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Starting With VEMP: The Fastest Way to Level-Up Your Vestibular Clinic

Presenter: Jay Jindal, AuD

Good evening everyone and welcome to a new session of the Inventis Academia Webinar series. First of all, thank you all for joining us live today. It is a great pleasure to introduce our speaker, Dr. Jay Jindal Aude. Dr. Jay Jindal is a renowned audiologist with nearly two decades of experience and the founder and CEO of Audiology Planet, a leading UK based audiology organization active in clinical care, education and training. So Dr. Jindal, thank you very much for accepting Academia's invitation.

Today's webinar is titled Starting with vemp, the fastest way to level up your vestibular clinic. In this session, Dr. Jindal will discuss the clinical value of VEMP, its role within the ENG, VHEAT and VNG battery, the most relevant protocols, and how to integrate cervical vamp and ocular vamp into routine clinical practice in a practical and effective way. Before we begin, I would like to remind everyone that you are welcome to submit your questions in the chat during the webinar. We will address them at the end of the session if time allows, of course. I would also kindly invite you to complete the short survey you will receive after the event.

You keep in mind that your figment is extremely important to us. And now, without taking any more of your time, I'm pleased to hand over to Dr. Jay Jindal. Enjoy the session, thank you so much and see you later. Thank you Anna and thank you Inventus for inviting me to this wonderful session. Hopefully it will be wonderful.

My name is Jindal and I'm a small time audiologist in Ukraine. I think Anna is very good in bigging me up every time I talk for Inventus, but because I'm invited more than once, I have some confidence that she means some of it when she says it. Anyhow, without further ado, we are going to dwell into how to start with vestibular evoke myogenic potentials and level up your vestibular clinic.

We're going to discuss some of the WAMP fundamentals. I'm going to spend a particular amount of time on EMG scaling whether to normalize or not normalize, which seems to be the holy grail of WAMP recordings. Basically, we are going to discuss the clinical value of wamps. We will discuss the protocols

that you can use within your clinic and some of the applications that you have in your clinic with the WAMP and the workflow. Many of the work that I've included in this is generated by AI.

Just a disclaimer for you. Please do not copy or distribute. It's strictly for educational purposes. I would like to start with the history of the human electrophysiology testing because I think if you know where you've come from, then you can plan where you're going with it. And it all makes a good narrative in the brain in order to retain the information as well.

First off, the electrophysiology is not new, as some of you will probably remember from your bachelor's study in audiology, etc. That about 100 years ago, Edgar Adrian, who actually got a Nobel Prize later on, he measured the single electrical discharge of a nerve fiber. Now imagine at that time with the analog technology how he managed to amplify this stimulus, how he managed to drive in the stimulus and amplify the response in order to get that physical valuable response, which led him to get the Nobel Prize. Huge achievement at the point. But the turning point in all this was the transistor.

Because before the transistors were invented, the researchers were using big vacuum tubes, etc. Whereas transistors replaced it with a smaller, more stable, less noisy apparatus which can be implemented clinically and in future. That became the norm for modern electronical circuits for electrophysiology. Now, I take the electrophysiology with a very simplistic view. I'm a simple man and you'll understand from the course of this presentation, if you haven't heard me before, that most of the ideas that I'll explain to you will be explained in a simple way.

So you know, I was one of my computer got busted recently and when I plugged it in, it wouldn't start at all. Now the first thing that I had to do is to open it up and find out where was it that the voltage wasn't reaching in that computer because the battery wasn't working, the charger wasn't charging. So I picked out my multi level meter. This is not mine, this is a photo from Internet. But I picked up my multi level meter and tried to understand whether the voltage was passing through the motherboard of the

computer or not.

And that very effortlessly reminded me that what we do within the electrophysiology testing is not very different from that. So be it. That we use a much more sophisticated amplifier to amplify those very, very low voltage points that the human nervous system will generate or human muscular system will generate, which is what we're going to talk about today. Also, we use a very refined technique these days to be able to get the response in a way that you can make it clinically useful. By end of the day, it is measuring voltage between the two points or the change in voltage between the two points to know whether a circuit is working or not.

That's basically what it is. What made it remarkably simpler and achievable is the signal averaging technique that started to develop from 47 onwards or 50, 1950s onwards. So first analog at that time signal leveraging concept came in when the researchers realized that if you repeat a stimulus and average the responses, so you know stimulus is usually time locked, so you measure it within a few milliseconds. When you average those responses and add them up, you can get a much more cleaner response and you can also reduce the noise which is generated by the bodily factors, the electrical factors around you and the machine factors that you're recording in and that gives you a utilizable response. It still was a monumentous task when we used to deal with the analog recordings.

So when things became more digital, that revolutionized in a way things in electrophysiology. And in fact the clinical auditory electrophysiology was born possibly in 70s when the first ABRs were recorded by Jewett and Williston. The paper is still present on PubMed. You can see the reference here where some of the first auditory brainstem responses were recorded. Now we've known that the auditory system, and the vestibular system in particular will respond to sounds.

We have known through the work of Petrio Tullio, who is nominated for the Nobel Prize as well, and we've known through the work of Paki, who first reported vestibular response to sound, that we will be

able to invoke these responses through the vestibular stimuli as well. And one of them we use in clinical practice today, which I will be talking about the signal averaging technique, the technique of recording the response, representing the response got further refined with the commercial systems. Vemp emerged within 90s to 2000 sort of way. And then from 2000 onward the signal averaging technique became even smarter. With particular reference to vemp.

There was EMG recording and scaling in introduced were in the commercial apparatus like the one that Inventis has Celesta, which is a beautiful machine. One One thing I have to say about Inventus is everything that they make looks beautiful. It works wonderfully well as well. But the cosmetics are really appealing in the Inventus equipment.

But lo and behold it was the transistors who made which made the low noise amplification possible, which enabled signal averaging, which made evoke potential clinically usable. That's the punchline for this slide. Now I'll briefly explain you how I Think about the vestibular system. Whether I'm talking to a patient or whether I'm thinking about the vestibular system in terms of reading and research, I think of vestibular system as a very specific and well engineered gyroscope, particularly when it comes to the semicircular canal system. You've got these three semicircular canals in three different directions.

And every time you move your head in a certain way, those canals will respond to the mechanical movement of the head, where an electrical signal is generated for the brain to know that the head is moving. So that the brain can put the eyes where the head is going to, right? One ear works in symmetry with the other ear so that when you move your head, the difference in the angular movement of one year with respect to the other ear will tell the brain that, okay, the difference is so much so the eyes have to be here. And if the difference is that much, the eyes have to be here. When that difference gets muddled up either through the vestibular neuronitis kind of problem or any other vestibular weakness, then the brain doesn't know where the eye should go.

