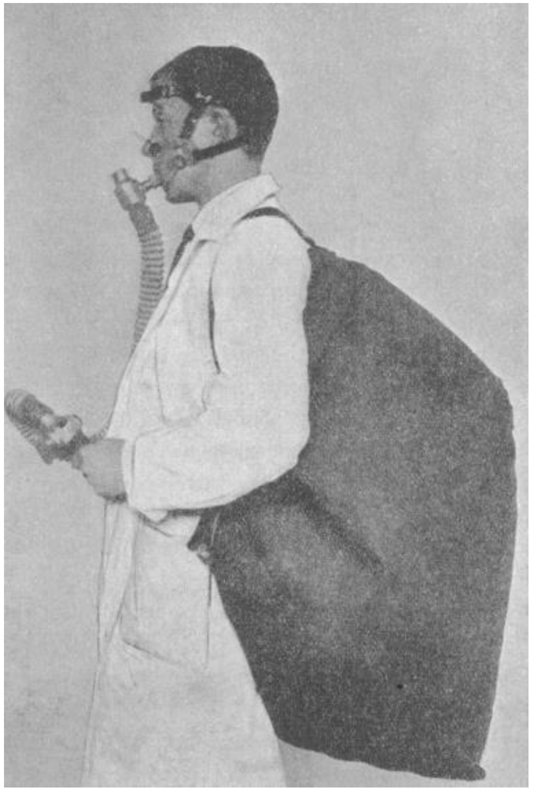
KPCOM Respiratory System Lecture 2
03/28/2025 0910-1000
Lung Blood Perfusion

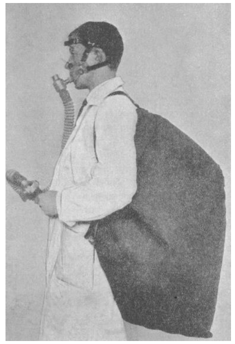


HN Mayrovitz PhD
mayrovit@nova.edu
drmayrovitz.com

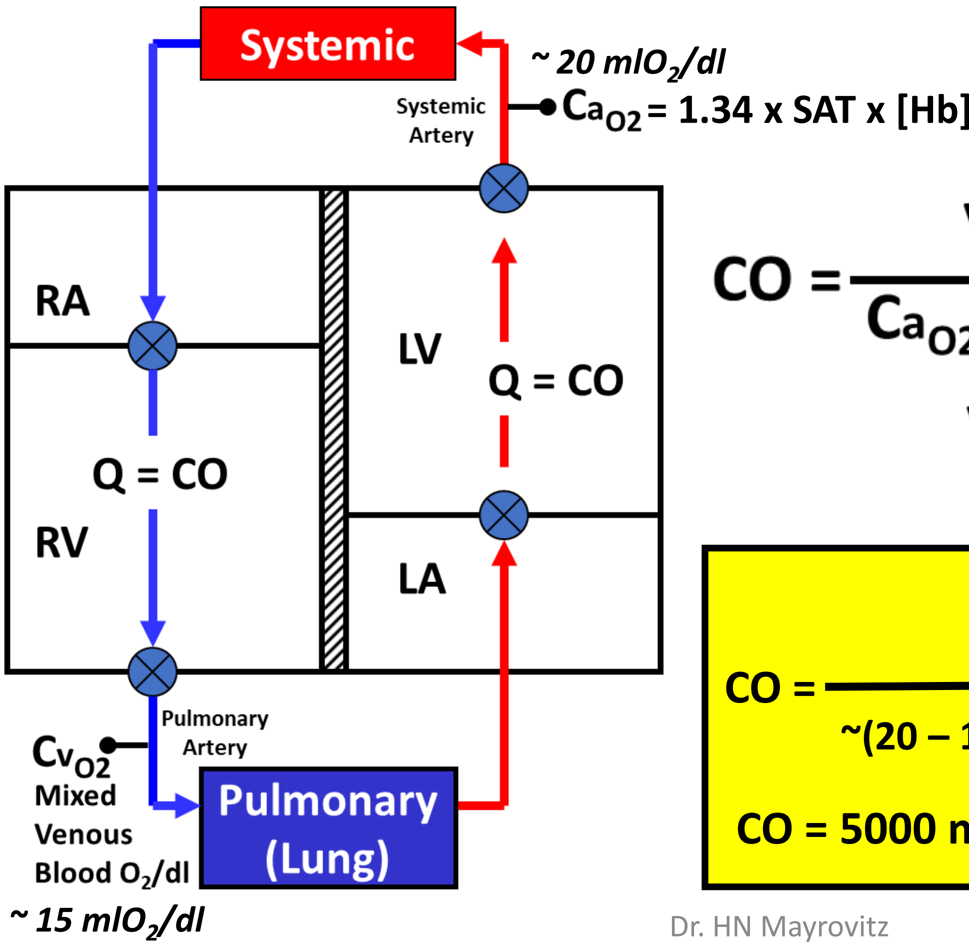
Determining Pulmonary Blood Flow = CO

Air FIO2 (0.21) → FEO2 (0.16)

$\Delta = -0.05$



Collect for 5 min → Measure Volume (V_T) → Minute Ventilation $\dot{V} = V_T/5$ → $\dot{V}_{O_2} = \dot{V} \times 0.05$ (Δ)



$$CO = \frac{\dot{V}_{O_2}}{Ca_{O2} - Cv_{O2}}$$ Fick's Equation

$\dot{V}_{O_2}$ = Oxygen Utilization

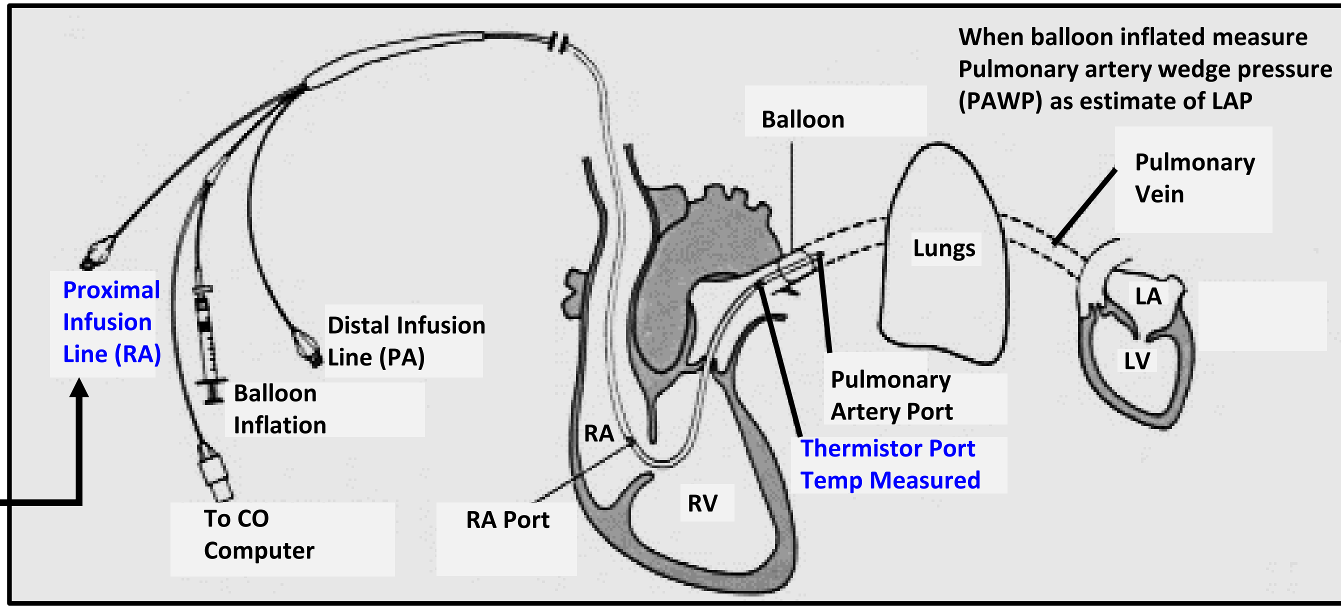
Example

$$CO = \frac{250 \text{ mlO}_2\text{/min}}{\sim(20 - 15) \text{ mlO}_2\text{/100ml} = 0.05 \text{ mlO}_2\text{/ml blood}}$$

