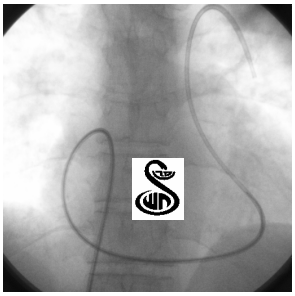
המודינמיקה



פרופ' אליו די סגני
מרכז רפואי שיבא, תל השומר

נוסחאות המודנמיות

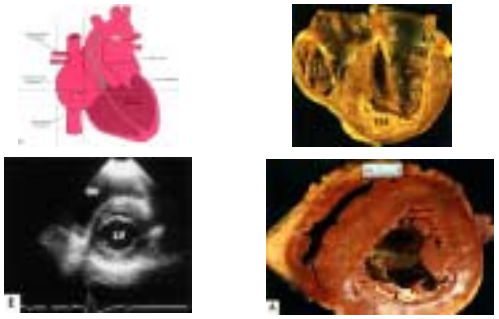
- $P = Q \times R$
- Poiselle`s law:

  Flow= P-P`× R^4/ lenght×viscosity
- Laplace`s law:

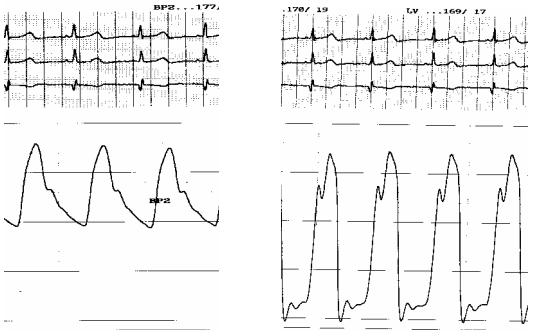
  Wall tension= P×R/2wall thickness

עקומות הלחץ

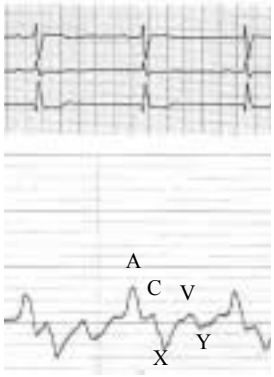
הפיזיולוגיה משקפת את האנטומיה של חדרי הלב



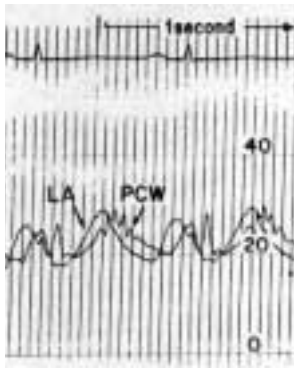
Arterial / Ventricular curve



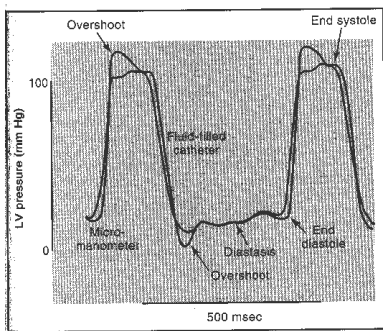
Right atrium



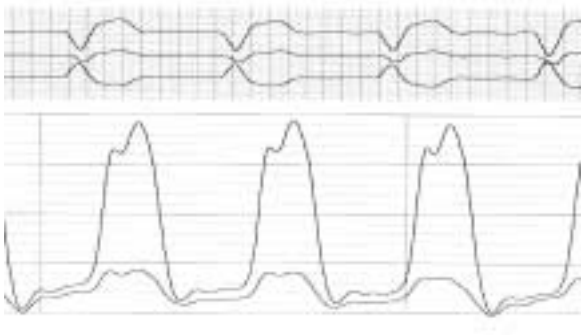
Left atrium



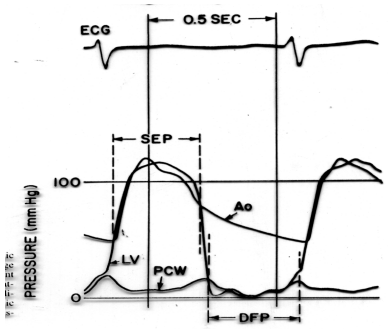
Pressure recording: fluid filled catheter vs micro-manometer



