Sheet 5 physiology – Electrocardiography-

*questions asked by some students

-why the ventricles lacking parasympathetic supply ? if you cut both sympathetic and parasympathetic supply of the heart the heart rate will increase and the contractility will decrease this means that the heart rate is under dominant control of the parasympathetic and the contractility is under dominant control of the sympathetic , maybe to have dominat effect on heart rate especially at night when you don't need the heart rate to be high and sympathetic needed to higher force of contraction in the morning

-in case of heart transplant what happens to the regulation by sympathetic and parasympathetic ? when you transplant a heart you cut the nerves , they are not able to increase heart rate, contractility , so in exercise the cardiac output will increase by intrinsic mechanism (e.g frank - starling:- you stretch the heart so the cardiac output will increase) not by extrinsic , normal people increase cardiac output by both mechanisms

Electrocardiography :- we are going to record the electrical changes , for diagnostic reasons for example if someone complaining of a heart problem we do ECG to see the electrical changes that will cause the mechanical consequences

Objectives

1. Describe the different "waves" in a normal electrocardiogram. (electrocardiograph is the machine we use while the electrocardiogram is the recording)
2. Recall the normal P-R and Q-T interval time of the QRS wave.
3. Distinguish the difference in depolarization and repolarization waves.
4. Recognize the voltage and time calibration of an electrocardiogram chart. (Because what we are recording is the electrical changes which is time (x axis) and voltage (y axis))
5. Point out the arrangement of electrodes in the bipolar limb leads, chest leads, and unipolar leads.
6. Describe Einthoven's law.

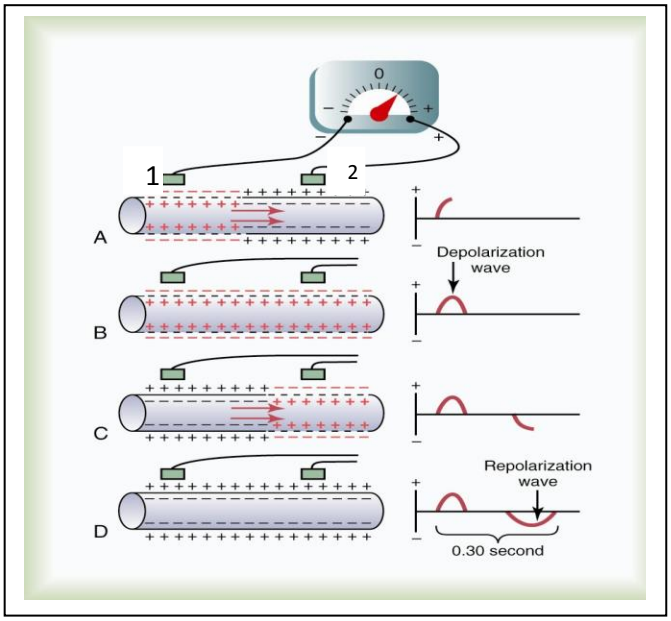
The electrocardiograph consist of galvanometer or voltmeters

When we record the action potential we put an electrode inside the cell and an electrode outside the cell (monophasic) but here in ECG we put two electrodes outside the cell and record the depolarization and repolarization (biphasic)

We have two electrodes we can't put them outside the heart, we put them on the skin , now the difference between depolarization and repolarization in heart muscle is around 110 MV and it

will be conducted to the skin through the surrounding fluids and tissues which are electrical conductors (contains lots of ions) but will be much reduced (because of resistance) maybe 1 mV ---too small so we need amplification to be noticed , i.e the electrocardiograph is a galvanometer with amplifiers

How we record it ?