CO = 5000 ml/min

Determining CO via Thermodilution Method

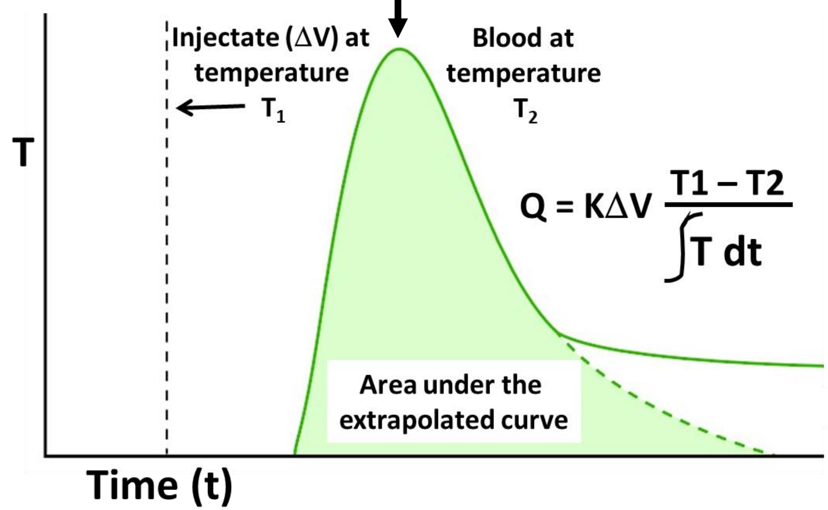
Thermodilution
Swan-Ganz catheter with thermistor placed into pulmonary artery via peripheral vein insertion



- Cold saline injected into right atrium at end of expiration

- Temperature changes at thermistor sensed and recorded

- Blood flow (cardiac output, CO) is determined from temperature profile



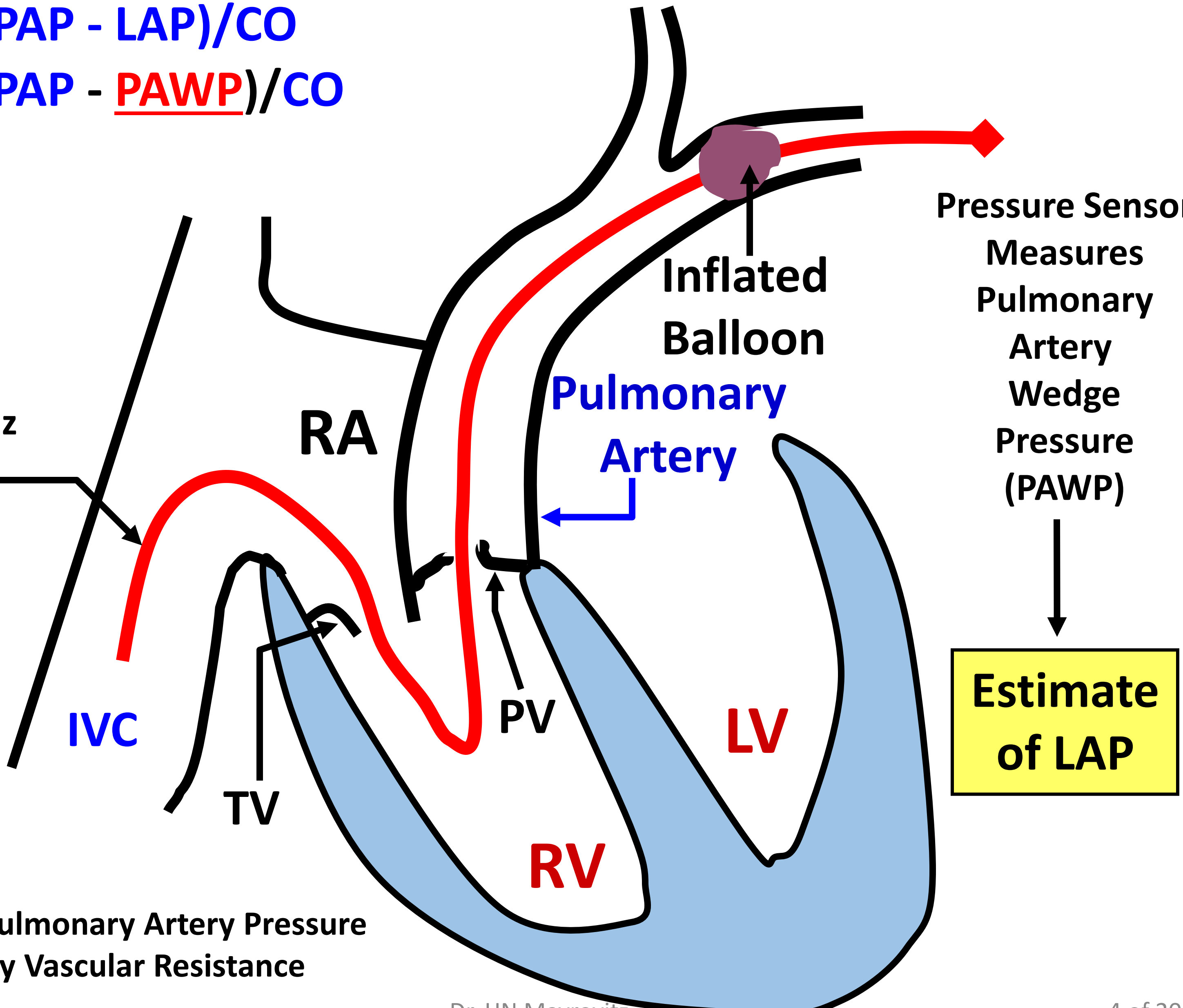
$$Q = K\Delta V \frac{T1 - T2}{\int T\,dt}$$

