SPECIAL ARTICLE

Care of the Child With Tympanostomy Tubes: A Visual Guide for the Pediatrician

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More than 2 million tympanostomy tubes are placed annually in the United States, primarily in children with chronic or recurrent otitis media refractory to nonsurgical management (J.S. Reilly, personal communication, 1994). Traditionally, the operating otolaryngologist has had the responsibility of caring for these patients, including: confirming middle ear disease, assuring tube patency, controlling refractory otorrhea, and managing complications such as tympanic membrane perforation or cholesteatoma. In response to pressures from a changing health care system, pediatricians are less able to refer children back to the otolaryngologist for routine tube surveillance, and must therefore perform it themselves, often with incomplete instrumentation and training.

An approach is presented here for the care of the child with tympanostomy tubes based on the authors' combined experience with thousands of intubated children, and on available information from the pediatric and otolaryngic literature. With appropriate postoperative surveillance and follow-up care, the morbidity from tympanostomy tubes can be minimized. Although there are other ways of achieving the same goals, these time-honored methods are safe and effective. Because this is a visual guide, photographs are liberally interspersed to clarify and reinforce the written material.

NORMAL TUBE APPEARANCE

There are hundreds of different tube designs and materials and at least five different potential insertion sites in the tympanic membrane. This bewildering array of devices can be reduced to two general types: short-term tubes (intended to remain in the eardrum for 8 to 15 months) and long-term tubes (intended to remain in the eardrum >15 months) (Fig 1A and B). Tympanostomy tubes stay in position, spanning the eardrum, because they have flanges on both inner and outer surfaces (grommet tubes), or have shafts too long to fit in the middle ear (T-tubes, etc.). They ultimately extrude as migrating keratin from the tympanic membrane accumulates between the surface epithelium and the tube's outer flange1 (Fig 2C). To resist extrusion, long-term tubes have either very large inner flanges, no outer flange to collect epithelial debris (Fig 1B, 2D), or both. As with any prosthesis, tube materials are selected for maximum biocompatibility2 and include metals (stainless steel, titanium, gold), plastics (silicon elastomer [Silastic], polytetrafluoroethylene [Teflon]), and calcium phosphate-based ceramic (hydroxyapatite). Most are placed in the pars tensa of the tympanic membrane, in any location except the posterosuperior quadrant that overlies the incus and stapes (Fig 3). Although the anterior half of the eardrum is generally chosen, location does not correlate with the duration of intubation.3 Rarely, tubes are placed between the tympanic annulus and bony ear canal as permanent devices.4

ASSURING TUBE FUNCTION

Proper function of a tympanostomy tube is assured if it is seen to span the eardrum, if its lumen is unobstructed, and if no middle ear effusion is present (Fig 2A). When these three features are observed, ventilation of the middle ear through the tube lumen will maintain good hearing and reduce the frequency, duration, and severity of subsequent otitis media episodes. An indwelling tympanostomy tube provides direct ventilation of the middle ear cavity via the external auditory canal, bypassing the child's own internal ventilation mechanism—an immature and poorly functional eustachian tube. The tympanostomy tube itself does not cure otitis media, but equalizes middle ear and atmospheric pressures by preventing early closure of the initial myringotomy opening. Consequently, an unobstructed lumen is essential for tube efficacy.

Visualization of a tympanostomy tube may be difficult if: the child is struggling; cerumen obstructs the external canal; a long-shafted tube has been used; the tube is oddly angulated; or the tube is placed in the anterosuperior quadrant of the tympanic membrane. Adequate cerumen removal and appropriate restraint are needed for any good ear examination; techniques are reviewed elsewhere.5 If tube function cannot be confirmed by visual inspection, pneumatic otoscopy and tympanometry are helpful. If an eardrum is immobile and translucent on pneumatic otoscopy with no other signs of middle ear effusion, the tube is probably functioning properly. A flat (type B) tympanogram, with a large volume measurement and normal hearing confirms that the outer and middle ears are

