



# Ventilation/ Perfusion

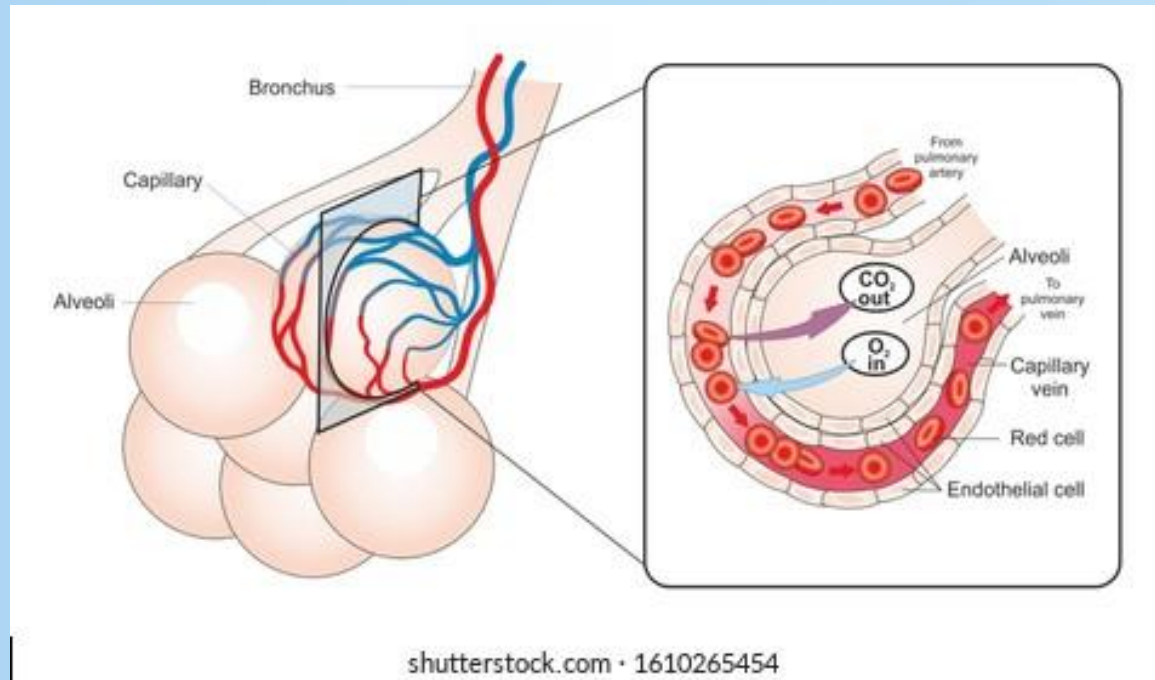
By Justyna Kacarow

# Today's Focus

How your body oxygenates the blood in your lungs

**Ventilation (V)** -  
air flow into the  
lungs

**Perfusion (Q)** -  
blood flow into  
the lungs



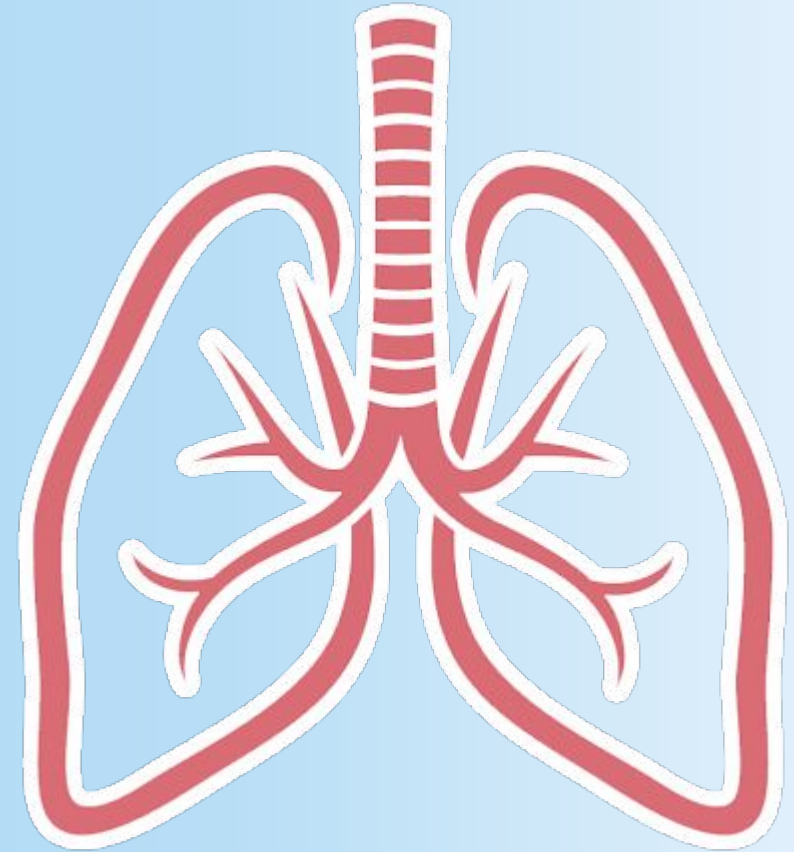
**A** - alveolar

**a** - capillary

# Pulmonary Blood Flow

Not like systemic blood flow!

- Lower blood pressure (25/8!)
- Lower resistance
- **Hypoxic vasoconstriction**



# Hypoxic Vasoconstriction

- Decreases in  $PA_{O_2}$  causes pulmonary vasoconstriction
  - Opposite effect is seen in other vascular beds
- Redirects blood flow to well-ventilated regions of the lung
  - Protective in certain lung diseases (no change in pulmonary resistance)
