

Well thanks, it's a pleasure to be here. You know I probably need to acknowledge that you know even though I am kind of the coordinator of all of our vestibular rehab in our group there is probably about 20 other clinicians that do what I do in my group and I'm so fortunate to have them, and many of them are here today. And you know so if I start to fade I'm just going to have one of them come up and finish the lecture because they could probably do just as good of a job or better job than me.

So learning objectives I think you have. So I don't know if we actually showed this graph earlier on today but this is typical recovery from concussion and most of you know that you know within the first few weeks we see a lot of spontaneous recovery of this injury. But I think that most of us are here to understand you know what is the issues behind the people that won't recover spontaneously, because I think the argument can be made that if we really just don't mess up the group that's going to recover spontaneously, if we just don't allow them to get reinjured there is not a lot we need to do other than you know just do some conservative management. But it's these 1 in 5 cases, these you know 20 to 30% of patients that really create a lot of our problems and create a lot of the morbidity associated with this problem.

So as you know I'm the vestibular lecture so the bias that I'm going to come at is that you know a lot of these patients that we see in this 1 out of 5 have vestibular problems, or at least a good portion do. So let's talk about this trajectory. And as I think a lot of the speakers yesterday really prefaced this lecture nicely and illustrated how vestibular problems do seem to come in part and parcel with a lot of these protracted recovery cases. So vestibular problems are common

after concussion and I'll show you that. They are often part of that delayed recovery process and you know so what that implies is that we have to have good assessment tools for understanding the vestibular system and also more importantly is we need to do some things to intervene to make it improve.

So many of you may be familiar with this study, it was done a few years ago but it was something that was actually enlightening for us. If you look at all of these on field signs or symptoms that were tracked in high school athletes looking at well are there any things that we can identify early on after the injury at the time of the injury that help us elucidate whether this is going to be a protracted recovery case. If you look at all of those signs and symptoms, amnesia, loss of consciousness, confusion, vomiting, you know light and noise sensitivity all of these things that you think potentially to be issues really only one factor stood out in predicting whether somebody was going to take - be in that protracted recovery group and that was dizziness. In fact vomiting and loss of consciousness which you know many people thought were probably going to be strong indicators were not. They predicted actually quick recovery. But patients who had or athletes who had on field dizziness were more than 6 times more likely to fall in that protracted recovery group, meaning that it took them more than 3 weeks to get better. So what is it? Is dizziness telling us about vestibular problems? We probably, at least in some cases it is.

Now since that study there have some additional literature that supports this even further, and these are not on field indicators but these are post-injury you know in office indicators. But two

studies published last year also echoed these findings. When these vestibular and sometimes vestibular and ocular findings are present, especially in our young patients it means that they are going to take longer to recover, they are going to have more PCS. And so this is something we have to look at more thoroughly.

So how do you figure out if perhaps your patient is in that vestibular/ocular subtype, particularly the vestibular subtype? Well of course we spent some time yesterday talking about family history and subjective history, and that's extremely important. Looking at those symptom lists, looking at whether vestibular and dizziness and balance problems are part of the tool, or part of the profile. I think most of us are familiar with balance testing as a way of assessing the vestibular system, right. Everybody knows about the BESS test, that's been the thing that's been out there, the earliest in the literature. But the problem with balance testing is it really only tells part of the picture when it comes to the vestibular system so it really wasn't sufficient.

And that's where the VOMS came from. And how many of you are familiar with the VOMS here as far as do you use it clinically? So I'm preaching to the choir on this side, and this side you guys aren't as familiar and that's fine. But that is the premise behind developing the VOMS is we needed something clinical that we could look at these other aspects of the vestibular system that were not balance. And then once those additional issues are identified through screening then more detailed clinical assessment of the vestibular and oculomotor systems is necessary.

So from a subjective standpoint what are the things that you are going to see or at least start putting you in that framework of understanding, or thinking that perhaps this patient has vestibular deficits? And you heard this from Mickey yesterday as well but these are the patients that typically will have dizziness as one of their prevalent symptoms. But there may be also some other things that are going along with that besides dizziness. They may have impaired balance, especially in the dark or in visually conflicting environments. They may have trouble with focusing their vision, they may feel like their vision doesn't catch up with their eyes. You know their eyes, they move and their visual field doesn't stay with their vision, or with their head movement.

They may have increased motion sensitivity, motion discomfort or even height problems. So with a patient that comes in and says you know I feel very uncomfortable at the top of my stairs and I never did that before, or I never had that before. That's an indicator. And then the big one is difficult in busy visual environments, and this is where you see kids have trouble in their school hallways whenever they are changing classes. You'll see patients be very uncomfortable in Target or Wall-Mart or at the grocery store, places like that. And those are those subjective factors and things in your clinical interview that start pointing you in the vestibular direction even before you do any physical exam.