So you move your head. The difference, the brain doesn't know where the eye should be, so it puts it where it thinks it would be and everything else tells it, no, you idiot, I should be here. So they go back and forth, which your patients will describe as the vertigo. That's one part of the vestibular system which we traditionally measure through calorics, which happen to be the gold standard in the vestibular measurements and have been for a long time. But remember, the calorics will only measure a very, very low frequency.

The type of frequency which the type 2 afferent neurons will respond to between 0.002 Hz to 0.004 Hz, which is so low that it's hardly possible to make it clinically within the if you are trying to demonstrate it to someone. Then comes the rotational chair which measures the middle frequencies. So from 0.001 to about 1 hertz. So you move the head one per second. And that's the sort of information that you get from rotary chair where both the type 1 and type 2 neurons will respond to whereas video head impulse test, which is the latest addition and a wonderful addition to the vestibular testing will measure much higher frequency.

So 2-5-hz sort of things. And that's why you have to move the head reasonably quick in order to get responses from the video head impulse test. I Guess if you were to think about the spectrum of frequencies that we are testing through these tests. Video head impulse test is testing the frequencies which are most commonly performed movements in the day to day world. And therefore when somebody has a vestibular insert, the first compensation happens in the higher frequency range because the patient is made to make those movements, the person is made to make those movements in everyday life and the brain is compensating every time those movements are made.

In my practice I see that if I see someone within the first three to six months of the vestibular weakness episode, I'll be able to get those catch up saccades and abnormal responses on vhit. And after that the VHIT becomes perfectly normal for most people, even when physiotherapy regime is not followed,

which has its own consequences by the way later on. And I'll allude to that in another slide towards the end of the presentation. But that's what happens. The other part of the vestibular system is usually the blind spot for most of the practices who are not performing the vestibular evoke myogenic potentials.

If we want to know about the autolith health. So remember, otolith organ is for linear acceleration sensing. So if you move your head, the angular acceleration is sensed by the semicircular canal system, whereas if you move your body, where your head goes with the body because it happens to be attached to the body, whether in the horizontal direction or in the vertical direction, as if you're on a lift or escalators or going up and down the stairs, etc. That is a function of the autolent system to tell the brain where the head is in the space. Because brain needs to know all the time where the head is so that the gaze can be stabilized, the posture and gait can be stabilized and the the body can be balanced on two feet, which if you think about it, quite a hard job.

Because I remember very vividly sitting in India in my little room, just having done my GCSE level exams there, where I read a news that Honda made a robot make two steps upstairs after they first made that robot about 20 years ago or so. So it took about 20 years of research and it became such a global news when a robot took two steps that I sitting in a small town in India was reading that news on the national, in the national newspaper. This happened in Japan, by the way. Now imagine a human child who starts walking between sort of 8 months to 15 months of age, much faster than that robot that Honda made. And Much more efficiently balancing the system which is possible because of the intricacies of the vestibular system, along with visual and proprioception, of course.

So human body is marvel of complex engineering and the more you read about it, more you understand the working order, more you marvel on it. Anyhow, there are three reflexes in the main that we think about in the vestibular domain. One of them is vestibular ocular reflex, the gaze stabilization mechanism which is the main purpose of or one of the main purposes of vestibular apparatus. The

vestibular spinal reflex is another reflex which happens within the vestibular system which maintains the posture and gait. Vestibulocolic reflex maintains the head stability.

Vestibulocolic reflex is a reflex which we use to stabilize the head in the space through the otolith mechanism and some other mechanisms involved in the central vestibular nervous system. And this is one of the mechanisms which drives some of the vestibular testing that we are going to do after this webinar in the clinics on Monday morning.

I found it really interesting in Jacobson and Shepherd where they've mentioned some of the other autolith function testing that you can do in clinic or you could do in the clinic research models. There's very interesting explanation of how these experiments were done. If anybody is interested, I highly recommend that you go through the books vestibular section and have a look at these experiments. As I said, in terms of measuring the semicircular canal system or the angular acceleration sensing system, we are using mainly the calorics and vhit. I hope everyone is using at least the and to be able to measure the autolith system.

We get some idea from the CVEMP and OVAMP now, although I put that it gives you information about secular pathways in terms of in the case of CVEMP and utricular pathways in in the case of OVamp, but it's not as clean and clear cut. So there's some research which will suggest that there are several different pathways involved in both of them. But particularly in the case of the OVamp, when an OVamp response is generated, it's more like any other electrophysiological testing that we do really. If you think about the abr, although it's five different peaks in the abr, we used to think that they come from very specific areas in the brain. But now with a newer knowledge and some of the not so new knowledge, we understand that the contribution to each of those comes from several different areas of the brain, rather than just one singular area.

But lo and behold, cvep, which is probably more robustly giving information about the saccule, is one of the main tests for the saccular function. And OVAMP does have a lot of information contributed to it by utricular health as well. Okay, so you can. So basically, when we think about the vamp response, we are not really measuring the vestibular voltage. Vamp is the voltage of the muscular energy that's happening within a muscle in the head and neck.

In case of the vamp generated in the response generated in the SEM muscle, which is a cervical muscle. We are measuring the change of the voltage within the sternocleidomastoid muscle. Now, that voltage is a function of how the secule is stimulated within the vestibular apparatus, because it turns out, as you stimulate the sacule, it tries to inhibit the function of that muscle so that the head can move freely as your body moves. That's the basic concept around it. So you stimulate the secule in one way, and stimulation of that circule will send a signal to the sternocleidomastoid muscle.

In the case of cervical wimp that we are trying to measure, and we measure the change in the activity of that muscle in order to get the idea about the health of the vestibular function or the secular function makes sense. We'll keep hammering on to that concept in a minute. But to be able to stimulate the saccule, we need a very high energy stimulus. That high energy can be provided by air conduction. So you can put an insert earphone in the ear and send sufficiently loud energy into the saccule.

The point to note here is that it doesn't matter whether the cochlear can hear that sound or not. So somebody could have a complete hearing loss or the partial damage in the cochlea. But as long as that stape is foot places thumping the fluid, it will still stimulate the secular hair cells, and they will in turn send the signal to the the scm, the sternocleidomastoid muscle, which we record in the form of the cbam. Okay, you can record that in the masseter muscle in the jaw as well, because it turns out as you move your head, you need to control the jaw position as well in a certain way. So my jaw is not dropping all the time.

It's upright. And there are certain changes which the gait, posture and balance, change of movement will dictate that you need to be able to control your head in a certain way, your gaze in a certain way, and your Jaw positioning in a certain way. So if it's to do with the neck position, while the change, which is a, which is the function of the saccule in vestibular organ, we measure it through the C vamp. If it's the gaze changes. So inferior oblique muscle in the eye, we measure it through the O bump.

