CHAPTER NINE

Role in Management of Otitis Media

Knowledge of the role that the dysfunctional Eustachian tube system plays in the pathogenesis of middle-ear disease and disorders is essential for effective management.

Some specific management options to treat and prevent otitis media and certain related conditions are related to Eustachian tube dysfunction, whereas others are not. An understanding of the role that tubal dysfunction plays in the currently available nonsurgical and surgical options can be helpful not only in the decision-making process to treat or not to treat but also the reasons for complications related to the treatment, such as post-tympanostomy tube otorrhea. From evidence-based clinical trials, some of the options have been shown to be effective, whereas others have yet to be scientifically proven. Thus, an understanding of the role of the Eustachian tube in the pathogenesis of the disease can provide a rationale for specific treatment options, even if proof of efficacy is lacking (see Chapter 6, “Pathogenesis”). This chapter presents the role that the Eustachian tube plays in management related to acute otitis media, otitis media with effusion, and Eustachian tube dysfunction; the latter conditions may be obstruction (including barotrauma) or the patulous Eustachian tube. Chapter 10, “Role in Certain Complications and Sequelae of Otitis Media,” deals with the complications and sequelae of otitis media and Eustachian tube dysfunction that are most likely related to tubal dysfunction, such as atelectasis of the middle ear, retraction pocket, and some aspects of acquired cholesteatoma, perforation of the tympanic membrane, and chronic suppurative otitis media.

Role of the Eustachian Tube System in Nonsurgical Management

Of the nonsurgical methods to treat and prevent otitis media, only some are related directly to the Eustachian tube, such as inflation of the tube and middle ear. Others are probably not, such as antimicrobial therapy, because the goal of antibiotics is to sterilize the bacterial infection of the middle ear and resolve the middle-ear effusion. On the other hand, related to prevention of otitis media, antibiotic prophylaxis may prevent bacterial infection of the nasopharynx, but there is no proof that prophylaxis targets the Eustachian tube. However, there are risk factors for otitis media that can be related to Eustachian tube dysfunction that can possibly be eliminated or reduced.

Management of Risk Factors for Otitis Media Related to the Eustachian Tube System

As described in Chapter 2, “Epidemiology,” there are certain risk factors for otitis media that are evidence based that are related to the tubal system. Others may be related to the system but currently lack convincing proof. Still others are unrelated, such as impaired immunity and a lack of breast-feeding.

As listed in Table 2–3, risk factors that are related to otitis media may or may not be altered. For example, it is well documented that the infant Eustachian tube has an immature structure and function, compared with the adult tube, but only growth and development will improve this risk factor in babies and young children (see Chapter 3, “Anatomy,” and Chapter 4, “Physiology”). Likewise, certain racial groups, such as the Aborigines of Australia and the Native and Inuit populations of North America, are known to be at high risk of otitis media. They are also at risk of developing perforation of the tympanic membrane and chronic suppurative otitis media, which may be related to several risk factors, one of which has been shown in the Apache to be a patulous or semipatulous Eustachian tube. It is not possible today to change the status of the structure of the Eustachian tube in these high-risk special populations. Even though future research may uncover the underlying cause of the genetic predisposition for otitis media to be related, to some degree, to dysfunction of the Eustachian tube, currently, there is no remedy.

On the other hand, there are potential inflammatory and abnormal pressure-related factors that can influence the Eustachian tube system and be eliminated or reduced. The presence of an upper respiratory tract allergy, smoking in the household, and attendance in child day care are all known risk factors that can potentially cause inflammation of the Eustachian tube system that can be eliminated (smoke exposure), treated and controlled (allergy), or modified (attending a day-care center...
with as few children as possible or no day care). But nothing can be done about the number of children in the family (and, as in day care, as the number of children increases, the rate of otitis media rises) or sibling order (the youngest are most affected). However, the use of a pacifier, thumb sucking with the nose closed, and sucking on an unventilated baby bottle are related to middle-ear disease in the infant, which is probably due to the development of abnormally high nasopharyngeal pressures adversely affecting the tube. Figure 9–1 shows my explanation of the effect of sucking on a pacifier when there is nasal obstruction (upper respiratory tract infection), which I have termed the Toynbee phenomenon (see Chapter 5, “Pathophysiology”). These activities can be eliminated. Even though a cause-and-effect relationship is lacking, gastroesophageal reflux has been associated with otitis media in children, and this is another potential cause of inflammation of the nasopharyngeal end of the Eustachian tube system that can possibly be controlled by positioning of the child during and immediately after feeding, diet, and medical treatment (see Management of Gastroesophageal Reflux Related to the Eustachian Tube System).

**Medical Management of Otitis Media Related to the Eustachian Tube System**

Unfortunately, no medical treatments have been proven to be effective in improving the function of the Eustachian tube in the human or animal when acute otitis media or otitis media with effusion is present. Likewise, none have proven to be effective in improving obstruction of the tube to prevent these diseases. Theoretically, because in individuals with preexisting tubal dysfunction, an upper respiratory tract infection can progress to Eustachian tube obstruction (partial), followed by middle-ear underpressures and otitis media with effusion or acute otitis media, medical treatment of the Eustachian tube at the initial stage of infection could prevent this cascade of events. There is evidence that a viral upper respiratory tract infection can cause pathologic changes in the tube. In the chinchilla animal model, an experimental influenza A virus infection of the nasopharynx revealed histopathologic changes in the Eustachian tube lumen (see Chapter 6).

The following are some of the studies in animals and humans that have addressed potential medical treatments directed at the Eustachian tube for treatment and prevention of otitis media. Table 9–1 summarizes studies that have evaluated the effect of medical treatments on Eustachian tube function in various animals. Table 9–2 summarizes studies that have assessed the effect of medical treatments in humans.

**Systemic Decongestant and/or Antihistamine Treatment?**

In an early limited (small sample size) study by Miller, 13 children who had had tympanostomy tubes in place had a small Foley catheter inserted into the external auditory canal.17 The ability to equilibrate applied negative middle-ear pressure during swallowing was assessed following oral administration of a decongestant (carboxamine maleate and pseudoephedrine hydrochloride) in a double-blind, placebo-controlled clinical trial. Of the 13 subjects, 5 responded to the drug, but none of the subjects responded to the placebo. In a later randomized, double-blind, placebo-controlled clinical trial, systemic pseudoephedrine hydrochloride was not effective in the prevention of otitis media with effusion following antibiotic treatment of acute otitis media or in the treatment of the middle-ear effusion that occurred; subjects who had an allergic history did significantly worse on the decongestant.

At our center, we assessed the effect of an oral decongestant with or without an antihistamine on the ventilatory function of the Eustachian tube. Two separate studies were conducted in 50 children who had chronic or recurrent otitis media with effusion and in whom tympanostomy tubes had been inserted previously. The first was a double-blind study that compared the effect of an oral decongestant, pseudoephedrine hydrochloride, with that of a placebo in 22 children who had an upper respiratory tract infection during an observation period. Certain measures of Eustachian tube function were significantly elevated above baseline values during the upper respiratory tract infection, which was attributed to intrinsic mechanical obstruction of the Eustachian tube. It was found that oral decongestants tended to alter these measures of Eustachian tube function in the direction of the baseline (before upper respiratory tract infection) values. Even though the effect was statistically significant, the favorable changes in measurements of tubal function were only partial and were more prominent on the second day of the trial, after the subjects had received four doses of the decongestant. However, the administration of a nasal spray of...
1% ephedrine had no effect on Eustachian tube function in these children.

In a second part of the clinical trial described above, a double-blind crossover design was employed. In this study of 28 children who did not have an upper respiratory tract infection, the effect of a decongestant-antihistamine combination (pseudoephedrine hydrochloride and chlorpheniramine maleate) was compared with that of a placebo. When the subjects were given the decongestant-antihistamine medication, there were favorable changes in certain Eustachian tube function measures that were not observed when the children received the placebo. Again, the response differences between the two groups were statistically significant. These two studies indicated that an oral decongestant appeared to favorably affect the Eustachian tube function of children who had an upper respiratory tract infection and that the combination of an oral decongestant and antihistamine had a similar effect on tubal function in children without an upper respiratory tract infection. However, an evaluation of the efficacy of these commonly employed medications had to await the results of randomized clinical trials in children with otitis media.

At our center, we conducted two large randomized clinical trials that evaluated the effect of a topical nasal decongestant spray on Eustachian tube function in 40 children with otitis media. In a follow-up to this trial, we wanted to determine if this combination of decongestant-antihistamine would be effective if we added an antibiotic. Mandel and colleagues reported that amoxicillin was effective, compared with placebo, in the treatment of otitis media with effusion, but the addition of the combination of the oral decongestant and antihistamine to amoxicillin provided no additional benefit over amoxicillin alone; more side effects were noted in children who received the decongestant and antihistamine combination. After these reports were published in the 1980s, the use of systemic decongestant-antihistamine combinations for otitis media fell sharply. We did not specifically recruit children who had allergic rhinitis in these two trials.

Stillwagon and colleagues recruited 10 adult volunteers who had ragweed allergic rhinitis and underwent progressive intranasal challenge with ragweed pollen out of the ragweed season. Before the challenge, the subjects received chlorpheniramine maleate and phenylpropanolamine or placebo in a double-blind, randomized, crossover design. All of the subjects had objective measurements of nasal and Eustachian tube function before and after the challenge. The investigators found a beneficial effect of the drug therapy on nasal and Eustachian tube function compared with placebo. They concluded that there is a role for antihistamine-decongestant treatment of allergic rhinitis, as well as of potential allergen-induced Eustachian tube dysfunction. Thus, there may be a beneficial effect on the Eustachian tube system in patients who have allergic rhinitis and Eustachian tube obstruction or even otitis media.

### Table 9–1. Effect of Medical Treatments on the Function of the Eustachian Tube in Animals

<table>
<thead>
<tr>
<th>Drug</th>
<th>Animal</th>
<th>Effect on Eustachian Tube</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surfactants</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surfactant</td>
<td>Rats</td>
<td>Lowered opening pressure</td>
<td>White, 1989⁶</td>
</tr>
<tr>
<td>Surfactant</td>
<td>Rats</td>
<td>Lowered opening pressure</td>
<td>White et al, 1990⁷</td>
</tr>
<tr>
<td>Tween surfactant</td>
<td>Gerbil</td>
<td>Lowered opening pressure</td>
<td>Fornadley and Burns, 1994⁸</td>
</tr>
<tr>
<td>Surfactant</td>
<td>Gerbil</td>
<td>Lowered opening pressure</td>
<td>Nemechek et al, 1997⁹</td>
</tr>
<tr>
<td>Surfactant</td>
<td>Gerbil, mouse</td>
<td>Lowered opening pressure</td>
<td>Chandrasekar and Mautone, 2004¹⁰</td>
</tr>
<tr>
<td>Surfactant, other</td>
<td>Guinea pig</td>
<td>Effect on otitis media</td>
<td>Kodama et al, 1993¹¹</td>
</tr>
<tr>
<td>Decongestants</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pseudoephedrine</td>
<td>Dog</td>
<td>Improved active opening</td>
<td>Dempsey and Jackson, 1972¹²</td>
</tr>
<tr>
<td>Noradrenaline</td>
<td>Dog</td>
<td>Increased patency</td>
<td>Sheffield et al, 1970¹³</td>
</tr>
<tr>
<td>Others</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roxithromycin</td>
<td>Guinea pig</td>
<td>Improved clearance</td>
<td>Sugira et al, 1997¹⁴</td>
</tr>
<tr>
<td>Sairei-to</td>
<td>Guinea pig</td>
<td>No change</td>
<td>Sugira et al, 1997¹⁵</td>
</tr>
<tr>
<td>Isoprenaline</td>
<td>Rats</td>
<td>Lowered opening pressure</td>
<td>Malm and White, 1984¹⁶</td>
</tr>
<tr>
<td>Isoproterenol</td>
<td>Dog</td>
<td>Increased patency</td>
<td>Sheffield et al, 1970¹³</td>
</tr>
<tr>
<td>Isoproterenol</td>
<td>Dog</td>
<td>Lowered opening pressure</td>
<td>White et al, 1990⁷</td>
</tr>
</tbody>
</table>

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### Topical Decongestant Therapy?

