Depolarization, Polarization, & Repolarization

The five phases of the cardiac action potential of a myocardial cell:

-these phases reflect the rapid sequence of voltage changes that occur across the cell membrane during the electrical cardiac cycle

-Phases 1, 2, 3 are *electrical systole*

-Phase 4 is *electrical diastole*

Phase 0:

Depolarization Phase

-known as upstroke, spike, or overshoot

-sharp, tall upstroke of the action potential when cell membrane reaches the threshold potential, triggering the fast sodium channels to open momentarily and permit the rapid entry of sodium into the cell

-phase begins when the cell receives an impulse

-membrane permeability increases to allow sodium to flow rapidly into the cell

-this is the explosive start of the action potential (depolarization)

-as the positively charged ions enter the cell, the interior of the cell becomes electrically positive to about +20 to +30 mV

-potassium leaves the cell

-calcium moves slowly into the cell through slow calcium channels

-cell depolarizes and cardiac contraction begins

-on the ECG, Phase 0 is represented by the QRS complex

-Phase 0 (depolarization) is immediately followed by repolarization, which is divided into 3 phases

Phase 1:

Early Rapid Repolarization Phase

-early, brief period of limited repolarization

-fast sodium channels partially close, terminating the rapid flow of sodium into the cell

-abrupt decrease in sodium permeability

-followed by a transient loss/outward movement of potassium from the cell

-net result is a decrease in the number of positive electrical charges within the cell and a drop in the membrane potential to 0 mV

Phase 2:

Plateau Phase

-this is the cell's early repolarization phase

-plateau phase allows cardiac muscle to sustain an increased period of contraction

-prolonged phase of slow repolarization of the action potential of the myocardial cell

-action potential reaches a plateau phase due to slow inward movement of calcium ions through slow calcium channels coupled with some continued outward potassium movement

-membrane potential remains about 0 mV because of a very slow rate of repolarization

-allows cell to finish contracting and begin relaxing

-calcium slowly enters the cell through the calcium slow channels

-potassium continues to leave the cell

-sodium enters the cell slowly

-on the ECG, Phase 2 is responsible for the ST segment and is part of the absolute refractory period

-the ST segment represents the early part of repolarization of the ventricles

Phase 3:

Terminal Phase of Rapid Repolarization

-late stage of repolarization

-begins with the downslope of the action potential

-inside of cell becomes markedly negative because of the rapid exit of potassium from the cell

-membrane potential returns to -90 mV (resting level) because of the flow of potassium from the cell

-repolarization finishes with an initial sharp increase of potassium permeability, causing potassium to rapidly leave the cell

-this causes the slow channels to close, stopping the influx of calcium and sodium

-repolarization is complete by the end of phase 3

-on the ECG, Phase 3 is represented by the T wave (ventricular repolarization)

Phase 4:

Period Between Action Potentials/Resting Membrane Potential

-this is the return to the resting state

-at the onset of Phase 4, the membrane has returned to its resting potential and the inside of the cell is once again negative (-90 mV)

-the cell is considered polarized (ready state waiting to react to a stimulus)

-BUT, there is still an excess of sodium inside the cell and an excess of potassium outside the cell

-at this point, the *sodium-potassium pump* is activated

-it actively transports the excess sodium out of the cell and the potassium back in

-because of this mechanism and the impermeability of the cell membrane to sodium during Phase 4, the myocardial cell normally maintains a stable membrane potential between action potentials

-the heart is polarized (ready for discharge)

-the cell will remain in this state until the cell membrane is reactivated by another stimulus