Etiology, Diagnosis, and Management of Vestibular Disorders in Children

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Presenter: Soumit Dasgupta, MD

- Welcome everybody and thank you very much for being with us today. The scientific delegation promoted by Inventis Academia and directed to all those interested in disorders and pathologies of the hearing imbalance system never stops. Inventis today is honored to announce the first lecture of three, managed by an international respected expert, Professor Soumit Dasgupta, Consultant Audiovestibular Physician, Neurotologist and a Clinical Lead in Pediatric Cardiology Alder Hey Children's NHS Foundation Trust in Liverpool. Thank you very much Professor Dasgupta for accepting our invitation. Here with us an old friend as well as a colleague of Professor Dasgupta, Professor Augusto Pietro Casani from Pisa University, President of the Vestibular Italian Society. Title of the lecture is Aetiology, Diagnosis and Management of Vestibular Disorders in Children.

As usual, I invite all of you to write down any questions in the space provided that you should see on the screen. After the event, you will receive a survey I kindly ask you to fill out. The survey will help us to understand your needs, to get your ideas in order to provide the best educational support ever. But now I leave the word to Professor Casani first, and to Professor Dasgupta immediately after. Enjoy the webinar.

- Thank you Anna. The only few words about my good friend Soumit Dasgupta. Professor Soumit Dasgupta is one of the leading scientist about vestibular problems and is particularly expert in vestibular disorder in children. This is a very important topic, sometime neglected must very, very important. So the presentation about assessment, diagnosis, aetiology and management of vestibular balance disorder in children will be a milestone in the knowledge about the problem of the vestibular system in children. So it is a great honor for me to present Professor Dasgupta, and now professor Dasgupta can start with its presentation. Soumit it's your. Thank you. Thank you very much Augusto and good evening to all. I work in Liverpool but I actually live in Manchester, so good evening from Manchester.

It's been quite nice today here. And obviously you would associate my city with the best football team in the world, which is Manchester United. So thank you very much Inventis for giving me the opportunity to do this because as my good friend and colleague Augusto said that pediatric vestibular disorders is subject which is extremely specialized and yet it gets a little bit ignored if I can use the term in the grand scale of things. But I'm very happy that there are a few of us very dedicated people, who are trying their best to promote this. So in flagship conferences about balance, we do get slots, albeit a very minuscule slot, but these things about pediatric vestibular medicine, pediatric balance as such is slowly emerging.

So as Professor Anna said that I work in Liverpool, and I am working in one of the largest tertiary pediatric hospitals in the world, which is Alder Hey Children's Hospital, but I also hold a few faculty positions as well. So today I'm going to talk to you about the pretty much the whole spectrum of pediatric vestibular medicine. I've got just two hours, which I have taken a lifetime to learn and with a lot of effort actually, so hopefully I'll be able to tell you about the importance of this, one. And two, my lectures are usually very, very, what I can say, very offbeat because I just don't talk to you about facts and lab boring sometimes, lab and boring scientific stuff, although I'm sure you enjoy them just much as I do.

I do intersperse my lectures with plenty of anecdotal incidents, videos and indeed a few movies. So that what I can tell you right now is before I start relax, sit back, if I can inspire you, you can learn and enjoy the show. So this is a customary slide, which I'll have to because I'll be talking about a few devices, but I don't have any dealings with them. This session I'll talk about the vestibular system in children, then we'll talk about how we assess, which is a work of art really. Then we'll talk about different pediatric vestibular disorders and I'll cite plenty of examples from my own series. Then we'll talk little bit about management. That is actually not very comprehensive, but I'll give you an idea.

And finally we are going to conclude. So the vestibular system, first of all, what is the vestibular system and why is it so important in children? Now, vestibular system has evolved in the animal and plant kingdom because when life began on earth, we were all tiny dots in this vast infinity called space. So there must be a system which will actually orient that organism in space. The only ubiquitous motion which is present for an eternity on earth is gravity. Now you all agree that gravity is a sense of motion, right? So something has to counteract or something has to act against gravity to make yourself palpable in space. And that's how the vestibular system evolved. The very first otolith organs, the utricle and the sacculus, very rudimentary and you'll be very, very surprised to know that even the tiniest sea creature has got some kind of otolith function.

They take their particles from the seabed and life began on sea. Once the organism started to learn about gravity, there was a problem which was faced by animals who were moving, who developed motion, not the plants, the animal kingdom who developed motion. Now that means that you are actually shifting your center of gravity and that has to be sensed by a newer organ. So a new organ evolved and that is essentially the semicircular canals. So remember the semicircular canals actually evolved from the otolith sensors. And now finally the animal kingdom evolved from different stages and the top, at the top of the trees, of course the human being who has got a very well-developed closed vestibular system.

But the vestibular system is actually most developed you have guest is right, is in the birds because their gravitational force is far more a flying bird because their gravitational pool is far more than animals on earth. So look at this movie and enjoy because this tells you what happens in the seabed. All the organisms, all the plants, all the animals that you will see in this video, they are essentially all sensing gravity and they all have got some kind of a vestibular system. I have put this to a music which is

very well known. It's Dvorak, it's a new world symphony. It's as if you are in a new world trying to discover things. And that's how the vestibular system evolved.

So that's how the vestibular system evolved. As you saw all of the plants and all the animals out there, they could sense themselves as tiny specs in this vast infinity called space. Without this human life doesn't exist. Now I am cheeky enough to tell everybody that the system which keeps you alive is not your heart, not your brain, not anything but the vestibular system. But I'm a very passionately biased man. So please don't quote me on this because people will take me as a daft human being. But remember, vestibular system is a key function in life and most importantly, this starts to develop very early, early on. So that's what I am going to now show you a little bit of the development.

So you all know this, I'm not going to dwell on this nitty gritty detail that there are two otolith organs and there are three semicircular canals. But very importantly, what is most important is the vestibular system is the only system which is endowed with maximum central connections. There is not a single area of the brain where it doesn't go. So you can imagine it sends its tentacles, it sends its forays to pretty much every area of the brain. Why is it like this? Why have we evolved so that this system, this vestibular nuclei, they communicate with every area of the brain. And the reason being this orientation in space is paramount in your life. First you have to know where in space you are, then comes the functions of life.

No wonder that the vestibular system connects to pretty much everywhere in the brain. And this is very important as we shall see letter because you need to know the anatomy of all these connections. Because unless you know the anatomy, the changes that you will see in your examination, which we will discuss in detail, you wouldn't be able to make out a diagnosis. So as far as development is concerned, of course in utero the vestibular complex is fully formed with good connections with the synapses,

the neurons, the ossification of the bony labyrinth is complete. Mechanical transaction is very well established in the otoconial but not in the semicircular system. And you can understand the reason why because in utero, in mum's womb, fetus is still subjected to the forces of gravity, but there is no movement unless mom moves.

So the fetus doesn't change the center of gravity, the mom does. So the semicircular canal function is yet to develop although it's fully anatomically formed. And this whole development is essentially controlled genetically. And there are 38 identified genes which have been identified, which are very important for vestibular function in utero, which determine how your vestibular system will be. And after birth, the moment the child is born, moves his head, moves his eyes, moves his arms, you have a change of center of gravity, the semicircular canal function starts to kick in, and it follows a very critical period of development for the simple reason external information is needed for the system to mature. You know, a child undergoes definite stages in his development as far as motor attributes are concerned, sitting, crawling, standing, you know, kind of, turning on his back.

These are all motor functions which are heavily guided by external world as well as the vestibular system. So this is the period of not genetically controlled but stimulus control development. And of course by that time, neurotransmitters and everything are pretty much well established, synaptic connections are there. So yes, we are getting there slowly and it takes some time for the vestibular system to function fully. One sec. Okay. So this is the kind of a flow chart for pediatric vestibular development. Zero years just after birth they get some primitive reflexes by which they try to orient themselves in space. As they grow up, low frequency vestibular function is established heavily guided by the smooth pursuits and the saccadic system.

But remember otolith function is still very much robust and on because that's from day zero that your otolith start functioning. However, during this period when a child is

growing up and trying to understand what motion is all about and as a result trying to move, you have to still orient yourself in space. And that comes very much from a somato sensory or tactile information. A child orients himself in space with touch up to a certain period of time. Of course at the same time remember vision is developing. So vision comes in, so by the age of four years, a human vestibular system can resolve very effectively low frequency movements. So you will see that a child later, two or three, they turn around round and round and round and they love that feeling because they feel very dizzy and drop on the floor.

As an adult, if you execute the same speed, you won't drop to the floor because your system can take it, but a child can't. I mean we have all done it because we love it. So from the age of four years to eight years, that's when the high frequency vestibular function from the semicircular canals they start to mature. And finally the whole system matures by the age of 15 years then it becomes adult-like. The vestibular ocular reflex also develops in a time directed fashion, low frequency at two months, high frequency four years plus. Now why is this important for us to know? This is very important for us to know for the very, very simple reason.

This system as it is developing may show immaturity and immaturity as you guys know, is pretty much sometimes a normal phenomena. Of course it can be due to a syndrome or a proper pathological disorder, but in a good number of children immaturity is just because it happens, it's not a pathology and it's not something to be concerned about. So imagine an immaturely developed vestibular system at the age of two years or even three years. You do a video head impulse test, it might be abnormal. Does it mean the child has got a vestibular problem? No, most certainly not, because you know that the semicircular canal view or high frequency has still got to matures, and in some kids it comes early, some kids.... The average time is about four years.

So this means that your choice of vestibular function tests pretty much is dependent on the stage of development of the child. And it's crucial, you cannot do all the tests that you would routinely employ in adults in the pediatric population. It's like an audiometry in a child. You see a child will do a visual reinforcement audiometry at an age where he wouldn't be able to do a pure audiometry, right? So you have to select your tests very carefully as to what tests can give you the maximum information without being contaminated by noises like an immature development. I hope it makes sense and that's why I would insist that for those you guys who would do pediatric vestibular stuff later on, you'll have to be absolutely conversant with the development of a child, especially the motor development that's so, so crucial.

I can't insist how crucial it is. And of course beyond the vestibular I've got a huge area of the brain which also acts in tandem. This is, I'm not going to dwell on this, this is basically a motor development list as to what could happen during what time, you have to take this history when you are examining a child, regardless of the child's age, right? A child coming to you at the age of 13 or 14, mid-teens, you'll have to ask from the parent what happened at what time? When did he crawl, when did he run? Every important information is written. Now hand upon heart for all of you guys who do see pediatric population or kids coming to you with vestibular problem, how detailed are you to take this motor development history?

It's absolutely crucial. You need to be trained in this and that's why dedicated training in pediatrics is very, very crucial if you want to do proper vestibular medicine in kids. Many functions, I'm not going to go through that in detail, you all know, but basically it not only orients in your space, but it gives you ocular mode of stability, gaze fixation, gaze stability, navigation. So important, navigation, human navigation is a vestibular function mediated by the vestibular system, the vestibular nuclear and the hippocampus and the entorhinal cortex, absolutely important. A typical vestibular

problem in a child and for that matter in adults is bumping into objects. My son when he walks doesn't know that there is a door in front of him.

He goes, he bangs into the door that is vestibular. How many times have you heard it and how many times have you actually thought this could be vestibular? So this is very vestibular navigational problems. You lose your sense of direction. It indicates, it contributes to peripheral muscle tone. So someone who is having a very, very flaccid muscle, for example the myopathic group, it can be due to a vestibular problem. In fact, about a fifth of myopathic like syndromes is contributed by vestibular dysfunction. And I get referrals from my neurological colleagues telling me that, you know, this child is present with muscle weakness. We have done everything. We have done, let's say mitochondrial mutations, we have done all the metabolic screens, we couldn't find nothing, would you mind having a look?

