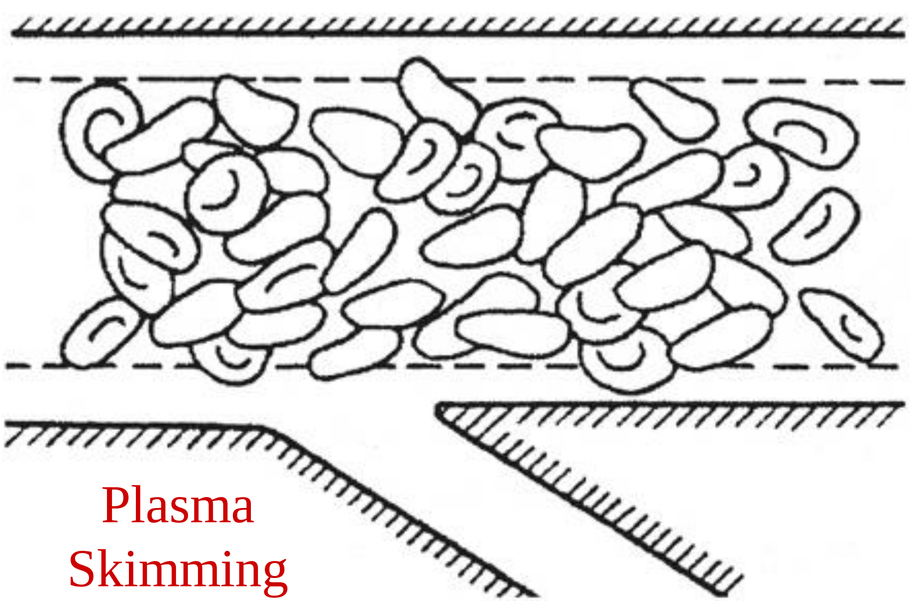
CVS Hemodynamics

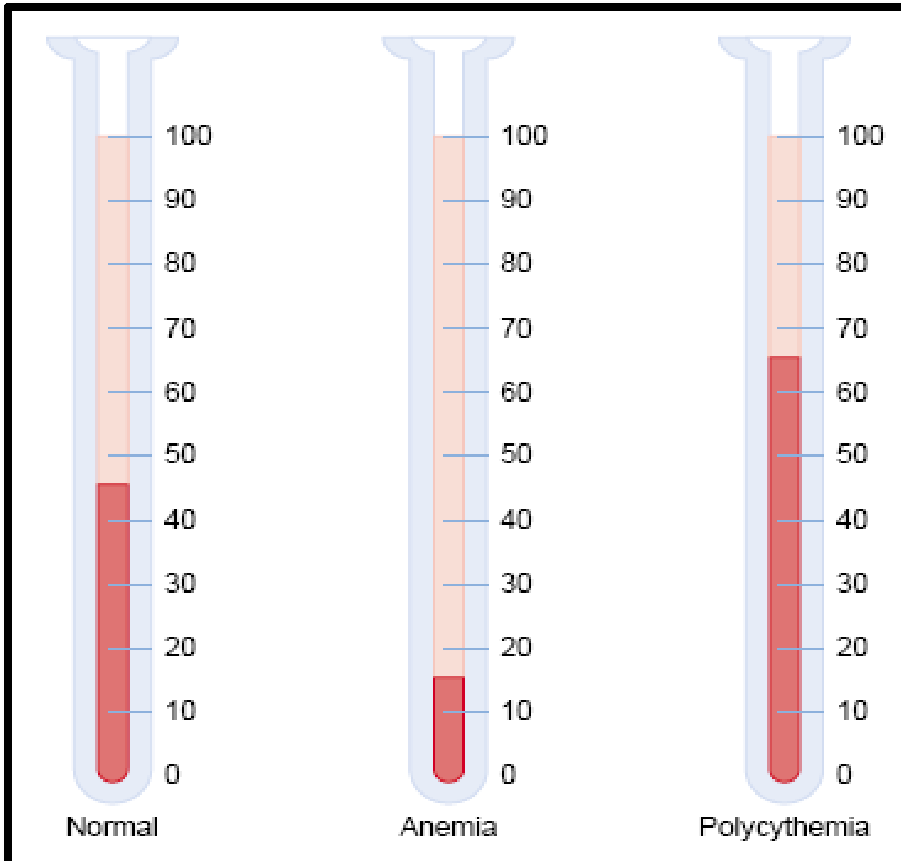
Faisal I. Mohammed, MD,PhD.

