جامعة الملك سعود
King Saud University

MED438
KING SAUD UNIVERSITY

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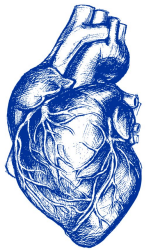
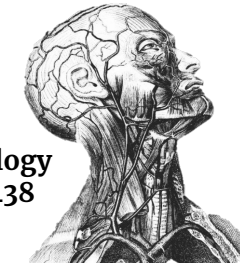
Lecture 2

Cardiac Electrical Activity

- Red: important
- Black: in male / female slides
- Pink: in female slides only
- Blue: in male slides only
- Gray: extra information

Editing file





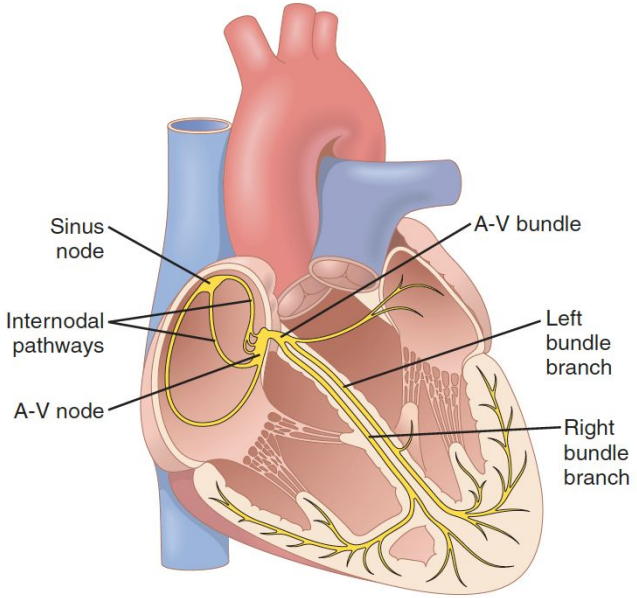
Physiology
MED438

Objectives:

- Know the components of the conducting system of the heart, the conduction velocities and spread of the cardiac impulse through the heart.
- Understand the control of excitation and conduction in the heart
- Identify the action potential of the pacemaker and the differences between pacemaker potential and action potential of the cardiac myocytes.
- Describe the control of heart heart rhythmicity and impulse conduction by the cardiac nerves, what is latent and abnormal pacemakers

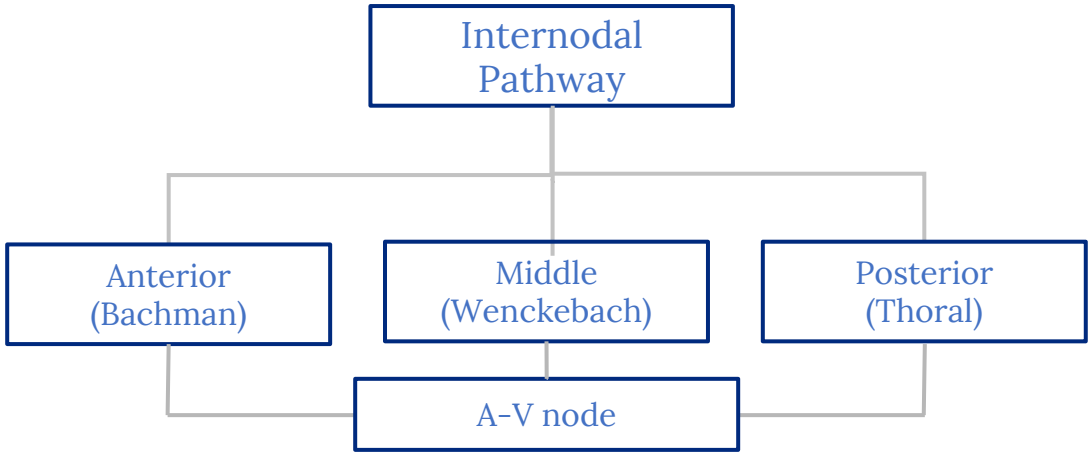
Components of the Conducting System

S	Sequence of Excitation	Conduction v (m/s)
1	Sinoatrial (S-A) node	0.05 m/s
2	Atrial muscles	0.3 m/s
3	Internodal pathway	1 m/s
4	Atrioventricular (A-V) node	0.03-0.05 or 0.01 m/s (slowest)
5	A-V Bundle (Bundle of His)	1 m/s
6	Right & Left Bundle Branches	1 m/s
7	Purkinje Fibers	1.5-4 m/s (fastest)
8	Ventricular muscles	0.3-0.5 m/s



