Università degli Studi Di Milano - Laurea in Scienze Infermieristiche
Polo Didattico "Ospedale Civile Legnano" - AA 2010-2011
Corso di Fisiologia Umana

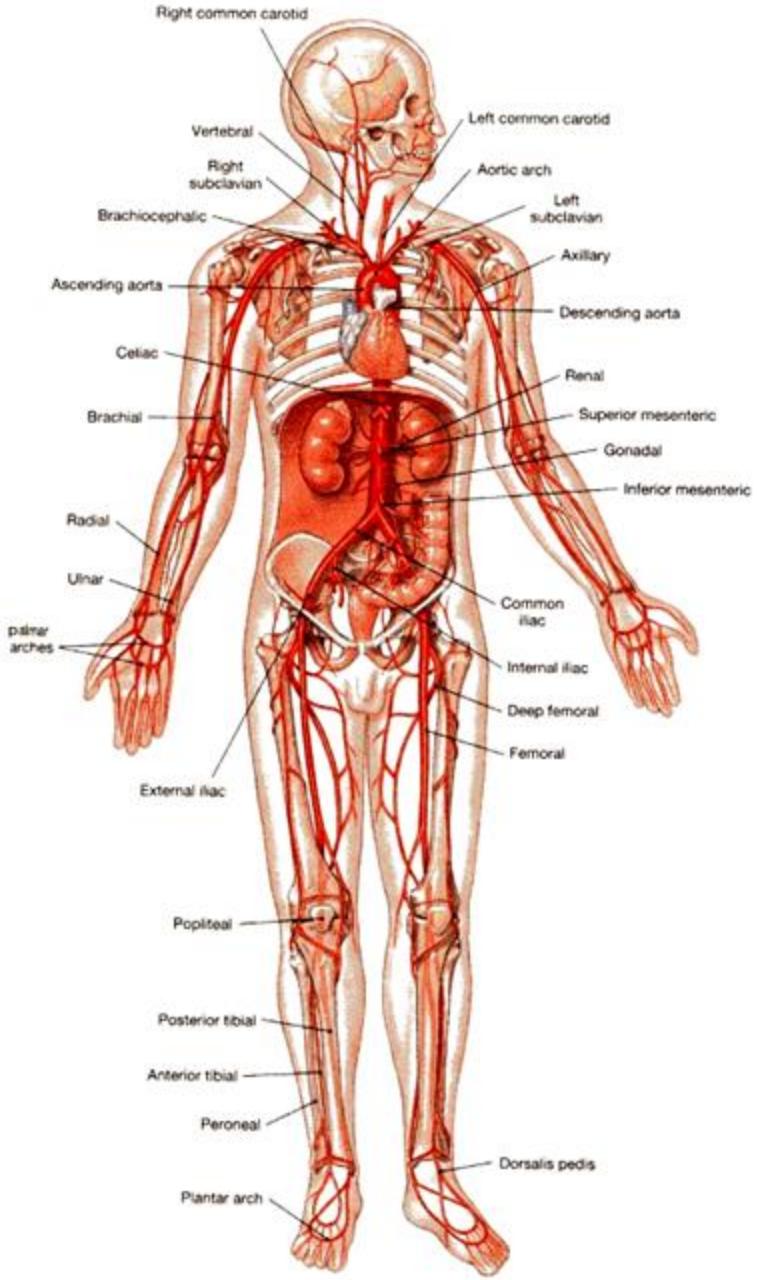
APPARATO CARDIOCIRCOLATORIO

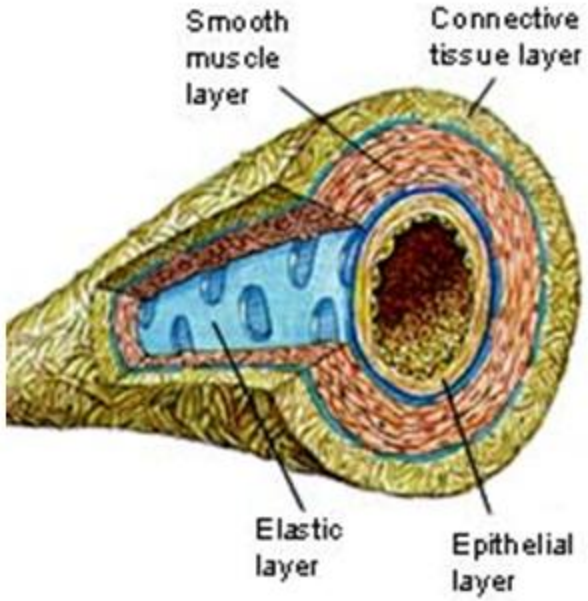
PARTE TERZA

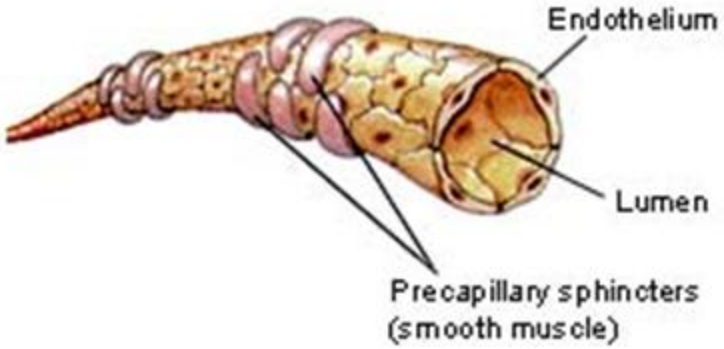
Dr. ALBERTO VIGNATI
Medicina Nucleare Legnano

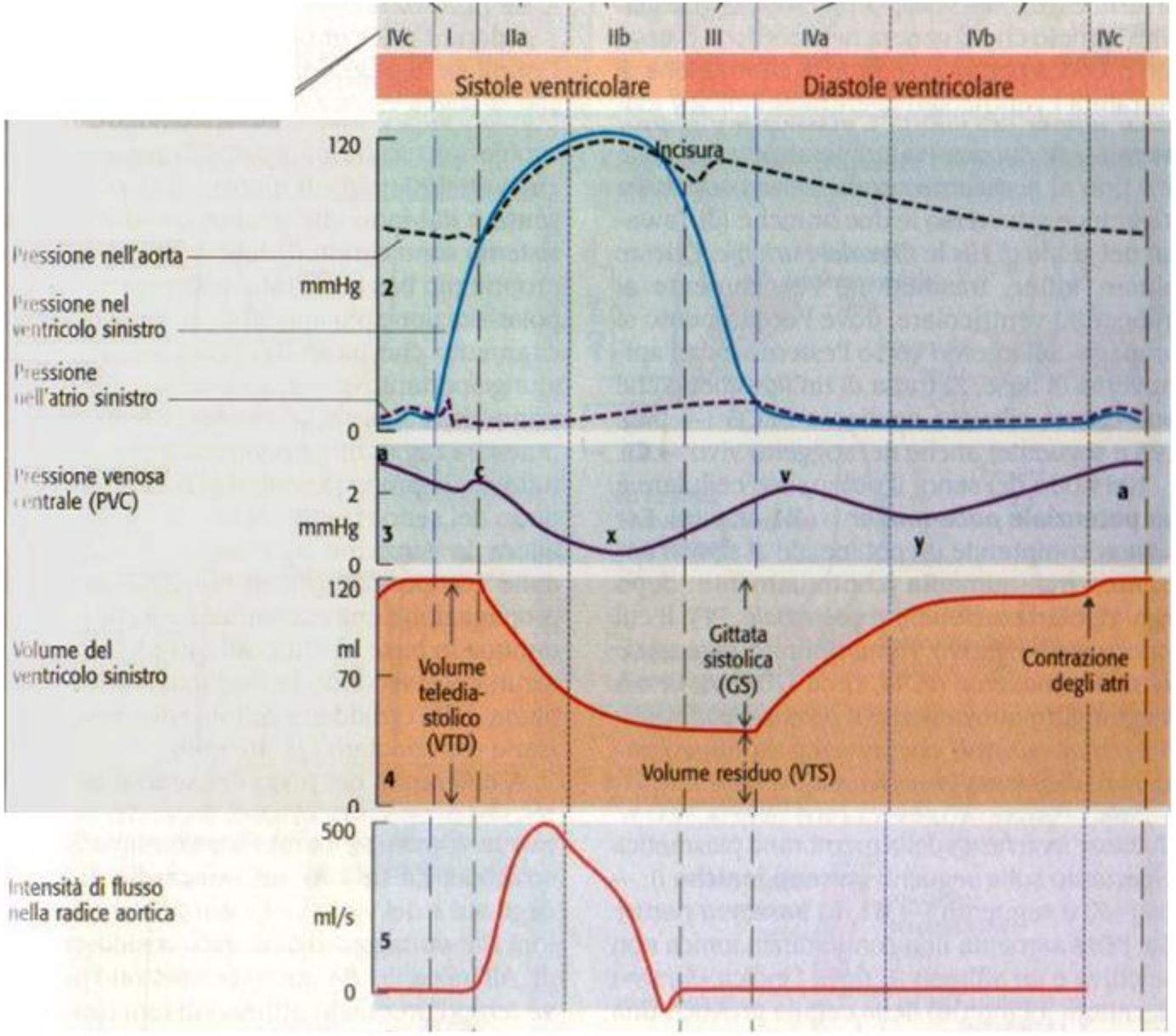
SISTEMA CIRCOLATORIO:

VASI
arterie

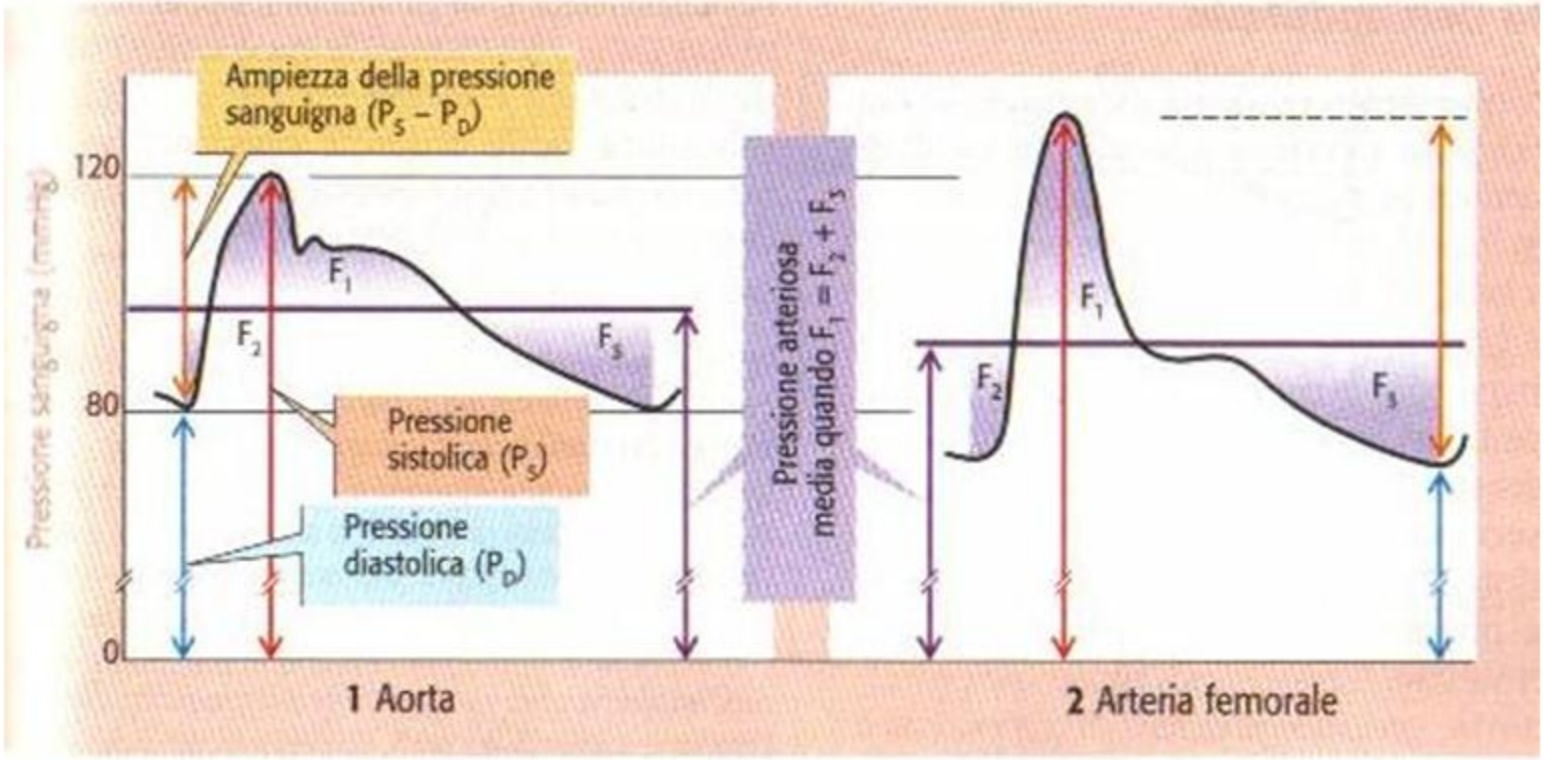

Right common carotid
Left common carotid
Vertebral
Right subclavian
Aortic arch
Left subclavian
Brachiocephalic
Axillary
Ascending aorta
Descending aorta
Celiac
Renal
Brachial
Superior mesenteric
Gonadal
Inferior mesenteric
Radial
Ulnar
Common iliac
palmar arches
Internal iliac
Deep femoral
Femoral
External iliac
Popliteal
Posterior tibial
Anterior tibial
Peroneal
Dorsalis pedis
Plantar arch

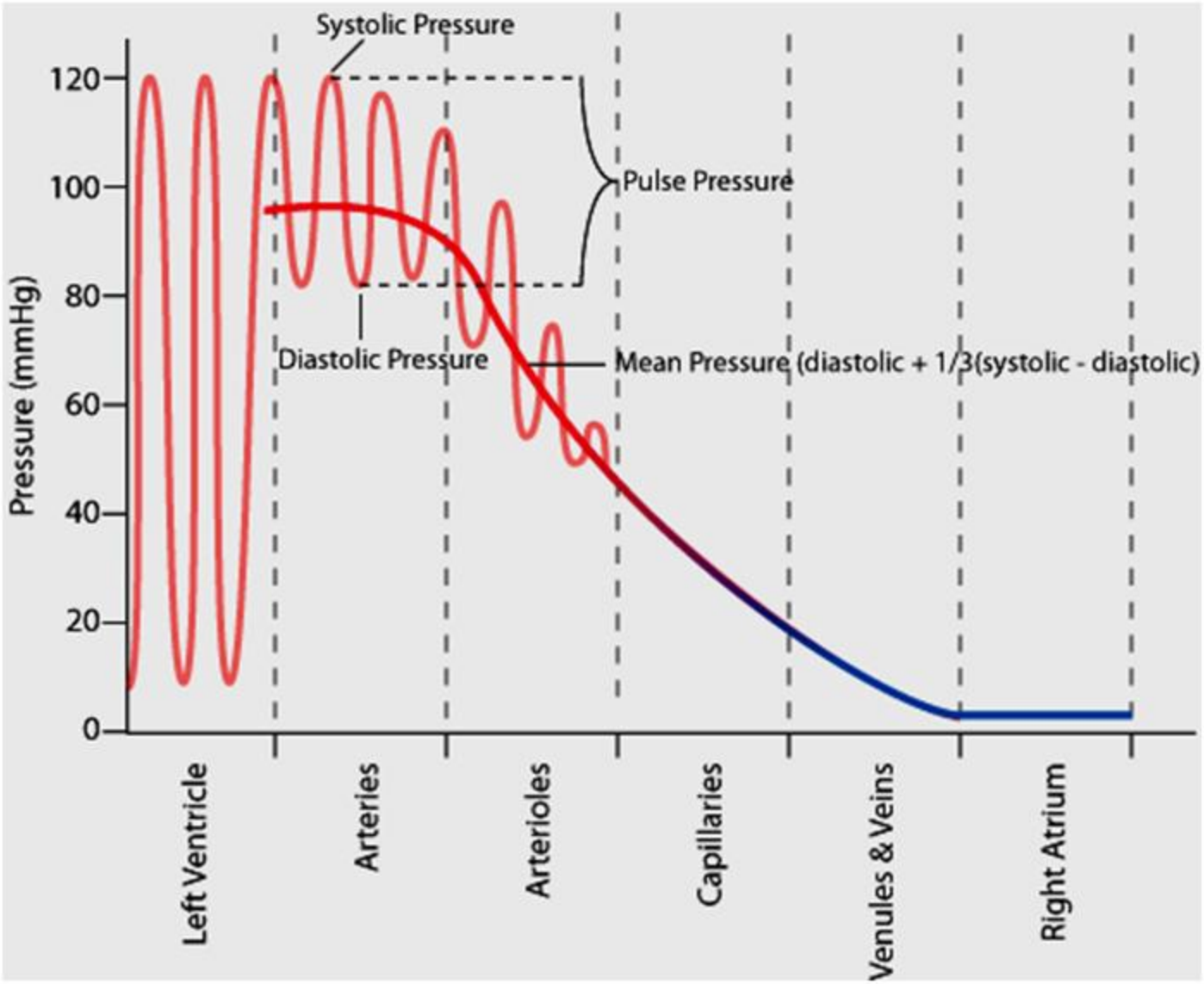

Smooth muscle layer
Connective tissue layer
Elastic layer
Epithelial layer

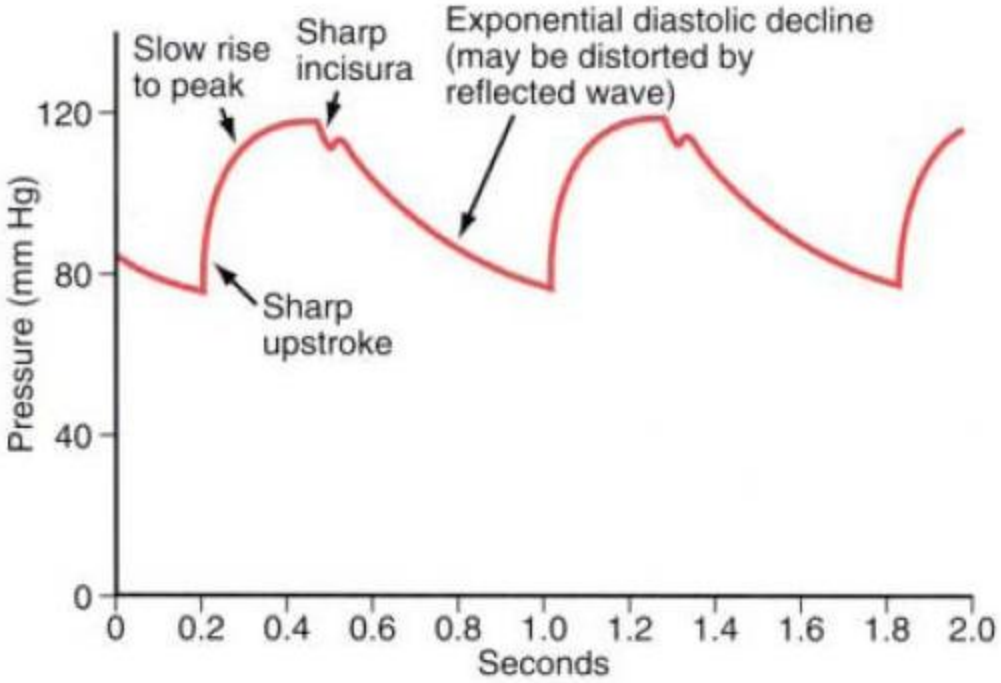

Endothelium
Lumen
Precapillary sphincters (smooth muscle)


IVc
I
IIa
IIb
III
IVa
IVb
IVc
Sistole ventricolare
Diastole ventricolare
120
Incisura
Pressione nell'aorta
mmHg
2
Pressione nel ventricolo sinistro
Pressione nell'atrio sinistro
0
Pressione venosa centrale (PVC)
a
c
v
a
2
mmHg
3
x
y
0
120
Volume del ventricolo sinistro
ml
70
Volume telediastolico (VTD)
Gittata sistolica (GS)
Contrazione degli atri
4
Volume residuo (VTS)
0
500
Intensità di flusso nella radice aortica
ml/s
5
0

A. Andamento della pressione arteriosa




Systolic Pressure
Pulse Pressure
Diastolic Pressure
Mean Pressure (diastolic + 1/3(systolic - diastolic)
Pressure (mmHg)
120
100
80
60
40
20
0
Left Ventricle
Arteries
Arterioles
Capillaries
Venules & Veins
Right Atrium

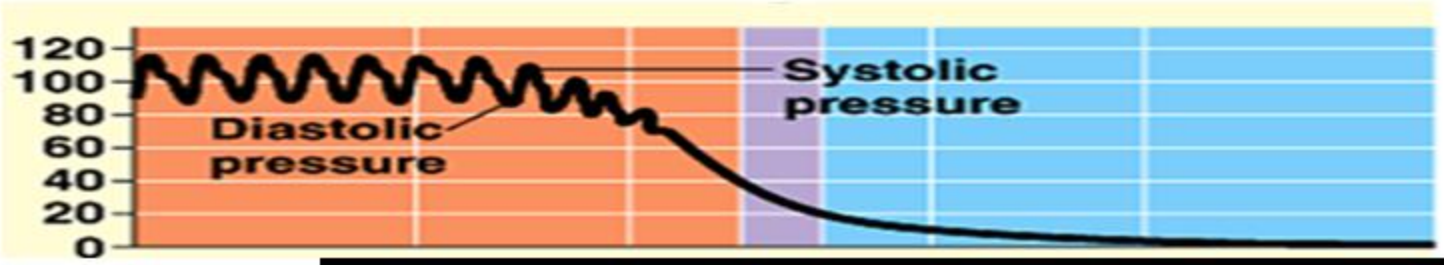


Pulse pressure is affected by:

1. The stroke volume output of the heart

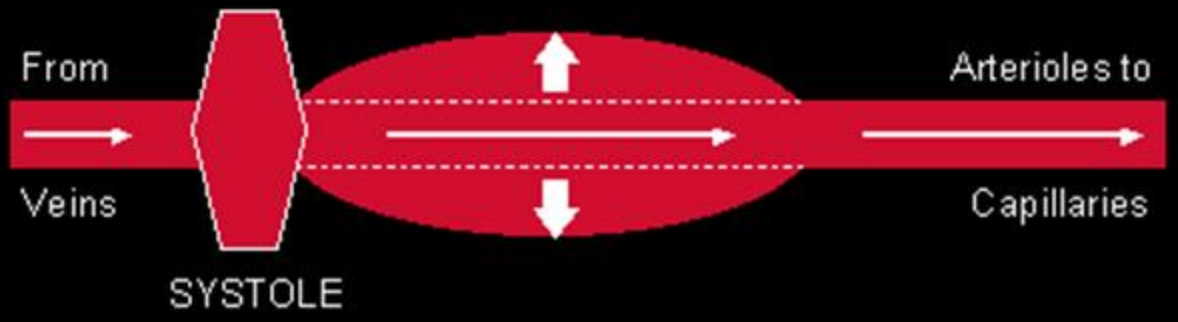
2. The compliance (total distensibility) of the arterial tree.