At our hospital, we evaluated the effect of a topical nasal decongestant spray on Eustachian tube function in 40 children with
tympanostomy tubes. Five tubal function variables were assessed by a modified-inflation test and forced-response test before and after the nose was sprayed with either oxymetazoline hydrochloride or placebo, according to a double-blind study design. The results showed no significant differences between the two treatment groups of the study children who had severe functional tubal dysfunction, as documented by constriction of the Eustachian tube lumen during swallowing (see Chapter 5). In another clinical trial, Jensen and colleagues applied topical xylometazoline chloride to the middle-ear end of the Eustachian tube through a perforation in older children and adults and found an effect only at unphysiologic high pressures. Turner and Darden conducted a randomized, double-blind, placebo-controlled clinical trial that evaluated the effect of phenylephrine hydrochloride nose drops versus normal saline (control) on middle-ear pressure in infants who had an upper respiratory tract infection. They reported that there was no effect from the decongestant on the abnormal middle-ear pressures.

**Interferon-β Serine?**

The effects of recombinant interferon-β serine were evaluated in 38 healthy adult volunteers who had experimental rhinovirus colds. Tymanometry revealed abnormal middle-ear pressures in at least one ear during 18% of observations in recipients who received interferon compared with 38% of observations in those who were in the placebo group. The findings suggested a possible role for antiviral therapy in altering the Eustachian tube–middle-ear dysfunction during the course of a viral upper respiratory tract infection.

### Table 9–2. Effect of Medical Treatments on the Function of the Eustachian Tube in Humans

<table>
<thead>
<tr>
<th>Drug</th>
<th>Subjects and Design</th>
<th>Effect on Eustachian Tube–Middle Ear</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decongestants/antihistamines</td>
<td>ETF in children</td>
<td>Effect in some?</td>
<td>Miller, 197017</td>
</tr>
<tr>
<td>Carboxamine maleate–pseudoephedrine hydrochloride</td>
<td>Children: prevention of OME after AOM</td>
<td>No effect on middle-ear pressures/OME on tympanometry</td>
<td>Olsen et al, 197818</td>
</tr>
<tr>
<td>Pseudoephedrine hydrochloride vs placebo (oral)</td>
<td>Adults with URI</td>
<td>No effect</td>
<td>Virtanen, 198219</td>
</tr>
<tr>
<td>Pseudoephedrine sulfate and dextrchlorpheniramine maleate</td>
<td>Children with TT and URI</td>
<td>Lowered elevated closing and residual pressure on ETF tests</td>
<td>Cantekin et al, 198020</td>
</tr>
<tr>
<td>Pseudoephedrine hydrochloride vs placebo (oral)</td>
<td>Children with TT and URI</td>
<td>ETF tests</td>
<td>Cantekin et al, 198020</td>
</tr>
<tr>
<td>Ephedrine nasal spray</td>
<td>Children with TT and URI</td>
<td>Lowered opening, closing, and residual pressures on ETF tests</td>
<td>Cantekin et al, 198020</td>
</tr>
<tr>
<td>Pseudoephedrine hydrochloride and chlorpheniramine maleate vs placebo (oral)</td>
<td>Adult volunteers with URI</td>
<td>No effect</td>
<td>Doyle et al, 19888</td>
</tr>
<tr>
<td>Chlorpheniramine, systemic</td>
<td>Adult volunteers with URI</td>
<td>No effect</td>
<td>Doyle et al, 199321</td>
</tr>
<tr>
<td>Pseudoephedrine hydrochloride and atropine sulfate, systemic vs placebo</td>
<td>Children with URI</td>
<td>No effect on tympanometry</td>
<td>Turner and Darden, 199622</td>
</tr>
<tr>
<td>Phenylephrine hydrochloride nasal spray</td>
<td>Children with URI</td>
<td>Effect only at unphysiologic high pressures</td>
<td>Jensen et al, 199023</td>
</tr>
<tr>
<td>Xylometazoline chloride</td>
<td>Older children and adults with perforation of TM</td>
<td>Effect on opening pressure</td>
<td>Olen and Holmquist, 199324</td>
</tr>
<tr>
<td>Xylometazoline</td>
<td>Adults with URI</td>
<td>No effect on forced-response or sniff test</td>
<td>van Heerbeek et al, 200425</td>
</tr>
<tr>
<td>Xylometazoline hydrochloride nose drops</td>
<td>Children with TT</td>
<td>Middle-ear pressures less on interferon by tympanometry</td>
<td>Sperber et al, 199226</td>
</tr>
<tr>
<td>Others</td>
<td>Adult volunteers following rhinovirus intranasal challenge</td>
<td>Middle-ear pressures less on interferon by tympanometry</td>
<td>Sperber et al, 199226</td>
</tr>
<tr>
<td>Terbutaline, systemic vs placebo (intranasal)</td>
<td>Healthy adult volunteers</td>
<td>Opening pressure reduced</td>
<td>White et al, 198927</td>
</tr>
</tbody>
</table>

AOM = acute otitis media; ETF = Eustachian tube function; OME = otitis media with effusion; TM = tympanic membrane; TT = tympanostomy tubes; URI = upper respiratory tract infection.
Rimantadine Treatment for Viral Upper Respiratory Tract Infection?

In a randomized, double-blind, placebo-controlled study at our center, 105 susceptible adult volunteers had a nasal challenge with a rimantadine-sensitive strain of influenza A (H1N1) virus, followed in 2 days by 8 days of oral rimantadine treatment. Even though the rimantadine-treated group had less virus shedding, symptom load, and sinus pain compared with the placebo group, there were no differences between the two groups in nasal patency, mucociliary clearance, nasal signs, or symptoms and signs of otologic disease. The investigators concluded that the outcome of this study does not support treatment with rimantadine to prevent the otologic manifestations of an upper respiratory tract infection caused by influenza A.

Surfactant?

As described in Chapter 4, surface tension–lowering substance has been identified in animal models. In experiments in the guinea pig and the gerbil, surfactant reduced the Eustachian tube opening pressure. In a recent experiment in the monkey, new assessments (compliance, hysteresis) of Eustachian tube function were used to evaluate the effect of surfactant on tubal function, which suggested that surfactant therapy may be successful only in stiff, inelastic tubes. In an even more recent series of experiments, Chandrasekhar and Mautone assessed the effect of intranasal aerosolized surfactant versus propellant (control) on the function of the Eustachian tube in gerbils and mice. They reported that surfactant significantly reduced the passive opening pressure, whereas the control substance did not.

Intranasal Topical Decongestant and Hydrocortisone for Prevention?

Despite the disappointing outcomes in most of the studies cited above, there may be an advantage to aggressively trying to prevent the tubal inflammatory stage at the onset of a viral upper respiratory tract infection, similar to preventing Eustachian tube obstruction and barotrauma during air flight (see Otitic Barotrauma [Barotitis]). Even though oxymetazoline hydrochloride could not be shown to be effective by Lildholdt and colleagues, presumably owing to the preexisting severity of the subject’s Eustachian tube dysfunction, I recommend spraying the drug into each nasal cavity (two sprays), waiting 5 minutes, spraying again (two sprays), waiting another 5 minutes, and then spraying with an intranasal topical aqueous hydrocortisone (two sprays). My rationale for this method of treatment is to first decongest the intranasal cavities; the second spraying 5 minutes later is an attempt to decongest the nasopharyngeal end of the Eustachian tube. The topical hydrocortisone has two potential effects: as an anti-inflammatory agent and to prevent the rebound phenomenon associated with prolonged use of an intranasal topical decongestant. I recommend this treatment regimen until the signs and symptoms of the intranasal viral infection are absent. It is important to start this treatment when the signs and symptoms are initially present because the study by Moody and colleagues showed (by tympanometry) that middle-ear underpressures were present prior to the onset of the signs and symptoms of a viral upper respiratory tract infection. My recommendation is based on anecdotal experience and not from proof of efficacy from a clinical trial. I am convinced from personal experience that the signs and symptoms of paranasal sinusitis can be prevented at the onset of a viral upper respiratory tract infection in some patients (including me) by using this regimen.

Summary of Medical Treatments

As described above, there have been many medical treatments reported that attempted to improve Eustachian tube function. But none have been proven to be safe and effective in randomized clinical trials with an adequate sample size that meets current scientific standards. Chapter 11, “Future Directions,” provides some research goals related to possible medical treatments that have potential merit.

Inflation of the Middle Ear

Several methods have been recommended in the past in which air is forced into the Eustachian tube and middle ear–mastoid in an effort to equalize intratympanic underpressures and eliminate middle-ear effusion. The first methods advocated were those of Valsalva and Politzer. Also, catheterization of the Eustachian tube through the nasal cavity has been used for over a century. Most recently, a balloon attached to a nasal tube has been invented. All of these methods are discussed in detail below.

Rationale for Inflation

There is theoretical merit for inflation of the Eustachian tube–middle-ear system. Figure 9–2 shows the flask model of the nasopharynx–Eustachian tube–middle-ear system (see Chapter 4). Liquid is shown in the body and narrow neck of an inverted flask. Relative negative pressure inside the body of the flask prevents the flow of the liquid out of the flask. This is analogous to an effusion in a middle ear that has abnormally high negative pressure. If air is insufflated up into the liquid, through the neck and into the body of the flask, the negative pressure is converted to ambient or positive pressure and the liquid will flow out of the flask. If the liquid is of high viscosity, however, the likelihood of air being forced through the liquid into the body of the flask is remote, especially if the thick liquid completely fills the chamber. Also, a thick, viscous liquid will not flow as readily as a fluid that is thin and less viscous. Therefore, in the human system, a thin, serous effusion would be more likely to flow out of the middle ear and out of the Eustachian tube than would a thick, mucoid effusion that fills the middle ear and mastoid cavities. The method is probably not effective in main-
Maintaining normal middle-ear pressure in children who have atelectasis caused by Eustachian tube obstruction (ie, high negative pressure) because experiments in animals have shown inflation of the middle ear not to be effective.41,42

Methods of Inflation

In theory, inflation of the Eustachian tube and middle ear should be an effective treatment option for patients with otitis media, Eustachian tube obstruction (abnormal middle-ear pressures), or both. In reality, there are several problems with this method of management.

Valsalva’s Maneuver The method of Valsalva is well known to pilots and scuba divers, who frequently use it to inflate the middle ear during descent. Valsalva’s maneuver is highly successful in most instances, but it is somewhat difficult for children to learn because it is a self-inflation technique that involves forced nasal expiration with the nose and lips closed (Figure 9-3).39

Valsalva’s method may be enhanced by first spraying the nasal cavities with topical oxymetazoline, waiting 5 minutes, spraying a second time, waiting another 5 minutes, and then performing Valsalva’s maneuver. This method is not very feasible or successful in children. Cantekin and colleagues tested 66 children between the ages of 2 and 6 years who had had chronic or recurrent otitis media with effusion and who had functioning tympanostomy tubes in place.43 They asked each subject to try to blow his or her nose with the glottis closed. None of these children could passively open their Eustachian tubes and force air into the middle ear by Valsalva’s method, even though they developed a maximum nasopharyngeal pressure of 538.8 \( \pm \) 237.0 mm H\(_2\)O. It was concluded that Valsalva’s method of opening the Eustachian tube in this age group was not successful owing to possible tubal compliance problems. Unfortunately, children in this age group have a high incidence of otitis media; for infants, who have the highest incidence of otitis media, the procedure cannot be used at all.

Politzerization Adam Politzer described a method of opening the Eustachian tube that involves inserting the tip of a rubber bulb into one nostril while the other nostril is compressed by finger pressure and then asking the patient to swallow while the rubber bulb is compressed (Figure 9-4).40 Some individuals, especially children, complain of a sudden “pop” in the ear as the

FIGURE 9-2. Flask model of theoretical rationale for inflation of air into the middle ear–mastoid through the Eustachian tube. The flask can be likened to the Eustachian tube system: the bulbous portion of the flask is the middle ear and mastoid and the narrow neck of the flask is the Eustachian tube. When a liquid is in the bulbous portion (middle ear–mastoid), a relative negative pressure develops as the liquid flows into the narrow neck (Eustachian tube). When air is forced into the bulbous portion, the negative pressure is equalized, or positive pressure is in the body of the flask, which facilitates liquid flow out of the flask through the narrow neck.

FIGURE 9-3. Valsalva’s maneuver for inflation of the Eustachian tube–middle ear.

positive pressure is forced up the Eustachian tube and have discomfit with the procedure. This method is also extremely difficult to perform in infants.

