Vascular hemodynamics-2

P=Q.R

- Q=P/R
- P=Q*R
- MAP= CO*TPR

- R unit is PRU: peripheral resistance unit.

Resistance

- Resistance occurs as a result of friction between the flowing blood and the intravascular endothelium all along the inside of the vessel.
- Resistance is the impediment to blood flow in a vessel, but it cannot be measured by any direct means. Instead, resistance must be calculated from measurements of blood flow and pressure difference between two points in the vessel.
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Conductance

• Conductance is a measure of the blood flow through a vessel for a given pressure difference.

• Conductance is the exact reciprocal of resistance:

• Conductance (the opposite to resistance) =1 / Resistance

• The conductance of the vessel increases in proportion to the fourth power of the diameter, in accordance with the following formula:

• Conductance ∝ Diameter 4

Poiseuille’s Law

- In the small vessel, essentially all the blood is near the wall, so the extremely rapidly flowing central stream of blood simply does not exist.

  By integrating the velocities of all the concentric rings of flowing blood and multiplying them by the areas of the rings, one can derive the following formula, known as Poiseuille’s law: • **F = π ΔPr4/ 8ηl**

F is the rate of blood flow, ΔP is the pressure difference between the ends of the vessel, r is the radius of the vessel, l is length of the vessel, and η is viscosity of the blood.

• The rate of blood flow is directly proportional to the fourth power of the radius of the vessel, which demonstrates once again that the diameter of a blood vessel plays the greatest role of all factors in determining the rate of blood flow through a vessel.

Resistance

• The blood vessels and the blood itself constitute resistance to blood flow.

• The relationship between resistance, blood vessel diameter (or radius), and blood viscosity is described by the Poiseuille equation.

Blood viscosity

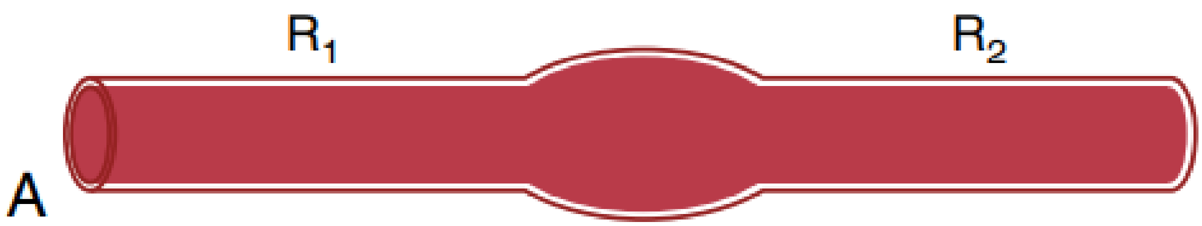
- The viscosity of whole blood at a normal hematocrit is about 3 to 4, which means that three to four times as much pressure is required to force whole blood as to force water through the same blood vessel.
- When the hematocrit rises to 60 or 70, which it often does in persons with polycythemia, the blood viscosity can become as great as 10 times that of water, and its flow through blood vessels is greatly retarded.
- Other factors that affect blood viscosity are the plasma protein concentration and types of proteins in the plasma, but these effects are so much less than the effect.

- ## Total vascular resistance

- The total resistance offered by a set of blood vessels also depends on whether the vessels are arranged in series (i.e., blood flows sequentially from one vessel to the next) or in parallel (i.e., the total blood flow is distributed simultaneously among parallel vessels)

Resistance

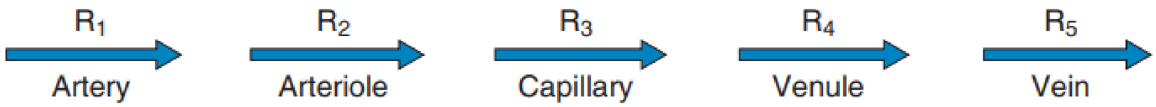
- • The arteries, arterioles, capillaries, venules, and veins are collectively arranged in series.
- • The total peripheral vascular resistance is therefore equal to the sum of resistances of the arteries, arterioles, capillaries, venules, and veins.