And low and behold when I see them, I find out that there is a vestibular dysfunction. So remember, muscle weakness is a presenting feature of vestibular weakness. It takes a very important role in cognition. In order to cognitively mature yourself you need a proper orientation in space, otherwise your cognition is affected. Higher center intellectual function is affected. Vestibular system is absolutely crucial for this and it has been recently found that it also takes part in autonomic control. Your vasomotor's tone, your heart and your pulse, they might be influenced by your vestibular system. It's a frightened flight reaction. So vestibular system does not just do orientation in space, it just doesn't present with dizziness, no, it does a lot, lot, lot more and that is the important thing which we need to understand.

Now, what is also very, very true in the pediatric population is their brain is very, very robust, right? Because they have got an immense cerebral plasticity, their brain is plastic just like a sponge very unlike mine, I'm an aging old brain, but many of you are very young so your brains are far more plastic than mine. Now a child's brain is very

plastic. So what happens is if someone does get a vestibular problem, the brain tries to compensate for it, simple. And that compensation because of the cerebral plasticity is very, very robust. Robust means that it can address the problem right away. As a result, the children hardly end up with any symptom. And if you don't get incepted, why on earth for example, me as a parent, why on earth would I bring my child to a hospital if my child doesn't have a symptom.

I receive children who are coming to me only when they decompensate. So my job is to, one, if there is a vestibular problem to identify what the vestibular problem is, to quantify how much weak it is. And number two, absolutely crucial to find out the cause for decompensation. I have got a few cases at the end, but I can tell you a small anecdotal story. I had a child of the age of 14, one, four. Who came to me with vague lightheadedness, went to the pediatrician, no problem detected, went to the neurologist, no problem detected including scans. Finally sent to me lightheadedness and this kid is travel sick, has got fear of heights, he bumps into door frames, typically vestibular, otolith semicircular canal.

So I saw him and I quantified a bilateral vertical canal weakness. So there were over seconds on pretty much all the vertical canals, laterals were intact, CVMs they were well, in my lab standards they were okay, but the reduced amplitudes in the sense that they were low normal amplitudes. So he clearly has a vestibular hyper function and he's coming to me because he's decompensated, he's lightheaded, right? So I was wondering what can be the cause presenting at the age of 13. But what was striking about the kid was that this kid was extremely tall. At the age of 14, he was about six feet, three or four and he had a huge arm span, what we call an albatross arm span, it's like an albatross wings spread out.

And then mom told me as she was leaving, my child is also very aggressive in the class. So he's bordering on violent, he has been frequently reprimanded, punished.

That told me a lot. Very tall stature, aggressive bilateral vestibular hypofunction, this is very likely some kind of a genetic syndrome, chromosomal abnormality going on, I didn't know what. And then when I checked his chromosomes, it was a klinefelter syndrome, Klinefelter syndrome identified from an audiovestibular clinic just because this kid was lightheaded. And that's my point. You need a thorough, holistic and complete knowledge about pediatrics, otherwise you're not doing your patient a favor. And we have trained very hard. I am a neurotologist, I have trained in otology, but I also took effort to spend at least two to three years training in pediatrics because otherwise I would never have this insight.

I would just depend on a set of reports in front of me, this, this, this, this, and that's it. I need that insight. So I'm not just looking into the child in a year, I'm looking into the child as a whole. So hopefully I'm able to make this point clearly to you guys. So the magic behind balance and motion. So it's very, very important for a child to grow up. Just read from this picture, it improves balance, improves motor skills, it kind of contributes to posture. It is important for different playful activities. So it's huge, it's a huge kind of ramification of this vestibular system. So basically therefore we can call our vestibular system our internal GPS.

So it's like satellite navigation which is orienting yourself and navigating yourself in space. So have a watch of this video and you'll see exactly, you'll find exactly what I mean. So that is basically what your vestibular system is, your internal GPS. So assessment, how do we assess? Now this is an art which can only come out of years of practice because it's not just a set pattern of asking vestibular symptoms. You'll have to really delve into the child's life to pick up very, very small but meaningful inferences. As you can imagine that history is sometimes not easy and the worst often there was teenage boys because what you ask them, you only get answered in grunts.

Teenage girls are no good because all you get is maybe, could be, I don't know, monosyllabic answers. So history might not be forthcoming. Therefore you need to identify vestibular behavior from the parents of theirs. I had a kid once where this kid was sent to me because this kid apparently is frequently falling. That's the only complaint. And mom then told me a very beautiful thing. She said, when my child slides down in a park, you know those slides. When he lands from the slide on the ground, he gets a very dazed expression in his face and can't stand up. Now this is very typically vestibular, decompensation after a provocation. So all these very finer bits comes out by intuition and you can actually make out vestibular behavior and parents are very astute to pick this up.

Obviously you need to equate yourself to the child, which means you have to improvise, have to continuously incorporate fun activities. Remember you are doing very complex assessment so you have to get the child's cooperation, and the second tester may be needed, we have already mentioned that. And then the most important thing when you are using your laboratory tests, you must have your own norms because norms in children are not very well established. So you cannot depend on what is in the existing literature. You can only get a range and an idea. So you must decide, you must fix your own laboratory norms. And that's the first thing that I did in Alder Hey was when we got our CVMs and VH and everything, we actually decided or we actually fixed our own norms by studying a group of normal kids.

And very importantly as you can subsequently see, aetiology and vestibular presentation are markedly different in children than in adults. So just transposing adult norms to the pediatric population is a thing which I'll ask you strongly to avoid. So what you do in adults, fine, your knowledge is adult-based, that's absolutely needed and crucial, but please do not transpose them to the child. Child behaves completely differently in many aspects of common disorders. For example, vestibular neuritis presents differently in a child. So please have that in mind when you are seeing a child,

that a child might not present with typical adult features and you need to know how the child presents and that's where your pediatric training comes in.

And the neurology neurotology interface is very, very blurred, because of a developing vestibular system which depends heavily on the neurological system, the brain. The two of them frequently overlap and they clash with each other. And that brings me to the important caveat that in order to do pediatric vestibular medicine, you need a very thorough grounding on neurology. We have gone through this neurology training and I can tell you that it is a big help in my inferences, my diagnosis. You'll have to know neurology, especially central vestibular neurology like the back of your hand. Otherwise in many instances you wouldn't be able to make a diagnosis. This is far more intense than you would find in adult and your approach has to be very holistic.

As I said, you are seeing beyond the inner ear. So you need our knowledge in pediatric neurology, development pediatrics, pediatric ophthalmology, you have to check the eyes. Pediatric medical specialties, especially the heart, you'll have to identify murmurs because remember Jervell and Lange-Nielsen is a syndrome autosomal recessive, which presents with significant vestibular loss. So pediatric vestibular phenotypes may span across specialties, and unless you know what these phenotypes or presentations are, it's very difficult for you to make out what is what. And vestibular rehabilitation is brilliant in kids because of the same cerebral plasticity, so it's absolutely crucial that you make a diagnosis. And you need the training because without the training you will not have the insight.

So what do we do? How do we assess? Let me bring in a very favorite character of mine, Mr. Sherlock Holmes. You know I am told that this is an international conference, so you guys are from all over the world, but I'm sure most of you would've heard about Sherlock Holmes and Dr. Watson, the quintessential detective who started the whole detective fiction after Edgar and Poe. He was not the first but he kind of put it on the

same footing. So this is from a book or a story where a murder was committed and they are now going to that English countryside to investigate. So Sherlock Holmes tells Watson that it is an offense to infer something without evidence.

You need the evidence, but once you get the evidence how to go about it. So there are two types of reasoning based of evidence. One is called a deductive reasoning. What do I mean by that? Deductive reasoning is what you do in research. You have a hypothesis, you then decide on some methods and you set about to prove the hypothesis and finally you prove or disprove the hypothesis. Deductive reasoning. However, in clinical medicine, especially in vestibular sciences, inductive reasoning. You collect the evidence first and then you make an inference based on that evidence, what is going on. And he cites a beautiful example. So just read this or actually I'll read it for you. This was Inspector Gregory, the quintessential British police who Sherlock Holmes thought at absolutely is a moron, but that's very typical.

So no one could figure this out, what's going on? And Inspector Gregory asks Sherlock Holmes, but it's a very difficult case because there are no clues and Sherlock Holmes says, "No, there is a clue, there is a curious incident of the dog at nighttime". Inspector says, "But the dog did nothing". Sherlock Holmes said, "That's the point. Why didn't he do nothing? Why didn't he bark? That clearly tells me whoever the murderer is is a known person". Now this is inductive reasoning. This is how we would diagnose a pediatric vestibular disorder and a cause for decompensation. You collect all the evidence, talk to the patient, do your test, do everything possible, then try to correlate it with the different disorders that you can fish out from your memory of pediatrics and then try to come up with a concrete diagnosis.

So inductive reasoning, and that's where I can tell you ladies and gentlemen, that's where the fun of pediatric vestibular medicine is. That is the intellectual stimulation. Every individual case is like a jigsaw puzzle where you do your inductive reasoning and

you try to figure out why didn't the dog bark? Why is this going on? What is why? Why is this? Why is a child who is having a nystagmus at rest after you do a head shake, the nystagmus disappears. Why is curiosity is the hallmark of inductive reasoning and I would strongly suggest that you follow this process. And I tell my residents and fellows all the time about this inductive reasoning. So the presentation history, I'm not going to read it through this slide because it can come in any guise, the ones which I have idolized, they are very typical of vestibular disorder.

So obvious dizziness. Obviously a child will not tell you I feel dizzy, I still feel spinning. Some of them do, most of them don't. They tell you that well, well I don't feel right, something is going on, and the parent says, I'm seeing my child's expression in the face, it looks as it is dizzy. So that's an art in itself. Bumping into things I've said. Sudden pole axing falls like Tumarkin's crisis. This usually happens in a condition called benign paroxysmal vertigo of childhood, BPVC. In fact they frequently get branded as epileptic when antiepileptic medications do not work and they end up with me. And a simple anti migraine falix takes everything. Periodic episodes of nausea and vomiting.

Of course vestibular migraine is extremely common. Delayed motor functions, now difficult in playground activities, very important. My child can't go on the swing, my child can't go on the trampoline, my child can't go on the bouncy castle. My child hates merry go rounds. This is primarily vestibular, believe me when I'm telling you. And this is you have to ask the parents the observation of vestibular behavior that's very, very important. So now of course you can understand that from this difficulty with ambulation in the dark is under the classic vestibular. Now you can see many of them overlap with neurodevelopmental conditions. For example, autism for example, attention disorders for example, sensory integration issues, they are common. For example, delayed motor function is common.

So do I mean that all these kids who are having delayed motor function end up with me, then my service will burst and it seems, I wouldn't be able to sustain a service. So there are some definite pointers and we have done this kind of checklist where it suggests that there could be a vestibular problem going on, and I've got brilliant colleagues in Alder Hey who can now accurately sense whether a vestibular problem is going on and do the absolutely appropriate reference to me. And the vast majority of the reference there is indeed a vestibular problem. But you know, it wasn't overnight that this happened. You have to engage your colleagues in different departments. When I started, I went to every individual department and told them, please remember this tiny, tiny organ in the inner ear which has got 64,000 sensory hair cells packed in one cubic millimeter.

It's straight out of science fiction. Cochlear is very sophisticated, but the vestibular system is more sophisticated than the cochlear. And so the important thing is that the moment your colleagues appreciate this, you'll have to put in a lot of effort to actually convince your colleagues about the system and to make the right reference. So typical key points, which is very much like the questions you would ask in adults, but remember you might not get a true answer back, so this is just key points in history. I'm not going to discuss this in detail because most of you would be knowing about this. Now remember, lot of contrast, this is never due to a vestibular problem. How it differs from adults from the history point of view is you wouldn't ask an adult were you born normally or were you born after a cesarean section?

You wouldn't ask a 35 year old man, did you walk at the right time? Did you crawl at the right time? But in kids birth history, family history, of course hearing symptoms, development history, every individual history is important. In Ototoxic history many of them would have, not many, few of them would have gentamicin therapy in the past. Everything, every important bit counts. Musculoskeletal pain because it could be a myopathy like syndrome, gluten sensitivity, which generates a cerebellar ataxia, you

have to ask about gluten. So it's a very comprehensive history and I can tell you that it's very, very important that you go through the entire historical algorithm and that's absolutely vital. Okay, so the next one. So this is the vestibular algorithm.