Politzerization was popular in the early part of the twentieth century among otolaryngologists as an office procedure. They used compressed air attached to a nasal olive tip to force air into a nebulizer, in an effort to inflate the middle ear and to insufflate medicines into the middle ear. One fairly popular agent in the past was chlorobutanol, but neither this rather obscure drug nor any other has ever been proven to be safe and effective in treating middle-ear effusions and is not recommended for clinical use at this time. Nevertheless, insufflating drugs into the middle ear may have merit in the future if they can be proven to be safe and effective (see the following section).

Catheterization of the Eustachian Tube Transnasal catheterization of the Eustachian tube with the classic metal cannula has been used to inflate the middle ear for more than a century (Figure 9–5). Catheterization of the tube was first described by a Parisian, Deleau, in the early part of the nineteenth century for diagnostic purposes and in an effort to improve hearing. The first method of introducing the cannula involves applying a topical, local anesthetic into the nasal cavity. The cannula is introduced along the floor of the nasal cavity until the instrument touches the posterior nasopharyngeal wall, and then it is turned toward the midline and brought forward until it stops at the posterior edge of the nasal septum. The cannula is then rotated laterally (about 180 degrees) until it enters the nasopharyngeal end of the Eustachian tube. More current methods use a rigid rod-lens telescope or a flexible fiberoptic laryngoscope inserted through the opposite nasal cavity to directly visualize the introduction of the cannula. This method is more feasible in older children and adults than in young children.

One advantage of introducing the cannula into the Eustachian tube orifice is that a medication can be insufflated or instilled into the tube and middle ear. Similar to politzerization, medicines were introduced in an effort to cure middle-ear effusions in the early part of the twentieth century. However, no drug has been proven to be safe and effective in clearing a middle-ear effusion using this method, and it is not indicated until a drug and this method meet the current standards of safety and efficacy. On a limited experimental basis, I have used a Eustachian tube cannula to instill an aqueous corticosteroid from an intranasal steroid nasal spray bottle into the middle ear of adults and have had success in clearing a middle-ear effusion. But this was only in a few "adult volunteers" who had barotitis media and who otherwise had no previous history of middle-ear disease. Thus, I do not currently recommend this treatment because it remains experimental.

Nasal Balloon Stangerup and colleagues described a method of autoinflation that consists of a balloon attached to a nasal tube, the Otovent nasal balloon (Abigo Medical AB, Askim, Sweden). The patient inserts it into one nostril and blows up the balloon through one side of the nose while the other side is closed with finger pressure (Figure 9–6). The technique can be used in adults but can be taught only to those who are 3 years of age and older (see below).

Problems with Inflation The major difficulty with both methods is determining whether the middle ear is actually inflated by the procedure. If a patient hears a "pop" or has a pressure sensation in the ear, there is only presumptive evidence of passage of air into the middle ear. Auscultation of the ear (listening for the sound of air entering the middle ear during the procedure) is helpful in determining whether the procedure is successful, but a sound may be heard even when air does not enter the middle ear. (A Toynbee tube has been used in the past to determine if an inflation method worked; the device is a length of rubber tubing with an olive tip at either end, one for the patient’s test ear and one for the ear of the examiner.) Objective otoscopic evidence that the middle ear is actually inflated would be constituted by the presence of bub-
bles or a fluid level behind the tympanic membrane when these findings were not present prior to inflation. Another excellent method for determining objectively if the inflation is successful is to obtain a tympanogram before and after the procedure: the compliance peak should shift toward or be in the positive pressure zone after inflation (Figure 9–7). If none of the results of these presumptive or objective methods of determining the success of inflation are definitive, then the clinician cannot be certain that the procedure has been therapeutic. Failure to achieve a successful result may be related to

- Inability of the patient to learn the method
- Insufficient nasopharyngeal overpressure to open the Eustachian tube passively
- Eustachian tube abnormality
- A middle ear filled with a very thick, mucoid effusion

**Clinical Trials** Unfortunately, the beneficial effect of the Valsalva and Politzer methods of inflation for treatment of otitis media with effusion or atelectasis has been subjected to only a limited number of randomized controlled trials. Most of the evidence has been anecdotal until recently. Gottschalk claimed to have had remarkable success with a modification of the Politzer method in over 12,000 patients; the average course of treatment was a minimum of 12 inflations in the office on 3 separate days.46, 47 Schwartz and colleagues showed that it is possible to inflate the middle ears of children at home by Politzer’s method; they documented the results of the method by tympanometry. If successful, the peak should be shifted toward the positive pressure zone after politzerization with air. First, the compliance peak is determined, followed by a second tympanogram after attempting inflation. If successful, the peak should be shifted toward the positive pressure zone.

![Figure 9-7. Tympanometric method of documenting successful inflation of the middle ear after politzerization with air. First, the compliance peak is determined, followed by a second tympanogram after attempting inflation. If successful, the peak should be shifted toward the positive pressure zone.](image)

In a systematic review of 35 potential articles that addressed autoinflation for treatment of “glue ear” in children, Reidpath and colleagues concluded that the evidence for efficacy is conflicting and that future clinical trials are warranted.55

In a later clinical trial from Denmark by Stangerup and colleagues, however, autoinflation was considered to be effective using the Otovent nasal balloon, which the child inserts into one nostril and blows up the balloon through one side of the nose while the other side is closed with finger pressure.45 The technique could be taught only to children who were 3 years of age and older, and during the trial, many of the children failed to use the instrument the prescribed three times daily during the 2-week regimen. In those children who had type B tympanograms on entry, the investigators concluded that the tympanometric conditions were “better” in the treated group than in the untreated children at the end of the 2 weeks, but there were no statistically significant differences after 2 or 3 months between the two groups. Because the effect was “short-lasting,” they advocated repeated use. Because this study had several shortcomings—for example, tympanometry only to identify middle-ear effusion, analysis by ear and not by subject—the safety and efficacy of this device await further study, especially when used repeatedly by children who have chronic and recurrent disease.

A clinical trial by Stangerup and colleagues reported success in using the Otovent in children who suffered from barotitis following air flight: 21% were relieved by Valsalva’s maneuver, but 82% could increase middle-ear pressure using the nasal balloon method.53 In a later study, Stangerup and colleagues again reported success in airplane passengers who developed barotitis during descent (see below).54

In a series of studies in monkeys, inflation of the middle ears was not effective in preventing the occurrence of
middle-ear effusion even when repeated over days using the inert gas argon\textsuperscript{56} and may be related to timing of the inflations to be potentially successful.\textsuperscript{57,58} A more recent study in the monkey model by Alper and colleagues revealed that inflation merely displaces the middle-ear effusion to other portions of the middle-ear cleft, which appears to be clear in the middle ear.\textsuperscript{42} Even though inflation failed in a monkey model to prevent or treat middle-ear effusion, as described above,\textsuperscript{42,56,59} a new clinical trial, funded by the National Institutes of Health, addressing the efficacy of this method, in addition to systemic hydrocortisone therapy, is currently being conducted at our center under the leadership of Cuneyt M. Alper, MD.

Inflation for Barotitis

At present, it would appear reasonable to recommend autoinflation of middle ears for prevention and treatment of barotrauma (following flying or swimming) if high negative middle-ear pressure, otitis media with effusion, or both are present. Inflation of the middle ear should be helpful under these circumstances because this condition is usually not due to chronic Eustachian tube dysfunction and inflation may resolve the acute, subacute, or chronic disorder rapidly. In a clinical study by Stangerup and colleagues, the prevalence of barotitis after an airplane flight was reported to be 25\% in children compared with only 5\% in adults.\textsuperscript{53} They also reported that only 21\% of the youngest children with middle-ear negative pressure could perform a successful Valsalva’s maneuver, whereas 82\% could increase the middle-ear pressure with the Otovent. More recently, Stangerup and colleagues conducted a controlled trial of the Otovent in preventing barotitis in adults, which revealed that this method was successful in preventing middle-ear negative pressure on descent during air flight—6\% in the treatment group versus 15\% in the control group—and when persistent negative middle-ear pressure developed following the flight, inflation equilibrated the negative pressure in 69\% of individuals who were not successful in using Valsalva’s maneuver to relieve the abnormal pressure.\textsuperscript{54} This study has merit and deserves to be tested by other investigators; future trials should also include children.

Conclusions Regarding Inflation

In conclusion, these procedures may be worthwhile for patients with barotitis and for those who have an occasional episode of otitis media with effusion or Eustachian tube dysfunction, but they are probably not helpful in children who have chronic or frequently recurrent middle-ear effusion, atelectasis, or both (see the section on atelectasis and retraction pocket in Chapter 10). When a middle-ear effusion not due to barotrauma is found in a patient, who only occasionally has a problem and in whom frequently recurrent or chronic disease is not suspected, then the procedure may also be successful, especially if a small amount of serous effusion is visible behind a translucent tympanic membrane. It is unlikely, however, that a mucoid or purulent effusion could be evacuated by this technique, and if it could be, it would probably recur immediately after the procedure.

Atelectasis of the tympanic membrane and middle ear, with or without high negative pressure, can also be treated by repeated autoinflation (Valsalva) or Politzer’s method, but even if the middle ear is successfully inflated, the benefit is usually only of short duration and the procedure must be repeated frequently. Therefore, it is unlikely that inflation will be successful in alleviating frequently recurrent or chronic Eustachian tube dysfunction for any length of time. There is also a remote possibility that bacteria can be forced into the middle ear from the nasopharynx during this procedure and the possibility that repeated autoinflation could cause the tympanic membrane to lose its stiffness (become hypercompliant).

\begin{table}[h]
\centering
\begin{tabular}{|l|c|c|c|c|}
\hline
\textbf{Entry Status and Treatment Group} & \textbf{None} & \textbf{Unilateral} & \textbf{Bilateral} & \textbf{Total Subjects} \\
\hline
\textbf{Unilateral effusion} & & & & \\
Inflation & 0 & 60 & 40 & 5 \\
Control & 11 & 78 & 11 & 9 \\
\hline
\textbf{Bilateral effusion} & & & & \\
Inflation & 7 & 7 & 86 & 14 \\
Control & 8 & 17 & 75 & 12 \\
\hline
\textbf{Total subjects} & & & & \\
Inflation & 5 & 21 & 74 & 19 \\
Control & 10 & 43 & 48 & 21 \\
\hline
\end{tabular}
\caption{Percentage of 40 Children with Middle-Ear Effusion Who Had Persistent Effusion 2 Weeks after Autoinflation or No Inflation (Controls)}
\end{table}

Adapted from Chan KH and Bluestone CD. Fisher’s exact test (two-tailed = 1.00).
Laboratory and clinical studies are continuing in more than one center in an effort to resolve the ongoing controversy regarding the efficacy of inflation of the Eustachian tube and middle ears of patients in preventing Eustachian tube dysfunction or otitis media, especially when a common cold is present, and treating these conditions when they are present.

Management of Eustachian Tube Dysfunction

Even when an effusion is not present in the middle ear, signs and symptoms of Eustachian tube dysfunction can occur. Abnormal function of the Eustachian tube can cause otologic symptoms despite the lack of otitis media. The symptoms can be intermittent or persistent, and the severity of the complaints can be mild, moderate, or severe. At the time of the examination, the tympanic membrane may have a normal appearance, and its mobility may or may not be impaired when tested with a pneumatic otoscope or by tympanometry; the tympanic membrane may or may not be retracted. The condition can be either of short duration (acute) or long-standing (chronic). The patient commonly will have a past history of Eustachian tube dysfunction or episodes of acute otitis media, otitis media with effusion, or both.

Two types of Eustachian tube dysfunction can be present: obstruction or abnormal patency (see Chapter 5 and Chapter 6). Also, rapid alterations in barometric pressure, such as when flying in an airplane or scuba diving, can cause obstruction of the Eustachian tube that can result in otologic symptoms (otitic barotrauma or barotitis), especially in children who have an underlying Eustachian tube dysfunction.

