PHYSIOLOGY

بسم الله الرحمن الرحيم

MID | Lecture 6

Abnormal ECG “Arrythmias”

وَلَقَدْ خَلَقْنَا الْإِنسَانَ وَنَعْلَمُ مَا تُوَسْوِسُ بِهِ نَفْسُهُ ۖ وَنَحْنُ أَقْرَبُ إِلَيْهِ مِنْ حَبْلِ الْوَرِيدِ

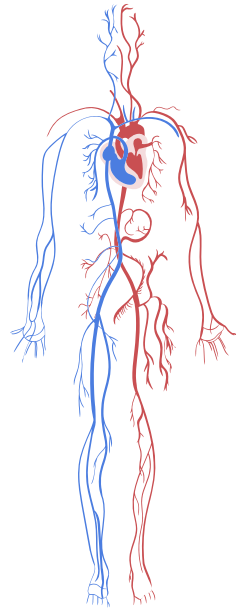
اللهم إنّا نعوذ بك من شرور أنفسنا ومن سيئات أعمالنا

Written by: Deema Nasrallah

Reviewed by: Lubna Alhourani

فريق دوبامين العلمي - THE SCIENTIFIC TEAM OF DOPAMINE

APPROVED
0500331



Electrocardiography – Abnormalities (Arrhythmias)-3-

Faisal I. Mohammed, MD, PhD

Causes of Cardiac Arrythmias

- Abnormal rhythmicity of the pacemaker

Arrhythmias: are abnormalities in electrocardiography.

- Shift of pacemaker from sinus node
  - Remember that we refer to the shift of the intrinsic activity of the heart from the **sinus node** to another place as an **ectopic pacemaker.**
- Blocks at different points in the transmission of the cardiac impulse
- Abnormal pathways of transmission in the heart
- Spontaneous generation of abnormal impulses from any part of the heart

Abnormal Sinus Rhythms

- Tachycardia means a fast heart rate usually greater than 100 beats /min. (Normal heart rate is 60–100 beats/min).

- Caused by:

(1) increased body temperature, (because the increased body temperature increases the permeability of ions, like Na+ and Ca2+).

(2) sympathetic stimulation (such as from loss of blood and the reflex stimulation of the heart) Sympathetic stimulation causes: Positive chronotropic effect (increased heart rate) and positive inotropic effect (increased contractility).

(3) toxic conditions of the heart, Such as hyperthyroidism (increase in T3 and T4 hormones).

Abnormal Sinus Rhythms

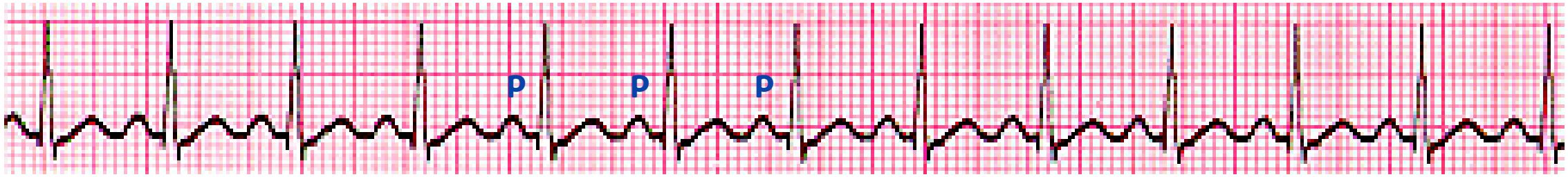
- In this ECG, each RR interval represents one cycle, and the number of the small squares between two consecutive R-peaks is 10 small squares:

  10 × 0.04=0.4sec -> Each cycle is 0.4sec.

  Heart rate: 60/0.4=150 beats/min (tachycardia).

- Note that the heart beats are regular.

Sinus Tachycardia

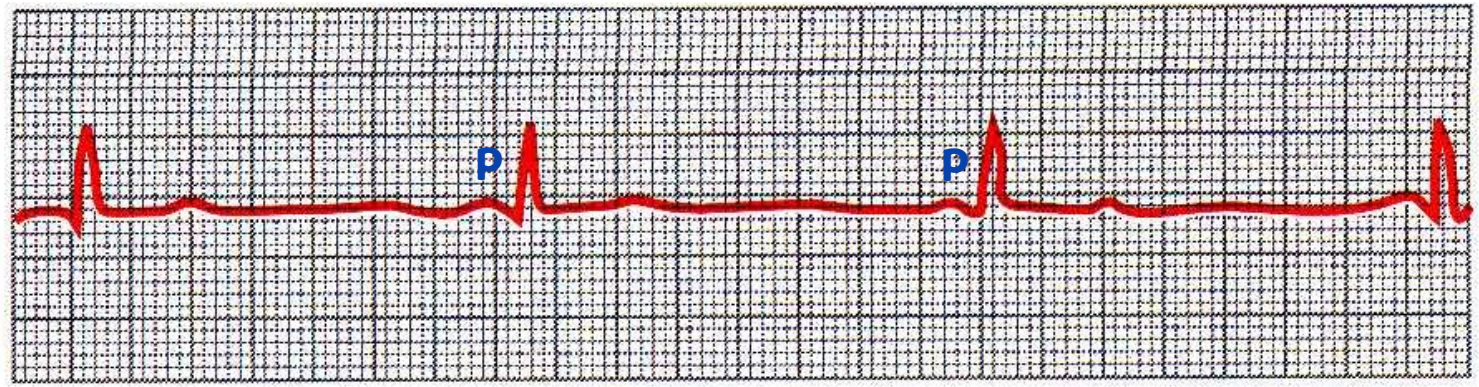


- Etiology: SA node is depolarizing faster than normal, impulse is conducted normally.
- Remember: sinus tachycardia is a response to physical or psychological stress, such as sympathetic stimulation, not a primary arrhythmia.

Abnormal Sinus Rhythms (cont'd)

- Bradycardia means a slow heart rate usually less than 60 beats /min
- Present in athletes who have a large stroke volume
  - Athletes have strong hearts that can generate larger **stroke volume** per beat (pumping more blood for each beat). Because of this increased pumping ability; athletes don't need a high heart rate to maintain a normal cardiac output.
  - Cardiac output = stroke volume × heart rate.
  - So, since their stroke volume is higher, their heart rate can be lower while still producing the same cardiac output. This lower resting heart rate is normal.
- Can be caused by vagal stimulation (parasympathetic stimulation causes negative chronotropic effect), one example of which is the carotid sinus syndrome (pressure on the carotid sinus, thus, overstimulation of the vagus).

Abnormal Sinus Rhythms (cont'd)



⇨ Heart Rate?

- RR interval is around 35 small squares:

35 × 0.04=1.4sec

Heart rate= 60/1.4=42 beats/min

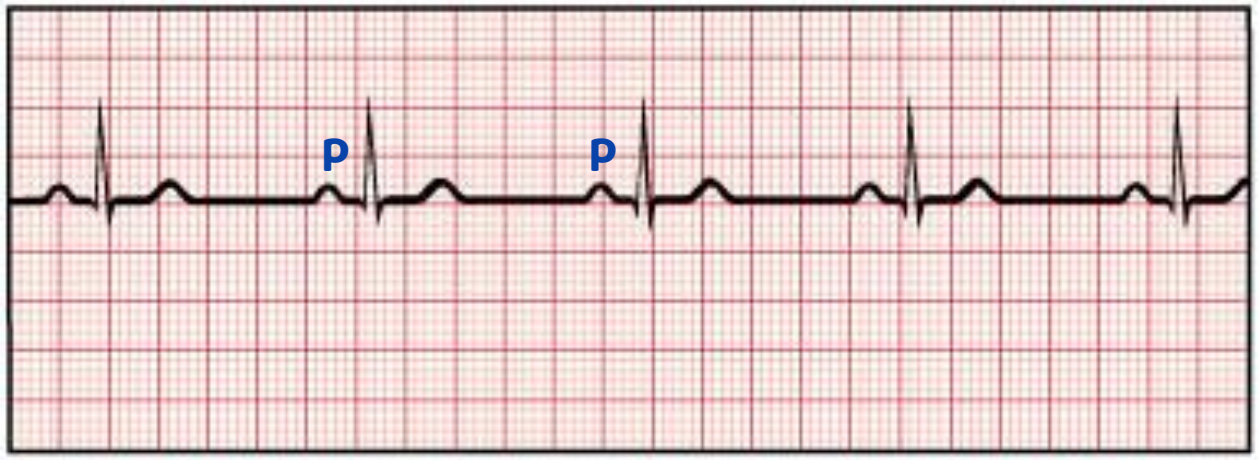
(Bradycardia).

Sinus Bradycardia

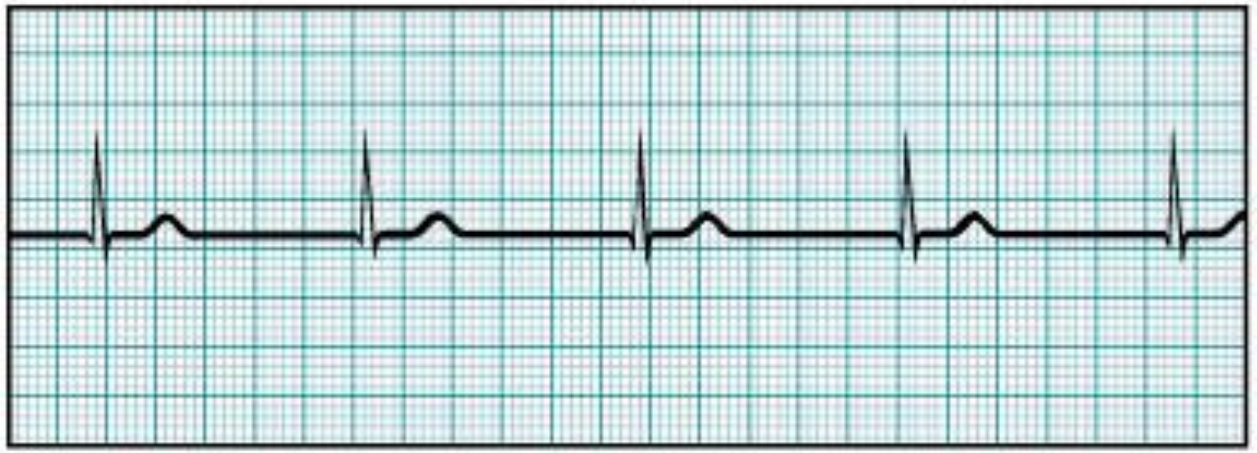
- Etiology: SA node is depolarizing slower than normal, impulse is conducted normally (i.e. normal PR and QRS interval) rate is slower than 60/beats per minute
- **Normal PR interval means normal conduction between the SA node and the AV node.**

Heart rate:
Number of small squares between two consecutive R peaks is 40:
40*0.04=1.6sec
60/1.6=38 beats/min (very slow).

