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Usefulness of 1000-Hz probe tone in tympanometry according to age in Korean infants

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ABSTRACT

Objective: Numerous studies have shown the superiority of a 1000-Hz frequency probe tone for evaluating the middle ear status of infants. However, most of these studies examined Caucasian populations. This study validated the 1000-Hz probe tone and evaluated the age at which it should be used in Korean infants.

Methods: Data from 83 infants (43 males, 40 females; mean age 9.2 ± 6.2 (range 1–30) months, 165 ears) were analyzed. Tympanograms were classified according to Baldwin's modification of the method of Marchant et al. and correlated with results based on combined diagnostic tests, including an endoscopic examination of the tympanic membrane, myringotomy findings, and the air and bone conduction auditory brainstem response (ABR) thresholds. Data were analyzed in five age groups, each covering a 3-month range. The traces were measured for both 226- and 1000-Hz probe tones. The sensitivity and specificity for the different age groups were also determined.

Results: For the 226-Hz probe tone, the tympanograms showed normal traces for most ears with otitis media effusions in infants younger than 12 months. By contrast, the tympanograms using the 1000-Hz probe tone showed abnormal traces in most of the infants with otitis media effusions in all age groups. In infants with no otitis media effusion, the tympanograms using both 226- and 1000-Hz probe tones were interpreted as normal in most cases in all age groups. In infants younger than 12 months, the sensitivity of the 226-Hz probe tone was very low (0–6.6%), whereas that of the 1000-Hz probe tone was very high (90–100%). In infants older than 13 months, however, the sensitivities of the 226- and 1000-Hz probe tones were 76.2% and 85.7%, respectively. Regarding specificity, the difference between the two probe tones was not significant for any age group.

Conclusions: This study confirmed the superiority of the 1000-Hz probe tone for evaluating the middle ear in infants. We recommend using a 1000-Hz probe tone at least up to the age of 12 months for Korean infants.

Introduction

Otitis media effusion (OME) is one of the most common diseases in infants. It is thought that OME occurs in more than half of all children in the first year of life [1]. Recurrent OME can result in mild to moderate hearing loss because it affects the mobility of the ossicles and tympanic membrane [2]. This hearing loss might affect language development and cognition [2]. In addition, OME frequently causes false-positive results in newborn hearing screening. Consequently, it is important to assess the middle ear status of infants accurately. However, the diagnosis of OME is difficult because children are restless during examination and they have small external auditory canals (EAC) [3]. Tympanometry in pediatric audiology is most commonly used to measure the middle ear pressure, which assists in the identification of OME. The conventional 226-Hz probe tone is a well-established method used in adults and children. Although the test is easy and the traces are

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easy to interpret, its validity for infants has been questioned. Studies have shown that tympanometry using a 226-Hz probe tone can produce normal traces in infants younger than 4 months with confirmed OME [4–6]. It is also possible to obtain abnormal traces using a 226-Hz probe tone in normal ears [7].

Numerous studies have reported the superiority of a 1000-Hz frequency probe tone. Meyer et al. suggested that a 1000-Hz probe tone is more reliable than a 226-Hz probe tone for diagnosing OME in infants younger than 6 months [6]. Hoffmann et al. recommended using a 1000-Hz probe tone in infants up to the age of 9 months [3]. Alaerts et al. suggested that for children younger than 3 months, a 1000-Hz probe tone always be used, for children between 3 and 9 months, a two-stage evaluation be performed: first at 1000-Hz and then with a 226-Hz probe in the case of a failed result [2].

However, most of these studies examined Caucasian populations and presented normative data. It has been reported that there are differences in the parameters of middle and external ear between the Asians and Caucasians such as static admittance, tympanometric width, tympanometric peak pressure, and ear canal volume [8]. To our knowledge, there is one study reported in the English-language literature has examined when a 1000-Hz probe tone should be used in Asian infants [9]. Therefore, this study evaluated the age at which a 1000-Hz probe tone should be used in Korean infants.

Materials and methods

Subjects

This study retrospectively analyzed data from 83 subjects (43 males, 40 females; mean age 9.2 ± 6.2 (range 1–30) months) who visited the Department of Otorhinolaryngology Head and Neck Surgery of Seoul National University Hospital from April 2011 to May 2012 to evaluate hearing or otitis media. After excluding ears with tympanic membrane (TM) perforation, missing medical records, or concurrent sensorineural hearing loss, this study included 152 ears. This research was approved by the Institutional Review Board (IRB No. 1408-019-601) and performed according to the Declaration of Helsinki.