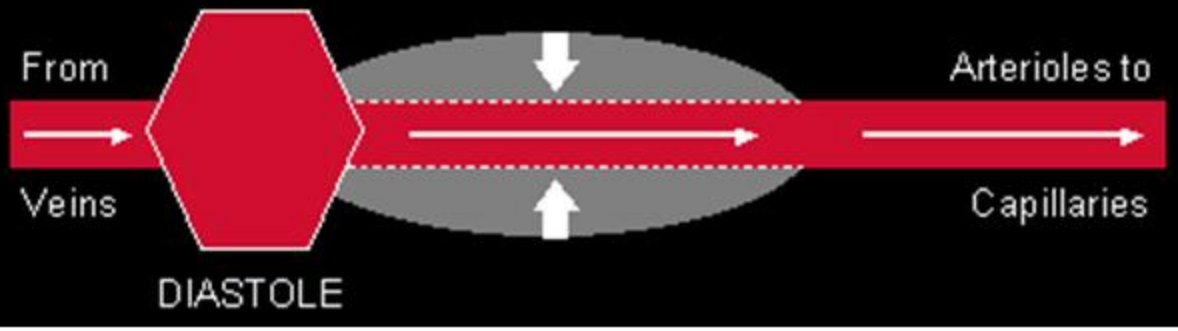
$$P_{pulse} = V_{stroke}/C_{arterial}$$

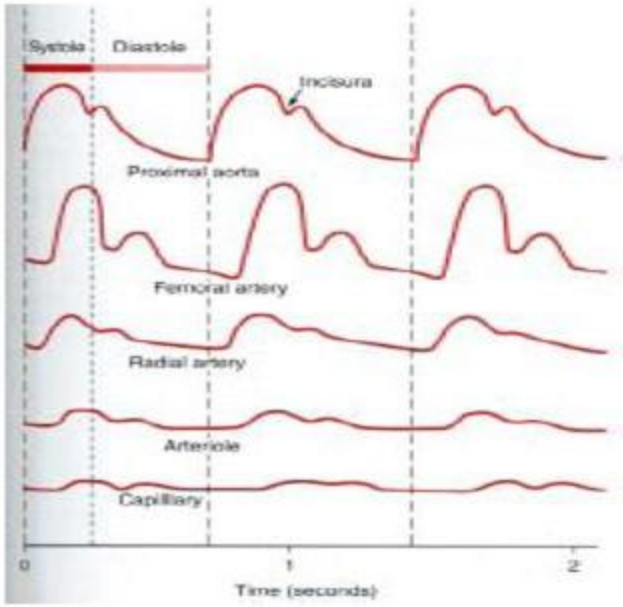


Arteries

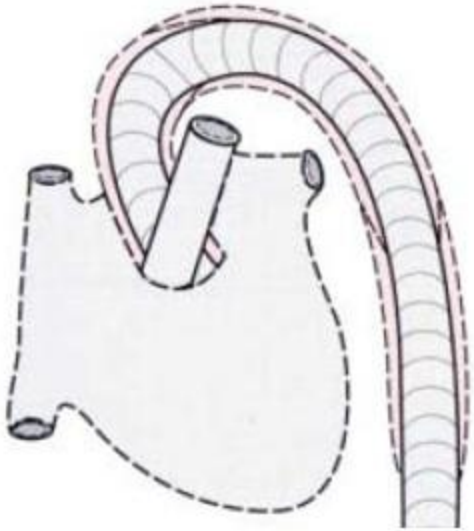
- Low resistance, rapid transit passageways
- Muscle & elastic connective tissue in walls
  - *elastic recoil*

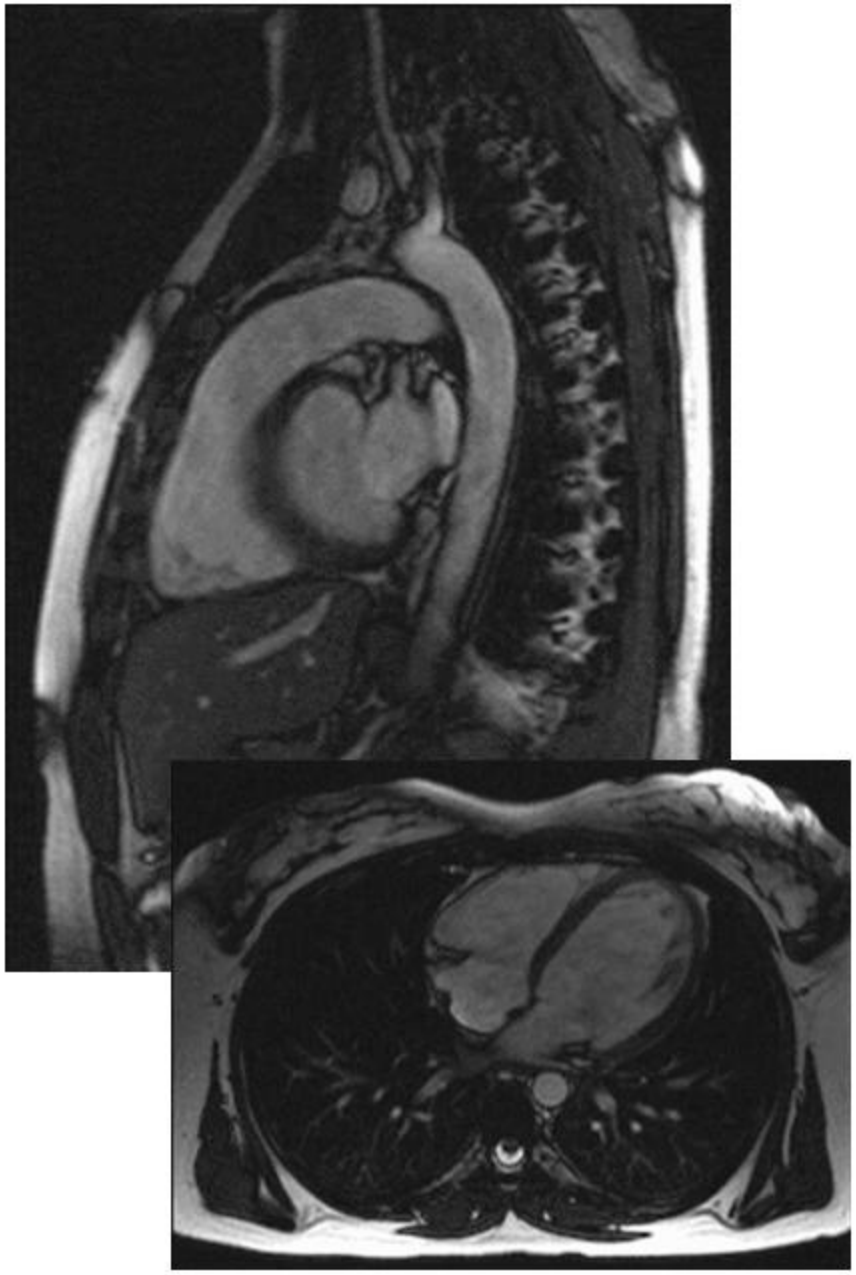




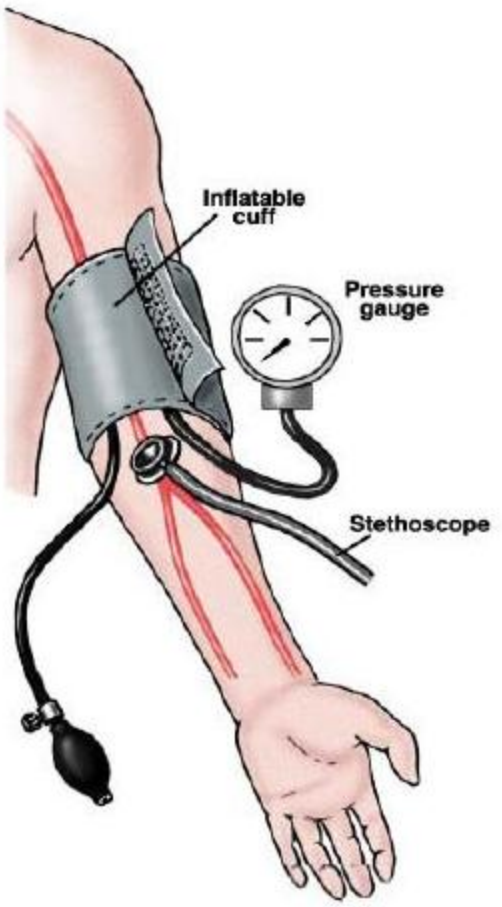


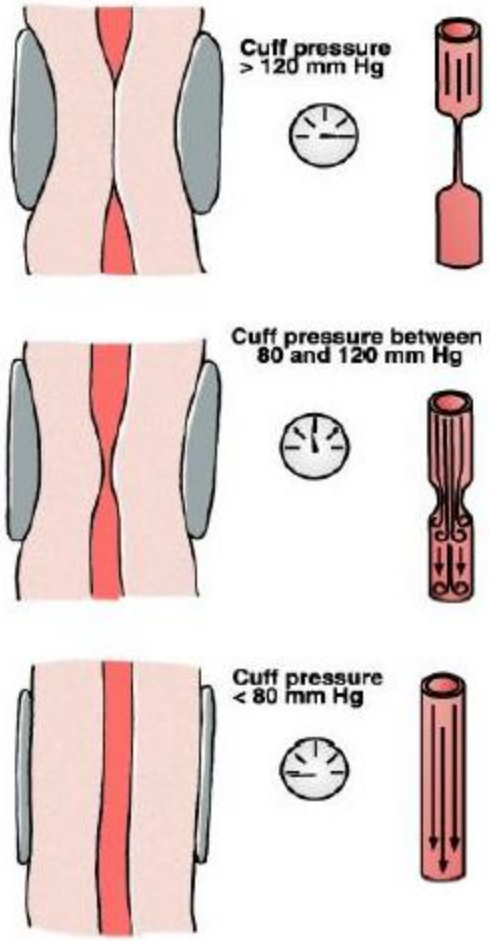
Damping $\propto$ Resistance $\times$ Compliance





MISURA DELLA PRESSIONE ARTERIOSA



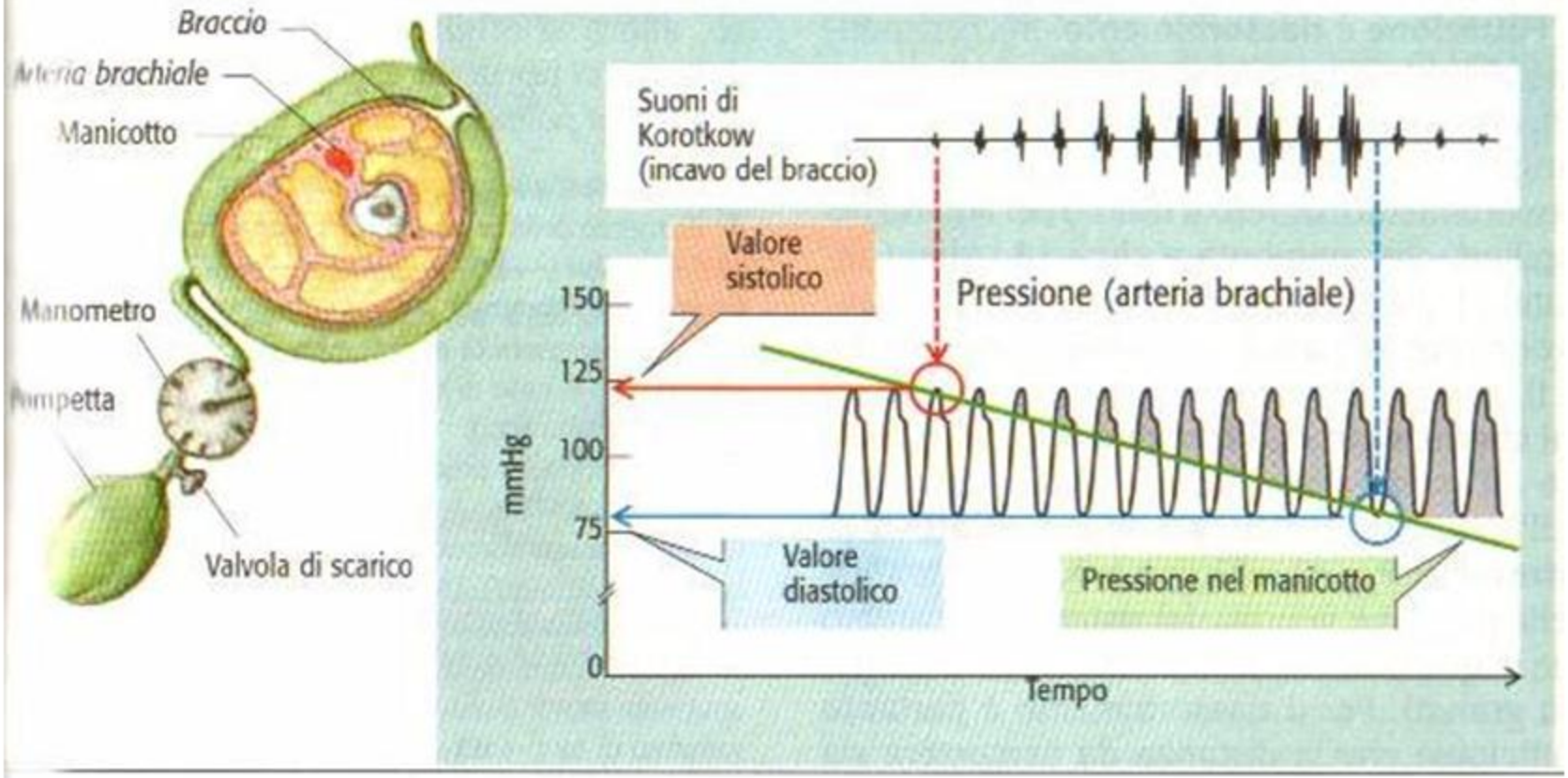


Pressione massima: primo rumore

Pressione intermedia: rumori diversi

Pressione minima: ultimo rumore

B. Misurazione della pressione sanguigna secondo Riva-Ricci



Autonomic Cardiovascular Control

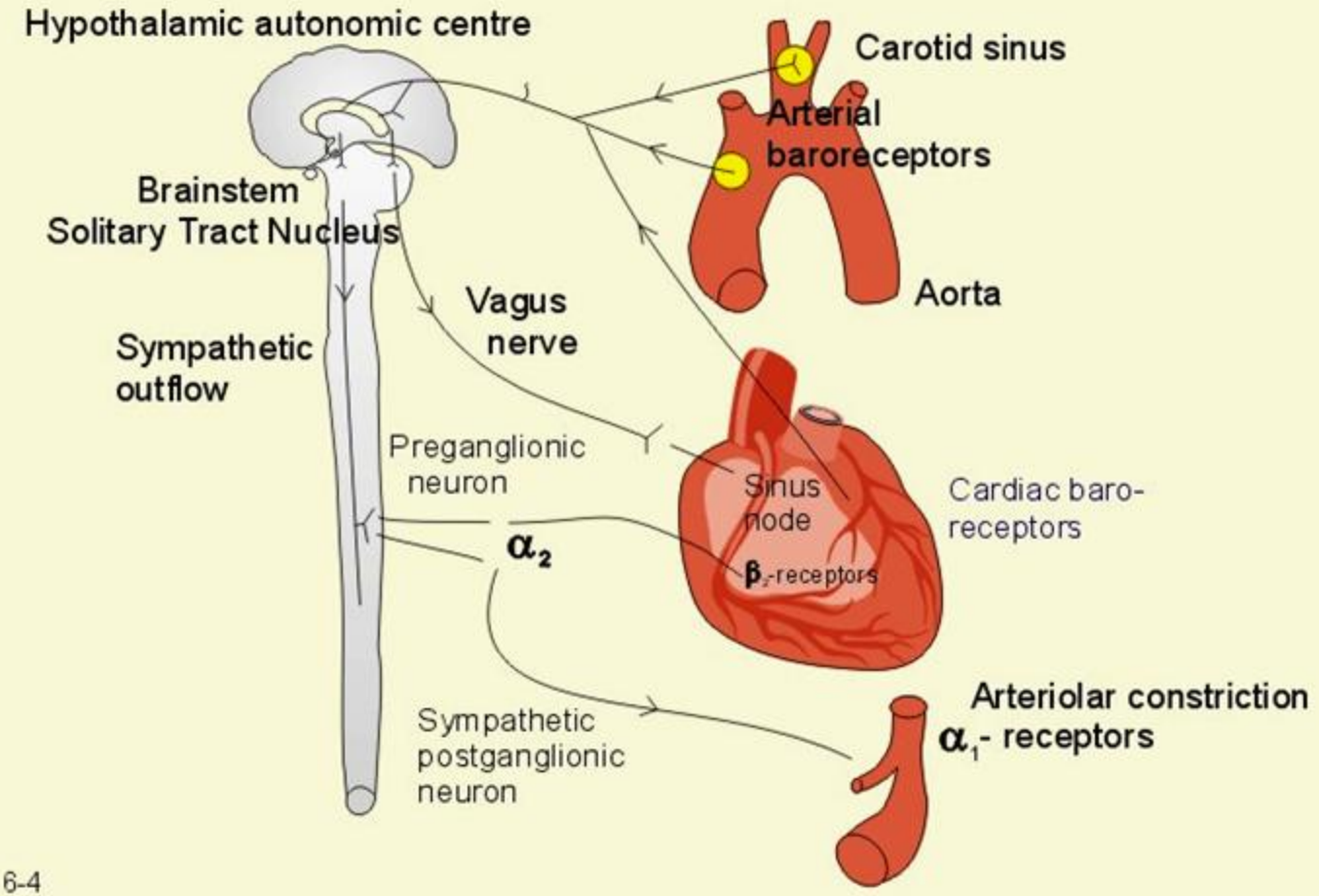
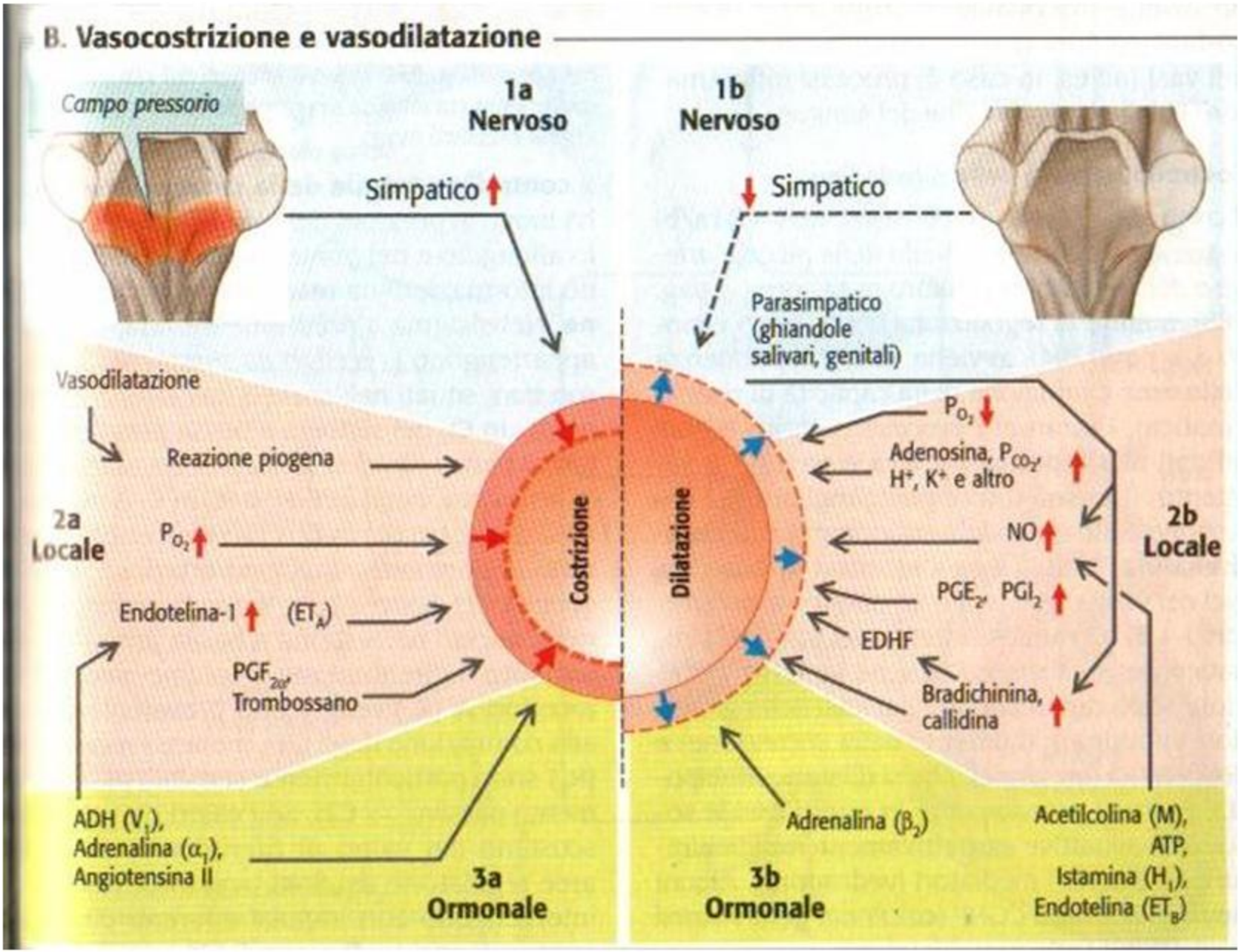


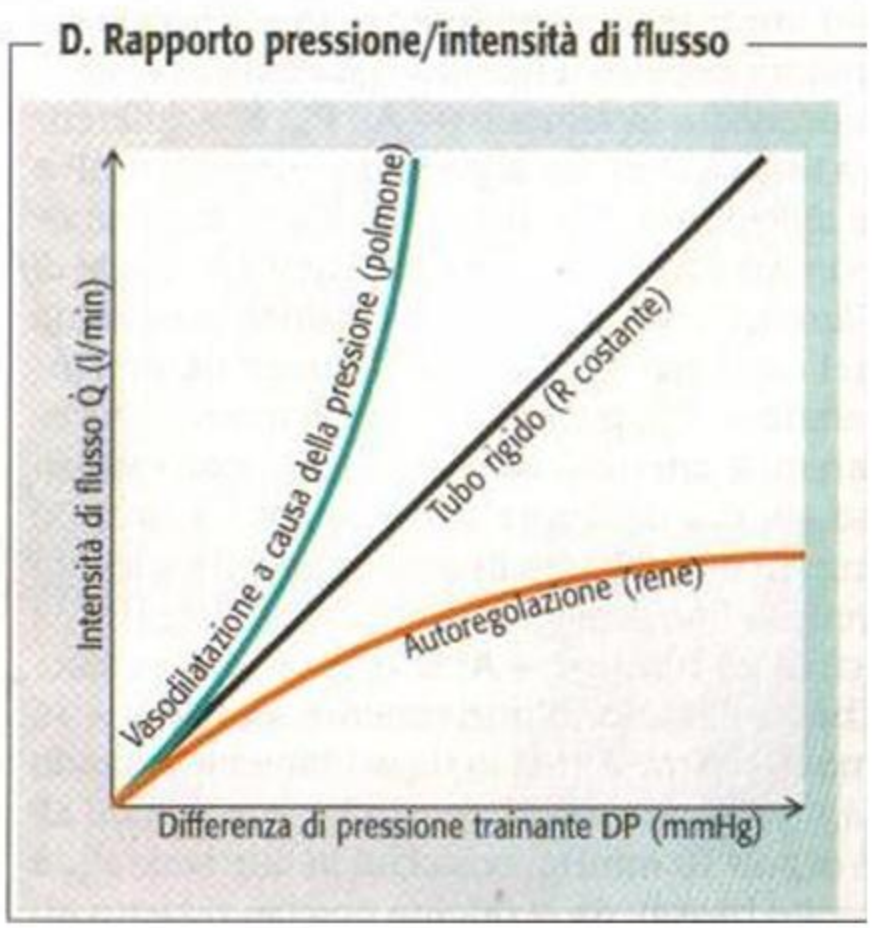
Fig. 6-4

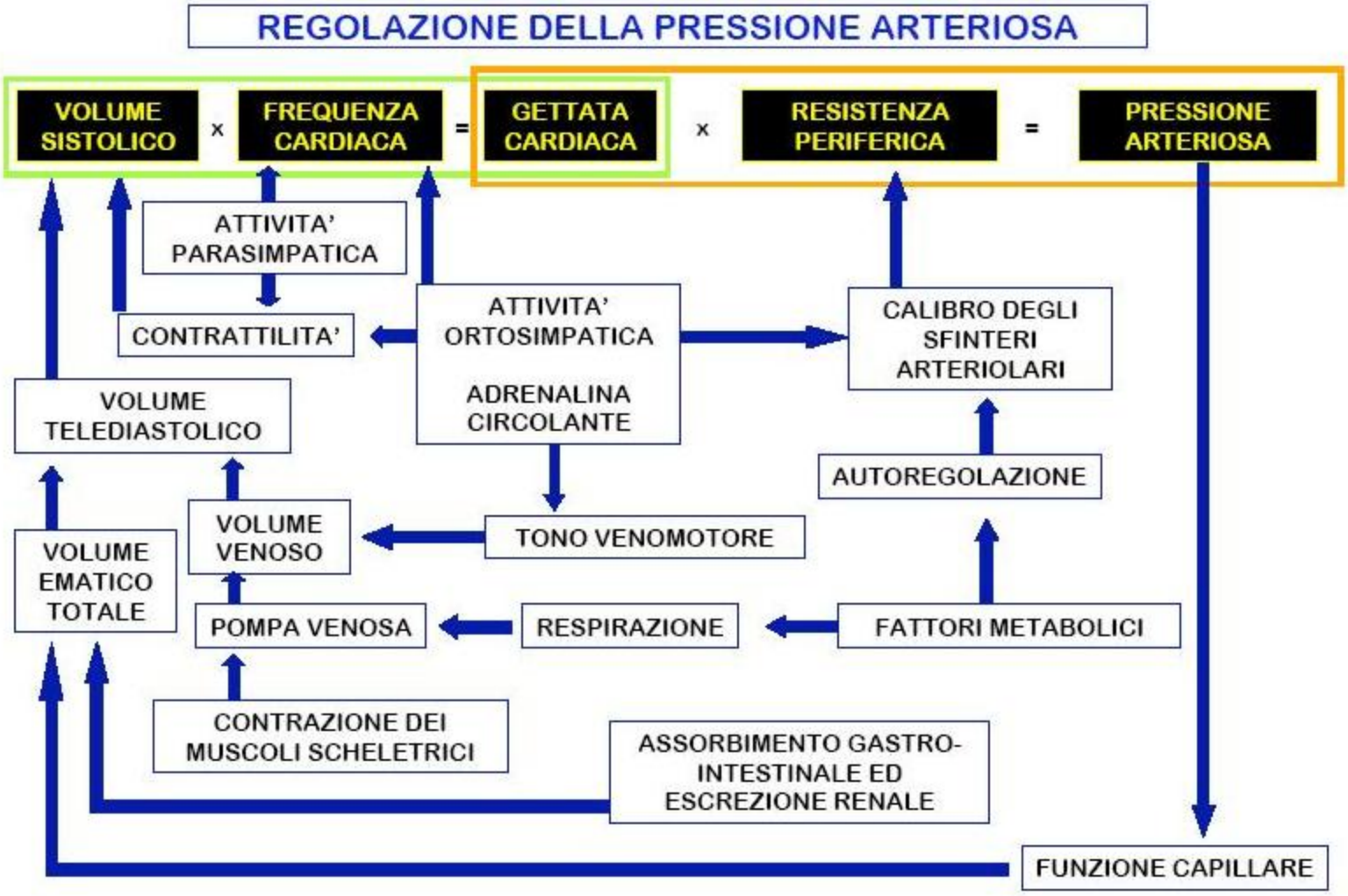
KMc

B. Vasocostrizione e vasodilatazione

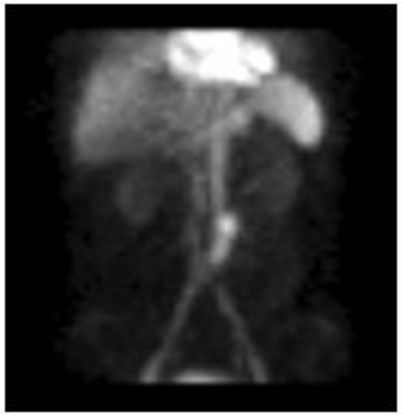


$Q = \Delta P / Resis$

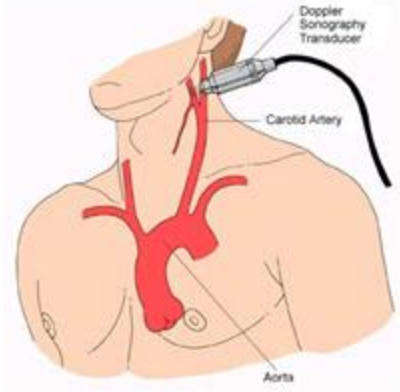



REGOLAZIONE DELLA PRESSIONE ARTERIOSA
VOLUME SISTOLICO
x
FREQUENZA CARDIACA
=
GETTATA CARDIACA
x
RESISTENZA PERIFERICA
=
PRESSIONE ARTERIOSA
ATTIVITA' PARASIMPATICA
CONTRATTILITA'
ATTIVITA' ORTOSIMPATICA
ADRENALINA CIRCOLANTE
CALIBRO DEGLI SFINTERI ARTERIOLARI
VOLUME TELEDIASTOLICO
AUTOREGOLAZIONE
VOLUME VENOSO
TONO VENOMOTORE
VOLUME EMATICO TOTALE
POMPA VENOSA
RESPIRAZIONE
FATTORI METABOLICI
CONTRAZIONE DEI MUSCOLI SCHELETRICI
ASSORBIMENTO GASTRO-INTESTINALE ED ESCREZIONE RENALE
FUNZIONE CAPILLARE

