# Venous Hemodynamics

Chapter 25

# Pressure/Volume Relationships

- Intraluminal pressure = pressure exerted on the venous walls from within the veins
- Interstitial pressure = pressure exerted on the venous walls from outside the veins

- Transmural pressure = difference between intraluminal pressure and interstitial pressure

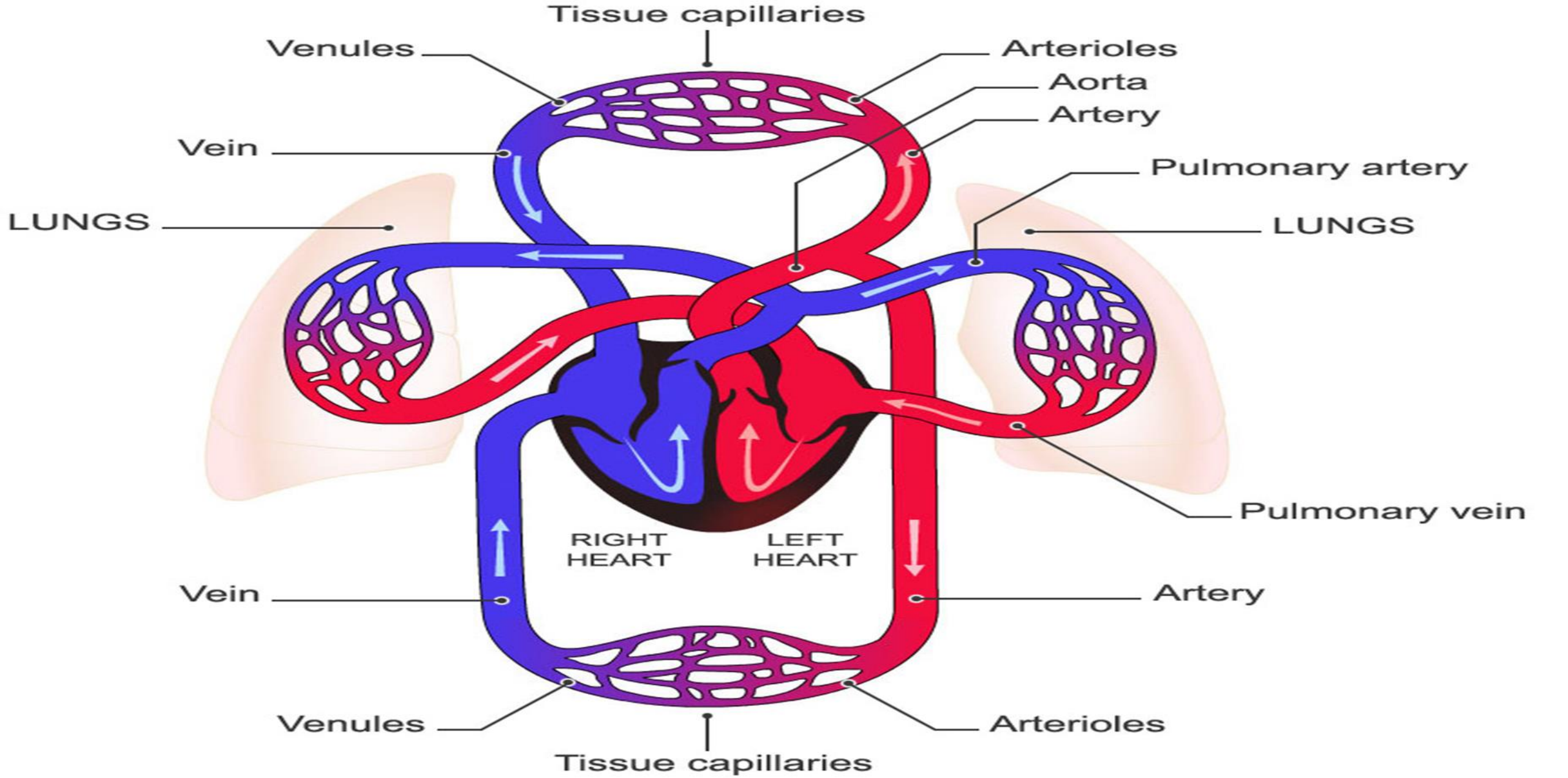
# Pressure/Volume Relationships

- Transmural pressure is related to the volume of blood in the vein
  - Determines the cross-sectional shape of the veins (i.e. dumbbell/elliptical shape or circular)
