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Wideband reflectance measurements in newborns: Relationship to otoscopic findings

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ABSTRACT

Objectives: Newborn hearing screening includes testing with otoacoustic emissions and the auditory brainstem response. Unfortunately, both tests are affected by the presence of material in the ear canal and middle ear such as vernix, meconium, and amniotic fluid. The objective of this study was to determine to what extent occlusion of the ear canal as seen on otoscopy affects wideband energy reflectance measurements in newborns. A secondary objective was to obtain additional normative wideband reflectance data in newborns.
Methods: Newborns from a well-baby nursery were enrolled. Wideband energy reflectance measurements and otoscopy were done immediately after the hearing screening. Occlusion of the ear canal as seen on otoscopy was described on a scale of 0–100%.
Results: A total of 156 babies were enrolled (mean age = 25 hours). A statistically significant difference in the reflectance at ambient pressure was found between the 0–70% and 80–100% occlusion groups. There was no significant difference in reflectance between the right and the left ears. The median reflectance pattern generally followed that of previous studies but in certain frequency regions the present reflectance values were higher.
Conclusion: A significant increase in reflectance occurs when 70%–80% of the ear-canal diameter is occluded. Taking otoscopy findings into account may improve the interpretation of reflectance measurements. However, further studies are required to better establish the relationship between canal occlusion and reflectance.

1. Introduction

Universal newborn hearing screening (UNHS) has become a standard procedure in many countries around the world and is based on automated testing with otoacoustic emissions (OAE) and the auditory brainstem response (ABR) [1,2]. A major problem is that both tests are affected by obstruction of the newborn's ear canal and/or middle ear by materials such as vernix, meconium and amniotic fluid which can lead to false positive results and may cause parental anxiety, a negative attitude towards the baby, prolongation of diagnostic time, increased costs to the system, and decreased confidence in UNHS programs [2–9]. For all of these reasons it is recommended that an improved and more reliable technology be developed for evaluating middle-ear status at the time of newborn hearing screening [1,2]. Tympanometry, using a 226-Hz probe tone provides an effective measure of middle-ear status in adults and older children [10]. However, since the newborn ear canal and middle ear undergo developmental changes during the first few months of life, 226-Hz tympanometry produces different tympanograms in this age group and is not recommended under 7 months of age [11,12]. With a higher probe-tone frequency more consistent tympanograms are produced that can predict middle-ear status in newborns more accurately [13,14]. However, even with a high probe-tone frequency, variable results are found in newborns [15]. Energy reflectance (ER) is defined as the ratio of the energy reflected back to the probe location to the incident energy delivered by the probe. Assuming that the energy absorbed in the canal is negligible (a better approximation for adults than for infants), then the ER equals the ratio of

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the energy reflected from the middle ear to the incident energy, uninfluenced by the location of the probe within the canal [16]. 'Wideband' measurements for both ER and admittance are performed over a wide range of frequencies at the same time [17]. This is in contrast to conventional measurements at a single frequency at a time. Wideband measurements have the advantage of being very fast (seconds), much faster than measurements with pure tones at multiple frequencies. Both ER and admittance can be measured under either pressurized (tympanometric) or non-pressurized (ambient) conditions. Wideband measurements may be able to serve as a complementary tool in newborn hearing screening. However, wideband measurements have not been described in relation to otoscopic findings and it is unknown how the results are affected by occlusion of the ear canal and middle ear by different amounts of materials present immediately after birth.

The first objective of this study was to determine whether a correlation exists between wideband ER measurements and different levels of occlusion of the ear canal. A second objective was to provide additional normative data for wideband measurements in newborns.

2. Materials and methods

The study was approved by the Institutional Review Board (IRB) of the McGill University Health Centre. Infants were recruited from the well-baby nursery at the Royal Victoria Hospital, Montréal, Canada. An IRB-approved consent form was used to obtain parents' written consent. The measurements and otoscopy took place immediately following the hearing screening. If the baby had a "refer" result on OAE, the research measurements were done after a subsequent ABR test. Testing was done with the baby in the crib or in the parent's arms. The more conveniently positioned ear was tested first. Whenever possible, an attempt was made to test both ears. A wideband tympanometry research system (WB Tymp 3.2, Interacoustics Inc.), based on a Titan probe and a modified AT235 instrument, was used to measure ER. Calibration was performed daily before a new set of data was obtained. The wideband signal was introduced through the probe into the subject's sealed ear canal. Ambient measurements were obtained by recording the acoustic response to clicks. If a leaky insertion occurred, a warning appeared on the screen. If the baby was crying or moving, or if the canal was too narrow to insert the measuring probe, the baby was excluded from the study. In one-month-old babies the equivalent air volume (estimated from the acoustical admittance) may be slightly negative at low frequencies [17]. However, large negative volumes are not expected to occur and may represent a probe leak. As was described by Keefe et al. [17], cases with equivalent volumes below -1.15 cm^3 were excluded from the study.

