Echocardiographic Assessment of Pericardial Effusion/Tamponade: The Essentials

John R Schairer DO FACC
Henry Ford Heart and Vascular Institute
No Disclosures

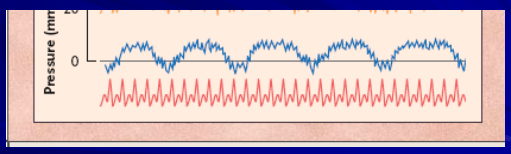
TABLE 1. Physical and Echocardiographic Doppler Signs Indicating Pericardial Effusion and/or Tamponade

Pulsus paradoxus
Loss of the Y descent on the jugular venous pulse
Pericardial effusion on echocardiograph
RV collapse
RA collapse
IVC plethora (dilated IVC with lack of inspiratory collapse)
Increased respiratory variation of flow across the mitral, aortic, and tricuspid valves
Ventricular interdependence (shifting of the septum in response to respiration with variation in ventricular dimensions)
Swinging heart
LA or LV collapse (rare)

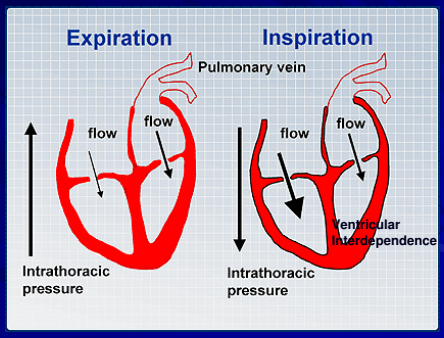
Outline

- Normal Anatomy and Physiology
- Pathophysiology of Tamponade
- Physiological basis for Signs of Tamponade
- Unique Presentations
- Putting It Altogether

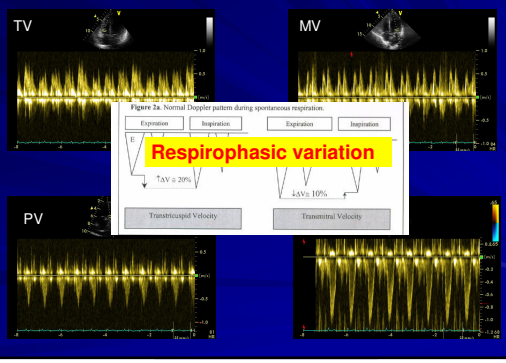
Intrapericardial & Intrathoracic Pressures



Physiology of Respiration

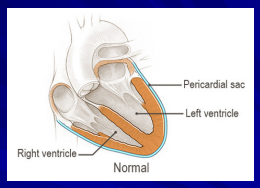


Doppler flow



Physiology

Fibrous Capsule
Parietal and visceral layers
Pericardial Space(PS) - 25-50 mL
Visceral surface creates PEF

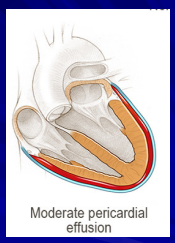


Normal

Total volume of the Pericardium
100cc/chamber = 400 cc
pericardial effusion = 50 cc
Total = 450 cc

Pathophysiology

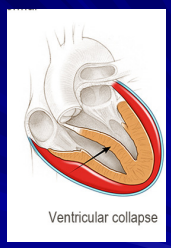
As Volume increases pressure increases
Initially manifest as abnormal diastolic function
RV thin walled structure more susceptible to pressure changes
Ventricles now fill against the common pressure of pericardium
If RV increases, LV must decrease
Ventricular interdependence
Increased respiratory variation across valves


Moderate pericardial effusion

Total volume of the Pericardium
100cc/chamber = 400 cc
pericardial effusion = 150 cc
Total = 550 cc