- Mechanism:
  - Determined by ALVEOLAR  $O_2$  ( $PA_{O_2} < 70$  mm Hg)
  - May also be determined by NO

# Other Regulators

## **Thromboxane A2**

- vasoconstrictor

## **Prostacyclin** (Prostaglandin I2)

- vasodilator

## **Leukotrienes**

- *bronchoconstrictor*

# Summary

Substance	Concentration	Lumen diameter
Oxygen	Decreased ↓	Decreased ↓
NO	Increased ↑	Increased ↑
Thromboxane A <sub>2</sub>	Increased ↑	Decreased ↓
Prostacyclin	Increased ↑	Increased ↑
Leukotrienes	Increased ↑	Decreased ↓

# Distribution of Blood Flow

Uneven due to gravity

- **Zone 1:**

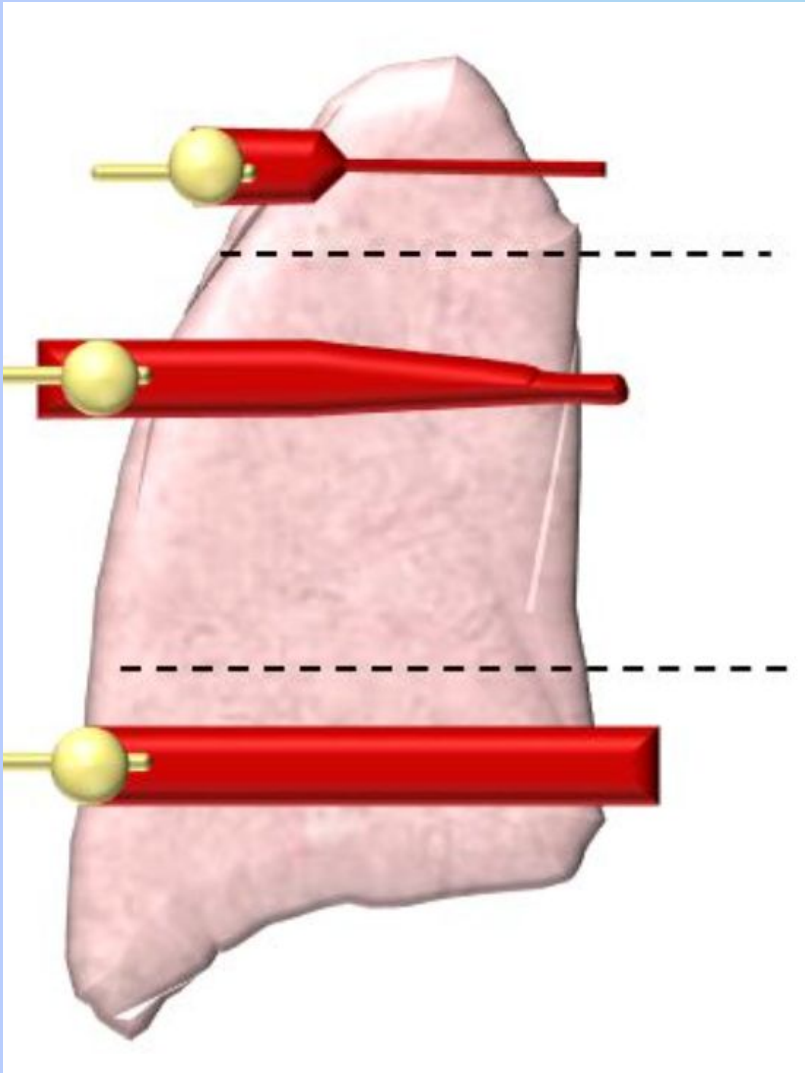
- Alveolar pressure ( $P_A$ ) > arterial pressure ( $P_a$ ) > venous pressure ( $P_v$ )
- Low flow rate

