Biomedical Signal Processing
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Lecture – 27
Waveform Analysis

So, we start the next topic that waveform analysis.

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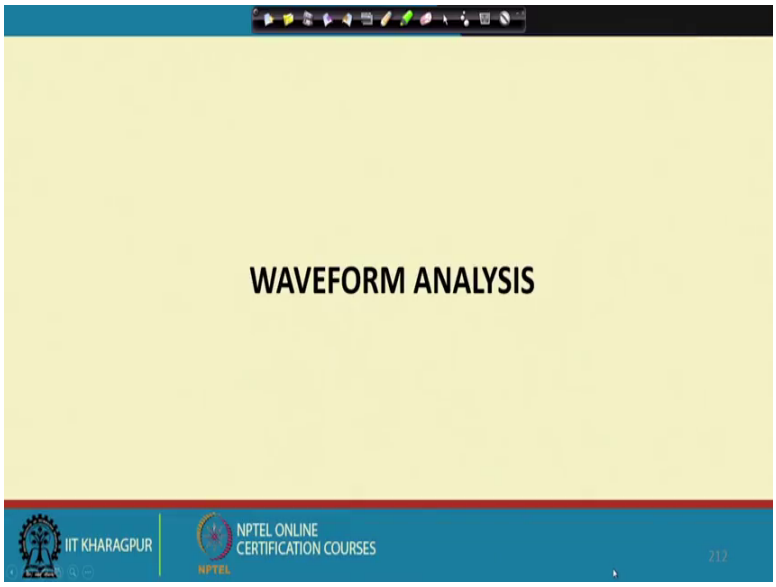

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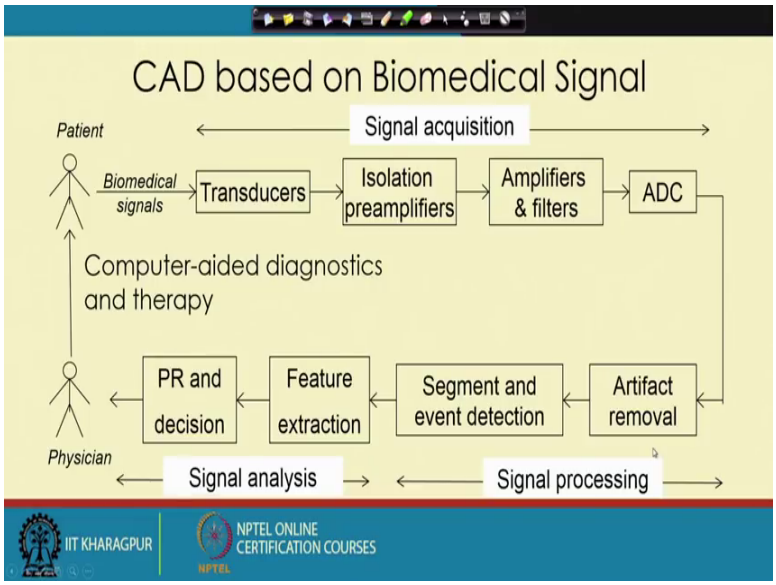

And here first we look at the big picture that from a subject, we are getting the biomedical signal and with the help of transducer, we are acquiring that the biomedical signal which are passing through the stages of isolation pre amplifier, amplifiers and filters then a to d conversion and after cleaning that signal; that means, after the artifact removal, we have actually detected the event and segmented that.

For example, for ECG signal once we know the bits or the QRS complex. Now we can segment out the different cycles of the ECG with the help of that the information of the QRS complex or that event. And then comes the feature extraction and the pattern recognition of it, so shape is a important feature. And here we are talking about that how the change in shape occurs for the biomedical signals and how that helps in the diagnostics. So, first we will go through several case studies.