Eustachian Tube Obstruction

When obstruction of the Eustachian tube is present, the tube periodically opens to regulate (ventilate) the gas pressure within the middle-ear cavity but at less frequent intervals than normal; in this case, high negative intratympanic pressure may be present for transient or prolonged periods (acute or chronic). The obstruction of the tube can be anatomic (mechanical), functional (failure of the opening of the tube), or both. Anatomic obstruction may be due to infection or allergy or possibly adenoids. Functional obstruction is idiopathic but is due to failure of the opening mechanism, which, in turn, may be caused by floppy tubal cartilage or abnormalities of the tensor veli palatini muscle or be secondary to the yet to be determined etiology of constriction of the tube during swallowing. This type of intermittent middle-ear regulation of middle-ear pressure can cause periods of otalgia, a feeling of fullness or pressure, hearing loss, popping and snapping noises, tinnitus, disequilibrium, or even vertigo. These symptoms are more commonly encountered in older children and teenagers than in young children. Most likely, infants and young children have these symptoms but rarely complain. Frequently, patients will have otologic symptoms on awakening and then periodically during the rest of the day. When symptomatic, the patient will commonly have a retracted tympanic membrane, which will have limited or no mobility to applied negative pressure and no mobility when positive pressure is applied during pneumatic otoscopy. This indicates the presence of negative pressure in the middle-ear cavity. Tympanometry can be helpful in confirming and documenting the high middle-ear negative pressure (see Chapter 8, “Diagnosis and Tests of Function”). But a patient may have no evidence of middle-ear negative pressure at the time of the examination because the pressure can fluctuate during the course of the day. Audiometric testing will frequently reveal normal hearing, but if high negative middle-ear pressure is present, there may be a mild conductive hearing loss owing to the impaired compliance of the middle ear. This disorder is relatively common in the third trimester of pregnancy and in children during puberty, especially girls, and can be present even when a past history of middle-ear infection is absent.

Management of the patient who has Eustachian tube obstruction is related to the frequency, severity, and duration of the symptoms and the underlying cause. If the condition is present only during episodes of an acute upper respiratory tract infection, medical treatment should be directed toward relief of the nasal congestion and counseling the patient and parent that the disorder will resolve spontaneously. A systemic or intranasal topical decongestant may be helpful for the nasal congestion. Inflation of the middle ear can be tried (see Inflation of the Middle Ear). I have recommended the method of sequentially spraying oxymetazoline and hydrocortisone in the nasal cavities, as described above for prevention, but with limited success. In my opinion, intranasal oxymetazoline is effective in preventing symptomatic barotrauma during descent in an airplane or during scuba diving (see below). When the symptoms are extremely troublesome and interfere with concentration, then a myringotomy may be required, but this surgical intervention is rarely necessary.

When symptoms are of a chronic nature, a search for an underlying cause (eg, paranasal sinusitis, nasal allergy, or hypertrophy of the adenoids) should be attempted and, if found, appropriate management should be instituted. Frequently, there is a strong family history of middle-ear disease, which implies a hereditary factor in children who have not only otitis media but also Eustachian tube obstruction (see Chapter 2). If no underlying cause is uncovered, then a trial with a systemic or topical intranasal decongestant might be helpful or inflation of the Eustachian tube–middle ear may be tried, but there is no evidence that these treatment options are effective for the short or long term. Unlike the clinical trials that were cited above when a chronic middle-ear effusion is present, there have been essentially no trials of medical treatments for the obstructive type of Eustachian tube dysfunction. Even the trials of medical treatments in humans and experiments in animals summarized in Tables 9–1 and 9–2 are disappointing. Again, I still recommend a trial of an intranasal decongestant and hydrocortisone, as
described above, for chronic symptomatic Eustachian tube obstruction that is troublesome to the patient.

When nonsurgical methods are unsuccessful, which is my experience, and the symptoms are troublesome to the patient, then myringotomy and insertion of a tympanostomy tube may be necessary to alleviate the symptoms while the tubes are patent and functioning. This treatment is successful but is only a "bypass" for the dysfunctional tubal system. The condition, even though chronic, will usually resolve with advancing age in children, but some pediatric patients, especially adolescents, may need to have the tympanostomy tubes replaced several times, and some may even need a "permanent" tympanostomy tube. This chronic disorder can persist throughout adult life, for which long-lasting tubes are essential (see Myringotomy and Tympanostomy Tube Related to the Eustachian Tube System).

When Eustachian tube obstruction is chronic, sequelae such as atelectasis of the middle ear (and tympanic membrane) are possible and can progress into a retraction pocket, which, in turn, can progress into a cholesteatoma.

**Abnormally Patent (Patulous) Eustachian Tube**

The other end of the spectrum of Eustachian tube dysfunction is abnormal patency. In its extreme form, the hyperpatent Eustachian tube is open even at rest (patulous) (see Chapter 5). Lesser degrees of abnormal patency result in a semipatulous Eustachian tube that is closed at rest but has low tubal resistance to gas flow in comparison with the normal tube. A patulous Eustachian tube may be caused by abnormal tubal geometry or a decrease in extramural pressure, such as occurs as a result of weight loss or, possibly, mural or intraluminal changes. These last conditions may be seen when the extracellular fluid is altered by medical treatment of another unrelated condition. Interruption of the innervation of the tensor veli palatini muscle has also been shown to be a cause of a hyperpatent Eustachian tube.60

Clinically, the presence of a patulous Eustachian tube is a relatively uncommon finding in adolescents and adults but is even less commonly encountered in young children. But, when present, this disorder can be misdiagnosed as Eustachian tube obstruction and inappropriately treated. The patient frequently complains of hearing his or her own breathing, voice (autophony), or both in the ear. Some patients become habitual "sniffers" because they can close the Eustachian tube lumen with the self-induced nasopharyngeal negative pressure. Patients with chronic Eustachian tube obstruction can be "puffers" or use the self-Valsalva maneuver, both of which produce positive pressure in the nasopharynx in an attempt to equilibrate the negative middle-ear pressure.

Otoscopy reveals a tympanic membrane that moves medially on inspiration and laterally on expiration; the movement can be exaggerated with forced respiration, especially with one nostril pinched closed. The condition is relieved when the patient is recumbent because mural and intramural pressure in the Eustachian tube is increased by venous engorgement in this position. The patient should therefore be examined in the sitting position. The diagnosis can also be made by measuring the immittance of the middle ear.61 A tympanogram is obtained while the patient is breathing normally, and a second one is obtained while the patient holds his or her breath. Fluctuation in the tympanometric line should coincide with breathing. The fluctuation can be exaggerated by asking the patient to occlude one nostril and close the mouth during forced inspiration and expiration or by performing the T onybee or Valsalva maneuver (see Chapter 5 and Chapter 8).

Management of a patulous Eustachian tube depends on first determining the cause of the problem. If the symptoms are of relatively short duration, the condition may subside without any active treatment. In children and teenagers, this condition is usually self-limited and probably due to age-related changes in the structure and function of the Eustachian tube and adjacent areas secondary to rapid growth and development. Interruption of the neuromuscular component of the Eustachian tube, such as from trauma or surgery, may be the cause, but more commonly rapid loss of weight is the underlying pathogenesis. In adults, a neurologic disorder may be present, but in children, the condition is most commonly idiopathic. When the symptoms are disturbing and the condition is chronic, active treatment is indicated. Myringotomy with insertion of a tympanostomy tube may be helpful in some patients, probably owing to the coexistence of obstruction and abnormal patency. But tympanostomy tube placement may exaggerate the symptoms if the tube is consistently hyperpatent. I prefer to place a tympanostomy tube prior to a more aggressive surgical procedure (described below) because the symptoms may improve, and a direct measurement of Eustachian tube function can be performed to confirm the diagnosis (see Chapter 8).

Medical management of this type of tubal dysfunction has been disappointing. Insufflation of powders into the Eustachian tube and instillation of 2% iodine or 5% trichloroacetic acid solution have also been advocated.62 Infusion of an absorbable gelatin sponge solution has also been suggested,63 as has injection of polytetrafluoroethylene (Teflon) into the paratubal area.64 All of these methods have major disadvantages. They are, for the most part, irreversible and may not improve the condition or may provide only temporary relief. Total obstruction of the Eustachian tube can also be a complication. Stroud and colleagues suggested the transposition of the tensor veli palatini through a palatal incision, but the procedure has not been shown to be safe and effective in a large number of patients by other investigators.65 DiBartolomeo and Henry reported initial success in treating 8 of 10 patients who had patulous tubes with a new intranasal medication composed of diluted hydrochloric acid, chlorobutanol, and benzyl alcohol.66 The safety and long-term efficacy of this experimental treatment have not been confirmed.67
At present, the most logical choice for relief when the discomfort becomes severe is a procedure that would alleviate the symptoms simply, reversibly, and without untoward reactions. A technique described by Bluestone and Cantekin was used successfully in adults but is rarely indicated or necessary in children because the patulous tube condition is usually self-limited in this age group.\(^6^8\) The procedure involves placement of a plastic catheter into the middle ear end of the Eustachian tube and is described in detail below.\(^5^9\)

**Otitic Barotrauma (Barotitis)**

Barotitis usually occurs in individuals who have Eustachian tube obstruction, either functional, mechanical, or both, most frequently during periods of upper respiratory tract inflammation.

**Air Flight** On ascent in an airplane, the normal Eustachian tube opens spontaneously; there is forced opening, and the relative positive middle-ear gas pressure is equilibrated with the cabin pressure. Most commercial aircraft are pressurized to an equivalent altitude of 7,000 feet. On descent, however, the Eustachian tube does not open spontaneously but opens by actively swallowing owing to contraction of the tensor veli palatini muscle, which equilibrates the relative negative middle-ear pressure. Jaw movements and Valsalva’s maneuver may successfully open the Eustachian tube when tubal dilation fails to occur during swallowing. If the Eustachian tube is totally mechanically obstructed, which is extremely rare in children and adults, then the patient will have otalgia and barotitis on both ascent and descent. Since functional Eustachian tube obstruction is the most common type of dysfunction of the tube, most individuals will have difficulty only on descent because the tube can easily open spontaneously during ascent; even infants and children without a history of middle-ear disease frequently have trouble on descent because their ability to actively open the tube by swallowing is inefficient compared with that of most adults (see Chapter 4).\(^5^3\) Children or adults may have little or no symptoms during flying in an airplane until they develop an upper respiratory tract infection or during a period in which their allergic rhinitis is present (inflammation of the nose and nasopharynx). Management is fairly straightforward. Keeping potential swimmers, especially children, out of the water during periods of colds or allergy is the

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best advice. The use of an intranasal decongestant spray prior to swimming and diving is an alternative for competitive swimmers, but for the casual swimmer, refraining from this activity is recommended.

Scuba Diving Use of a self-contained underwater breathing apparatus (scuba) is not a common recreational activity in young children, but it is not uncommon in older children and adults. The pathophysiology during descent and ascent is similar to that described above during flying in an airplane, and the methods of prevention and treatment are also similar. But there are pathophysiologic differences between flying in an airplane and scuba diving, such as the adverse effect of the prone and head-down body position during immersion when scuba diving, secondary to venous engorgement of the Eustachian tube and middle-ear mucosa (see Chapter 5).72 Also, Shupak and colleagues tested 42 Israeli scuba diving candidates in a pressure chamber using tympanometry to assess middle-ear pressures before and during a simulated dive.73 They concluded that the ability to autoinflate the middle ear at sea level was not a good criterion for whether the candidate could or could not equalize middle-ear pressures during the dive. Thus, it would be unwise for a recreational scuba diver who has difficulty equalizing middle-ear pressures during scuba training to continue to pursue this sport. Also, I do not recommend scuba diving for any individual who has had recurrent or chronic otitis media or Eustachian tube obstruction because an adverse outcome may occur (eg, traumatic rupture of the tympanic membrane) and may even be life-threatening if severe vertigo develops owing to inner ear barotrauma. Scuba diving is not a physiologic activity that evolved in humans, and when this activity is associated with possible severe middle and inner ear complications, it should be avoided. The enthusiast should try swimming with a snorkel because there are not the same strains on the Eustachian tube system, even with “free dives” at reasonable depths.

