A View Through
THE OTOSCOPE
Distinguishing Acute Otitis Media
From Otitis Media With Effusion

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Contents

3 Epidemiology of Otitis Media
3 Etiology of Otitis Media
4 Clinical Classification of Otitis Media
4 Issues Complicating Diagnosis of Otitis Media
4 Instruments Used in Diagnosing Otitis Media
8 Prevention of Otitis Media
10 References
Otitis media is the most frequently occurring principal diagnosis among preschool children. An estimated 20 million cases occurred annually in the United States between 1993 and 1995. The number of recognized cases of otitis media and the apparent frequency of recurrences have increased significantly in the past 2 decades, as have the associated costs. According to a recent study, the annual direct and indirect costs of treating acute and chronic otitis media in children younger than 5 years of age were estimated at more than $5 billion. Of further concern are the possible indirect effects of otitis media on children's cognitive, language, speech, and emotional development, but these relationships remain to be clarified.

**EPIDEMIOLOGY OF OTITIS MEDIA**

Many studies have focused on the epidemiology of otitis media in the first 2 years of life—the period of greatest risk for the disease—using cross-sectional, retrospective cohort, and prospective cohort designs. However, most studies have had limitations in design, methodology, scope, or generalizability. One recent study conducted at the University of Pittsburgh delineated the occurrence and course of otitis media during the first 2 years of life in a sociodemographically diverse population of more than 2200 infants, and identified related risk factors. This study was part of a long-term investigation of possible effects of early-life otitis media on speech, language, cognitive, and psychosocial development. The study affirmed the importance of certain risk factors for the development and persistence of otitis media, particularly low socioeconomic status and exposure to large numbers of other children. Other, less important variables independently related to the occurrence of otitis media were sex (boys were more affected than girls); duration of breastfeeding (longer was better); and exposure to tobacco smoke.

In the Pittsburgh study, the term middle-ear effusion (MEE) was used to encompass all types of otitis media in which effusion was present—ie, acute otitis media (AOM) with or without otorrhea, otitis media with effusion (OME), and otorrhea through a tympanostomy tube. Of 2253 infants followed in this study until the age of 2 years, the proportions having one or more episodes of MEE between age 2 months and ages 6, 12, and 24 months, respectively, were 47.8%, 78.9%, and 91.1%. Overall, the mean cumulative proportion of days on which MEE was present was 20.4% in the first year of life and 16.6% in the second year of life.

In contrast with other studies, this study found that the prevalence of otitis media in black lower-socioeconomic-status infants was as high as, if not higher than, in white lower-socioeconomic-status infants, and certainly higher than in white middle-class infants.

The possibility that allergy contributes to chronic or recurrent otitis media, especially in children older than 3 years, has been debated. Conflicting results have been reported on the prevalence of atopy in children with OME; however, new data suggest that allergy may play a role in the pathogenesis of OME.

**ETIOLOGY OF OTITIS MEDIA**

**Pathophysiology**

The eustachian tube has three principal functions: ventilation, protection, and clearance. Impaired middle-ear ventilation is implicated in most cases of otitis media. The mucosa that lines the middle ear relies on a continuing supply of air, which, under normal circumstances, comes from the nasopharynx via the eustachian tube. Any interruption of this ventilatory process, such as a viral illness or barotrauma, can initiate a complex inflammatory response that includes the development of secretory epithelial cells in the middle-ear mucosa, compromise of the mucociliary transport system, and the effusion of liquid into the middle-ear cavity.

**Current Microbiology**

Presently, three organisms are the principal causes of AOM: *Streptococcus pneumoniae*, *Haemophilus influenzae*, and *Moraxella catarrhalis*. *S pneumoniae* causes up to 40% of AOM cases, and infections caused by this pathogen may be the least likely to resolve without treatment. *H influenzae* accounts for about 25% to 30% of AOM cases, and *M catarrhalis* is responsible for 10% to 20%. Organisms that cause AOM less frequently include group A streptococci (3%), *Staphylococcus aureus* (2%), and gram-negative organisms such as *Pseudomonas aeruginosa* (1% to 2%). Respiratory viruses, alone or in combination with bacterial pathogens, have been identified in 30% to 40% of patients with AOM. In a recent study, respiratory syncytial virus was the principal virus found in the middle ear in patients with AOM, but other pathogens also were present.
Bacterial Resistance

