Tympanometry in Newborn Infants—
1 kHz Norms

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Abstract
With the rapid implementation of universal newborn hearing screening (UNHS) programs, a test of middle-ear function for infants is urgently needed. Recent evidence suggests that 1 kHz tympanometry may be effective. Normative data are presented for newborn intensive care unit (NICU) graduates tested at a mean age of 3.9 weeks (Study 1) and full-term infants tested at 2–4 weeks (Study 2) who passed an otoacoustic emissions (OAE) screen. Nearly all infants tested had single-peaked tympanograms. The norms are evaluated for a group of full-term infants who were screened with OAE (Study 3) and two groups of infants (NICU patients and well babies) who were not screened by OAE (Study 4). The 5th percentile for static admittance for NICU and full-term babies was identical, allowing a single pass-fail criterion. Using that criterion, well babies who passed an OAE screen (Study 3) yielded a 91% pass rate. Those who passed the OAE screen had substantially higher 1 kHz static admittance than those who failed, suggesting a strong relationship between middle-ear transmission characteristics and OAE responses. The pass rate was lower for newborn well babies and NICU graduates who were not screened by OAE (Study 4).

Key Words: Infant hearing, otoacoustic emissions, tympanometry, universal newborn hearing screening

Abbreviations: UNHS = universal newborn hearing screening; CA = chronological age; GA = gestational age; OAE = otoacoustic emissions; TEOAE = transient-evoked otoacoustic emissions; DPOAE = distortion-product otoacoustic emissions; TPP = tympanometric peak pressure; ABR = auditory brainstem response

Sumario
Con la rápida implementación de los programas de tamizaje auditivo universal en recién nacidos (UNHS) se necesita urgentemente una prueba de función del oído medio en infantes. La evidencia reciente sugiere que la timpanometría de 1 kHz puede ser efectiva. El estudio presenta información normativa obtenida de graduados de una unidad de cuidados intensivos neonatal (NICU), evaluados a una edad promedio de 3.9 semanas (Estudio 1) y de infantes de término evaluados a las 2-4 semanas (Estudio 2), quienes pasaron un tamizaje de emisiones otocústicas (OAE). Casi todos los niños evaluados mostraron timpanogramas de un solo pico. Las normas se evalúan para un grupo de infantes de término que fueron tamizados con OAE (Estudio 3) y para dos grupos de infantes (pacientes de la NICU y bebés normales) que no fueron tamizados con OAE (Estudio 4). El percentil 5 para la admittance estática fue idéntico, tanto para los graduados de la NICU como para los bebés de tér-
With the rapid implementation of universal newborn hearing screening (UNHS) programs, there is a need for a test of middle-ear function to distinguish sensorineural hearing loss from middle-ear pathology. This distinction is important for (a) identifying screening fails caused by transient external-ear or middle-ear conditions, (b) determining the need for medical management of middle-ear disease, and (c) determining the need and timing of follow-up procedures such as auditory brainstem response (ABR) testing with or without sedation. Tympanometry, using the conventional 226 Hz probe tone, has been shown to be an effective test for identifying effusion and other middle-ear pathologies in preschool- and school-aged children (Nozza et al., 1992, 1994) and has become a routine clinical test for audiologic and otologic evaluation of children and adults. However, conventional tympanometry is not an effective test in young infants. Quite early in the advent of tympanometry as a clinical test, Paradise et al. issued the following warning regarding the interpretation of tympanograms from infants under seven months of age: “While ‘abnormal’ tympanograms appear to have the same significance as in older subjects, ‘normal’ tympanograms are of no diagnostic value, since they may be associated with either effusion or the absence of effusion” (1976:207). Others have also reported normal 226 Hz tympanograms in the presence of confirmed middle-ear pathology (Balkany et al., 1978; Hunter and Margolis, 1992) and considerable clinical experience among many audiologists supports those observations. Although Paradise et al. attributed the poor sensitivity of tympanometry to the underdeveloped osseous portion of the ear canal in infants, a physical explanation is lacking. An increase in canal volume with positive air pressure and a decrease in volume with negative pressure is expected to produce a monotonically increasing admittance as pressure changes from negative to positive. The ear canal wall movement that has been observed in infants (Paradise et al., 1976; Holte et al., 1990) does not account for a normal, peaked tympanogram in the presence of middle-ear effusion.