Factors influencing Blood Viscosity

1) Hematocrit.
2) Plasma proteins.
3) Diameter of the blood vessel.
4) Temperature.

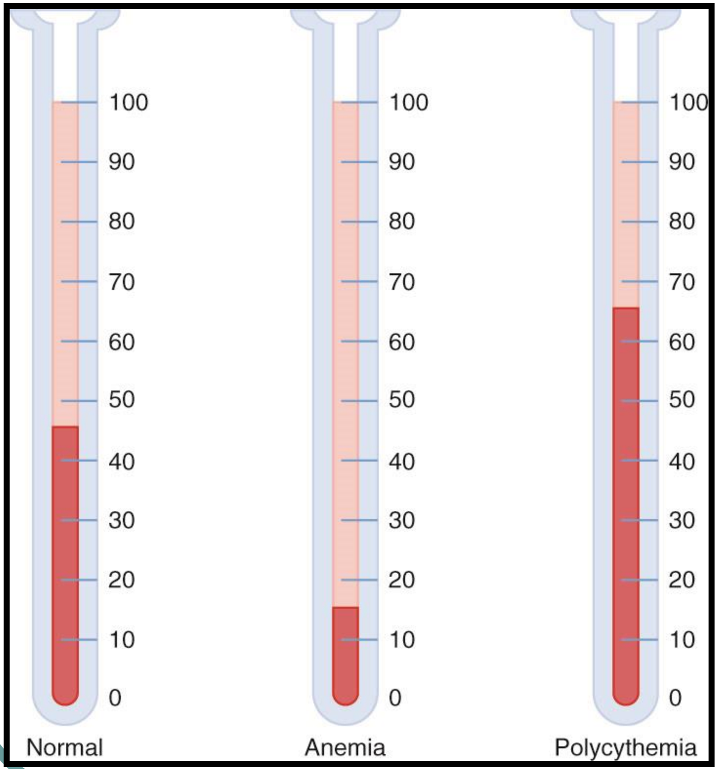


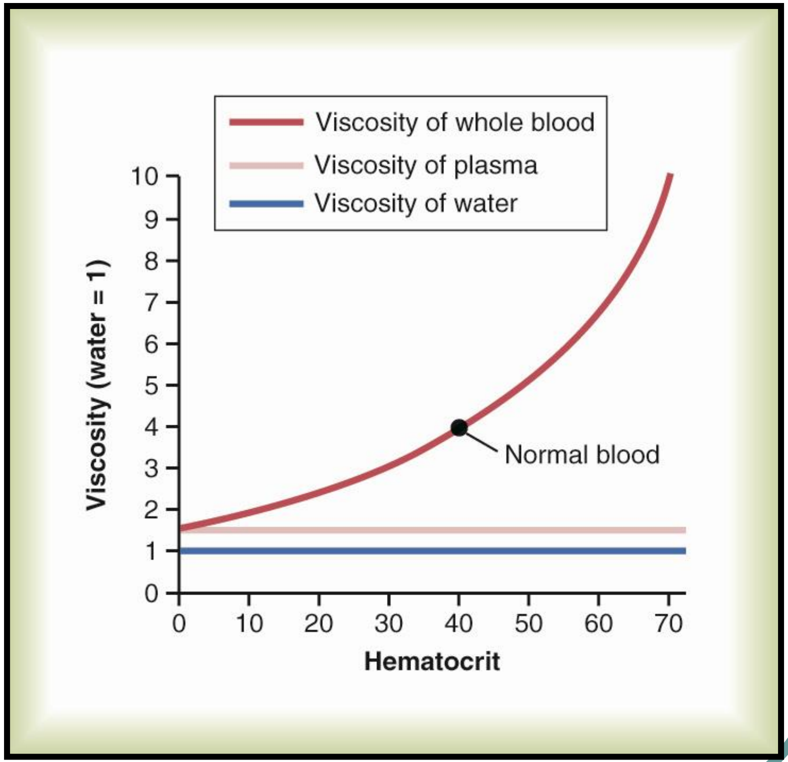
Plasma Skimming



Hematocrits in a healthy (normal) person and in patients with anemia and polycythemia.

