Special Topics Call

"1000 Hz Tympanometry:

Uses and Abuses"

By Wendy D. Hanks, Ph.D.

Gallaudet University

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Steve Richardson: Hi, welcome to the special topics teleconference, “1000 HZ Tympanometry: Uses and Abuses hosted by CDC EDHI. This is Steve Richardson at EHDI in Atlanta. I'd like to welcome our speaker Dr. Wendy Hanks. She is an Associate Professor of Audiology at Gallaudet University. She received her masters from Brigham Young. Her CFY was completed at the Mayo Clinic in Rochester and she received her PHD from Wichita State University. Her research interest is pediatric audiology. Her current research explores normative 1000 Hz tympanometry data for several groups including newborns and preschoolers. She

is a member of the Pediatric Subcommittee for AAA.

To keep the call running smoothly and a short time for questions, we'll let Dr. Hanks finish her presentation and then open the call up for questions.

Dr. Wendy Hanks: Thank you, my pleasure. Good afternoon, or good morning, everyone, depending on what time zone you are in. I hope that most of you have the PDF, because I was planning on the talking through some of those slides to help with the presentation. This talk came about after a presentation that I had done and was working with different audiologists, with questions on how do I use 1,000 Hz tympanometry and how do I justify the purchase of that equipment.

So if we go to **slide number 2**, this next series of slides will give you some ammo if you need justification for purchasing equipment. As we talk about the prevalence of middle ear effusion, in infants starting back in '93 with the Rhode Island studies, they found in full term babies the presence of conductive loss is 17 out of 1,000. For NICU babies the prevalence is 36 out of 1,000.

So, depending on your newborn hearing screening program that could add up to quite a few children.

The **next slide** continues on with Roberts and colleagues in 1995. They reported a high rate of middle ear effusion which they assumed to be amniotic fluid in normal newborns. Paradise set prevalence at 3 months, 15% suburban and 33% urban areas.

That will give you some literature, some data to go with, depending on what type of setting you are in also.

Slide 4. As we're looking at those working in the NICU, there is a higher prevalence of otitis media or middle ear effusion with a longer length of stay in the NICU. Sutton and colleagues found if the baby was in the NICU for greater than 30 days, that child had 4 times the risk of having abnormal tympanograms. Yoon et al, found out of 82 NICU graduates they evaluated, 37% later had abnormal

tympanometry in one ear and 29% had abnormal tympanometry in both ears.

We can see there is a prevalence with that, with newborns.

So if we look at **slide 5**, we can see if this middle ear effusion is not resolved; they are at developmental risk, and, again, the Rhode Island studies have shown that children, even if they just failed their newborn hearing screening due to conductive loss are at high risk for persistent or fluctuant mild to moderate hearing loss with those losses ranging from 15 to 45 dB with a mean of 30dB for 500 to 4,000 Hz. Doyle, et al, found that 58% of neonates identified with effusion within the first 48 hours of life went on to have chronic otitis media during the first year of life with thresholds exceeding 25 dBHL.

So, if there will be 58% of neonates with otitis media, why do we need to conduct tests? We conduct them because many newborn hearing screenings use otoacoustic emission testing and OAEs are influenced by the presence of middle ear effusion. If you are using TEOAEs, 70% of the children will have absent OAEs if their tympanograms are abnormal.

So, many of your failures with OAEs may be due to middle ear effusion. With that background in mind, I started thinking about what tympanometry protocols are being used with infants. There are a couple studies recommending 1,000 Hz. What are audiologists doing, what are they finding, how many people are using the 1,000 Hz probe tone?

So one of my students sent out a survey -- I'm now on **slide 8**. We sent this survey via e-mail and we sent the request on the EHDI listserve, on the Educational Audiology Association listserve and on the AAA Soundoff listserve, and 153 audiologists responded. Just as a side note, I found out later after I sent out the e-mail you're not supposed to request surveys on the AAA Soundoff listserve, so don't do that if you are thinking about it, I don't want to get anybody in trouble. I wasn't surprised by our results in that 13% of our respondents were male and 87% were female. I was pleased that we did receive responses from 35 states, the District of Columbia and the Mariana Islands. I think we have a pretty good spread of people across the United States.

