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Audiological Tests, the Tools of the Trade

At our January 2009 meeting Georgette Schroeder, Pediatric Audiologist at Lutheran General Hospital, began with the lingo, explaining common terms used in audiology and a quick review of the anatomy and function of the ear:

The Outer Ear gathers sound waves in the environment and channels them to the middle ear. **The Middle Ear** transforms the sound waves into mechanical vibrations and acts as an amplifier. **The Inner ear** or **cochlea** stimulates the hair cells inside the cochlea. It does a second transformation of the energy that is an exact replication of the sound waves that entered the outer ear. The cochlea also acts as an amplifier as it sends the energy along to the **Auditory Nerve.** This nerve takes the information from the ear, through the brainstem, to the brain for interpretation. What was that sound you just heard?

Georgette explained the different types of hearing tests:

The Audiogram shows what someone's hearing is like. It is a graph. Across the top are different frequencies from low to medium to high pitch. Running down the side is a range of loudness of sound in decibels. The audiologist uses a hearing test to determine what the softest sound is that one can hear across the frequency range that is most important for speech. These thresholds of hearing are then plotted on the audiogram graph to 'show' the range of hearing for that person.

Georgette explained that she can sometimes use a child's behavioral responses to determine what they have heard. Sometimes she must use a physiological test to *estimate* the audiogram. Behavior testing requires a consistent motor response to sound. For example a two year old might be asked to drop a block into the bucket when they hear the sound. Typically developing infants can usually do a form of behavior test at 7-9 months of age. They might look to the speaker or to a toy that then lights up when the child looks to the place of the sound. Children with Down syndrome may test at 8-9 months, others may wait until a year or more. A child must be able to give a consistent motor response. Some may be too scared to go into the testing booth, or they may have motor involvement. When a consistent response is not possible, there are physiological tests that can be used.

Tympanometry, or a tympanogram is a physiological test that can check ear drum movement, middle ear pressure and Eustachian tube function. It can also test ear canal volume, obstruction, a perforation in the ear drum, or a tube placed in the ear drum to allow air to the middle ear when fluid is a problem. This is one test that can be administered in the pediatrician's office if they are equipped. However, the tympanogram is not a measure of what sound can be heard. A flat tympanogram indicates dysfunction. It may mean the ear drum is not vibrating due to fluid present behind the ear drum, in the middle ear. It may also mean too much wax, or an infection. Wax present in the ear canal is normal. It cleans out the dead skin cells and generally moves out on its own. Wax is only a problem when one produces too much or the ear canal is very narrow.

The Otoacoustic Emissions test, or OAE, tests for healthy functioning of the outer haircells in the cochlea. Proper functioning is highly correlated with normal hearing. When haircells are not shown to be functioning, hearing loss exists. We are born with all the hair cells we are ever going to have. A babies' ear is completely developed at 10 weeks gestation, which is why all those baby books tell moms to talk and sing to their babies. They will know mom's voice at birth. Each hair cell in the cochlea bends and moves. But to this day, scientists are not sure what the exact function of the inner haircells is.

The OAE test is used as a hearing screening tool for every newborn infant in all 50 states and most developed countries in the world. We know that the earlier the hearing loss is found, and intervention begun, the better the outcome. Generally a screening OAE *pass* is interpreted as intact inner, middle, and outer ear mechanisms. The OAE is quick. A child needs to hold still only 10-20 seconds per ear for a screening, and 1-2 minutes for a diagnostic test across a broader frequency range. Georgette is a happy audiologist when she can get a normal behavior test AND a normal OAE.

The OAE is limited however. When *anything* obstructs the pathway to and from the cochlea, it leads to the inability to record the response, and evaluate the cochlear functioning. Possible diagnoses for failing an OAE screen include obstruction of the external ear, such as ear wax, middle ear dysfunction, such as perforation of the tympanic membrane or ear drum; serious or acute otitis media (ear infections), cholesteatoma (skin growth in the middle ear), eustachian tube dysfunction, ossicular malformation (malformation of the small bones in the middle ear) or sensorineural hearing loss.

The Auditory Brainstem Response or ABR is the power tool of hearing tests. It is used when a behavioral hearing test cannot be done successfully and one really needs to know what the child's hearing is like. This test has many names…ABR, AER, BAER, BAEP. But it is all the same. The ABR is a very small electrophysiological response that can be recorded with the surface electrodes. In this test electrodes are secured to the head and a sound is administered in the ear. The ABR tests the hearing nerve at the level of the brain stem. It does not test how the brain uses the sound. When a child cannot be tested with a behavioral test, the ABR can be used to estimate hearing sensitivity and the behavioral audiogram. It can also be used for newborn screening. However, the ABR must be given on a sleeping child. It is often used on a very young child who can sleep through the test, or a child must be sedated.

The Auditory Steady State Response or ASSR, is the newest physiological test. Like the ABR it is a neural response, but it has several advantages. The sounds used to elicit the response are more frequency specific so the predicted audiogram can be closer to the child's true hearing thresholds. This is very helpful in testing children with severe to profound sensorineural hearing loss. The ABR can measure hearing loss to 80 dB, (decibels). The ASSR can measure hearing loss up to 120dB.

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