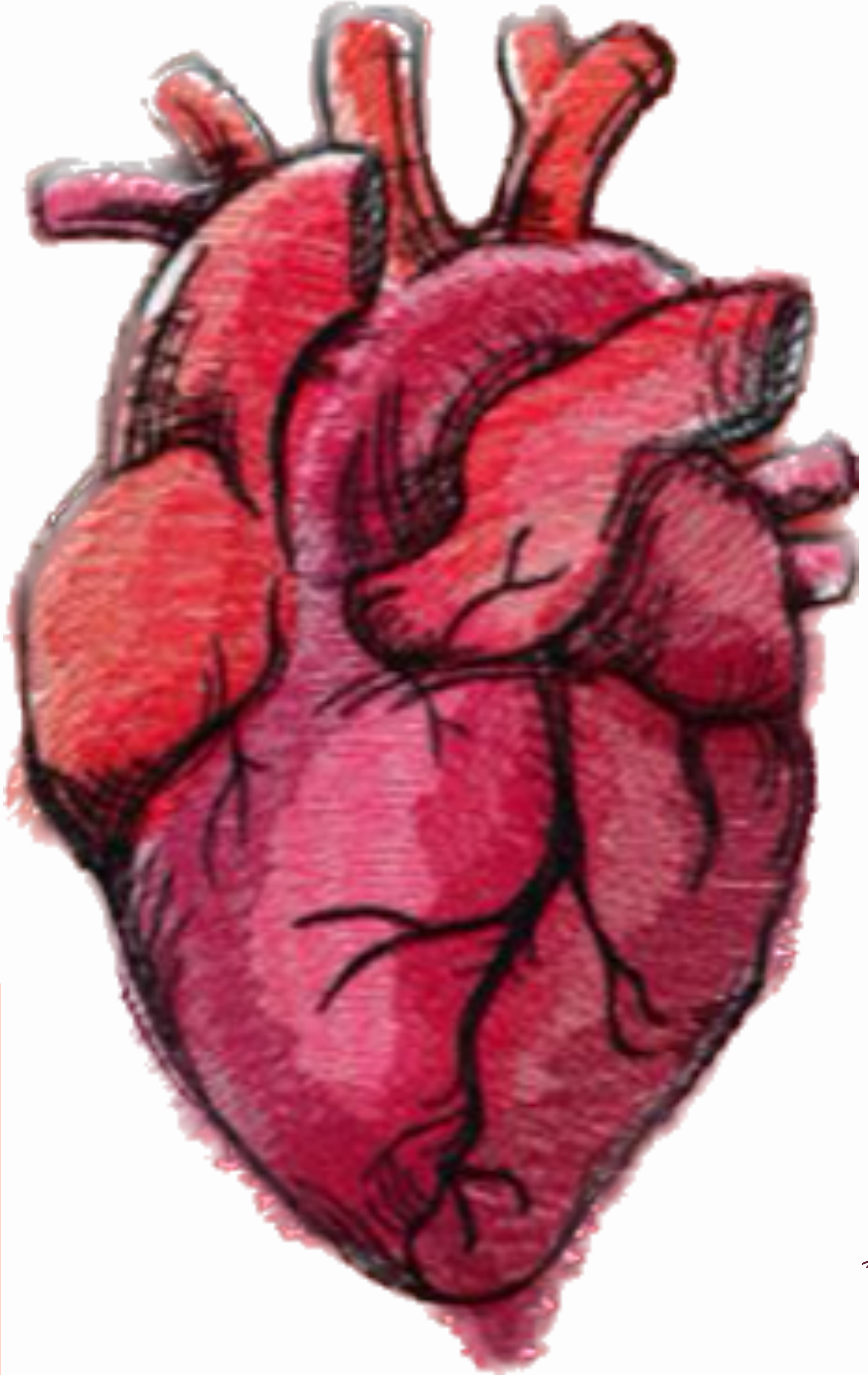

النادي الطبي

CARDIOVASCULAR SYSTEM

SUBJECT : physiology

LEC NO. : 3

DONE BY : Abdullah Bani Mustafa

وَقُل رَّبِّ زِدْنِي عِلْماً

Scan me!

The Electrocardiography (ECG) I

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Lecture Objectives:

1. Describe the principles of voltage recording in a volume conductor and its application to recording from the heart.
2. Explain ECG waveforms and intervals in relation to the instantaneous pathway of waves of depolarization through the cardiac muscle.
3. Identify voltage and time calibration of the ECG.
4. Explain the normal ECG.

Definition

An electrocardiogram (ECG) is an amplified, timed recording of the electrical activity of the heart, as detected on the surface of the body.

ECG is useful to determine:

doesn't detect heart failure
↳ weak contraction but normal AP

1. The anatomical orientation of the heart.
2. The relative sizes of the heart chambers.
3. Various disturbances in rhythm and conduction.
4. The extent, location, and progress of ischemic damage to the myocardium.
5. The effects of altered electrolyte concentrations.
6. The influence of certain drugs (notably digitalis, antiarrhythmic agents, and calcium channel antagonists).