S-A Node and Internodal Pathway

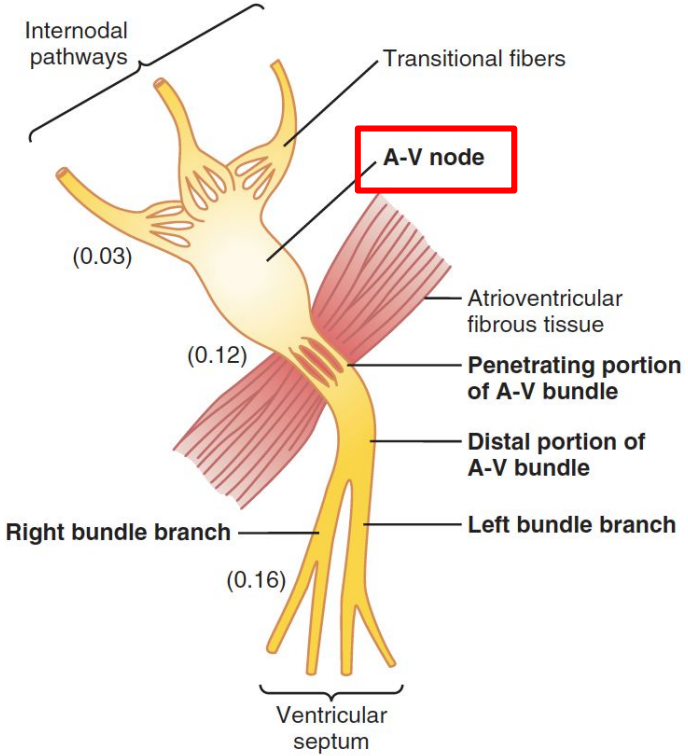
- SA node is located in the superior posterio-lateral wall of the right atrium.
- It's made up of specialized cardiac cells that have an unstable membrane potential which can generate action potentials.
- It's considered the normal ***pacemaker*** of the heart.
- It generates an impulse to the atrium and internodal pathways to the AV node.



A-V Node and Bundle of His

- AV node is located in the posterior wall of the right atrium.
- It receive impulses from SA node & transmits it to the ventricles through the AV bundle
- AV node has a very slow conduction velocity because of the **decrease in number of gap junctions.**
- This delays atria and ventricular contractions and this delay is important to: **(0.13s /one-sixth of a second)**

  1- Allow atria to empty before ventricles
  2- Protect ventricles from pathological high atrial rhythm
- The bundle of His prevents impulses from travelling backward from ventricle to atria

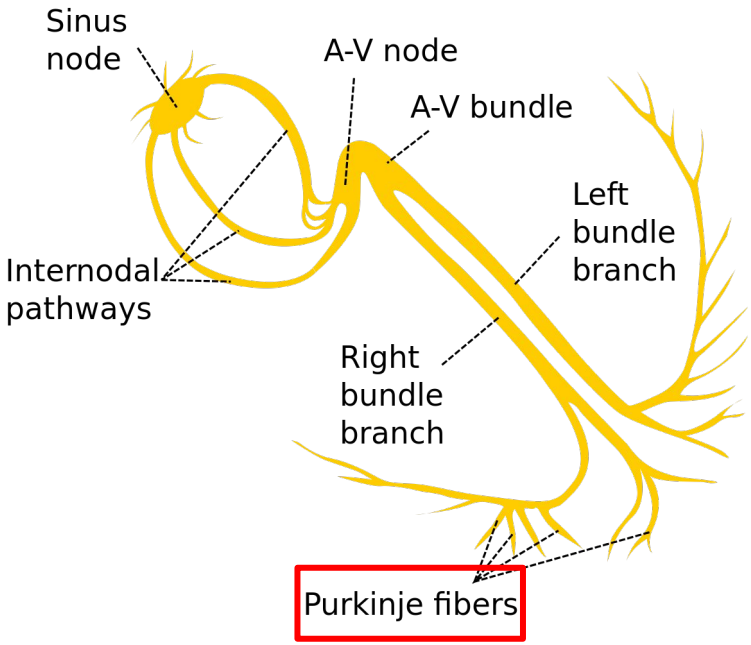


Purkinje Fibers

- Are continuous branches from the bundle branches inside the ventricular wall.
- They are very large fibers with very high conduction velocity due to the **increase in permeability of gap** junctions to ions.

