

# NEONATAL HEARING: AN EVALUATION FOR LANCASTER

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## INTRODUCTION

All parents want to know that their newborn baby is normal in all respects. It is easy to count fingers and toes or to see any physical defect. Hearing, however, is much more difficult to examine with any reasonable certainty, even for an audiologist. Traditional methods of testing using reflex reactions, distraction techniques or pure tone audiometry are either inappropriate at this early stage or give only the broadest possible idea of the integrity of the auditory pathway.

The value of hearing in early life, especially in the development of language, is accepted and well documented and thus the earliest possible assessment of hearing function should be viewed as a high priority. Until recently this was not really possible until the child was at least six months old, when testing by skilled specialists would determine the hearing threshold levels. Clearly any improvement would be welcome, and such a test has recently been introduced on a pilot basis in the Lancaster area. Some babies from South Cumbria have also been examined. The test is called Transient Evoked Otoacoustic Emissions (TEOAE), more generally called simply OAE.

## THE OAE TEST

The test method and protocol were developed by Professor Kemp and his colleagues<sup>(1)</sup>, who built upon an idea proposed by Gold in 1948<sup>(2)</sup> that the hair cells within the cochlea create a sound emission themselves when they are flexed by the movements within the Organ of Corti during stimulation by an incoming sound wave. This emission can then be picked up by a sensitive microphone placed within the external auditory canal. The more hair cells stimulated and working, the greater is the returning response or cochlear echo. Such a response is increased by the recently described 'cochlear amplifier' which uses the electromotility of the outer hair cells (OHCs) within the cochlea to enhance the shearing forces applied by an incoming sound to the hair cells.

This rather simplistic explanation of the otoacoustic response masks the flexibility with which it may be used. Clinically, three prime measurements may be used in examining the auditory function:

- Transient Evoked Otoacoustic Emissions (TEOAE). These are the types of emissions analysed by our own ILO 88 equipment. The emissions arise a little while after the applied stimulus, usually a click, and may last 25mS or longer. The use of a click stimulus, which is a broad band and non-frequency-specific stimulus, means that the information retrieved from the OHCs is itself not frequency-specific, though it is recognised that the

resultant response comes from the areas of the cochlea that respond to the high frequencies of sound, ie >1kHz. The exact level is dependent upon the anatomical structure of the particular ear. The returning emissions' sound pressure rarely exceeds 20dBSPL (SPL is the intensity of a sound measured according to the pressure it applies on a given surface. dBHL is the loudness of a sound pressure as perceived by an ear). They are remarkably constant over a period of many years<sup>(3)</sup>. There are some differences between the neonatal responses and those obtained from more mature individuals. The OAE response is a little larger in neonates and covers a broader frequency spectrum than that for adults. A more complete description of these phenomena can be found in reference 4.

- Spontaneous Otoacoustic Emissions (SOAEs) are emissions present in the absence of an external stimulus. They are recorded as a very narrow band emission and are found in up to 60% of all humans, even those with normal hearing. There are few other correlations. Some authors have reported that SOAEs are more likely to occur in females than in males. Others have shown links between the SOAE frequency and tinnitus, although this is disputed. Another author reports that only 4% of tinnitus is caused by SOAEs.<sup>(5)</sup>
- Distortion Product Otoacoustic Emissions (DPOAEs) result from the stimulation of the cochlea with two separate tones, which create an interference tone as a result of their interaction. They are similar to the other two types of emissions in that they are very stable over long periods and are a function of the OHCs. They do have some useful characteristics, one of which is the ability to obtain frequency-dependent information over a wider frequency range. It has been shown that the results mirror those taken by means of a normal subjective pure tone audiogram<sup>(6)</sup>. Another advantage is the speed with which the test may be undertaken, typically less than 60 seconds per ear.

## LOCAL NEED

Approximately 240 babies are admitted to the Special Care Baby Unit each year, and it is agreed that they are at a greater risk of some form of sensorineural deafness than the general neonatal population. There is about a tenfold risk of sensorineural hearing disorder greater than 50dBHL<sup>(7)</sup>. This on its own is ample indication for routine testing of these babies. The overall costs of the test elsewhere were £30-£40 per test (1992 values). The potential for very early identification of hearing deficits, and thus earlier treatment, is great. A number of parents will be saved considerable anxiety by having normal test results from their new child, an important consideration where a family history of deafness is present.

