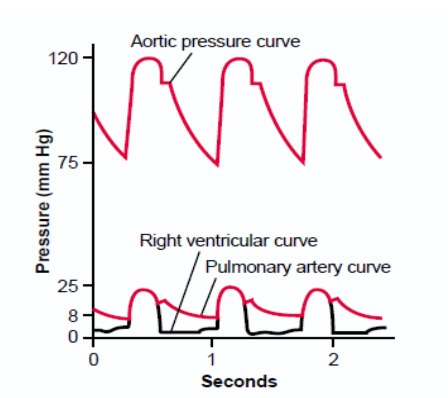
<u>Pulmonary circulation</u>

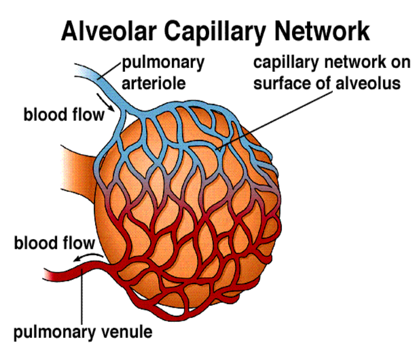
<u>Lung Blood supply</u> : lungs have a unique blood supply system :

1. Pulmonary circulation
2. Bronchial circulation

1- Pulmonary circulation :

- receives the whole cardiac output like the systemic circulation 5L/min
- pulmonary artery is thin and the wall thickness is 1/3 of aortic artery. it carries the deoxygenated blood from the right ventricle to the blood-gas interface in the lung .
- Arteries and arterioles are thin , distensible , large diameter and have little smooth muscle in the wall → **large compliant** vessels.
- Pulmonary capillaries form capillary basket.
- low vascular resistance : 5 folds less than the systemic circulation and the mean pulmonary artery pressure is low 15 mmHg (25/8 mmHg) .
- Pulmonary veins are short, highly distensible and carry oxygenated blood from the lungs to the left atrium of the heart





2- Bronchial circulation :

- It is a part of the systemic circulation. It supplies trachea down to the terminal bronchiole and pleura with O2 and nutrients.
- It empties into bronchial veins and make anastomosis with the **pulmonary veins** which drain into **Lt atrium** rather than to the Rt atrium →↑ left ventricle output 1-2% and decrease Hb saturation with O2

Pulmonary circulation	Bronchial circulation
Arises from the RV	Part of systemic circulation
Receives entire cardiac out put 5L/m	Receives 1-2 % of Cardiac out put
Carry deoxygenated blood	Carry oxygenated blood
Low pressure	High pressure
Low resistance , High compliance	High resistance , low compliance
Supplies the gas exchange area	Supplies the conducting and supporting structure
Drains into pulmonary veins then LA	Makes anastomosis

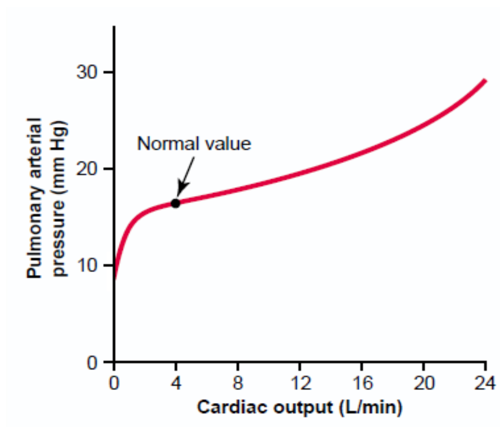
Lymphatics :

- Lymphatics channels are more abundant in the lung than in other organs. size range from 1 mm at the bronchial periphery to 10 mm along the trachea. Drains in unidirectional way into right thoracic duct
- maintain negative pressure →help in preventing pulmonary edema

Regulation of pulmonary blood flow :

A. **Cardiac output :increase** pulmonary circulation which can accommodate increasing blood flow in exercise by :
   1. ↑ number of open capillaries
   2. Distend all capillaries

   These two factors ↓pulmonary vascular resistance →very little rising in pulmonary arterial pressure even during maximum exercise.



