Course: Electrophysiology of Heart

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Lecture 10: ECG-- Interpretation

Hello everyone. So, today we will start our next topic that is the Interpreting Cotation of ECG. So, previously we had discussed the various configurations of waves in the ECG and what are the calibrations done. So, today we will see how to read an ECG, how do we calculate an heart rate, what is the cardiac axis and significance of various segments and intervals. Now, this is a ECG which consists of various waves, segments and intervals. Now, before that I would like to say T wave is because of the ventricular repolarization it is showing the upward deflection.

We also see presence of another small wave that is U wave which is also because of the repolarizations as well as the after the polarization of the papillary muscles which we get sometimes in the ECG. Now, the waves we have P wave, then we have the QRS complex Q wave, R wave and the S wave. Then we have the T wave mainly these are the 5 waves, then we have the segments and the intervals. Now, the basic difference between the segments and intervals means the segment is a straight line it would not include any waves.

While interval means it includes the waves the straight line as well as the wave. For example, if I want to calculate or measure P R segment that means I would not be including P wave. The P R segment will start from the end of P wave and the onset of the R wave or the Q wave. That is the P R segment it is neither including the P wave it is not including the Q wave or the QRS complex. Now, if we want to measure the P R interval at this time we have to include the P wave that means the onset or the beginning of the P wave and the end of and the starting and the onset of the R wave or the Q wave.

So, that is the P R interval as you can see here this is the onset of the P wave and this is the onset of the beginning of the Q wave or sometimes we refer to as the R wave if Q wave is not present. So, P R interval is inclusive of the P wave and P R segment is not consisting of any wave it is the isoelectric line or the straight line. Similarly, we have S T segment and also we have the T P segment. Intervals we have the besides P R interval we have the Q T interval. The significance of Q T interval is it is the duration of the

action potential which is mainly determined by the Q T interval it consists of both ventricular depolarization as well as repolarization.

Now this is the slide which had already been discussed where we had discussed about the calibration of the ECG how it is done. Now in the x axis this is the x axis is the y axis the x axis mainly denotes the time in milliseconds or seconds and y axis usually denotes the voltage or the amplitude in the milli volt usually. And we already have seen that the ECG paper usually rolls at the speed of 25 millimeter per second which usually gives at the level of x axis one small box one millimeter corresponding to 0.04 seconds. And in the y axis one millimeter corresponding to 0.

1 milli volt as per the calibrations. Now why this seconds is important because we calculate the various waves duration various segments and intervals duration based on this one millimeter is equal to 0.04 seconds formula. So now we have the ECG paper running at the speed of 25 millimeter per second which means in one second it could roll over 25 millimeter or 25 small boxes. Because each box is of length by breadth one millimeter by one millimeter which means if I had to calculate in one minute how much length or how many boxes it will cover.

That means in 60 seconds it will cover 25 into 60 1500 millimeter or 1500 small boxes. So, if I want to calculate the heart rate we have to take the ECG paper or ECG signals and we have to see for various RR interval. That means we have to calculate the number of small boxes between the two R waves. You take any two consecutive R waves and you calculate the number of small boxes present in between those two R waves. For example, here if we see in this paper we have 5 3 around 16 small boxes we have 16 small boxes.

So, our heart rate will be 1500 divided by the number of squares which lies between the RR interval here it is 16 it will give around 93 beats per minute. So, this is the heart rate and in this way we calculate the heart rate. Here heart rate means we are talking about the ventricular heart rate mainly. So, this is the way we are calculating heart rate in case of a regular rhythm. Now regular rhythm means heart rate normally beating at regular intervals.

That means it is observed when we check for the various the small boxes or the duration or the interval between the two R waves. Each successive R waves if we see the cycle length if it is similar then we say the heart is beating at regular rhythm or regular interval. In this way 10 percent up to 10 percent of variation is acceptable in adjacent cycle length which is considered to be normal. Because in case of physiological arrhythmia or sinus arrhythmia whenever we inspire or we take deep breath at that time

our heart rate increases while during expiration when we are expiring our heart rate decreases it is a normal physiological phenomena. So, it accounts for around 10 percent of the changes in the rhythm, but that is acceptable.

But if any abnormalities happen more than this 10 percent or any change in the cardiac rhythm occurs this is known as arrhythmia and that is pathological. And we will study in details of various types of arrhythmia how it looks in the ECG in further lectures. So, the question is we have calculated the heart rate whenever the rhythm is regular that is 1500 by your number of small boxes in the arrh interval. Now, if I had to calculate for the sake you just remember this thing because if you so that you do not get confused. In case of large boxes if you have to calculate then you calculate this by r r large boxes.

