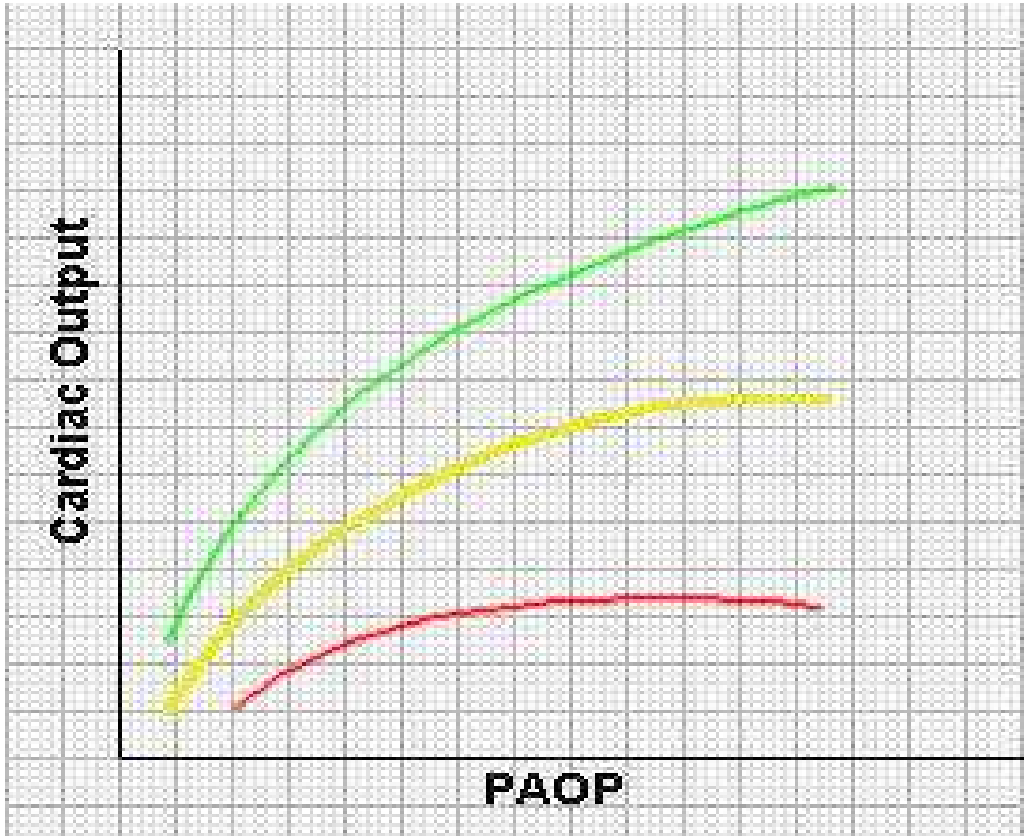
EMODINAMICA

PRECARICO

“Lunghezza della fibra miocardica in telediastole”



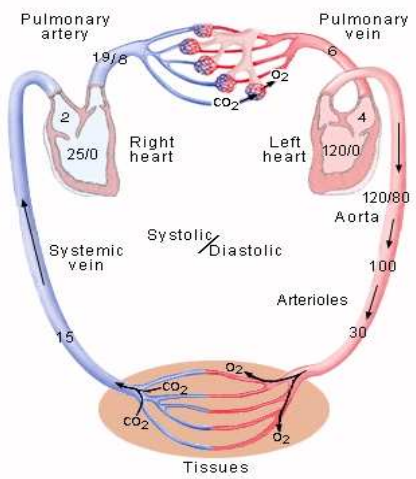
Curve di Frank-Starling

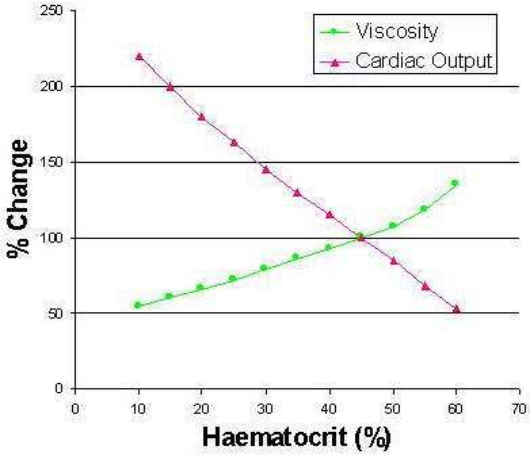
POSTCARICO

“La somma di tutte le forze che si oppongono all'accorciamento della fibra miocardica durante la sistole”