Pathophysiology

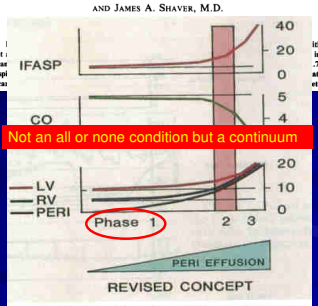
Chamber size decreases and output drops
Cardiogenic shock


Ventricular collapse

Total volume of the Pericardium
100cc/chamber = 300 cc
pericardial effusion = 250 cc
Total = 550 cc

Cardiac Tamponade: Circ August 1978
Hemodynamic Observations in Man

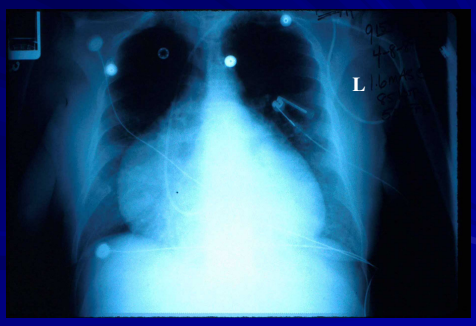
P. Sudhakar Reddy, M.D., Edward I. Curtiss, M.D., James D. O'Toole, M.D., and James A. Shaver, M.D.



Not an all or none condition but a continuum

...ponade. IFASP = inspiratory fall in arterial systolic ... left ventricular pressure; RV = right ventricular ... (*From* Reddy PS, Curtiss EI, Uretsky BF: The ... in pericardial effusion. Am J Cardiol, in press; with ...

Phase I - Changes in Cardiac Configuration



Quantifying Pericardial Effusion

Many different methods: Volume calc., Descriptive (Horowitz)

	P. space	Amt of fluid
None		
Small	<10 mm	≤ 100cc
Moderate	10 to 20 mm	100 to 500cc
Large	≥20 mm	≥ 500 cc

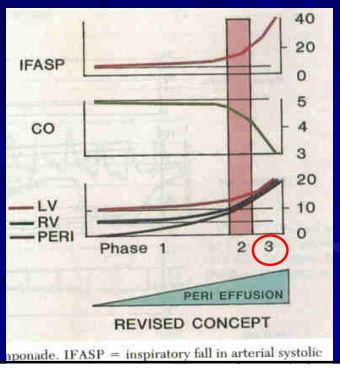
Echo free space may not be uniform even if circumferential. Best to make several measurements and document view and location so they can be reproduced from one study to the next.

GUIDELINES AND STANDARDS 2010

Guidelines for the Echocardiographic Assessment of the Right Heart in Adults: A Report from the American Society of Echocardiography

Inferior Vena Cava	Change with Resp or "Sniff"	Right Atrial Pres. (mmHg)(range)
Normal (≤ 2.1 cm)	Decrease >50%	3(0-5)
Normal (≤ 2.1 cm)	Decrease <50%	8(5-10)
Dilated (>2.1cm)	Decrease >50%	8(5-10)
Dilated (>2.1cm) IVC Plethora	Decrease <50%	15(10-20)

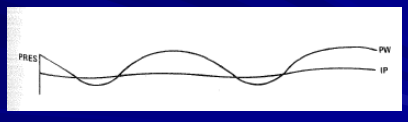
Physiology of Signs of Tamponade



...ponade. IFASP = inspiratory fall in arterial systolic

Respirophasic variation

- In tamponade, flow into both ventricles takes place against a common stiffness.*
  - IPP=RA=RVFP=W=LA=LVFP



*Pulsus can be seen in some patients in Phase II

Respirophasic variation

- Filling of the chambers is competitive i.e.
  - Respiratory changes in venous pressure difference alternately favoring RV and LV filling
  - Filling of one ventricle and resultant shifting septum impede filling of the other ventricle ie ventricular interdependence

Pulsus Paradoxus >10 mmHg

- False positive
  - Asthma/COPD
  - RV infarction
  - Heart failure
  - Severe LV impairment
- False Negative
  - Severe hypotension
  - Aortic regurgitation
  - ASD
  - Severe diastolic dysfunction
  - RVH without pulmonary HTN

