Lecture 3

Physics of Cardiovascular System

Part 2

By

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Blood Flow Laminar And Turbulent

Laminar (silent) if all blood flow were laminar information could not be obtained from the heart with stethoscope

If increase the velocity of the fluid in the tube by reduction the radius it will reach the critical velocity Vc, when laminar flow change into turbulent flow. The critical velocity will be lower if there is restriction or obstruction in the tube.

Osborne Rynold studied the property in

1883 $Vc = k \eta / \rho R$

R ; radius of the tube
K ; constant 1000 for many fluid

For aorta has radius = 1 cm in adults

$Vc = (1000) (4 \times 10^{-3} pas) / (10^{3} kg / cm^{3}) (10^{-2} m) = 0.4 m/s$

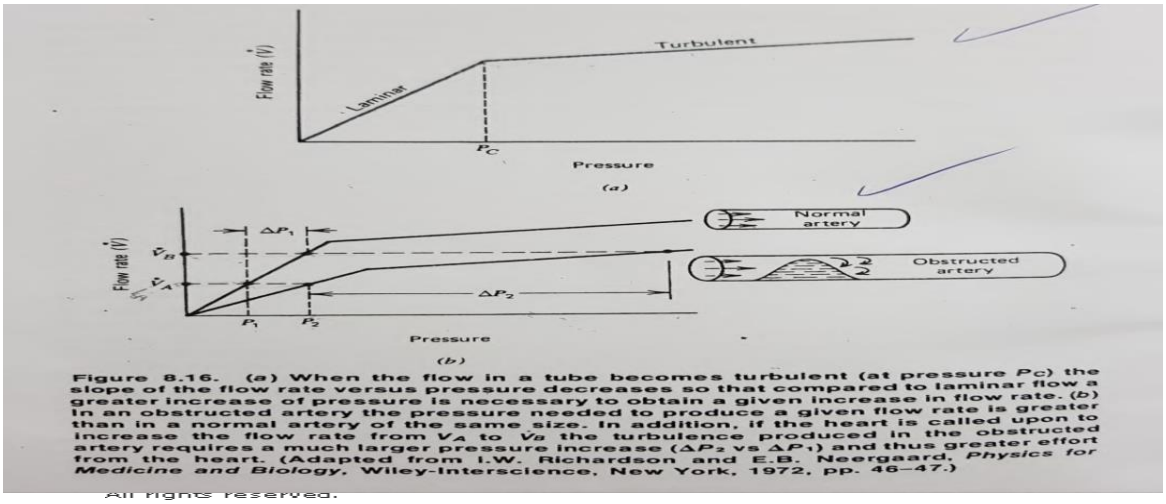

Figure 8.16. (a) When the flow in a tube becomes turbulent (at pressure P_C) the slope of the flow rate versus pressure decreases so that compared to laminar flow a greater increase of pressure is necessary to obtain a given increase in flow rate. (b) In an obstructed artery the pressure needed to produce a given flow rate is greater than in a normal artery of the same size. In addition, if the heart is called upon to increase the flow rate from V_A to V_B the turbulence produced in the obstructed artery requires a much larger pressure increase (ΔP_2 vs ΔP_1) and thus greater effort from the heart. (Adapted from I.W. Richardson and E.B. Neergaard, *Physics for Medicine and Biology*, Wiley-Interscience, New York, 1972, pp. 46–47.)

Figure 7-3: effect of gradual tapering of tube on velocity

The Physics Of Some Cardiovascular Diseases

Work load of heart increases

by ;

1- Hypertension

2- Tachycardia

Disease

1- Heart attack, caused by blockage one or more arteries of the heart muscle.

person has heart attach may still have normal ECG.

2- Congestive heart failure, characterized by enlargement of the heart and reduction in the ability of the heart to provide adequate circulation.

Medical treatment of congestive heart failure help to reduce the work load on the heart.

3- Heart valve defects are of two types, the valve either does not open enough (stenosis) or it does not close well enough (insufficiency)

The Physics OF Cardiovascular Diseases Involving In The Blood Vessels

1- A more common vessel problems is the formation sclerotic plaques on the wall of the artery, increase the velocity in that region with a decrease in wall pressure because of Bernoulli effect.

2- If the valve defective and let the blood run back down it will pool in the vein, and the vein will become varicose.

The viscosity of blood depends on temperature change from (37-0) increases the velocity of blood by a factor 2.5 in addition to viscosity ,

other factors affect the flow of blood in the vessel; the pressure difference from one end to the other, the length of the vessel, and its radius.

Poiseulle's law stats that the flow of a given tube depends on the pressure difference from one end to the other P1-P2, the length of the tube L, the radius R and viscosity of blood.

Flow rate = (P1- P1) (Π / 8) (1/ η) (R4 / L)

If radius is doubled the flow rate increases by 24 or by 16. This law applies to the rigid tubes of constant radius, since the major arteries have elastic walls and expand slightly at each heartbeat, so blood does not obey this law exactly

in addition the blood viscosity changes slightly with flow rate, however this effect is negligible.

A disease clinically causes varicose vein, these enlarged surface veins in the legs results from a failure of the one way valves in the veins.

The pressure in the leg vein is about 90 mmHg (115 cm of blood) due to a column of blood above it.

The slandered treatment for varicose veins is surgical removal of offending vessels. There are usually adequate parallel veins to carry the blood back to the heart.