If we want to measure the inhibition of the masseter or jaw muscle, we'll measure it through the masseter bump. So the idea is you stimulate the saccule enough with high energy and then measure the inhibition of the muscles or excitation of the muscle. And again, I'll go through it once again to clarify it further on this slide. We are trying to understand how to stimulate the saccule enough. Now we can send the air conduction signal, whether that's to the tone burst.

We usually use a low frequency tone burst, for example 500 Hz, or whether you use the bone conduction, where you use sufficiently high stimulus, probably about 70dB NHL at either 250Hz or 500Hz, which provides enough energy for the stapes to move enough to thump that fluid so that the circule can be stimulated. Okay, I hope I didn't convolute it too much.

The rate of stimulus, how many times the stimulus is reaching to the circulus? 5 Hz. So five times a second. You take in case of Cwamp cervical vamp, about 60 sweeps, in case of Ovamp, slightly more, perhaps 6200. If you are doing a bone conduction vamp with the bone conduction stimulus, you will need to take slightly more averages.

The response pattern is such that when you use the event, it's an ipsilateral response, whereas in case of oamp it crosses the midline. Therefore, the response will be contralateral that you're measuring on your screen. You can use it, you can use the air conduction for threshold estimation of what is the threshold of generation of vamp. There are lots of indications of how you can use an early and late onset Meniere's disease. You can use it for superior semicircular canal dehiscent screening as well.

And we'll go through those conditions. In the end, if there is a middle ear pathology, conductive loss is a really good way of killing the wemp. So you know, this relates to the transformer effect of the middle ear. So middle ear actually amplifies the sound for the cochlear because the sound is traveling from air conduction medium to the fluid medium. Therefore, the ear has a natural ability, the middle ear has a natural ability to amplify those sounds.

And if there is an attenuation to the sound because of problems in conductive pathway, then the vamp response gets affected because the stapes doesn't get enough energy to sump that fluid again. Okay, makes sense. Whereas if somebody has a conductive pathology, you can't use air conduction vamp, you will be able to use one conduction vamp, which is a really good way of differentiating whether somebody has a middle ear pathology or not as well. Because if you think about the superior semicircular canal dehiscence in that you will notice an inner ear conductive hearing loss on the audiogram which you shouldn't confuse with the middle ear conductive loss. And again, it will become more clear when I show you the diagram.

These are the standard considerations if you're using air conduction or bone conduction transducers. So the air conduction calibration is more standardized than then the bone conduction transducer. You know, depending on Whether you're using B71, B81, you can actually use a mastoid shaker as well.

I know, and I have the one that inventist does and that can produce the bond conduction mems too. As I said, the air conduction will be blocked completely by the conductive loss. Sometimes even a 5dB conductive loss is enough to block the air conduction bumped. So think about it. It's never really 5 decibels because we measure PTA in 5 decibels steps.

So what we call 5 DB could easily read 9 decibels conductive loss. And that's enough to cause that attenuation of the acoustic energy passing into the secu. Bone conduction obviously bypasses the

middle eases and therefore you can still make sure that enough energy is reaching to the sacube.

Air conduction is highly air specific, whereas bone conduction as there is almost zero interoral attenuation, it can simulate both ears. Comfort level is generally high with the air conduction, whereas bone conduction can be slightly uncomfortable as you need to be able to exert certain pressure for the calibration of the bone conduction to work around the head with the headband of the bone conduction, which is true for PTA as well. To be fair, these are some of the equipment specific parameters that Anna has kindly passed me on from Celesta, so you could have a look at them. You could take a screenshot if you like. But I'll just quickly explain to you that here we have a tone bus selected at 500Hz, which is a verifaction.

You can have a condensation polarity as well with a Blackman envelope. So the envelope of the signal indicates the rise and fall of the signal that you're using. Rise, plateau and fall. You can use three or four different monoliths. And it just so happens that this system recommends you use black one.

Here headphones are selected. I usually do vamps with insert earphones.

Stimulation rate is about 5 hertz. I usually use 5.1. That takes off some of the edges of some artifacts that can happen. EMG scaling. We'll talk about it in detail.

I usually don't use control rejection, so I let all the EMG activity come in and then I will make certain decisions about whether I want to use scaling or not. There are pros and cons for both the scaling method, which again I'll explain in second what it is, and the monitoring method. Those are the two methods where you could record what's happening within the muscle filters. So the filters are to remove the irrelevant noise basically and the audit. The electroacoustic filters are relevant to specific response that we are trying to measure.

So depending on the response characteristics you select those filters, it may be different for ABR, corticals, etc. Etc. Basically, the low pass filter lets frequencies higher than the one selected pass through and the high pass filter is the opposite of that.

So we want to remove all the low frequency drift, like movements and electrode drifts and breathing, etc. And we want to remove all the high frequency noise like electrical interference, EMG spikes, ambient noise, etc. And that's the criteria to apply the filters as low pass and high pass in any electrophysiology testing. Here we are using about 10 to 30 hertz of the high pass filter and about 1000 to 2000 hertz, 1000 to 1500 hertz. I would say in most of the researches that I've seen, these are similar sort of parameters for OVAM here.

OVamp response is usually smaller than the CWAMP response, which is a larger response. So CWAMP response doesn't usually need artifact rejection. Whereas OV tends to show better results if you use the artifact rejection as well at the same time. So it takes out extraneous noise which, which will sort of extend the time of the test a little bit as it's a small response and it's a smaller contraction of the muscle as well. We don't really need to control the emg.

And this one you can do if you wanted to, but I'm not sure how beneficial that will be. Similar sort of high pass and low pass filters will be appropriate for ovamp as well. Now, let's talk about the cwamp and let's talk about the sternocleidomastoid muscle, because that probably is one of the major things when you're trying to understand why you should do vamp and why they function and why you get the response as well from the system. So this SEM muscle, as we call, we call it, it's one of the largest muscle in the human neck. It connects the base of the mastoid with the clavicular bone.

Now, every muscle in the body, you will remember from your physiology lectures, perhaps has a baseline activity. That baseline activity is rather small. But if you contract that muscle, that baseline activity becomes bigger. And it just so happened the secular response to sound will reduce the activity

in the sternocleidomastoid muscle. And when you measure them, you're actually measuring that reduction in the activity.

So imagine now there is a baseline activity. You produce the sound. That baseline activity, even without the contraction, is still reducing. But it's not enough for us to clinically record anything. You know, I liken it to if you squeeze a dry sponge, you can't get any water out.

