

Practice of Otology During the First Quarter Century of the American Otological Society (1868–1893)

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Objective: To describe the practice of otology in America during the first quarter century of the American Otological Society (AOS).

Methods: Two sources were used to determine the most prevalent disease conditions cared for and surgical procedures undertaken during this era. All articles published in the AOS transactions between 1868 and 1893 were studied as were the otology textbooks published by 6 of the first 10 Presidents of the Society.

Results: The primary emphasis of late 19th century American otological scholarship was on chronic ear infection with numerous articles focusing on complications of otitis including frequent descriptions of fatalities. Much emphasis was placed upon the Eustachian tube with catheterization and insufflation a major part of otological practice. Due to limitations in technology, the overwhelming focus was on diseases of the ear canal and middle ear. Understanding of

temporal bone anatomy was much superior to that of physiology. Erroneous speculations on the function of the middle and inner ear were common. Surgical interventions were largely limited to myringotomy and mastoidectomy, the latter of which was sometimes life saving during the preantibiotic era.

Conclusion: The latter half of the 19th century saw the emergence of otology as a specialty in America and many emerging diagnostic and therapeutic advances were adopted. While capabilities were notably limited during this era, the efforts of a small band of pioneer otologists in the founder generation of the AOS contributed greatly to the progress of the emerging specialty. **Key Words:** 19th century—American Otological Society—History of otology.

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In honor of the 150th anniversary of the American Otological Society (AOS), founded in 1868, we reflect upon the way otology was practiced in America during the first quarter century of the Society. In the first half of the 19th century, the decades leading up to the formation of the AOS, the diagnostic and therapeutic armamentarium of the otologist was decidedly limited. Indeed, the field was so devoid of capabilities that few reputable American practitioners were willing to take up the challenge of treating ear diseases. In this era of patent medicines, the void was filled by charlatans who peddled ineffective concoctions hawked with assurances of their miraculous curative power. That the title “aurist” became synonymous with quack served to diminish the attractiveness of otological practice among reputable practitioners.

The last quarter of the 19th century was a time of rapid maturation of otology as a clinical and surgical field. During this period many important advances in

otological therapy, both in medical and surgical realms, were achieved. While otological practice in America during this formative era was well behind what it was in leading centers of Europe (especially Vienna, Berlin, and London), the founding generation of the AOS played a major role in incorporating these emerging methods and refining their use for the benefit of the American public.

Our goal is to describe the clinical practice of otology in the United States during the quarter century between 1868 and 1893, an era worthy of special study as it was a transformational epoch during which otology first took root as a specialty in America.

METHODS

The primary resource for determining American otological practice in the early years of the AOS was the Transactions of the American Otological Society over its initial quarter century (1868–1893) (1). An additional source are the otology textbooks authored by 6 of the first 10 Presidents of the AOS including those of Roosa, Blake, Buck, Burnett, Pomeroy, and Bacon (2–7).

Anatomy

A large focus of scholarship leading up to the 19th century dealt with anatomy of the ear. As with many specialties of this

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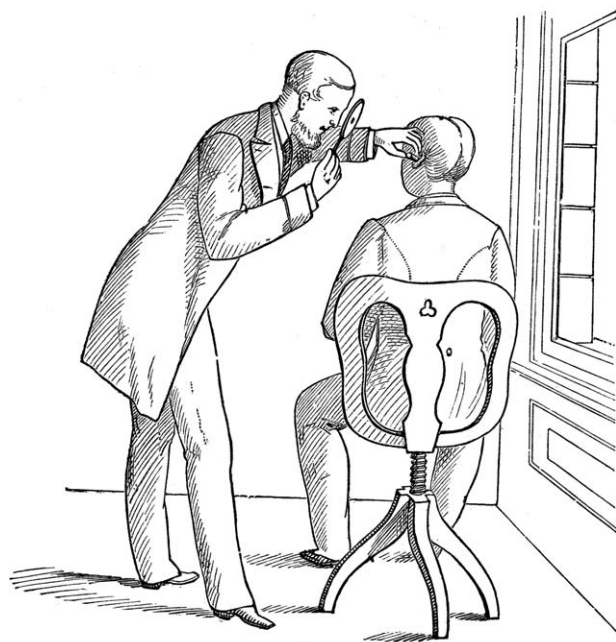


FIG. 1. Examination of the ear via sunlight reflected off of a hand held mirror (3).

era, knowledge of gross anatomy was much better established than that of physiology, diagnostics, or therapeutics. In recognition of the pre-eminence of anatomy, the early issues of the AOS Transactions began with a section detailing advances in anatomical knowledge over the previous year.