Note:

The ECG, however, cannot give **direct** information about the contractile performance of the heart. Other tools must be used for such an evaluation.

electrocardiogram : is an implified, timed recording of the electrical activity of the heart, as detected on the surface of the body

in other words it's recording of producing AP and passing it from place to another

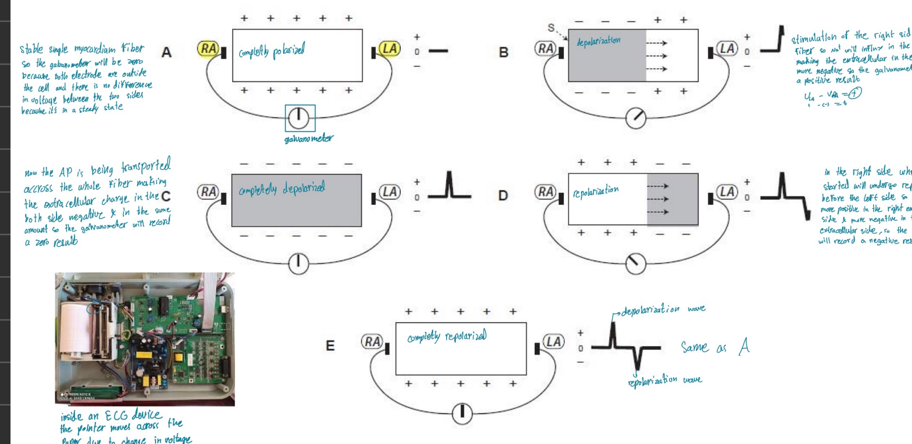
Note ECG is not the AP because AP is measured by two electrodes one inside the cell & the other one outside the cell while ECG all electrodes are outside the cell so it record the creation & passage of AP from one point of the heart to another.

ECG is useful to determine

very important to know so when we analyze ECG

1) the anatomical orientation of the heart
   how the heart is located in the body
2) The relative size of the heart chambers
   eg. in case of hypertrophy in one of chambers or the whole heart the voltage will increase → higher deflection.
3) Various disturbances in rythm & conduction
   Regular heartbeat or not, the conducting system & AP production & transmision.
4) The extent, location & progress of ischemic damage to myocardium
   very important clinically
5) The effects of altered electrolyte concentrations
   eg Ca^{+2} or K^+ → hypokalemia or hypercalemia
6) The influance of certain drugs (digitalis, antiarrhythmic agents & calcium antagonist)

Recording from a single cardiac fiber

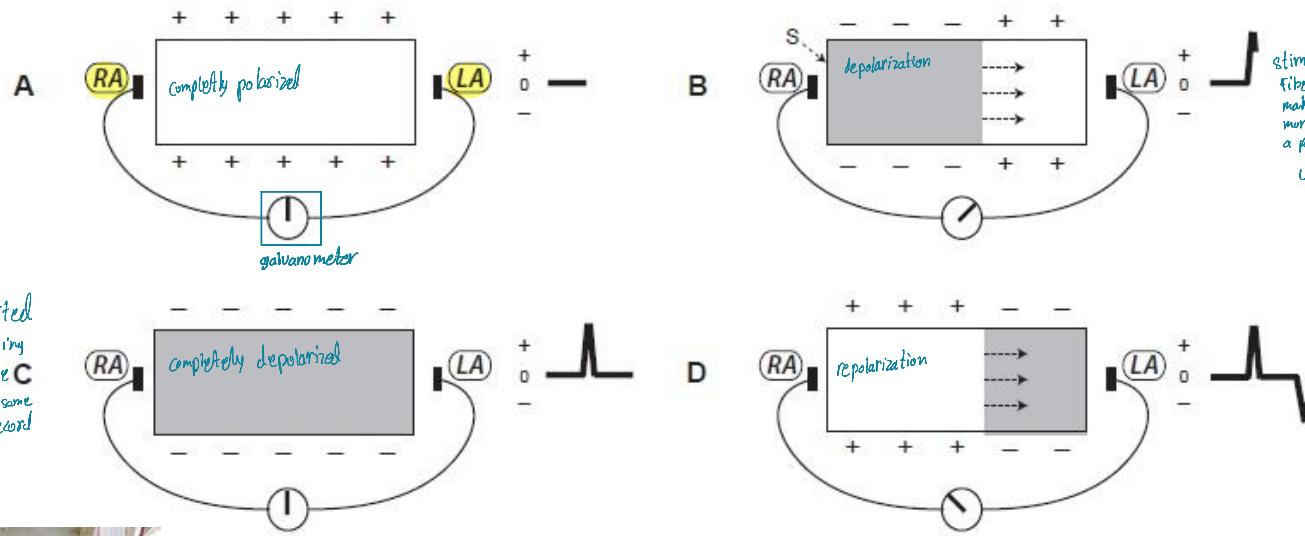


1. Shows depolarization and repolarization waves.
2. The two waves are in opposite direction. one postive & one negative depend where electrolide are located
3. No potential is recorded when fiber is either completely polarized or completely depolarized.

