CHAPTER

Introduction to Hemodynamic and Electrophysiology 1

Introduction

The flow of blood through the circulatory system of the body is governed by hemodynamics, a physiological and scientific principle.

Primary Functions of Blood

- The movement of blood gases, nutrition, and wastes.
- pH, body temperature, and water content homeostasis (regulation).
- Safeguarding.

Cardiovascular system is responsible for blood circulation. It consists mostly of the heart, which serves as a pump, and the blood arteries, which transport the blood.

Coronary Blood Flow

- The heart muscle's resting coronary blood flow is approximately 225ml/minute (0.7 to 0.8 ml/gm).
- During diastole, the cardiac muscle relaxes entirely, allowing blood to flow freely through the left ventricular capillaries.
- During cardiac muscle compression, phasic fluctuations in coronary blood flow occur.
- During cardiac contraction, the inner layer of the heart muscle has a substantially higher intramyocardial pressure than the outer layer.

Control of Coronary Blood Flow

- Local blood flow control is influenced by oxygen demand.
- Factors that influence oxygen consumption.
- In coronary system, there is a condition known as reactive hyperemia.

Stroke Volume

- The amount of blood pumped by the left ventricle of the heart in a single contraction.
- Only about 2/3 of the blood in the ventricle is discharged with each beat.

Cardiac Output

- Blood flow is commonly measured inlitres per minute.
- The entire amount of blood circulating through the circulatory system is referred to as cardiac output (CO).
- Cardiac Output = Stroke Volume x 5 L/min Heart Rate.
- Blood pressure (force of blood against side wall) and resistance (blood viscosity, vessel length,vessel elasticity, Vasoconstriction/ Vasodilation) are factors to consider.

Blood Pressure Regulation

- Vascular resistance and cardiac output determine blood pressure.
- Vascular resistance is modulated by neurological and hormonal inputs at the level of the arterioles.
- Heart rate and stroke volume, which are both regulated by blood volume, determine cardiac output.
- Renal sodium excretion or resorption, in turn, regulates blood volume.
- Renin, a key blood pressure regulator, is released by the kidneys in response to reduced blood pressure in afferent arterioles.

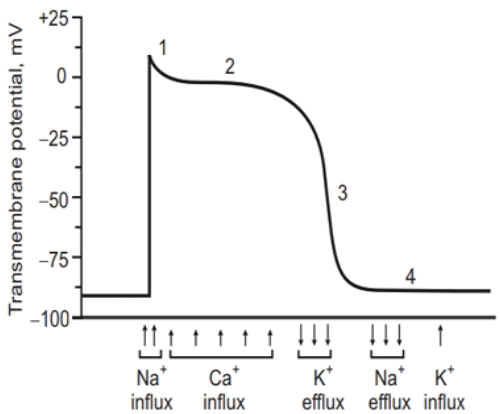
Electrophysiology of Heart

Physiology of Cardiac Muscle

There are three different types of cardiac musclefibre:

1. The atrial muscle is one of the most important muscles in the body.
2. Muscle of the ventricle.
3. Excitatory and conductive musclefibres with specialized functions.

Action Potential in Cardiac Muscle



Phase 0 (Rapid Depolarization)

Phase 1 (Early Repolarization)

Phase 2 (Plateau)

Phase 3 (Repolarization)

Phase 4 (Resting Membrane Potential)

(a) Generation of Impulse:

Electrophysiologically, two types of myocardial fibre can be distinguished.

I. Nonautomaticfibres:

These are normal, functional cardiac fibres that are unable to generate their own impulse. During diastole, the resting membrane potential (approximately 90 mV negative within) remains constant. When stimulated, they depolarize quickly (fast 0 phase). After a high overshoot (+30 mv), the membrane potential is maintained for a lengthy period of time (phase-2, plateau phase), during which Ca2+ ions enter the cell and produce rapid contraction repolarization (phase-3) occurs when the membrane Na+K+ concentration rises.

When the pump is started, ithasatendencytore-establish the resting pattern of ionic distribution Once reached, the resting membrane potentialnot deterioration (stable phase-4).

(ii) Automaticfibres:

Patches of automatic tissue can also be found in the interatrial septum, A-V ring, and surrounding the great vein apertures. The majority ofPhase-4, or slow diastolic depolarization, is a distinguishing trait of these fibres.The membrane potential decays spontaneously after repolarizing to its maximum value. When it comes toWhen a critical threshold value is reached, the system automatically depolarizes. As a result,They're able to generate their own impulse. The rate at which a particular fibre generates impulses.Depending on the maximal diastolic potential, phase-4 depolarization slope, andthe threshold potential's value.