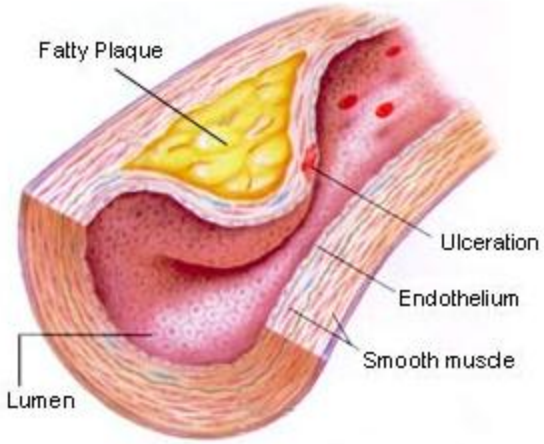
ANEURISMA



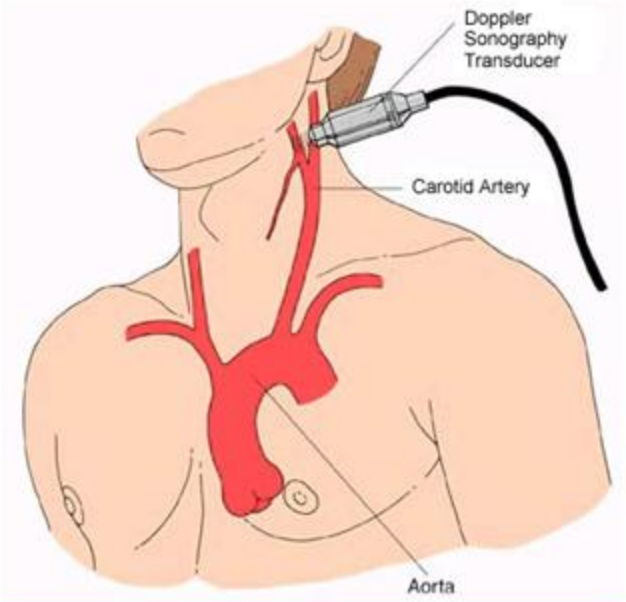
↑ **ANEURISMA**



STENOSI



↑ **STENOSI**



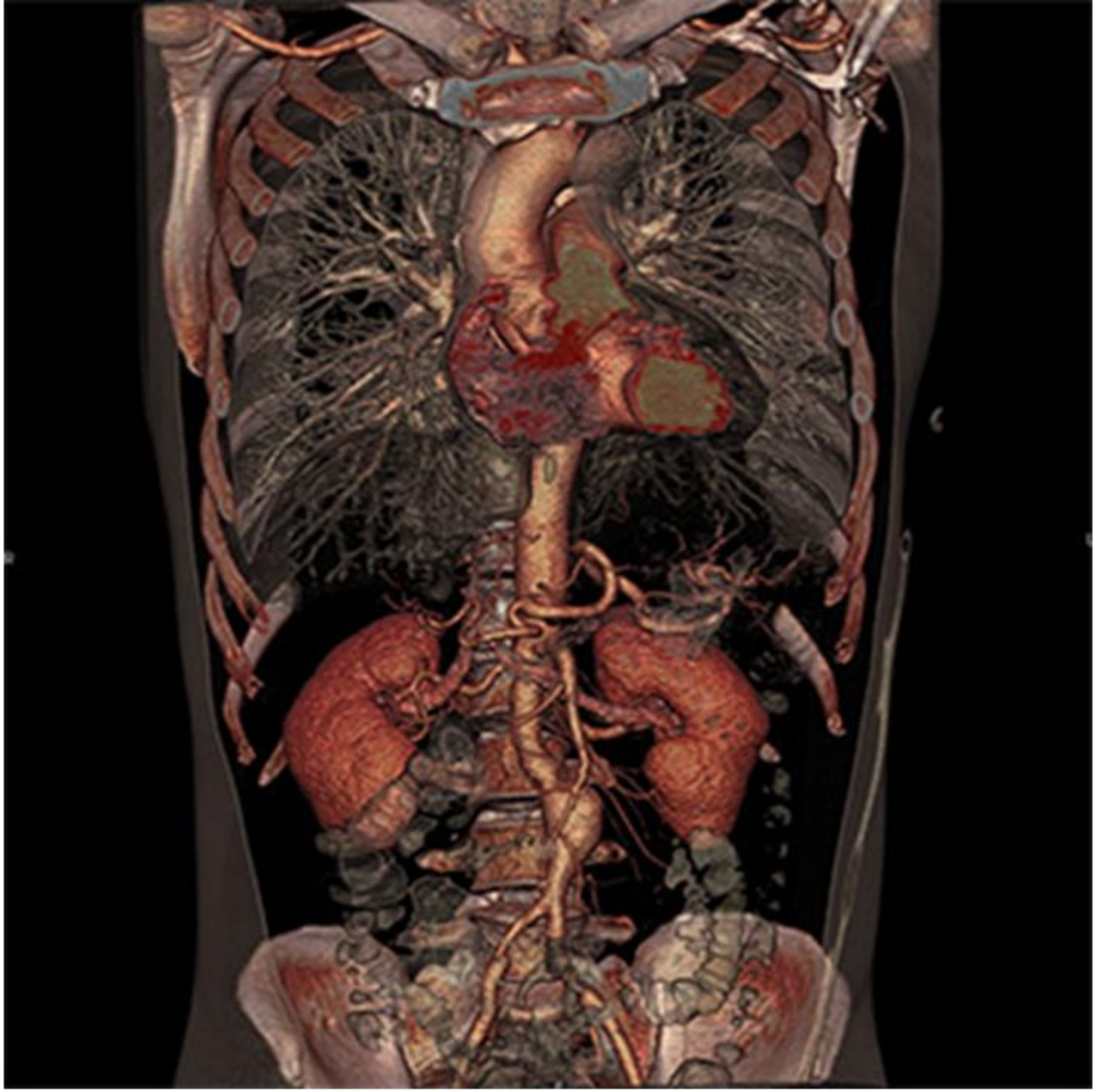
SORGENTE SONORA FERMA

SORGENTE SONORA IN AVVICINAMENTO

ECO -> SEZIONE VASO (A)
DOPPLER -> VELOCITA' SANGUE (v)

FLUSSO = A . v

ECO-COLOR-DOPPLER



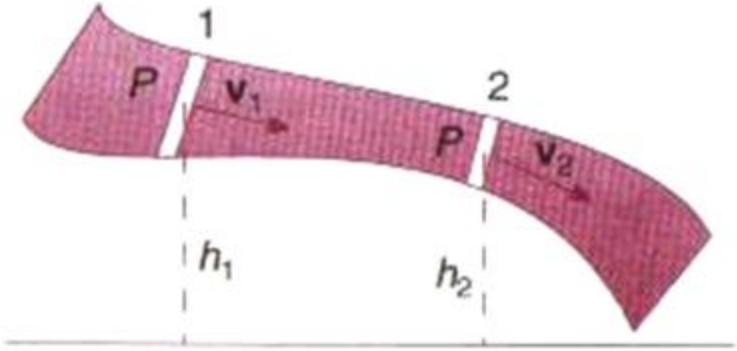
8.2.3 Teorema di Bernoulli

In un condotto in cui scorre un fluido con densità ρ vale la seguente relazione:

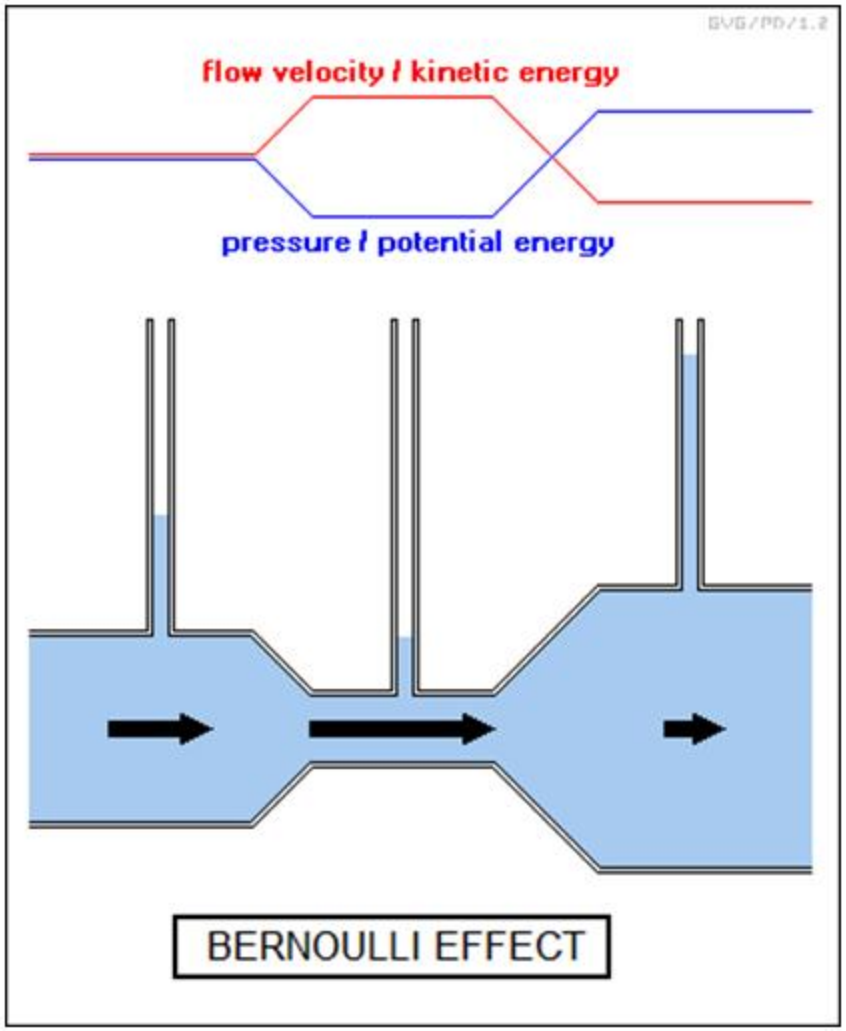
$P+\rho gh + \frac{1}{2}\rho v^2 = \text{costante}$

$$\frac{P}{\rho \cdot g} + h + \frac{v^2}{2g} = \text{costante}$$

dove h è l'altezza, rispetto a un riferimento orizzontale, di un qualsiasi punto all'interno del condotto, v la velocità del fluido in quel punto e P la pressione del fluido nel medesimo punto. I tre termini a primo membro hanno tutti le dimensioni di una lunghezza e sono detti, rispettivamente, **altezza piezometrica**, **geometrica** e **cinetica**.



Il teorema di Bernoulli afferma che, in ogni condotto, la somma delle altezze piezometrica, geometrica e cinetica è costante.



TEOREMA DI BERNOULLI

$P+\rho gh + \frac{1}{2} \rho v^2 = \text{costante}$

PRINCIPIO DI VENTURI

$P+ \frac{1}{2} \rho v^2 = \text{costante}$

TEOREMA DI BERNOULLI $P+\rho gh + \frac{1}{2}\rho v^2 = \text{costante}$

PRINCIPIO DI VENTURI $P+\frac{1}{2}\rho v^2 = \text{costante}$

LEGGE DI LAPLACE per cilindro: $P = T / r \quad T = P.r$

per sfera: $P = 2T / r \quad T = P.R / 2$

EQUAZIONE DI CONTINUITA' FLUSSO = S . v = costante

ANEURISMA→

S↑ v↓ → v↓ Psangue ↑ →

r ↑ Pparete ↓ →

Ppar < Psang→ ↑ ANEURISMA

STENOSI→

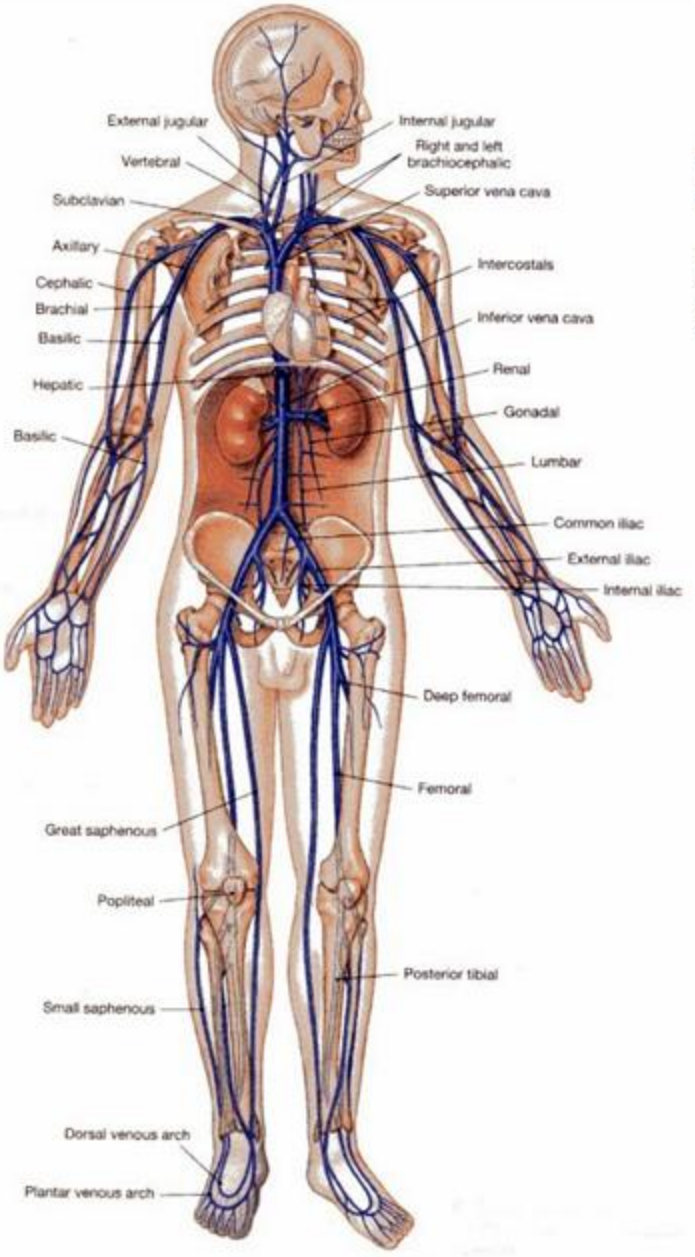
S ↓ v↑ → v↑ Psangue ↓ →

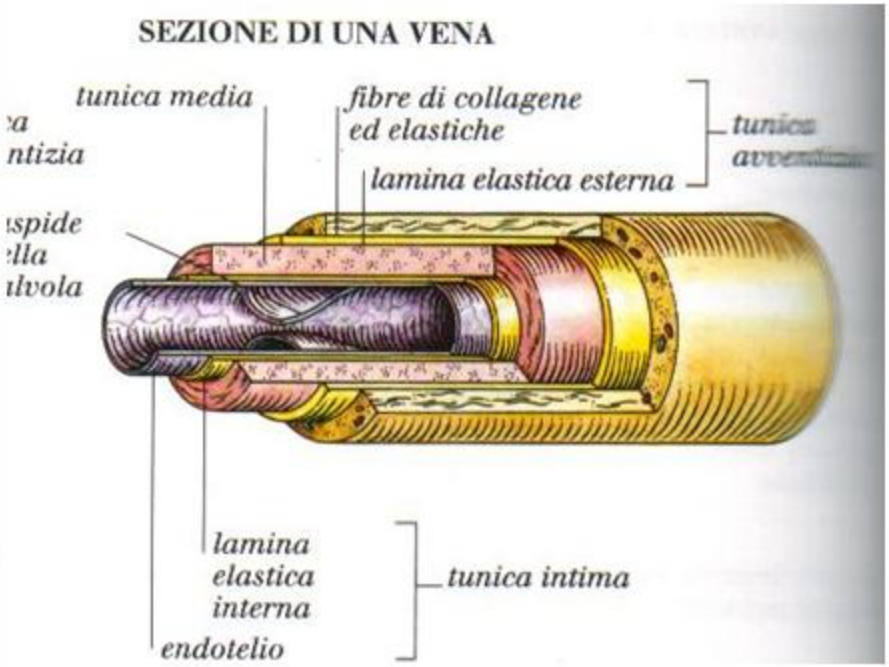
r ↓ Pparete ↑ →

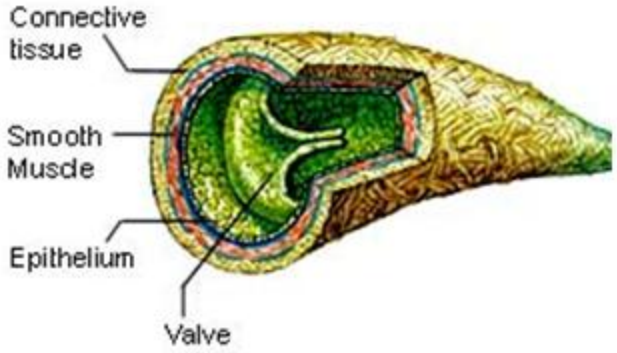
Ppar > Psang→ ↑ STENOSI

SISTEMA CIRCOLATORIO:

VASI
Vene


External jugular
Internal jugular
Vertebral
Right and left brachiocephalic
Subclavian
Superior vena cava
Axillary
Intercostals
Cephalic
Brachial
Inferior vena cava
Basilic
Hepatic
Renal
Gonadal
Basilic
Lumbar
Common iliac
External iliac
Internal iliac
Deep femoral
Femoral
Great saphenous
Popliteal
Posterior tibial
Small saphenous
Dorsal venous arch
Plantar venous arch

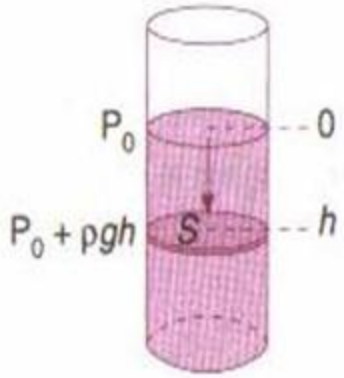

SEZIONE DI UNA VENA
tunica media
fibre di collagene
ed elastiche
lamina elastica esterna
lamina
elastica
interna
endotelio
tunica intima