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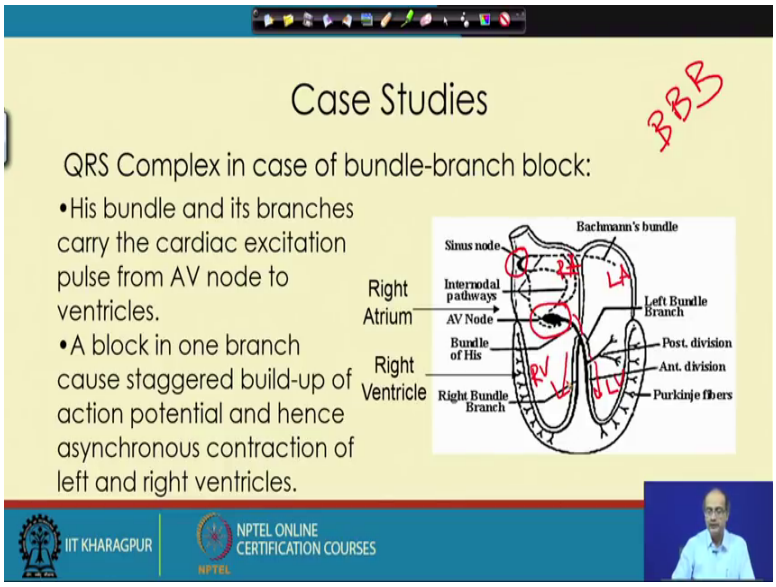

Here we look at the case of the QRS complex in case of that bundle-branch block; in short we call this as actually B B B; this bundle branch block we call as B B B. Now what it means? That we have the SA node which actually acts as a the lead in the Korez that and. It gives a signal that the heart should start the contraction and in response to that upper chambers of the atria that the right and the left atrium they actually gets contracted and AV node, it actually arrests this signal does not allow it to flow to the ventricles so, that the transfer of the blood from the atrium to the ventricles, it can get the sufficient time and the transfer becomes complete.

Now once AV node releases that signal after some time, after adding the delay; then it would pass through the bundle of his and get distributed from here through these two branches and through the help of Purkinje fiber, it will get into that left ventricle and right ventricle and in these process that it actually spreads very quickly to all parts of the ventricle. And both the ventricles all parts of it actually contract simultaneously unlike the atriums where the message spread slowly and the contraction also spreads slowly.

Now, the ventricles they simultaneously all the points actually they can get contracted and we get the signal out of it that is called the QRS complex. Now if there is any imperfection in these branches; then what will happen? One of the ventricle will get the signal earlier than the other. And because of that that two that ventricles, they would not actually contract simultaneously and out of it we will find that there is a lag between them. And the QRS complex of the two also would be different; that means, instead of a single QRS complex both will give rise to a two different; that QRS complex which will have some overlap, but they would not be synchronized. So, that will give rise to a little different kind of picture.

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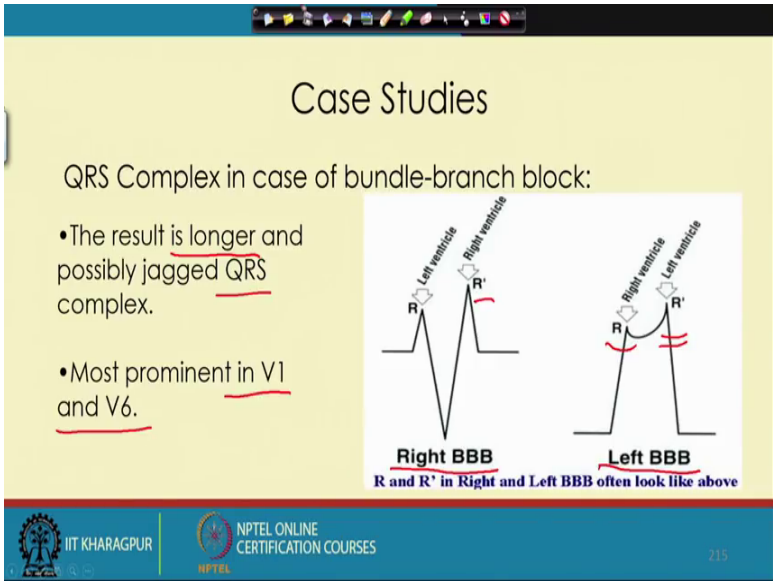

So, let us see that how it looks like that in the first case, here we are showing that left ventricle that is contracted fast; that means, block was in the right one, so, it is called the right bundle block. So, the right ventricle it has contracted late and the corresponding the R wave comes late which is written as R dashed. So, it gives rise to a jagged actually

waveform here; now it can happen in other way around also if the right one contracts before followed by the left one in that case that is possible if there is a left actually bundle block.

So, in that case that the right one will actually precede and in this case also we get that they are not synchronized and we have a jagged waveform. And as a result in both the case the QRS complex, it will be not only jagged; it will give rise to a longer waveform; that means, it will spread over that time. And such kind of waveforms or the abnormalities; it is most prominent in that chase leads that V 1 and V 6 in these two chase leads they get actually we can get them very clearly.