Although mostly anecdotal, evidence is accumulating that tympanometry with a higher probe frequency may be more sensitive to middle-ear disease in infants than 226 Hz tympanometry (Shurin et al., 1976; Marchant et al., 1986; Hunter and Margolis, 1992; Rhodes et al., 1999). Normative studies of tympanometry in newborns are complicated by the lack of a “gold standard,” an independent method for assuring that only normal ears are included in the study. In older children and adults, pneumatic otoscopy and surgical findings...
are used for this purpose. In infants, surgical findings are seldom available, and otoscopic observations are suspect (Eavey, 1993; Rhodes et al., 1999). Because otoacoustic emissions (OAEs) require efficient transmission of sound to and from the cochlea, normal OAEs provide some level of assurance of normal middle-ear transmission. OAEs are clearly an imperfect gold standard because emissions can be recorded from some ears with middle-ear disease. In a study of two- to seven-year-old children, van Cauwenberge et al. (1996) reported an 8% prevalence of TEOAEs in 85 ears with otitis media with effusion and flat tympanograms. Doyle et al. (1997) reported a 33% TEOAE pass rate in newborn infants with reduced tympanic membrane mobility determined by pneumatic otoscopy. Although the sensitivity and specificity of pneumatic otoscopy in newborns is unknown, it is likely that many of these babies had middle-ear effusion.

In this report we present normative data for 1 kHz tympanometry from two groups of infants who underwent newborn hearing screening tests. These are presented in Study 1 and Study 2. Study 1 provides normative data for NICU babies tested prior to discharge. Study 2 provides normative data for full-term infants who were tested at 2–4 weeks chronological age (CA). Three independent data sets are evaluated against these norms. In Study 3, the norms were applied to 1 kHz tympanograms from a new group of full-term infants tested at 1–3 days CA who had passed an OAE screen. In Study 4, the norms were applied to another group of full-term newborns tested at 0–2.5 days CA, and a group of NICU graduates tested at a mean CA of 5.3 weeks (mean gestational age GA = 35 weeks) who were not screened by OAE. Clinical cases are presented that illustrate the potential use of 1 kHz tympanometry for evaluating middle-ear function in infants.

**STUDY 1**

**Method**

A retrospective analysis was conducted of the results of a study of UNHS methods in newborn intensive care unit (NICU) patients who were near discharge (Rhodes et al., 1999). Ears were included if they passed a transient-evoked OAE (TEOAE) screen tested with a commercial system (Otodynamics ILO88). A pass was defined as reproducibility exceeding 0.50 at three of the following frequencies: 1.4, 2.0, 2.8, 4.0 kHz.

Tympanograms were recorded utilizing a 1 kHz probe frequency with a commercially available middle-ear analyzer (Grason-Stadler GSI-33 version 2). Admittance magnitude data were exported to a database system (GSI DataLink) that made this analysis possible. Ear-canal air pressure was swept in a positive-to-negative direction at a rate that varied from 600 daPa/s at the tails to 200 daPa/sec near the peak.

For the most part, tympanograms had clearly defined, single peaks. A few had double peaks. Normative data were calculated from 105 ears of 65 NICU patients (mean CA = 3.9 weeks; mean GA at test = 37 weeks). Seven ears were excluded because there were no discernible peaks or because the tympanogram shape was irregular and uninterpretable.

