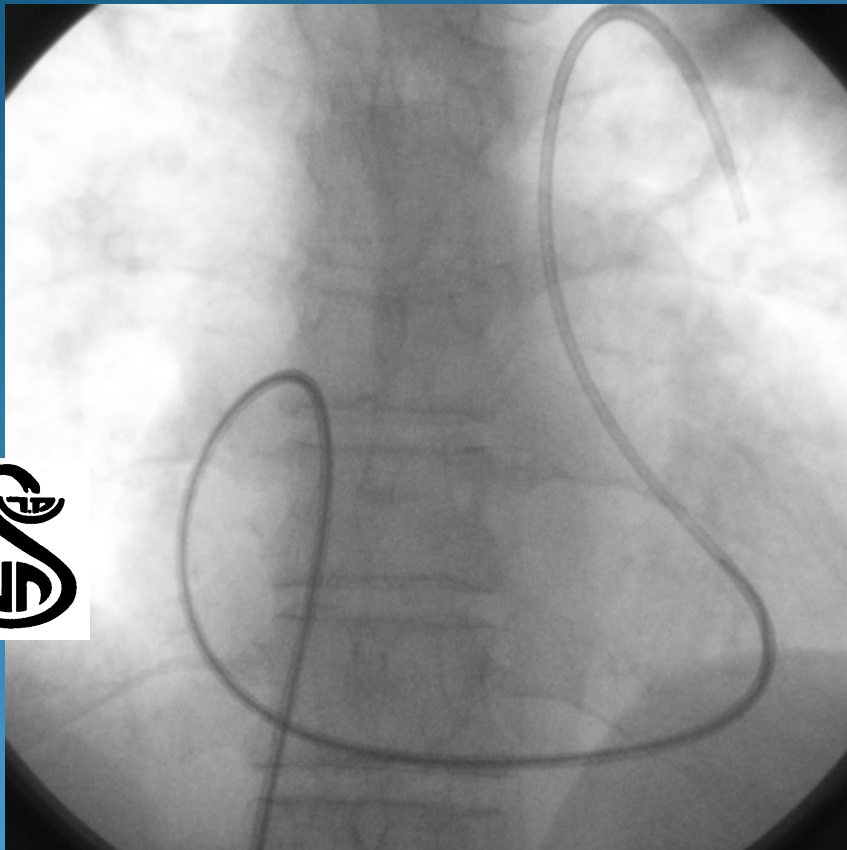


המודינמיקה

פרופ' אליו די סגני

מרכז רפואי שיבא, תל השומר



הוראה לצנתור

- מחלת לב איסכמית

- תעוקת חזה

- ACS

- אי-ספיקת לב

- מחלות מסתמיות

- הכנה לניתוח

- הערכה מדויקת של חומרת המום

- מומים מולדים

- יתר ל"ד ריאתי

המודינמיקה

• הערכה המודינמית:

• לחצים

• תפוקת הלב

• ריכוזי חמצן

• -תנגודת

• שטח מסתם

• דלף

• הנתונים הפיזיולוגים מכוונים את הטיפול

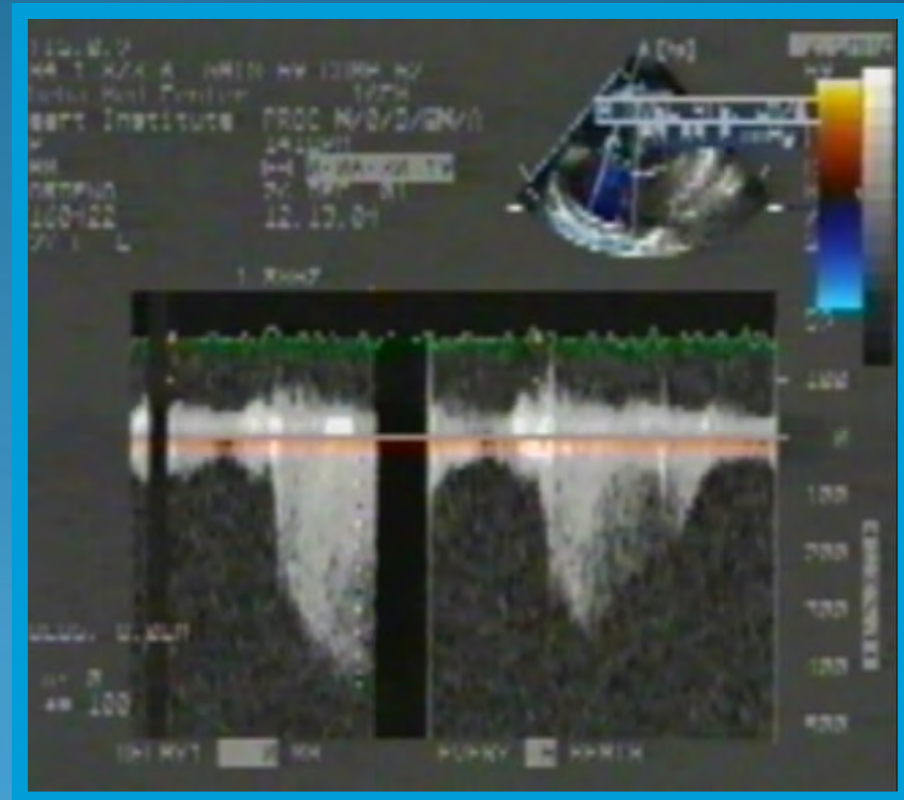
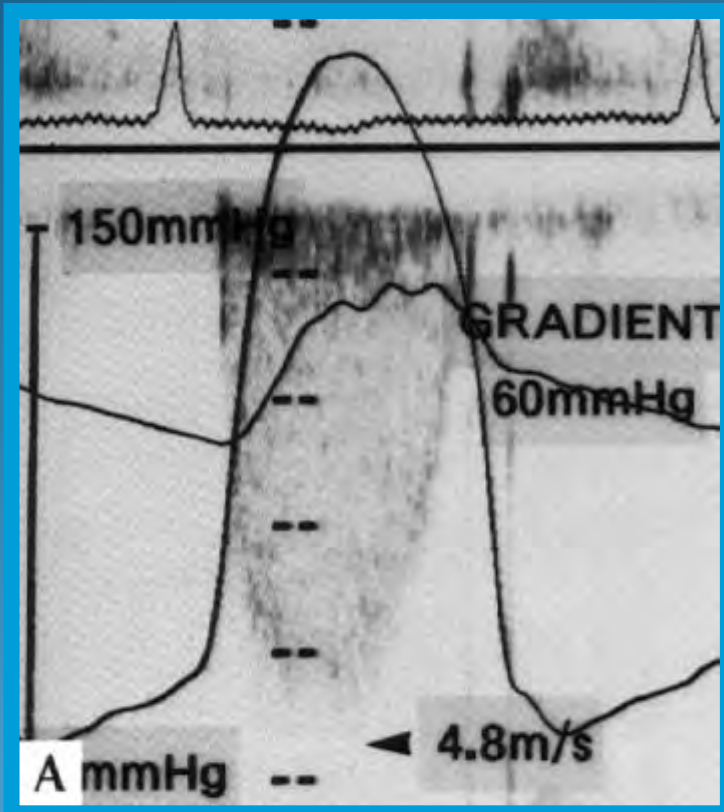
שיטות קליניות להערכה המודינמית

- צנתור לב

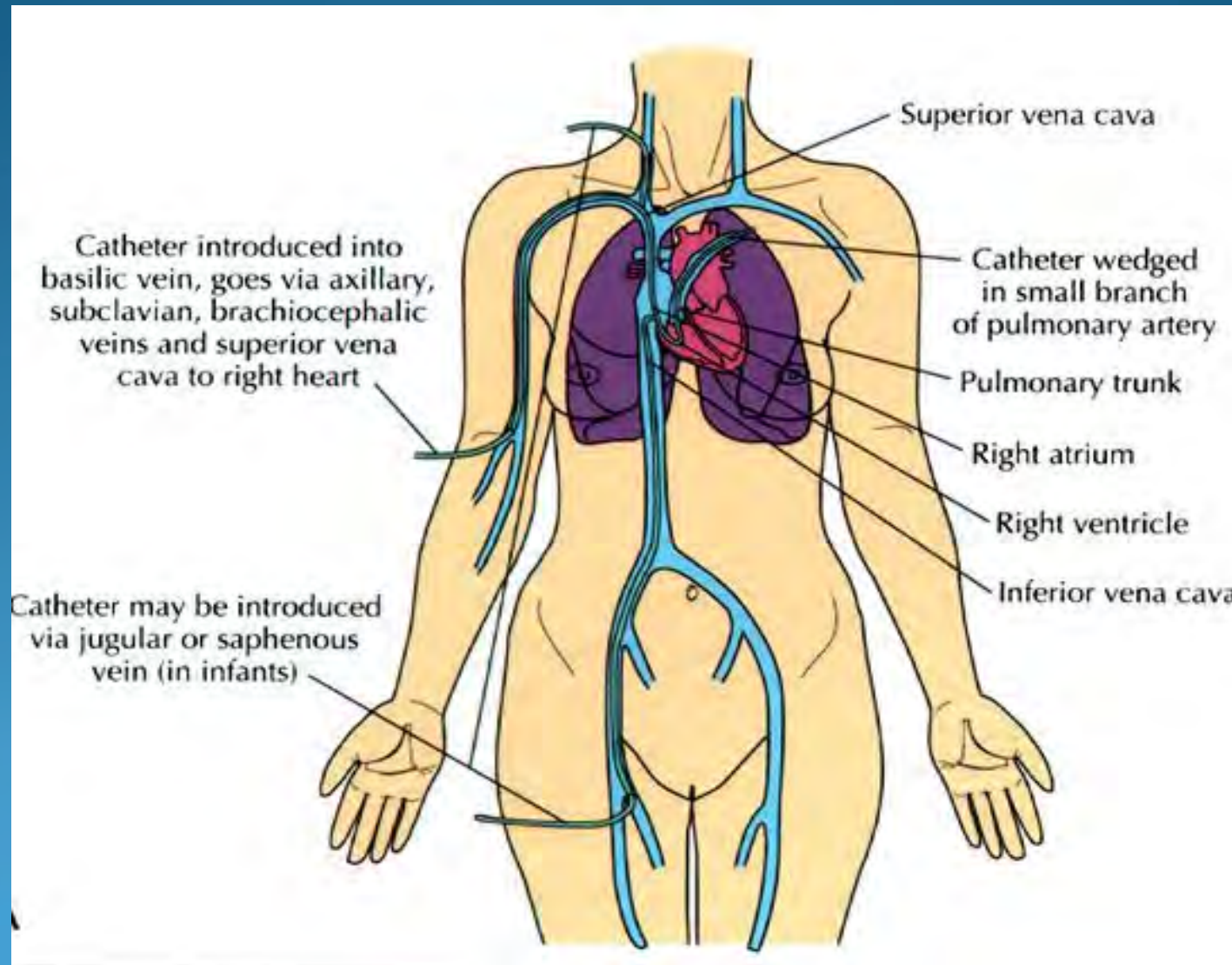
- אקו-דופלר

- עקומות הדופק

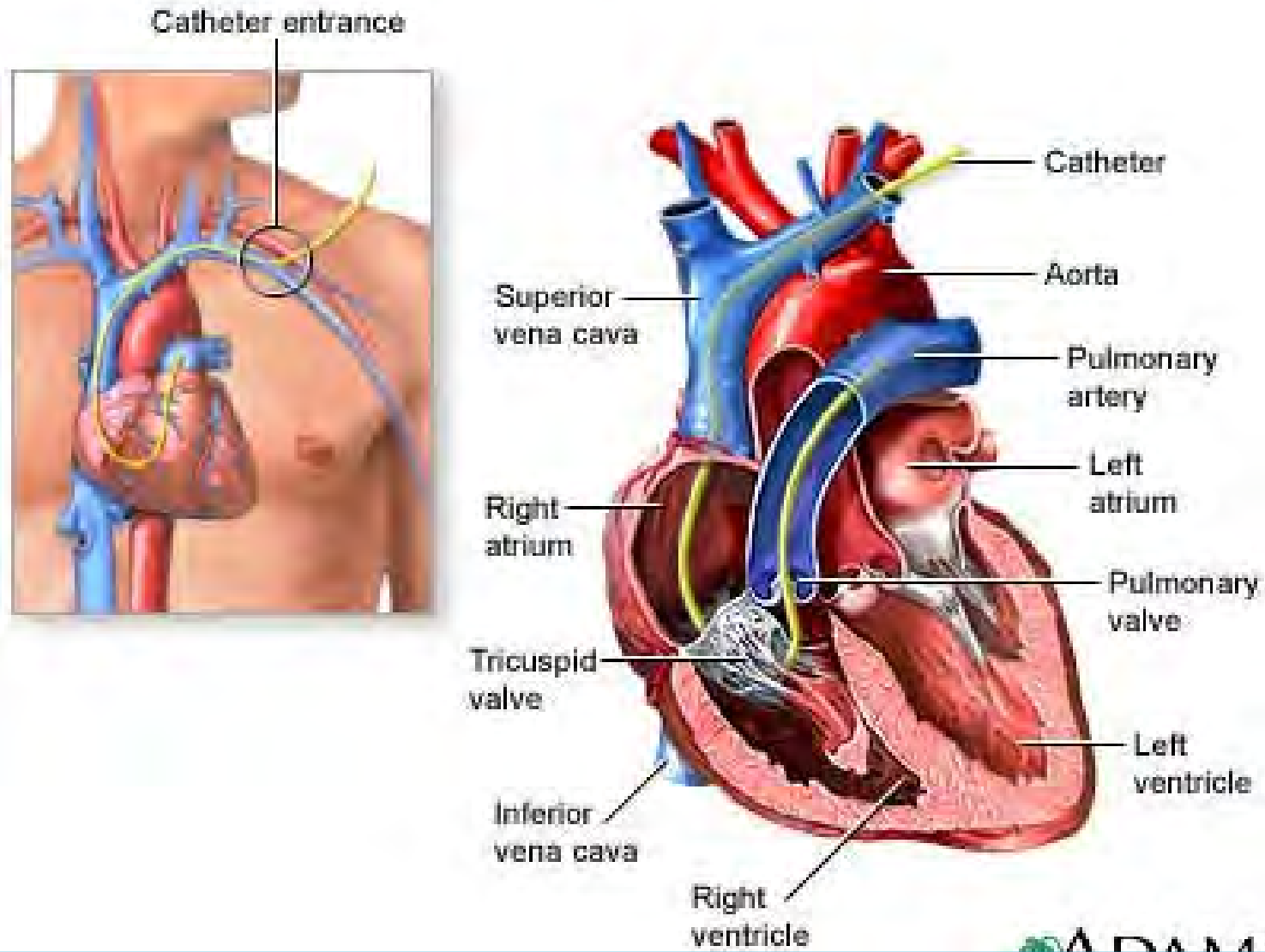
מדידות המודינמיות באקו-דופלר



צנתור ימני

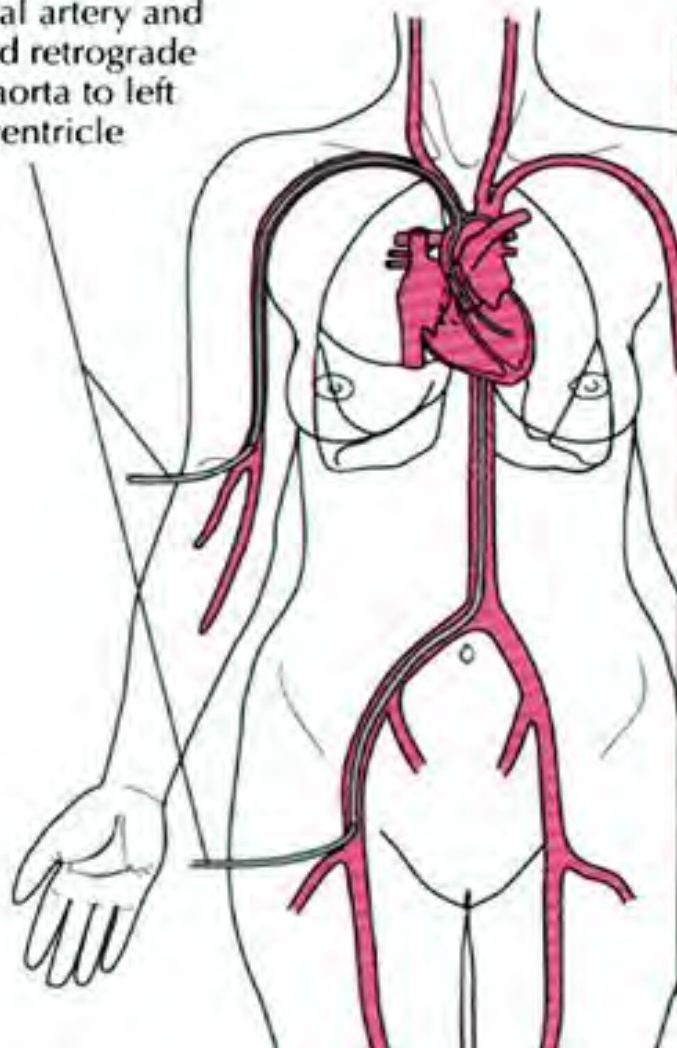


צנתר Swan-Ganz



צנתור שמאלי

Catheter introduced into brachial or femoral artery and passed retrograde via aorta to left ventricle



Transseptal puncture: catheter with sheathed needle introduced into saphenous or femoral vein, passed up inferior vena cava to atrium; needle (now unsheathed) punctures interatrial septum to enter left atrium; catheter may then pass to left ventricle



Catheter introduced via basilic vein and superior vena cava to right side of heart, passes through ventricular septal defect to left ventricle, thence to aorta (may also pass through atrial septal defect)

הערכה המודינמית:

