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## **Introduction**

Pediatric mastoid disease is potentially life threatening disease that has seen a decline since the introduction of antibiotics. However, it is still present today, and understanding of the surgical treatment of this disease is vital for every otolaryngologist.

## **History**

The first mastoidectomy was credited to Louis Petit, who used a trochar to drill into the mastoid. Trephination, the drilling of holes into the skull, has been done since prehistoric time and there are many fossils which show holes in skulls.

Schwartz, however, was the first to describe the mastoidectomy with instructions and detailed drawings on how to perform the surgery. What he described was the cortical mastoidectomy, which was the main technique used in the preantibiotic time. He used the chisel and gouge, which was used extensively until the 1950's, when more modern techniques were developed.

In 1910, Dr. Bondy described the modified mastoidectomy for the first time. Then in 1922 Lempert introduced the electrically driven drills in ear surgery. Dr. Wullstein introduced the operating microscope in 1930, which paved the way for modern mastoidectomies.

Dr. House revolutionized mastoidectomy by introduction of the suction irrigations system and inventing the canal wall up mastoid, which is popular today.

## **Anatomy**

The temporal bone is divided into four parts, the petrous, the tympanic, the mastoid and the squamous portion.

The mastoid region is where mastoidectomies are performed. The transmastoid surgery provides access to the facial nerve, the carotid, the jugular, and the internal auditory canal.

When comparing an adult vs. child temporal bone, there are two main differences. First, the infant has an underdeveloped mastoid that is highly aerated. Second, the tympanic ring is also underdeveloped.

## **Indications**

The most common indications for pediatric mastoid surgery are cholesteatoma, acute or chronic mastoiditis and the coexistence of the two diseases.

Less common are temporal bone neoplasm, fractures, CSF leak, and facial nerve decompression.

## **Classical procedures**

The classical procedures are:

- Canal wall up:
  - Simple mastoidectomy
  - Complete Mastoidectomy (facial recess)
- Canal Wall Down:
  - Modified Radical mastoidectomy
  - Radical Mastoidectomy
- And combination procedures: tympanomastoidectomy, neurotologic approaches.

## **Simple Mastoidectomy**

This is indicated for the acute surgical Mastoiditis, called “coalescent mastoid”, which is when a collection of fluid forms in the mastoid which obliterates the normal air cells.

Therefore, this is used for medical management failure, Cholesteatoma that extend to the air cells, cochlear implants and other non common procedures.

## **Surgical preparation**

A preoperative audiometry is a must. No one should operate on an ear unless the status of the hearing is known and recorded. This not only protects the physician from accusations of

iatrogenic hearing loss, but also provides a guide during surgery on how extensive the surgery need be.

An image study is also essential. A CT temporal bone that is high resolution is the preferred image study. This is key for assessment of pneumatization and identification of the tegmen and sigmoid sinus.

## **Procedures and Methods**

Muscle relaxants should be avoided. Nerve monitoring is useful, especially in revision surgeries, but some authors suggest this is not essential.

The patient should be place in the supine positions, with their head turned away from the affected side. Hair is either shaved or tape out the surgical field. The microscope is balanced at 225-300mm distance.

The post auricular incision is made. In young children, usually less than 4 yrs old, the mastoid tip is not well developed. This causes the stylomastoid foramen to be more superficial, which allowing the facial nerve to be vulnerable to damaged. Therefore, the incision in young children is made more posterior and more superficial.

The cortex is exposed by making a cut through the linea temporalis with a vertical cut, and another incision extended posteriorly to mastoid tip, in “T” fashion. An elevator can then be used to elevate the soft tissue off the cortex.

Retractors can then be used to keep the wound open. At this time, identification of the landmarks is key. One should identify the linea temporalis, the cribriform area, the spine of Henle, and MacEwen’s triangle. The MacEwen’s triangle is defined as the posterior border of the EAC, the anterior line of the zygomatic arch, and a line that connects the two. The antrum is located 15mm medial to this.