### Table 1 Normative Tympanometric Values from 1 kHz Tympanograms from 105 Ears of 65 NICU Patients

<table>
<thead>
<tr>
<th>Birth GA (wks)</th>
<th>Test CA (wks)</th>
<th>Test GA (wks)</th>
<th>TPP (daPa)</th>
<th>Y+200</th>
<th>Y-400</th>
<th>Y Peak</th>
<th>Comp Y (+200)</th>
<th>Comp Y (-400)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>32.8</td>
<td>3.9</td>
<td>36.7</td>
<td>-9</td>
<td>1.4</td>
<td>0.6</td>
<td>2.2</td>
<td>0.8</td>
</tr>
<tr>
<td>SD</td>
<td>4.2</td>
<td>3.8</td>
<td>2.7</td>
<td>48</td>
<td>0.3</td>
<td>0.2</td>
<td>0.7</td>
<td>0.5</td>
</tr>
<tr>
<td>Max</td>
<td>41.0</td>
<td>20.1</td>
<td>44.7</td>
<td>145</td>
<td>2.9</td>
<td>1.4</td>
<td>5.4</td>
<td>3.4</td>
</tr>
<tr>
<td>Min</td>
<td>23.0</td>
<td>0.1</td>
<td>31.3</td>
<td>-188</td>
<td>0.8</td>
<td>0.4</td>
<td>1.0</td>
<td>0.1</td>
</tr>
<tr>
<td>5th percentile</td>
<td>26.0</td>
<td>0.4</td>
<td>32.6</td>
<td>-93</td>
<td>0.9</td>
<td>0.4</td>
<td>1.3</td>
<td>0.2</td>
</tr>
<tr>
<td>50th percentile</td>
<td>32.4</td>
<td>2.1</td>
<td>36.6</td>
<td>-5</td>
<td>1.3</td>
<td>0.6</td>
<td>2.1</td>
<td>0.8</td>
</tr>
<tr>
<td>95th percentile</td>
<td>40.0</td>
<td>10.9</td>
<td>41.0</td>
<td>53</td>
<td>1.9</td>
<td>1.0</td>
<td>3.4</td>
<td>1.6</td>
</tr>
</tbody>
</table>

**Note:** Data from Rhodes et al., 1999. Birth GA = gestational age at birth; Test CA = chronological age at test; Test GA = gestational age at test; TPP = tympanometric peak pressure; Y+200 = admittance at 200 daPa; Y-400 = admittance at -400 daPa; Y Peak = admittance at tympanometric peak; Comp Y (+200) = peak admittance at Y+200; Comp Y (-400) = peak admittance at Y-400.
Descriptive statistics are reported for the admittance tail values (200 daPa and -400 daPa), peak admittance (uncompensated), compensated static admittance\(^1\) (peak-to-negative-tail difference and peak-to-positive-tail difference) and tympanometric peak pressure (TPP). When double peaks occurred, the peak admittance was obtained from the higher peak.

The mean CA at the time of test was 3.9 weeks, and the mean GA at birth was 33 weeks (Table 1). This means that on average, the patients are not quite full-term at the time of test, but they have had time for their ears to accommodate to the external environment. This is an important aspect of this subject group that is discussed further below.

### Results

Descriptive statistics for characteristics and tympanometric measures are presented in Table 1. The shaded area in Figure 1 represents the 90% range for static admittance, a commonly used statistic for describing normative tympanometric data (e.g., Margolis and Heller, 1987). The vertical lines represent the 90% range for TPP, the pressure at which peak admittance occurred. The 5th percentile for static admittance

![Figure 1](image1.png)

**Figure 1** Normative tympanometric values from 1 kHz tympanograms from 105 ears of 65 NICU patients. The symbols (diamonds, squares, and triangles) represent the 5th, 50th, and 95th percentiles for admittance values at the positive tail (+200 daPa) and peak relative to the negative tail (-400 daPa). The vertical lines represent 5th and 95th percentiles for tympanometric peak pressure. Data from Rhodes et al., 1999.

Descriptive statistics are reported for the admittance tail values (200 daPa and -400 daPa), peak admittance (uncompensated), compensated static admittance\(^1\) (peak-to-negative-tail difference and peak-to-positive-tail difference) and tympanometric peak pressure (TPP). When double peaks occurred, the peak admittance was obtained from the higher peak.

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![Figure 2](image2.png)

**Figure 2** Normative tympanometric values from 1 kHz tympanograms from 46 ears of 30 full-term babies. The symbols (diamonds, squares, and triangles) represent the 5th, 50th, and 95th percentiles for admittance values at the positive tail (+200 daPa) and peak relative to the negative tail (-400 daPa). The vertical lines represent 5th and 95th percentiles for tympanometric peak pressure. Data from Zapala et al., 1997.