ΔV = volume injected
K – calibration constant

Determining Pulmonary Artery Wedge Pressure

PVR = (MPAP - LAP)/CO

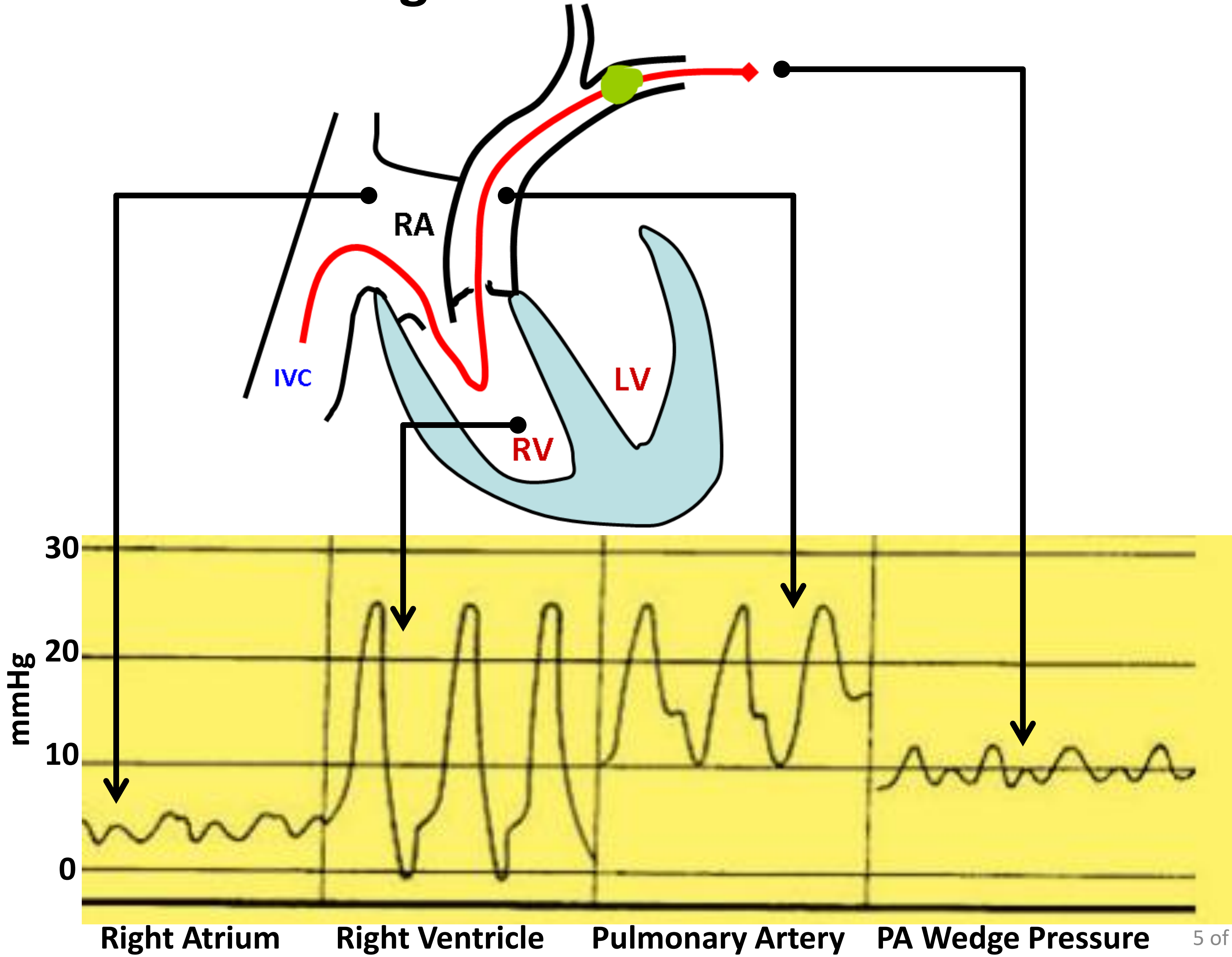
PVR = (MPAP - PAWP)/CO



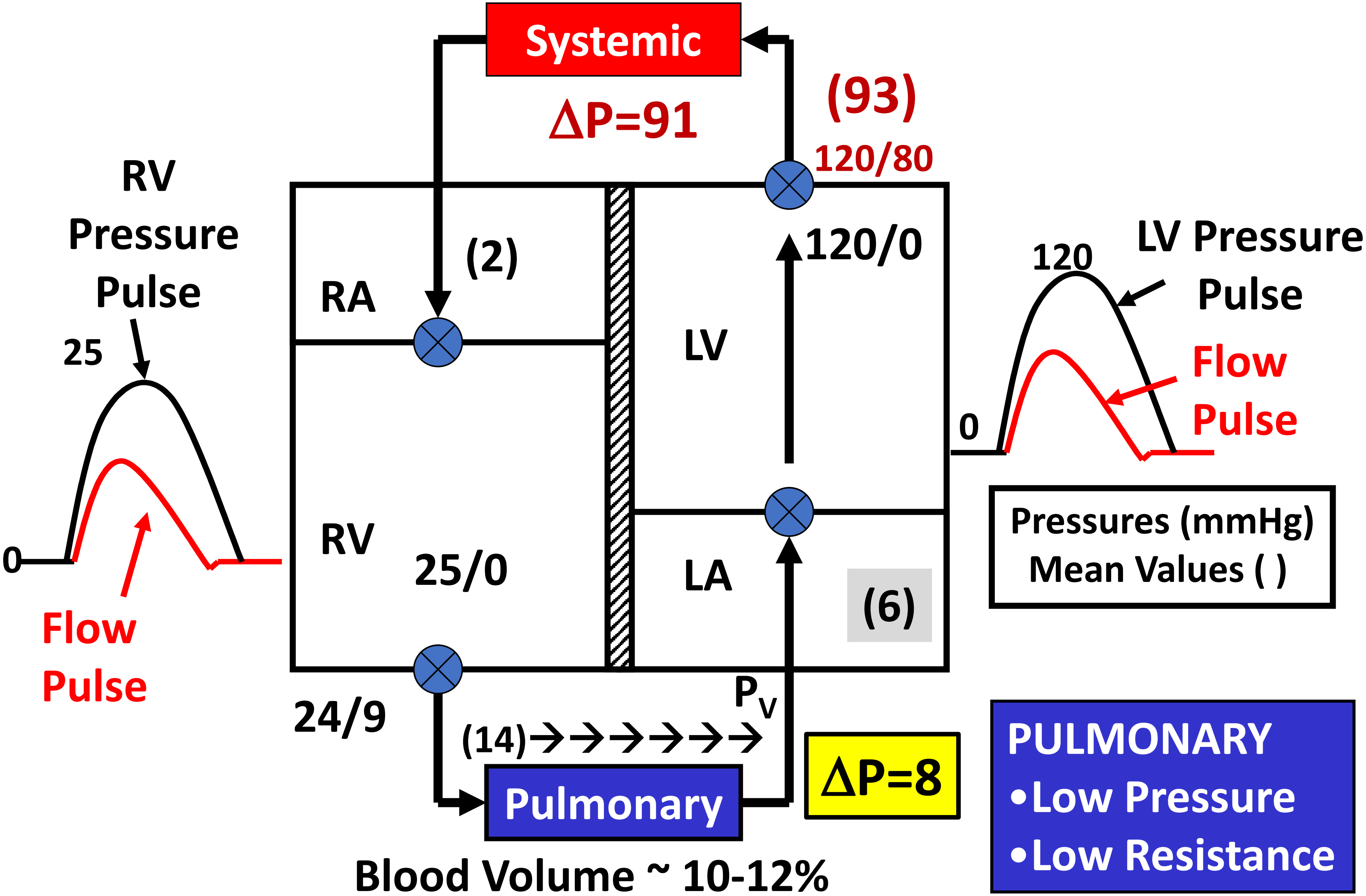
MPAP = Mean Pulmonary Artery Pressure

PVR = Pulmonary Vascular Resistance

Right Sided Pressures

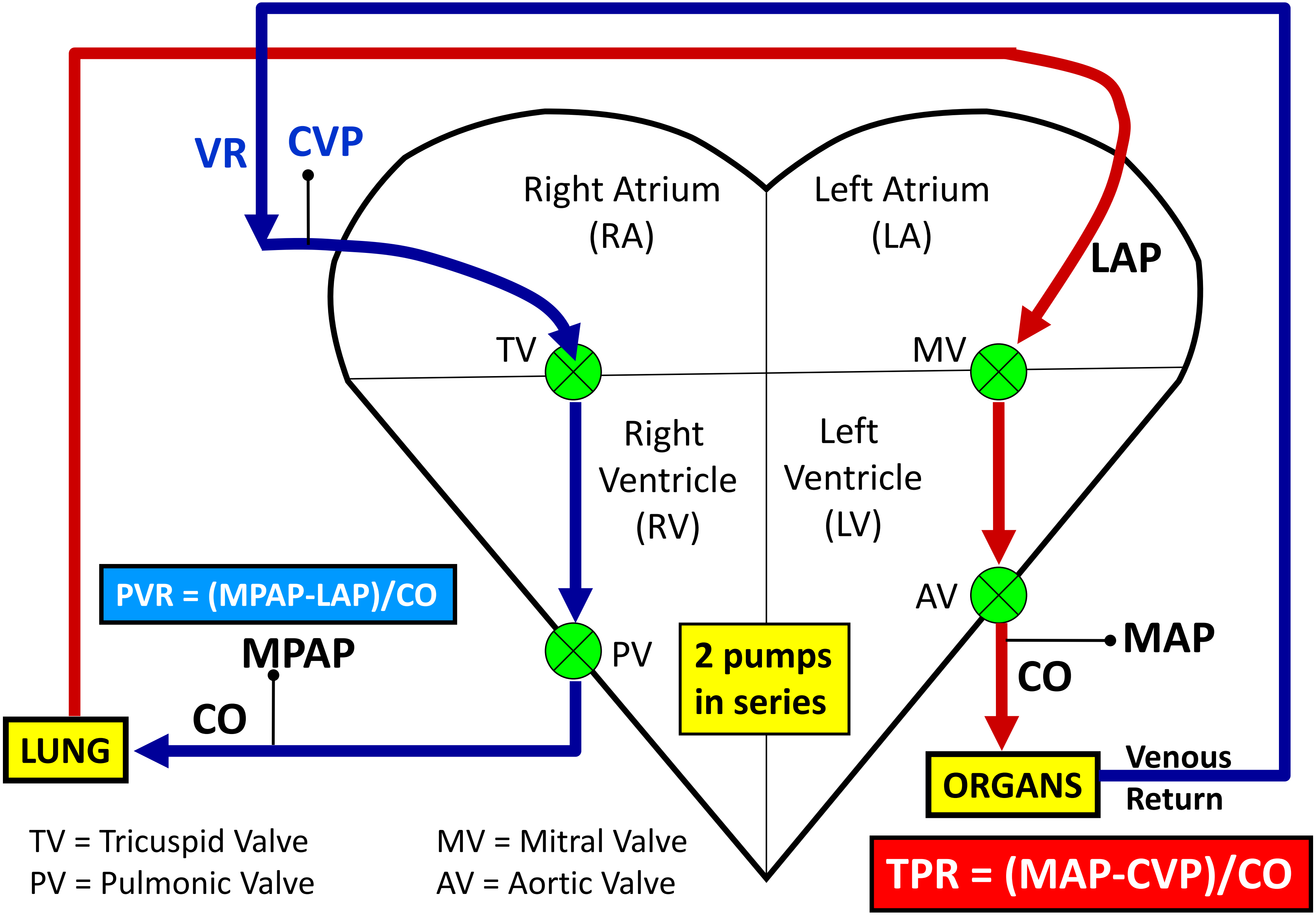


Pulmonary Pressure and Flow Features



PULMONARY
- Low Pressure
- Low Resistance

Pulmonary and Systemic Vascular Resistances



TV = Tricuspid Valve
PV = Pulmonic Valve

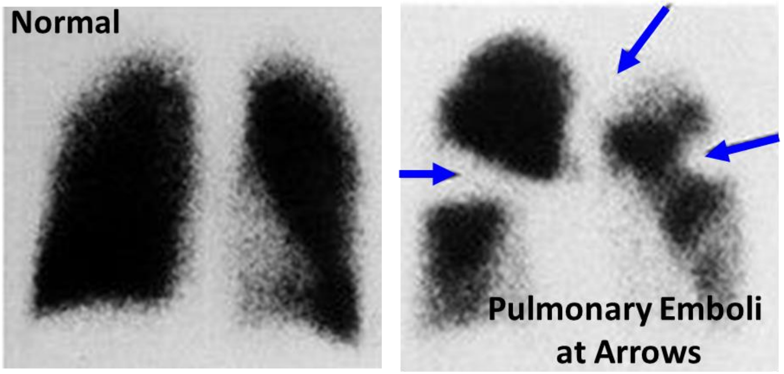
