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Hearing Screening in Infants

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Abstract
Hearing screening in infants helps to identify babies who have permanent hearing loss as early as possible. This helps the parents to get the desired support at the earliest. Right from the day of birth, babies begin to learn language skills by listening to and interacting with those around them. If these opportunities are not there, their language development can be delayed. Early diagnosis of hearing loss and beginning of its intervention helps to keep children's development on track and improve their future language and social development. If the child is diagnosed with hearing loss, then the parents should seek immediate help in form of treatment and intervention from an otolaryngologist and an audiologist. Thus, hearing screening in infants is essential.

Keywords: Audiology, Otoacoustic Emission, Auditory Brainstem Response, Hearing Screening, Reinforcement Audiometry

Introduction:
One of the most amazing and important accomplishments of infancy and early childhood is the development of language. By 4 years, they know more than 1,500 words and begin telling stories. Children with solid language skills often become strong readers and writers. Such delays can be prevented or reduced through early interventions. Family members can encourage a baby's language by listening, singing and speech during natural daily routines. It is important to remember that not every child is the same. Children reach milestones at different ages. All auditory mechanisms seem ready at 6 to 7 months of gestation. Clinical observations suggest that some very premature infants born at 25 weeks react to sound. Support for these observations come from high resolution ultrasound imaging.

Pathophysiology:
The most basic auditory function is the ability to detect acoustic energy; how well it is done is described as Sensitivity. The electrophysiologic techniques to study sensitivity in infants, the most utilized has been auditory brainstem response (ABR) audiometry. The latency of the infant's brainstem response decreases from before birth until the second year of life. This decreasing latency reflects a maturing auditory system, attributed to the process of myelination (Starr *et al*, 1977) [5]. Visual reinforcement audiometry (VRA) has been tremendously successful with most babies above about 5 months of age. Using VRA, Moore and Wilson (1978) showed that infants 6 to 12 months of age have quite low sensitivity threshold. In addition to detecting soft sounds, infants can localize sound. Localization is probably one of the more basic auditory abilities. Hearing is a distance sense; thus, the ability to detect sound is even more helpful when an individual can tell where the sound is coming from (consider hunting /escape).

Phonetics:
It seems a universal belief that incredibly young babies recognize and prefer their own mother's voice. Data supports this belief. Newborns can distinguish between their mother speaking in her native tongue versus speaking in an unfamiliar language, even when the signals have been low pass filtered (Mehler *et al*, 1988) [10]. Perhaps babies are sensitized prenatally to respond to their mother's voice (DeCasper and Fifer, 1980) [9]. Languages have categories of speech sounds called Phonemes. The ability to perceive speech sounds as belonging to categories denotes the ability to detect a difference between stimuli. Infants group speech sounds into phonetic categories in adult like fashion (Kuhl, 1987) [4]. A baby's first words are music to a parent's ears. General milestones can serve as a guide to normal speech and language development. These milestones help doctors and other health care providers determine when a child might need extra help.