ECGs, Normal and Abnormal



(a) Sinus rhythm (normal)


(b) Nodal rhythm – no SA node activity

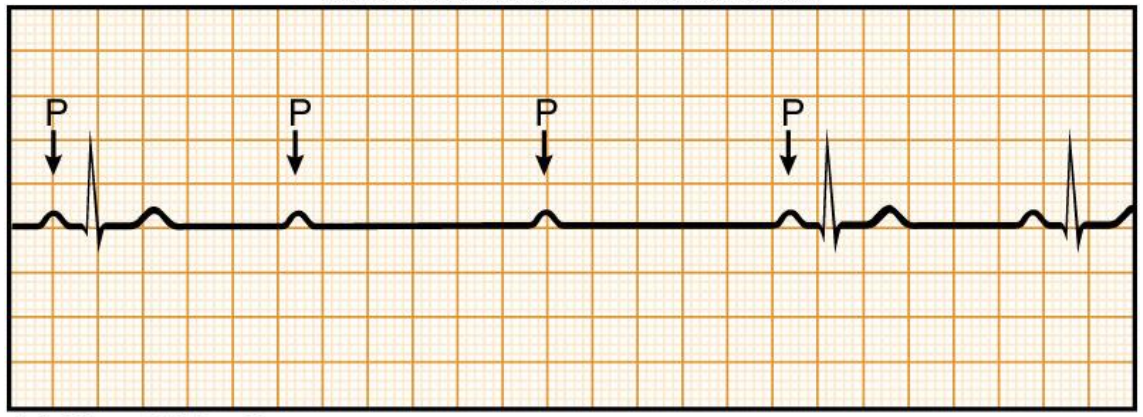
- No P waves.
- This can be due to atrial fibrillation or due to no SA node activity .

Sinoatrial Block

- In rare instances impulses from S-A node are blocked.
- This causes cessation of P waves.
- New pacemaker is region of heart with the fastest discharge rate, usually the A-V node, so the heart rate will be between 40-60 beats/min.

Note: no P waves and slow rate

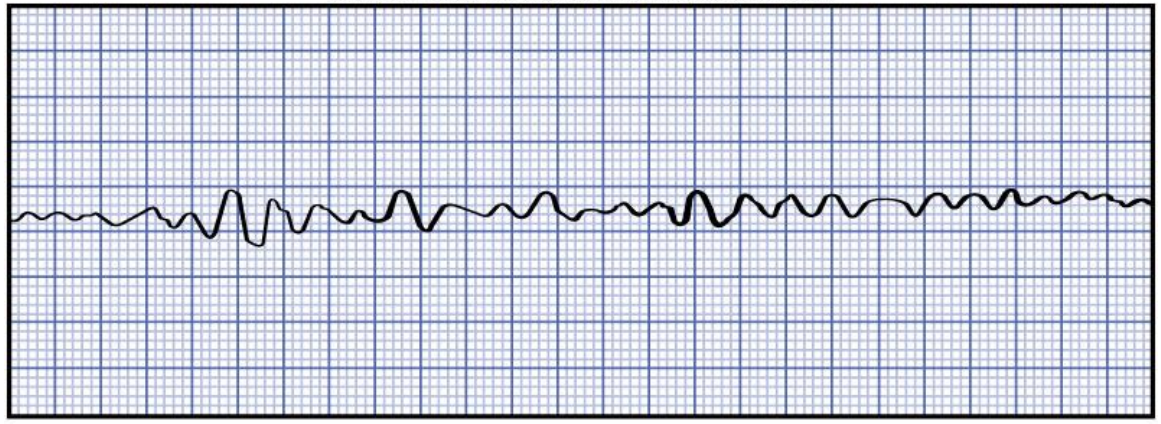
ECGs, Abnormal



(c) Heart block

Heart block refers to impaired conduction between the atria and ventricles. If the AV node is damaged, the electrical impulse cannot pass normally from the atria to the ventricles. As a result, the PR interval becomes prolonged, exceeding 0.2 seconds.

Arrhythmia: conduction failure at AV node



(e) Ventricular fibrillation

This saw-toothed shape with no QRS complexes indicates ventricular fibrillation, a lethal condition. In this state, the ventricles do not contract synchronously, so the heart cannot pump blood, and the cardiac output falls to zero.

No pumping action occurs

Atrioventricular Block

- **Impulses through A-V node and A-V bundle (bundle of His) are slowed down** (prolonged PR interval more than 0.2 sec) **or blocked due to :**
  - (1) Ischemia of A-V nodal or A-V bundle fibers (can be caused by coronary ischemia or pressure).
  - (2) Compression of A-V bundle (by scar tissue or calcified tissue).
  - (3) A-V nodal or A-V bundle inflammation (rare).
  - (4) Excessive vagal stimulation like carotid sinus syndrome or stokes-adams syndrome (compression on the carotid sinus).

Atrioventricular Block

We have 3 degrees of heart block:

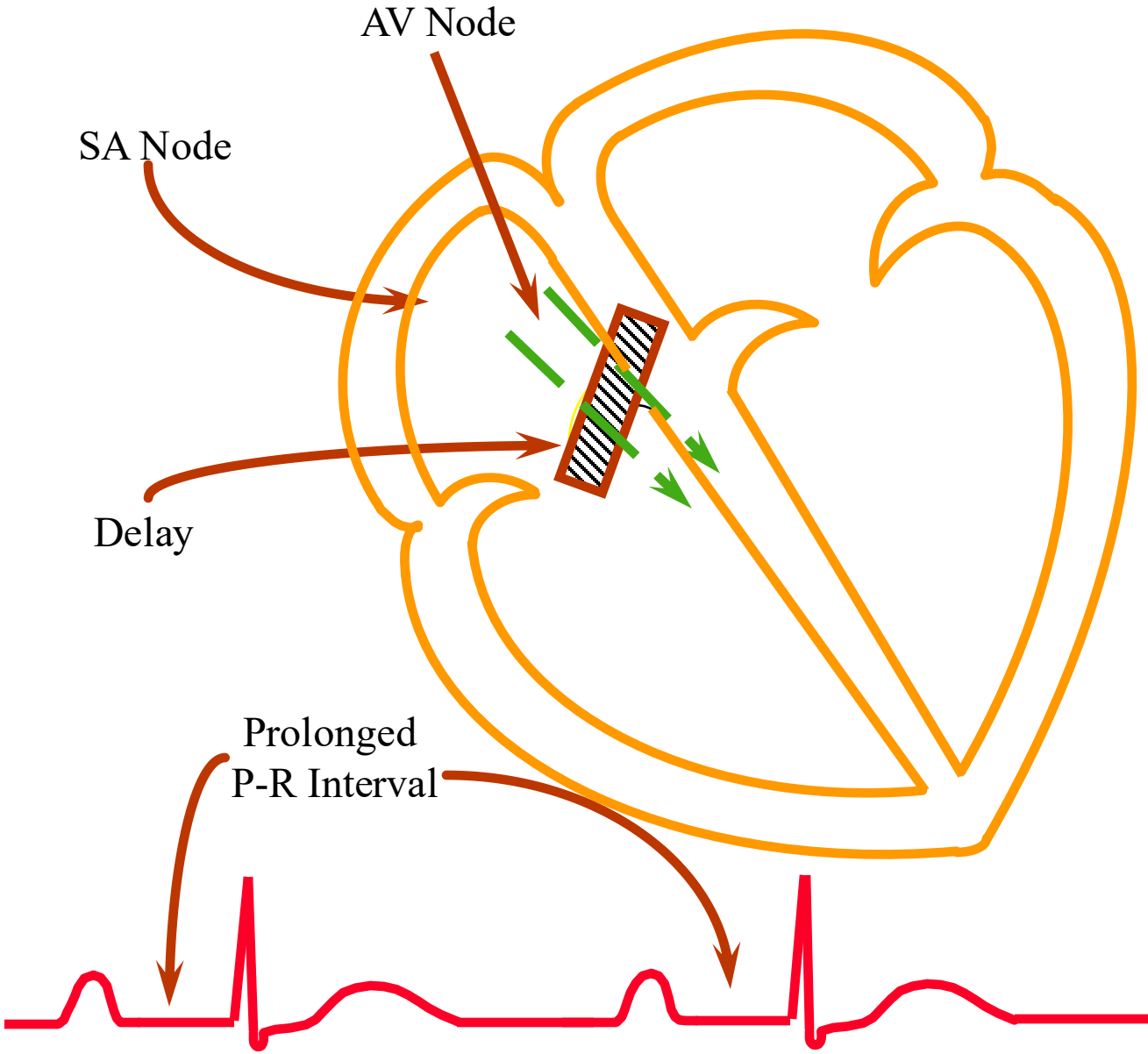
- The first two are incomplete heart block
- The third one is a complete heart block

Incomplete Heart Block: First Degree Block

- Normal P-R interval is 0.16 sec (0.16-0.2 is considered normal)
- If P-R interval is > 0.20 sec, first degree block is present (but P-R interval seldom increases above 0.35 to 0.45 sec)

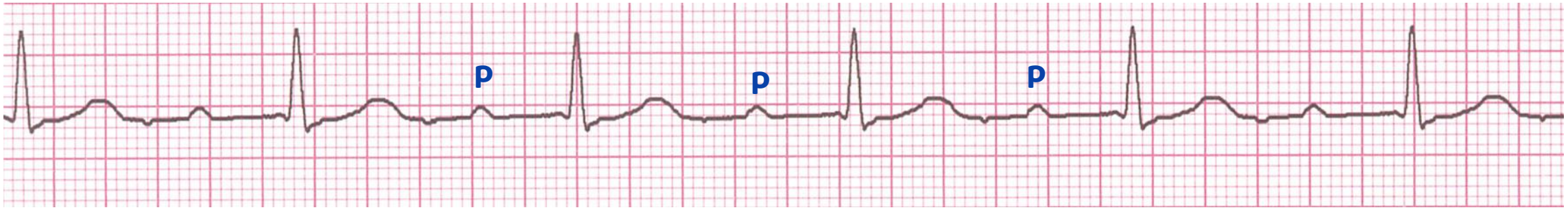
- The most important thing here is that each P wave is followed by QRS complex.

