

# Hearing testing in children

## Hearing screening

### Universal newborn hearing screening

UNTIL recently, one deaf child would be sent home from their birthing hospital in Australia every two days, often without having the hearing loss detected until they were well over 18 months of age.

US research into speech and language outcomes in deaf children has shown that babies who have their hearing loss detected and treated (usually with hearing aids) by the age of six months have significantly better language and educational outcomes than those detected later.

To improve the detection of hearing loss in newborn babies, both in well babies and those who are "at risk" for hearing loss (see table 4), automated hearing screening using one or both of two methods has been introduced to several birthing hospitals in Australia, starting with a program in WA in 2000 testing 46% of all neonates.

Similar programs have recently begun in NSW, Victoria, ACT, SA and the NT and are proposed for Tasmania and Queensland as either pilot studies or as part of regular newborn screening. Newborn hearing screening programs have been mandated or introduced in the US, UK and many European countries.

We are fortunate in Australia to have the services of Australian Hearing, which provides free amplification and hearing monitoring to all hearing-impaired children and maintains a national database on children fitted with hearing aids.

### Transient evoked oto-acoustic emission

One method of testing cochlear function in the newborn is to use the principle of transient evoked oto-acoustic emission, in which a transient sound introduced to the ear canal elicits an "echo" in the presence of intact outer hair cells in the cochlea (figure 2).

This is not a hearing test per se and will not detect the rare condition of auditory neuropathy (see previous page), and is not particularly effective in the first 24 hours after birth or in the presence of ear canal obstruction or middle-ear fluid.

However, it is a relatively easy test to perform and may painlessly provide a "pass or refer" result within 2-3 minutes, although discussion with the parent, preparation of the baby and recording of results may take up to 20 minutes per baby.

In about 80% of babies a pass is obtained on the first tests, but the remainder will require further testing during their hospitalisation or several weeks later at a follow-up clinic.

In WA, where more than 30,000 babies have been tested, babies who fail the initial screening are retested using a second technology — the automated auditory brainstem response (see below) — giving, in all, a pass rate of almost 98% in many programs. The remaining 2% of babies are referred for definitive diagnostic testing in a paediatric audiological centre.

### Automated auditory brainstem response

This test is a variation of the standard diagnostic auditory brainstem response, which uses a template to measure the auditory pathway from ear canal to brainstem, with pass or fail settings around 35dB, eliminating all but a very mild hearing loss (figure 3).

This method of testing is more accurate than transient evoked oto-acoustic emission, as it includes more of the auditory system (ear canal to lower brainstem) and has high specificity in the first few days of life. However, it generally takes longer to perform, is more invasive, and it is more expensive to purchase the equipment and administer.

Automated auditory brainstem response screeners cost about \$30,000 plus \$5-\$20 of disposables per test, while transient evoked oto-acoustic emission screeners cost \$7000-\$10,000 each, with \$1 of disposables. The former is the methodology for all babies in level 2 or 3 nurseries and for at-risk babies.

### Screening by distraction testing

Screening of hearing by distraction testing is generally performed by child health nurses when the child is aged 7-9 months, as part of regular health screening. This test relies on the infant's response to various auditory stimuli, such as rustling paper behind the child, and has been a mainstay of paediatric hearing assessment.

The test has a questionable reliability and has been discredited in several countries, particularly the UK. However, despite the advent of universal newborn hearing testing, it does have a role in detecting children with progressive or acquired sensorineural hearing loss and the more common conductive hearing loss secondary to OME.

It is also an opportunity for the parent to comment on their impressions or concerns regarding their child's hearing, especially if newborn hearing screening has not been performed.

If a parent feels their baby cannot hear, the health professional must ensure the child's hearing is tested both behaviourally and objectively to rule out a hearing loss. It is

Figure 2: Baby being screened with evoked oto-acoustic emission.



Figure 3: Baby being screened by automated auditory brainstem response.



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### Audiological testing

#### Behavioural observation audiometry

Distraction testing, as mentioned above, is a form of behavioural observation audiometry testing. When performed as an audiological test rather than a screen, behavioural observation audiometry usually requires two audiologists — one to present the auditory stimulus and the second to monitor the child's response behaviour.

A range of response behaviours is monitored — from a startle reflex to eye widening, searching, smiling, laughing or pointing. These results do not indicate threshold but rather the level of the child's responsiveness to sound.

#### Conditioned orientation response and visual reinforcement audiometry

With the realisation that infants are active recipients of auditory information and, given the chance, will interact with their acoustic environment, behavioural testing techniques suitable for children aged eight months to two years were developed.

These tests allow infants and young children to actively demonstrate what they perceive, allowing an assessment of their functional hearing

Table 4: JCIH criteria for hearing screening of neonates when universal screening is not available\*

- Family history of hereditary childhood sensorineural hearing loss
- In utero infection such as cytomegalovirus, rubella, syphilis, herpes and toxoplasmosis
- Craniofacial abnormalities, including those with morphological abnormalities of the pinna and ear canal
- Birthweight <1500g
- Hyperbilirubinaemia at a serum level requiring exchange transfusion
- Ototoxic medications, including but not limited to the aminoglycosides, used in multiple courses or in combination with loop diuretics
- Bacterial meningitis
- Apgar score of 0-4 at one minute or 0-6 at five minutes
- Mechanical ventilation lasting 10 days or longer
- Stigmata or other findings associated with a syndrome known to include a sensorineural and/or conductive hearing loss

\*American Academy of Pediatrics. Joint Committee of Infant Hearing 1994 Position Statement. *Pediatrics* 1995; 95:152-56.

### Take-home message regarding hearing in children

- Any child at any age can have their hearing tested
- If a mother feels her child is deaf, testing to definitively rule out or confirm hearing loss is essential
- Universal newborn hearing screening is best practice for early detection and habilitation and to optimise the language and educational outcomes of babies with hearing loss
- If a child requires middle ear surgery, including grommets, it is essential, when possible, to obtain pre- and postoperative audiometry
- Central auditory processing testing may be invaluable in the school-aged child with learning or behavioural problems in the presence of a normal audiogram
- Even central auditory processing disorders can possibly be prevented with the astute and timely management of early middle ear disease

### Pure tone audiometry

Pure tone audiometry is the most simple but also the most complete test of the auditory system. It effectively measures from the ear all the way through to the auditory cortex, the centre of the brain where sound is perceived.

With headphones it assesses the child's response to pure tones at different frequencies and allows the audiologist to obtain ear-specific threshold information. Some children will accept headphones and indicate they have heard the auditory stimulus by placing toys or blocks in a box (figure 4).

Bone conduction hearing testing uses a bone conductor placed over the mastoid bone, which delivers the stimulus directly to the cochlea, thus bypassing the external and middle ear.

This allows assessment of the status of the child's baseline hearing. The nature of the hearing loss (conductive or sensorineural) can be determined by comparison to the pure tone air conduction test (under headphones).

Speech perception testing enables us to obtain more complex information about the child's auditory and communication abilities. The four response tasks include detecting, discriminating, identifying,