Preliminary Use of Endoluminal Ultrasonography in Assessment of Middle Ear with Effusion

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Otitis media with effusion is a common otologic problem in children. Methods for diagnosis of OME include microscopic examination, pneumatic otoscopy, and tympanometry. Even though tympanography has high accuracy in predicting effusion, some false-positive cases also occur.1-3 The practicality of ultrasonography in diagnosis of otologic effusion has been tried initially with A-mode sonography by Abramson and coworkers.4 Alvord and Fine, using B-mode scan designed originally for ophthalmic use, also demonstrated effusion in a two-dimensional manner.5 Currently, a smaller scanner using high frequency ultrasound beams is being used for endoluminal evaluation in various tubal organs.6-9 We used this instrument through external ear canal in an attempt to obtain a high-resolution picture of the middle ear with effusion.

Endoluminal ultrasonography with small-caliber and high-frequency transducer is suitable for transcanal assessment of middle ear with effusion. An endoluminal ultrasound transducer (size 6 French, 20 MHz) with a side-viewing scanning plane was used to image 12 ears of six children suspected of having effusion in the middle ear. Sonographic findings were compatible with those of operation in 10 diseased ears. One false-negative result was obtained, and one trial was aborted owing to trauma to the canal wall. The present study proves utility in demonstrating fluid behind the tympanic membrane. A promising use of endoluminal ultrasonography for middle ear evaluation might be expected if some modification could be made to the transducer. KEY WORDS: Endoluminal sonography; Otitis media; Middle ear.

ABBREVIATIONS
OME, Otitis media with effusion

MATERIALS AND METHODS
Six children with OME managed medically for more than 3 months (Table 1) were scheduled for myringotomy and ventilation tube insertion, with or without adenoidectomy. Tympanometry was repeated on...
the day of or 1 day before the surgery. Results of tympanometry were classified as type A, B, or C based on Jerger’s definitions. In type A the pressure-compliance curve shows a sharp maximum at or near 0 mm H2O; in type B, the tympanometry curve shows no maximum peak, with compliance remaining essentially unchanged over a large range of pressure variation; in type C, the maximum in tympanogram is shifted to the left, equaling or exceeding –100 mm H2O. After general anesthesia was induced and before the performance of myringotomy, an endoluminal catheter with an ultrasound transducer (SSD-550, Aloka, Tokyo, Japan) was passed into the proximal end of external ear canal while viewing through the surgical microscope (Fig. 1). The transducer was of size 6 French in diameter and was rotated mechanically in a transparent sheath filled with sterile water. Scanning frequency was centered at 20 MHz, and the scanning plane was perpendicular to the rotating crystal. Echo gain was adjusted to show only the interface of bony canal wall. The head of the transducer was placed into the inferior recess formed by the ear drum and the canal wall. The tip of catheter was adjusted to attach to the inferior canal wall as close as possible to avoid contacting the ear drum. Once the catheter was stabilized, 1 ml of distilled water was instilled into the canal. The ultrasound transducer was then turned on to determine if reflection echo occurred through the effusion deep to the tympanic membrane. The position of the transducer was adjusted outside the intact ear drum with minimal movement during the assessment. After the sonographic evaluation, the added water in the ear canal was removed with suction, and myringotomy was performed to determine if an effusion was present. Ventilation tube insertion was then performed.

RESULTS

The results of sonography were defined as positive if reflection signals were recorded behind the plane of the tympanic membrane (Fig. 2). The results would not be considered to show OME if only signals of inferior ear canal wall and tympanic membrane with air reflectance were seen (Fig. 3). Table 1 shows the results of preceding tympanometry, endoluminal ultrasonography, and myringotomy in these six patients. Preoperative diagnoses using sonography were correct in 10 of 12 ears. Sonographic evaluation of one ear was aborted owing to traumatic hematoma of external ear canal. One ear with effusion was misinterpreted as negative by sonography. Eight ears with effusion showed Jerger type B tympanogram; the other two showed type C tympanogram. Two ears without effusion showed type B or C tympanogram.

DISCUSSION

High-resolution ultrasonography can provide a direct view of pathologic processes of the middle ear. Our study demonstrated the feasibility of using endoluminal ultrasonography in middle ear evaluation. Theoretically, the method should be of high accuracy in diagnosing OME because of its lower false-positive rate, as shown in our study. If the catheter is properly placed, it is also possible to identify small parts of middle ear, and precise anatomic measurements could be made. This technique also allowed for dynamic evaluation of tympanic membrane motion or volumetric changes in the middle ear cavity.

Table 1: Results of Tympanography, Sonography, and Myringotomy

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yr)</th>
<th>Sex</th>
<th>Ear</th>
<th>Tympanogram</th>
<th>Sonogram</th>
<th>Operative Finding</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.5</td>
<td>F</td>
<td>Left B</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>2a</td>
<td>5</td>
<td>M</td>
<td>Left B</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>2b</td>
<td></td>
<td></td>
<td>Right B</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>M</td>
<td>Left B</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>4a</td>
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<td>M</td>
<td>Left B</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>4b</td>
<td></td>
<td></td>
<td>Right B</td>
<td>Failed</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
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<td>7</td>
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<td>+</td>
<td>+</td>
<td>+</td>
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<td>F</td>
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<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td>Right B</td>
<td>+</td>
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</tbody>
</table>

Figure 1 Placement of the catheter in the external ear canal. Note that the tip of the catheter was placed at the recess formed by the ear drum and the canal wall.
Detection of pathologic conditions of the middle ear, especially OME, has been tried with A-mode and B-mode ultrasonography using an ophthalmologic probe placed in the external ear. Although these trials were successful, probably they could have been improved with a smaller intracanal probe and a higher frequency transducer. We were therefore encouraged to use the endoluminal transducer in an attempt to obtain a close-up and high-resolution image of the middle ear. The initial trial was relatively satisfactory. However, the imaging plane of the SSD-550 transducer was perpendicular to the axis of the probe shaft. This allowed lateral cross-sectional imaging, but not imaging in front of the catheter. We therefore had to place the tip of catheter at the most proximal portion of the ear canal to have some portions of mesotympanum included in the sonographic scanning field. However, the tip of the catheter would cause irritation or even trauma to the ear canal or tympanic membrane, especially in small children. For the present design, the procedure was thus relatively invasive. Another problem of this side-viewing transducer was its poor orientation on 360 degree radial scanning. Sometimes identification of the middle ear structures would be difficult without good landmarks and orientation. A forward-viewing endoluminal ultrasound transducer has recently become available, and its validity was demonstrated by an in vitro study. With some modification of this instrument, more convenient and reliable detection of OME would be possible using sonography.

One false-negative result, diagnosed with ultrasonography, was found in this study. It may have been due to improper placement of the transducer, because the ear canal was relatively small in case 3. However, using ultrasonography, two ears with type C tympanogram were detected to have effusion. At present, it is too early to compare the validity of ultrasonography to that of tympanometry. Further study with a larger sample is needed to assess the reliability of this technique.
Even though the application of ultrasonography in the depiction of middle ear pathologic processes was far from optimal for clinical use, this preliminary study has shown the potential of endoluminal ultrasonography in imaging the middle ear using effusion as a transmission medium. With the forward-viewing transducer and some modification of the technique in catheter insertion, we anticipate the further use of ultrasonography in the imaging of middle ear cavity for diseases, such as vascular anomaly, glomus tumor, retraction pouch, and cholesteatoma.

REFERENCES