First Degree Heart Block



- The block decreases/delays the conduction rate. (but not an actual blockage of conduction).
- Note that each P wave is followed by QRST.

1st Degree AV Block



- Etiology: Prolonged conduction delay in the AV node or Bundle of His.

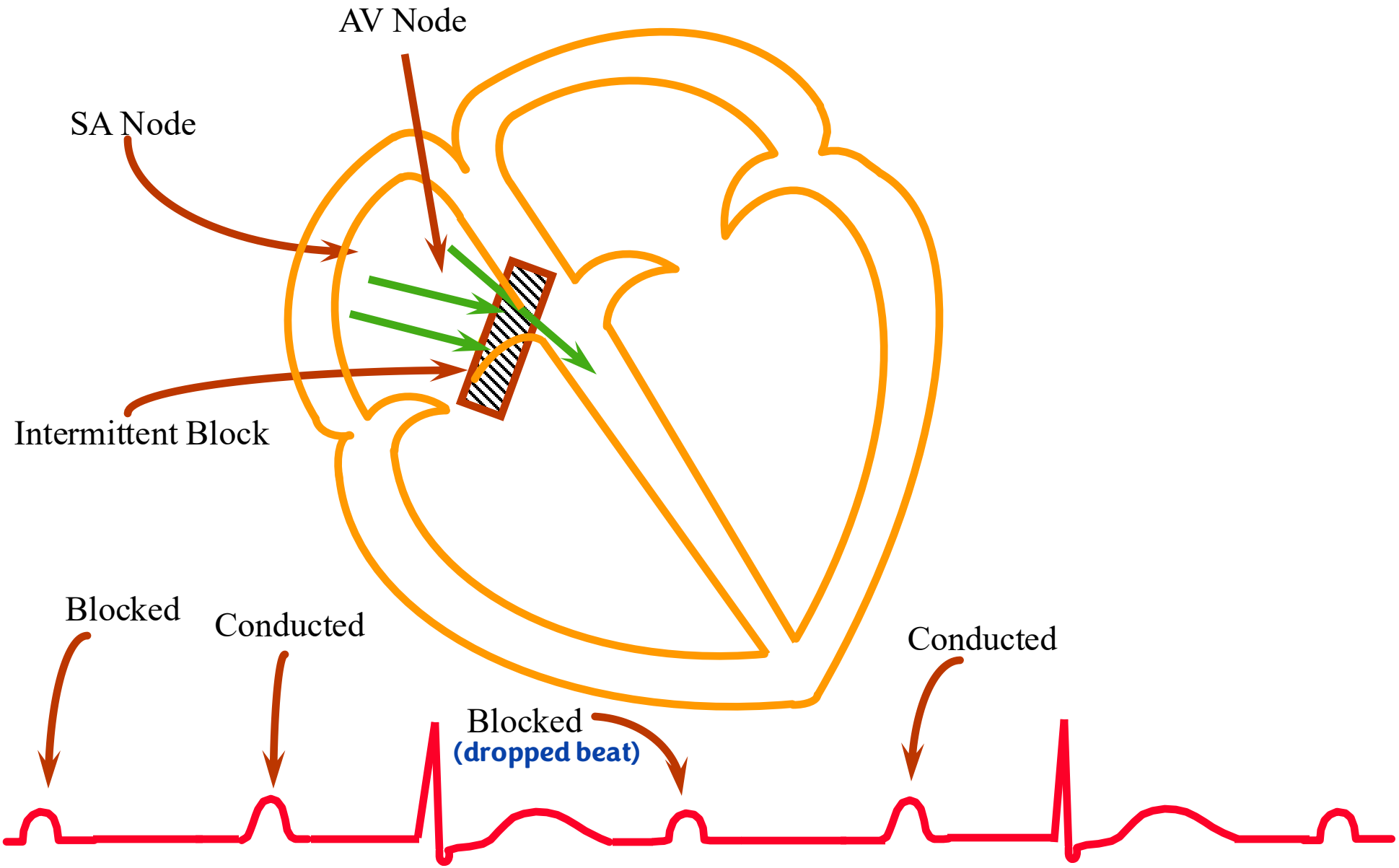
- Remember the PR interval is from the beginning of the P wave, till the start of the Q wave.
- Here the PR interval is 10 small squares:
  0.04 × 10=0.4sec -> PR interval is prolonged and since each P is followed by QRS it is first degree heart block.

Second Degree Incomplete Block

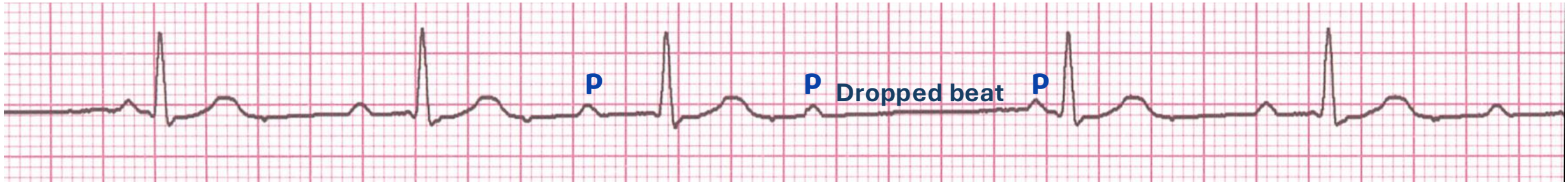
- P-R interval increases to 0.25 - 0.45 sec
- Some impulses pass through the A-V node and some do not thus causing "dropped beats".
- Atria beat faster than ventricles.

- In second-degree heart block, the PR interval is still longer than 0.2 seconds, but not every P wave is followed by a QRS complex. Only some atrial impulses make it through the AV node.
- This happens in a repeating pattern, such as every 3 P waves with 2 QRS complexes or every 4 P waves with 3 QRS complexes. We describe this as **3:2** or **4:3** conduction, where the **first number** is the number of **P waves** and the **second** is the number of **QRS complexes**.
- Because this pattern repeats consistently, it is called **regular irregularity**.
- Impulses that pass through the AV node produce QRS complexes, while those that aren't conducted are called **dropped beats**. Patients may feel these dropped beats as palpitations, often described as the heart skipping or falling down (خفقان).

Second Degree Heart Block



2nd Degree AV Block,



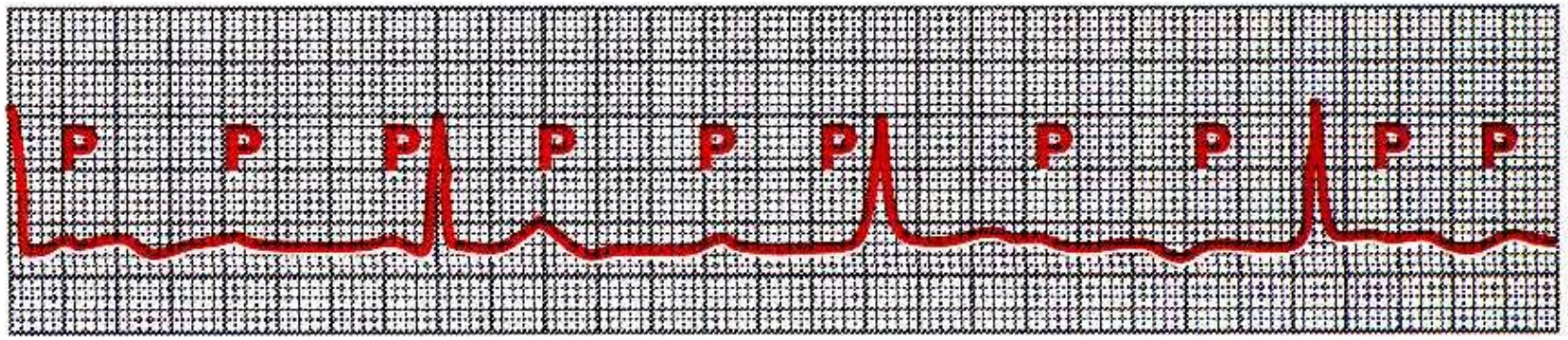
- Etiology: Each successive atrial impulse encounters a longer and longer delay in the AV node until one impulse (usually the 3rd or 4th) fails to make it through the AV node.