### Table 2: Normative Tympanometric Values from 1 kHz Tympanograms from 46 Ears of 30 Full-Term Babies Tested at 2–4 Weeks Chronological Age

<table>
<thead>
<tr>
<th></th>
<th>TPP (daPa)</th>
<th>Y+200</th>
<th>Y-400</th>
<th>Y Peak</th>
<th>Comp Y (+200)</th>
<th>Comp Y (-400)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
<td>-10</td>
<td>1.4</td>
<td>0.8</td>
<td>2.7</td>
<td>1.3</td>
<td>1.9</td>
</tr>
<tr>
<td><strong>SD</strong></td>
<td>68</td>
<td>0.4</td>
<td>0.4</td>
<td>1.2</td>
<td>1.0</td>
<td>1.3</td>
</tr>
<tr>
<td><strong>Max</strong></td>
<td>200</td>
<td>2.3</td>
<td>1.7</td>
<td>7.0</td>
<td>5.0</td>
<td>6.0</td>
</tr>
<tr>
<td><strong>Min</strong></td>
<td>-200</td>
<td>0.7</td>
<td>0.0</td>
<td>0.8</td>
<td>0.0</td>
<td>0.1</td>
</tr>
<tr>
<td><strong>5th percentile</strong></td>
<td>-133</td>
<td>0.8</td>
<td>0.3</td>
<td>1.2</td>
<td>0.1</td>
<td>0.6</td>
</tr>
<tr>
<td><strong>50th percentile</strong></td>
<td>0</td>
<td>1.4</td>
<td>0.8</td>
<td>2.5</td>
<td>1.0</td>
<td>1.7</td>
</tr>
<tr>
<td><strong>95th percentile</strong></td>
<td>113</td>
<td>2.2</td>
<td>1.4</td>
<td>4.8</td>
<td>3.5</td>
<td>4.3</td>
</tr>
</tbody>
</table>

**Note:** Data from Zapala et al., 1997. TPP = tympanometric peak pressure; Y+200 = admittance at 200 daPa; Y-400 = admittance at -400 daPa; Y Peak = admittance at tympanometric peak; Comp Y (+200) = peak admittance at Y+200; Comp Y (-400) = peak admittance at Y-400.
compensated from the negative tail (-400 daPa) is 0.6 mmho. This value is used as the pass-fail criterion in Studies 3 and 4.

**STUDY 2**

**Method**

A retrospective analysis was conducted of a study of full-term infants who failed a hospital TEOAE screen (Otodynamics ILO88) and passed a re-screen at 2–4 weeks (Zapala et al., 1997). The pass-fail criterion for the TEOAE screen was a +6 dB signal-to-noise ratio in at least three of four frequency bands from 1.4–4.0 kHz. Tympanograms were recorded with the same instrument and parameters as those used in Study 1. As in Study 1, tympanograms were usually characterized by single peaks. A few had double peaks, in which case the higher peak was taken as the uncompensated peak admittance. None was excluded.

**Results**

Normative data are reported for 46 ears of 30 full-term infants tested at 2–4 weeks who passed the TEOAE screen. Admittance results are presented in Table 2. The 90% range for static admittance is shown as the shaded area in Figure 2. The range of admittance was much greater than that for the NICU graduates in Figure 1, but the 5th percentiles were identical for the two groups.

![Figure 3](null) Pass-fail rates for 1 kHz tympanometry for 170 ears of 87 well babies tested at 15 to 76 hours after birth who passed or failed a DPOAE screen. Those that passed the DPOAE screen, 135 ears (91%) had static admittance that exceeded the pass-fail criterion. Of the 24 ears falling outside the normal static admittance range, 13 (54%) passed the DPOAE screen and 11 (46%) failed. There were 22 ears that failed DPOAE screen and passed the ABR screen; of those, 50% had static admittance exceeding the 0.6 mmho pass-fail criterion. Tympanograms could not be obtained due to

**STUDY 3**

**Method**

1 kHz tympanograms were recorded from 87 full-term newborns with a GSI-33 middle-ear analyzer. The babies ranged from 15 to 76 hours old at the time of the test. All had been screened with a commercial DPOAE screening instrument (Biologic AudX Plus). Those who did not pass the DPOAE screen passed a subsequent automated ABR screen. Because sensorineural hearing loss was ruled out by the ABR screen, the DPOAE fails are probably due to external-ear or middle-ear abnormalities. Tympanograms were considered to be normal if the negative-tail-compensated static admittance equaled or exceeded 0.6 mmho.