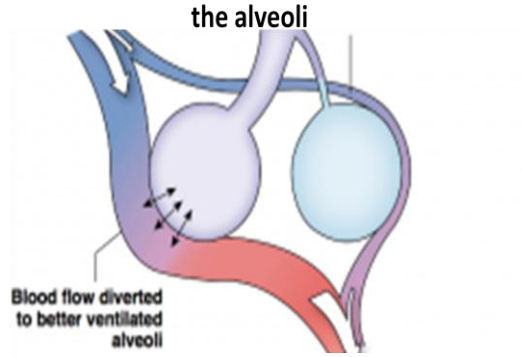
B. Autonomic control :

Sympathetic → vasoconstriction through α1 Receptores → ↓pulmonary blood flow

C. Local tissue factors :

- In contrast to systemic circulation: Pulmonary vessels constrict when **PO2↓** (**Hypoxic vasoconstriction**) by O2-sensitive potassium channels in pulmonary artery smooth muscle cells. their conductance is ↓in proportion to the degree of hypoxia → ↓K efflux →depolarization →activates voltage-dependent calcium channels→↑intracellular calcium →smooth muscle contraction → vasoconstriction
- While systemic arteries contain ATP dependent K channels that permit more K efflux with hypoxia and cause vasodilation instead of vasoconstriction

Low PO2 → arteriolar vasoconstriction around the alveoli



Blood flow delivered to the better-ventilated alveoli

- This reflex has advantages for **optimizing pulmonary function by shifting blood away from poorly ventilated areas to well-ventilated area(blood-gas exchange occurs).**

D. chemical factores :

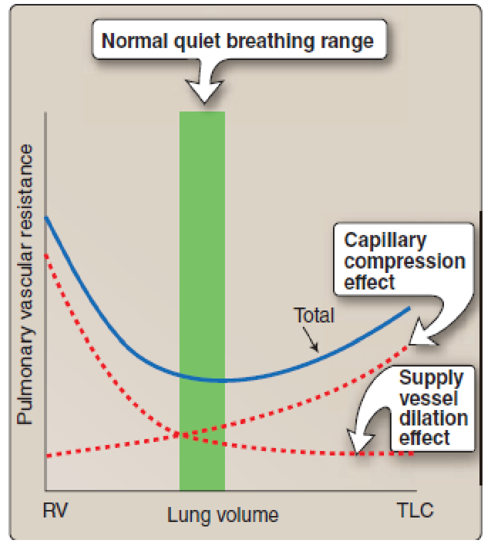
1. Angiotensin II and serotonin(5- HT1 receptor) ,thromboxane →contraction of smooth muscle fibers of pulmonary blood vessels wall →↓blood flow (vasoconstrictors)
2. Histamine and bradykinin →relaxation of smooth muscle of blood vessels wall →↓ resistance →↑blood flow (vasodilators)

E. **<u>lung volume :</u>**

1. Above FRC (large lung volume) → expand lungs→ pulling force transmitted to the supplying blood vessels embedded in lung parenchyma(arteries and arterioles) → dilation and resistance ↓. On the other hand, the septal capillaries in the alveolar walls are stretched so that their diameters ↓. The net effect is ↑in overall pulmonary vascular resistance.

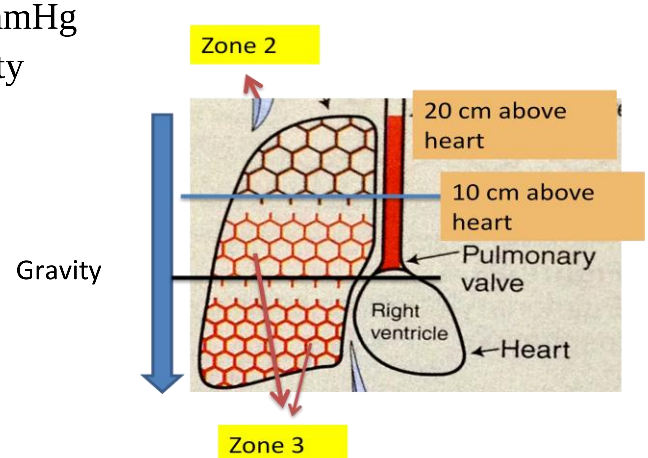
2. Below FRC (small lung volume): Although the resistance of the capillaries ↓ (no compression by alveoli) , the pulmonary vessels outside the alveoli tend to collapse as their walls are no longer being stretched by the surrounding lung tissue→↑ their resistance.

3. **<u>Net results :</u>**
   - pulmonary vascular resistance increases in large and small lung volume.
   - Resistance are lowest during quiet Breathing (FRC)



F. <u>gravity :</u>

1. Pulmonary blood pressure :
   - is 25/8 mmHg at the level of pulmonary valve in the heart .
   - In supine position : arterial pressure is equal in apex and base(no gravity effect) .
   - In erect position : arterial pressure ↓ 0.77mmHg / cm to each 1 cm above the heart and increases 0.77 mmHg for each 1cm below the heart (gravity effect).