- **Zone 2:**

- $P_a > P_A > P_v$
- Flow is driven by the difference between  $P_a$  and  $P_A$ , not  $P_a$  and  $P_v$

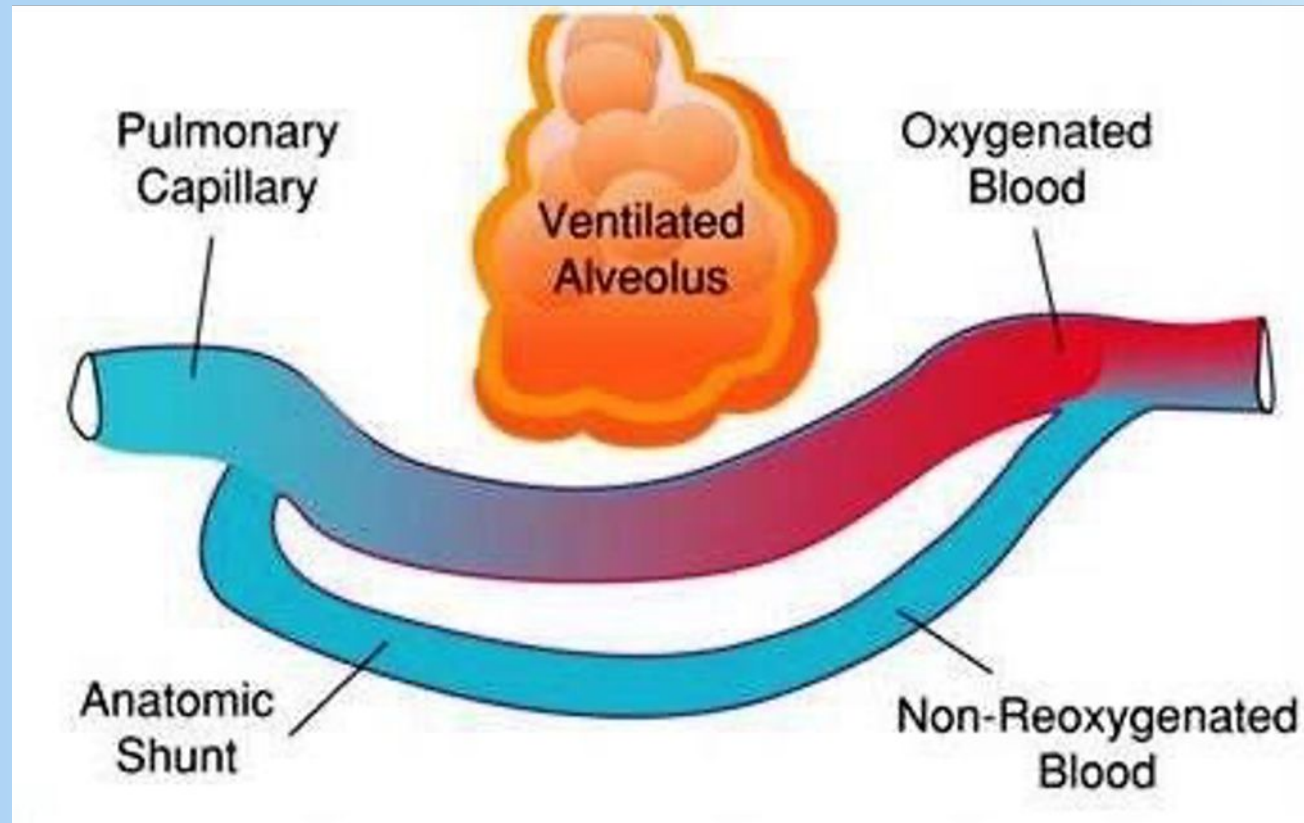
- **Zone 3:**

- $P_a > P_v > P_A$
- Blood flow is driven by  $P_a$ - $P_v$  gradient
- Highest flow rate, most open capillaries



# Shunts

An amount of blood flow that is diverted or rerouted from the alveolus



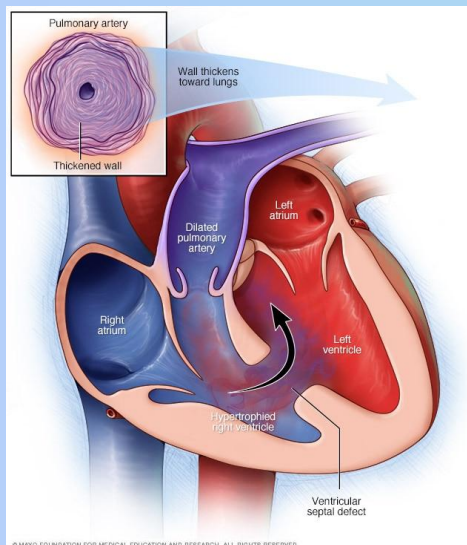
*Can be physiologic - 2% of blood normally bypasses the alveoli!*



# Pathological Shunting

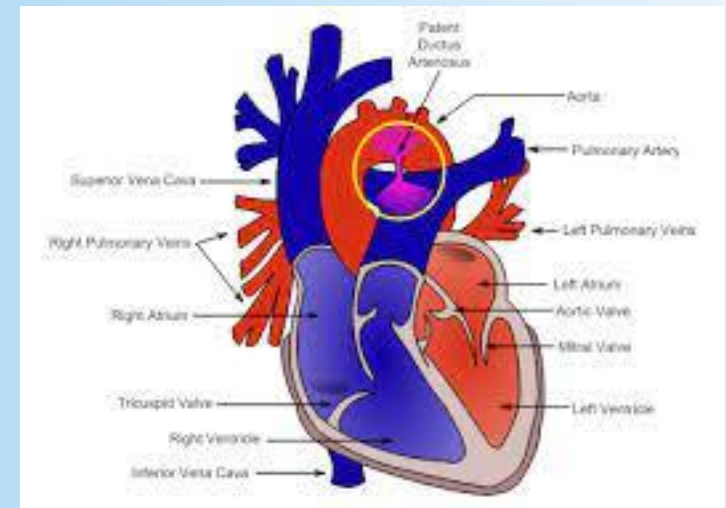
## Right-to-Left Shunting

- ALWAYS results in uncorrectable hypoxemia
- $P_{a_{CO_2}}$  changes minimally
- Eisenmenger syndrome