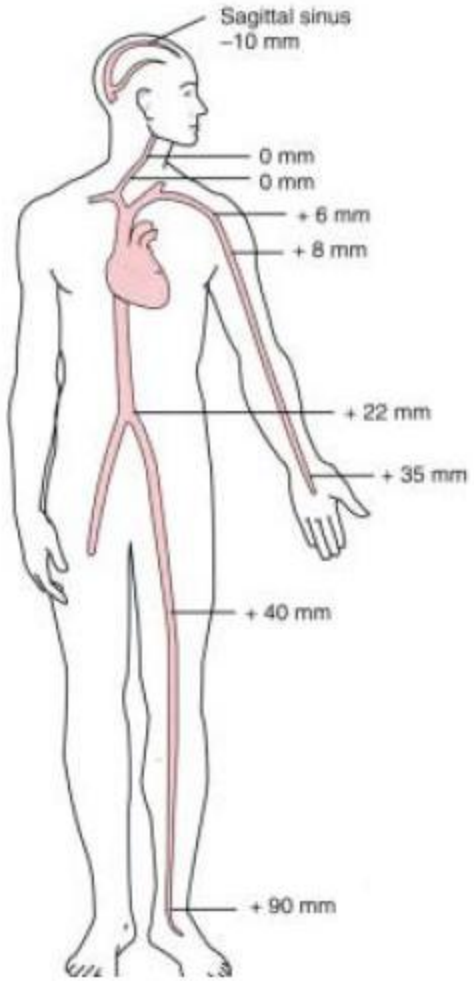

Connective tissue
Smooth Muscle
Epithelium
Valve

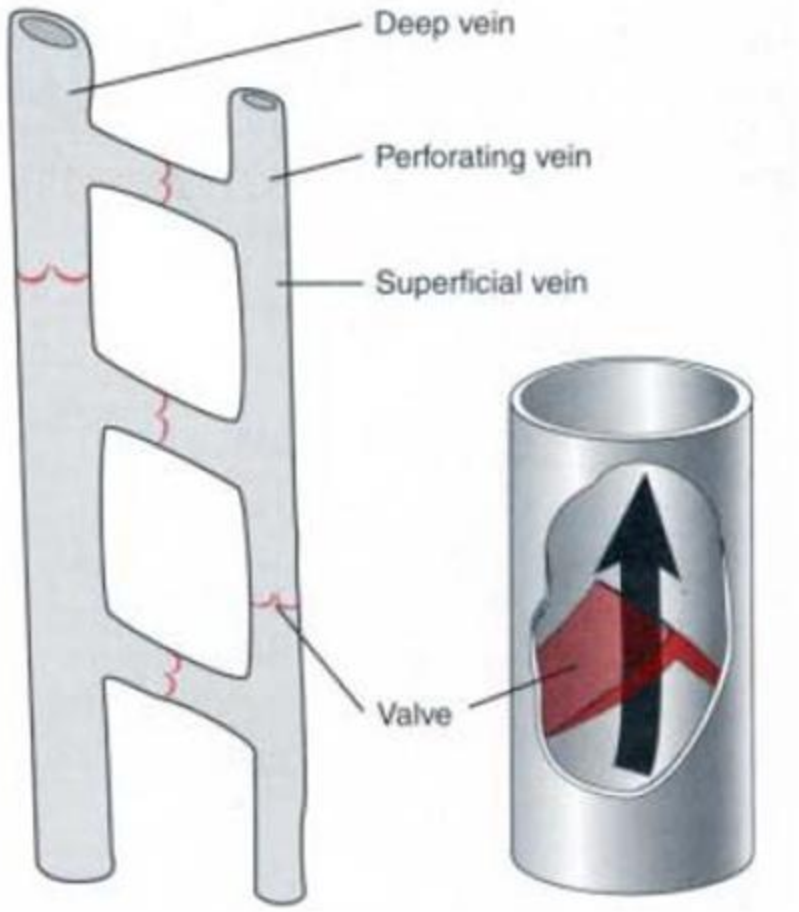
8.1.4 Legge di Stevino

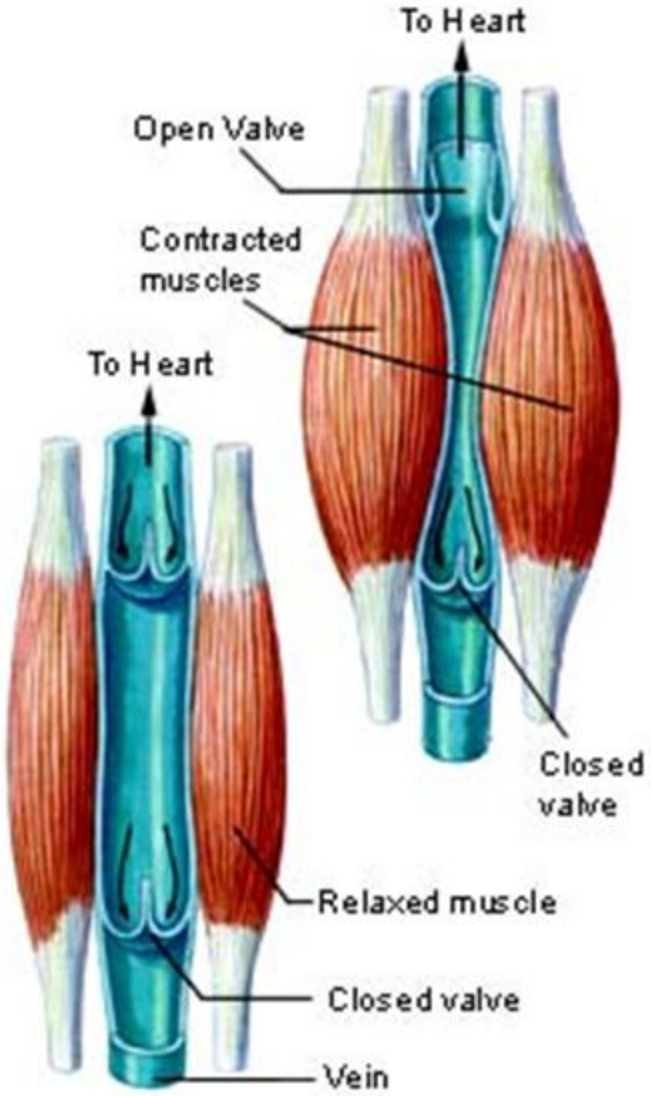
La pressione esercitata da un liquido non dipende dalla forma del recipiente che lo contiene. La pressione idrostatica o aerostatica (pressione dovuta al solo peso del fluido) è proporzionale alla profondità h e, se ρ è la densità del fluido e g l'accelerazione di gravità, vale:

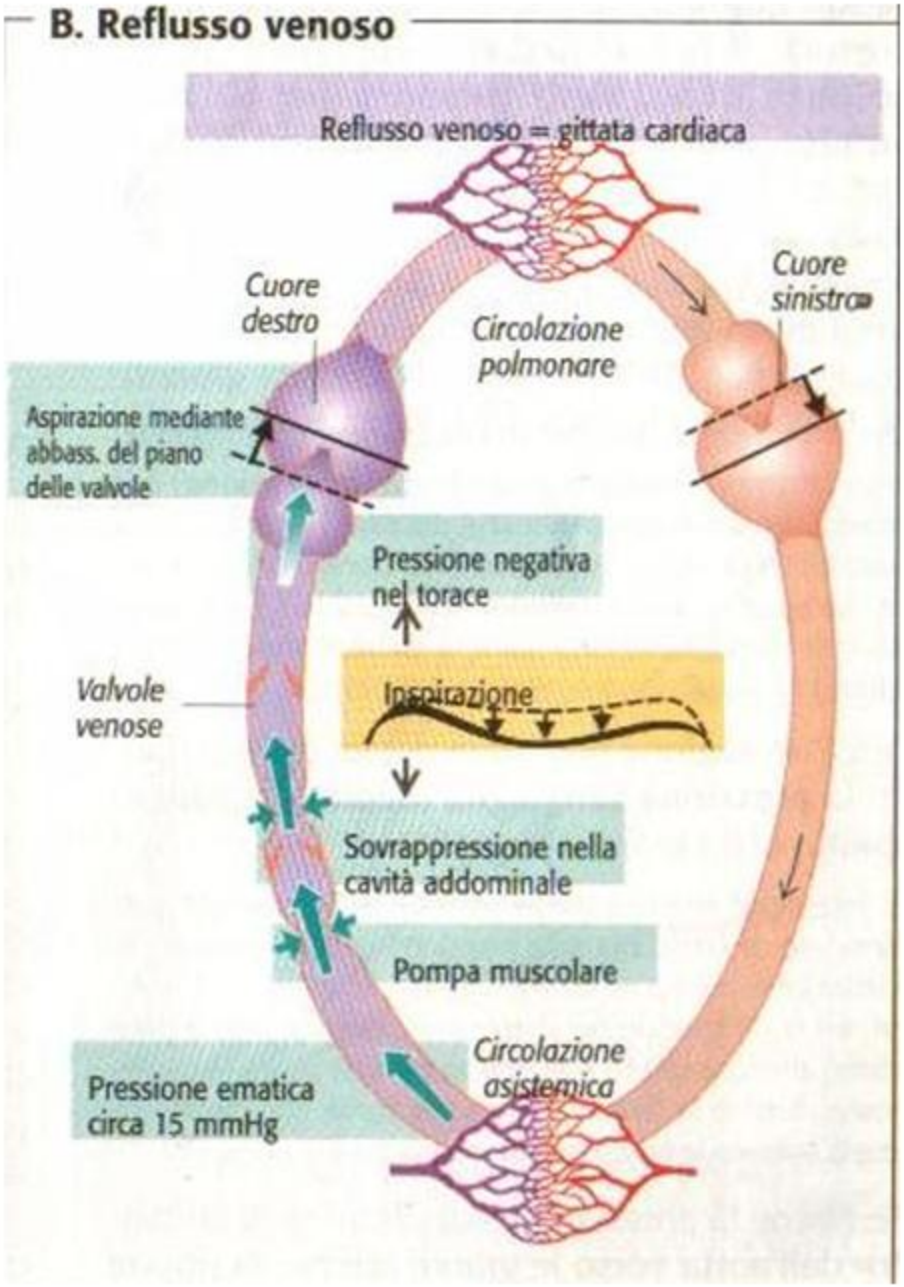
$$P = \rho g h$$





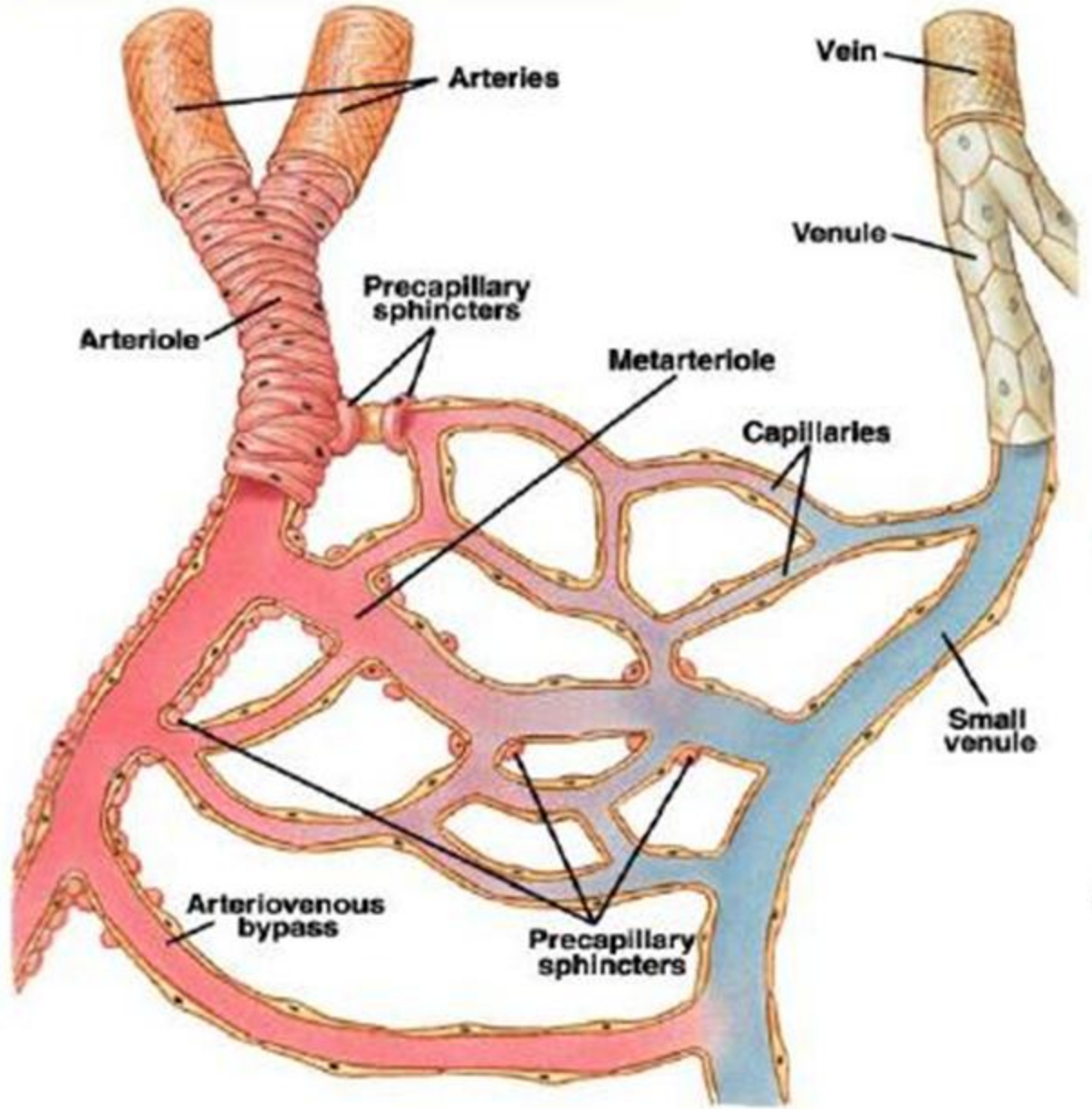

Deep vein
Perforating vein
Superficial vein
Valve


To Heart
Open Valve
Contracted muscles
To Heart
Closed valve
Relaxed muscle
Closed valve
Vein

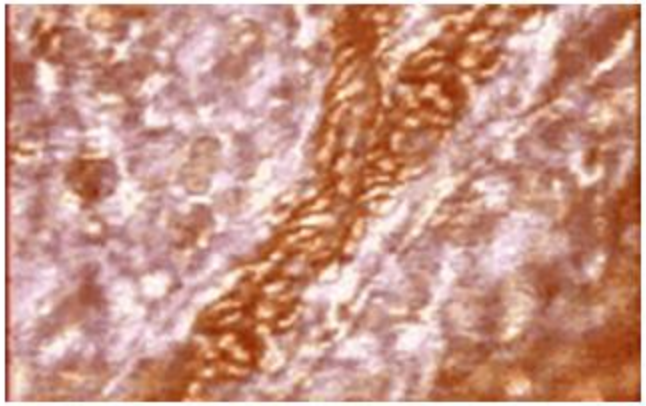

B. Reflusso venoso
Reflusso venoso = gittata cardiaca
Cuore destro
Circolazione polmonare
Cuore sinistro
Aspirazione mediante abbass. del piano delle valvole
Pressione negativa nel torace
Valvole venose
Inspirazione
Sovrappressione nella cavità addominale
Pompa muscolare
Circolazione asistemica
Pressione ematica circa 15 mmHg

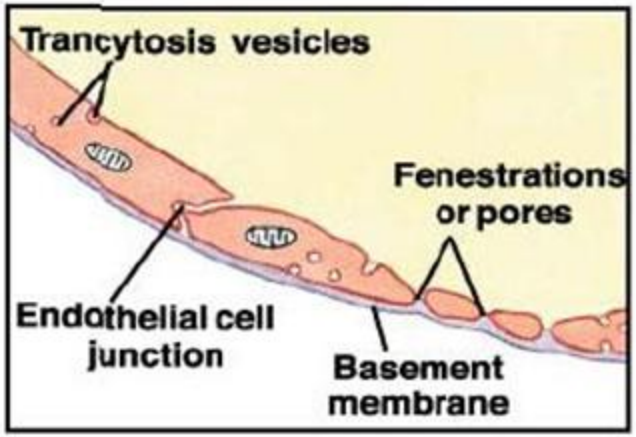
SISTEMA CIRCOLATORIO:

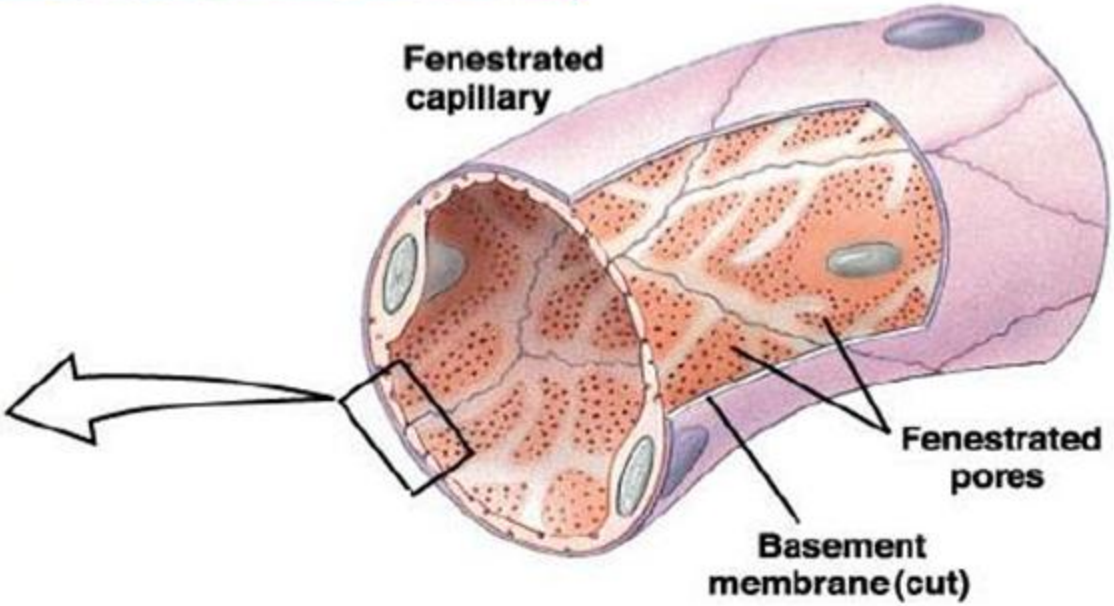
VASI
capillari e linfatici

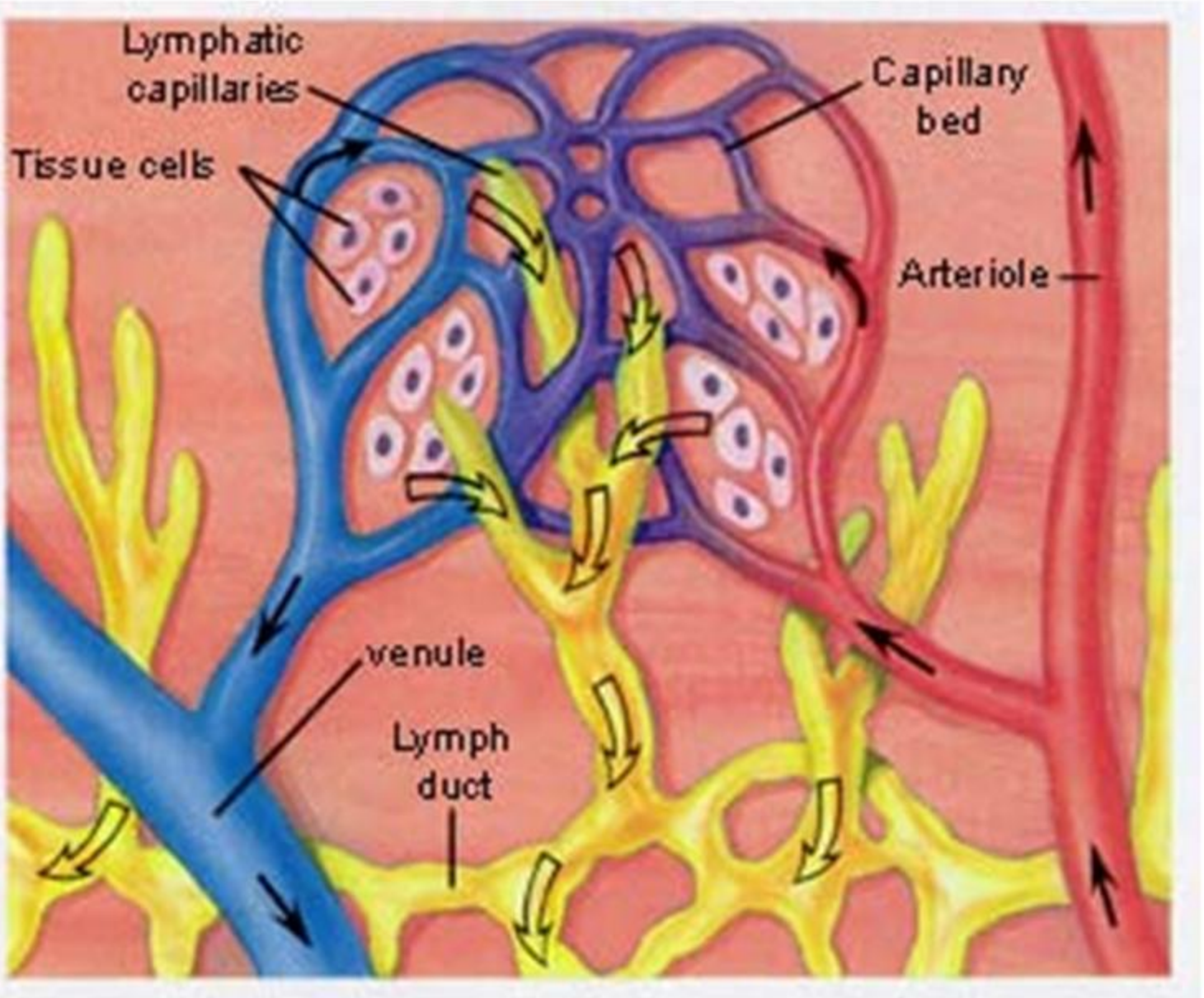

Arteries
Vein
Venule
Precapillary sphincters
Arteriole
Metarteriole
Capillaries
Small venule
Arteriovenous bypass
Precapillary sphincters

