Course: Electrophysiology of Heart

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Lecture 19: Autonomic Function Tests-1

Hello everyone. So, today we will start our next topic that is Autonomic Functions. So, Autonomic Function Test. Now, Autonomic Function Test in today's lecture we will discuss about the basic non-invasive Autonomic Function Test available. So, Autonomic Function Test there are several assessments by which we can assess or perform the Cardiac Autonomic Function Test. And these Autonomic Function Test depends on which neurotransmitters we want to check or which pathway we want to check or which fibers we want to check whether we want to check sympathetic fibers or whether we want to check parasympathetic fibers.

Now, the domains are different, but the non-invasive Autonomic Function Test which we usually use that is heart rate variability from the ECG recording, the 24 hour holter monitoring and the baroreflex sensitivity. This all usually measures our cardiac autonomic tone. The provocative test which we use provocative test means these are the actually stress test. These are nothing, but the card to assess the cardiac autonomic functions.

We put our body into some stress purposefully and stress means we are giving a stimulus. After giving the stimulus we are checking what is the autonomic reactivity going on in our body. How we check the autonomic reactivity by the response by the reflex mechanism our body is undergoing through and the response it is showing. And those responses are usually quantifiable. We quantify that responses and then we assess whether it is abnormal or normal.

So, the procedures which are used for evaluating autonomic reflexes are Valsalva manouvre, deep breathing techniques, Cold pressure test, the heart rest response to standing that is from lying to standing positions. Sometimes we also use the head tilt test also. The blood pressure response to sustained hand grip and the mental arithmetic stress

test or MAST. So, we will see this test one by one. These are the simple basic non-invasive test and before moving on to each test it is always advisable to perform the test in a group.

That means, by only assessing with one test or suppose Valsalva manouvre or cold pressure test or sustained hand grip. We just cannot conclude or give any conclusion to the autonomic functions in any person. Because the autonomic nervous system deals with several pathways. So, for that we need to run a battery of test in a person. And the individuals reactivity to different tests are also different.

So, it is always better to perform 3 to 4 test as a whole in a person and then conclude on the autonomic status or the autonomic tone cardiac autonomic tone in that person. So, all the test usually the physiological basis of all the test is usually the baroreflex pathway which we had already discussed. The baroreflex pathway consist of the main center that is the medulla. In the medulla we have the nucleus tractus solitarius and we have a depressor area we have the pressure area. The pressure area is usually the vasomotor area which usually stays tonically active and mainly the rostroventrolateral medulla and the depressor area is the caudoventrolateral medulla.

Now, the afferent inputs are usually from the glossopharyngeal nerve and the vagus nerve that is the tenth nerve. This afferent inputs are sensed by the special receptors which are present that is baroreceptors and the chemoreceptors this we had already discussed. They take the signals to the nucleus tractus solitarius of the medulla that is the center. And then from the nucleus tractus solitarius either depending on the signals the baroreflex mechanism occurs whether the pressure area gets activated or the depressor area gets activated. So, based on that signals come through the pressure area or depressor area or the cardiac inhibitory center or cardiac vagal center or the nucleus ambiguous which usually gives the signals through the parasympathetic pathway.

And the other peripheral pathways the through the sympathetic path the sympathetic fibers usually come from this pressure area or the depressor area. And finally, they give signals to the myocardium and the blood vessels whether to go for increased contractility or decreased contractility vasoconstriction or vasodilatations increased blood pressure or decreased blood pressure. Now, respiration is something which usually affects directly the vasomotor center or the because of the chemo trigger zone because of the chemoreceptors central chemoreceptors which are present in the medulla. And also there are higher centers like limbic centers and hypothalamus where several activities which go on that is a circadian rhythm they also affect this baroreflex pathways they have also significant influence over this baroreflex pathway. So, based on this whole scenario we have different types of test the hand grip test the cold pressure test generally the

sympathetic domain is tested over here because there is a higher center which also acts in this case.

The deep breathing test usually acts for the respiration and the valsalva monover and we have the lying to standing test they usually stress on the parasympathetic domain usually. Now, coming to the valsalva monover the protocol of this monover is the this test is usually done in a sitting position. The patient is asked to blow into a mouth piece that is the forced expiration is done. Now, this forced expiration is done into the mouth piece which is attached to a sphygmomanometer or blood pressure recording apparatus. Now, any expiratory pressure the expiratory pressure is usually kept at 40 millimeter of mercury for 15 seconds.