You need to wet the sponge and then you squeeze it and then you get the water out. And therefore what you want to do is increase the baseline activity to a level so that then when the secular function decreases that activity, we can record that voltage on the screen in the form of CVEMP response in the case of owamp is the excitation of that inferior oblique muscle that we are recording. In the case of cvemp, it's the inhibition of that activity in the muscle that we're recording. So in a very strange way, you could call it a CM vamp rather than a C vemp if you like. And the response that we're measuring is actually that reduction in that contraction of that muscle or the reduction in the potential of the contraction in that muscle, which shows up at that wiggly line on the screen as B13 and 23 response.

Okay, makes sense.

So this is how it will look. This cervical one comes from this muscle in the body. In fact, the placement of electrode on this muscle, it's very important too. You have to be able to place those electric electrodes symmetrically to be able to measure whether one secular function is more than the other or not. That's one of the pre requirements.

If they are placed unevenly, not at the same point on the muscle, then you are in a problem. The electrode too high or too low becomes an issue as well. So the general idea is that you put electrode just above the midline, laterally on the muscle. So just above the midline of the muscle, you can trace that muscle all the way down to the clavicular joint here. So you turn your head and you can run your

fingers along it.

This is about a 10 centimeter, 11 centimeter long muscle. And generally speaking, the midpoint is just at the level of the chin for most people. And if you put the electrode just above that, literally so as you turn it, it's still on, significantly on the just above the midpoint, you will get the best responses. You need to make sure that that's completely symmetrical with the other side. Either you measure it with your fingers, how many, how much distance away it is from the base of the mastoid, or you gaze it in terms of where the chin is and where it should be, or you measure it with a measuring tape.

It doesn't matter as long as it's symmetrical. If it's symmetrical, then you can compare one year's response with the other in a much better way. Right. That's the first requirement. The second requirement is that the, the level of contraction of that muscle has to be symmetrical on both sides.

That you do with that you do with either monitoring the level of contraction of that muscle, which you can do through the modern system. So now we have a traffic light system which will tell you whether there's enough contraction of the sternocleidomastoid muscle as you turn your head or not, you gaze that number and you show that to the patient that this is the number, this is the traffic light, green, orange, red that we've got. So, so, and as they turn on the other side, we want similar sort of muscle contraction so that we are measuring like, for like response. In the case of ovam, this is, by the way, a very old picture of mine when I was doing it through the BSA protocol. Now that has been, I believe, revoked some time ago.

And most people nowadays put the positive electrode just here where the inferior oblique muscle is diagonally just at the edge of the eye. And the negative electrode is put in the middle of the eyebrows. This is one way of doing it. And I've got a pretty robust response there, to be honest. So there's nothing wrong with this electrode arrangement, but it seems that for generalized population, it works better if the electrode is right next to the inferior oblique muscle as close to the eyes as possible, without really

Pinching the electrode in their eyes.

This picture I just put in to prove the point that with a dry sponge you can't squeeze any water out, therefore you can't measure the C meaningfully if the muscle is not contracted. You first increase the muscle activity by contracting it. The muscle activity increases and then you can note down how much the secular activity will decrease that activity. And once you do that, this response, which is, if you really think about it, a fast Fourier transition in real time of the frequency response that you're getting in that time domain. Okay, so this is a representation of how the voltage is changing as the secular is sending the inhibitory response to the SEM, and how it's changing as the peripherally utricle or the the over pathways are sending signal to the eye muscle to excite it in a certain way.

Okay, so that's the graphical representation of that change in voltage happening because of the excitation of the pathway and the inhibition of the pathway. That's all you're measuring, basically. Okay, let's talk about emg. To scale or not to scale? Scaling or normalizing.

The average or absolute value of pre stimulus EMG means that you divide it by the response amplitude. Okay, so you record the vampire, you record the bump, you measure the pre stimulus activity in the muscle and you divide this P1N1amplitude by the pre stimulus baseline EMG. That's how you normalize the response on both sides.

Whereas the other way of making sure you're measuring like for like is when you monitor the EMG in a steady window. So as you turn on the screen with Celesta and I know with Neuro Audio, with Eclipse, you'll see an EMG monitor which will give you a needle and a value of the a contraction, whether it's 50 microvolt, 100 microvolt, 70 microvolt, whatever, you note down that number and you aim for the similar sort of contraction of the muscle on the other side. So you're actively monitoring it. You can use blood pressure cough for it. If you don't have the traffic light system within your equipment, some people use a technique where the subject will lie in supine position and raise their head slightly.

So when they raise their head, it gives a symmetrical contraction to both sides of the muscle as well. So depending on how your equipment work and how you feel about it, all the monitoring can be achieved either manually or digitally through the system.

Here is an example that the contraction of the muscle is proportional to the response that you get. So the more that you turn your head and twist your head. The more pressure you put on SEM, the bigger the response. If you can see this, the response in the first trace, which is this one, the lower trace, P1, N1amplitude from the same year from the left ear is 82.2 microvolt. But the EMG activity there was only 63 microvolt.

And as I asked the patient to turn and twist the neck a little bit more, the EMG activity increased to 101.7 microvolt. And therefore the response had almost 110 points. Lead if you like, or it amplified by 110 times. Now, if I compare this with that, this is a definite asymmetry in the system if they're coming from two different years, right? And that's why what you do is you take the absolute amplitude and divide it by the average EMG activity, where you get a scale data which looks like this.

So the scaled amplitude for the bigger trace is 1.9 and for smaller trace is 1.3. So suddenly the difference becomes very little. Right? That's the idea of scaling. But it's not without its own problems.

There are researches which will tell that the normalization or scaling presupposes that a linear relationship exists between contraction and the response. So you contract it, and as much as you contract, the response will decrease or increase accordingly. But that may not be as clean as that. So if you look at this particular work that's presented in Canadian audiologists, basically all these points are the responses that the researchers have received. And as they are closer to this dashed line, that means the linearity is achieved.

And because they're further away, it's a nonlinear response, at least within the subjects of this particular study. So I guess to date it is unknown with a great clarity, whether normalization will work across the board. It may be that it works for the patients or people with normal secular function, but whether that's true for common vestibular pathologies as well or not, there are lots of doubts about that. And therefore, if you can monitor the activity of the muscle as you're doing the vamp, through the electronic monitor, or through blood pressure, cough, etc, or through the positioning of the patient in a certain way, that you're achieving equal contraction on both sides, that seems to me that it's a better way of recording the response. Whereas if you're normalizing it, you have to consider that there are times when the linear relationship may not exist.