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connected by an functioning tube or a perforation. A “normal” peaked tympanogram suggests a clogged or extruded tube. A flat tympanogram with small volume measurement indicates a nonfunctioning tube with a middle ear effusion. The acoustic reflectometer may detect a middle ear effusion, implying that the tube is nonfunctioning, but cannot directly assess lumen patency. If a tube becomes clogged with dried middle ear effusion or blood (Fig 2B), it can sometimes be cleared by the application of an ototopical drop for 5 to 7 days. Otic suspensions are preferable to solutions because their mildly acidic pH is less irritating to the middle ear mucosa; hydrogen peroxide and other cerumolitics are contraindicated for this purpose. If the child tastes the drops or complains of stinging (with acidic drops) they are likely reaching the middle ear or eustachian tube indicating that the tympanostomy tube is functioning properly. A skilled otolaryngologist can often unlog plastic grommets by sliding a 3F metal suction catheter through the tube lumen using the binocular otomicroscope for visualization. This should not be attempted without magnification and is usually unsuccessful with metal or long-shafted tubes.

POSTTUBE OTORRHEA

Approximately 10 to 30% of children with tympanostomy tubes will experience at least one episode of otorrhea while the tubes are in place (Fig 2H). Discharge after intubation may occur in up to 10% of children within 2 weeks of surgery.7 Surgical technique, ear canal preparation, and antibiotic drops have no effect on the incidence of postinsertion otorrhea.8,9 Delayed otorrhea has been reported in 25% of children 4 to 8 years of age with tubes placed for chronic effusions,10 and is more frequent for infants and children with tubes inserted to control recurrent acute infection.11 In temperate climates tube otorrhea occurs most often in the winter, coinciding with the upper respiratory tract infection season, and in the summer, coinciding with the external otitis (swimmer’s ear) season.

The need for water precautions while tubes are in place is controversial. Although every controlled study has found statistically equivalent rates of tube otorrhea in swimmers (mean 15%) versus nonswimmers (mean 20%),12-14 the impact of the type and location of aquatic activity on otorrhea is unknown. Water probably does not enter the middle ear during bathing, showering, or surface swimming, but may enter during diving or head dunking.14 Chlorinated pools harbor relatively few bacteria, and water precautions are generally unnecessary; however, lakes, ponds, rivers, and bath water may have higher bacterial counts. In general, avoiding gross contamination of the middle ear by pathogen-containing water is prudent,15,16 and fitted ear plugs should be used when this is likely to occur (eg, head dunking in the bath).

Treatment of tympanostomy tube otorrhea is also controversial and is based on limited studies. When young children develop acute otorrhea associated with an upper respiratory tract infection, or as a result of otitis media, the pathogens cultured are the same as those obtained by tympanocentesis through an intact eardrum in acute otitis media (eg, Streptococcus pneumoniae, Moraxella catarrhalis, Haemophilus influenzae).17 Treatment with oral antibiotics is generally indicated, and β-lactamase coverage may be required based on the prevalence of resistant organisms in the community. However, viral myringitis (an erythematous eardrum without purulent infection) or a very early otitis media may abort spontaneously without drainage occurring, because middle ear ventilation is provided by the tube. Therefore, antibiotics may be withheld pending the development of visible otorrhea in the tube orifice or in the external auditory canal. When otorrhea is unresponsive to an initial course of oral antibiotics, or when water contamination is the likely cause, the incidence of infection with Pseudomonas aeruginosa and Staphylococcus aureus is much higher.18 In this setting, ototopical drops with activity against P aeruginosa have proved effective. A suspension of neomycin, polymyxin B, and hydrocortisone with acidic pH (Cortisporin otic suspension and others), or gentamicin or tobramycin ophthalmic drops are most commonly used for empiric therapy of otorrhea. Of these agents, only Cortisporin and equivalents have Food and Drug Administration approval for the treatment of otorrhea. When otorrhea is refractory, selecting ototopical drops based on culture and sensitivity of organisms from the ear canal is recommended. Clotrimazole solution has
Fig 2. A. Normal functioning tympanostomy tube; B. Tube with clogged lumen; C. Early phase of tube extrusion with squamous debris beneath the outer flange; D. T-tube with accumulated squamous debris; E. Extruding tube. Tube is angulated and inner flange is extruding. Note tympanosclerosis distant from the tube site; F. Extruded tube. Both flanges are visible; tiny residual perforation will close within days; G. Tympanic membrane after tube extrusion. Arrow indicates dimer at former tube site; H. Tube otorrhea; I. Long-term tube occluded and surrounded by granulation; J. Retraction pocket cholesteatoma of posterosuperior pars tensa. Squamous debris is hidden under granulation tissue; K. Retraction pocket cholesteatoma of the posterosuperior pars tensa from neglected otitis media with effusion; L. Retraction pocket cholesteatoma at former tube site, simulating a perforation. Arrow indicates pars flaccida retraction.
TUBE EXTRUSION

