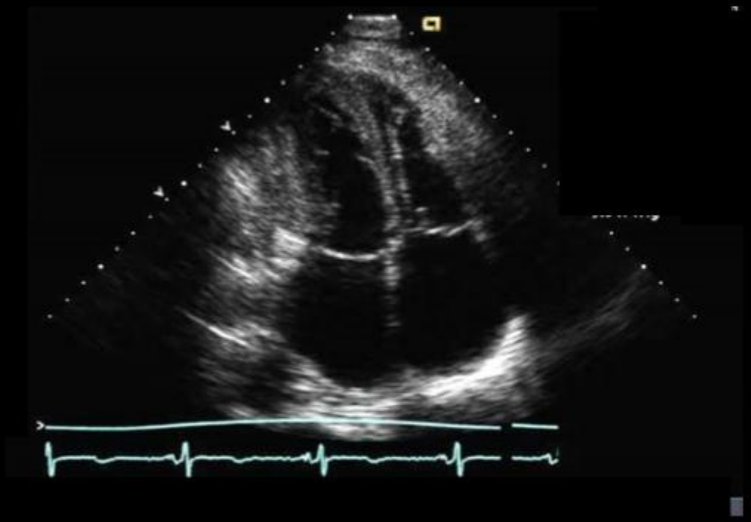
MR 214-76-04
157655

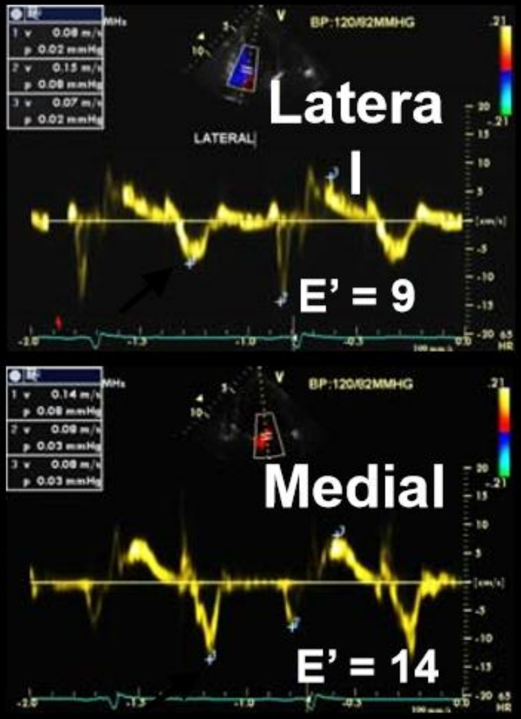
Constrictive Pericarditis
Echo-Doppler



Miranda and Oh Prog Cardiovasc Dis 2017;59(4):369-379

Annulus Reversus





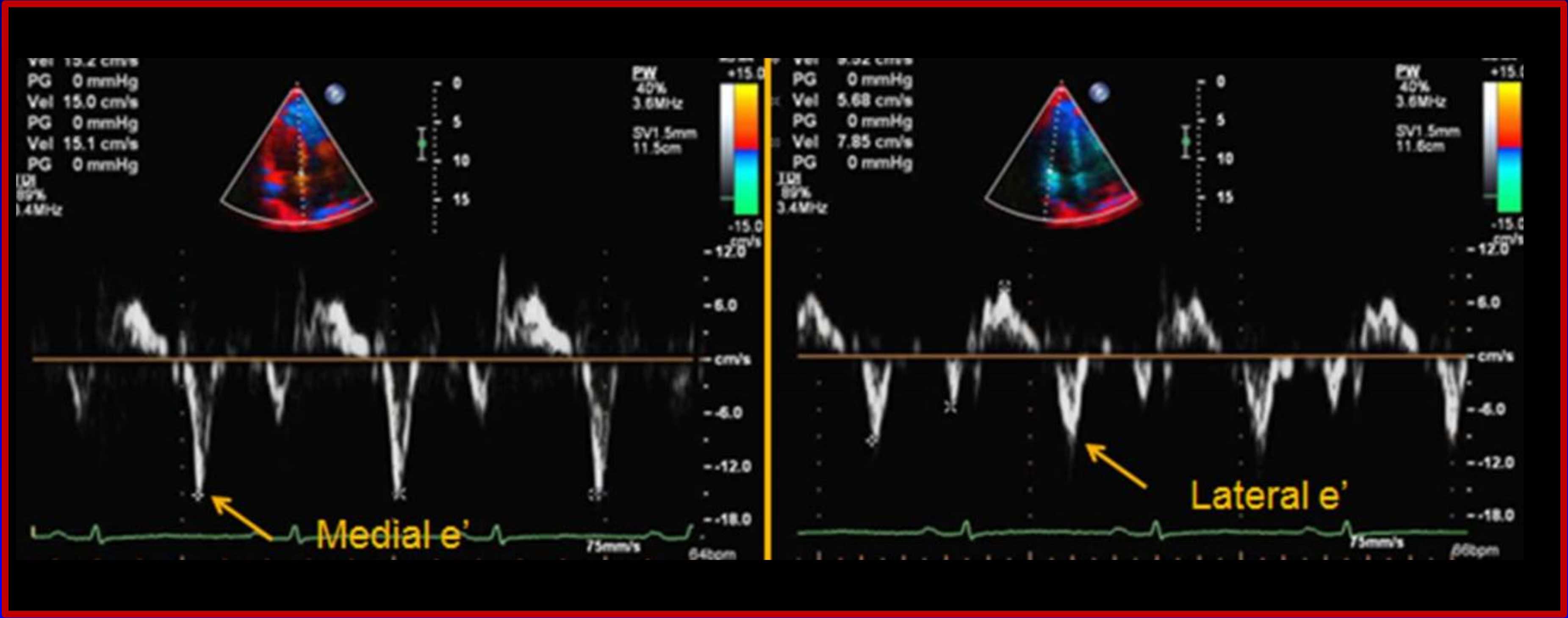
Lateral < Medial:
75% of constriction cases