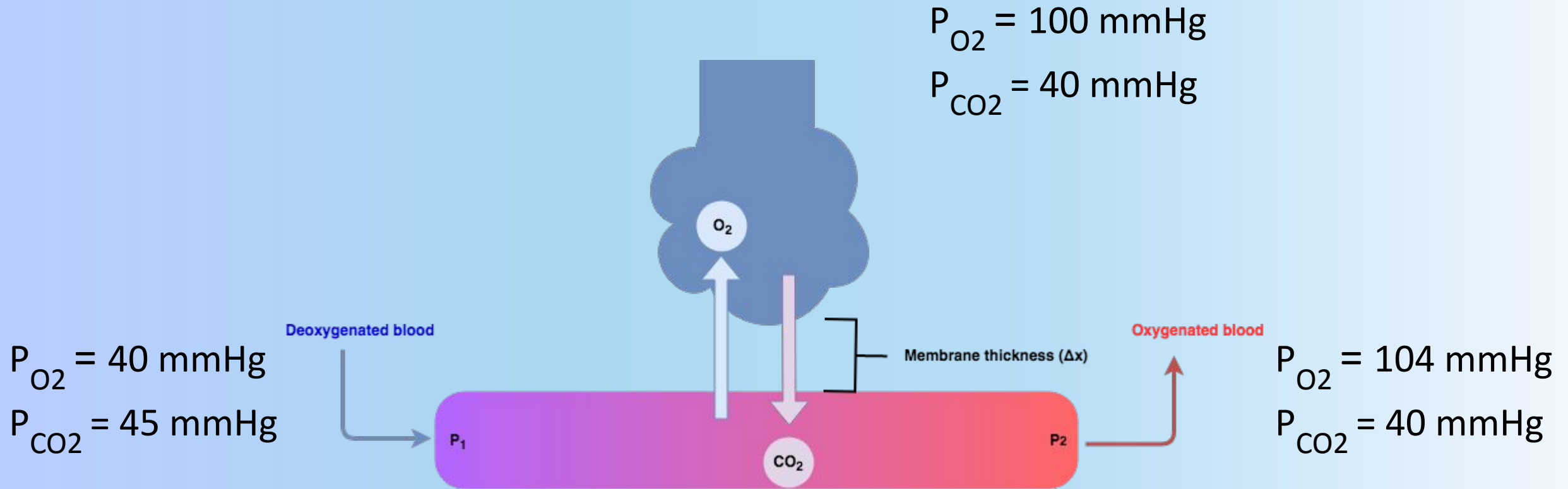


## Left-to-Right Shunting

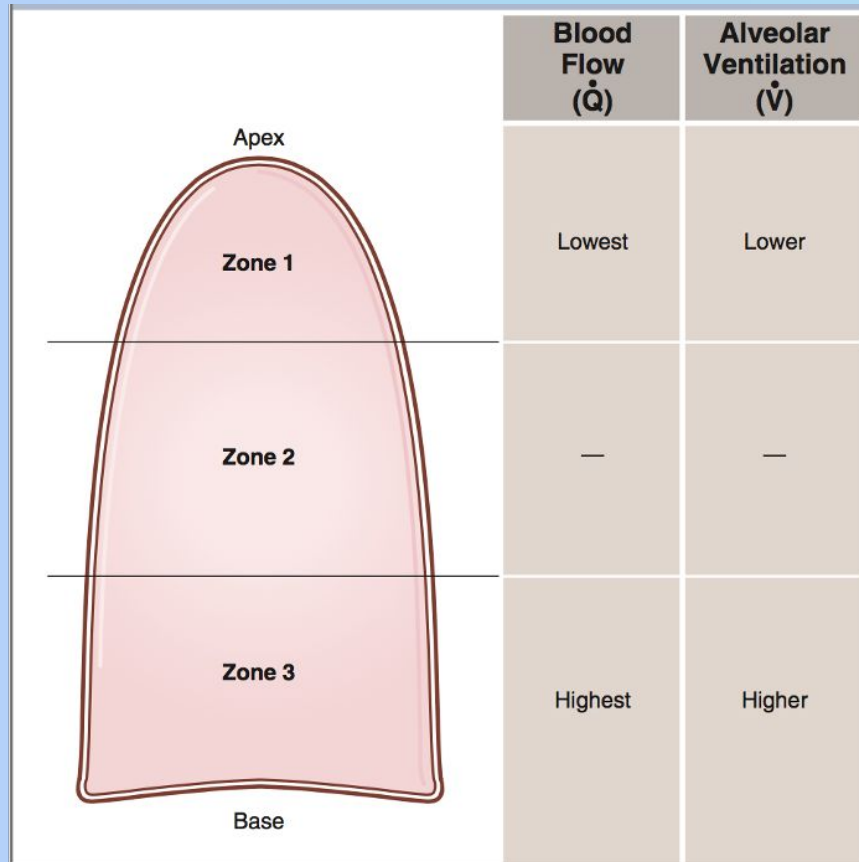
- Does NOT cause hypoxemia
- $P_{O_2}$  increases in right ventricle
- Patent ductus arteriosus



