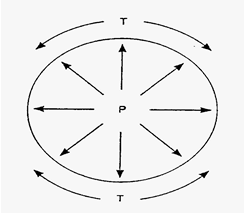
**Lecture:**

**Biophysical consideration for circulation**

**Ohm's law :**

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| Blood flow through a blood vessel is determined by two factors:  (1) *pressure difference* of the blood between the two ends of the vessel, also sometimes called "pressure gradient" along the vessel.  (2) the impediment to blood flow through the vessel, which is called *vascular resistance.*  **Blood Flow (Q) = ∆ Pressure (P) / Resistance (R).**  **Poiseuille's equation:**vascular resistance (R) means impediment to blood flow through the vessel **.**The following equation is called **Poiseuille's equation.**  **R = 8ηL/ π r4**  η = Viscosity of blood.  L = Length of vessel.  r = radius of vessel.  π =22/7  From this equation factors affecting resistance are:  1- Viscosity of blood, and length of the vessel. Resistance is directly proportional to them.  2-Vessel radius: It is inversely proportional to the forth power of the vessel radius.  The unit of resistance is pressure unit divided by flow unit which is expressed in R unit. For example, when the mean aortic pressure is 90 mmHg and the left ventricular output is 90 ml/s, the total peripheral resistant is 90 mmHg/90 ml/s = 1 R unit**.**  **Blood viscosity** The blood viscosity depends on:   1. **Hematocrit:** It is the percentage of red blood cells volume.The viscosity of blood increases as the hematocrit increases. 2. **Plasma protein concentration**. Increased plasma protein cause increase viscosity. But this effect is less than the effect of hematocrit.   the viscosity of the plasma is about 1.8 times as viscosity of water. Whole blood is 3 -4 times as viscous of water.  **Blood velocity:**  It is displacement of blood per unit of time (eg. cm/s). The blood velocity (V) is proportionalto blood flow (Q) divided by the area of the conduit (A).  **Velocity (cm / s) = Flow (ml /s) / Area (cm²)**.  **V = Q/ A**  The average velocity of fluid movement at any point in a system is inversely proportionate to the total sectional area at that point. Therefore, the average velocity of the blood is higher in aorta (small cross sectional area) and lower in the capillaries (large cross sectional area), which have 1000 times the total cross-section area of the aorta .  **Laplace law :**In a vessel containing a gas or a liquid under constant pressure, such as a balloon or blood vessel, the outward force exerted by the pressure stretches the wall of the vessel, creating tension. This tension exerts an inward force that balances the outward force of the pressure, so that the system comes to equilibrium, figure-1. Laplace law states that tension in the wall of a cylinder (T) is equal to the product of the transmural pressure (P) and the radius (r) divided by the wall thickness (w):  T = Pr/w  The **transmural pressure** is the pressure inside the cylinder minus the pressure outside the cylinder, but because tissue pressure in the body is low, it can generally be ignored and P  equated to the pressure inside the viscus. In a thin-walled viscus, wall thickness (w) is very small and it too can be ignored, but it becomes a significant factor in vessels such as arteries. |

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**Figure-1**Relation between distending pressure (P) and wall tension (T) in hollow viscous**.**

**Resistance and capacitance vessels**

the veins are an important blood reservoir. Normally, they are partially collapsed and oval in cross-section. A large amount of blood can be added to the venous system before the

veins become distended to the point where further increments in volume produce a large rise in venous pressure. The veins are therefore called **capacitance vessels.** The small arteries and arterioles are referred to as **resistance vessels** because they are the principal site of the peripheral resistance.

**Starling forces:**

The rate of filtration at any point along a capillary depends on a balance of forces called

Starling forces, the four primary forces that determine whether fluid will move out of the

blood into the interstitial fluid or in the opposite direction are:

1- The capillary hydrostatic pressure (Pc): It tends to force fluid outward the capillary membrane.

2- The interstitial hydrostatic pressure (Pi): It tends to force fluid inward through capillary membrane.

3- The plasma colloid osmotic pressure (πc): It tends to force fluid inward through the capillary membrane.

4-The interstitial colloid osmotic pressure(πi).

**Fluid movement = K (Pc + лi) – (Pi + лc)**

If the *result* is positive, there will be a net *fluid filtration* across the capillaries to the interstitial spaces. If itis negative, there will be a*fluid absorption* from the interstitial spaces into the capillaries.Figure-2

Normally fluid moves into the interstitial space at the arteriolar end of the capillary and into the capillary at the venular end.