B. Alex Randall of Philadelphia (AOS President 1903–1905) was an influential figure in advocating for the importance of anatomy in teaching ear surgery. At the 1895 American Medical Association meeting he stated: “the aural surgeon must have the topography of the ear and the surroundings clear in his mind and ready at his finger ends, when operating on the mastoid or still more within the tympanum, is evident to all (8).” He cautioned that without knowledge of proper anatomy, an ear surgeon:

“... endangers the structures beyond – the stapes, chorda and possibly the facial nerve, if operating up and back, the mucous membrane of the promontory below and the head of the jugular in the floor of the tympanum. The reported cases where the jugular has been thus opened are probably far fewer than the occurrences of the accident, for it must not be forgotten that the thinnest of bone, often dehiscent, alone intervenes. As to the facial nerve, its bony canal is not infrequently incomplete just above and behind the oval window; and aside from injury as the result of operation or even of mere probing or cleansing with cotton, this anatomic condition should not be forgotten in its relation to Bell’s palsy (8).”

Nevertheless, Randall recognized the imperfection of anatomical material: “many text-books of surgery, anatomy, and even of otology are distinctly at fault. Misstatements abound and pass current without the brief examination needed to correct them (8).”

Examination of the Ear

During this era, advances were made in speculae, illumination, and even the initial efforts at photographic documentation of the ear. Various specula were designed and employed to dilate the auditory canal and focus light on the tympanic membrane and middle ear. Much like today, however, there were limits to this form of direct visualization, with Clarence J. Blake (AOS President 1877–1878) lamenting at the 5th annual meeting of the AOS in 1872 that “the examination with the aural speculum... affords no view of the more remote portions of the tympanum beyond the limits of the circumference of the membrana tympani” (9). To overcome this, he developed a middle ear mirror over a century before modern endoscopes allowed angled views of the tympanic cavity. He argued for its benefits by reporting his use “when there is... destruction of the membrana tympani, or even a large perforation, it is possible to introduce a reflecting surface which shall give, with proper illumination, a view of those portions of the tympanum beyond the boundary of the perforation (9).”

The need for good illumination was universally accepted, and for centuries light sources included sunlight, candle, oil lamp, and limelight. The general consensus was summarized in Gorham Bacon’s (AOS President 1891–1894) text, “day-light from a northern exposure is the most satisfactory, since by this means the natural color of the drumhead will be observed (2)” (Fig. 1). There were many options available when adequate sunlight was not available, including various forms of gas and candle-lamps (Fig. 2) (10). With the proliferation of electricity and development of batteries, further modifications were made to existing headlamps, including a modification of the Trouvé lantern. Sexton presented these then state-of-the-art technologies at the 21st annual meeting of the AOS in 1888 and extolled the device as a “valuable acquisition to the aural surgeon when called upon to make an examination or operate at night in the sick room where ordinary light only is employed (11).” (Fig. 3). Of course, gas-powered lamps were commonplace at the time, however the discerning advantage of this design was that by eliminating a live flame, “[t]here need be no fear of igniting the ether used in narcosis” (12). The electric light garnered a great deal of discussion, but the new technology had vocal advocates, with C.H. Burnett (AOS President 1884–1885) proclaiming “I operated by sunlight, but I had the battery ready to use if the latter grew dim (12).”

Concentration of light on the ear was the key for proper illumination needed during exams and procedures. Texts of the

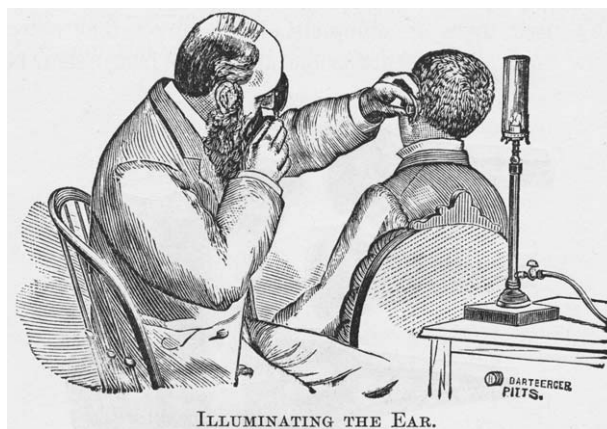


FIG. 2. Gas lamp artificial illumination for otoscopy (10).