$$R_{total} = R_1 + R_2 + R_3 + R_4 \ldots$$

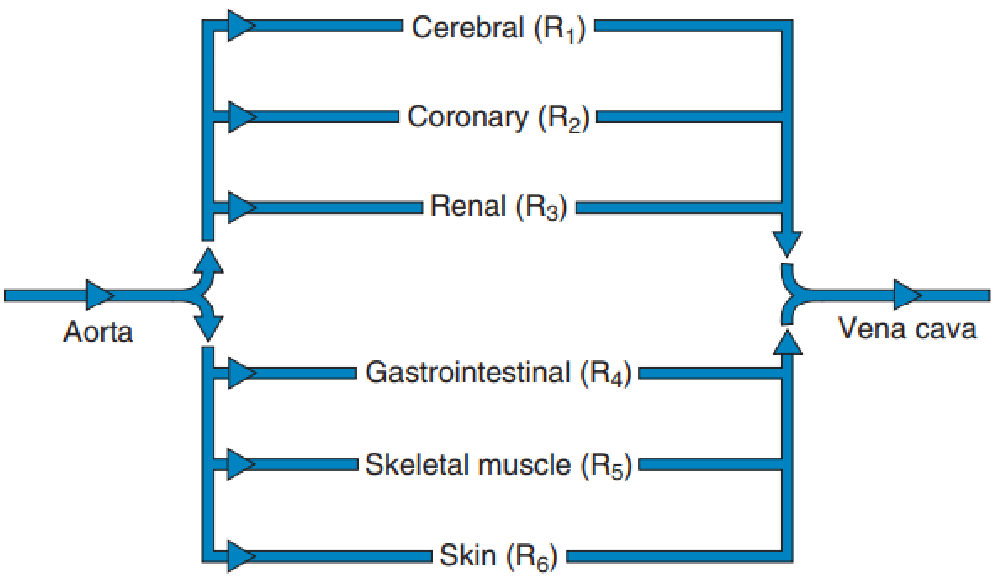
SERIES RESISTANCES

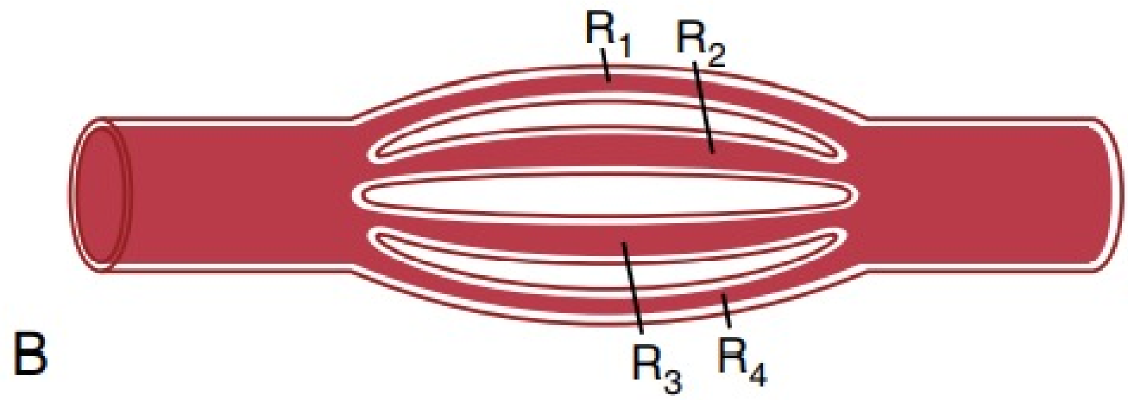
$$R_{total} = R_1 + R_2 + R_3 + R_4 + R_5$$



PARALLEL RESISTANCES

$$\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} + \frac{1}{R_5} + \frac{1}{R_6}$$





$$\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} \cdots$$

- Blood vessels branch extensively to form parallel circuits that supply blood to the many organs and tissues of the body. This parallel arrangement permits each tissue to regulate its own blood flow, to a great extent, independently of flow to other tissues.
- for a given pressure gradient, far greater amounts of blood will flow through this parallel system than through any of the individual blood vessels.
- Therefore, the total resistance is far less than the resistance of any single blood vessel. Flow through each of the parallel vessels is determined by the pressure gradient and its own resistance, not the resistance of the other parallel blood vessels. However, increasing the resistance of any of the blood vessels increases the total vascular resistance.
- For example, brain, kidney, muscle, gastrointestinal, skin, and coronary circulations are arranged in parallel, and each tissue contributes to the overall conductance of the systemic circulation.

- Blood flow through each tissue is a fraction of the total blood flow (cardiac output) and is determined by the resistance (the reciprocal of conductance) for blood flow in the tissue, as well as the pressure gradient.
- Therefore, amputation of a limb or surgical removal of a kidney also removes a parallel circuit and reduces the total vascular conductance and total blood flow (i.e., cardiac output) while increasing the total peripheral vascular resistance.

Arterioles

- In the systemic circulation, about two thirds of the total systemic resistance to blood flow is resistance in the small arterioles.
- The internal diameters of the arterioles range from as little as 4 micrometers to as much as 25 micrometers.
- fourth power law makes it possible for the arterioles, responding with only small changes in diameter to nervous signals or local tissue chemical signals, either to turn off the blood flow to the tissue almost completely or, at the other extreme, to cause a vast increase in flow.