לחצים

תפוקת הלב

ריכוזי חמצן

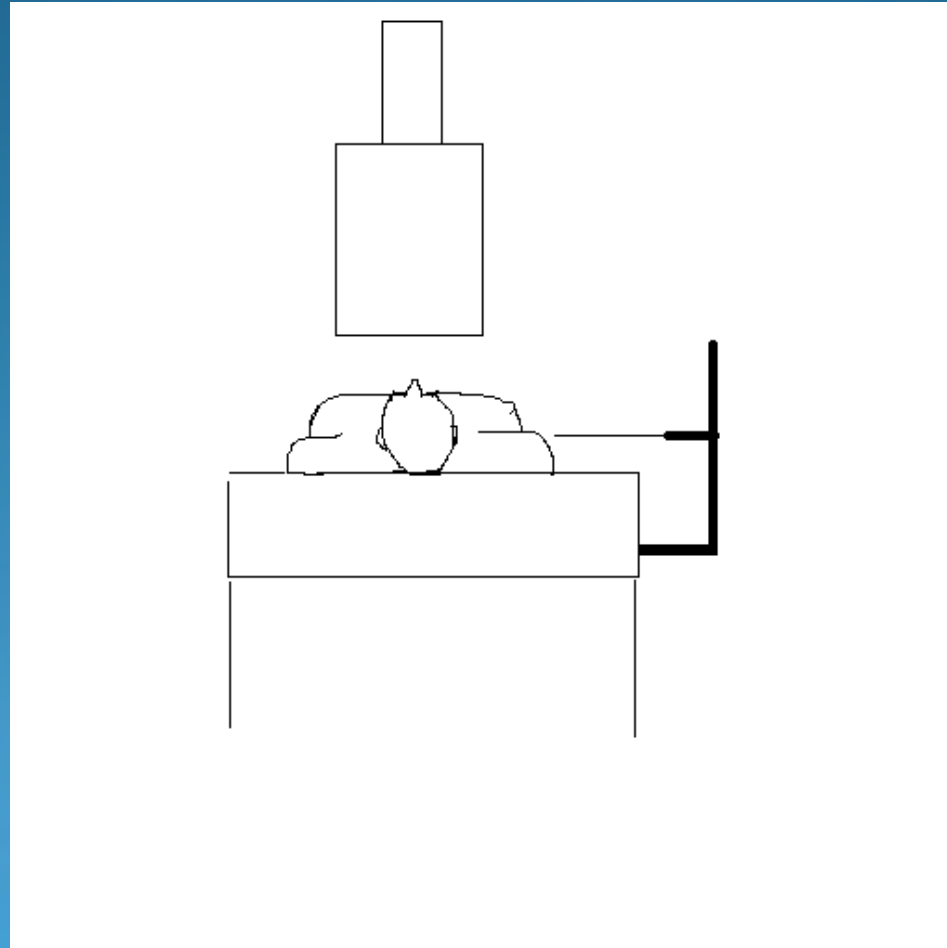
עקומות הלחץ

Pressure transducer

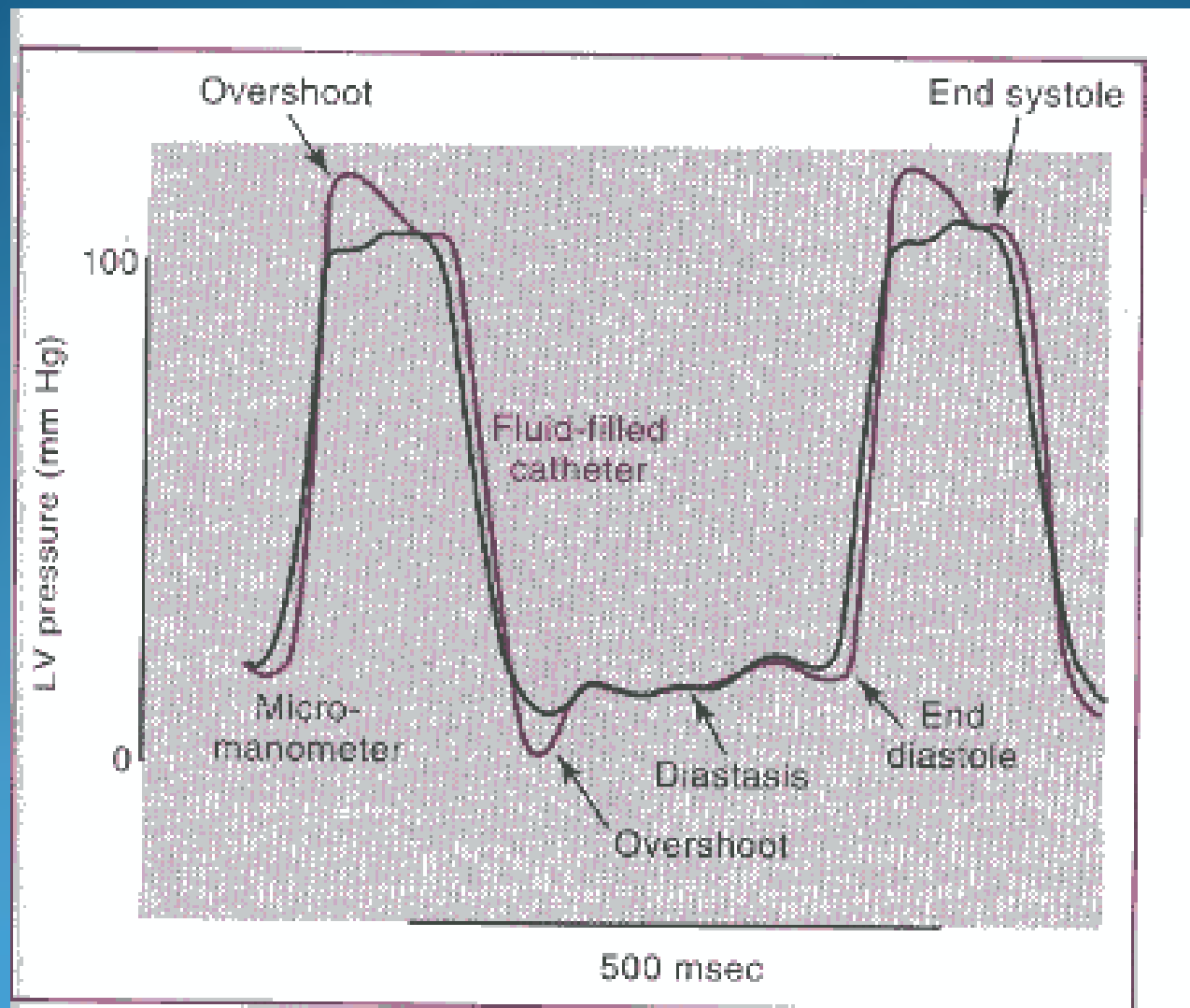
מתמר

- הופך את הסיגנל המכאני לחשמלי ולאנלוגי: עקומות הלחץ
- Frequency response
- Damping
- הבדל בין מערכת fluid filled ובין micromanometer