Now you'll get a recording I'm told by Anna. So this is very useful. This is the vestibular quantification algorithm depending on the age of the child, just like your augumentry So from birth to six months, six months to 12 months, you get different kinds of tests which you can employ that test which you routinely employ in adults. For example, the cVEMP the VNG, the vHIT, the chair, all these things, you can't use it in all kids. So that is a very, very important thing. You'll have to select your tests very, very carefully. So six months to 12 months you can still do a vHIT, but it's a remote vHIT, and remember the vHIT is negative, abnormal. It doesn't necessarily mean there's a vestibular problem because the system is still maturing remember.

And mounted vHIT, which is two different equipments. You do it at a slightly lesser age because you need a band which might not fit the child size head. This is the vestibular gram first prevented by Ulma. So it's a little bit busy, I'm sorry. But as you can see, the vestibular sensory epithelia, the best membrane is very frequency specific. So no topic, just like the cochlear and why not? They're developing from the same optical code. So you've got different range of movements, a low frequency, mid frequency, high frequency, then different kinds of frequency specific movements in the otolith system. You know you get different kinds of developmental reflexes. Detailed history, you nowadays with the vHIT you have got the functional head impulse and the suppression hitting pulse.

Suppression hit impulse our experience in children is very, very positive. So all these tests that can be employed in a child, depending on the slide that I showed you before, you'll have to select your tests. And on the right, these are all central tests. Now obviously this lecture doesn't let me, it doesn't allow me to individually discuss or

describe the test, which I'm sure most of you would be familiar with. But remember, these tests can be imminently employable in children provided you select the correct test for the correct age. So there are three types of video head impulse test gear. So one is obviously the ICS Impulse. One is the IC chem Interacoustics and one is synopsis by Inventis.

Now that advantage of this is of course it's a mount, it's not a mounted camera, it's a remote camera. So it can be done in very young children. And these two, they can be used from the age of two years onwards. You might get special bands which will fit around the child's head and you need toys. But the most important thing you need your hands, eyes and brain. If you do not have anything, then all you can do is you can actually ask your assistant with the parents' permission to shoot the eye movements with an mobile phone, a good mobile phone and then play it back, enlarge it, make it a slow motion. And you can very clearly see the eye movements.

It's that easy. So for every individual child, when you are assessing, you do a very thorough clinical assessment first. Sometimes I get asked by my residents, one of them ask me, how can you check the vestibular system in a child under at the age of one? Because you know you can use a remote camera vHIT, you can still use a cVEMP, but how do you get the clinical information, especially let's say a child under the age of six months where you can do nothing, where there is no VEMP no vHIT. Yes you can do it. All these reflexes, they have got a very strong vestibular contribution. In fact, that day I saw a child three months old, CMV hearing loss where three of these reflexes were abnormal so I could make out CMV has led to a problem in the vestibular function.

So it can be done and you need training to do it. You need neonatal experience and infant experience to do it. And this can be very eminently done to get an idea, not very, very kind of quantifiable, I agree. But to get an idea of, and then once you get an idea that the vestibular system is not working properly, obviously you can monitor the child,

and early rehabilitation is quite effective. Obviously you can't rehabilitate the child under the age of one year. It's very difficult because how, what would you, what are you doing? But even then you can still improvise, which I'm going to show you later on. Different angular motion sensor tests, you all know about this.

These are all looking into different frequencies zones that's very important. Caloric ultra low neurophysiological vHIT very high. So different kinds of tests. Now obviously you would know about all these tests pretty much the same as in the adults. And here I'm going to present a few videos. This is a clinical head impulse test, which is in a bilateral congenital sensoral hearing loss child with bilateral vestibular hypofunction. You can't see it very well here, but we have with a slow motion you would see a very clear catch-up saccade. So that's the first one. That's the clinical, this is the video counterpart of a clinical halmagyi head thrust as you can see that once I move the head to the left, there is a clear catch-up saccade it's coming there it go one saccade, on the right nothing. On the left clear saccade.

Okay great. So this is high frequency vestibular function. This is a classical vestibular nystagmus horizontal nystagmus, this was a Alexander's grade one. So it's a quick phase and a slow phase. The other thing you'll have to know your nystagmus like the back of your hand, not just vestibular and nystagmus. As of now there are at least 59 different kinds of eye movements, which you can call nystagmus. You need to know all of them if you really want to know. That obviously doesn't come easy, but with plenty of experience you would be able to pick up the eye signs. So I'm not making the pre-pro suggestions that you have to know all of them now, but please keep your mind open and at least try to figure out is this central, is this peripheral?

If it's central, different algorithm. If it's peripheral, different algorithm. So this one have a look. This one is a head heat test, which is a physiological counterpart of high frequency utricular function. As you can see when I move the head on one direction,

there is a saccade, that's it. There is saccade there, there is a saccade there. So this is when you move the head linearly on one side, this is a head shake, which is middle frequency function. It doesn't tell you the side, but it gives you the asymmetry unilateral, as you can see, you shake the head passively and there is a nystagmus there. The next one is what we would call a hyperventilation test.

So this is when you ask the patient to hyperventilate, I'll just forward this a little bit and you see a very classical nystagmus. Now this is not a frequency specific test, but this test is an etiological test. So because this will tell you that there is something going on in the cerebral angle, as you can see that there is a nystagmus hyperventilation and you can of course physically quantify it, you can write it down or you can actually measure it. So that's a hyperventilation test. And finally, Hannabals test positive pressure or triggered pressure in third windows or early menus where you get this very classical Hannibal's test. So I'm actually pressing on the triggers now. You'll see what will happen, still pressing and you'll see a very classical nystagmus, which appears this was a posterior semi, sorry, a lateral superior semicircular canal basis.

It'll come, you'll have to wait. One thing about pediatrics is you need a lot of patients. There it comes. Beautiful. Now remember they won't tell you that I'm having autophony. Smaller kids they won't tell you that I'm having tulios. Yeah, mom will tell you that when there's a screeching ambulance, my son gets a dazed expression on his face. Please excuse me, I keep on saying he and son, for all the ladies, no disrespect meant. He or she, it's difficult to keep on keep on lecturing otherwise, so if I default, I stick to a he. My son, when he hears an ambulance screeching noise, he gets a dazed expression in his face and almost loses his balance.

Now that's classical tulios. But he'll have to ask, that's the leading question that you'll have to ask. So this is the chair test, which you can imply easily. Now of course you need the chair. You sit the young slightly older child on a chair, slap the VNG goggles

and measure, otherwise very small children, you can use it from the age of six months. You put the mum on the chair and the child sits on the lap and you watch the eyes. If you don't have VNG control, you can just watch the eyes with your mobile phone. A viewer reflex is usually symmetrical and should be present. In children with problems you hardly get a viewer. Now the thing, important thing is always tell mom that I'm going to move you around in a chair, there is a possibility that you might get sick.

When you do this to children the children absolutely squeal in delight. They love it. But the problem is, on two occasions, two mothers got sick and one of them complained against me because I didn't want her, it's only about 1.5 degrees per second. But even then she got sick. Now because I'm a sad case, maybe that told me a story that this mom is motion intolerant. So maybe there's a genetic vestibular problem going on. So you see, I see vestibular in everything I can come across. So far of the translational motor sensor tests, you know of two, I'm sure one is the subjective visual vertical, and one is of VEMP. But remember there are other tests. There is an ocular counter rolling, there is a skew deviation.

One third of skews are associated with a vestibular problem. And you get the head heave test, which I've also said. So these all tests, they all can be done in children. So this is a classical head here again. As you can see, this is not a thrust by the way. Wait for the second I'll show you, it's on the right. There we go. Nothing there. There we go. Nothing there. There we go. Nothing there. This is not a thrust, this linear movement by the way. This is an ocular counter rolling. You turn the child's head all the way to the shoulder and you see the eyes rolling beautifully. Now this is coming from the utricular saccular system.

Point A to point B displacement is static roll coming from the utricle and the physical movement of the rolling is saccular which we call the dynamic counter roll. So a static utricle dynamic saccular and you can get abnormal one in one or two. And this is an

abnormal one. You saw that one which was normal. The abnormal on one side, you'll hardly find... In fact on both sides you hardly find the eyes move. There is a little bit of static counter roll there, but hardly any dynamic rule. If you do a cVEMP from this one, very likely the cVEMP will be abnormal, sorry, the OEM will be abnormal. Then you subject the kids to a full vestibular spinal test battery, which is basically Romberg unterberg and all those tests, and of course your VNG will tell you VNG, ectopic eye movements or nystagmus, smooth pursuit saccades, viewer are suppression test.

Now sometimes your expected nystagmus may be perverted, which means horizontal head shake may generate a vertical nystagmus. Vertical head shake might generate a horizontal nystagmus. We call it a perversion of nystagmus, which is a sign of course of vestibular cerebral pathways or even the brain stem. And of course non vestibular movement disorders. For example, ataxia. There is a vestibular ataxia, but you will have to know neurological ataxia for example, many neurological conditions present with typical gait ataxias and it's very important to make the child walk and watch the gait. And if necessary, sometimes we would send our patients to a gait laboratory, and it's very crucial to distinguish between central and peripheral on their own, or whether they're coexisting because on this will be dependent on your treatment.

So this is one of the vestibular spinal tests that I do, use a form cushion with the eyes closed, it takes out properception, it takes out vestibular, it takes out visual input. If the child balance, then that integration is intact. This is my lab by the way. Celebral tests are very important coordination. And of course you do the full VNG works and this is how you do a foam test test, that doesn't stop. You'll have to do a full musculoskeletal motor, cardiovascular and neurological assessment. Also, you'll have to put in a visual assessment as well. But it's ideal that you send him to our ophthalmological if you think there is a visual problem. And then depending on what you find inductive reasoning, you have collected the evidence, maybe your scan is needed, maybe blood tests are needed, maybe posturography is needed.

I do not do routine dynamic posturography for the simple reason. It doesn't give you any idea about the vestibular system per se, except not working properly, except prognostic purposes if a person is improving from vestibular rehab. But dynamic posturography does not tell you much about a physical vestibular quantification and it's resource intent, so I do not do a dynamic posturography. I have seen many labs routinely subject someone including an adult to every possible test that you can think of. It's not needed in most instances because from the test battery, which I showed you, you can glean enough information. So the rest of the tests become purely academic and you can, you might have to do genetic testing as well.

So that's the way you assess. Now the key point is, I'll show you in a minute, one sec. So assessment of vestibular system in children is a unique artistic skill set that requires wisdom, knowledge, years of dedicated training and most importantly have to continuously improvise. And I'm going to play you two videos which illustrates the point brilliantly. The first one is the very famous Beethoven's Fifth by Berlin Philharmonic, Herbert von Karajan. It's a classic piece. And the second one, he's a 16 year old guy who's got the knowledge, who's got everything and he improvises. So enjoy this two beautiful videos. Now that is what I call expertise art. That's what I call improvisation. That's what you need to be doing when you are assessing a child who's hardly talking back to you as regards vestibular function is concerned.

So I hope that we have created the mood and well, I think that we have addressed some very, very important issues. So we are at the halfway and now we will go on to pediatric vestibular disorders. Originally I thought that I might actually take a little bit of gap here, but I am going to... We will carry on just for the brevity of time because I'm sure that all of you, guys must be very, very tired. Okay. Right. So pediatric vestibular disorders, let's have a look as to what we get in real life. So first of all is of course the aetiology. First of all is of course the aetiology. So as you can see that varieties of

etiologies, but the most important part of pediatric vestibular disorders is of course migraine and BPVC.