Slide 10 -- I asked where do you practice? I wanted an idea of those of you who were pediatric audiologists, in what areas are you practicing. So, we find most are in hospital settings, physician's offices, private practice, a few in private speech and hearing clinics and public schools, about 20 in the university and then a variety of other settings including public health clinics, early intervention, government facilities, etc. So you can just see where each of you stands in that employment setting, and if we met that employment setting for you. So next I wanted to know how much experience have pediatric audiologists had with zero to 3-year-olds.

So, **slide 11** shows that number, and I was quite surprised to see the amount of experience that pediatric audiologists that responded to the survey had had, the great majority have six or more years of experience testing zero to three year olds. That was a good sign. So I wanted to know which. Since zero to three is such a broad range, how many children do we test a week?

Slide 12 is broken down by age group. And we can see that the majority of people are seeing between one and 10 children per week in all of the different categories. A large subset are seeing 11 to 20 per week and then a very small number are seeing 31 or more children per week. And the zero through 3 age was well represented for all of the groups. Then I wanted to know where is 1000 Hz probe tone is being used.

Slide 13. This shows us that not a lot of audiologists are using it during the initial newborn hearing screening. About 28 out of 153 were using it during the initial newborn hearing screening, more around 50 were using it for the second newborn hearing screening, about 30 in other screenings, but the majority were using it in the initial diagnostic evaluation and in evaluations following that. Some that responded to the survey did not use 1000 Hz tympanometry at all. And others just said they didn't have access to the equipment or didn't test infants, etc. So now I'm

interested to know as we finish up if this is how the majority of you are using it. If you want to use it in a different way, how I might be able to help you answer questions in order to do that? In order to answer those questions I needed to know what equipment was being used.

Slide 14: I looked at every model that could be used and this survey also included questions on the 226 Hz probe tone and, so, some of those pieces of equipment are there. But by and large the majority of the audiologists used a Grason-Stadler, Madsen Otoflex or Interacoustic brand, and those are the three that currently offer 1000 Hz tympanometry. With that in mind, many of the samples I will put up on the slides are from Grason-Stadler equipment because that's what the majority of people were using. Next, I wanted to know what probe tone they were using for which age.

Slide 15: As expected, the majority of people used 226 Hz with 7 months and older, but there were 30 people that used 226 Hz in the zero to 6 month level. And the research has shown that using 226 Hz from zero to 6 is invalid, so it is not recommended that we use that. Again, the majority did use 1000 Hz for the zero to 6 months and about 25 continued to use it up to about a year just to make sure they were covering all of their bases. **Next** I wanted to know about pump speed, how fast are you running those tympanograms, because the results of the normative data are for very specific pump speeds. I wanted to know if the normative data was representative of what people were using. If we look at 226 Hz, the majority of people are using 600/200, or straight 200 daPa per second, the 600/200 applies to Grason-Stadler equipment. Almost all the equipment does a 200 daPa straight; 50 daPa is with the Grason-Stadler equipment. If there were others, we would show it out there in the black.

The same pattern is seen with the 1000 Hz tympanometry. The norms for the 1000 Hz tympanometry have all been done with the blue or 200 daPa per second pump speeds. The other thing interesting is the pressure at which you stop the tympanogram. For the normative data, which we'll talk about in a few minutes, you calculate static acoustic immittance from the positive tail or from negative 400

which is usually the equipment default. I wanted to know are people actually using that or are they stopping at different times?

Slide 17 showed that the majority of people are using -400 daPa -- letting the tympanometers run out either to the negative 400 or the equipment default which is generally negative 400. Some are stopping it earlier; some stop right after the peak, and that's been my experience in chatting with audiologists. Some of the time, you know, it's going to depend on the baby, how cooperative they are, sometimes we can stop it right after the peak, a little sooner if you feel you are getting a good peak. But then you can't use the normative data that is normed from the negative tail if you do that, so I wanted you to know that so that we could chat about that also.