Hematocrit and Viscosity Effects on Blood Flow





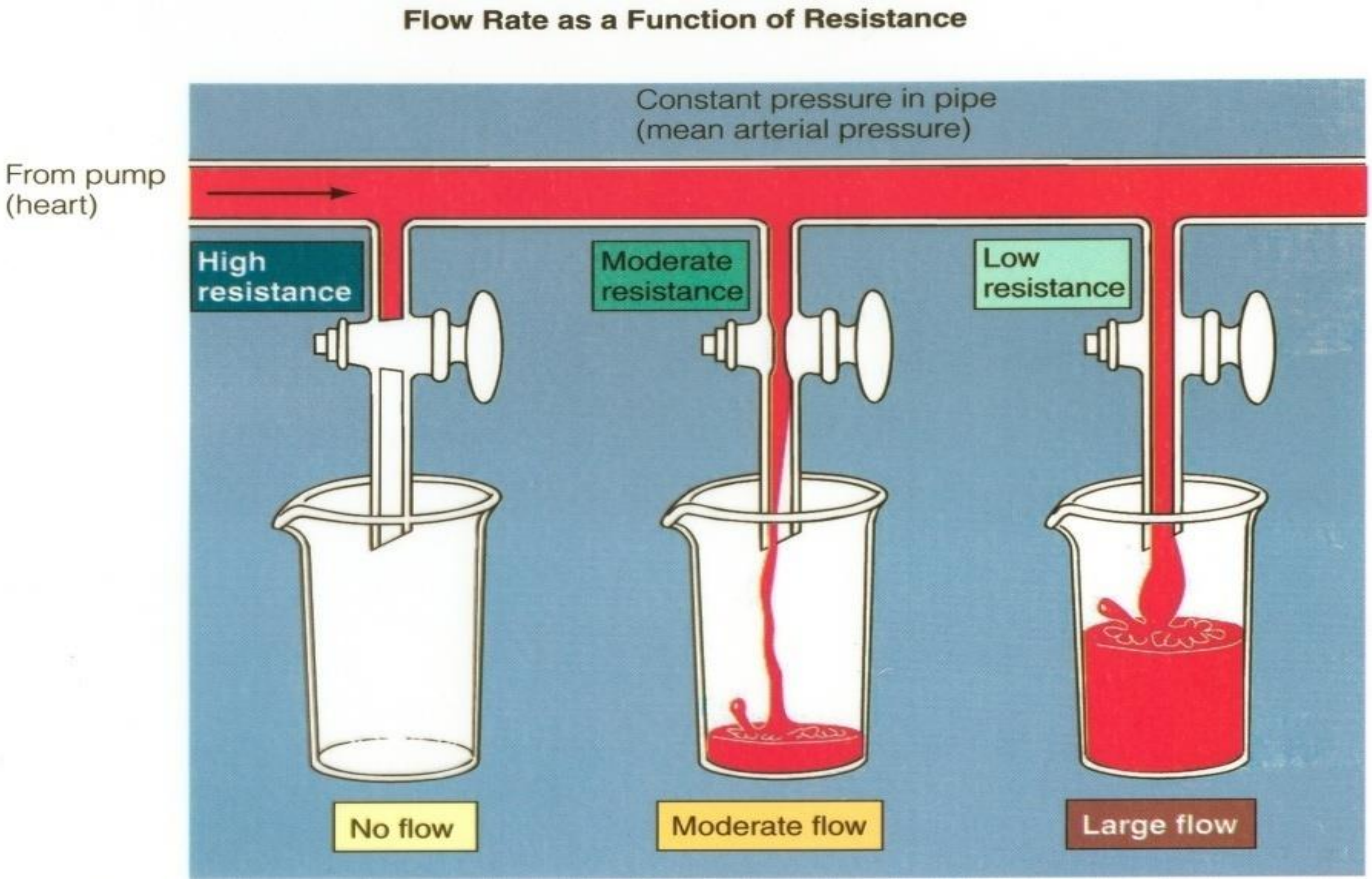
How Would a Decrease in Vascular Resistance Affect Blood Flow?

