Automated auditory brainstem response hearing screening in NICU graduates
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Efficacy of Automated Auditory Brainstem Response Hearing Screening in Very Preterm Newborns.

Based on the article:
*Efficacy of Automated Auditory Brainstem Response Hearing Screening in Very Preterm Newborns*
*J Pediatr* 2001;138:674-8
6.1 Abstract

Objective: To investigate the efficacy of an automated auditory brainstem response (AABR) hearing screening method in very preterm newborns in the neonatal intensive care setting.

Study design: In this prospective cohort study, 90 consecutive preterm newborns (<32 weeks' gestational age) had AABR hearing screening weekly from birth until a bilateral pass result was obtained. If the newborn had a unilateral pass result, AABR screening was repeated in the same week. Data were analysed by using the Kaplan-Meier survival function technique, resulting in a cumulative pass rate curve for postmenstrual age. Cox's regression method was used to analyse the effect of co-variables, such as sex and growth restriction, on pass rates.

Results: Median gestational age was 29.5 weeks (range, 25.3-31.9 weeks), and median birth weight was 1115 g (range, 600-1960 g). Mean age was 6.2 days (SD 4.3) at first test, 15.7 (SD 8.1) at second test, and 21.4 (SD 8.6) at third test. Eighty percent (CI: 70.2%-89.8%) of the newborns passed at 30.3 weeks' postmenstrual age, 90% (CI: 83.6%-96.4%) passed at 31.2 weeks, and 100% passed at 34 weeks' postmenstrual age. The attainment of these pass rates correlated to postmenstrual age was not significantly influenced by sex, growth restriction, or gestational age at birth. Postnatal pass rates (in days) were strongly influenced by gestational age.

Conclusion: AABR pass rates of >80% can be obtained from 30 weeks' postmenstrual age. Therefore AABR neonatal hearing screening can be used before discharge from a neonatal intensive care unit.

Table 7: Risk criteria for hearing loss in the neonatal period according to the American Joint Committee on Infant Hearing.

- Family history of congenital sensorineural hearing impairment
- Congenital perinatal infections (Syphilis, TORCH)
- Craniofacial anomalies
- Birth weight < 1500 g
- Hyperbilirubinaemia exceeding a level needing exchange transfusion
- Use of ototoxic medication in potential toxic dose (e.g.: aminoglycosides, diuretics)
- Bacterial meningitis
- Severe birth asphyxia (Apgar ≤ 4 at 1 min or ≤ 6 at 5 min)
- Mechanical ventilation > 4 days
- Syndromes associated with sensorineural hearing loss
6.2 Introduction

Neonatal hearing screening has been a topic of interest since objective measurements of hearing loss became possible in the newborn. Intervention before the age of 6 months after early screening and detection significantly improves language development.\(^1\) Congenital hearing loss is present in 0.1 % of the general population and is much more frequent in an at-risk population of newborns (1%-2%).\(^2\) Most newborns who need neonatal intensive care fulfil the at-risk criteria of the Joint Committee on Infant Hearing\(^5\) (Table 7) Because of the high incidence of persistent hearing loss among the neonatal intensive care unit population, the National Institutes of Health recommends hearing screening for NICU graduates.\(^6\)

In many western countries neonatal intensive care has been centralized in tertiary units. Discharge of clinically stable preterm newborns to local hospitals before 32 weeks' postmenstrual age is normal practice. Follow-up of this NICU population is not yet uniformly organised. Therefore screening for hearing loss should preferably be carried out before discharge from the NICU. An automated auditory brainstem response hearing screening device is available for screening purposes, and screening is recommended from 34 weeks' gestational weeks onwards.\(^7\) It is important to know whether preterm newborns may pass the AABR hearing screener before this recommended age. The aim of this prospective cohort study is to establish the efficacy of AABR hearing screening in preterm newborns before the age of 32 postmenstrual weeks. The primary end point is to establish the postmenstrual age at which more than 80 % of the children pass the first test. The secondary end points are the effects of sex, gestational age, and intrauterine growth restriction on these pass rates.

![Distribution of risk factors](image.png)

**Figure 9:** Distribution of risk factors according to the JCIH.
6.3 Methods

This prospective cohort study was performed in 2 NICU's in the Netherlands from January 1998 to December 1998. All newborns were included after parental consent was obtained. Inclusion criteria were gestational age <32 weeks with or without any of the at-risk criteria according to the JCIH. Exclusion criteria were congenital malformations or syndromal manifestations known to be associated with congenital hearing loss.

