

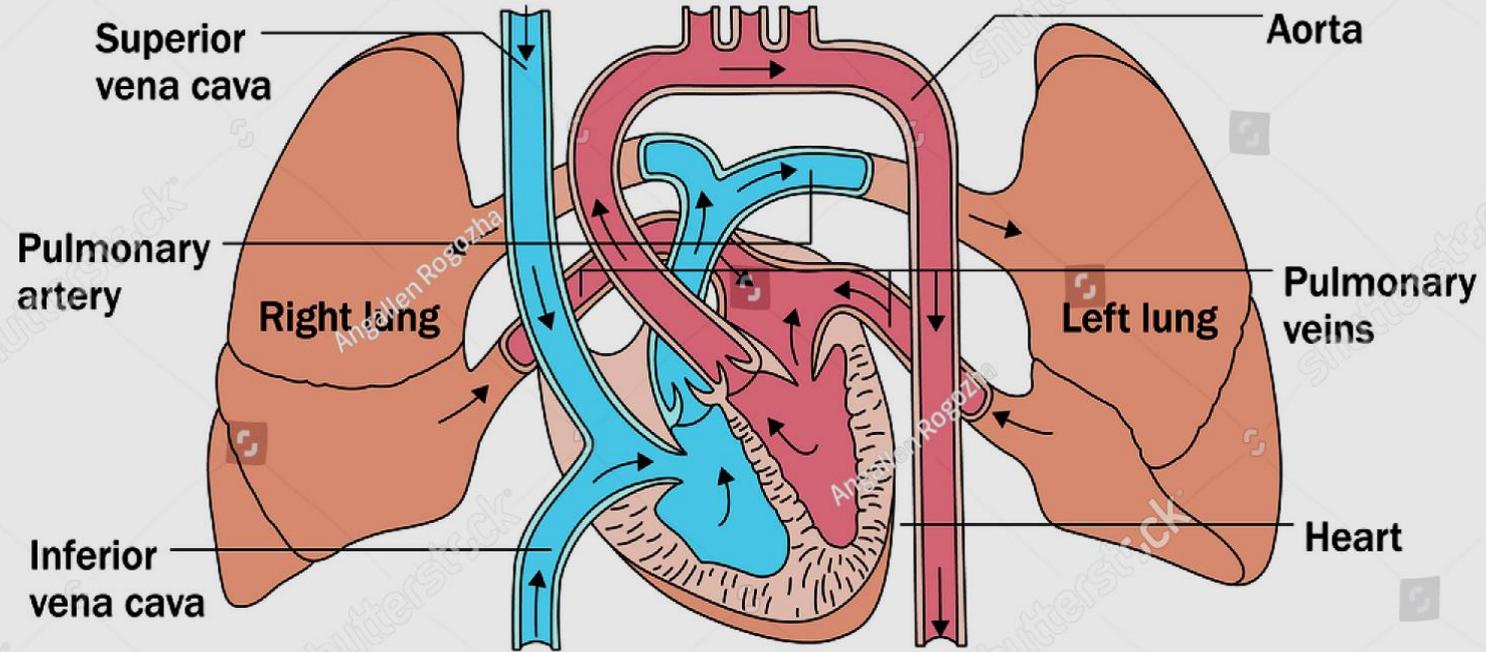
3- Pulmonary Circulation.

By
Dr. Sherif W. Mansour

Prof. of Physiology , Mutah school of Medicine .
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Pulmonary circulation



The pulmonary circulation

The pulmonary circulation is that part of circulation which lies between the **right ventricle and left atrium**.

•**The pulmonary circulation is characterized by:**

- 1)The wall of right ventricle and pulmonary vessels are **30%** of left ventricle and aortic thickness.
- 2)The volume of the blood in pulmonary vessels is about **one liter** of which about 100 ml in capillaries.
- 3)The pulmonary vascular system is distensible low pressure system in which the **pulmonary artery pressure = 24/10 mmHg** (average **15 mmHg**) and the **left atrium pressure = 5 mmHg**, so the driving force for blood return = $15 - 5 = 10$ mmHg (in systemic circulation = $100 - 0 = 100$ mmHg).
- 4)The mean velocity of the blood in the pulmonary artery = 0.4 m/sec. and the blood travel across pulmonary capillary in 0.75 sec. during rest and 0.3 sec. during exercise.
- 5)The pulmonary capillaries are large, with many anastomosis and exposed to **-ve intrathoracic pressure**.