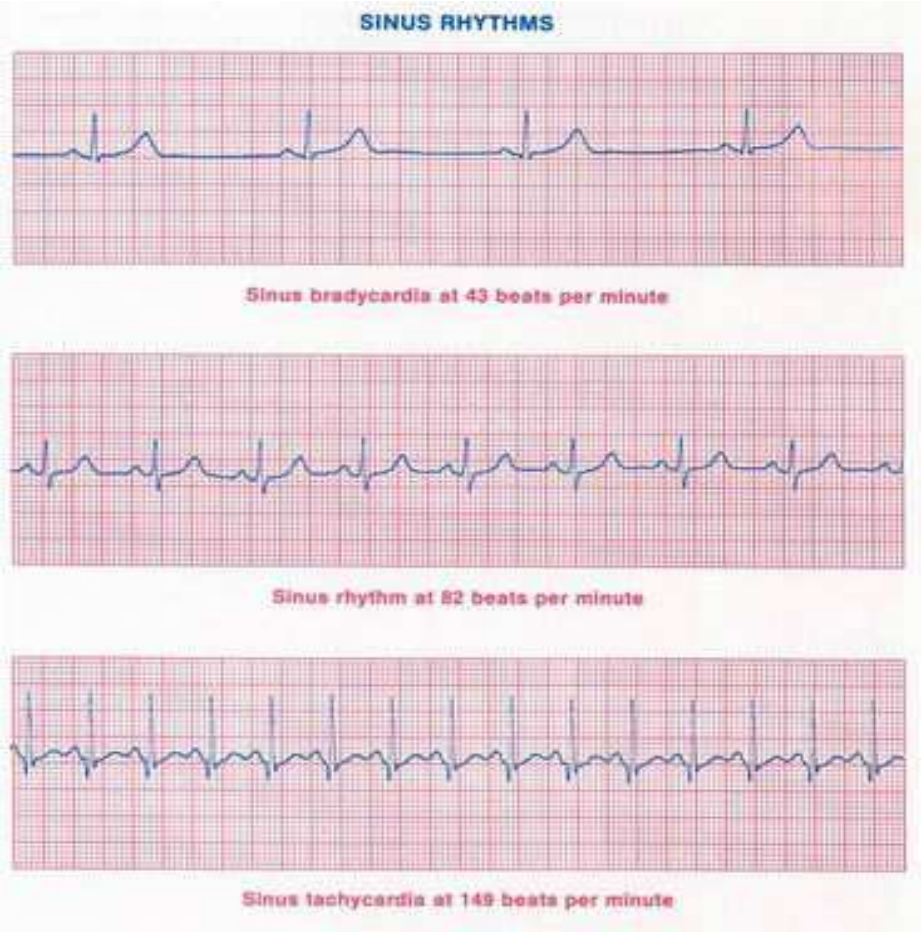
$$\delta = \frac{P * rh}{2}$$

P = Systolic pressure
r = ventricular radius
h = wall thickness
δ = wall stress

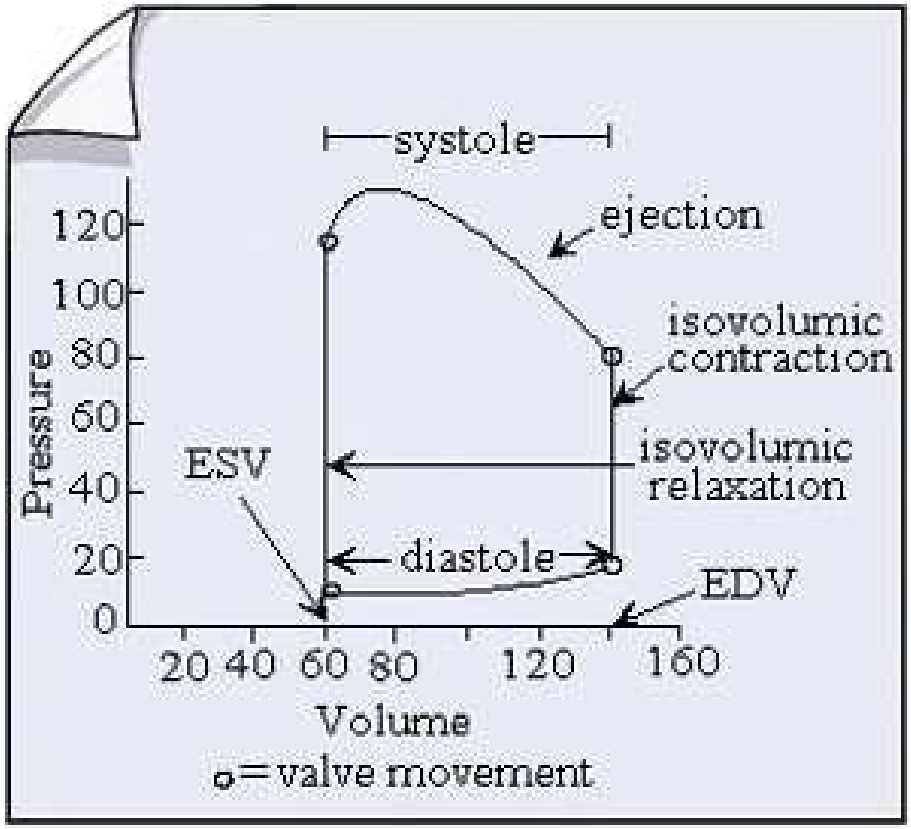




FREQUENZA CARDIACA

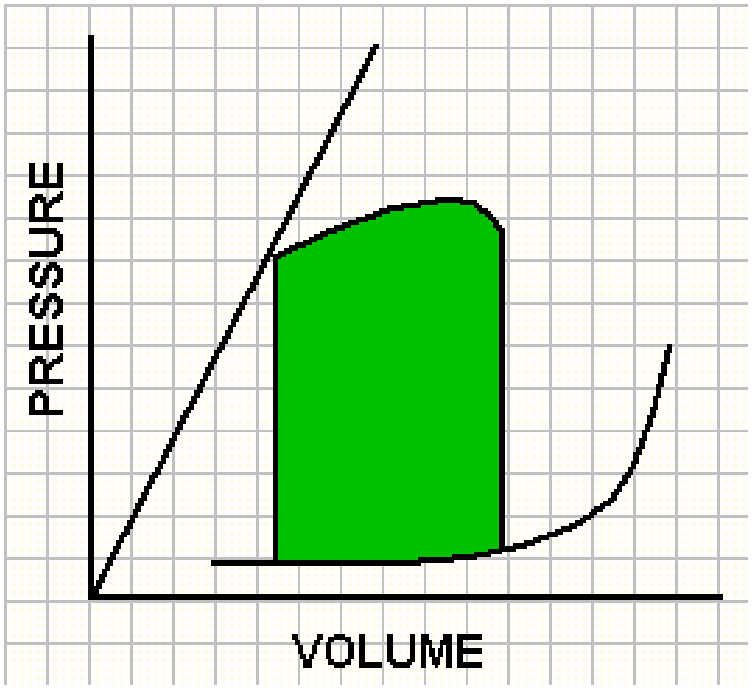


STATO CONTRATTILE



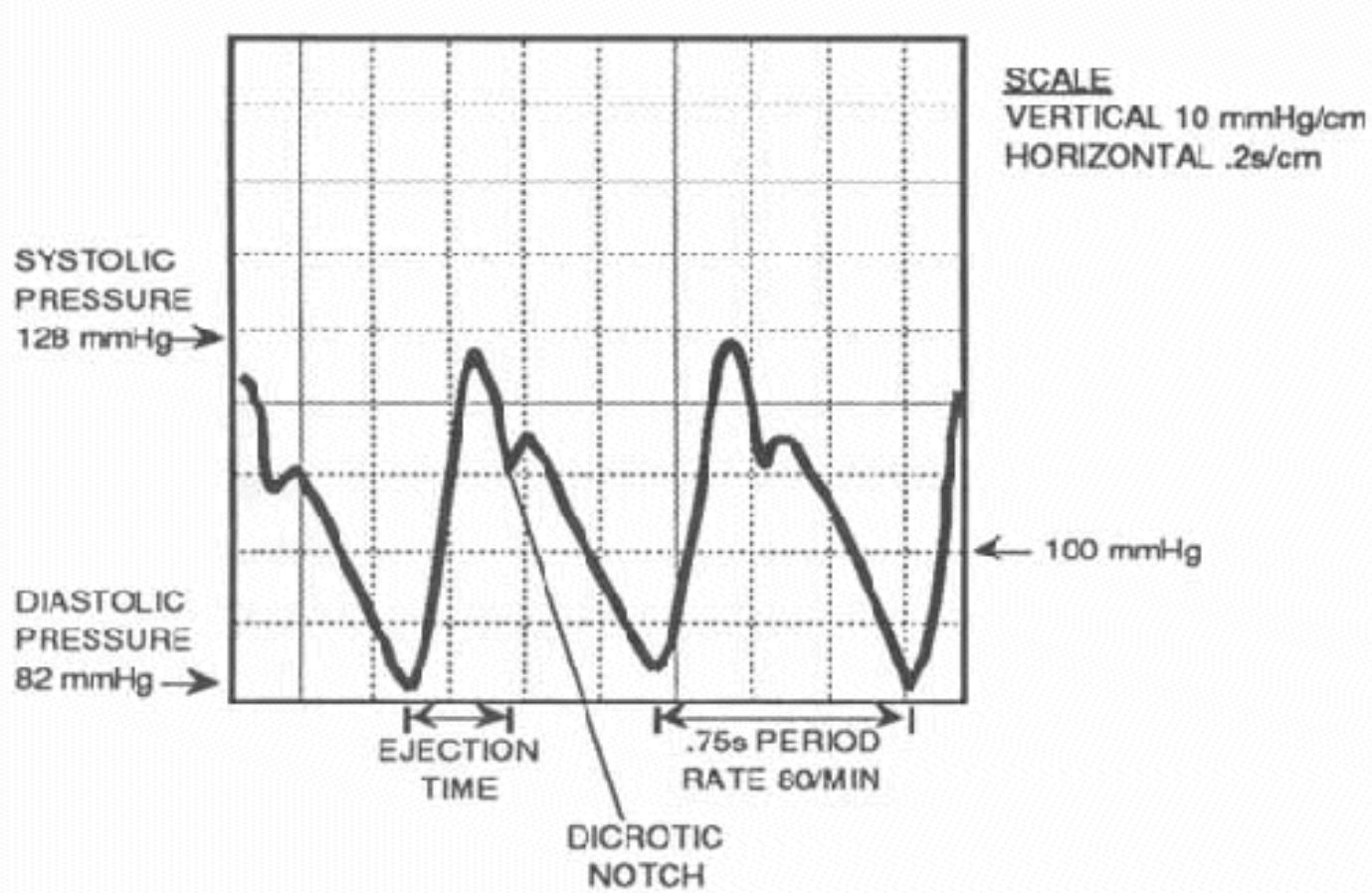
STATO CONTRATTILE

“La forza e la velocità con la quale la fibra miocardica si contrae”

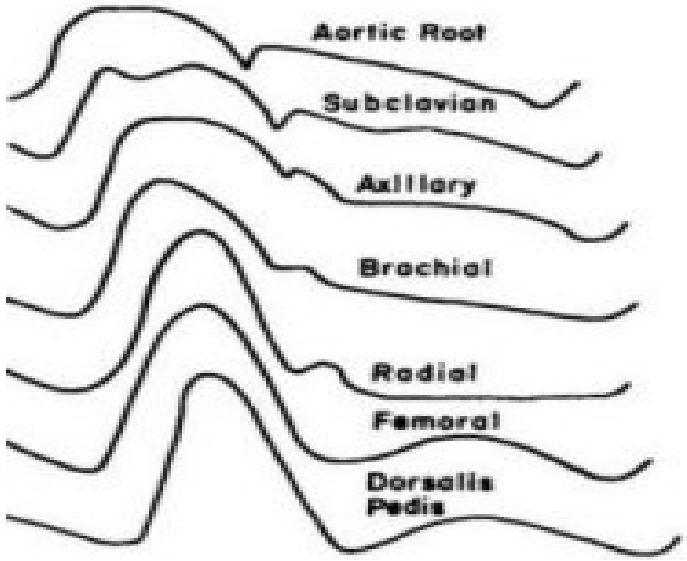


Curve Pressione/Volume

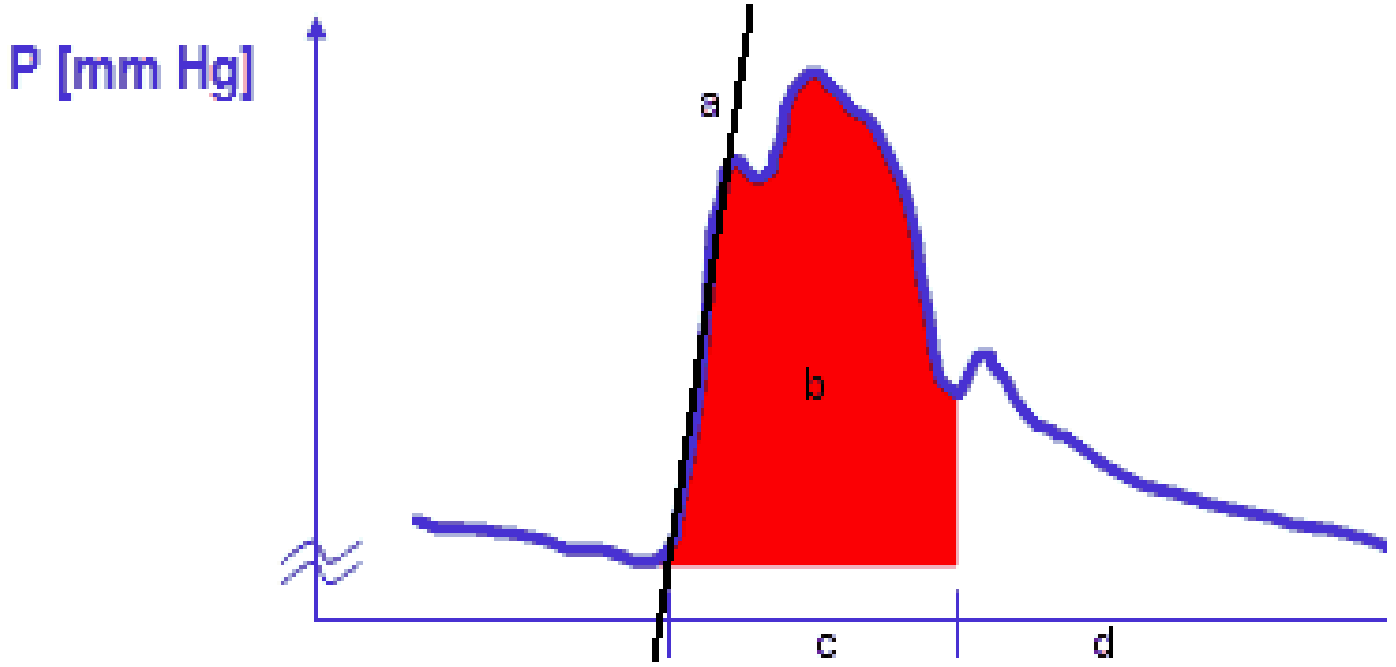
Pressione arteriosa cruenta



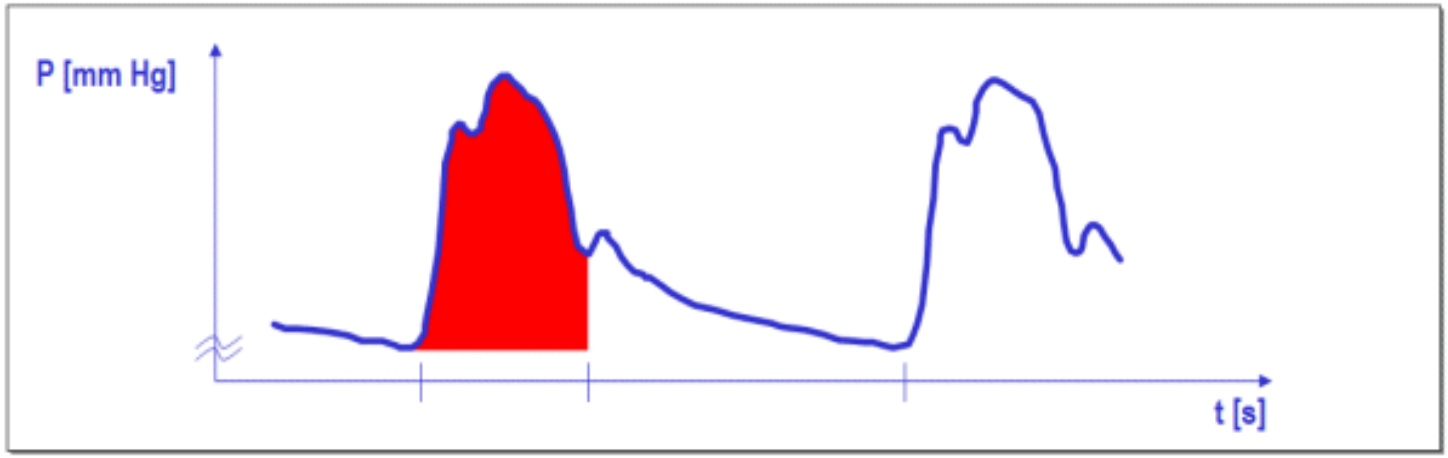
Pressione arteriosa cruenta



Pressione arteriosa cruenta



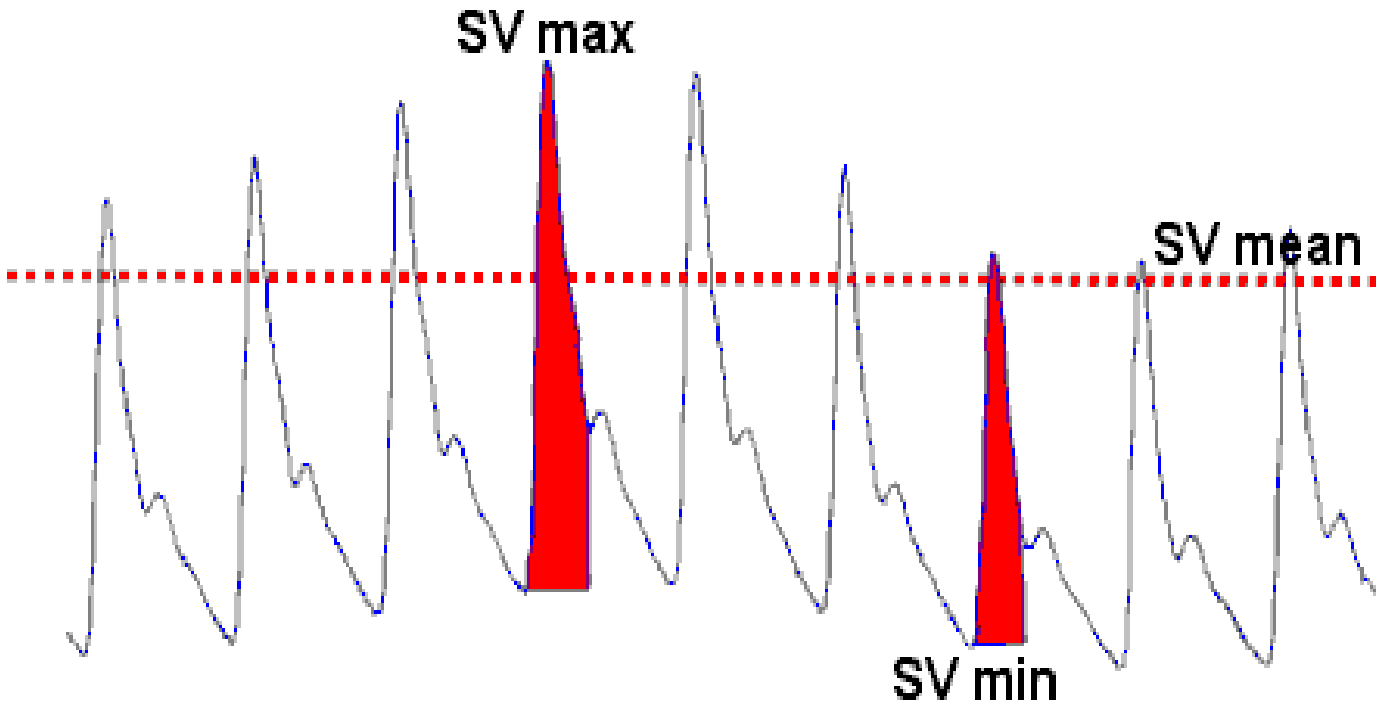
Pressione arteriosa cruenta



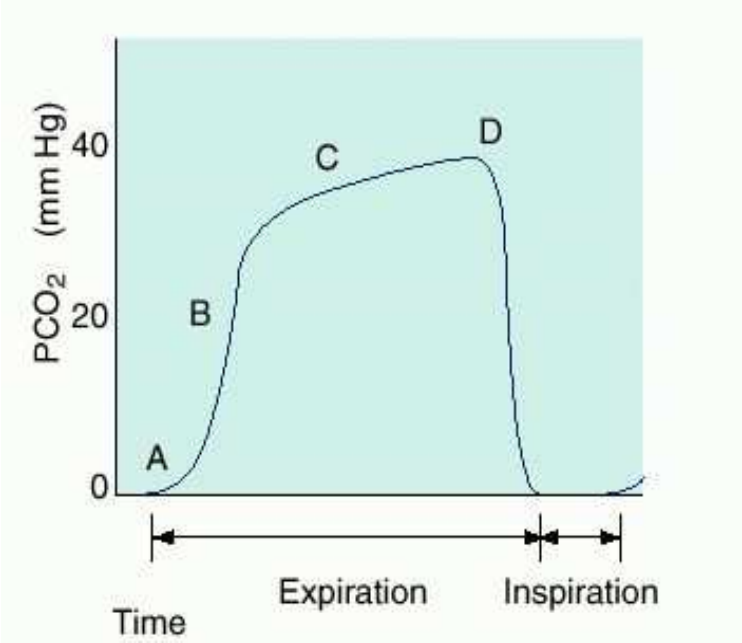
$$PCCO = cal \cdot HR \cdot \int_{Systole} \left(\frac{P(t)}{SVR} + C(p) \cdot \frac{dP}{dt} \right) dt$$