Next, one can start with a burr cut along the temporal line. In general, a large burr is preferred over the smaller ones. The cutting burr is better for cortical bone, and the diamond burr is used for thin bone over the facial nerve, sigmoid, tegmen, etc. Suction irrigations are used to prevent excessive heat which can damage vital areas, also to remove bone dust from your field. Saucerization (drilling of the edge of the mastoid bowl) is used to provide better exposure. One should now identify the tegmen as a pink color of bone superiorly, which also has exposed vessels once you are close to the dura. The deepest part of the surgery is the antrum. Once the epitypanum, zygomatic cells, body of incus and head of the malleus is identified, then your dissection is complete. Cultures are then taken and a typanostomy tube can be place if needed.

## **Complete mastoidectomy**

This is an extension of the simple mastoidectomy, with more access to the attic, labyrinth, endolyphatic sac and facial nerve. A complete mastoidectomy can be described as a simple mastoidectomy with a facial recess approach. The canal wall remains up for this operation.

Indications are the same for the simple, but with greater access to the mastoid cavity and facial nerve, which is more common in cholesteatoma surgery.

First, the complete mastoidectomy starts with a simple mastoidectomy. The EAC is first thinned laterally to medially. The medial portion will be the facial recess. This is bound laterally by the chorda tympani, medially by the facial nerve and superiorly by the fossa incus.

Once access to the facial nerve recess is achieved, gaining access to the epitypanum may be necessary. Also, the incus may need to be removed if it is eroded. One must be aware of facial nerve dehiscence, which is up to 50% of temporal bone surgeries.

### **Modified Radical Mastoidectomy**

This is more commonly used for cholesteatoma surgery. In this surgery, the canal wall is taken down, but the tympanic membrane is maintained. Indications for this surgery are the same for the previous surgeries, but used when the previous surgeries have failed, such as when irrigation fluid fails to flow from the middle ear to the mastoid region.

The modified mastoidectomy is started as a complete mastoidectomy, but the posterior canal wall is removed. Care is taken to preserve the tympanic membrane, which is replaced. The mastoid cavity is enlarged after this surgery, so care must be made to saucerize the edges so that the surrounding soft tissue may collapse into the defect. However, the mastoid is never grafted or obliterated in children, as with adults. This is because residual disease is more likely to be present in children, which would be obscured with grafting. Also, the mastoid cavity will become less aerated in time.

However, removal of the posterior canal wall is very undesirable in children.

### **Radical mastoidectomy**

This surgery is the removal of the mastoid cavity, the external canal, and the middle ear. This was once performed frequently in the past, but is limited in its usefulness since the use of antibiotics. As well, the previously described surgeries have replaced the use of the radical mastoidectomy.

Therefore, the indication is mainly failed surgeries that need to be more extensive. An uncommon use in children is for better access to the temporal bone for tumors.

The radical mastoidectomy is started as a modified radical mastoidectomy. However, the tympanic membrane, the malleus and the incus are also removed. Next, a meatoplasty is done, which is the removal of the soft tissue and conchal cartilage.

### **Complications of mastoidectomy**

The peri-operative complications include facial nerve injury, sensorineural hearing loss, post operative infection, brain herniation, cerebrospinal fluid leakage, and bleeding.

Delayed complications include posterior canal breakdown, pericondritis, mucosalization of the mastoid bowl, and stenosis of the external canal.

### **Canal wall up vs. Canal wall down**

There is controversy over the use of the canal wall up vs. the canal wall down. The canal wall down provides the best exposure to the mastoid which will be the best procedure to eliminate the disease. However, having this done requires periodic cleaning of the mastoid bowl, which is uncomformable. In children, this requires general anesthesia. Also, swimming, which is common in children, predisposes open mastoids to infections. Therefore every attempt should be made to no do a canal wall down in children.

However, in canal wall up surgery, the exposure is not as well, and therefore residual disease may be present. That is why a second look operation is needed to look for reoccurrence of disease. This is done 6 months after the surgery, which is different from the 12 months of adult surgery. If residual disease is found, it is then removed if possible, and then a re-exploration surgery is done. Otherwise, the surgery is converted to a canal wall down procedure.

### **Conclusion**

It is important to understand the indications, the anatomy and different techniques and why they are performed. Each operation should be tailored to each child. In children, they have a smaller mastoid tip which predisposes them to facial nerve injury. Every attempt should be made to retain the canal wall up. Follow up and re-exploration is key to prevent and control reoccurrence of the disease.

