

NEONATAL HEARING SCREENING AND ASSESSMENT

AUTOMATED AUDITORY BRAINSTEM RESPONSE

INFORMATION AND GUIDELINES FOR SCREENING HEARING IN BABIES

Editor: Steve Mason¹

**Contributors: Clive Elliott², Guy Lightfoot³, Dave Parker⁴,
David Stapells⁵, John Stevens⁶, Graham Sutton⁷, Mike Vidler⁸**

1. Medical Physics Department , University Hospital, Nottingham, UK.
2. Audiology Department, Freeman Hospital, Newcastle, UK.
3. Clinical Engineering Dept., Royal Liverpool University Hospital, Liverpool, UK.
4. Centre for Human Communication and Deafness, University of Manchester, Manchester, UK.
5. School of Audiology and Speech Sciences, University of British Columbia, Vancouver, Canada
6. Department of Medical Physics and Clinical Engineering, Central Sheffield University Hospitals, Sheffield, UK
7. Audiology Department, Royal Berkshire Hospital, Reading , UK.
8. Audiology Department, Birmingham Children's Hospital, Birmingham, UK.

INTRODUCTION

Following the publication of the systematic review on Universal Neonatal Screening¹ a national group was formed to discuss some of the issues of implementation of Universal Neonatal Hearing Screening. Several meetings of this group have been held to discuss technical issues and it was felt appropriate to produce consensus documents on test methodology where this was possible. The click-evoked ABR (air conduction) was the first of these documents to be published² and more recently recommendations on the tone-pip ABR and bone conduction ABR have been produced. Since the ABR is widely employed in the initial screening process, the group has also decided to put forward information and guidelines regarding the automated collection and analysis of the ABR as a screening test (automated ABR: AABR)

SCOPE

The document sets out to provide information and guidelines for testing babies in the first few months of life by AABR using primarily air conduction click stimuli for the purposes of screening for hearing loss. Clicks are widely employed for neonatal screening and the majority of reported studies have employed the click stimulus. However in the future it is possible that other electrophysiological methods, such as the tone pip ABR, might become an alternative technique.

Equipment that carries out AABR testing is available from some manufacturers. The test protocols for this type of equipment are usually fixed and are specific to different manufacturers. Data collection parameters, implementation of the test, and scoring algorithms will be discussed. General aspects of ABR methodology have been reported previously² and will not be included in detail in this document.

DEFINITION OF THE AUTOMATED ABR (AABR)

Recordings of the ABR performed with an highly automated and standardised procedure for data collection for the purpose of screening for hearing loss. The presence of a response (pass) or absence (refer) at the screening intensity level of the stimulus is determined primarily by a clinically proven machine scoring algorithm operating on-line.

IDEAL FEATURES OF THE AABR SCREENING TEST

- Easy application and checking of recording electrodes
- Quick and user-friendly test procedure
- Portability for flexible implementation
- Objective (machine) pass and refer test results on each ear
- High sensitivity and high specificity
- Print-out of test results
- Availability of recorded waveforms for skilled review and audit

PATIENT PREPARATION

Many aspects of the preparation of the baby for testing are similar to those described in the air conduction click-evoked ABR protocol² and reference should be made to the relevant sections in that document. Supplementary information is given here.

Test Environment

If AABR testing is performed outside the designated clinic area, for example on the ward or in the community, levels of acoustical and electrical interference must be sufficiently low so as not to influence the results of the test. Careful selection of the local test area or room may be necessary in order to achieve satisfactory environmental conditions.

Choice of electrodes and application

Electrodes should ideally be low cost and disposable in order to meet the demands of screening large numbers of babies. If re-usable electrodes are employed then appropriate precautions must be taken to avoid the risk of cross infection. Since testing is often performed on very young babies extreme care must be adopted regarding preparation of the skin for placement of the electrodes. The use of harsh skin preparation materials should be avoided.