MV = Mitral Valve
AV = Aortic Valve

Clinical Correlations

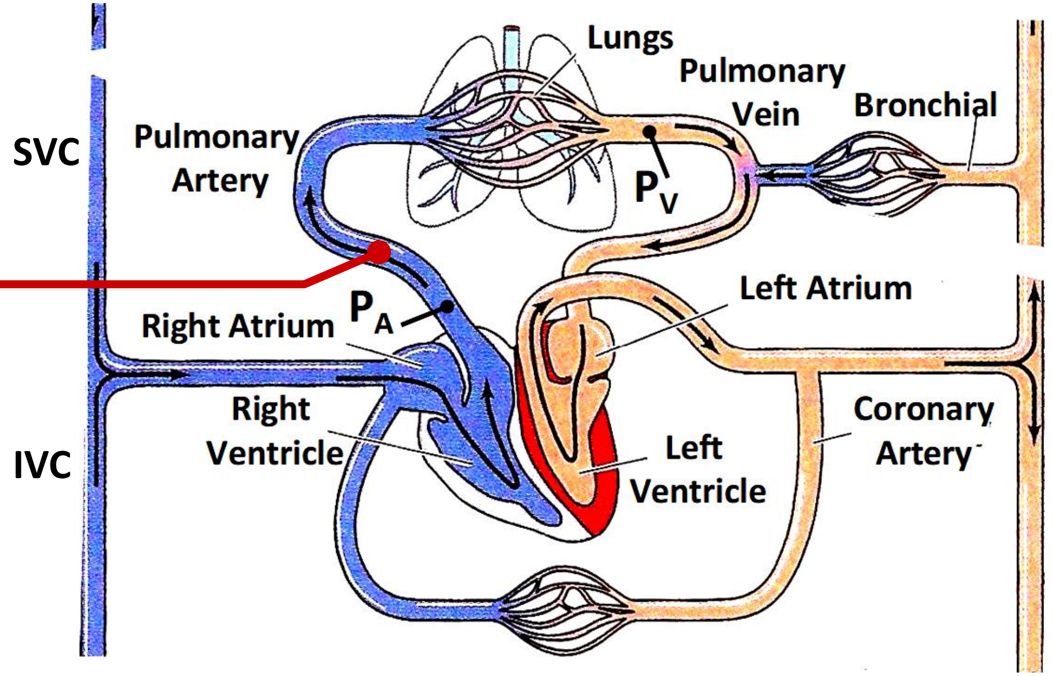
Clinical Correlation: Pulmonary Embolism

- Inject radiolabeled albumin (^{99m}Tc-labeled macroaggregated albumin)
- Detect distribution of radiation (Gamma-camera)

Lung Perfusion Scan



Blood Clot/ Emboli



Clinical Correlation: Pulmonary Artery Hypertension

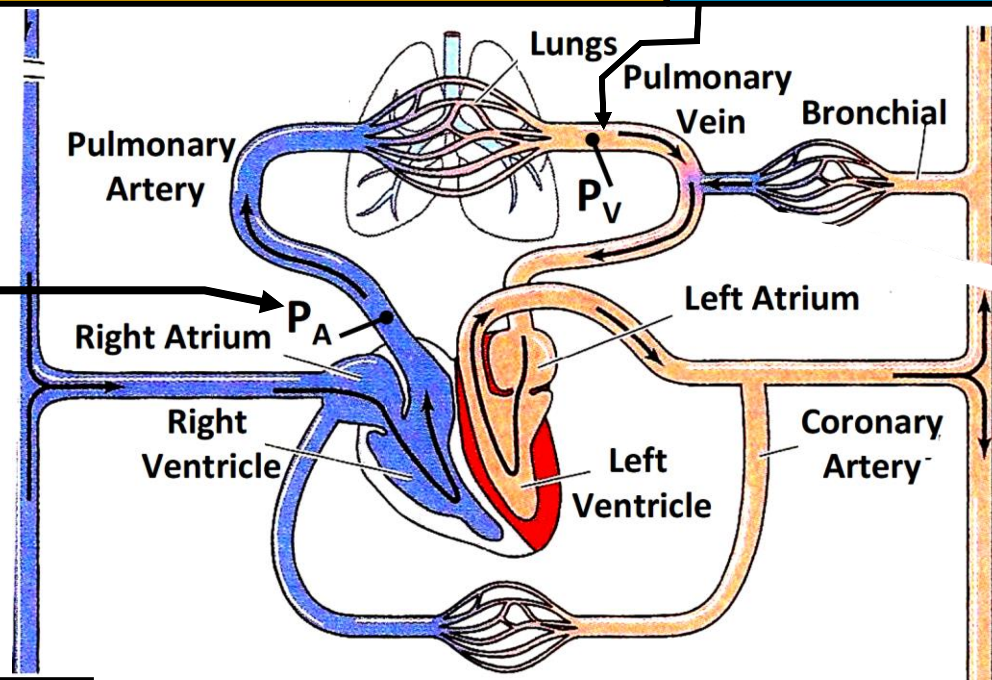
ENDOTHELIAL CELL VASOACTIVE COMPOUNDS

↓ **Nitric Oxide**
Prostacyclin

↑ **Thromboxane**
Endothelin

Vasoconstriction & Wall Hypertrophy
"Precapillary"