- cal: Patient-specific calibration factor (determined by thermodilution)
- HR: Heart rate
- P(t): Area under pressure curve
- C(p): Aortic compliance
- dP/dt: Shape of pressure curve

Pressione arteriosa cruenta

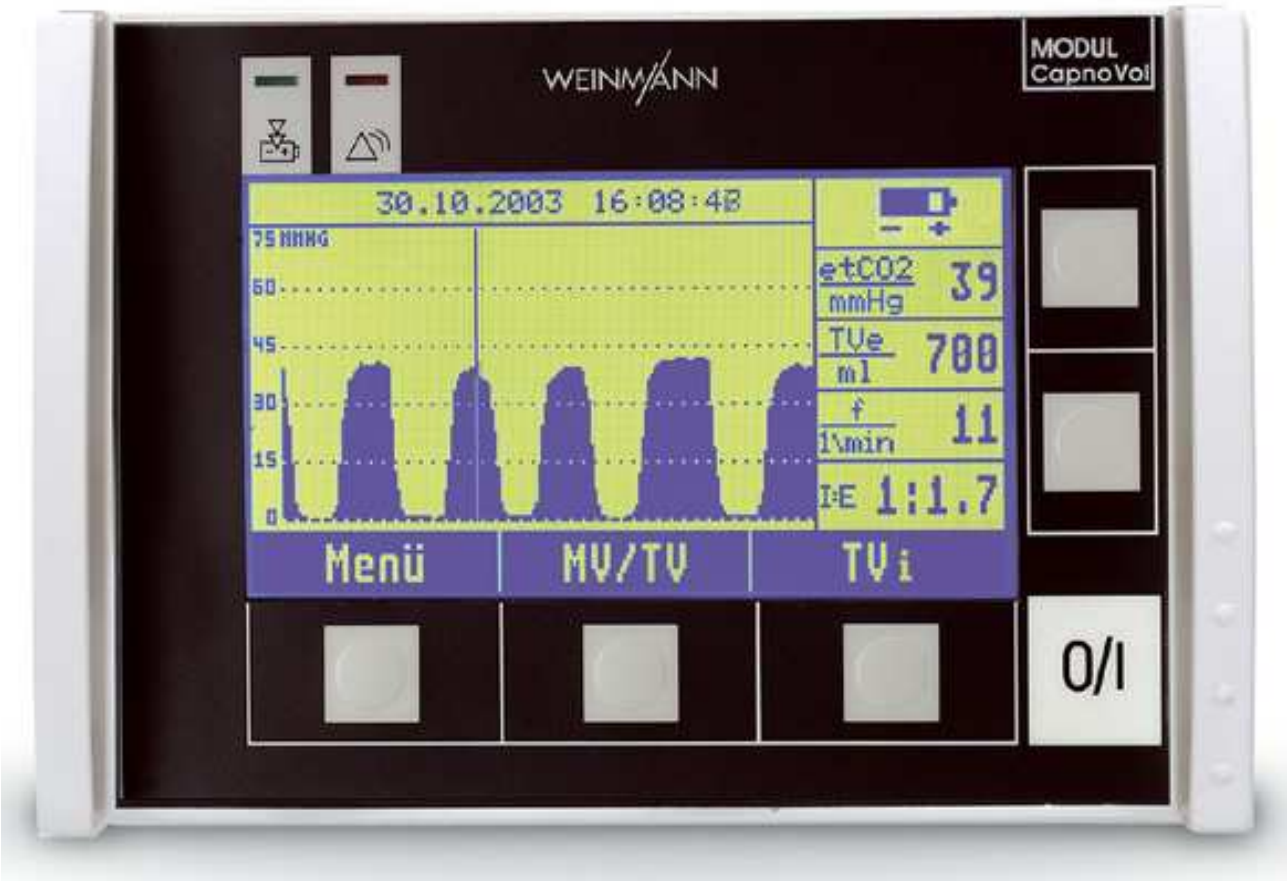


Capnografia

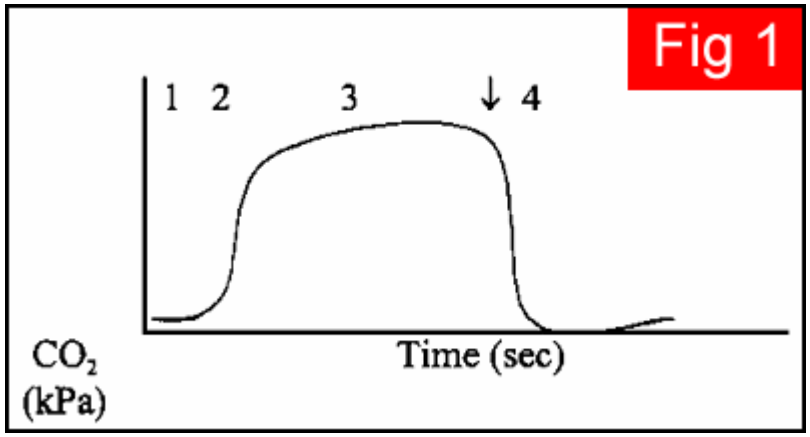


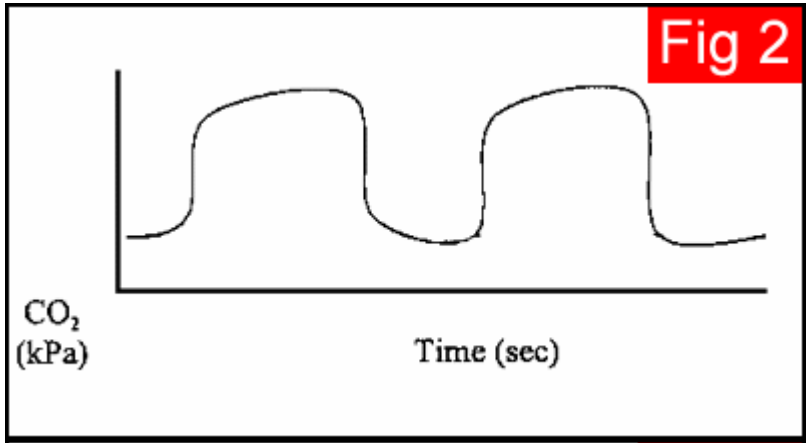
- (A), Carbon dioxide cleared from the anatomic dead space
- (B), Dead space and alveolar carbon dioxide
- (C), Alveolar plateau
- (D), End-tidal carbon dioxide tension (PETCO2)