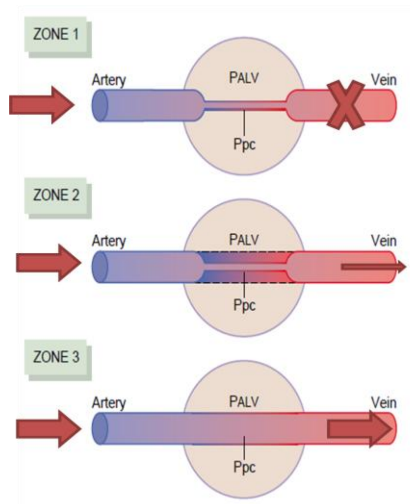


2. Regional differences : based on blood flow through pulmonary vessels , lungs can be divided into 3 zones
   a) Zone 1(no flow) :
      - **Alveolar pressure > systolic pressure > diastolic pressure.**
      - **No blood flow through the cardiac cycle because the alveolar capillary pressure is below the alveolar pressure all the time .**
      - It is **not present** in normal lung

- **it can be found in :**
  I. Sever hemorrhage or circulatory shock →↓ pulmonary pressure < 15 mmHg systolic pressure .
  II. Increase alveolar pressure > 10 mmHg (positive pressure ventilation).

b) **Zone 2 (moderate or intermittent flow) :**
- **systolic pressure> alveolar pressure> diastolic pressure**
- It is found at 10 cm level above the mid level of heart and up to the apex
- Flow is moderate (intermittent)

c) **Zone 3 (maximal or continuous flow)**
- **systolic pressure > diastolic pressure > alveolar pressure**
- found in the lung area at 10 cm above the midlevel of the heart and down to the base .
- No vascular collapse , capillary at the base are typically distended by the gravity
- Flow is maximum.

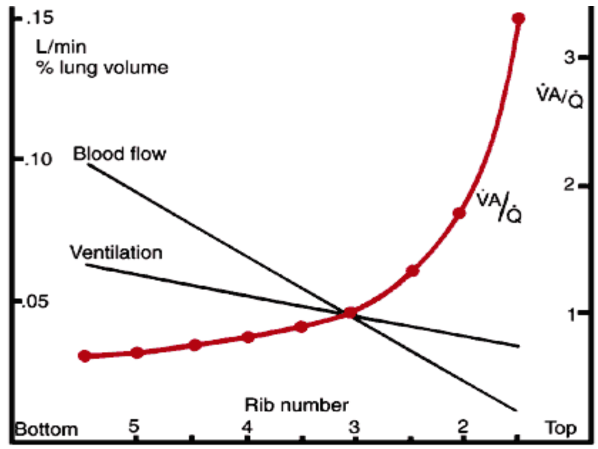


ventilation /perfusion ratio (V_A/Q) :

- Pulmonary circulation is **perfused** with 5 L/min ,Alveolar **ventilation** 4 L/min→ **V_A/Q =0.8**
- gravity significantly affect alveoli ventilation and perfusion

1. At apex (highest ratio) :
   - ↓Alveoli ventilation **VA** (they already expanded)
   - ↓↓ alveolar perfusion **Q** (vessels are compressed by alveolar pressure.)
   - **decreasing in perfusion more than ventilation → high VA/Q ratio**
   - **physiologic dead space**
   - **VA/Q =2**
2. Middle (normal ratio)
   - **VA/Q =0.8 .**

3. Base (lowest ratio) :
   - ↑ventilation **VA** : Alveoli are compressed and ventilate well in inspiration.
   - ↑↑ alveolar Perfusion **Q** .
   - **Increasing in perfusion more than ventilation → low VA/Q ratio**
   - **Physiologic shunt**
   - VA/Q is **low** (0.5)



Note :

- ➢ Other Conditions that produce significant low V_A/Q ratio:
  severe bronchial obstruction (asthma) ,infection (pneumonia) and occlusion of the airway (mucus plug, foreign object).

- ➢ Local changes In the ventilation perfusion ratio occurs in some lung disease ex : pulmonary embolism causing ventilation /perfusion mismatch .it can be tested by using radioactive substances in a test called (ventilation /perfusion scan)

<u>Shunt :</u> shunted blood is a fraction of the venous blood that enters the systemic circulation without passing through functioning lung tissue and being oxygenated

- Anatomical shunts: (Right to left shunt) blood bypass the normal process of gas exchange .i.e : blood enters the systemic circulation without being oxygenated by blood-gas interface through direct connection of venous and arterial blood →decrease O2 saturation of arterial blood ex :shunt that have structural basis like bronchial vein anastomosis with pulmonary veins .

- physiological shunt : The total quantitative amount of shunted blood that do not participate in gas exchange process and it includes the wasted blood due to Low ventilation perfusion ratio in addition to anatomic shunt.