הלחץ בחדר השמאלי ובחדר הימני



Time intervals

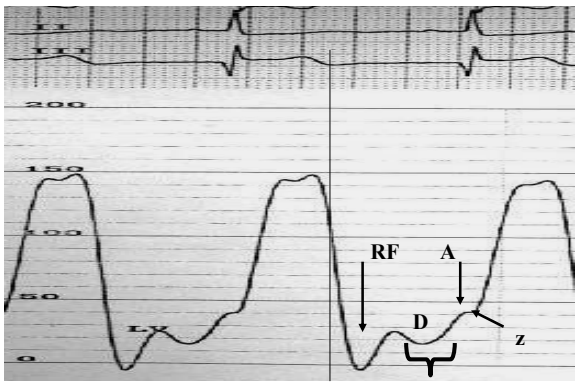


The cardiac cycle

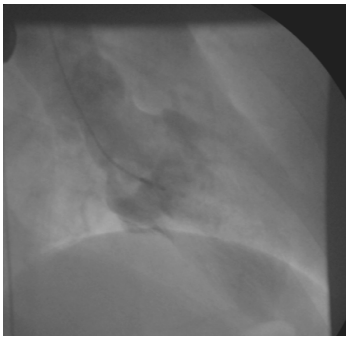
Systolic and diastolic time intervals

The tall V wave

Diastolic time intervals



Mitral stenosis



Mitral stenosis
mitral insufficiency?

Mitral insufficiency

Tall V Wave
in L to R shunt (acquired VSD)

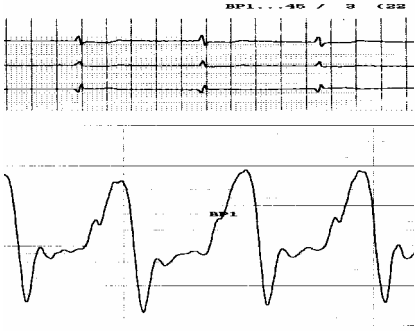
Mitral insufficiency
"ventricularization"

V wave determinants

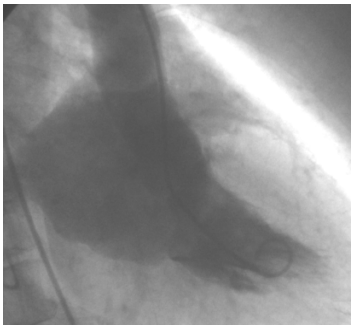
V wave results from the pressure-volume relationship of the atria which is determined by:

- Atrial flow
  - Antegrade
  - Retrograde
- Atrial wall compliance
- Ventricular compliance

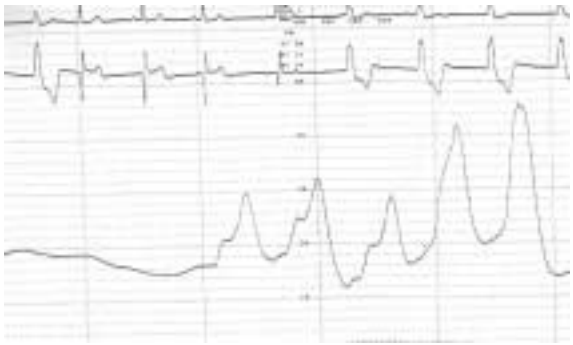
Severe tricuspid insufficiency.
Ventricularization of RA pressure



Mitral insufficiency
grade 4



Mitral insufficiency
pacing induced

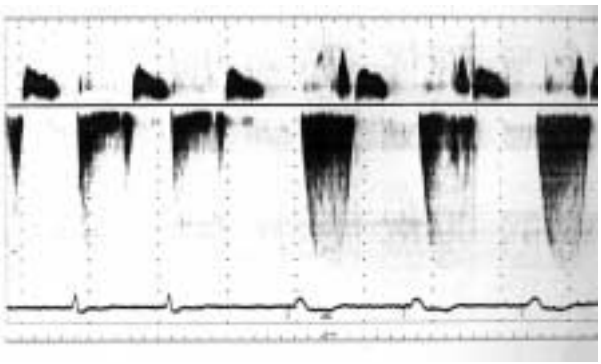


An important clinical application of V wave analysis

הימודינמיקה:
היצרות מסתמי הלב

<u>לא מפל לחצים בלבד!</u>

Mitral insufficiency
pacing induced



Aortic stenosis:
Aortic valve area

- Gorlin:

