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Maturation of auditory brainstem responses in young children with congenital monaural atresia

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ABSTRACT

Objective: To date, the impact of conductive hearing loss on the auditory pathway at brainstem level has only been investigated in animal studies, which showed a species-specific delay of maturation. In this study, the functional maturation of auditory brainstem response (ABR) parameters in humans with unilateral atresia of the external auditory canal was investigated.
Methods: 42 newborns and toddlers ranging in age from 13 days to 11 months were included. The click-evoked ABR interpeak latencies (IPL) of the atretic ears and the contralateral ears with normal hearing were evaluated. The children had no comorbidities and had never been fitted with any kind of hearing aid. The absolute latencies (AL) and IPL of a matched control group were compared to the contralateral normally hearing ears of the children with unilateral atresia.
Results: The mean air-bone gap in the ears with atresia was 44 dB HL. Despite this partial acoustic deprivation, no significant difference between the IPLs of normal ears and ears with atresia could be detected. Both for AL and IPL, the differences between the normal ears and the control group were all within 1 standard deviation to the mean.
Conclusion: The data showed that the monaural acoustic deprivation by a block of sound conduction does not produce any delay of functional maturation at brainstem level in this group of patients. With regard to the AL and IPL on brainstem level, no differences between the normal ears of children with unilateral atresia and children with bilateral normal hearing could be detected.

1. Introduction

The congenital stenosis of the external auditory canal or aural atresia is a developmental anomaly causing sound conductive hearing loss (SCHL) in the affected ear [1]. To date, the impact of a complete conductive hearing loss on the auditory pathway at brainstem level has only been investigated in animal studies, which have showed a species-specific delay of maturation as well as plastic changes of binaural interaction [2–5]. As there are numerous studies, which examined the effect of SCHL in humans at cortical level, the impact on the postnatal maturation of the human auditory pathway at brainstem level during the first year of life was not researched so far. This question is of clinical relevance, as the indication of and time for hearing aid fitting in these young children with monaural atresia and contralateral normal hearing is still controversial [6–9].

The postnatal maturation of the human auditory pathway at the anatomical [10] and electrophysiological level is almost complete at brainstem level after the first two years of life and can be objectively evaluated by the decrease in absolute latencies (AL) and interpeak latencies (IPL) of the auditory-evoked brainstem potentials (AEP) [11,12].

The aim of this study was to compare the maturation of auditory brainstem response (ABR) parameters between the deprived and the normal ear in a group of children with congenital monaural atresia during their first year of life.

2. Methods

2.1. Subjects

In the time period between 2004 and 2014, around 6000

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children with suspected hearing loss in the subjective audiometry and missing OAEs underwent ABR recordings in a tertiary referral centre. From this collective we, included 42 newborns and toddlers (26 male and 16 female) ranging in age from 13 days to 11 months (median 63.5 days) with a unilateral atresia of the external auditory canal (32 right and 10 left). The contralateral outer ear was of normal hearing and without any signs of malformation. The children had no comorbidities or syndromes and had never been fitted with any kind of hearing aid.

The audiometric inclusion criteria were ABR thresholds with air-conducted click stimulation between 50 and 70 dB HL on the atretic side and 10 and 20 dB on the normal side (Fig. 1). The ears with atresia showed no more than 25 dB HL sensorineural hearing loss, which was calculated from the parallel shift of the wave V intensity-latency function due to the conductive component (Fig. 2).

Patients were distributed into four age groups with 9–13 patients per group. Age group 1 included eleven (7 male, 4 female) patients ranging in age from 13 to 29 days.

Age group 2 comprised ten patients (7 male, 3 female) between one and two months of age. The patients included in this group ranged in age from 33 to 58 days. The patients between two and four months of age were pooled into age group 3. These nine patients (7 male, 2 female) ranged in age from 69 to 118 days. Age group 4 contained nine patients (5 male, 4 female) between four and twelve months of age who ranged in age from 132 to 319 days.

2.2. Control group

Out of those 6000 children described in 2.1 a control group of 42 children matched in age (median 60 d, min. 6 d; max 320 d) and sex (27 male; 15 female) was chosen. These children showed bilateral ABR thresholds with air-conducted click stimulation at 10 dB HL. The absolute latencies and IPL in these children were evaluated at mean intensities of 79.2 (±3) dB HL.

2.3. Brainstem evoked reponse audiometry (BERA)

The Nicolet Bravo system (Viasys®, CareFusion, San Diego, California, USA) was used for ABR recordings in all subjects. Alternating Clicks (condensation and rarefaction) with a duration of 140 μs were monaurally presented at a repetition rate of 21.3 per second up to a maximum intensity of 102 dB nHL using circumaural TDH-39 headphones. The acoustic stimuli were attenuated in 5 dB steps down to visual detection levels of Jewett wave V (Fig. 1). The near-threshold responses were recorded twice in order to control for reproducibility. The filters of the amplifier were set between 150 and 1500 Hz.