In **Slide 18**, we're talking about what parameters most audiologists use to determine if the tympanometry is normal. And for 226 Hz it is what we would all expect, ear canal volume through static compliance and not used as often is tympanometry width or gradient. At 1000 Hz we don't use ear canal volume as much, but again tympanometric peak pressure, static acoustic immittance and the other as listed. The majority of the norms only list static acoustic immittance for normative data, so I'm not sure what everyone was using for tympanometric peak pressure as far as norms, but those have not been listed. It is not appropriate to use the ear canal volume at 1000 Hz, and we'll get into that in just a minute also.

Finally, one of the last questions I asked in the survey, which is **Slide 19**, was what norms are people using? What are you using for normative data? And I selected eight of the most popular or the robust studies in tympanometry and asked and for 226 Hz, most people used either the ASHA Screening Guidelines or Jerger Types. The only two normative data sets that I listed are the second one Kei, et al, in 2003 and Margolis, et al, in 2003, the blue and the black.

Some people are using those for 1000 Hz tympanometry. Others are using inappropriate norms.

All those -- all the rest of them were developed for 226 Hz and not for 1000 Hz.

So I could see that that might be where some of the abuse was coming in with using 1000 Hz tympanometry.

The question I get comes from **Slide 20**, so then how do I interpret these tympanograms? I will go over basic immittance, for some it will be very elementary. For others, the audiologists who've been working out in the field for 20 years or more, it's been a long time since your basic immittance class, and, so, I will review some of those concepts with you. Let's start talking about peak static acoustic immittance. Some people still call it static compliance, static acoustic compliance. It's all the same thing. We are looking at how much does the middle ear system move naturally from its natural state to when we pressurize the ear. If we go back to our basics of how immittance was developed, the 226 probe tone was the first one to be used. And that information was all based on an adult ear in a calibrated ear canal volume of a basic 2 cc coupler because that's the basic adult size of the ear canal.

So, all of those values for ear canal volume are based on the 2 cc coupler for the 226 Hz probe tone. Now, when we change the frequency of the probe tone, then we are also changing the wavelength and the interaction of that tone in the ear canal. For simplicity's sake, the manufacturers changed the measurement of the equivalent ear canal volume by the amount that the frequency increases from 226. For instance, if you are using the 678 Hz probe tone, the equivalent ear canal volume will be three times larger than that of 226 because 678 Hz is three times larger than 226. And if we are using the 1000 Hz, then the ear canal volume that is listed will be approximately 4.4 times larger than that of 226. So, if you just started using 1000 Hz tympanometry and you are a little freaked out by the large ear canal volumes - that's where it's coming from. The baby does not have a perforation, that is where the larger equivalent volumes are coming from.

Let's go to the **next slide**. Why do we put so much emphasis on peak static acoustic Immittance and how do we measure it? The first bullet is: Do we go from the positive tail or the negative tail? By this I mean as we're looking at the

beginning and ending of a tympanogram, the positive tail would be on the far right around the plus 200, that's called the positive tail of the tympanogram, the negative tail would be around the negative 400. In 226 Hz tympanometry there has been a lot of research done; it's also been looked at with 1000 Hz. The research shows the negative tail gives us the most accurate measurement. However, all of the equipment manufacturers use the tail of the starting or the initializing pressure to compute that peak static acoustic immittance. So, if you are using Grason-Stadler or Madsen equipment, static acoustic immittance is being computed from the positive tail, not the negative tail. I haven't been able to get an answer yet from Interacoustics on how they actually calibrate that equipment, so I'm not sure. I'm fairly positive Interacoustic also measures it from a positive tail. Now, if you go from the negative to the positive direction in your pressure sweep, then it would calculate the static acoustic immitance from the negative tail, but most people start at the positive 200 and go negative. Why is it so important?

Slide 23. This is the immittance characteristic or component that gives us the most information because it is most altered by ear disease; it increases with discontinuity and decreases with space occupying lesions in the middle ear. Other components are affected by it, but not as much.

For instance, tympanometry peak pressure is more an indicator of Eustachian tube dysfunction than ear disease, so that's why it is not emphasized as much. Let's get to the norms for 1000 tympanometry.