**Results**

Results for 170 ears are shown in Figure 3. Of the 170 ears, 148 (87%) passed the DPOAE screen. Of those that passed the DPOAE screen, 135 ears (91%) had static admittance that exceeded the pass-fail criterion. Of the 24 ears falling outside the normal static admittance range, 13 (54%) passed the DPOAE screen and 11 (46%) failed. There were 22 ears that failed DPOAE screen and passed the ABR screen; of those, 50% had static admittance exceeding the 0.6 mmho pass-fail criterion.
excessive activity from four ears, and these were excluded from the calculation of pass-fail rates. Of the four ears that could not be tested by tympanometry, three could not be tested by DPOAE, and one passed the DPOAE screen.

Figure 4 shows the mean 1 kHz static admittance calculated from peak to positive tail $Y_{tm}(+)$ and peak to negative tail $Y_{tm}(-)$ for full-term newborns who passed the OAE screen and for those who failed. Static admittance is substantially higher for those who passed the OAE screen. The strong relationship between OAE pass-fail status on static admittance suggests that many screening failures may result from middle-ear rather than inner-ear factors.

STUDY 4

Method

1 kHz tympanograms were successfully recorded with a GSI-33 Middle Ear Analyzer from 85 ears of 54 healthy full-term infants (Mean CA = 24; Range 5–62 hours) and from 74 ears of 44 NICU patients who were near discharge (mean CA = 5.3 weeks; Range 0–23 weeks; mean GA at time of test = 35 weeks; Range 32–47 weeks). Subjects were not screened by otoacoustic emissions or ABR. Pass-fail results for both groups were based on the 0.6 mmho criterion for negative-tail-compensated static admittance.

Tympanograms could not be obtained from 23 ears of well babies and 14 ears of NICU babies.

Results

Pass-fail results for both groups are presented in Figure 5. The pass rate for full-term babies (64%) was substantially lower than the pass rates in Studies 1–3. The pass rate for NICU babies (82%) was higher than the full-term babies from this study but substantially lower than the pass rates in Studies 1–3.

DISCUSSION

The 1 kHz tympanograms obtained in Study 1 and 2 were almost always single-peaked and free of artifacts and irregular patterns. The consistency of patterns allows a reasonably simple pass-fail criterion based on the compensated static admittance. The pass-fail judgment can be made easily by visual inspection of the tympanogram or can be determined automatically by the instrument.

The negative-tail compensated static admittance was selected for the pass-fail criterion. This was chosen in preference to positive-tail compensation because of the larger mean value on the negative tail side. The larger value makes it easier to distinguish between a normal tympanogram and one that is flat or nearly flat.

Subjects were excluded from Studies 1 and 2 if they failed an OAE screen. Pass-fail criteria were different for the two studies. In Study 1, the OAE was a pass if the reproducibility exceeded 0.5 in three of four frequency bands. In Study 2 a pass was defined as a signal-to-noise ratio of 6 dB in three of four frequency bands. The frequency bands were the same in the two studies. A reproducibility of 0.5 corresponds to a signal-to-noise ratio of 3 dB (Gorga et al., 1993). A 6 dB signal-to-noise ratio corresponds to a reproducibility of 0.71. Thus the pass-fail criterion was more strict in Study 2. In spite of the more strict criterion in Study 2, there was substantially more variability in tympanometric values (compare shaded areas of Figure 1 and Figure 2). It is likely that the greater variability in Figure 2 is related to the greater age of the subjects and the resulting normalization of middle-ear mechanics that results from clearance of prenatal ear canal.
It is important to note that except for a few subjects in Study 1, the subjects in Studies 1 and 2 were at least two weeks CA. Figures 1 and 2, then, are not representative of newborns but of babies who have had a few weeks to adjust to the external environment. Most likely, the middle-ear and ear canal space are cleared of prenatal material and filled with air. In contrast, the babies in Studies 3 and 4 (except the NICU babies in Study 4) were tested during the early neonatal period. Their ears may not have completed their adaptation to the external world. This may be a reason for the lower pass rates in those studies. The results of Study 3 suggest that although pass rates for newborns may be lower than for older infants, the pass rates are sufficiently high that the test may be useful for identifying potential middle-ear problems.