For all AEP recordings the contralateral ear was masked in case of stimulus levels above 40 dB HL. Measuring the non-atretic ear, the contralateral atretic ear was masked at minus 30 dB with respect to stimulus level plus sound conductive hearing loss (for example: at 50 dB HL stimulus level the contralateral ear was masked with 50–30 dB HL plus 50 dB sound conductive HL = 70 dB HL). For measuring of the atretic ear, the normal masking paradigm of minus 30 dB was used.

The ABRs were differentially recorded using scalp electrodes between the vertex and ipsilateral mastoid and 1500 sweeps were averaged.

The AL of Jewett waves I, III and V and the IPL of waves I- V, I –III and III- V were evaluated in both ears at suprathreshold levels. The visual inspection and definition of peaks I, III and V was carried out

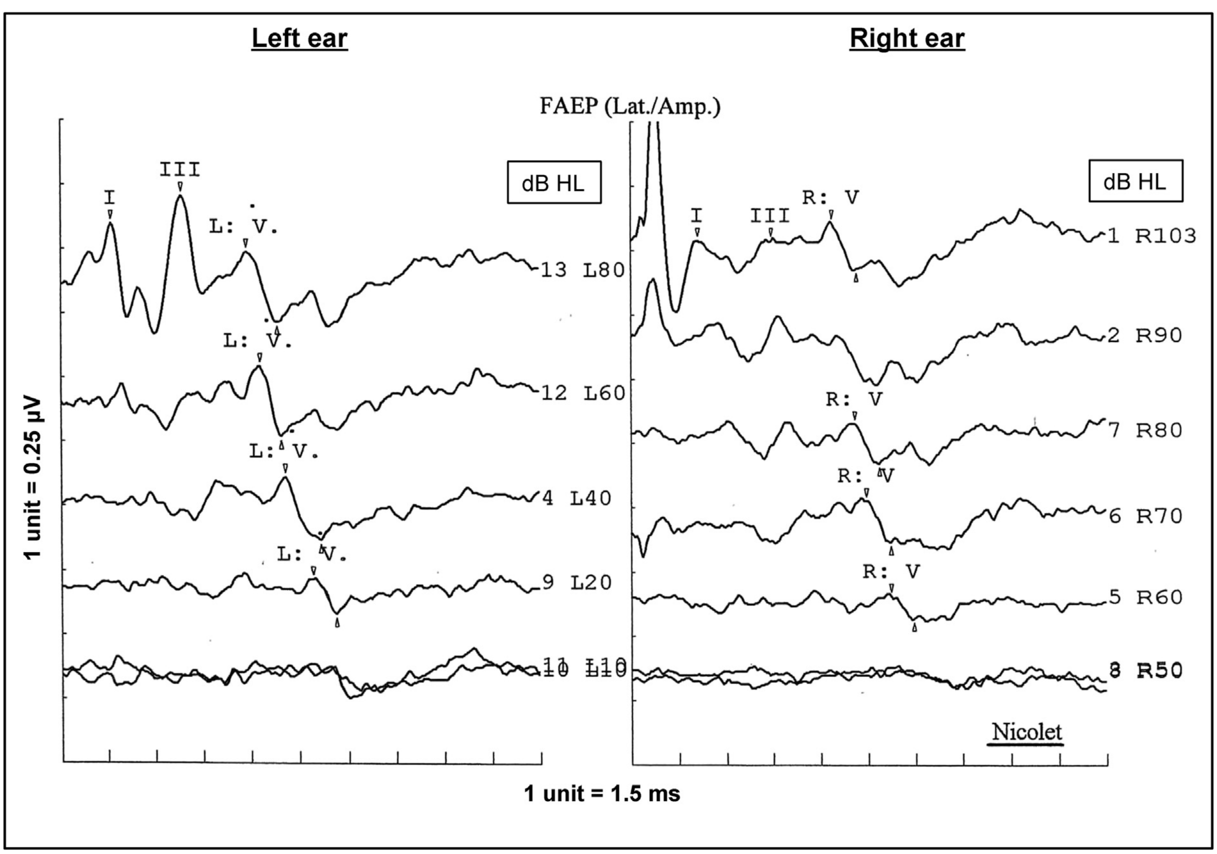

Fig. 1. Visual identification of Jewett Wave I, III, V and ABR thresholds in one exemplary patient aged ten months (same Patient as in Fig. 2). In the healthy left ear, wave V threshold was identified at 10 dB HL. The right ear with an external auditory canal atresia showed a threshold at 50 dB HL.