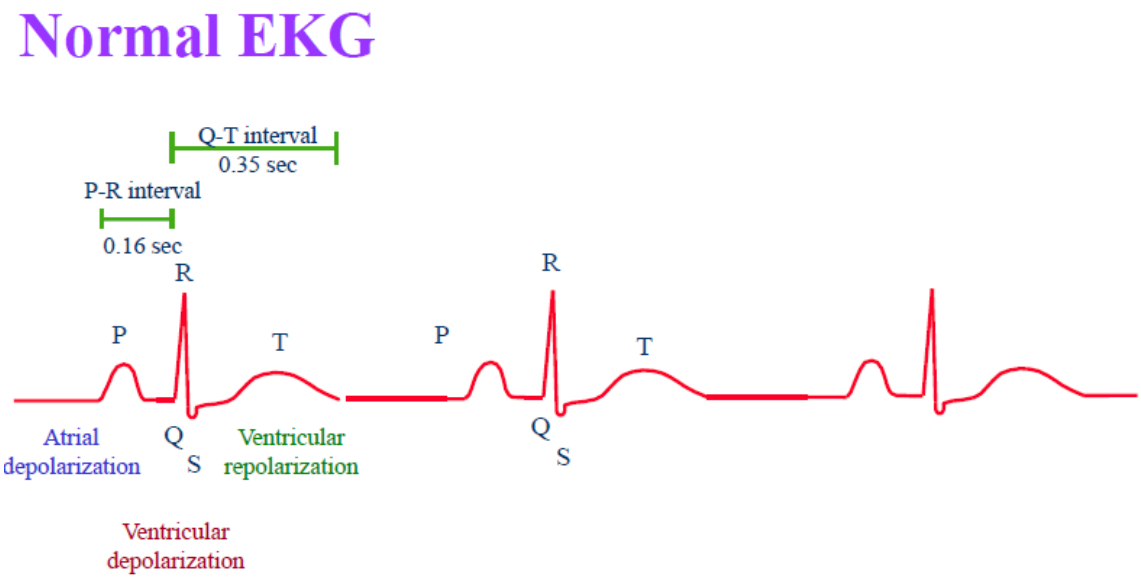
In the picture suppose we have a muscle fiber represented by A,B,C,D we put the first (-ve) electrode in point 1 and the second (+ve) in point 2 in the beginning the membrane is polarized i.e no potential difference .
A) depolarization happens, negative charges outside and positive charges inside so there will be potential difference between 1 and 2 and will increase until we reach half way of the muscle in that case we record the highest potential difference (the pointer moves to the right) then will decrease until we the depolarization reach all the muscle fiber
(B) ---no potential difference
(the pointer will go back to zero) when the muscle is completely depolarized this is called isoelectric line
-now if you want the depolarization curve to be down you have to define your recording that you want the depolarization to be downward deflection but it was agreed internationally as a standard that the depolarization curve is upward deflection and the repolarization curve is downward deflection
C) now we come to the repolarization , it will start from point 1 (negative inside and positive outside) and since the charges direction is different the pointer will move to the opposite direction , so the repolarization curve will be downward deflection and same thing when we reach halfway we record the maximum repolarization and when we exceed it the pointer will go back and when the membrane is completely repolarized --- isoelectric line (D)
-the change in depolarization is faster than repolarization (dV/dT is higher)

-so we are going to record depolarization and repolarization , these electrodes should be far from each other we put them around the heart one on the right hand and one on the left hand and record , we put another electrode on right hand and left foot and record, and on the left hand and left foot and record
-every recording we call it lead , and because you want to understand what is going on in the heart you take different views (right hand & left foot , left hand & left foot)
-so we have 3 leads :-
Lead I :- right hand & left hand

Lead II :- right hand & left foot
Lead III :- left hand & left foot

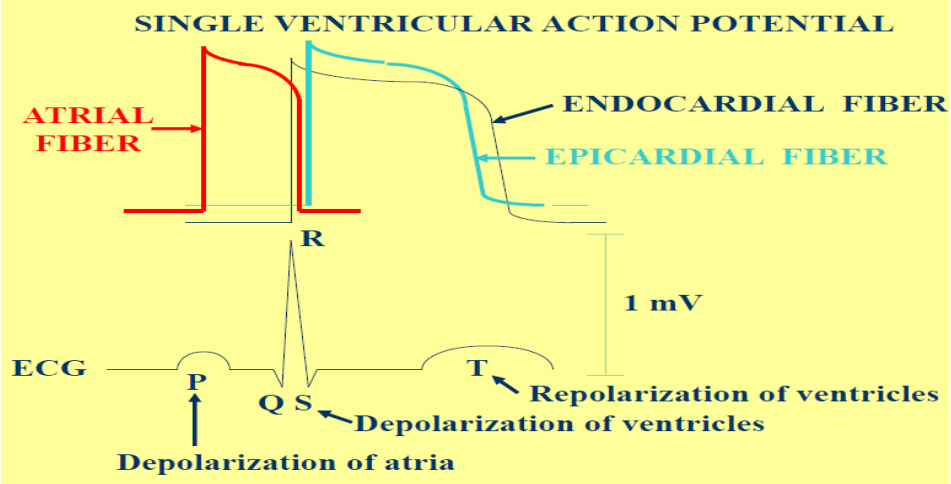
Note that no potential is recorded when the ventricular muscle is either completely depolarized or repolarized