- Small pressure changes are required to expand a vein's normal dumbbell shape to a circular shape
  - Veins can carry 3-4X more blood than their corresponding artery *without* an increase in pressure

# Venous Pressure

- Blood leaves the capillary bed and passes through venules and into veins of increasing size with thicker, more muscular walls
- Velocity of blood flow increases as the veins approach the heart
- Cross-sectional area of the IVC is larger than the Aorta – slower flow in the IVC than Aorta

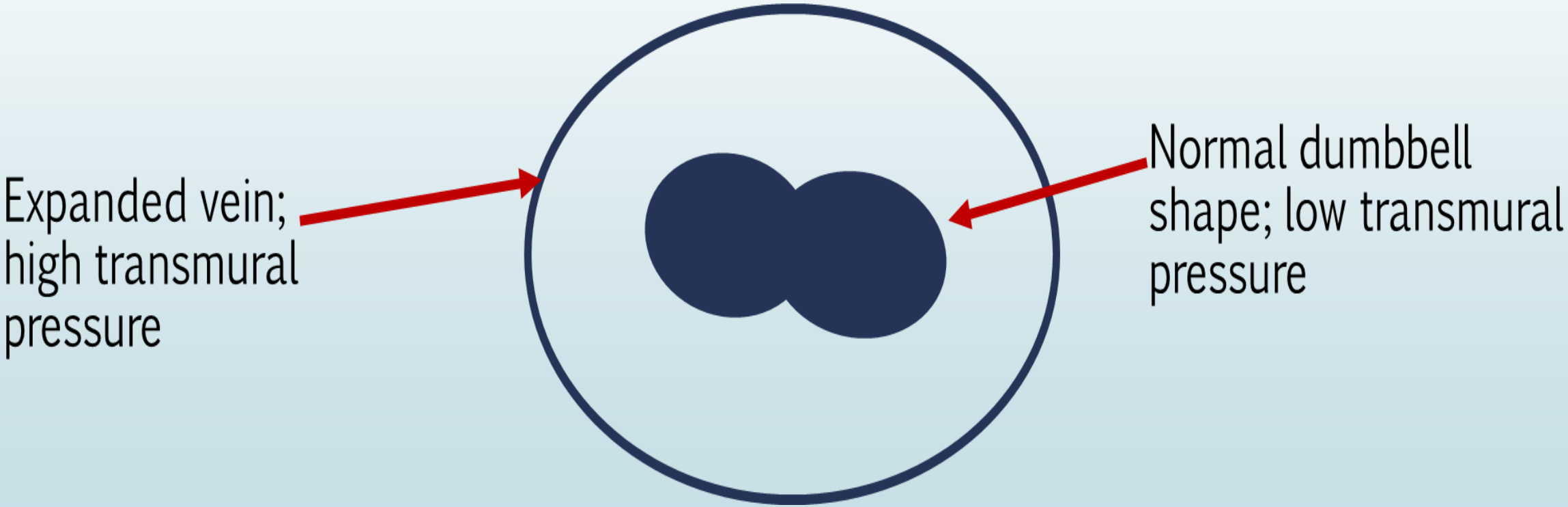
***** The greatest proportion of circulating blood is located in the venous vessels *****