# Diffusion of Gases



# Distribution of Air Flow



	Blood Flow ( $\dot{Q}$ )	Alveolar Ventilation ( $\dot{V}$ )
Apex Zone 1	Lowest	Lower
Zone 2	—	—
Zone 3 Base	Highest	Higher

Also uneven due to gravity BUT less so than blood

$V/Q$  = proportion of blood participating in gas exchange

# V/Q Relationships

V/Q DISTRIBUTION IN THE LUNG					
	Blood Flow (Q̇)	Alveolar Ventilation (V̇)	V̇/Q̇	PaO <sub>2</sub>	PacO <sub>2</sub>
Apex Zone 1	Lowest	Lower	Highest (3.0)	Highest (130 mm Hg)	Lower (28 mm Hg)
Zone 2	—	—	—	—	—
Zone 3 Base	Highest	Higher	Lowest (0.6)	Lowest (89 mm Hg)	Higher (42 mm Hg)

$$\downarrow V / \downarrow Q = \uparrow V/Q$$

Average is 0.8

$$\uparrow V / \uparrow Q = \downarrow V/Q$$

# V/Q Mismatch

## Dead Space ( $V/Q = \infty$ )

- *Ventilated* areas that are not *perfused*
- Alveolar gas = humidified inspired air
- $PA_{O_2} = 150$  mm Hg,  $PA_{CO_2} = 0$

Bl $\infty$ d flow obstruction

## Shunt ( $V/Q = 0$ )

- *Perfused* areas that are not *ventilated*
- Pulmonary capillary blood = mixed venous blood
- $PA_{O_2} = 40$  mm Hg,  $PA_{CO_2} = 46$  mm Hg