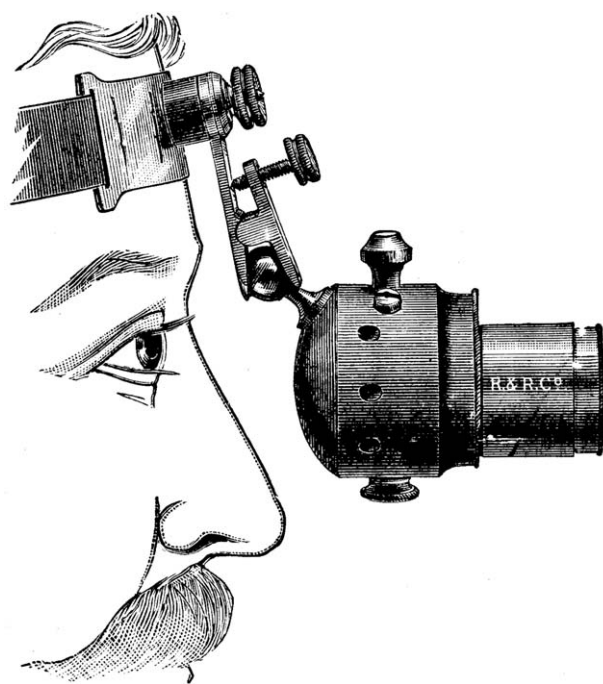


FIG. 3. Early electric headlight used in examination of the ear (12).

time provided descriptions of various reflectors, either head-mirrors or hand-mirrors, to direct light into the ear. Controversy did exist, with most authors providing recommendations of their preferred reflectors, consisting of “a concave mirror, with an aperture in the middle which allows the surgeon to look through the opening” (2), with specific details extolling their preferred devices. Daniel Bennett St. John Roosa (AOS President 1874–1876) advocated for the hand-mirror, stating it is “universally conceded by the profession, that this method is altogether the best that has yet been suggested” (3), while Albert H. Buck (AOS President 1879–1880) extolled the head-mirror and stated, “no one who has ever once experienced the comfort of working with a good forehead-mirror would ever think of returning to the habitual use of the hand-mirror (4).” Newer electric headlights had the advantage of not requiring a separate concentrator.

As the otologic equipment of the time was becoming more sophisticated and ubiquitous, the annual meeting of the AOS remained a gathering point to share interesting new diagnostic and clinical pearls. One such example was the demonstration and identification of a vascular tumor of the tympanic membrane by history and examination alone by Buck. At the 14th annual meeting in 1881, he described a woman with “slight impairment of the hearing” who on otoscopy possessed “a dark object which stood out in bold relief from the outer surface of the membrane tympani. . . the transition from the black of the tumor to the greyish white of the healthy drum membrane was abrupt,” leaving little doubt in his mind of the diagnosis of a vascular tumor (13).

At the 22nd meeting of the AOS in 1889, Randall presented a series of lantern slides of ear examination to demonstrate “how excellently photography may be made to serve us by the use of projections upon the screen in teaching our specialty” (14). The slides were black and white with grainy resolution, but nevertheless were of important teaching value. As Randall put it: “the essential value of photography is in its absolute accuracy

they have entirely abstained from retouching the negatives; preferring that their pictures should show imperfections in point of beauty, or even more serious shortcomings, rather than labor under suspicion of being warped from the truth (15).”