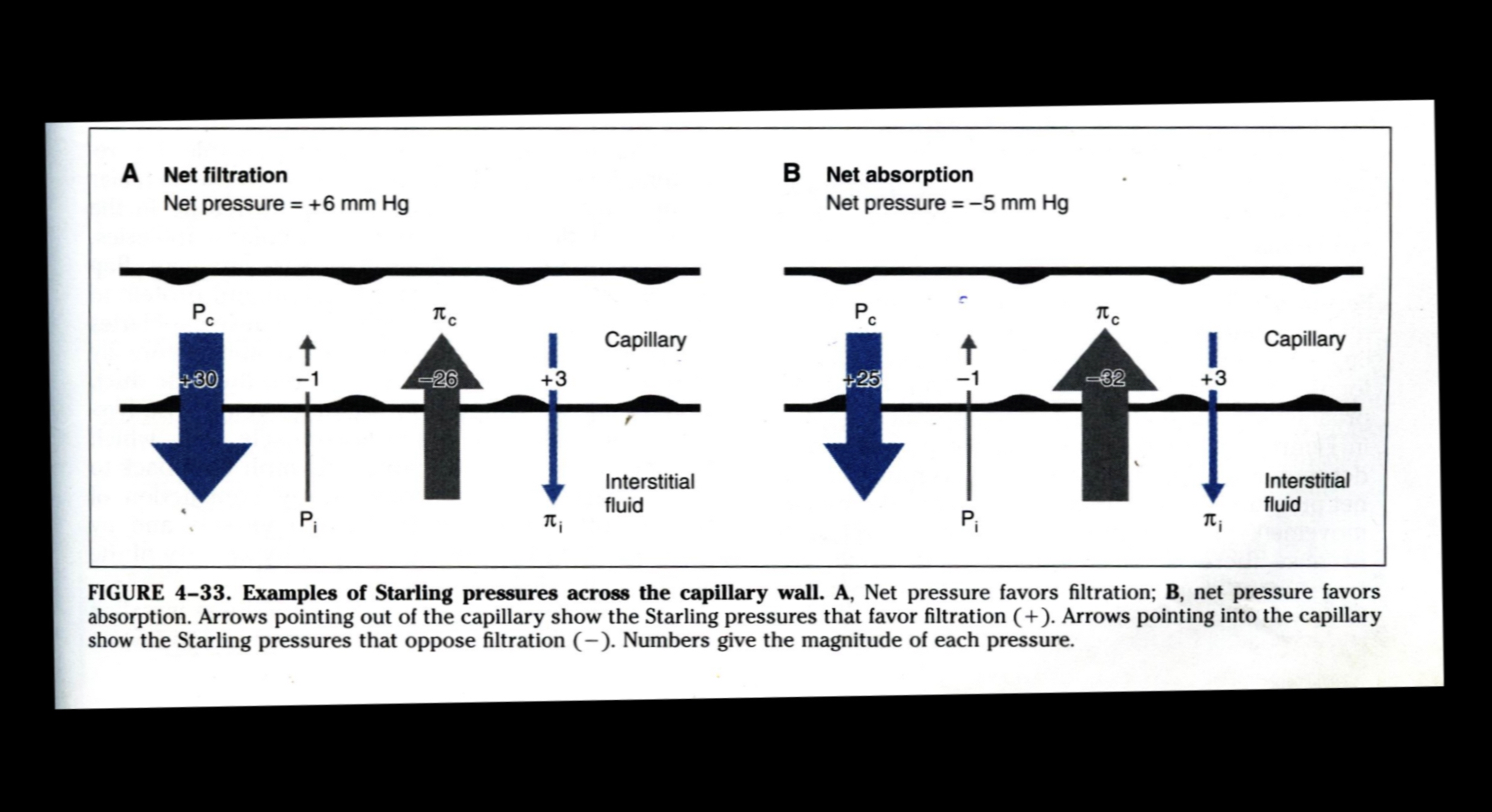


Figure-2 Starling forces

**Effect of gravity on blood pressure:**

The pressure in any vessel below heart level is increased and that in any vessel above heart level is decreased by the effect of gravity. The magnitude of the gravitational effectis 0.77 mm Hg/cm of vertical distance above or below the heart at the density of normal blood. Thus, in an adult human in the upright position, when the mean arterial pressure at heart

level is 100 mm Hg, the mean pressure in a large artery in the head (50 cm above the heart) is 62 mm Hg (100 – [0.77 × 50])and the pressure in a large artery in the foot (105 cm below the heart) is 180 mm Hg (100 + [0.77 × 105]). The effect of gravity on venous pressure is similar.