Tissue capillaries
Venules
Arterioles
Aorta
Artery
Vein
Pulmonary artery
LUNGS
LUNGS
Pulmonary vein
RIGHT HEART
LEFT HEART
Vein
Artery
Venules
Arterioles
Tissue capillaries
Arterial circulation
Venous circulation

# Venous Resistance

- Veins are compliant:
  - Expandable with increased intraluminal pressure
  - Collapsible with decreased intraluminal pressure

# Venous Resistance



# Hydrostatic Pressure

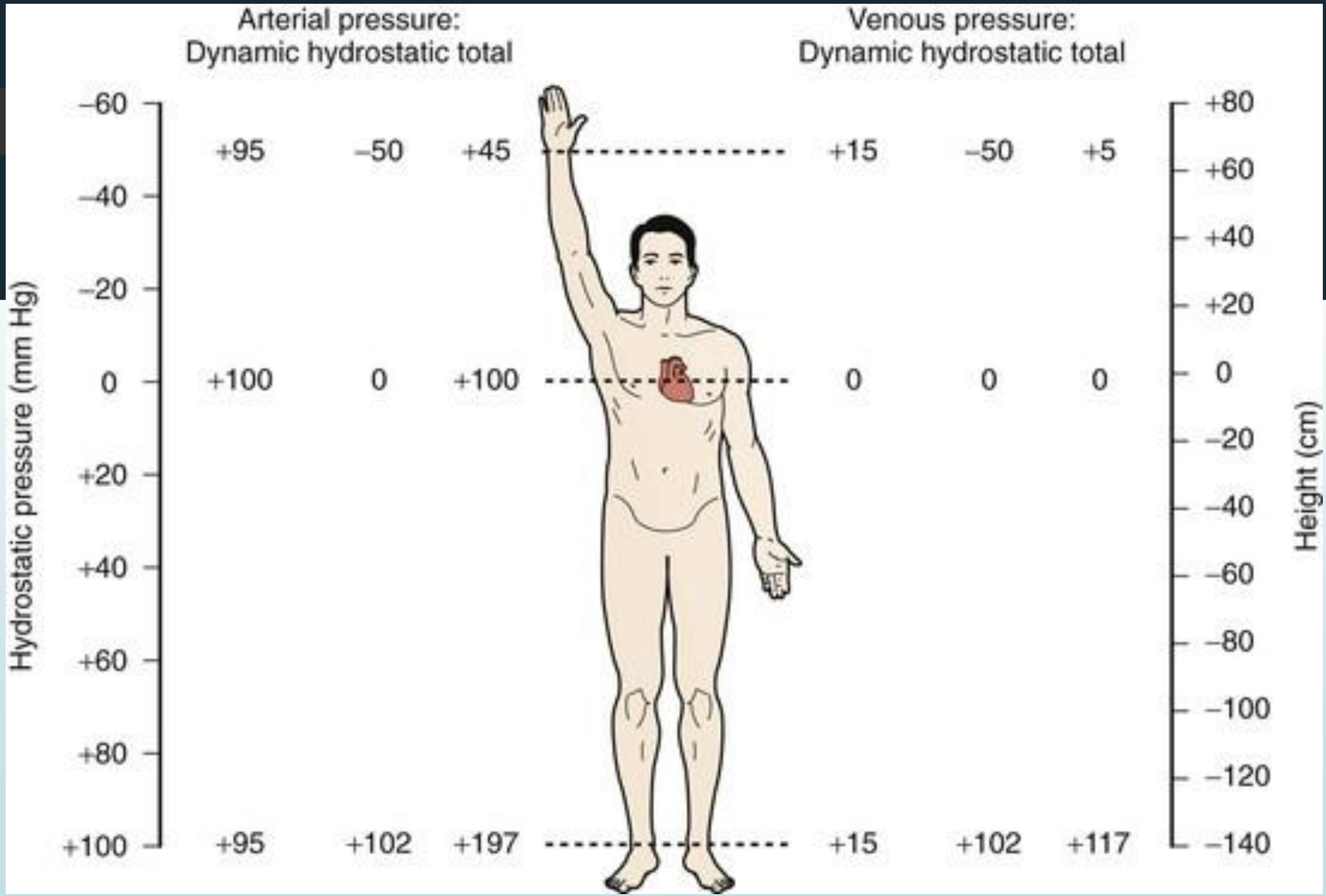
- Equivalent to the weight of a column of blood extending from the heart to the level being measured

