CONDUCTIVE SYSTEM OF HEART

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ORIGIN AND SPREAD OF CARDIAC IMPULSE

The heart has a special system for

- **generating rhythmical electrical impulses to cause rhythmical contraction of the heart muscle.**
- **conducting these impulses rapidly through the heart.**
- **Atrial contraction starts 1/6 sec prior to ventricular contraction**

AUTOMATICITY/RHYTHMICITY

- **Automaticity means the ability of the cell to undergo depolarization spontaneously causing the production of electrical impulses.**

- **Rhythmicity means that spontaneous depolarization occurs at regular intervals i.e in a rhythmic manner.**

CARDIAC IMPULSE

- **The action potential in the heart is also called the cardiac impulse and like action potential in the nerve fibers**

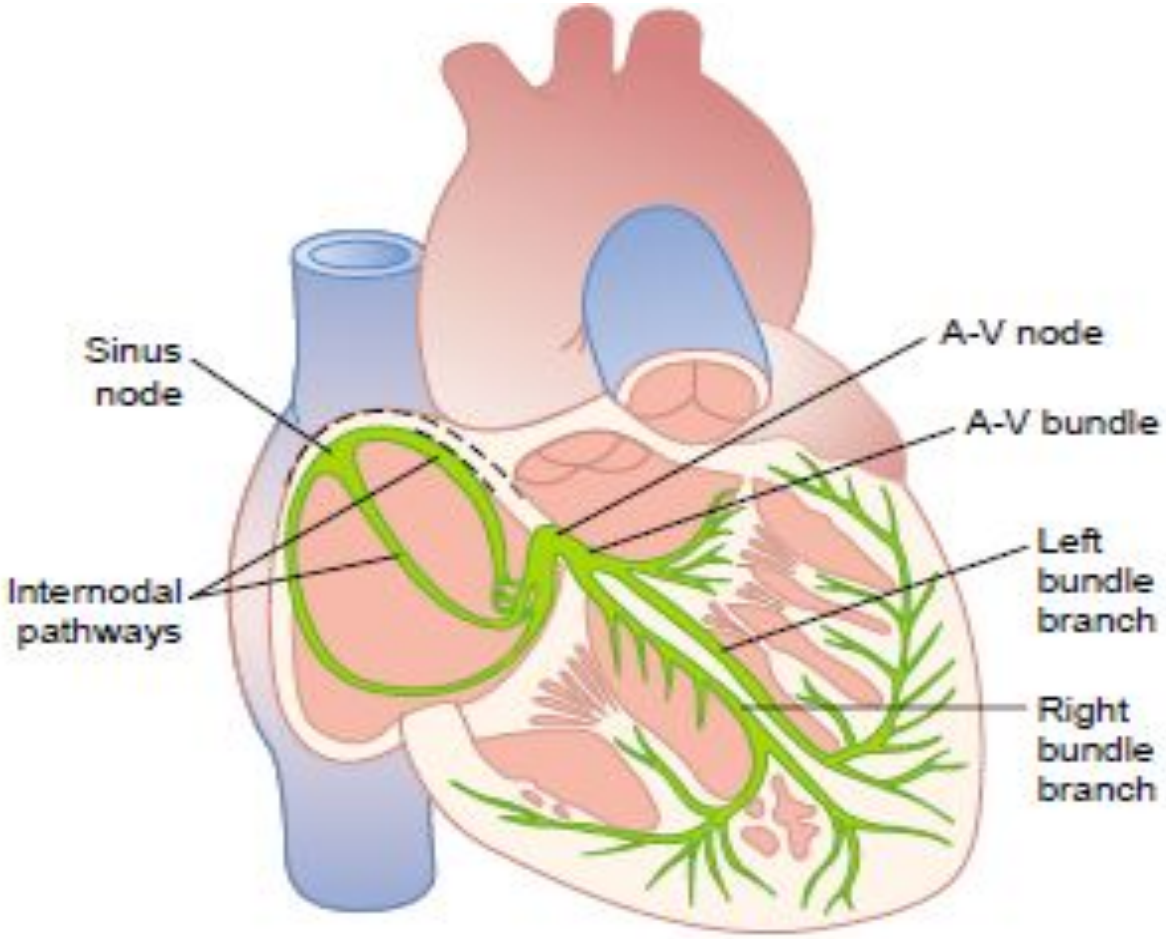
- **It travels through the conducting system of the heart**