The third, particularly in cases of pathologies, we are very unsure about it. So you may have to Be judicious, and you may have to make sure that you understand the difference between how EMG is monitored or scaled, and perhaps the best of both is what I did in the previous example where I was monitoring it at the same time as scaling it. Now, this one is an example just to show you, where I purposefully ask the patient to contract more during one recording and less during the other recording. But usually I would ask them to have the similar sort of contraction across repeated recordings. And then I will look at the scale values as well if I need to, particularly if the monitoring is not perfect.

And between those two, usually you'll get a better idea of the symmetry or asymmetry of the system, which is the whole idea. So maybe for normalization there's not enough data. However, the strongest recommendation that I can make on the basis of what I have seen is to control the level of EMG activation to reduce the misinterpretation, because the idea is that you're not just comparing the response with a population data, but you're comparing one year's response with the other year. Hope that makes sense. Some of the normal values which have been mentioned across literature are these.

Now you really have to look at the methodology of the research and whether they've used the scaling, scaled EMG tracing or normalized or monitored EMG tracing, etc. Particularly in case of CWAM, what's the technique that they used to contract the muscle before you can rely on any of this normative data? It's an interesting and useful starting point, but I would advise that all the clinics who are starting out vemp, they collect their own normative data, perhaps start with staff and family members, etc. Just collect 5 or 10 normative data, see how your data set fits with the prevailing research. And I've given you some more example here, which you can look at in your own time because you'll have access to this presentation.

So see which data set mimics your own normative data and perhaps you can look at their methodology and compare it with yours. And that probably will give you a better idea of what you should consider. Norm for your own clinic.

Here you have widely proposed neural pathways for both the CVEMP and OVAMP circular autolith system. The CVEMP measurement relies on the inferior vestibular nerve, vestibular nucleus, vestibular spinal tract and SEM muscle response, whereas the ovum pathway usually is considered to include utrical utricular system, superior vestibular nerve and vestibular nucleus, medial longitudinal fasciculus oculomotor muscle nerve pathway and contralateral inferior oblique muscle of the eye. Okay, straightforward.

We move on to the clinical pathologies. Now, one of the major uses where I think vamp got maximum attention was the condition known as superior canal dehiscence syndrome. You all know about it as qualified audiologists, but essentially the way that I think about it is that cochlear is like a double or triple glazed window. So once the glazing is. When the glazing is intact, the heat stays in, the sound stays out.

It's really sealed. But if there's a problem with the glazing, so if one layer of glazing doesn't work, or two layers of glazing don't work, then the heat will go out and sound will come in. So the system becomes more acoustically transparent than not. So a little bit of energy stimulates the system a lot more. And that's why when that happens, when there is a third window present in the cochlear bone, then the pressure leaks out.

The direct visual metaphor is probably akin to a high pressure shunt being present apart from those two membraneous windows at the level of staples and the round window. So that means that when we are trying to stimulate the saccule, we don't need as much of the energy that will need when the cochlea is completely closed or intact. Okay. So a little energy can send a lot more sound pressure into the secular system. So secular function will get activated, which will inhibit the SEM activity, which we'll be able to measure on our computer screen.

Which means that when somebody has that hole in the cochlea, the threshold at which we elicit the vamp will be reduced. So the usual thresholds will start from about 85, 80, 85 at least DBNHL, but most people will have them present at 95 to 100 DB NHL. In the case of the hole in the cochlea, you can stimulate the ear with energy in 70-75 db NHL of bone burst and you will still be able to get a massive response. So that's a telling sign that somebody might have problem with the intactness of the bone. In the cochlea, the amplitude of the responses are very large at if you look at the normal levels, 85 and 95 dB level.

And also there's at least one research which suggests that the hallmark or a telling sign of SED is that the vamps will present even on the higher frequencies. So usually the best frequency to obtain WAMP, particularly the AC WAMP, is 500 Hz. Whereas in SCD cases, VAMPs have been recorded with 4000 Hz frequency as well. Okay, remember with SED the some of the symptoms are that you hear your own voice loudly, autophony, you hear the internal sounds, sometimes even the eye blinks and eye

movements, heartbeat, footsteps, etc. It's very peculiar.

You have sound induced dizziness or tulio phenomenon or pressure induced dizziness. So sometimes during the tympanometry or acoustic reflex decay testing, you can see the nystagmus in the eyes, particularly if you put frenzel glasses and you feel off balance and steady. Remember, with any autolith problem, it's not the gyration issue, it's not the angular movement, it's actually the linear acceleration that gets affected. So you don't feel the rotatory vertigo, but what you feel is the balance symptoms which are related to more linear movements. Okay.

This is one of the cases that I saw a few months ago. 47 year old female. And as you can trace vamps down to 65 decibel, I usually combine these two traces together. In this case I didn't need to, but sometimes if there's more noise then it makes sense to just have one clean trace there. So that's the CVAMP for this person which went down to 65 dB.

And I also had a massive ovum. Now, curiously enough, she didn't have very low uncomfortable thresholds. Her uncomfortable thresholds were quite huge really for somebody with a massive wall in the cochlear in a year. And also look at the pure tone audiogram and the conductive loss as well that she presents with. Of course it was in presence of normal tympanometry and the telling sign.

So imagine that even before doing vemp. I was very suspicious about this left ear conductive loss because I happen to do acoustic reflexes on everyone.

So if there is a conductive loss, that will completely destroy the acoustic reflexes. In theory. But this person had a massive reflex present acoustic reflex present on tympanometry at 500 Hz, which is one of the most telling signs for me that there's something wrong with the inner ear rather than the middle ear. A middle ear pathology will not result in acoustic reflex. And sometimes SSCD will even mimic a hearing loss like you'll see in some of the advanced otosclerosis cases.

And again, the differentiation point within your audiological testing will be acoustic reflex testing because with otosclerosis always and always the acoustic reflexes will be absent. You cannot have acoustic reflexes with conductive Loss, whereas with SSCD you will usually have acoustic reflexes present as long as the inner hair cells are not affected in that ear, whether noise or whatever. But that's the discussion for some other day where I'm proposing that inner hair cells health is more closely related to the acoustic reflex production than the outer hair cells in the cochlear. Let's move on. And very interestingly, it's not only that you can see the SSed with vamps when there is SSCD present, but if you plug the canal dehiscence and you can see the vamp response actually normalize.

So.

One more thing before I move on, actually the person that I showed to you, in fact their radiology work, which came in later, showed it proposed that there was definite superior semicircular canal dehiscence on the left side, but there was probable dehiscence on the right side. However, the VEMPs, which unfortunately I didn't plot here, pasted here, the VEMPs were completely normal on the other side and therefore functionally the saccular function was absolutely normal. Which means that there was no indication that even if there were problem with the bone, they were affecting the inner ear in the way that the left ear was affected. Which was quite significant for the ear noise and throat consultant to refer this patient to us because their management plan would have gotten affected if there was a bilateral SSEG rather than unilateral. And probably the diagnostically they might have been thinking about other things as well.