I. Conduction:

Purkinje fibres(quick channel fibres that depolarize when exposed to Na+ current, but not in SA and A-V nodal cells, which are refractory for a long time, even after. The highest resting potential (Ca2+ channel reactivation is time-dependent). The Na+ channels become inactivated as the resting membrane potential (RMP) decreases between –80 and –60 mV. As a result, the lower the RMP, the better.When activation occurs, the number of Na+ ions decreases.The slope of the '0' phase indicates the number of channels that can be enabled. The AP amplitude and conduction velocity are reduced by depolarization. If a medication lowers the slope of the 0 phase, the membrane responsiveness curve shifts to the right, inhibiting conduction (at any given resting membrane potential). The inverse is true.

Taking a drug that causes the curve to shift to the left. The membrane response curve can also be altered. Small cells on the upper edge of the

A-V node have a very slow conduction velocity (20 mm/sec). Purkinje fibres(PFs) have the fastest conduction velocity (4000 mm/sec), except near their 'gate zone' with ventricular fibres or when they switch between types.

I. Excitability

By raising and decreasing excitability, hyperpolarization and modest reductions in resting membrane potential, respectively, decrease and increase excitability.The gap between it and the threshold's potentialAsa result, rapid channel fibres have ahigh excitability.During the final portion of phase 3, the body is often super-normal. When the resting membrane is intact, however, the fibre becomes inexcitable when its potential falls below the threshold potential.

I. Refractory period

The most essential pharmacological parameter is the effective refractory period (ERP), which is the shortest time between two propagating APs. It's intimately related to the AP's length (APD). In rapid channel fibres, an AP can be elicited even before complete closure.

Because Na+ causes repolarization, channels recover in a voltage-dependent manner above the voltage threshold. the possibility of crossing the line. Asa result, the ERP/APD ratio is one. When the fibre has fully repolarized, the Ca2+ channels, on the other hand, gradually recover in a time-dependent manner. Fibers have a greater than one ERP/APD ratio. The ERP/APD ratio is raised by most antiarrhythmic medications.

Electrocardiogram (ECG)

Action potential propagation generates electrical currents in the heart, which can be sensed as electrical signals on the body's surface. An electrocardiograph (ECG) is a machine that records these fluctuating signals. Electrocardiograms are recordings of the heartbeat (ECG). As a result, the ECG is a composite record of action potential generated by all of the heart's muscle fibres throughout each heartbeat.

Four electrodes are placed on the limbs (limb leads) and six electrodes are inserted in various locations on the chest in clinical practise (chest leads). These electrodes detect the electrical changes in the heart. Each device's electrical impulses were recorded. The electrodes differ slightly due to their changing position in relation to the heart.

The comparison of these recordings with each other and with the normal one aids in identifying issues such as:

(i) Any irregularities in the conduct route
(ii) Any sort of enlargement of the heart
(iii) Any type of damage to the heart.
(iv) Aches and pains in the chest of any kind

Three distinct waves can be identified in an ECG.

- Pwave: Atrial depolarization is represented by the P wave, which propagates from the SA node across contractile fibres in both atria. On the ECG, it appears as a little upward deflection.
- QRS complex: As the action potential spreads across the QRS complex, the second wave occurs. Ventricle contractile fibres, suggesting rapid ventricular depolarization The QRS complex, which began as a descending wave, has evolved into a massive, upright triangle wave. A deflection will occur, followed by a descending wave.
- T wave: when the ventricle is relaxed, the third wave appears, signifying ventricular relaxation. This wave appears as an upward deflection in the shape of a dome. T wave differs from the QRS wave in that it is smaller and wider. This is due to the fact that the repolarization process takes longer.

The magnitude of each wave on the ECG aids in the interpretation of any abnormalities, such as:

(i) Larger P waves indicate an expanded atrium.
(ii) When the Q wave is increased, myocardial infarction is a potential.
(iii) An increased R wave usually indicates ventricular enlargement.

(iv) T wave interpretation can be done as follows:

(a) If there is insufficient oxygen delivery to the cardiac nucleus (as in the case of a heart attack), It happens flatter than normal if you have coronary artery disease.

(b) In the case of a high K+ level,It also gets increased in the blood.

References

Introduction to Hemodynamic and Electrophysiology of Heart (jsmasipharmacy.blogspot.com).

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