$$AVA = \frac{CO/SEP \times HR}{44.3\sqrt{\Delta P}}$$

- Hakki:

$$AVA = CO/\sqrt{\Delta P}$$

Aortic stenosis

HOCM
קרדיומיופטיה היפרטרופית חסימתית

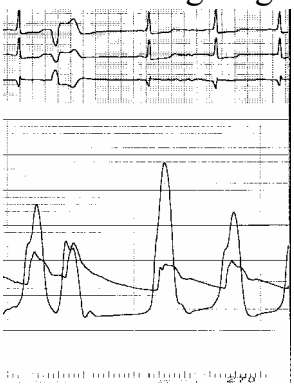
- קול רביעי
- אוושה סיסטולית פליטתית
- אין קליק
- **Valsalva**

Aortic stenosis:
pressure curve morphology changes with severity

before valvuloplasty

after valvuloplasty

HOCM
Brockenbrough sign



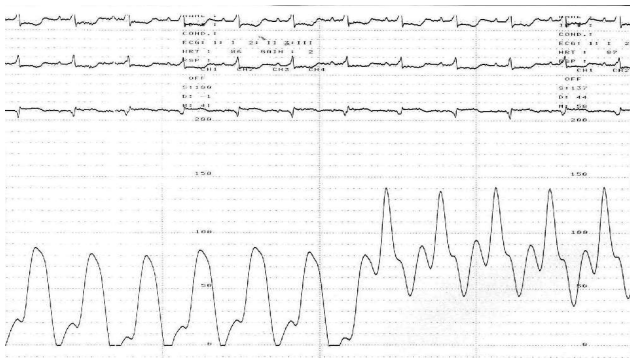
HOCM
effect of Valsalva

Mitral stenosis:
Mitral valve area

Gorlin:

$$MVA = \frac{CO/DFT \times HR}{31.15\sqrt{\Delta P}}$$

?



תפקוד סיסטולי

Mitral stenosis

LV performance
Angiographic LVEF

מדדים של תפקוד סיסטולי

Contractility index
- dp/dt max
- dp/dt/ max isometric pressure
- Vmax
- Vce

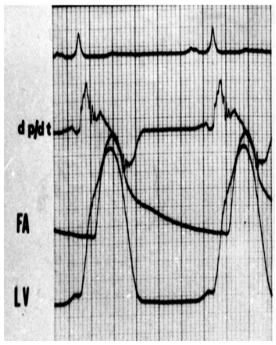
- PEP/SEP

Performance index:
- Ejection fraction

נוסחת הלחץ

$$P = Q \cdot R$$

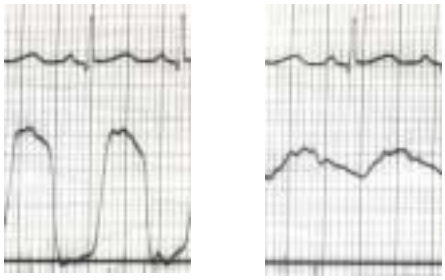
Myocardial contractility:
force-velocity related indexes:
isometric contraction



[16:06] LEFT VENTRICLE

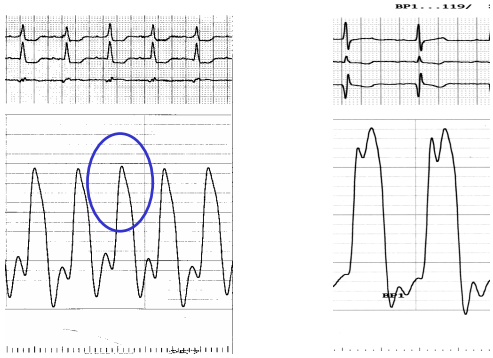
HEART RATE	61	[bpm]
LV BDP	1	[mmhg]
LV EDP	32	[mmhg]
LV PEAK SYST	127	[mmhg]
LV MEAN SYST	84	[mmhg]
LV MEAN DIAS	21	[mmhg]
LV MAX DP/DT	1058	[mmhg/sec]
LV MIN DP/DT	-995	[mmhg/sec]
LV PEAK VCE	17.3	[/sec]
LV V MAX	28.6	[/sec]