* Note: ECG cannot give direct information about contractile preformance of the heart. → can't detect heart failure because the ECG detect the electricity of the heart not the contraction mechanism, so it might be normal AP while there is weak contractility due to a defect in muscles

Recording from a single cardiac fiber

stable single myocardium fiber so the galvanometer will be zero because both electrode are outside the cell and there is no difference in voltage between the two sides because it's in a steady state



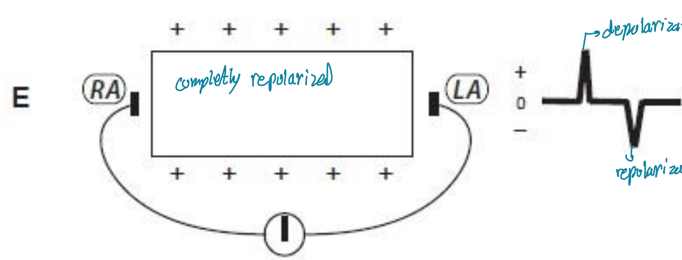
stimulation of the right side of the fiber so Na+ will influx in the right side making the extracellular in the right side more negative so the galvanometer will record a positive result

$V_A - V_{RA} = (+)$

now the AP is being transported accross the whole fiber making the extracellular charge in the both side negative & in the same amount so the galvanometer will record a zero result

in the right side where AP started will undergo repolarization before the left side so it will be more positive in the right extracellular side & more negative in the left extracellular side, so the galvanometer will record a negative result

inside an ECG device the pointer moves across the paper due to change in voltage



Same as A

1. Shows depolarization and repolarization waves.
2. The two waves are in opposite direction. one postive & one negative depend where electrolides are located
3. No potential is recorded when fiber is either completely polarized or completely depolarized.

Recording from the whole heart

The normal electrocardiogram is composed of the following;

first wave

P wave – atrial depolarization wave (appears just before the beginning of atrial contraction). passage of AP from SA node to AV node atrial depolarization wave, the electrical chang happen before the mechanical (contraction)

second wave

QRS complex – ventricular depolarization wave (appears just before the beginning of ventricular contraction). It coincides with phase 0 of cardiac action potential. → depolarization wave in ventricle and appear before the contraction, phase zero of non-specific AP

third wave

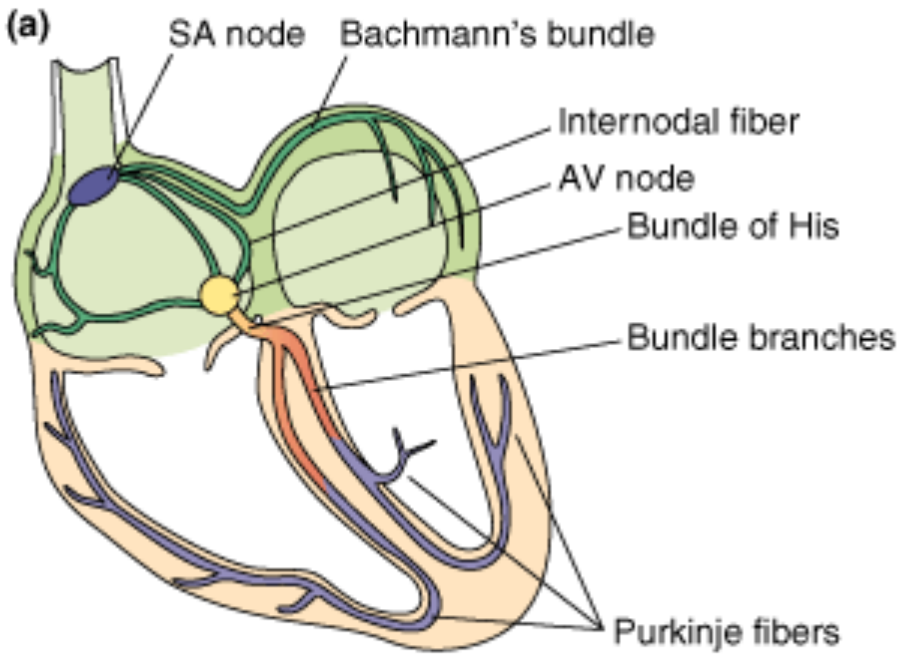
T wave - ventricular repolarization wave. It coincides with the end of repolarization phase (phase 3) of cardiac action potential. T waves that are abnormal either in direction or in amplitude may indicate myocardial damage, electrolyte disturbances, or cardiac hypertrophy. repolarization of ventricles same as phase 3 in AP

fourth wave doesn't always show up

U wave – can appear occasionally. It could be due to slow repolarization of the papillary muscles.

