Introduction

Johannes Mueller in 1838 first described a “layered pearly tumor of fat, which was distinguished from other fat tumors by the biliary fat or cholesterin that is interspersed among sheets of polyhedral cells.” This was a misnomer at the time. Luchae later in 1885 described a cholesteatoma behind an intact tympanic membrane, likely the first accounts of a congenital cholesteatoma. Today, we define cholesteatoma as a cyst-like expansile lesion of the temporal bone lined by stratified squamous epithelium that contains desquamated keratin. These most often occur in the middle ear and mastoid, but can occur anywhere in pneumatized temporal bone.

Cholesteatomas need sooner than later management because of their locally destructive properties. These lesions can cause infections, otorrhea, bone destruction, hearing loss (mostly conductive), facial nerve weakness or paralysis, vertigo via labyrinthine fistula, lateral sinus thrombosis, and intracranial complications. Cholesteatomas can get infected with bacteria, the most common being pseudomonas aeruginosa and staphylococcus aureus. The molecular cascade of events surrounding cholesteatoma has been studied. This includes induction of matrix metalloproteinases, release of oxygen radicals and other inflammatory factors being released. This leads to cholesteatoma’s destructive properties leading to proteolytic activity, bone remodeling and resorption, and recruitment of inflammatory cells.

Classification and Pathogenesis

The classification of cholesteatomas is broken down by their theories of pathogenesis. The first general type is congenital cholesteatoma. This is an epidermal inclusion cyst behind an intact tympanic membrane. There are two main theories of their origin. The first hypothesizes the invasion of misdirected Ectodermal cells within the external auditory canal migrating through the tympanic isthmus into the middle ear space. The second hypothesizes that embryonic rest remnants form epithelial tissue. Findings by Teed and Michaels in 1936 and in the 1980s respectively showed that in human fetal temporal bones there is an Ectodermal or epidermoid collection in the middle ear cleft that may be the
Cholesteatoma, an Overview

2013

Northrop in 1998 showed in human neonatal temporal bones that congenital cholesteatomas existed with epithelial rests.

Congenital cholesteatomas occur in the anterior superior region of the tympanic membrane about two-thirds of the time. They can also be found less commonly in the tympanic membrane and in the petrous apex. The incidence has been quoted to be 0.12 per 100,000 people. The mean age of presentation is about 4.5 years of age. It is more common in males than females in a ratio of about 3:1. There are a couple of criteria that are generally agreed upon in differentiating a cholesteatoma into the congenital type: absence of tympanic membrane perforation, absence of history of recurrent ear infections, absence of previous otologic surgeries, and a normal pars flaccid and pars tensa without retraction. There have been multiple staging systems proposed with most determining the stage by the anatomical area they involve along with involvement of the ossicles or mastoid.

There are 4 general theories for formation of acquired cholesteatomas: metaplasia, implantation, proliferation, retraction. These theories are all debated and point of controversy. Metaplasia is the reversible change of a differentiated cell type to another mature differentiated cell type. In the middle ear, it is theorized to transform chronically inflamed respiratory mucosa into keratinizing epithelium. A well known example of metaplasia is Barrett’s esophagus. In the implantation theory, it is thought that after a perforation of the tympanic membrane, keratinizing epithelium is introduced directly into the middle ear space. The edges of the perforation migrating is also part of this theory evidenced by the tympanic membrane epithelium sharing properties with cholesteatoma epithelium. The proliferation theory is the idea that the keratinocytes of the basal layer of the tympanic membrane form cone-like extensions that grow into the middle ear rather than externally. The retraction theory supports that chronic eustachian tube dysfunction (ETD) leads to the formation of a retraction pocket in the weakest portion of the tympanic membrane which is the pars flaccida and posterior-superior part of the pars tensa. The pars flaccida lacks a fibrous layer, making it weaker than other parts of the tympanic membrane. This continued negative pressure deepens the retraction pocket and keratin debris accumulates.