## LOCAL PROTOCOL

The purchase of the equipment for the Trust by the Morecambe Men's Committee was an essential first step. With this equipment we have undertaken studies to clarify how best TEOAEs may be used in identifying hearing loss in vulnerable infants.

We have decided against universal neonatal screening at this stage. The pilot project, reported here, was undertaken without extra finance or other resources.

## METHOD

The pilot project was undertaken during the period from 9th February 1995 to 6th September 1995, a total of 29 weeks. During this time 53 babies were tested, resulting in 106 ear examinations. An average referral rate of 1.8 per week was thus established. The average gestational age of these babies was 43 weeks (range: -12 to +216 days after the expected date of delivery). The average post-birth age was 46 days.

Babies 'at risk' (Table 1) were identified by the relevant consultant paediatrician and referred directly to the audiology department in Morecambe. An appointment was made for the child to attend within the 40-44 weeks gestational age period, and a leaflet explaining the test was also given to the parents.

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|--|
| 1. Prematurity                         |
| 2. Family history of deafness          |
| 3. Intensive care                      |
| 4. First arch syndrome                 |
| 5. Chromosomal disorder                |
| 6. Maternal rubella                    |
| 7. Toxoplasmosis/Cytomegalovirus       |
| 8. Hypothyroidism                      |
| 9. High bilirubin level                |
| 10. Other (eg pre-auricular skin tags) |

Table 1 - Babies at risk; indications for referral

At the appointment an examination of the external ear canals was carried out as a prerequisite of testing. Many neonates were found to have wax or other debris which might prevent a successful test. TEOAE testing was then carried out on each ear in turn. If a pass result was obtained for each ear (Fig 1), then the parents were informed and the child discharged. If the result was a fail (Fig 2) from either ear, tympanometry was conducted to assess the state of the middle ear. A child showing abnormal middle ear function was asked to return in two weeks, to allow time for the middle ear problem to be resolved. Those with a normal tympanogram were tested with Brain Stem Evoked Response audiometry (BSER) as the suggestion then would be that an absent OAE response in the presence of normal middle ear function represented a sensorineural hearing loss.

As all three tests should ideally be conducted when the child is asleep, it was sometimes necessary to wait for the child to settle or bring the child back for retesting.

During the study period most children were required to attend no more than two appointments. Only where sedation was required to ensure cooperation were additional appointments needed.