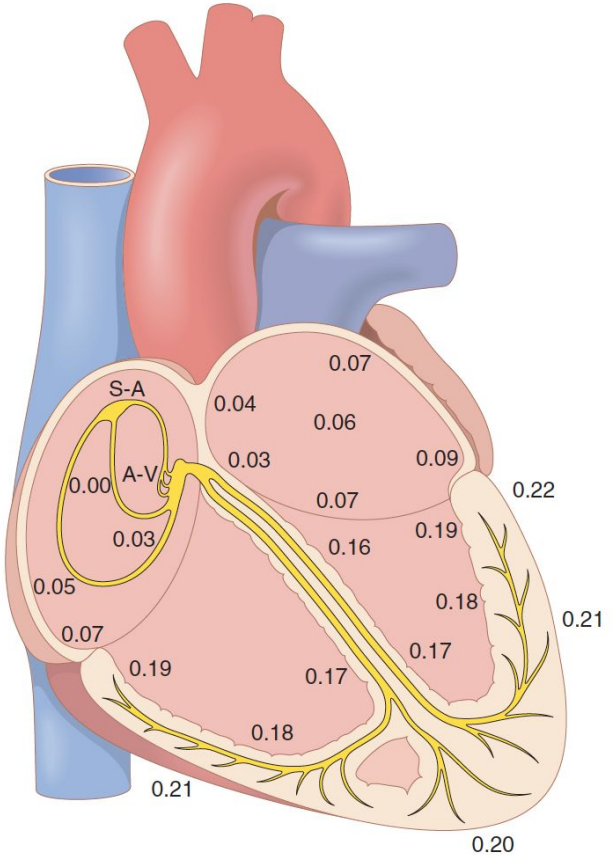
Significance:

- Ensure that the ventricular muscles are stimulated simultaneously. (synchronous contraction)



Extra from Guyton p. 126

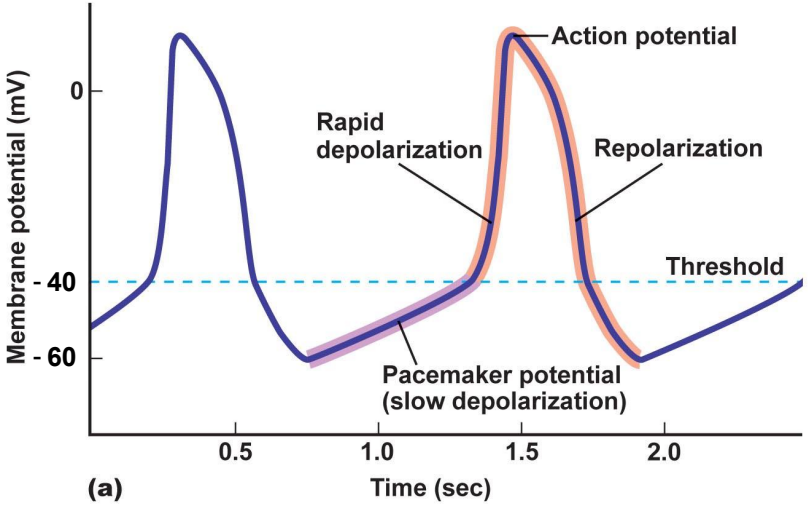
The numbers on the figure represent the intervals of time, in fractions of a second, that lapse between the origin of the cardiac impulse in the sinus node and its appearance at each respective point in the heart. Note that the impulse spreads at moderate velocity through the atria but is delayed more than 0.1 second in the A-V nodal region before appearing in the ventricular septal A-V bundle. Once it has entered this bundle, it spreads very rapidly through the Purkinje fibers to the entire endocardial surfaces of the ventricles. Then the impulse once again spreads slightly less rapidly through the ventricular muscle to the epicardial surfaces. It is important that the student learn in detail the course of the cardiac impulse through the heart and the precise times of its appearance in each separate part of the heart; a thorough quantitative knowledge of this process is essential to the understanding of electrocardiography,



