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# Threshold changes of ABR results in toddlers and children

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ABSTRACT

*Introduction:* Auditory brainstem response (ABR) is a clinically established method to identify the hearing threshold in young children and is regularly performed after hearing screening has failed. Some studies have shown that, after the first diagnosis of hearing impairment in ABR, further development takes place in a spectrum between progression of hearing loss and, surprisingly, hearing improvement.
*Objective:* The aim of this study is to evaluate changes over time of auditory thresholds measured by ABR among young children.
*Material and Methods:* For this retrospective study, 459 auditory brainstem measurements were performed and analyzed between 2010 and 2014. Hearing loss was detected and assessed according to national guidelines. 104 right ears and 101 left ears of 116 children aged between 0 and 3 years with multiple ABR measurements were included. The auditory threshold was identified using click and/or NB-chirp-stimuli in natural sleep or in general anesthesia. The frequency of differences of at least more than 10 dB between the measurements was identified.
*Results:* In 37 (35%) measurements of right ears and 38 (38%) of left ears there was an improvement of the auditory threshold of more than 10 dB; in 27 of those measurements more than 20 dB improvement was found. Deterioration was seen in 12% of the right ears and 10% of the left ears. Only half of the children had stable hearing thresholds in repeated measurements. The time between the measurements was on average 5 months (0 to 31 months).
*Conclusion:* Hearing threshold changes are often seen in repeated ABR measurements. Therefore multiple measurements are necessary when ABR yields abnormal. Hearing threshold changes should be taken into account for hearing aid provision.



## 1. Introduction

The universal newborn hearing screening program was introduced for early detection of hearing impairment in children. The newborn hearing screening often uses otoacoustic emission (OAE) tests. The OAE tests show the activity of the outer hair cells of the cochlea after stimulation with a sound. Therefore it indicates also function or damage of the inner hair cells. Every newborn with a repetitively negative screening result should obtain a further hearing evaluation using auditory brainstem response (ABR). The ABR gives information about the function of the cochlea, the hearing nerve and partly the brain pathways for hearing. It serves for detecting auditory nerve deficits. Moreover it is a valid objective method to determine hearing threshold from very young children to older children or even adults with conductive or sensory hearing loss who cannot sufficiently participate in pure tone audiometry. The test can be performed in natural sleep, under sedation or general anesthesia [1]. The proper quantification of a hearing impairment is a precondition for the adequate rehabilitation and fitting of hearing aids or preparing for cochlear implantation.

Insufficient hearing is one major cause of disturbed speech acquisition and should be addressed as early as possible. According to the European and American guidelines, hearing loss should be treated in the first months after birth in order to diminish unfavorable effects on speech acquisition. As a result of these procedures, even congenitally deaf children can reach normal speech competence when treated early enough [2].

In most of the young children with hearing impairment, the cause of hearing loss is still unknown [3]. At the first detection of

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hearing loss, a prognosis about the development of the hearing threshold is rarely possible. Therefore, follow-up ABR measurements are needed. Some studies have shown that after the first diagnosis of hearing impairment, further development can range between progression or sometimes improvement. Changes are reported especially in preterm born children showing adverse results. Kang et al. [4] reported some cases of deterioration of hearing level from mild to severe hearing loss. On the other hand, 34% of the cases demonstrated hearing threshold improvement of more than 20 dB. Some factors that can influence hearing recovery or hearing deterioration in newborns are for example hyperbilirubinemia, prematurity, intensive care unit treatment, low birth weight or neonatal sepsis [5–7].

Another critical issue is that ABR in natural sleep might reveal increased hearing thresholds when measurements are disturbed by artefacts due to motoric activity. Therefore, only one ABR measurement might not be sufficient for the reliable detection of hearing threshold.

The aim of this study is to analyze the frequency of changes of ABR results among children with respect to possible reasons for hearing loss, in particular to evaluate the variation of the auditory threshold following the first rating.

## 2. Subjects and Methods

### 2.1. Patients

In a retrospective evaluation of all ABR measurements in children between 2010 and 2014 from 897 patients, 116 children with multiple measurements were included. Half of them were male, half female. The age of the children started at one month to 45 months. All parents of the children were informed about the performance of the test and its purpose. Data of children with auditory neuropathy spectrum disorder were excluded as ABR results are consistently pathological and do not allow for analyzing changes of the hearing threshold.