So, I am the l is for large boxes and i is for the small boxes. So, 1500 by the number of small boxes present in the r r interval we calculate as the heart rate. Now, that is in case of the regular rhythm, but in case of irregular rhythm how you will calculate the heart rate. So, there is variation in the rhythm. So, at that time we take a 10 seconds ECG recording and then we count the number of beats present on that ECG.

And since we have taken the recording for 10 seconds we multiply whatever beats we are getting into 6 and we get the heart rate in case of irregular rhythm when the rhythm is irregular. For example, this ECG you can see the rhythm is absolutely irregular and how you here it is not possible to calculate heart rate by this conventional formula of 1500 by r r. So, here we go for the 10 seconds ECG rule. Here we take count the number of beats in the 10 seconds. So, suppose if I count from here to here around we get 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33.

So, we are getting 33 beats in 10 seconds of ECG. So, if I want to calculate the heart rate over here I will multiply this 33 into 6 and around we get 190 beats per minute. So, here the heart rate in this case of irregular rhythm it will be 198 beats per minute. So, calculation of heart rate in case of regular rhythm calculation of heart rate in case of irregular rhythm these two are different. Now coming to the P wave the first wave the first positive deflection.

So, whenever we are talking about P wave we are talking about atrial depolarization. This we know and how we also know how the configuration of P wave is upward or positive deflection and in which leads it will give positive deflections. The most important thing is duration of this P wave should not be more than 0.1 seconds. In other way we should remember it should not occupy more than 2.

5 or 2 and a half small squares. Now each small square is of 0.04 duration.

So, 2.5 small square 2.5 into 0.04 it will give 0.1 seconds and that is what is written on the slide. So, duration should not be more than 0.1 seconds the amplitude also should not be more than 2.

5 millimeter tall. So, this is the duration it will give the duration in seconds and this is this is around 0.1 seconds and this is the amplitude and this also should be within the 2.5 millimeter. Now the configuration it had already been told in the previous lecture it should be positive in lead 1 and lead 2 also from V 2 to V 6 the chest rates. But in AVR lead it should always be negative this is very important in AVR lead the P wave should be negative actually all the waves are negative in AVR lead.

Now the abnormality in the P wave we see when the P waves are tall, tall means it is here you can see here you can see here you can see here you can see that the P waves are tall. Tall P waves or any tall waves means the amplitude or the voltage is more and the amplitude is strongly dependent on the vector or the electromagnetic force generated. The more strong vector the more strong amplitude or the voltage and the strong vector is dependent on the length or the musculature which means there is atrial hypertrophy which is occurring in this case which is leading to the strong positive vector and leading to the tall P waves. Now this tall P waves in case of right atrial hypertrophy right atrial enlargement is also known as P pulmonale this is also known as P pulmonale pointed peak P waves. In case of left atrial hypertrophy we also get a different type of P wave you can say this P wave it is a notched or bifid appearance or a bit of M shepherd.

This is the M shepherd P wave where definitely the duration has been prolonged and the peculiarity is it is bifid or notched. This type of P wave is seen in left atrial hypertrophy it is known as P mitrali. In right atrial hypertrophy we have seen picked P waves or tall P waves that is P pulmonale in case of notched bifid P waves which is seen in typically left atrial enlargement that is P mitrali. So, this much you have to know about the P waves. Next we come to the P R interval already we had told the P R interval is beginning of the P wave and the starting of the R wave or the Q wave.

Now, P wave duration is 2.5 boxes the P R segment duration which is a straight line is also 2.5 boxes. So, which means this P R interval should be within 5 boxes 2.5 and 2.5 it is very easy to remember P wave 2.

5 boxes P R segment duration is 2.5 boxes. So, this P R interval will be within 2.5 boxes. So, that is the normal interval of P wave P R interval which should range between 0.

1 to 2.2 seconds. If we say the 5 boxes means 5 millimeter I am talking about which

means 5 into 0.04 that means 0.2 seconds. So, this is the normal P R interval it should be within this range 0.

12 to 0.2 seconds. The abnormality occurs when the duration is either too short which is less than 0.12 or if the duration is prolonged which is more than 0.02 seconds. In case of short P R interval the abnormality is usually seen in case of Wolf Parkinson White syndrome and atrial premature beads. And in case of long P R interval where the duration is usually prolonged that is seen in heart block especially the first degree heart block.

So, this much you have to remember with the P R interval. Now, QRS complexes as QRS complex consist of 3 waves the QRS waves it signifies the ventricular depolarization. Before moving on to the QRS complexes P R interval signifies the atrial depolarization as well as the conduction through the AV node and the bundle of his this has already been discussed. So, QRS complex the duration should not be more than 0.11 seconds which means here also it should constitute or should fall within 2.

5 or 2 and a half small boxes. So, it is very easy to remember P wave 2.5 boxes P R interval 2.5 and 2.55 double of the P wave boxes and QRS also 5 2.5 boxes should be within QRS which means it should the duration should be within 0.