Again, if we look at **Slide 24**, it's important to note that all of these studies have defined their norms in that you must have a defined peak to use the norms. If the tympanometry does not have a peak, then you really shouldn't be using it. You will just have to state that there was an abnormal morphology and you couldn't interpret it. So, by peak, the way we define it was it has to start out at a lower point, come up and then go back down again. Margolis and his colleagues found the referral point or the 5th percentile for NICU babies and full term babies is .6 mmhos, and that is when you go from the peak of the tympanogram to the negative tail. This study was done with Grason-Stadler equipment, and the values were

hand calculated.

Now, the Kei, et al, study is the next one down. This is a group from Australia, and they used Madsen equipment and they just used the information that was from the equipment. Using the peak to positive tail method, the 5th percentile there is .39 mmhos for the cutoff. I didn't give you the 95 percentile or range because we're not usually concerned with discontinuity for a baby. The 5th percentile would be what you would use if it's less than either the .6 mmhos, if you are using the negative tail or .39 mmhos if you are using the positive tail. If it's less than these norms, then you need to be referring for a medical evaluation.

Our **next slide**, discusses a study that just came out and there's a typo, Swanepoel, et al, is in 2007, not 2006. They did things differently. This group is from South Africa. They looked at the uncompensated peak admittance, so they just looked at where the tympanogram peaked. They found the 5th percentile for full term babies is at 1.4 mmhos. It correlated well with the Margolis et al. study. They also found age and gender differences by using this method. So I think we need to look at further studies to see if this method is one that we would like to use in the United States. I'll go over that a little more in just a minute or two.

If we go to the **next slide**, I have it drawn out as to what is peak static acoustic immittance. It's again the difference between the positive tail or negative tail and the peak of the tympanogram. And it can be measured in a lot of different ways so I will go over how that is done.

Slide 27 is a printout of a 226 Hz tympanogram from a Grason-Stadler. This is what I would think that most people are familiar with. This is with the baseline-on or it's a compensated tympanogram. What has happened here is when the ear canal is pressurized to the positive 200, then the equipment measures the ear canal volume; and on this example in the blue box it says that it is at .6 ml or milliliters. That then becomes the reference point or the zero point for the tympanogram. So the equipment subtracts out the ear canal volume and records the tympanogram. It then calculates the difference between that positive 200 tail

and the peak of the tympanogram which on here happens to be 0.5. Subtract the difference and we get our static acoustic immittance in the circle as 0.5.

I'm sure most everyone knows how to figure that, so let's look at the next tympanogram **(Slide 28)**. It's the same ear, the probe hasn't been moved, we just now have the equipment in the baseline-off or in the non-compensated mode. The ear volume is added back in, and it looks like the tympanogram is moved up. We are just seeing the variability with the ear canal volume there. We see the ear canal volume listed at C1 as 0.6 and the peak is listed as 1.2, so with this one if it's not compensated you have to calculate by subtracting the ear canal volume from the peak and that's the 1.2 minus the .6, and you get static acoustic of .6 which is similar to .5 in the previous slide. The new Swanepoel study just took that peak of the 1.2, so that is how their study is different. They just took the peak and they did not compensate for ear canal volume or for the actual movement of the middle ear system. And that is how it's different. I think that that is also why they saw more gender variations and age differences, because they are adding that variability of the ear canal volume in there. So it will depend on what type of seal you have and how deep the insertion is, all of that will change more with looking at just the peak than with the static acoustic immittance.

Let's move then to **Slide 29**. This is the first one that is at 1000 Hz. This one is not an infant ear; this is an adult ear. It happens to be my ear because I'm my best guinea pig. For the Grason-Stadler equipment, you need to have the baseline off and look at the non-compensated display in order to be able to use the equipment most effectively. Generally with 1000 Hz tympanograms, the negative tail of the tympanogram goes below or sometimes quite a bit below the positive tail. If you use the baseline-on mode you don't see the movement of the tympanogram and it looks like you just have a flat line. We see here with the 1000 Hz we still get the ear canal volume which on this sample is at 3.0. Because we're at 1000 Hz, then to get the true ear canal volume we would have to divide it by about 4.4 and that gets us back down to the .6 ear canal volume. We see that the peak of the tympanogram listed under the circle is not listed at all. If you are using the Grason-Stadler equipment, you have to calculate this by hand.