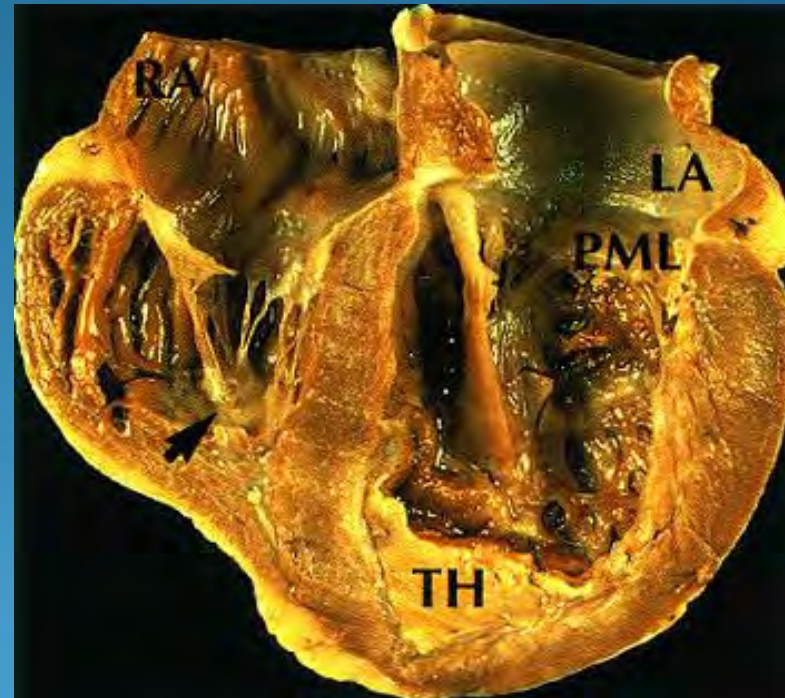
איפוס המתמר



Pressure recording: fluid filled catheter vs micro-manometer



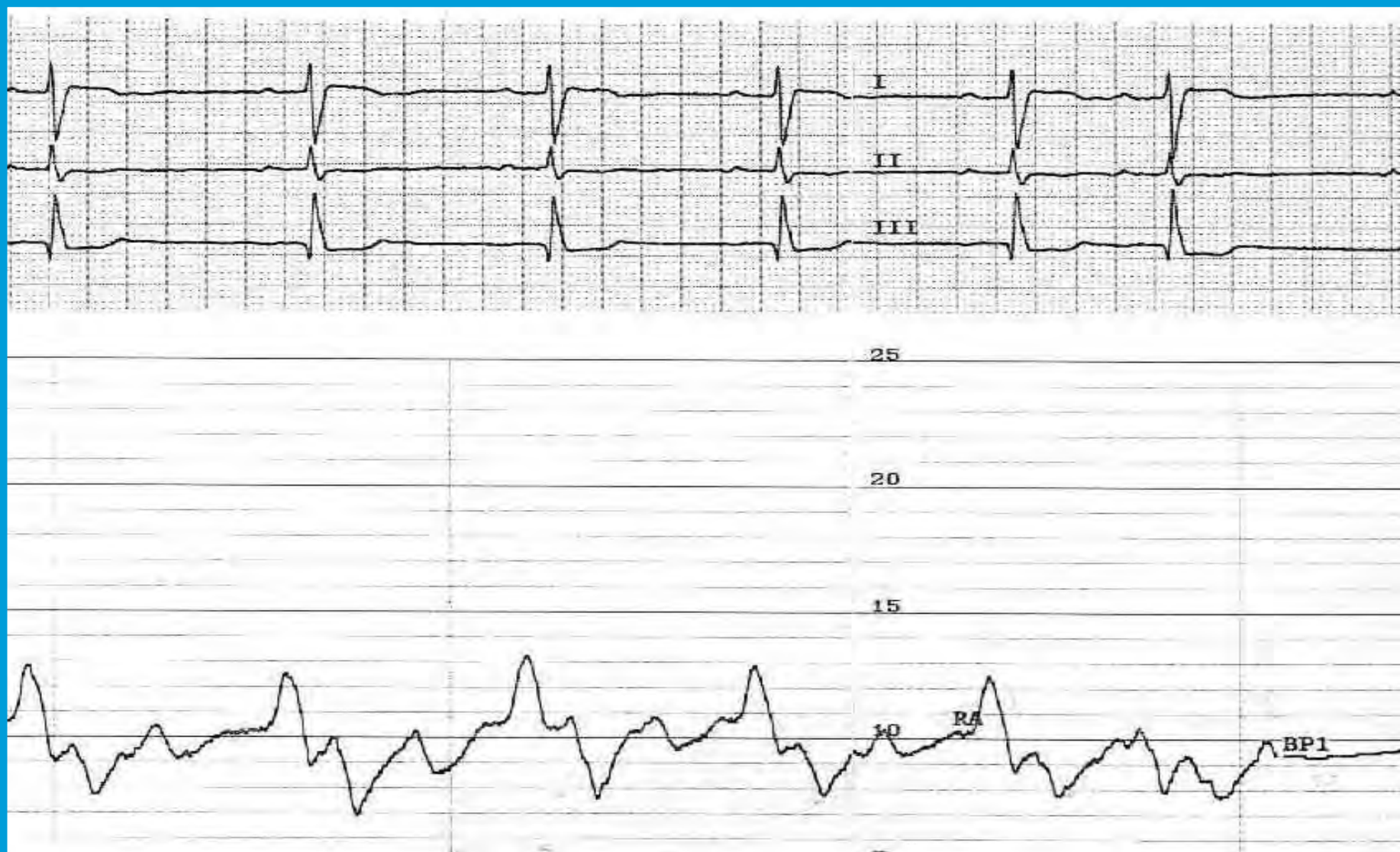
הלחץ בפרוזדור ובחדר



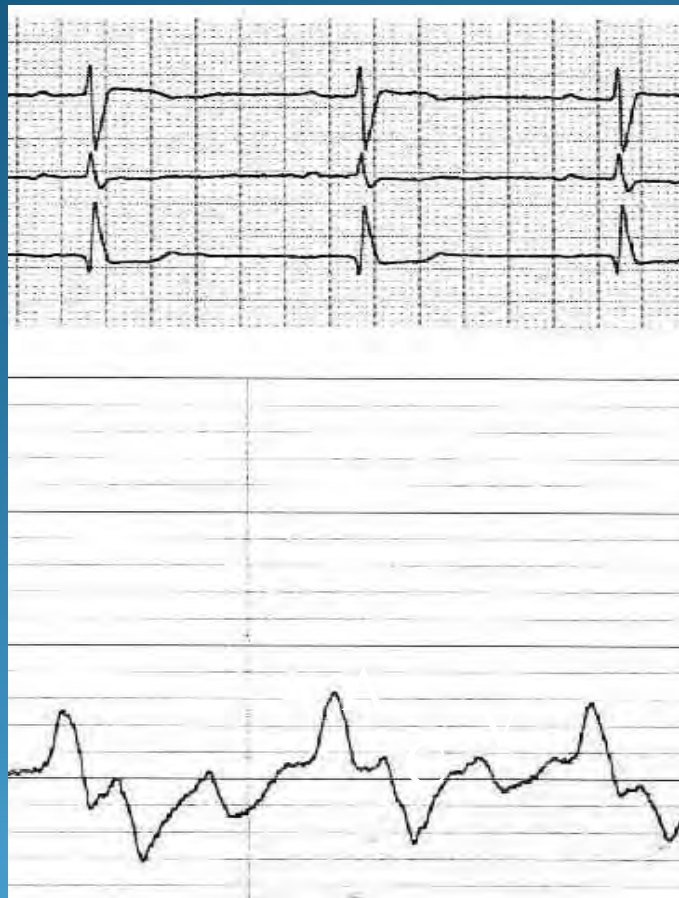
הלחץ בחדר השמאלי ובחדר הימני



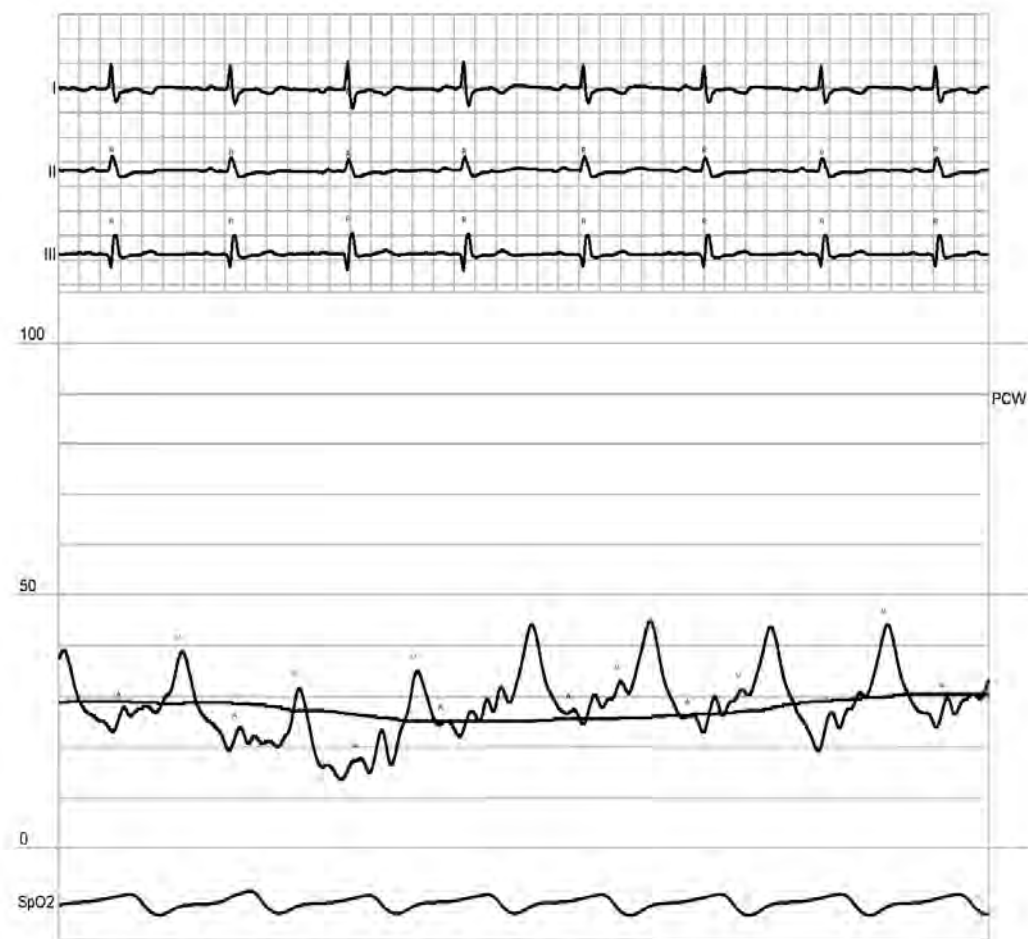
Right atrium



פרוזדור ימני ושמאלי



X

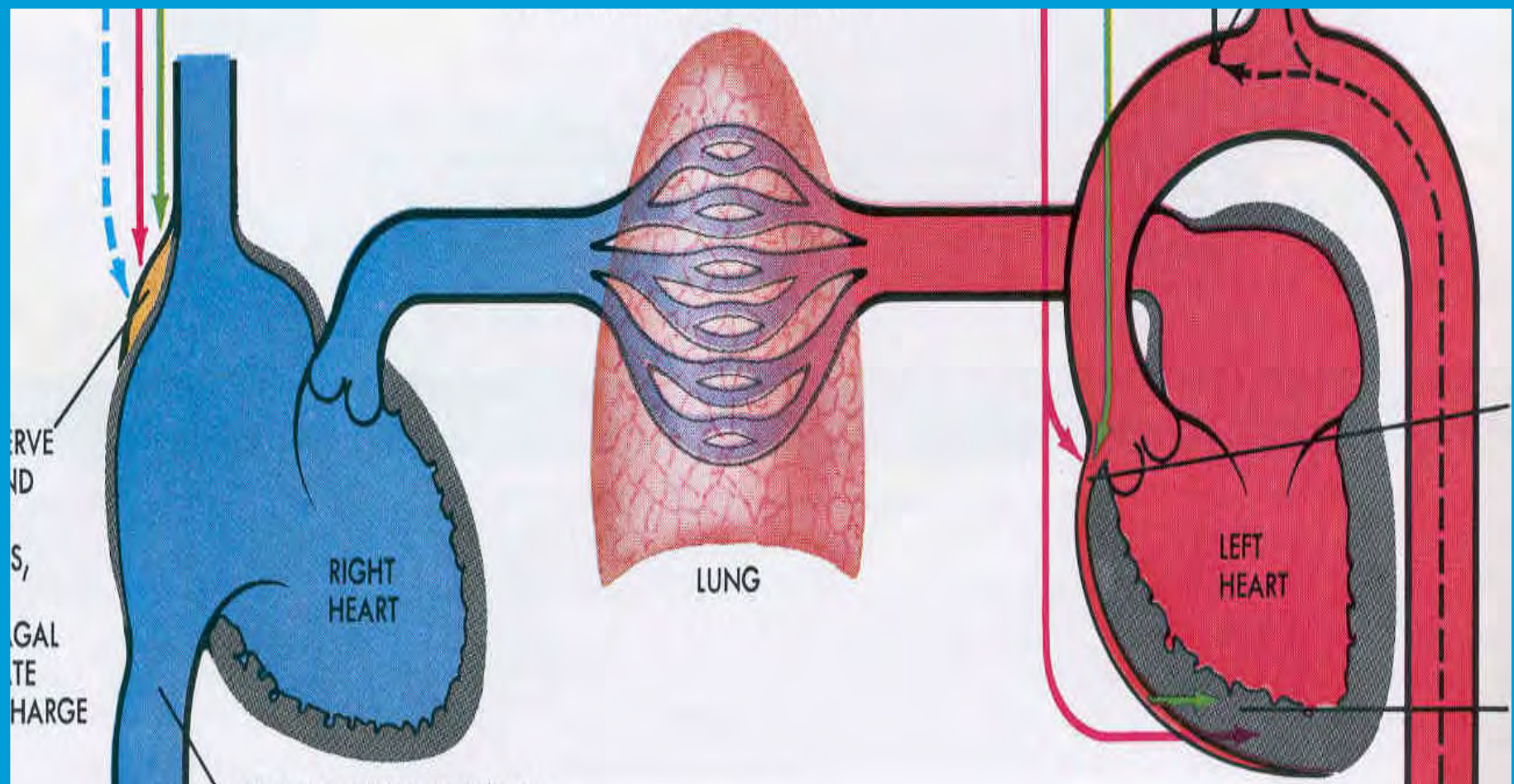


HR: 74 bpm Resp: Off Spo2: 99 % Temp: Off NIBP: Off

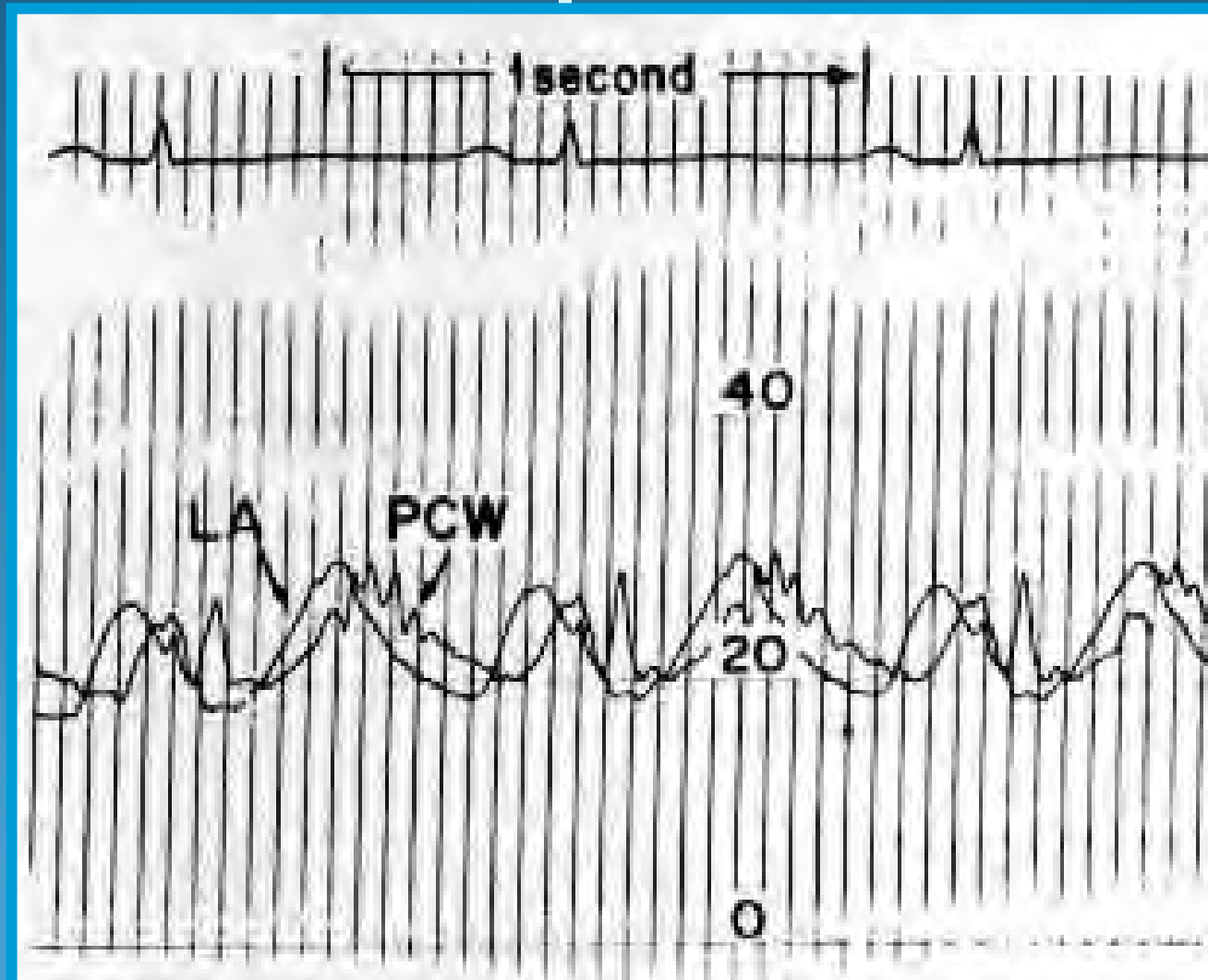
P1: PCW 26/36 (28)

לחץ בנימיות הריאה

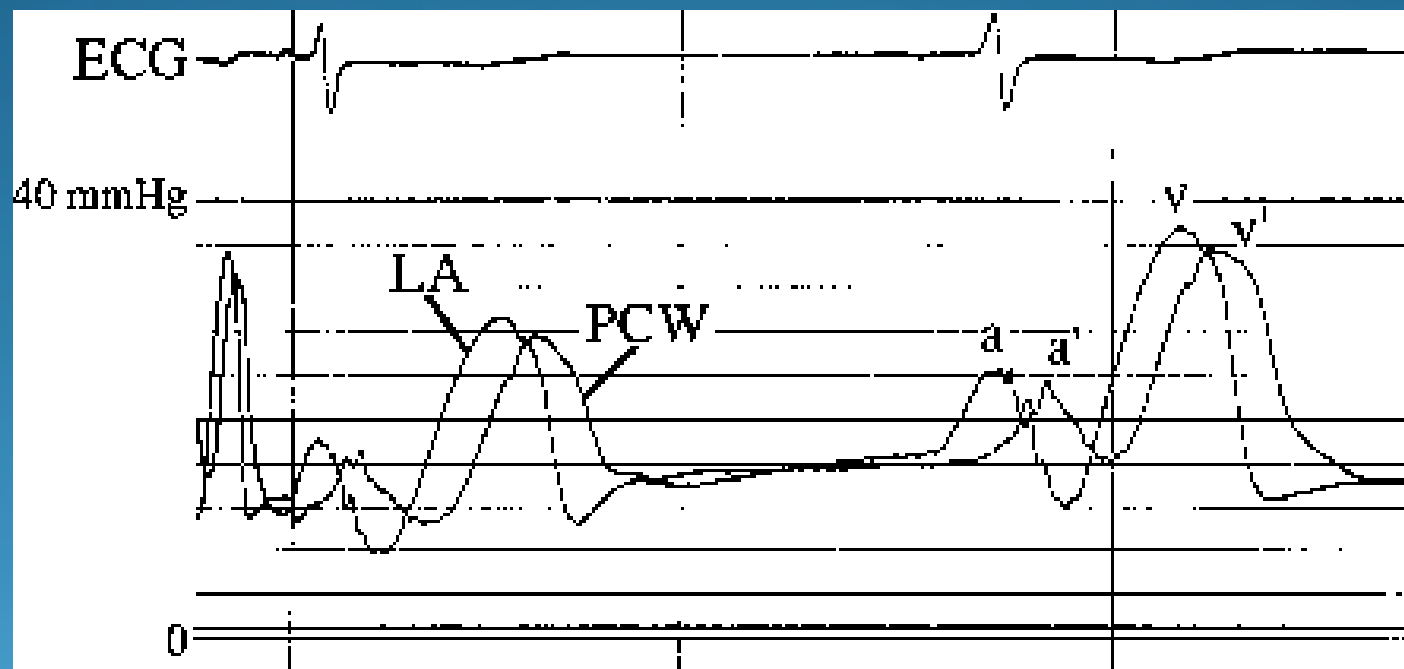
pulmonary capillary wedge pressure



PCWP and LA pressure



לחץ בנימיות הריאה ובפרוזדור השמאלי

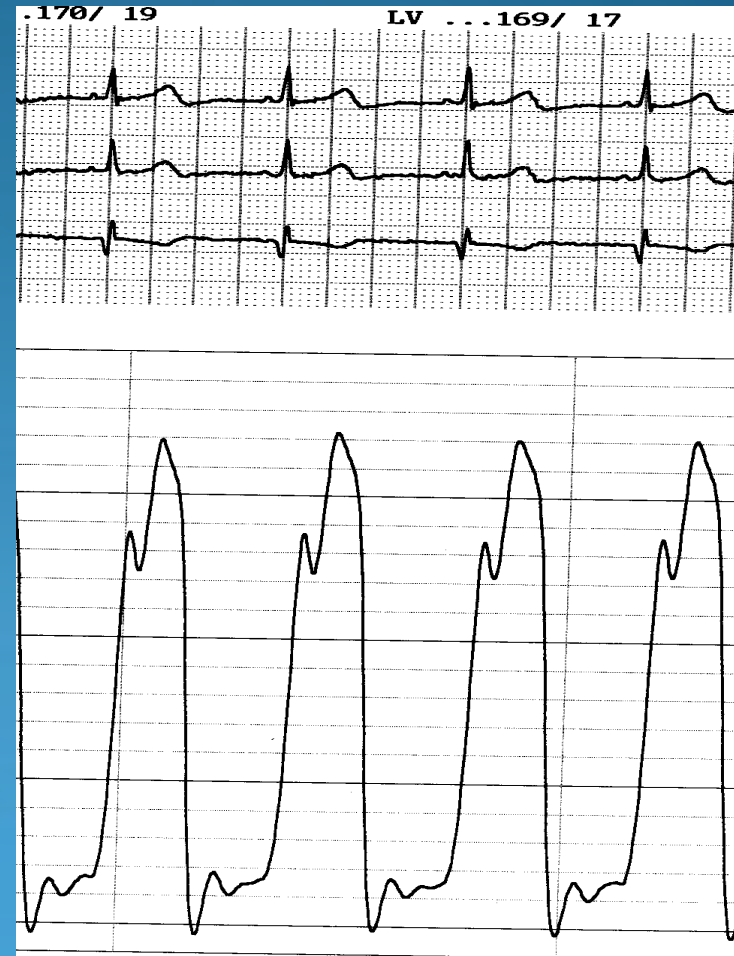
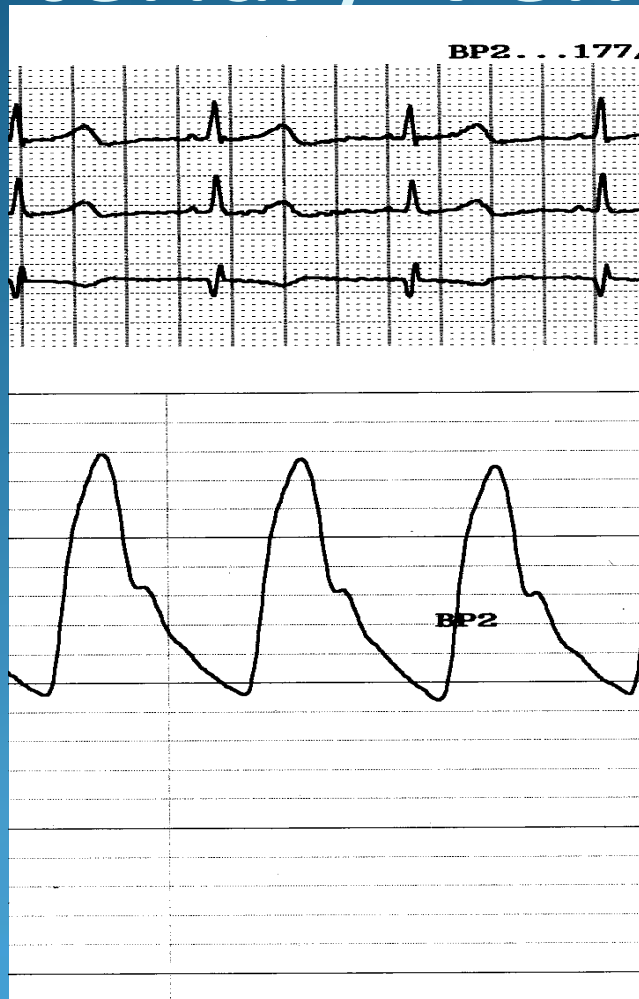


Source: Fuster V, O'Rourke RA, Walsh RA, Poole-Wilson

P: *Hurst's The Heart*, 12th Edition: <http://www.accessmedicine.com>

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Arterial / Ventricular curve



לחצים תקינים

● לב שמאלי

● פרוזדור PCWP

(12)

● חדר 120/12

● אאורטה 120/80

● לב ימני

● פרוזדור (5)

● חדר 30/5

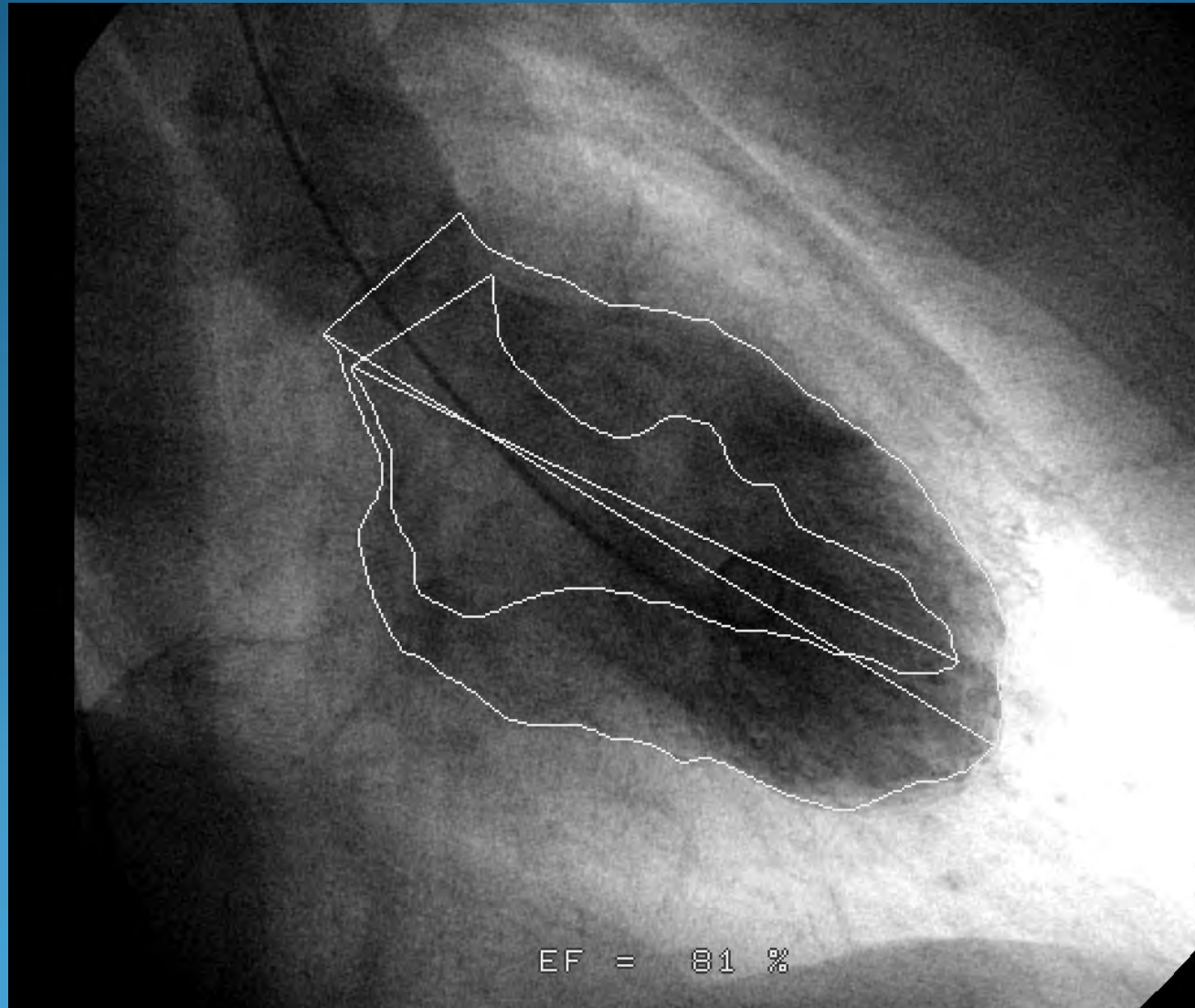
● עורק הריאה 30/12

(20)