Third Degree Complete Block

- ☞Total block through the A-V node or A-V bundle
- ☞P waves are completely dissociated from QRST complexes
- ☞Ventricles escape and A-V nodal rhythm ensues

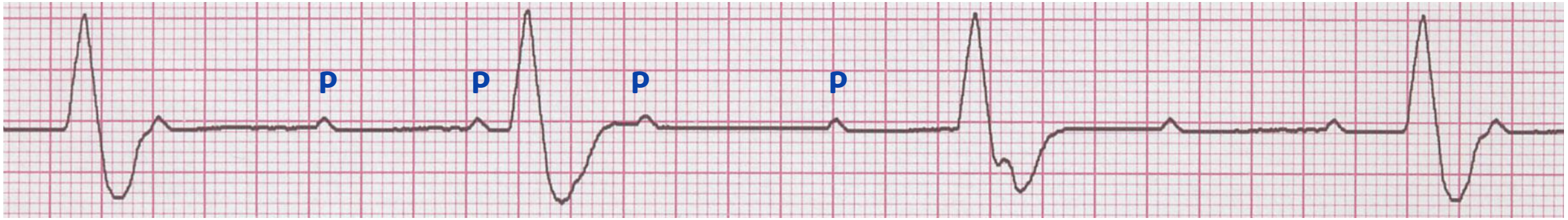
> ➢ The ventricles escape the nodal rhythm because they are not supplied by the vagus nerve.
> However, in Guyton the term "escape" here refers to the ventricles escaping the control by the atria and beating at their own rate.

- ➢ In third degree block, there is also prolonged PR interval, but there is no association between P and QRS. Total block of the AV node.
- ➢ The heart rate is going to be below 40 because now the intrinsic activity is from purkinge fibers (15-40 beats/min).



HR = 37

3rd Degree AV Block



- Etiology: There is complete block of conduction in the AV junction, so the atria and ventricles form impulses independently of each other. Without impulses from the atria, the ventricles own intrinsic pacemaker beats at around 15 - 40 beats/minute.

Stokes-Adams Syndrome

- Complete A-V block comes and goes.
- Ventricles stop contracting for 5-30 sec because of overdrive suppression meaning they are used to atrial drive.
- Patient faints because of poor cerebral blood flow
- Then, ventricular escape occurs with A-V nodal or A-V bundle rhythm (15-40 beats /min).
- Artificial pacemakers connected to right ventricle are provided for these patients.

More details in the next slides

Stokes-Adams Syndrome

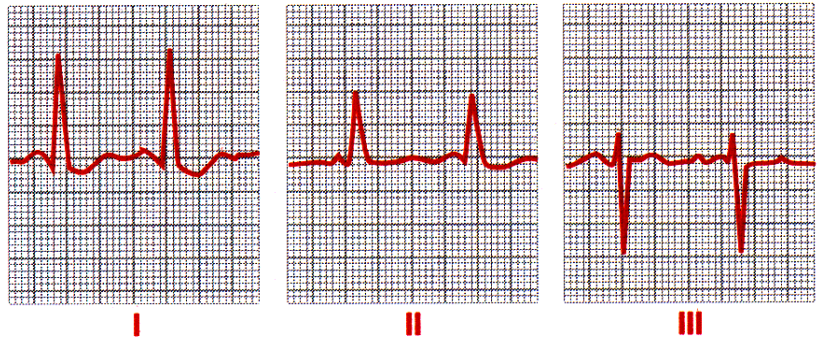
- ✓ Pressure on the carotid sinus causes extreme stimulation of the vagus nerve, leading to a marked decrease in heart rate, and the AV node may be completely suppressed. When this happens, the heart stops beating for about 15–30 seconds.
- ✓ After this pause, the Purkinge fibers resume firing at their own intrinsic rate of 15–40 beats/min. However, they do not resume immediately because this is a biological system and needs time to recover due to **overdrive suppression**.
- ✓ Overdrive suppression means that the Purkinge fibers were previously receiving impulses at a higher rate (around 70 beats per minute) from the SA node, so they were conducting 70 impulses/min to the ventricular muscle, and the ventricles contracted at that rate. Their normal intrinsic rate is therefore suppressed by the higher rate coming from the SA node.
- ✓ However, when the SA or AV node becomes suppressed, the Purkinge fibers eventually **escape the suppression** and take over with their own rate, (vagus nerve doesn't supply the ventricles and doesn't affect the Purkinge system); otherwise, the heart would not resume any rhythm.

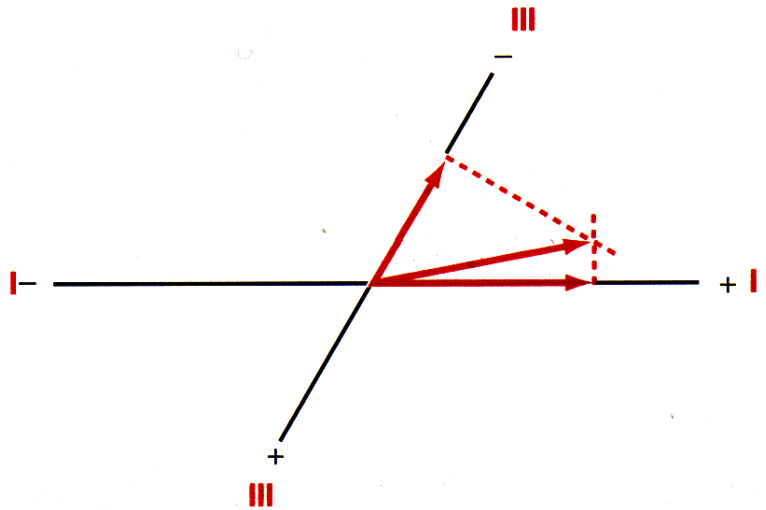
Stokes-Adams Syndrome

- ✓ This situation can come and go because when the pressure on the carotid sinus subsides, the suppression also disappears.
- ✓ Patients faint during this pause because there is no cardiac output and, therefore, low cerebral blood flow for a short time. When the Purkinje fibers begin firing again and the heart starts pumping, the patient regains consciousness.
- ✓ The treatment for complete heart block is the placement of an artificial pacemaker. It is inserted through the antecubital vein and passed through the axillary vein, jugular vein, superior vena cava, right atrium, and into the right ventricle, where it is fixed to the ventricular muscle. These pacemakers are battery-operated, and the battery, usually placed under the skin, can last around 8 to 10 years. Some pacemakers have a fixed rate, while others can adjust the rate automatically. Patients can live normal lives with these devices.

Factors Causing Electrical Axis deviation

- Changes in heart position: left shift caused by expiration, lying down and excess abdominal fat, short and obese.
- Right shift caused by thin and tall person