And I believe Anthony spoke about the VOMS yesterday so I won't go into it much. For those of you that are familiar with it great, for those of you that aren't it's just a brief screening tool. So this is a very watered down version of the vestibular assessment that a vestibular physical

therapist would do, but it's a way to start elucidating whether the vestibular system is creating some noise as well as some ocular issues as well. So if you use this in conjunction with your balance measures, with your subjective reports, with your past medical history you are going to have a more complete picture of what kind of clinical profile your patient is experiencing.

And I believe we showed these yesterday but it just goes to show that how these vestibular issues and oculomotor issues as well are very prevalent following a concussion. You see that the two items that are pointing to the vestibular assessment of the - in the VOMS are the last two items, the VOR and the Visual Motion Sensitivity items. And in our sample approximately 50% or more patients acutely or subacutely after concussion are experiencing these types of complaints so we know it's highly prevalent. And as Anthony spoke about yesterday in controls we just don't see problems in these areas. So the blue are the patients and the controls are the orange and you just see that there is a huge difference. And we heard from Alicia yesterday also who explained that those patients who probably are controls who are symptomatic are more likely those patients that are motion sensitive or have some of those profiles that are you know underlying on the vestibular system normally.

So again anybody that's familiar with the vestibular system so all my colleagues that know about the vestibular system you can ignore this part, this is for those of you that kind of think about this word. And I always laugh because every month or so I have a patient that comes in and says to me so can you explain a little bit more about this vestibular system to me? And I realize how much of an enigma it is. So this is for the basic of the vestibular system. So what it is it's two

parts. One is the peripheral system which includes the peripheral system which is the inner ear, so it's that bony labyrinth in which you know your hearing apparatus as well as your motion detector apparatus is housed. So that's where you have your semicircular canals, your otolith organs, the things that detect movement and then the vestibular nerve and ganglia that are associated with that. And then just importantly if not importantly where that peripheral system projects to centrally is the central part of the vestibular system, so that's the vestibular nuclei, the cerebellum. There is a lot of autonomic and thalamic interplay with the vestibular system, that's why you get a lot of motion sensitivity, cerebral cortex issues. So the vestibular system, and we'll talk about can be impaired both peripherally and centrally or one or the other after a concussion.

So from a functional standpoint it's pretty simple, there are two main functions. One is to stabilize your vision, so as I'm standing here talking with you all the reason that I am not losing my balance is because my vestibular system allows my gaze to be stabilized as I move my head. And then the second part is balance control, and the vestibular system contributes to balance control by creating those sensory inputs. But it's also combined and duplicated by other sensory systems like your vision and your somatosensation. So there is a overlap in balance control where the vestibular system works part and parcel with those other two systems.

So I don't want to sound too simplistic because again my vestibular colleagues will understand that vestibular rehabilitation is incredibly complex and there is a lot of things that go into it. But when we talk about concussion and concussion only there are four basic things that we see. And

99.99% of the time, although we did have a case last week where they fell outside of this 99.99%. But 99.99% of cases you are going to see one of these four or more than one of these four issues emerge: benign positional vertigo, VOR impairment so problems with that gait stability mechanism, balance impairment and visual motion sensitivity. And those are the things that need to be screened and need to be evaluated and then if they are present that's what vestibular therapists need to address.

A word about vestibular therapy because some people are really not believers. There is emerging literature about vestibular therapy. Now for those of us that have been doing it for a while we know that there is a lot of great evidence, excellent evidence about vestibular rehab in non-concussed populations. We know that it has, it's very evidence based. But in concussion it's of course slower to emerge, but there are 3 studies that have been published and probably more to come soon about how the efficacy of vestibular rehab after concussion, one is in a military subset, one we did here in Pittsburgh in a retrospective chart review a few years back and then there was a randomized controlled trial done in Canada looking at the implementation of vestibular, vestibular/cervical therapy in patients and actually influenced return to play and helped to enhance outcomes and recovery.

So let me go back to those 4 issues that you see after concussion that affect the vestibular system. So Benign Paroxysmal Positional Vertigo, BPPV, now this is something that many people are

familiar with. So actually how many of you guys in here are familiar with the concept of BPPV? Okay, so at least a good bit. Perfect. All right so and then let me just ask one other question, so how many of you only deal with young athletes in this room? So many of you. but how many of you see a mixed population of patients that are both young and old, older? Okay. So for those of you that only deal with young athletes you are probably never going to have a problem with BPPV, but all of you that raised your hand about dealing with a mixed population, patients that are 40 and above you are going to see this. And this is a peripheral problem, so this is one of the few of those problem areas on my list where the problem is in the inner ear itself and there is little crystal, otoconia that get dislodged when you halve the concussion forces. So it's a very mechanical problem. These patients will have typically have vertigo when they move their head in certain directions and that's really the hallmark is that if somebody comes in and complains that they are dizzy just sitting there in your office that's not BPPV, but if they are having dizziness that's related to changing their head position, like lying down in bed, turning over in bed, getting out of bed then BPPV needs to be screened for.