The wideband system provided the results as energy absorbance (=1 – ER) as a function of frequency, with 60 data points between 0.24 and 8 kHz. The absorbance measurements were transformed into reflectance for analysis. The median reflectance of each occlusion group (increments of 10%) was plotted to identify trends and grouping of the reflectance results in relation to the occlusion grade of the ear canal.

After the reflectance measurements, otoscopy was performed using a manual otoscope (Welch Allyn Inc.) by a trained and highly experienced otolaryngologist or by a medical doctor who was guided, trained and supervised by the otolaryngologist. The otoscopy was performed only once so the baby would not be disturbed and to avoid the parents' withdrawal from the study. Therefore, an inter-rater reliability assessment was not possible. The occlusion of the ear canal was described on a scale of 0%–100% with increments of 10%. A clear canal with no visible debris was denoted by 0%, while complete occlusion was denoted by 100% (The manual otoscope used in this study did not permit recording of images, but in Fig. 1 we illustrate our estimation of occlusion using an image taken separately with a video-otoscope.). The otoscopic field was visually divided into half and then into smaller subdivisions. Occlusion was recorded as the sum of the areas of the subdivisions. A statistical analysis with a linear mixed model was used to examine whether differences exist in ER between right and left ears, and among the occlusion groups. The statistical software SPSS 18 was used for analysis.

a

b

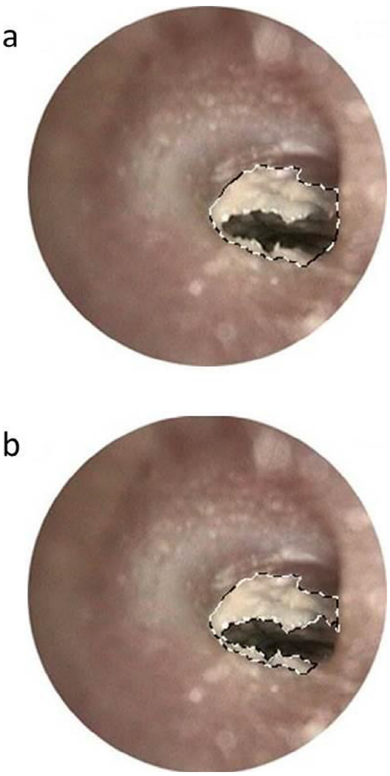

Fig. 1. Example of ear-canal occlusion in a newborn. (a) The ear canal is outlined. (b) The occlusion is outlined. Our estimated grade of occlusion in this case would be 60%.

3. Results

A total of 156 babies were included. There were 80 females and 76 males with a mean age of 25 hours (range 12–54). In 10 babies the measurement was done only in the right ear, and in 10 other babies it was done only in the left ear, so measurements were done in 292 ears. Three ears were excluded because the equivalent volume was too negative, so 289 ears are included in the results that follow. Table 1 summarizes the demographic characteristics. On otoscopy, most of the ear canals were found to contain some amount of material and it was difficult to identify and evaluate the status of the TM. To explore whether there is a correlation between the ear-canal occlusion and the ER results, the median for each occlusion group was plotted for the right and left ear. As seen in Figs. 2 and 3, the largest separation between occlusion groups occurred between the 0–70% groups and the 80–100% groups. This separation is more pronounced below approximately 400 Hz and between 840 Hz and 6 kHz in the right ear, and below 400 Hz and between 1.6 and 3.2 kHz in the left ear. For the investigation of whether a difference in reflectance exists between the right and left ears, between the two main occlusion groups (0–70% and 80–100%) and among different frequencies, the 60 frequency data points were divided into 6 groups of 10.

There was no significant difference in reflectance between the right and left ears. Table 2 shows a comparison of the mean reflectances of the two main occlusion groups for the six groups