Exostoses

Surgical methods of removing obstructive exostoses developed during the 19th century included cauterizations, galvanic electrolysis, dilatation with a bougie as well as surgical extraction with chisel, forceps, rat-tailed file, or dental drilling engines (16). References made in the Transactions of the AOS indicate that exostoses of the external auditory canal were less common in the United States than in Europe in the late 19th century, yet treatment of the bony growths was seen as effective (17). When Burnett presented a series of cases at the AOS in 1887, he provided a detailed description of his technique using forceps and chisels performed under local anesthesia with 5% solution of hydrochlorate of cocaine. Corenelius Agnew (AOS founding member) lauded his techniques: “As specialists we should be careful to see that what we may do here shall belong to the great mass of surgery. I am therefore glad to see that there is really nothing new in the operation described. The chisel and bone forceps are instruments which have been used from time immemorial in the removal of osteomatous growths (18).”

Five years later, Roosa presented a similar case and his experiences, first noting that the only appropriate indications for such a procedure included, “The patient was suffering considerably from the sense of fullness, tinnitus, and loss of hearing on that side,” or “[a]n otitis media was very likely to recur, and an obstruction in the outlet of the pus would surely be dangerous and possibly fatal to her life (17).” He claimed his techniques provided “considerable improvement in the hearing power” and “the obstructive symptoms were declared to be much alleviated (17).” Roosa then expounded on his use of instruments: “It is a maxim in all surgery, political economy, and war, never to use any means beyond the necessity or the requirements of the case. Those who use the chisel and mallet, I think use means beyond the requirements of the case, and those which have no special advantages, but some disadvantages (17).” Howe agreed, stating: “I have not used the chisel at all. It seems to me rather odd that it should be discussed, when we have an instrument so infinitely its superior, in the drill which the dentists have given us. I have used that a number of times. This instrument we have under perfect control and we know exactly the amount of pressure exerted. There is, to my mind, no comparison between the dentists’ drill and the chisel (17,19).” (Fig. 4).

Foot powered drills entered dental practice in the 1870s and were sometimes used in ear surgery (20). Drilling efficiency decreased as the practitioner’s leg became progressively more fatigued from pumping the treadle during lengthy procedures. To the relief of surgeons’ lower extremities, electric drills were introduced into otologic practice in the last decade of the 19th century (21).

Cerumen

Understandably, cerumen management was one of the most effective treatments available for hearing loss during this era. Oren D. Pomeroy (AOS President 1890) presented a series of 100 cases of impacted cerumen, concluding a cause-and-effect relationship between impaction and chronic aural catarrh (22). The composition of cerumen was well documented, and it was considered an “established fact that at least the uppermost layer of the epithelium lining the external auditory canal moves constantly from within outward (4).”

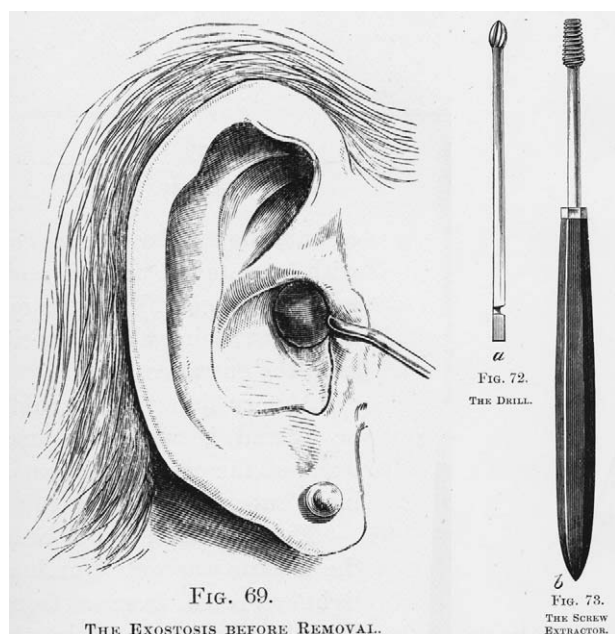


FIG. 4. Exostoses were removed with either a chisel, hand drill, or screw extractor (19).

Typical treatment, as Pomeroy explained, involved aural lavage. He went on: “As we are in the habit, at the Manhattan, of removing cerumen by syringing at the first sitting with simple warm water. . . some excuse is furnished for those who delight in ear-picks, spoons, etc., for removal of the cerumen (22).” Buck recommended, “removal of the masses could be effected much more quickly and pleasantly by the use of the curettes, the cotton-holder, and the angular forceps, than by any other plan (4).”