Slide 31: I'll show you kind of how I do it. I eyeball the peak over to the side axis. If I'm doing it by the positive tail I take the positive tail which is listed as the .30 minus the peak, which I estimated at about a 4.3 and the static acoustic immittance is 1.3, and that's well above the .39 cutoff listed by the Kei, et al, norms. So this tympanogram is well within normal limits.

Slide 32: If I wanted to do the same thing for the negative tail, we'll take the same peak of 4.3; we just estimate where that negative tail is. To me it looks like it's about 2.6. Subtract that, our static acoustic immittance is 1.7 and that again is well above the norms of .6 for referral. So this tympanogram would also be within normal limit.

Slide 33: This is a reminder again of why we need to use 1000 Hz instead of 226 Hz tympanograms in infants. The ear canal and middle ear characteristics of the neonate ear, the infant ear, are totally different of that of an adult ear, and we just don't get valid results with a 226 Hz tympanogram.

The infant ears are cartilaginous, do not ossify until at least 4 months of age, and we can get movement of the ear canal and/or probe. The middle ear space is smaller in volume and may contain mesenchyme, amniotic fluid, all sort of things. There could be again some vibratory motion of the external ear that adds to the resistive components. All of those together make it so the infant ear is more resistive than the adult, more stiffness loaded. These differences make the mass and resistive components more prominent. That's why we can't use 226 Hz. You can get very reliable results at 226 Hz, but not valid, so you can get a normal-looking tympanogram with fluid at 226 Hz in an infant ear. You could also get a flat 226 Hz tympanogram with a normal ear with 226 Hz. So it just is not valid to use.

Slide 34: One thing that I've come across as I've been working with infant ears with the Grason-Stadler equipment depends on the altitude you're at. This is for those of you in the mountainous regions. One study I did was at an altitude of 4950 feet and we got a lot of complaints of probes saying there was a leak or occluded when I had just run a 226 Hz tympanogram successfully. In working with

the manufacturer we found that as the equipment makes altitude adjustments, the ear canal volume decreases. The altitude adjustments are based on adult ears and usually the ear canal volume itself is large enough that it doesn't affect whether you can run a tympanogram or not. On NICU ears that are so tiny, many of them, their ear canal volumes with the 226 were at about a .2, so when it rounded for the altitude adjustment, then the equipment thought that the ear was occluded or there was a leak.

So what you have to do is if you are in that altitude and starting 1000 Hz tympanometry, talk to your equipment distributors and there is a little elongation tube that you actually put on your probe tip to help to solve that problem. Also, the equipment rounds to the nearest tenth in the ear canal volume, and, again when we are down there with those .2 ear canals, sometimes it rounds the wrong way and again says it's occluded. This can also happen if we still have fluid in that middle ear. It can be pushing out on the TM and making the ear canal volume even smaller, and that is sometimes where you can get the leak or the occluded warning. In that first study I did with the high altitude, 25% of NICU or neonate ears could not be evaluated with 1000 Hz tympanometry until we got that equipment adjusted. Sometimes we will get leaks or occlusions because of the shape of the neonatal ear canal. It's more slit-like, not cylindrical; it will depend on probe placement.

Occasionally if it looks like the probe is in very well and it's good, we might get some standing waves because of the sides of the ear canal and interaction with the 1000 Hz wave form. So you might just play around with different tips, wiggle the tips a little bit and see if it's a standing wave procedure to solve that problem.

Slide 36: Another one that we have to look out for is room noise either in the NICU or well baby areas. So if you are using tympanometry in there as opposed to in your diagnostic evaluations, if the background noise is close to the level of the probe frequencies, then you can get some interference and the equipment will interpret that as feedback. You also need to know that as the probe frequency increases, the intensity of the output decreases. If you have a louder NICU or well baby area, that could also be a problem that you might need to change the area where you are testing or put the babies in isolettes.