CHF
"Postcapillary"

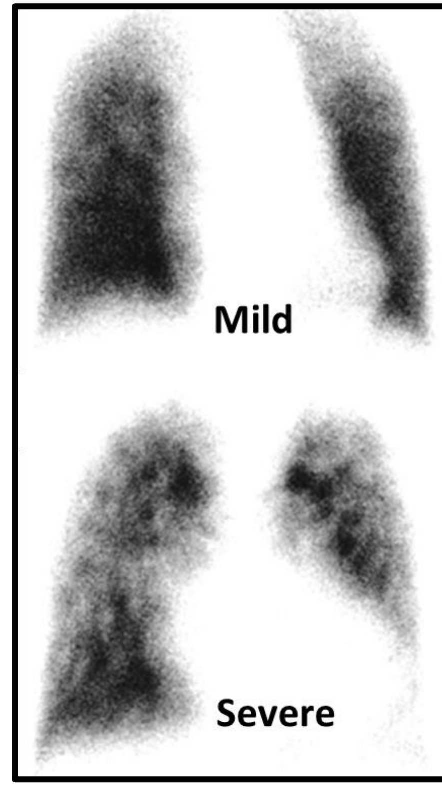


Resting Mean P_A > 25 mmHg

Hoeper, MM
Eur Respir J
2009;34:790-791

Normal P_A
14.3 ± 3.3 mmHg

Perfusion Lung Scans

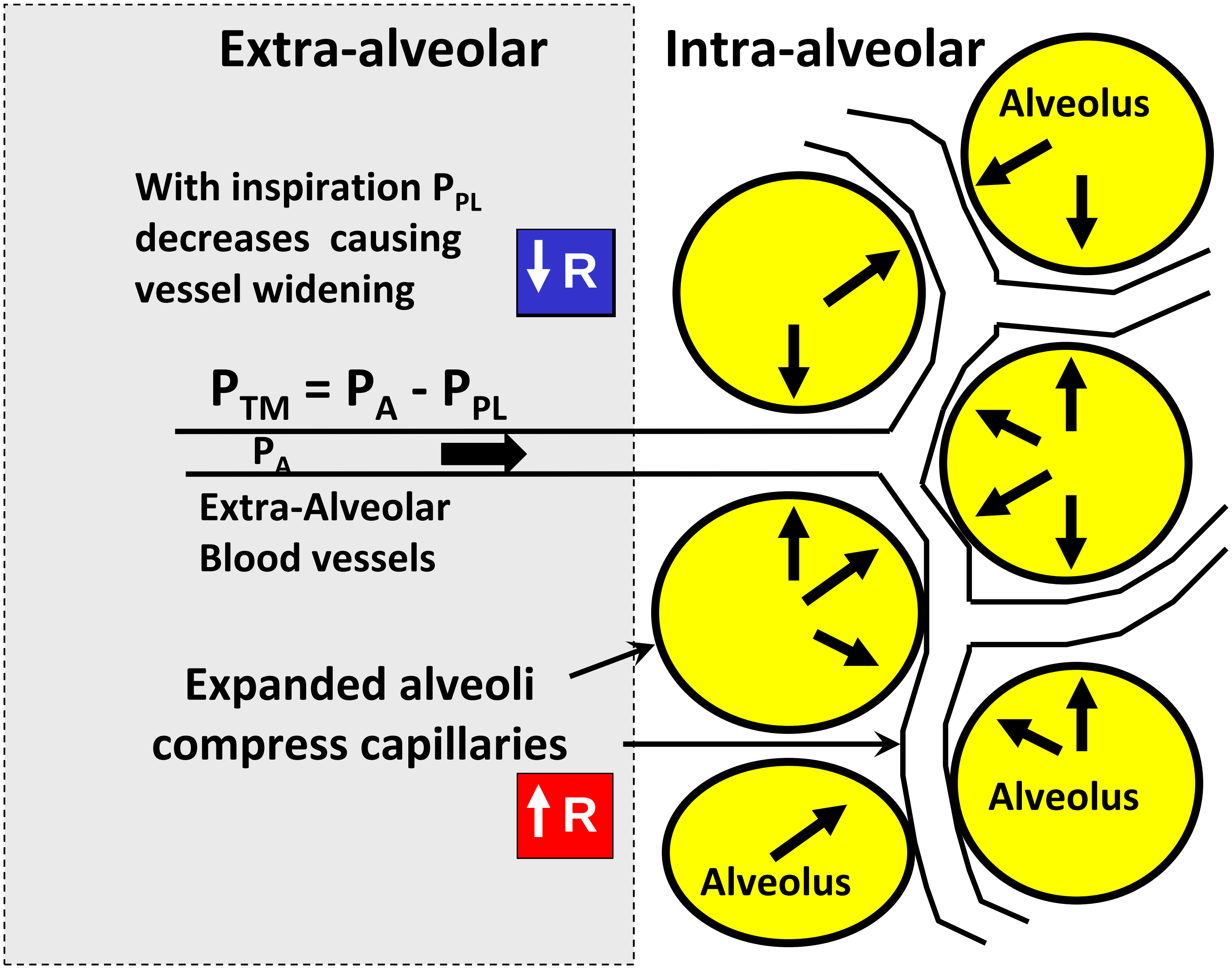


After: Fukuchi et al.
J Nuclear Med
2002;43(6)757-761

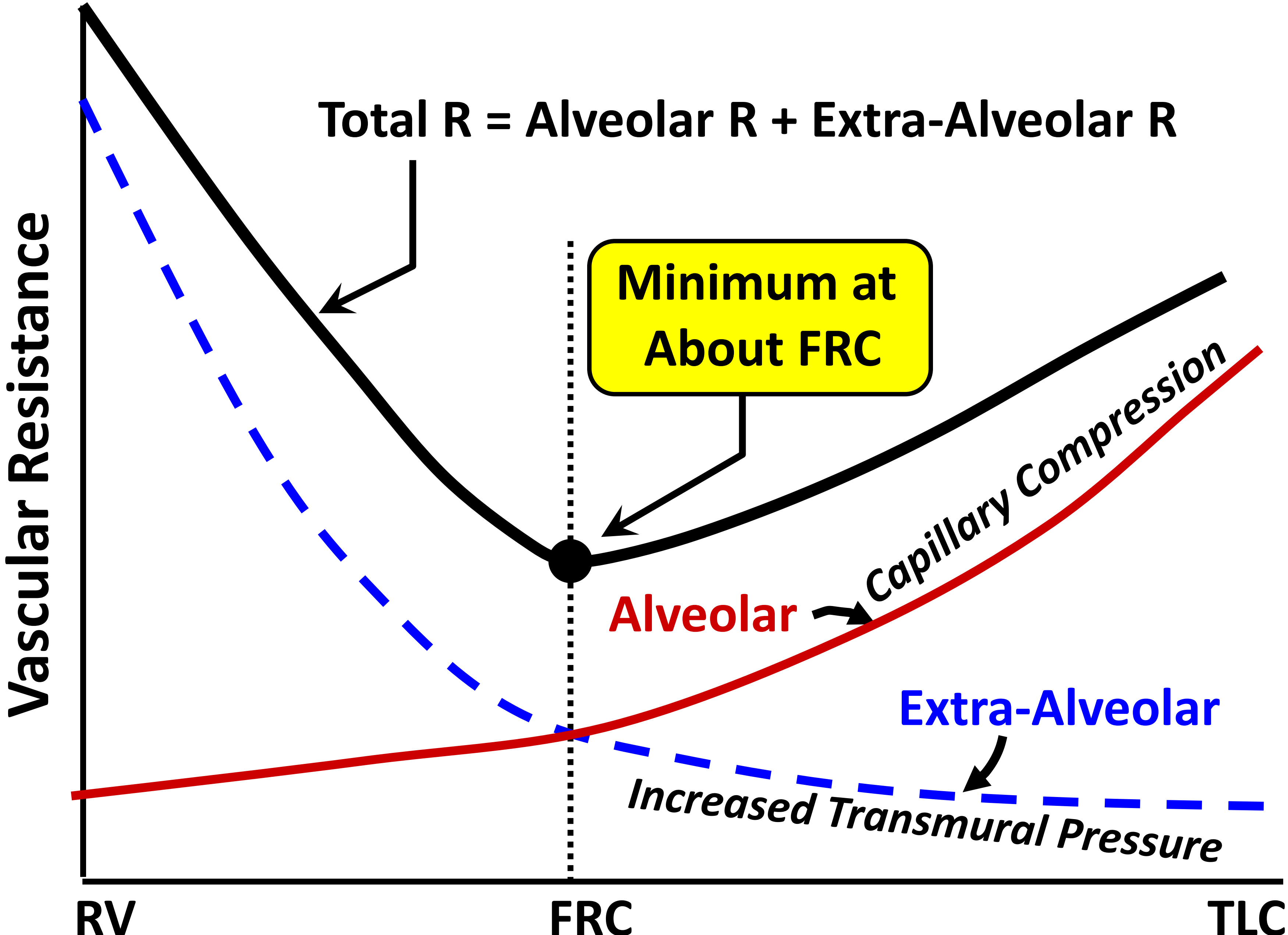
Blood Flow Determinants

Lung Volume Affects Vascular Resistance

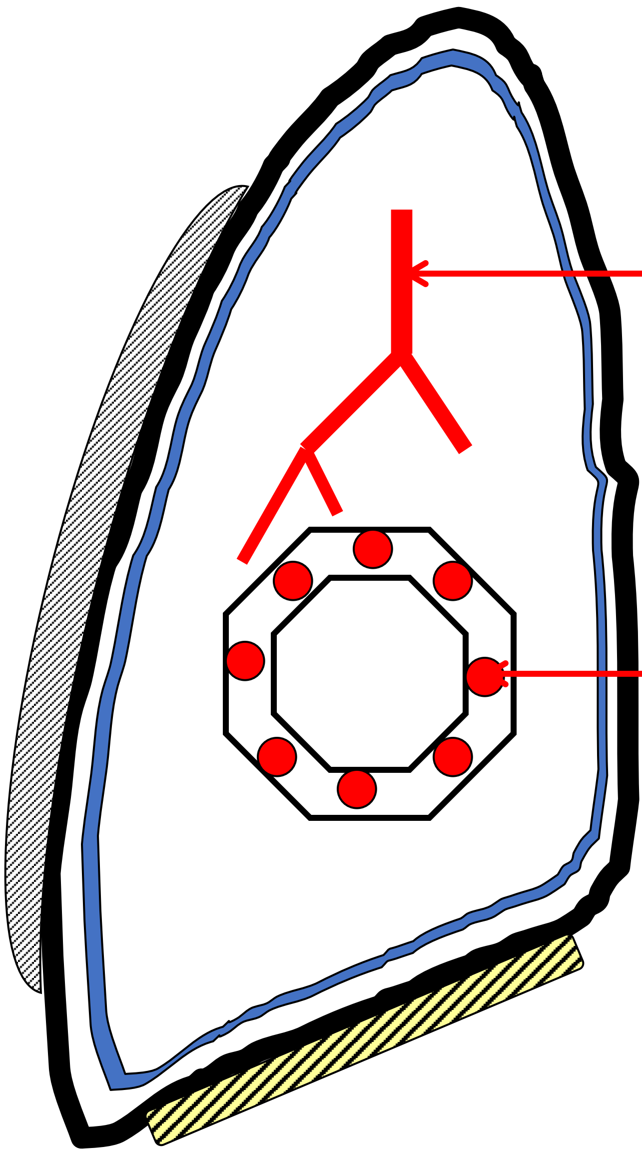
Opposite effects on intra and extra alveolar vessels