That's by far the communist. This study we did in 2017 has changed because during that time we were not picking up enough migraine cases for the simple reason we were slowly establishing service and we didn't get many referrals. But now I can tell you confidently that vestibular migrants are common. Peripheral vestibular disorder comes next, traumatic head injuries, so and so forth. These are the different aetiologies as far as we know. And this was originally published by Delaware Wilmington, but we have replicated this. So as you can see there are quite a few conditions which spans well beyond the vestibular system. And it's not uncommon. Prevalence is 8-18% between one to 15 years, and 35% of all pediatric balance disorders are due to the vestibular system, that's about a third.

So congenital disorders, of course, structural deformities. So there could be any kind of structural deformity. You have heard about Michel's deformity, which is complete aplasia, but there can be any number of combinations which lead to improper formation. Anatomical and physiological formation of the vestibular system. Recognized syndromes there are a few, for example, branchiotorenal spectrum, CHARGE syndrome, goldenhar, pendred, trisomy 13, 18, 21. Down syndrome. Down syndrome if you scan, you'll find about five to 7% of them have got a vestibular dysmorphia. How many times do we actually check physically the vestibular system in a kid with Downs? We don't. But they do have balance problems and they can be treated. So noonan/turner, wildervanck, craniofacial syndromes these are all different syndromes which can present with a vestibular dysplasia.

Quite a few genetic syndrome with otic structural deformities. For example, we have spoken about the Jervell Lange-Nielsen syndrome, then Alport, Alstorm, Usher, some chromosomal. And the ataxia group is very interesting. Spinal celebral ataxia, episodic

ataxia. There's a new one called ARASCS which is autosomal recessive ataxia of Charlevoix-Saguenay, which is a very new condition we have recently identified from a vestibular clinic. This kid was sent to us I think from pediatrics and we picked up ataxia and we picked up some wonderful central eye signs which led us to scan the brain. And this kid has cerebellar ARASCS syndromes diagnosed from a vestibular clinic at pediatric vestibular clinic, and of course the hereditary sensory motor neuron group, the prototype is Many genetic syndrome, non syndrome hearing losses can present the vestibular dysfunction.

For example, some autosomal dominant varieties like a 9, 11, 15, 28 and some recessive varieties, especially two, four and 12. There are other genetic conditions now we don't have to discuss in detail, but remember it can very well be genetic. Metabolic condition now I had a wonderful discussion about many as disease in a child with a colleague who I hopefully have joined, George. So George, if you're here, is a very important metabolic condition, which is called X-linked hypophosphatemic crickets, which presents with tri vascular metabolic defects leading to secondary endo lymphatic hydrops. It's very important to exclude this child who's present with the menias disease. Von Hippel Lindau syndrome presents with endolymphatic sac tumor. DIDMOAD can present with vestibular dysfunction and of course some auto failure in varieties they might present with an ANSD along with a vestibular nerve disorder as well.

So the congenital disorders are usually bilateral unless the dysplasias on one side, however, they're mostly bilateral so they don't present with classical symptoms of dizziness as you would call it. So there would be motor developmental delay. A third of congenital hearing losses are associated with vestibular loss as well. So the chances of vestibular loss is much more if a child has also got a hearing loss. Isolated vestibular loss without a hearing loss, which is congenital is rare. It can happen, I've seen that happen but it's rare. So you can have unsteadiness and classical vestibular attacks

here, navigational difficulties, clumsy and incoordination. It might have a cognitive delay, behavioral difficulties, why is it so important to explore playground activities?

The reason is one, you see one of the very important parts of your growing up is actually playing. If a child is apprehensive that if when I go on a swing I might fall and I feel so dizzy, I won't like it. He's trying to avoid it and that will make him avoid playground activities and a very important interaction with his friends, that leads to withdrawal, that leads to a neurodevelopmental condition for example, they might present with attention deficits, autism, their cognitive development is delayed. So you can imagine the ramifications or the legacies of a vestibular hypofunction can affect the behavior of the child. They can present with learning problems, cognitive, I said, or a muscle hypotonia, which makes their movements difficult.

One important thing that you will find when kids are with vestibular hypofunction, they have got a significant problem in reading skills. The reason being they continuously keep on having the retinal slip. In spite of compensation, this retinal slip prevents them from reading properly. And if they've got francoselopsia then of course that is very difficult for them when they try to read. So first example, child with late onset mixed hearing loss, motor development delay, mixed theory loss, neurodevelopment issues, later identified as ASD, multi spectrum disorder, very apprehensive about physical activities, loved football but was unable to play it. Learning deficits was behind his peer group. And when we rehabilitated him after we identified his condition, so as you can see there's clear catch-up saccade on the right anterior plane and his VEMPs on the left is absent twice, on the right they're present but with a low threshold.

So low threshold by the way. We scanned him typical Christmas tree appearance of the cochlear with an absent modulus and we genetically typed him. And this was a X-linked gusher, POU4 mutation. So this is how you identify your children from inductive reasoning, getting the evidence first and then making a informed judgment as

to what's going on. Example two, child with late development of motor skills and unsteadiness. Again sensory hearing loss, all scans, normal travel sickness and acrophobia. These are otolith symptoms. Then you immediately know something is going on there and had a severe vestibular weakness. As you can see, vHIT was positive on all canals, low gains with catch-up saccade, no VEMPs. And we did this test.

So this was a bilaterally positive head heave, this is not a thrust by the way. Watch carefully. That's a saccade there. There are two saccade on either sides. You see two movements when you move the head. So bilateral otolith, bilateral semicircular canal dysfunction, all, pretty much all frequencies with sensory hearing loss looks very much like a cochlear vestibular problem. Very likely non syndromic because no other syndromic nystagmus was absolutely fine. And when we chat typed the gene, this was a MYO&A mutation, which if I'm not mistaken, I think it's DFNB2. So you figure out that this is a DFNB2 mutation. That's a MYO7A mutation. So next I come to ontological disorders. Now this is the aetiology is resembling the adults, but the presentation is different.

So you can have infective inflammatory lesions. A more very important is autoimmune, your disorder. You can have auto toxicity, traumatic third window disorders. You can have endolymphatic hydrops BPPV, but they're exceedingly rare, you hardly find them, but they're always secondary. And you get metabolic conditions for diabetes, melitis, thyroid disorders, et cetera, which lead to some kind of vascular syndrome in terms of hyper viscosity, which deprives the vestibular end artery oxygen as a result leading to hypoxic vestibular damage, but they also affect the cochlear as well. So they lead to hypoxic or ischemic cochlear vestibular damage. So all of our vestibular patients where we obviously find a vestibular problem, will have to do these tests in order to figure out the cause.

And acute vestibular event, is it the same as in adult? No, acute vestibular viral neuritis, it's much less common. If there is a vestibular event in a child which is acutely presenting, there is usually a cause. It could be inflammatory, it could be infected, but not the ubiquitous by default viral neuritis, which you would find frequently in adults. So I've given you the different reasons for an acute vestibular event. So there are quite a few, including a sickle cell crisis might present like an acute vestibular event. And I have unearthed myeloid leukemias from my clinic following an acute vestibular event. So can you imagine a blood cancer diagnosed from an vestibular clinic because of decompensation. And the phenotype is characterized by a sudden onset of dizziness with or without hearing loss, followed by a near total recovery.

Now this recovery is very, very different from that in adults. In kids the recovery is more quick than in adults. And in adults sometimes you'll find yes, I started to get back to my feet in three days, but my problems lingered for weeks and weeks and weeks, classical. In kids two days back on their feet as if nothing has happened. And this is once again because of cerebral plasticity and an OME can generate either an acute phenotype or a chronic problem due to ionic alterations. But OME by and large it is not very common for OME to produce vestibular weakness. There are many papers who say otherwise, but at least in our series, an OME unless complicated with CSOM later on does not generate vestibular hyper function.

It might, but it's not common. That's in our experience. But literature says otherwise. The next spectrum is recurrent vestibulopathy RV chronic presentation. Now this is where the child decompensates due to a factor and it's our job to figure out why there is decompensation. So this is dizziness mainly on provocation. For example, exercises, stress, anxiety, a medical illness, a common cold, et cetera, et cetera, et cetera. It can be frequent, you know, but they're usually short lasting. They usually are accompanied with visual vertigo. We are challenging visual environments. For example, light in a very bright store, a superstore where the child will be unable to go or will avoid to go

because the lights hurt eyes. So not exactly a photophobia, but essentially this is when they feel very intensely disorientated when they are presented with a challenging visual surrounding.

And it's very important to diagnose that definitive compensation, they do lead to a significant limitation restriction in life. And if you're thorough in your investigations, you will not stop at just quantifying a vestibular weakness. You will stop to figure out a cause of decompensation. And I can assure you, as I said, if you follow the algorithm which I showed you before, you'll pick up varieties of medical conditions for the first time for your clinic and these and the vestibular problems can be treated very imminently, plus if you find a physical cause you treat the physical cause as well. So you need to liaise continuously with your colleagues because obviously if I pick up an autoimmunal disorder, that's beyond my comfort zone, right?

So I'll liaise with my rheumatological colleagues and they need to know why you are referring to them, so that's why it's very important that you engage them right at the beginning. And the whole thing you know, does it lead to a 3PD like syndrome? Now to be very frank, 3PD is very new. Of course in adults I've seen it. But in 3PD in children, although there are not plenty, there are publications which say that 3PD in children can happen. In our experience, maybe I've seen one or two, it doesn't happen because they are very quick to come to you, number one, not quick means they need to be picked up very quickly when they come to you.

But I have seen kids coming to me after five, six years, no diagnosis given. Nevertheless, even then what happens is because of cerebral plasticity, it doesn't go to the 3PD stage. But yes, I have seen kids coming from cans with a vestibular problem. I would say it's not common, it can happen. So inflammation, infection, so phenotype can be acute or chronic. Different bacteria and virus, spirochaetes include syphilis. Autoimmune ear disorder can be syndromic, which is a systemic connected to

disorder, or it can be specifically non syndromic only limited to the inner ear and it may extend to a vestibulopathy. Example, this child came to with an acute imbalance, joint pain, hearing loss, almost overnight. Seen by pediatrics, strong visual vertigo.

Whenever the child was trying to move the head they were difficult. Walking was with support, had to hold onto mom's arm, very difficult to ambulate in the dark. So very clearly some vestibular problem going on. And inherited this child I think when an inpatient referred to me by my neurological colleagues. Was admitted under neurology. As you can see right-sided vHIT is completely messed up, right-sided cVEMP is cross asymmetry with the left side according to our lab norms. And this was the eye test which we picked up. Just wait for it. That's a head heave on the right, nothing on the left. See that very clear movement had raised inflammatory markers, severe SNHL on the right first steroids and then vestibular rehabilitation with excellent outcome back to square one.

But now being diagnosed with juvenile rheumatoid arthritis. Once again the diagnosis was from us. Example of infection. Child with treated external artery canal, sarcoma with proton beam three years back roughly. Presented in acute sensor and hearing loss and severe dizziness, after three days complete recovery and started going back to school after four weeks completely asymptomatic from vestibular aspect, because that happened was sent to me and we found out a left-sided vestibular hypofunction, no cVEMP and of course vHIT was positive. And when we also scanned this young person, we also found that there was a superior semicircular canal under labyrinthitis because of the proton beam. So the proton beam actually precipitated or made the system vulnerable to the system, thus did not require any kind of rehabilitation.

Space occupying lesions. Of course they can be acute. Now commonest CPA turmour is vestibular schwanomma but not the classical that is usually associated with NF2. But I have seen all sorts, I've seen meningiomas and angiomas as well. Other important

ones which sometimes can play up and they might sometimes be reported as incidental for example, arachnoid cysts, epidermoid cysts, granulomas and very importantly cross arterial compression which is vestibular paroxysmia. So the artery presses on the vestibular cochlear nerve generating vestibular paroxysmia where hyperventilation test is positive by the way, and arteriovenous malformation. Malignant tumors are quite uncommon but they might happen. And different types of vestibular phenotypes which we discussed before, and the space of violation itself maintains the vestibular decompensation.