So that's an interesting point where you can aid even the radiological findings to your testing, which become really useful for everyone involved in the care of this person.

And as you would remember, the O vamps are related to the superior branch of the vestibular nerve and the C vemps are related to the inferior branch of the superior nerve. Therefore, if someone happens to have a problem only on in the superior branch, their ovums will be absent and sewams will be present, which happens in superior vestibular neuritis or neuronitis, which probably is a better word for it, which is the most common form of neuronitis by the way. But some people can really have a selectively affected inferior vestibular neuronitis.

That differentiation is very important because if you look at this, one of my cases where the only thing that we found abnormal here was low vamp and statistically lower than the left vamp in amplitude. Generally speaking, most researchers will consider that the weakness is present if the vamp responses are about 35 to 40% lower than the other. So here there was right Side cwam, which was reduced hour. Everything within the video had impulse and even the monothermal caloric testing was perfectly within symmetrical range. So this person didn't have any problem within the conventional issue that happens within the vestibular system, which is superior vestibular neuritis.

And their problem was more apparent in the inferior branch of the nerve, which you won't be able to pick up from either caloric. And as I said, in the first three to six months, you can still see some problems with the video head impulse test when there's a vestibular weakness in somebody system. But if you see a patient after six months of initial onset, then VHIT is likely to be quite normal as well. So the only test who could tell us whether they had vestibular neuronitis in the past which they had symptoms of was cvemp in this case. You remember that horizontal canal which is tested during caloric test is actually stimulated by the superior vestibular nerve.

And because that pathway was intact for the patient, the caloric responses were pretty good. Now knowing it is one thing. So your clinical history can be related to your objective vestibular testing, which is great. So you know, lo and behold, if you are in this profession, if you talk to the patient for 10

minutes and you don't have a small idea where you are expecting the problem, you are in trouble, right? So if I only did caloric testing like I used to do 10 years ago on this patient, their case will be completely confusing for me because they had the symptoms of neuronitis.

And if I'm not recording it, then I'm thinking what else is going on here? Whether it's sporadic dizziness, whether it's intermittent dizziness, whether it's chronic dizziness or whatever else. But here the diagnosis was rather easier. But diagnosis is not the only thing. It also governs the rehabilitation of the patient once you've diagnosed them properly.

So vestibular rehabilitation, you can train your rehabilitation specialist, whether it's an audiology team that you refer for VR or you do it yourself or a physio team, you can train them, you can educate them, you can share with them the information from your testing in a certain way which helps them to devise those exercises. So this patient of mine doesn't need any gaze stabilization work because their gaze stabilization is complete, right? They need more habituation work for the autolith system. So they need, for example, vertical motion habituation where they get exposed to, they get gradual exposure to vertical stimuli, repeated sit and stand and steps up and Steps down, mini squats, basically to reduce the sensitivity to vertical acceleration. They need some sort of balance training, I guess.

So I use this balance form quite a lot. So most patients who see me for vestibular rehabilitation will get this foam. I usually ask them to buy it from a popular online website, the one that link that we send to them that comes with exercises as well, which they can do on foam or even on an uneven surface. You can progress it to eyes Closed, where you're relying on the vestibular system much more because you've challenged the proprioception system and you've shut off one third of your balance system by closing the eyes. So the vestibular system will get more push.

You can add the head movements to force the reliance on vestibular input as well, and you can get them to do different tasks. There's a website called Vestibular first and they put lots of very interesting

and cute videos of vestibular rehabilitation on LinkedIn, which I keep sharing with the physio who works with us, Mr. Tom Wright. So we have a bromance going on on the Vestibular first videos and some other stuff that we see on YouTube and we send it to each other to be able to make sure that we're using all the modern techniques and interesting ideas implemented in our clinic to help these patients of us. The next step is head body control work. So this is more sort of vestibular, call it reflex attunement if you like.

Slow head tails up and down, resisted head movements, maintaining the head stability while the trunk moves. So you know, gyrating like you're dancing. It's quite good fun when you do it in a fun way.

The other things where dynamic gait and vertical challenges come in, so you're walking with head nodding, changing in cur day training, you're picking up things from the floor, putting them on one side or the other. In my other life, I do some work with badminton training and we use these sort of techniques in order to develop that posture balance, the dynamic portion balance as needed in the racket sport like badminton as well. And then we generally integrate all of this to the other vestibular work as well. A bit of gay stabilization work included with that work is also helpful for certain patients, along with often underlooked aspect, which is the counseling and the parasympathetic nervous training too. So vagus nerve stimulation and how that relaxes and increases the restfulness of the body and mind system, which actually helps with everything else, including the balance.

Again, there's another lecture which I can do on that and some other time. Lot of them. Response research is present in the area of Meniere's disease, of course, because it relates to the saccule function. And we know that in the late stages, in about 60 to 70% people, the VAMP from the Meniers diseased ear can completely atrophy. So it can be completely absent.

Here we're talking about the C vemp in the early and mid stages. There's a lot of research which suggests that it may be that CM CWAM frequency tuning alters as the secular function gets affected in

Mennou's disease. Which means that although in theory a normal healthy person will get a higher amplitude at 500 hertz. In the case of Meniere's disease, the differentiation is that they start getting more or bigger response at 1000 Hz. If somebody is suspected to have Meniere's disease, you can do that frequency tuning cWamp and if you get a ratio of 500 Hz amplitude to 1000 Hz amplitude in the tune of about 1.04, so it's slightly more than that, then you suspect that there's secular dysfunction due to Meniere's disease.

Very neat concept, and it does work.

There is a study example of the comparison of Cwamp amplitude at 1000 Hz and 500 Hz, and in this study it's actually shown that this tuning curve seems to be more specific than the other prevalent tests, the ecog, SP and AP ratio. So see the specificity, how low it is for caloric and ecog, whereas how high it is for that tuning curve that we obtained in cervical vamp.

So just to recap, if you have normal bilateral vamp, we are all good. We don't need to worry about the otolith organs. If the vamp is absent, then we are worrying about the weakness, particularly with the secular dysfunction or CVAMP absent, we are thinking about inferior vestibular lesion or could be late Meniere's disease or even cochlear hydrops which will show that sort of response. If the OVAMP is absent, we're thinking about the utricular pathways and the nerve lesions which are in the superior portion of the vestibular nerve. If the CVEMP is enhanced and it has low threshold, we are thinking about a hole in the bone of the cochlea.