Now in lead I we put negative electrode on right hand and positive electrode on left h and (internationally agreed) and we get this ECG



- P wave then QRS then T wave and so on
-the x axis is time and the y axis is the voltage
-P wave: depolarization of atrial myocardium.
- **QRS complex**: ventricular depolarization
T wave: repolarization of ventricles
-the time between first R and the next R is what we call the **cardiac cycle** or heart beat
- when we look at the ECG above we should ask 2 questions :-
1)where is the atrial repolarization ?
-the repolarization of atria occurs during QRS, it occurs during the depolarization of the ventricles and because the depolarization of ventricles occurs with higher electricity its masks the atrial repolarization
-but if they go away of each other as in some diseases we can see atrial repol arization when the heart rate is much slower like in AV block (heart rate is 35-40)
2) the T wave represent repolarization , then why it's upward deflected ?

- if we go back to the figure in page 2 the depolarization occurs from point 1 to point 2 and al so the repolarization occurs from point 1 to point 2 but what if it occurs from point 2 to point 1 then the pointer will move to the same direction as the depolarization
- now in the heart the depolarization starts from the endocardial area to the epicardial area and from the base to the apex of the heart while the repolarization starts from the epicardium to the endocardium and from apex to the base so because the repolarization doesn't start from the same direction as depolarization the T wave is recorde d as upward deflection
(the atrial repolarization shows as downward reflection)
-the first reason is when the ventricles depolarize it contract and develop pressure inside(during systole) this pressure gradient will be more in the endocardium and less in the epicardium and this changes the permeability of ions and delays repolarization
And the same thing pressure will be higher in the base more than apex

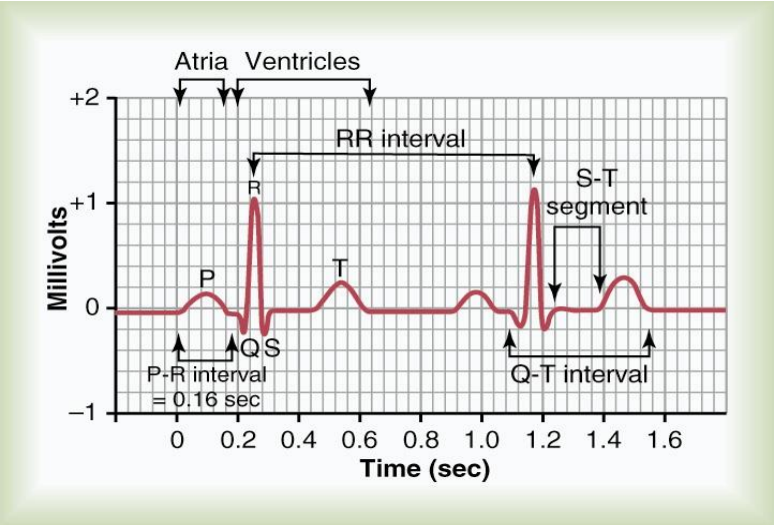


-also because of inherent properties , as you see from the figure above, the repolarization of the epicardium happens before the repolarization of the endocardium and this also explains why the T wave is recorded as an upward reflection
- also you can notice that atrial repolarization happens at the same time of ventricular depolarization that's why atrial repolarization doesn't show up .
- as we said before the time between R and another R is the cardiac cycle also the time between p—p and T----T,… but we prefer R because it's a large spike (too much electricity in ventricles and very fast that's why it appears as a large spike with high voltage)
-when we record from skin won't the skeletal muscle depolarization and repolarization affects the conduction to the skin ? When we record ECG we tell the patient to be relaxed physically and mentally , if not there will be slight abnormality especially in the isoelectric
- if the cardiac cycle between R – R is one second then the heart rate will be 60 beats / min
One beat ----- one second
X ---------- 60 seconds (1 min) so the heart rate = 60 /1 =60 beats /min

-so you can know the heart rate from the ECG

-if the time between R—R is 0.6 ----- heart rate = 60/0.6= 100 beats /min
-if the time between R----R is 0.8 ------- heart rate =60/0.8= 75 beats / min (for teaching purposes we take these values as the normal ones and calculate the other values that we need But the normal heart rate is 60-80)