So this is the nystagmus which I showed you before. This was a child with acute presentation, lower six cranial nerves knocked out, immediate scanning and a huge artery veal formation as you can see pressing on the vestibular cochlear nerve bundle and the lower six cranial nerves. And the right side was completely messed up, severely deranged. And this kid was rehabilitated with two things, not rehabilitated treated. One was for vestibular paroxy mixed spells which came after the acute event. I give him carbamazepine and his dizziness was completely gone, because remember vestibular paroxysmia is a neuralgic pathology, just like trigeminal neurology and carbamazepine works very well, and then we subjected him to vestibular rehabilitation after he got... After his tube AVM was debunked with stereotactic gamma knife, and he's doing quite well as well.

Although the poor chap, his swallowing still hasn't come back and is spec fed. Ototoxicity is a huge topic, I can't cover everything but it's a significant problem in children. And this is important because childhood malignancies, one of the most important drugs is cisplatin, and cisplatin is significantly vestibular toxic in about 40 to 41% of cases, not as much as carboplatin with carbamazepine is about one to 2%. So the range of vestibular toxicity in cisplatin starts from 15 to 40, so it's important. But how many times do we actually check the vestibular system? But thankfully in Alder Hey we do them. So these are the different medications which can cause vestibular

hyper function, they can present acutely or they can present with a recurrent vestibulopathy like picture once they get decompensated.

One important consideration here, Ototoxicity is always bilaterally symmetrical unless there is a cerebral tine angle tumor which is pressing on the vestibular cochlear nerve. So if you get an asymmetrical hearing after cisplatin therapy, then you can bet that the tumor was in the posterior fossa. Otherwise, everywhere else cisplatin will generate bilaterally symmetrical hearing loss and that's very, very important because I have seen reports where there is a unilateral hearing loss following cisplatin therapy attributed to the cisplatin therapy. That's a wrong inference, it has to be both unless the tumor itself or whatever the pathology itself is physically compressing the vestibular cochlear nerve. Different genetic risk factors including cranial radiation, so radiation and ototoxicity, ototoxic drugs, they potentiate each other and it's very important that we keep on monitoring these kids.

Typical example, child with severe unsteadiness after second cycle of cisplatin for medullablastoma, I think that was an adrenaline medullablastoma developed a SIOP 2. The Boston of toxicity scale hearing loss, which is six kilohertz on was loss. We put this child on ototoxicity rescue, which is a cocktail of anti-labyrinthine medication. So cine beta is still in different combinations to take out his dizziness. But remember you should not use these medications for a long time, it's purely a stop gap. Long-term use of these medications, which is ubiquitous, is completely not recommended and condemned because they may suffice with central vestibular compensation and this should not happen in a child, it's just to give him some symptomatic relief for the first few days.

He was left with record in vestibulopathy affecting childhood and excellent results with vestibulopathy rehab. So as you can see, six canals knocked out, no cVEMP. Trauma is very important, and the important thing is frequently a labyrinthine injury gets ignored

after a head trauma. In the grand scale of things, adult or pediatrics, if there is a hit to the head then people or medical professionals are very involved with feeding the brain injury, the traumatic brain injury or other skeletal injury and as a result, the small organ, which is an about magnificent organ, our vestibular system gets ignored. But it is not uncommon or not infrequent after a head injury for the vestibular system to be affected and 25% of them remain undiagnosed even after five years they're still not diagnosed, because they don't get sent.

So there can be two types of low direct or acceleration distillation injuries. They're often missed, they're often not diagnosed properly. It has got a huge legal implication as well. And of course implications to lifestyle. The important thing for us to understand is the force of the head injury. The actual, the inertial mechanism of the head injury is not related to a vestibular damage. So you can have a very simple trivial blow to the head knocking out the vestibular system, or you can have a child with a Glasgow coma scale of five out of 15, unconscious incubated where the vestibular system is failed. It can happen in these two extremes, but usually it takes some amount of force to upset the vestibular system.

Different legacies. So what does the trauma lead to? Chronic vestibular syndrome. If you see a child with a BPPV in your clinic, you've established a BPPV in a child, then you must find out why. And usually trauma is the commonest implicating cause. But it can also happen in childhood and lymphatic hydrops, not many as endo lymphatic hydrops. It can happen in instances for example, where the auto corneal particles are freely floating. For example DVA enlarged vestibular because of general enlargement of the end lymphatic space. So BPPV of the idiopathic variety in children is extremely rare. If it happens usually after a head injury. You can get a vestibular migraine, vestibular processing syndromes, post traumatic meniere's, once again meniere's is very uncommon idiopathic meniere's disease, is very uncommon in children because of the way the trivascular behaves.

So it's very uncommon. It's usually secondary. Traumatic third window lesions for example, perilymph fistula, semicircular canal dehiscence, isolated otolith damage, which my good friend and colleague Leonardo Manzari has taken the lead. And indeed I met two wonderful guys in Dubai in IFOS, Matthew Sue from South Korea and Tosh Morofishi from Japan. They were the first to propose this entity and I owe it to them that now we pick up more and more and more of these conditions, especially after a head injury. So if you're assessing someone with a head injury and not doing VEMPs, you're not doing the right thing. You might have completely normal everything but symptoms and you have to do a VEMP and of course you can get a complete transaction of the vestibular nerve.

This is an example, trivial injury child trying to reach something from the fireplace and then fell and hit the back of his head. Was dazed for a little while, but the parents are very astute took the child straight to ANE, ANE observed him for a while and everything was completely hunky dory. But then what happened was he ended up having a school entry screening, hearing test, and lo and behold, one side the hearing was not present, dead. We did vestibular function test, no symptoms by the way. And you can see that this was an anterior canal sparing vestibular impulses. Now I believe last time my colleague and friend Andrea Castellucci was talking about canal sparing vHIT.

Anterior canal sparing vHIT is found of course in ototoxicity, especially following gentamicin, not as much as cisplatin, and it can also be found in head injury. There can be a number of reasons proposed, but I'm not going to go through them. So this kid had superior semicircular diseases following trauma as well. So this was a head check which we did and you see the check comes up clearly with nystagmus. So no intervention needed, then why are we doing it? What's the point? Someone asked me if the child is asymptomatic, why are you even doing this? Well, if there is an obvious history to tell you that there could be a vestibular problem or a labyrinthine damage, it

is crucial to find out whether there is a weakness because that will lead you to do what we call a situational counseling.

Situational counseling means you have to warn the parents and the child of different provocations which he should avoid because that will decompensate the system completely. So it's a modification of lifestyle that he has to adopt. At the same time, you'll have to mindful that you do not take away his childhood. It's not easy, but it can be done very, very imminently. That's what the point is. Third windows, we have picked up about 75 third windows in our clinics because you need a very, very low threshold and the phenotype is different. They do not have the same phenotype as that of adults. If a child is able to tell you, they'll tell you what conductive dysacusis and misophonia.

I can't stand the breathing of my friend besides me. I can't stand people eating in front of me. Pulsatile tinnitus, I hear a beep which beats my heart. Hearing loss ranges from conductive hearing loss to Franken sensory hearing loss and vestibular assessment will show a VEMP abnormality. But this VEMP abnormality doesn't have to be necessarily a high amplitude low threshold. A VEMP abnormality may be an asymmetrical VEMP. You might not even get a VEMP response because in case third window disorders actually physically affect the otolith system. So if the saccade is not working properly will not return VEMP signal. So you get all different kinds of combinations and that's why it's important to make the call in a child in a completely different way.

The commonest is enlarge vestibular aqueduct and they usually generate because the symptoms are so in a way exotic and strange that they generate a very significant emotional reaction. In fact, a few commissions that I've mentioned before that I got from mental health services are actually third windows. I had someone who was very fond of singing in the school choir, but to the person's horror found that can't do anymore because the child's own voice was so distressing to the child, said that to everyone. Everyone said this doesn't happen. What do you mean you can't hear you?

You don't like your own voice so you are making things up. No one really cared. Finally ended up in emotional wreck, avoided school, withdrawn, ended up with mental health.

Mental health, had a human to send them to us and we kind of detected a bilateral posterior semicircular canal aplasia and we have actually published it in frontiers, and remarkable response to surgery. One of my colleagues from down south from London actually treated this young person. Different kind of third window examples. The ones in yellow, they are happening in children or they actually have been picked up by us in our lab. So I'm not going to go through this in detail, I don't have the time, but these are the different third windows that you can get. Example, this young person presented with autophony, misophonia and disequilibrium, very disequilibrium, very strong emotional reaction. Had a vestibular left-sided vestibular hypofunction.

See the mixed floss here very clearly. Excellent results with CBT we have to do CBT and vestibular rehabilitation. This case no surgery was needed and as you can see that this had dilated and this is actually official north canal basis, which you not clearly, which you can't see and the hugely dilated internal meters in this case we have also published in frontiers. So both these as I said, are quite uncommon, right? And usually they present with normal vestibular function, test battery and the difference between and why the classical idiopathic meniere's disease, which is MD. There's a distinction between MD and MS. MD is meniere's disease, MS is meniere's syndrome. Meniere's syndrome is secondary enderichydrops, meniere's disease by definition is idiopathic which you find in adults.

And these are the different reasons that children, adults behave as far as pathogenesis is concerned, it's to do with triavascularis, history is not very forthcoming, and it's almost always secondary and usually progresses over a period of time. This I was lucky, I was lucky because I first saw this young person and made a diagnosis of probable MD as prevented by Barany's criteria. And then I asked the local place to do a

hearing test and there was a low frequency since hearing loss. So I converted it to a definite MD. Now when I saw this person, the person was unsteady and dizzy, I did VFT it showed a mild left-sided weakness. Only I could find out some head shake abnormality, vHIT was normal the hearing loss, LFHL.

There was one instance where the hearing dropped suddenly came to me and I successfully salvage it with steroids. So there was steroid responsiveness. And then I suddenly get a call from that that my child is very, very dizzy. I have videoed her eye movements. Would you mind having a look? This is by a normal handheld mobile phone, this movement. So the movement actually had the whole child on the bed. I'm not showing you because of anonymity. I have taken permission for this, just showing the child's eyes. This was what I saw. This is the only instance in my life in an adult child when I actually got someone during an acute spell. Very clearly see. Severely dizzy with this, roaring noise in the ears and complete blockage of the ear.

This person has responded very well to the first line of MS with diuretics and with a betainehistic. And this person is actually on the cards for an intra panic steroid. So this is once again an autoimmune ear disorder because ESR was raised when I checked. Now I'm about to start the ball rolling to figure out whether there is a systemic autoimmune condition. But luckily the person is symptom free. So the balance disorders in pediatrics is literally a huge spectrum. Now so far we have covered the peripheral vestibular system, but pediatric balance incorporates central and peripheral vestibular system, and this is a central beat. So as you can see there are so many conditions which can present like a vestibular phenotype, dizziness, lighted-ness, unsteadiness, difficult balance, so on and so forth.

So all your test battery is basically geared to exclude or to confirm either a central or a peripheral problem, or it can be a mixed problem for all you know. And that's why it's very important to take a full history because history in central vestibular disorders are

different from that in peripheral. History is important followed by your vestibular quantification. Once again, inductive reasoning at the end of your test battery you'll be in a position, believe me when I tell you this, you'll be in a position to accurately say what is going on. And that's the beauty of pediatric vestibular medicine. In most of the instances you can make a diagnosis, you can figure out a cause that idiopathic pediatric vestibular weakness is not as common as known vestibular weakness, or vestibular aetiology.

So different kinds of causes, HA7, hypoxic ischaemic encephalopathies, neurodegenerative conditions for example multiple sclerosis and all those things. Any brain disorder can actually present with some kind of a disorientation space. And why not the brain integrase information, doesn't it? So variable neurological features you can present with movement disorders, you can present with dizziness disorientation. And very importantly if a dizziness actually improves with eye closure, you can bet it's not vestibular. But the difficult bit is to figure it out to actually make the child tell you that this is happening. Fainting episodes you might have fainting episodes which is classically central, but person with a vestibular peripheral vestibular disorder will never, never faint. Positional dizziness, you know, navigational difficulties may be a part of central as well as peripheral, usually peripheral, but it can be mixed.