$$\uparrow \text{FLOW} = \frac{\Delta P}{\downarrow \text{RESISTANCE}}$$

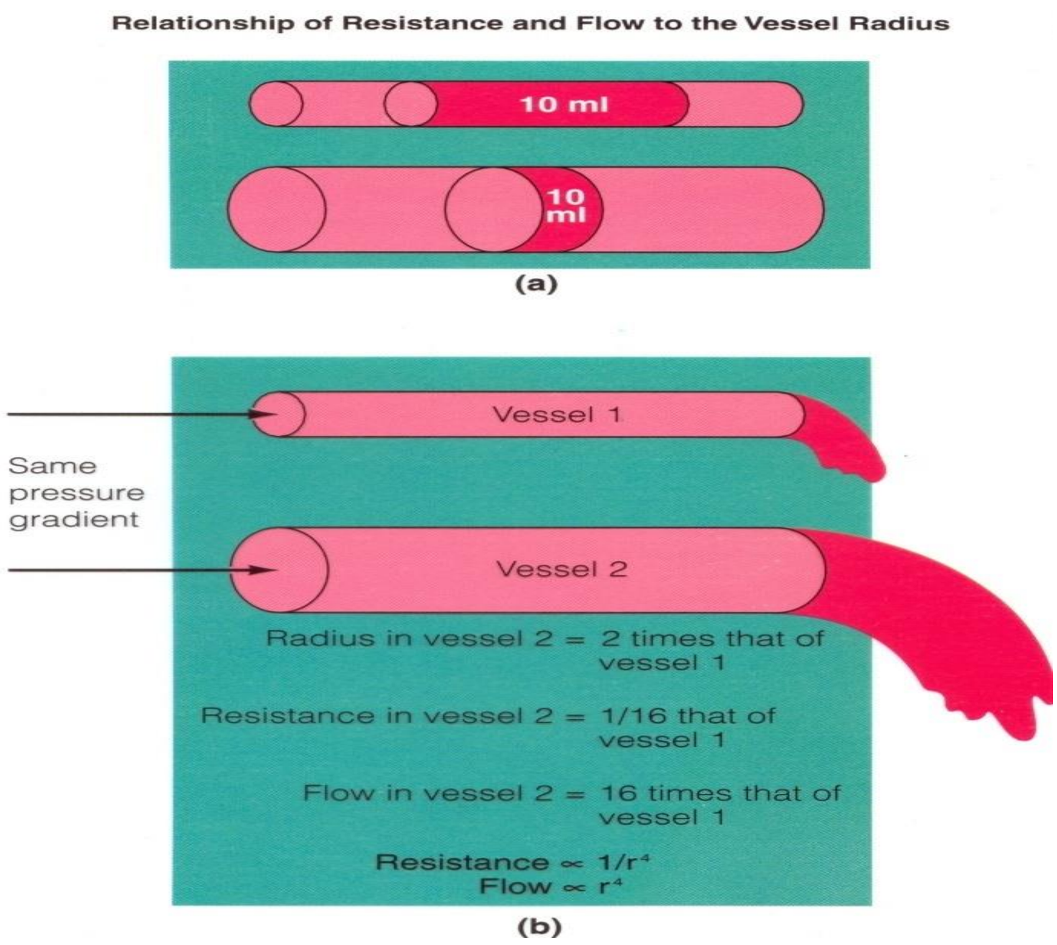
Conversely,

$$\downarrow \text{FLOW} = \frac{\Delta P}{\uparrow \text{RESISTANCE}}$$

Poiseuille's law …cont

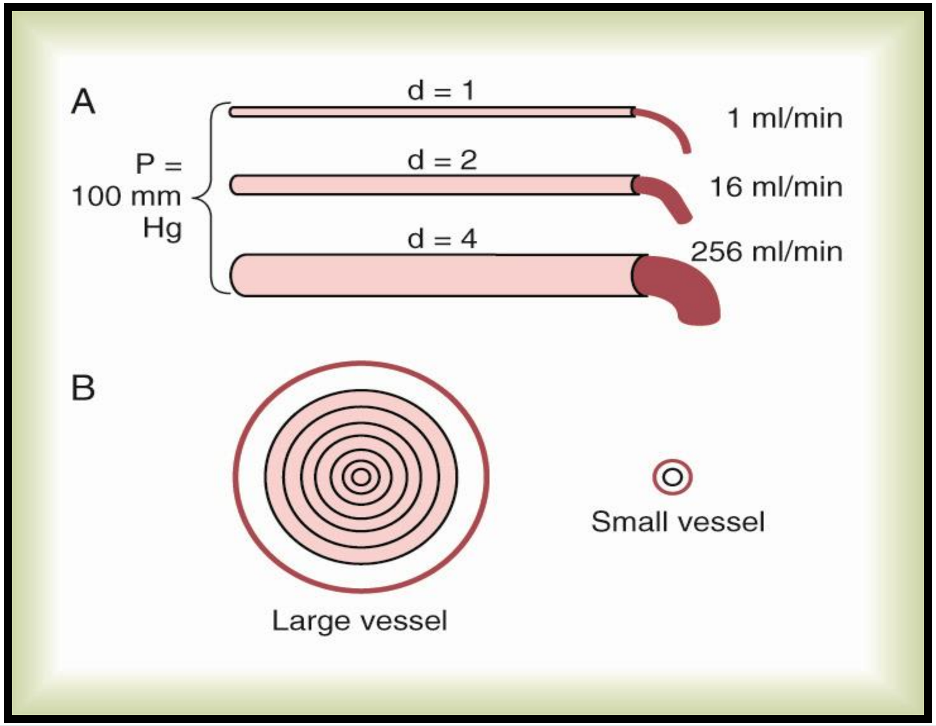


Poiseuille's law …cont

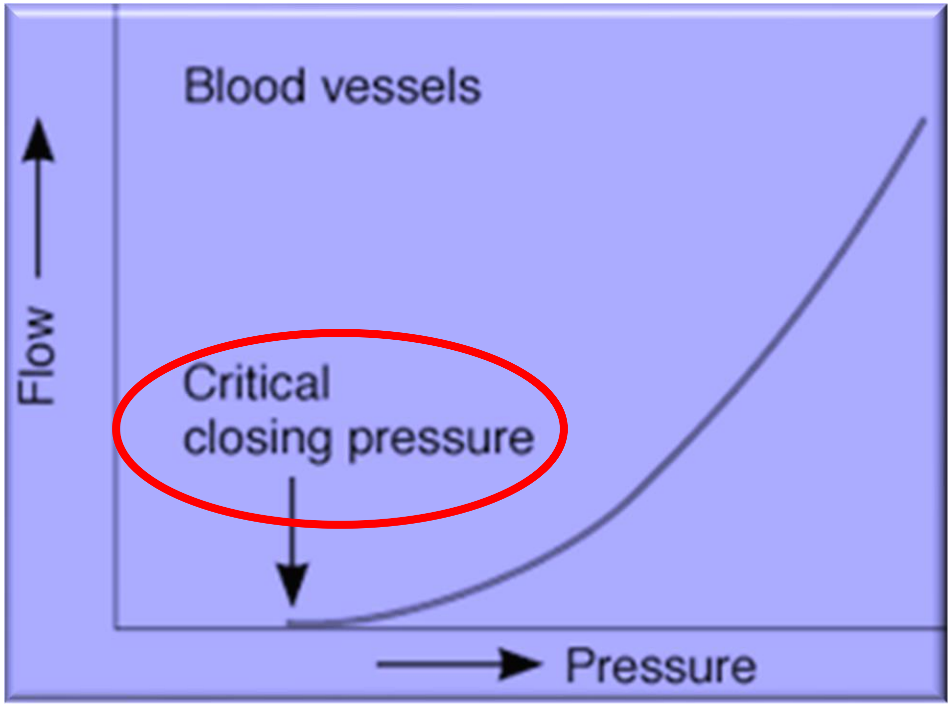


Effect of Vessel Diameter on Blood Flow

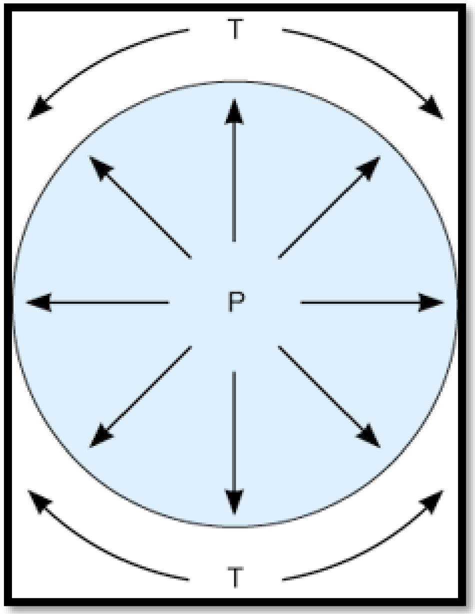
- Conductance is very sensitive to change in *diameter* of vessel.
- The conductance of a vessel increases in proportion to the *fourth power of the radius.*



Relation of pressure to flow in thin-walled blood vessel.