Aortic stenosis:
pulsus parvus et tardus

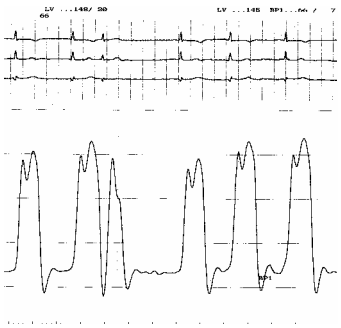


Systolic dysfunction: pulsus parvus

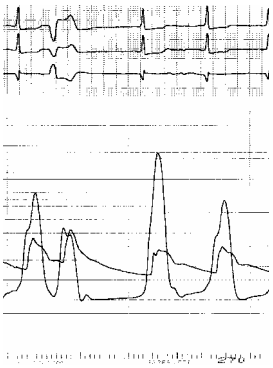
- LVEF 20%
- Normal



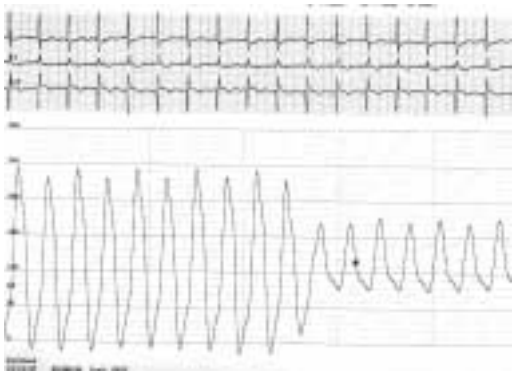
The influence of diastolic dysfunction on post-extrasystolic potentiation in a patient with LVEF=45%



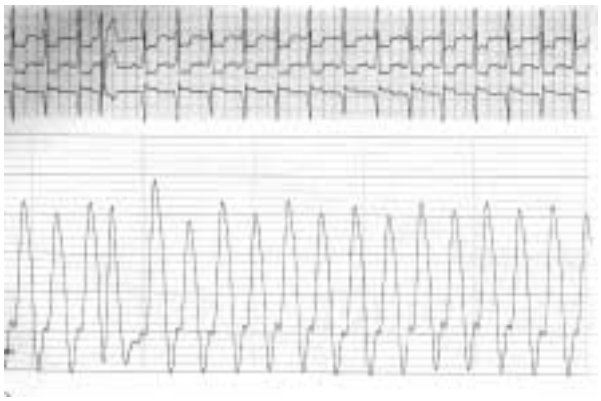
Post-extrasystolic potentiation:
increased LV pressure
decreased PEP/SEP



Mechanical alternans in aortic stenosis



Mechanical alternans



מדדים של תפקוד דיאסטולי

Myocardial properties

- Isovolumic relaxation
  - ✓ -dp/dt
  - ✓ Tau
- Passive characteristics
  - ✓ Compliance
  - ✓ Stiffness*
  - ✓ Distensibility

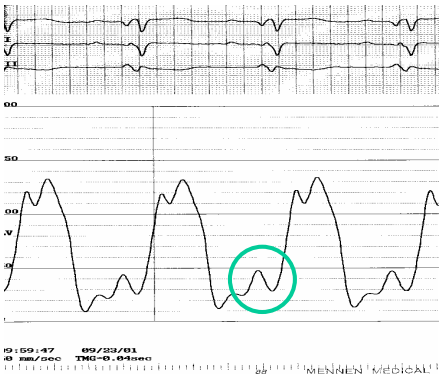
  Diastolic P/V curve

Performance (diastolic dysfunction)

- Hemodynamic
  - ✓ **LVDP**
  - ✓ Mean PW pressure
  - ✓ Diastolic PA pressure
- Echo-Doppler
  - ✓ E/A ratio
  - ✓ Pseudo-normalization
  - ✓ *Restrictive pattern**