Circ CV Img 4: 399, 2011

from Mayo Clinic

Constrictive Pericarditis

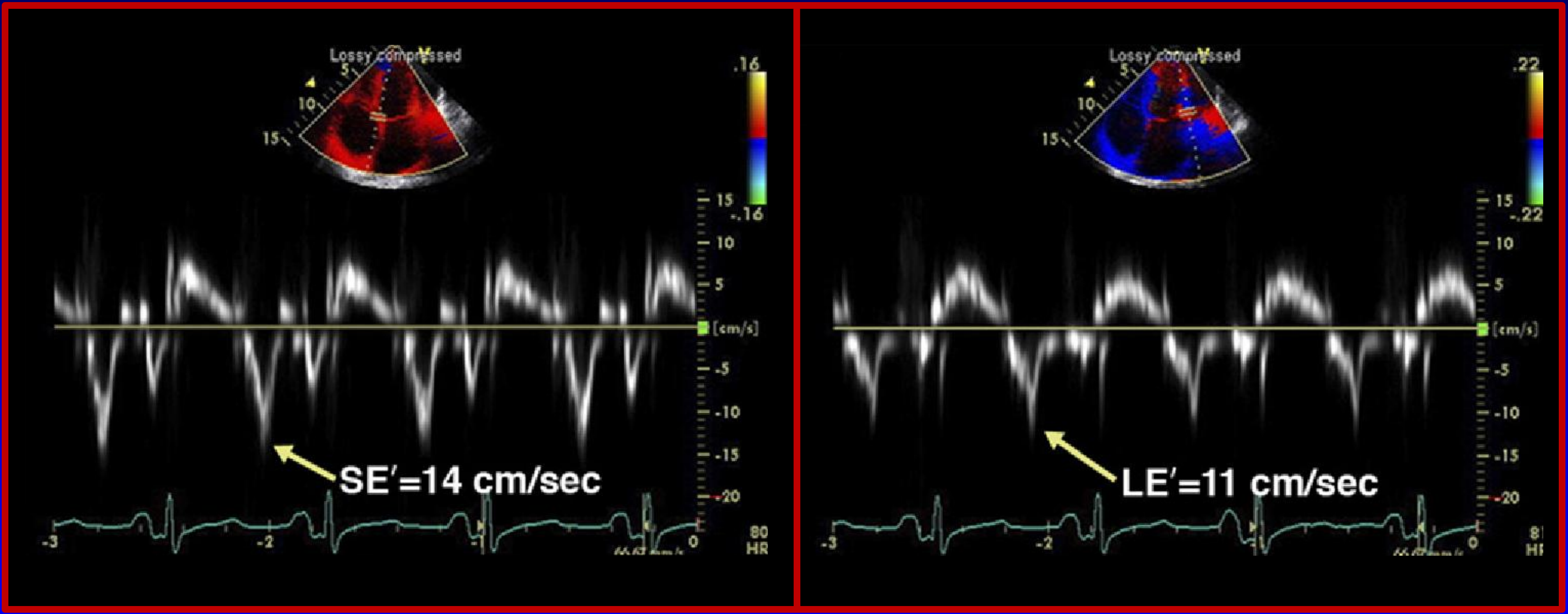
Annulus Reversus