And a small air leak in the system can be there to prevent the closure of the glottis during the monover because valsalva monover is nothing but forced expiration against the closed glottis. Now, till 15 seconds we are maintaining the pressure at the end of the 15 seconds we will release the pressure. Due care is taken in between you should not take the deep breathing the ECG and the stethography the respiratory recording is also going on. So, the stethography of the stethogram is also recorded for 1 minute to get the base baseline values. And then the continuous recording is done during the monover 30 to 45 seconds also post recovery that is following release the release of the respiratory strain.

Now, the stimulus here is the forced expiration through the closed glottis this is that is the stimulation we are blowing into the mouth piece that is the forced expiration. The afferent receptors are the baroreceptors and of course, the afferent nerves that is the sinus nerve the glossopharyngeal nerve and the vagus nerve. The efferent here is the parasympathetic that is the cardiovascular and the cholinergic nerve fibers as well as the sympathetic nerve fibers. The response we see is the depicted usually in the 4 phases. Now, valsalva monover comprises usually an abrupt rise in the intrathoracic pressure there is a transient elevation of the intrathoracic pressure as well as the intra abdominal pressure which is usually seen or which is usually done provoked by the straining.

Because we are giving forced expiration through the closed glottis. So, it is sort of mechanical event which is going on. Now, because of that there is also other phases which is going on which is obtained as the response. So, we will see the 4 phases in the valsalva monover. Now this is the mean arterial pressure which is usually recorded and this is the heart rate changes we are getting.

So, the mean arterial pressure you can see this is the 15 seconds of the strain we are which we are keeping. So, this is the phase 1, this is phase 2, this is phase 3, this is phase

4. In the phase 1 we can see there is a transient increase in the blood pressure. Now, what we will do we will just correlate the blood pressure recordings the mean arterial pressure recording with the heart rate recording. So, when there is a transient increase in the blood pressure we can see there is decrease in the heart rate that is all about the phase 1.

Now, this transient increase in the blood pressure is because of the mechanical event because of the straining process of the forced expiration which we had done which is followed by the phase 2. Now, in phase 2 what we can see there is a fall in the blood pressure and this fall in the blood pressure is correlated with the increase in the heart rate which is seen in the phase 2. Now, this fall in the blood pressure is mainly because of the increased intrathoracic pressure and the increased intra abdominal pressure during the valsalva monover. This increase intrathoracic pressure has lead to decreased venous return. This decreased venous return has lead to the decrease in the stroke volume and the cardiac output and hence the blood pressure decreases in the phase 2.

Now, in the later part of the phase 2 there is a slight increase in the blood pressure. Now, this slight increase in the blood pressure is because of the baroreflex mechanisms the baroreceptors which are not sensing the change in the blood pressure. So, the vasomotor center is getting activated and so there is increase in the blood pressure which is happening in the later phase of the phase 2. Coming to the phase 3 where we have released the strain. Now, this is also a mechanical event which is occurring.

So, because of the release of the strain again we get a decrease in the blood pressure which is accompanied with the increase in the heart rate. And finally, phase 4 where we see rise in the blood pressure because there is no strain there is no ah increased intrathoracic pressure. So, the venous return has normalized. So, there is increased in the mean arterial pressure and the heart rate is decreased. So, this is all about the 4 phases of the valsalva monovar.

The physiological basis of the valsalva monovar I had already discussed the intrathoracic pressure, increased intrathoracic pressure is giving rise to the decreased venous return, decreased stroke volume, decreased cardiac output and hence the decreased baro ah decrease the blood pressure. Because of the decreased blood pressure there is no stimulation of the baroreceptors there is no firing from the baroreceptors. So, the vasomostor center is active. So, there is no inhibition of the pressure area there is no inhibition on the constriction. So, there is increased sympathetic outflow and also there is decreased inhibition on the cardiac inhibitory center.