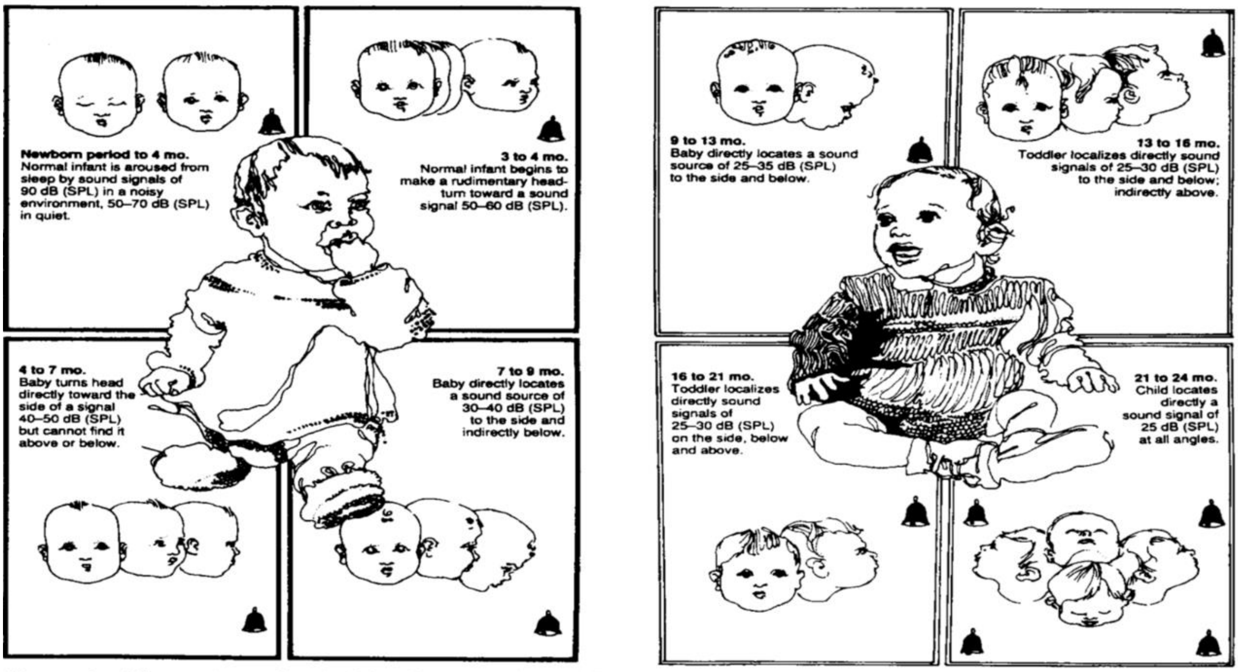


Figure 1 Illustrations of typical development of sound localization in infants. Left panel shows infant responses from newborn to 9 months. Right panel shows infant responses from 9 to 24 months. (Adapted with permission from Northern and Downs, 1991.)

Milestones:

By the end of 3 months

- Smile when a familiar person appears.
- Make cooing sounds.
- Quite or smile when spoken to.
- Seem to recognize voices.
- Cry differently for different needs.

By the end of 6 months

- Make gurgling sounds when playing or left alone.
- Babble and make a variety of sounds.
- Use his or her voice to express pleasure and displeasure.
- Move his or her eyes in the direction of sounds.
- Respond to change in the tone of voices.
- Notice that some toys make sounds.
- Pay attention to music.

By the end of 12 months

- Try to imitate speech sounds.
- Say a few words, such as « dada », « mama », and « uh-oh »
- Understand simple instruction, such as « come here »
- Recognize words for common items, such as « cup »
- Turn and look in the direction of sounds.

By the end of 18 months

- Recognize names of familiar people, objects, and body parts.
- Follow simple directions accompanied by gestures.
- Say as many as 10 words.

By the end of 24 months

- Use simple phrases, such as « more milk »
- Ask one-to-two-word questions, such as « Goodbye-bye?
- Follow simple commands and understand simple questions.
- Speak about 50 or more words.
- Speak well enough to be understood at least half the time by parent and other primary caregivers.

Hearing Screening Tests for Newborns:

Serious hearing loss occurs in about 2 to 3 of every 1,000 newborns. Without screening or testing, hearing loss may not be noticed until the baby is more than 1 year old. Social and emotional development along with performance in school may also be affected. Most hearing loss is present at birth (congenital). But some babies develop hearing loss after they are born. Hearing loss is more likely in:

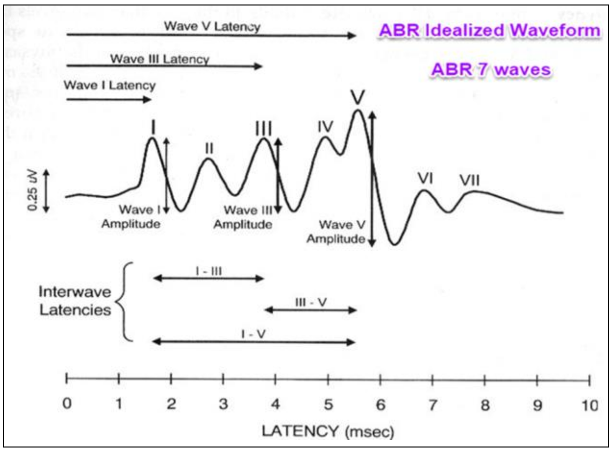
- Babies who are born early (premature)
- Babies with infections
- Babies with respiratory problems requiring long term use of breathing machines and certain medicines

Because of these risks, many health organizations now recommend Universal Infant Hearing Screening. Today nearly all newborns are screened for hearing loss. This allows earlier treatment to prevent delays in language and development.