The pass rates for both groups of Study 4 were substantially lower than Studies 1–3. Three factors may have contributed to the higher fail rates. First, unlike the babies in the other studies, the babies in Study 4 were not screened by otoacoustic emissions. This may have resulted in inclusion of transient and middle-ear conditions that were excluded from other studies. Second, the patients were younger than those in Studies 1 and 2. A high proportion of the full-term infants that failed tympanometry in Study 4 were under 15 hours of age at the time of test. Of the NICU group, 41% were under 35 weeks GA at the time of test. Third, the NICU babies in Study 4 probably had more serious health problems resulting in a longer mean length of stay (37.3 days) compared to those in Study 1. These factors have been reported to increase the likelihood of otitis media (Sutton et al., 1996; Vento et al., 1995), perhaps contributing to the higher tympanometry fail rate in Study 4.

The results of Study 2 show a wider range of values compared to Study 1. Nevertheless, the 5th percentile for negative-tail-compensated static admittance for these full-term babies is identical to that of the NICU graduates of Study 1 who were slightly pre-term at the time of test. The 5th percentile of the static admittance (peak-to-negative-tail difference) is 0.6 mmho from Study 1 and Study 2. Because a high static admittance is not usually an indication of pathology in newborns, a single cutoff value of 0.6 mmho is a reasonable pass-fail criterion for all babies up to 4 weeks chronological age range, regardless of corrected age.

Although the 90% range for tympanometric peak pressure is provided in the results of Study 1 and 2, it is not clear how this information should be used with regard to pass-fail decisions. For older children and adults, tympanometric peak pressure has not been useful as a predictor of middle-ear disease and is usually not considered in screening algorithms (Margolis and Heller, 1987). Whether an abnormal tympanometric peak pressure is significant in the infant population is not known. The normal ranges presented here may be useful for evaluating that question in future studies and in clinical practice.

The norms provided here provide a criterion for identifying middle-ear dysfunction in newborns that may be helpful for distinguishing between screening fails caused by sensorineural hearing loss and those caused by transient external and middle-ear conditions. It is important to note that an OAE or ABR fail in combination with a tympanometry fail does not rule out sensorineural hearing loss. These babies require careful follow-up to insure that permanent hearing loss does not coexist with a temporary middle-ear condition. In most cases, the baby will pass a rescreen after the middle ear has normalized. In some cases, treatment for otitis media is necessary. In unresolved otitis media, a sedated ABR may be needed to assess air-conduction and bone-conduction sensitivity.

**CASE STUDIES**

The following cases illustrate the potential value of 1 kHz tympanometry in the clinical evaluation of infants.

**Case 1**

This one month old was born in a hospital that did not offer newborn hearing screening and was referred to the Audiology Clinic because of a pre-auricular tag, a risk factor for hearing loss. He passed the otoacoustic emissions screen and had normal 226 Hz and 1 kHz tympanograms (see Figure 6).
suggesting normal hearing and normal middle-ear function.

Case 2

This seven-week-old infant, who was not screened for hearing loss in the newborn nursery, was referred for a hearing evaluation by her otolaryngologist because she has a cleft of the soft palate. A velar cleft involves the muscles of the nasopharynx, and the Eustachian tube is typically nonfunctional. Consequently, middle-ear effusion is very likely. TEOAEs were absent bilaterally. 226 Hz tympanograms are normal by the negative-tail-compensated static admittance ≥ 0.6 mmho criterion. The baby had normal otoacoustic emissions.

Figure 6 226 Hz and 1 kHz tympanograms from a one-month-old infant who was referred for testing because of a pre-auricular tag, a risk factor for hearing loss. 226 Hz tympanograms show clear peaks. 1 kHz tympanograms are normal by the negative-tail-compensated static admittance ≥ 0.6 mmho criterion. The baby had normal otoacoustic emissions.

Figure 7 226 Hz and 1 kHz tympanograms from a seven-week-old infant with a velar cleft. The 226 Hz tympanograms show well-defined double peaks. The 1 kHz tympanograms are flat. The baby was subsequently treated for otitis media with effusion with tympanostomy tubes.