So quite a few things can happen. Vestibular migraine is commonest, sometimes very difficult to fit. Barany's criteria will have to depend on what parents are telling you, and unfortunately it's a simple condition but it proves to be a real bugger in terms of life, quality of life. They mess up the child's life completely, which means they can't go to school, avoidance behavior and before you know, it goes to a point of no return. Variable vestibular function test results both peripheral and central signs are encountered, and it may coexist with an endolymphatic hydrops and BPPV. So in other words, vestibular migraine can predispose to either ELH or BPPV. This is a mechanism

which I'm not going in any detail, but you know about the different nuclear, especially the trigeminal pain path pathway and the cortical spreading depression.

So it could be vascular at level of the vestibular nuclei. Different types of vestibular migraine in ICHD-3. So cyclical vomiting, we get frequent referrals, abdominal migraine. Some of my vestibular migraine kids also have abdominal migraine. VPV benign paroxysmal vertigo of childhood under age of four years, and benign paroxysmal torticolis is recently Barany has published criteria on vestibular migraine in children. Example, child with an acute dizzy spell followed by recovery where persistence of episodic spells lasting for hours with classical photophobia, phonophobia difficulties in quick head movements, very severe reduction in confidence. Star hockey player can't play hockey. So as you can see, vestibular function test is completely normal. But this is what I found on VNG, not very carefully.

This is with optic fixation. You see a very clear upbeat nystagmus. Now possibly I'll have to cut it short because what happened was when we took away the vision, this was on removal of vision and you see it exacerbated and not only that, there was a gazebo element to it. So bizarre kind of central science, and that with the complaint led us to diagnose a vestibular migraine, change our life completely with propranolol. That's the beauty of diagnosis. You put the smile back on the child's face. And remember when you are treating a child, you are treating the parents. I mean many of you are parents. How would you feel that your child is going from pillar to post banging our head, diagnosis not being done, no life, missing school, missing friends, missing playground activities.

You give them a diagnosis, you start treating and they get better. How do you think you'll feel if it happens to your child? Got forbid it won't. How do you feel? How would you feel? So that's why vestibular medicine in pediatrics is so rewarding, that sometimes I wonder that it's worth that I have become a doctor. Honestly, I can tell you

it's absolutely, I get different kind of reactions once the children get better. It ranges from weeping, crying, giving me a hug, smiling, getting presents for me, which I of course can't accept. So getting a phone from the school and that's what we are here for, right? Making lives better. We are not saving lives here.

No. We are not like you know in an intensive care unit, but we are making lives better, which is good enough for me. Example one neurological. Child with undiagnosed proximal myopathy, severe ataxia, positional dizziness that somewhat sounds like a BPPV. Feels better in the dark, not vestibular. Frequent falls, tinnitus, auditory processing problems, chronic symptoms also had migraine, also had migraine. Vestibular battery completely normal. But when we did the eye test, look what happens. Central gaze, nothing, but huge gazebo nystagmus and the rebound phenomenal income takes the by back to the central. So that told me this is a vestibular cerebral problem. Now with all those eye movements, you can be very specific where the lesion is.

You can tell that this is in the parapantan nuclear formation. This is in the interstitial nucleus. This is in the red nucleus, this is in the cored nucleus. This in the inter cortex. Your eye signs will tell you, and I would be very happy if you can join me when I take you through different eye signs. At least 40 of them in my next lecture. So please, please, I would be delighted if you can join me, you'll understand what I mean. So this is one of them. And what was the diagnosis? We treated the vestibular migraine brilliantly with pizotifen, partial response to vestibular rehabilitation ataxia slightly better, but central vestibular regions do not respond that well. And that's why we are still continuing but much better than before, at least not using the wheelchair anymore.

What was the diagnosis by the way? So cerebellar ataxia, right? Which is kind of shown objectively. So the next step is of course we'll have to do some special scans. We did scans and the scan was normal. So we were thinking is this some kind of a

genetic condition, which is so subtly it doesn't show up on a scan, but we'll only show up in the eyes. Yes it was, we got in touch with our genetic colleagues, which is we thought that it sounds like an episodic ataxia they agreed, this was an episodic ataxia with mutation in the CSEN1 gene, which is a calcium channel gene that leads to all these different cerebral things and very, very kind of... He's now being counseled by the genetics team and I think my neurological colleagues are also looking into his symptoms as well.

Now obviously I don't know what kind of medicines they're using as yet. So you can imagine once again that sheer amount of wealth of information that you get from a vestibular clinic. But what is my point of showing you all this? Look, we are foraying, we are journeying beyond the vestibular system. You'll have to know your central vestibular system. In other words, the brain like the back of your hand. Otherwise you'll never have the insight to make all these diagnoses. And I agree this doesn't come overnight. You'll have to specially train in pediatric neurology.

You'll have to train in pediatric eye movement disorders. We spend a lot of time with this when we were training. So in order to develop the insight, you need the training. So second neurological disorder example, child once again with ataxia vestibular function normal. Once again, positional dizziness. BPPV tests were normal. Neurophysiotherapy fixture. But what you can see is normal weight low VOR again, which I think is clinically insignificantly, but she could hardly suppress her vestibular reflex. It's a shimp. And you don't see any saccade because she can't suppress her VOR. We did the VOR cancer test. You see that's when you put two fingers in front of your eyes and rotate the chair. You should not see saccades, but this kit came up with beautiful saccades.

This should be smooth. Diagnosis cerebellar demyleination diagnosed from this clinic. One second presenting with Barany's Criteria of migraine had hydrocephalus. So a programmable shunt was put in, did all the possible vestibular function tests.

Everything was normal except a slight low peak seconding velocity in machines. But eye movements, look what happens, nothing on spontaneous gaze. But when you are looking up, you see there's a bizarre nystagmus appearing. It's almost like an upbeat nystagmus and there is an ocular in the upward gaze. So this is a classical symptom, classical syndrome which we call paranal syndrome. And this is because of a dorsal midbrain lesion and eventually it was found out to be an stenosis of the aqueduct of Sylvian that led to the hydrocephalus.

We don't stop there. We have done vestibular, vestibular peripheral and central. But there are other causes for pediatric balance disorders, right? Cardiovascular disorders, lightheadedness, metabolic disorders, musculoskeletal disorders, ocular abnormalities especially convergence. And the last bit is psychogenic. You'll find many, many, many papers, plenty of people telling you psychogenic dizziness in a child is common. I would beg to differ, it is not common. The reason being, if you are thorough in your approach we will find out a course. You'll call something a psychogenic when you exclude other causes, right? In vestibular problems or balance problems in kids, you usually find out a course. So yes, it is there but it's not common. So I would beg to differ.

And very importantly, for kids who come to you with falls and trips, there might not be vestibular, there might be musculoskeletal. Discrepancy leg length, unequal leg lengths, one, two, tele three, genuine, four axilla, five scoliosis. These all mess up with perception leading to falls and trips. All you need to do is to identify and send them to the correct physiotherapist, not vestibular physiotherapy, muscular skeletal physiotherapy. Of course, in some instances you have to do the vestibular tests. So we have finished now aetiology, a very brief word about management. First is diagnosis. The process is very rigorous. Clinical test, mobile phone, history can also make you do the diagnosis. Not essential, you get very, very Sorry. Sophisticated lab results.

customized vestibular rehabilitation depends on your tests, lifestyle changes, pharmacological intervention treatment. So you'll also have to find out a cost for central decompensation. And correct diagnosis and management that's key. That's why it's in yellow, leads to a most favorable outcome and that leads to a significant improvement of quality of lives. This is a complex algorithm. So you get different kinds of vestibular disorders when it's idiopathic, when it's cause found, it's pretty much symptomatic treatment plus different kinds of approaches. Let's see them one by one. Cognitive approach. Very important, possibly one of the most important bits, you'll have to achieve some closure. These kids and parents come to you after some time, no diagnosis, you tell them what's wrong and what you can do.

That will lead to a cognitive wellbeing in the child, that will lead to cortical endorphin release that will make the child feel better. In other words, simple promote compensation. You are addressing the uncertainty. I can't stress how important this is. How important is it to make a diagnosis and tell your kids and their parents what's going on? Because remember, sometimes even the parents don't have a life and how many times my colleague will vouch for this as well, my colleague does the same thing as I do. We see these parents and children who break down once we tell them what's going on, and you see the results immediately. So the cognitive approach is absolutely crucial to improve.

Once again, we are pouring into holistic medicine, right? We are not here just to pick up an abnormality in a vHIT or a cVEP or a very, very wonderful, let's say a fantastic periodic alternate nystagmas indicating a problem in the interstitial saccade, we are not doing that, we are doing beyond. We are treating the child as a person, we are telling the child what's going on so that you develop self coping strategies and you get a feeling and appreciation what is going on? What can I do? What can be done? And I'll be positive. That's why looking or diagnosing into vestibular problems, well it's not as time critical as a cancer treatment or a surgery, no, but it's still time critical because the

longer the child suffers for this, the difficult for us to apply this cognitive approach effectively because the thing is ingrained, we call this a cognitive latching effect.

So that's why I'm taking such a long time to explain this. This approach is absolutely crucial. And yes, we have been trained in pediatric psychology as well. So the way a person reacts to an illness is different. There can be an ambivalence. Well, it has happened to me so what? One is denial, nothing has happened to me. And one is objective, yes, something has happened to me. Let me appraise the situation, seek medical help. There are three different types and it very, very, very well depends from person to person. For example, if I get a common cold, even if I don't get a fever, I'll be taking an off sick for two or three days because I'll be having the classical man flu.

If it happens to my wife, she'll carry on exactly the same way, right? So the way we react to our illnesses is very variable and you are actually capitalizing on that one. The next is lifestyle changes, which I said it's crucial to make a diagnosis so that you can execute situational counseling and teach the child how to live from now on. Very importantly, you'll have to factor in one important fact. At all times you must be mindful that you are not asking the child to restrict in such a way that childhood activities, the activities with which a child grows up with which nourishes his brain, which leads to his development distortive. I'll give you a simple example.

I had a child who was anorexic. Now that child was living on chocolates, had vestibular migraine. When I said that you have to come out of migraine immediately the pediatrician told me then, how are we going to maintain this child's nutrition? Close calm. I treated a child who is a keen martial arts person, in fact almost a champion. That child had bilateral enlarged vestibular aqueduct When I told that child, sorry, you can't do this anymore because after all head trauma, he burst out crying and he wouldn't talk to me. So what do I do? It's a very, very difficult and close call. So you'll have to strike somewhere in the middle and this will come to you over a period of time.

So you'll have to be very mindful. You are not taking over the child's life. That's very, very important. So you see, once again, I'm trying to stress the point, practicing pediatric vestibular medicine is not just the inner vestibular system, it's very much the child. Please, you know, try to build this into your ethos, your philosophy of approaching children, that I'm not just as your a vestibular physician, I'm here to make the child life better. And of course if the life is bad due to the vestibular system, you have to treat the vestibular system, that's a given. But overall you have to address plenty of other things beyond the vestibular system. So situation of counseling is very important.

Quite a few I've put there, and you know I'm not going to discuss them in detail, but they're quite intuitive and they're quite, quite simple to understand. Pharmacological intervention, there are a few instances where you can actually use drugs, but generally drugs are avoided because they mess up with central compensation. So you can use it in acute vestibular events, vestibular migraine, you can use one drug after the other. Vestibular paroxysmia, meniere's syndrome, cyclical vomiting, travel or motion sickness, which is an auto cortical mismatch, or even otolith semicircular mismatch. So all these things can be done. Now one thing which must be avoided is an umbrella referral for vestibular rehabilitation. So a child presenting you with dizziness, regardless whether you do the test or whether you actually physically demonstrated a problem in your tests, you send them straight to vestibular physiotherapy, which frequently happens in adults.