- **Hydrostatic Pressure = PGH**
  - P – specific gravity of blood
  - G – acceleration due to gravity
  - H – distance from the heart

# Hydrostatic Pressure

- Heart is reference level for all patients

- Hydrostatic pressure related to position:
  - Supine – negligible, approximately 0 mmHg
  - Standing – Approximately +100 mmHg at ankle
  - Extremity raised above head – Approximately -50 mmHg

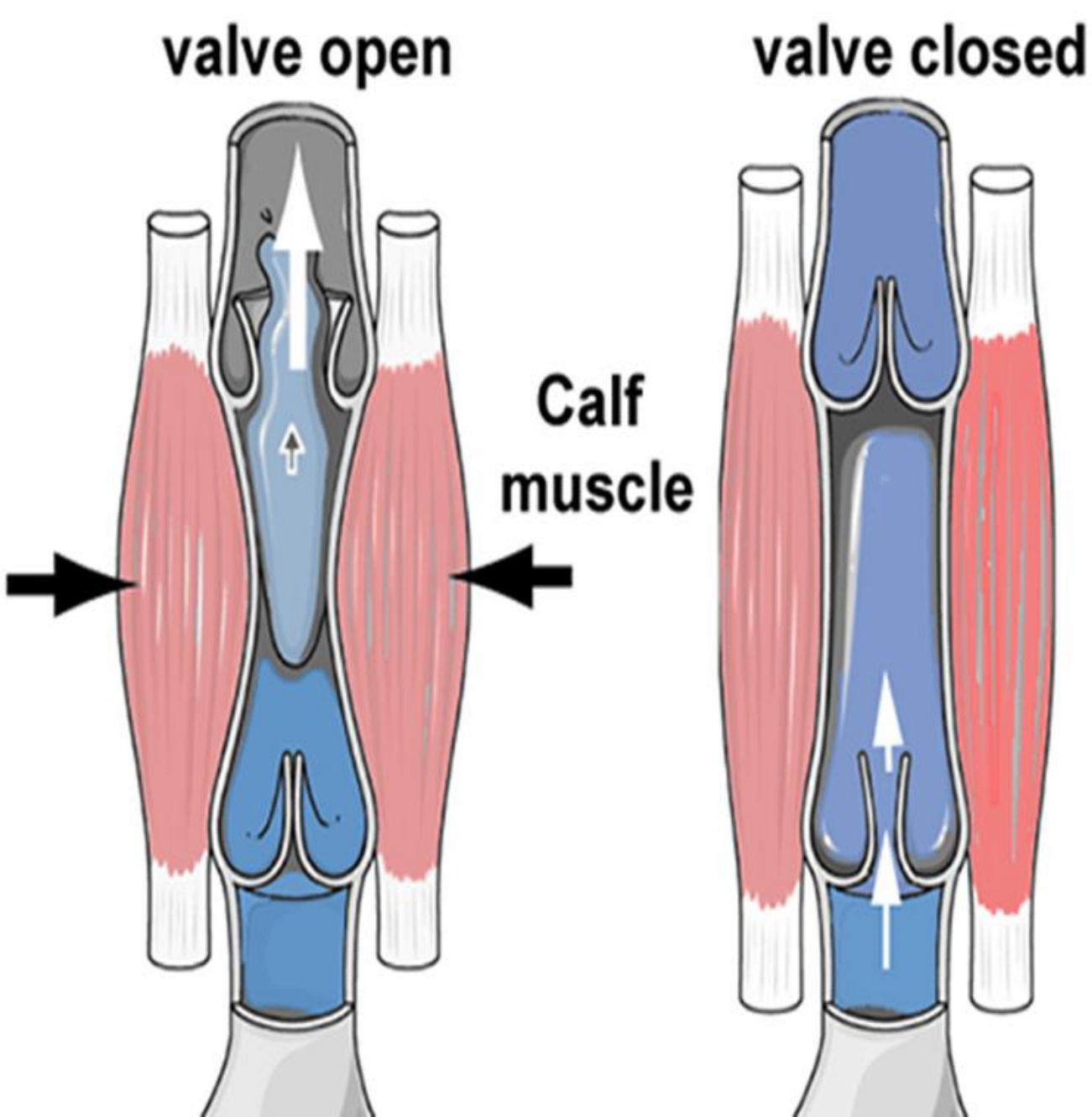

Arterial pressure:
Dynamic hydrostatic total
Venous pressure:
Dynamic hydrostatic total
Hydrostatic pressure (mm Hg)
Height (cm)
−60
−40
−20
0
+20
+40
+60
+80
+100
+95
−50
+45
+15
−50
+5
+100
0
+100
0
0
0