So, there is decreased vagal outflow or the vagal withdrawal is occurring which is causing the increased heart rate, increased contractility, increased vasoconstriction and

increased blood pressure or rise in the mean arterial pressure. Now, what we check for this ah valsalva monovar is the valsalva ratio. We check for the longest RR interval during the phase 4 that means, when the ah when the strain is already released and the shortest RR interval during the phase 2. That means, longest RR interval in phase 4 divided by shortest RR interval in phase 2 will give the valsalva ratio which usually lies or which usually is more than equal to 1.

21. So, this is the normal valsalva ratio which we get. Now, if the person is not able to ah do this test you have to instruct the person properly how to do and repeat the test if it is not been done properly. Now, coming to the next test that is hand grip test. Now, in the hand grip test first we record the basal blood pressure. Then we instruct the ah subject to hold the to give a maximum grip on the hand grip dynamometer.

We use an instrument over here that is hand grip dynamometer where we usually perform the isometric exercises isometric exercises. So, we ask the subject to grip maximally with maximum force with their dominant hand for a few seconds. Now, the value of this maximum ah grip is noted in terms of maximum voluntary contraction. We take three recordings we ask the subject to do three times and then we go for the maximum recording. The maximum value of this recording gives the maximum voluntary contraction.

We note the value then we change this or we bring down this value to the 30 percent. That means, we take 30 percent of the maximum voluntary contraction. Then we ask the subject to maintain this 30 percent maximum of the maximum voluntary contraction for 4 minutes. If he or she is able to do for 4 minutes is well and good if he is not able to do then he should ah indicate that to the investigator. So, after the subject has started the contraction the blood pressure is measured anytime just before the release of the grip.

And again the reading is taken 2 minutes after the release of the grip this is nothing, but the post recovery we want to see. For every autonomic function test it is not that we will only take the recording before the test and during the test. We have to take the recording a post test that means, what is happening ah 2 to 3 minutes after the test. We need to see whether the ah the body has come back to normal from the stressful situation. If the body is not able to coming back to the normal from the stressful situation that means, there is some ah sympatho vagal imbalance in the body present.

So, the stimulus here is the isometric exercise which we are asking to do we are asking the ah subject to take the maximum grip. The afferents over here are both the myelinated as well as the unmyelinated fibres which are ah from the muscles. The efferent over here is the adrenergic system the sympathetic domain the sympathetic fibres. Valsalva

monover takes into account both sympathetic as well as parasympathetic domain, but hand grip test usually take the sympathetic domain because the isometric exercise is usually associated with the sympathetic outflow. And the response over here is rise in the diastolic blood pressure with increase in the heart rate.

So, calculation we do we have to check for the reactivity or the stress reactivity or the cardiac autonomic reactivity. So, we check for the delta that is means reactivity autonomic reactivity that is the highest ah diastolic blood pressure during the test minus baseline diastolic blood pressure. So, the normal values ah that is more than usually there is increase in the diastolic blood pressure which is normal. And this happens more than or equal to 16 millimetre of mercury. If this increase in the ah diastolic blood pressure occurs within 11 to 15 millimetre of mercury there is a borderline dysfunction.

If it is occurs ah below 10 millimetre of mercury that is abnormal. So, this is below or equal to 10 millimetre of mercury this is abnormal. So, these are the normal values you have to remember in case of ah isometric hand grip test. Now, why this is happening the physiological basis is the voluntary muscle activities as I told you that is associated with the sympathetic outflow to the cardiovascular system which is causing the increase in the heart rate and hence the blood pressure. As well as the diastolic blood pressure is increased because of the accumulation of various metabolites.

Since we are doing isometric exercise because of this enhanced exercise activity there is accumulation of various metabolites which is causing the sustained sympathetic activity. So, this is causing the rise in the diastolic blood pressure mainly. So, this is all about your hand grip test. Now, we come to the cold pressure test. In cold pressure test again the first initial the BP recording is taken the subject is instructed that if he is not able to keep his hand in water ah for 1 minute he should indicate that to the ah investigator.

Now, in hand in cold water means the temperature of the cold water should be in between 4 to 8 degree centigrade. In some part of the articles ah literature it is given ah that it should be kept at 4 degree centigrade. In other literature it is given it is it should be kept at 10 degree centigrade by conventionally the institutes have made their own way. But based on the maximum literature what we have got the temperature should be in between 4 to 8 degree centigrade. The patient immerses the hand up to 1 minute if he is not able to do for 1 minute then he should say that before ah withdrawal of his hand.