And the other thing about BPPV after concussion as with all types of traumatic brain injury this is one that I would probably suggest that you send to somebody that knows what they are doing as far as vestibular therapy because it is often not the typical easy case of BPPV after concussion. We see it much more often bilaterally, we see it more often in multi-canal and that's trickier to treat and you probably need things like video infrared goggles to treat it appropriately. So just know that if you do suspect BPPV you might just not want to send it after concussion to you



know somebody that dabbles in vestibular therapy, you may want to make sure you send it to somebody that can really assess it. And the way that you manage it is through canalith repositioning maneuvers, or particle repositioning maneuvers, which basically try to reposition those crystals back to where they belong.

Okay, so VOR impairment, and this is again that ability to stabilize your gaze when your head is moving. And it's extremely important. And what we see after concussion is that, and this may be because of central or peripheral problems but we see that that problem with keeping your gaze stable becomes disrupted so that patients complain of blurry vision or that complaint that I spoke of earlier where people feel like their eyes and head aren't matched together starts to crop up. And what you'll see is this emerges more with faster movement. So patients that basically are sedentary won't really notice much trouble until they start moving faster and then they start to see these kinds of symptoms occurring.

So most people don't understand how the VOR is responsible for functions in life, and again if you are moving at just normal everyday speeds and you are very sedentary and not really getting outside of your home you may not notice a VOR problem because head velocity speeds that are slower don't necessarily require much robust activity of the VOR. However as soon as you get into more aggressive activity, things even as simple as you know cleaning your house, those normal activities of daily living, then you start to elicit that response and that's what we see often

is that patients initially don't feel much but as they start trying to engage in their normal life then if they have a VOR problem it will come out. And then when you get into things like sports of course you need that, you need that system because these high frequency or high speed head movements really your visual system can't do the job. Your vestibular system has to be active. And the reason for that is that your visual system actually acts much slower than your vestibular system.

So let me illustrate that for you. All right so everybody take something out that they can read, so take either your program or something that you can focus on. All right, and what I'd like you to do is to - I want you to oscillate that back and forth okay at fast speeds, so really fast back and forth, back and forth and try to focus on something as you are doing that, okay. How many of you are having difficulty still reading what you are trying to see? Right, okay, so it's very, very difficult to do that. Now I want you to do the opposite, so you are going to hold that steady and now this time I want you to oscillate your head back and forth at that same speed. Okay, see how much better that works. Okay, that's your VOR, that's your VOR in a nutshell. So what happens is you have to use your visual system along with your VOR system for things to stay stable in your world, otherwise things just don't work.

So what do we do about VOR problems? Well the nice thing is that they are incredible amenable to treatment. There is fabulous literature that shows how adaptable the VOR response is, which

is good for us. So vestibular therapists are going to do a host of things that are related to you know moving your head. So it might be as simple as you know just focusing on a target, I don't know if this one will work. Just focusing on a target much like what we just did here and moving your head but it doesn't stop there. Then you need to do things that make it much more dynamic and active. So basically then as you deal with somebody that's an athlete you have to work on things like changing posture, changing position, changing environment, changing demands of the task, so things of that nature will absolutely help the VOR system to respond the way it's supposed to.

Okay. So visual motion sensitivity, this is I can't stress enough how much - this is probably the thing that you are going to spend the most time on in vestibular rehab. The VOR issues will come along, BPPV can be treated very fast, visual motion sensitivity is something that absolutely takes longer and is more complicated to treat but it's incredibly important to work on. So these are the patients that have kind of a heightened awareness of visual motion. They have this hypersensitivity of their optokinetic system and what happens is that normal visual stimulus that doesn't really influence most people becomes hyper-perceived. There is a lot of terms out there in the literature, we call it visual motion sensitivity because again we deal with a population where we need to have some terms that are understandable but there are other terms that have been you know put out there like space and motion discomfort, or visual vertigo, things of that nature that pretty much mean the same thing. But these patients are really the ones that really can't walk in supermarkets, they can't be in crowds, they can't be at PNC Park last night, they

can't be at heights. In Pittsburgh we have tons of bridges and tunnels, patients will avoid tunnels and they will drive you know 10 miles around to try to not go through the Squirrel Hill Tunnels, things of that nature. And certainly it's something we need to address.

So I put this up here just because some people have - want to understand you know what does visual motion sensitivity mean to your patient? Well if you stare at something like this it's a pretty uncomfortable picture, right. It's a little unsettling, you kind of feel like things are moving when they are not really moving. As soon as you look at something that you think is moving it's no longer moving. And that's a very unsettling feeling and if you look at this for some people in the room you might even feel like it starts to bring on a feeling of discomfort, even slight anxiety you know when you look at that it makes you very uncomfortable. Well patients that have visual motion sensitivity feel this way all the time and this feeling is amplified in any environment where there is things going on around them.