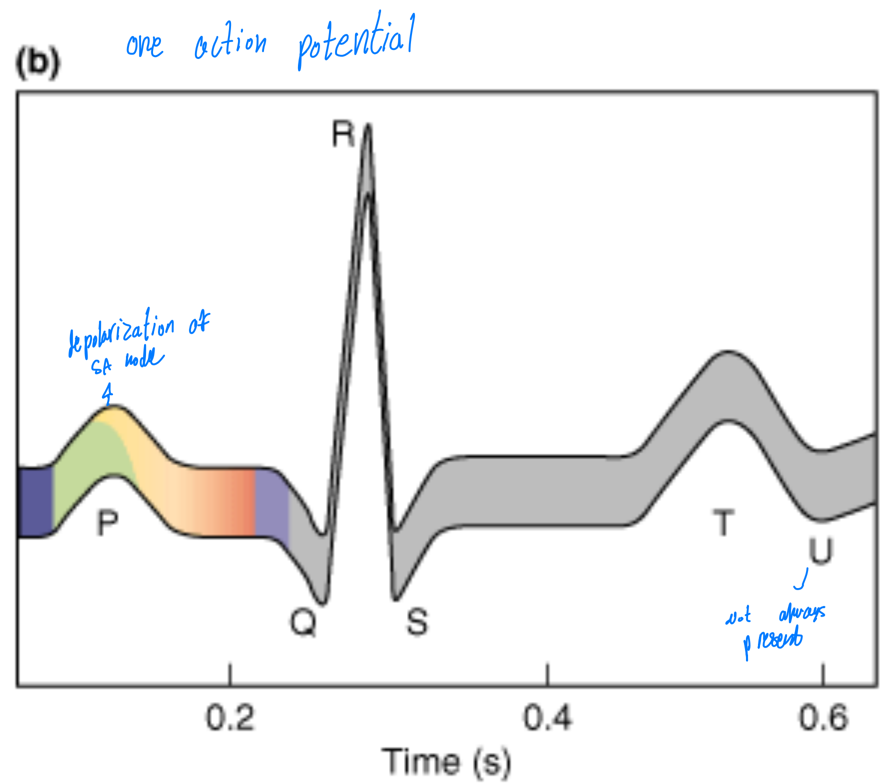
▶ Conduction System of the Heart

(a)

