Cardiovascular Physiology
Blood Flow
Fall 2019-2020

Part 15-16

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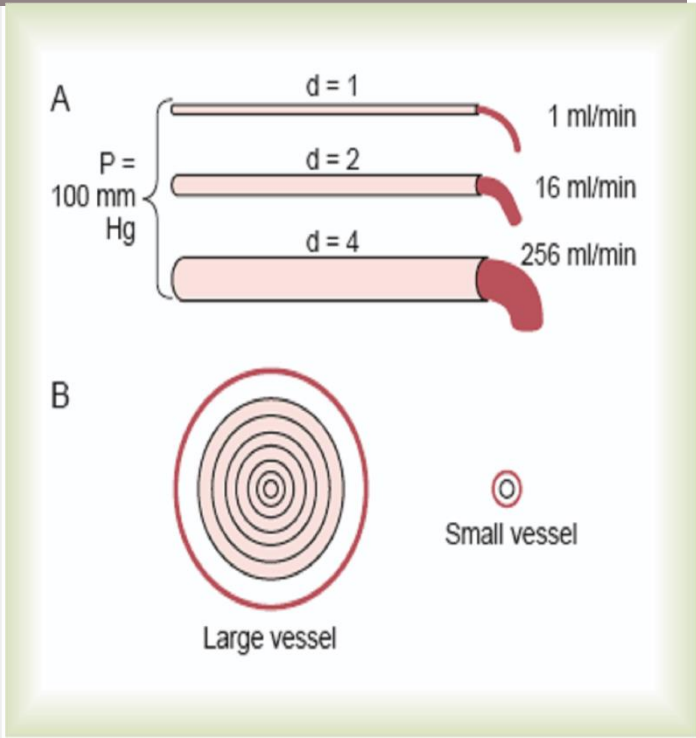


Outline

- Blood flow.
- Laminar blood flow.
- Turbulent blood flow.
- Conductance .
- Fourth power law .

Blood Flow.

Blood Flow

- means simply the quantity of blood that passes a given point in the circulation in a given period of time.

- -blood flow is expressed in milliliters per minute or liters per minute .The overall blood flow in the total circulation of an adult person at rest is about 5000 ml/min.This is called the cardiac output .

Blood flow

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. Resistance occurs as a result of friction between the flowing blood and the intravascular endothelium along the inside of the vessel.
- The flow through the vessel can be calculated by the following formula, which is called Ohm’s law:

$$F = \frac{\Delta P}{R}$$

- Thus, the difference in pressure between the two ends of the vessel, not the absolute pressure in the vessel, that determines rate of flow.

Laminar Flow of Blood

❑ Laminar Flow of Blood:

- ✓ When blood flows at a steady rate through a long, smooth blood vessel, it flows in streamlines, with each layer of blood remaining the same distance from the vessel wall.
- ✓ Also, the central most portion of the blood stays in the center of the vessel .
- ✓ This type of flow is called laminar flow or streamline flow, and it is the opposite of turbulent flow, which is blood flowing in all directions in the vessel and continually mixing within the vessel.

ParabolicVelocity Profile During Laminar Flow

- -When laminar flow occurs, the velocity of flow in the center of the vessel is far greater than that toward the outer edges.
- -This effect is called the “parabolic profile for velocity of blood flow.” because The fluid molecules touching the wall barely move because of adherence to the vessel wall. The next layer of molecules slips over these, the third layer over the second, the fourth layer over the third, and so forth. Therefore, the fluid in the middle of the vessel can move rapidly