11 seconds. Now, the QRS complexes when we talk about the 2 most important the 2 important waves that is R wave which is usually positive deflection wave and the S wave which is very negative deflection waves. We need to know when this R waves are positive and when this S waves are negative this we had already seen in the previous lecture. Just to recap lead 1 lead 2 B 4 to B 6 the R wave is dominant AVR S wave is dominant as well as B 1 and B 2 we get dominant S wave. We do not get to see any Q waves in AVR or B 1 and B 2 the S wave dominance or the S wave depth should not exceed 30 millimeter. If it is exceeding 30 millimeter you can see over here the negative deflections of the S wave these are abnormalities and also the tall R waves which means again the strong vector is same in case of the ventricles which usually occurs because of the ventricular enlargement or ventricular hypertrophy.

So, this is all about your QRS complexes and the low amplitude of QRS complexes is seen in case of marked M phi sigma pericardial effusion and mixy rima. These are the important causes where you get the amplitude or low voltage QRS complexes high voltage QRS complexes is seen in case of ventricular hypertrophy since it is an event of the ventricles. Now, coming to the ST segment ST segment should be isoelectric it should be the straight line. Sometimes it in normal construction of the conditions also there could be an elevation and this elevation is usually seen in case of B 1 and B 2

leads. But this elevation usually ranges falls within the range within 1 millimeter.

But if the ST depression or elevation is more than 1 millimeter that is abnormal and this is very much seen in case of acute myocardial infarction. The J point significance is very important over here J point is the point which is between the QRS and the ST segment. When my S the S wave is ending and the beginning of the ST segment that is the junction or the that is the point that is J point. These are the various shapes of ST segments elevations been shown which is usually seen in different pathologies specifically myocardial infarction. So, in this way we could get various forms of ST segments anomalies.

The second the final and the last important wave is T wave this T wave is mainly because of the ventricular repolarization. We have already discussed this is because of the ventricular repolarization. The T waves is usually upright it gives an upward deflections specially in the lead 1 lead 2 and V 4 to V 6. In other leads it could be biphasic, but the main important thing is in AVR it should be inverted. The abnormalities of T waves the tall T waves we see in case of acute myocardial infarctions where it is accompanied usually with the ST depression or elevations.

And hyperkalemia when the potassium extracellular potassium levels is increased. Inverted T waves we see in case of bundle branch block in case of ventricular hypertrophy in case of digitalis effect or the degoxing effect and in case of myocardial ischemia. Now, QT interval is of very much significance since it tells about the total duration of depolarization and repolarization that is nothing, but our action potential. So, this action potential durations which usually ranges between 250 to 400 milliseconds that is denoted by QT interval. But this QT interval is variable and it is subjected subjective to the change in case of heart rate.

And our heart rate also changes fluctuates normally in we see in case of inspiration as well as expirations we had already discussed about the physiological that is sinus arrhythmia. So, in this case the corrected QT interval is important. So, we have to calculate the corrected QT interval which is usually measured by Basets formula. The Basets formula tells corrected QT interval is QT divided by root over RR interval. So, QT divided by root over RR interval will give you the corrected QT interval and the interval should range within 0.

35 to 0.45 seconds. The abnormalities we see in case of prolonged QT interval usually when we give anti arrhythmic drugs whether you are giving sodium channel blockers or whether you are giving potassium channel blockers usually the action potential duration gets increased or prolonged. In that case we see the prolonged QT interval we also see

prolonged QT interval in hypokalemia as well as myocardial infarctions. But in case of hypercalcemia we usually see shortened or decreased QT interval that is less than 0.35 seconds. Now the question is how to calculate the cardiac axis the QRS axis or the cardiac axis is nothing, but it represents the overall electrical activity direction in which this electrical activity of the heart is occurring.

The overall direction of the hearts electrical activity is represented by the QRS axis or the cardiac axis. Any abnormalities in this QRS axis it indicates either there is a block conduction block or there is the ventricular hypertrophy. Normally the axis ranges in between minus 30 to plus 110 degree. So, minus 30 degree to 110 degree this is the normal range in which the normal axis of our heart usually lies. But if we go beyond this minus 30 degree we usually say left axis deviations if we go beyond this plus 110 degree we usually say it is right axis deviations.

And in between this is indeterminate axis and or sometimes we call it as no man's land. And so the left axis deviations usually consist of left ventricular hypertrophy and left anterior hemi block. And right axis deviations the most common example is right ventricular hypertrophy or we see that the left posterior hemi block these are the very important conditions. Now, how you calculate this cardiac axis we can calculate this cardiac axis in two ways one we can approach take the help of enthalvens law or enthalvens triangle the other approach is of quadrant approach. So, the first approach enthalvens triangle approach is we see there we have three leads any three leads you can use, but for convention we generally use or we ask the students to use usually lead 1 that is of 0 degree and lead 3 this is the lead 3 I am just plotting it like this because this is lead 3 this is lead 1 this is lead 2.