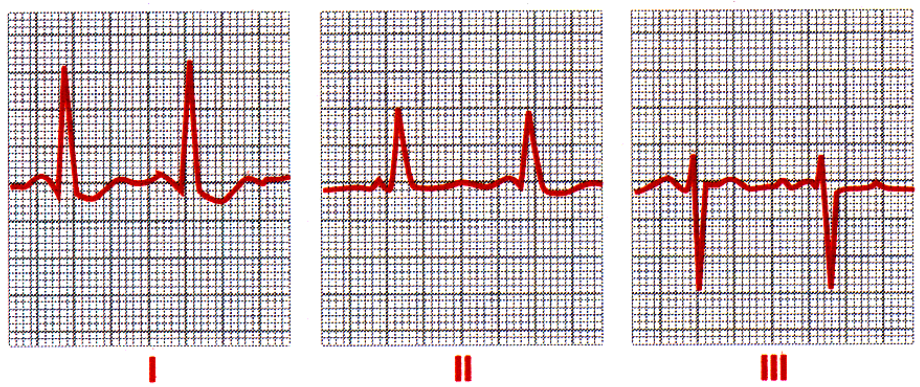


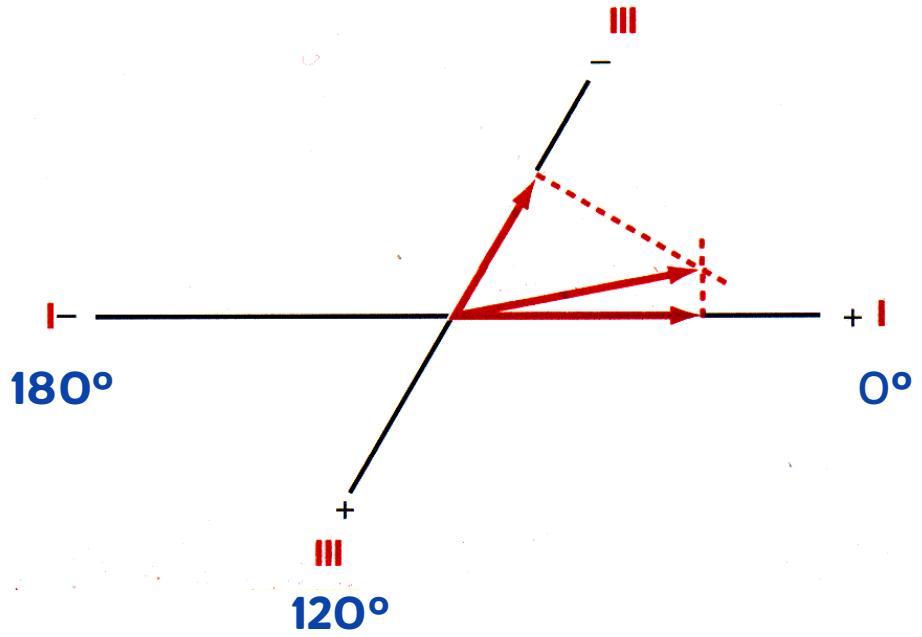
More details in the next slide

Factors Causing Electrical Axis deviation

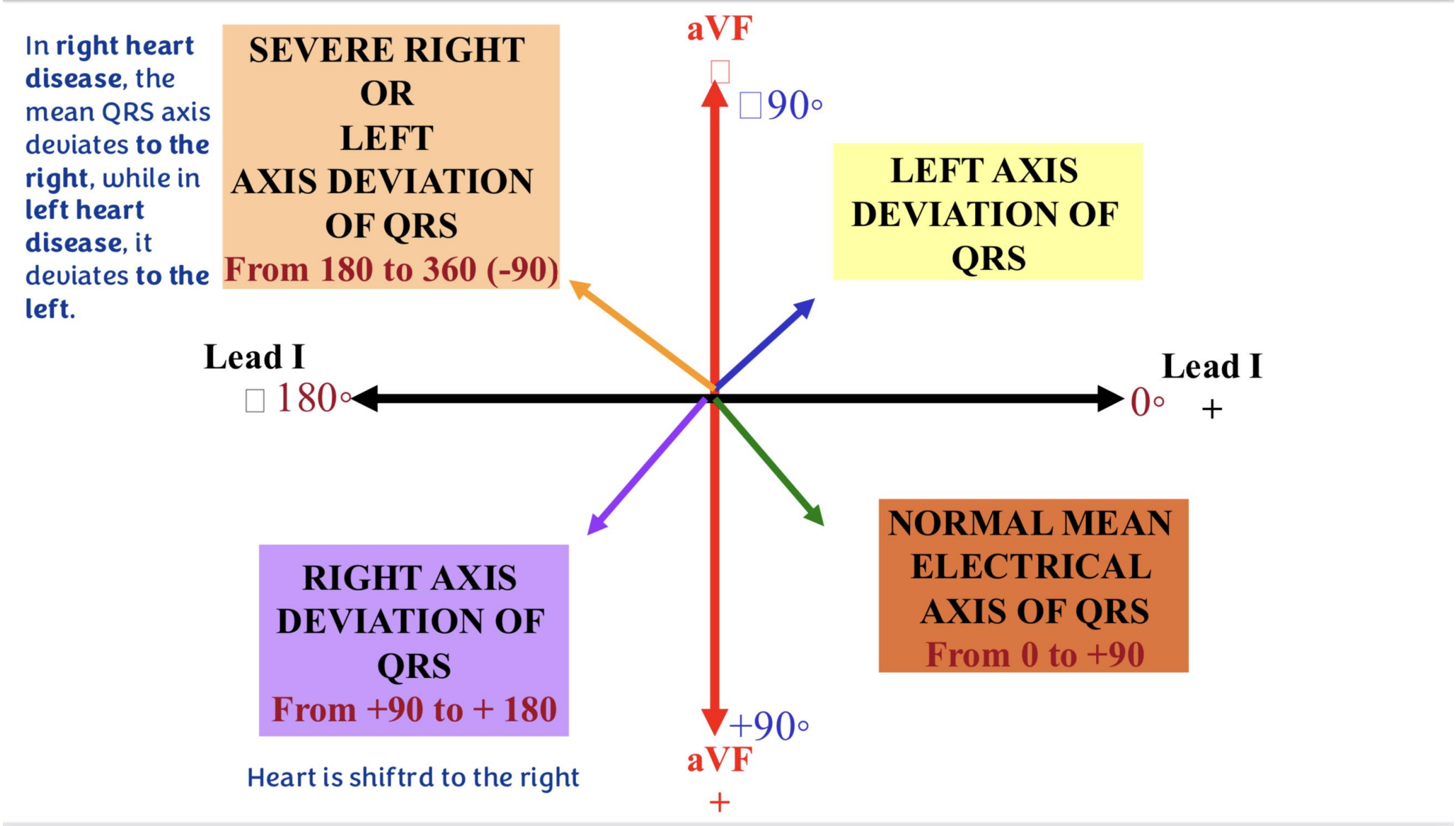
Mean Electrical Axis calculation:

- To determine the mean electrical axis, we can use **any two limb leads**, whether **unipolar or bipolar**.
- We obtain the **algebraic summation of the QRS complex** in each selected lead and draw a perpendicular line from it (in this example we used lead I and lead III).
- These two perpendicular lines will intersect at a point.
- Draw a line from the **center of Einthoven's triangle** to the point of intersection—this line represents the **mean electrical axis**.
- In this example, the calculated axis is **-40°**, which indicates **left axis deviation**.





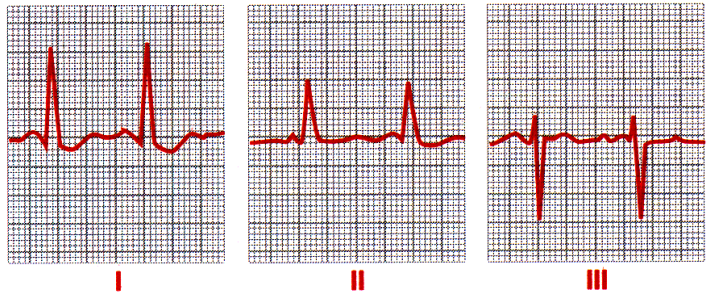
The doctor went over the details in this slide from Modified 5 again:

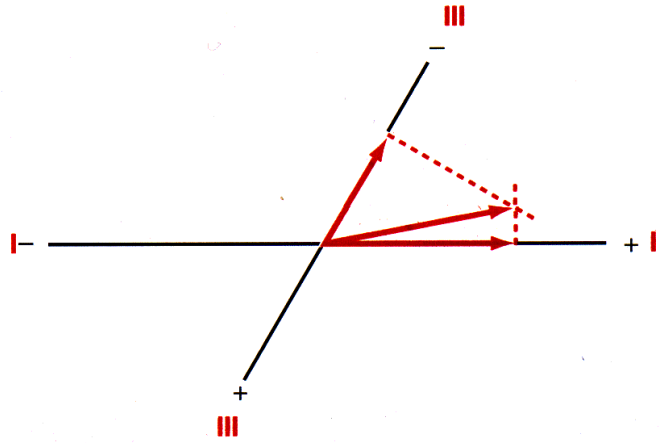


Factors Causing Electrical Axis Deviation …cont'd

- Hypertrophy of left ventricle causes a left axis shift, and it is caused by:

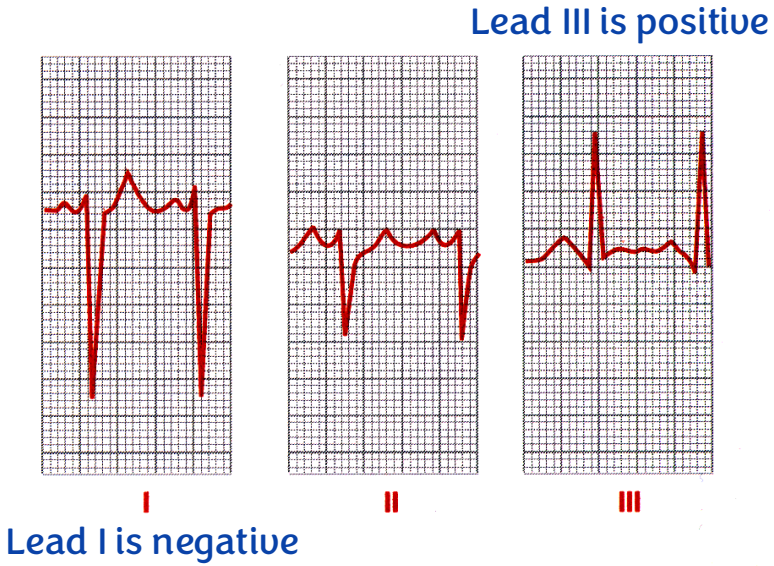
1. Hypertension: where the heart must generate a higher pressure to overcome the elevated pressure in the aorta. This increased workload is called pressure overload, and it leads the left ventricle to hypertrophy.
2. Aortic stenosis: in which the aortic valve is narrowed. The left ventricle must produce very high pressure to force blood through the narrowed opening, leading again to hypertrophy and, consequently, left axis deviation.
3. Aortic regurgitation: where the aortic valve does not close properly and blood flows back into the left ventricle during ventricular contraction. This backward flow causes dilation of the left ventricle, a form of cardiomegaly.





- All these conditions can cause a slightly prolonged QRS complex on the ECG because of increased muscle mass and high voltage

Factors Causing Electrical Axis Deviation (cont'd)

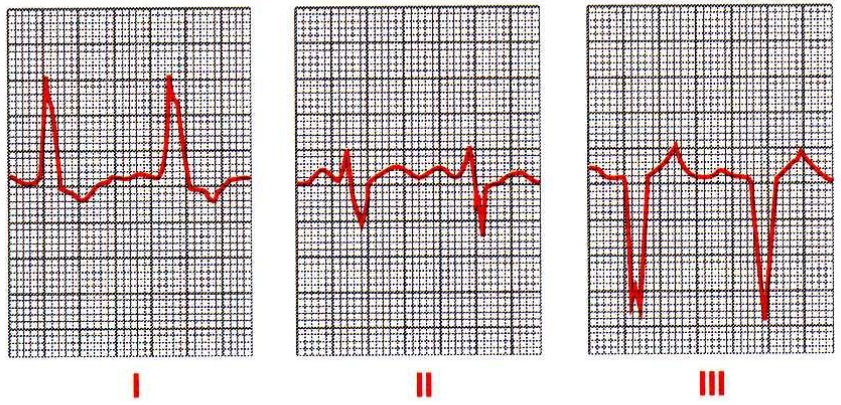


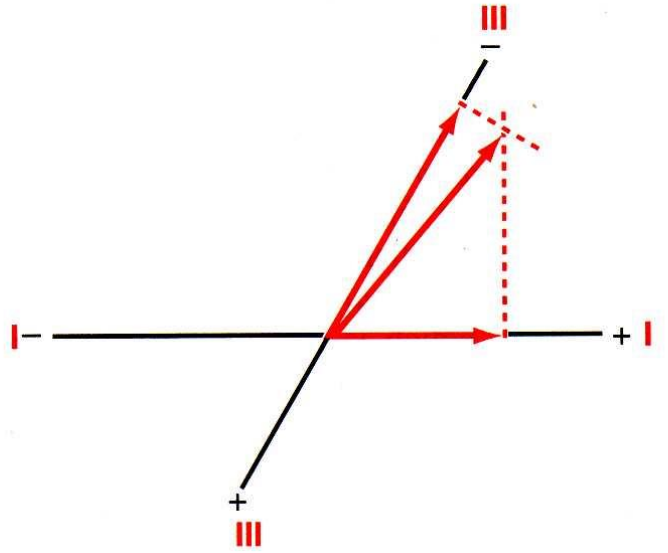
- Hypertrophy of right ventricle (right axis shift) caused by pulmonary hypertension, pulmonary valve stenosis, interventricular septal defect. All cause slightly prolonged QRS and high voltage (in lead 1, denoting the right side of the heart).