Foreign Bodies in the Ear Canal

Foreign bodies and cerumen of the external auditory canal were referenced sporadically in the AOS transactions of the times, because as William W. Morland put it: “[n]otwithstanding the triteness of the subject, its real and constant importance will perhaps justify me in occupying a few moments in regard to it (23).” In one of the more extensive series on the subject at the 21st meeting of the AOS in 1888, Sexton presented 101 cases with meticulous categorization of the various types of foreign bodies and methods of removal (24).

In the absence of conductive hearing loss, some otologists would reassure patients that, “foreign bodies, if undisturbed, may remain in the ear for an almost indefinite period without exciting any local irritation, though now and then reflex disturbances in other regions may be traced to this source (24).” Theobald described this “aural reflex” in greater detail at a subsequent meeting of the AOS as irritation of the ear canal causing cough and dysphagia (25). Interestingly, Sexton also noted that, “[t]he seed of fruit of other germinating objects, however, sometimes sprout in the canal, giving rise to irritation,” prompting sooner removal for some objects than others (25).

A common first-line treatment for cerumen and foreign bodies was aural syringing (Fig. 5) (26) as, “a strong stream of water being thrown into the ear, directed between the object and the canal wall, so that the former shall be carried out of the canal by the return current (24).” This was deemed safe for most general practitioners, and even patients, to perform.

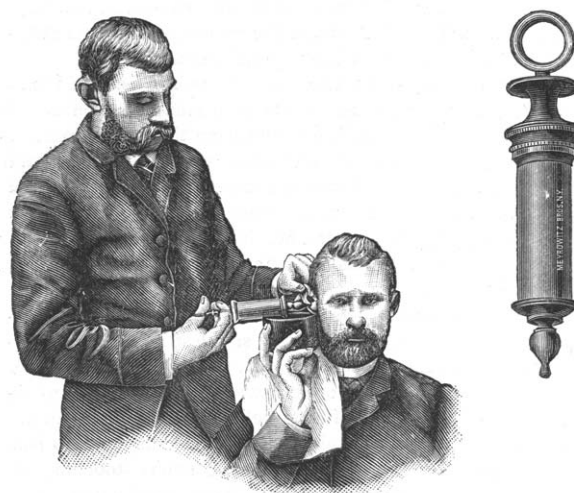


FIG. 5. Method of syringing the ear for removal of cerumen or purulence as described by DB St John Roosa (26).

Anything more challenging was best left for the skilled otologist, and it was recommended to, “remind the general practitioner that the syringe should be first resort, and we may even say, his only weapon (23).”

Otherwise, with the use of a head mirror, light source, and speculum foreign bodies were removed with, “various hooks and forceps, wire loops, the adhesive method, the galvano-cautery for breaking down organic substances, and others too numerous to mention (24).”

For more challenging cases, J. Orne Green (AOS President 1881–1883) described a new approach: “a semicircular incision was made above and behind the auricle, through the periosteum, and the periosteum with the auricle and cartilaginous meatus carried forward till the edge of the osseous meatus was reached; the insertion through in its upper and posterior part. The little finger inserted immediately felt a loose foreign body which was readily seized with forceps (27).” Objections to this approach were numerous, some suggesting that, “[t]he idea of separating the auditory canal from the squamous process of the temporal bone. . . is so absurd that it ought to be ranked among the exploded notions of the barbarous ages (27).” Ironically, this is a routine technique today in postauricular surgery.

Ear Trauma

Traumatic insults to the ear, both routine and extraordinary, were described by late 19th century otologists. For the removal of a small metallic bullet, with round edges making grasping with forceps difficult, Lucien Howe of Buffalo, NY recommended “the use of galvano-cautery for the removal of lead substances (28).” In doing so, he heated an electrocautery device and melted the fragmented bullet into a solid mass and allowed it to cool together to be withdrawn in entirety. While this was considered an extreme and invasive measure to those assembled, Howe insisted, “if a man with the experience also of Dr. Buck, finds it necessary to dissect off the back part of the ear and bring it forward, it seems that there are cases which do not readily yield to treatment, and even when they do, we do not see the bad results that follow (28).”