Pressure Chambers Patients who are receiving hyperbaric oxygen treatments in a pressure chamber can also develop barotitis. Again, the most important risk factor is the preexistence of Eustachian tube obstruction—the rare patient with a patulous Eustachian tube would not be at risk—and the presence of inflammation (including the effects of radiation). The pathogenesis of this occurring is similar to that described above during air flight and diving. Fernau and colleagues recommended myringotomy and tympanostomy tube placement as a prophylactic measure for patients who are to undergo hyperbaric oxygen treatments prior to entering the pressure chamber if they have difficulty equalizing the abnormal pressures.24

Management of Allergy Related to Eustachian Tube System

As discussed in Chapter 5, the possible role that allergy plays in the pathogenesis (and etiology) of otitis media may be by one or more of the following mechanisms:

- The middle-ear mucosa functioning as a “shock (target) organ”
- Inflammatory swelling of the Eustachian tube mucosa
- Inflammatory obstruction of the nose
- Aspiration of bacteria-laden allergic nasopharyngeal secretions into the middle-ear cavity

Related to these potential mechanisms, Bernstein and colleagues concluded, after conducting a clinical study, that a small number of patients may have the middle ear as the target organ, but they postulated that the Eustachian tube might have been the target organ in many other subjects (see Table 5–5).76 Also, as described in Chapter 6, studies at our hospital involving adult volunteers demonstrated a relationship between intranasal challenge with respiratory viruses, antigen challenge, allergic rhinitis, and Eustachian tube obstruction.30,77–81 In a double-blind, crossover study by Friedman and colleagues that involved adult volunteers without otitis media, Eustachian tubes became obstructed when the subjects were challenged intranasally with the antigen to which they were sensitive but not when they were challenged with a placebo (ie, an antigen to which they were not sensitive).77 None of these allergy studies produced otitis media in the volunteers, but apparently none had preexisting Eustachian tube dysfunction. As discovered in some of the virus studies, adult volunteers who had preexisting Eustachian tube dysfunction were prone to developing Eustachian tube dysfunction and middle-ear pathology.82 In a study by Skoner and colleagues, nasal and Eustachian tube function was altered during natural pollen exposure.83

Mogi and colleagues, from animal studies in the laboratory, concluded that immunoglobulin E–mediated immune reaction in the middle ear is a causative factor in the production of middle-ear effusion and that the Eustachian tube is anatomical.

FIGURE 9–8. Artist’s drawing showing that diving deeply into water can result in acute barotitis media when the swimmer has an upper respiratory tract infection, especially in individuals who have a preexisting dysfunction of the Eustachian tube.
ly and functionally altered in type I allergic reactions of the nose, but tubal dysfunction is transient and does not result in a middle-ear effusion.84,85 They also concluded, however, that this dysfunction does interfere with middle ear and tubal clearance. To date, there is no animal model that verifies that allergic nasal and tubal disease causes a middle-ear effusion. In the human, the allergic condition is prolonged, which could then result in an effusion. An animal model that corresponds to the pathogenesis in the human has not been developed.

Hurst and Venge and Hurst demonstrated an elevated level of eosinophil cationic protein in the middle-ear effusion and mucosa of patients with allergies and otitis media, which suggests that type I allergy has a role in the pathogenesis of otitis media.86,87 Bernstein suggested that there is some supporting evidence that food immune complexes, mainly dairy products, may be an important etiologic factor in infants who are otitis prone.88 No study reported, however, has shown that elimination of dairy products in otitis-prone infants is effective. Both of these reports suggest that the middle ear is a target organ. I remain unconvinced (see the end of this section).

Management options that are evidence based from clinical trials have not been reported. Nevertheless, there does appear to be some evidence that chronic and recurrent otitis media with effusion may be associated with upper respiratory tract allergy. Therefore, until our knowledge of the origin, method of diagnosis, and management of allergy in relation to otitis media increases, when a patient has recurrent or chronic middle-ear disease and evidence of upper respiratory tract allergy, management of the allergy should be considered as a treatment option. Because no convincing clinical trials of the treatment options have been reported, however, no single method of treatment can be recommended.

One of my conclusions regarding management of patients who have allergic rhinitis and otitis media, related to the available studies, is that inflammation of the nasal cavities can obstruct the nose, which might result in the Toynbee phenomenon, and adversely affect the Eustachian tube system. Thus, one goal of management should be to prevent nasal obstruction. Intrasal topical aqueous steroids are beneficial during the allergy season. The adult volunteer challenge studies were impressive in that the antigen did cause Eustachian tube obstruction, so that another goal would be to reduce nasopharyngeal allergic inflammation, which might be accomplished using topical steroids. An allergy workup to identify the offending allergens would be a reasonable option, following which allergy control and immunotherapy could be considered. Even though no data support the use of the antihistamine-decongestant combinations in allergic children who have otitis media, there is some evidence from the study by Stillwagon and colleagues that these agents may be of benefit in adults.80 In an animal model of otitis media and nasal allergy by Suzuki and colleagues, a beneficial effect of the antiallergic drug azelastine hydrochloride showed promise in promoting clearance of middle-ear effusion.89

My own bias related to the hypothesis that the middle ear is a target organ is that if that is true, why does the middle-ear mucosa not continue to produce secretions, similar to allergic rhinitis, following tympanostomy tube placement? My answer to this question is that the middle-ear disease is the result of Eustachian tube obstruction and negative middle-ear pressure that is relieved by tympanostomy tube placement. One could argue that the mucosa does produce inflammatory secretions and that clearance is enhanced by the tube. But the middle ear appears to be normal after tubes are inserted. My skepticism also relates to cases I have had when the middle-ear fluid was not otitis media. For example, a child had a tympanostomy tube placed in his eardrum that resulted in profuse otorrhea (and rhinor- rhea) despite the tube placement; the child had a cerebrospinal leak, and the liquid was thought to be a middle-ear effusion.90 Obviously, placement of a pressure-equalizing tube had nothing to do with the pathogenesis of spinal fluid entering the middle ear from the inner ear. My opinion is that the nasopharyngeal end of the Eustachian tube system and the tube itself are the most likely sites involved in the pathogenesis of middle-ear disease in allergic individuals. I remain unconvinced that the middle ear can be the only target organ in the absence of the signs and symptoms of upper respiratory allergy. Thus, diagnosis and management should be directed toward these sites. Placement of tympanostomy tubes in these patients is beneficial when nonsurgical methods of management fail.

Future research goals related to these issues are many, but the most obvious is that there have been no randomized clinical trials of the “best” allergy management options versus placebo (controls) (see Chapter 11).

Management of Gastroesophageal Reflux Related to the Eustachian Tube System

As described in Chapter 6, several recent reports have suggested that gastroesophageal reflux disease may be involved in the pathogenesis of Eustachian tube–middle-ear pathology. In humans, Tasker and colleagues measured pepsin concentrations in middle-ear effusions from children using enzyme-linked immunosorbent assay and enzyme activity assays, and of the 54 specimens, 45 (83%) were positive.91 In another report from the same research group, Tasker and colleagues assessed the levels of pepsin or pepsinogen protein in 65 middle-ear effusions of children, of which 59 had levels 1,000-fold higher than serum levels.92 This was attributed to reflux of gastric contents into the middle ear. Poelmans and colleagues performed tests for reflux in adults who had chronic otitis media with effusion or Eustachian tube dysfunction and reported that there was an association and that treatment with antireflux medication was effective in relieving the otologic symptoms.93 This was not, however, a randomized clinical trial.

In animals, Heavner and colleagues were able to demonstrate a transient inflammation of the Eustachian tube second-
ary to multiple exposures of a gastroesophageal refluxant instilled into the middle ears of a rat model.\textsuperscript{94} In a similar study, White and colleagues instilled gastric juice into the nasopharynx of the rat model, which resulted in Eustachian tube dysfunction.\textsuperscript{95} At this time, it is still uncertain that gastroesophageal reflux is involved in the pathogenesis of Eustachian tube–middle-ear disease, even though there appears to be an association in both humans and animal models.

The question of management of gastroesophageal reflux in children and adults who have recurrent and chronic middle-ear disease is controversial owing to the lack of a proven cause-and-effect relationship.\textsuperscript{96} Currently, I include questions concerning symptoms of reflux disease (e.g., arcing the back and frequent vomiting in the infant, chronic or recurrent hoarseness, frequent belching and clearing the throat, recurrent croup, heartburn, stomach discomfort) in children who have recurrent acute otitis media and chronic otitis media with effusion. Even though definite proof of causation is lacking, reflux disease may be causing the ear disease in some symptomatic patients. Thus, I treat these children for both diseases; even though there is only an association, both usually require management. Because there is no feasible “gold standard” test for reflux, a 24-hour pH probe study notwithstanding, I usually recommend dietary control, positioning in the infant during and following meals, an \(H_2\) blocker such as ranitidine, or even a proton pump inhibitor (e.g., omeprazole) for moderate-to-severe cases. Those patients who are unresponsive to this relatively routine management plan I refer to a gastroenterologist.

**Role of the Eustachian Tube System in Surgical Management**

Dysfunction of the Eustachian tube system can be simply classified into the system being either too closed (obstruction) or too open, or there is abnormal pressure at either end of the system (see Chapter 5). Unfortunately, there are currently no definitive surgical procedures to correct the most common type of Eustachian tube dysfunction—failure of the opening mechanism, especially tubal constriction—that have met evidence-based criteria. Even though functional obstruction and its attendant middle-ear disease are most common in infants and young children, this dysfunction improves with advancing age. For adolescents and adults whose functional obstruction persists, a definitive operative procedure to improve function, if safe and effective, is a goal for future research. Determining the etiology of and corrective procedure for constriction of the tube would also be an important goal (see Chapter 11).

In the patient with a cleft palate who has functional tubal system dysfunction (including the open cleft), surgical repair of the palatal muscle sling and achieving adequate velopharyngeal function are possible. However, the most effective surgical procedure to reduce the rate of otitis media in these patients awaits future investigation (see Cleft Palate Surgery Related to the Eustachian Tube System). Currently, for functional tubal obstruction, we only have a bypass procedure for this type of dysfunction—myringotomy with tympanostomy tube insertion. This has met current evidence-based criteria (see Myringotomy and Tympanostomy Tube Placement Related to the Eustachian Tube System), but anatomic obstruction involving the system may be corrected by surgery, depending on the etiology, such as a cholesteatoma at the middle ear end of the Eustachian tube (see the following section). Also, there are experimental surgical procedures recommended for the nasopharyngeal end of the Eustachian tube system, as described below (see Laser Eustachian Tuboplasty).

Even though we do not have a surgical procedure to correct functional obstruction of the Eustachian tube, we do have surgical procedures to obstruct the tube: obliteration of the Eustachian tube when chronic or recurrent otorrhea is a problem in patients who have had a radical mastoid, as described in detail in Chapter 10. We can also surgically close the tube when it is chronically abnormally patulous, which is described below.

**Surgery on the Middle-Ear End of the Eustachian Tube System**

As described in Chapter 5, the dysfunctions of the Eustachian tube system can involve pathology within the middle ear that can anatomically obstruct the middle-ear portion of the Eustachian tube and cause middle-ear disease secondary to the obstruction, even when the other portions of the tube are structurally and functionally normal. One example is a congenital cholesteatoma in the middle ear that obstructs the protympanic portion of the tube in which the cartilaginous portion is structurally and functionally normal. Surgical removal of the cholesteatoma can restore normal tubal function. Other similar pathologic conditions include middle-ear tumors and even middle-ear mucosal disease, including polyps. If a patient who has otherwise normal Eustachian tube function has a traumatic perforation of the tympanic membrane, which is followed by chronic suppurrative otitis media, medical treatment (or surgical eradication) of the middle-ear disease and repair of the tympanic membrane can restore the Eustachian tube system to normal function.

More commonly, the Eustachian tube itself is too closed (tubal obstruction that is functional, anatomic, or both) or too open (patulous or semipatulous). Also, a dysfunctional tube can be present when the middle ear end of the system is too open when a tympanic membrane perforation is present or too closed when an acquired cholesteatoma is in the middle ear. Management of both of these complications of otitis media and tubal dysfunction is discussed in Chapter 10. As described in previous chapters, pathophysiology of the Eustachian tube system plays an important role in the pathogenesis of middle-ear diseases and disorders, which results in chronic and recurrent middle-ear underpressures, otitis media, or both. Also, the pat-
ulose tube dysfunction can cause troublesome symptoms. For these conditions, surgery related to the tubal system can be help ful, such as myringotomy, tympanostomy tube placement, and surgery for the patulous tube, all of which are presented below.

**Myringotomy Related to the Eustachian Tube System**

Myringotomy has been a very effective operative procedure for treatment of middle-ear disease for over 200 years, ever since Sir Ashley Cooper first introduced it. Prior to the advent of the widespread use of antimicrobial agents for acute otitis media, routine myringotomy, as an adjunct to antimicrobial treatment, has been shown to be no more effective than antibiotics alone; myringotomy alone is not as effective as antibiotics alone.

Thus, today, myringotomy is reserved only for selected cases and is performed primarily by otolaryngologists and a handful of primary care physicians; the indications are usually limited to those patients who have severe otalgia or when suppurative complications are impending or present.