COMPONENTS OF THE CONDUCTIVE SYSTEM

- SA node
- Internodal pathways
- A-V node
- A-V bundle
- Right and Left bundle

  branches

CONDUCTIVE SYSTEM



LOCATION OF THE SA NODE

- **SA node is a small, ellipsoid strip of specialized cardiac muscle about 3mm wide, 15 mm long, and 1mm thick.**
- **Location: at the junction of superior vena cava with right atrium**
- **SA nodal fibers connect directly with the atrial muscle fibers.**

SA NODE

- **SA node is the pacemaker of the heart because it contains more number of small round P cells which are called pace maker cells**
- **More number of gap junctions are present.**
- **Normally SA node is responsible for generating the electrical impulses that bring about the mechanical activity i.e contraction of the heart.**

SA NODE CONTD

- SA node has the fastest rate of autorhythmicity.
- The impulse spreads in all directions
    1. cardiac muscles of atria
    2. interatrial tract to left atrium
    3. inter nodal tracts to AV node

EXPERMENTAL EVIDENCE TO PROVE THAT S.A NODE ACTS AS A PACE MAKER OF THE HEART

1. S.A node becomes electrically negative before any other part of the atria which indicates that it is the first region to become active
2. Stimulation of S.A node increases heart rate
3. Local cooling and warming of S.A node
4. Artificial destruction of S.A node leads to immediate stoppage of heart

ROLE OF INNERVATION OF HEART

- **Parasympathetic stimulation increase the permeability of S.A nodal fibres to potassium leads to reduced rate of impulse generation and reduced excitation of conducting system**
- **Sympathetic stimulation increases the permeability of S.A nodal fibres to calcium leads to increased rate of impulse generation and increased excitation of conducting system**

SPREAD OF CARDIAC IMPULSE FROM SA NODE TO ATRIAL MUSCLE

The cardiac impulse after it's origin in the SA node spreads through out the atrial muscle through 2 routes.