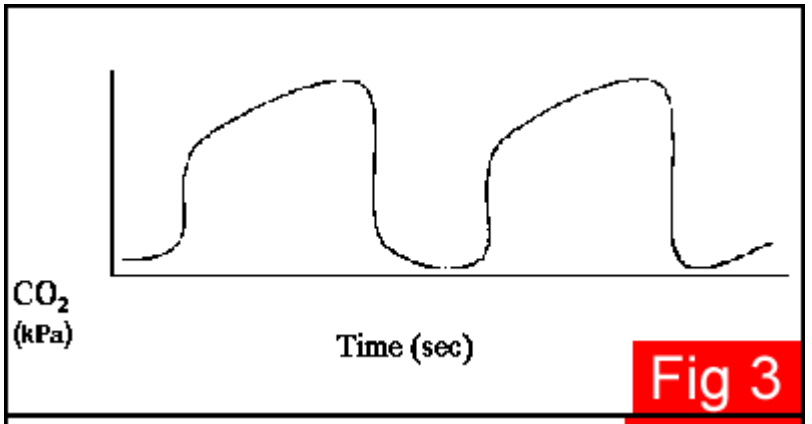
Capnografia

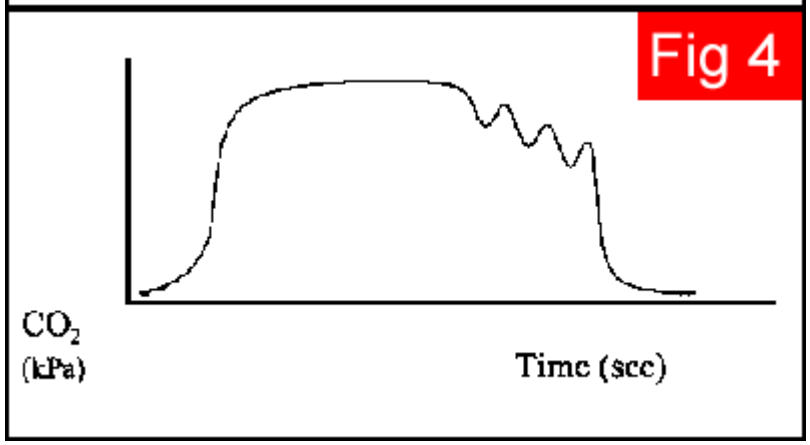


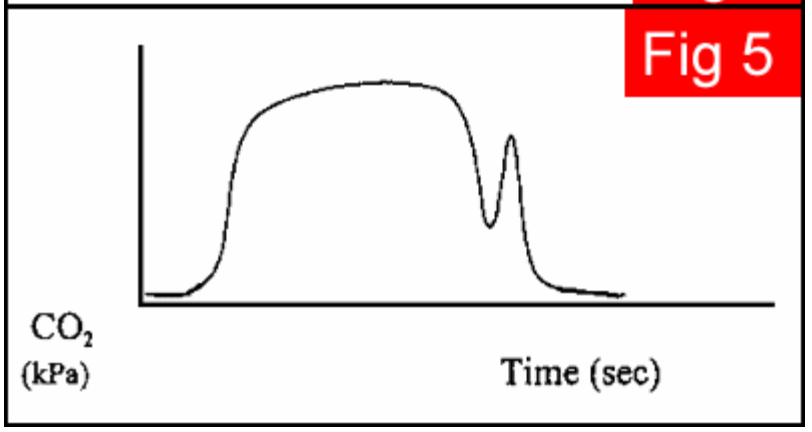
Capnografia



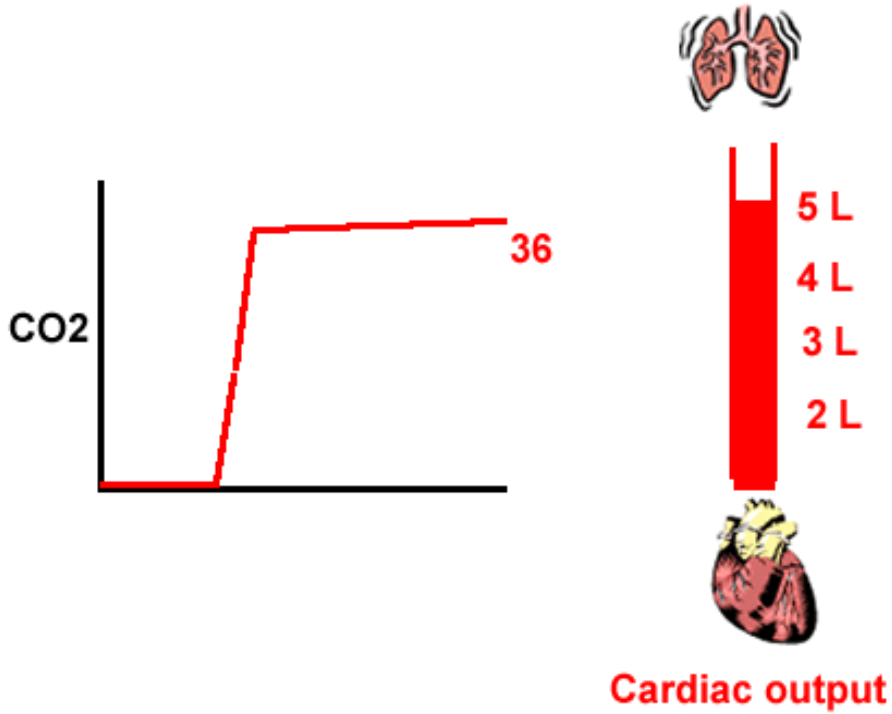






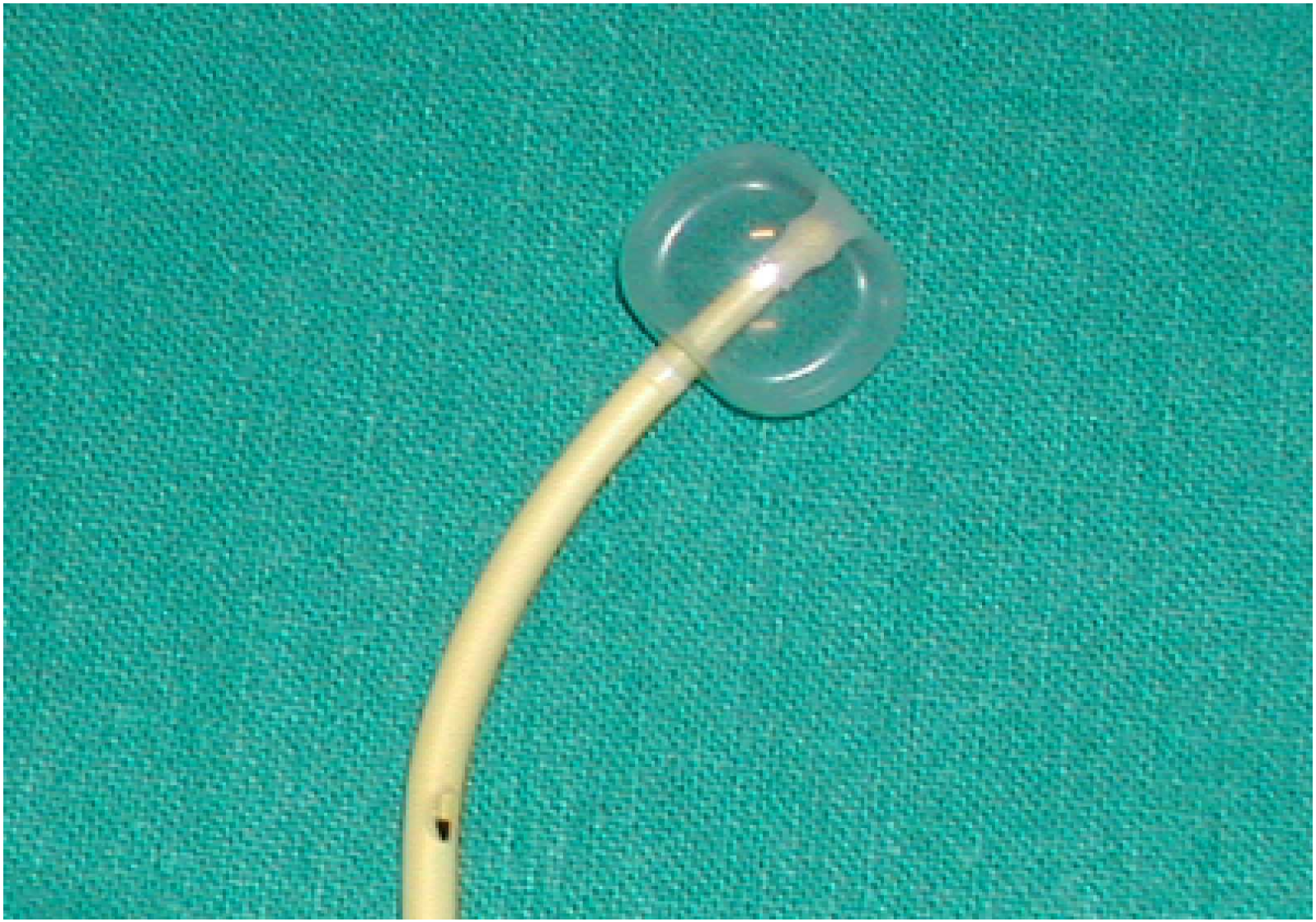


Capnografia



Swan-Ganz

PAC



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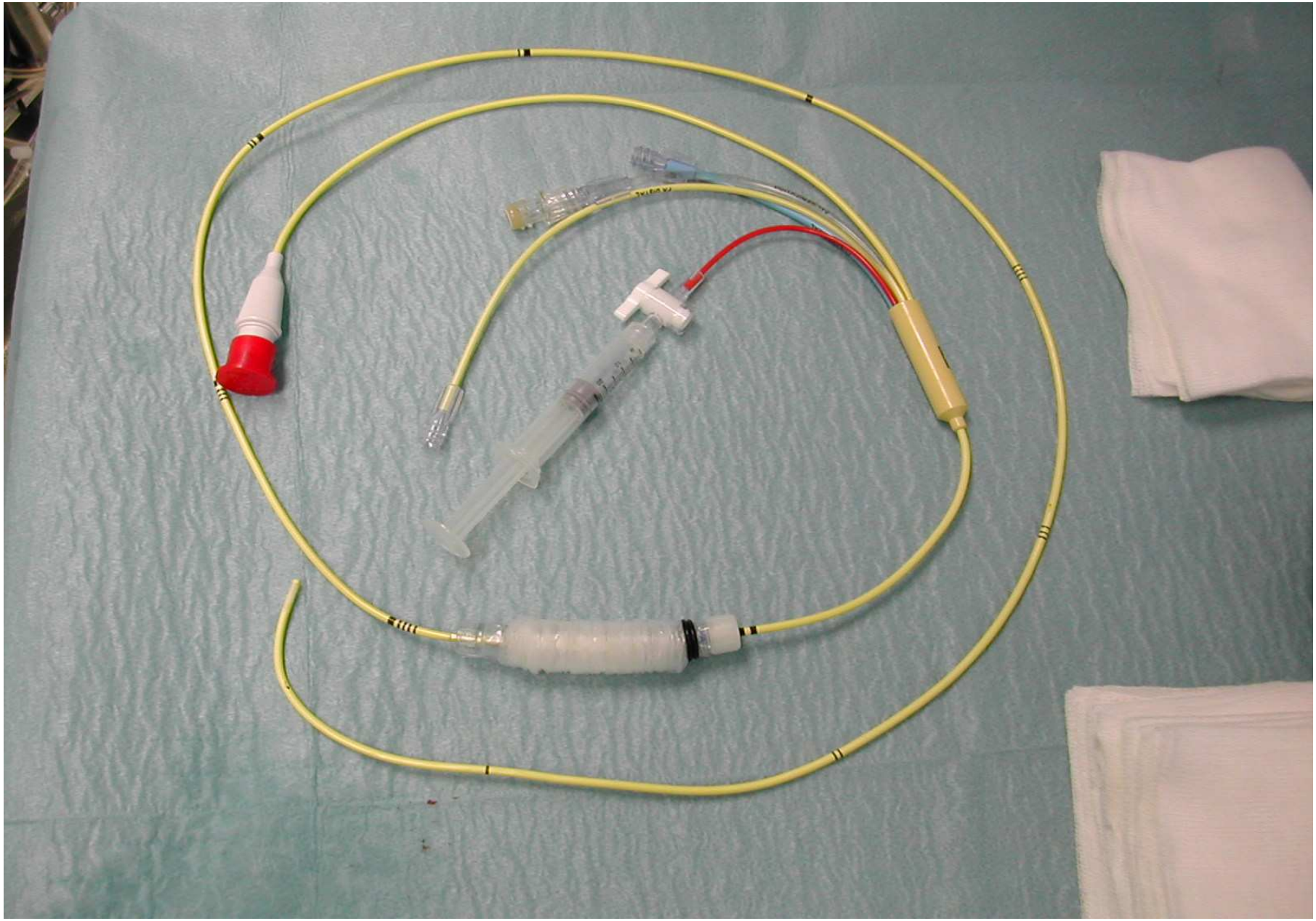

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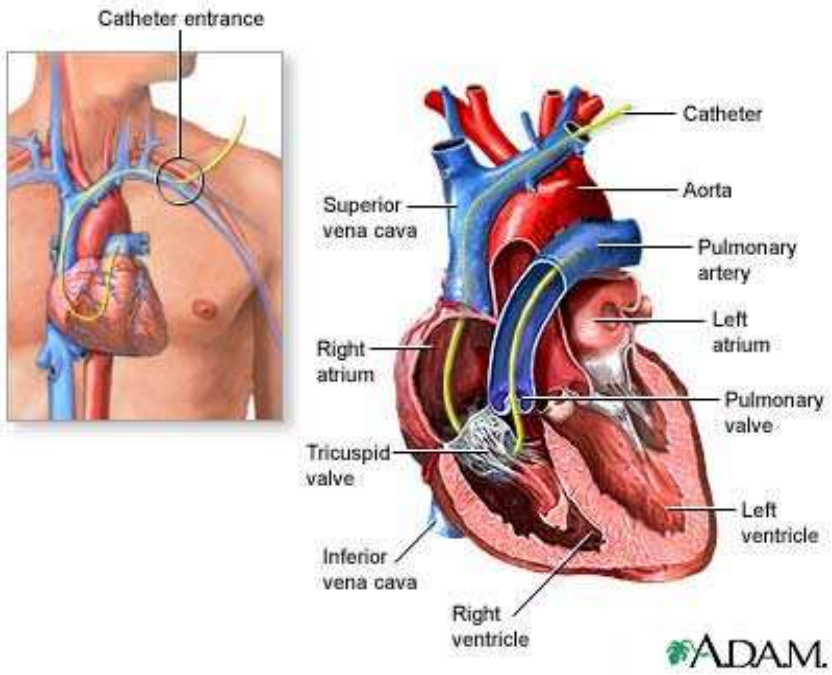
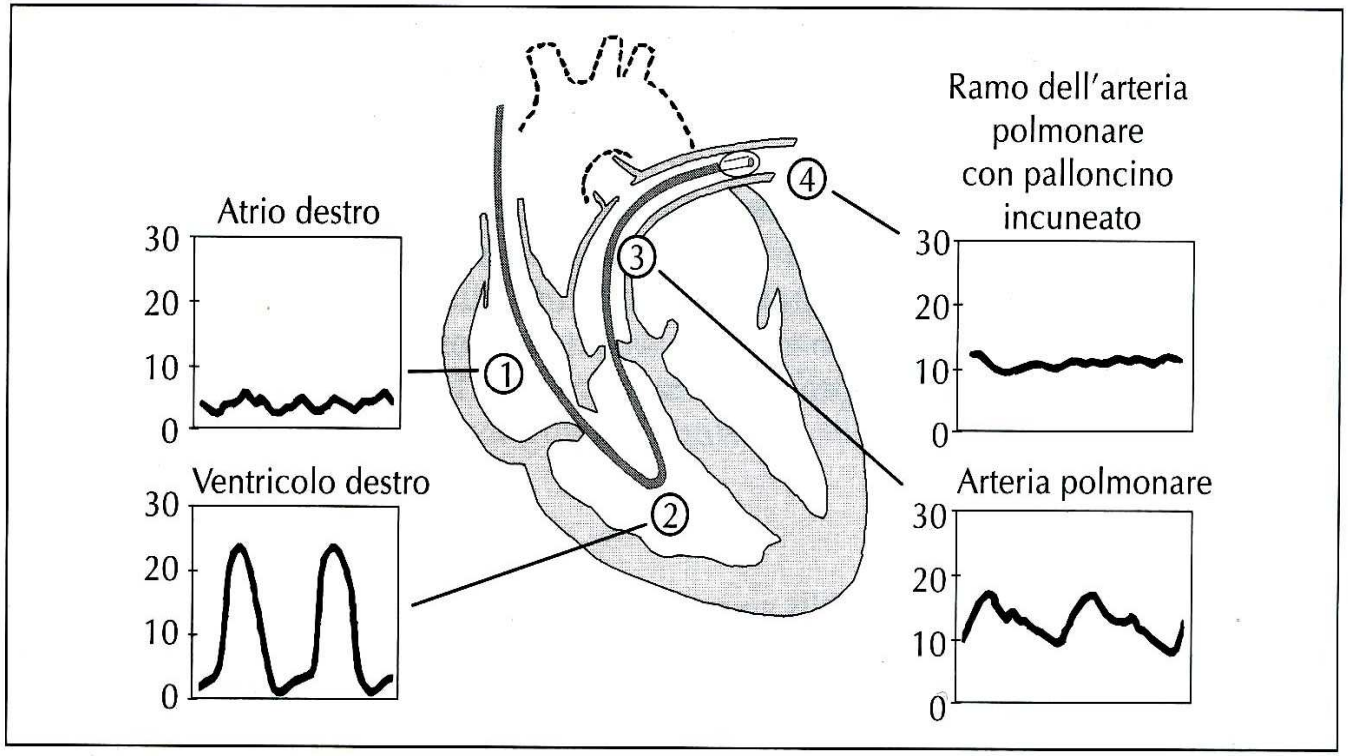
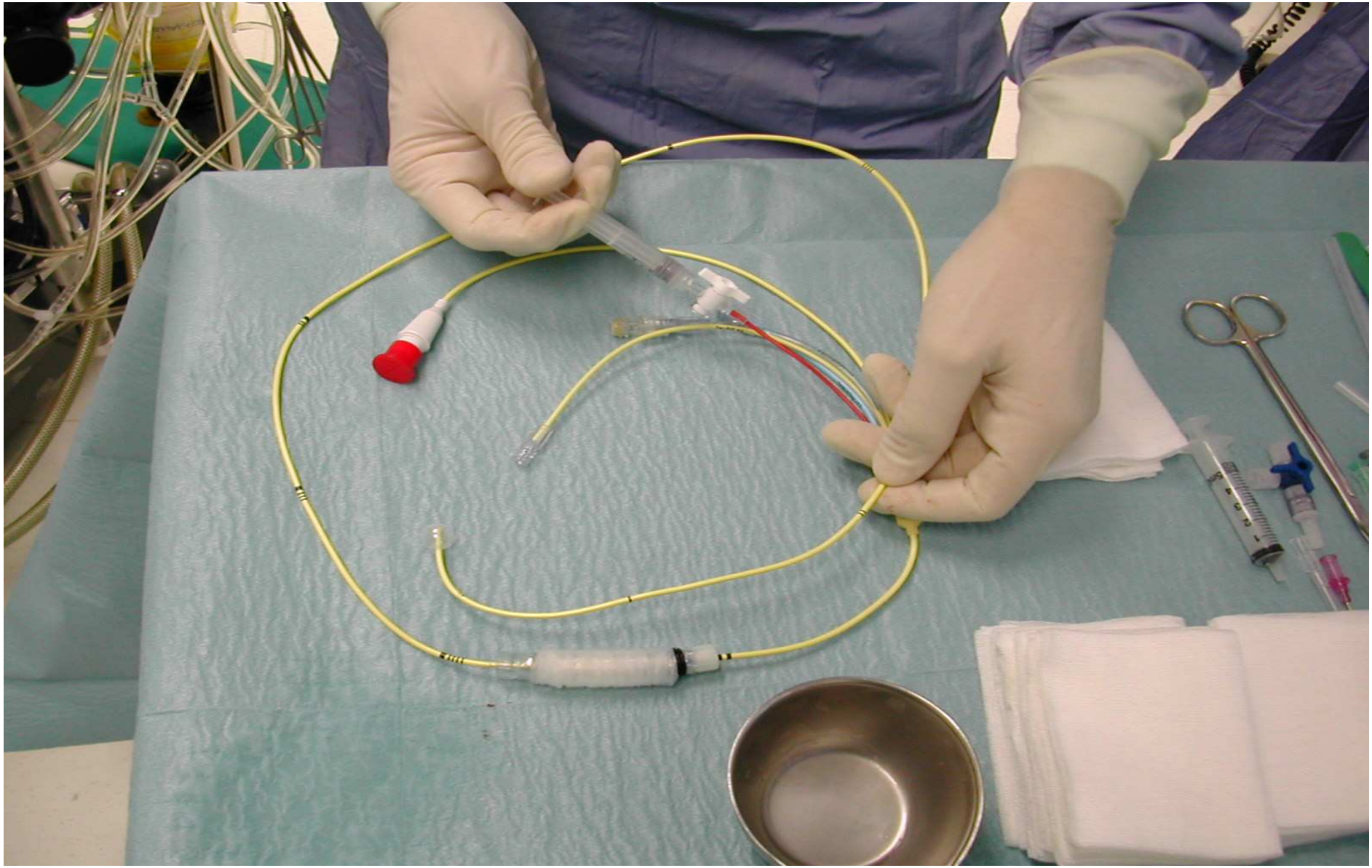