Law of Laplace:
i.e. <u>T = P x r</u> and P = T/r



Relation between distending pressure (P) and wall tension (T) in a hollow viscus

Hemodynamic laws… cont

- Dispensability = proportional change in volume per unit change in pressure

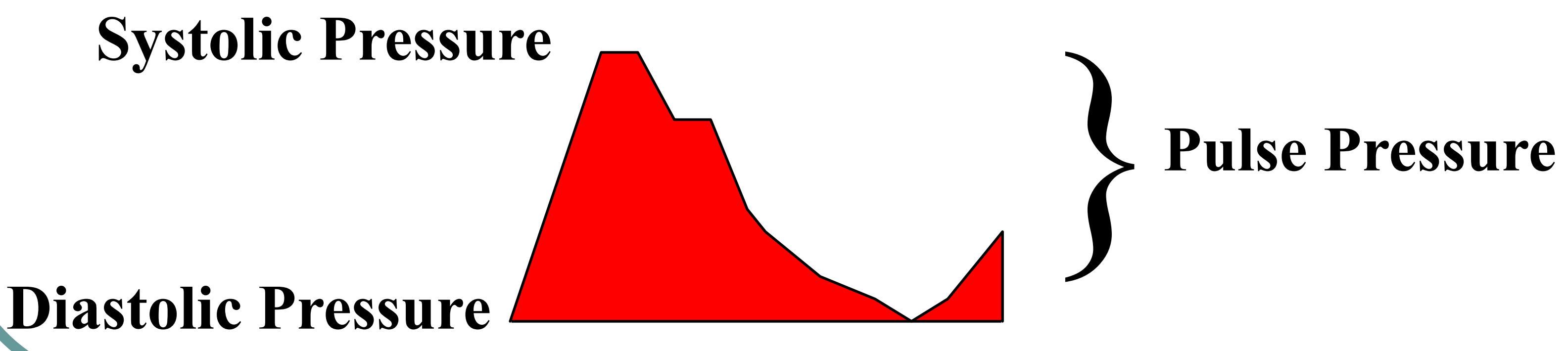
  $D = \Delta V / \Delta P * V$

- Compliance total change in volume per unit change in pressure

  $C = (\Delta V / \Delta P) = D * V$

Arterial Pulsations

- The height of the pressure pulse is the *systolic pressure* (120mmHg), while the lowest point is the *diastolic pressure* (80mmHg).
- The difference between *systolic* and *diastolic pressure* is called the *pulse pressure* (40mmHg).



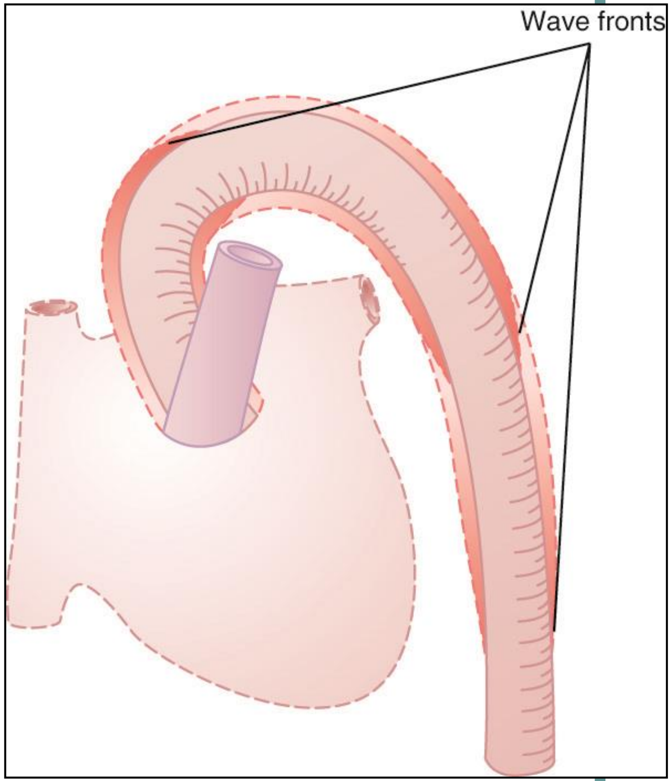
Pulse Pressure

- Definition: Systolic pressure – Diastolic pressure
- Factors affect pulse pressure (PP)
  - Stroke volume (SV)- ↑ SV ↑ PP
  - Compliance (C) - ↑ C↓ PP
  - PP ≈ $\dfrac{SV}{C}$
  - Pulse wave travels through the arterial wall
  - Velocity of travel of wave is inversely proportional to compliance
  - Velocity in aorta around 5 meters/sec., 10 meters/sec in medium sized and up to 40 meters in arterioles