The duration of tube function is largely dependent on tube design. Hourglass-shaped Shepard grommets have a mean duration of function of 8 months. The commonly used grommets with right angle flanges (Fig 1A) last about 12 months. Long-shafted tubes last 20 months or more (Fig 1B). When tubes are inserted into tympanic membranes focally weakened by chronic disease or previous tube insertion (Fig 2C), or in areas of tympanosclerosis (Fig 2E), earlier extrusion is common.

As squamous debris accumulates under the outer flange of a grommet tube, it first lifts up from the surface of the eardrum (Fig 2C). The inner flange becomes visible just behind the eardrum. The tube usually tips posteriorly as the inner flange begins to extrude (Fig 2E). When both flanges are clearly in view, extrusion is complete (Fig 2F). A long-shafted tube will often accumulate a column of migrating epithelium along its length, although it is still in place and functioning (Fig 2D).

A small percentage of tubes will not extrude spontaneously from the tympanic membrane and surgical removal may be required. This is much more common with long-term tubes. Most otolaryngologists will wait at least 2 years before considering the surgical removal of an uncomplicated tube. Flexible silicone tubes occasionally may be removed in the otolaryngologist's office, but, for rigid materials, general anesthesia is usually necessary. In children with long-term tubes or multiple prior intubations, a paper-perm or adipose plug myringoplasty performed at the time of tube removal may increase the rate of perforation closure.

COMPLICATIONS AFTER TUBE EXTRUSION

The physician's job is not finished once both tympanostomy tubes have extruded. A child with middle ear disease severe enough to require tubes remains at risk for recurrent infection and effusion, and for several late complications of tube placement and chronic eustachian tube dysfunction. Routine microscopic examination of the tympanic membrane by the otolaryngologist is recommended at 6 and 12 months after tube extrusion.

Tympanostomy tubes may be associated with structural changes in the tympanic membrane. Whether these changes are caused by the tube itself or by the otitis media that necessitated the tube is presently unclear. Long-term tubes, however, are associated with the highest incidence of structural changes. The eardrum is composed of an outer squamous layer facing the ear canal, an inner mucosal layer facing the middle ear, and radial and circular fibrous layers sandwiched in between that provide strength. After a tympanostomy tube has extruded, the resultant perforation heals as a dimer composed of only the squamous and mucosal layers (Fig 2G). This creates a potential area of weakness in the eardrum that is more susceptible to perforation during subsequent middle ear infection, and to retraction due to eustachian tube dysfunction or chronic middle ear effusion (Fig 2L).

Formation of focal areas of collapse (retraction pockets) are the first step in the genesis of an acquired

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Fig 3. Normal tympanic membrane. A, anterior pars tensa; P, posterior pars tensa; F, pars flaccida; M, malleus; I, incus seen through tympanic membrane.

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proven effective in eliminating otorrhea when yeast species are cultured from the ear canal. Of some concern, however, is the fact that Cortisporin and several other ototopical antibiotics cause sensory-neural hearing loss when placed in the noninfected, middle ears of rodents. Although this ototoxicity has not been shown in nonhuman primates or humans, it would seem prudent to limit the use of these agents, instilling them only during the period of active ear drainage.

Cleansing the ear canal (aural toilet) is commonly performed by otolaryngologists in concert with antimicrobial therapy. Direct suctioning of the tube orifice under the otomicroscope is preferred to assure adequate cleaning. If this is impossible because of equipment limitations or an apprehensive child, drying the ear canal with multiple cotton applicators or suctioning with an 8F catheter are alternative ways to clear debris and permit the entry of ear drops. If otorrhea is refractory to outpatient therapy, specific antipseudomonal therapy based on culture of the tube orifice, daily aural toilet, and ototopical drops will control almost all otorrhea. Some otolaryngologists prefer surgical removal of tympanostomy tubes in this setting. Although this often will stop the otorrhea, recurrent otitis requiring a third anesthetic for tube reinsertion is common. Oral ciprofloxacin has been used on an experimental basis for outpatient management of pseudomonal otorrhea, but is still officially contraindicated for use in children.