Catheter entrance
Catheter
Aorta
Superior vena cava
Pulmonary artery
Left atrium
Right atrium
Pulmonary valve
Tricuspid valve
Left ventricle
Inferior vena cava
Right ventricle
A.D.A.M.

PAC

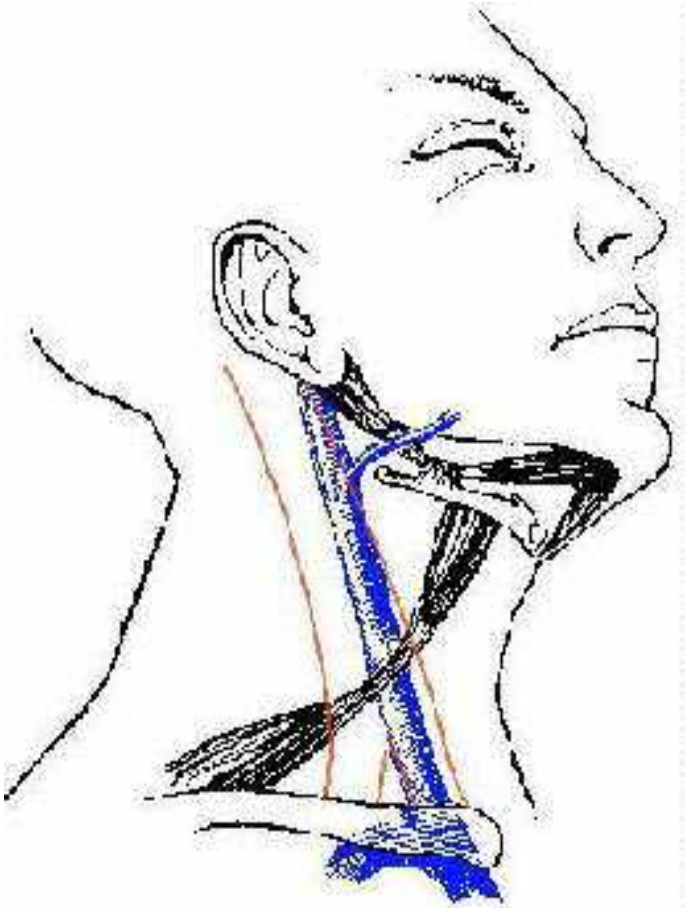

Atrio destro
30
20
10
0
Ventricolo destro
30
20
10
0
Ramo dell'arteria polmonare con palloncino incuneato
30
20
10
0
Arteria polmonare
30
20
10
0
1
2
3
4

PAC



PAC

Giugulare interna

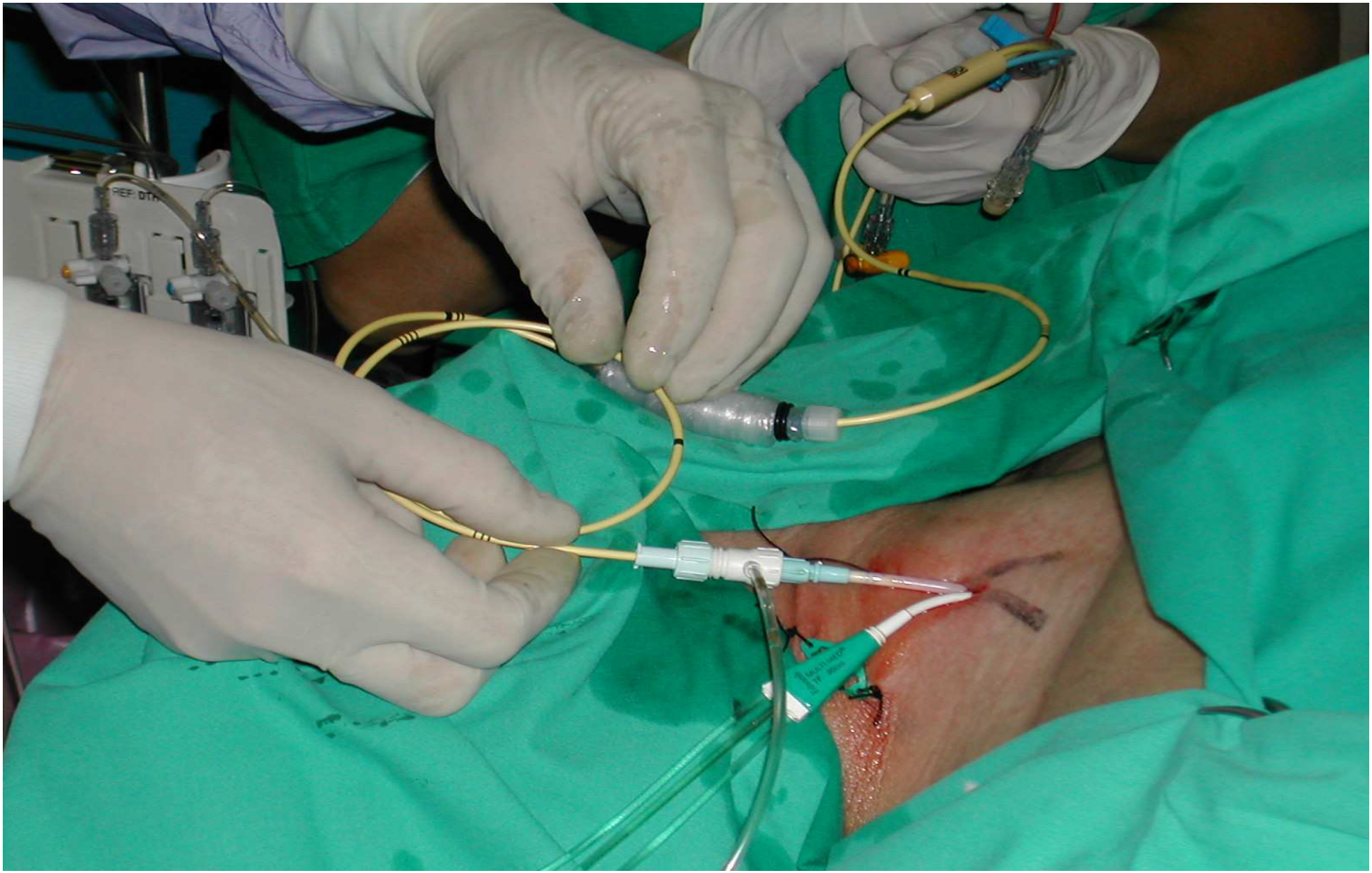


PAC

PAC

PAC

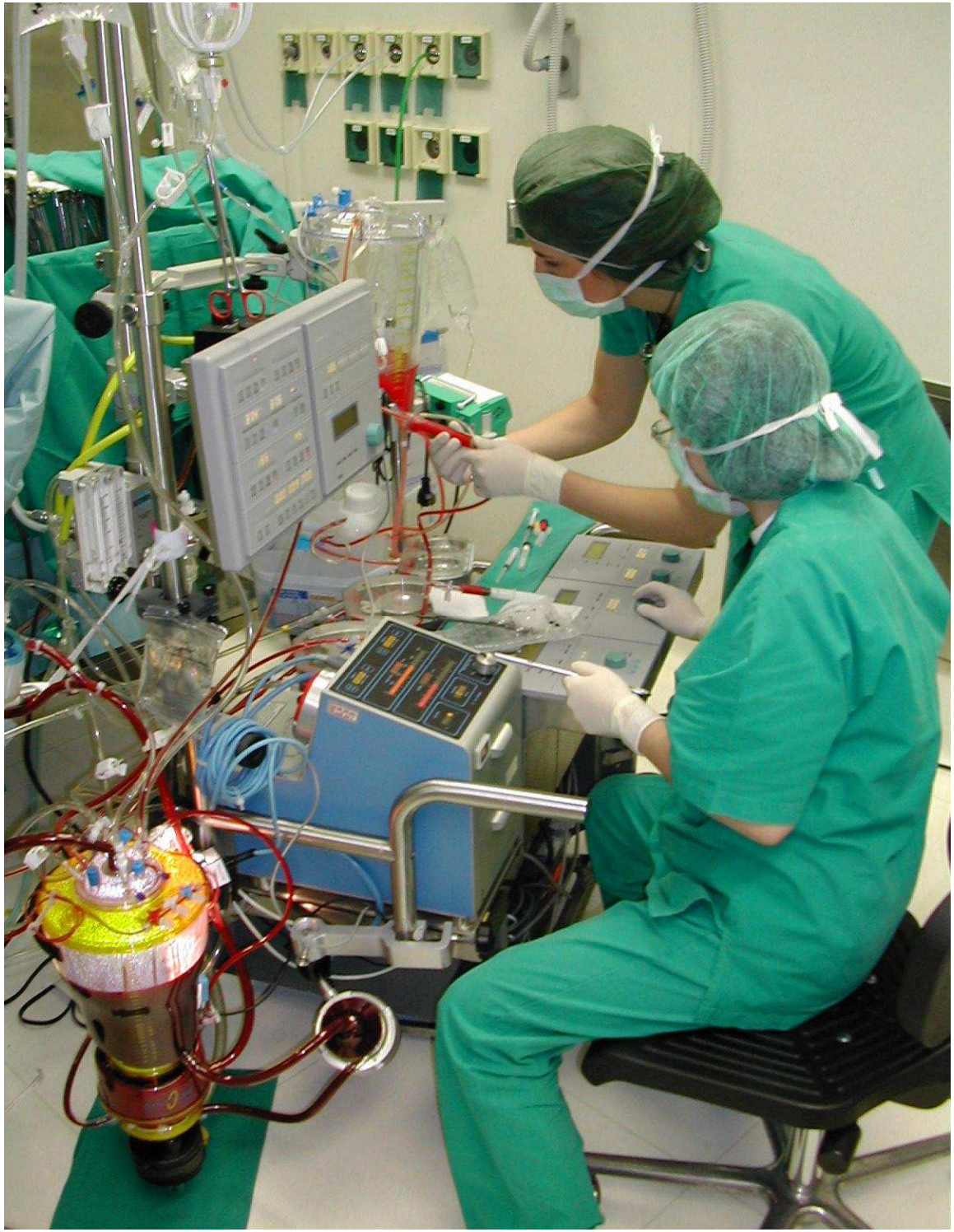
PAC



PAC


II
aVF
V
1mV
FC
107
ST1
ST2
ST3
Tsang
36.8
94/60 (71)
CVP
(4)
PAP
18/9 (13)
C.O.
PLET.
SpO2
100
ETCO2
27
FiCO2
FARR
9
Pitto