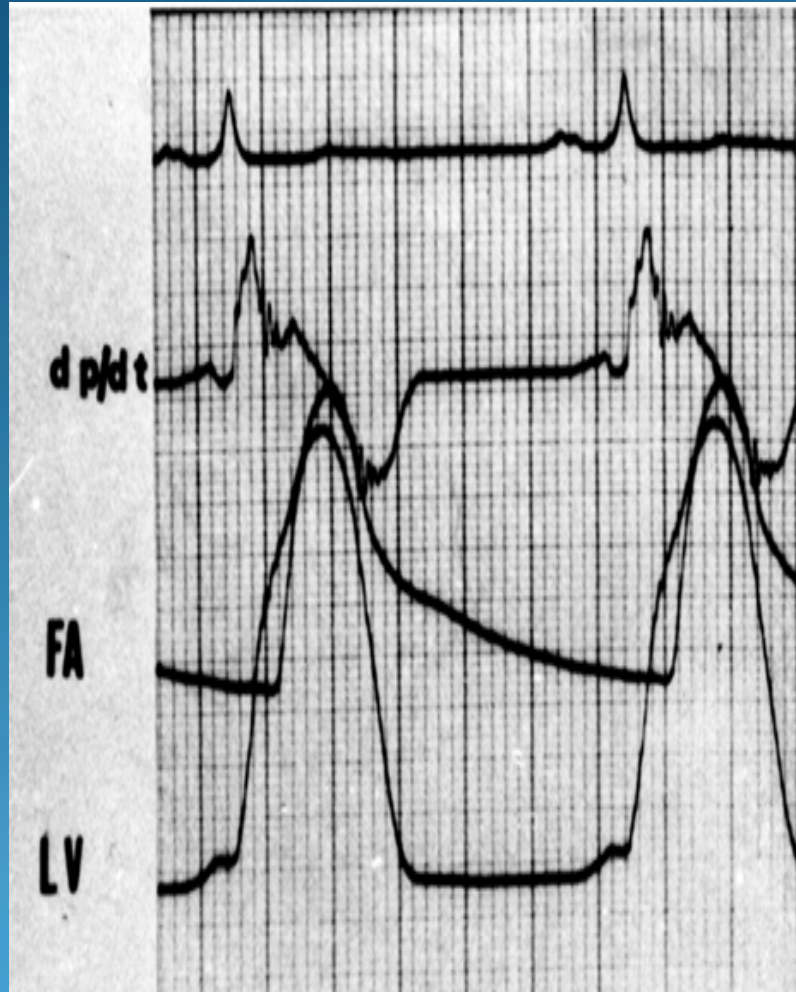
תפקוד סיסטולי

LV performance

Angiographic LVEF



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]

Systolic dysfunction: pulsus parvus

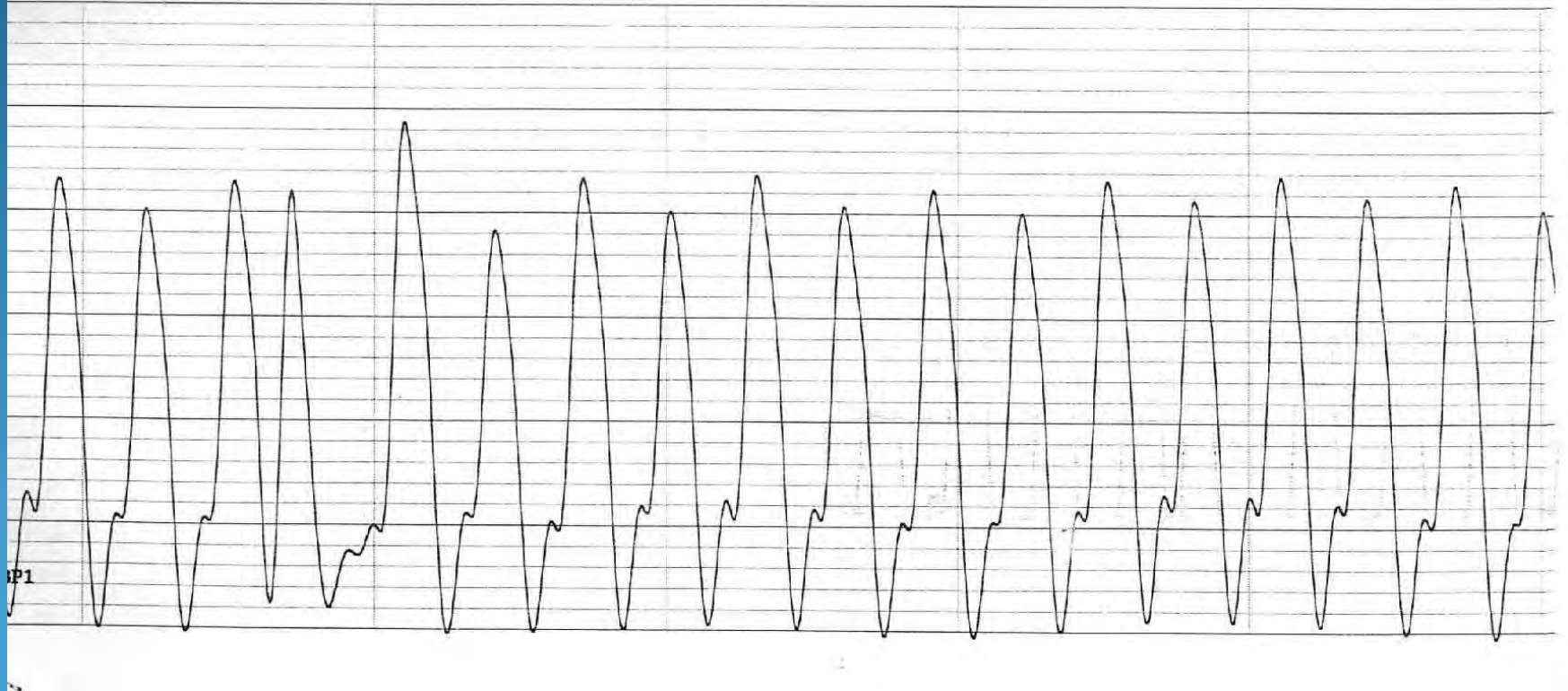
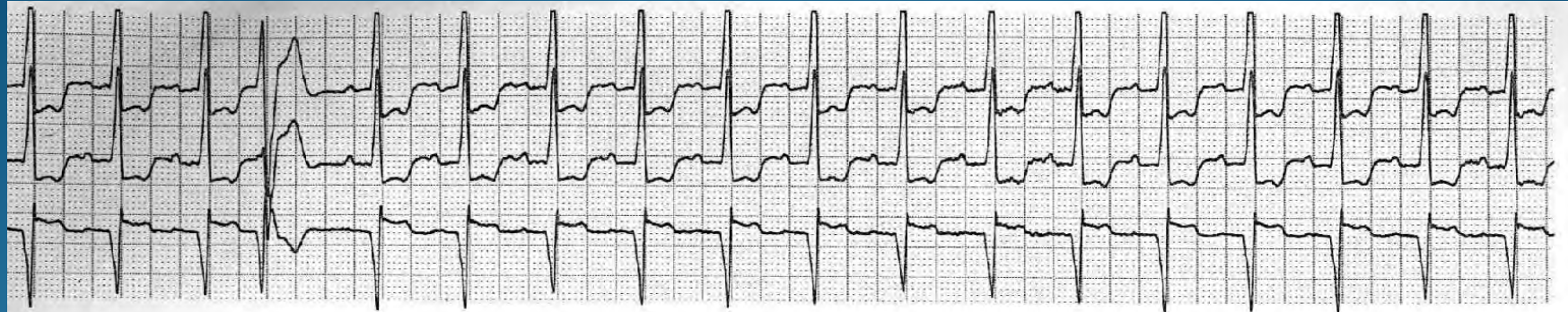
- LVEF 20%



- Normal



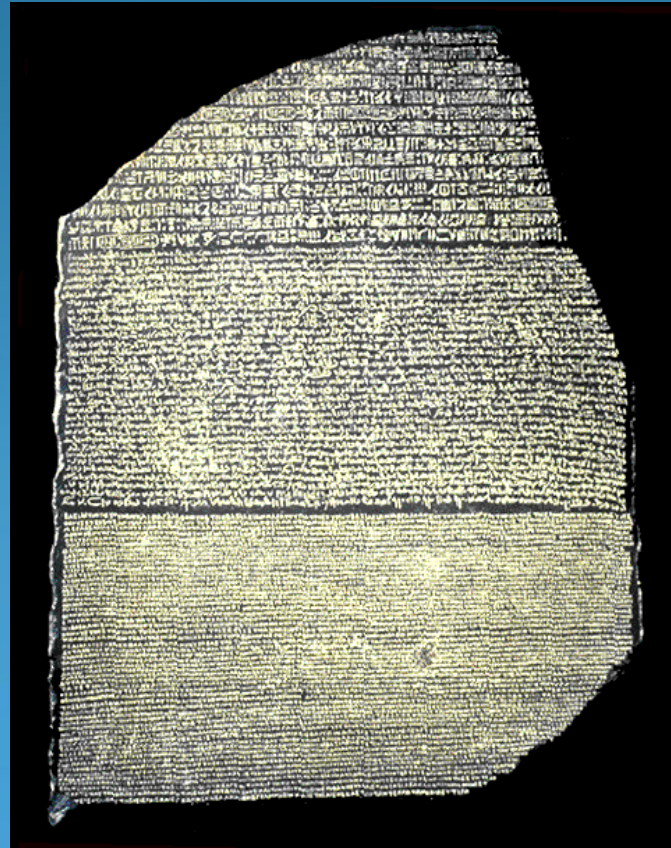
Mechanical alternans



תפקוד דיאסטולי

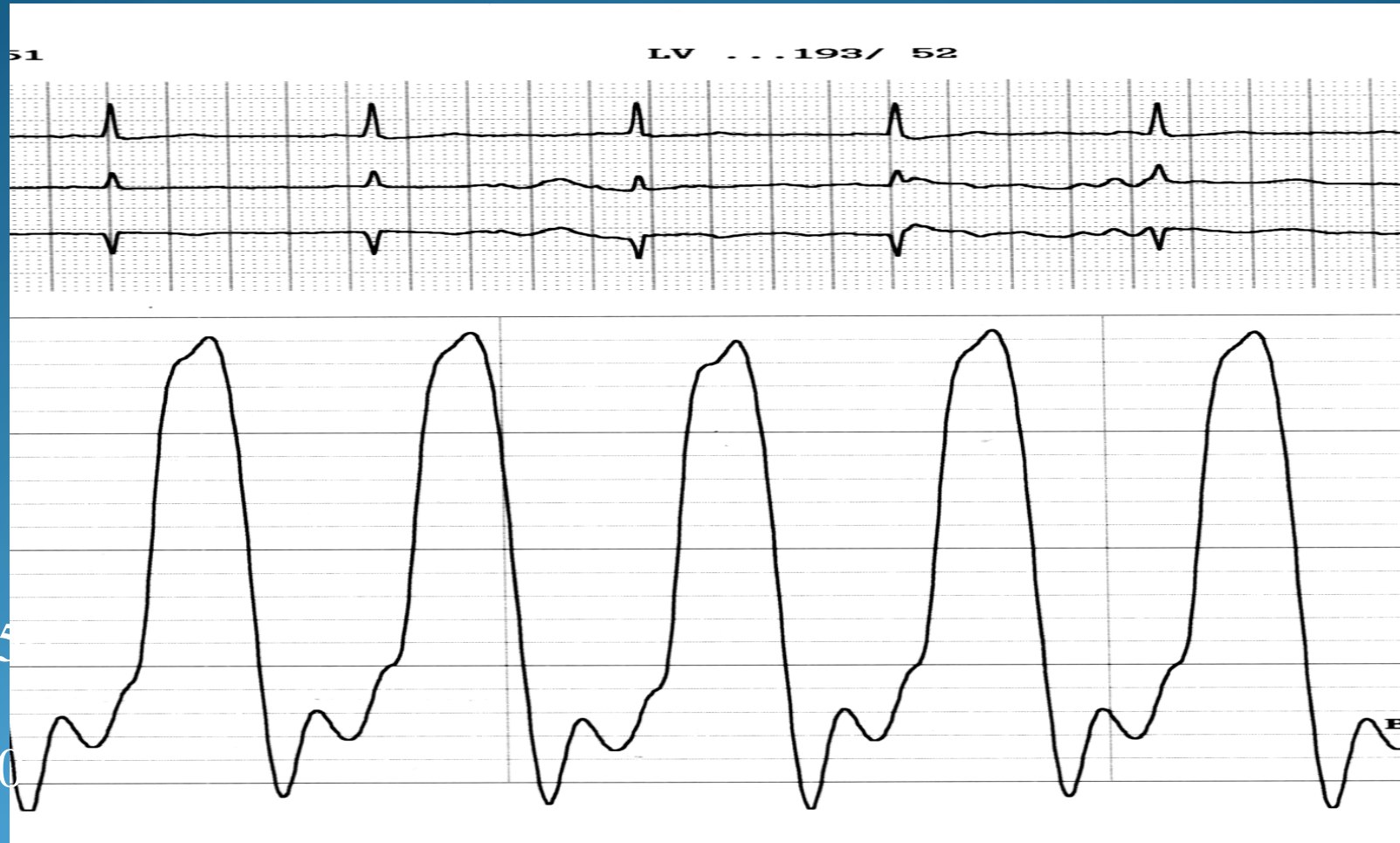
Evaluation of diastolic filling of left ventricle in health and disease: Doppler echocardiography is the clinician's Rosetta stone.