Lung Vascular Resistance is minimum about FRC

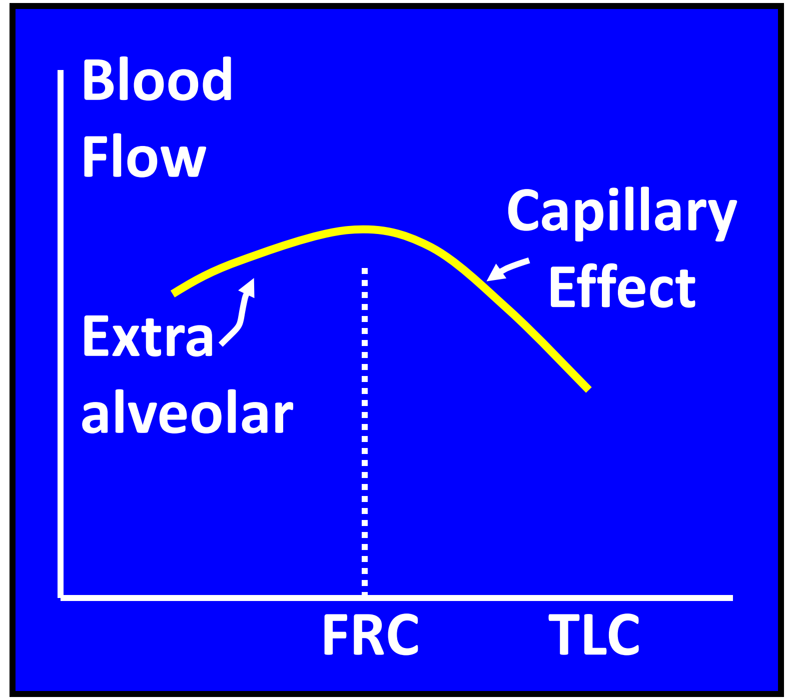


Summary: Blood Flow Varies with Lung Volume

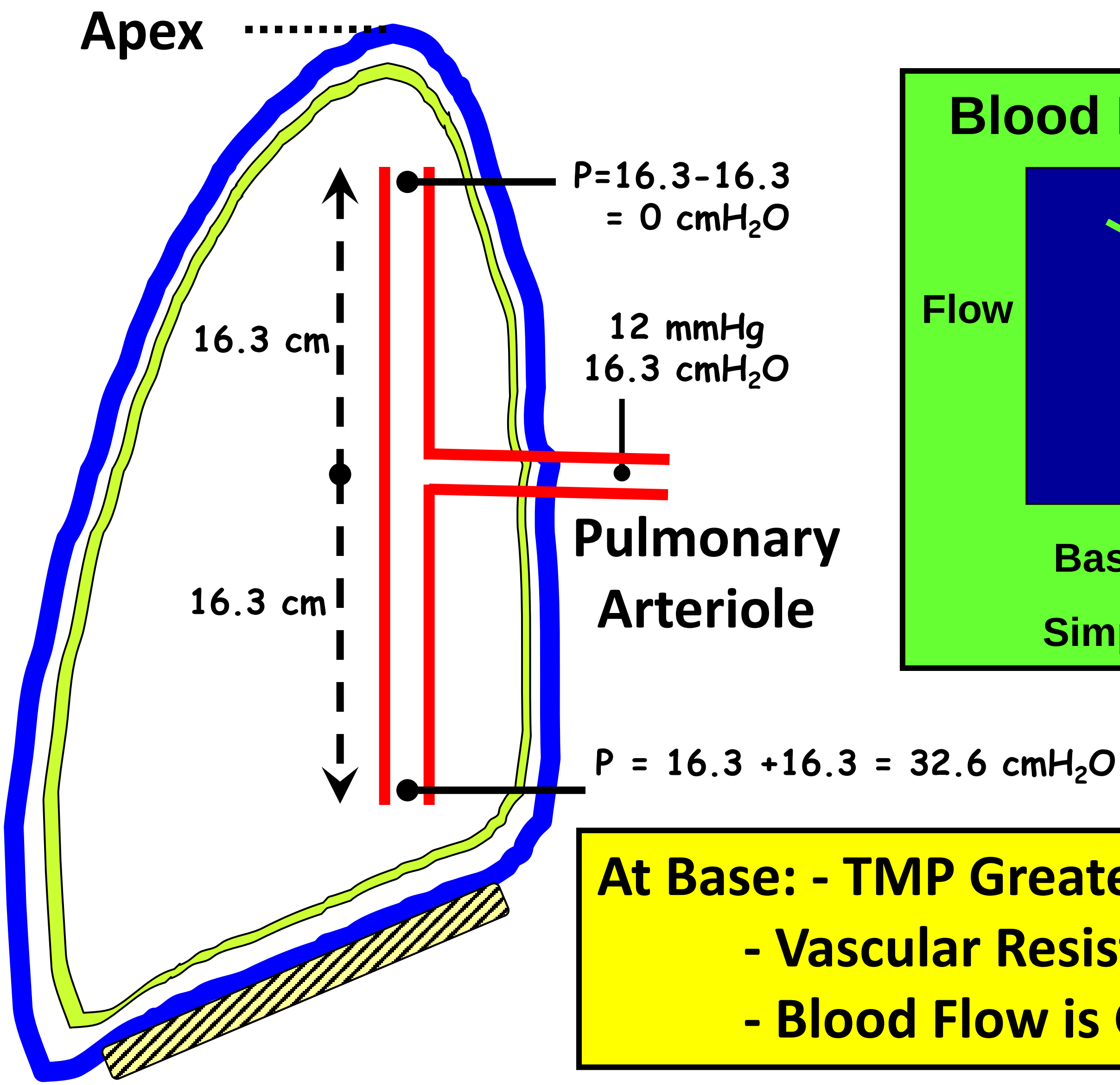


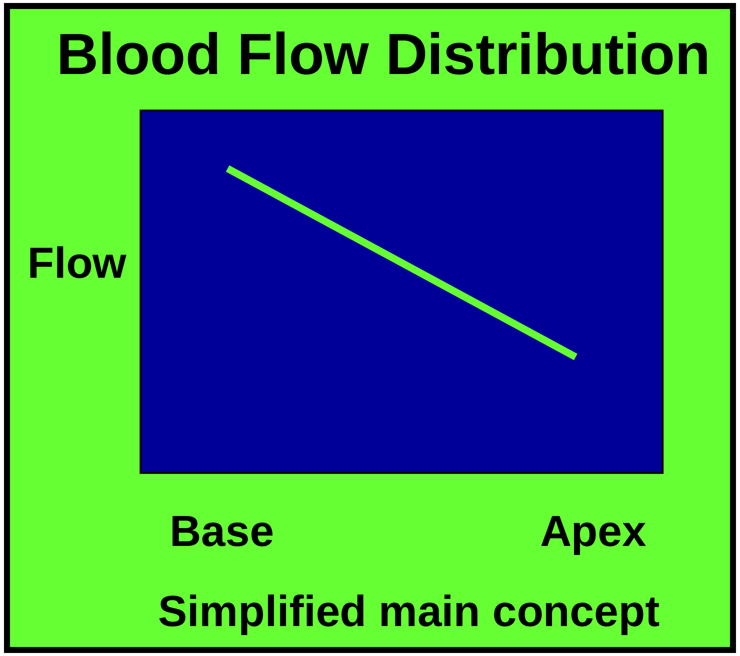
Extra-alveolar blood vessels widen due to traction and P_{TM} increase