STRUTTURA DEI CAPILLARI

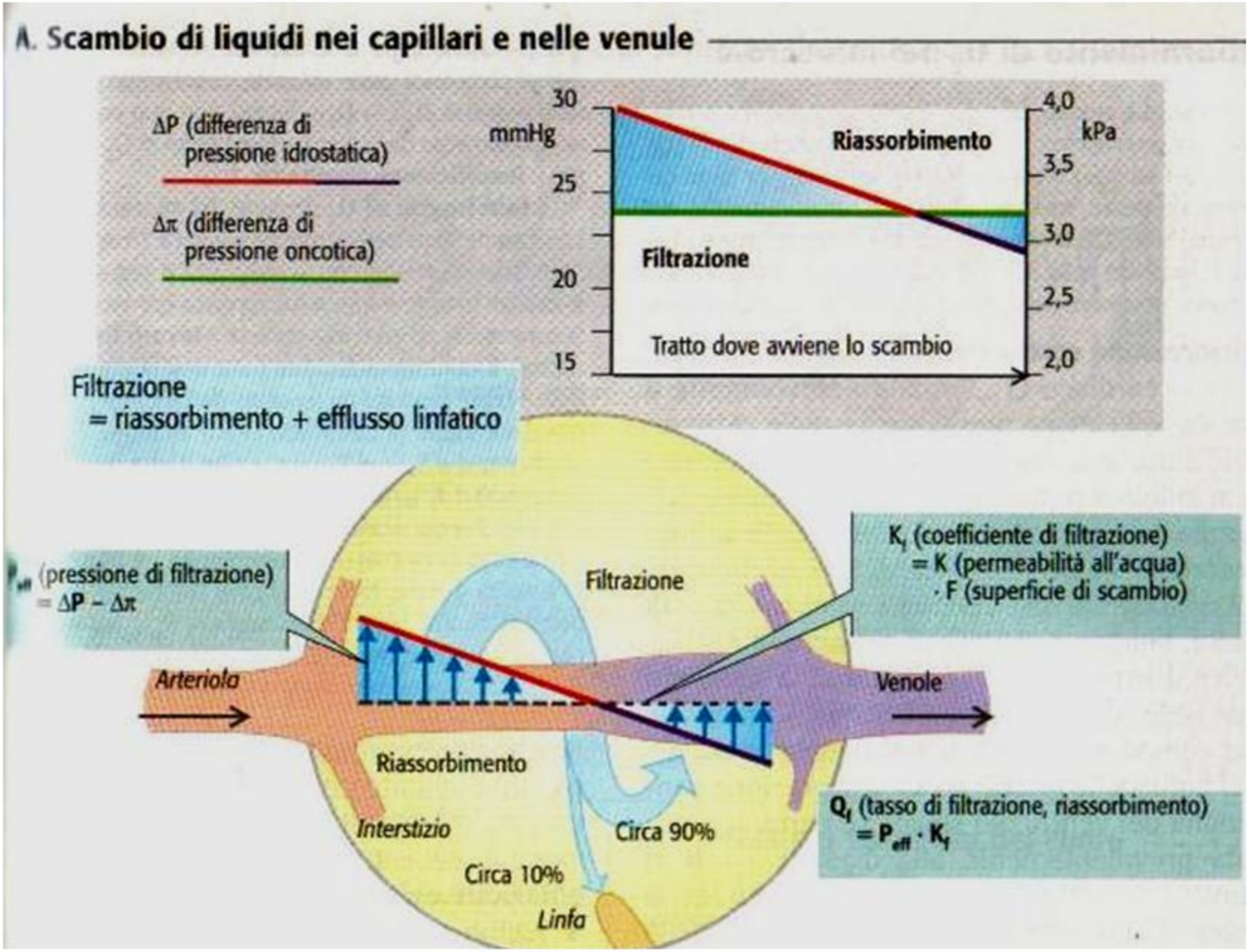




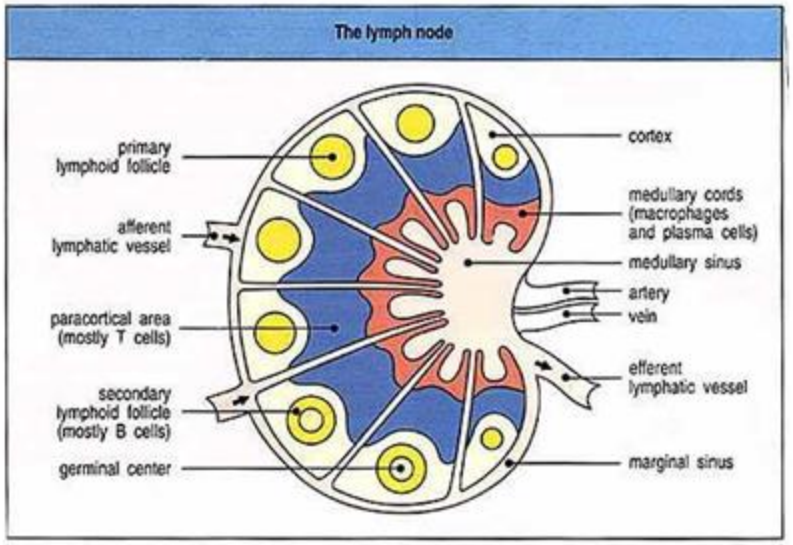


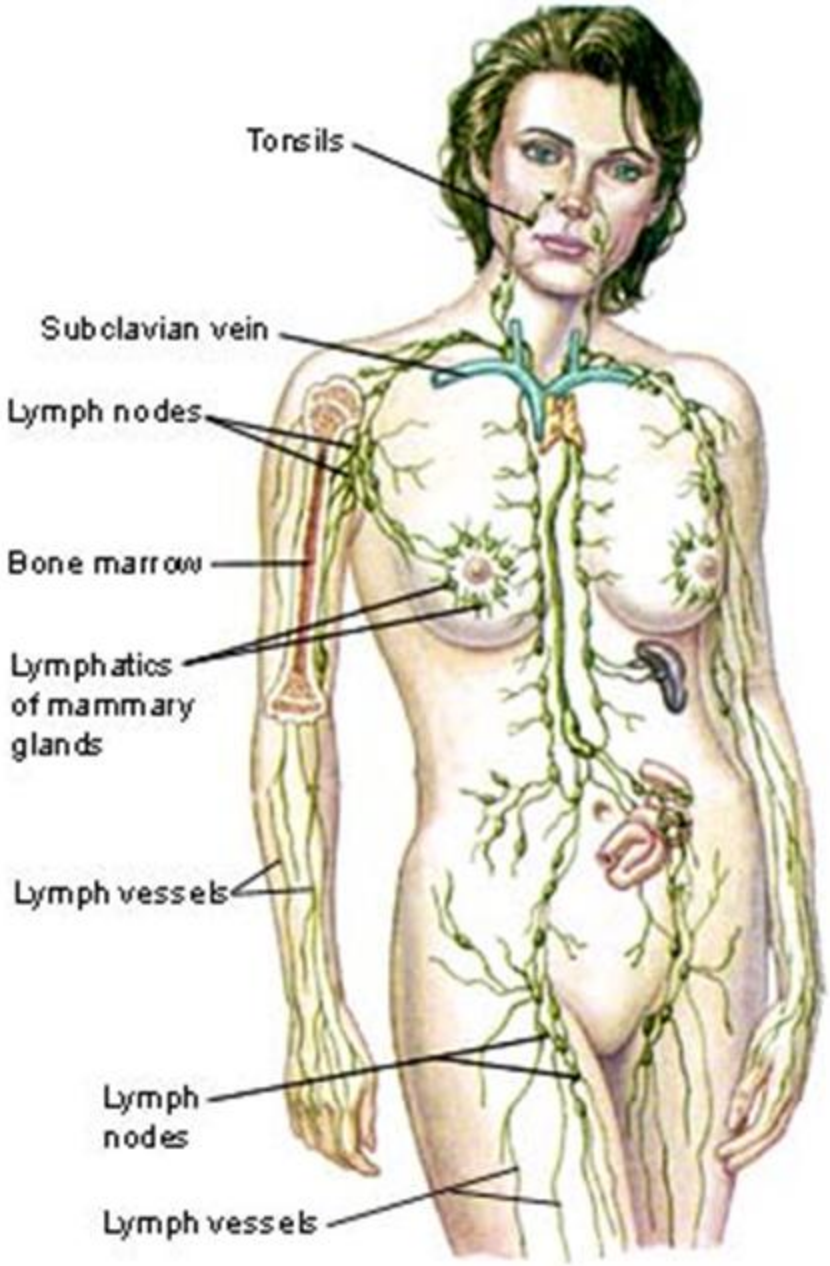

Lymphatic capillaries
Capillary bed
Tissue cells
Arteriole
venule
Lymph duct

A. Scambio di liquidi nei capillari e nelle venule

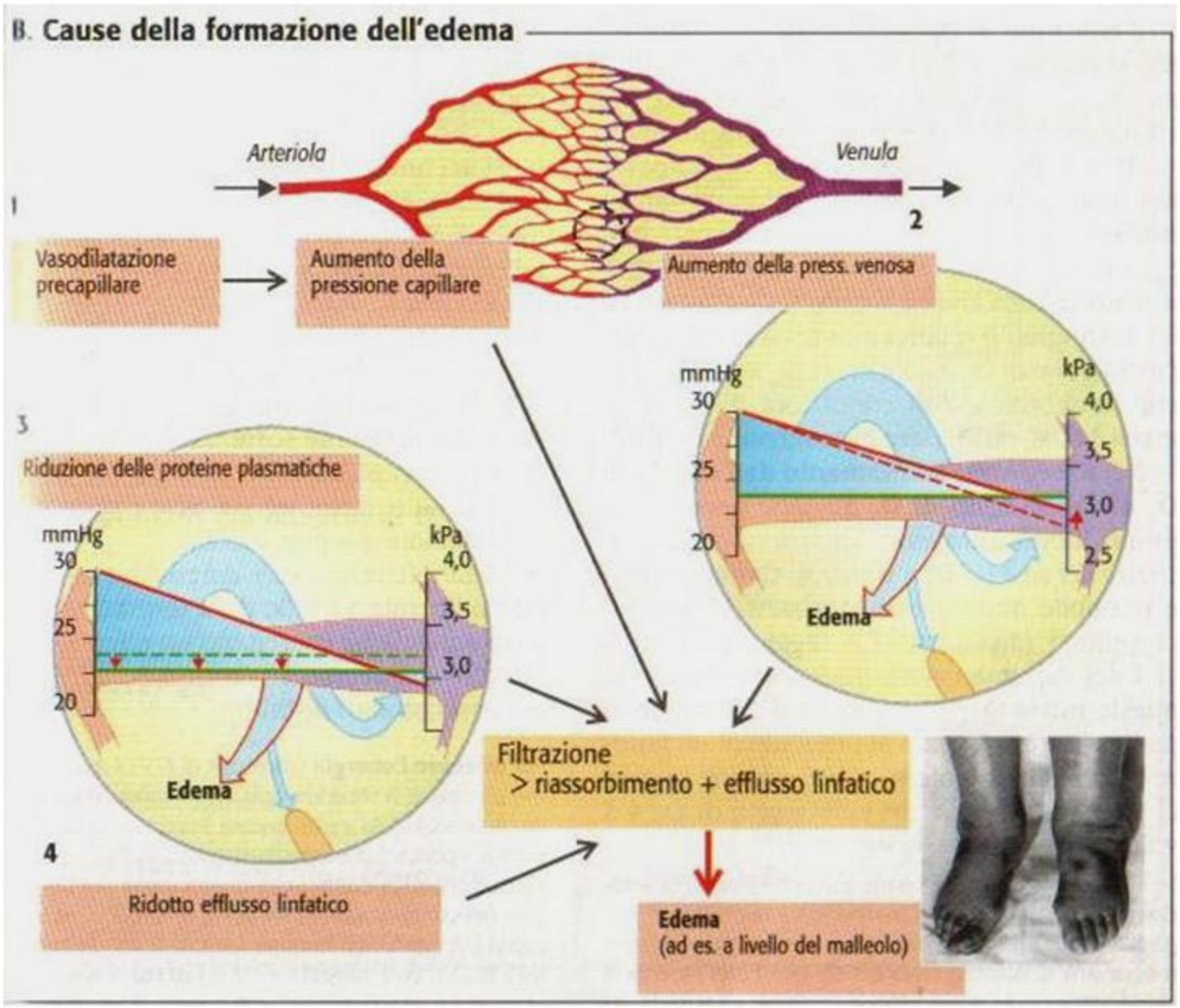


Sistema linfatico





B. Cause della formazione dell'edema



EDEMA
è un aumento del liquido interstiziale nei tessuti all'esterno dei vasi sanguigni e delle cellule.

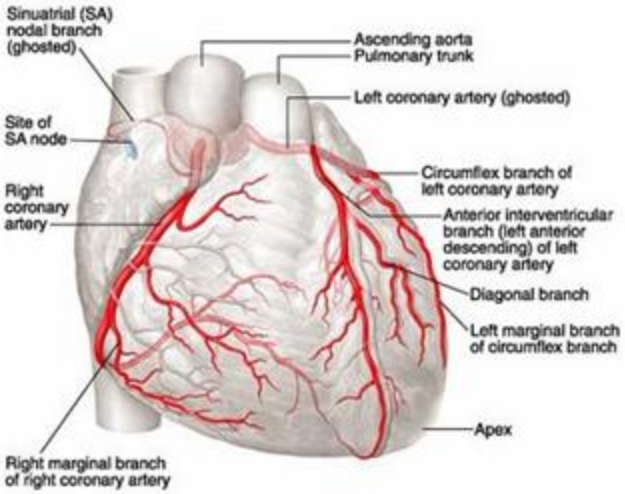
Cause:
-VASODILATAZIONE
-INSUFF CARDIACA
-IPOPROTEINEMIA
-STASI LINFATICA

Casi particolari:
-Idrotorace
-Ascite

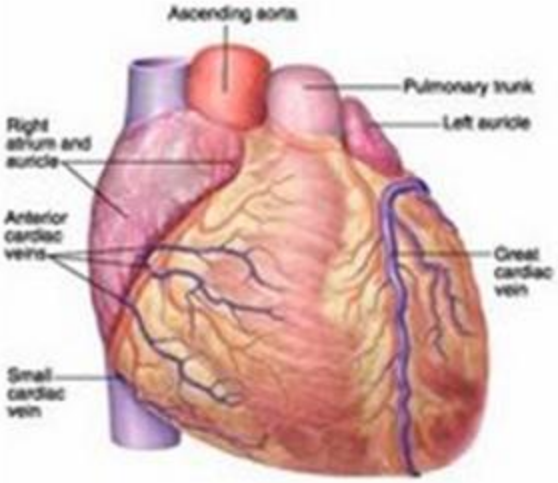
SISTEMA CIRCOLATORIO:

VASI
Coronarie

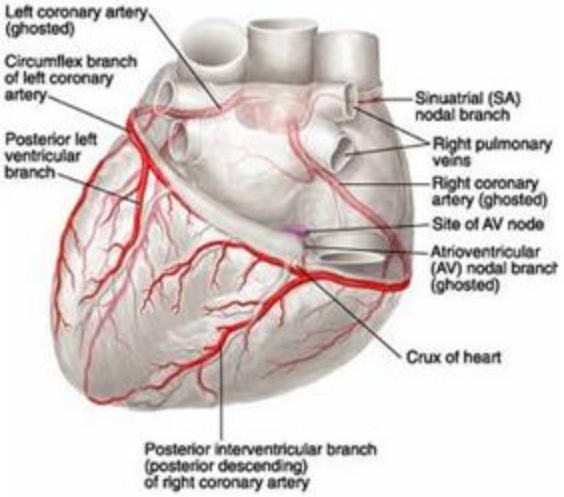
A. Normal arterial pattern, anterior view



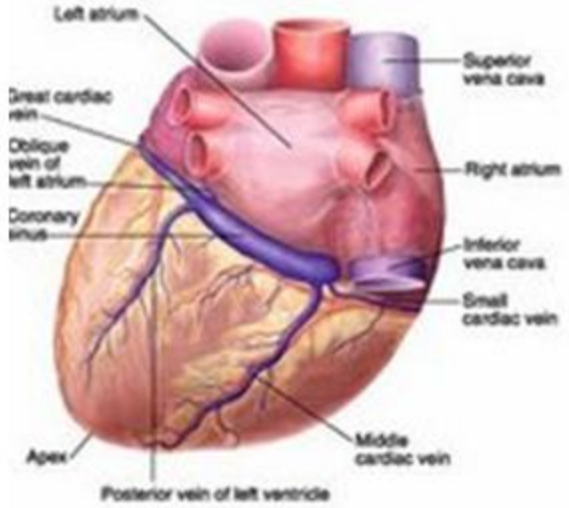
A. Anterior view

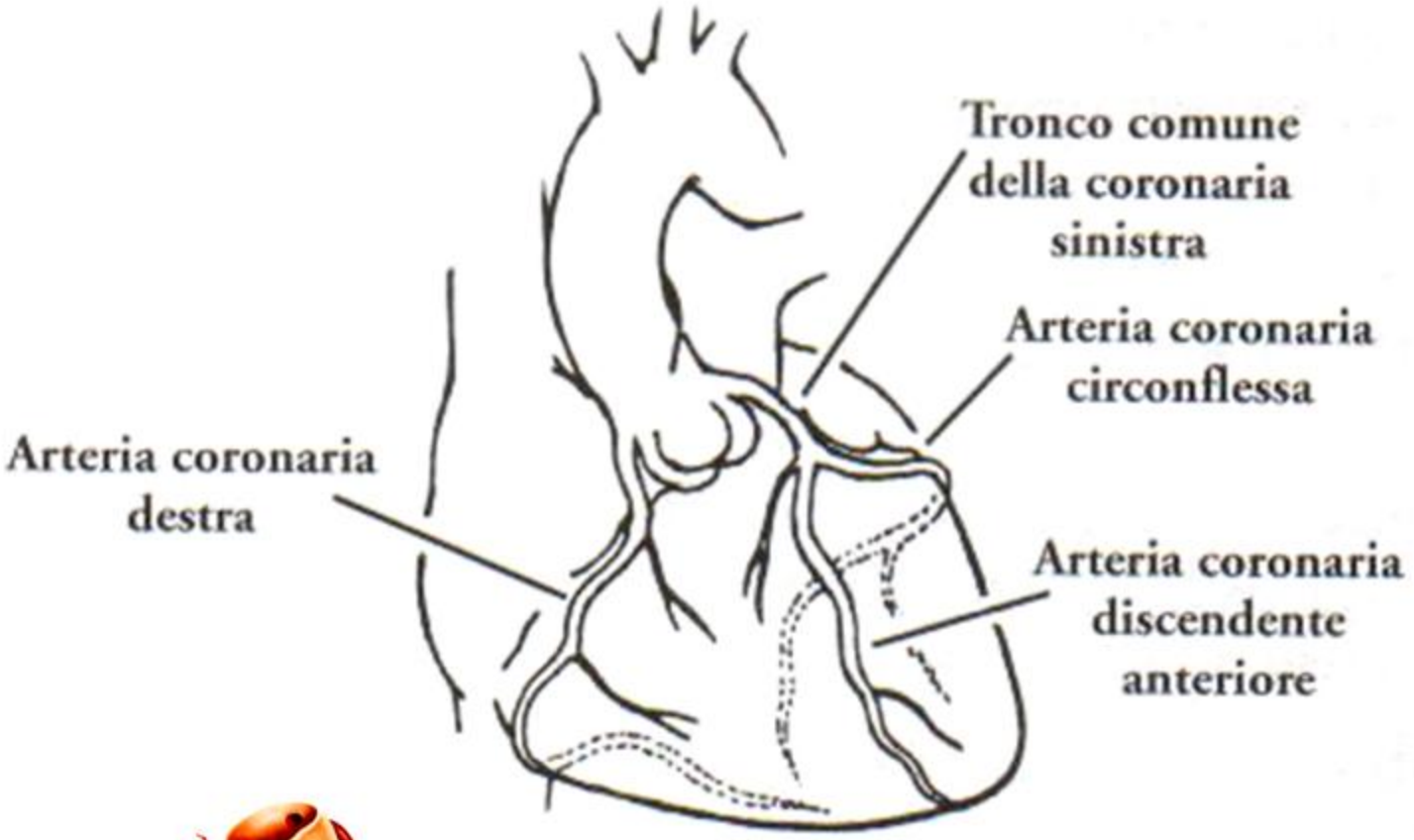


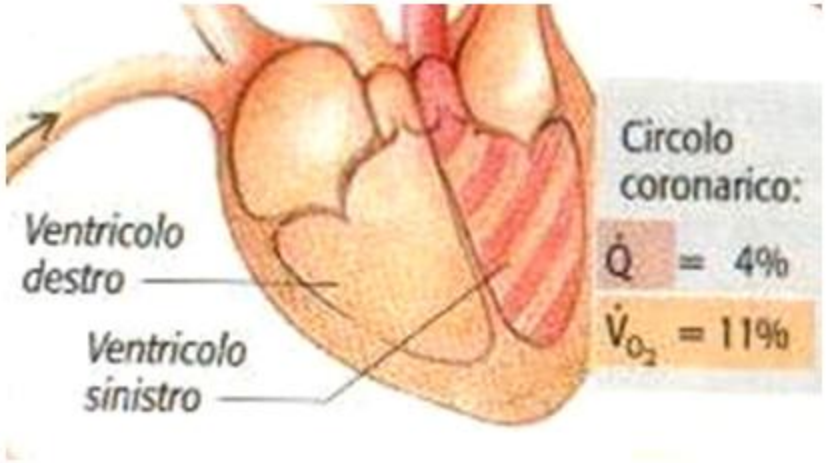
C. Normal arterial pattern, posteroinferior view

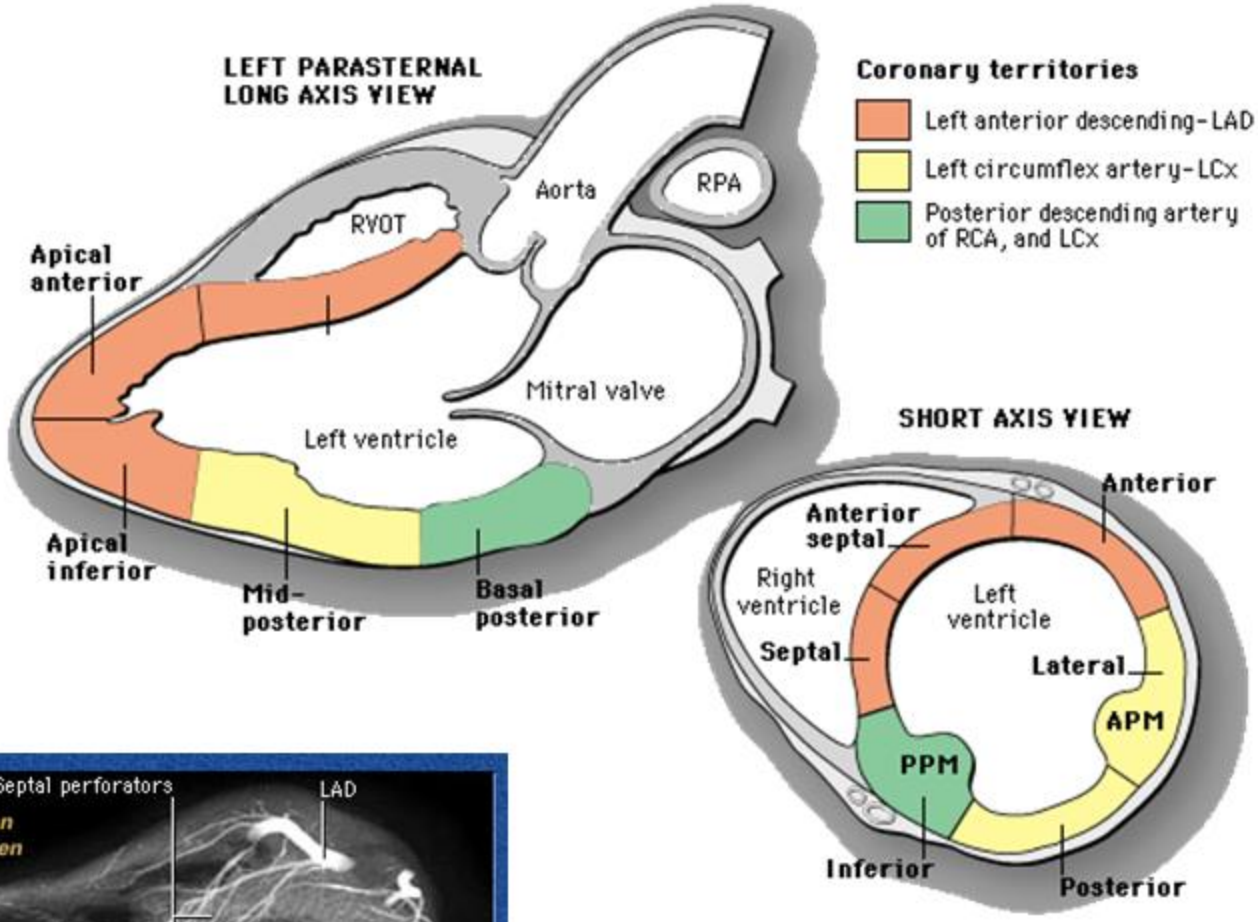


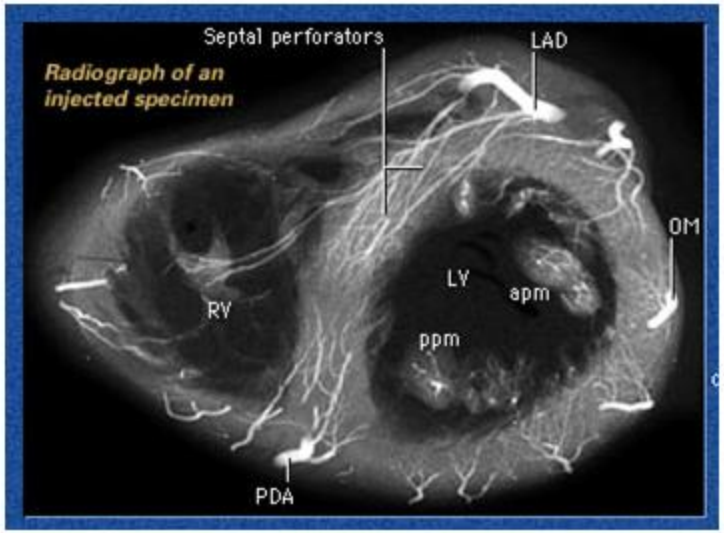
C. Posteroinferior view



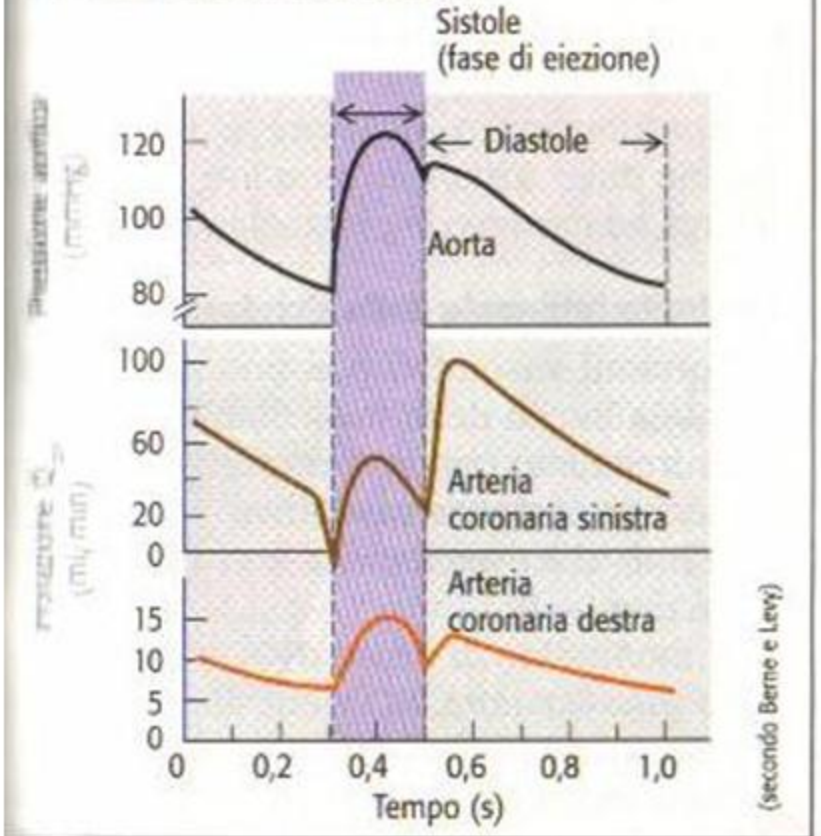

Tronco comune della coronaria sinistra
Arteria coronaria circonflessa
Arteria coronaria destra
Arteria coronaria discendente anteriore


Ventricolo destro
Ventricolo sinistro
Circolo coronarico:
$\dot{Q}$ = 4%
$\dot{V}_{O_2}$ = 11%