Recently, Sudhoff and Tos brought to light the combination of the retraction and proliferation theory. Immunohistochemistry was performed on attic cholesteatomas which showed proliferation of keratinocytes within epithelial cones growing toward the underlying stroma. These cone-like extensions penetrated the basement membrane. Keratinocyte differentiation was shown to be oriented toward the center of the long cones, forming lakes of keratin or microcholesteatomas. These opened to the surface of the retraction and to the neighboring cones. Their 4-step theory consists of retraction pocket formation, proliferation of the cones and fusion, expansion of this formation, and lastly bone resorption.

Retraction Pocket

Because of the likely pathogenesis being partly due to retraction, the diagnosis and management of retraction pockets are important in the prevention and surveillance of cholesteatomas. Retraction pockets have multiple causes. ETD whether caused by allergic rhinitis, acid reflux or other processes physically produces a negative pressure in the closed middle ear space resulting in medial displacement of the tympanic membrane. Repeated bouts of otitis media can weaken the lamina propria of the tympanic membrane. Retraction most commonly occurs in the pars flaccida due to its lack of the middle
fibrous layer. These pockets can be watched with tincture of time or intervention may be needed. The underlying cause of ETD can be treated; for example, treating allergic rhinitis with nasal steroid sprays. Tympanostomy tubes may be placed to relieve the negative pressure. Tympanoplasty with or without combination of mastoidectomy may be warranted depending the severity.

The grading of retraction pockets has been an evolving topic. Tos in 1982 first graded pars flaccida retraction pockets. Grade I is a retracted pars flaccida that is not in contact with neck of the malleus. Grade II is a retracted pars flaccida that is in contact with the neck of the malleus “clothing” the neck. Grade III is a retracted pars flaccida that is in contact with the neck of the malleus and limited erosion of the outer attic wall or scutum present. Grade IV is a retracted pars flaccida that is in contact with the neck of the malleus and severe erosion of the outer attic wall or scutum present. Sade in 1976 proposed a staging system of atelectasis of the tympanic membrane. Stage 1 is mild retraction. Stage 2 is retraction onto incudostapedial joint. Stage 3 is retraction onto the promontory. Stage 4 is adhesion of the pars tensa to the medial wall of the middle ear. In stage 3, the tympanic membrane can be lifted off the middle ear medial wall; whereas in stage 4 it is not possible. Sage made a separate staging system of posterior superior retraction pockets. Others including Charachon in 1992 and Black and Gutteridge in 2011 have proposed other staging systems.

**Anatomic Considerations**

Anatomy of the middle ear is important as it dictates common routes of spread. The middle ear space is divided into the mesotympanum, hypotympanum and epitympanum. Cholesteatoma will commonly follow the paths of the different ligaments and folds. Most frequently, cholesteatomas originate in the posterior epitympanum, posterior mesotympanum, and anterior epitympanum in respective order.

Epitympanic cholesteatomas originate in Prussak’s pouch between the pars flaccida and the neck of the malleus. The floor of this pouch is the lateral process of the malleus and its associated folds. Epitympanic cholesteatomas most commonly pass posteriorly through the superior incudal space and the aditus ad antrum. They can also pass into the posterior mesotympanum descending through the floor of Prussak’s pouch into the posterior space of von Troeltsch. This space is between the tympanic membrane and the posterior mallear fold; its inferior edge is the chorda tympani nerve. When spreading to this area, the stapes, round window, sinus tympani or facial recess may become involved.

Posterior mesotympanum cholesteatomas are usually secondary to pars tensa retraction pockets. These pass medial to the malleus and incus. They can invade the sinus tympani, which is between the facial nerve and medial wall of the mesotympanum. They can also invade the facial recess which is bounded by the fossa incudis and facial nerve medially and chorda tympani nerve laterally. Anterior epitympanum cholesteatomas are the result of retraction anterior to the head of the malleus. These may extend to the supratubal recess via the anterior pouch of von Troeltsch’s space.