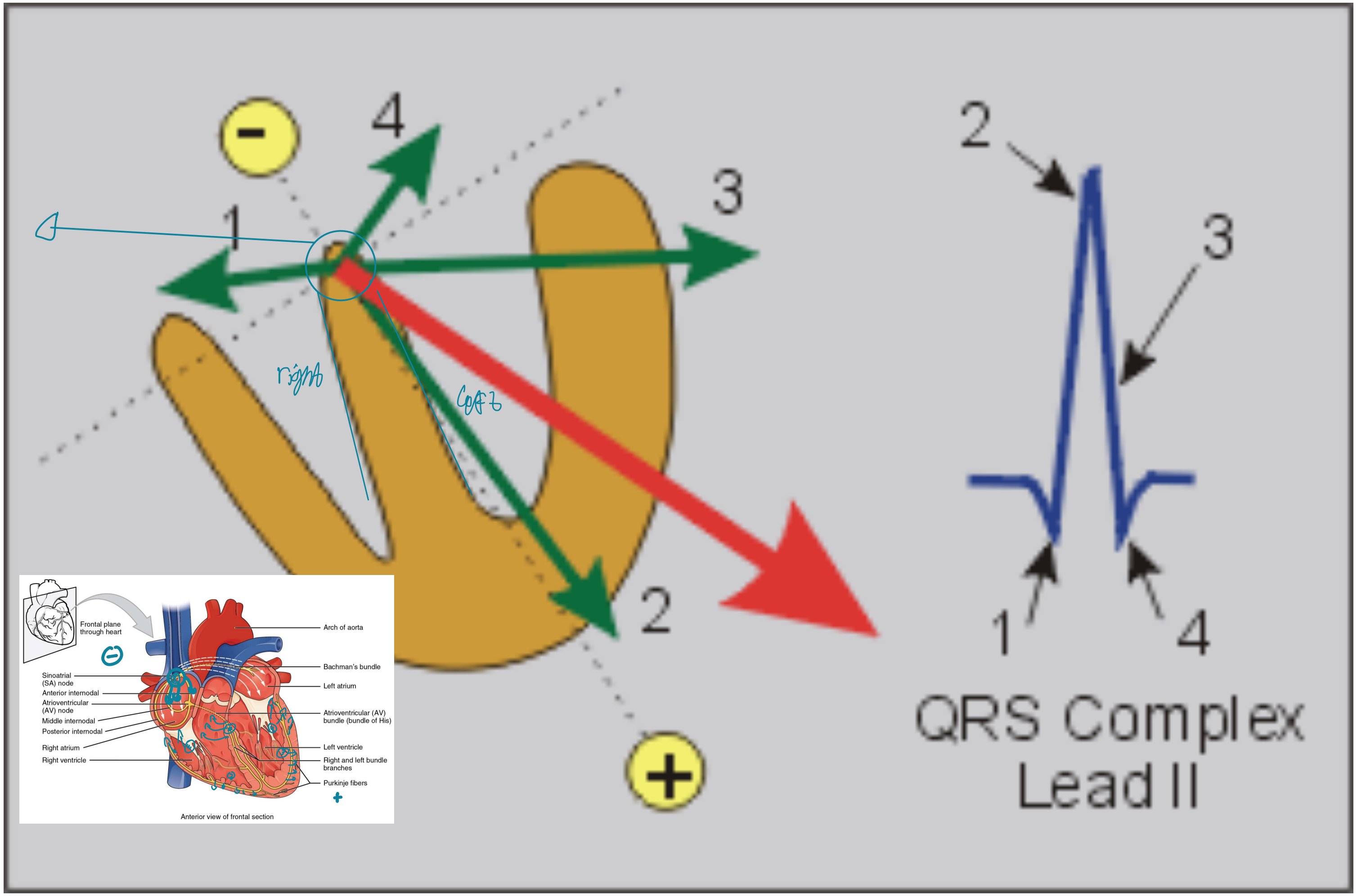


Papillary muscle the last one receive blood so U wave it's for the pipillary muscle

(b)



imagine it as bundel of His

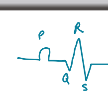


① P → depolaraization (+) charge towards (+) electrode so

② → depolarization of the septum by left branch of bundel of His (+) charge towards (−) electrode

③ depolarization towards the (+) electrode from both brungles

④ repolarisation the upwords parts (+) charge towards (−) electrode



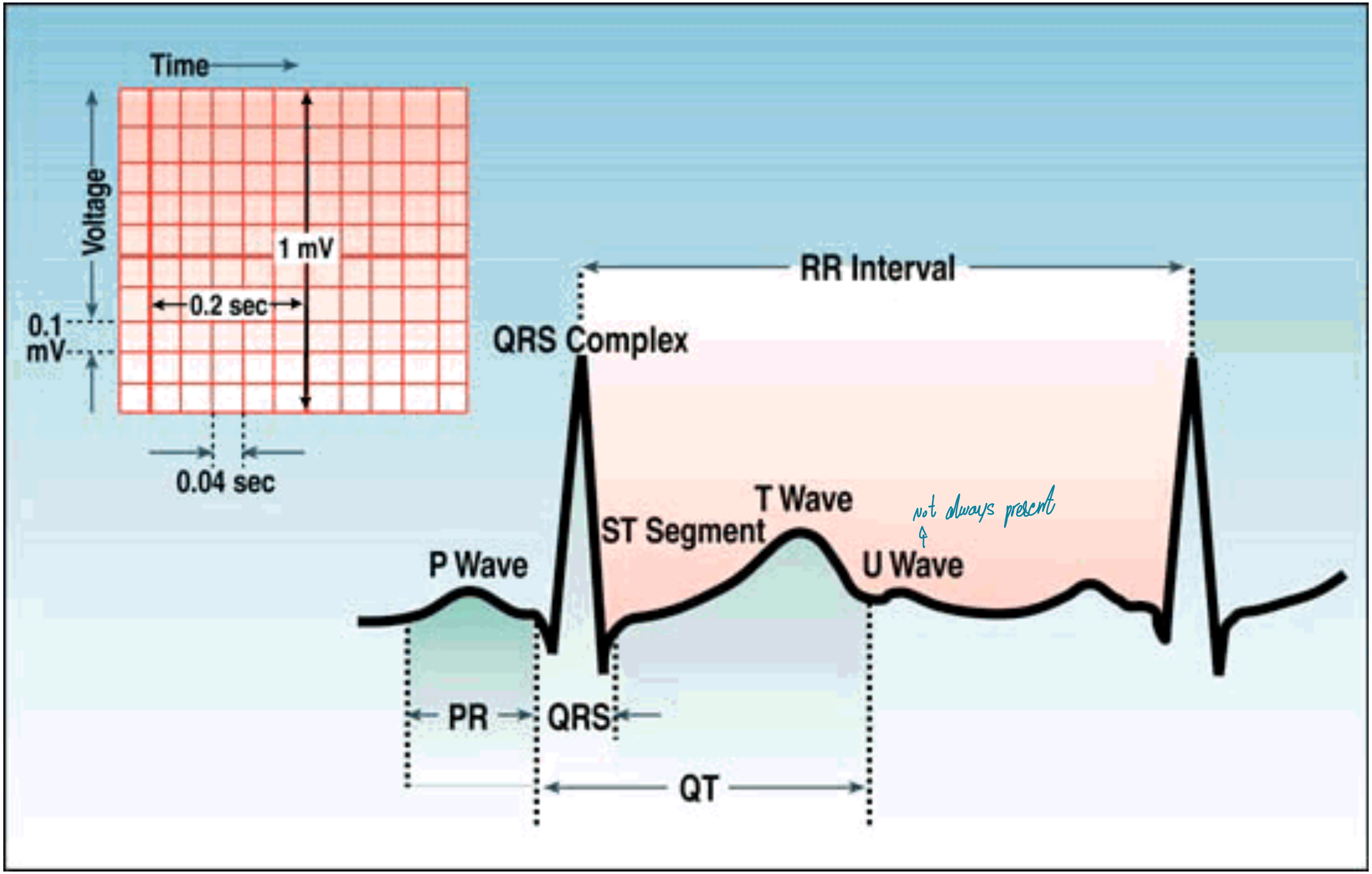
⑤ repolarization of ventricles (−) charge towards (−) electrode

