

BENG 100 Frontiers of Biomedical Engineering
Professor Mark Saltzman

Chapter 8

SUMMARY

- The cardiovascular system is comprised of a pump, the heart, which circulates a specialized fluid, blood, through an elaborate system of branched vessels.
- The blood is a special fluid comprised of cells dispersed in a protein-rich fluid called plasma. White blood cells are involved in the inflammatory response and immune function; red blood cells transport oxygen to tissues.
- The blood circulates in the body through a network of vessels including arteries, veins and capillaries.
- Many of biophysical properties of the circulation can be deduced using a simple engineering model: fluid flow in a straight cylindrical tube.
- The heart is equipped with a muscular wall that contracts to pump blood from its chambers (atria and ventricles) to other parts of the body.
- The heart's muscular wall is made up of self-excitabile cardiac cells that contract in response to electrical stimulation.
- The heart contracts rhythmically to create blood pressure, which drives blood flow.

KEY CONCEPTS AND DEFINITIONS

aneurysm – an excessive localized enlargement of an artery caused by a weakening of an artery wall.

arteriole – a small branch of an artery leading to a capillary.

atrial systole – the contraction of the heart muscle of the left and right atria.

atherosclerosis – an arterial disease characterized by the deposition of plaques of fatty material on their inner walls.

axial pressure drop – the internal pressure drop measured at different points along the axis of a vessel.

bifurcation – the division of a blood vessel into two or more branches.

bruits – Sounds created the eddies of turbulent flow.

capillaries – a fine branching network of blood vessels in between venules and arterioles.

cardiac cycle – the sequence of events that occurs in one heart beat.

compliance – the property that describes a materials ability to deform with the application of a pressure or stress.

constriction – the narrowing of blood vessel diameter due to muscular contraction within the vessel wall.

diastole – a phase of the heart beat when the heart relaxes to allow the heart chambers to fill with blood from the veins.

dilation – the widening of blood vessel diameter due to relaxation of smooth muscle in vessel wall.

eddies – the circular flow of fluid in a direction counter to the current generated due to fluid movement.

electrocardiography – a measurement of electrical activity in the heart using electrodes placed on the skin of the limbs and chest.

fenestrated capillaries – capillaries that have larger openings to allow larger molecules to diffuse.

laminar flow – a term used to describe fluids that flow in straight parallel layers without interference between layers.

Laplace's Law – this law describes the relationship between pressure drop and wall tension in inflated vessels such as a capillary or an alveolus red blood cells – one type of blood cell shaped in the form of a biconcave disk that contains hemoglobin in order to transport oxygen and carbon dioxide to and from the body tissues.

resistance – a property that characterizes a substance's ability to oppose flow of another substance.

Reynolds number – A dimensionless number used to characterize whether a fluid will lead to a laminar or turbulent flow.

stroke volume – the volume of blood ejected when the ventricle contracts.

systole – a phase of the heart beat when the heart contracts to pump blood from its chambers to the arteries.

transmural pressure difference – the difference in pressure within the vessel and pressure in the interstitial fluid outside of the vessel that is necessary to keep the blood vessel inflated.

turbulent flow – a term used to describe chaotic fluid flow in which the fluid no longer follows the parallel streamline.

viscosity – the measure of the resistance of a fluid to deform under shear stress.

QUESTIONS

1. Veins and capillaries are both low-pressure vessels. Explain why veins typically have thicker, stronger walls than capillaries?
2. How is compliance related to wall tension in the wall of a vessel? Which type of vessel is more compliant: veins or capillaries? What property allows these vessels to be more compliant? What function does this higher compliance serve?
3. Using internet resources investigate what an artificial pacemaker is and how it works. Why is it important to control a patient's heart rate?