Intra-alveolar capillaries narrow and elongate with increased V_L



Gravity Affects Vascular Resistance





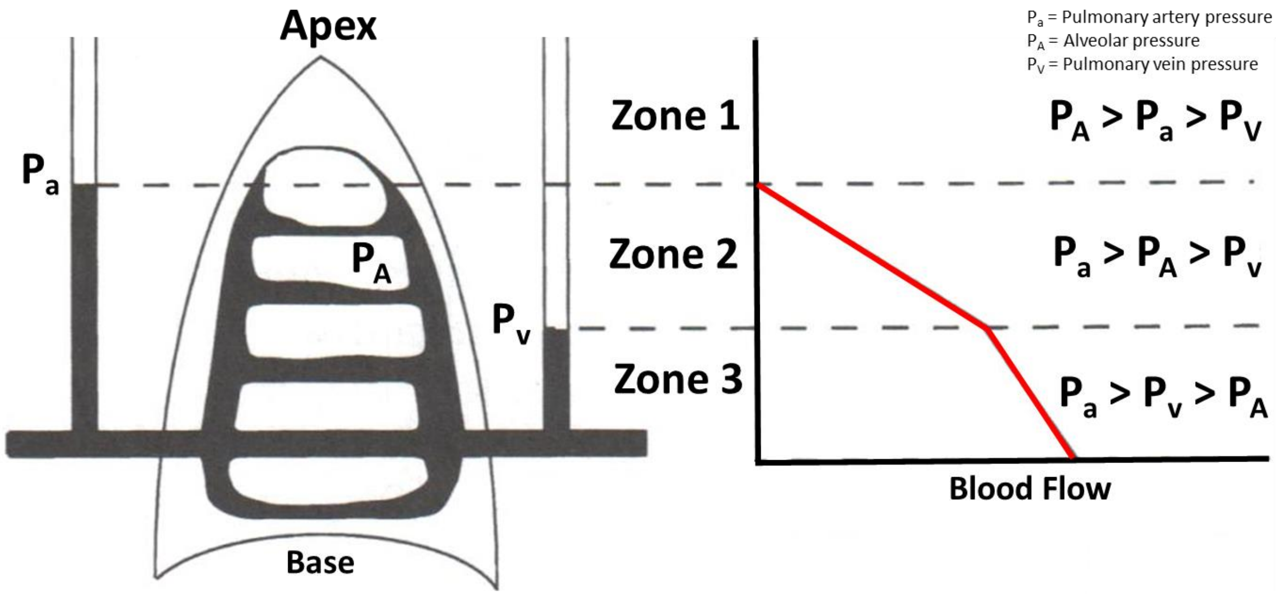
At Base: - TMP Greater

- Vascular Resistance Less

- Blood Flow is Greater

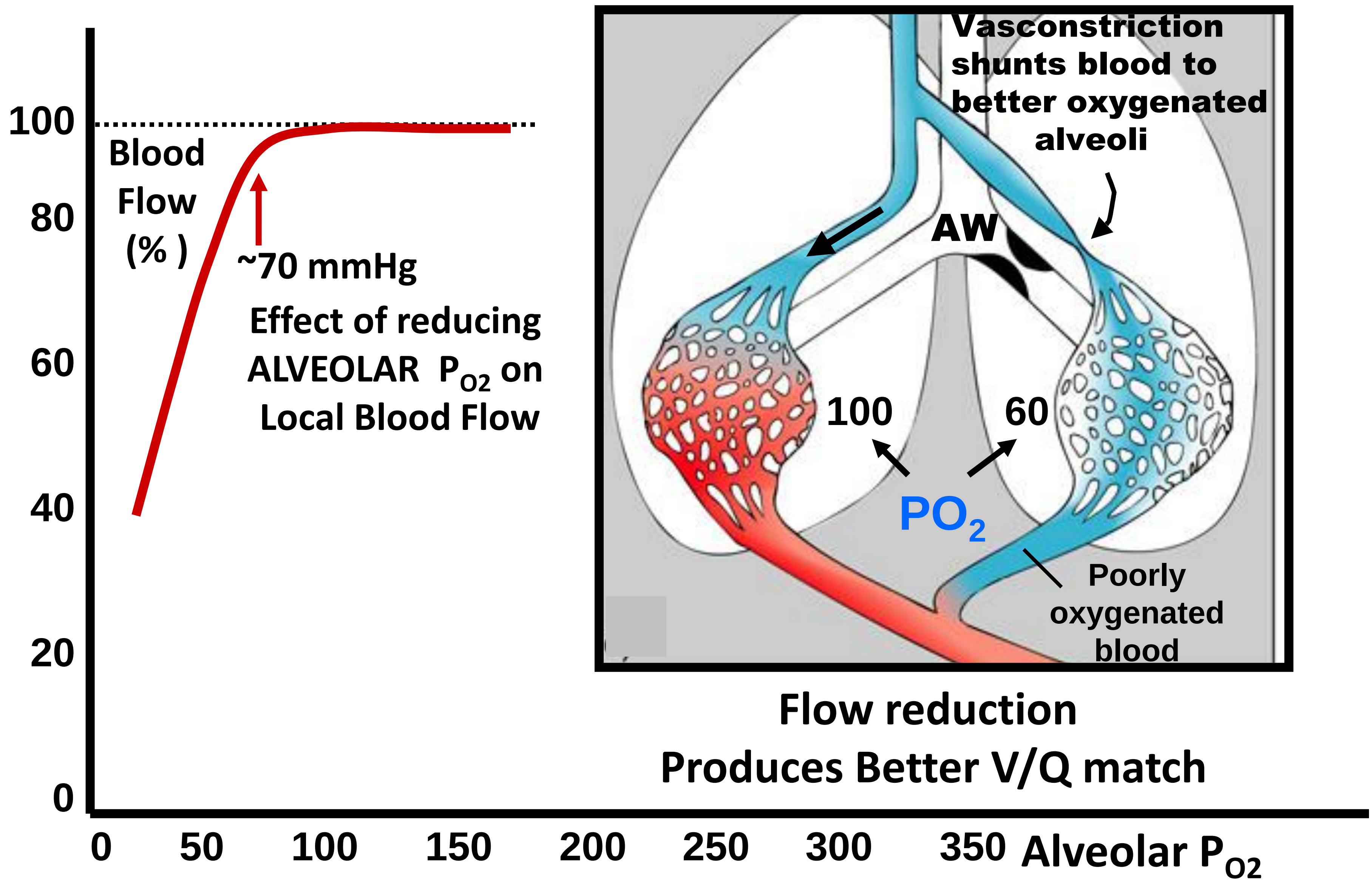
$1\ cmH2O = 0.736\ mmHg$

Gravity: 3-Zone Dependent Lung Model



- Thin-walled vessels can collapse
- If surround pressure (P_A) > P_a then Q =0 (Zone 1)
- Not normally occurring but may occur with
  → low ABP e.g. Hemorrhage
  → positive pressure ventilation
- If collapsible state (Zone 2) Q ~ $P_a – P_A$
  → Could be intermittent pulses of flow
- If non-collapsible state (Zone 3) Q ~ $P_a - P_v$

Hypoxic Pulmonary Vasoconstriction



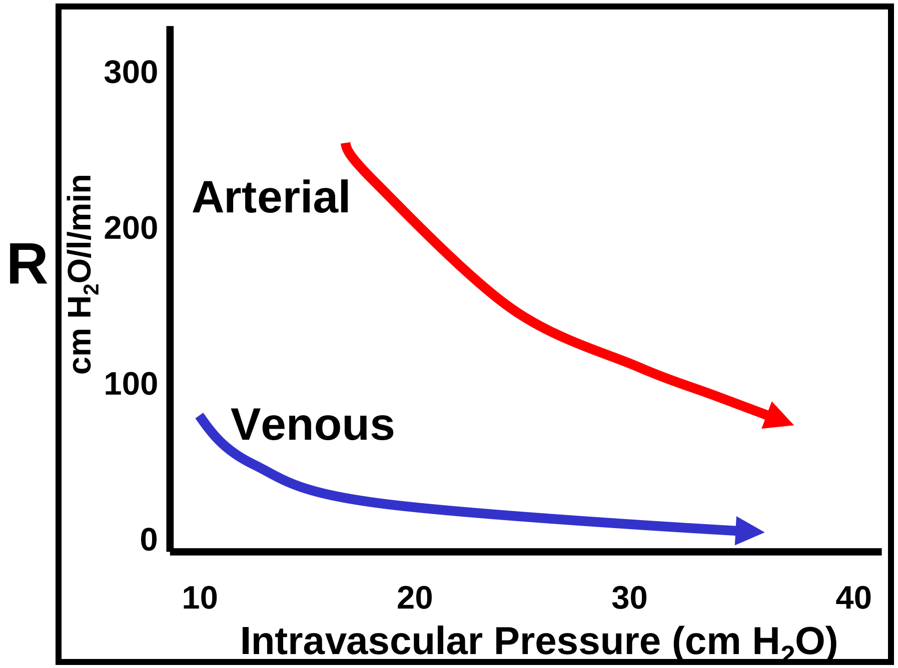
Intravascular Pressure Affects Vascular Resistance

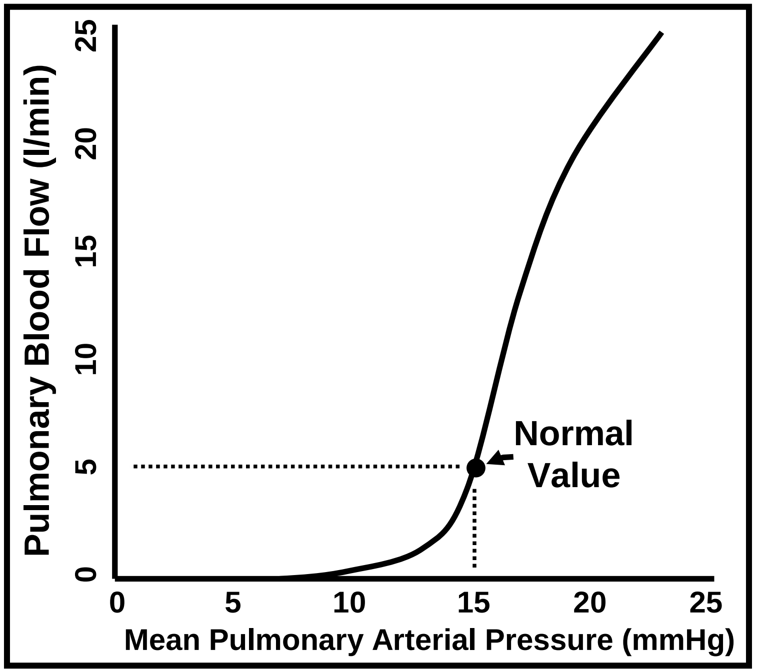
Increased Intravascular Pressure

↓

Decreased Resistance

- **Vessels Widen**
- **Capillary Recruitment**
- **Capillary Distention**





Factors Contributing to Blood Flow Reductions

- *Local Hypoxia* (HPV)------ **Constriction in hypoxic regions**
  Effect: Shifts flow to regions with higher alveolar PA_{O2}

- *Systemic Hypoxia* ------ **General pulmonary constriction**
  Effect: Increased RV and PA pressures - Pulmonary HTN

- *LA pressure increase* ---- **Reflex pulmonary constriction**
  Effect: Protects against pulmonary edema but HTN

Intravascular Obstructions: **thrombi, emboli, parasites etc.**

- ***Obliterative or Obstructive Lung Diseases***

Emphysema ---- tissue loss with loss of capillaries
Interstitial Fibrosis ---- vascular tissue replaced by fibrosis

- ***Pulmonary hypotension*** **---- vessel critical closure ALSO**
- ***External Compression*** **……..**

Interactive Short Answer Questions

1. As you are taking a deep breath what happens to your pulmonary vascular resistance?
2. As you go from a standing to a supine position what happens to the lung base vascular resistance?
3. In which lung zone is the likelihood of alveolar dead space most likely?
4. What is the approximate normal value for the average pulmonary artery pressure?
5. What is the approximate threshold for pulmonary artery hypertension?
6. Increasing transmural pressure in the pulmonary artery does what to vascular resistance?
7. In what way does emphysema contribute to decreased pulmonary blood flow?
8. What is hypoxic pulmonary vasoconstriction?
9. Which segment of the pulmonary vascular tree normally has the least vascular resistance?
10. During inspiration starting at FRC what happens to vascular resistance of alveolar capillaries?

End Respiration Physiology Lecture 2