Nishimura and Tajik *J Am Coll Cardiol* 1997



Diastolic dysfunction

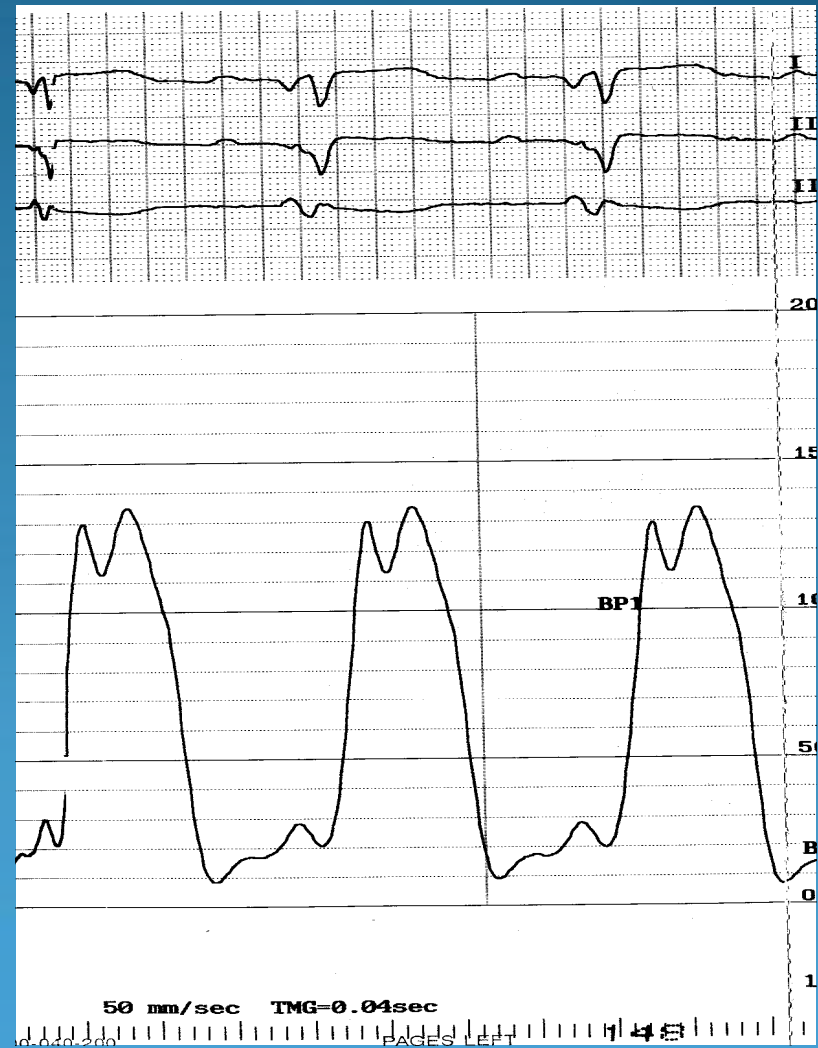
Increased LVEDP



Diastolic failure due to delayed relaxation

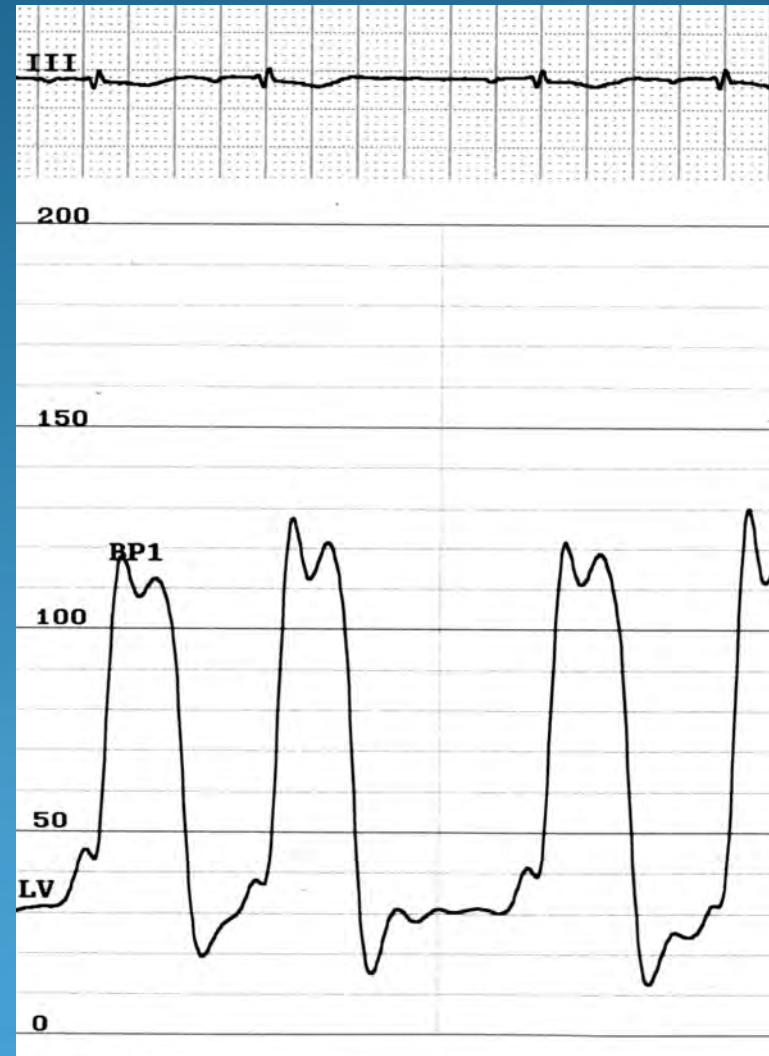
base

NTG



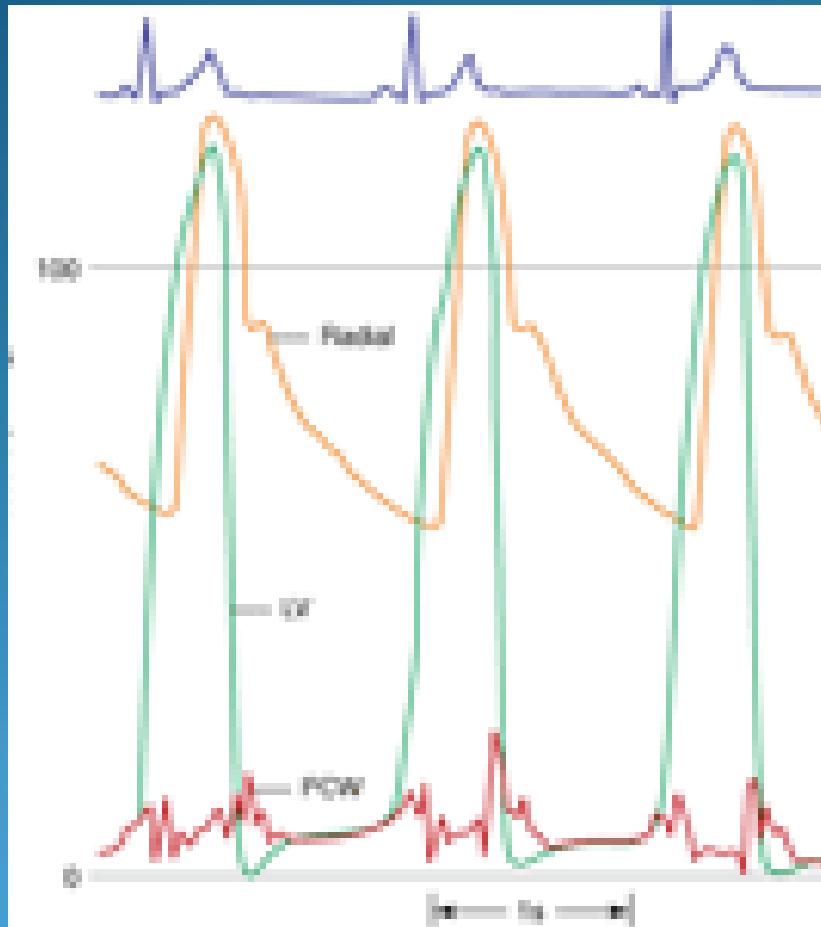
Decreased distensibility

Square root sign



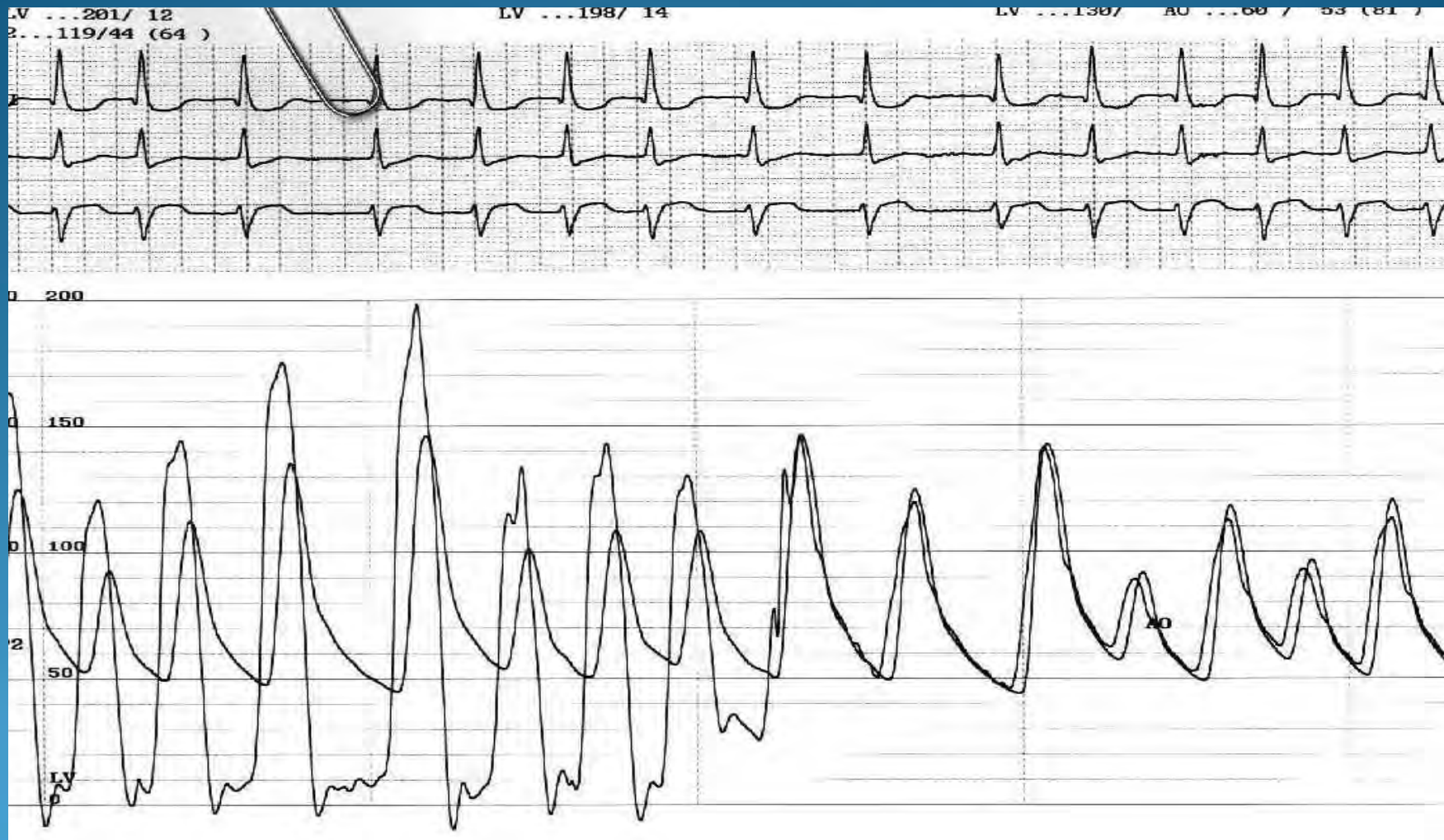
הערכת מומי המסתם: היצרות

מפל לחצים



Aortic stenosis

pull-back and femoral artery



הימודינמיקה והיצרות מסתמי הלב

לא מפל לחצים בלבד!

המודינמיקה

- הערכה המודינמית:

- לחצים

- תפוקת הלב

- ריכוזי חמצן

תפוקת הלב

תפוקת הלב

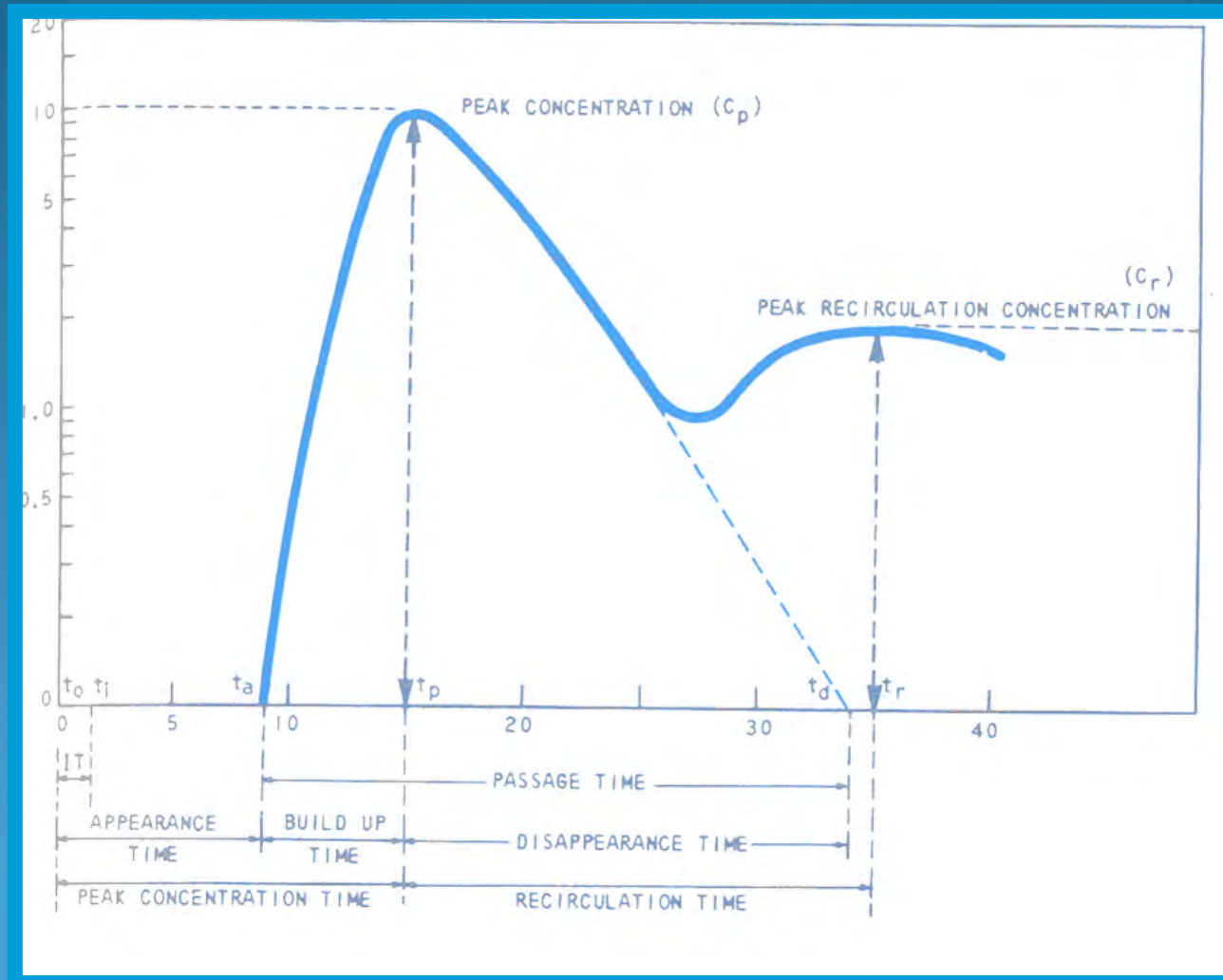
- Fick:

O₂ consumption/A-V difference

- **Dye dilution curves:**

Thermodilution (Swan-Ganz catheter)

Thermodilution



Aortic stenosis: Aortic valve area

- Gorlin:

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

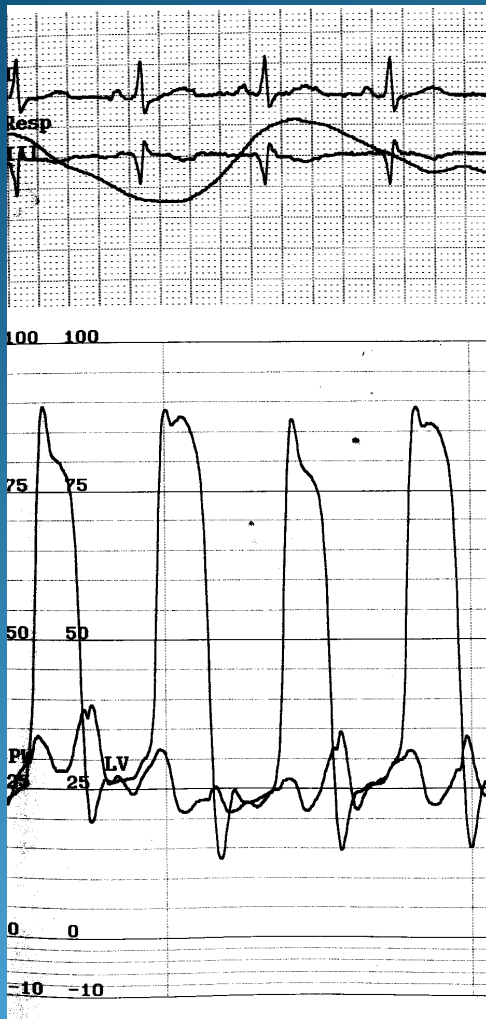
- Hakki:

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

Low gradient aortic stenosis



היצרות מיטרלית



P1: PCW 32/36 (34)

P2: LV 98/7,17

Mitral stenosis:
Mitral valve area

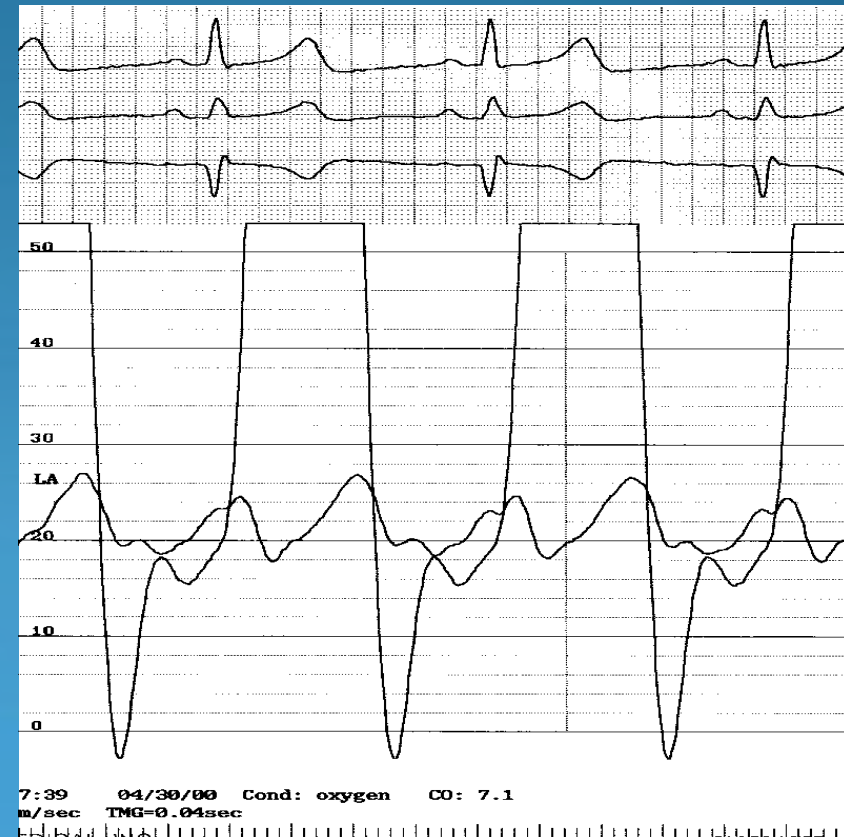
Gorlin:

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

Mitral valvuloplasty

pre

post

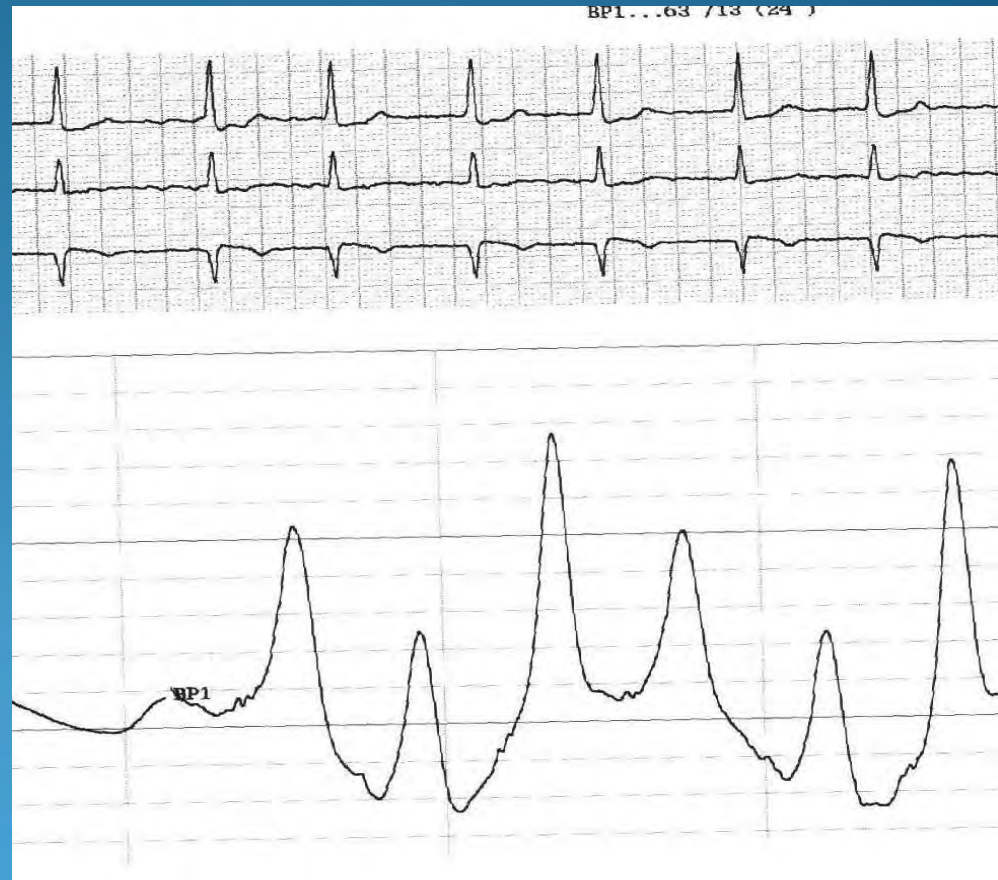
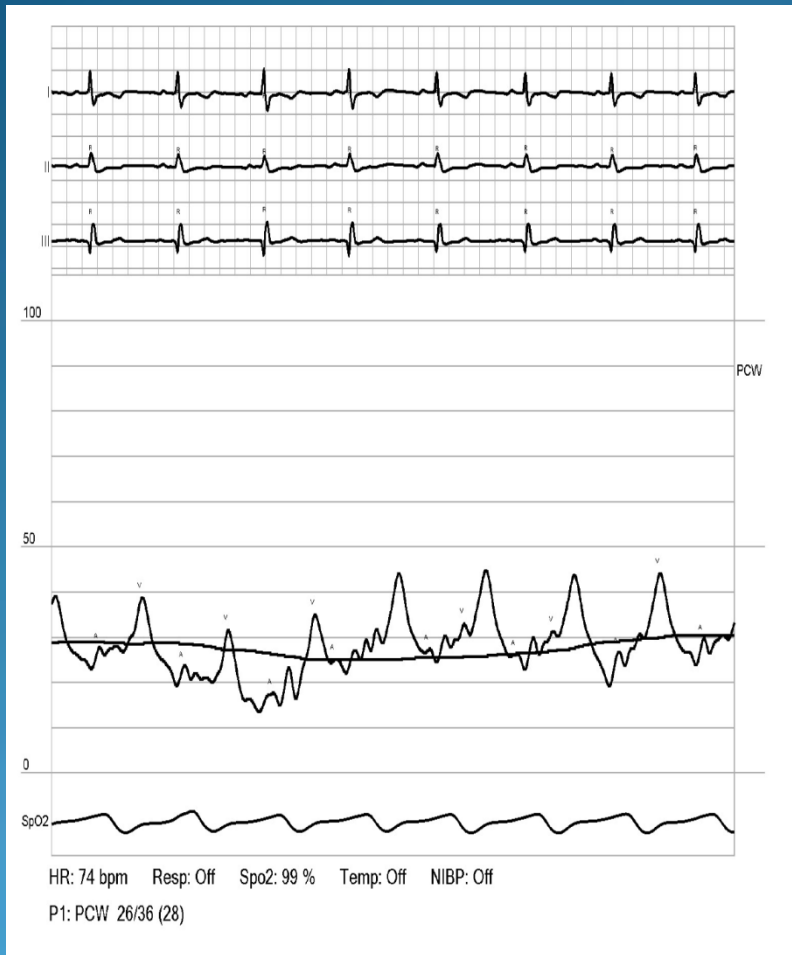


הערכת מומי המסתם:

אי-ספיקה מיטרלית וטרקוספידלית

איספיקה מיטרלית

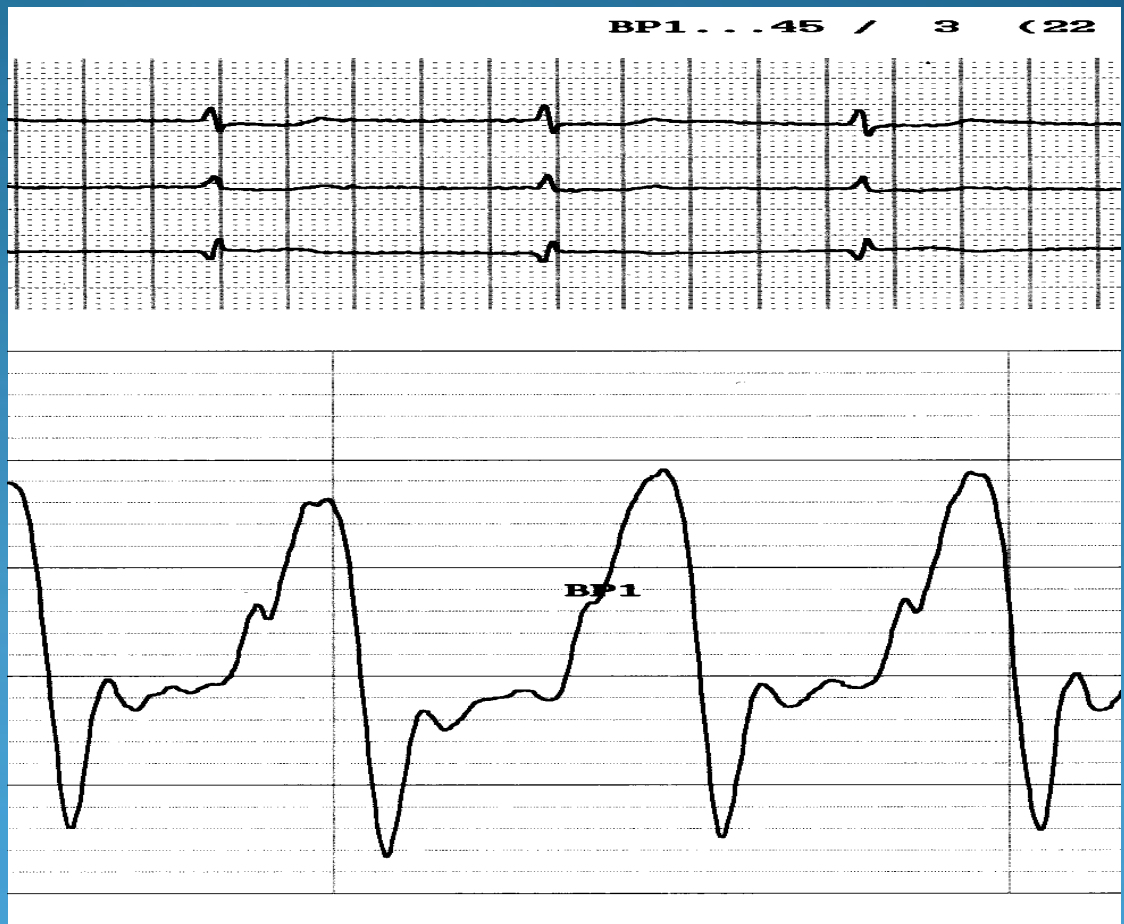
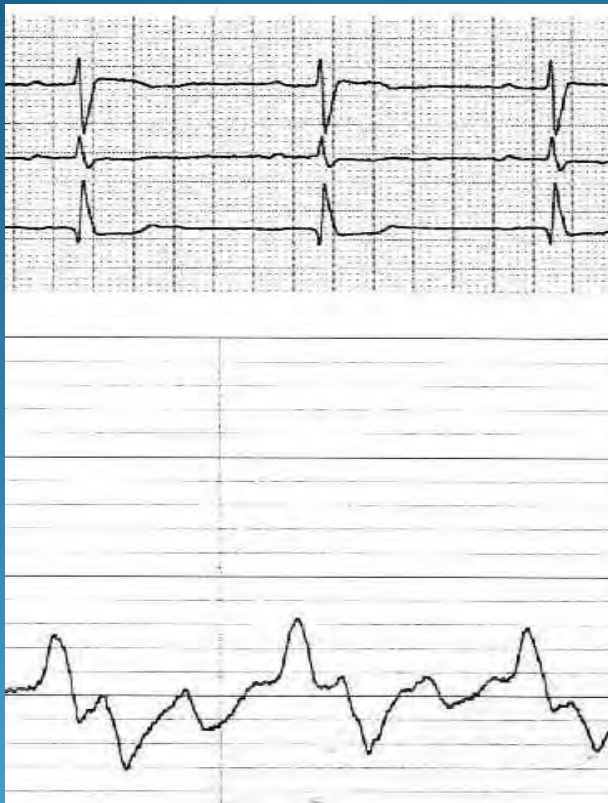
גל V גבוה



Mitral insufficiency grade 4

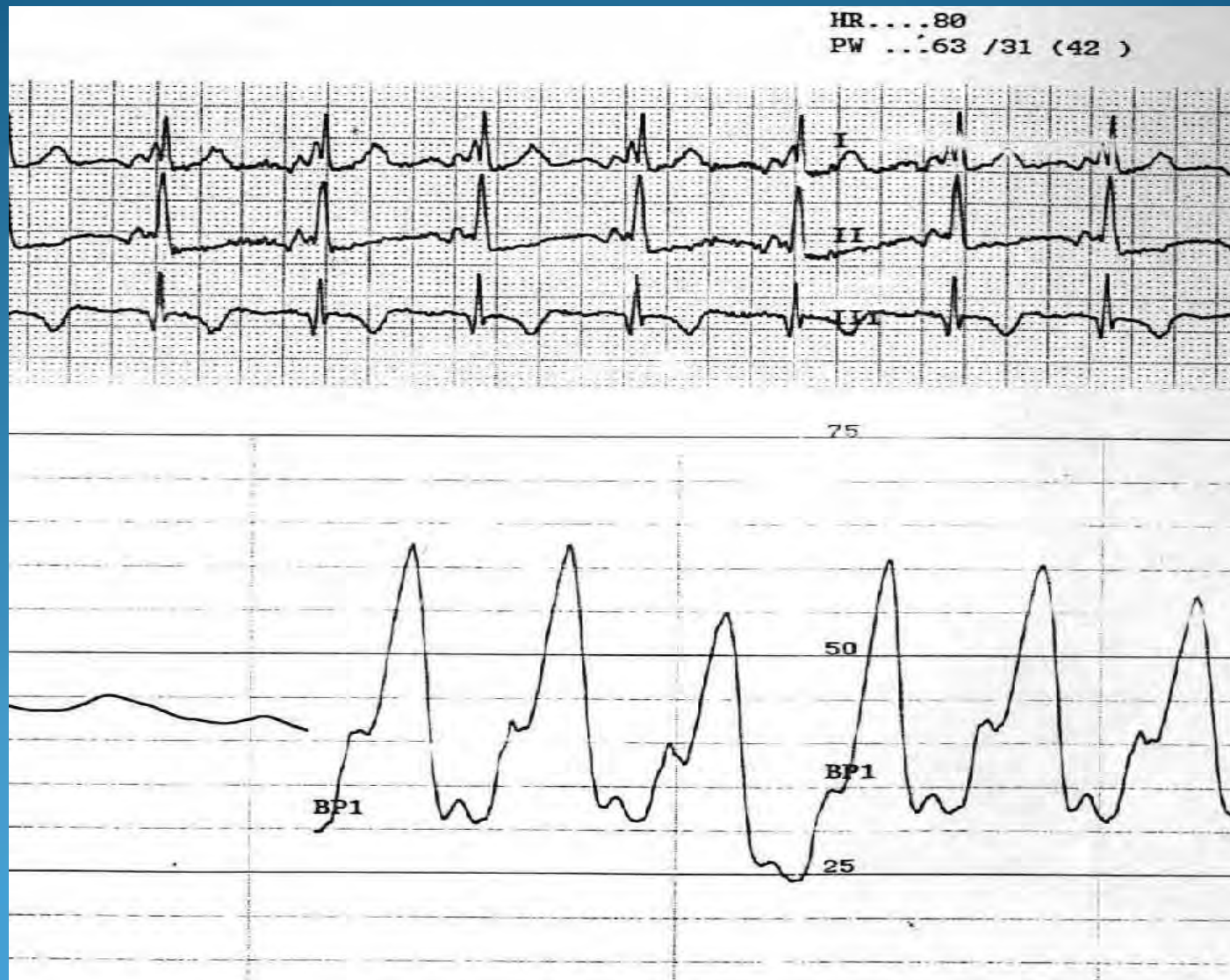


Severe tricuspid insufficiency. Ventricularization of RA pressure



Mitral insufficiency

“ventricularization”

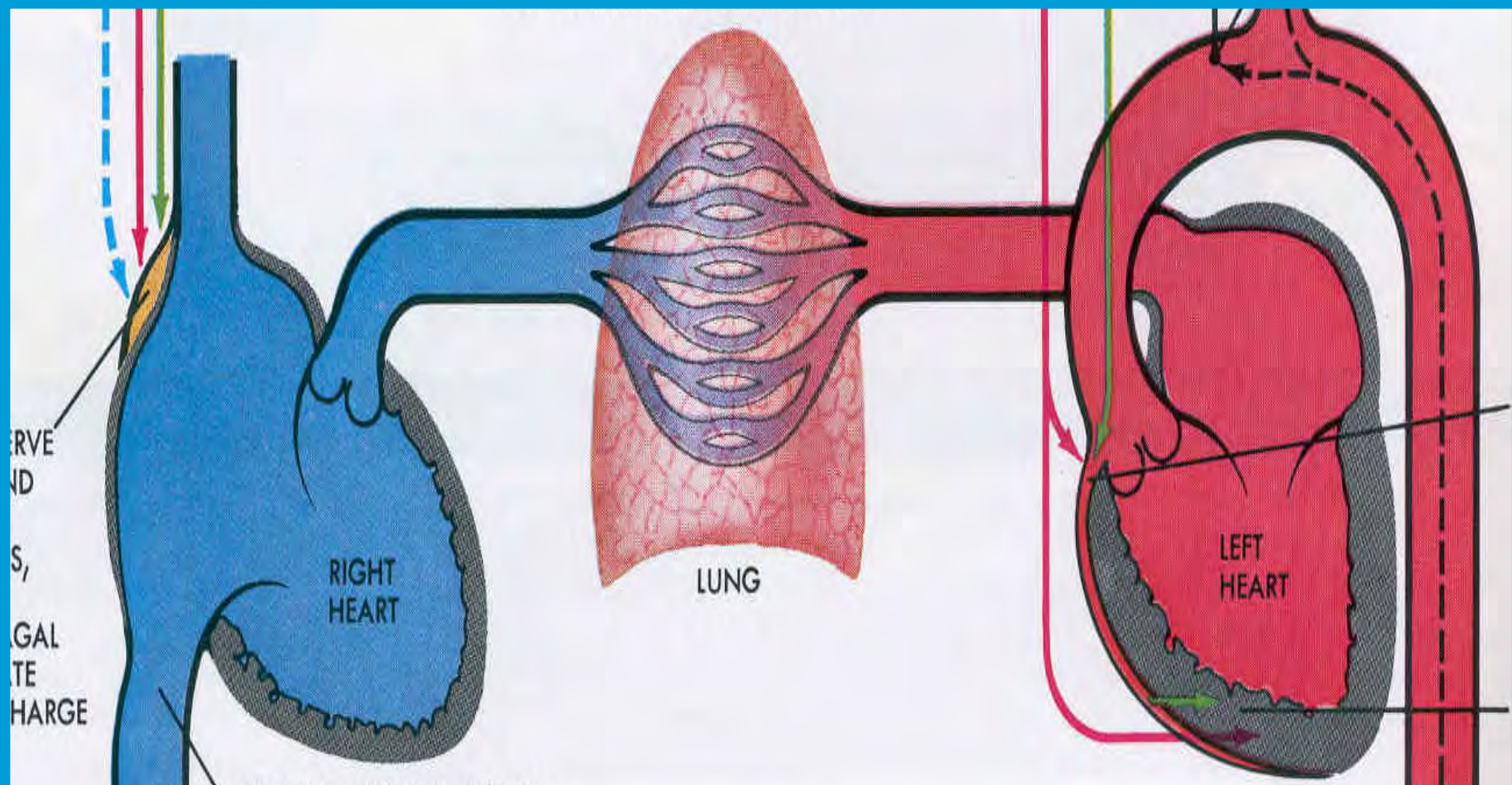


נוסחאות המודינמיות Resistance-R תנגודת

$$P=Q \cdot R$$

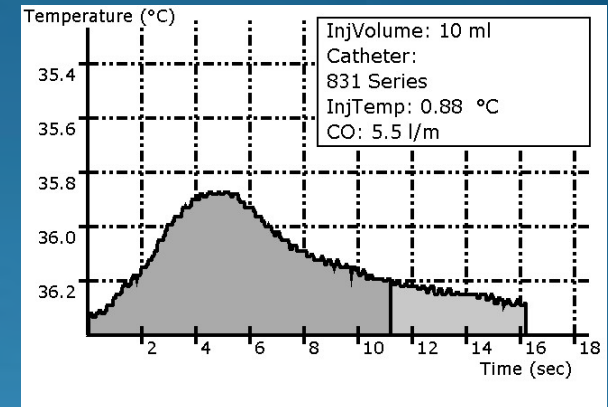
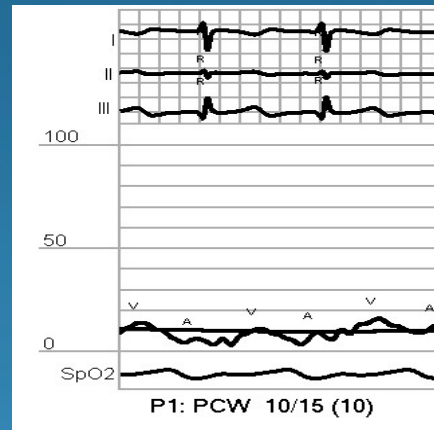
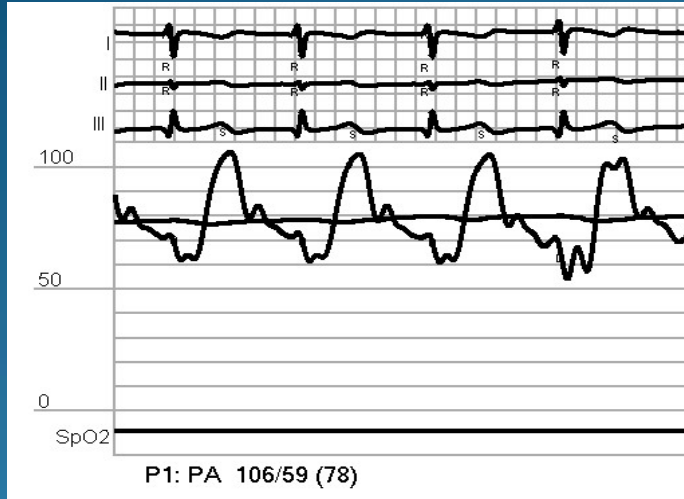
$$R=P/Q$$