+95
+102
+197
+15
+102
+117
+80
+60
+40
+20
0
−20
−40
−60
−80
−100
−120
−140

# Muscle Pump

- Veins are reservoirs for the blood to collect in
- Muscles will squeeze the vein to send blood to the heart
  - With effect calf-muscle pump, at least 60% of the blood will be ejected
  - This decreases venous pressure and pooling; increases venous return to the heart and cardiac output

# Muscle Pump

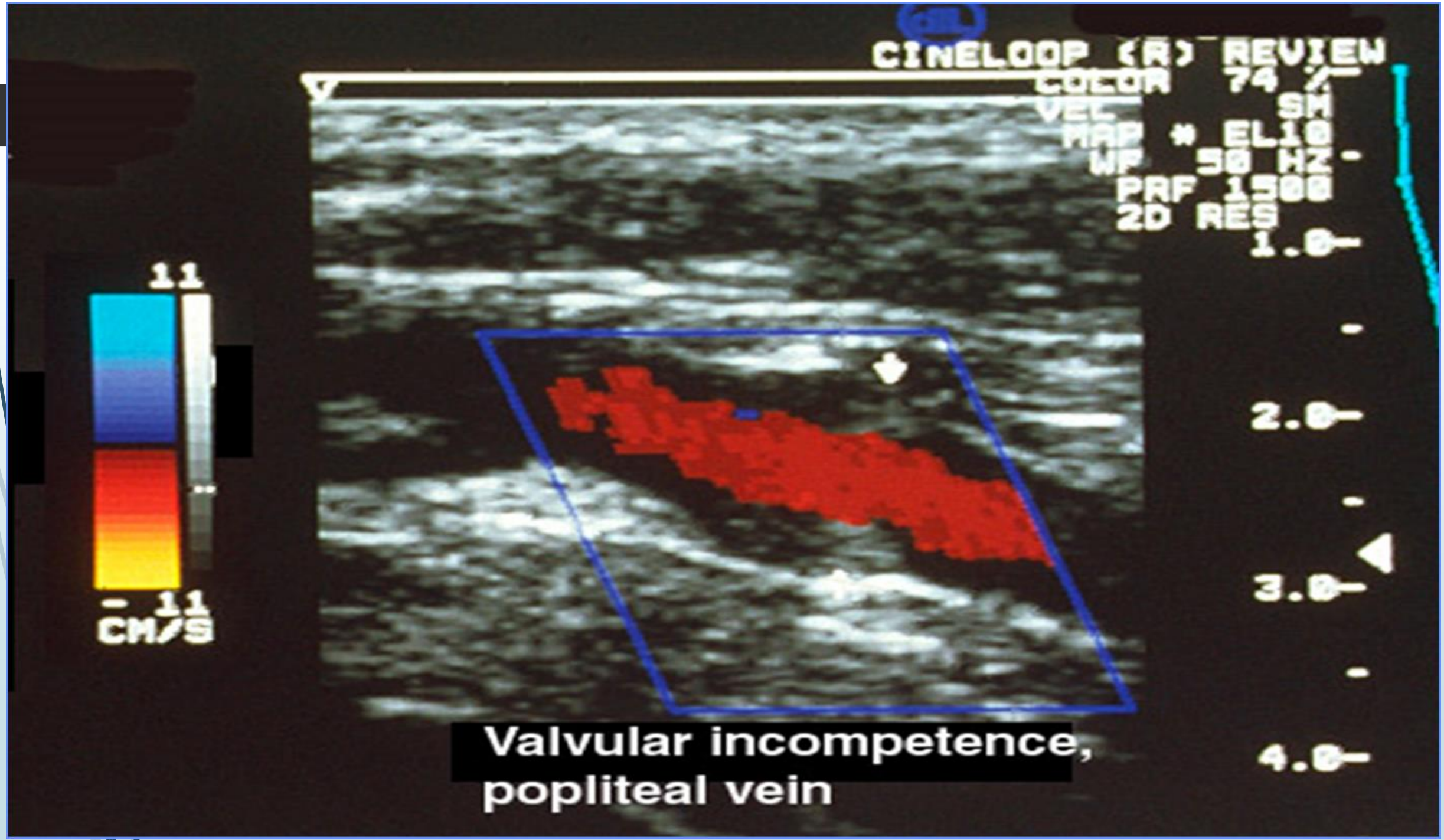
- Proper working muscle pumps:
  - Blood move from superficial to deep system
  - Competent valves prevent blood from refluxing
  - Venous volume and pressure decrease
  - Venous return to the heart increases


