



PHYSIOLOGY TEAM 432

LECTURE : 2

Cardiac electrical activity

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OBJECTIVES

Not Given in both sides

MIND MAP

Excitatory and Conductive System

Purkinje fibers

(Bundle of His)

AV node

Internodal Pathway

SA node

Generate Action potential (electrical impulse)

Hyperpolarizing

Repolarizing

Depolarizing

Pre-Potential

The Specialized Excitatory and Conductive System of the Heart :

1. The sinoatrial (***S-A node***)
2. The internodal pathway
3. The atrioventricular (***A-V node***)
4. The atrioventricular bundle (***Bundle of His***)
5. Purkinje fibers

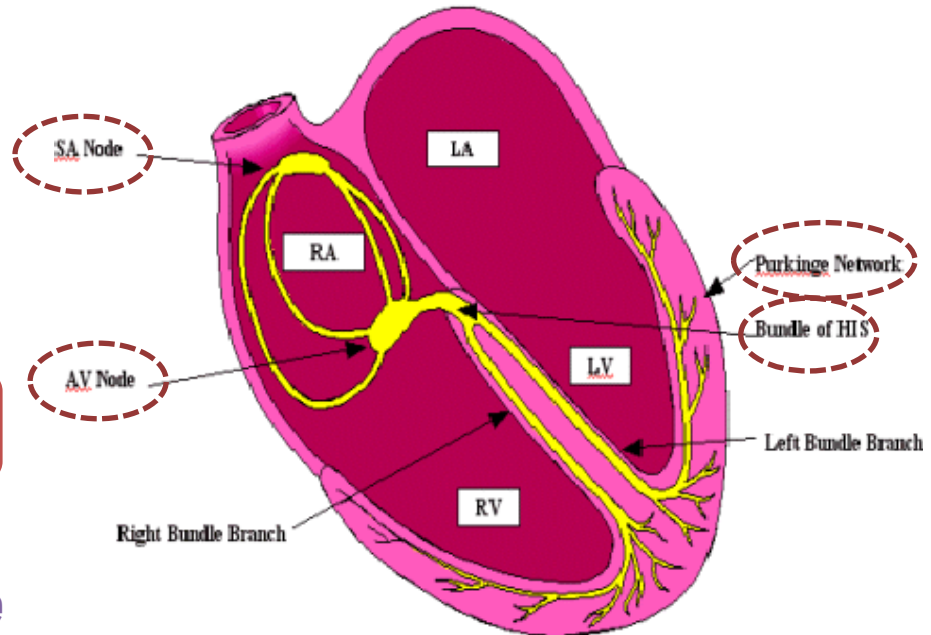
Automaticity of the heart:
_the heart is capable of :

1- **Generating**
rhythmical electrical
impulses

2- **Conduct** the impulses
rapidly through the
heart

* **The atria contract first**
(before **the ventricles**)

To allows filling of the ventricles before
they pump the blood into the circulation



Rhythmical = متوازن / Conduct = يوصل

	Location	Features
Sinoatrial node (S-A node)	<u>Superior lateral</u> wall of the right atrium	<ul style="list-style-type: none"> - Pacemaker of the heart - Highest frequency - Capable of originating action potentials
Atrioventricular (A-V) node	<u>Posterior</u> wall of the right atrium	- Delay in the conduction of impulses (0.1 sec) **
The Purkinje System	* Inner wall of the ventricles	<ul style="list-style-type: none"> - very large fibers - Transmit action potentials at a very high velocity ***

Ventricular muscle contract at almost **the same time**

* : not mention in the slide .

** : To allow the atrium to contract before the ventricle .

*** : because it has a very high permeability of gap junction = Ions are transmitted easily from one cell to the next .

Difference in action potential In the S-A node:

* Resting potential is less negative **-55 mV** instead of -85 mV

1

↓ This by it self , it inactivates the fast sodium channels

- The fast sodium channels are **inactivated**
- Only the slow sodium channels can be **activated**

2

As a result, the atrial nodal action potential is **slower** to develop than the ventricular muscle

* the return of the potential to its negative state occurs **slowly**

Self- Excitation of S-A node :

* Leaking of Positive sodium ions to the inside

3

↓ Why ?