After birth, AABR hearing screening was performed weekly until a bilateral pass was obtained. In the case of a unilateral negative test result, the hearing screening was repeated in the same week.

The postmenstrual age at the time of the first positive test result (a bilateral pass) after birth was determined. When there was a negative test result, the postmenstrual age of a successful AABR hearing screening was considered to occur in the middle of the time interval between the last negative test result and the first positive test result. All tests were performed in the incubator in the NICU. In one of the NICU's (NICU 2) initial hearing screening was not performed during artificial ventilation. Those children entered the study at a slightly later age.

Newborns were classified as appropriate for gestational age or small for gestational age according to the intrauterine growth curves of Kloosterman.

Material

We used the ALGO 1E (Natus Medical Inc, San Carlos) AABR hearing screener. This automated hearing screening method uses auditory brainstem response measurement with a broadband click stimulus, which tests at frequencies greater than 1000 Hz.

Technical specifications for the click stimulus are as follows: duration = 100 microseconds; intensity = 35 dBnHL; polarity = alternating; acoustic frequency spectrum = 700 to 5000 Hz (± 5 dB); filter settings: 0.05 to 1.5 kHz, 6 dB high pass, 24 dB low pass. Built-in artefact rejection for myogenic, electrical and environmental noise interference ensures that data collection is halted if testing conditions are unfavourable. The automated screener provides a dichotomous pass or fail report; no test interpretation is required by an audiologist. Successful screening requires relative infant comfort, proper application (electrode impedance <12000 ohms) of surface electrodes in a non-cephalic electrode montage: noninverting = high forehead, inverting = nape, and common = mastoid or shoulder, application of adhesive circumaural headphones, and presentation of the click stimulus.

Statistical Analysis:

Descriptive variables and test results were entered on the computer and analysed with the Kaplan-Meier survival function technique, resulting in a graphical output of the pass rate. Because some children may have had a positive test at birth, the exact time when
they developed a positive test result is not known (left-censoring occurred).\textsuperscript{10} All children were monitored weekly until they had a positive test result (so no right-censoring occurred).\textsuperscript{10} Therefore, on a negative time-axis, the Kaplan-Meier technique illustrates the estimated time until the first positive test result (For reasons of aesthetics, this axis has been mirrored in this publication). Cox’s regression analysis was performed to determine the effect of sex, gestational age, and SGA on pass rates. Statistical computations were performed using SPSS for Windows software (version 8.0; SPSS Inc, Chicago, Ill).

6.4 Results

AABR hearing screening was carried out in 90 newborns. No children were excluded. The median gestational age was 29.6 weeks (range, 25.1-31.9 weeks) and the median birth weight was 1115 g (range, 600-1960 g). Table 8 shows the distribution of risk factors according to criteria of the JCIH. First tests were performed 20 times, and second tests were performed 8 times while newborns were receiving ventilatory assistance. A pass or negative result was obtained in all attempts. Thirteen newborns passed the screening while receiving ventilatory assistance. The mean total test time was 15 minutes (SD = 8). Fifty-four of 90 newborns passed the first test, 28 of 90 passed the second test, and 8 passed the third test. All children passed bilaterally. Mean postnatal age at the first test was 5.5 days (SD = 4.2), 15.8 days (SD = 8.7) at second test, and 21.4 days (SD = 8.6) at third test. For descriptions of these groups, see Table 8.

<table>
<thead>
<tr>
<th>Tests</th>
<th>Birthweight Gram</th>
<th>Gestational age weeks</th>
<th>1st test postnatal days</th>
<th>2nd test postnatal days</th>
<th>3rd test postnatal days</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (n=54)</td>
<td>1300 (600-1960)</td>
<td>30.1 (25.1-31.9)</td>
<td>5.5 (4.2)</td>
<td>15.8 (8.7)</td>
<td>21.4 (8.6)</td>
</tr>
<tr>
<td>2 (n=28)</td>
<td>1030 (600-1655)</td>
<td>28.5 (25.1-31.9)</td>
<td>6.9 (4.5)</td>
<td>15.4 (6.0)</td>
<td>21.4 (8.6)</td>
</tr>
<tr>
<td>3 (n=8)</td>
<td>910 (600-1370)</td>
<td>27.9 (25.1-28.7)</td>
<td>8.1 (3.7)</td>
<td>15.4 (6.0)</td>
<td>21.4 (8.6)</td>
</tr>
<tr>
<td>Total (n=90)</td>
<td>1115 (600-1960)</td>
<td>29.6 (25.1-31.9)</td>
<td>6.2 (4.3)</td>
<td>15.7 (8.1)</td>
<td>21.4 (8.6)</td>
</tr>
</tbody>
</table>