valve open
valve closed
Calf muscle

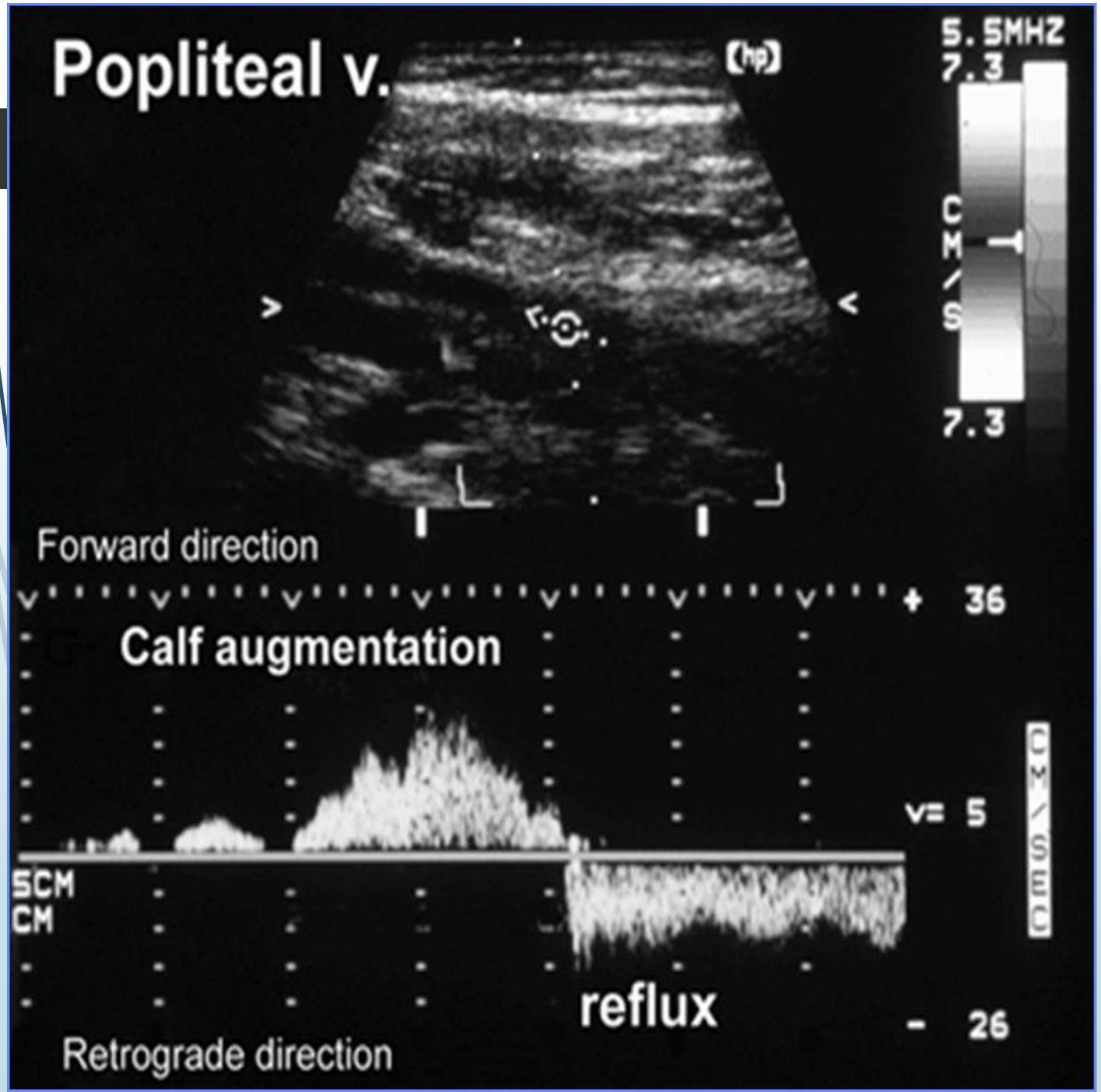

Valve

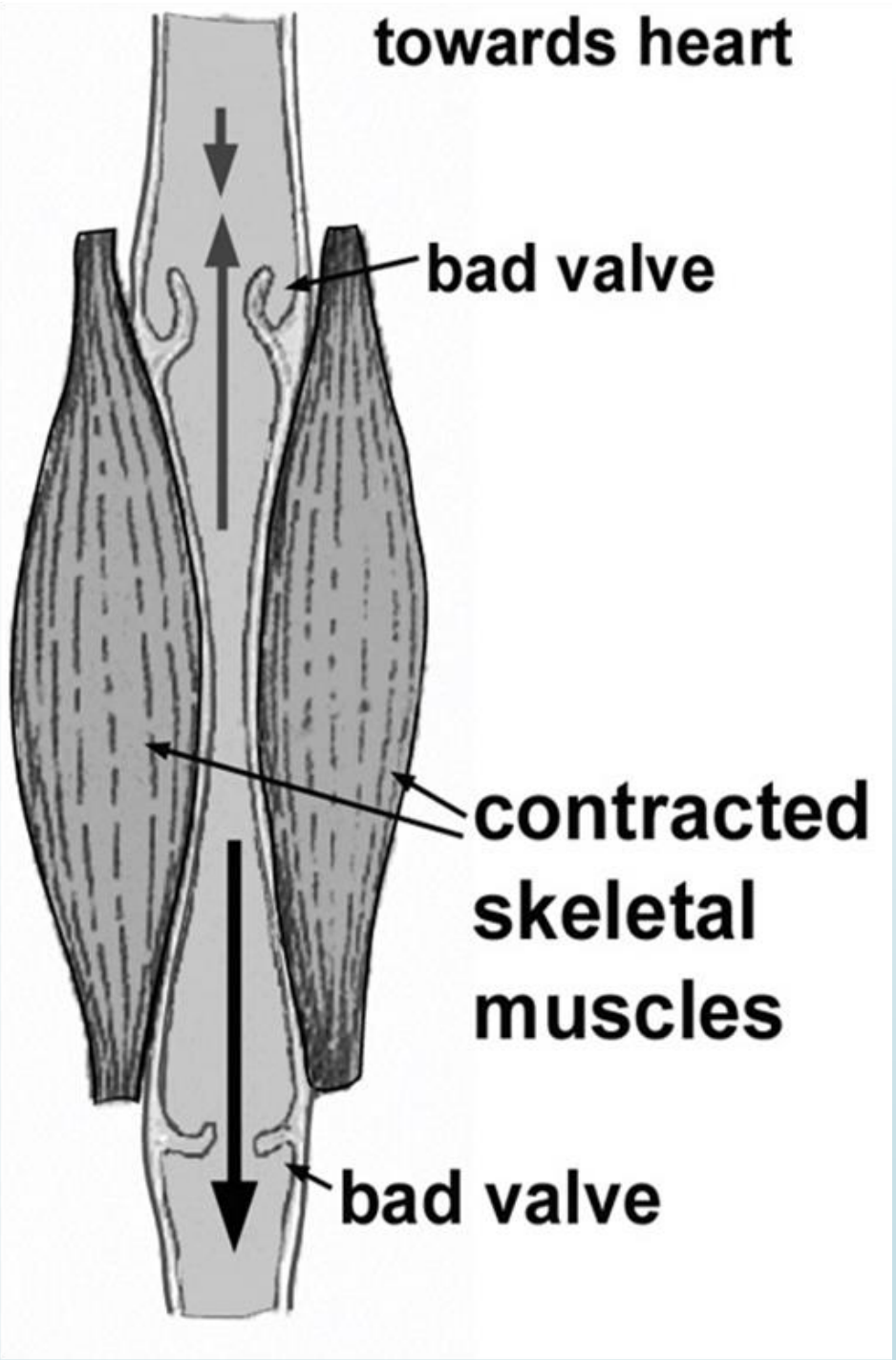
# Muscle Pump

- Improperly working muscle pumps:
  - Incompetent valves allow blood to reflux
  - Venous volume and pressure increases
  - Pooling of blood in the veins occurs leading to venous hypertension




Valvular incompetence, popliteal vein


Popliteal v.
5.5MHZ
7.3
CM/S
7.3
Forward direction
+ 36
Calf augmentation
V= 5
5CM
CM
reflux
- 26
Retrograde direction


towards heart
bad valve
contracted
skeletal
muscles
bad valve

# Muscle Pump

- During Muscle Relaxation:
  - Upon relaxation of the calf or leg muscles, the deep venous system has a low/absent venous pressure
  - Blood flows from the superficial veins into the deep veins via the perforating veins because a pressure gradient exists

# Respiration

- **During inspiration**:
  - Increase in intra-abdominal pressure
    - Decrease blood from the lower extremity
  - Decrease in intra-thoracic pressure
    - Increase in blood flow from the upper extremity

# Respiration

- **During expiration**:
  - Decrease in intra-abdominal pressure
    - Increase in blood flow from the lower extremity
  - Increase in intra-thoracic pressure
    - Decrease in blood flow from the upper extremity

# Valsalva Maneuver

- Patient takes a deep breath in and holds it, as they are bearing down and having a bowel movement
  - Intra-thoracic and intra-abdominal pressure increase
  - All venous return is suspended
- **Augmentation**: patient releases their breath and stops bearing down
  - Venous signal is heard

# Valsalva Maneuver

- Abnormal Valsalva:
  - When the patient bears down and augmentation of venous flow is heard
    - Normally due to incompetent valves
    - Can be a result of venous disease (i.e. DVT)
- Do not use Valsalva on patients who have severe coronary artery disease, acute MI, or hypovolemia
  - Stops blood flow to the heart and could start initiate cardiac arrest