The blood pressure is taken just before the hand is taken out. Now, this is that is why ah the investigator should know when the person is taking out his hand because we need to record the blood pressure just before the person is taking out the hand. Conventionally if we if we go we have to take it at the end of the 1 minute. The blood pressure is again

taken at 1.5 minute means post recovery and 4 minute after the hand is withdrawn from the cold water.

Here the stimulus is immersion of the hand in the cold water. The afferent here is the nociceptors if you are some ah and the temperature pathways. Now, the person dipping ah his hand in the cold water of 4 to 8 degree centigrade he might not be able to keep it for 1 minute because of the pain pathway or the nociceptive stimulation. So, the afferents are the nociceptive and the cold receptors pain and the temperature pathways mainly the spinothalamic pathways. The efferent here is again sympathetic or adrenergic the response is rise in the blood pressure.

So, calculation the reactivity also we check here by ah subtracting the highest diastolic blood pressure during the test from the baseline diastolic blood pressure. Increase in the diastolic blood pressure more than 10 millimeter of mercury is usually considered to be normal anything below that is considered to be abnormal. The physiological ah basis is ah already I had told that the cold water will cause the stimulation of the nociceptors. And the signals of this nociceptors will be taken by the spinothalamic pathway to the somatosensory area of our brain. And while ah travelling this gives ah the output to the hypothalamus the autonomic regulator the seat regulator which finally, cause the rise in the which will cause the sympathetic outflow in the heart and cause the increase in the pressure.

Next coming to the slow or deep breathing test in slow or deep breathing test the breathing should be smooth slow and deep. Most of us we have seen ah in the ah yogic breathing or the pranayama what we do that the breathing should be very slow and deep not fast. The investigator should ah give the hand signal to maintain the rate of breathing and timing of the breathing. Now, before performing the test the investigator should always train the person that how the breathing should be done. Otherwise if the cycles are not maintained the intervals are not maintained that the person has to repeat the test.

So, for ah 6 cycles we have to take ah per minute in 1 minute the 6 cycles of deep breathing has to be done. And each cycle should consist of an inspiratory phase and an expiratory phase. The inspiratory phase or the inspiration should last for 5 seconds the expiratory phase should last for 5 seconds. If you are taking inspiration deeply for 5 seconds you have to expire also deeply for 5 seconds.

So, that is the that will constitute your 1 cycle. So, baseline recording of ECG and with the stethogram that is the respiratory recording is taken for 30 seconds after the deep breathing is started the recording of the respiration and ECG is continued throughout the test. The stimulus is the regular and the ah deep breathing with 6 cycles or 6 breaths per

minute the afferents is the central ah obviously, the medulla. And the efferent we have the central ah that is the brain obviously, the CNS we are talking about. Efferent we have the parasympathetic domain that is the cardiovascular or the cholinergic pathways. And the response is again the increase in the heart rate this is all we ah see with the with the inspiration our heart rate increases with the expiration our heart rate decreases.

And increase in the heart rate with the inspiration and decrease in the heart rate with expiration this is nothing, but the physiological sinus arrhythmia. The calculations what we are supposed to do when we check with this the shortest RR interval are when we are taking ah inspiration or when we are taking the deep breath the heart rate increases. When the heart rate will increase which means the RR interval will get decreased. So, that is why you get short RR interval during the inspiration the opposite occurs during the expiration at that time the heart rate in ah decreases.

So, we get the long or the large RR intervals. So, the e is to 1 ratio what we have to take is the ratio of the longest RR interval and the ratio of the ah shortest ratio of the longest RR interval to the shortest RR interval which is average during the 6 cycles. And delta HR the heart rate if we want to ah consider the difference between the maximal and the minimal heart rate during the inspiration and the expiration taken respectively for the 6 cycles. The normal values more than 15 ah the the heart rate more than 15 beats per minute getting increased is normal less than that is abnormal these 2 1 ratio more than equal to 1.21 is considered to be normal. The next is the lying to standing test ah or the the same principle is generally seen in the head tilt position also.