Development of bacterial resistance occurs by a variety of adaptive mechanisms and is an increasing clinical problem in children with otitis media. Although certain strains of *H influenzae* and most strains of *M catarrhalis* are resistant to amoxicillin by virtue of their production of ß-lactamase, in most cases such resistance can be overcome by combining amoxicillin with clavulanic acid (a ß-lactamase inhibitor) or by use of a ß-lactamase-resistant drug. However, resistance to the penicillins by various strains of *S pneumoniae*, which is mediated by a different mechanism—that is, modification of penicillin-binding proteins—is not affected by measures to block or resist ß-lactamase activity. The prevalence of penicillin-resistant *S pneumoniae* has increased in many parts of the United States in recent years. It is higher in young children who have recently received treatment with ß-lactam drugs and in those who are exposed to large numbers of children, such as those who attend day care or who are in large families. Within a few years, it is anticipated that the proportion of strains of *S pneumoniae* that are penicillin-resistant may reach levels of 40% to 50% and that half the resistant strains will have high levels of resistance. Additionally, many penicillin-resistant strains of *S pneumoniae* also are resistant to other antimicrobial agents, including macrolides and the newer cephalosporins.

Because antimicrobial treatment of otitis media is an important contributor to the development of bacterial resistance, judicious use of antibiotics is necessary. (Treatment of otitis media will be covered in part 2 of this educational program.) At the same time, accurate and timely diagnosis of AOM is important in avoiding potential problems such as mastoiditis, meningitis, and hearing impairment.

**CLINICAL CLASSIFICATION OF OTITIS MEDIA**

Otitis media is a general term for middle-ear inflammation, ranging from acute to chronic and with or without symptoms. Most management strategies require that otitis media be classified clinically as either AOM or OME, a distinction that, to some extent, is necessarily arbitrary and often varies among clinicians.

OME (also referred to as nonsuppurative otitis media, MEE, secretory otitis media, and serous otitis media, among others) is diagnosed if, on pneumatic otoscopy, either 2 of 3 tympanic membrane (TM) abnormalities (abnormal color, including white, yellow, amber, or blue; opacification other than due to scarring; and decreased or absent mobility) or bubbles or air-fluid interfaces are present, and if there are no signs of acute inflammation that would constitute evidence of middle-ear infection. The main symptom associated with OME is hearing loss; however, it is often inapparent in infants and young children.

A diagnosis of AOM is made when, in addition to evidence of MEE, there is recent ear pain and/or marked redness or distinct fullness or bulging of the TM. Fever or irritability may or may not be present, and symptoms are highly variable.

OME may occur either as an aftermath of an episode of AOM or as a consequence of eustachian tube obstruction due to another cause, such as an upper respiratory tract infection. However, OME also may precede and apparently predispose to the development of AOM. Thus, these two forms of otitis media may be considered segments of a disease continuum. A clinical classification of otitis media is summarized in Table 1.

**ISSUES COMPLICATING DIAGNOSIS OF OTITIS MEDIA**

Accurate diagnosis of otitis media in infants and young children is often difficult. Symptoms may be absent or inapparent, especially in chronic stages of the disease, and they frequently overlap with those of upper respiratory illness. Specifically, ear pain is often absent in children with AOM, and fever and irritability may be present in children with acute respiratory infections and associated OME. The eardrum may be obscured by cerumen, and subtle changes in the eardrum may be difficult to discern. Other factors complicating diagnosis may include lack of cooperation on the part of the patient, less-than-optimal diagnostic equipment, and inadequate assistance or lack of experience in removing cerumen and performing pneumatic otoscopy.

**INSTRUMENTS USED IN DIAGNOSING OTITIS MEDIA**

Several instruments are available to help optimize the accuracy of the clinician’s diagnosis of otitis media. The pneumatic otoscope (model 20200, Welch Allyn, Inc.) is the standard tool used in diagnosing otitis media. Valuable also is a surgical head (model 21700, Welch Allyn, Inc.), which greatly facilitates cleaning cerumen from an infant’s
external auditory canal and performing diagnostic tympanocentesis or myringotomy. Ancillary diagnostic techniques include tympanometry and spectral gradient acoustic reflectometry. Tympanocentesis may be helpful in selected cases to supplement the information derived from otoscopy in guiding therapy.

**Clearing the Canal**

To obtain optimal visualization, the external auditory canal should be reasonably clear of cerumen. If the TM is initially obscured by cerumen, a Buck curette (Storz N-400-0) may be used to carefully remove the cerumen from the canal (Figure 1), preferably under direct observation through the surgical head of an otoscope. Often any remaining bits can then be wiped away using a Farrell applicator (Storz N 2001A), with its tip (triangular in cross-section) wrapped with a bit of dry or alcohol-moistened cotton to create a dry or wet “mop.” Alternatively, gentle suction may be applied, using a No. 5 or 7 French ear suction tube. Restraining the patient in the prone position (Figure 2) throughout the procedure, turning the patient’s head to the left or right as each ear is cleared, is often advisable. One adult, usually a parent, can place one hand on each of the patient’s buttocks and brace the patient’s hips against the examining table, using his or her own weight for additional bracing if necessary. Another adult can restrain the patient’s head with one hand and the patient’s free arm with the other, changing hands for the procedure on the opposite ear.