Multiple additional reports of traumatic injury to the auricle and tympanic membrane were offered. Examination techniques

of the time allowed for detailed descriptions and accounts, such as the following account of a traumatic insult to the middle ear from a hairpin:

“On examination I found the membrana tympani presenting a sunken appearance, the short process very prominent, and the malleus handle apparently twisted. . . a curious line extending obliquely across the malleus handle from below upward and backward near its extremity. On inflating there appeared a false point of motion where this line crossed the bone. The diagnosis of fracture was made, and the patient advised to allow the ear as absolute rest as possible.”

“Through the opening in the drum-membrane could be seen a dislocation of the incudo-stapedial joint, which had probably occurred at the time of the accident. The bones in sight were necrosed, as was ascertained by touching them with a probe (29).”

Auricular hematomas were often thought of as a disease of lunacy, with Howe offering, “it is usually associated, as is well known, with some form of insanity, either paresis, melancholia, or mania (28).” Additionally, it was generally accepted that, “the disease is rather rare in the female (28).” When Howe presented a case of an auricular hematoma, the fact that his patient was sane was itself note-worthy. Management at the time was, “generally considered best to allow such extravasations of blood, to subside as best they may (28).” In cases warranting intervention, he suggested injecting irritating mixtures, such as alcohol or ergot, subcutaneously. Sexton, on the other hand, offered that, “[i]n milder cases he has resorted to the withdrawal of the blood by aspiration. . . Where a large clot has formed, it may be necessary to make an incision (30).”

One of the more amusing reports was of a, “hitherto kind and gentle horse, on the preceding evening had suddenly seized the lady’s ear while she was hitching him and bitten it entirely off (31).” Holt presented the case, commending that “the horse did his work well” in completely severing the entire auricle. He found that debriding nonviable cartilage and suturing the auricle back on “was all there was left to be done.” Fortunately, the wound healed well and by “combing the hair a little lower than customary the disfigurement is but little noticed (31).”

Otitis Media

A great deal of attention was given to otitis media by members of the AOS during late 19th century. In 1877, Burnett described:

“When alluding to acute inflammation of the middle ear, the greatest stress was laid on preventing suppuration. If in spite of all efforts, suppuration does occur, or if before the patient consults any one concerning his aural disease, suppuration shall have become established in the ear, then every endeavor must be made to check the discharge. There should be no fear to do this as promptly as possible, for so long as chronic purulent discharge comes from an ear, the patient is in danger (5).”

Therapy at the time included topical and surgical interventions aimed at ceasing purulence, preventing complications of otitis, and providing symptomatic relief. Otologists would perform syringing and aural douches, often with warm water,

to cleanse the ear. Various topical therapies were introduced during the period, both solutions and powders.

Pomeroy and C.J. Kipp (AOS President 1908) noted that weak solutions such as common salt water were less irritating than pure water in the presence of perforation (32). Burnett, on the other hand, preferred treatment with hydrogen peroxide, which he presented at the 19th meeting of the AOS in 1886 (33). Arthur Mathewson (AOS President 1895–1899) used sulfuric acid and, “obtained most satisfactory results from the application of sulphuric acid. . . it dissolved away the dead bone, while it spared the osseous tissues still retaining vitality, and promoted the process of repair through healthy granulations (34).”

Powders could either be packed or blown into the ear. Holt extolled new powder blowing devices: “the powder blown into the ear. . . is carried en masse to the desired point and applied evenly to all parts (35).” He continued: “The advantages of this form of powder blower are: It can be obtained of the apothecaries at any time. It costs but a trifle. It can easily be kept clean and ready for use (35).” One such commonly used powder was boric acid, which Theobald reported, “the results which I have obtained from it have been exceedingly gratifying (36).”

J.B. Emerson alluded to the importance of proper ventilation of the middle ear when he wrote, “In some cases of deep-seated inflammation of the auditory canal or mastoid cells, in which it is necessary to establish drainage through a fistula, we are often much embarrassed by the rapid growth of granulations or by the closure of the fistula by the natural process of healing (37).” He tried many solutions to this problem, specifically to keep the external auditory canal patent and free from granulation tissue, before concluding: “I have used the various means for keeping such fistulae open, and I believe that in the flexible catheter we have a tube which best fills the requirements (37).” Seely, on the other hand, argued that, “treatment in a rational manner began, of course, with catheterization of the Eustachian tube (38).” Sexton was a champion of tympanic membrane and ossicular chain removal in the treatment of otitis media. He presented his surgical technique and noted the advantages in, “prevention of recurrent accumulations of mucous or purulent matter in the attic and antrum, the cure of otorrhoea together with the relief of the attendant pain, deafness, and distressing acoustic phenomena (39).” When his patient reported improved hearing postoperatively, he remarked, “[t]his marked improvement in hearing was quite unexpected by me, and has given rise to the conviction that the operation may be recommended for deafness alone in many cases where the drum is obstructed by the results of chronic purulent inflammation (39).”

