# PROPERTIES OF CARDIAC MUSCLE

# INTRODUCTION

- The muscle contracts when it is stimulated.
- Contraction of the muscle is a physical or mechanical event.
- Electrical potential in the muscle during resting condition is called RESTING MEMBRANE POTENTIAL
- Electrical changes that occur in active conditions , when the muscle stimulated are together called ACTION POTENTIAL

## RESTING MEMBRANE POTENTIAL

- Defined as the electrical potential difference (Voltage ) across the cell membrane under resting condition
- Negativity inside and Positivity outside the muscle fiber.
- Condition of during resting membrane potential is called POLARISED STATE.
- Constant RMP in skeletal muscle is– 90 mV

## ACTION POTENTIAL

- Occurs in 2 phases
- 1.Depolarisation- Inside of muscle becomes positive and outside becomes negative
- 2.Repolarisation- Muscle reverses back to RMP

# EXCITABILITY

Intial response to a stimulus is electrical activity in the form of action potential.

- Followed by mechanical activity in the form of contraction ,secretion.

## RMP in cardiac muscle

- Single cardiac muscle fiber : -85 mV to – 95 mV
- Sinoatrial (SA) node : -55 mV to 60mV
- Purkinjie Fibers :-90 mV to – 100 mV

# ACTION POTENTIAL

- **Duration of action potential in cardiac muscle is 250 to 350msec**

## 4 phases

1. **Initial depolarisation**
2. **Intial repolarisation**
3. **A plateau or final depolarisation**
4. **Final repolarisation**

## Initial depolarisation

- Very rapid and lasts for 2 msec ( 0.002 sec )
- Amplitude of depolarisation - + 20 mV

## Intial repolarisation

- Short period of about 2 msec
- Represented by a notch

## Plateau or Final Depolarization

- Muscle fiber remains in depolarised state
- Forms plateau or stable period in AP curve.
- 200 msec in atrial muscle
- 300 msec in ventricular muscle fiber
- Contraction time of cardiac muscle is 5 to 15 times longer than skeletal muscle.

## Final Depolarisation

- Slow process and lasts for 50 to 80 msec before the re-establishment of RMP

# IONIC BASIS OF ACTION POTENTIAL

## 1. Intial Depolarisation

- Rapid opening of fast Na – and influx of sodium ions as in skeletal muscle .

## 2. Intial repolarisation

- Transient short duration due to slow efflux of pottasium ions and slow sodium influx.

# 3.Plateau or depolarisation

- Due to opening of calcium channels and longer period by influx of calcium ions
- Slow influx of sodium ions continues
- Entry of Ca + and Na + ions in the muscle fiber

- Positivity inside producing prolonged depolarisation
- Important role in muscle contraction

## 4. Final Repolarisation

**Efflux of pottasium ions**

**Number of K + exceeds number of Ca + ions entering in**

**.**

**Negativity inside –Final repolarisation**

**At this stage , all Na + ions move out and K + ions enters in to cell by activation of SODIUM - POTTASIUM PUMP**

**Simultaneously Ca + ions move out through sodium calcium pump .**

# RHYTHMICITY

- Ability of a tisssue to produce its own impulses regularly is called as AUTORHYTHMICITY or SELF EXCITATION.
- Heart – Specialised excitatory structure from which discharge of impulses is rapid and impulses are spread to other parts through specialised conducting sysytem - PACEMAKER

## PACEMAKER

- Impulses for heart beat are produced .Formed by P cells.
- LEWIS SIR THOMAS in 1918 named SA node as Pacemaker of heart.
- SA node – Modified cardiacmuscle fibers which do not have contractile elements.
- Impulses pass from SA to RA
- Rate of production of impulses is more than other parts.
- About – 70 to 80 /minute

# RHYTHMICITY IN HEART

- SA Node : 70 to 80 /minute
- AV node : 40 to 60 /minute
- Atrial muscle : 40 to 60/minute
- Purkinje fibers : 35 to 40 /minute
- Ventricular muscle : 20 to 40 /minute

## ELECTRICAL POTENTIAL IN SA NODE

- RMP –Pacemaker potential
- Pacemaker potential is unstable resting membrane potential in SA node called as PREPOTENTIAL
- Each impulses triggers the next impulses mainly due to unstable RMP.
- RMP - - 55 to – 60 mV as different from other cardiac muscle ( -85 to – 95 mV )