If there's a high asymmetry ratio. So significant intraoral amplitude asymmetry side of lower amplitude suggest dysfunction. So if it's more than 35 to 40%. Now again, if you do your own data, you will get a better idea with your technique, with your system, what that symmetry ratio should be. And if the vamps are absent bilaterally, you might be thinking about bilateral autolithic dysfunction, bilateral vestibular loss, or if you haven't done it properly as well.

So you want to make sure that your EMG and the effort that contraction will take for the stimulation of the muscle is appropriate, and you want to make sure that it's monitored. You want to make sure that if monitoring wasn't possible, it's at least scaled, and make sure your technique is right and proper. Or consider bilateral menus disease as well, which is rare, but does happen again. The same thing said in a different way. You can have a look at that in your own time.

The last bit of this session is how you put all this into your clinical practice. Now, see, once you create a proper system of vestibular testing, the average OVamp and CVEMP shouldn't take more than 15 to 20 minutes. Okay. I think if you do frequency tuning. So in my practice, we usually send an online form to the patients before they come in the clinic.

And if there are any indication, either in the referral letter or in the form, that we might have to do frequency tuning. So if there's a suspicion of Meniere's disease, then I leave slightly longer time for the vamp, or sometime I have to call the person again. But usually once you've made a system of how you get the referrals and triage those patients who might need more time, etcetera, you own onto your protocol selection and you know what you're doing in terms of AC bc when there's a conductive loss present, you have your electrode setup and emg. It's little things like how they're placed within your tray that makes some difference in time and effort. Sometimes, you know, if you have a system for that, you never run out of electrodes, for example, which I found out the hard way in the initial phases of my practice.

You have a system in place to understand how many recordings you will need, how you will make sure, as the patient turns, which screen they will be looking at. If you're monitoring the emg, all that will make a small difference in the time that it will take for the patient. And once you've recorded the response, what are you going to do with that response in terms of interpretation and integrating it into your, into your report? Once you have all these things figured out, which you will if you do 3, 4, 5 normative data

with your Staff with colleagues, with family members. It shouldn't really take more than 10 to 20 minutes for most people to do the VAM so they can really be bundled up with VHI with your head impulse in possibly a one hour appointment.

If you're doing the VNG and Calorics as well, you need slightly longer. Most of my appointments are two hours where I managed to do vamps, VHIT and caloric and VNG on everyone. We do a high frequency head shaker test as well and sometimes some additional tests that I'll do. But I spent about 20 minutes on history and talking to the patients too. Once you develop a system of how you're going to do the test, which one will you do first and some of the questions that you might need to ask, how you can include them.

For example, when you're waiting during the caloric irrigations, between the irrigations there's about five to seven minutes and some of the questions I ask the patients at that time. So the report work I do within that time, I say to them, okay, you lie down the bed, take a nap if you need to, and I'll do my paperwork and make sure that your report is ready in time as well. So again, with that sort of organization and system, you should be able to do most of this work within sort of 90 minutes to two hours. Some of my colleagues are more efficient than me, so they, I know, spend about 60 to 90 minutes on this work. I do it, I guess slightly more leisurely in two hours because I spend a lot of time talking with the patients.

Well, at the same time, some of the common pitfalls and troubleshooting is of course, number one problem with the CM CVEMP is the contraction of that muscle. So you need to make sure you really understand what you're measuring, which is the reduced muscular activity, voltage activity, and therefore it's important that you contract the muscle before you reduce it. So remember my analogy with the sponge that you squeeze and get the water out and if there's more water, more water can come out of the sponge as well when you squeeze that. So we're squeezing the activity in that muscle

and how you record that EMG activity is one of the major pitfalls within the CVEMP testing electrode placement. So if they're not symmetrically placed, then you will get asymmetrical response because different areas of the muscle will have different reduction in the voltage.

If there's middle ear pathology, that can kill the air conduction bumps completely. So you might want to think about your bone conductor, bone conductor calibration, etc. During the ovamp, the gaze angle is important. Most clinicians will do an ovamp at about 30 to 40 degree gaze. And again, the symmetry is important.

So you might want to mark a point on the ceiling with that sort of gaze where they can look at. Every time you're trying to measure your ovamp response, you want to make sure that sources of noise and artifacts, you know, jewelry, clothes, phones, microwaves in the clinic and more recently I found that the one of the laser machines that the podiatrist next door was using in one of the hospitals I work in that seemed to have affected the electrical activity within my electrophysiology machine. So you have to try and reduce the sources of noise and artifacts and try to stick to the norms that you develop for your own system, for your own technique to be able to interpret the asymmetry, but take into account the patient's problem in the first place as well. And it all has to be one common narrative, from the clinical history to the functional problem, to this objective assessment relating to the rehabilitation of the patient. Okay, and these are some of the things that we've spoken about today.

I'll leave this slide for you to read later on. And some good sources of information and cross references are of course this book, which is on my desk pretty much all the time, albeit the last edition now, and this particular piece of work in neurology practice guidance, cervical and ocular vestibular potential testing is pretty robust evidence base as well in this area. Consider that some of the evidence will be developed on the basis of different technique than you use today and now. Some of the evidence is before the time of EMG monitoring and scaling. And you will have to be judicious in applying those

norms to your own practice if you use a different technique, different parameters, etc.

Etc. And with that I thank you for listening patiently.

Okay, I'm here again, Dr. Jindal. Hi Anna. Hello Dr. Jindal. Thank you very much for these truly rightful and highly practical presentation. In my opinion, it was an excellent lecture on vamp.

Clear, comprehensive and extremely valuable from a clinical perspective. And let me say I want to thank you once again for sharing not only your knowledge, but also your experience and your practical approach with Vemp. So, Dr. Jindal, let's see if there are any questions from the audience. I can see a couple of questions. Dr. Jindal, may you be so kind to click on the questions and answers folder and answer to Dr. Juana Irina Popa, who ask a couple of questions.

Okay, so the question is what degree of amplitude increase in CMM should make a suspect many year at taboo menus disease? I guess so. In fact, it's the other way around. If there's a suspicion that Meniere's disease is present, or secondary endolymphatic hydrops is present, it appears that it will reduce the secular activity and therefore the secular function will be less rather than more. And if the saccule is not responding as well as it should, then it will reduce the muscle activity lesser.

So you will record a lesser voltage of difference in the muscle activity. So the difference, the response will reduce in size. You compare that response, that reduction, with the other ear, and if the difference is more than 35%, that generally is considered a significant difference.

Thank you so much, Dr. Jindal. If you want to proceed with the other questions, it will be great.

There's a question, based on your experience, is an EMG better performed with the patient in a lying position or sitting in a chair? So I. I don't think that it matters whether somebody is lying on a couch and

raises their head or sitting in the chair. What matters is how much of the EMG activity that they've been able to attain. And with the modern system we had. So, you know, there was a time when I used to use Nav Pro system for measurement, which didn't have any EMG scaling in my machine anyways.