Medial velocity greater than lateral velocity

Constrictive Pericarditis

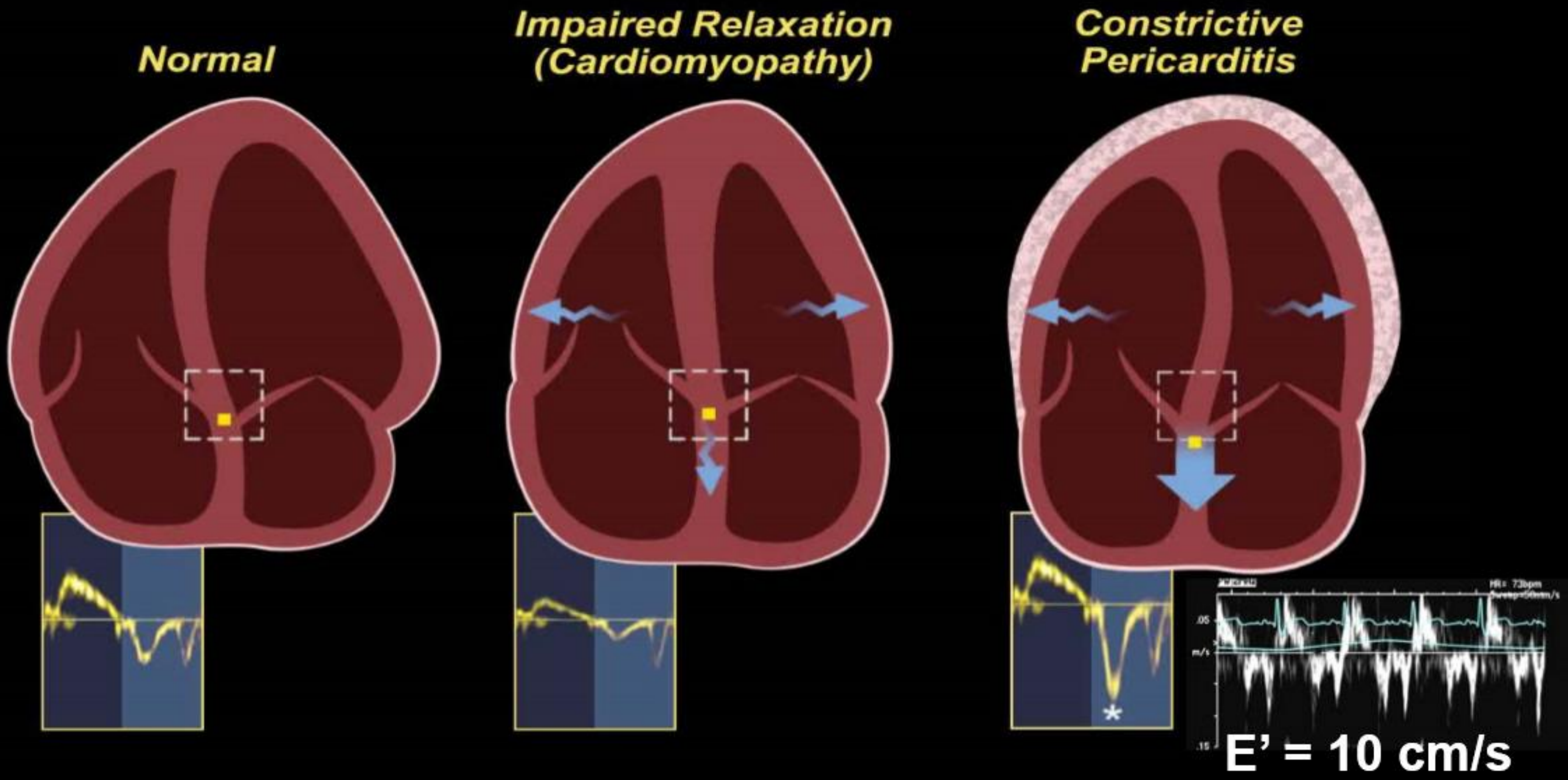
Annulus Reversus



Septal e’ Lateral e’