Electrode contact impedance

Acceptable levels of contact impedance for the surface recording electrodes vary according to the AABR system being used. Some systems have automated impedance testing facilities which will not allow the test to proceed unless values are below specified levels (for example 10k Ω)

Electrode location

In many AABR systems the location of recording electrodes is similar to that employed in conventional ABR testing².

STIMULUS

Stimulus type

Typically a click stimulus generated by an electrical pulse of 100 μ s pulse duration with alternating polarity. The stimulus is sometimes interleaved between the right and left ears in order to enable pseudo-simultaneous testing of both ears.

Stimulus rate

Relatively high stimulus rates are employed to minimise test time (typically faster than 30 clicks per second).

Stimulus level

The screening level of the click stimulus is typically in the range 35dBnHL to 50dBnHL with respect to normally hearing young adults. Any comparison in the performance of different AABR systems must take into consideration the baseline calibration of the click stimulus (ppeSPL). The value of ppeSPL on which the dBnHL is based may be different for different AABR systems. The recommended value in the air conduction click protocol is 33dBpeSPL².

Earphone

Many types are in use including Telephonics TDH39/49, insert earphones e.g. type EAR-3A, and custom designed ear shells. Before positioning the earphone, the external ear canal should be checked for any easily removable debris or blockage before placement of the earphone. Earphones should be carefully positioned so that the ear canal is not occluded by any excess pressure.

DATA COLLECTION

The following test parameters for data collection are fixed as part of the automated test protocol. They must not be changed as this may invalidate the machine scoring algorithm.

- Gain or sensitivity of the amplifier
- Level of amplitude artefact rejection

- Filter bandwidth
- Acquisition window
- Number of averaging sweeps

WAVEFORM ANALYSIS

The presence or absence of a response in the recorded waveform is determined objectively using a machine based scoring algorithm. Statistical and mathematical techniques are typically employed such as correlation and response to noise amplitude ratio³, template methods⁴, and Fsp based analysis⁵. The algorithm must be clinically proven in terms of its performance (eg. sensitivity and specificity) ^{6,7}. The false negative rate of an AABR screening test can be investigated using no-sound trials in a relatively small population of babies.

The screening test on each ear is designated a pass or refer depending on whether or not a response is present. Occasionally, a re-test decision may be recommended if the result is marginal or if the test conditions are unreliable. The algorithm should provide a separate result for each ear so that referral of babies for further testing can be initiated using either unilateral or bilateral referral criteria.

PRESENTATION OF RESULTS

The results of the screening test determined by the algorithm should be clearly presented as a pass, refer or re-test on each ear separately. Ideally a print-out from the equipment should be available that can be included in the case notes of the child. On some equipment the recorded ABR waveforms are displayed and available as a print-out. This enables a review and audit of the results of the screening test by a skilled observer. Under no circumstances should this interpretation be performed by inexperienced personnel as part of the screening test.

REFERENCES

- 1/ Davis A, Bamford J M, Wilson I , et al. A critical review of the role of neonatal screening in the detection of congenital hearing impairment. Health Technology Assessment 1997 (1) (10).
- 2/ Stevens JC et al. (1999) Click auditory brainstem responses testing in babies- a recommended test protocol. British Society of Audiology News bulletin, December Issue
- 3/ Mason SM (1984) On-line computer scoring of the auditory brainstem response for estimation of hearing threshold. Audiology 23:277-296
- 4/ Kileny PR (1998) New insights on infant ABR hearing screening. Scandinavian Audiology Supplement 30: 81-88.
- 5/ Sininger Y (2000). Power-optimised Variance Ratio (POVR). Presented at the Association of Research in Otolaryngology, February 2000.
- 6/ Mason SM, Davis A, Wood S, Farnsworth A (1998). Field sensitivity of targeted neonatal hearing screening using the Nottingham ABR Screener. Ear & Hearing 19: 91-102.

7/ Herrmann BS, Thornton AR, Joseph JM. (1995) Automated infant screening using the ABR: development and validation. American Journal of Audiology 4: 6-14