## RESULTS

Comparison of Figures 1 and 2 demonstrates that it is

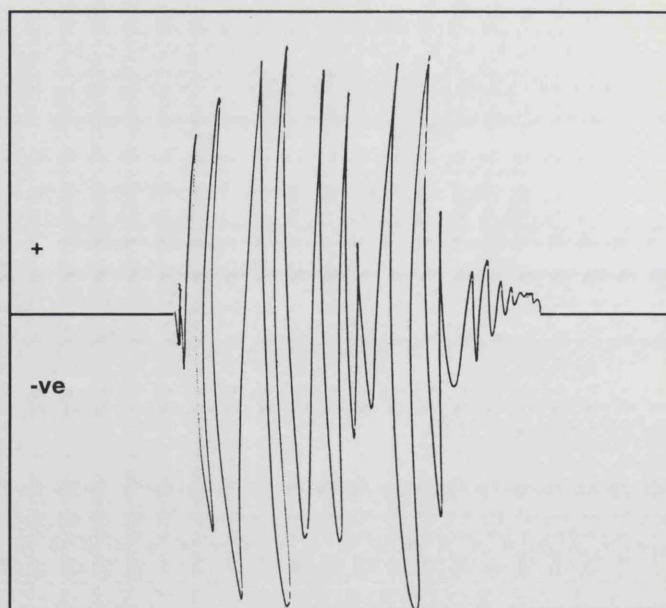


Figure 1 - Pass response

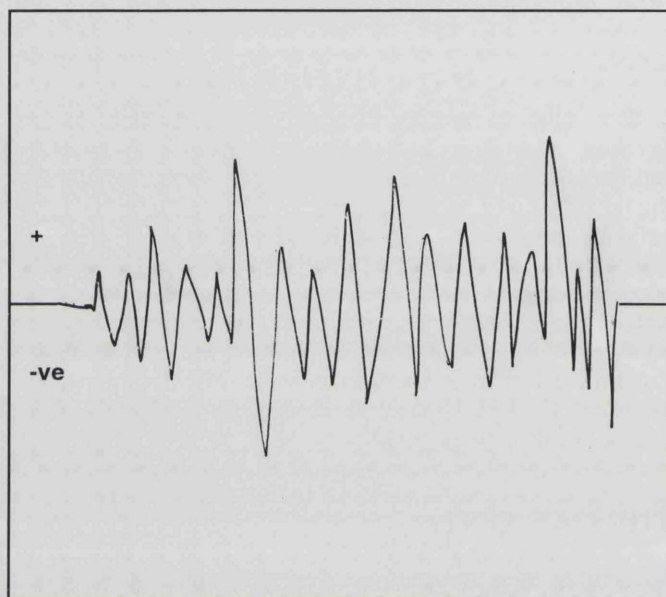


Figure 2 - Fail response

straightforward to tell the difference between a pass and a fail response, and thus interpretation of the result is immediate.

The results of the first OAE screening are shown in Table 2. These indicate that 66% of the ears tested passed the test first time. In only 13% was it impossible to obtain a result at the first attempt. Table 2 also illustrates the recorded status of the middle ear of those which failed to give an OAE response. Those who did not have a normal middle ear were brought back for retesting and BSER if needed. Fifty per cent of the ears demonstrated a normal tympanogram. These patients were tested with the BSER equipment.

OAE 'pass'	70 ears	66%
OAE 'fail'	22 ears	21%
No result	4 ears	3%
DNA	10 ears	10%

Table 2 - OAE results

Type A	11 ears	50%
Type B	6 ears	27%
Type C	1 ear	5%
No result	4 ears	18%

Table 3 - 'Failed' OAE tympanometry results

Normal BSER	1
Abnormal BSER	8
Pass on repeat OAE	2

Table 4 - BSER results in the presence of normal middle ear function

The others who failed the first OAE screening test and had abnormal tympanograms were asked to return approximately two weeks later. This would allow time for any potential URTI or middle ear problem to resolve if possible. I took the view that when such complications were still unresolved then progression to repeat OAE testing, tympanometry and BSER would be undertaken anyway to avoid further appointments for the young family.

Of those ears which did not have a normal tympanogram nine passed the OAE screen on retest whilst two (belonging to the same patient) failed to attend for the first or second appointment. Thus of the 106 ears tested only one gave a false positive result, ie indicated hearing loss when there was none found by other tests. This gives a sensitivity of greater than 99%. A similar figure has been found by other workers<sup>(8)</sup>. It gives encouragement for the future use of this test as an early hearing screening device.

Like Stephens and his colleagues<sup>(8)</sup>, however, I would not advocate the use of OAE testing in isolation. It should be coupled with tympanometry, BSER and otoscopy and in this protocol forms a powerful tool in the early identification of sensorineural deafness.

## AFTERCARE

It is important to ensure that parents do not see the hearing test(s) as an end in themselves. Those parents whose child passes the OAE and/or BSER test can be reassured about their baby's hearing and told that the hearing will also be checked at eight months as well as all the other usual milestones. Hearing loss can come in later life and a good hearing screen in the neonatal period does not guarantee continued aural health.

Equally, it is important that those children who are suspected of having a sensorineural hearing loss are given expert attention at the earliest possible moment. In these cases a referral is made to the Lancashire Paediatric Audiology Service where the results can be verified and any necessary treatment started. This will be arranged by the consultant paediatrician after consultation with the parents.

## DISCUSSION

Outlined above is a new method of testing the hearing of neonatals. Its efficacy has been well demonstrated not only by our own limited study but by those of others.

The continued use of this procedure will depend heavily upon a full cost/benefit analysis as the current project was undertaken without funding, which presented some problems. But benefit should not be measured simply as the number of

sensorineurally deaf children found by the early use of this technique. Other factors need to be considered. Firstly, and perhaps most importantly, there is a benefit to the parents of those children who pass the OAE and/or BSER screen. Many will have been through a traumatic first few weeks with their new charges. They must surely experience a measure of relief at the news that their child's hearing is at least normal at the cochlear/brainstem level.

Secondly, and most obviously, very early intervention can now be undertaken on those children with confirmed hearing defects. It remains to be seen over the long term exactly what benefits will accrue to the child but we must assume that they will be significant.

The future of the screening of neonatal hearing itself is also very much under discussion. It has been suggested<sup>(9)</sup> that the procedure should be used to replace the current health visitor testing as it would be more objective and bring substantial savings.

It is clear, however, from this brief study that the introduction of neonatal hearing screening for those babies who have been resident in a SCBU has been beneficial.

## REFERENCES

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