# Action Potential and Ionic basis

- Depolarisation – very slowly and threshold level is – 40 mV then rapid depolarisation up tp + 5 mV
- Rapid repolarisation occurs and RMP becomes unsatble and reaches threshold level slowly.
- RMP – Pacemaker
- Na + ions leak into pacemaker fibers - Slow depolarisation.
- Slow Influx of Ca 2+ ions – further slow depolarisation forming later part.
- AP starts with rapid depolarisation by influx of Ca 2+ ions
- Repolarisation starts – by efflux of K + ions drom acemaker muscle fibers.
- Development of more negativity beyond level of RMP.
- Same process repeats again leading to development of pacemaker potential which triggers the next AP.

# CONDUCTIVITY

- Has specialised conductive system through which impulses from SA node are transmitted to all other parts of the heart.
- Formed by modifed cardiac muscle fibers.
- Specialized cells which conduct impulses from SA node to the ventricles.
- Conductive tissues of the heart are called as the JUNCTIONAL TISSUES.
- COMPONENTS
- AV node
- Bundle of HIS
- Right and left bundle branches
- Purkinje Fibers

# Situation of components

- **SA node– Right Atrium below SVC**
- **AV nodes- Right posterior portion of Intra- atrial septum**
- **Impulses from SA node are conducted through out right and left atria**
- **Impulses reaches the AV node via INTERNODAL FIBERS.**
- **3 types of INTERNODAL FIBERS**
- **1.Anterior internodal fibers of Bachmann**
- **2. Middle internodal fibers of Wenckebach**
- **3.Posterior internodal fibers of Thorel.**

# PROCESS

- **Fibers from SA node converge on AV node and interdigitate with fibers in AV node.**
- **From AV node BUNDLE OF HIS arises**
- **It divides into right and left branches which runs either side of the interventricular septum.**
- **From each branch of bundle of His, PURKINJIE FIBERS arise and Spread all over Ventricualr myocardium.**

# 1. VELOCITY OF IMPULSES

- **Atrial muscle fibers : 0.3 meter /second**
- **Internodal fibers : 1.0 meter /second**
- **AV node : 0.05 meter /second**
- **Bundle of HIS : 0.12 meter /second**
- **Purkinje fibers : 4.0 meter /second**
- **Ventricular muscle fibers : 0.5 meter /second**

# CONTRACTILITY

- Ability of the tissue to shorten in length ( contraction) after receiving a stimulus.
- Following are the contractile properties.

## ALL –OR –NONE LAW

- When a stimulus is applied, whatever may be the strength ,the whole cardiac muscle gives maximum response or it does not give any response at all.
- Below threshold level if strength of stimulus is not adequate ,the muscle does not give response.

After experiment , its proven that

- Amplitude of all contractions remains same ,irrespective of increasing the strength of stimulus
- Cardiac muscle obeys ALL –OR –NONE LAW
- Law is applicable only because of its SYNCYTIAL arrangement of cardiac muscle.

# STAIRCASE PHENOMENON

- Gradual increase in the force of contraction is called STAIRCASE PHENOMENON
- When the ventricles of a quiescent heart of frog is stimulated at short interval of seconds,
- Without changing the strength,the force of contraction increases gradually for first few contractions and then it remains same.

## Causes

- Beneficial effect which favilitates the force of successive contraction.

# REFRACTORY PERIOD

❖It is the period in which the muscle does not show any response to a stimulus.

## 2 types

❖Absolute refractory period - Is the period during which the muscle does not show any response what ever may the strength of the stimulus.

❖Depolarisation occurs and second one is not possible.

❖Relative Refractory period - Is the period during which the muscle shows response if the strength of stimulus is increased to maximum.Stage will be repolarising.

- **Refractory Period in skelatal muscle – 0.01 sec 1 st – 0.00 5 sec 2 nd -0.005 sec**
- **Refractory Period in Cardiac muscle - 0.53 sec 1 st – 0.27 sec 2 nd – 0.26 sec**
- **Long refractory period in cardiac muscle. Extends through out the contraction period of cardiac muscle.**