תפקוד דיאסטולי

Diastolic failure due to delayed relaxation. Increased "a"wave



Diastolic dysfunction Increased LVEDP

Delayed relaxation

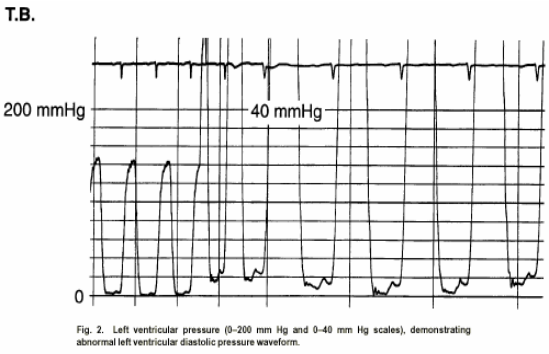
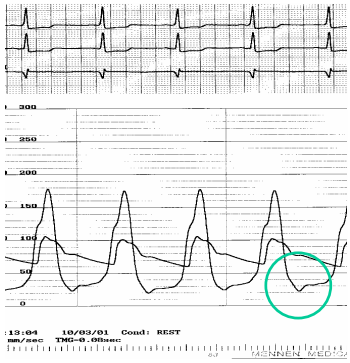
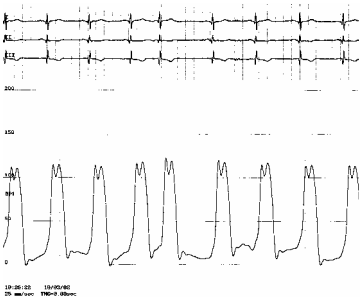


Fig. 2. Left ventricular pressure (0–200 mm Hg and 0–40 mm Hg scales), demonstrating abnormal left ventricular diastolic pressure waveform.

HOCM
delayed relaxation

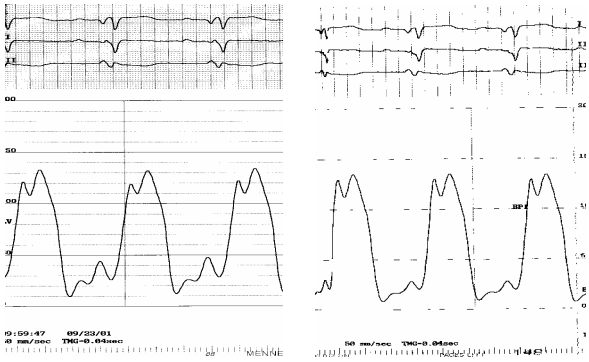


Delayed relaxation respiratory and post-extrasystolic changes



Diastolic failure due to delayed relaxation

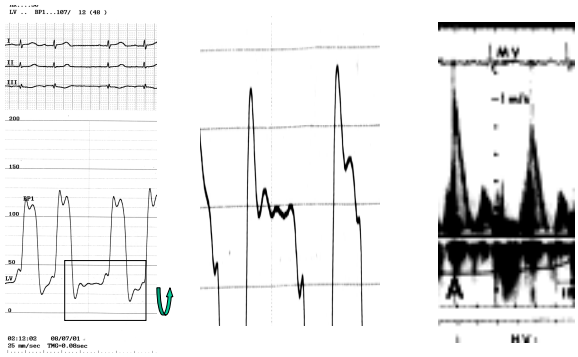
base NTG



Increased stiffness
slope of the diastolic pressure curve

Delayed relaxation and…

Restrictive pattern

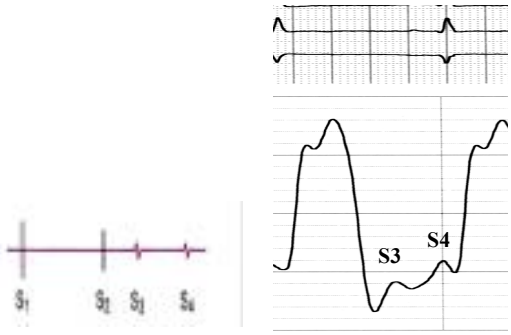


Decreased distensibility
Square root sign

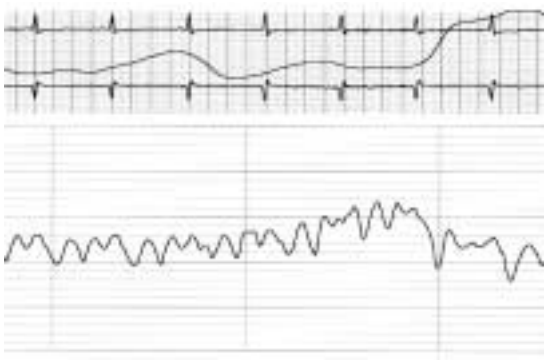
Constrictive pericarditis:
2 groups of hemodynamic signs