ORDINARY

- Atrial muscle fibers

Conduction velocity

0.3 m/sec

SPECIALIZED

- Anterior inter nodal bundle of Bachman

- Middle inter nodal bundle of Wenkebach

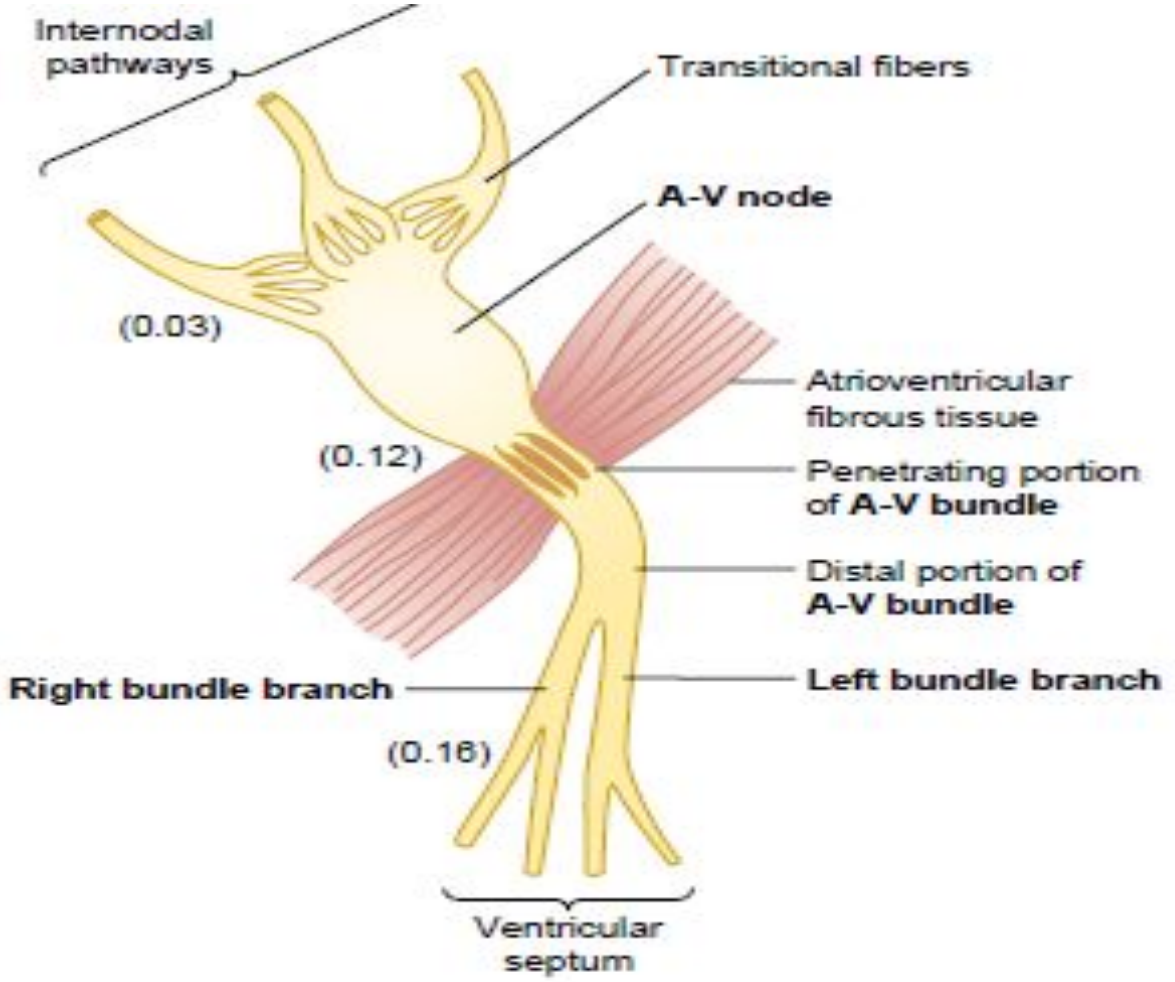
- Posterior inter nodal bundle of Thorel

Conduction velocity1m/sec

INTER NODAL PATHWAYS

- These (specialized) inter nodal pathways conduct the impulses at a faster rate than the ordinary atrial muscle fibers.
- The cause of rapid conduction in these bundles is the presence of specialized conduction fibers.
- These pathways connects S.A node and A.V node
- From S.A node a conducting tract arises and directly enters into the left atrium – Bachman's bundle

CONDUCTION OF CARDIAC IMPULSE



AV NODE

The AV node is located in the posterior wall of the right atrium immediately behind the tricuspid valve.

Rate of impulse discharge lesser than S.A node because presence of lesser p cells

Annuli fibrosii: It is fibrous, non conductive, connective tissue ring

which separates atria and ventricles

A.V node generates impulses whenever

1. S.A node is out of order

2. Blockage of conduction from S.A node

A V NODAL DELAY

- **Due to the slow conduction in AV node**
- **before the impulse reaches the penetrating portion of AV bundle – 0.09sec (A.V node)**

AV NODAL DELAY

- **In the penetrating portion of AV bundle – 0.04 sec.**
- **In the AV node and AV bundle system- 0.13 sec (Total delay).**
- **From the sinus node to the AV node – 0.03 sec**
- **Total delay of 0.16 sec before the excitatory signal finally reaches the contracting muscle of ventricles.**

CAUSE OF SLOW CONDUCTION IN THE A-V NODE

The cause of slow conduction

1. Diminished number of gap junctions between the successive cells in the conducting pathways.

2. Cells are made up of small diameter fibers

3. Presence of Multiple sub branches

As a result of which there is great resistance to conduction of excitatory ions from one conducting fiber to the next.