**Indications** The current indications for myringotomy are the following:

1. **Suppurative complications of acute otitis media.** Whenever a patient, usually a child, has acute mastoiditis, labyrinthitis, facial paralysis, or one or more of the intracranial suppurative complications, such as meningitis, myringotomy and aspiration should be performed as an emergency procedure. Tympanocentesis should precede myringotomy to identify the causative organism. In addition, the insertion of a tympanostomy tube should be attempted to provide prolonged drainage.

2. **Severe otalgia owing to acute otitis media.** A patient can develop severe otalgia at the onset of acute otitis media for which myringotomy will provide immediate relief. Culture of the effusion is recommended.

3. **Adjunctive procedure to tympanocentesis.** Whenever diagnostic tympanocentesis is indicated, myringotomy for drainage may follow the needle aspiration, especially when a copious amount of middle-ear effusion is present in a patient who has an acute otitis media; tympanocentesis is primarily for aspiration of middle-ear effusion to obtain a Gram stain, culture, and susceptibility studies. Tympanocentesis is indicated when acute otitis media is present and
   - The patient is critically ill.
   - There is persistent or recurrent otalgia, fever, or both, in spite of adequate and appropriate antimicrobial therapy.
   - Acute otitis media occurs during the course of antimicrobial therapy given for another infection.

4. **Acute barotitis.** When a patient develops acute barotitis during descent in an airplane, scuba diving, or hyperbaric oxygen treatment, the Eustachian tube “locks,” causing extreme middle-ear underpressures and tearing of the middle-ear mucosa, which can lead to severe otalgia and an effusion. If a spontaneous rupture of the eardrum does not occur, myringotomy can provide immediate relief.

**Pathophysiology of the Eustachian Tube System Related to Myringotomy** As described in Chapter 5, when an effusion is present in the middle ear, it becomes “trapped” with the development of increasing middle-ear negative pressure as the liquid attempts to drain out of the Eustachian tube (the effect of liquid in an inverted flask). In addition, the negative middle-ear pressure impairs mucociliary and muscular clearance (drainage). Figure 9–9 shows a cartoon illustrating the effect of a hole made in the body of the inverted flask model when liquid is “trapped” in it by the negative pressure in the flask. The negative pressure is relieved by the hole, which converts the pressures from negative to ambient, allowing the liquid to drain out of the flask. Similarly in the human, middle-ear effusion becomes “trapped” until a myringotomy perforates the tympanic membrane, permitting the effusion to clear.

**Myringotomy and Tympanostomy Tube Placement Related to the Eustachian Tube System**

It is not surprising that Adam Politzer was the first to introduce the use of tympanostomy tubes 150 years ago, given his hydrops ex vacuo theory of the pathogenesis of middle-ear effusion, but they did not become widely accepted, probably owing to infectious otorrhea as a complication in the preantibiotic era. It was not until Armstrong reintroduced them in 1954 that they became increasingly popular. It has been estimated that 2 million tubes are manufactured yearly and, presumably, are inserted through the tympanic membranes of probably more than 1 million patients.

The efficacy of tympanostomy tube insertion for treatment of chronic otitis media with effusion and for prevention of recurrent acute otitis media is now evidence based. However, there are other indications that have not been subjected to randomized clinical trials but are widely accepted.

**Indications for Insertion of Tympanostomy Tubes** The following are the indications for placement of grommet-type tympanostomy tubes:

1. **Suppurative complications**—when a suppurative complication is suspected or is present. Insertion of a tympano-
tomy tube at the time of tympanocentesis or myringotomy can provide more prolonged drainage and aeration of the middle-ear cleft. A wide-field myringotomy should also be performed in the inferior portion of the tympanic membrane to provide adequate drainage; the tympanotomy tube is inserted through a radial incision in the anterosuperior (or anteroinferior) quadrant. A Gram stain, culture, and susceptibility studies should be obtained.

2. **Chronic otitis media with effusion**—a middle-ear effusion that is chronic and does not respond to medical management (and is not improving) and has persisted for at least 3 months when bilateral or 6 months when unilateral. Insertion at an earlier time would be reasonable when there is significant hearing loss (eg, > 25 dB), speech or language delay, a severe retraction pocket, or disequilibrium or vertigo or when tinnitus is present.

3. **Recurrent acute otitis media**—especially when antimicrobial prophylaxis fails to prevent frequent, severe, and long-lasting disease. However, long-term, low-dose antibiotic prophylaxis is associated with the emergence of antibiotic-resistant otitic pathogens. Minimum frequency for considering tympanostomy tube insertion would be three or more episodes during the previous 6 months or four or more attacks during the previous year, with one being recent.

4. **Recurrent otitis media with effusion**—recurrent episodes of otitis media with effusion in which the duration of each episode does not meet the criteria for chronic disease, but the cumulative duration is considered to be excessive (6 to 12 months).

5. **Eustachian tube dysfunction**—for Eustachian tube obstruction, even in the absence of middle-ear effusion, when the patient has persistent or recurrent signs and symptoms that are not relieved by medical treatment. Signs and symptoms would include hearing loss (usually fluctuating), disequilibrium or vertigo, or tinnitus. Also, tympanostomy tube placement may be required prophylactically when there is a need for hyperbaric oxygen therapy or when a patient has troublesome symptoms (eg, autophony) related to a patulous Eustachian tube.

6. **Atelectasis and retraction pocket**—when atelectasis of the middle ear, with or without a retraction pocket, is chronic and unresponsive to medical management (see Chapter 10).

7. **Adjunctive to tympanoplasty**—when a tympanoplasty (with or without a mastoidectomy) is performed and when Eustachian tube function is thought to be poor, such as when an acquired cholesteatoma is present in young children (see Chapter 4). (Eustachian tube function testing is usually not feasible prior to surgery for cholesteatoma, unless a tympanostomy tube is in place or a perforation is present; if a tube or perforation is present, the middle ear should not be infected.) Tympanostomy tube insertion at the time of the surgery for the cholesteatoma can be helpful in preventing a recurrence of the otitis media and middle-ear atelectasis and, more importantly, development of another retraction pocket that can progress into a new cholesteatoma (recurrence) (see Chapter 10).

![Figure 9-9](image)

**Figure 9-9.** A, Middle-ear effusion “trapped” in the Eustachian tube system is similar to the inverted flask model in which liquid is also “trapped” in the body of the flask owing to the negative pressure within it. B, When a myringotomy is performed, the middle-ear effusion clears (drains) down the Eustachian tube, which is analogous to a hole made in the body of the flask that converts the negative pressure to ambient, allowing the liquid to flow out.

*Pathophysiology of the Eustachian Tube System Related to a Tympanostomy Tube and Its Complications* The rationale for the procedure may be found in certain physiologic and pathophysiologic aspects of the Eustachian tube system. As described
in Chapter 4, the Eustachian tube has three important physiologic functions in relation to the middle ear: middle-ear pressure regulation, clearance (drainage) of middle-ear secretions out of the Eustachian tube, and protection of the middle ear from the entrance of unwanted nasopharyngeal secretions (and sound protection). The tympanostomy tube fulfills two of these physiologic functions of the Eustachian tube. A functioning tympanostomy tube would maintain ambient pressure within the middle ear and mastoid and provide adequate drainage both down the Eustachian tube and through the tympanostomy tube into the ear canal. However, the protective function of the Eustachian tube is impaired by tympanostomy tube insertion because all of the conventional tympanostomy tubes used leave an opening in the tympanic membrane, and the physiologic middle-ear gas cushion is lost when the tympanic membrane is open (Figure 9–10). Therefore, reflux of nasopharyngeal secretions into the middle ear may be enhanced because a tympanostomy tube eliminates the middle-ear gas cushion, a situation that can result in reflux otitis media and otorrhea. Figure 9–11 shows the flask model in which liquid does not flow into the body of the flask when it is intact owing to the buildup of backpressure in the bulbous portion of the flask. But when the body of the flask is not intact, liquid flows readily. Also, the middle ear is susceptible to contamination from the external auditory canal (water during bathing and swimming) when a patent tympanostomy tube is in place. Figure 9–12 shows the flask model to illustrate that two of the three physiologic functions are fulfilled by the tympanostomy tube, but the third—protection—is impaired owing to reflux and contamination.

Thus, a tympanostomy tube is not a prosthesis for the Eustachian tube because it does not fulfill the protective function. It is a pressure-equalizing tube and permits drainage, but similar to a tracheotomy tube, it is a bypass for a dysfunctional organ (Eustachian tube vs larynx), but the protective function is lost. In both the tympanostomy tube and the tracheotomy, contamination from water can result in infection: patients with tracheotomy tubes do not swim under water. The similarities between the Eustachian tube system and the larynx and lower airway are described in Chapter 4.

**Type of Tube Related to the Eustachian Tube System**  For routine treatment of chronic otitis media with effusion and prevention of recurrent acute otitis media in the child, I prefer the Armstrong-type tube, which is biflanged. The average life of this tube is approximately 1 year, as demonstrated by three clinical trials at our center. For most children, the natural history of recurrent acute otitis media and chronic otitis media with effusion is usually 12 to 18 months. A more long-lasting tympanostomy tube may be necessary on an individualized basis. Much controversy exists concerning the indications for insertion of tympanostomy tubes that are more or less “permanent.”

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**FIGURE 9–10.** Of the three physiologic functions of the Eustachian tube, within its system, a tympanostomy tube only provides ventilation (pressure regulation) and drainage (clearance). The third function, protection, is impaired.

**FIGURE 9–11.** The flask model showing no flow of liquid when the body of the flask is intact. When there is a hole in the body, liquid flows into it because there is no buildup of backpressure.
Insertion of such tubes may be warranted in selected patients: those in whom tympanostomy tubes have frequently been tried and in whom Eustachian tube dysfunction appears to be not only chronic but also not likely to improve in the near future, such as in patients who have had skull fracture or skull base surgery or who have another cause of permanent anatomic (mechanical) obstruction of the Eustachian tube. Permanent tubes may also be used in teenagers and adults with long-standing chronic otitis media with effusion or severe atelectasis that is unlikely to improve with time. The Per-Lee and Goode T tubes are associated with a high likelihood of development of a chronic perforation following either spontaneous extrusion or removal. Although rarely encountered, stenosis of the external auditory canal can occur when the Goode T tube remains in place for an excessively long period. Therefore, these more long-lasting tubes are indicated when a permanent perforation is desirable. Permanent tubes, however, should be used sparingly in children because the incidence of otitis media with effusion and atelectasis of the tympanic membrane progressively decreases with advancing age. This is true even for children with a cleft palate who have had repeated tube placements. When “permanent” tympanostomy tubes are used in children, the function of the Eustachian tube should be tested periodically, if feasible, to determine when or if there is evidence of improvement so that the tubes can be removed.

As I concluded in Chapter 8, even though there are many methods to assess Eustachian tube function, there is currently no known method that surpasses observation of the middle ear when the tympanic membrane is intact over time. Therefore, the best way to determine if a patient needs another tympanostomy tube after the tube extrudes spontaneously is to examine the patient and his or her ears relatively frequently over time.

**Removal of Tympanostomy Tubes Related to the Eustachian Tube System** Once tympanostomy tubes have been inserted, they should be permitted to extrude spontaneously into the external auditory canal and not be removed too early. The rationale for such management is based on experience rather than on any controlled clinical trials. In children with tympanostomy tubes in place, Eustachian tube function has not been shown to change significantly, even after several years.

There are indications to remove tubes in selected children. In general, indications for removal of tympanostomy tubes are similar to the decision-making process to repair a chronic perforation of the tympanic membrane, which I describe in Chapter 10. Tympanostomy tubes can be removed as an office procedure without the aid of either local or general anesthesia, especially when the tube is partially extruded or there is chronic infection involving the tympanic membrane. This method of removal is more feasible in adults than in children. In children, tympanostomy tubes are removed under general anesthesia in the operating room because the procedure is usually painful and the rim of the perforation can be denuded of epithelium and the defect closed, that is, “paper patch” myringoplasty following removal of the tube; I prefer to use Steri-Strip (3M, St. Paul, MN) to close the defect. This method appears to result in a higher rate of closure of the perforation than when the tube is removed with no attempt to close the defect.