### **Discussion**

**QUESTION: When do you perform a mastoidectomy?**

**REPLY: A mastoidectomy should be done when coalescence is formed in the mastoid which disrupts the air cells. Otherwise, patient should have IV antibiotics and a myringotomy with tube placed.**

**QUESTION: What the difference in terminology between simple mastoidectomy and complete mastoidectomy?**

**REPLY: Some authors suggested that the difference between the simple mastoidectomy and the complete mastoid was that the complete had the facial nerve recess opened. This difference in terminology may have arisen from the fact that reimbursement coded more for complete mastoidectomy.**

**QUESTION: Facial nerve monitoring?**

**REPLY: It is now the standard of care to have facial nerve monitoring in all cases of mastoidectomy, no matter if it is a repeat surgery or not.**

## **Discussant's Remarks – Francis B. Quinn, Jr., MD**

During my childhood (the 1930's), with many earaches and many myringotomies, I learned that to a parent, the work "mastoid" brought fear and desperation. The "Mastoid Operation" in those days, often performed with mallet, gouge and curette, was attended by a significant mortality despite the availability of the sulfadiazine drugs. Looking back on the literature of those times, one can suspect that the death rate from complications of otitis media, or, in the parent's perception, from the mastoid operation itself (called in those days, the "simple mastoidectomy" and later for medicolegal reasons, the "complete mastoidectomy") was often performed too late in the course of the disease, when the infection had already spread to the meninges, the sigmoid sinus, the brain parenchyma, the petrous pyramid or the vestibular labyrinth. .

During my years as an active general otolaryngologist armed with the penicillins, the question would come up of whether or when to perform a complete mastoidectomy on a child with particularly severe or protracted purulent otitis media. Lacking the CT scan and the tympanostomy tube, we relied upon the appearance of the eardrum, a four view temporal bone xray and the textbook signs of acute mastoiditis (displacement of the pinna, postauricular edema and tenderness, sagging of the external canal roof, unremitant otalgia, fever and malaise.) Radiologic demonstration of coalescence of the mastoid cells was an absolute indication for surgery.

Today's presentation while complete and illustrative, offers no guidance on whether and/or when to perform the complete mastoidectomy operation in a case of unresponsive acute purulent otitis media and mastoiditis. By coincidence, in today's xray conference, we saw CT images of a mastoid bone with extensive coalescence of the pneumatic septae accompanied by indisputable evidence of destruction of the overlying mastoid cortex and a soft tissue abscess at the mastoid tip. The resident informed us that in this case the treatment was limited to antibiotic drugs and myringotomy with insertion of tympanostomy tube. The child recovered, but no follow-up CT scan was available. If this is representative of the current view, is there a place for the complete mastoidectomy at all in today's practice? Or have we forgotten the "silent mastoiditis" of Francis Lederer and George Shambaugh, Jr., wherein the latent mastoid infection finally announced itself in the form of meningitis, epidural abscess, brain abscess, and the like?

I will offer you an old Irish proverb, "*The wisdom of winter is madness in May*" and will turn to Dr. Mukerji and Dr. Pine for their experience in this now rare but potentially devastating disease.

## **Discussant's Remarks: Shraddha S. Mukerji, MD**

The indications for mastoidectomies in the pediatric population are similar to those in adults. Due to differences in anatomy especially in relation to the underdevelopment of the mastoid and tympanic part of the temporal bone, the facial nerve is much superficial in children younger than 4 years of age as compared to adults. One has to be careful while making the post-auricular incision.

Choice of approach depends upon extent of disease, presence of intracranial complications, parental choice and reliability of follow-up.

The most important indication for simple mastoidectomy is acute coalescent mastoiditis with or without subperiosteal abscess formation.

Modified Radical Mastoidectomy is performed for cholesteatoma which have recurred despite a formal Canal wall up mastoidectomy, or in the presence of a canal wall cholesteatoma. Every attempt needs to be made to decrease the size of the cavity since pediatric mastoids are well pneumatized and cholesteatomas tend to aggressive and extensive.

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