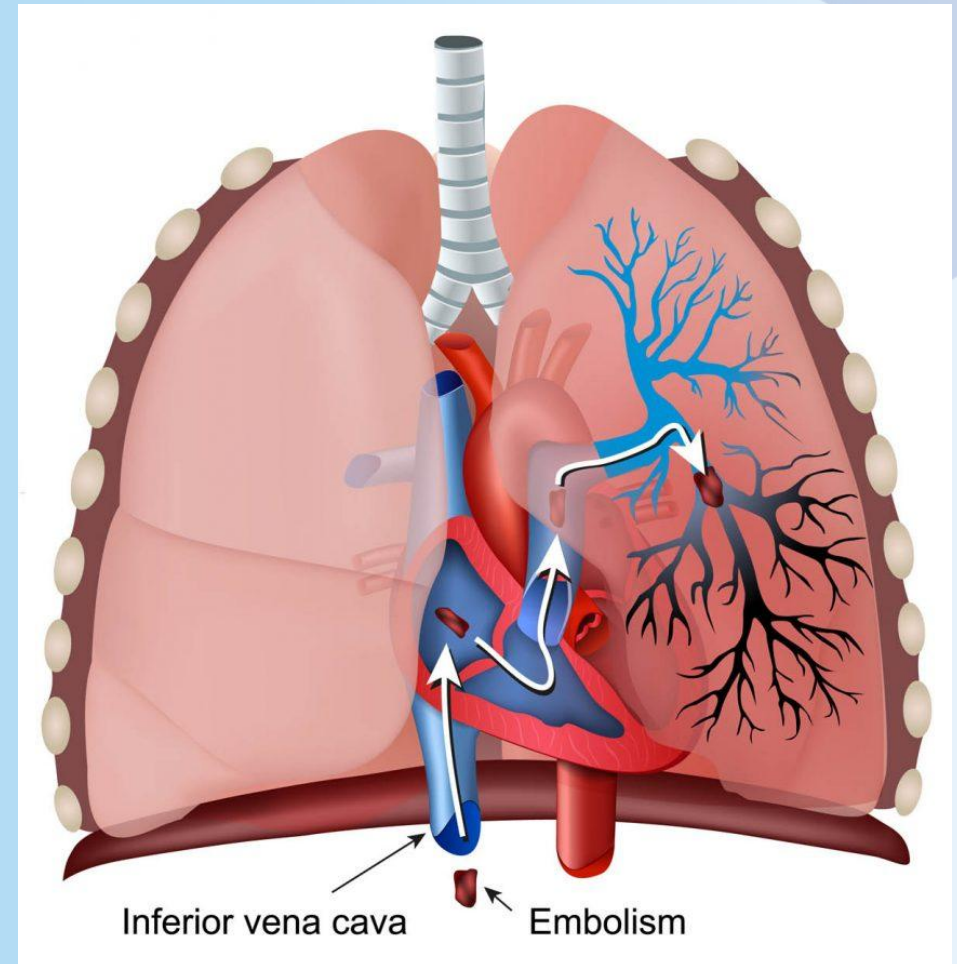
“ $0$ irway” obstruction

# Pulmonary Dead Space

## Pulmonary Embolism

- Blood clot (embolus) obstructs flow to pulmonary tissue
- No oxygen exchange can happen

*Ventilated but not perfused ( $V/Q = \infty$ )*