Now the reason why visual motion sensitivity is hard to treat also and requires a bit of time is that it usually isn't - it's usually an indicator that there is more going on with this patient than just a vestibular system problem. It usually means that there is some other coexisting pathology and so we often see it kind of traveling along with the migraine traits and the anxiety component. So often in these patients that have this vestibular presentation we are treating posttraumatic migraine and/or anxiety mood issues. And I always say to the people that I work with and my

students is if you see patients have this heightened visual motion sensitivity you need to look and dig for anxiety and migraine issues because more often than not you are going to see them traveling together. And then you need to address all three. So again these folks need to be in vestibular therapy, they often will need some type of medication, they may often need behavioral or psychotherapy to go along with their problem.

So what do we do for it? Well we actually again this is a system that can be adapted or habituated because if you think about it it's a hypersensitive system, so we need to do things that dampen that sensory response. So we gradually expose patients to provocative stimuli. Now I can't say enough how that has to be done in a very skilled way because if you can imagine and probably many of you have had experience with patients like this, you can trigger a whole host of negative responses if you are too aggressive with this. And then on the flip side you can completely allow somebody to become agoraphobic if you don't address it. So it's kind of finding that right dosage of what you can have them practice and handle, it's the skill of treating this. The big thing you have to manage is their anxiety responses and you also have to be wary of provoking migraine when you do this.

So this is a picture of our virtual reality grocery store. We have a virtual reality cave we call it at our Eye and Ear Institute here in Pittsburgh, and this is a research based paradigm, but this is you kind of take somebody - so that's a treadmill that they are standing on and they have this grocery

cart handle. And then the rest of it is just is a projected screen and you can make the grocery store busy or you can make them search and scan for things. But the idea is that this is a way of dosing and progressing treatment. Now we don't all have access to something like this so we figure out ways in real life to have patients practice things of that nature using - you know we use a lot of videos, we use a lot of backgrounds, we use a lot of environmental stimuli. But it's incredibly important to be able to kind of train and desensitize that system.

So I put balance last because I think this is the thing that most people are aware of is the balance problems that you see after concussion. So we know that balance problems present very commonly acutely and subacutely after the injury. And what it's related to often is problems with the sensory organization, using three sensory inputs, and balancing the inputs of your vision, your somatosensation and your vestibular system. So the ability to use, especially the ability to use the vestibular sensation seems to be impaired, especially early after concussion. And measuring that of course the gold standard is using computerized dynamic posturography which is fabulous. We have you know in some of my clinics we have this, in some we don't. The other clinical measures that actually do correlate well to computerized dynamic posturography is the CTSIB, The Clinical Test for Sensory Interaction and Balance and then the BESS test as most of you are aware of for athletes. Again those are good substitutes when you don't have computerized dynamic posturography available to you.

But as we said and I believe Anthony showed this slide yesterday is that you can't rely on balance to be the end all, be all of the vestibular system evaluation because it just doesn't correlate to all of those other factors which I spoke of. It doesn't correlate to BPPV and VOR issues and VMS, and this is what we showed yesterday of how it doesn't relate at all to the items on the VOMS. So it's certainly a piece of the puzzle but needs to be tempered with the other measures.

So the other thing is that balance testing is incredibly important after a concussion is that we know that patients early on and actually sometimes it's one of the most powerful ways of demonstrating to an athlete that they actually are concussed right. You have them stand, have them stand on a piece of foam and close their eyes and they cannot maintain their balance. Well that freaks them out, sometimes even more than some of the symptoms. So that's really a great measure. But the problem is that recovery from these balance deficits, these sensory organization deficits really occurs more quickly than many of the other issues and symptoms after a concussion, so even though it's an important component it's not the only component for vestibular system recovery. So you need to dig further beyond the balance improvement.

And for training balance the big - the key components are that you have to make patients use their vestibular system to balance, so you have to change the surface. You have to change the visual environment, reducing their vision or changing the visual complexity. But it doesn't stop

there, then balance is dynamic, it's more than standing on one foot. It's about putting you in environments and having to multitask and to have cognitive distraction. So again kind of only training balance in a very uni-dimensional way is probably not sufficient for training.

So I think I'm hopefully on time. Vestibular problems we know happen very frequently after concussion, are probably important to recognize because they are probably part and parcel with a lot of those patients that are going to take longer to recover. Hopefully if we intervene earlier we can help affect that recovery trajectory. That's at least our premise is that if we know that this is an important finding and we begin treatment a little earlier we can sometimes negate some of these negative consequences that cause patients to take longer to get better.