SIGNIFICANCE OF AV NODAL DELAY

- **The cardiac impulse does not travel from the atria to the ventricles too rapidly.**
- **This delay allows time for the atria to empty their blood into the ventricles before ventricular contraction begins. This increases the efficiency of the pumping action of the heart.**
- **It is primarily the AV node and it's adjacent fibers that delay this transmission into the ventricles**

SIGNIFICANCE OF AV NODAL DELAY CONTD

- A. V nodal delay which is beneficial in pathological conditions like atrial fibrillation in which all the electrical impulses from atria cannot reach the ventricle [inherent]
- Drugs like digitalis and beta blockers promotes A.V nodal delay inturn reduces heart rate
- Vagal stimulation also increases A.V nodal delay
- Sympathetic stimulation decreases A.V nodal dela

AV BUNDLE OR BUNDLE OF HIS

- **Bundle of His: special conducting pathway it arises from A.V node**
- **Bundle of His is the only conducting mass between the atrial and ventricular musculature**
- **It transmits the cardiac impulses from the AV node to the ventricles.**
- **Conduction velocity is low at penetrating portion**
- **Maximum at distal portions**

RIGHT AND LEFT BUNDLE BRANCHES

- **After penetrating the fibrous tissue between the atrial and ventricular muscle, the distal portion of the A-V bundle passes downward in the ventricular septum for 5 to 15 mm toward the apex of the heart.**
- **Then the bundle of His splits into two branches which are called right and left bundle branches that lie on the respective sides of the ventricular septum.**

RIGHT AND LEFT BUNDLE BRANCHES CONTD

- **Each branch spreads downward toward the apex of the ventricle, progressively dividing into smaller branches.**
- **These branches inturn course sidewise around each ventricular chamber and back toward the base of heart.**

PURKINJE FIBERS

- **Purkinje fibers are very large fibers**
- **They transmit action potentials at a velocity of 1.5 to 4.0 m/sec.**
- **The rapid transmission of action potentials through the Purkinje fibers: by a very high level of permeability of gap junctions at the intercalated discs between the successive cells of Purkinje fibers.**

PURKINJE FIBERS CONTD

- **The ends of Purkinje fibers penetrate about one third of the way into muscle mass and finally become continuous with cardiac muscle fibers.**
- **From the time the cardiac impulse enters the bundle branches until it reaches the terminations of Purkinje fibers, the total elapsed time averages only 0.03 sec.**

PURKINJE FIBERS CONTD

- **The rapid conduction through the purkinje fibers ensures that different parts of ventricles are excited almost simultaneously; this greatly increases the efficiency of heart as a pump.**

ONE- WAY CONDUCTION THROUGH AV BUNDLE

- A special characteristic feature of the A-V bundle: one way conduction,
- In the abnormal states, action potentials travel backward from the ventricles to the atria.
- This prevents re-entry of cardiac impulse by this route from the ventricles to the atria.

ONE- WAY CONDUCTION THROUGH AV BUNDLE CONTD

- **Fibrous barrier:**
- **acts as an insulator**
- **prevents the passage of cardiac impulse between the atrial and ventricular muscle through any other route**
- **except forward conduction through A-V bundle itself.**

CONDUCTION IN THE CARDIAC MUSCLE

- **Once the impulse reaches the ends of the Purkinje fibers and it is transmitted through the ventricular muscle mass by the ventricular muscle fibers themselves.**
- **For transmission of the cardiac impulse from the endocardial surface to the epicardial surface requires another 0.03 sec.**

- **Thus the total time for transmission of cardiac impulse from the initial bundle branches to the last of the ventricular muscle fibers in the normal heart is about 0.06 sec.**

CONDUCTION SPEED IN CARDIAC TISSUES

Tissue	Conduction Rate (m/s)
SA node	0.05
Atrial pathways	1
AV node	0.05
Bundle of His	1
Purkinje system	4
Ventricular muscle	1

TIME TAKEN FOR THE CARDIAC IMPULSE

SA node

↓ **0.03 sec**

AV node

↓ **0.13 sec**

Bundle branches

↓ **0.03 sec**

Purkinje fibres

↓ **0.03 sec**

Endocardial and epicardial surface of ventricles

NORMAL RATE OF IMPULSE DISCHARGE

Tissue	Impulse discharge per minute
SA node (normal pacemaker)	70-80
AV node	40-60
Bundle of His and Purkinje fibers	20-40


THANK YOU