- Sometimes the interventricular septum does not close completely, producing a **ventricular septal defect (VSD)**. In this condition, blood flows from the left ventricle (where the pressure is higher) into the right ventricle. The increased volume and pressure cause the right ventricle to become hypertrophied and dilated, leading to **cardiomegaly**. The enlarged right ventricle generates stronger electrical forces toward the right side of the heart, leading to **right axis deviation** on the ECG.

Factors Causing Electrical Axis Deviation …cont'd

- Bundle branch block-**Left** bundle branch block causes **left** axis shift because **right** ventricle depolarizes much faster than **left** ventricle. QRS complex is prolonged. By the same token **Right** bundle branch block causes **right** axis deviation.





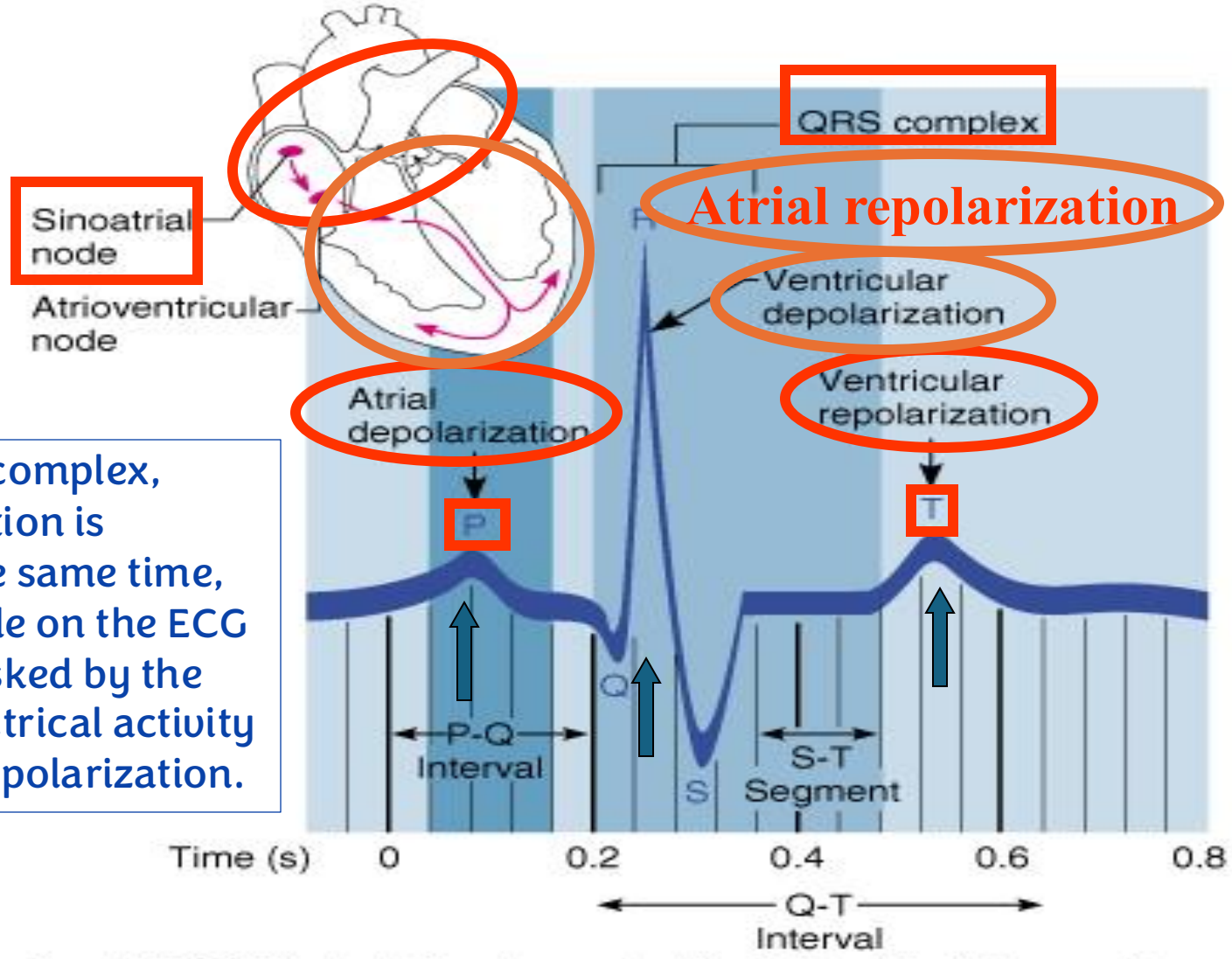
Bundle Branch Blocks: Left and Right:

- ✓ In a **left bundle branch block**, the right ventricle receives the impulse normally and depolarizes first. Because the left bundle is blocked, the left ventricle does not get activated through the fast Purkinge system. Instead, it receives the impulse slowly through the ventricular muscle (remember the ventricular muscle conducts impulse much slower than the purkinge fibers). This delayed conduction means the right ventricle finishes depolarizing while the left ventricle is still depolarizing. Since electrical current flows from the area that is already depolarized to the area still polarized, most of the current moves **from right to left**, producing a **left axis deviation**. The slower spread of depolarization also causes a **prolonged QRS complex**.

- ✓ In a **right bundle branch block**, the situation is reversed. The left ventricle depolarizes first because it still receives the impulse through the left bundle branch. The right ventricle receives the impulse late through the ventricular muscle, so it depolarizes more slowly. As a result, electrical currents move **from left to right** for most of the depolarization period, creating a **right axis deviation**. As mentioned before, the depolarization takes longer than normal, so the **QRS complex becomes prolonged,** (the QRS represents the time of ventricular depolarization).

ECG Deflection Waves

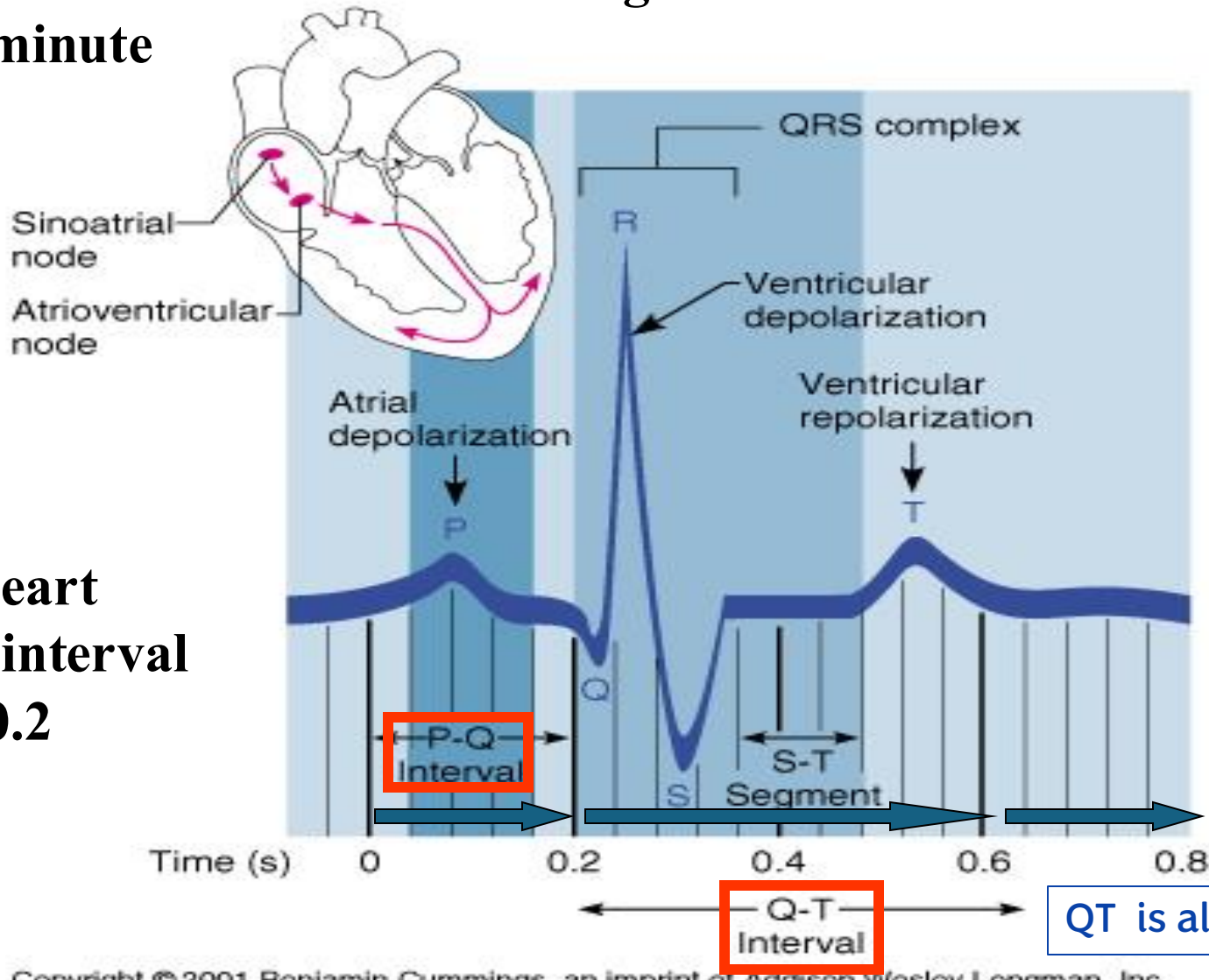
(Pacemaker)



During the QRS complex, atrial repolarization is happening at the same time, but it is not visible on the ECG because it is masked by the much larger electrical activity of ventricular depolarization.