Next slide: With all of this information, what else do you think we need to do? We still don't have all of the best information yet on how do I interpret the “other” tympanograms, those who don't have a clear peak or an abnormal morphology. I will show you some of those in the next few tracings; we don't have a good handle yet on how to handle those. It's not been shown yet in research if you can use the norms interchangeably, if you can switch back and forth between pieces of equipment. And can you switch back and forth between whether you use the positive tail or negative tail to calculate your static acoustic immittance?

I prepared this slide just before the Swanepoel article came out. Do we need norms for tympanometric pressure in newborns? Swanepoel and his associates found there were differences between children less than one week old and children that were one to four weeks old, and they found that overall the normative range for all of them was between 80 daPa and -75 daPa, so those are the first normative ranges to look at tympanometric peak pressure. We need to research this area more, we need to go further out than four weeks of age to see how tympanometric peak pressure is influenced with older infants. Can you think of any other questions that you have that need to still be answered?

Slide 38: Let's look at some case studies then. The first one is a normal 2-month-old that was referred for a rescreen. He had present and robust transient evoked otoacoustic emissions. The top tympanogram is 1000 Hz and the bottom is 226. Looks like the 226 is valid but we don't know until we actually do the 1000 Hz, so I'm just showing you lots of different morphologies that you can see with 1000 Hz tympanometry and what it will look like.

Next slide: This is a two-month-old that was referred for a diagnostic ABR; she had absent TEOAE's for the right ear. Turned out after the evaluation that there was a unilateral moderate to severe hearing loss.

We're confirming it was sensorineural in that the tympanogram was within normal limits. You can see where the negative tail does go down quite a bit more than the positive tail. If you didn't have the uncompensated the tympanogram would be

hard to interpret.

The **next slide** is from a study that I did with some NICU babies, part of a longitudinal study. I wanted to see if during the time they were in the NICU if we could see any maturation. What I wanted to show you was that this infant was stable, no complaint of middle ear effusion. If you look at the bottom, that's the 226 Hz tympanogram. That's very typical of what we will see with 226Hz -- a double peaked tympanogram, and again you can get those with middle ear effusion or without middle ear effusion. Now, what do you think is going on with the top one? There is the 1000 Hz, it has a definite peak there, but why do you think we have the ski slope, any ideas?

Call Participant: Does it have anything to do with the rate of change of the pressure?

Dr. Hanks: Good guess, but not solely related to the rate.

Call Participant: The direction?

Dr. Hanks: Not the direction because it's going positive to negative.

If it went negative -- I didn't show that, sorry, that would be very good.

If you start out negative with the newborns, then it can look like this also.

Call Participant: Speed of change?

Dr. Hanks: Not the speed of change. But good questions. What we figured out was that the probe tip is being pulled against the ear canal wall as the pressure gets more negative. So if you look it's almost down to zero. That's telling us the probe is almost against the ear canal wall. You can start off doing fairly well, and

because of the problems we talked about earlier with the ear canal movement, etc., sometimes the probe is still pulled against the ear canal wall even if you are going from the positive to negative direction. So if you get something like that, then just reposition it, run it again and you should get a more normal-looking tympanogram. If you get something that looks like that, that is telling me the probe has pulled up against the canal wall.

The **next one** is a 10-day-old referred for a rescreen with absent TEOAEs in the left and present in the right. These results were consistent with the birth screening and so the child was referred for a diagnostic ABR. And with this one it was surprising because I would have expected the right to have failed if I were looking just at tympanometry. The left one is on the top, you can see that there is a definite peak there although it is not a real clean peak and the bottom one is a little more rounded. But it does still meet the criteria for a pass, and, so, this just tells us again that we have to use all of our results together and not one test alone in documenting what is going on with these infants' ears.

Slide 42: This is another one we will get often unfortunately. This is one of the "other" tracings. To me this tympanogram does not have a peak so you really couldn't use norms effectively with this. One of the other audiologists said, well, no, it goes down a little bit and then comes up. So I said, okay, let's figure out whether it passes the norms. It does not meet the positive tail norm as it is less than .39 mmhos, but it does meet the negative tail norm. So then we're saying which one are we going to take? And this goes back to the question of "Can we use them interchangeably?" More research needs to be done in this area in order to answer that question. This infant was referred for a diagnostic ABR. She had present acoustic reflexes, ABR clicks down to 20 dB and 500 Hz tone bursts down to 25dB, present TEOAEs, so putting all that together this baby passed the referral. But I couldn't say that she passed the tympanogram so I would have wanted her back later to look what was going on with that ear. But I assured the parents at this point it looked like there was at least nothing worse than a mild hearing loss and most likely within normal limits. You will also get this shape of tympanogram fairly regularly in that it starts out at a higher volume and moves down and sometimes

you will get a small peak. This is another area we need to investigate as we can with actual amniocentesis to see what is going on.