Other that leads also will get the effect of it, but it will not be so clear in that way that what has happened inside. So, this is one example we get that by looking at the shape of the QRS complex; we can get that there is that bundle block maybe the left or in the right bundle block or more precisely we can say that bundle branch block.

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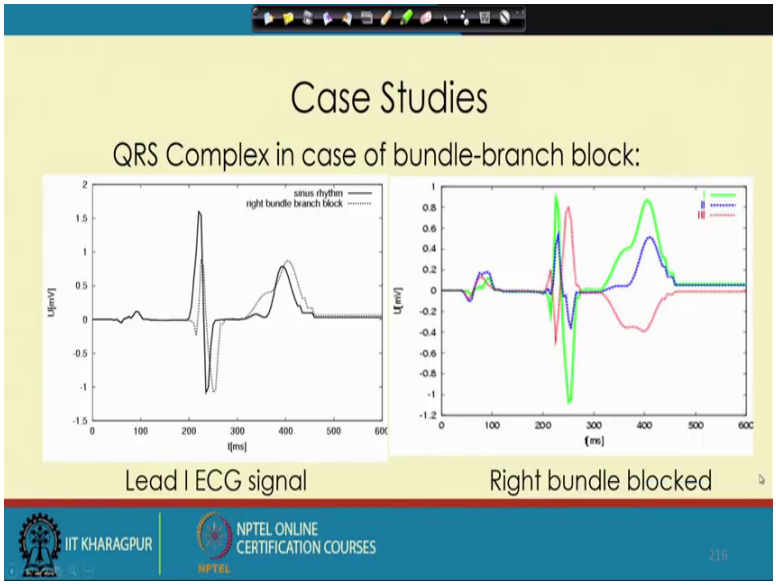

Next is that we see that what is the change in the that lead 1 signal that; for the lead 1 signal, we are showing here that the normal signal is in that solid line and dotted signal in case of actually bundle block; we see that the QRS complex that height has reduced because it is not synchronized. The spread has increased and it has also affected the T wave also and this is not just limited to that lead 1; all the leads have the impact of it.

Here we are showing that in this particular case that how the lead 1, lead 2 and lead 3 will get affected; that lead 1 is shown in green color, lead 2 in blue color and lead 3 in the red color. So, all of them they are getting affected and we can actually see the changes in all, but the amount of effect that depicted in each of the lead that would be different.

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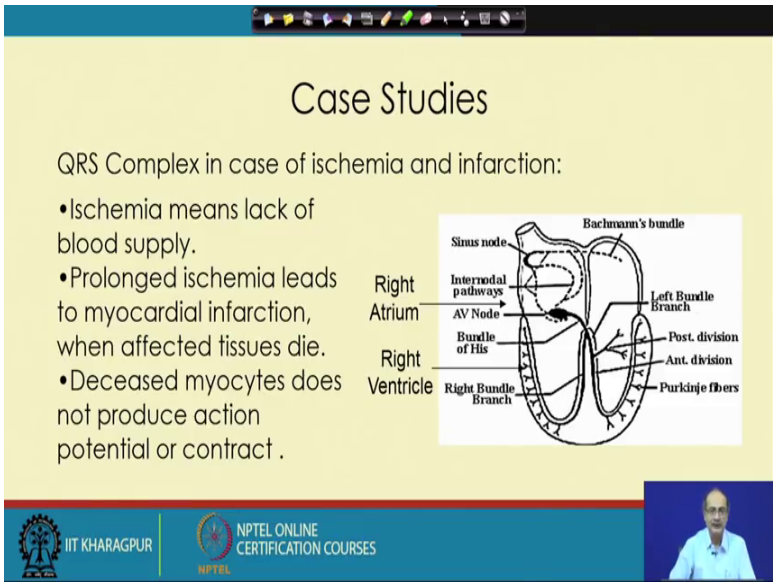

So, this is the case of a right bundle block and now we will go for more studies. Now again let us go back to the original actually that service provided by the pump called heart. That this pump in the body, it helps to pump the blood continuously throughout the body and that the blood is a carrier of the oxygen and the glucose; even if the cells can actually withstand without the glucose or the new trend in that way for some time and use it from its own reserve.