ECG Deflection Waves

60 seconds ÷ 0.8 seconds = resting heart rate of 75 beats/minute



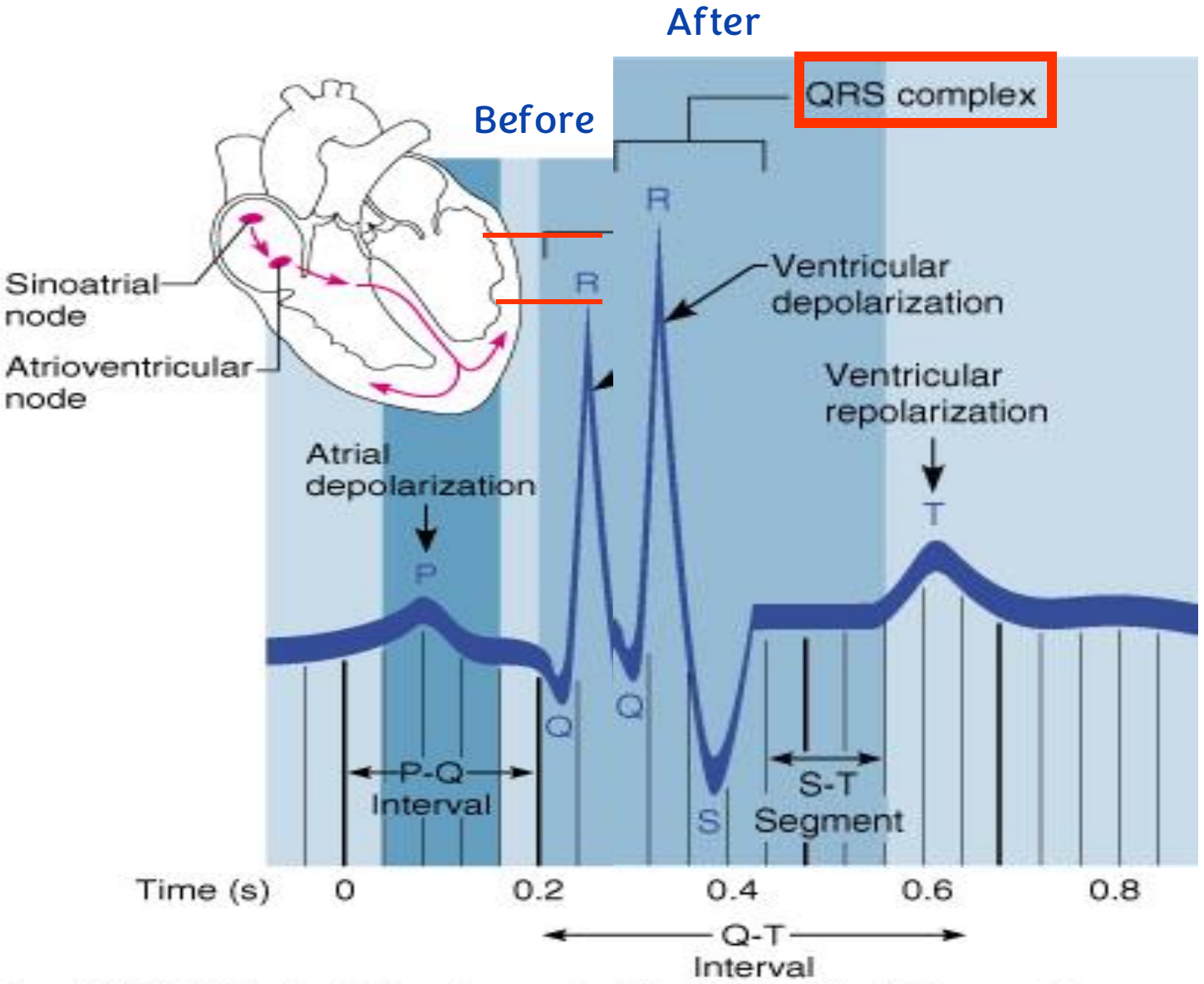
1st Degree Heart Block = P-Q interval longer than 0.2 seconds.

QT is almost half of the RR interval

ECG Deflection Wave irregularities

Enlarged QRS =

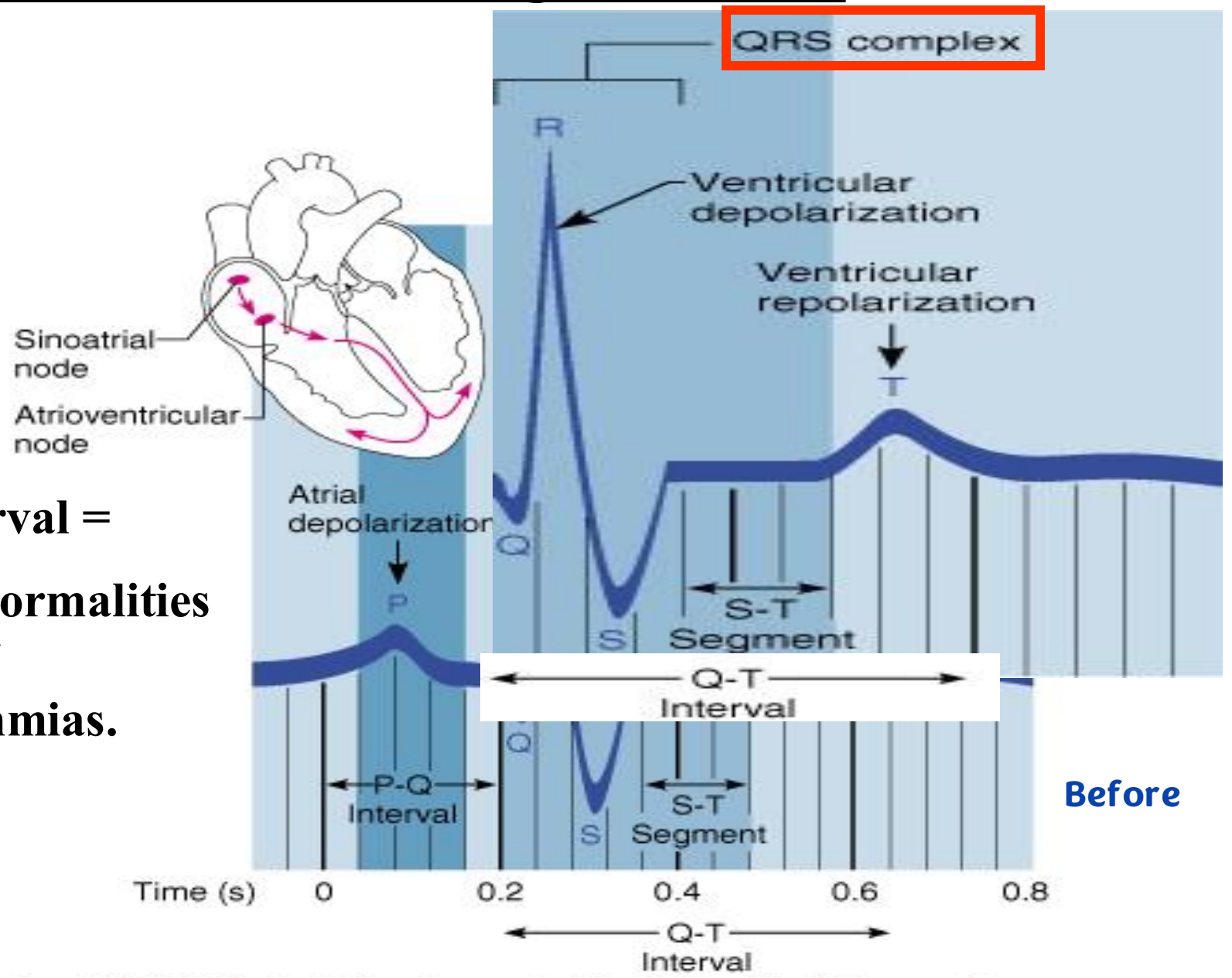
Hypertrophy of ventricles



ECG Deflection Wave Irregularities

Prolonged QT Interval =

Repolarization abnormalities increase chances of ventricular arrhythmias.