Types of Testing:

1. **Auditory Brainstem Response (ABR):**

Previously, popularly known as Brainstem Evoked Response Audiometry (BSERA). This test uses wires (electrodes) attached with adhesive to the baby's scalp. While the baby sleeps, clicking sounds are made through tiny earphones in the baby's ears. The test measures the brain's activity in response to the sounds. This is a painless test and takes only a few minutes. BERA is an effective and non-invasive means of assessing the functional status of the auditory nerve and brainstem auditory sensory pathway. It is not significantly altered by the state of consciousness, drugs, and variety of environmental factors.

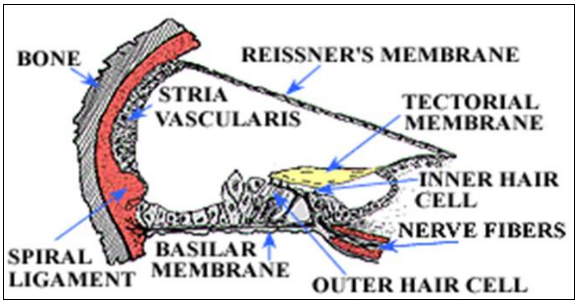


Neural Generators of the BERA:
BERA is generated by the auditory nerve and subsequent structures within the auditory brainstem pathways. Information regarding the origin of individual wave components of BERA was provided by Moller and Janetta.

Following Waves are Generated During this Test:
Wave I: It represents from the compound action potential in the distal portion of cranial nerve VIII.
Wave II: generated by the proximal VIII nerve as it enters the brainstem.
Wave III: Generated mainly in the cochlear nucleus (second order neuron).
Wave IV: It arises from pontine third order neuron. Mainly located in superior olivary nucleus, but additional contributions may come from cochlear nucleus and nucleus of lateral lemniscus.
Wave V: Generation of wave V reflects activity of multiple anatomic auditory structures. Sharp positive peak of wave V arises mainly from the lateral lemniscus. Wave V is the component analyzed most often in the clinical application of the BERA.
Wave VI and VII: These waves appear to be generated in the inferior colliculus, perhaps in the medial geniculate body.

2. Evoked Otoacoustic Emissions (EOAE)

This test uses a tiny, flexible plug that is inserted into the baby's ear. Sounds are sent through the plug. A microphone in the plug records the responses (otoacoustic emissions) of the normal ear in reaction to the sounds. There are no emissions in a baby with hearing loss. This test is also painless and is often done in a few minutes while the baby is asleep. Otoacoustic emissions (OAEs) are sounds of cochlear origin, which can be recorded by a microphone fitted into the ear canal. They are caused by the motion of the cochlea's sensory hair cells as they energetically respond to auditory stimulation. OAE or otoacoustic emission testing is the recording of sounds that the ear produces itself. They appear to be generated by motile cochlear outer hair cells.

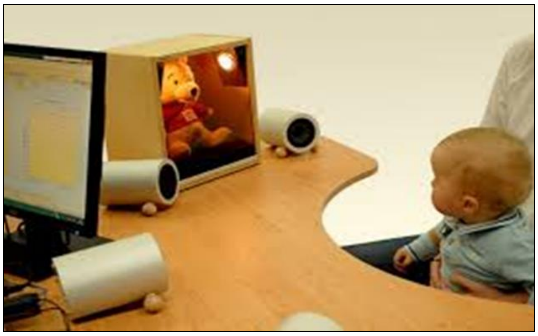


Anatomy of the Inner Ear

There are 2 types of Otoacoustic Emissions in Clinical Use

Transient otoacoustic emissions (TOAEs) or transient evoked otoacoustic emissions (TEOAEs) - Sounds emitted in response to an acoustic stimulus of very short duration; usually clicks but can be tone-bursts. Distortion product otoacoustic emissions (DPOAEs) - Sounds emitted in response to 2 simultaneous tones of different frequencies. Any small defect in the peripheral auditory system (middle and inner ear) which can cause even a mild to moderate deafness with make the OAE undetectable. The click evoked OAEs re recordable if the hearing is normal that is, within 30dBHL. If the hearing threshold is above 35-40dB, the TOAEs cannot obtained at all.

3. Visual Reinforcement Audiometry (VRA)



Visual reinforcement audiometry (VRA) is a test that allows an audiologist to assess hearing in infants and toddlers too young for normal tests. VRA relies on behavioral conditioning to train very young kids to respond to sounds. It is designed for children aged between six months to three years. VRA uses both audiometer and visual reinforcers to test a child's hearing threshold levels. Standard pure tone audiometers use headphones and a feedback button, so they are not practical for infants. VRA replaces the headphones with earphones (usually with foam tips) or free field speakers. Visual reinforcers such as video animations or lighted toys are placed 90 degrees to each side of the patient to "train" the child to look toward the direction of the sound.