**Clinical Evaluation**

The evaluation for a patient with a cholesteatoma starts with a standard history and physical. A complete otologic history is necessary. This includes any history of hearing loss, tinnitus, otorrhea, otalgia, vertigo. It is important to ask about previous recurrent otitis media, otologic surgeries including
myringotomy with tube placement, tympanic membrane perforations, allergic rhinitis or any other reasons for ETD. A complete physical including head and neck exam with an emphasis on otologic exam is essential. In the external auditory canal, it is important to note any polyps, granulation tissue or erosion of the bony canal. Tympanic membrane should be examined for intactness or any perforations as source of otorrhea. Fistula test with pneumatic otoscopy may be performed; if positive, erosion of the inner ear may be present, most commonly the horizontal semicircular canal. Tuning fork is also recommended to uncover any conductive hearing loss. Cranial nerve exam with emphasis on the 7th cranial nerve and any neurological exam for dizziness or vertigo may also be performed.

Ancillary tests are also essential to the work-up of cholesteatomas. Complete audiological exam is recommended. Audiometry consisting of pure tone averages with air and bone conduction, speech reception thresholds and word recognition. Tympanometry is also done to show middle ear status. Hearing loss is usually conductive and can vary considerably depending on the extent of the disease. Moderate conductive deficit in excess of 40 dB indicates ossicular discontinuity. This discontinuity is usually of the long process of the incus or capitulum of the stapes. Mild conductive loss may be present in extensive diseases if the cholesteatoma transmits sound directly to the stapes or footplate, a natural myringostapedioxy.

Radiological studies can be obtained. Plain films are not obtained anymore. Computed tomography (CT) is the study of choice. The CT is of the temporal bones without contrast. The most useful cuts are axial and coronal planes with fine 1 millimeter (mm) cuts. Visualization of important structures and consequences of the disease can be appreciated including scutum erosion, expansion of the antrum, ossicular discontinuation, facial canal erosion, tegmen dehiscence, otic capsule erosion and petrous ridge involvement. MRI can also be obtained if suspicion is high for the following: dural involvement, subdural or epidural abscess, herniated brain parenchyma, inflammation of the labyrinth or facial nerve or sigmoid sinus thrombosis.

CT is not essential for preoperative evaluation, and there is controversy over the relevance of mandatory CT before surgery. Some otologists believe in CT for all patients about to undergo mastoidectomies and some believe it is only necessary in only a handful of cases. When considering CT, there are certain situations that it provides more benefit. Patients with chronic suppurative otitis media may have distorted anatomy as well as one with congenital craniofacial anomalies and previous otologic surgeries. When there is sensorineural hearing loss, vestibular symptoms or facial nerve palsies, then imaging is more encouraged. When the diagnosis is in doubt with only a small attic retraction, CT is helpful in determining any bony erosion or determining whether a white mass on the tympanic membrane may be tympanosclerosis, cartilage or actual cholesteatoma. If a patient wishes to avoid surgery or is nor medically prepared for surgery, monitoring with CT imaging may be done.

Management

“Good judgment comes from experience, but experience comes from bad experience.”

Prevention is always the best way to treat disease. Managing retraction pockets without cholesteatoma is a good way to start. If the patient has ETD, whether it is from allergic rhinitis or any
other cause, treating the underlying cause can prevent cholesteatomas. Tympanostomy tubes may be placed for chronic ETD or recurrent otitis media. Tympanoplasty may also be indicated.

Patients can present with chronic otorrhea with associated infection. Otomicroscopy may be performed with debridement or suctioning of the infected tissue. Antibiotic otic drops including fluoroquinolones and/or steroids may be used to dry up the ear. Surgery in an infected, wet ear is always more difficult than a dry ear with less friable tissue. Acetic acid or other anti-fungal medicines may be applied to the ear to eradicate any infection. Medical management will not eradicate cholesteatoma as it is a surgical disease. However, in patients with advanced age, poor health or ones that refuse surgery, treating them symptomatically with ear drops and routine surveillance may be done.