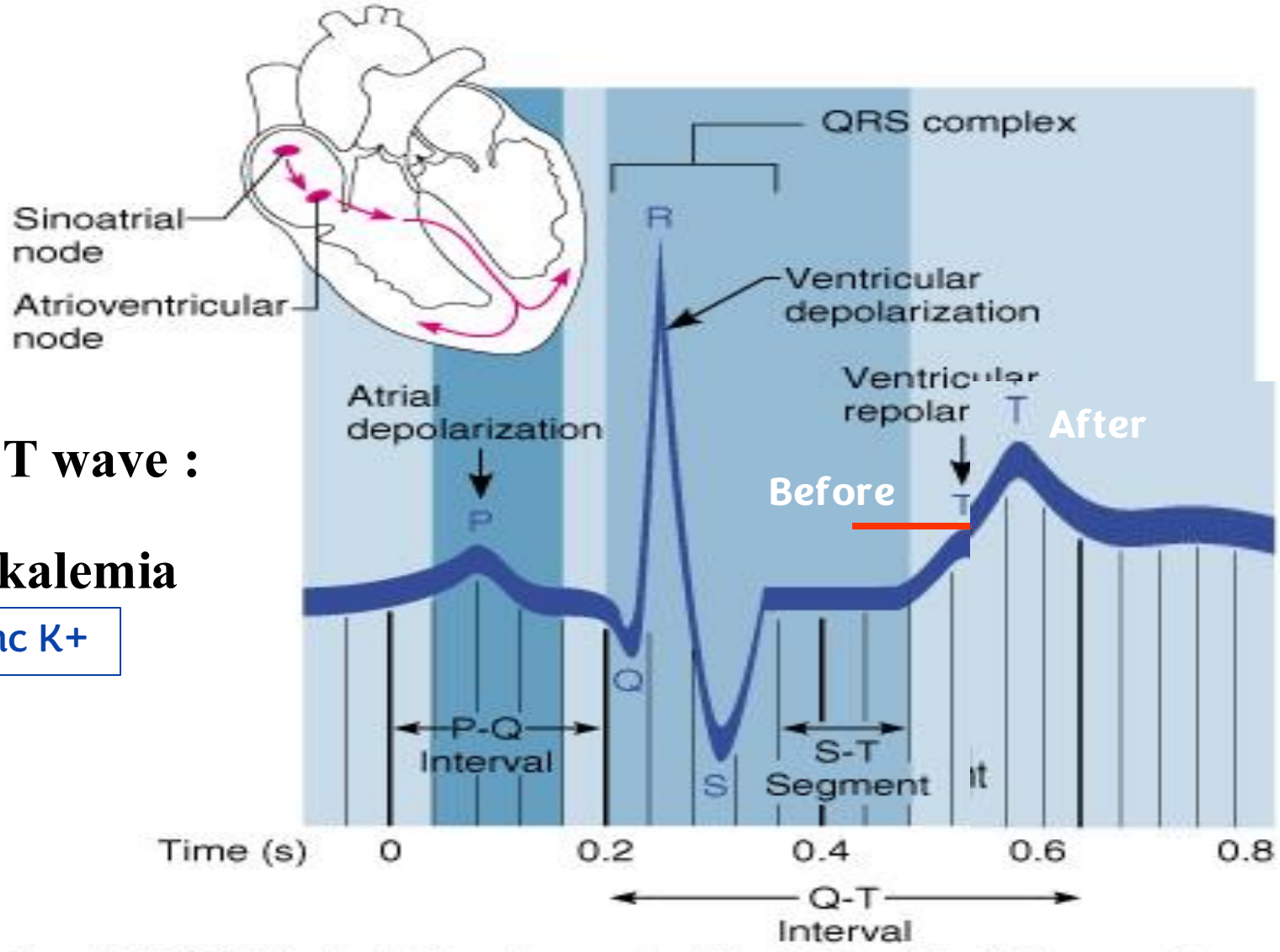


ECG Deflection Wave Irregularities

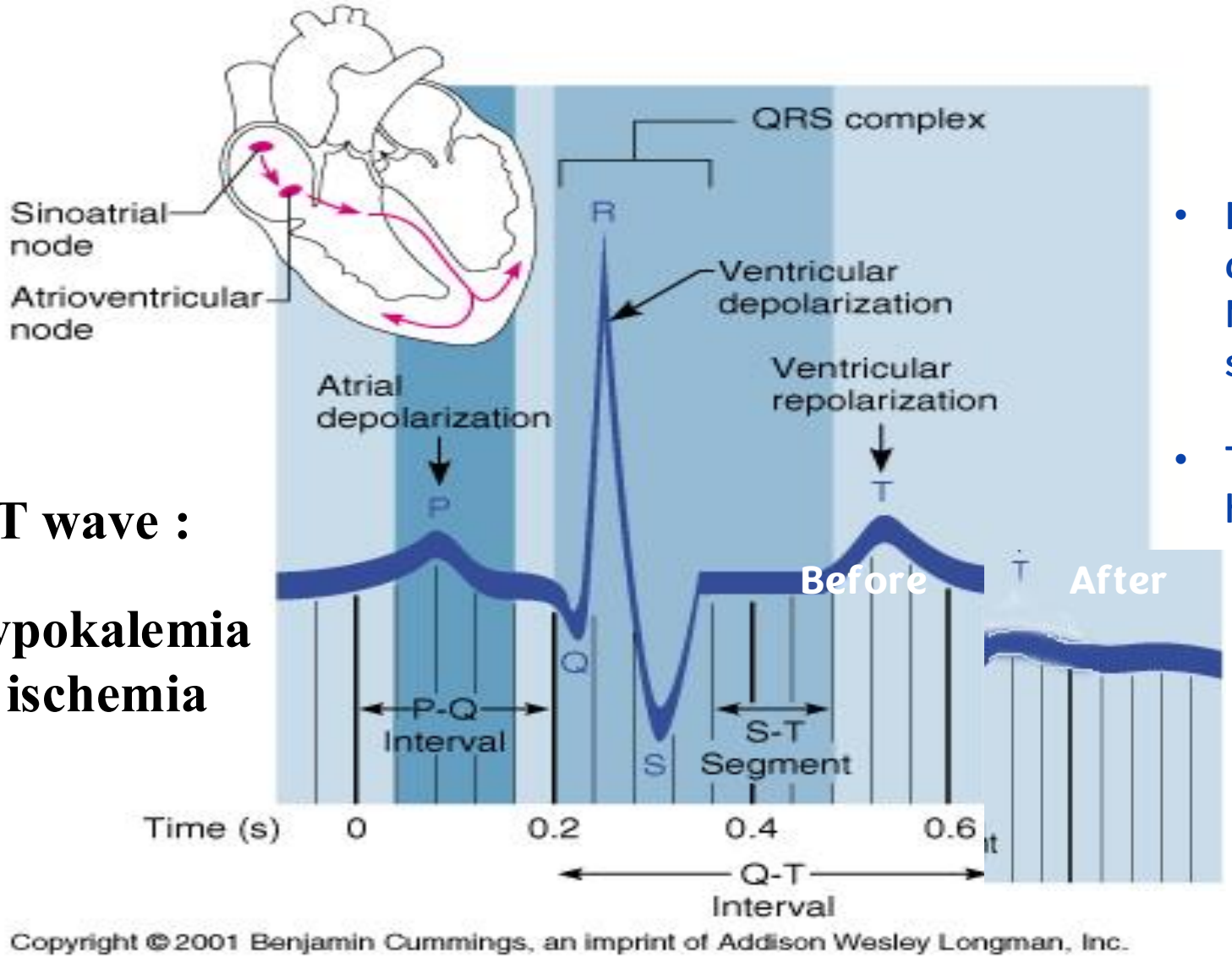
Elevated T wave :

Hyperkalemia

Inc K+



ECG Deflection Wave Irregularities



Flat T wave :

Hypokalemia or ischemia

- In case of ischemia, you will have either depressed or elevated ST segment. Mainly for ischemia you look for the ST segment .
- The isoelectric line is the TP interval here.

Increased Voltages in Standard Bipolar Limb Leads

- If sum of voltages of Leads I-III is greater than 4 mV, this is considered to be a high voltage EKG.

- Most often caused by increased ventricular muscle mass (hypertension, marathon runner).

Decreased Voltages in Standard Bipolar Limb Leads

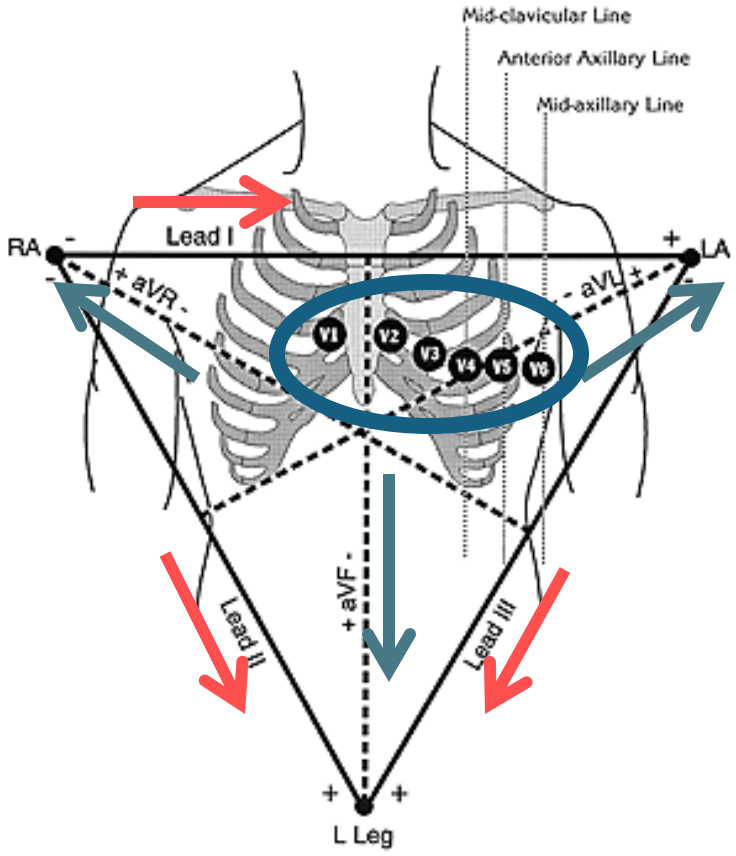
- Cardiac muscle abnormalities (old infarcts causing decreased muscle mass, low voltage EKG, and prolonged QRS).

- Conditions surrounding heart (fluid in pericardium (cardiac tamponade) , pleural effusions (in the lung), emphysema(enlarged chest) seen in some chronic smokers).

The heart is far from the exploring electrode. It's is far because there are some layers between them, it could be the pericardium or the pleura by which the heart gets far from the exploring electrode.

The 12-Leads include:

- 3 Limb leads (bipolar)
  (I, II, III)
- 3 Augmented leads (unipolar)
  (aVR, aVL, aVF)
- 6 Precordial leads
  (V_1- V_6)



Thank You

PHYSIOLOGY QUIZ LECTURE 6

External Resources

رسالة من الفريق العلمي

References:

1. Guyton and Hall Textbook of Medical Physiology, 14th edition, Chapter 13

Scan the QR code or click it for FEEDBACK

Corrections from previous versions:

Versions	Slide # and Place of Error	Before Correction	After Correction
V0 → V1			
V1 → V2			