**Otoscopy: Diagnostic Accuracy**

Recognition of the presence or absence of MEE is often difficult, even for experienced otoscopists. Pediatric clinicians vary in their otoscopic skills, and for most, training in pneumatic otoscopy is informal and sporadic. To improve diagnostic accuracy, 27 physicians and 3...
nurse practitioners at the Children’s Hospital of Pittsburgh participated in an otoscopic validation program from December 1980 to March 1990, during which the accuracy of the clinicians’ otoscopic diagnoses were compared with myringotomy findings. The program resulted in an improvement in diagnostic skills for many of the participants; sensitivity or specificity, or both, increased over time.

Pneumatic Otoscope

The pneumatic otoscope should have sufficient brightness (halogen bulb with $\geq 100$ footcandles) and an air-tight system that permits the application of positive and negative pressure (Figure 3). Pneumatic otoscopy permits assessment of the contour of the TM (normal, retracted, full, bulging), its color (gray, yellow, pink, amber, white, red, or blue), its translucency (translucent, semiopaque, opaque), and its mobility (normal, increased, decreased, absent), in arriving at an assessment of middle-ear status (Table 2). The normal TM is translucent, pearly gray, and has a ground-glass appearance (Figure 4). Specific landmarks can be visualized. They include the short process and the manubrium of the malleus and the pars flaccida, located superiorly. These are easily observed and help to identify the position of the TM. Inward movement of the TM on positive pressure in the external canal and outward movement on negative pressure should occur, especially in the superior posterior quadrant.

When the TM is retracted, the short process of the malleus becomes more prominent and the manubrium appears shortened because of its change in position within the middle ear. Inward motion occurring with positive pressure is restricted or absent because the TM is frequently as far inward as its range of motion allows. However, outward mobility can be visualized when negative pressure is applied.

If the TM does not move perceptibly with applications of slight positive or negative pressure, MEE is likely. Sometimes the application of pressure will make an air-fluid interface behind the TM (which is diagnostic of MEE) more evident.

<table>
<thead>
<tr>
<th>Type of otitis media</th>
<th>Discharge</th>
<th>Contour</th>
<th>Color</th>
<th>Luster and light reflex</th>
<th>Translucence</th>
<th>Mobility</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOM</td>
<td>Present or absent</td>
<td>May range from neutral to markedly bulging</td>
<td>Red, white, or pale yellow</td>
<td>Variable</td>
<td>Early in course may be normal; usually diffusely opaque; less often, air-fluid interface</td>
<td>Usually impaired</td>
</tr>
<tr>
<td>OME</td>
<td>Absent</td>
<td>Retracted, neutral, or slightly full</td>
<td>White, yellow amber, or blue</td>
<td>Variable</td>
<td>Usually diffusely opaque; less often, air-fluid interface</td>
<td>Usually impaired</td>
</tr>
</tbody>
</table>

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As stated earlier, AOM is diagnosed if, in addition to MEE, there is recent ear pain or marked redness, or distinct fullness or bulging, of the TM; in contrast, OME is diagnosed if fluid is present in the middle ear but there are no signs of acute inflammation (Figure 5).

In patients with AOM, the TM is frequently bulging (Figure 6). The malleus may be obscured and the TM appears red or pale yellow or white and opaque. The TM may resemble a bagel without a hole, with a central depression or with a layer of white or yellow fluid (pus) behind the TM.\textsuperscript{29}

The algorithm in Figure 7 may be used as a guide to (1) determine the presence or absence of MEE on the basis of TM findings on pneumatic otoscopy, and (2) classify otitis media as either AOM or OME on the basis of the clinical history and otoscopic findings.