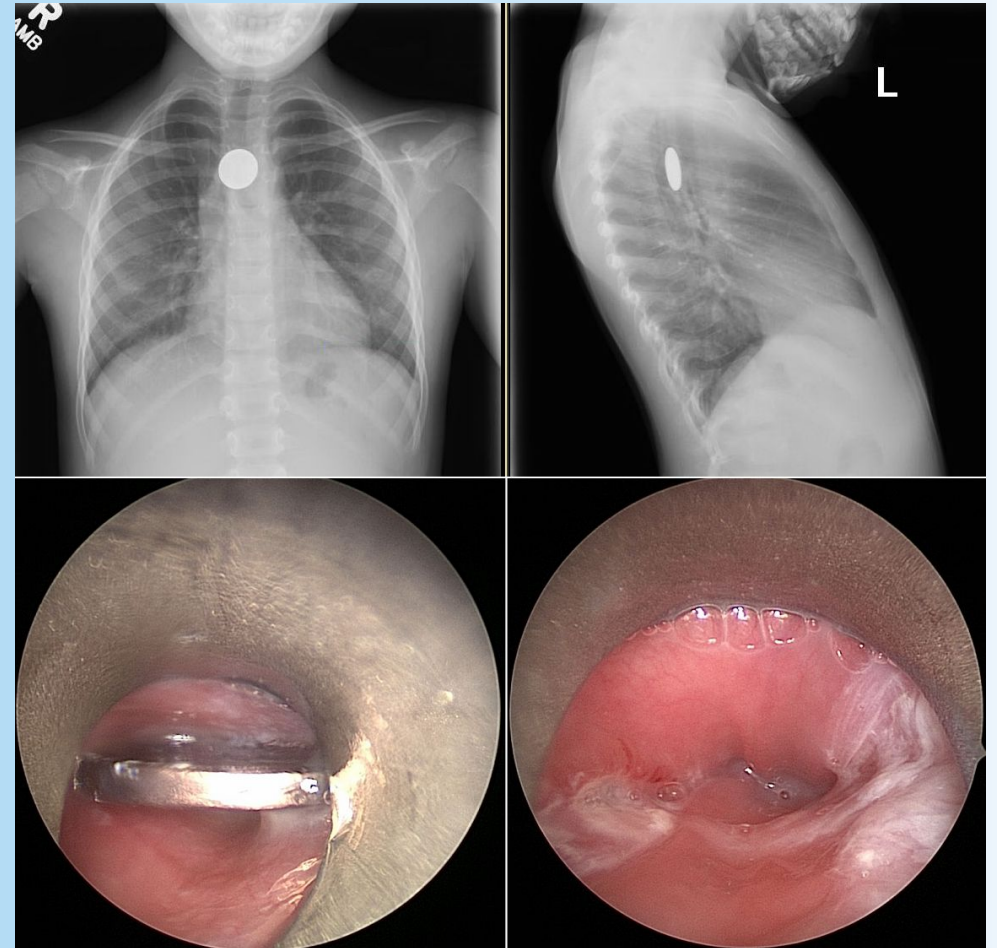


# Pulmonary Shunting

## Foreign Body Aspiration

- Children often inhale small objects
- Object blocks air flow
- No oxygen exchange can happen

*Perfused but not ventilated ( $V/Q = 0$ )*



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