- Classic signs
- Dynamic respiratory changes

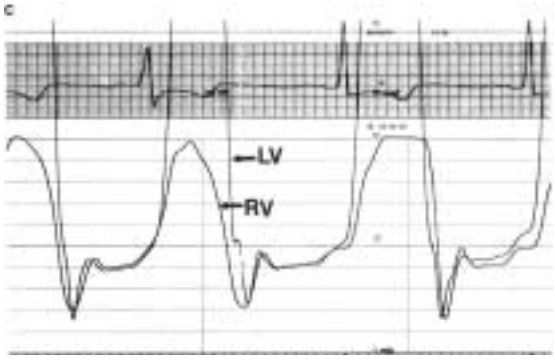
קול שלישי ורביעי:
חלון קליני על התפקוד הדיאסטולי



Kussmaul's sign



Constrictive pericarditis
classic signs



Constrictive pericarditis classic signs

Criteria	Sensitivity	Specificity	PPV
• Pr. Equalization	60	38	4
• RVD/RVS >1/3	93	38	52
• PAP <55	93	24	47
• Lack of RAP change	93	48	58

Hurrel et al. *Circulation* 1996

CP: 15 pts **R:** 21 pts

Constrictive pericarditis classic signs

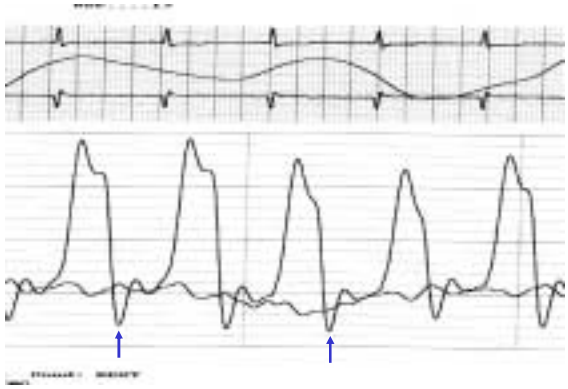
Criteria	PPV	Overall PV
• Pr. Equalization	92%	85%
• RVD/RVS > 1/3	95%	76%
• RVSP > 50	90%	70%
• All 3 criteria	91%	

Vaitkus and Kussmaul *Am Heart J* 1991

CP: 82 pts **R**: 37 pts

Constrictive pericarditis Ventricular interdependence

Dissociation of intrathoracic and intracardiac pressures



מה שונה ומה משותף בין: Constrictive pericarditis Pericardial ובין tamponade

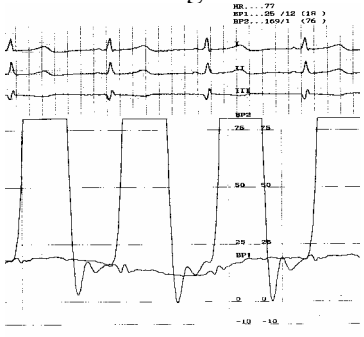
Constrictive pericarditis Dynamic respiratory changes

Criteria	Sensitivity	Specificity	PPV
• PCWP/LV	93	81	78
• LV/RV interdep.	100	95	94

Hurrel et al. *Circulation* 1996

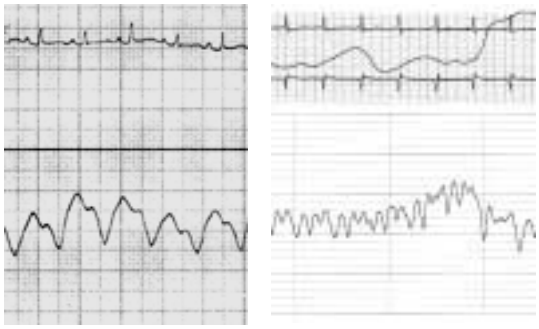
CP: 15 pts **R:** 21 pts

Pericardial tamponade: dynamic respiratory changes of PW-LV gradient



Right atrial pressure curve in

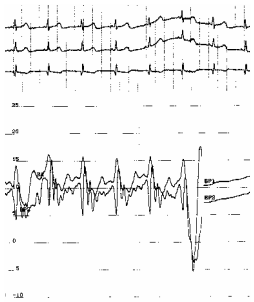
Pericardial tamponade and Constrictive pericarditis



Quiz: Constriction or Tamponade?

Right atrial and Intra-pericardial pressure in pericardial tamponade

- Tamponade



- Post pericardiocentesis