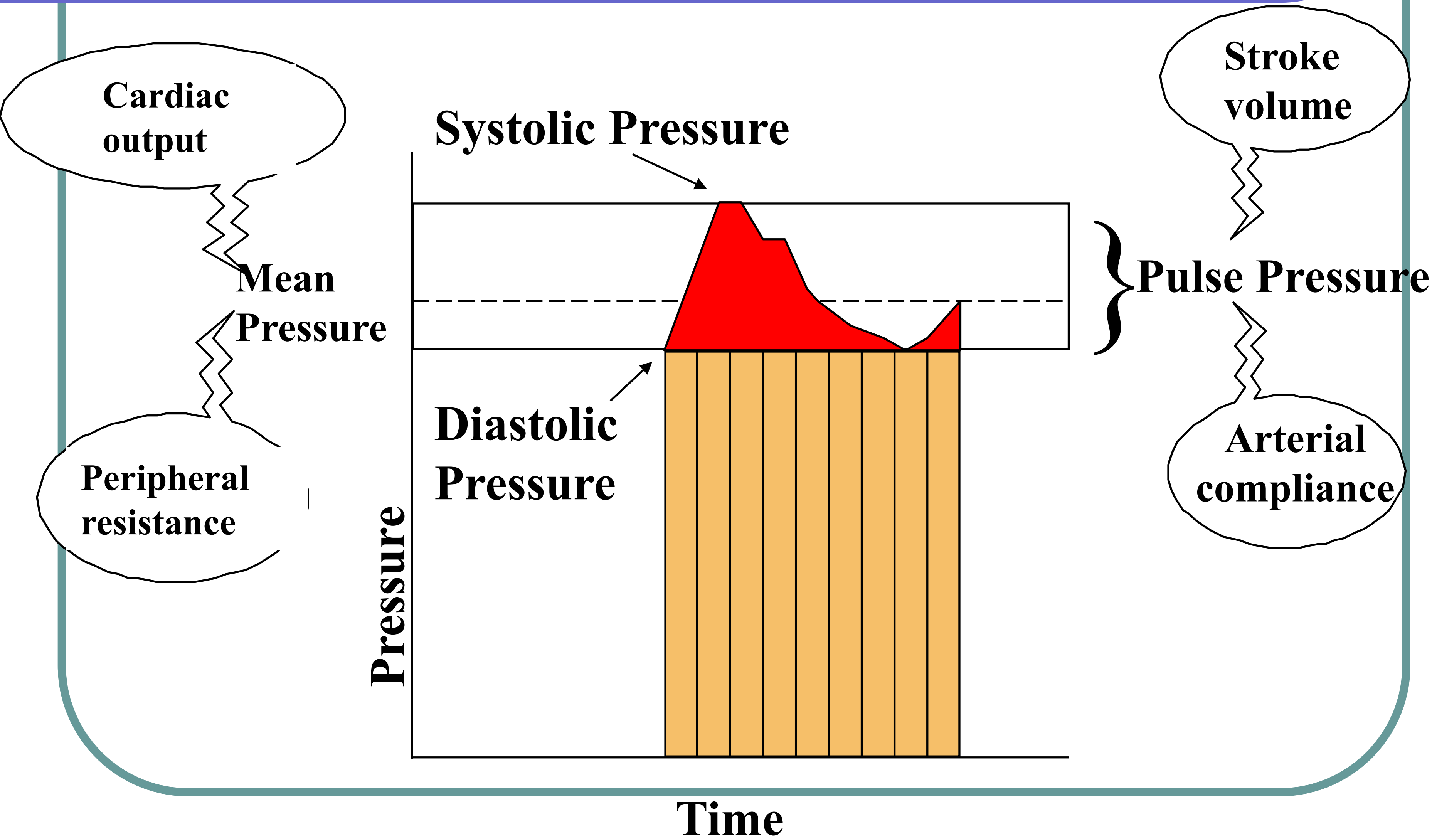
Factors Affecting Pulse Pressure

- *Stroke volume*—increases in stroke volume increase pulse pressure, conversely decreases in stroke volume decrease pulse pressure.

- *Arterial compliance*—decreases in compliance increases pulse pressure; increases in compliance decrease pulse pressure.