Female slides

Action Potential of Pacemakers

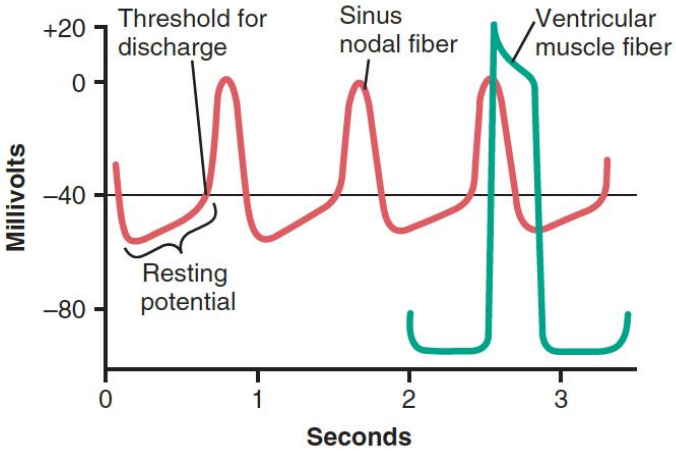
Phase	Description	Potential
1	**Na+ is leaky** in the cell membrane of pacemakers. This will gradually decrease the membrane potential.	-60 mV
2	**Ca++ influx** through transient Ca++ Channels. This phase is called **pre-potential phase**.	-40 mV (firing level/threshold)
3	**Ca++ influx** through long lasting Ca++ Channels causes rapid depolarization.	+10 mV
4	Rapid repolarization due to **K+ efflux** and membrane potential returns to normal	-60 mV
The cycle is repeated by self excitation due to the heart automaticity		



Female slides

Differences Between Action Potentials ✦

Pacemakers	Cardiac Muscles
Doesn't need a stimulus	Needs a **stimulus**
RMP = **-60 mV**	RMP = **-90 mV**
Max = **+10 mV**	Max = **+20 mV**
Small magnitude	**High** magnitude
Pre-potential stage	**NO** pre-potential stage
Depolarization is **gradual**	Depolarization is **rapid**
Depolarization is due to **Ca++**	Depolarization is due to **Na+**
Has a **spike**	Has a **plateau**

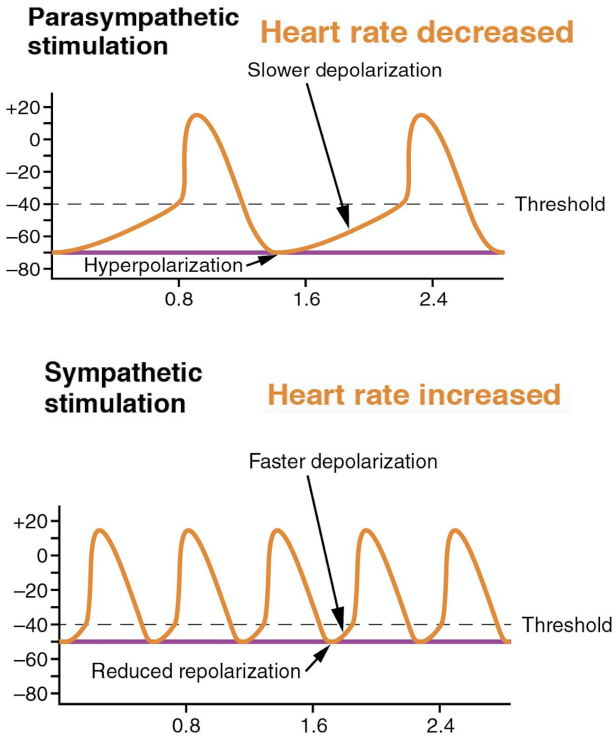


Control of Heart Rhythmicity & Conduction

Female slides

Parasympathetic	Sympathetic
Vagus nerve to the SA and AV nodes	Sympathetic trunk
Increase K+ permeability	Increase Na+ & Ca++ permeability
Decrease prepotential slope of SA node (slows heart rate)	Increase prepotential slope (accelerates heart rate)
Decrease transmission to AV	Increase transmission to AV node which will increase contraction

Strong stimulation of the **vagi** (parasympathetic effect) could completely stop rhythmical excitation by the SA node, which will block transmission of impulses from the atria to the ventricle (AV node). This could cause the Purkinje fibers to develop its own rhythm. This is called "***ventricular escape***".