Slide 43: This four-month-old was referred for diagnostic ABR. Tone burst thresholds were obtained down to 25 to 30 dBnHL for 1000, 2000 and 4000 Hz. A .500 Hz tone burst was obtained at 40 dB, and then the child woke up prior to bone conduction. TEOAEs were absent and the baby was referred to ENT for middle ear effusion. This one, **(Slide 44)** 226 Hz on the left, you can see there is some movement there, and there was something that looked like a peak, but if we go to the 1000 Hz tympanogram, the left ear was just done two times to ensure and that is a flat tympanogram for the 1000 Hz on the left ear. And there was a 15 dB difference between her air conduction and bone conduction click thresholds, so they were referred to the ENT for middle ear effusion. Then the last one **(Slide 44)** is also flat, so you can see on the bottom screen we are seeing some movement for a 226 but not with a 1000 Hz tympanogram. Another thing that is important with this one is that with the diagnostic ABR it was still done even though there was a flat tympanogram, there was no response to the ABR to either click or tone burst stimuli. So they were referred to the ENT for medical workup for hearing loss with middle ear overlay. It's important not to wait for the middle ear overlays to be corrected before we start working with their hearing loss.

In summary, we found that 1000 tympanometry is effective and reliable. There is normative data that are available. It should be incorporated, especially for diagnostic assessments. Always correlate it with your other diagnostic measurements and I think we need some research to answer some of the questions that I have addressed and to see how it might be helpful to use in the actual first screening with newborn hearing screening program. I still think we need more training on the appropriate use of tympanometry and make sure the data are used consistently and correctly.

Thank you, and I'll take any other questions.

Call Participant: Could you repeat what equipment the case study was normed on?

Dr. Hanks: Grason-Stadler. Both the Tympstar or GSI 33; it's the same piece of equipment, just a different edition but the actual use is the same.

Call Participant: I'm interested in when you start to go toward the diagnostic route instead of continuing to have the MEE treatments as far as how long do you wait.

Dr. Hanks: Well, we've had some reports that parents were waiting six, nine months before there was any treatment started to look at the hearing loss. That's too long. If they're through the diagnostic eval and they are a month out, they need to be referred.

Call Participant: Thank you.

Call Participant: What has been the biggest problem you have seen in how the tympanometry has been used in newborn hearing screenings?

Dr. Hanks: The biggest thing is people not knowing how to use the norms and not using 1000 Hz but using 226 instead of 1000 Hz and then not knowing that you have to have a peak in order to use the norms. And to make sure you are using the appropriate norms. It is important to decide which ones you want to use and to use the right set of values.

Call Participant: Some of the manufacturers use the 678 Hz. Have you seen that at all?

Dr. Hanks: That was left over from some of the very beginning research.

It was useful when it was the highest frequency that was there before the 1000, but I personally don't use 678 anymore. In my survey I also used 800 Hz or included 800 Hz because the Interacoustics equipment also includes 800 Hz. I think only one person used the 800 Hz probe tone.

If you know a lot about tympanometry, you can use 678 Hz to see how close it is to the middle ear resonance and that can give you different ideas of different pathologies. But you have to be familiar with all of the literature in order to use it easily.

Call Participant: Are you also just recording the pass-fail rather than the old terms of using different measurement types?

Dr. Hanks: Because we are using it for newborn hearing screening, then that's what I've emphasized today is that's the bottom of the norms. The norms do include a normative range with a top also for the normative range for the static acoustic immittance, but I've used the bottom of the range more because with newborns we were looking more at space occupying lesions rather than discontinuity.

Does that answer your question?

Call Participant: Yes, thank you.