PAC



PAC

parametri misurati

- Pressione Venosa Centrale
- Pressione in Arteria Polmonare
- Pressione di Occlusione in Arteria Polmonare
- Gittata Cardiaca
- Saturazione di Ossigeno dell'Emoglobina del Sangue Venoso Misto
- Temperatura Centrale

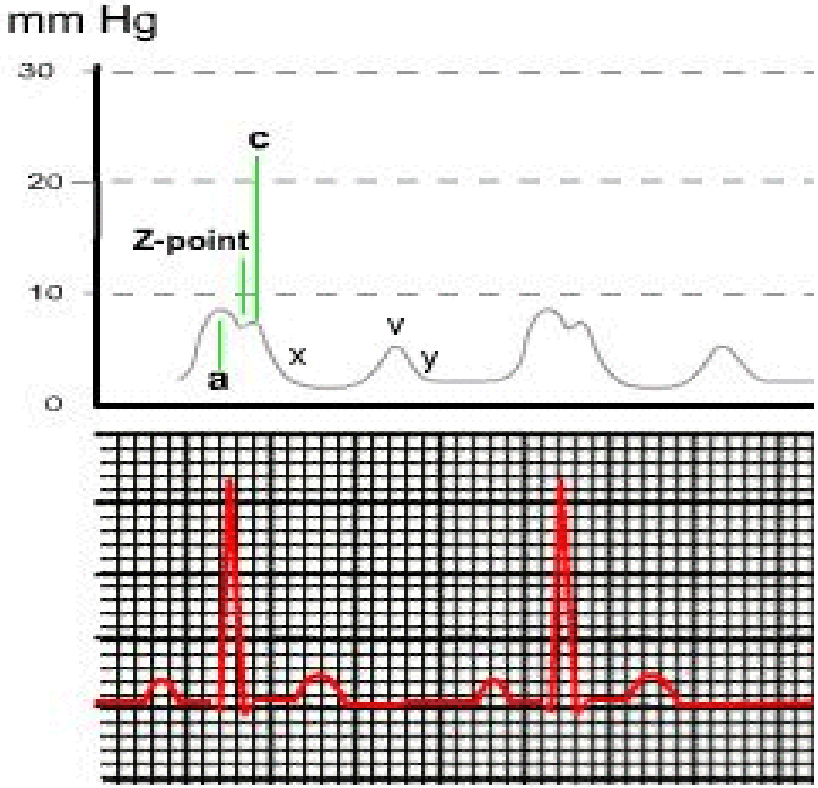
PAC

Parametri Calcolati

- Resistenze Vascolari Sistemiche:
  SVR=(MAP-CVP * 80)/CO
- Resistenze Vascolari Polmonari:
  PVR=(MPAP-PAOP * 80)/CO
- Lavoro Cardiaco:
  SW=(MAP-PAOP) * SV * 0,0136
- Delivery di O2:
  DO2=CO * [(Hb * 1,36 * SaO2) + (PaO2 * 0,003)]
- Pressione di perfusione coronarica:
  PPC=DAP-PAOP
- Consumo di O2:
  VO2=CO * (CaO2-CvO2)