Instruments

A GSI TympStar Middle Ear Analyzer (ver. 2) was used for the 226- and 1000-Hz probe tones.

Testing

A probe that fit in the subject's EAC was selected. The test procedures were performed by a professional audiologist in a quiet room and the tympanogram traces were obtained with 226- and 1000-Hz probe tones in random order. Traces that were difficult to interpret owing to artifact due to the restlessness of the infant or an escape of pressure were repeated. Each tympanogram was printed and interpreted by the authors, who were blind to the results of the endoscopic examination of the TM, myringotomy, and air and bone conduction auditory brainstem response (ABR) threshold. To minimize the interpreter differences, all traces were classified by two independent authors who were otology fellows with 1 and 2 years' experience, respectively.

In this study, we used Baldwin's modification of the method of Marchant et al., who suggested a classification in which a baseline was drawn from a pressure of +300 to −400 mmH_2O and the peak susceptance above the baseline was measured. Traces with no peak or a trough-shape implied middle ear dysfunction [10]. Baldwin devised a method that used admittance instead of susceptance and a baseline was drawn from a pressure of +200 to −400 mmH_2O [9]. A line was drawn vertically from the baseline to the peak of the trace either above (positive) or below (negative) the baseline. The admittance traces were classified as positive (normal middle ear function), negative (abnormal), or indeterminate (could not be classified as either positive or negative).

An example is shown in Fig. 1. Excluding three ears for which the traces were classified as indeterminate, 149 ears were analyzed. The middle ear status was assessed by combining the results of three tests: (a) an endoscopic examination of the tympanic membrane ($n = 99$ ears); (b) myringotomy during ventilation tube insertion under general anesthesia ($n = 20$ ears); and (c) the air and bone conduction ABR threshold ($n = 149$ ears). The examination of the TM and the air and bone conduction ABR were the main elements used to judge the middle ear status and myringotomy complemented these results. Subjects' ears that met at least two of the following criteria were considered to have OME:

1. Air-fluid level, air bubble, or amber color in TM on endoscopic examination;
2. serous or glue discharge at myringotomy during ventilation tube insertion; and
3. air bone gap (ABG) > 20 dB HL at the ABR threshold.

The ABR thresholds were tested with the Navigator Pro system. A click stimulus with a 100-ms pulse duration with alternating polarity was presented through an insert ear phone transducer at a repetition rate of 11.1/s. A 10-ms (or if necessary 20 ms) post-stimulus recording window was used to average at least 1024 stimulus repetitions. Responses were bandpass filtered between the negative and positive electrodes at 300–3000 Hz. Bone conduction thresholds were measured with a Radioear B71 bone conductor placed on the mastoid of the test ear. To elicit the head shadow effect, masking was introduced at stimuli above 50 dB nHL.

The data were analyzed for five age groups, each covering a 3-month span. The subjects were divided into groups without (OME(−)) and with (OME(+)) OME. The categories of the traces were measured for both 226- and 1000-Hz probe tones. The sensitivity and specificity were determined for the different age groups.

Results

Of the 149 ears, 98 (65.7%) had no OME and 51 (34.2%) had OME. The numbers of ears with or without OME according to age group are described in Table 1.

Distribution of tympanogram types

Fig. 2 shows the distribution of tympanogram types according to the age groups using the 226-Hz probe tone in the OME(−) and OME(+) groups. In the OME(−) group, the 226-Hz probe tone mostly produced accurate data consistent with the middle ear status in all age groups. By contrast, in the OME(+) group, the tympanograms were recorded as normal in most ears regardless of the presence of OME, except in infants older than 13 months.

Fig. 3 shows the distribution of tympanogram types according to age group using the 1000-Hz probe tone for the OME(−) and OME(+) groups. For the OME(−) group, the tympanograms using the 1000-Hz probe tone were interpreted as normal in most cases in all age groups. For the OME(+) group, the tympanograms using the 1000-Hz probe tone showed abnormal traces in most cases in all age groups. That is, the 1000-Hz probe tone gave reliable results in infants of all ages examined regardless of the presence or absence of OME.