That's a completely wrong approach because remember vestibular rehabilitation is not invasive, absolutely not. It's not like surgery or medicine, but there can be complications. What are those complications? First complication is because it heavily capitalizes on cerebral plasticity, the brain might be fatigued. So if you are driving a child who's already cognitively challenged with vestibular rehabilitation or even an

adult, then the brain won't be able to take it. And that's not nice. So you have to be very choosy and selective where you are absolutely sure it'll work. But when you have decided it's going to, if you can prescribe it, then it works like absolute magic. It changes the quality of life of the child completely. And the outcome is of course measured by pediatric psychometric vestibular questionnaires like the Vanderbilt Dizziness Handicap Inventory of the Pediatric Berg Balance Scale.

It should be instituted early because at that time the cerebral plus cerebral cortex is most robust after an assault or a damage to establish new synaptic and neuron connections that not delay the system gets more saturated, so it's earliest as possible, not often possible though. And if there is an active medical condition, for example in the vestibular system or otherwise, like a vestibular migraine, vestibular paroxysmia and then vestibular rehabilitation is not the right thing to do. Initially you'll have to treat the condition first with medications or whatever. And then if there is residual vestibular weakness with record and vestibular you go for vestibular rehabilitation. So the point is it should not be prescribed as a blanket kind of a thing in everybody, you'll have to be selective.

And I've seen so many instances where nothing has been demonstrated, just dizziness, straightforward vestibular rehabilitation, that's not the right approach according to me. So different kinds of vestibular rehabilitation techniques. Of course I'm not going to detail them because it is separate, super, super, super niche subject, pediatric vestibular rehabilitation, they are very, very, very few centers in the world. And one of the top ones is Dr. Jennifer Christie, who's a good friend of mine from the University of Alabama in Birmingham who comes and teaches in my course, who has taken it to a different level altogether. So I'm going to show you two different videos of improvisation. Once again, improvised, improvised. You saw Beethoven Fifth played by the genius in the guitar, right?

So once again improvise your vestibular rehabilitation play with the child and that's what you need to do. So just have a look at these videos, how we play with the kids. This is done by my two colleagues. One of the second video you'll see happened to be my resident and the first one is someone I work closely with he lives in Manchester. So the first video.

- [Voiceover] Snuggle up with your child on your knee with a book with pictures. There will need to be some smaller details in the pictures to pick out, for example, animals or colors. Bounce your child up and down on your knee whilst asking them to point to certain colors, animals or pictures on the pages. To make it harder you can make the target pictures smaller, or move around more with the bouncing. If your child likes games on a tablet, you could use this instead of a book. For older children, they can bounce sitting on the edge of a sofa, or on a space hopper whilst playing spot the difference or wears Wally.

- [Voiceover] Sit your child on a towel on a smooth floor, pull them around on a towel ride. The aim is to stretch and upset their balance just a little so that they can practice correcting. You can make it harder by making the ride a bit faster or making the journey a bit more wobbly. Take care with safety here to prevent any bumped heads by watching how your child is managing at a slower speed first.

- So as you can see there, these are improvised. The first one is gaze stabilization and the second one is reinforcing your vestibular integration. So these things work and the kids just love it, but you'll have to devise your own. And Jennifer is an absolute genius in this because she devises all this beautiful play techniques which are so important. So as you can see it's not the same as that of in adults. Of course, you know you might do surgery, you might move up to move particles in BPPV and comorbid medical conditions which you have unearthed as a result of your investigations, which are

maintaining vestibular decompensation, they can be treated as well. And of course cochlear implant in a severe profound hearing loss leads to a significant improvement.

And that's very strange, you know vestibular function testing in a congenitally deaf child, and you see the vestibular function is all completely over the place, right? And there is motor development and delay and so and so forth. Then these child undergoes a cochlear implant bilateral, you repeat the tests, they haven't changed. But the child's subjective balance has just improved beyond, beyond belief. And the reason being, although the vestibular function itself doesn't compensate the level of a osteo nuclei, but this cochlear implant delivers sound actually nourishes the Vestal cortex. And this has been replicated by many of my colleagues all over the world. So it's just that in the angular region when the vestibular cortex and auditory cortex come close together, there's a lot of connection between the two.

So one actually nourishes the other. In fact, for neurodevelopmental condition, you can use vestibular physiotherapy for autism, vestibular physiotherapy for autism is now slowly coming into being, how? Because the same area in the cerebral cortex, they kind of mutually feed each other. So please think about this, that this is a very interesting new angle or new research topic, very much multidisciplinary. You need to factor in everything, what I've written here. Music therapy is a good way of vestibular rehabilitation and you need so many people in your team. So it's just not me, it's many people around me because this system is not easy, it's very complex and unless you engage your colleagues, then you won't achieve the outcome that you're looking for.

So finally, very rewarding, very stimulating, makes my life worth. Makes any vestibular physician dealing with children worth. We have mentioned that repeatedly. It's quite limited. We are trying our best to propagate this and I'm so happy that in many flagship balance conferences we do get a slot. The last one was in IFOS, Dubai, and then there would be one in Belgrade next month, and there's ESPO coming up all of everywhere.

I've been given a slot to present my case just to raise. And you know, I'll tell you something, and this is very, very personal, but I can share with you. Why do I do all this? Why am I so passionate? Of course I do this to tell people just like yourselves and everybody else dealing with vestibular signs that this is very important for us to diagnose.

So it's kind of purely academic. However, a bigger cause is inspiration. Look, when I was training, I was inspired by so many of my mentors. Even now I get inspired by so many of my colleagues. One example is Prof, Augusto Casani. He inspires me. So inspiration leads to a better learning. According to me, if I get inspired by someone, I'm going to follow him till the end of the world and learn from him all the time. And I have really been inspired and learned from so many colleagues. Even now, every conference I go, I learn. The point is, how am I inspiring others? And everywhere I go with these lectures, I get so much response you wouldn't believe.

Young, bright people, residents, consultants, established consultants, they come to me. However, in all my career I had the greatest reward. And if any of you are in my LinkedIn profile, you'll see the picture. This man in IFOS, Dubai was our gatekeeper. So he was scanning our cards before we could enter for CPD. Non-medical person, he worked in an estate company and does this in his free time to earn some money. After I finished the lecture, I came out and I was surrounded by quite a few people and then he came up to me and he told me, doctor, I had no idea that this can be, that there is such a thing as balance in children and I had no idea that it can be treated.

You have opened my eyes, I feel inspired. Non-medical person doesn't have a clue about what the vestibular system is. I've managed to inspire him and that I can tell you is one of the greatest rewards in my life coming it from him. So it's very important that you not only carry this with you to everybody you know, but also try to inspire them to do what you are doing. And that's where your life as a teacher is, comes to a full circle.

I hope I have managed to convey this feeling to you that it's just not listening to someone, it's getting inspired by him. And today, after all this, and I think there are quite a few of here, if you get inspired by what I'm telling you, then that is the biggest indication of this lecture organized by Inventis.

Different norms, different phenotypes, and it's a very, very intense process leading to intervention which makes a significant difference. And it's very, very multidisciplinary, and the other thing you must remember, medically inexplicable symptoms may be due to a vestibular disorder. So if no one can do anything, if they come to you, we can manage to find out a vestibular disorder. Not in all cases, but in quite a few cases. So you are more than welcome to come to my course, which I organize in Alder Hey in Liverpool. It's a beautiful city, it's very historical and it's got Beatles and it's a wonderful football team. Although I must say this publicly, I'm Man United, that's our vestibular lab on the left.

But this course is for two days with international faculty who come and enrich our course, we get a significant number of delegates. So please get in touch with me, you can have my email from Inventis and get in touch with me and keep a track. Our dates are not yet finalized, but it'll be, it's also done with the University of Liverpool. And lastly, my final video of the day. This is a girl, young teenager, dancing to a ballet. Just look at her balance. This is what we want our children to be, this kind of balance. One disclaimer, please, please don't try this at home because you wouldn't be able to do it. So that ladies and gentlemen is the vestibular system in all its glory and that is a magnificent thing. So I conclude here. Thank you very much everybody, and I'm more than happy to take questions. So Anna, if I might ask you, how do we do that? Do I just go to the questions?

- I'm here. First of all, I just want to thank you very much Professor Dasgupta for your presentation. An outstanding learning opportunity, more than a learning opportunity let

me say, this lesson is a source of inspiration and further curiosity I will say. So we can start with the question now. So please a professor open the folder question from your screen, from go to webinar panel and let's start.

- Just, there's hardly anything. Sorry, my desk screen doesn't... I mean, I can't see.

- I can see one question Professor Dasgupta.

- If you want---

- Oh you sorry, sorry. Yeah, I've got it. It's just that you have to scroll down, yeah, yeah.

- Perfect.

- You scroll down here. I'll just scroll down. Why isn't it happening? Okay, let's see. Okay, let's have a look. Sorry Anna, this is not working. I mean, I can't get the questions. Can you read them to me if you can see. You can just read them to me please.

- Of course. So the third question from Mr. Ortiz. I dunno, to be honest, the clerk. Audiometric or vestibular examination is known to be time consuming. How much time do you take for a proper vestibular examination of children, and how is it organized with multiple session?

- Okay, very good question. So when I first came and joined, I was given 10 minutes, but then I fought very, very hard and now I get one hour, 15 minutes for one child, of which 30 to 40 minutes, 30 minutes are reserved for history, 30 minutes for testing, and 15 minutes for discussion. So 30 minutes for testing means I do all my tests. So I do my vHIT, I do my VEMP and everything. So initially, obviously there's a lot of struggle

because you can't do everything. So we try to provide with a one stop shop for diagnosis and assessment. And then if there is rehabilitation, we'll have to bring them back. But originally, but essentially at least one hour, 15 minutes, ideally one and a half hours for one patient. If have practiced, then you can manage initially with struggle, but then it'll fall into a routine and you can do everything in one and a half hours, that's what we do.

- Okay. Thank you so much. Then I can see a lot of congratulations professor. Congrats, congrats. I will surely provide the recording and they are asking to get the recording as well. Absolutely. What is your feeling--

- Oh, there is one more question I can see Anna, and that is... Yeah, I can see it now. I just see it now. What is your feeling of POTS? What is your feeling of POTS? Now POTS is of course a congenital condition. Yes, you would assess the blood pressure I said in most... I mean nowadays I don't usually assess the blood pressure in all because the complaint itself will tell me whether it's coming from the heart or not. POTS as an entity is very controversial. Many people don't believe it. I can tell you that some of my cardiology colleagues, they don't believe it either. Now I will send them for a cardiology opinion when they fulfill the definition of POTS which is fluctuate variable heart rate or pulse rate in lying, sitting and standing position.

But the treatment, I will leave it to my cardiology colleagues because it's not within my comfort zone. I'm not an expert and it would be right for me to treat it. But yes, my feeling about POTS is I think there is something there. But the final details, I leave it to my cardiological colleague, but yes, it's one of the differential diagnosis, absolutely. Right. Next one. Okay, your views regarding Ehlers-Danlos. That's a brilliant question actually, because only the other day I was sent a child by my rheumatological colleague with a family history of Ehlers-Danlos. It's very interesting because mum is

actually walking with a walking stick because of Ehlers-Danlos, and they're looking into the child with Ehlers-Danlos.

Now I physically quantified his entire vestibular system and the only thing which I could find was reduction of peak psyched velocity, which as you know is a sign of compensated vestibular weakness, bilateral reduction of peak psyched velocity. So here there could be a vestibular involvement in Ehlers-Danlos and it has been reported, vestibular system in Ehlers-Danlos, that is audio vestibular system. You might have a vestibular involvement in Ehlers-Danlos because the very essence, the genetic nutrition involving the collagen disorder, that collagen actually is expressed in the cochlear as well as the vestibular system. So yes, possibility and I have picked up a compensated bilateral vestibular weakness and the child did have dizziness, but because his compensated doesn't have it anymore.