Most tympanostomy tubes remain in the tympanic membrane for 6 to 12 months, although some have been known to remain in place for years. In the three Pittsburgh studies that evaluated the Armstrong-type tube for treatment of chronic otitis media with effusion and for prevention of recurrent acute otitis media, the tube life was approximately 1 year; 50% were extruded in 12 months and 75% in 18 months. In children in whom tympanostomy tubes have been inserted bilaterally and in whom one tube subsequently extrudes but the other remains in place for a prolonged period, the remaining tube can usually be removed if the opposite middle ear remains free of high negative middle-ear pressure, middle-ear effusion, or both for at least 1 year after the spontaneous extrusion of the opposite tube. This method of management is based on the observation that Eustachian tube function is usually about the same in both ears in children. If high negative middle-ear pressure, otitis media with effusion, or both occur during the obser-
vation period, the tube in the opposite ear should not be removed. Unfortunately, this method of management cannot be employed in adults because Eustachian tube function may not be symmetric.

Removal of tympanostomy tubes depends on several factors, such as the following:

- Age of the patient
- Duration of time the tube has remained in place
- Unilateral versus bilateral tubes
- Status of the contralateral ear when the tympanic membrane is intact
- Eustachian tube function
- Presence or absence of recurrent or chronic otorrhea (and the frequency, severity, and duration of the otorrhea)
- Patency of the tube
- Season of the year

One of the most important factors is the age of the patient because most studies of the epidemiology of otitis media show that the disease has a peak in infancy and declines rapidly after about the age of 6 years (see Chapter 2). In addition, the structure and function of the Eustachian tube and the child’s immunity are usually more mature after 6 years of age. Removing the tube in selected children who are younger, however, may be of benefit, such as when there is unilateral recurrent otorrhea through a tube—apparently owing to reflux of nasopharyngeal secretions into the middle ear—that is not controlled medically, the contralateral tympanic membrane is intact (no tube is present), and the ear has been free of middle-ear disease for 1 year or longer.

The indications for removing tubes are as follows:

1. Presence of a retained unilateral tympanostomy tube in patients who are 6 years of age or older, when the contralateral tympanic membrane is intact and the middle ear has been free of disease for 1 year or longer.
2. Selected similar children younger than 6 years of age in whom the decision is based on the factors listed above.
3. Presence of retained bilateral tympanostomy tubes in children in whom Eustachian tube function is now considered within normal limits owing to growth and development or when a nonsurgical (allergy control or treatment) or surgical (adenoidectomy, repair of cleft palate) management may have improved Eustachian tube function.
4. Presence of frequently recurrent otorrhea through a tympanostomy tube that is not prevented by ototopical antimicrobial prophylaxis (ie, ototopical agent at the first sign of an upper respiratory tract infection). The frequency, severity, and duration of the episodes; age of the patient; and duration in which the tube has been in place are important in decision making.
5. Following chronic otorrhea, especially when the criteria described in the first two conditions are met.
6. When the tympanostomy tube is imbedded in granulation tissue, which is unresponsive to medical treatment.

Complications and Sequelae Related to the Eustachian Tube System The complications and sequelae associated with tympanostomy tube placement that are related to the Eustachian tube system are

- Otorrhea while the tubes are in place or through a perforation of the eardrum following spontaneous extrusion or removal
- Following extrusion or removal, development of an atrophic scar (dimeric membrane) that develops into a retraction pocket, which can progress into an acquired cholesteatoma

Other sequelae can occur but are not related to the function of the tubal system, such as a residual perforation following extrusion or removal of the tube, scarring and formation of a dimeric membrane following extrusion or removal (which are cosmetic problems), and cholesteatoma formation owing to invagination of epithelium at the edges of the defect, which can occur irrespective of the status of the function of the tubal system.

Otorrhea. By far, the most common complication of tympanostomy tube insertion is otorrhea through the lumen of the tube. From a meta-analysis of tympanostomy tube sequelae, Kay and colleagues reported that the rate is approximately 16% immediately following insertion and later in 26%; recurrent otorrhea occurred in 7.4%, and 3.8% developed chronic otorrhea. Garcia and colleagues, from their meta-analysis, concluded that the use of ototopical drops at the time of surgery was effective in reducing this rate, especially when the middle ear contained mucoid or purulent effusion.

The treatment and prevention of otorrhea are similar to the recommendations I have made when acute otorrhea occurs and a perforation of the tympanic membrane is present. These are presented in Chapter 10. This is appropriate because a perforation can occur following spontaneous extrusion; the rate for short-term tubes is 2.2%, and for long-term tubes, the rate is 16.6%. Also, we provided an extensive discussion of the treatment of acute and chronic otorrhea elsewhere.

Retraction pocket and cholesteatoma. Following spontaneous extrusion or removal, atrophy of the tympanic membrane at the site of the tube placement can occur, which can
develop into a retraction pocket.\(^{126-129}\) The rate of retraction pockets from the meta-analysis by Kay and colleagues was 3.1%.\(^{118}\) When recurrent or chronic negative middle-ear pressure remains a problem owing to chronic Eustachian tube dysfunction, the pocket can progress to a cholesteatoma. In the meta-analysis by Kay and colleagues, cholesteatoma developed in 2.6%.\(^{118}\) It occurs at the site of the tube insertion, either by invagination of squamous epithelium or from a retraction pocket that develops owing to persistent Eustachian tube dysfunction and the subsequent negative middle-ear pressure. Golz and colleagues reported the rate of cholesteatoma to be 1.1% and attributed this relatively high rate to the use of Goode T tubes and when repeat tubes were needed.\(^{130}\) I provided an extensive discussion of the role of the tubal system in the pathogenesis and management of retraction pockets and acquired cholesteatoma in Chapter 10.

Patulous Eustachian Tube: Bluestone’s Method of Catheter Obstruction

A continuously open Eustachian tube is termed patulous, and some patients (most frequently adults) complain of autophony and of hearing their own breathing. Some of these patients are habitual “sniffers” because they temporarily close the lumen of the tube with this maneuver. Rapid loss of weight is often the predisposing factor in some, but not all, patients. In 1981, we reported on a surgical procedure to obstruct the tube in selected patients who had a patulous Eustachian tube and who had been unsuccessfully treated medically who were relieved of their symptoms by this surgical procedure.\(^{131}\) Later we reported on nine patients who had had the procedure and whose follow-up ranged from 4 months to 15 years. Six of the nine patients had no further or infrequent symptoms, but three reported no relief.\(^{132}\)

The procedure has undergone some modifications during the last 20 years and now has a better chance of success than the technique originally described.\(^{67,124}\) When the external auditory canal is relatively small, an endaural approach is employed, but if the anterior canal wall and tympanic membrane are completely visualized, the transcanaal approach is used and an anterior tympanomeatal flap is elevated to visualize the middle-ear orifice of the Eustachian tube. We now use a pressure manometer intraoperatively. Prior to replacing the tympanomeatal flap, the manometer (or tympanometer) is used to assess the opening pressure of the now-occluded Eustachian tube. A sterile olive-tip probe is introduced into the external auditory canal, and the pressure is raised to 400 to 600 mm of H\(_2\)O. Maintenance of pressure in this range represents adequate occlusion of the tubal lumen. If there is a low opening pressure, there is usually an open space somewhere around the tube, and a small amount of tissue is used to fill the gap.\(^{124}\)

The procedure is as follows:

1. An incision is made for an anterior tympanomeatal flap. If the anterior canal wall obscures adequate visualization of the operative site, a microdrill is used for an anterior canalplasty, or the endaural approach is used (Figure 9–13).

2. The anterior tympanomeatal flap is elevated, and the orifice of the Eustachian tube is identified (Figure 9–14).

3. An intraoperative test of Eustachian tube function is obtained with the pump-manometer portion of an immittance audiometer, in which the earpiece is inserted into the meatus of the ear canal. An opening pressure is obtained by increasing the pressure on the pump-
manometer (Figure 9–15). Because the patient is supine on the operating room table, the opening pressure will not be zero or close to zero because the Eustachian tube will be engorged with venous blood in the supine position. An opening pressure of about 200 mm H₂O will be recorded. This recording will be compared with a repeat one following placement of the catheter into the Eustachian tube.

3. A small-bore polyethylene tube (eg, no. 90) is introduced into the orifice of the Eustachian tube to determine the site, direction, and approximate length of the catheter to be inserted (Figure 9–16).

4. A small length of the catheter (flared-end portion attached to a Replogle Suction Catheter [Kendall] Argyle-LTP, Chicopee, MA) is cut; the portion of the flared tip of the catheter is used (Figure 9–17).

5. Bone wax is inserted into the lumen at the flared end of the catheter (Figure 9–18).

6. The narrow end of a catheter is inserted into the orifice of the Eustachian tube toward the isthmus until it is tightly in place and the flared end is in the middle ear but not touching the malleus (Figure 9–19).

7. The intraoperative test of Eustachian tube function is repeated to determine if the tube is effectively closed (Figure 9–20). The opening pressure should be elevated to approximately 500 to 700 mm H₂O.

8. If the opening pressure is not sufficiently elevated, which is due to a leak around the catheter, a piece of muscle, fascia, or perichondrium should be inserted into the lateral side of the osseous portion of the Eustachian tube between the catheter and the bony wall of the tube (Figure 9–21).

9. A tympanostomy tube is inserted into the anteroinferior portion of the tympanic membrane (Figure 9–22).

It is important that the flared end of the catheter is not touching the malleus because it may interfere with hearing and that the narrow portion of the catheter fits snugly toward the isthmus of the Eustachian tube (Figure 9–23).

The tympanostomy tube should be left in place until it spontaneously extrudes. Some patients will not require replacement of the tympanostomy tube if their middle ear remains aerated and they are without middle-ear symptoms; apparently, there is sufficient gas passing from the nasopharynx around the catheter into the middle ear, but their Eustachian tube is no longer patulous, and the patient is relatively asymptomatic. However, some patients will require repeat tympanostomy tube placements if they develop the signs and symptoms of middle-

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**Figure 9–15.** Test for a patulous tube. A, The Eustachian tube that is not patulous will have a passive opening pressure in response to applied positive pressure. B, When the patient is upright and a patulous tube is present, no passive opening is noted. At surgery, using the pump-manometer portion of an immittance audiometer, a previously sterilized olive tip is inserted into the external auditory meatus and an opening pressure is obtained by applying positive pressure. The opening pressure will be lower than normal but not zero because the patient is in the supine position on the operating table (see text).

**Figure 9–16.** No. 90 polyethylene tubing is inserted into the Eustachian tube orifice to confirm the site and to determine the direction to place the catheter and the approximate length of catheter that is needed.
FIGURE 9–17. The catheter (flared-end portion attached to a Replogle Suction Catheter [Kendall] Argyle-LTP, Chicopee, MA) is cut so that a portion of the flared end is left. Approximately 8 to 10 mm is sufficient to reach the isthmus but not touch the malleus.

FIGURE 9–18. Bone wax is inserted into the flared end of the catheter to obstruct the lumen.

FIGURE 9–19. The catheter is inserted into the Eustachian tube orifice so that there is a tight fit, with the flared end toward the middle ear, but not touching the malleus, and the narrow portion of the catheter toward the isthmus; the length of the catheter can be tailored to the patient’s middle ear and tubal anatomy.

FIGURE 9–20. Another Eustachian tube opening pressure is obtained with the immittance audiometer to determine if the pressure is elevated sufficiently (see text).
FIGURE 9–21. If the opening pressure is not adequately elevated even though the catheter is secured tightly in the Eustachian tube, a small portion of muscle, fascia, or tragal perichondrium can be inserted between the catheter and the lateral wall of the osseous portion of the Eustachian tube to provide a better seal.

FIGURE 9–22. A tympanostomy tube is inserted into the tympanic membrane to regulate middle-ear pressure postoperatively.

FIGURE 9–23. Lateral view of catheter placement showing, ideally, the narrow portion of the catheter inserted toward the isthmus of the Eustachian tube and the flared end of the catheter not touching the malleus.
ear disease or Eustachian tube obstruction because the catheter may be completely obstructing the lumen. One of the advantages of this method is that if there are any significant postoperative problems with the catheter (eg, otorrhea), it can be removed, but this should be carried out by elevating the anterior tympanomeatal flap as an operative procedure. I have removed the catheter only in one patient because of symptoms of Eustachian tube obstruction, and even that individual wanted the catheter replaced because the symptoms of the patulous tube were more disconcerting than those associated with tubal obstruction.