1. High sodium ion concentration in the extracellular fluid outside the nodal fibers
2. Already open sodium channels

* Leakiness of the sinus nodal fibers to **sodium and calcium** ions causes their self- excitation

Sodium and calcium leakage

Is the cause of Self-Excitation of S-A node

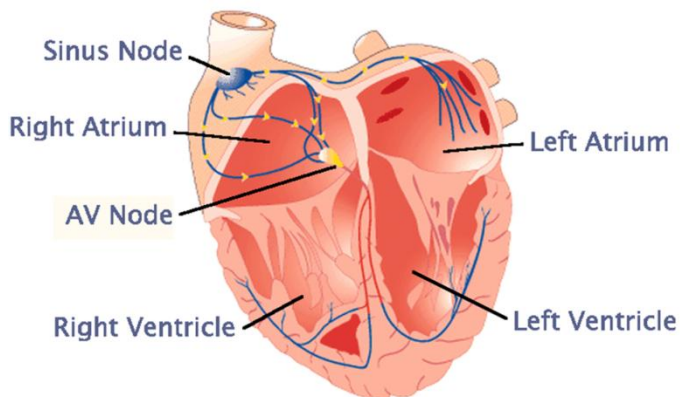
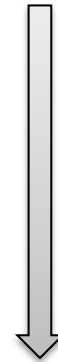
Conduction of Impulses :

- **Inter-nodal pathway and transmission of the cardiac impulse :**

The end of the SA node connect **directly** with the surrounding atrial muscle fibers. Therefore the action potential travel through the enter atrial muscle mass and then **eventually** to the AV node.

Note : not in the slide but Dr.ashruf said it's important:

One of the small atrial fibers called "anterior interatrial band" pass through the anterior walls of the atria to the left atrium! and cause the contraction of the left atrium by passing the impulse to it!



ان الاشارة ما تنتقل مباشرة بين SA node والـ AV node بل تنتقل عن طريق الفايبرز الموجودة في العضلات ثم تنتقل الى الـ AV node

How does the action potential terminate ?

1. The sodium-calcium channels become inactivated after certain period of time
2. open of potassium channels (potassium out)

* Potassium channels remain open for another tenth of a second causing hyperpolarization (potassium out) -55 to -60 mV

- Atrioventricular (A-V) node:

Is Located in **the posterior wall** of the right atrium.

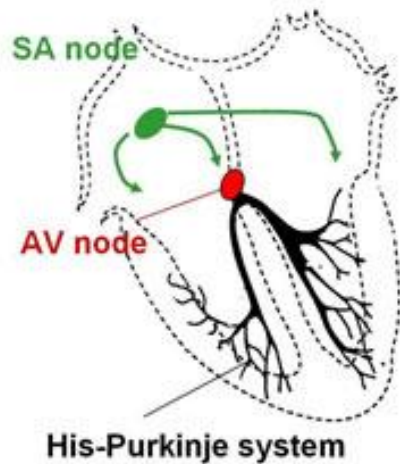
AV node is organized so that the impulse doesn't travel rapidly to the ventricles!

This **Delay** in the conduction of impulses (**0.1 sec**)



will allows time for the atria to empty the blood into the ventricles before ventricular contraction begin.

• The Purkinje System



The Purkinje fibers will penetrate **atrioventricular fibrous tissue** .

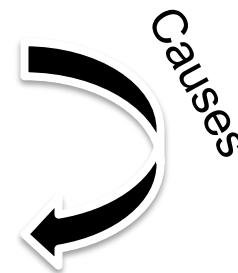
- Divides into right and left bundle branches
- each branch spread toward **the apex** of the heart
- divide into small branches
- penetrate and become continuous with cardiac muscle fibers

Features of Purkinje fibers:

Purkinje fibers are very **large**.