That oxygen is very important if it is starved of oxygen; that the metabolism will stop; it will not be able to release the energy and it will become actually start dying actually. So, it will first stop for some time; it will not be able to do the normal operation and if that situation continues, it will permanently die.

So, that is the first stage that when it is starving from the oxygen; it is called ischemia and if it permanently becomes dead, it is called infarction. Ischemia means lack of blood supply and if it is prolonged; the tissues start dying and in case of myocytes also the same thing happens and it will not produce any action potential. Now how that happens in case of that heart?

See heart in this case can be compared with a power plant; in a power plant that to run the power plant again a lot of power is required for example, a thermal power plant if we take as an example about 2 percent of the energy generated by that a thermal power plant it actually is consumed by the power plant itself, it needs to run the very big fans; which provides a draft that air is passed through the boiler that to keep the fuel running and then the smoke you need to discharge at high altitude.

So, for all these things and other operations about 2 percent of the power actually is consumed by the power systems itself. Same way that the heart is actually giving the blood to all parts of the body; if part of it is actually needed for the heart itself, if those supply lines are getting disturbed then that part of the heart it starts actually starved of oxygen and they get into the condition of ischemia.

Now why so much of energy or blood supply is needed for the heart? Because heart is always pumping and it is spending energy for that contraction all the time; so, it is very important that it gets that nourishment both that glucose and the oxygen. And if it is deprived of it immediately, it will become actually inactive it gets into the ischemic condition and if it becomes prolonged then part of those cells, those muscles actually tissues they will start dying.

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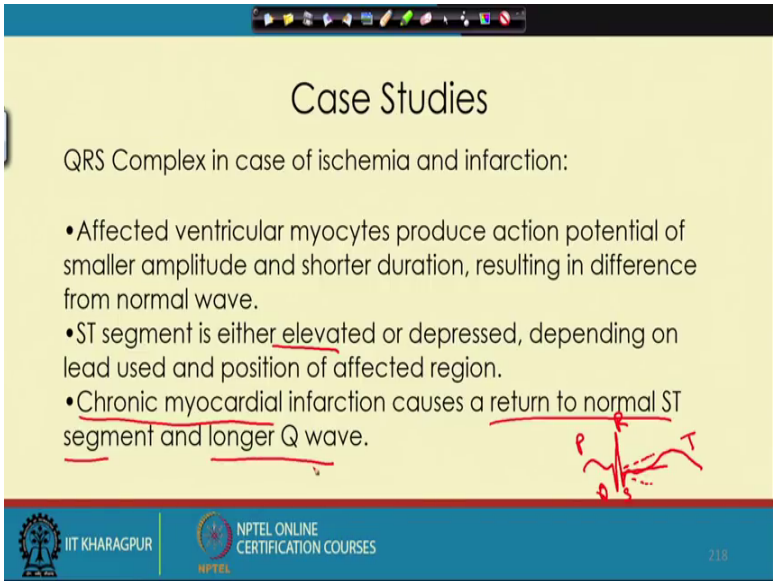

So, here we see that how that happens the affected ventricular myocytes produce the action potential of the smaller amplitude and shorter duration resulting in difference from

normal wave. The moment it becomes ischemic, it cannot perform the regular duty in a proper way and they are actually not only the contraction also becomes weak. They are that signal amplitude also changes in behavior and that gets actually reflected in the ECG signal.

Now if we look at most specifically in the S T segment that we get the change more pronounced; either the S T segment, S T segment is a actually after the QRS complex that this is the P wave, then you have the QRS complex; then we have the that T wave. So, that this is P, Q, R, S; so, these part is actually isoelectric line or zero electric potential the kind of actually signal would come here. Instead of that it is either elevated; that means, going up or getting depressed, going down. So, all such kind of abnormalities can happen in the S T segment and; however, when it becomes a chronic; that means, from ischemia it has gets into infarction.

Some of the cells they die that in case of that chronic case that again somehow it gets back the balance and it returns to a normal S T segment; however, longer Q wave. So, then you would not find any difference of the S T segment and from that the doctors can tell that from the S T segment that whether there has been a heart attack; that means, a stoppage of actually pumping of the blood for that ischemia has come and that has left an impression in the S T segment, once it is getting healed; that means, one month before it has happened, now S T segment again is coming back to its original position. So, from that the doctor can tell that how old was that attack.

At least whether it is a fresh one or it is already has gone into a permanent actually state it is not a that very recent phenomena; the heart has taken care of that abnormalities and again performing the duty on the remaining muscle cells.