Values for birth weight and gestational age are expressed as median (range). Values for age at first, second, and third test are expressed as mean (SD)
Figure 10 shows the postnatal pass rates of the AABR hearing screening in days for each gestational age group. With multivariate analyses (Cox's regression), this effect of gestational age is significant ($P<0.005$). There was no statistically significant effect of sex ($P=0.98$) or SGA ($P=0.81$) on postnatal pass rates in days.

In Figure 11 the Kaplan-Meier curve is expressed in pass rates as a function of postmenstrual age. The log-rank test of pass rate distribution as a function of gestational age at birth was not significant ($P=0.25$). Eighty percent of the screened children (CI: 70.2%-89.8%) passed at 30.3 weeks' postmenstrual age. Ninety percent (CI: 83.6%-96.4%) succeeded at 31.2 weeks' postmenstrual age. At 34 weeks, all newborns had passed the AABR hearing screening.
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Cumulative AABR pass rate and postmenstrual age

Figure 11  AABR rates and postmenstrual age

6.5 Discussion

In this prospective cohort study, weekly AABR hearing screening showed a pass rate of 80% from 30 weeks' postmenstrual age on, 90% from 31 weeks on, and a 100% pass rate at 34 weeks' postmenstrual age in newborns with normal hearing. Gestational age was not a significantly determining factor on pass rates for postmenstrual age.

Neonatal hearing screening is rapidly becoming "standard care" in the United States according to the 1994 JCIH consensus statement. The European Consensus Development Conference in 1998 provided a strong impulse for efforts to run universal or high-risk register screening programmes. Both statements agree that the development of children with bilateral hearing impairment can be improved with early detection (<3 months), followed by treatment started before the age of 6 months.

In the neonatal period, conventional ABR is considered to be the most reliable method for assessment of the hearing level. The conventional ABR method is not widely used for screening because it is time-consuming and it requires highly qualified staff. AABR hearing screening is the method of choice for neonatal hearing screening in a NICU setting. The AABR hearing screener provides workers in this field with the ability to
screen for hearing abnormalities in the ward, in the incubator, and during nasal continuous positive airway pressure therapy, without being disturbed by ambient noise and myogenic activity. The reliability is very high: sensitivity of 100 % and specificity of >96%. The device used in this study was the ALGO-1E (Natus Medical Inc). More advanced models are now available. Because the AABR technology in essence has not been changed, generally comparable results can be expected.

The click-evoked ABR usually appears during the 27th week of gestation but may occur as early as the 25th week. Development of the infant ABR is usually complete by the second year of life. The use of the AABR hearing screener is recommended from 34 postmenstrual weeks onward, but this study shows that preterm newborns may fulfil the internally programmed template-matching algorithm criteria of the AABR at an earlier stage. In many countries neonatal intensive care is centralized. The child is discharged to the local hospital, often before 34 weeks' postmenstrual age. Follow up may occur later than the appropriate time for AABR neonatal hearing screening. Therefore hearing screening before discharge to the local hospital should be part of the regular neurologic investigations for potential neurologic sequelae in this high-risk group.

In the Netherlands, AABR neonatal hearing screening in the NICU's is now being implemented as part of a universal neonatal hearing screening programme. The advantage of hearing screening as early as in the NICU period is the high programme coverage of at-risk newborns that can be achieved. A disadvantage of hearing screening at this early age is the possibility that progressive hearing loss caused by perinatal events could be missed. For instance, after congenital cytomegalovirus infection and extracorporeal membrane oxygenation, progressive hearing loss may become apparent beyond the age of 1 year. Ongoing evaluation for acquired or progressive hearing loss after the neonatal period is required.

SGA is frequently associated with intrauterine undernutrition, which may have a deleterious effect on brain or nervous tissue growth and function. In this study SGA was not a significant determining factor on pass rates for AABR hearing screening. This supports the results of Kohelet et al, who found no abnormalities in brainstem auditory-evoked function in SGA newborns in the early neonatal period. This study supports the use of AABR hearing screening before 34 weeks' postmenstrual age in clinically stable very preterm infants.
6.6 References