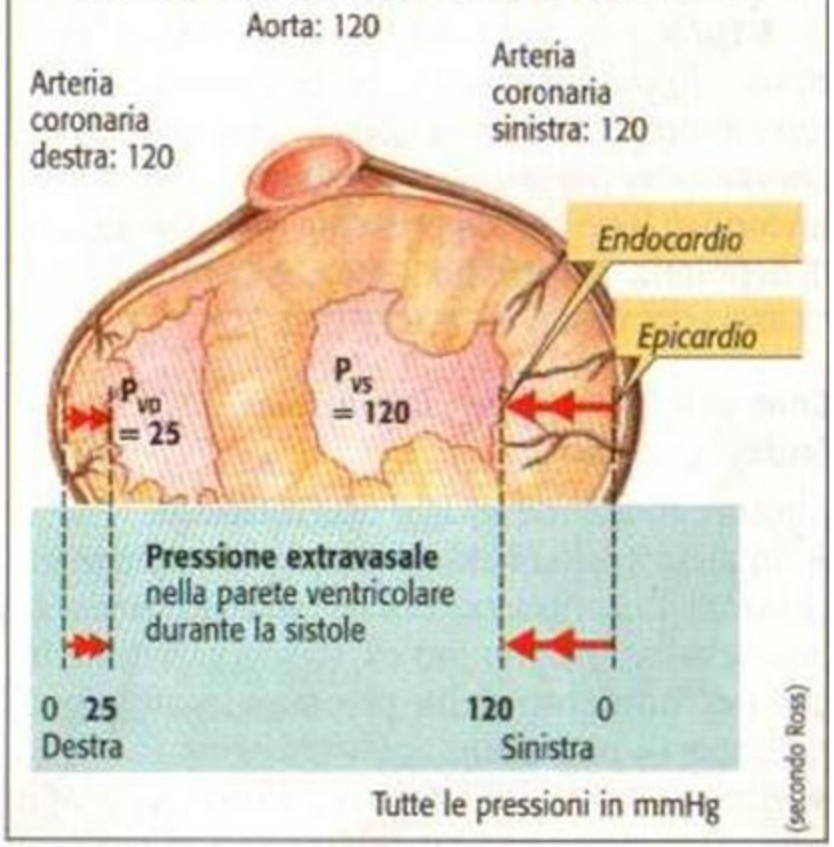

LEFT PARASTERNAL
LONG AXIS VIEW
Aorta
RPA
RVOT
Apical
anterior
Mitral valve
Left ventricle
Apical
inferior
Mid-
posterior
Basal
posterior
Coronary territories
Left anterior descending-LAD
Left circumflex artery-LCx
Posterior descending artery
of RCA, and LCx
SHORT AXIS VIEW
Anterior
Anterior
septal
Right
ventricle
Left
ventricle
Septal
Lateral
APM
PPM
Inferior
Posterior


Septal perforators
LAD
Radiograph of an
injected specimen
OM
LV
apm
RV
ppm
PDA

B. Irrorazione coronaria

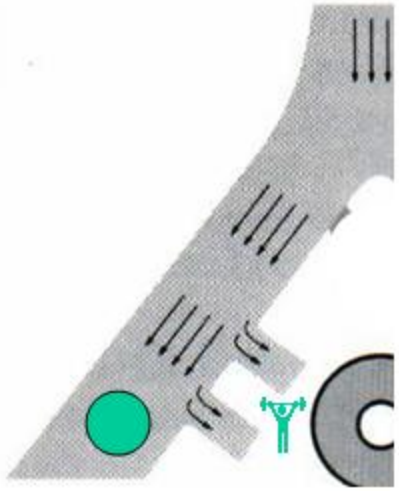


C. Pressioni sistoliche nel cuore

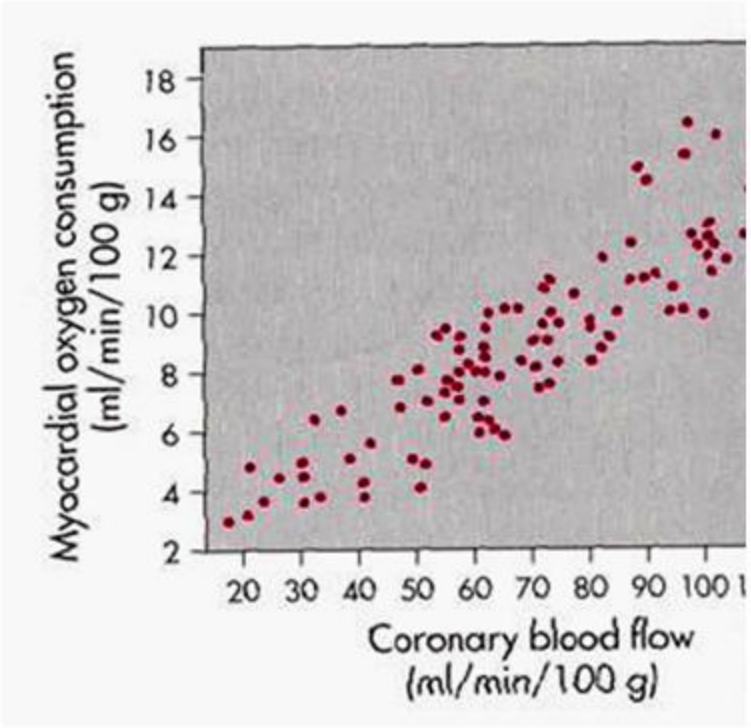


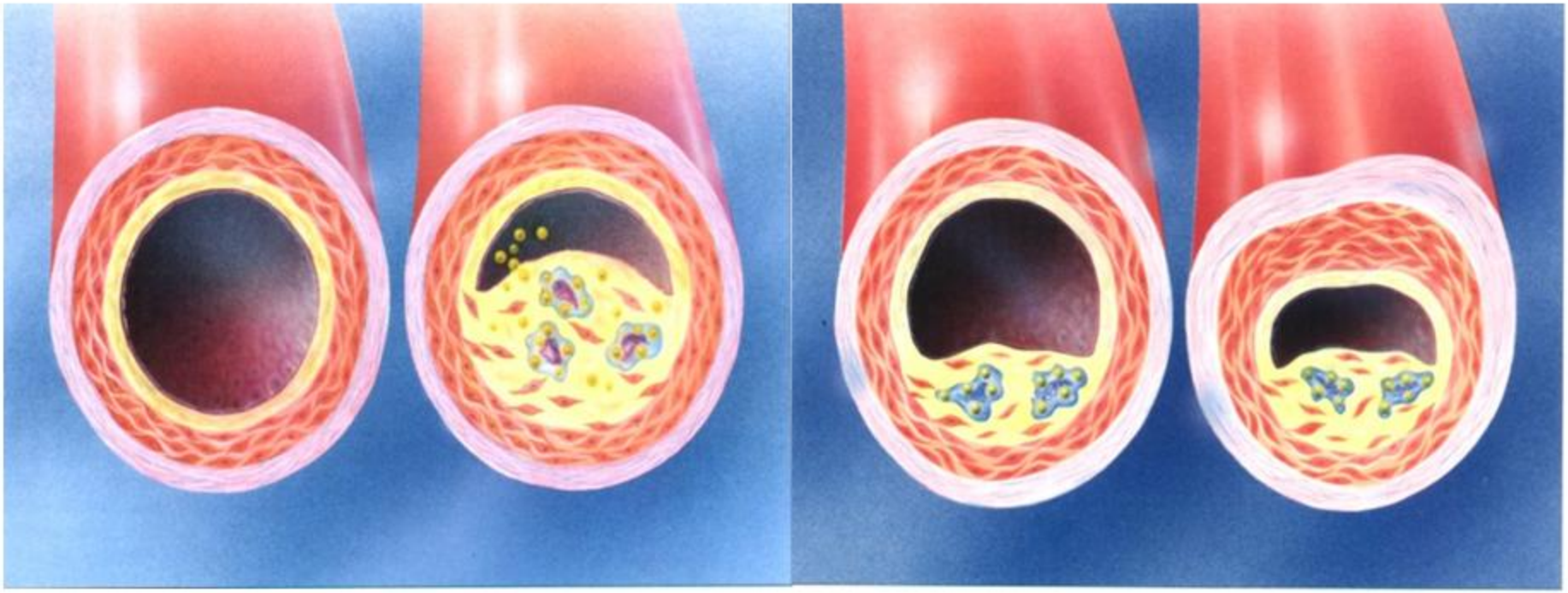
RISERVA CORONARICA

riposo



sforzo





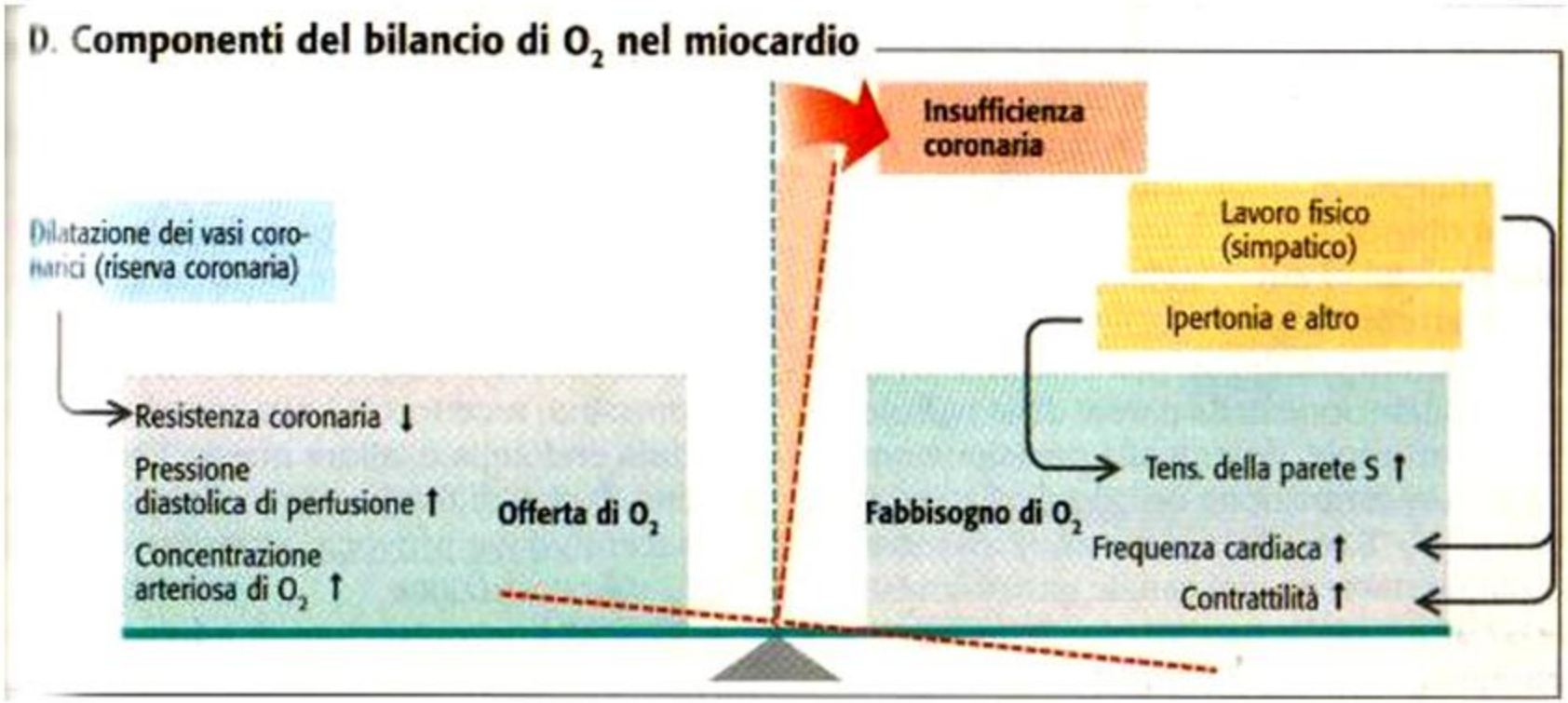
Coronaria normale

Placca ateromasica subocclusiva (>75%)

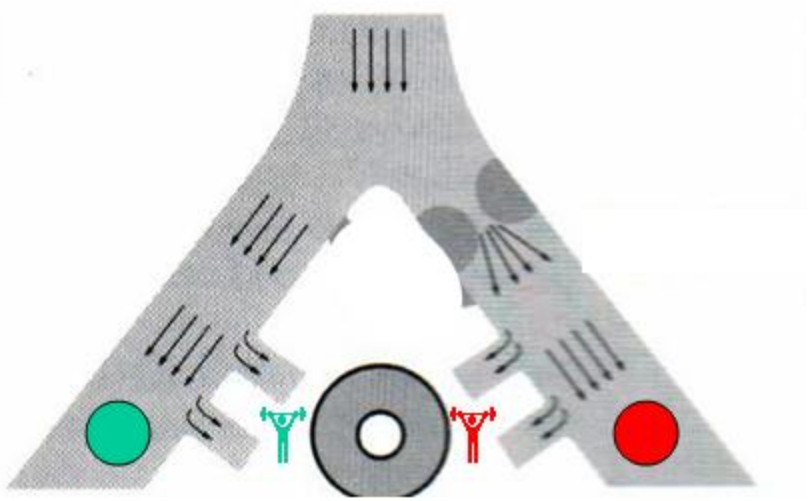
Placca stenosante (< 50%)

Placca ateromasica associata a vasospasmo

CAD = CORONARY ARTERY DISEASE



riposo

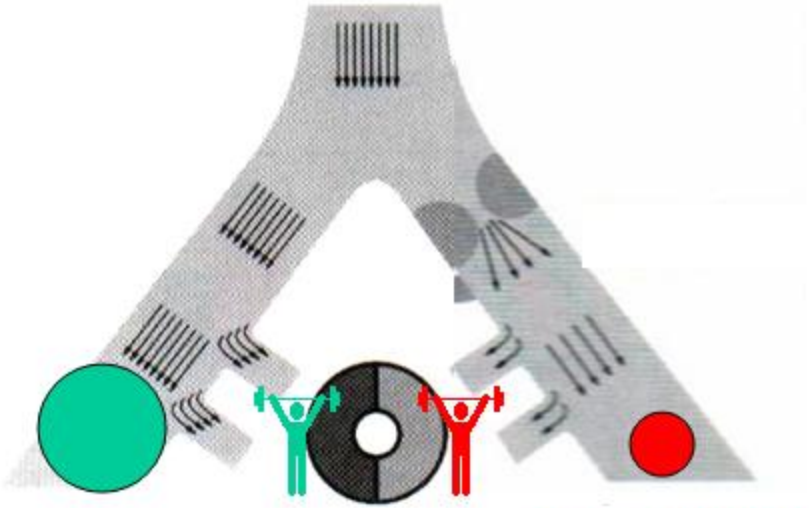


PERFUSIONE OMOGENEA

NORMALE

CAD → RRC

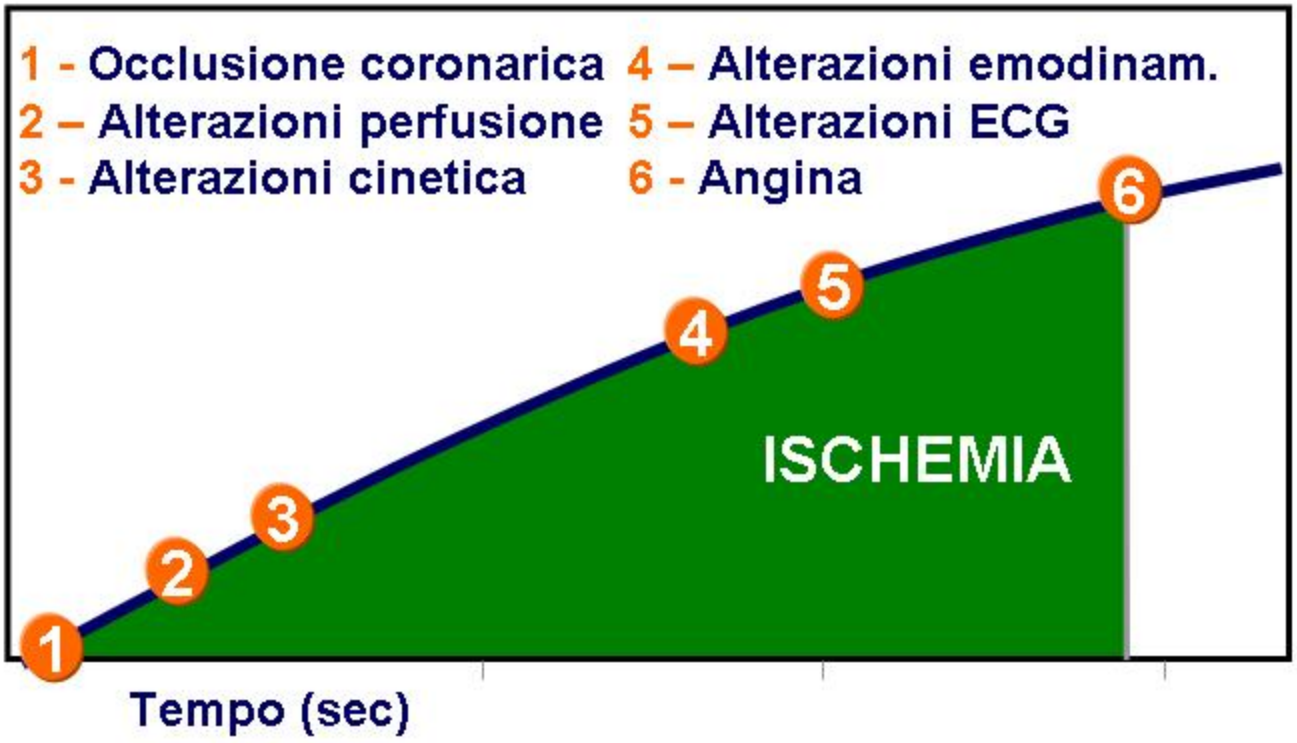
sforzo



PERFUSIONE NON OMOGENEA

ISCHEMIA

Cascata Ischemica



Quadri clinici della cardiopatia ischemica

- Sindromi coronariche stabili:
  - *angina da sforzo*
  - *angina a riposo*
  - *angina mista*
- Sindromi coronariche acute (instabili):
  - *angina instabile*
  - *infarto intramurale (non Q)*
  - *infarto transmurale (Q)*
  - *angina variante (vasospastica) di Prinzmetal*

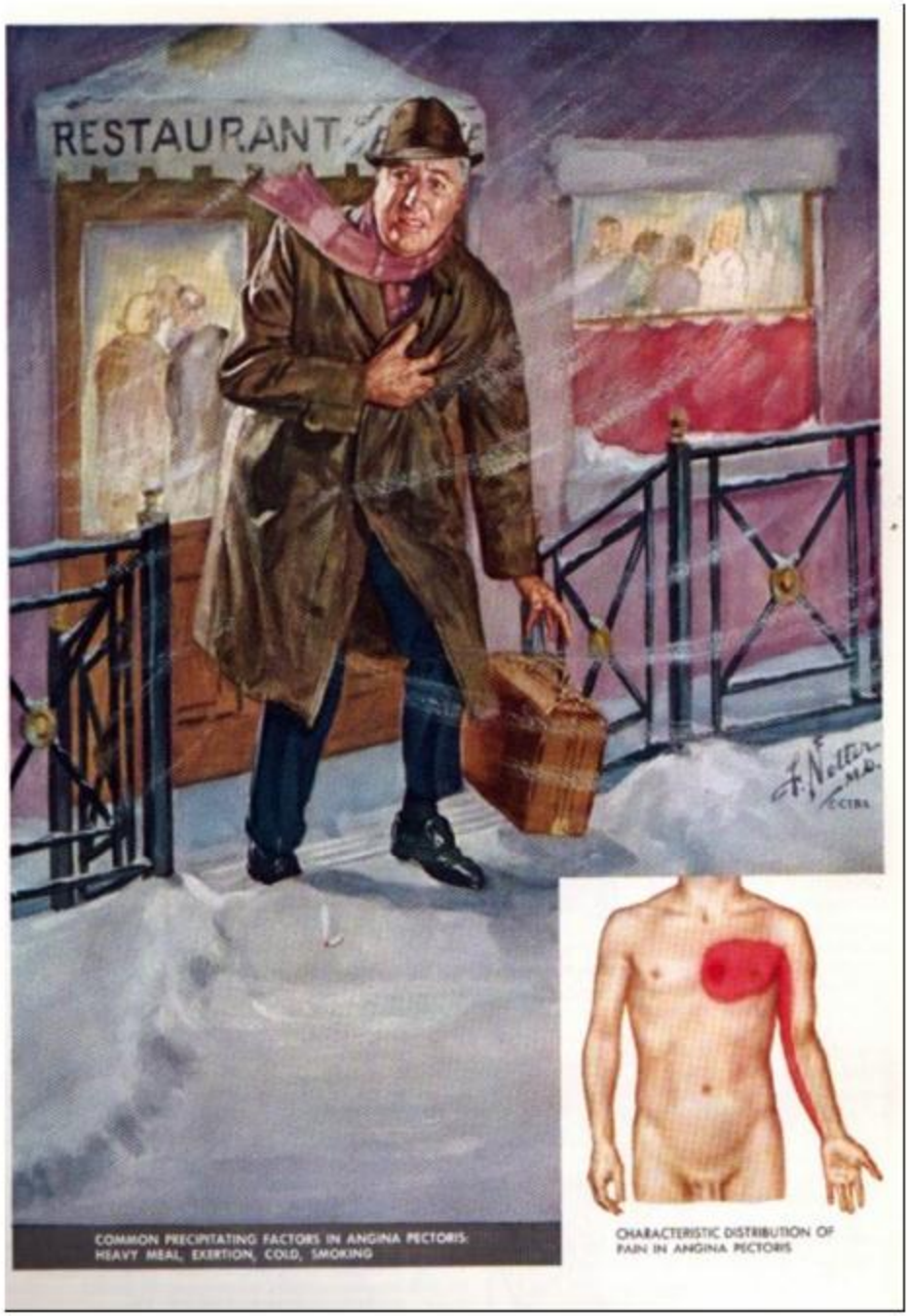
Angina pectoris

Fattori precipitanti:

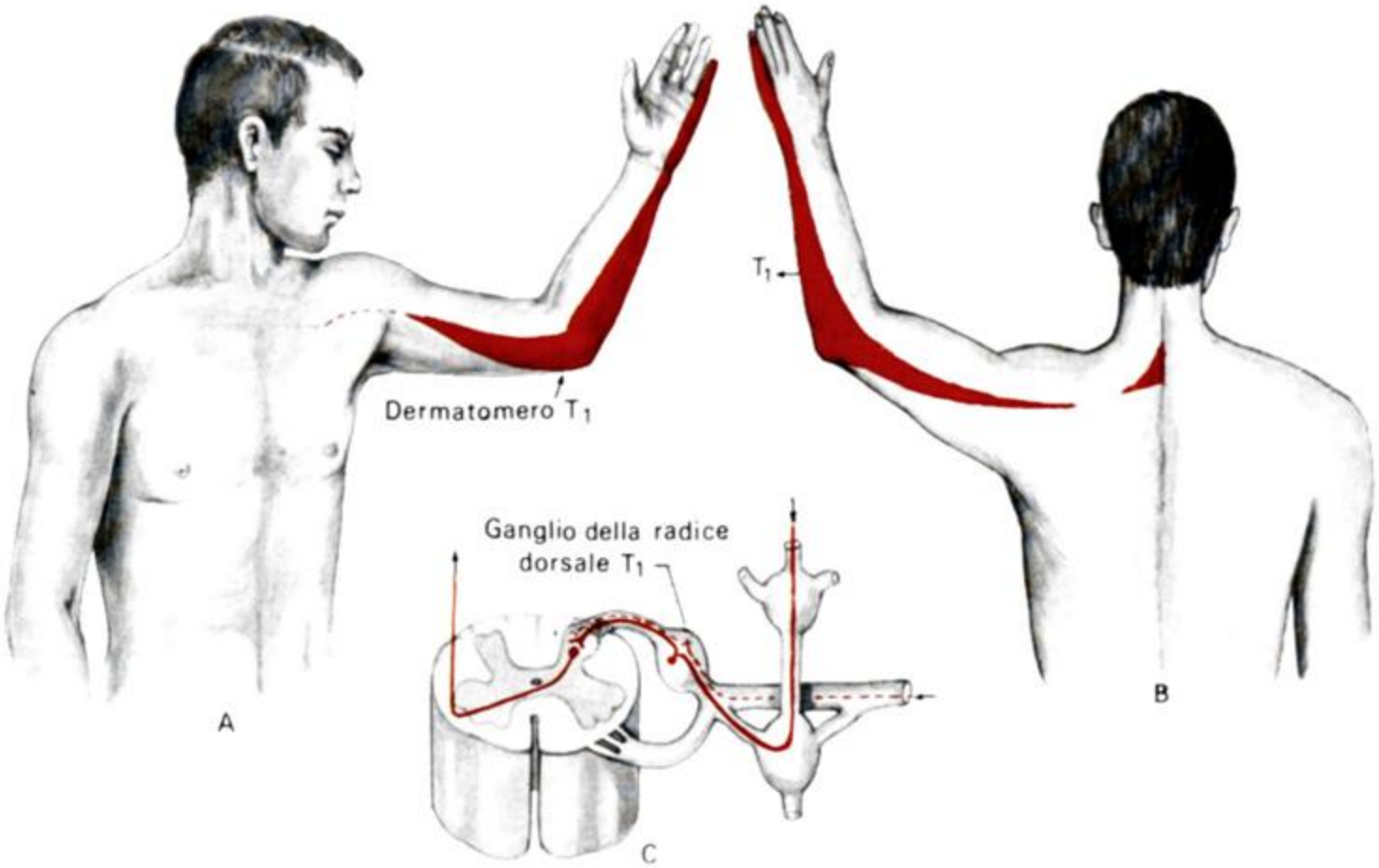
- ✓ sforzo, lavoro con braccia sopra le spalle.
- ✓ freddo, contro-vento
- ✓ camminare dopo un pasto abbondante
- ✓ Crisi ipertensiva,
- ✓ Paura, rabbia, ansia, …
- ✓ Rapporti sessuali