תנגודת ריאתית



יתר ל"ד ריאתי ראשוני

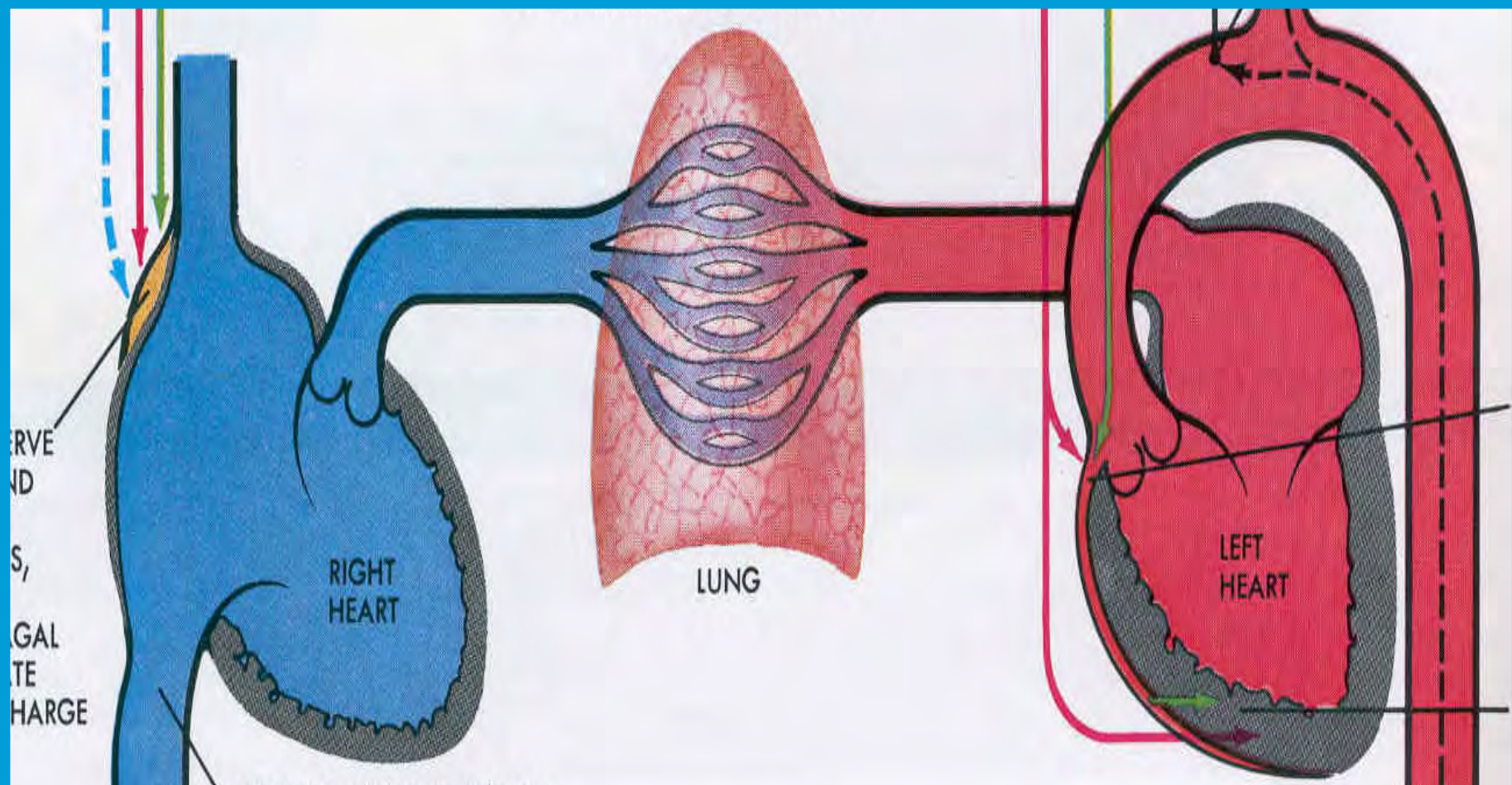
תנגודת ריאתית מוגברת



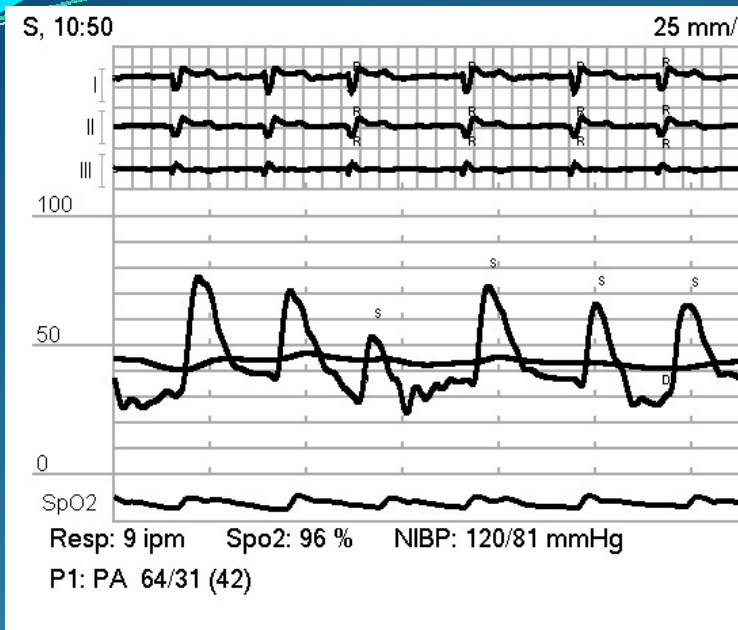
- PA mean 80
- PW 10
- CO 4.17 l/min
- TPVR 19 w/u
- PVR 16 w/u

- $R=P/CO$
- $TPVR=P \text{ pulm}/CO$
- $PVR=P_{\text{pulm}}-PCWP/CO$

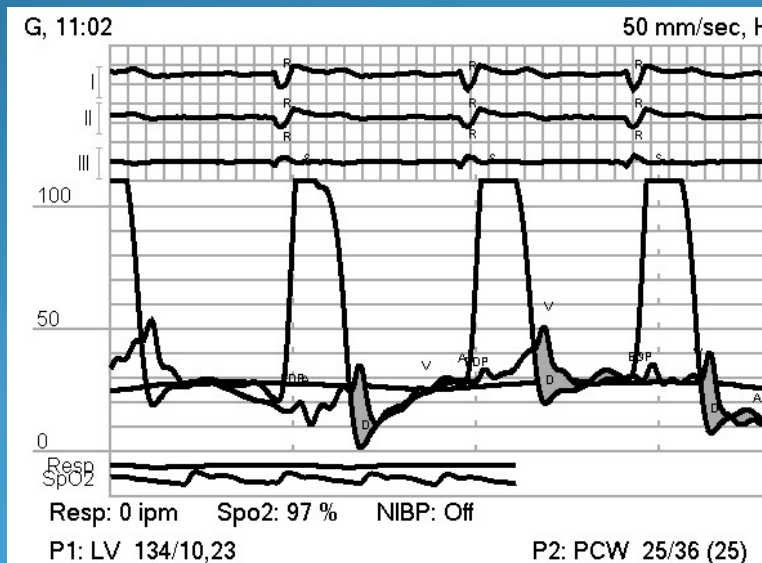
תנגודת ריאתית



יתר ל"ד ריאתי משני תנגודת ווסקולרית תקינה

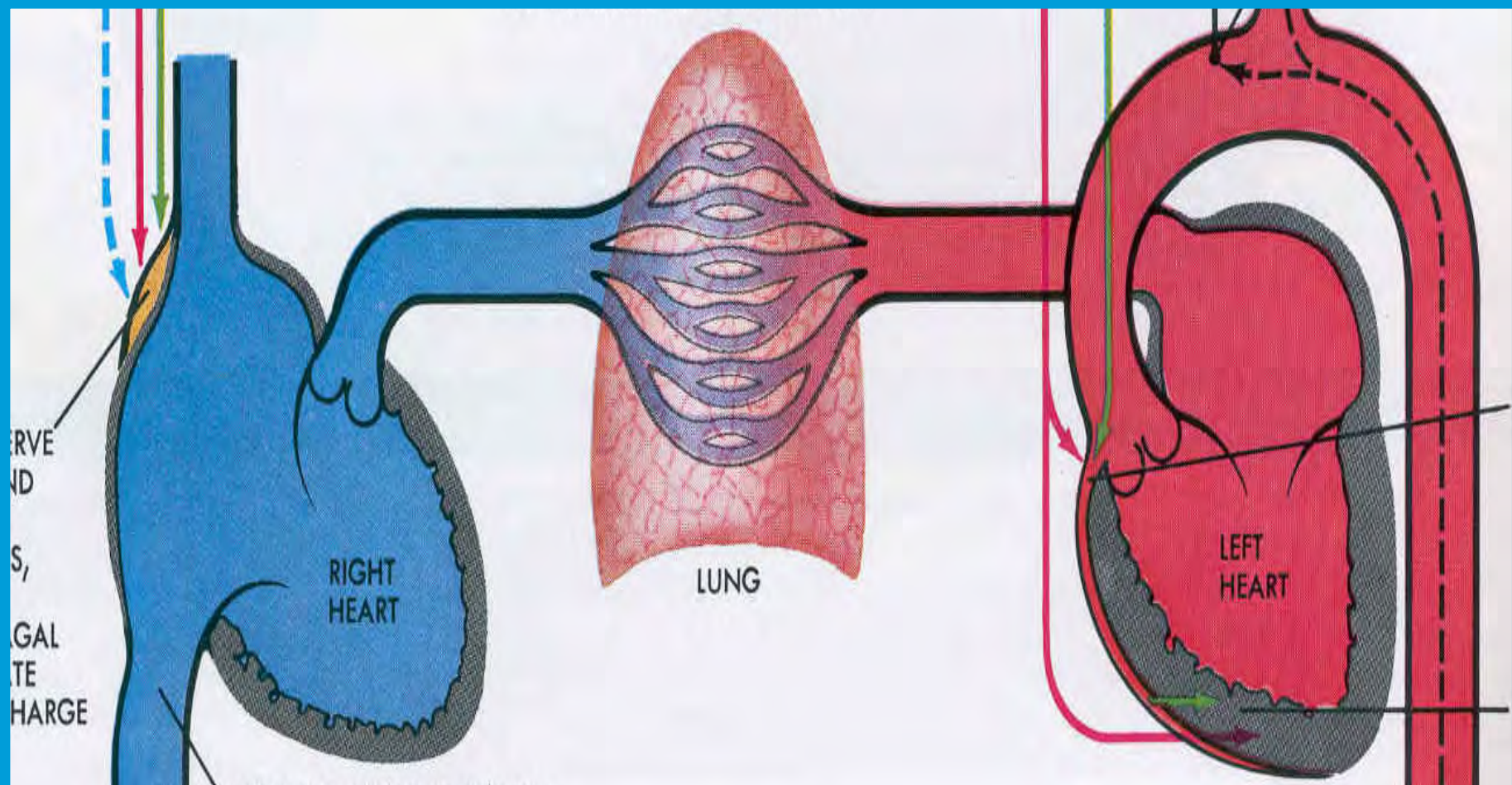


- PA mean 42
- PW 26
- CO =4.3 l/min



- TPVR=9.8 w/u
- PVR=3.9 w/u

תנגודת ריאתית



המודינמיקה

• הערכה המודינמית:

• לחצים

• תפוקת הלב

• ריכוזי חמצן

ריכוזי החמצן-דלף

L=>R shunt

Blood samples

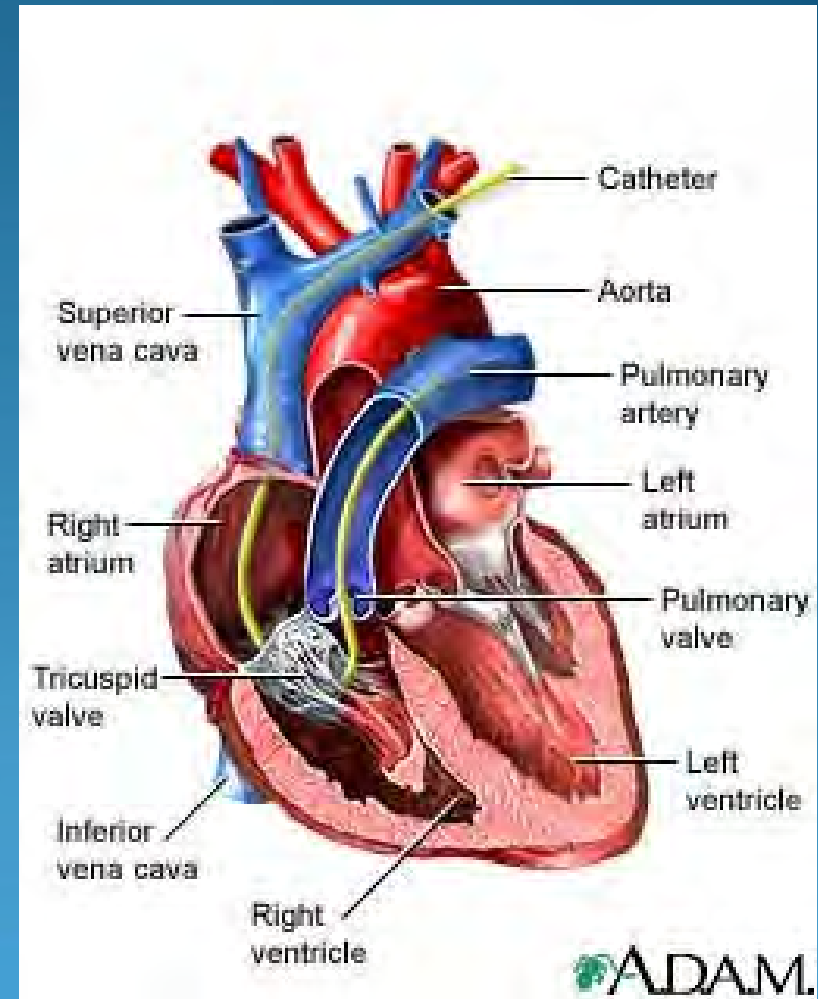
- SVC
- IVC
- RA
 - High
 - Mid
 - Low
- RV
 - In
 - Out
- PA
 - Trunk
 - R
 - L
- LV
- Ao
- PV
- LA

MVB

PAo₂

SAo₂

PVo₂



ASD secundum



L=>R shunt

Blood samples

- SVC
- IVC
- RA
 - High
 - Mid
 - Low
- RV
 - In
 - Out
- PA
 - Trunk
 - R
 - L
- LV
- Ao
- PV
- LA