6)The lungs are the only organs which receives **101%** of cardiac output (all C.O.P of Rt. vent + 1% of COP of left ventricle to the **bronchial arteries**).

7)The pulmonary artery carries non-oxygenated blood & the pulmonary veins carry oxygenated blood.

8)The pulmonary odema is **rare** and very serious conditions, if occur **acutely** it leads to death within one hour from sever hypoxia and heart failure.

9)**Safety factors against pulmonary odema are:**

a) Low pulmonary capillary pressure (**10** mmHg) while the osmotic (oncotic) pressure of plasma proteins = **25** mmHg, so alveoli are always dry.

b) **Surfactant** decreases surface tension, which attract fluid towards alveoli.

c) The **rich lymphatic** circulation carries any fluid remains out the capillaries.

* Factors controlling pulmonary blood flow:

1) Nervous control: • Sympathetic stimulation via alpha adrenoceptors → VC of pulmonary bl. vs → decrease bl. flow by 30%.

• Parasympathetic stimulation via muscarinic receptors → VD of pulmonary bl. vs → increase bl. flow.

2) Oxygen & Co₂:

- ↓O₂ & ↑ Co₂ levels as in obstruction of bronchi → **vasoconstriction** of the pulmonary vessels in this area of hypoxia to shift blood to well ventilated area (this occur in **localized** hypoxia).

- But in **generalized** hypoxia (↓O₂ inspired) → generalized VC of pulm. vessels → ↑ pulmonary pressure → opening of closed capillaries → ↑ surface area for **gas exchange** → ↑O₂ supply & Co₂ loss.

3) Chemical regulation:

a- Pulmonary arterioles are **constricted** by: catecholamines, angiotensin-II, thromboxane-A₂ prostaglandin-F_{2α}, dopamine, phenylephrine.

b- Pulmonary arterioles are **dilated** by: acetylcholine, histamine, bradykinin, prostaglandin I₂, Ca⁺⁺ channels blocker, ↑O₂ and endothelium derived substance as nitric oxide.

4) Physical regulation:

a) Effect of gravity:

- In **recumbent** position: **400** ml of bl. is shifted to pulmonary circulation.
- In **standing up**: This blood shifted to lower limb and the **basal parts** of the lung has more blood than the **apical parts**.

b) Effect of cardiac output:

- ↓ COP as in haemorrhage → ↓ pulm. circulation and also pulm. vasoconstriction occur.
- ↑ COP → ↑ pulm. flow with more opening of capillaries.

c) Effect of Respiratory movement:

- **Inspiration** → ↑ negativity of intrapleural pressure → ↑ venous return → ↑ pulm. bl. flow but the pulmonary pressure **decreases** due to **passive** widening of pulmonary vs. under the negative intrathoracic pressure

- **Expiration** → the reverse effects.

- **Forced expiration** against closed glottis (Valsalva' maneuver) → +ve IPP → compression of pulm. vessels → ↓ flow but lead to **increase** in the pulm. pressure.

Functions of the pulmonary circulation:

- 1- Gas exchange
- 2- Defensive function
- 3- Blood reservoir
- 4- Metabolic function
- 5- Removal of thrombi (filtering).

Physiologic shunts:

It was observed that:

- O₂ tension in alveoli & pulm. veins = **100 mmHg**
- O₂ tension in **arterial** bl. = **95 mmHg**

This is because some venous blood (2%) passes directly to the arterial blood without oxygenation in the alveoli :

- 1- Venous blood from some parts of **lung parenchyma** are drained directly into the **pulmonary veins**.
- 2- Some **coronary venous blood** drained directly into the **left heart**.