**Tympanometry**

Tympanometry is a simple, rapid, atraumatic test that offers objective evidence of the presence or absence of MEE.\textsuperscript{32,33} It is easily administered by paraprofessional personnel.\textsuperscript{33} The tympanogram provides information about TM compliance in electroacoustic terms that can be thought of as roughly equivalent to TM mobility as discerned visually from pneumatic otoscopy.\textsuperscript{4} Compliance (also termed acoustic admittance) is measured in millimeters and is rated as high when it is $\geq 0.5$ mL, intermediate when it is $<0.5$ mL but $>0.2$ mL, and low when it is $\leq 0.2$ mL. In addition to compliance, the tympanogram also provides information about middle-ear pressure (measured in mm H$_2$O and categorized as normal, negative, or positive) and the peak, or shape, of the curve.\textsuperscript{34} A peak falling between $-100$ and
+50 mm H₂O signifies normal middle-ear pressure; a peak at <–100 mm H₂O signifies high negative pressure; and a peak at >+50 mm H₂O indicates high positive pressure. The tympanographic peak will be either sharp, suggesting a low likelihood of MEE; rounded, suggesting a greater likelihood of MEE; or flat, suggesting a high likelihood of MEE (Figure 8).33

It is important to note that although tympanometry is quite sensitive in detecting MEE, its positive predictive value is limited.35 Accordingly, abnormal or questionable tympanograms are not infrequently found in association with normal middle-ear status, especially in infants. On the other hand, the tympanogram is sometimes normal early in the course of AOM.

Use of tympanometry may be helpful in office screening, by obviating the need for routine otoscopic examination in difficult-to-examine patients more than 6 months of age whose TMs have been visualized previously, who are asymptomatic, and whose tympanograms are classified as normal, and by identifying patients who require further attention because their tympanograms are abnormal.4 Tympanometry also may be used to help confirm, refine, or clarify questionable otoscopic findings; to objectify the follow-up evaluation of patients with known middle-ear disease; and to serve as validators (or invalidators) of otoscopic diagnoses of MEE.4 Importantly, tympanometry cannot distinguish the effusion of OME from that of AOM.

**Table 3. Risk of MEE as Determined by Acoustic Reflectometry**

<table>
<thead>
<tr>
<th>Spectral gradient level</th>
<th>Spectral gradient angle (°)</th>
<th>Risk of MEE</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>&gt;49</td>
<td>High</td>
</tr>
<tr>
<td>4</td>
<td>40–59</td>
<td>Moderate to high</td>
</tr>
<tr>
<td>3</td>
<td>60–69</td>
<td>Moderate</td>
</tr>
<tr>
<td>2</td>
<td>70–95</td>
<td>Low to moderate</td>
</tr>
<tr>
<td>1</td>
<td>&gt;95</td>
<td>Low</td>
</tr>
</tbody>
</table>

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**Spectral Gradient Acoustic Reflectometry**

Reflectometry is a relatively new adjunctive technique that measures the condition of the middle ear by assessing the response of the TM to a sound stimulus.36 New versions of this technology employ an analysis of the reflectance of sound waves with respect to frequency, with results presented as spectral gradient angles that correspond to the likelihood of MEE.32 As shown in Table 3, a spectral gradient angle of >95° indicates a low risk of MEE. The instrument, known commercially as the EarCheck Pro™ (Becton Dickinson),32 is small and portable, and readings are attained rapidly.37 Cerumen partially occluding the ear canal does not affect the findings obtained using this instrument.38

Reflectometry has been reported to be equivalent to tympanometry for the diagnosis of MEE using the presence or absence of MEE at surgery and pneumatic otoscopy as standards.36 As in the case of tympanometry, reflectometry cannot distinguish the effusion of OME from that of AOM.

**Tympanocentesis**

Diagnostic tympanocentesis—which involves puncturing the TM and aspirating middle-ear liquid to permit the identification of infecting organisms—became a lost art for most pediatricians trained following the advent of the antimicrobial era.39 Today, with the increasing incidence of antimicrobial resistance among organisms causing otitis media, the use of diagnostic tympanocentesis has taken on greater importance.30 In the hands of an experienced physician, tympanocentesis is relatively free from serious complications and can provide valuable information.30,40 (Tympanocentesis will be discussed in part 2 of this educational program.)

**PREVENTION OF OTITIS MEDIA**

In part because of concern about possible long-term developmental sequelae, research into the prevention of otitis media has become a high priority.41 Breastfeeding has been shown to provide some protection against otitis media in infancy,6,42-44 and breast milk—as distinct from breastfeeding—was found to provide variable protection
against the development of otitis media in infants with cleft palate. An association between exposure to tobacco smoke and the risk of OME also has been reported. In addition, studies consistently point to a link between exposure to large numbers of children, whether in day care or in the home, and the occurrence of otitis media.

In children with recurrent or chronic otitis media, current approaches to the prevention of middle-ear disease include tympanostomy tube placement, adenoidectomy, and, in selected cases, antimicrobial prophylaxis during upper respiratory tract infection episodes, as well as administration of pneumococcal vaccine and influenza vaccine. Presently, the vaccine approach seems to hold the most promise for prevention. In addition to vaccines now available, other vaccines against common viruses predisposing to AOM may eventually be developed and prove valuable.