While the child sits upright on a parent or caregiver's lap in a soundproof room, the audiologist plays a tone or some other sound to one of the child's ears. At first, the audiologist lights up the boxes in conjunction with the sound. This "trains" the child to respond by shifting her eyes or turning her head toward the sound source. Once a child understands what to do, the audiologist can "reward" the child by briefly delaying the visual stimuli.

This instrument is s handheld infant screening audiometer with a light can be used for VRA. The instrument can deliver sounds at different intensities and frequencies. The instrument is calibrated in way that when it is held at 1 meter from the infant's ear, they hear the sound at intensities marked in the attenuator dial of the instrument.

4. Auditory Steady State Response (ASSR)

This is an auditory evoked potential test that can be used to objectively predict frequency specific hearing threshold in all patients irrespective of age, mental state and degree of hearing loss.

It can estimate the hearing threshold at 500, 1000, 2000 and 4000Hz, objectively. It is different from tests like BERA, middle latency response (MLR) and late latency response (LLR) and overcomes some of the inherent limitations of these tests.

Estimated Audiogram Derived from ASSR

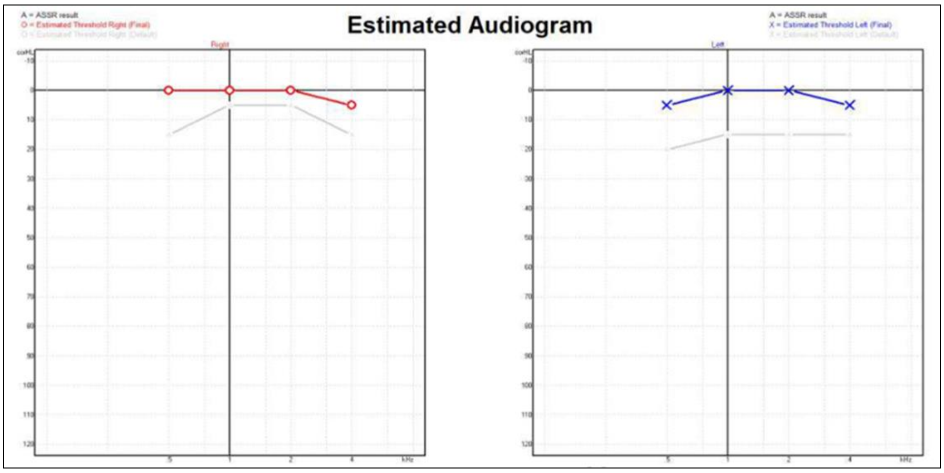


Table 1: Differences between ASSR and BERA

ASSR	BERA
Continuous stimuli at high repetition rate	Single stimulus
Objective, sophisticated, statistics-based mathematical detection algorithm to detect and define hearing thresholds	Detection of the response is done manually
Amplitude and phases in spectral (frequency) domain is done	Amplitude, latency, peak detection done in time domain
Multiple frequencies and both ears together can be tested	Single frequency and one ear at a time to be tested
Can test severe to profound hearing loss and specify the hearing level in this category	Can test up to severe hearing loss; cannot specify exact hearing threshold above 80dBnHL hearing loss

Conclusion

This article has provided the knowledge about the development of Auditory skills infants and necessity of hearing assessment in them. Newborn screening and diagnosis help ensure all babies who are deaf or hard of hearing are identified as soon as possible. Then, they can receive early intervention that can make a big difference in their communication and language development. Proper assessment of all infants with hearing loss especially if it appears to be congenital requires a well-integrated multidisciplinary approach that includes genetic evaluation as well. The earlier the child is diagnosed, better is the result of remedial measures. Best results are obtained if the remedial measures are undertaken before the child reaches six months of age. Problem is that for hearing assessment in infants, no single test is foolproof and adequate to completely evaluate the hearing faculty in an infant. Cross checking is the rule and is a mandatory requirement. Different test both electrophysiological (like OAE/BERA/ASSR) and behavioral (like Free Field Audiometry/VRA) must be combined to confirm and re confirm the status of the auditory function. Public awareness about auditory development and assessment of hearing in infants leads to enhancement of wellbeing of society.

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