Medial velocity greater than lateral velocity

Annulus Paradoxus

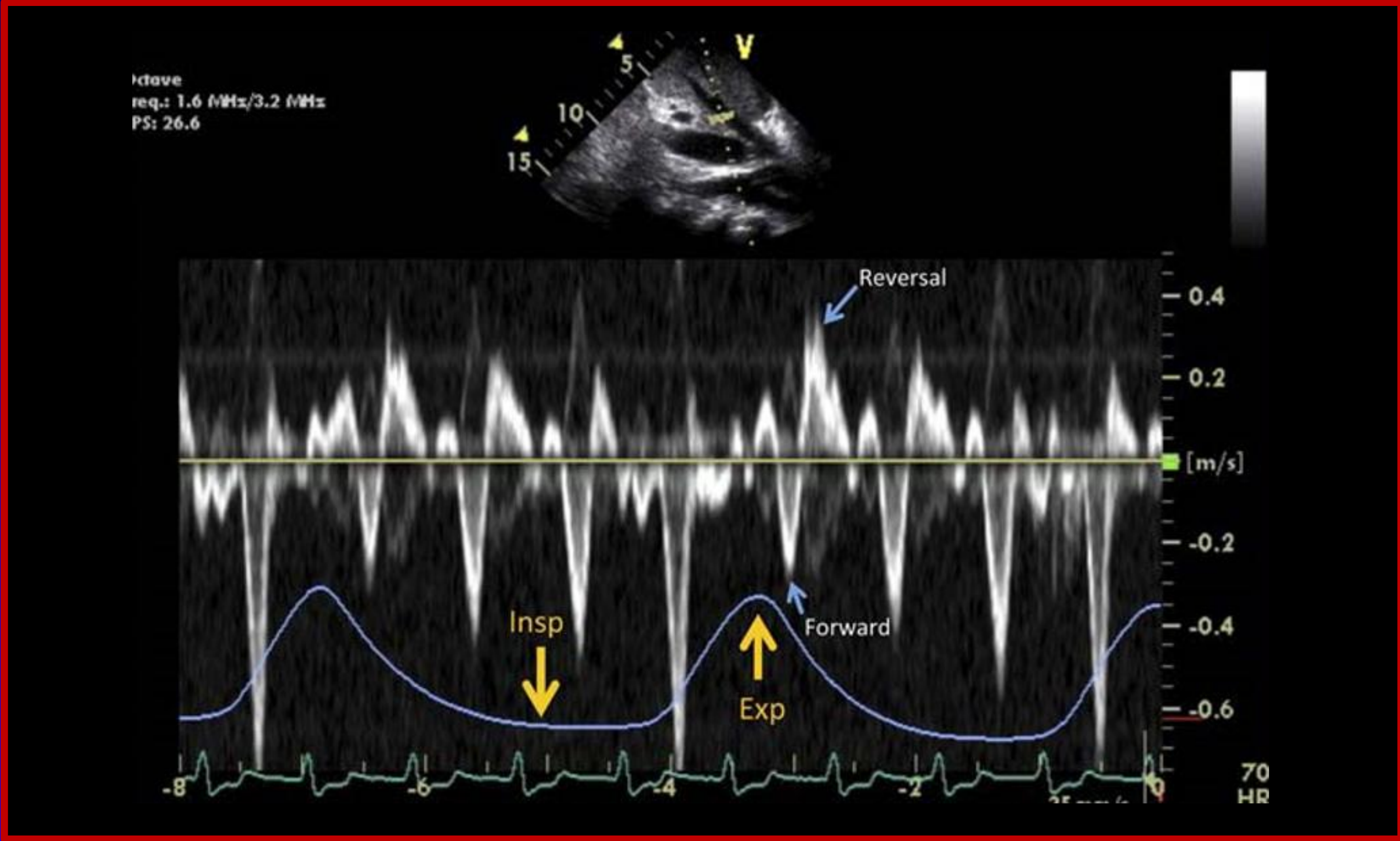


* With CHF, consider constriction if E' > 8 cm/s

from Mayo Clinic

Constrictive Pericarditis

Diastolic Hepatic Vein Reversal



Prominent diastolic flow reversals in expiration

Summary

Consider Constrictive Pericarditis

- Abnormal septal motion → "bounce"
- Dilated IVC and hepatic veins
- Restrictive filling pattern
- Exaggerated respiratory variation
- Normal tissue Doppler in CHF
- Expiratory diastolic reversal in hepatic veins

Pericardiocentesis

Discussed later - Interventional echo

The End