→ waves of ECG

the paper of ECG is made up of squers each side is 1mm long → dark red & faint red columns the space between the two dark red columns is 5mm the paper moves to the right and the pointer/needle is located on the dark red row <zero line>, the speed of the paper is 25mm/s in one second 25 squer → how much time needed for 1 mm

$25 = \frac{1}{t} = \frac{1}{25} = 0.04$ second

1 mv → will rize 10mm



Recording from the whole heart

→ it's important for the functionality of the AV node eg. sympathetic stimulation ↑ heart rate ↓ delay so the PR interval will be shorter than 0.12

called PR because the Q wave is likely to be absent.

PQ or PR interval – measured from the *beginning* of P wave to the *beginning* of the QRS complex. It measures about 0.12-0.20 sec. This interval represents the delay of the depolarization wave at the AV node. The PR interval shortens as heart rate increases. increase in time → heart block → Not blood block but block of the depolarization wave eg. atherosclerosis → no enough blood into AV node more time

QT interval – represents the contraction interval of the ventricle (electrical systole). This interval lasts from the *beginning* of the Q wave to the *end* of the T wave. It measures about 0.35-0.43 sec. The QT interval shortens as heart rate increases (i.e. it varies inversely with the heart rate). myocardium in ventricle AP → in case of sympathetic stimulation causing decrease in AP so the QT interval will be shorter

* the shortening in length of PR & QT interval in case of ↑ in heart rate it will be more clear for the QT

1/2 PR interval

QRS duration – It measures about 0.06-0.10 sec. If longer, it indicates longer time is needed for the depolarization wave to finish its propagation in the myocardium.

most important

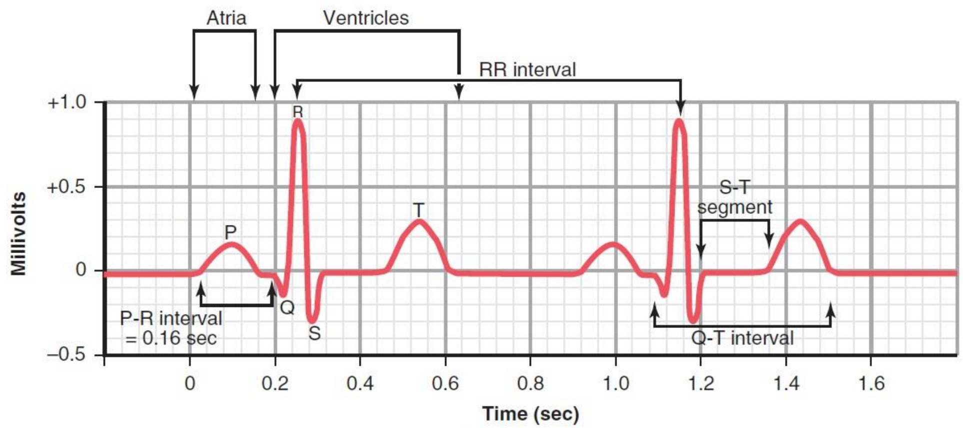
ST segment – It corresponds to the plateau phase of the non-pacemaker action potential. It extends from the end of the S wave to the onset of the T wave. Its average is 0.08 sec. This segment should be on the iso-electric line (zero line). The normal ST segment has a slight upward concavity. Up or down deviation of this segment indicates the presence of **current of injury** (ischemic damage to the myocardium).

QT - QRS = ST

0.32 s

represent zero because all myocardium is depolarized so any up or down of this segment indicat current injury such as angina, ischemia or MI etc...