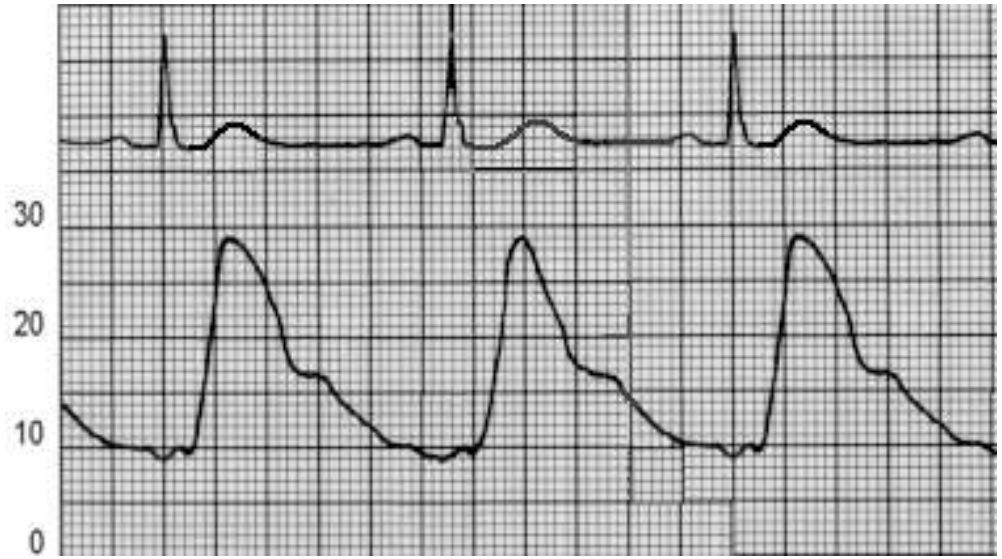
PAC

Pressione Venosa centrale



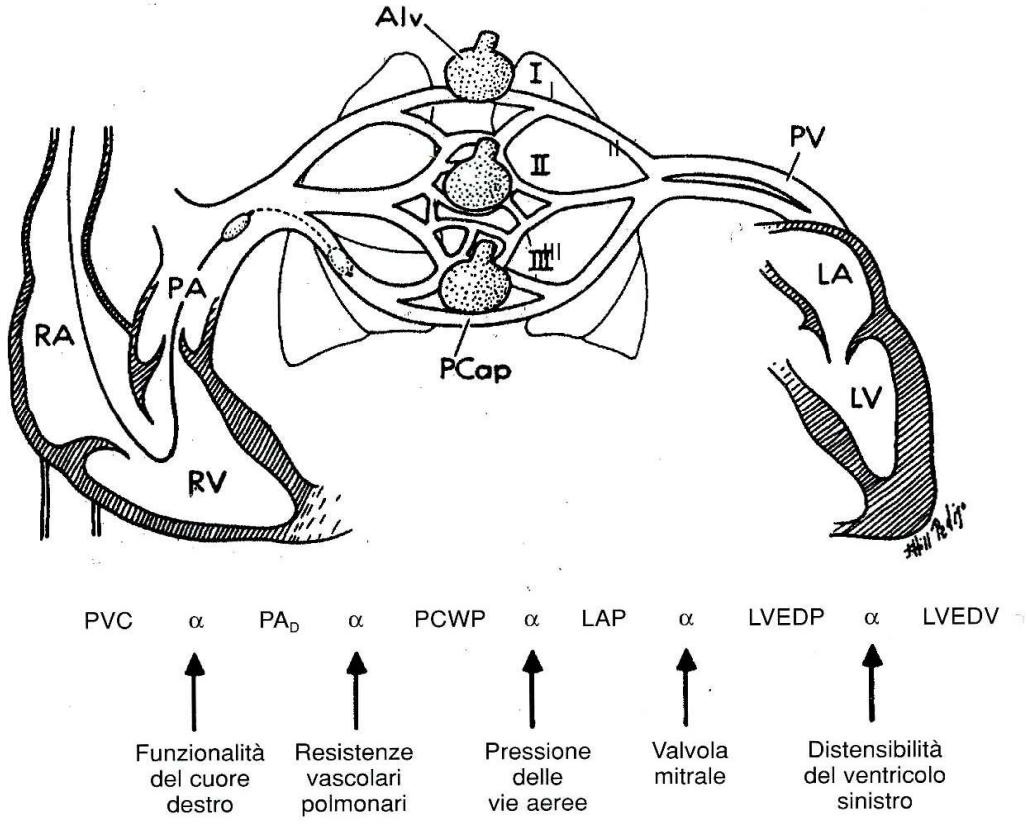
PAC

Pressione Arteria Polmonare



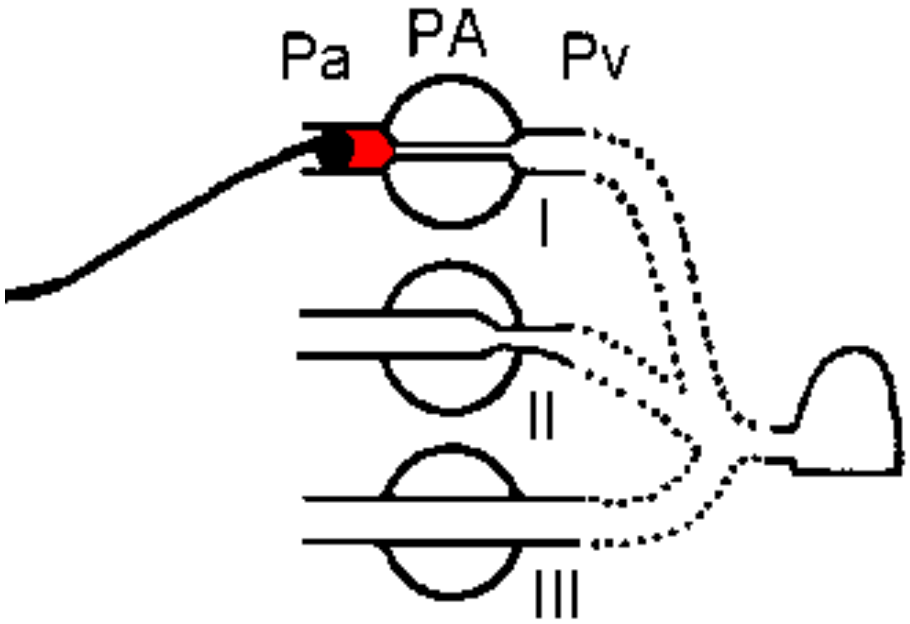
PAC

Pressione di Occlusione



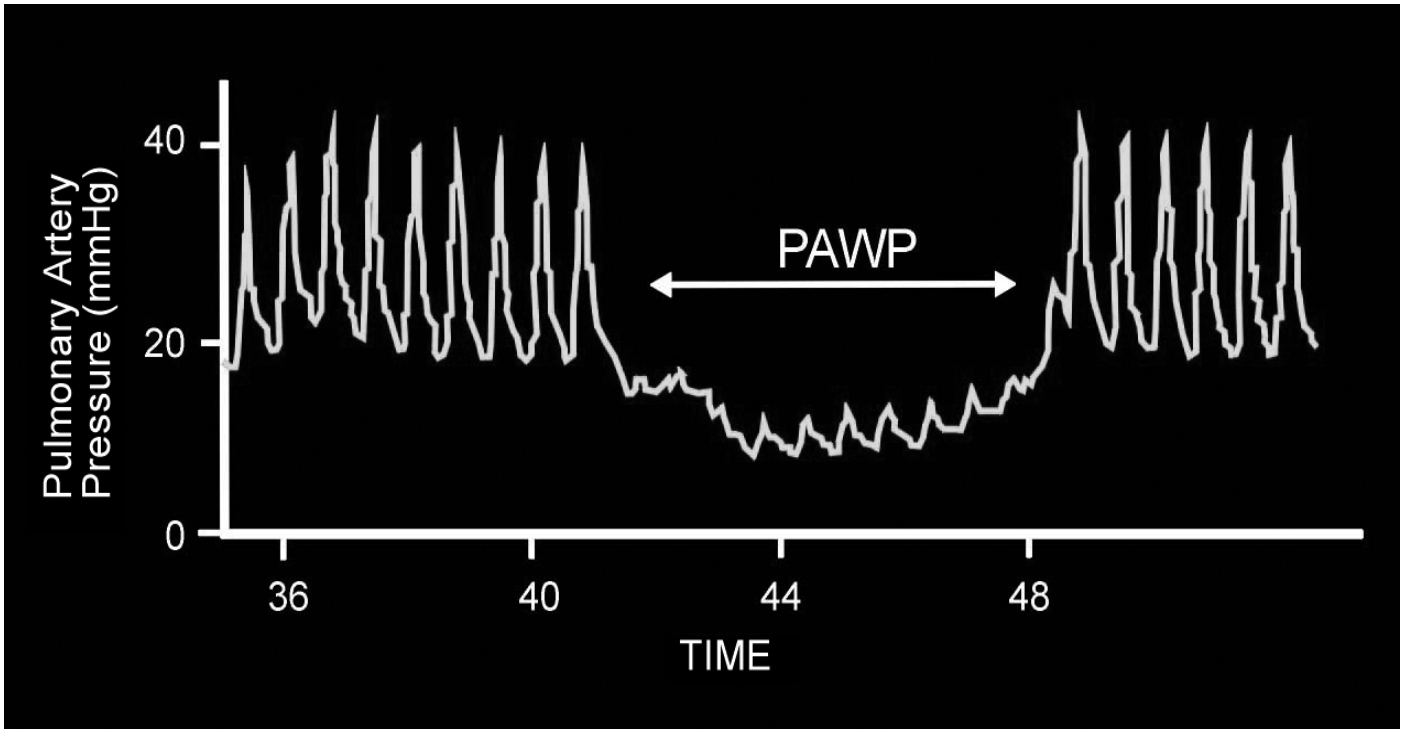
PAC

Pressione di Occlusione



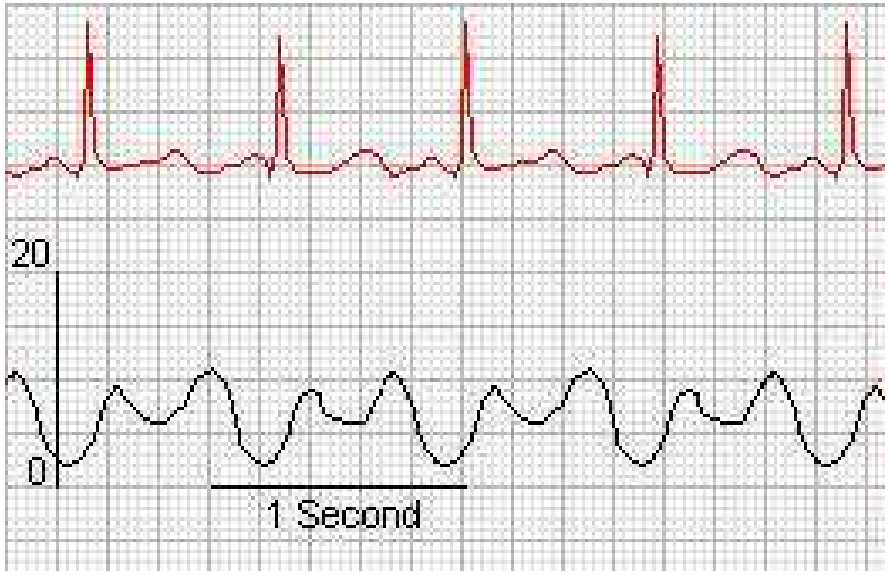
PAC

Pressione di Occlusione



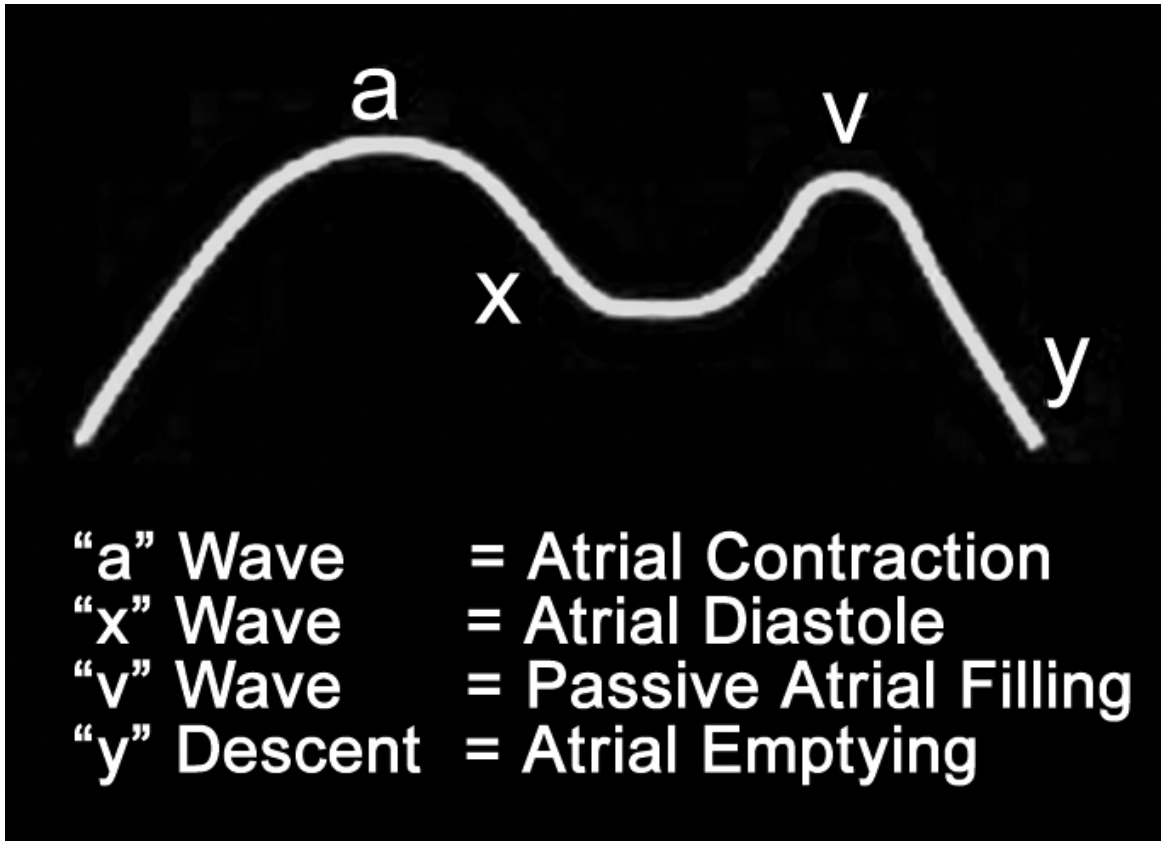
PAC

Pressione di Occlusione



PAC

Pressione di Occlusione

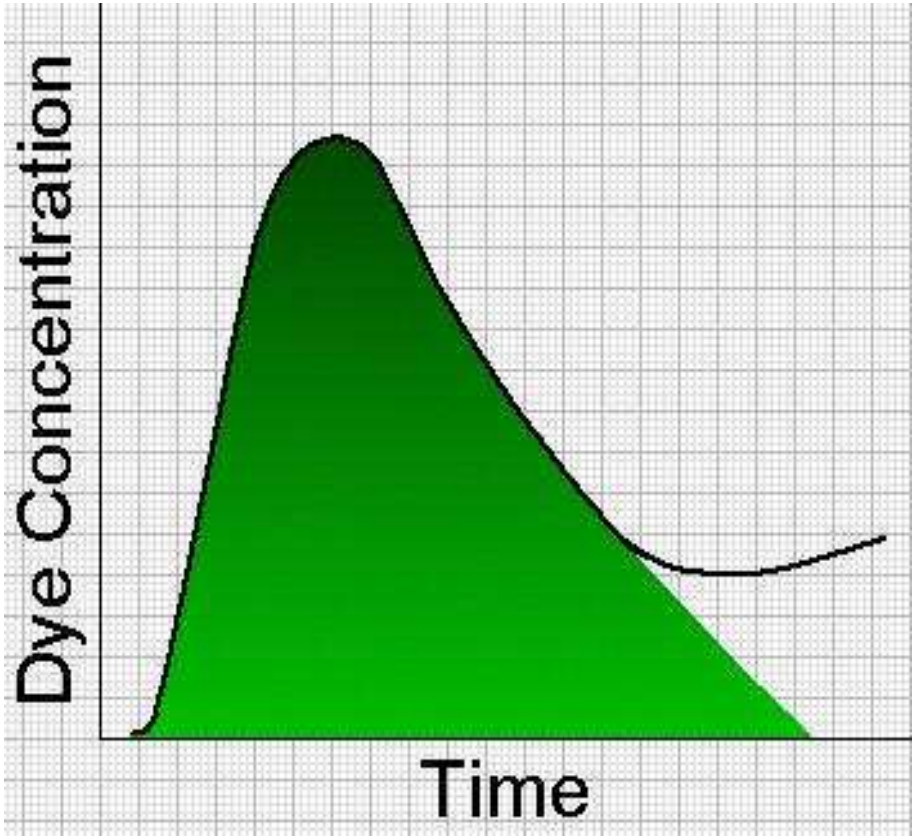


Pressione di Occlusione in Arteria Polmonare (estrapolazioni)

- Il LVEDV è correlato alla lunghezza della fibra miocardica de VS in telediastole
- Il LVEDV è correlato alla LVEDP
- La LAP è correlata alla LVEDP
- La PVP corrisponde alla LAP
- La PAOP è una misura affidabile della PVP

PAC

Gittata Cardiaca



The Stewart-Hamilton Equation:

$$Q = (V(Tb-Ti)K1K2)/(Tb(t)dt)$$

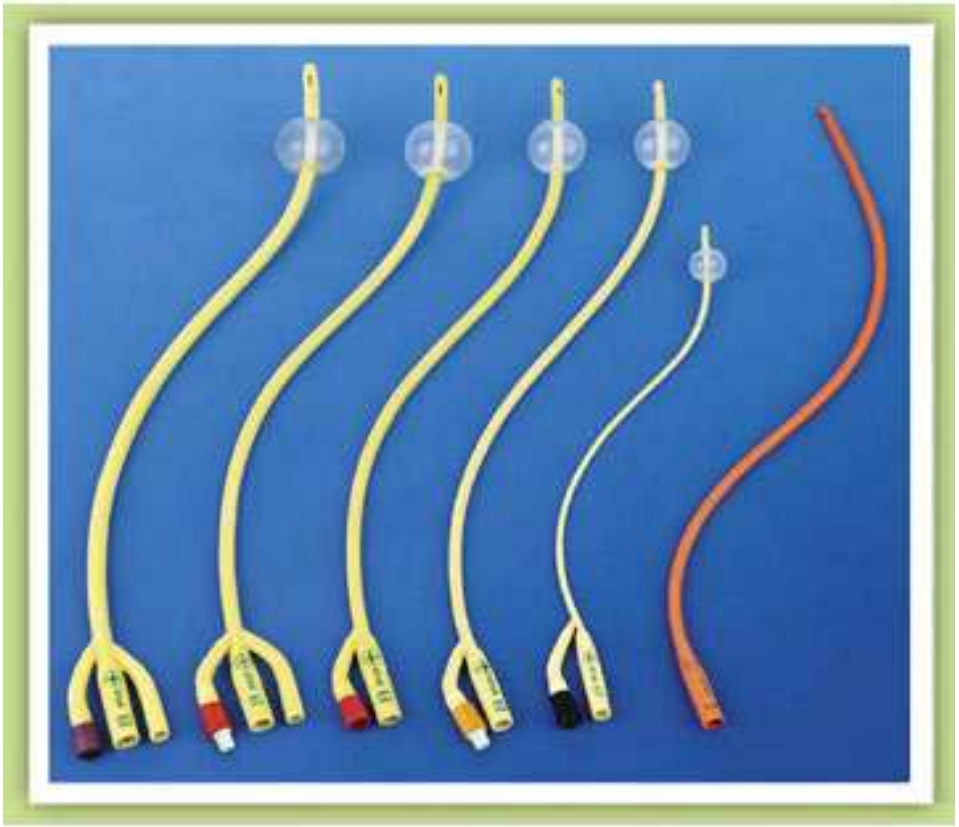
Where:

Q = cardiac output, V = volume of injectate, Tb = blood temperature, Ti = injectate temperature, K1 = catheter constant, K2 = apparatus constant, Tb(t)dt = change in blood temperature over a given time.