Hearing status on all children was examined according to the national guidelines using otoscopy, tympanometry, OAE-measurements and ABR. The first ABR test was performed on both ears. For the follow-up evaluation of hearing, first OAE (Echoscreen Plus, Fischer-Zoth, Germering, Germany, or Madsen Capella, Otometrics, Denmark) measurement was repeated; ABR was performed only on those ears that showed no OAE. This corresponds to repetitive ABR measurements of 104 right and 101 left ears. Data collection was restricted to children aged less than three years at the first measurement. In some cases more than two tests were performed. A total number of 459 ABR measurements were evaluated.

**Table 1**
Perinatal factors and comorbidities with possible effect on hearing (n = 116).

| Diagnosis | n | % |
|---|---|---|
| Preterm birth | 20 | 17 |
| Down's syndrome | 6 | 5 |
| Cytomegalovirus infection | 4 | 3 |
| Others (e.g. hereditary, rare syndromes, asphyxia) | 19 | 16 |
| no cause known | 67 | 58 |

Indications for the ABR tests in the children included were repeated failure in the newborn hearing screening, possible intrauterine infection with cytomegalovirus, history of hereditary hearing loss, and increased ABR thresholds during the first measurements. Table 1 shows the presumed reasons for the hearing disorder.

### 2.2. ABR measurement

The ABR tests were performed in a noise-absorbing and electrically shielded room. The measurement was acquired in natural sleep or under general intravenous anesthesia using Propofol.

Measurements of ABR with click and a narrow-band-chirp (NB-chirp) stimuli were performed consecutively. First, click stimuli were used for threshold (Jewett wave V) and waveform analysis (Jewett I to V). Then NB- chirp stimuli were used for threshold estimation based on the detection of reproducible Jewett wave V at different sound pressure levels (see Figs. 1 and 2).

The NB-chirp evoked ABRs were recorded with the Interacoustics Eclipse EP25 ABR system®. The click ABRs were measured either with the identical system or the ZLE-ABR system, each with alternating polarity. Sometimes additionally non-alternating polarity was used when no potentials were detectable

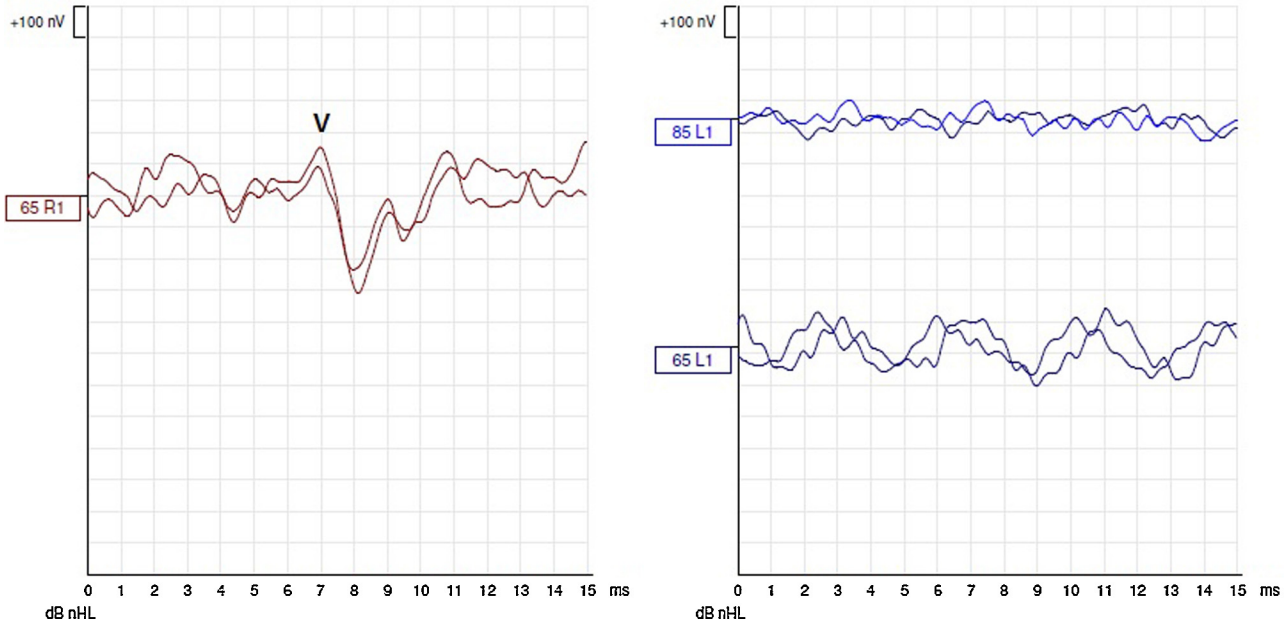


**Fig. 1.** ABR with click stimuli: normal on the right side, hearing deficit on the left side.