The protocol is patient is instructed about the test that the test will be conducted ah after the 10 minutes of supine rest. And during the rest the basal values of the ECG recording and the blood pressure recording should be taken. He is told to attend the standing posture within 3 seconds that means, 1 2 3 with this 3 counting the patient the patient or the subject should ah stand from lying position. If the if the person is lying down I will count 1 2 3 within this 3 count the patient should stand. And within this 3 count only you have to take the blood pressure and the heart rate recording already you have taken at the base line.

Then you have to take at the 0.5 or 0.5 second then first second and second then 2.5 then fifth minute. Now, even if you do not take the recordings in so many ah ah seconds or the so many minutes what is important is at least you have to take it for ah ah at 0.

5 0.5 minute. Then you have to take it for first then you have to take and ah take for fifth that means, during the test before the test you anyway you are taking the recordings during the test and post recovery you are taking. Now, why 0.5 and 1 is important

because ah that means, you are recording the blood pressure already when the person is ah ah getting up. Because the baroreceptors in our body act very fast within seconds they will act. So, if you could not record at that time you will be ah surely going to miss the diagnosis.

So, the stimulus is change of the posture from lying to standing position the afferent here is the baroreceptors and the cranial nerves ninth and tenth. The efferent here is both sympathetic and parasympathetic as we had seen in Valsalva monover. The response is nothing, but the baroreceptor reflex mechanism that is initially there will be increase in the heart rate followed by decrease in the heart rate and there will be fall in the blood pressure systolic blood pressure. So, the fall in the systolic blood pressure is 10 millimeter of mercury which is considered to be normal. 10 11 to 29 millimeter of mercury is definitely borderline and if the systolic blood pressure is falling more than 30 millimeter of mercury.

Then the person is having autonomic dysfunction or imbalance then it is considered to be abnormal. Now, this test should not be done with the person who is ah who is having severe orthostatic intolerance. In case of severe orthostatic intolerance usually the systolic blood pressure drops more than 35 millimeter of mercury more than 35 to 40 millimeter of mercury. So, in those persons and in case of pregnant women also ah where we generally see hemodynamic instability.

So, this test should not be done. The physiological basis of this test is the venous decreases mainly because of the pulling of the blood to the peripherals ah peripheral regions. That means, in the lower limb that results in the decrease in the blood pressure. And when there will be decrease in the blood pressure what will happen there will be no sensing of the baroreceptors. That means, there is decreased firing of the baroreceptors and that will finally, stimulate the vasomotor center and hence increase in the heart rate and increase in the blood pressure and cardiac contractility. Now, ah another important ah thing we have to remember is during hand grip test which usually ah signifying vice the sympathetic domain the change in the diastolic blood pressure is seen ah.

When the person is having a severe hypertension suffering from severe hypertension. That means, the blood pressure is more than 180 millimeter of mercury or the any person or any subject is suffering from coronary artery disease you are not supposed to take this test for this ah for that person. So, and in case of deep breathing test the main important ah precaution or the main important ah contraindication is if the person is having some acute respiratory ah infections then you are not supposed to take this test. So, these are the certain precautions or these are the certain conjunctivations of this autonomic function test. Otherwise the parameter we measure in deep breathing test is delta heart

rate the valsalva monovar we check for the valsalva ratio.

The hand grip test change in the diastolic blood pressure then line to standing test or head test usually the fall in the systolic pressure. The other test which I also mentioned is of mental arithmetic stress test usually we give a mental arithmetic task to the subject. And before the task we record the baseline values we are measuring the ECG we are measuring the blood pressure. During the test we measure the same parameters and post recovery that means, after the test we ah measure the same parameter that that is the blood pressure and the ECG. Now, the test usually in mental arithmetic stress ah task what we give we ask ah the person to suppose subtract ah 3 from 100 in a continuous fashion.

That means, if you if I have been given this task I will do 100 minus 397, 97 minus 394, 94 minus 391, 91 minus 388. So, in this way I will ah give on I will be doing this calculations mentally ah till the investigator ask me to stop and obviously, the parameters the hemodynamic parameters are measured. So, in this way also the autonomic function test ah these are ah tested. So, these are the ah summary of the autonomic function test these are the references from where ah ah today's lecture is taken and so, we conclude today's lecture. Thank you.