Surgery on the Nasopharyngeal End of the Eustachian Tube System

As described in Chapter 5, there can be pathology at the proximal end of the Eustachian tube system that interferes with Eustachian tube function, even when the tube itself is functioning normally, such as hypertrophied adenoids or nasal obstruction (rhinosinusitis, allergy, or deviated septum). Nasal obstruction caused by a severely deviated nasal septum was corrected in navy diving recruits tested in a pressure chamber that resulted in their ability to perform Valsalva’s maneuver following the surgery but not before. Also, Buchman and colleagues demonstrated in the ferret animal model of complete nasal obstruction the Toynbee phenomenon, which resulted in abnormal middle-ear pressures, even though the Eustachian tube itself was normal in structure and function. These are some of the pathologic conditions that can be corrected at the proximal end of the Eustachian tube system, which can result in the system returning to normal.

The Eustachian tube itself can be dysfunctional in addition to other portions of the proximal end of the tubal system. This is the case when a child has an unrepaired cleft palate. After repair of the palate and providing good velopharyngeal function, function of the tubal system can be improved, to some degree (see Cleft Palate Surgery Related to the Eustachian Tube System). The role of the Eustachian tube related to adenoid hypertrophy is presented below.

Adenoidectomy Related to the Eustachian Tube System

There are now outcomes of clinical trials that have shown that adenoidectomy is effective for management of chronic otitis media with effusion in children who had had no prior ear or throat surgery, in children who had had one or more prior tympanostomy tube placements, and for prevention of recurrent acute otitis media in subjects who had had prior insertion of tympanostomy tubes. These indications are evidence based. The positive outcomes from these clinical trials were unrelated to the size of the adenoids at the time of randomization. A later clinical trial by Paradise and colleagues showed only a modest and short-term efficacy from adenoidectomy for prevention of recurrent acute otitis media in children who had no prior tympanostomy tube surgery. Given that there was only short-term efficacy of adenoidectomy (and adenotonsillectomy), and given the risks of these operations, neither was recommended as a first surgical procedure for children who have not received a previous tube insertion and whose only indication for the operation is recurrent acute otitis media.

Effect of Adenoidectomy on Eustachian Tube Function

We conducted a study in the early 1970s in an attempt to improve criteria for the preoperative selection of patients for adenoidectomy. Radiographic studies of the nasopharynx and Eustachian tube prior to and after adenoidectomy related to clinical outcomes were reported (see Chapter 8). Of 27 patients who had preoperative obstruction of the nasopharyngeal end of the Eustachian tube, adenoidectomy appeared to be helpful in 19 (70%) (Figure 9–24). The results appeared to be quite poor in children with nasal allergy: only 2 of 10 had good results. Furthermore, children who preoperatively showed reflux of contrast media from the nasopharynx into the middle ear did not benefit from adenoidectomy. In this study, 20 of 33 children (60%) seemed to have a favorable response to adenoidectomy, but 8 had worse middle-ear disease after the operation than before. For example, a few of the children who had asymptomatic otitis media with effusion prior to adenoidectomy developed...
oped recurrent acute symptomatic otitis media following the procedure.

We also studied the pressure regulation (ventilation) function of the Eustachian tube using the inflation-deflation manometric technique both before and after adenoidec- tomy in a group of children with otitis media with effusion in whom a tympanostomy tube had been previously inserted.\textsuperscript{138} Inflation-deflation studies of the Eustachian tube were obtained in ears that remained intubated, aerated, and dry both before and 8 weeks after adenoidec- tomy. Nasal pressures during swallowing were also determined in some. The results of this study indicated that following adenoidec- tomy, Eustachian tube pressure reg- ulation function improved in some, remained the same in oth- ers, and appeared to have been made worse in a few children. Improvement was related to a reduction in extrinsic mechanical obstruction of the Eustachian tube or to nasal obstruction owing to hypertrophied adenoids (Figure 9–25), whereas in those in whom the function was judged worse, the tube was considered to be more pliant after the adenoidec- tomy than before. This increase in compliance was attributed to a loss of adenoid support of the Eustachian tube in the fossa of Rosenmüller. A comparable situation was described in the radi- ographic study in which several of the children demonstrated reflux of radiopaque liquid medium from the nasopharynx into the middle ear after the adenoidec- tomy but not before (Figure 9–26). Neither of these studies included control subjects.

In another clinical trial of adenoidec- tomy conducted at our hospital, Eustachian tube pressure regulation function stud- ies employing the inflation-deflation manometric technique were performed prior to and after randomized selection of chil- dren for the study and at any time an upper respiratory tract infection supervened; the degree of nasal obstruction was assessed. Because Eustachian tube ventilatory function has been shown to be affected adversely by an upper respiratory tract infection,\textsuperscript{140} it is important to assess this function when an upper respiratory tract infection is present and when infection is absent in children both before and after randomization into either the adenoidec- tomy or the control group. However, the outcomes of this study failed to demonstrate any currently measurable effect of adenoidec- tomy on Eustachian tube func- tion; therefore, the hoped-for preoperative test to determine ideal candidates for adenoidec- tomy was not possible.\textsuperscript{141} Owing to methodologic and design problems in the study, children with large adenoids that resulted in postnasal obstruction were not entered into the study because such children had had an adenoidec- tomy and myringotomy and tympanostomy tube procedure performed initially. Therefore, the trial answered the question only for those children who had relatively small adenoids that did not obstruct the nose. It is possible that if such patients were entered, an effect of adenoidec- tomy on the func- tion of the tube would have been observed (Figure 9–27). By not entering patients with adenoids that cause nasal obstruction, the hypothetical Toynbee phenomenon would not have been present, that is, nasal obstruction affecting the Eustachian tube and middle ear during closed-nose swallowing (see Chapter 5).

In a follow-up study by Buchman and Stool, obstruction of the Eustachian tube using manometric testing prior to ade- noidec- tomy was documented, which was relieved following the surgical procedure, but this was an uncontrolled case report.\textsuperscript{142} Nevertheless, obstruction of the Eustachian tube by the ade- noids is one possible cause of middle-ear effusion. The position of the adenoids in the nasopharynx may be a critical factor in the obstruction. Wright and colleagues visually assessed the position of the adenoids, in patients with and without otitis media, at the time of adenoidec- tomy and found that laterally placed hypertrophied adenoids were associated with those chil- dren who had otitis media.\textsuperscript{143} They postulated that lateral hypertrophy was a possible reason that the reported clinical tri- als showed the efficacy of the operation, irrespective of the size of the adenoids. In the trials conducted by Gates and colleagues

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**Figure 9–25.** Artist’s drawing of two possible mechanisms that adenoids could be related to Eustachian tube dysfunction and otitis media. Left, As depicted in Figure 9-24, one way is extrinsic compression of the pharyn- geal end of the tube. Right, A second mechanism can be hypertrophied adenoids causing nasal obstruction, which, during swallowing, could result in the Toynbee phenomenon (see text).

**Figure 9–26.** Postoperative submento-vertex view radiograph, with con- trast material, showing reflux of radiopaque media from the nasopharynx through the Eustachian tube and into the middle ear, bilaterally. Prior to adenoidec- tomy, no reflux of media was noted.
Indications for Adenoidectomy

Currently, I recommend adenoidectomy for management of otitis media—when otitis media is the only indication—primarily for children who have failed to have resolution of their chronic otitis media with effusion or recurrent acute otitis media, despite a trial of tympanostomy tube placement. At the time of adenoidectomy, I may or may not reinsert tympanostomy tubes depending on the current status and past history of the middle-ear disease. When chronic otitis media with effusion is present, myringotomy, with or without placement of tympanostomy tubes, is an option. The Gates and colleagues trial showed that for children who had chronic otitis media with effusion and who had had no prior tympanostomy tube placement, adenoidectomy and myringotomy, with and without tympanostomy tube placement, were more effective than myringotomy, with or without insertion of a tympanostomy tube. However, in those subjects who had adenoidectomy and only myringotomy, almost 20% needed repeat surgery in the future (i.e., tympanostomy tube), whereas in the adenoidectomy, myringotomy, and tube group, postoperative otorrhea was a problem. When recurrent acute otitis media is present, I usually also insert tympanostomy tubes as an adjunctive procedure at the time of adenoidectomy because our first trial showed that tympanostomy tubes provided short-term benefit and adenoidectomy provided more long-term efficacy.

Although some clinicians advocate removal of the adenoids in children who have either a chronic perforation of the tympanic membrane or a tympanostomy tube in place and develop troublesome recurrent acute otitis media, chronic suppurative otitis media, or both, no randomized clinical trials have been reported that support adenoidectomy for these indications. Nevertheless, because the operation is effective for recurrent acute otitis media—without perforation—and for chronic otitis media with effusion, adenoidectomy is a reasonable management option for these patients as well, especially for those children who have nasal obstruction secondary to hypertrophied adenoids.

Also, some clinicians recommend adenoidectomy prior to tympanoplasty (or myringoplasty) in an effort to improve the success rate of this operation, but, again, there are no data to support performing an adenoidectomy for this indication. Tympanoplasty enjoys a rather high rate of success even when the adenoids are not removed in children, but when the initial attempt to repair the perforation of the tympanic membrane fails, it seems reasonable to remove the adenoids prior to revision tympanoplasty. Because adenoidectomy might compromise the function of the Eustachian tube during the postoperative period, it seems prudent to perform tympanoplasty at a later date.

Cleft Palate Surgery Related to the Eustachian Tube System

As described in Chapter 5 and Chapter 7, “Pathology,” the infant with an unrepaired cleft palate has documented abnormal anatomy and pathophysiology of the Eustachian tube system.
that can help explain the pathogenesis of the universal occurrence of otitis media. But also presented is another pathophysiologic defect in these patients in that there is no velopharyngeal closure during swallowing (and speech). If infants with an intact palate are able to inflate their middle ears during crying, as a physiologic compensatory mechanism for their ineffective active tubal opening, especially during descent in an airplane, then infants with an unrepaired cleft palate have an additional handicap: the proximal end of the Eustachian tube system is too open. If the infant with an unrepaired cleft has difficulty insufflating air into the middle ear during crying, then repair of the palate function, especially when velopharyngeal competence is achieved, should be improved after the repair.

Following palatoplasty, some infants have a reduction in the rate of otitis media, whereas others do not, which has been suggested to be related to the status of Eustachian tube function. Doyle found that in those patients who had persistent otitis media despite the repair, 70% had tubal constriction, in contrast to dilation, on swallowing.151 In the monkey model of cleft palate, Doyle and colleagues concluded that an abnormal nasopharynx, rather than aberrant tensor veli palatini muscle function, appeared to be related to the middle-ear disease.152

Some clinicians have also observed a reduction in otitis media following pharyngoplasty to improve velopharyngeal function. In addition, troublesome chronic otorrhea may be improved with palatoplasty.153 Most likely, providing effective velopharyngeal closure aids in improving the Eustachian tube system, in addition to possible benefits from repairing the "muscle sling," which is purported to improve muscular active opening of the tube. Guneren and colleagues failed to find any difference in Eustachian tube function when they compared the Veau-Wardill-Kilner two-flap palatoplasty and the Furlow double-opposing Z-plasty operation.154 The most effective method of palatoplasty to achieve improvement in the tubal system and the rate of middle-ear disease awaits future research (see Chapter 11).

**Laser Eustachian Tuboplasty**

Several surgical procedures on the Eustachian tube have been proposed in the past to correct tubal dysfunction,155–159 but these procedures have not been successful and are not currently advocated.

Most recently, however, laser Eustachian tuboplasty has been proposed to correct functional obstruction.160 Following visualization of the Eustachian tube, primarily in adults, Poe and colleagues, using videoendoscopy, hypothesized that the nasopharyngeal end of the tube was dysfunctional,161–165 which then led them to perform experimental laser surgery on the tubes of patients with long-standing middle-ear disease.160,164 The laser surgery is directed at the nasopharyngeal end of the tube. These surgeons reported improvement in middle-ear disease, which was apparently free of any significant intraoperative or postoperative complications, with follow-up lasting 3 years in some patients. The study was not a randomized clinical trial, which makes the outcome difficult to evaluate because there is a natural cure rate that could have been evaluated if a control group of patients was included. Even though there is no way to know exactly which structures and how much tissue was removed, this procedure deserves more investigation. One way is to perform intraoperative tests of Eustachian tube function in animals that have had removal of the tissue targeted by these surgeons followed by histopathologic evaluations. If scientific merit can be demonstrated in an animal model, then a randomized clinical trial would be the next step (see Chapter 11).

**References**

20. Cantekin EI, Bluestone CD, Rockette HE, Beery QC. Effect of oral decon-