And therefore I was relying mostly on how the patient was contracting the muscle. And in that case, I will get them to lie in the supine position and raise their head to a safe. To the same level on one side and again the same level on the other side, which was probably the best way for me to make sure that they were symmetrical. I tried the blood pressure cuff myself, but that didn't work as effectively for me as as portrayed in some of the research per se. But nowadays you have a really good system of monitoring that EMG activity, and I don't think we need to take any shortcut.

So you could select any of the major equipment these days, whether it's Celesta or other equipment present in the market, and they all will help you to monitor that activity quite well. So you don't need to take any second guesses in that. And the patient position in that case doesn't matter that much as long as you are comparing the apples for apple. So whether raising the head in supine position or turning the head and twisting it in sitting position, as long as the contraction is similar on both sides, we are fine.

Okay.

Is Finding latency values outside normal range in MEM testing is sufficient finding on its own to justify neurological referral. If you are very sure that you've done everything in the right way, in the way that you expect to do, yes is the answer. So once you've done a few patients, once you've seen a few vamp responses, and once you've calculated your own norms for those responses, and then you find somebody with significantly off latencies, I think it is a matter for you to figure out what to do next. And when in doubt, I'd say you refer out, which is a mantra that James hall gave to me.

Do you search the threshold during web testing? Not generally. So if I suspect the superior semicircular canal dehiscence, then you go looking for the. For the thresholds.

I can't see any other clinical reason to look for the threshold per se, but generally speaking, I'll say to them that I need to send a loud sound into your ear and the sound is very loud, but it's not uncomfortably loud. If it is uncomfortable, you need to let me know. I would have done the uncomfortable thresholds already, so I would have some idea where the patient's uncomfortable threshold is and how loud I can go. But because this is a continuous sound, I still warn them that the effects of the loud sound on the earth, and if they have a tinnitus, you warn them about the effect of loud sound on tinnitus as well. One way for me to try and reassure the patient somewhat with the level of the sound is I say to them, look, when I say vowel like ah, that's similar sort of frequency as that sound.

And at the level of my ear, that sort of level of ah is about 95 under decibel, right? At 3ft it might be about 65, 70 decibel. And then I say to them, and the numbers that we use during the testing are around 95dB as well. And lo and behold, that works on most people. But you have to be as careful as you will be during the PTA and uncomfortable level testing in producing that sort of loud SPL level at the level of eardrum and bombarding it.

Bombarding the inner yoga.

Can you do them for infants? Yes, and I know many pediatric vestibular specialists will do that. They get the infant to turn the head by one method or other. So, for example, when turning for milk, latching on the breast, or turning for a toy, etc. And hook them up with the electrode.

And some of the infants seem to tolerate that loud noise in their ear and give a good vamp response. I personally don't do it. I've seen Dr. Richard Gantt's work, which he's got a lovely picture of a little infant

or toddler on his website doing wemp and he talks about it much more eloquently than I do, so perhaps you can look at his website.

So, I am not a pediatric vestibular specialist. The next question is about how do you assess balance in children under 5? And I think Inventus has more webinar from other much more experts in this area, so perhaps I'll refer you to them. I guess the basic principle of testing for everyone will be exactly the same. So you're trying to measure the five different organs that help us balance.

As far as the vestibular testing is concerned, there's three semicircular canals and two autolith organs. Now, whether you do it with a rotary chair and vamp, whether you do it with a video head impulse apparatus, and whether you're able to do caloric testing on somebody who is five to seven years old, some of my colleagues have done it. The youngest child I've seen in NHS once for caloric was about 6 or 7 years old. So that's the limit of my experience, I guess.

Do I perform ECOG and cwams in many disease? I don't, I'm afraid. That's one of my intention, to do ECOG and start doing it more regularly than I have been, but it hasn't happened so far that managed to do it regularly. I have very limited experience actually in ECoG, although I have done it on some normal people in the past.

If vamp responses are absent and the patient is above age of 70, do you comment the age as contributing factor? Yes, definitely. The research will suggest anybody over 60 may have depleted vamp. So, you know, as we get older, nothing gets better, whether it's semicircular canal function. So you can look at Anusharma in us, her work or its autolith function.

Nothing gets better as we get older, I'm afraid. The hair cells are hair cells, the sensory cells, and just like all other senses, they start depleting. So most research will suggest the absence of vamp Response in over 60 may be a normal finding. Now, I don't really stop testing people at 70 vamp on

people at 70, because what I want to see is if the response is present and it's asymmetrical, which becomes an important finding for me. If it's absent, it probably is not material, but if it's present in one ear and absent in the other.

That becomes more material finding for me. I usually tend to test vamp in people older than 60, as long as they are healthy enough to be able to perform that contraction activity that we need for the CVEMP generation. In my area, we have a lot of people who will give me a run for money and running and any other physical activity in that age bracket. So I don't stop there. But you're right that age is a contributing factor for the absence of them.

Does vamp result depend on patient's position, lying or sitting? It depends on the contraction of the muscle more than lying or sitting positions. And it just so happens some people can contract the muscle more when they're raising their head than when they're sitting and turning and twisting their neck. So the vamp results are dependent, as the name suggests, it's a myogenic potential, the change in the contraction of the muscle. They are dependent on the contraction, the base contraction of the muscle, rather than the position itself.

Okay, there's a comment in the end and you can read it.

That's fine, Dr. Jindal. Okay, let's see if there are any questions from the audience, but maybe. I'm sure they will all come as soon as they close the session and as usually happens, so, Dr. Jindal, thank you very much one more time for this insightful and highly practical presentation. Presentation much appreciated as usual. Thank you so much, Anna, for inviting me.

You've been a wonderful host. And thank you to the audience, who've been a wonderful audience as well. Thank you. I. Before we close, I just would like to mention that Shrestha Inventis platform for auditory and vestibular evoke potential remains a part of our ongoing commitment to advance the

industry.

We are also pleased to announce that starting from September 2026, Celeste will be expanded with HEAR Lab ACA Aided Cortical Assessment, our new cortical module. Before saying goodbye, I would like to ask whether there are any final questions from the audience, but. No, that's fine. Okay. I'm also pleased to remind you that the next Inventis Academia webinar will take place on May 6, featuring Dr. Michael Kalber with the session Persistent postural perceptual dizziness a common cause of chronic symptoms.

Thank you once again to our speaker, Dr. Jindal, and thank you all for attending. Have a wonderful evening or a wonderful afternoon, depending where is your country? Bye for now. Thank you, Anna. Thank you, inventors, and thank you, everyone.

Bye bye. Thank you, everyone. Bye.