When otorrhea fails to respond to intensive medical management, granulation tissue about the tube (Fig 2I), an occult cholesteatoma (Fig 2J), or unusual pathogens such as Candida albicans, actinomycms, or aspergillus should be suspected. Referral to an otolaryngologist is warranted for binocular microscopy and early intervention to prevent the development of more serious sequelae.
cholesteatoma. Retraction pockets also occur in the posterosuperior quadrant of the pars tensa (Fig 2K), and in the pars flaccida, just above the malleus short process (Fig 2L). If these enlarging, narrow-mouthed pockets collect squamous debris, and egress of the material is impossible, granulation tissue formation and secondary infection ensues (Fig 2). This usually occurs as an ear draining with visible granulation overlying the retraction pocket when the purulence is suctioned away. Although local care with ototopical drops and systemic antibiotics may temporarily stop such ear drainage, the retraction pocket cholesteatoma often requires surgical treatment to prevent recurrent infection and, ultimately, bony destruction in the middle ear and mastoid.

A tympanic membrane perforation that remains after tube extrusion is generally tiny (<2 mm in diameter) and closes rapidly; usually it is not even witnessed (Fig 2F). Persistent perforation after tube extrusion does occur and its incidence is related to tube type and the length of time it was in the eardrum. Most large series quote a permanent perforation rate of 0 to 4% for short-term tubes, and a 12 to 25% rate for long-term tubes.46,47 Tympanic membranes with extensive tympanosclerosis or thinning have a higher rate of permanent perforation. Most otolaryngologists will wait 6 to 12 months for a perforation to close spontaneously before undertaking a tympanoplasty for surgical closure.48 Best results are achieved when the child has been free of active middle ear disease for 1 year, to assure the highest closure rate and to avoid having to reintubate a tympanic membrane that has been grafted successfully.49

Tympanosclerosis is a poorly understood scarring process of the eardrum and middle ear mucosa, characterized by collagen, calcium, and phosphate deposits in the middle layer of the tympanic membrane. The hallmark of tympanosclerosis is hard, white plaques visible on otoscopy (Fig 2E). It can occur at the site of a former tube, but may involve any part of the eardrum or middle ear lining. Tympanosclerosis may also occur secondary to chronic middle ear inflammation in unintubated ears. Fortunately, the hearing impairment caused by tympanosclerosis is typically >0.5 dB, which is inconsequential.41 Cholesteatoma behind an intact eardrum must be differentiated from tympanosclerosis, because both appear as white lesions.

WHEN TO REFER TO THE PEDIATRIC OTOLARYNGOLOGIST

The guidelines presented above should allow the pediatrician to handle most routine tube care without the need for otolaryngic referral; however, there are situations in which prompt referral is necessary. The pediatric otolaryngologist is more familiar with middle ear anatomy, and can perform a more complete otologic examination using appropriate restraints, binocular microscopy, and specialized instrumentation.

Referral is recommended for: (1) routine otologic surveillance every 4 to 6 months during intubation; (2) routine otologic surveillance at 6 and 12 months after extrusion of both tubes; (3) tube otorrhea, especially when recurrent or chronic; (4) recurrent episodes of acute otitis media during intubation; and (5) an occluded tube without a middle ear effusion.

Referral is strongly advised for: (1) inability to visualize a previously visualized tube; (2) bloody otorrhea; (3) persistent otorrhea; (4) otorrhea uncontrolled by oral antimicrobials and ototopical drops; (5) deterioration in hearing; (6) granulation tissue adjacent to the tube; (7) suspicion of cholesteatoma; (8) retention of a tube more than 2 years; and (9) tympanic membrane perforation surrounding the tube.

Tympanostomy tubes are an effective, safe, and well-tolerated intervention for carefully selected children with chronic or recurrent otitis media. Ongoing communication between the pediatrician and pediatric otolaryngologist will minimize the potential morbidity from tubes and the underlying factors that originally resulted in otitis media. It is hoped that this article will help to facilitate such communication.

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TOP INVESTIGATOR AT GOVERNMENT HEALTH AGENCY ACCUSED OF SEX HARASSMENT

WASHINGTON, Aug. 7—The man in charge of investigating misconduct in science for the Federal Government has been accused of misconduct of another sort: sexually harassing an office manager by seeking sexual favors from her in return for good employee ratings.


Noted by J.F.L., MD