Transmit action potentials at a **very high velocity** (0.1-4.0 m/sec)

1. very high **permeability** of gap junctions
2. ions are transmitted easily from one cell to the next
3. enhance the velocity of transmission



And that's why Ventricular muscle contract at almost **at the same time**

Control of Excitation and Conduction in the Heart

- * The impulse normally arise s in the sinus node
- * The Sinus Node is the Pacemaker of the Heart

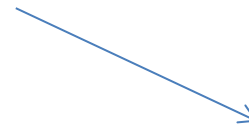
Abnormal Pacemakers

Ectopic pacemaker: a pacemaker elsewhere than the sinus node . Why ?



Any other part of the heart develops a rhythmical discharge rate that is more rapid than that of the sinus node

Example: the A-V node or in the Purkinje fibers



Blockage of transmission of the cardiac impulse from the sinus node to the other parts of the heart

Example: A-V block = cardiac impulses fails to pass from atria into the ventricles

Control of Heart Rhythmicity and Impulse Conduction by the Cardiac Nerves

* The heart is supplied with both **sympathetic** and **parasympathetic (vagi)** nerves

all parts of the heart with strong supply to the ventricles

mainly to the S-A and A-V nodes

↑ rate of rhythm of the S-A node

↑ transmission of impulses to the A-V node

- force of contraction
- (+ve Inotropic effects)

↓ rate of rhythm of the S-A node

↓ transmission of impulses to the A-V node
(-ve Inotropic effects)

Strong stimulation of the **vagi**:

- Stop completely the rhythmical excitation by the S-A node
- Block completely transmission of cardiac impulses from the atria to the ventricle
- Some point in the Purkinje fibers develops a rhythm of its own (**Ventricular Escape**)

Control of Heart Rhythmicity and Impulse Conduction by the Cardiac Nerves :

	Sympathetic	Parasympathetic (Vagus Nerve)
Supply	all parts of the heart with strong supply to the ventricles	mainly to the S-A and A-V nodes
Rate of rhythm	↑ rate of rhythm of the S-A node	↓ rate of rhythm of the S-A node
Transmission of impulses	↑ transmission of impulses to the A-V node	↓ transmission of impulses to the A-V node
Force of contraction	↑ force of contraction	_____
Inotropic effect	Positive	Negative

The difference between Ventricle action potential and SA node :

	Ventricle Action Potential	SA Node Action Potential
Resting Membrane potential (RMP)	(-85 to -95)	(-55 to -60)
Fast sodium channels	Open	Closed The cause: the membrane potential is -55 mV (more negative)
Slow Calcium-sodium channels	Open In the plateau phase	Open
Speed Of Develop	Faster	Slower the cause: Only the slow sodium channels can be activated
Speed Of Return to RMP	Faster	Slower

SUMMARY

- SA Node is able to **generate** the electrical impulse and **conduct** it through the heart (by **AV node** and **internodal pathway**)
- SA node is the **pacemaker** of the heart
- SA node action potential is 4 phases : (pre-potential - Depolarizing - repolarizing - hyperpolarizing)
- AV node **delay** the impulse (0.1 sec) to allow the ventricle to be filled with blood
- Purkinje fibers are very **large** and **fast**

	Channel	Ion
Pre-Potential	Sodium leak channels	Na ⁺ inflow
Slow Depolarizing	Sodium-calcium slow channels	Ca ²⁺ inflow
Repolarizing	Potassium channels	K ⁺ outflow
Hyperpolarizing	Potassium channels	K ⁺ outflow

SUMMARY

Dr.Ashruf Notes :

- SA node is **faster** than AV node (the cause is : in the AV node the pre-potential phase is flat) but the **fastest** is Purkinje fibers!
- SA node is the **pacemaker** and the phase that responsible about that is the **Pre-Potential Phase!!**
- Why the heart beat become fast then slow? The cause s the **sympathetic** (make it fast) and **parasympathetic** (make it slow) nerve supply!

THE END

**If there are any problems or suggestions
Feel free to contact:**

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THANK YOU

Actions speak louder than Words