Cardiac Tamponade and Pericardial Effusion: Respiratory Variation in Transvalvular Flow Velocities Studied by Doppler Echocardiography

CHRISTOPHER P. APPLETON, MD,* LIV K. HATLE, MD, RICHARD L. POPP, MD, FACC
Stanford, California

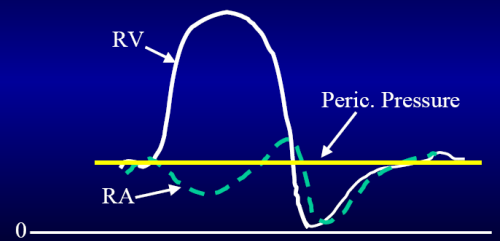
JACC 1988;11:1020-30

Percentage change from first beat of expiration to first beat of inspiration.

Patient Group	IVRT (ms)	M1 (cm/s)	T1 (cm/s)	LVET (ms)	Ao (cm/s)	PA (cm/s)
Normal (n=20)	2	-4	14	-3	-4	5
Tamponade (n=7)	85	-43	85	-21	-26	40
Eff – Variation (n=8)	32	-31	74	-9	-17	49
Eff – No Variation (n=7)	3	-5	32	-2	-4	6

RA Systolic Collapse

Intrapericardial Pressure > RA pressure in early systol



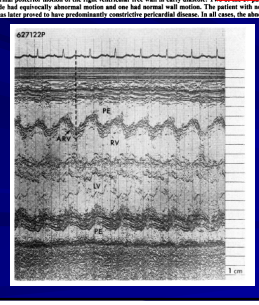
Don't forget the y descent

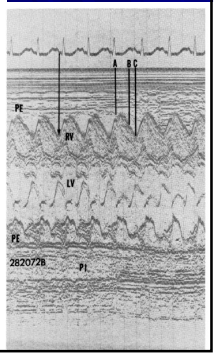
Diastolic Collapse of the Right Ventricle with Cardiac Tamponade: An Echocardiographic Study

William F. Armstrong, M.D., Bruce F. Schilt, M.D., Debra J. Helper, M.D., James C. Dillon, M.D., and Harvey Feigenbaum, M.D.

Circ June 1982

SUMMARY The value of a newly described echocardiographic sign for the detection of cardiac tamponade was retrospectively evaluated in 91 patients. M-mode echocardiograms were reviewed in 86 patients, 36 of whom had concurrent two-dimensional echocardiographic examinations; in five patients, only two-dimensional echocardiography was performed. Cardiac tamponade was clinically present in 17 patients, 14 of whom had abnormal posterior motion of the right ventricular free wall in early diastole. Two of these 14 patients with tamponade had equivocally abnormal motion and one had normal wall motion. The patient with normal wall motion was later proved to have predominantly constrictive pericardial disease. In all cases, the abnormal wall

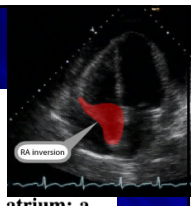




Diastolic Collapse of the Right Ventricle with Cardiac Tamponade: An Echocardiographic Study

William F. Armstrong, M.D., Bruce F. Schilt, M.D., Debra J. Helper, M.D., James C. Dillon, M.D., and Harvey Feigenbaum, M.D.