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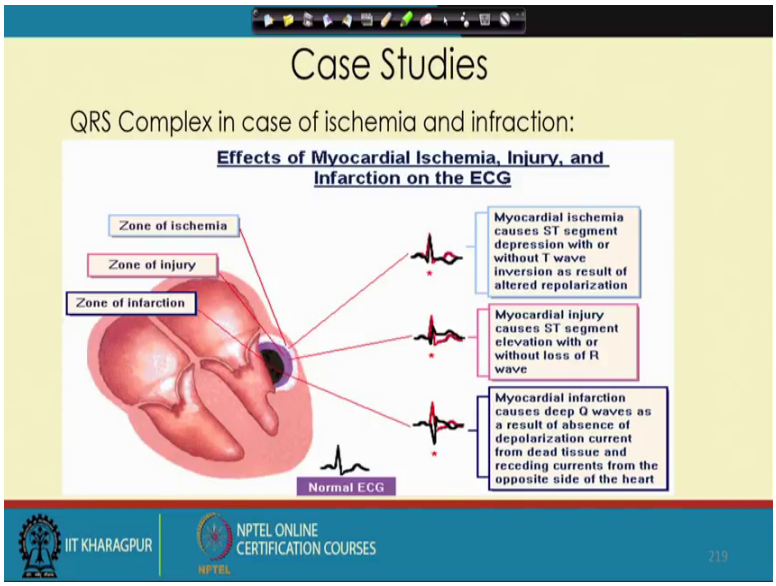

No here we see that effect more clearly with the help of an animation. So, you can see the first part that it was when it was normal, we have the normal ECG and then slowly the changes are happening that the first stage is a myocardial infarction that causes a deep in Q wave and as you can see that S T segment also is getting affected and then as it gets healed.

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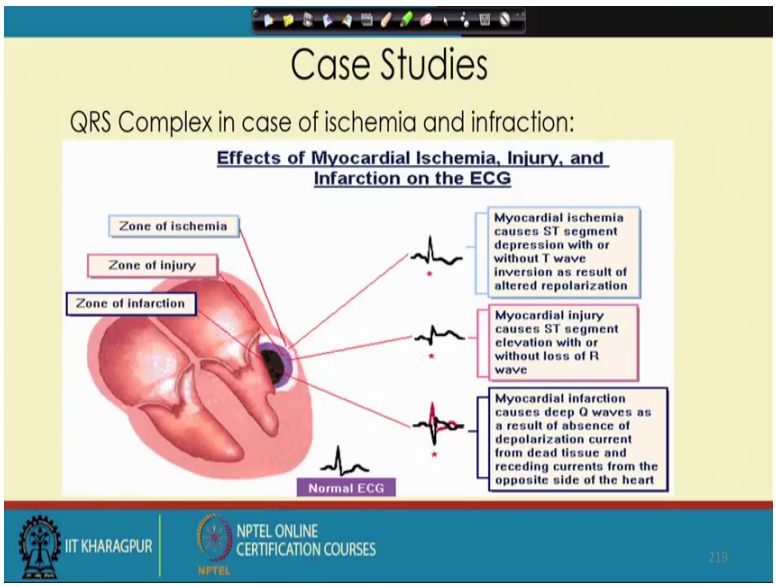

Then again there is a change in the S T segment. So, first the infraction is happening then the zone of injury that we get that there is a change in the S T segment and some of them

they are dying. And once they die again pm our ECG signal it gets back to the original form.

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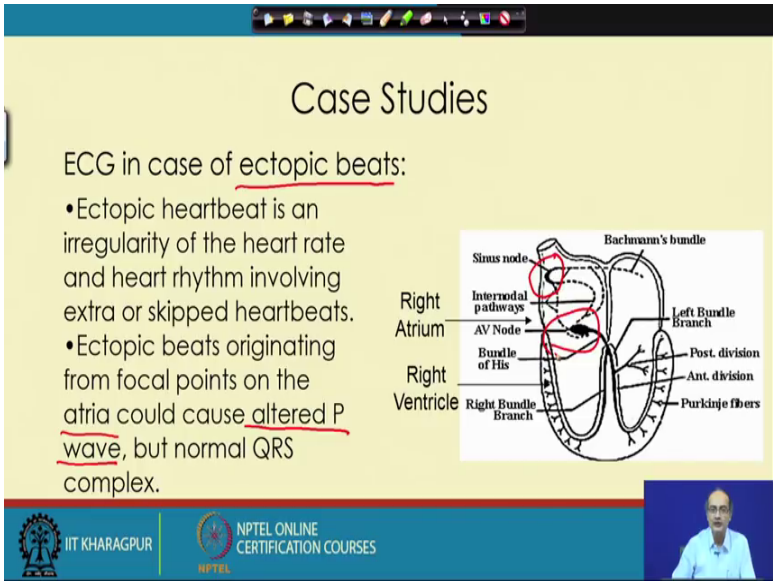