Standardized EKG's:-
Sometimes we call it EKG because the first people who invented Electrocardiograph are the Germans and in Dutch the word cardiology is written by K instead of C

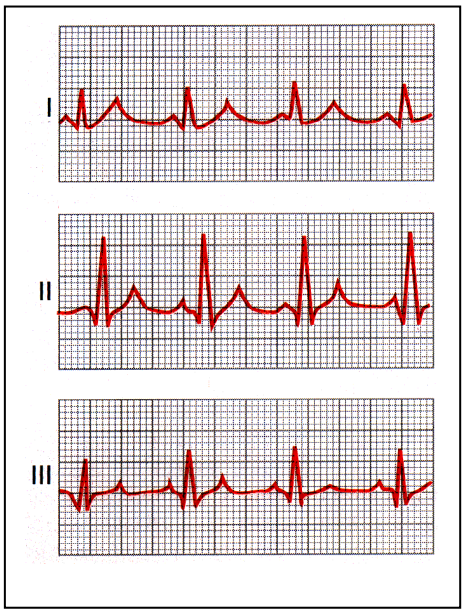


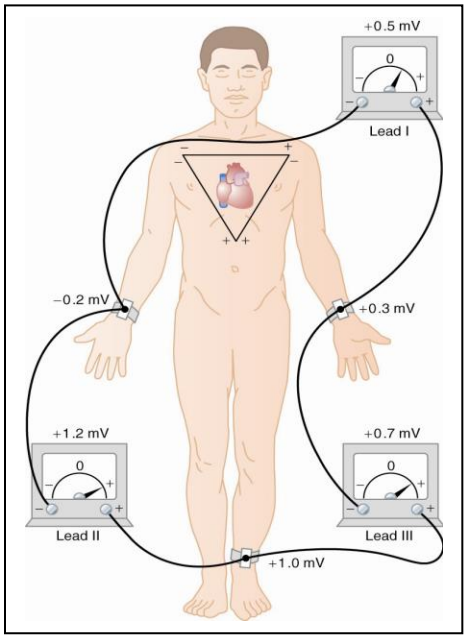
-the recording is on a paper which is divided into squares , small and large squares
-the speed of the machine is 25mm/second and every small square is 1mm so every small square = 1/25= 0.04 second , so you can count the squares between R---R and multiply by 0.04 to know the cardiac cycle
-also for the voltage every 10mm = 1mV
-RR interval is one cardiac cycle
-**PR interval** :- when we say interval it must include a wave so PR interval is from the beginning of P to the beginning of Q but Q doesn't show up sometimes that's why we say P-R interval
P-R interval represent the conduction of wave from the atria (SA node) to the ventricles
-when you say segment there is no waves , on the isoelectric line
-**P-R segment** :- from the end of p to the beginning of Q or R
S-T segment :- from the end of S to the beginning of T
*P-R interval is usually less than 0.2 seconds if it's more then there must be AV block
-parasympathetic stimulation isn't going to prolog the P-R interval it's going to prolong the wave (Q-T interval) and if it prolong P-R not more than 0.2 second

*The AV block is 3 degrees :-
- first degree :- P-R interval >0.2 seconds and each P is followed by QRS

-second degree:- P-R interval > 0.2 seconds and not each P is followed by QRS (more Ps than QRS but there is regularity (pattern)
-third degree :- complete dissociation between P and QRS (heart rate is 15-40)
*1st and 2nd are called incomplete heart block the 3rd is called complete heart block
***S-T segment** :- when we say segment we don't look for time we care whether they are upward deflected or downward deflected
-elevated S-T segment is an emergency indicates infraction or ischemia to the heart
*QRS is from beginning of Q to the end of S , should be less than 0.12 seconds , prolonged in bundle branch block where the conduction will happen through muscles or hypertrophy of ventricles
Lead I :- right hand (–ve)& left hand (+ve)
Lead II :- right hand (-ve) & left foot (+ve)
Lead III :- left hand (-ve) & left foot (+ve)

- Always the right hand is negative and the left foot is positive
- Right foot is the earth (we don't record from it)





-we call them bipolar limb leads (because we used 2 electrodes on the limbs)
-we have 12 leads :-
3 bipolar limb leads
3 unipolar limb leads
6 unipolar chest leads

GOOD LUCK ☺

Done by Ramiz Alyacoub