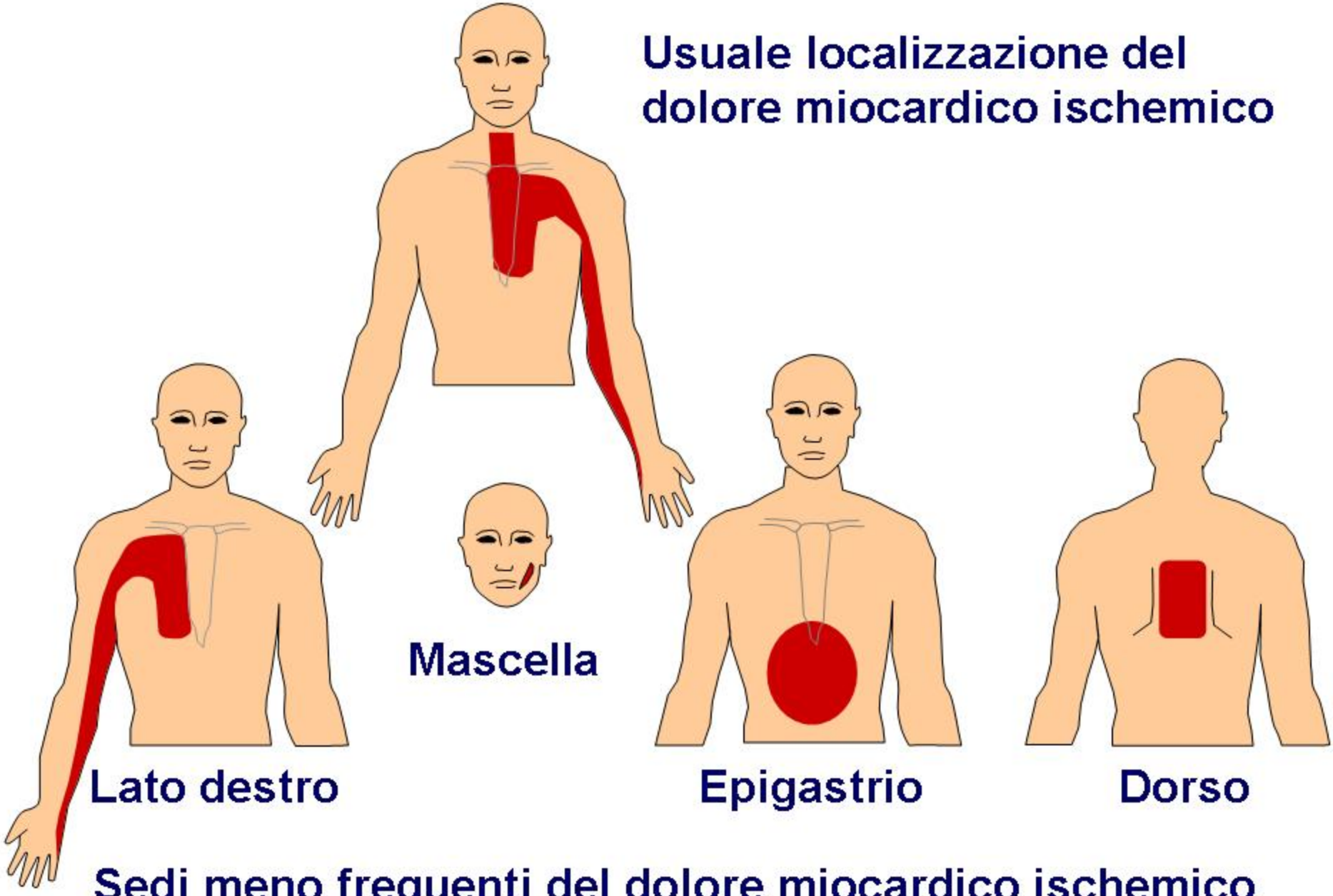
Sintomi:

- ✓ Respiro corto, vertigini, palpitazioni, debolezza.
- ✓ Dolore toracico gravativo, irradiato arto sup lato ulnare

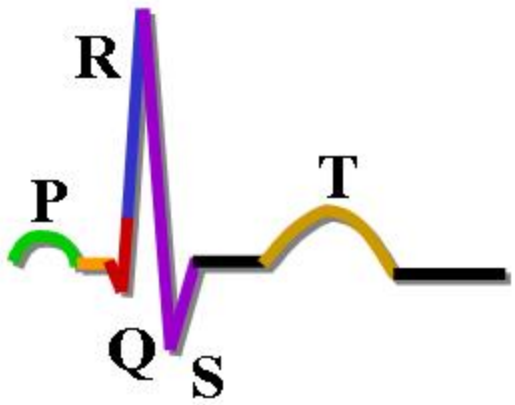


Patogenesi del dolore *radicolare riferito al dermatomero T1* nell'angina pectoris



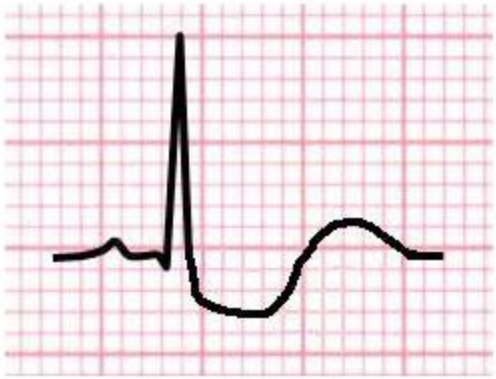

Usuale localizzazione del dolore miocardico ischemico
Mascella
Lato destro
Epigastrio
Dorso
Sedi meno frequenti del dolore miocardico ischemico

ECG NORMALE



ISCHEMIA

subendocardica



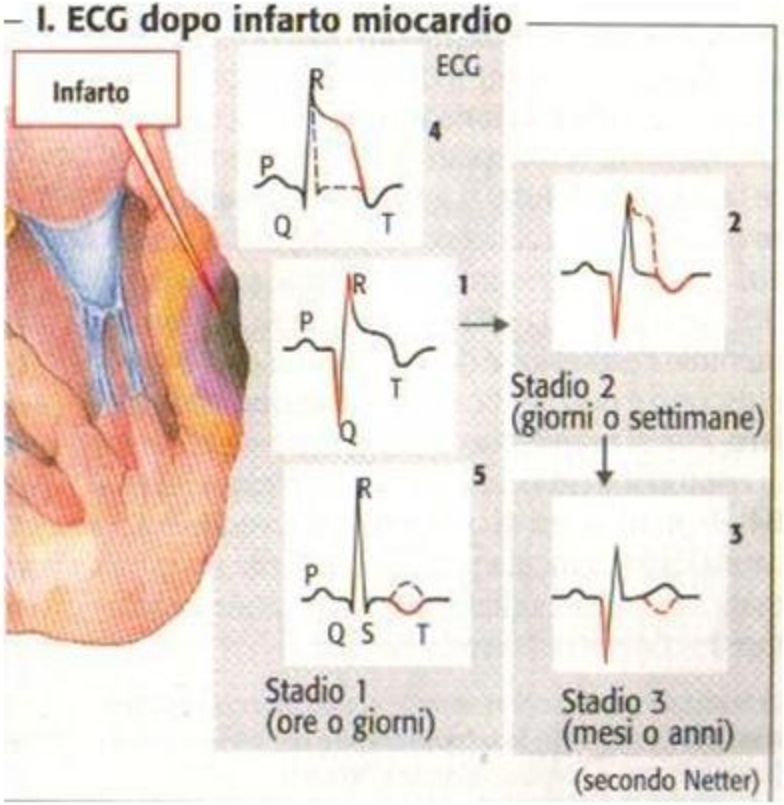
SOTTOSLIVELLAMENTO ST

T INVERTITE

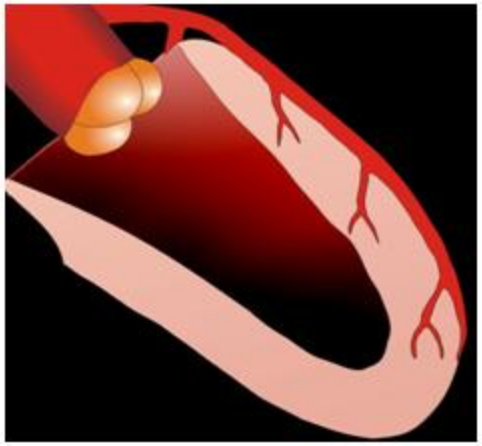
Infarto

Il dolore è il sintomo con cui l'infarto si manifesta più frequentemente al suo esordio; è presente nell'85% dei casi e ha le caratteristiche tipiche del dolore anginoso, ma più intenso e prolungato, spesso accompagnato da irrequietezza, sudorazione, astenia, nausea, più raramente vomito e dispnea.

La durata del dolore di solito è oltre 20-30 min.



INFARTO TRANSMURALE



INFARTO PARZIALE

INFARTO TRANSMURALE

ISCHEMIA

T INVERTITE

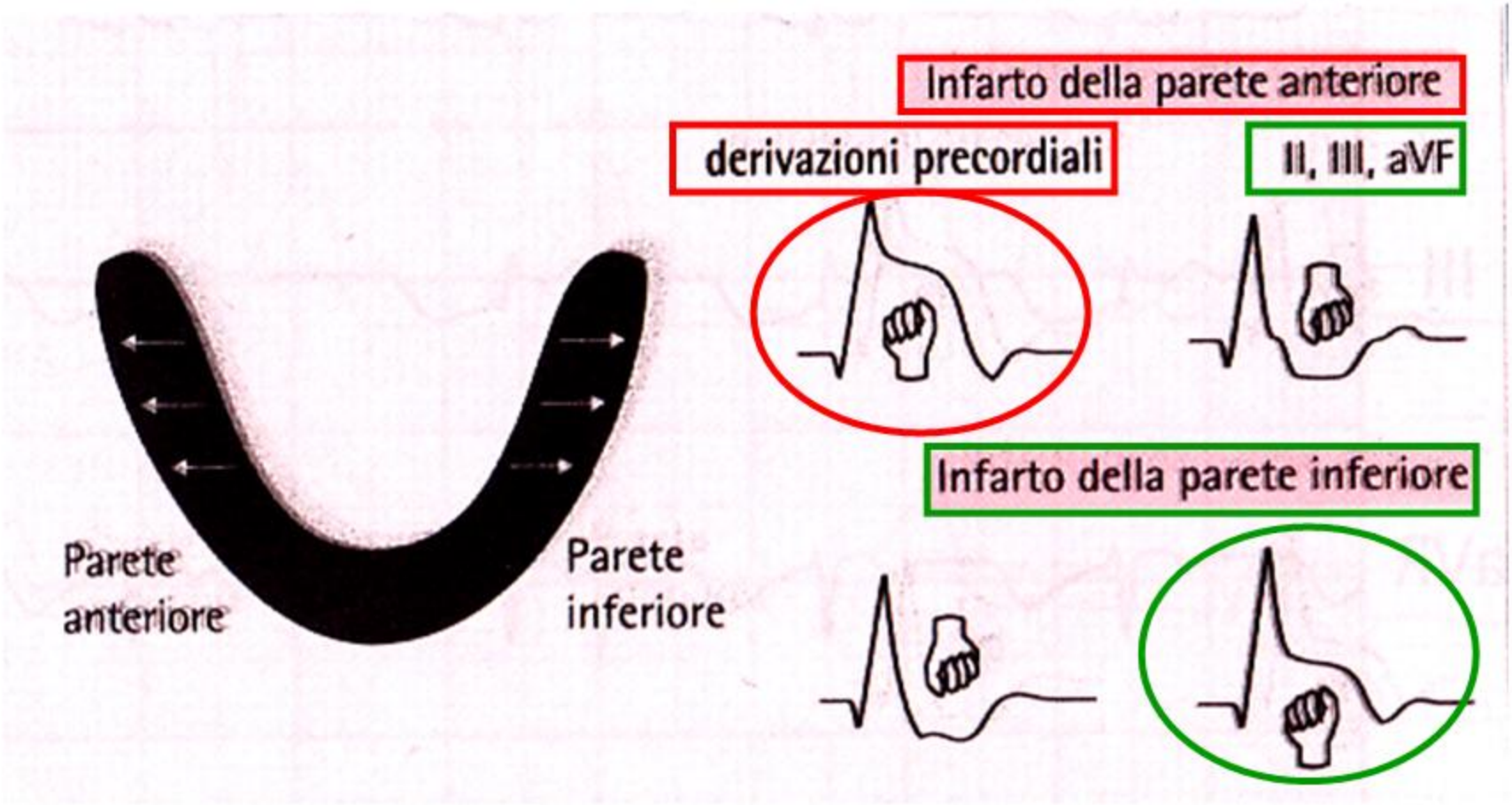
LESIONE

SOPRA-
SLIVELLAMENTO
ST

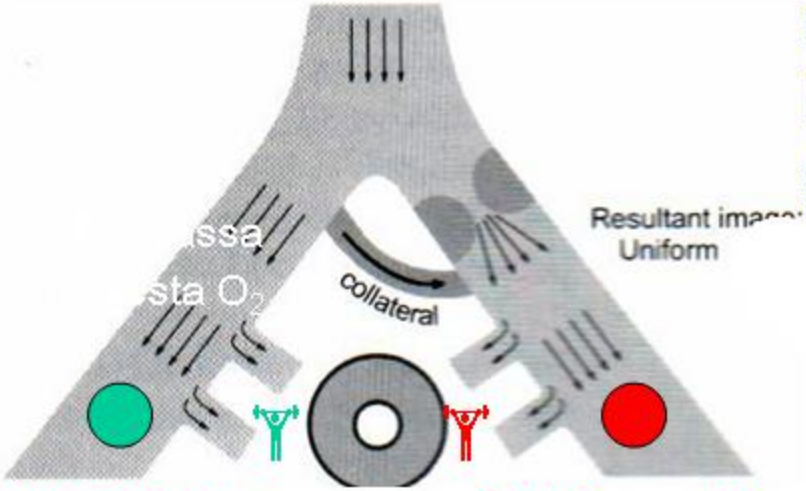
NECROSI
(+ lesione)

ONDA Q

INFARTO TRANSMURALE



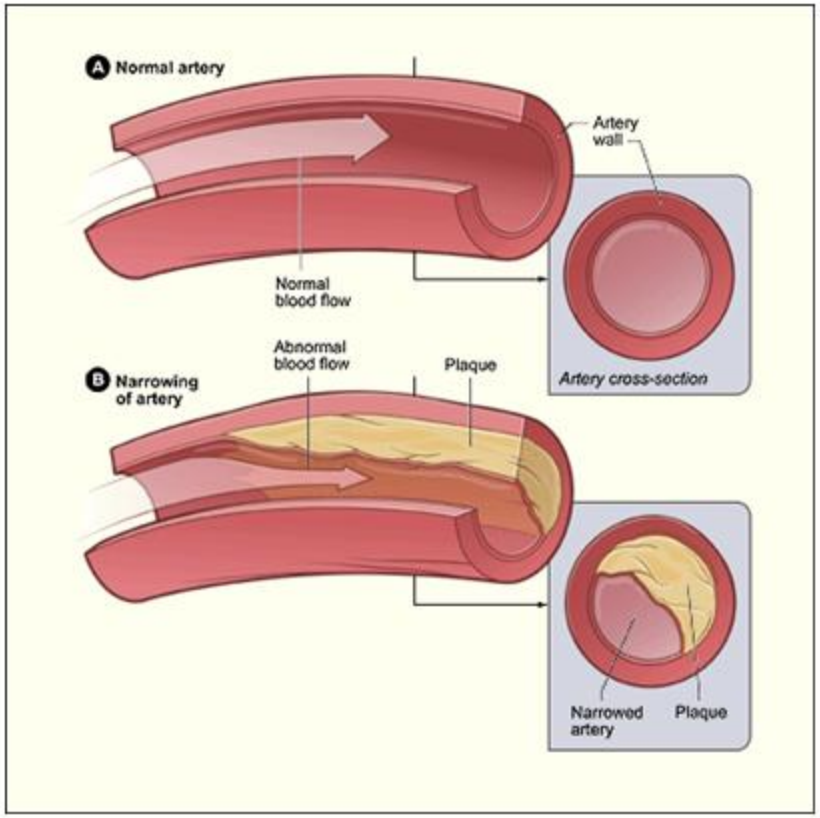
COME DIAGNOSTICARE LA MALATTIA CORONARICA (CAD)?



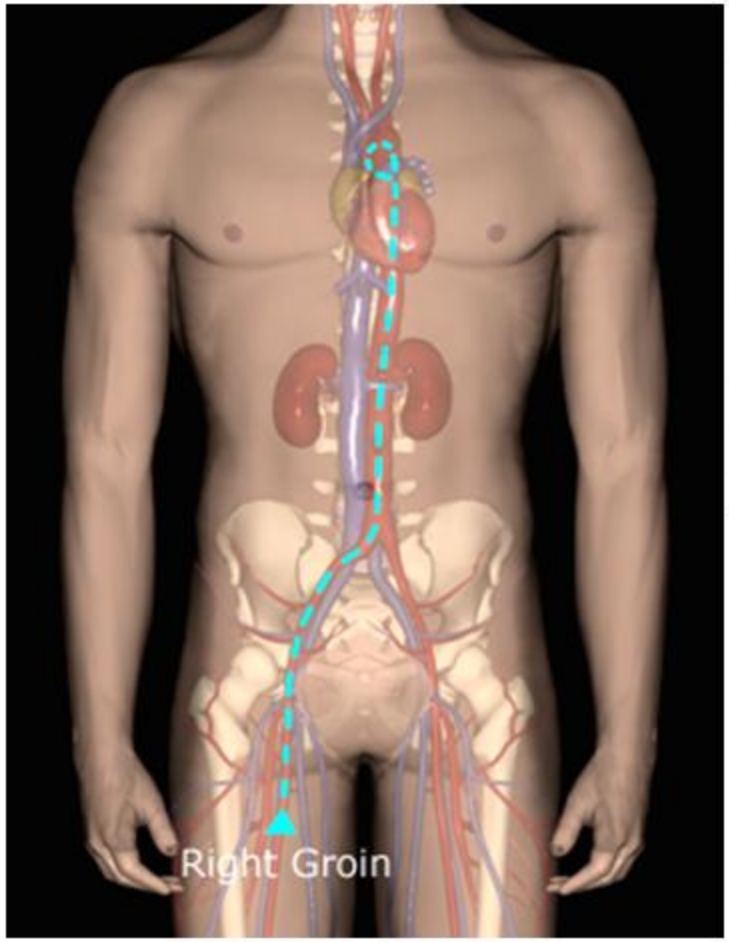
NORMALE **CAD → ?**

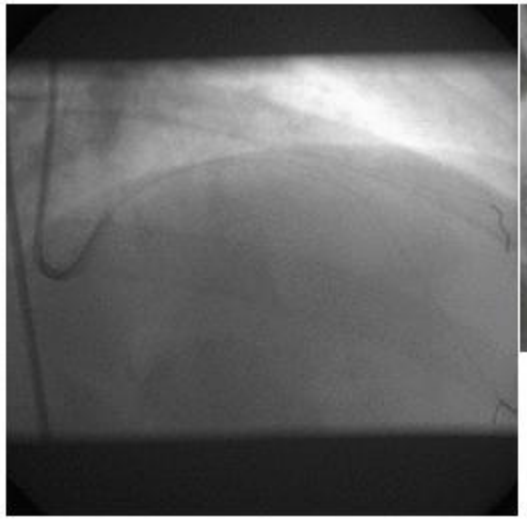
riposo

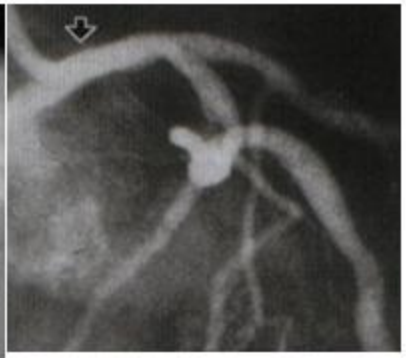
1. visualizzazione della stenosi → CORO, TAC
2. evidenziazione degli effetti funzionali della stenosi → TEST PROVOCATIVI



1. visualizzazione della stenosi → CORO, TAC



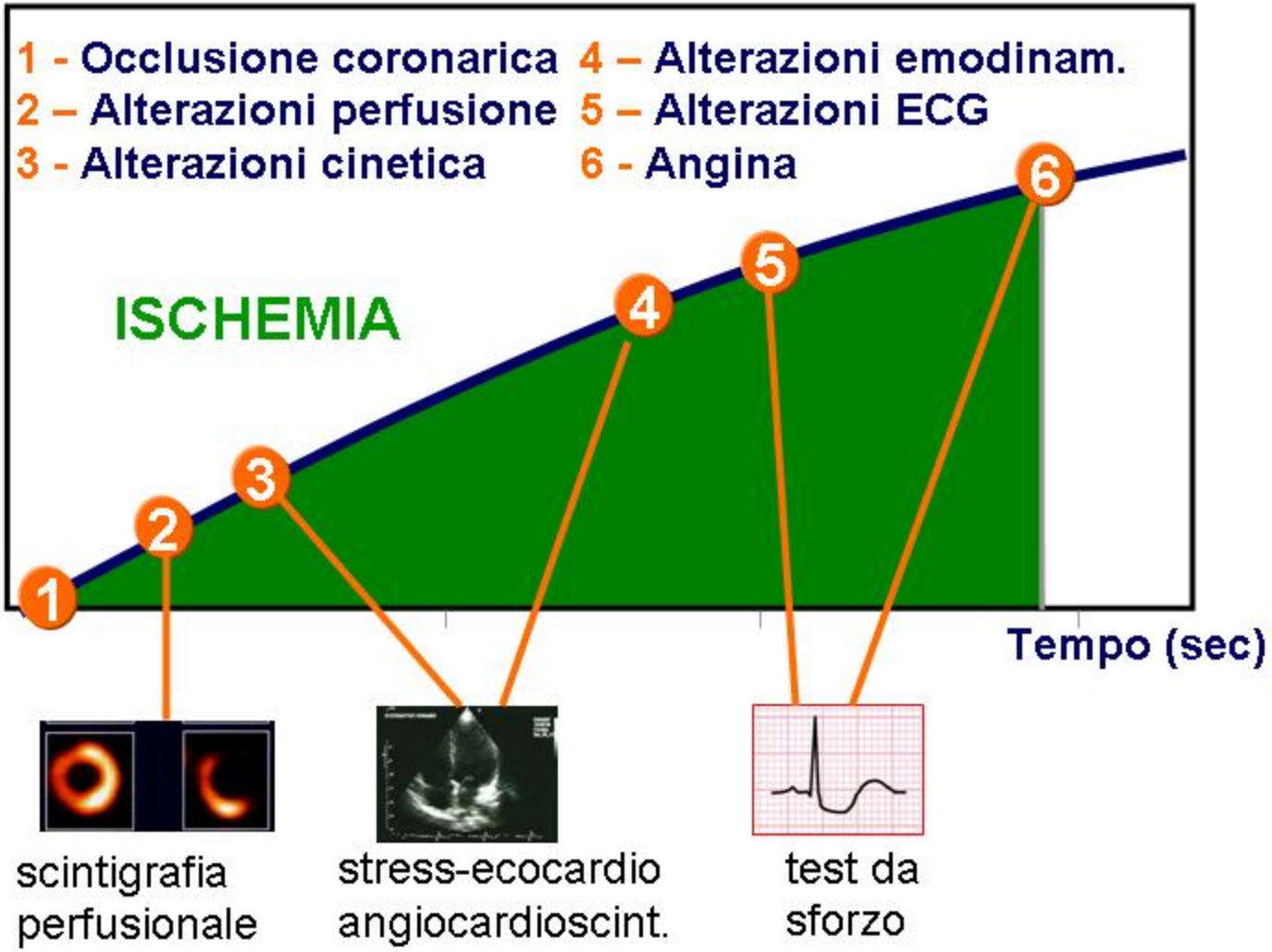




coronarografia

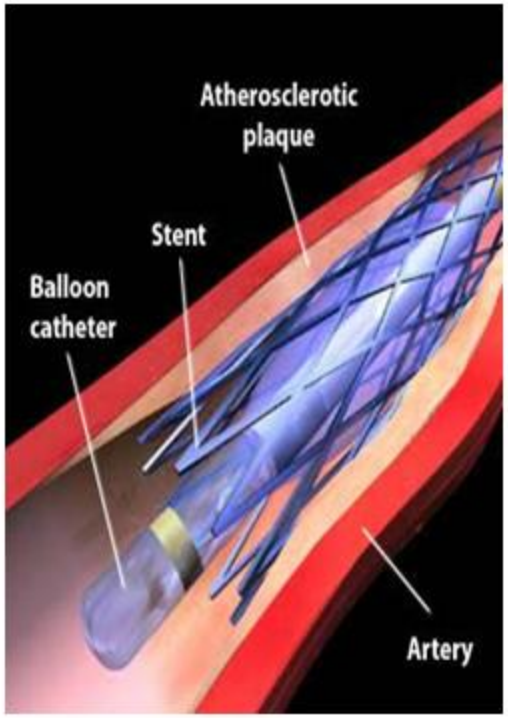
coronaro-TAC

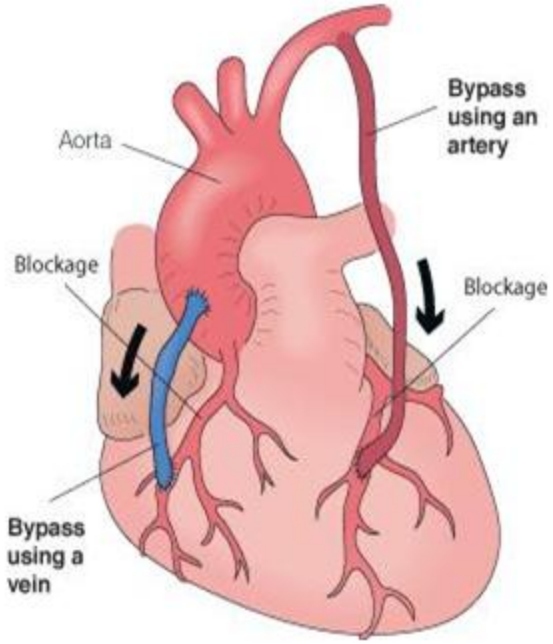
2. effetti funzionali della stenosi → TEST PROVOCATIVI (stress-test)