So, that is the thing is shown by this actually animation; now we go for another challenge which is similar to t the other one which brings a change; however, the change is more here in this case that we have already told that when we have the; heart is beating which should beat so, long we are alive that here the lead is taken by the SA node.

So, we can tell it is like a that lead singer or a that the master in the orchestra; now that sinus node actually is not alone in this business though it is the strongest one and the first one to give that signal, there are many other nodes nearby which actually that joins in the process and generates that signal to give it enough strength so, that it spreads throughout the heart.

Now, if due to some abnormality they lose actually the sanity and lose the synchronism with the sinus the node; then the problem occurs. If they give the signal before SA node or much after they SA node; we are getting actually multiple signals instead of a single signal we are getting multiple triggers and that gives rise to spurious; actually the peaks in the ECG and spurious actually contractions are happening and that is what we call as a ectopic beats.

So, here the main thing is that when we have that the SA node and the supporting nodes; they are not in synchronism. Either we are getting instead of a single bit multiple actually inputs or sometimes the SA node signal is becoming weak. And that beat is missed all together, in both the case we have problem not only in the ECG signal it will affect the performance of the heart. Because if it is skipped then we miss actually a beat beating or a cycle, the heart is not pumping for a cycle. If it is a extra beat, then what will happen? The activity that is going on each one of them has some time measure to complete it part.

But if it cannot complete its part in between another signal comes; their job is not completed and the efficiency of the heart will go down; that will affect the supply of the blood throughout the body. Now if this ectopic beat, if it is originated near the focal point that is the in the atria, it would actually alter the P wave. But fortunately that as we have the AV node which erase the signal; the amount of delay the AV node will actually introduced by the time both the that real and the that extra beat both will pass through.

So, AV node is intelligent enough to suppress that extra node and it will pass only one actually excitation to the ventricles. So, ventricular wave or the QRS complex is not effected, but P wave will be affected because there is no such filtering mechanism before; it is getting the signal directly from the SA node and the other nodes. So, in case of skipped actually beats will means that P wave and in that case all the QRS wave also and if the extra bit comes then the one P wave will be followed by another P wave and we will get a jagged kind of wave form; we will get extra beats in that case.

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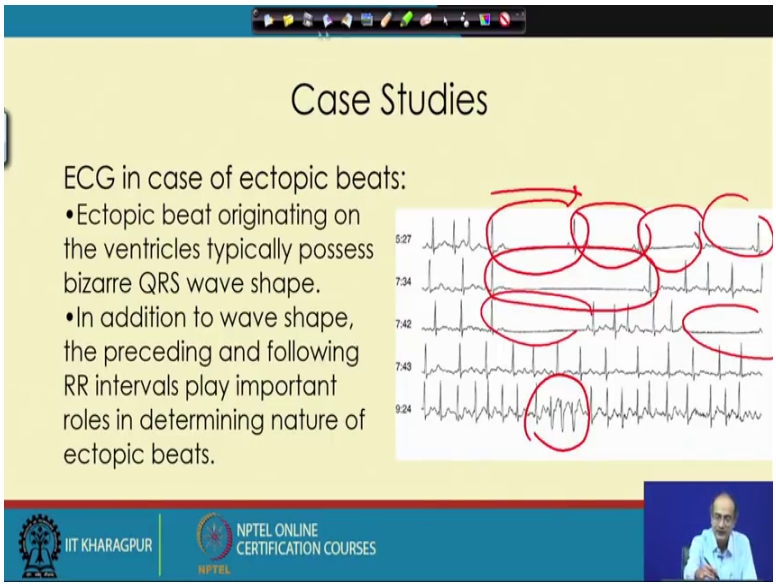

So, let us see that how they look like. So, first we see that for a patient over the time that how the waveform is changing in the right hand side that 527, 734. So, at different instants, we are getting that in this case that ectopic beats, they are originated that in different parts.