Voltage and Time Calibration of the Electrocardiogram

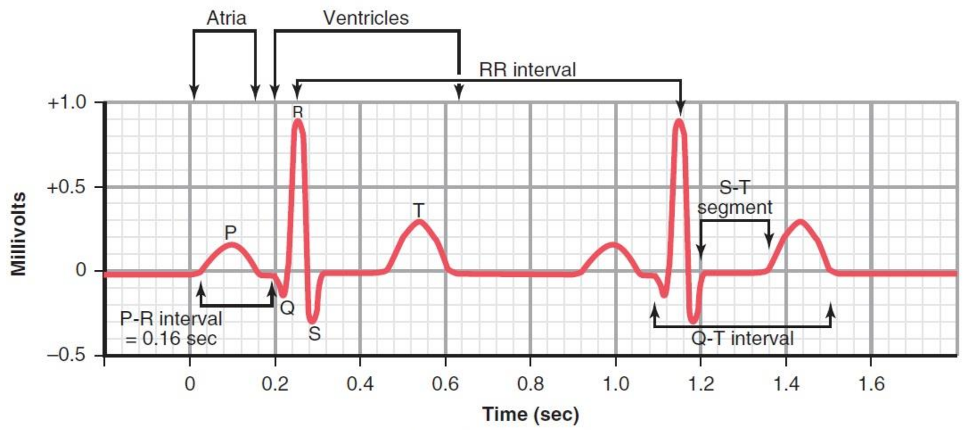


Normal electrocardiogram

the last part of the heart that beome depolarized is the near bare of ventricles

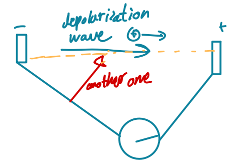
- All recordings of ECGs are made with appropriate calibration lines on the recording paper.
- Electrocardiograph machine is calibrated so that 10 of the small line divisions (=10 mm) upward or downward ECG represent 1 mV, with positivity in the upward direction and negativity in the downward direction.
- A typical ECG is run at a paper speed of **25 mm** per second, although faster speeds are sometimes used. Therefore, each 1 mm in the horizontal direction is **0.04 second**
- Each 5 mm segment is indicated by a dark vertical lines and represents 0.20 second.

Voltage and Time Calibration of the Electrocardiogram (cont.)



Normal electrocardiogram

the wave is perpendicular to the electrode so a very high deflection



it's get closer to the positive electrode but farther more than the blue one so the deflection will be smaller

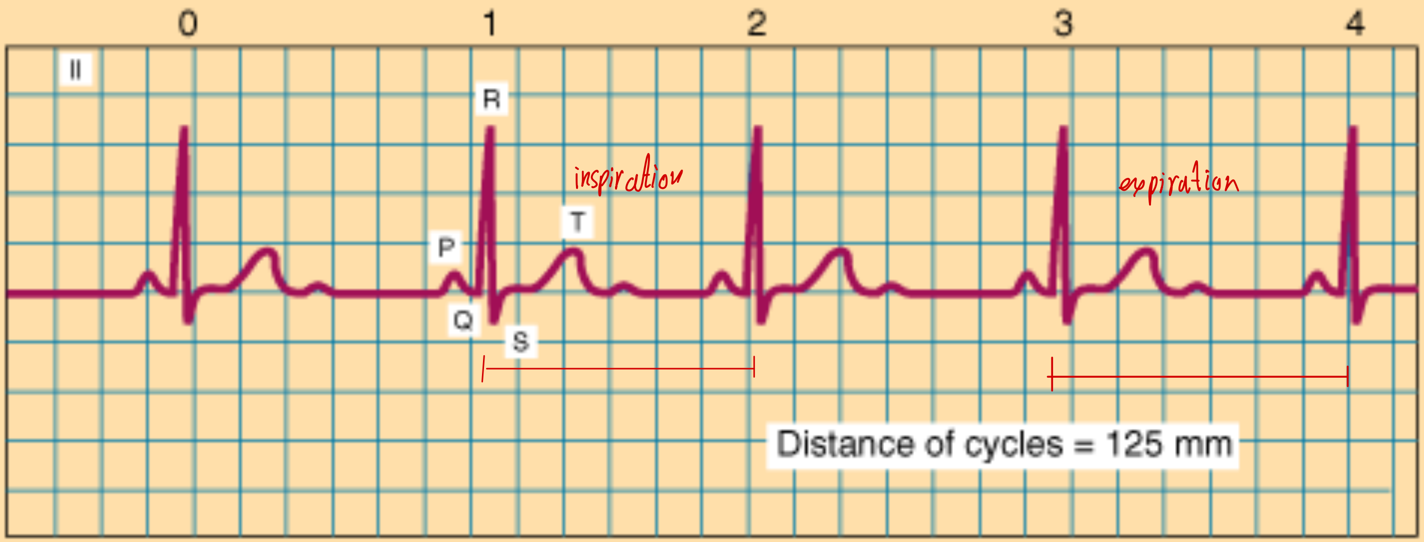
more the depolarization is 40° the higher the deflection wave

- The recorded voltages of the waves in the normal ECG depend on;
  1. The manner in which the electrodes are applied to the surface of the body.
  2. How close the electrodes are to the heart. The closer the electrode the greater the recorded voltage. if we put the electrode on the chest front of the heart it will be closer than when we put the electrode under the armpit because under the armpit is more distant from the heart than on the chest
  3. The mass of myocardium from which the voltage it is generated
     ↳ higher the mass higher the voltage eg. hypertrophy of one chambers a very high deflection
- The QRS complex voltage may be as great as 3 to 4 mV (if electrodes placed on the chest) (average 1.0 to 1.5 mV) (↳ electrodes placed on arms & legs) from the top of the R wave to the bottom of the S wave.
- The voltage of the P wave is between 0.1 and 0.3 mV.
- The voltage of the T wave is between 0.2 and 0.3 mV.