There are certain surgical goals when approaching this disease. The most important goal is to obtain a safe ear. This is to prevent any of the potential consequences and complications of untreated cholesteatoma as mentioned above. Effort should be made to remove all disease including diseased bone, mucosa and other granulation tissue and polyps. Another goal is to reduce recidivism. Less planned and unplanned surgeries are always more desirable and potential of complications from revision surgery. In addition to eradication of disease, keeping the ear dry is also important. Keeping the posterior canal wall is desirable. Lastly, preserving hearing or improving with ossicular chain reconstruction (OCR) can benefit the patient’s quality of life.

There are many variations of mastoidectomy including radical, modified radical, canal-wall-down (CWD), canal-wall-up (CWU) among other variations. Before the mid-1905s, there was only radical and modified radical mastoidectomy. Wullstein and Zollner introduced tympanoplasty. In 1958, House started tympanomastoidectomies with preservation of the posterior canal wall. However, there was a high rate of re-retraction and recurrence. The introduction of plastic sheeting through the facial recess and other methods reduced this recidivism. Today, CWU is more common.

Radical mastoidectomy is the most invasive of the types of mastoidectomies. This is rarely performed today but still has indications. In this procedure, the mastoid antrum, tympanum and external auditory canal are all converted into a common cavity exteriorized through the external meatus. This meatus is enlarged with meatoplasty to allow proper mastoid bowl debridement. The tympanic membrane and all ossicular remnants are removed. The stapes is spared but no OCR is performed. The eustachian tube is plugged. A modified radical mastoidectomy is when the mastoid antrum, tympanum and external auditory canal are all converted into a common cavity exteriorized through the external meatus, usually requiring a meatoplasty. However, it differs from the previous procedure because of it sparing the tympanic membrane and ossicles.

Mastoidectomies with tympanoplasty have different variations, mainly CWU mastoidectomy versus CWD mastoidectomy. The CWD mastoidectomy involves the removal of all mastoid air cells, lateral and posterior walls of the epitympanum, amputation of the mastoid tip. The posterior bony external auditory canal wall is lowered to the level of the facial nerve. The anterior epitympanic recess if exteriorized by removing the cog. Meatoplasty is also performed. The indications for CWD mastoidectomy is many including: cholesteatoma in an only hearing ear, bilateral disease, multiple previous procedures, erosion of the posterior bony external auditory canal, labyrinthine fistula or poor eustachian tube function. The decision for this over CWU mastoidectomy can be made intra-operatively.
if surgical access is limited, if there is extensive cholesteatoma, etc. The advantage of CWD mastoidectomy is that residual disease is easily detected and recurrent disease is less frequent. The disadvantages include an open cavity requiring months of recovery, a mastoid bowl needing lifetime maintenance, dry ear precautions, hearing aids not fitting well, overall less hearing. Chang performed a retrospective review of his experience and showed that there was a low recurrence rate of 3.8% and low otorrhea rate at 9.6%. He also showed how preserving the stapes superstructure significantly improved postoperative hearing with a low air bone gap. Kos et al. also performed a retrospective review of 259 cases of CWD mastoidectomies. They showed low rates of recurrence with also low rates of complications.

The CWU mastoidectomy preserves the posterior bony external auditory canal. There is usually a second staged procedure 6-18 months after the initial procedure. The purpose of this is to remove any residual cholesteatoma and OCR. CWU mastoidectomy has some relative contraindications including a cholesteatoma in an only hearing ear, labyrinthine fistula, or poor eustachian tube dysfunction. The advantages of this procedure are that it only takes weeks to heal, no mastoid bowl and hearing aids fitting better. The disadvantages include it being technically more difficult, requirement of a second procedure, more difficult in detecting residual disease and a higher recurrent disease rate.