Call Participant: So, you're using this as part of the newborn screening program?

Dr. Hanks: I am currently doing research on that, I don't have those data yet, but I want to know how people were using it. That's why I did the survey and found out there were about 30 out of the 153 that were using it as part of the newborn hearing screening program because many of the programs will do multiple screens before the child is dismissed or discharged. What I'm looking at now, actually one of my doctoral students is looking at, is if we add tympanometry to the initial

newborn hearing screening and if we get a flat tympanogram and a failed OAE the first time, can that save us from doing multiple screenings with that infant before discharge? Some screening programs look at the infant several times. Some do it early morning, they do it again later in the afternoon and then again the next morning before discharge. So sometimes they get three evaluations before discharge. So I'm saying we are going to do all three and then see does the tympanogram stay flat for all three? If it does, then we don't have to try to follow-up on that baby; we just say there is a problem and refer from there.

Call Participant: How are you recording the results of the tympanograms on a formal report from 1000 Hz? Are you reporting them similarly to the 226 or using a normal versus an abnormal report?

Dr. Hanks: I use it similar to a 226, because the normative data is there, as long as it's within the range of greater than .6 to hmm, I'm sorry, I don't even remember the top range, perhaps 2.2. Then it's in normal limits, so I will say normal mobility and pressure.

Call Participant: So, I'm sorry, so you're saying that normal is .6 to 2.2?

Dr. Hanks: It's going to depend on which study you're using. So you need to get the actual studies and decide which norms you are going to use. You will want to use the 95th percentile and 5th percentile to define your normal range.

Call Participant: And I am at a high altitude, so once you got that elongated tube, did you not have any other problems? That was just the main issue?

Dr. Hanks: Yes, then we didn't get the occluded or the leak messages all of the time.

Call Participant: Okay. But the norms were the same? You were still able to use the same norms?

Dr. Hanks: You will need to talk to Grason-Stadler. I'm now at sea level, I'm not using that, but you need to talk to your equipment representative to see how much of a change that introduced into it. It will change your ear canal measurements, so you will have to talk to them about how to calculate that difference. Where are you at?

Call Participant: New Mexico.

Dr. Hanks: Dr. Lisa Hunter at the University of Utah has equipment with that adjustment, and she might also be able to answer that question for you. (I just found out that Lisa has left the U of U – how do you want to handle this???)

Call Participant: Okay, thank you.

Call Participant: When you report to a pediatrician that the baby has middle ear effusion, are you finding that they are actually doing much to treat that?

Sometimes we found that our primary cares and the ENT's are a little hesitant to do that, but we have been sort of forging ahead with the diagnostic part of that and then trying to, by doing bone conduction, trying to assess how much of that is a conductive loss so we don't waste the time, and I think that's what I think I heard you say before.

Dr. Hanks: Exactly. I think with everything else it does depend on the pediatricians, go back and educate, educate, educate as much as you can.

If you can get involved at their grand rounds at the hospital and tell them about the

current research that may help. Many of them might have been taught the studies from Paradise that started way back in '76, and he said you can't do tympanometry on newborns. That's true because it was 226 and that might be all they were taught. So I think we have to educate our physicians. The 1000 Hz tympanometry is valid when used appropriately. After they understand that, then that will be their medical decision on if there is a fever along with it, etc., on how they might work with that effusion, but it should be followed closely.

Call Participant: Thank you.

Call Participant: If there's time for one more question, how do you feel the Swonepoel study impacted your comments today?

Dr. Hanks: Well, they look at things very differently than we have within the United States, and I think it would be interesting to look at. But I just think that this method is going to be influenced by not subtracting out the ear canal problem we will get a lot more variability. So I just don't know I'm ready to use that one yet.

Call Participant: Okay, not being familiar with the study, that was the main difference by not taking away the anatomy?

Dr. Hanks: Right. So I'm not sure yet, but it is just a new way of looking at it. Sometimes that is good. So I'll just have to try it out and see what I think.

Call Participant: Okay. Thank you.

Steve Richardson: Any more questions for Dr. Hanks? Okay. Dr. Hanks, thank you very much. The EHDI Program appreciates your taking the time to lead the session.

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