▶ ECG Used to Calculate Heart Rate

during inhalation the HR is higher so less distance between the 2 R

during exhalation the HR is lower so more distance between the 2 R



25 mm → 1 second

1500 mm → 1 minute

in Regular heart beat

$$\text{Heart Rate} = \frac{1500}{\text{R–R interval}}$$

1500 → length of the paper after 1 min

R–R interval → in mm

↳ average between the long & small

Effects of Changes in The Ionic Composition of The Blood on ECG Recording

Note:

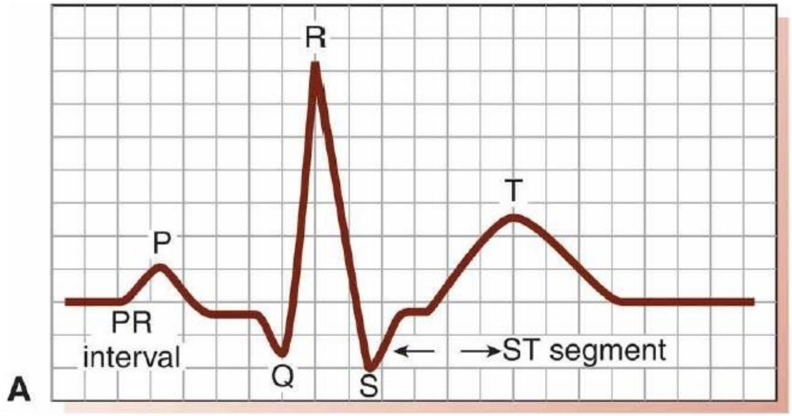
Clinically, a fall in the plasma level of Na^+ may be associated with low-voltage electrocardiographic complexes. Changes in the plasma K^+ level produce severe cardiac abnormalities.

Hyperkalemia → prolongation of the PR interval + appearance of tall peaked T waves.

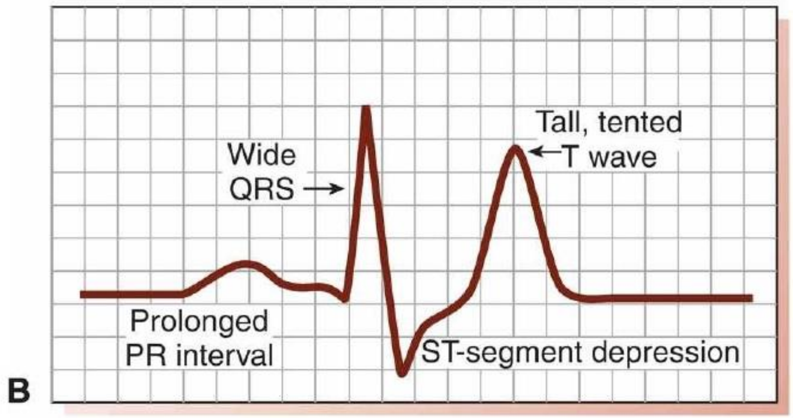
Hypokalemia → flattened T wave + ST-segment depression + prominent U waves frequently superimposed upon T waves.

Hypocalcemia → prolongation of the QT interval.

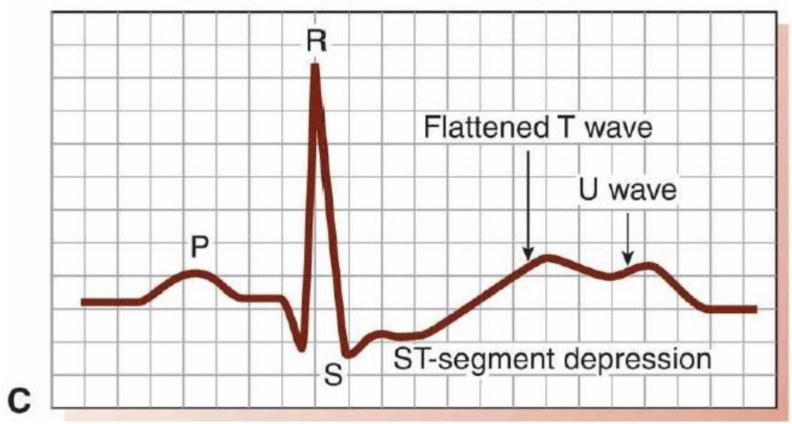
(Calcium increases potassium conductance during phase 3. Therefore, low serum Ca^{2+} levels can thus delay the repolarization of the ventricles, and this is revealed on the ECG as an abnormally long QT interval)



Normal



Effect of hyperkalemia



Effect of hypokalemia

Test Question:

Q. The PR interval of ECG corresponds to?

A. Ventricular repolarization.
B. Ventricular depolarization.
C. Conduction through AV node.
D. Repolarization of AV node and bundle of His.
E. Timing of second heart sound.