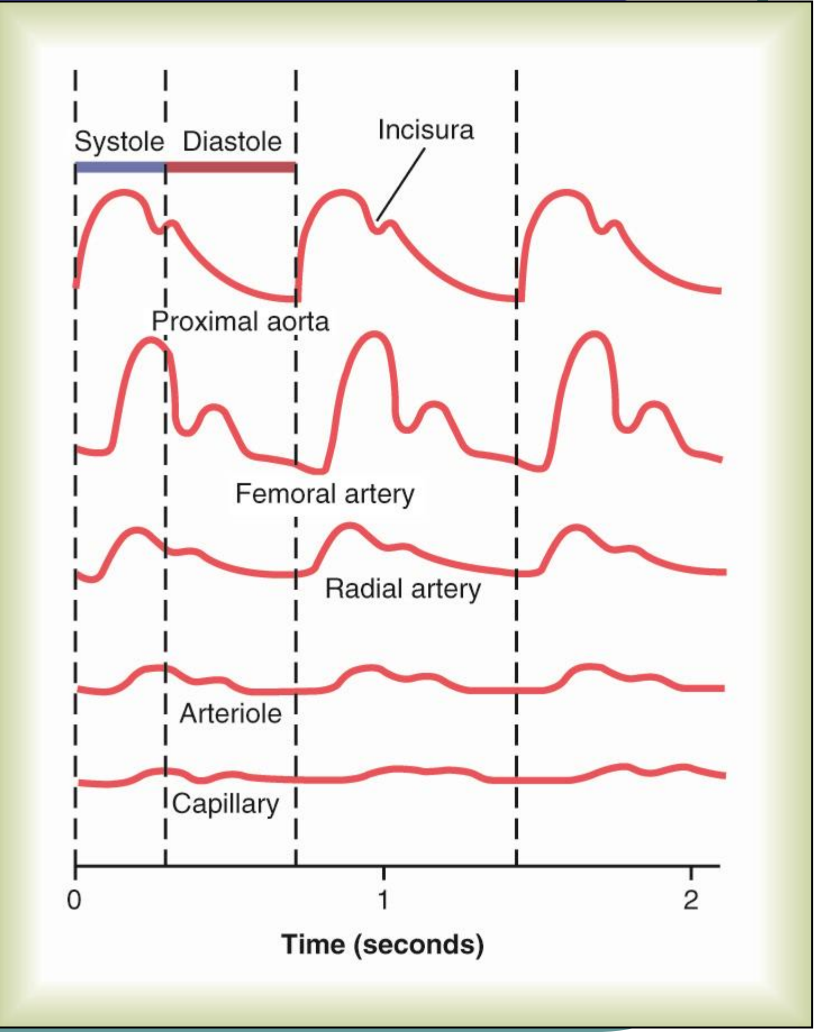


Arterial Pulse



Damping of Pulse Pressures in the Peripheral Arteries

- The intensity of pulsations becomes progressively less in the smaller arteries. Pulsations travel along the wall of the arteries
- The degree of damping is proportional to the resistance of small vessels and arterioles and the compliance of the larger vessels.



Abnormal Pressure Pulse Contours

- *Arteriosclerosis*–decreases compliance of arterial tree, thus leading to increase in pulse.
- *Patent ductus arteriosus*–associated with low diastolic pressure and high systolic pressure, net result is very high pulse pressure.
- *Aortic regurgitation*–condition associated with backward flow of blood through the aortic valve. Low diastolic and high systolic pressure leads to high pulse pressure.

Vascular Distensibility

- *Vascular Distensibility* is the fractional increase in volume for each mmHg rise in pressure
- Veins are 8 times more distensible than arteries
- Pulmonary arteries are relatively distensible
- Vascular Distensibility = $\dfrac{\text{Increase in volume}}{\text{Increase in pressure x Original volume}}$

Vascular Capacitance

- *Vascular capacitance* is the total quantity of blood that can be stored in a given portion of the circulation for each mmHg.
- *Capacitance* = Distensibility x volume
- The capacitance of veins is 24 times that of arteries.

$$\text{Vascular compliance} = \frac{\text{Increase in volume}}{\text{Increase in pressure}}$$

Volume-pressure Relationships in Circulation

- ⌘Any given change in volume within the arterial tree results in larger increases in pressure than in veins.
- ⌘When veins are constricted, large quantities of blood are transferred to the heart, thereby increasing cardiac output.

Thank You