

**BRIEF REPORT**

# Normal neonatal brainstem audiometry in preterm infants predicted normal hearing later in childhood

Preterm infants have an increased risk of hearing loss<sup>1</sup> and should be thoroughly evaluated during the neonatal period. At Turku University Hospital, all infants born very preterm (VPT) at  $\leq 32$  weeks, and/or with very low birthweight (VLBW) of  $\leq 1500$  g, are examined using brainstem auditory evoked potential and brainstem audiometry (BA) recordings near term age. Click-evoked BA has been found to correlate well with later hearing levels examined with pure-tone audiometry, but studies have included very few premature infants.<sup>2</sup>

We investigated associations between neonatal BA and pure-tone audiometry results in all VLBW and/or VPT babies, born at the Hospital from 2002 to 2006 when they were around 5 years of age.

Infants who underwent neonatal BA recording and had later pure-tone audiometry results were included. Their BA was recorded at the hospital using eight-channel Viking IV equipment (Nicolet Biomedical Instruments), with broadband rarefaction click stimuli delivered through tubal insert earphones to each ear. The first stimulus intensity was at 35 dB normalised hearing level (nHL), with a frequency of 33.3 Hz and masking white noise in the contralateral ear. If necessary, the intensity was increased to 65 dB nHL, in increments of 10 dB nHL, until waves III and V were recognisable. At the time of the study, the lowest stimulation screening level for BA was 35 dB nHL.<sup>3</sup> BA was considered abnormal if wave III or wave V was seen at 45 dB nHL or higher in either ear. Otoscopy was conducted before the recordings. A pure-tone screening audiometry was conducted on both ears, at 20 dB hearing level (HL) at a primary healthcare centre or at the hospital. Pure-tone averages (PTA) over the frequencies of 500, 1000, 2000 and 4000 Hz were calculated. A PTA<sup>0.5–4 kHz</sup> was considered normal if the level was 0–25 dB HL bilaterally and abnormal if above 25 dB HL in one or both ears. The 25 dB HL limit was recommended by the World Health Organization as the threshold for normal hearing when the data were being collected.<sup>4</sup> It is also a reasonable screening level to identify children who need hearing rehabilitation.<sup>5</sup> Statistical analyses were carried out using SPSS Statistics, version 26 (IBM Corp). The study was approved by the local Hospital Ethics Review Committee in 2016 (46/1801/2016).

This study comprised 117 VPT and/or VLBW infants with a BA conducted at a corrected mean age of 1 month and PTA<sup>0.5–4 kHz</sup> results at a mean age of 5 years (Table 1). All the children with normal BA also had normal PTA<sup>0.5–4 kHz</sup> results. Five children had both abnormal BA and PTA<sup>0.5–4 kHz</sup>. A further 24 children had an abnormal BA, but normal PTA<sup>0.5–4 kHz</sup>. According to McNemar's test, the proportion of abnormal results was higher in the BA than in pure-tone audiometry

**TABLE 1** Clinical characteristics of 117 children in the study group.

Boys, n (%)	65 (56)
At birth	
Weight, grams, median (IQR), range	1220 (885–1417.5), 560–2120
$\leq 1500$ g, n (%)	99 (85)
Gestational age, weeks, median (IQR), range	29 (27–31), 23–35
$\leq 32$ weeks, n (%)	101 (86)
$\leq 1500$ g and/or $\leq 32$ weeks, n (%)	117 (100)
Small for gestational age, n (%)	34 (29)
BA recordings	
Corrected age (months) at the time of BA recordings, median (IQR), range	1.0 (0.2–1.1), –1.0 to 6.6
Abnormal BA <sup>a</sup> , n (%)	29 (25)
Pure-tone audiometry	
Age (years) at the time of audiometry, median (IQR), range	5.0 (5.0–5.2), 4.0–7.8
Abnormal audiometry <sup>b</sup> , n (%)	5 (4)
Hearing loss diagnosis, n (%)	6 (5)

Abbreviation: IQR, interquartile range.

<sup>a</sup>BA was considered abnormal if wave III or wave V was seen at 45 dB nHL or higher in the right and/or left ear.

<sup>b</sup>Pure-tone audiometry was considered abnormal if the PTA<sup>0.5–4 kHz</sup> was over 25 dB HL in the right and/or left ear.

**Abbreviations:** BA, brainstem audiometry; HL, hearing level; nHL, normalised hearing level; PTA, pure-tone average; VLBW, very low birthweight; VPT, very preterm.

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measurements ( $p < 0.0001$ ). The sensitivity and negative predictive value of neonatal BA were both 100% for later hearing ability. The specificity was 79%, and the positive predictive value was 17%.

We found that BA was a sensitive method for hearing screening in preterm infants due to the perfect negative predictive value in this study. None of the neonates with a normal neonatal BA threshold of  $\leq 35$  dB nHL showed a subsequent abnormal PTA<sup>0.5-4kHz</sup> threshold of  $> 25$  dB HL. However, an abnormal neonatal BA did not necessarily predict abnormal hearing in a later pure-tone audiometry test. This finding was supported by previous studies, where a click-evoked BA tended to overestimate the severity of hearing loss.<sup>2</sup> In preterm infants, this can be due to ongoing auditory maturation during the neonatal period. In addition, middle ear effusion can cause transitory hearing loss, leading to BA abnormalities, and affect positive predictive values. Nonetheless, the vulnerability of these high-risk neonates to late-onset or progressive hearing loss should be considered.<sup>2</sup>

In conclusion, neonatal click-evoked BA was associated with later PTA<sup>0.5-4kHz</sup> in preterm infants and showed excellent sensitivity and a negative predictive value, which is a prerequisite for a reliable screening method. Prospective follow-up studies are needed on larger preterm cohorts, using BA and subsequent hearing tests. This would help to determine the age at which early BA findings would optimally predict later hearing deficiencies and enable early interventions.

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## CONFLICT OF INTEREST STATEMENT

None.

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