MVB

PAO₂

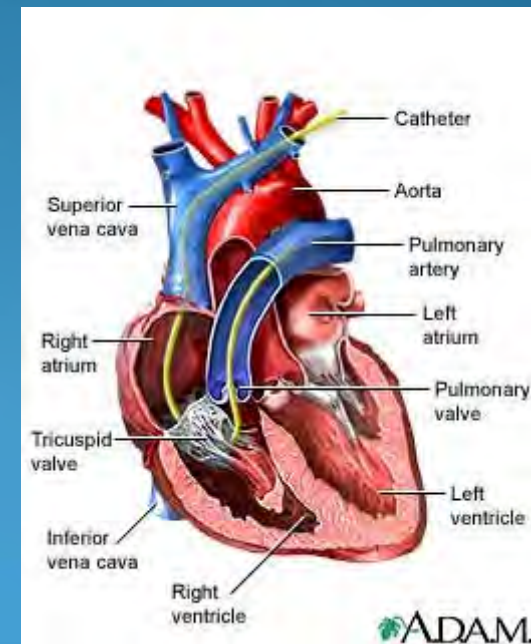
SAO₂

PVO₂

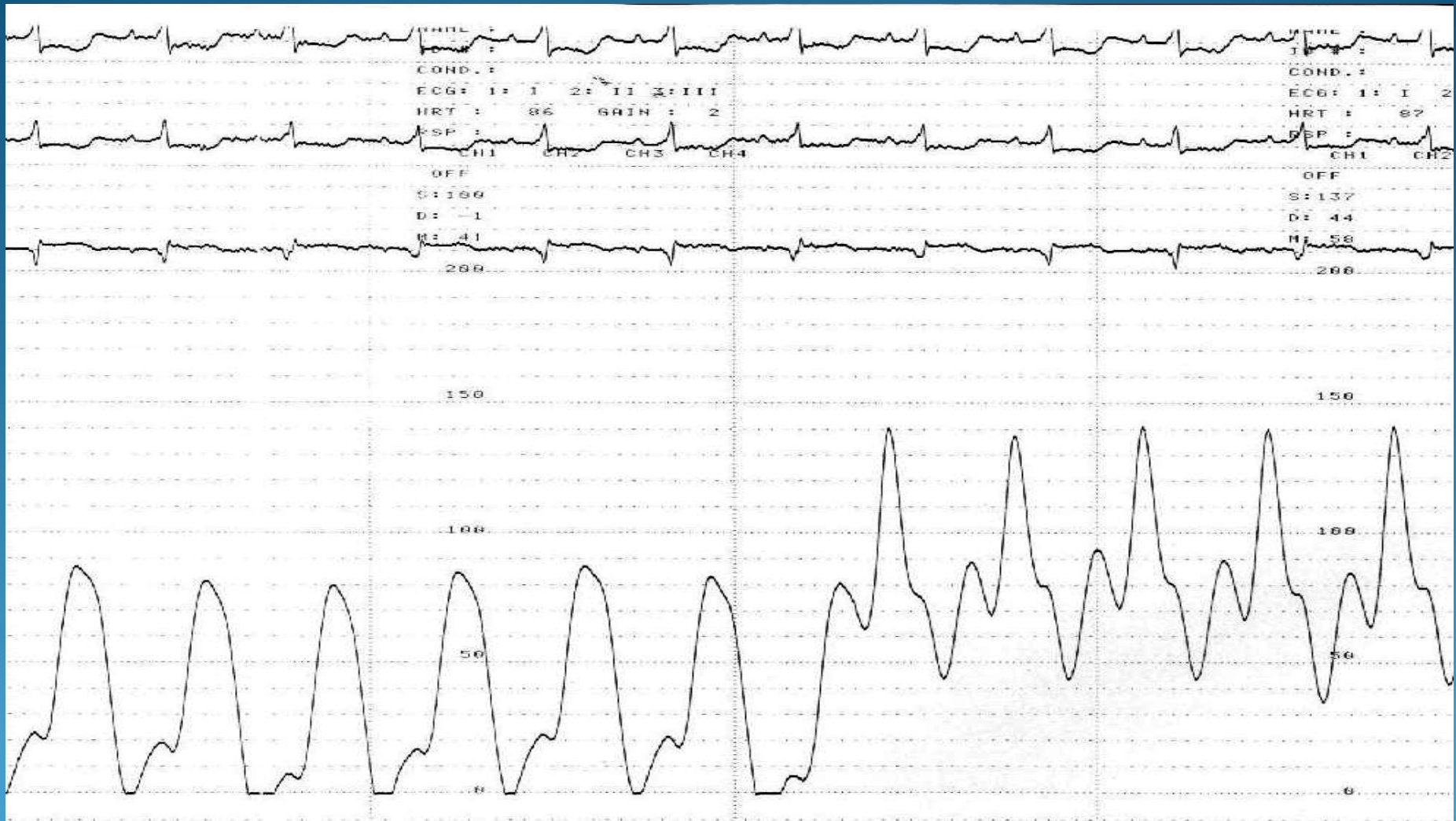


L=>R shunt

- Oxygen content = O_2 saturation \cdot 1.36
- $QP = VO_2 / A_{O_2} - PA_{O_2}$
- $QS = VO_2 / A_{O_2} - MVB$
- $QP/QS = VO_2 / A_{O_2} - PA_{O_2} / VO_2 / A_{O_2} - MVB$
- $QP/QS = A_{O_2} - P_{aO_2} / A_{O_2} - MVB$
- $MVB = SVC_{+2} \cdot IVC / 3$



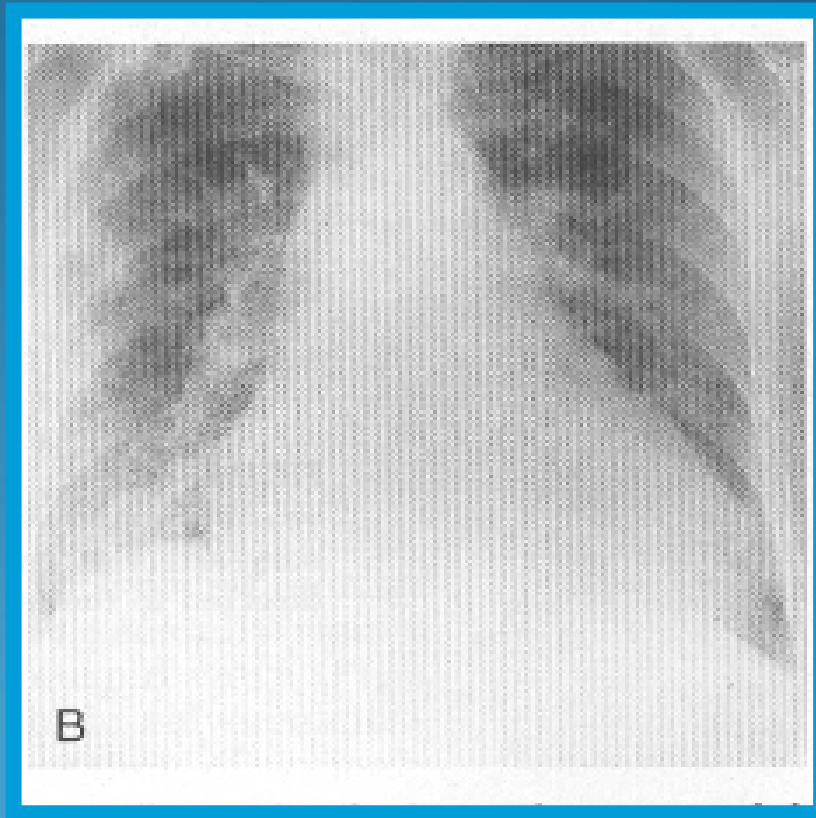
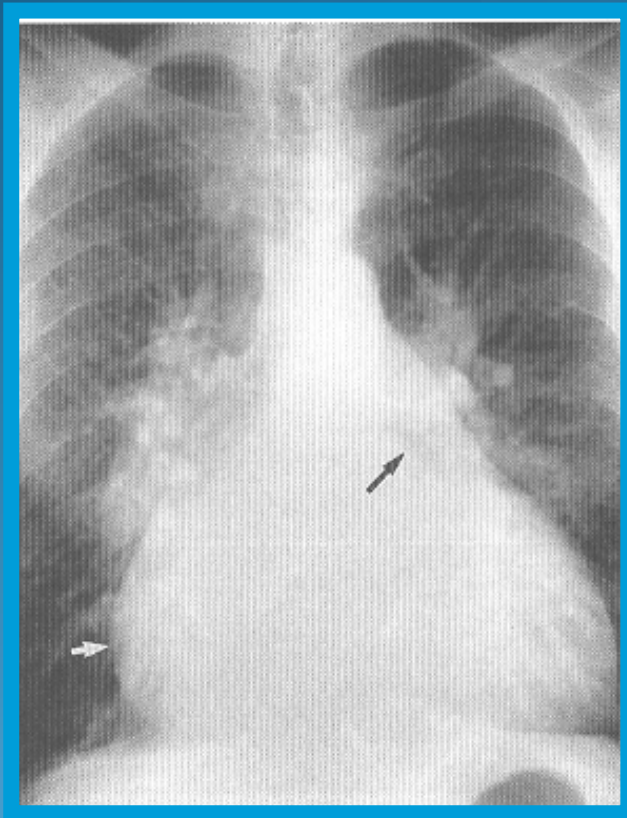
?



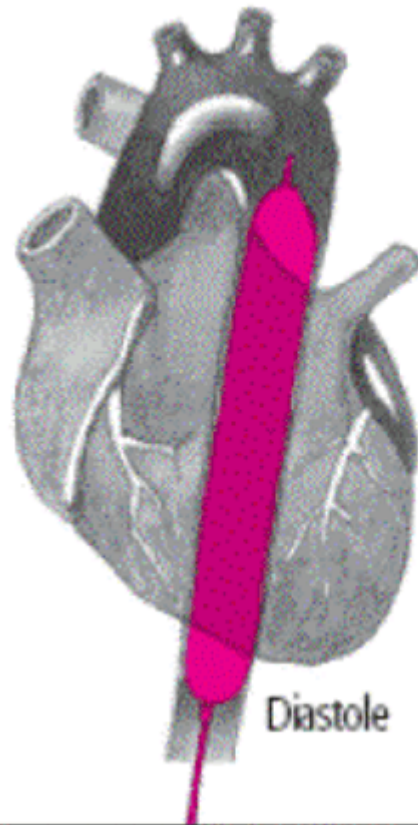
מצבים המודינמיים קריטיים בטיפול נמרץ

- הלם קרדיוגני :
- חדר שמאלי
- חדר ימני
- אי-ספיקה מיטרלית חדה
- קרע של הספטום - VSD
- הלם היפוולמי hypovolemic shock
- ARDS
- טמפונדה של הלב

CHF

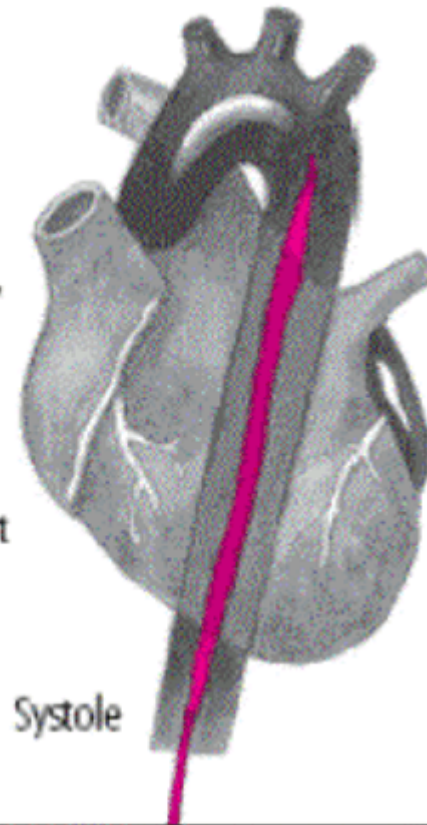


The ins and outs of the IABP



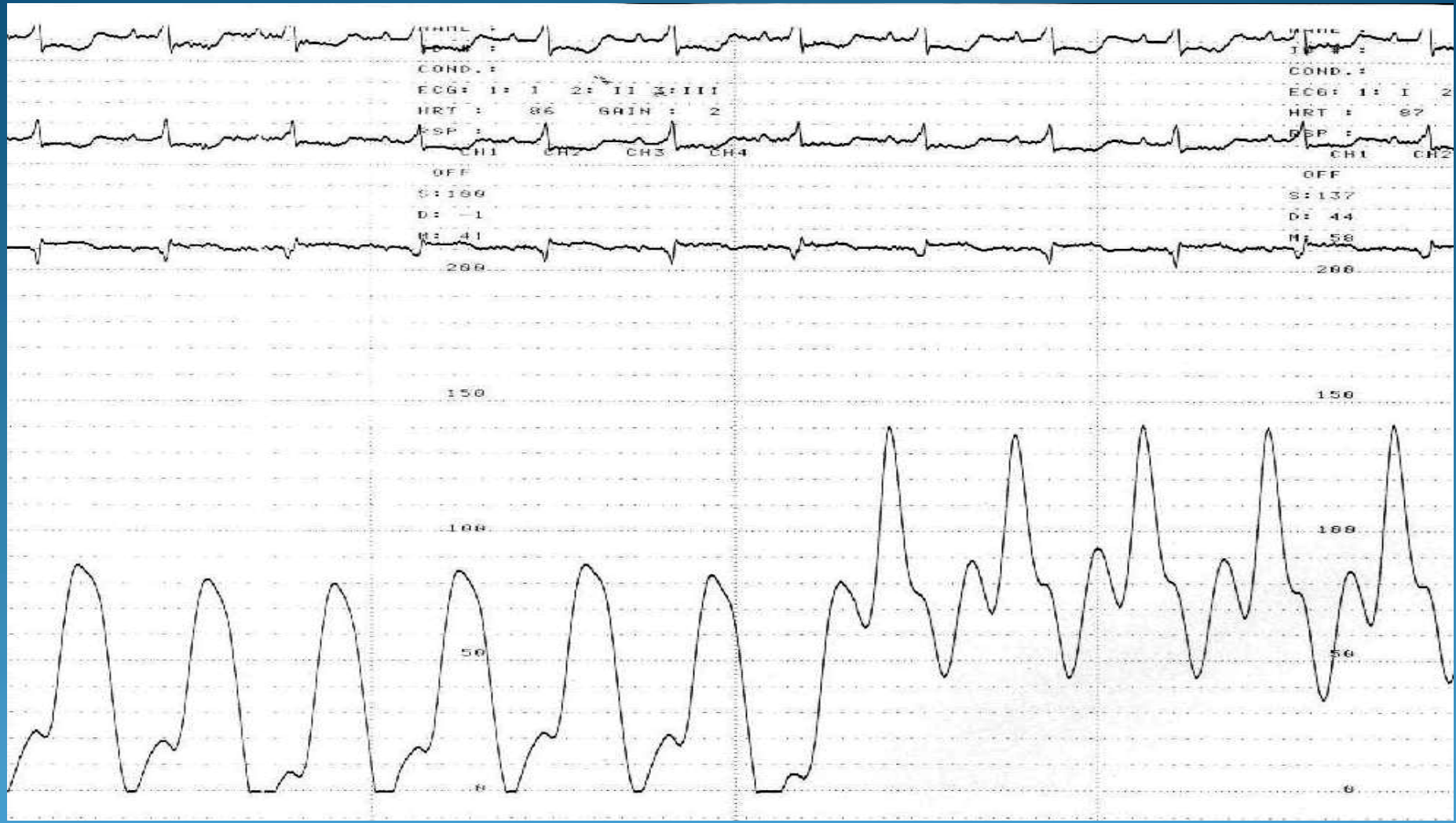
Diastole

The IABP rapidly shuttles helium gas in and out of the balloon, which is located in the descending aorta. The balloon is inflated at the onset of cardiac diastole and deflated at the onset of systole.



Systole

IABP

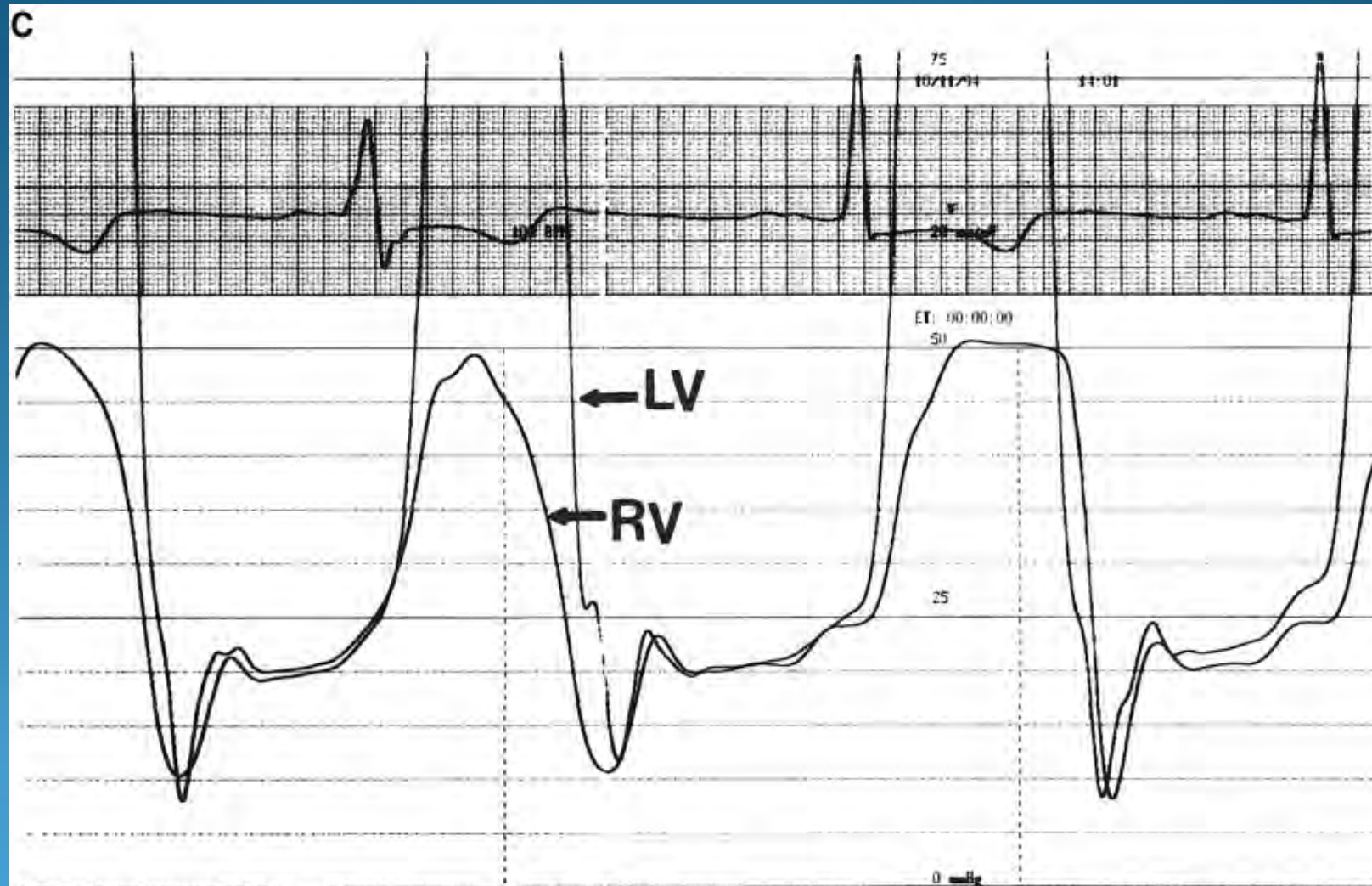


Constrictive pericarditis:

2 groups of hemodynamic signs

- Classic signs
- Dynamic respiratory changes

Constrictive pericarditis classic signs



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 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

Dissociation of intrathoracic and intracardiac pressures



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

HOCM

Brockenbrough sign



Post-extrasystolic potentiation HOCM versus AS



Hidden HOCM

effect of extrasystoles



HOCM effect of Valsalva