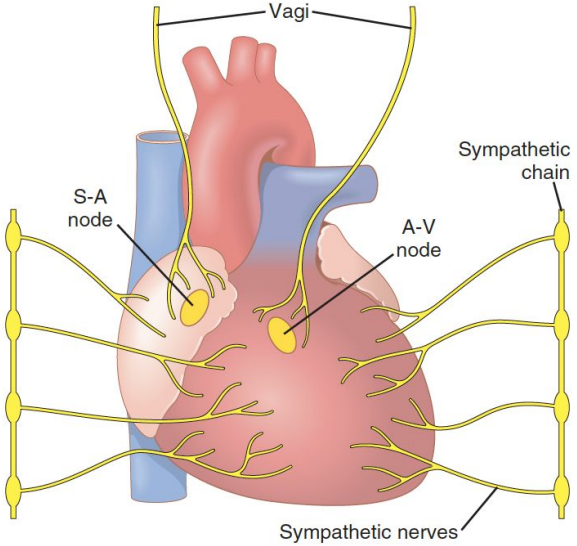


Female slides

Latent Pacemakers

- The SA node is the normal pacemaker of the heart , and has the highest rhythmicity.
- It sends impulses at a rate of 105 impulse/min, but it's decreased to 70 impulse/min by the vagus nerve (vagal tone).
- The AV node, His bundle, & Purkinje fibers also have the ability t set a pace, but they are normally suppressed.
- They are called "***latent pacemakers***" & function only if:

1. The SA node is damaged.
2. Its impulse is blocked.
3. The rate of firing of the latent pacemakers increases.



SA Node (70 impulse/min)	AV node "A-V nodal rhythm" (50-60 impulse/min)	Purkinje Fibers "Idioventricular rhythm" (28-40 impulses/min)

Ectopic (abnormal) Pacemakers

An ***ectopic pacemaker*** is a pacemaker other than the sinus node (SA node).

Causes:

- Other parts of the heart develop a rhythmical discharge rate that's more rapid than the SA node.
- Blockage of transmission from the SA node to other parts of the heart.

Example:

- In AV block, the SA node cannot transmit the impulse to the ventricle, thus the purkinje fibers will become an ectopic pacemaker with its own rhythm.
- Upon excess caffeine, lack of sleep, anxiety, and stress, the purkinje system can be over-excited and will create its own rhythm becoming an ectopic focus or pacemaker.

Quiz

1. Which of these has the highest conduction velocity?
   - **A.** Purkinje fibers
   - **B.** Atrial muscles
   - **C.** AV node
   - **D.** Wenckebach internodal pathway

2. Which of these prevents backward deflection of impulse?
   - **A.** SA node
   - **B.** AV node
   - **C.** Bundle of His
   - **D.** Purkinje fibers

3. Which of these is the approximate atria-ventricular delay?
   - **A.** 0.15 s
   - **B.** 0. 3 s
   - **C.** 0.013 s
   - **D.** 0.4 s

4. Which of the following is the correct reason for the increase in pacemakers RMP (-60 mV)?
   - **A.** Release of Ca++ through transient channels
   - **B.** Release of Ca++ through long lasting channels
   - **C.** Decreased K+ permeability through cell membrane
   - **D.** Leakage of Na+ through the cell membrane

5. Which of these best describes ectopic pacemakers?
   - **A.** Increase in CO due to sympathetic effect
   - **B.** Blockage of AV node
   - **C.** Bradycardia following a heart attack
   - **D.** Any pacemaker other than AV node

SAQ:

1- Differentiate between AP of pacemakers and cardiac muscles.

Slide 9

2- Explain why purkinje fibers are so important

Synchrous contraction of ventricles

Answers: A - C - A - D - B - C

Leaders

Sedra Elsirawani Abdulrahman Alhawas

Members

- Lama AlZamil
- Arwa AlEmam
- Noura AlTurki
- Ghada AlSadhan
- Nouf AlShammari
- Nouf AlHumaidhi
- Taibah AlZaid
- Ajeed AlRashoud
- Reem AlGarni
- Raghad AlKhashan
- Leen AlMazroa
- Nouran Arnous
- Maha AlNahdi
- Badr Almuhanna
- Abdulrahman Almezaini
- Omar Aldosari
- Omar Alghadir
- Ibrahim Alshaqrawi
- **Abdullah Aldawood**
- Abdullah Shadid
- Meshari Alzeer
- Mohammed Alhamad
- Abdullah Alassaf
- Khalid Alkhani
- Amjad Albaroudi
- **Mohammed Alhuqbani**