There are other variations to the mastoidectomies previously discussed. Transcanal anterior atticotomy may be performed for very limited cholesteatomas limited to only the middle ear, ossicular chain or epitympanum. Bondy modified radial mastoidectomy has been described where the epitympanum is involved but this procedure has largely been abandoned. Mastoid obliteration with either autologous tissue or other biocompatible tissue is also described in the literature. This is thought to prevent re-retraction of the tympanic membrane by decreasing air absorption from the middle ear space and the mastoid.

Controversy

There is controversy between the uses of CWD versus CWU mastoidectomies. Postoperative hearing seems to be about equal. Healing is significantly quicker in CWU mastoidectomy. Residual disease seems to be equal. Recurrent disease is only technically possible in CWU mastoidectomy as retraction pockets are possible. CWD mastoidectomy does not require 2nd look planned procedures. In some situations, most otologists would agree to perform CWD over CWU mastoidectomy including patients with poor follow-up, avoid recurrence. Some patients for cosmetic reasons prefer CWU without meatoplasty. In pediatric patients, there should be more inclination for CWU to avoid a mastoid bowl for their whole lives. CWD mastoidectomy is recommended in more elderly patients who have higher surgical risk with the goal of just a simple and safe procedure. In 2003, Syms and Luxford published a retrospective review of 486 ears comparing CWU and CWD mastoidectomy. They showed that CWD mastoidectomy resulted in 14.6% residual cholesteatomas with the range reported in the literature being 6-13%. CWU mastoidectomy had 3.2% residual cholesteatoma after the second planned procedure. CWU mastoidectomy resulted in only 10% of patients undergoing additional procedures after their second planned procedure.

There is also controversy between the decision whether to perform OCR at the time of the primary surgery or wait until the planned second procedure. Nadol argues for OCR at the time of
primary surgeon saying that there is no need for maximal conductive hearing loss for 6-18 months. In the end, primary versus secondary OCR depends on the individual situation. Delaying OCR allows the middle ear and tympanic membrane to heal, allows motivation for patients to return for their planned second procedure, allows proper post-operative aeration of their eustachian tube and prevents an environment which may scar and fibrose. Controversy is also present regarding facial nerve monitoring, whether to have it in all cases or just challenging cases such as revision or ones where the normal anatomy is distorted. A 1990 survey showed that most experienced otologists do not believe that facial nerve monitoring is obligatory as it can be an extra expense, silent transections still occurring and that the monitoring can be started intra-operatively if the case is deemed difficult. Others argue that this is a good safety net and routine use can gain one experience with the machine.

Conclusion

Cholesteatomas are benign growths in the ear that have the potential to cause complications affecting ear drainage, hearing, labyrinthine issues and intracranial issues. Their pathogenesis is debated but a combination of the proliferation and retraction theories are likely. The goal of surgery is to first have a safe ear, and then the goals can be oriented towards preservation of hearing and balance and dryness. The best procedure for cholesteatoma is debated on paper. Ultimately, the management of cholesteatomas has to be individualized to the patient with surgeon experience taken into account.

FACULTY DISCUSSION: Dayton Young, MD on Dr. Son’s Presentation

Back to the causes of cholesteatoma - you need to know the four theories: eustachean tube problems, retraction essentially, negative pressure, and inflammation. And it's those two things that are going to lead to recurrent cholesteatoma. With the whole process of the eardrum being sucked in and then inflammation making it form adhesions trapping areas where air can't be ventilated, and then pulling the eardrum down, is where the pathogenesis comes from.

So, in your surgery, you're really trying to prevent those things, prevent areas where you're going to get the drum sticking to the promontory and adhesions in various places and that's why putting silastic or plastic helps to prevent adhesions. It's also why you try to avoid operating on a really inflamed ear if you can. If you do operate on an inflamed ear you might put plastic in there taking it out later. That's actually a pretty good way of preventing those adhesions, putting the plastic in and then taking it out later.
Bibliography