Based on the audiologic evidence of otitis media, a bilateral myringotomy was planned at the time of the palatal closure. Tympanometry was repeated with a 226 Hz probe tone at age seven months. The right tympanogram was flat. The left tympanogram had a well-defined peak with a static admittance (peak – negative tail) of 0.3 mmho. The palatal closure was performed at age nine months. Myringotomies were performed, and tympanostomy tubes were placed. The right ear contained mucoid effusion. The left ear contained serous effusion. On follow-up visits, the tubes were patent. No additional hearing testing was performed.

Case 3

This 2-month-old male patient, who was not screened in the nursery, was referred to the Audiology Clinic by his pediatrician because of parental concern that he did not respond consistently to sound. Recently, he had been responding more to loud sound but not to softer sounds. The pregnancy and delivery were uneventful, and there is no significant family history of hearing impairment. He was hospitalized three weeks earlier for 3 days for a viral infection. The mother reports that he has been congested for the past couple of days.

226 Hz and 1 kHz tympanograms are shown in Figure 8. The 226 Hz tympanogram from the right ear appeared to have a well-defined peak with static admittance that is normal for older children. The left ear tympanogram was flatter but appeared to have a peak. The 1 kHz tympanogram from the right ear did not have a clear peak, and
the admittance decreased with negative pressure, possibly due to ear canal collapse. The left ear tympanogram was essentially flat. Otoacoustic emissions were absent bilaterally. An auditory brainstem response (ABR) evaluation, performed with the patient in natural sleep, produced responses down to 30 dB nHL clicks bilaterally, with slightly delayed latencies at all levels tested.

He was referred to a pediatric otology clinic where he was seen at age three months. Pneumatic otomicroscopy revealed opaque, immobile eardrums without inflammation bilaterally and an air-fluid line on the left. Because there was no inflammation, antibiotics were not prescribed, and he was referred to his pediatrician for follow-up.

He was seen again in Audiology at seven months when he had flat 226 Hz tympanograms. Limited behavioral responses were obtained by visual reinforcement audiometry that suggested normal or near-normal hearing. Another test performed three weeks later with sound field and bone conduction visual reinforcement audiometry indicated a conductive hearing loss in at least one ear. He underwent bilateral myringotomy with tympanostomy tubes at eight months. Behavioral hearing testing performed two weeks after the surgery indicated significantly improved hearing, and the parents reported increased vocalizations.

Cases 2 and 3 raise some interesting questions about management of infants with early otitis media. The interval between the initial audiologic evaluation, which produced strong evidence of middle-ear disease, and treatment (myringotomy and tympanostomy tubes) was seven months for Case 2 and six months for Case 3. These children probably had mild hearing loss during this period. In Case 3, the observation that his vocalizations increased immediately after the surgery suggests that the hearing loss may have had a significant effect on his speech and language development.

Clinical guidelines do not exist for surgical treatment of otitis media in children under one year of age. The Agency for Health Care Policy and Research (1994) guideline for one- to three-year-old children recommended myringotomy for patients with effusion persisting for 4–6 months. Myringotomy and tubes for children with effusion persisting for 3 months was described as an option “based on limited scientific evidence and Panel consensus” (1994:55). The appropriate time for surgery for infants under one year of age is not clear, but the following factors may suggest a relatively aggressive approach. First, early occurrence of the initial episode of otitis media increases the risk of chronic and recurrent disease (Daly et al., 2002). In these two cases in which testing produced evidence of effusion in the first two months, fluid may have been present for most of the first year of life. Second, untreated hearing loss in the first year of life may have a significant impact on development (Yoshinaga-Itano et al., 1998).

The lack of a clear guideline for treatment of middle-ear disease in infancy is partially attributable to the lack of an effective diagnostic test for this population. The routine use of 1 kHz tympanometry for assessing middle-ear function may provide a basis for evaluating the benefits of various treatment options.

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NOTES

1. The term static admittance here indicates the peak-to-tail difference in admittance magnitude. Because there are phase angle shifts as the ear is pressurized, the measurement does not accurately estimate the admittance at the tympanic membrane. See Margolis and Hunter (2000:389) for a discussion.

REFERENCES