So yes, it can happen. That's a very good question and very coincidentally saw that yesterday, or not yesterday, last week. What medication do you prefer as a first choice of vestibular migraine? I use the double vary approach. Propranolol, propranolol, and propranolol. The reason being a, it's not only an anti migrant prophylaxis in a child, but also very importantly it takes away anxiety. Now remember in a child of vestibular migraine association with very, very, very strong anxious element, they're so anxious that lose all their confidence. So if I've got a medication which addresses both, so be it. The next line is... If it doesn't work, the next line is Pizotifen, which is an antidepressant as well. So that works and it works very well with adolescent population because of propranolol being a beta blocker in adolescents, boys and girls, it might not work that well.

Pizotifen does, Pizotifen doesn't work then I go to the, well not magic bullets, but very potent drugs for example, topiramate tricyclics, sodium valproate, flunarizine. So there are lots of choice and somewhere down the line my child will respond. Do you treat?

Okay, so the treatment of vestibular paroxysmia. Drug of choice carbamazepine. But carbamazepine has got a lot of side effects and you need to monitor blood discretion. Recently there has been evidence that you can still use the propranolol in very early stage. For example, we are talking about shabbat. So vestibular paroxysmia due to cross arterial compression is graded by a classification called Shabbat classification, which is grade one, two, and three. Grade one you can use propranolol because the theory is it slows down the velocity of the blood as a result of which, because the blood is not hyperdynamic during a period of stress or anxiety or exercise.

When the paroxysmia spells happen, it leads to a lowering down of the velocity of the blood giving to some tangible benefit. Now I have tried it in two kids and anecdotally it works. But yes, more research needs to be done. So I had a patient in fact who had a vestibular paroxysmia because of Shabbat one along with vestibular migraine. Propranolol has taken up everything it has. So it's a triple mammy with propranolol. So that's your answer, but not for Shabbat two or Shabbat three. There you have to use carbamazepine. Okay, we often see children during puberty. Puberty, are there hormonal changes which influence balance? Well, normal physiological hormonal changes will affect balance if usually in young girls who have attained menarchy, because remember losing a lot of blood during the initial part of periods does lead to iron efficiency, which is a recognized cause of lightheadedness.

So this lightheadedness is when you are standing up from a sitting, it's mainly vascular kind of a lightheadedness. So yes, iron efficiency enemia or any enemia due to hormonal changes because of manilogia can lead to a problem with balance. But by and large, overall hormonal imbalance should not lead to a problem with vestibular system. In fact, today I was asked in my hospital about a thing called a pregnancy vertigo. Vertigo should not happen in pregnancy because vertigo is spinning vestibular pregnancy is lightheadedness, yes, because of the vascular changes. So yeah, normal physiological processes should not lead to a problem. In recent weeks, I had 11 year

old girl affected by vestibular migraine and congenital stigmas. Goo one, now, congenital nystagmus of course, can be picked up with good amount of certainly just by VNG.

Obviously because vestibular migraine is so common, vestibular migraine can affect any child. Now if this child who you have seen has got any additional eye signs and therein I'm opening a can of worms, if someone's eyes are continuously moving because of congenital nystagmus, how or not can be there be an eyesight? You can still have the eye sign. My trick is, and I'm gonna tell you the secret, my trick is a congenital nystagmus will always have a null point, wait for the null point and then try to watch what's happening to the eyes. So if you pick up a nystagmus during the null point, then yes, that gives you a clue to the diagnosis. From the treatment point of view, you would treat this as just as a vestibular migraine with the seven grader approach, which I told you different medications.

And congenital nystagmus it itself of can be treated but that is very much an ophthalmological domain. You know, I wouldn't treat a congenital nystagmus on my own, although I am aware of how to treat it, but I'm not going to treat it on my own because most of my congenital nystagmus is, unless they're associated with syndromes like ocular saccade or anything else, what I would do is these children do very well because the null point sustains life. Null point is very, very well developed. But if ever you get a child with congenital nystagmus and with vestibular problem, you can still do a vHIT. Wait for the null point, do a head thrust when you have the null point and then you'll get very clear cut vHIT.

In fact, I can share a few traces of beautiful vHIT on congenital nystagmus. Yeah, I can do them all. You can do vHIT you can VEMP, you can do a VEMP you can do everything because you are right. You have to exclude other things, right for vestibular migraine. So that's good. So I think that answers your question. All my congenital

nystagmus they undergo the full test. Why we saw such a slow diet in meniere's disease. Good point. I don't suggest low salt. That philosophy has somewhat changed in my books because I used to, but now I think it's hydration, which is more important. It's mobilization of salt, which is more important than low salt. Even in hypertension rather than restricting salt, the fluid intake needs to be regulated because that will lead to a proper distribution of salt.

However, because it's included in the Meniere's diet modification or whatever it is in one of the leaflet which I give to my patients, adults, children it's very uncommon. I would use the low salt, right? But if they forget about it, then I won't push on it. So yeah, low salt is an accepted way and the reason being it prevents from it kind of affects the ionic imbalance, the sodium, potassium, leading to less formation of the endophytic fluid, same as in hypertension. In other words, it doesn't draw water into the endolymphatic space. It prevents it with a low salt. That's the accepted kind of thing. But as I said, it's very important for us to consult the patients regarding proper mobilization of the salt.

What criteria do you have for scanning a child, for example, if they have vestibular? Okay, good. Now, if a child is coming to you with dizziness, either from secondary care or from a colleague, remember one thing, at least this is my series and I think many people would agree, psychogenic dizziness is very rare in kids. A child does not make up a dizziness just like that. We sometimes make up things if we are trying to achieve some other objectives. For example, we can make up a pain. It's hurting. We can make up a headache. We can make up a sprain, I can't walk. But a child usually does not make up dizziness because dizziness as a symptom needs to be accurately described by the child.

And therein they fail because they often can't describe what they feel unlike an adult. So if you get a child walking through your doors with dizziness, then yes, if your

vestibular function tests even one of them is abnormal. If there is any neurological stigma that you have found like ataxia and all those things, in that case I will scan and if it's a clear cut case of vestibular migraine, I will scan Barany's fourth criteria exclusion of other vestibular conditions. How do I know this is not a third window? You know Simon, Carrie said third window is a great mimic and I have seen third windows present exactly with the similar phenotype. I showed you Parino syndrome.

That kid presented to me with vestibular migraine. It's only after the scan that we figured out that there is a mid-brain rosal mid-brain lesion. That kid with ataxia, it was only after a... He was also vestibular migraine. It was only after he presented to me with vestibular migraine that I picked up the CSCNA1 gene mutation. So absolutely I would scan in order to exclude Barany's fourth criteria. I have been branded as being over the top. Not exactly wasteful, but scans are not needed. I insist scans are needed. So that's my answer to you. I would scan them. Yes, absolutely I will. 750 TB. What do you mean by tb? I'm not sure, 750 TB better for VEMP as far as acoustic trauma is concerned.

So I'm not sure, are you asking me that? Do you have to do VEMP in acoustic trauma? Acoustic trauma, there can be two types of trauma. One is well acoustic trauma. I would suggest that you are talking about noise. The vestibular system is far more robust than the cochlear system to withstand noise. I have never seen a single vestibular damage following loud noise. I haven't, number one. Number two is there is only one documented or two documented instances of perle fistula leading to vestibular symptoms of the noise. But generally they don't happen. So I'm not sure what you mean by acoustic trauma because I didn't speak about acoustic trauma. Does physiotherapy have a strong impact on children with vestibular disorders or does it only help with symptomatic management?

It does everything. So of course it's for symptoms, but yes, it improves the vestibular input to the central nervous system. So it's so symptomatic as well as it's actually putting the child back on its feet. So if you're asking me whether it helps in the aetiology, no it probably doesn't, because vestibular physiotherapy is like a medicine neurosurgery. It's a treatment to get rid of the symptoms rather than... And that's why it's so important to find out a cause because that's a different treatment altogether. How can I use vHIT to monitor semicircular canal function with meniere's disease? Oh, that's a good point. So in meniere's disease vHIT can be normal, vHIT can be deranged. Now vHIT will be abnormal when there is an obvious weakness in response to the meniere's.

Now in that case, what you can do is you can accurately use vHIT to assess compensation. How? So let's say in the initial phase when the damage is very well established, you get overt covert saccades and these saccades will be very much dispersed. There'll be more overts than coverts. At least 75% to 80% will be overts and the remaining coverts and they will be dispersed over a large temporal window for example up to 350 milliseconds. As compensation or as treatment progresses. And of course there will be a low view again. As treatment proceeds, your saccades will slowly become clustered. So instead of 350 milliseconds, it'll go down to maybe 200, 150. So you'll get clustered saccades it is a shear shot sign of compensation and your overts will slowly start to disappear, but the coverts will not.

The coverts will still be there. Then you supplement it with a shimp test and in the shimp test you'll find that the asymmetry which was there before that has gone down the peak saccade velocity has improved. That's very important. So the peak saccade velocity also improves when you are getting compensation. So there are quite a few ways just by vHIT. But at the end of the day, I would suggest that objective testing to assess compensation might not correlate with the subjective sensation the patient is having. So do not bank too much on the tests. go by what your patient tells you, which

means symptomatically, how much is the patient. You can use psychometric questionnaires like DHI or others, the Heart Scale or whatever you can.

So those are also very good outcome measures. So just instrumentation. For example, you can even have a recovery of VEMP thresholds, but just based on the instrumentation, do not judge whether there's a compensation, it has to be agreeing with the symptoms that you get. Tone burst. Well, acoustic trauma, whether you use a tone bust or click. In my institution we always use a tone bust for everything. So if you have any evidence that tone bust is actually better for acoustic trauma, please please feel free to share it with me. But to my mind, I would use a tone bust for everything, and 750, yeah, we can use a 750. What about blood tests? Yes, blood tests, you'll have to do very basic stuff.

I am not decompensated bilateral vestibular hyperfunction with a child presenting me with very vague, vague, vague, vague lightheadedness and very tired. So fatigue and a little bit of weight loss. Sent to me first because of lightheadedness, I did a simple blood test. Guess what? Myeloid leukemia. So yes, simple routine blood test. You can do vitamin assist, for example, B12 folate to see whether there's an anemia, vitamin D, thyroid function test because thyroid disorders can lead to bilateral vestibular hypofunction, which I've seen in my clinic. You can use the kind of the renal function tests to see about the various kind of electrolytes. Remember metabolic conditions are important cause for decompensated vestibular lesion. So yes, I would do the blood tests. Most of them get all the blood tests. Yeah, I think that concludes it. Anna? That's all the questions. So if you can please send me the questions to me.

- No, no more questions to be honest. Okay, one more. Can you see it professor?

- I'll see. Wait one second. One sec.

- It is a kind of congratulations. Thank you for highlighting the essence of healthcare. The patient's wellbeing is the most important stuff. In these current times of-

- Completely agree.

- Of healthcare, it's always--

- Completely agree with you. Sometimes you we'll agree that we lose sight of it because you know, as specialists we kind of focus on the organ that we have training, but I teach my residents and fellows that it's not that you'll have to see beyond. If you do not address how the child is reacting to the illness, then you probably are not doing a complete, you're not adopting a complete approach, if you know what I mean.

- No more question Professor Dasgupta. So I think that we are close to an end.

- Yes, thank you so much Anna. This was a very good one. Thank you. You gave me two hours, luxury.

- More than two hours, two hour and half.

- Love it. Usually I get half an hour to 40 minutes. That's all I get.

- So I want to thank you once again, Professor Dasgupta, he has been a source of inspiration, as I said in outstanding learning opportunity.

- Thank you.

- We'll be with Professor Dasgupta next April the sixth for the second lecture of this fantastic series. Vestibular complications and legalities following head injuries. So I

kindly ask you to keep checking Inventis social pages and register for futures events promoted by Inventis Academia. Remember, you will receive soon survey I kindly ask you to fill out. The survey will help us to understand your needs and your suggestions. Thank you very much Professor Dasgupta once again.

- Thank you.

- Bye for now. Thank you.

- Bye. Bye bye.