So, this is lead 3 which usually lies at angle of 120 degree. So, this is our lead 3 this is our lead 2. Now, how you plot the axis over here generally we have two waves over here the most positive deflection in case of QRS complex is R wave and the most negative deflection in case of QRS complex is generally S wave. So, we take the net or the average deflection that means, R minus S in case of various leads we may not get a negative deflection we can get only a positive deflection in that case we have to take only the R wave. But in case of biphasic deflections at that time we have to include both the R wave and the S wave and we have to go for the net deflection that is R minus S. So, for example, in case of lead 1 if we are taking suppose in this diagram we can see the deflection is of the R wave, but there is no since there is no S wave or also we do not have any Q wave.

So, there is no negative deflections we only got plus 8 or positive deflection waves. So, plus 8 we will plot in the lead 1 axis that means, 1 2 3 4 5 6 7 8. So, this is the plus 8 we

will plot in lead 1. Next if we see lead 3 since we are taking the lead 3 here in lead 3 we could see a negative wave that is S wave also and this is the R wave. So, R wave is giving a deflection of plus 5 millimeter and S wave is giving a deflection of minus 2 millimeter.

So, plus 5 minus 2 this is plus 3. So, plus 5 and minus 2 plus 3 we will be plotting in the lead 3 1 2 3. So, in this way we have plotted. So, this is an arbitrary diagram since we do not have a graph paper over here. So, just ignore the whatever interval difference is happening. So, 8 plus 8 I have plotted in the lead 1 axis and plus 5 I have plotted in the lead 3 axis.

We will draw a perpendicular from lead 1 suppose we have drawn a perpendicular from lead 1 we will also draw a perpendicular from lead 3 wherever it is meeting. So, this is Sthis two perpendiculars are intersecting the point at which it is intersecting. So, this is the point. So, we will draw a line to this intersections and this is nothing, but this is our cardiac axis.

So, as you can see this cardiac axis is falling actually between 0 to 120 degree probably this the angle will be 60 degree do not take you have to take the angle from the 0 degree. So, this is the 60 degree. So, the lead here the cardiac axis is 60 degree. So, it is a positive 60 degree. So, it is lying in the normal range as I told you can take any leads if you want to take lead 1 and lead 2 you can go with lead 1 and lead 2, but for a conventional for safer for accurate or for a better way we just take lead 1 and lead 3 and it is good usually it is like easy for the students to calculate.

Now, we go for the quadrant approach. In the quadrant approach we usually take two leads that is lead 1 and AVF. Lead 1 and AVF then we check for what are the deflections we are getting in lead 1 and AVF whether we are getting positive deflections whether we are getting negative deflections we can get any of the deflections in case of lead 1 or lead AVF. So, then we try to put this deflections in this combinations. Suppose in lead 1 if you get a positive deflection as well as in case of lead AVF you get a positive deflection you get the normal axis which means positive in lead 1 positive in AVF it is a normal axis. Suppose you get a negative deflection in lead AVF and you get the positive in lead 1 so that means you get a left axis deviation.

Suppose you get a negative deflection in lead 1 and a positive deflection in lead AVF that means it is a right axis deviation. And in case of negative deflections when both the leads are negative that means it is indeterminate axis. If you just want to calculate the same mean using an enthalvenge triangle also you will get the same results. So, this is all about the quadrant approach you have to remember this combinations and you should

place the axis into one of the any of the four quadrants below.

So, the summary is the main rules you have to remember while reading the ECG. The first thing is when you get an ECG paper you should check the summary is nothing but the rules. The PR interval as I told you should be within the 5 boxes.

So, it is 120 to 150 degrees to 200 milliseconds or 0.1 to 2.2 seconds. The width of the QRS complex again should be within 2.5 boxes that means it should not exceed 0.1 milliseconds 0.1 seconds or 110 milliseconds. Now, QRS complex should be dominantly upright usually we that means dominant R waves we get in lead 1 and lead 2.

All the waves should be negative in case of AVR. There should be R wave progression this R wave progression we have already seen in case of chest leads. So, in chest leads we see there is an R wave progressions from V 1 to V 5 specifically and there is a slight dip in the V 6. So, this R wave progression is very important. All the waves are negative in AVR means you have placed all the leads correctly that means technically you do not have any problem.

The ST segment should start isoelectric you should be aware of J point. The P waves should be upright in lead 1 lead 2 and lead 2 V 6. The P waves should be upright in lead 1 lead 2 and lead 2 and lead 6 anything you get apart from this usually we consider it as abnormal. So, these are the rules to be very much specified while reading an ECG. Hence these are the references we have taken with this I would like to conclude to this topic. Thank you.