The ectopic beats originating on the ventricles actually modifies the QRS complex also and that along with that as the QRS complex is affected, what we have that RR interval also gets affected by that. And in this typical case for this particular subject what we see that sometimes that the beats are missed, we get that this region; for this first wave again beats are missed in between.

So, in between lots of beats are missing; 734 situation has improved, but again a longer actually number of beats are missed 720 also it is getting missed. So, these are I think happened that this bit kind of cases and below it is having ventricular actually ectopic beat. So, we get QRS complex has got reversed; so, that different kind of thing is happening at different moment and we can see that from the ECG actually waveform

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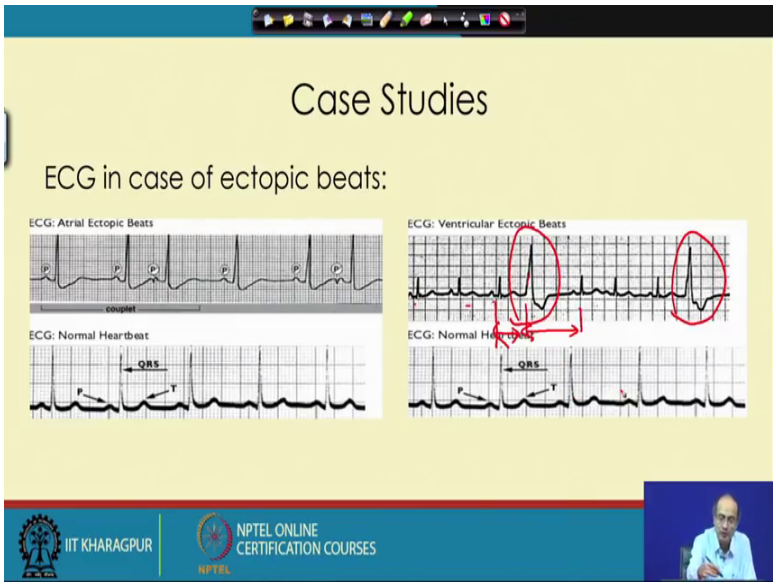

Here we show that more clearly in the left hand side, we are showing the ECG that atrial ectopic beats first that we see that here that sometimes that in a below that we are seeing a normal one; we have the RR interval, we see the first thing we notice that it is more or less uniform the changes are variations are very less and the same signal waveform is repeated; that means, in the waveform shape there is less change.

On the other hand that in the top when we see that time to time we are getting an extra bit. So, here that after the first wave; it seems to be normal then we have a P wave QRS and before it complete it could complete the T wave that is another actually the signal is cominga P wave is generated disrupting the T and again a QRS complex we are getting that is why the gap between these two RR interval is becoming smaller.

The normal gap was like this see that the previous one previous cycle compared to that suddenly we are getting an extra bit. Again, it is becoming normal, again normal then again at the time of the T wave; a P wave is again coming and extra bit is causing actually that change in the P wave; the P wave is modified and we have the RR interval has become short. So, this is the example of actually a ectopic beat it is originated at the that the atrium. So, that is affecting the P wave and the RR interval.

The second one is ventricular ectopic beat below is the normal that wave; this is a normal wave and again we see that we can clearly get P, Q, R, S, T and RR interval remains to be uniform. Whereas, in the top we see that we have very small magnitude of that QRS

may be we you need to adjust the scaling to capture the whole signal so, that it does not go into the saturation.

And this is showing actually the plot in that roll of paper on which that ECG is traditionally that captured. So, to keep it within the bandwidth the scale I think is reduced and we see suddenly going here we get a huge peak; T wave has reversed.

Again there is a huge peak; so, what it suggests? That there is something special happening; a extra actually beat has come and if you look at these complexes, their width have also increased. So, width has also increased that T wave is getting affected. So, these are the examples of actually ventricular ectopic beat and such kind of changes will also create problem in the detection of the R wave.

And thereby the RR interval calculation also will get affected. In fact, if you look more carefully you see that the difference between the RR wave here and the previous one see they are very different. Then normal that the time difference was there between 2 RS or a RR interval, here it has become short here this is a untimely one signal has come and we get this ectopic beat and which is coming with waveform. And also shortening the previous that RR interval and increasing the next one and creating the problem for the whole actually the signal.

So, with this we complete that the case studies and in the next session, we will start with the techniques to take care of them.

Thank you.