CO come valutazione della funzione contrattile

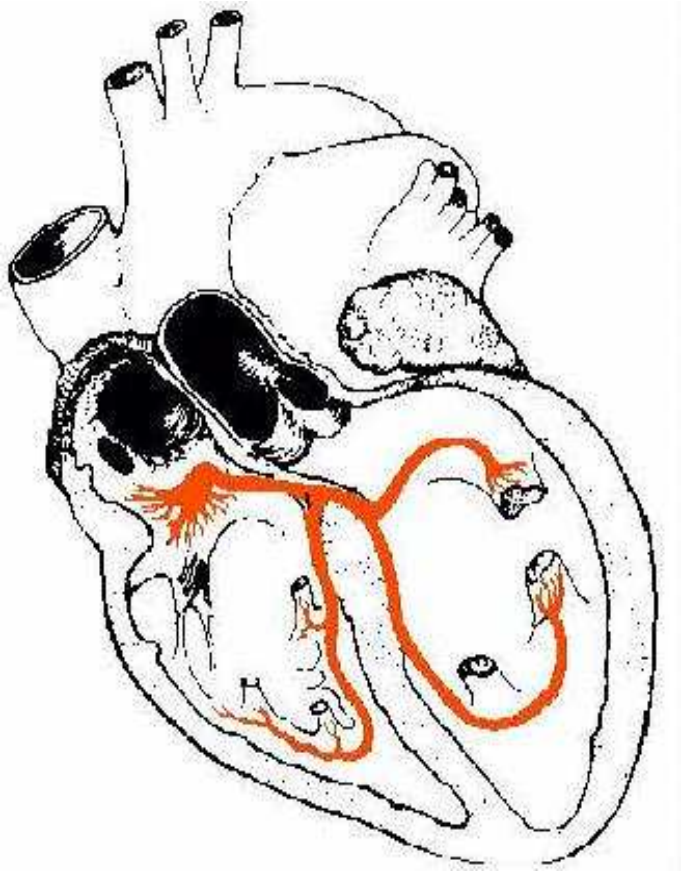
- I dati del PAC non danno indicazioni sulla funzione contrattile regionale
- Un ventricolo dilatato con bassa FE può avere un normale CO
- A parità di funzione contrattile il CO varia in funzione del pre-post carico e della frequenza

Swan Ganz ?



Complicanze PAC

BAV III



Complicanze PAC

Infarto Polmonare

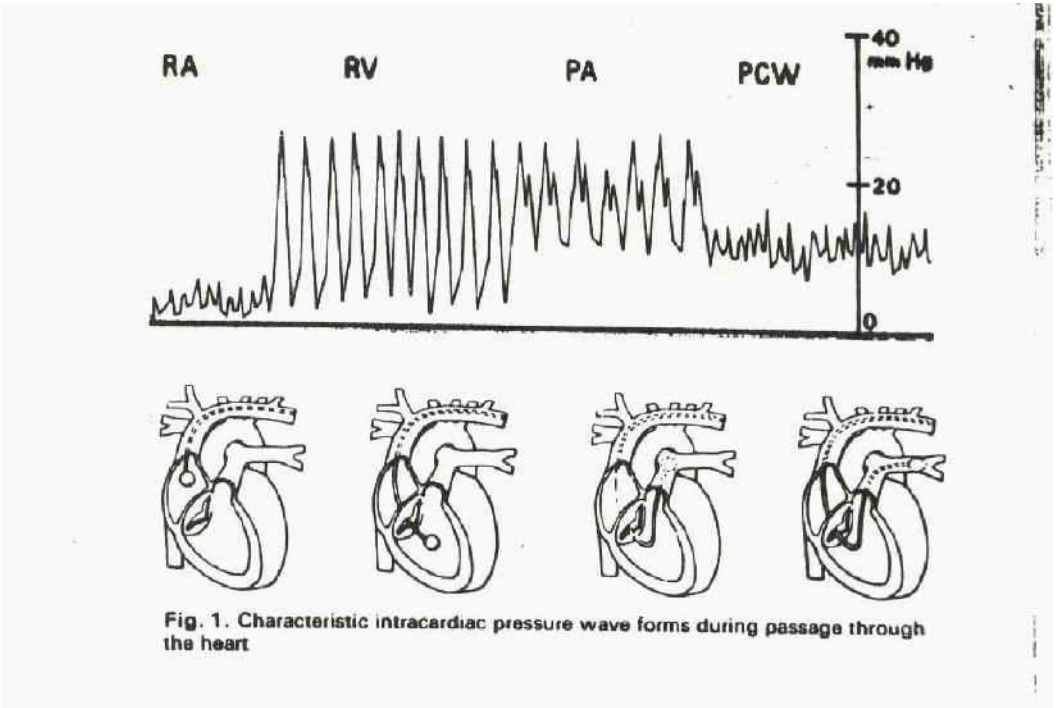


Fig. 1. Characteristic intracardiac pressure wave forms during passage through the heart

Complicanze PAC

Rottura Arteria Polmonare

- Riportato tra 0,05 e 0,2 % con una mortalità del 30-50% che sale al 75% su pz scoagulati
- Fattori di rischio: età avanzata, genere femminile, ipertensione polmonare, stenosi mitralica, scoagulazione
- Rischio iatrogeno: onde “V” elevate in insufficienza mitralica

PAC

Valori di riferimento

CO	5 - 7 L / Min
CI	2.8 - 4.2 L / Min / M2
SV	50 - 110 ml / beat
SVI	30 - 65 ml / beat / M2
LVSW	80 - 110 g.m
RVSW	10 - 20 g.m

PAC

Valori di riferimento

LVSWI	45 - 60 g.m / M2
RVSWI	5 - 10 g.m / M2
SVR	900 - 1400 dyne.sec.cm-5
SVRI	1500 - 2400 dyne.sec.cm-5.m2
PVR	150 - 250 dyne.sec.cm-5
PVRI	250 - 400 dyne.sec.cm-5.m2
PVR:SVR ratio	0.15

$$Qs/Qt = (Cc'O2 - CaO2)/(Cc'O2 – CvO2)$$

Where: Cc'O2 = Pulmonary end-capillary oxygen content, CaO2 = arterial oxygen content,

CvO2 = mixed venous oxygen content, Qs = shunted flow and Qt = cardiac output.

$$VO2 = CO * (CaO2 - CvO2)$$

Where:

CaO2 = Arterial oxygen content in ml / L

CvO2 = Venous oxygen content in ml / L

$$DO_2 = CO * Hb * 1.36 * SaO_2 + 0.03 * (PaO_2)$$

Where: Hb = haemoglobin concentration in gm/L. 1.36 combining power of haemoglobin. SaO_2 = haemoglobin saturation.

For many purposes, the dissolved oxygen in the blood can be ignored, in which case the equation reduces to:

$$DO_2 = CO * Hb * 1.36 * SaO_2 \text{ or:}$$

$$DO_2 = CO * CaO_2$$

Where:

CaO_2 = Arterial oxygen content in ml / L

$$SVO2 = SaO2 - (VO2 / CO * 1.36 * Hb)$$

Controindicazioni assolute PAC

- Tricuspid or pulmonary valve stenosis.
- The presence of a prosthetic tricuspid or pulmonary valve.
- Right atrial or right ventricular masses.
- Cyanotic heart disease.
- Latex allergy.
- Previous pneumonectomy.

Controindicazioni relative PAC

- A patient at risk of severe arrhythmias.
- Anticoagulation.
- Proposed pneumonectomy.
- Attempted flotation during cardiopulmonary bypass.

Cardiogenic shock.

- an elevated heart rate,
- an increased systemic vascular resistance,
- a reduced stroke volume and cardiac output
- systemic hypotension,
- an elevated PAOP,
- metabolic acidosis.

Haemorrhagic shock.

- low left and right sided filling pressures,
- an elevated heart rate,
- an increased systemic vascular resistance,
- reduced stroke volume and cardiac output
- systemic and pulmonary hypotension,
- a reduction in the end-diastolic and end-systolic volumes for both right and left ventricles.

Septicaemic shock.

- an elevated heart rate and cardiac output,
- a decreased systemic vascular resistance,
- a preserved stroke volume
- systemic and pulmonary hypotension

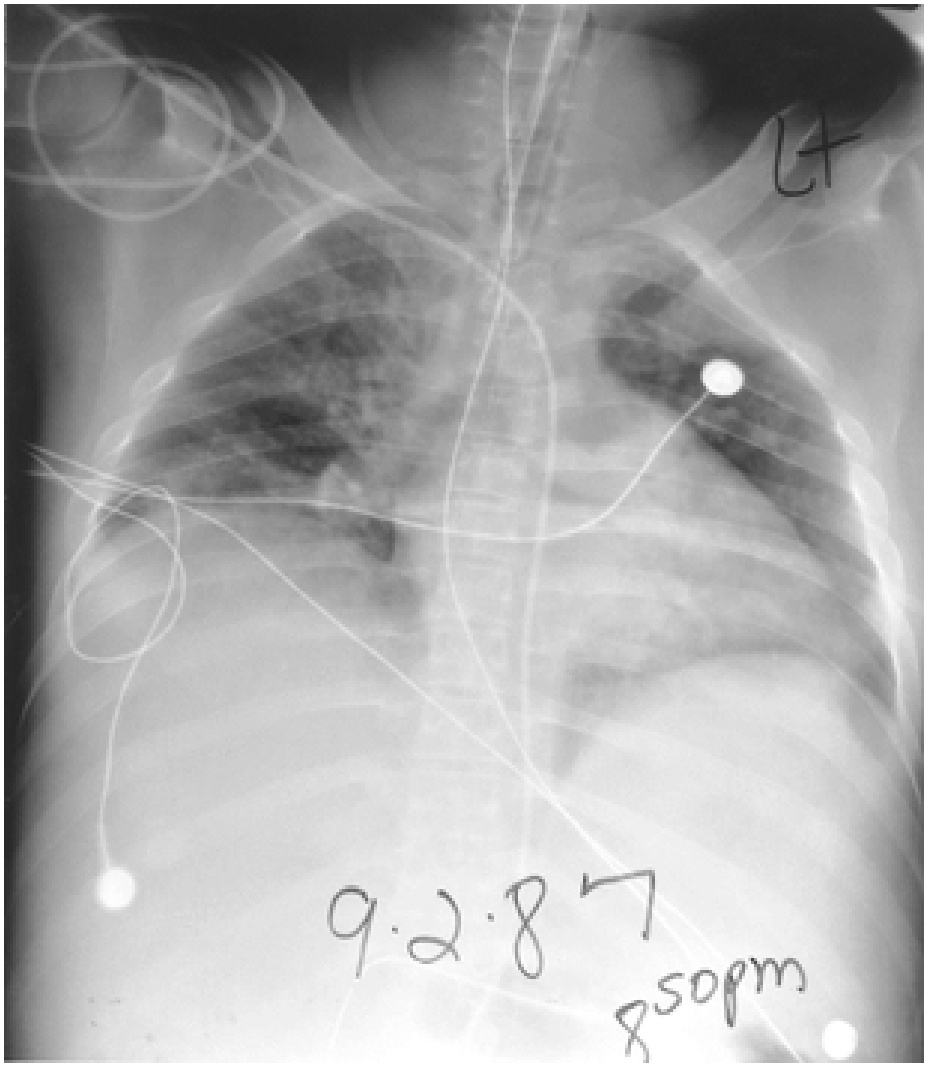
Cardiac tamponade

- an elevated heart rate
- a low cardiac output
- an increase in left and right sided filling pressures
- an equalization of left and right sided filling pressures
- an increased systemic vascular resistance
- an exaggerated blood pressure response to respiration
- a paradoxical rise in central venous pressure if breathing spontaneously

Guidelines for safe usage of Pulmonary Artery Flow-Guided Catheters

- Balance risk versus benefit.
- Slowly inflate balloon while continuously monitoring the pulmonary artery waveform.
- Upon transition from the pulmonary artery to PAOP trace, immediately stop inflation
- If an overwedge pattern is observed, immediately deflate the balloon and withdraw the catheter 1-2 cm. Slowly reinflate the balloon; a normal wedge pressure waveform should be noted.
- Minimize duration of PAOP measurements.
- If balloon inflates with less than 1.5 cc of gas, withdraw the catheter at least 1-2 cm.
- Spontaneous tip migration may occur; therefore continuously monitor the PA trace for 'spontaneous wedging'. If this occurs, withdraw the catheter 1-2 cm or until a normal PA tracing reappears.
- Minimize number of PAOP measurements in patients who are elderly, have received anticoagulants or have pulmonary hypertension.

A patient is admitted to ICU and intubated for hypotension and hypoxemia. Arterial blood gas measurements while the patient was being ventilated with an FiO2 of .7 and PEEP of 10 cm H2O demonstrated a pH 7.36, PaCO2 34 mm Hg, and PaO2 of 65 mm Hg. A right subclavian introducer sheath is inserted, through which a pulmonary artery catheter is passed but a wedge tracing cannot be obtained. The chest radiograph above is obtained. A blood sample is withdrawn from the distal port of the pulmonary artery catheter and sent for blood gas analysis.



1. Of the following possible results, the one predicted by the chest radiograph is:

A) pH 7.36, PaCO2 34 mm Hg, and PaO2 of 35 mm Hg

B)pH 7.33, PaCO2 41 mm Hg, and PaO2 of 35 mm Hg

C) pH 7.22, PaCO2 66 mm Hg, and PaO2 of 35 mm Hg

D) pH 7.36, PaCO2 34 mm Hg, and PaO2 of 65 mm Hg

E) pH 7.33, PaCO2 41 mm Hg, and PaO2 of 195 mm Hg