- This sign was present in 16 of 17 patients with clinical tamponade (1 patient had constrictive pericardial disease).
- In all cases the abnormal motion reverted back to normal after pericardiocentesis
- Presence of this sign in equivocal tamponade suggests it may be an early indicator of tamponade physiology
- Associated with a 21% decrease in cardiac output and no change in mean aortic pressure



DIAGNOSTIC METHODS
ECHOCARDIOGRAPHY

Circ 1983

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

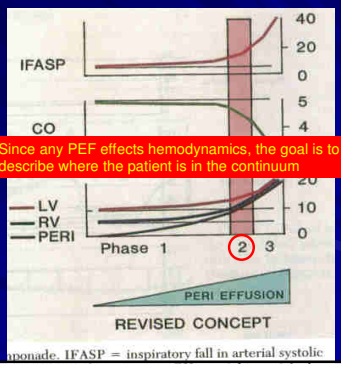
LINDA D. GILLAM, M.D., DAVID E. GUYER, M.D., THOMAS C. GIBSON, M.D., MARY ETTA KING, M.D., JANE E. MARSHALL, B.S., AND ARTHUR E. WEYMAN, M.D.

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

False negatives

- RVC
  - Pulmonary HTN
  - Infiltrative Cardiomyopathy
  - RVH
- RAC
  - RA hypertension – Tricuspid regurgitation
  - Ventricular rhythm – Pacemaker
  - Pulmonary HTN

Physiology of Signs of Tamponade



Since any PEF effects hemodynamics, the goal is to describe where the patient is in the continuum

...ponade. IFASP = inspiratory fall in arterial systolic

Cardiac Tamponade and Pericardial Effusion: Respiratory Variation in Transvalvular Flow Velocities Studied by Doppler Echocardiography

CHRISTOPHER P. APPLETON, MD,* LIV K. HATLE, MD, RICHARD L. POPP, MD, FACC
Stanford, California

JACC 1988;11:1020-30

Percentage change from first beat of expiration to first beat of inspiration.

Patient Group	IVRT (ms)	M1 (cm/s)	T1 (cm/s)	LVET (ms)	Ao (cm/s)	PA (cm/s)
Normal (n=20)	2	-4	14	-3	-4	5
Tamponade (n=7)	85	-43	85	-21	-26	40
Eff – Variation (n=8)	32	-31	74	-9	-17	49
Eff – No Variation (n=7)	3	-5	32	-2	-4	6

Pericardial disease is a continuum, not just an end point

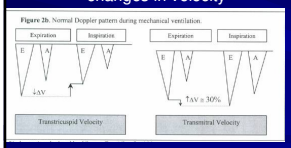
Variations On A Theme

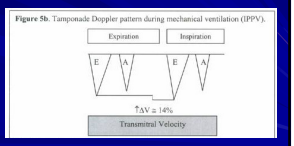
Variations on a Theme Elevated LVFP

- In Hypertension and Uremia, LV filling pressure is significantly higher, therefore RV filling pressure must rise more to equilibrate with the LV and form a common stiffness.
- The compensatory rise in systemic venous pressure may fail to maintain cardiac output before equalization of pressures occurs i.e. Right Heart Tamponade without pulsus paradoxus.

Variations on a Theme Ventilators

- Normal
  - IPPV* will produce opposite respirophasic changes in velocity
- Tamponade
  - MV opposite direction and attenuated





*Intermittent Positive Pressure Ventilation

Variations on a Theme

- Hypertensive Tamponade
  - All the features of CT
  - Have BP >200 mmHg
  - Pulsus paradoxus is present
  - History of hypertension
- Loculated effusions
  - Usually post op
  - Post MI
  - Only that chamber has signs of CT

Summary - Physiology

- Intrapleural and intra pericardial pressures are normally equal and fluctuate with respiration.
- The RA and RV are thin walled structures and more susceptible to changes in pericardial pressure changes.
- All amounts of pericardial effusion have hemodynamic abnormalities, Therefore pericardial disease is a continuum
- RA pressure elevation is the result of increased PP and is best estimated by IVC changes.
- Pretest likelihood of PT is important

Conclusion:

- Clinical Diagnosis - ✓ HR, BP, the patient
- Echo/Doppler
  - Size of PEF
  - IVC plethora
  - Right Heart Collapse
  - Respiratory Variation
- Comorbid conditions

Thank you