20. Electrical activity of the heart. Spread of the cardiac impulse through the heart. The normal electrocardiogram.

Electrical activity of the heart. Spread of the cardiac impulse through the heart.

- As the SA node fires, each electrical impulse travels through the right and left atrium. This electrical activity causes the two upper chambers of the heart to contract.
- The electrical impulse then moves to the AV node. This node sits just above the ventricles. Here, the electrical impulse is held up for a brief period. This delay allows the right and left atrium to continue emptying it's blood contents into the two ventricles.
- The AV node thus acts as a "relay station" delaying stimulation of the ventricles long enough to allow the two atria to finish emptying.
- Following the delay, the electrical impulse travels through both ventricles.
- The electrically stimulated ventricles contract and blood is pumped into the pulmonary artery and aorta. The ventricles then recover from this electrical stimulation.

The normal electrocardiogram

Electrocardiography - graphic recording of the electrical activity produced by the conduction system and the myocardium of the heart during its depolarization & repolarization cycle.

- Atrial depolarization is directed towards the positive electrode. A positive deflection is recorded, the P wave.
- AV node and bundle of His are too small structures to give rise to skin potential. The P-Q segment is recorded.
- Ventricular depolarization starts at left aspect of the septum. Depolarization goes away of the positive electrode. A negative Q wave is recorded.
- Ventricular depolarization goes from endocardial to epicardial surface, towards the + electrode. A great number of cells are rapidly involved and the high voltage R wave is recorded.
- Left posterior ventricular wall is the last part to depolarise, deflection away from the + electrode. The negative S is recorded.
- All ventricular cells are depolarized and in the stage of plateau of the AP. There is no potential difference between the electrodes. Flat S-T segment is recorded.
- Ventricular repolarization starts from the apical epicardial surface and continues upward. Left leg is closer to the positive charges. The positive T wave is recorded.
When blood flows through a long smooth vessel it flows in straight lines, with each layer of blood remaining the same distance from the walls of the vessel throughout its length.

When laminar flow occurs the different layers flow at different rates creating a parabolic profile.

The parabolic profile arises because the fluid molecules touching the walls barely move because of adherence to the vessel wall. The next layer slips over these, the third layer slips over the second and so on.

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.

Turbulent flow means that the blood flows crosswise in the vessel as well as along the vessel, usually forming whorls in the blood called eddy currents.

When eddy currents are present, the blood flows with much greater resistance than when the flow is streamline because eddies add tremendously to the overall friction of flow in the vessel.

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, in accordance with the Reynold’s equation.

When Reynolds number increases above about 200 turbulent flow will result.

**Interrelationships among pressure, flow and resistance.**

Relationship between blood flow and pressure is exponential. Increase in arterial pressure not only increases the force that pushes blood through the vessels but also distends the vessels at the same time, which decreases vascular resistance.

Blood flow through a blood vessel is determined by two factors:

- Pressure difference of the blood between the two ends of the vessel, also sometimes called "pressure gradient" along the vessel, which is the force that pushes the blood through the vessel.
- The impediment to blood flow through the vessel, which is called vascular resistance.

\[ Q = \Delta P/R \]
As blood traverses the capillary, water molecules and dissolved substances diffuse back and forth through the capillary wall, providing continual mixture of the interstitial fluid and plasma.

Lipid-soluble substances, such as oxygen and carbon dioxide, can diffuse directly through the cell membranes without having to go through the pores.

Water-soluble substances, such as glucose and electrolytes, diffuse only through intercellular pores in the capillary membrane.

The primary factors that affect the rate of diffusion across the capillary walls are as follows:

- The pore size in the capillary.
- The molecular size of the diffusing substance.
  - Water and most electrolytes, such as sodium and chloride, have a molecular size that is smaller than the pore size, allowing rapid diffusion across the capillary wall.
  - Plasma proteins, however, have a molecular size that is slightly greater than the width of the pores, restricting their diffusion.
- The concentration difference of the substance between the two sides of the membrane.
  - The greater the difference between the concentrations of a substance on the two sides of the capillary membrane, the greater is the rate of diffusion in one direction through the membrane.
  - The concentration of oxygen in the blood is normally higher than in the interstitial fluid, allowing large quantities of oxygen to move from the blood toward the tissues.
  - Conversely, the concentrations of the waste products of metabolism are greater in tissues than in blood, allowing them to move into the blood and to be carried away from the tissues.
29. Role of the nervous system for rapid control of arterial pressure.

Sympathetic nervous system provides rapid control of arterial pressure by causing vasoconstriction and stimulation of the heart. At the same time that sympathetic activity is increased, there often is reciprocal inhibition of parasympathetic vagal signals to the heart that also contribute to a greater heart rate. As a consequence, there are three major changes that take place to increase arterial pressure through stimulation of the autonomic nervous system:

- Most arterioles throughout the body are constricted
  - causing increased total peripheral resistance and raising the blood pressure.
- The veins and larger vessels of the circulation are constricted
  - displacing blood from the peripheral vessels toward the heart and causing the heart to pump with greater force, which also helps raise the arterial pressure.
- The heart is directly stimulated by the autonomic nervous system, further enhancing cardiac pumping.
  - Much of this is caused by an increased heart rate. In addition, sympathetic stimulation directly increases the contractile force of the heart muscle, thus increasing its ability to pump larger volumes of blood.

An important characteristic of nervous control is that it is rapid, beginning within seconds. Conversely, sudden inhibition of nervous stimulation can decrease the arterial pressure within seconds.