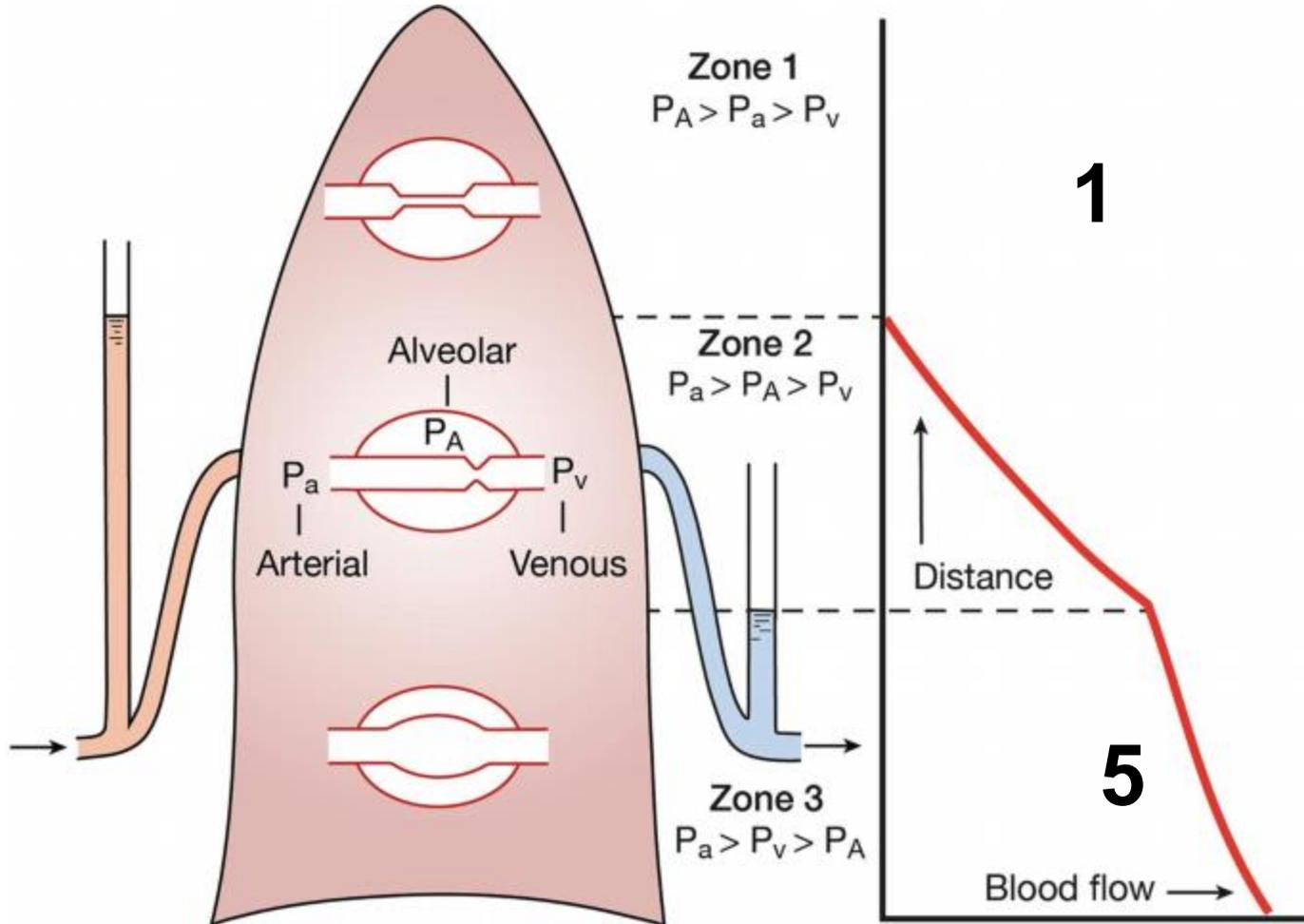
N.B.: Regional pulmonary blood flow: (Gravity effect)

- In **upright position** the pulmonary blood flow at **base** of the lung = **5** times as at lung **apex** and the pulmonary pressure in **base is higher than at apex** by **23** mmHg.
- The pulmonary blood flow depends on either the pressure inside the capillaries and outside the capillaries (alveolar pr.). So, the lung can be classified into **3 zones** according to blood flow in relation to cardiac cycle:

Zone I: **No blood flow** at all (alveolar pressure > capillary pressure)

Zone II: Blood flow occurs **only during systolic pressure** but the diastolic pressure is less than alveolar pr.

Zone III: **continuous blood flow** as the blood pressure is always above alveolar pressure in both systole & diastol.



-**In normal healthy lung** during **standing**, there are **zone II (Apex)** and **zone III (at base)** and during **recumbent position** all lung are of **zone III**.

So, in cases of **hypertension** with more blood flow to the lung during lying down lead to severe **dyspnea**.

-**Zone I** presents abnormally if the person breaths air under **positive pressure** in which intra-alveolar pressure reaches **10 mmHg** also occur in **hypovolemic shock**.

-**During muscular exercise** the pulmonary blood flow increases in all parts of the lung via opening of new capillaries especially the **apex** which was already closed capillaries during **rest**.

Thank You