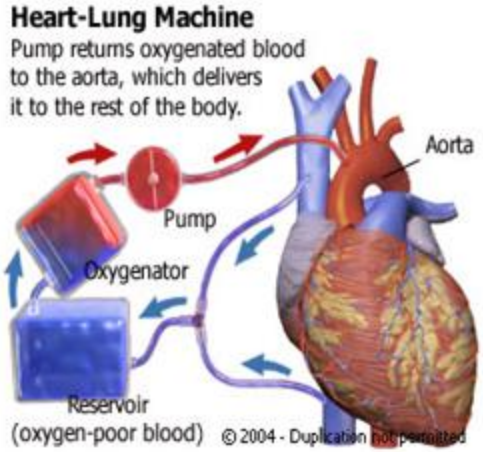


RIVASCOLARIZZAZIONE:

- Angioplastica percutanea (PTCA)
- By-pass aorto-coronarico (CABG)



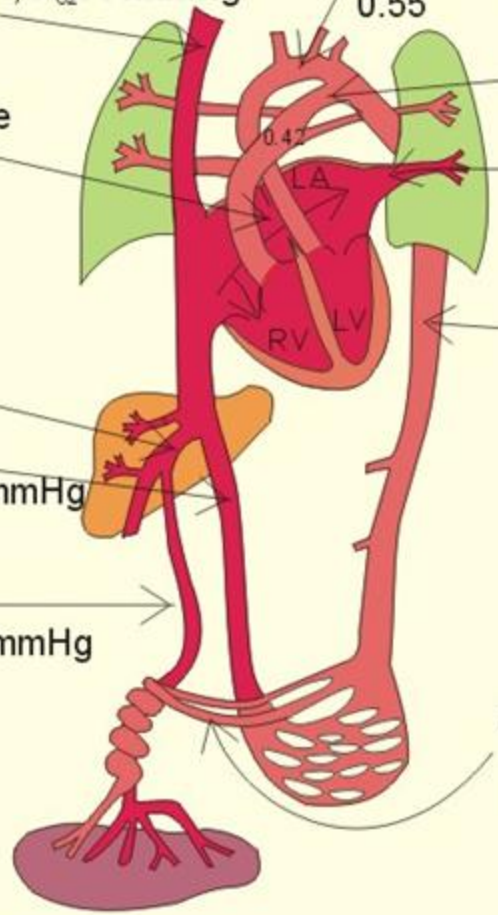




SISTEMA CIRCOLATORIO:

CIRCOLAZIONE FETALE

FOETAL CIRCULATION



Superior vena cava
Sat. = 25% ; P_{O2}: 13mmHg
0.15

Sat. = 65% ; P_{O2} : = 25 mmHg
0.55

Ductus arteriosus 0.30
Sat. = 52%

Foramen ovale
Sat. = 67%
0.45

Sat. 40%
Lungs 0.12

Descending aorta
Sat. = 55% ; P_{O2} : = 22 mmHg
0.73

Ductus venosus

Inferior vena cava
Sat. = 25% ; P_{O2} = 13 mmHg
0.18

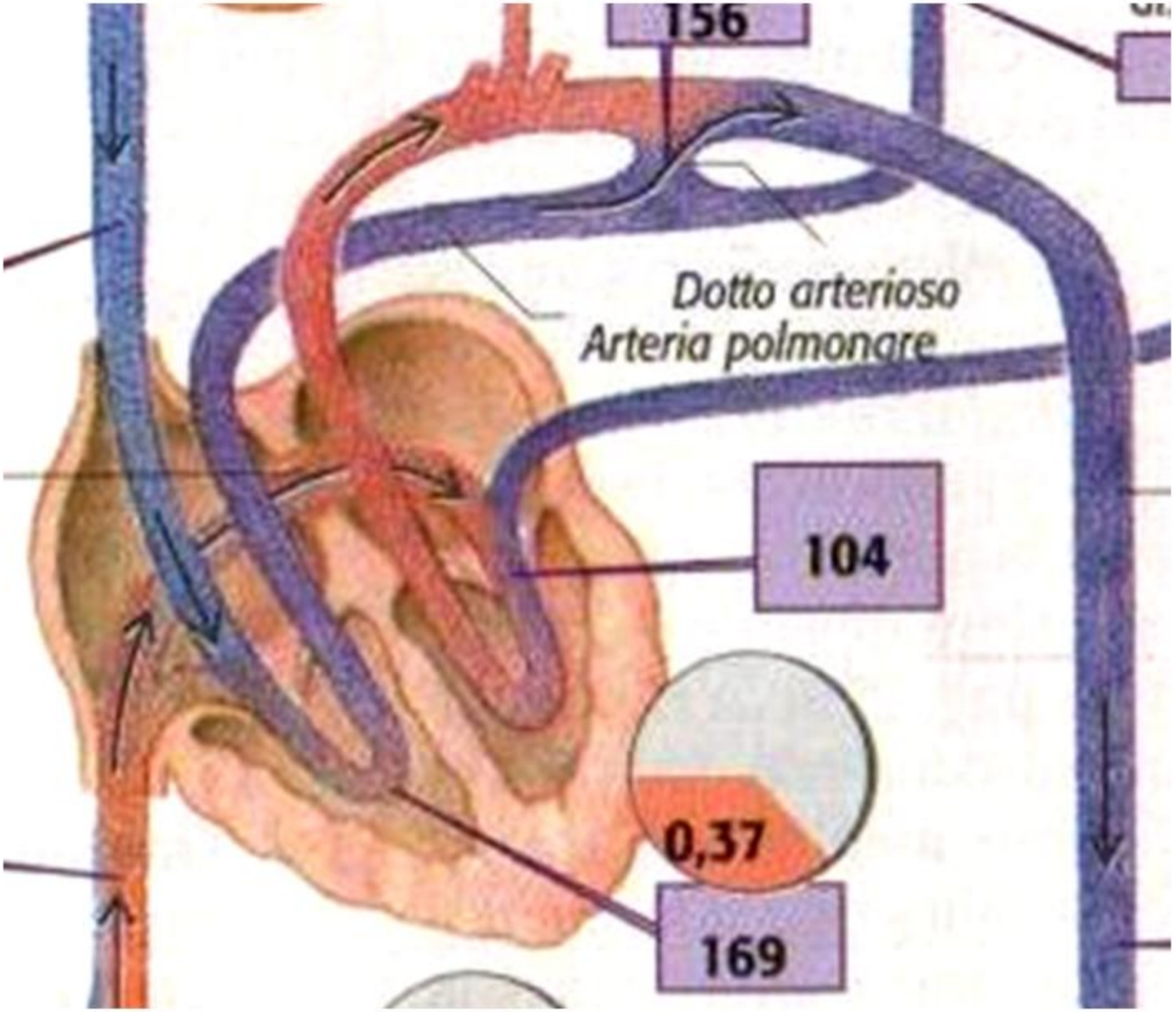
Umbilical vein
Sat. = 80% ; P_{O2} = 30 mmHg
0.55

Umbilical arteries
Sat. 55% ; P_{O2} : = 22 mmHg
0.55

Placental barrier
10 m^2

Fig.12-2

KMc


156
Dotto arterioso
Arteria polmonare
104
0,37
169

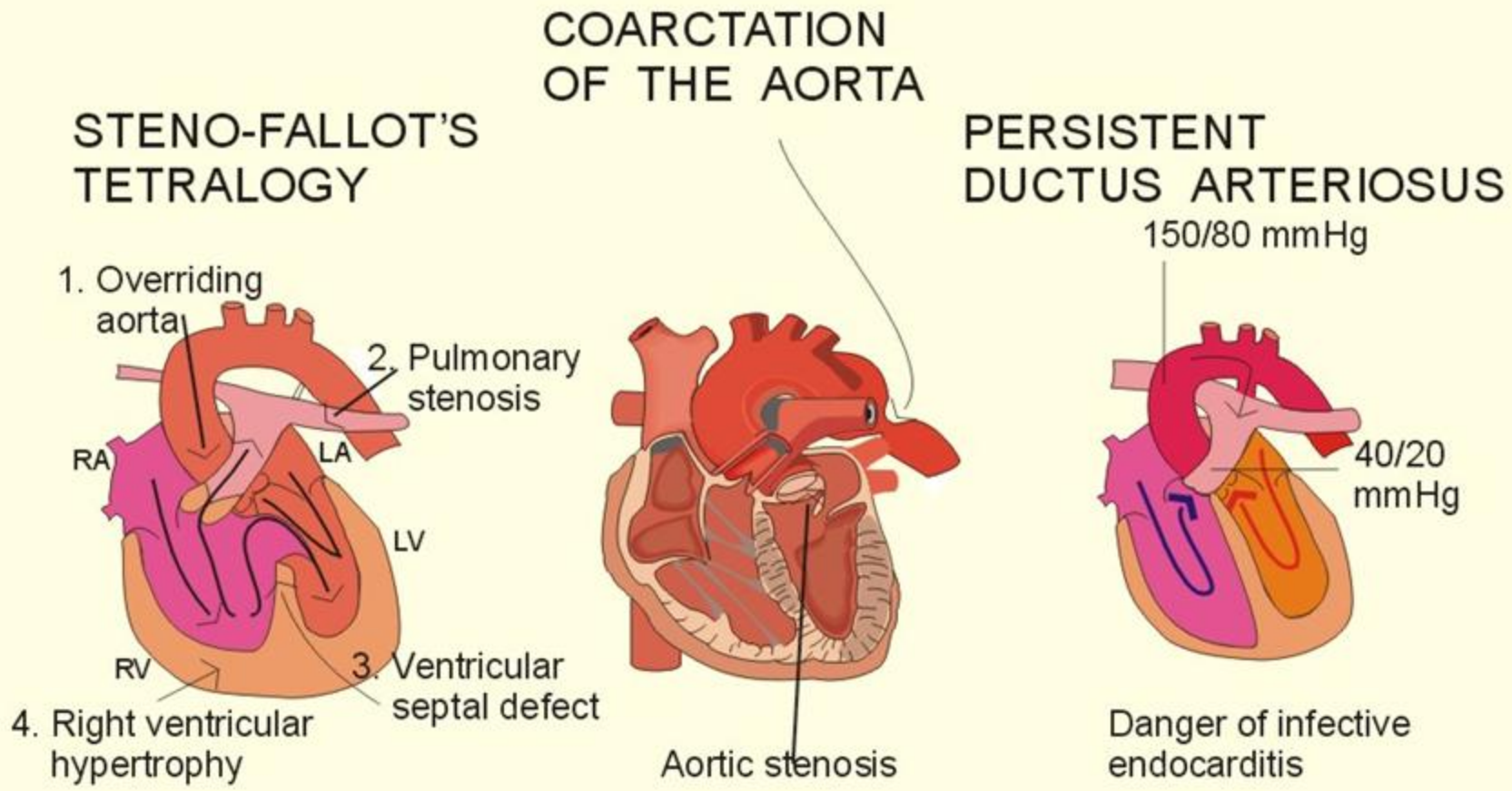
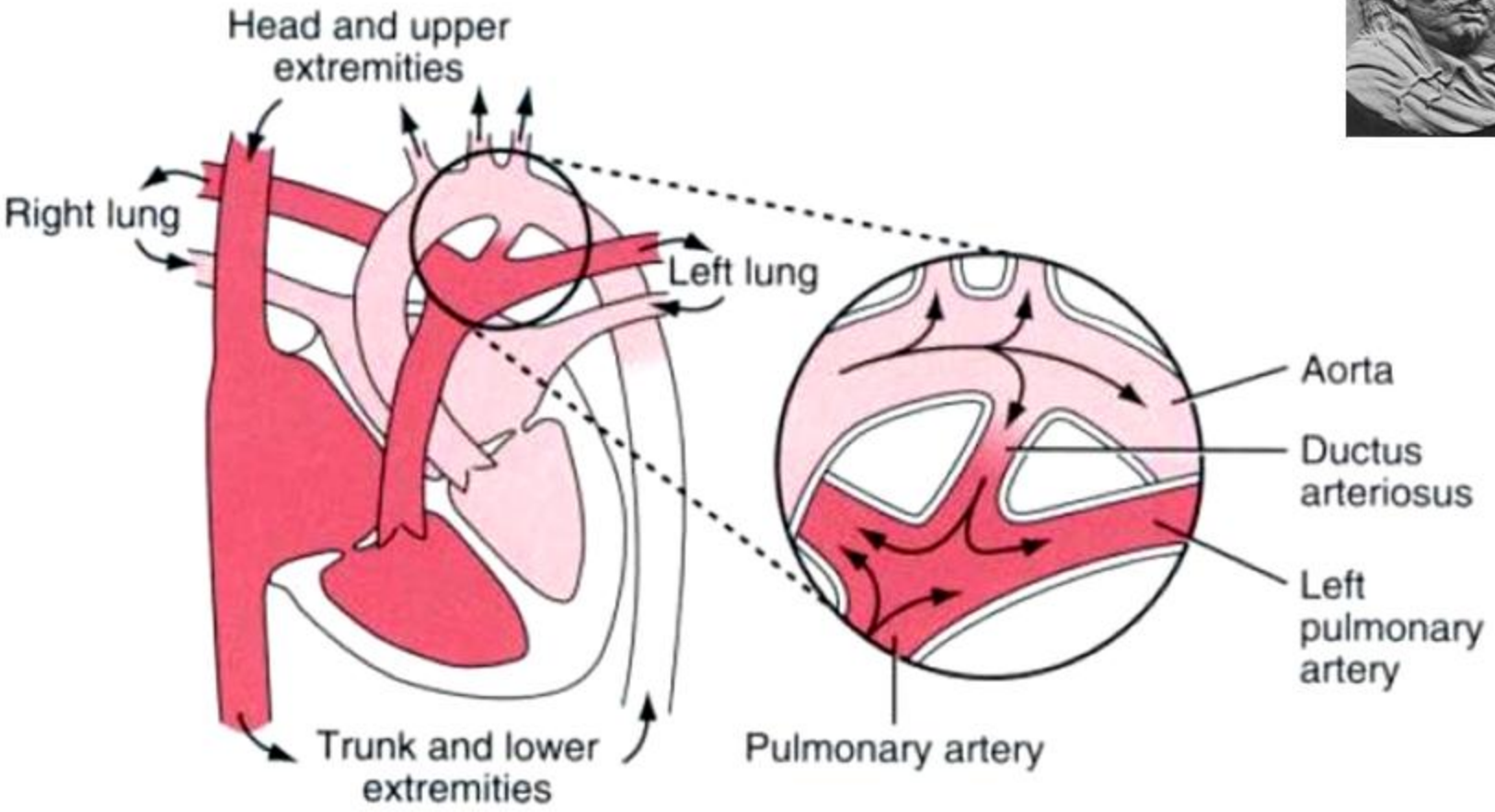

COARCTATION
OF THE AORTA
STENO-FALLOT'S
TETRALOGY
PERSISTENT
DUCTUS ARTERIOSUS
1. Overriding aorta
2. Pulmonary stenosis
RA
LA
LV
RV
3. Ventricular septal defect
4. Right ventricular hypertrophy
Aortic stenosis
150/80 mmHg
40/20 mmHg
Danger of infective endocarditis

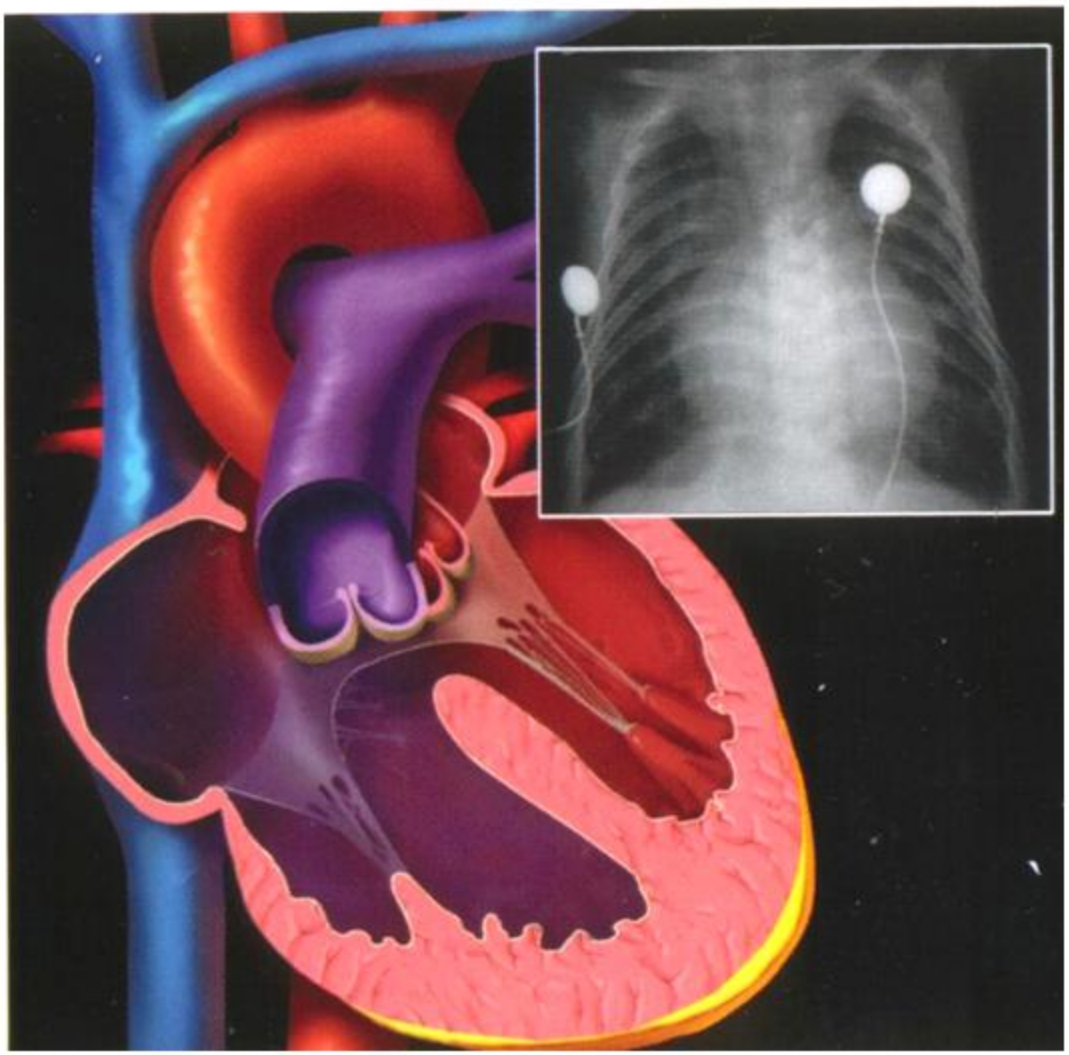
Fig. 12-7

KMc

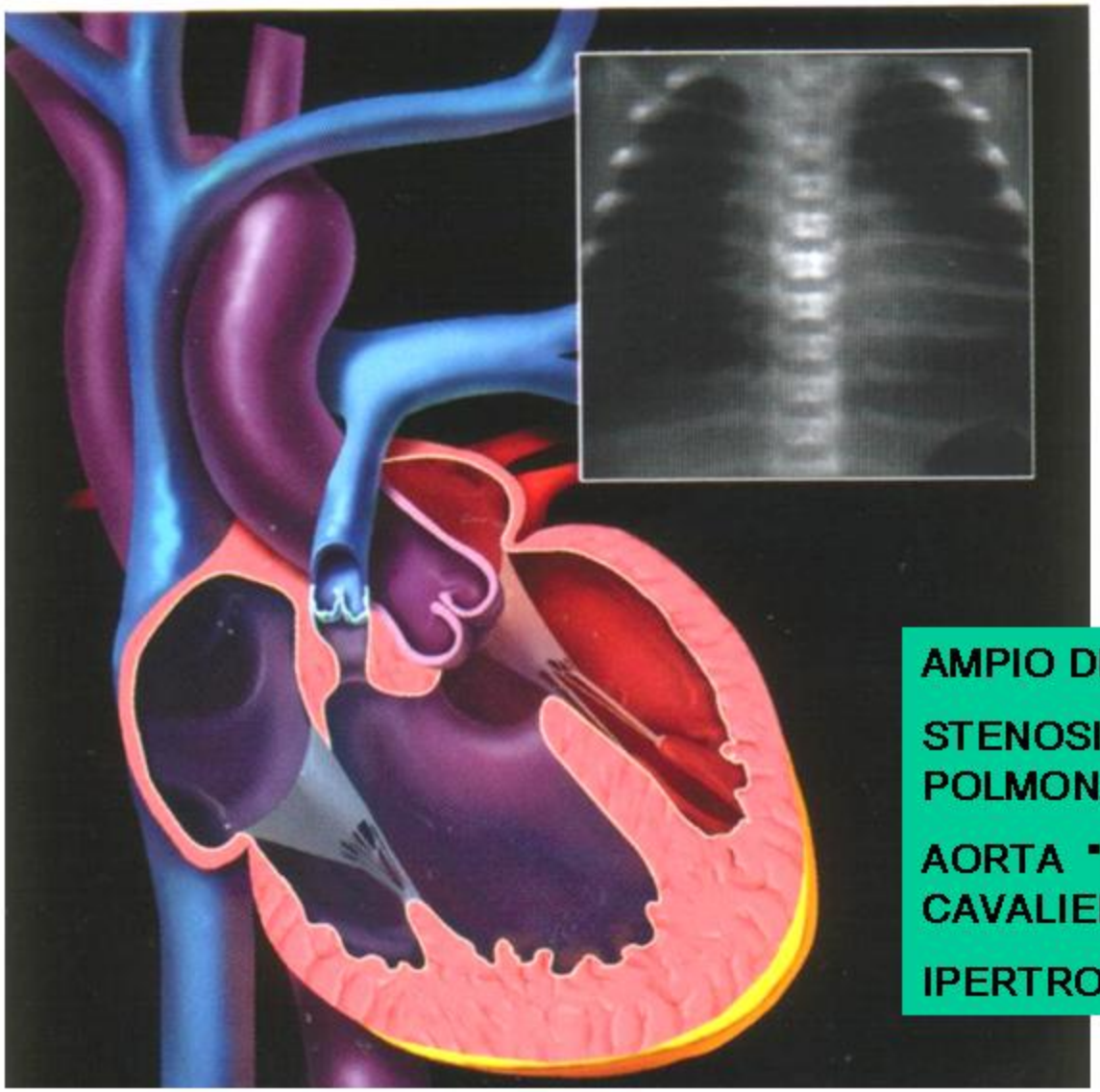
BOTALLO PERVIO



Left to Right Shunts



Tetralogy of Fallot



AMPIO DIV

STENOSI POLMONARE

AORTA "A CAVALIERE"

IPERTROFIA VD