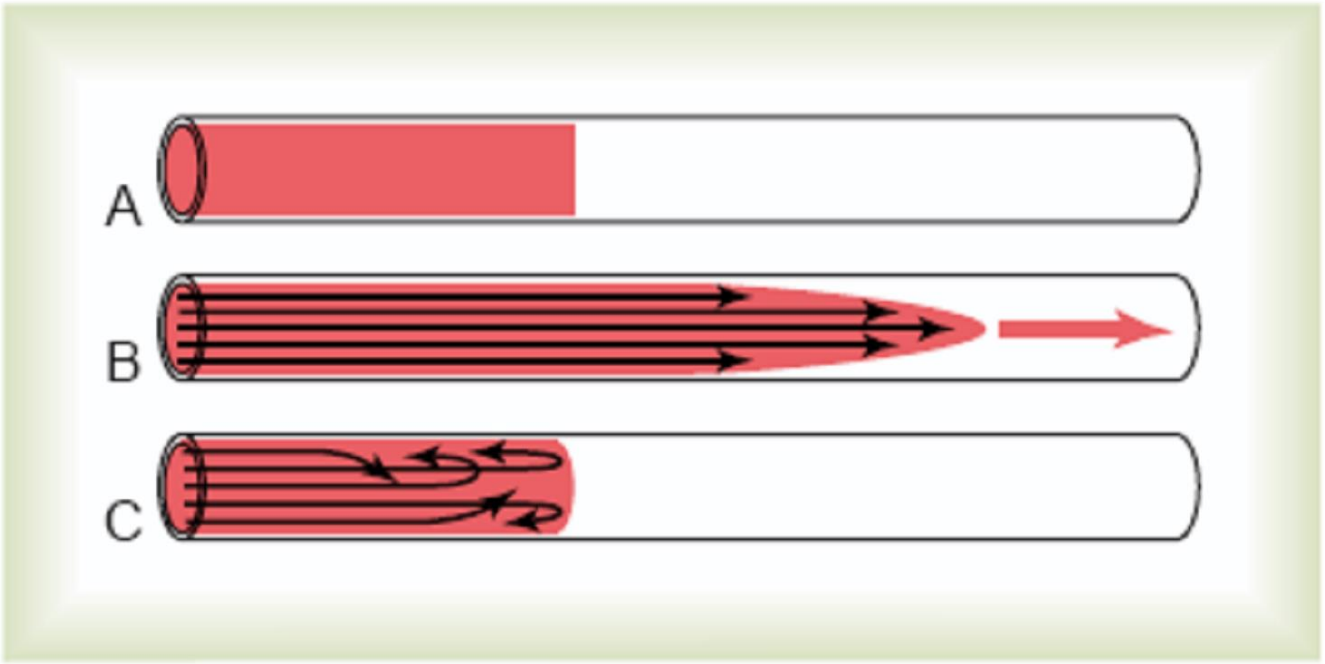


Figure 14–6

A, Two fluids (one dyed red, and the other clear) before flow begins; *B*, the same fluids 1 second after flow begins; *C*, turbulent flow, with elements of the fluid moving in a disorderly pattern.

Turbulent Flow of Blood

- ✓ When the rate of blood flow becomes too great, when it passes by an obstruction in a vessel, when it makes a sharp turn, or when it passes over a rough surface, the flow may then become turbulent, or disorderly, rather than streamline.
- ✓ -Turbulent flow means that the blood flows crosswise in the vessel , usually forming whorls in the blood called eddy currents.
- ✓ --The tendency for turbulent flow increases in direct proportion to the velocity of blood flow, the diameter of the blood vessel, and the density of the blood, and is inversely proportional to the viscosity of the blood .

Conductance” of Blood in a Vessel

Conductance:

is a measure of the blood flow through a vessel for a given pressure difference. This is generally expressed in terms of milliliters per second per millimeter of mercury pressure.

It is evident that conductance is the exact reciprocal of resistance in accord with the following equation:

$$\text{Conductance} = \frac{1}{\text{Resistance}}$$

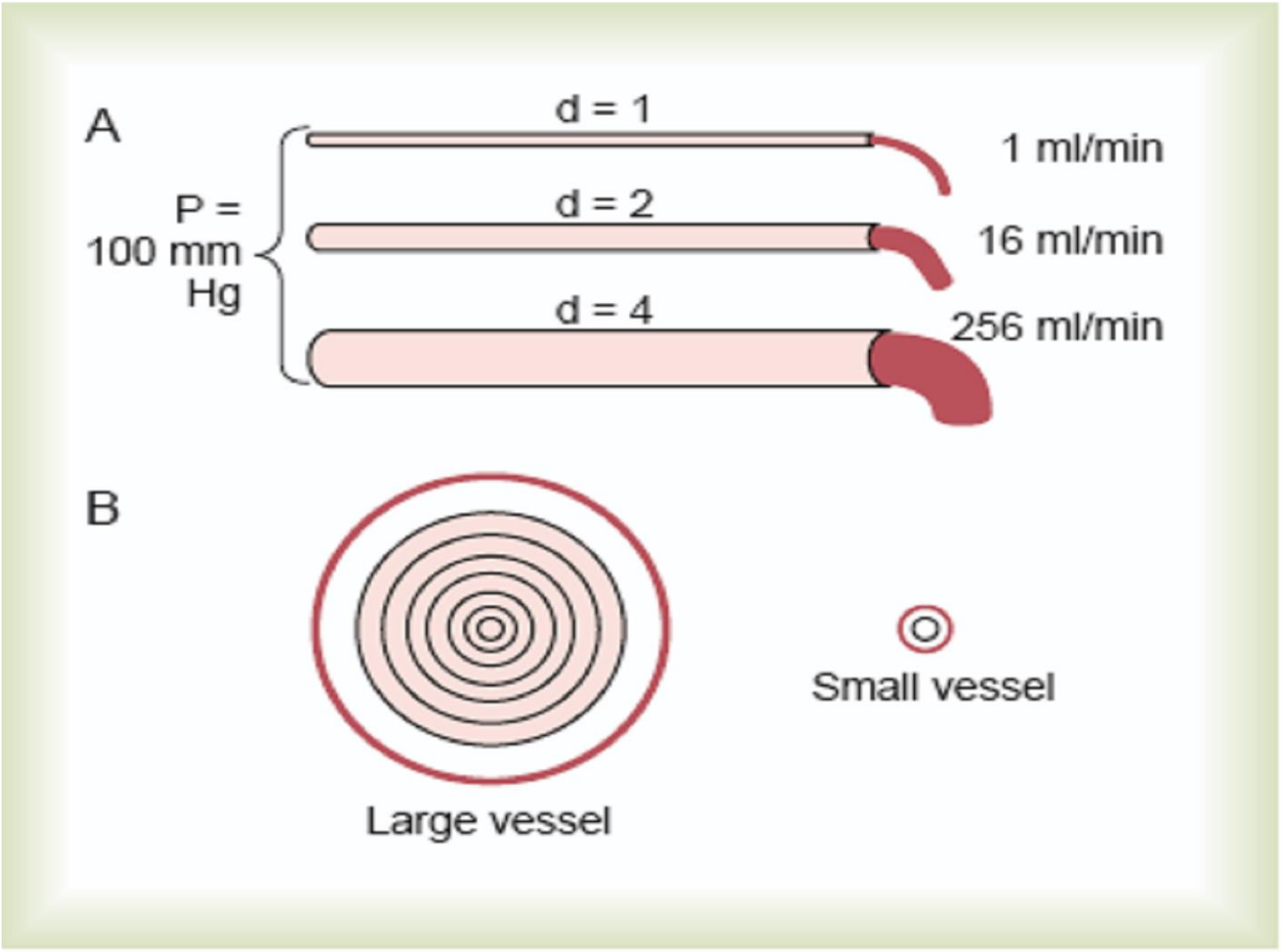
Conductance

Slight changes in the diameter of a vessel cause tremendous changes in the vessel's ability to conduct blood when the blood flow is streamlined.

If there are three vessels with relative diameters of 1, 2, and 4 but with the same pressure difference of 100 mm Hg between the two ends of the vessels. Although the diameters of these vessels increase only fourfold, the respective flows are 1, 16, and 256 ml/mm, which is a 256-fold increase in flow.

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

$$\text{Conductance} \propto \text{Diameter}^4$$


A
d = 1
1 ml/min
P =
100 mm
Hg
d = 2
16 ml/min
d = 4
256 ml/min
B
Small vessel
Large vessel

Fourth Power Law

the importance of Fourth Power Law

- ✓ --The internal diameters of the arterioles range from as little as 4 micrometers to as great as 25 micrometers. However, their strong vascular walls allow the internal diameters to change tremendously, often as much as fourfold. a fourfold increase in vessel diameter can increase the flow as much as 256-fold.
- ✓ Thus, this fourth power law makes it possible for the arterioles, responding with only small changes in diameter to nervous signals or local tissue chemical signals to increase the blood supply as much as needed .


Thank You