There was perhaps no bigger proponent of this form of surgery than Burnett, who advocated for excision of the tympanic membrane and middle ear contents for the treatment of a multitude of conditions (40–43). With regard to otitis media, he believed a diseased ear drum and ossicles could obscure and harbor difficult to reach disease. Despite this, as was standard practice at the time, he would begin: “to treat symptoms, as my predecessors in the case had done, and for one year I applied all known rational means of treatment to the case. . . but all without any good result, simply because I had not reached and could not get at the true disease in the attic, so long as the membrana tympani and the malleus barred the way (42).” In those cases that failed, he would ultimately recommend surgery: “We see, therefore, that the operation of excision of the membrana tympani and the malleus offers not only a great means of curing chronic purulency, especially of the attic, but also of relieving deafness due to a stiffened membrana and ossicles, by the removal of pathological bands prohibiting free oscillations in

the ossicles, and by thus permitting sound waves to fall directly upon the stapes in the oval window (42).”

Myringotomy

The Eustachian tube has long been used to provide access to the middle ear and as a means for ventilation and drainage of accumulated tympanic fluid. During this period, there was increasing interest in the role of transcanal paracentesis or myringotomy first popularized by Sir Astley Cooper in 1800 (44). The subject was raised for discussion frequently at meetings of the AOS, and early American aurists played a role in leading the field, as Roosa proudly remarked on the subject, “for nowhere in the world is otology cultivated with more zeal, and, as it seems to me, with more knowledge, judgment and skill, than on this side of the Atlantic (45).” Comparative treatments at the time included “galvano-cautery, eye-lets, myringectomy, and acids, to maintain permanent openings in the membrane,” as well as division of the tensor tympani (45).

Many remained skeptical of the efficacy of the procedure and of the risks it posed. In cases of serous effusion, Roosa himself favored watchful waiting and noted that many cases resolved spontaneously. For persistent effusions, he favored as small of an incision as possible to drain fluid, noting that size is relative by comparing, “What would be a free incision in a finger becomes excessively large in a drum-head (45).”

Blake argued that the procedure and trauma to the tympanic membrane itself could cause irritation and worsen serous accumulation, stating that even in cases where, “a free evacuation would seem to be strongly indicated. . . even here such a procedure lavishly indulged in, while it gives immediate relief, may be the cause of future and prolonged trouble (46).” He continued to advocate for treatment via the Eustachian tube, arguing that, “Although the immediate results of the paracentesis. . . may be very gratifying, it is to be found as a rule that the ultimate results of treatment of the naso-pharyngeal and tubal affection alone, however tedious this may seem, are very much better (46).”

However, in cases that failed more traditional Eustachian tube approaches, Pomeroy was a proponent of paracentesis, presenting 10 cases and his results improving tinnitus, hearing, and aural fullness. He detailed technical points of the procedure: “[t]he point at which the punctures were made was just behind the short process of the malleus, sufficiently far to avoid the incus, and as high up as possible, without striking the chorda-tymp. nerve, although that has been pricked once or twice, without, however, doing any harm (47).” He concluded, “I am inclined to the belief that paracentesis in this class of cases often helps us along in the treatment, and without imperiling the present state of the patient (47).”

Roosa, ever cautious and echoing the sentiments of many at the time, warned, “I still regard paracentesis of the membrana tympani as an operation not to be lightly undertaken, and always to be performed with gentleness (45).”

Tympanostomy Tubes

One ubiquitous reality in otology is the tendency for myringotomy incisions to heal, and although placement of a tympanostomy tube is widely used today, practices were not as standardized in the 19th century. Various iterations were developed using a wide array of materials and designs, including aluminum, silver, gold, hard rubber, and gutta-percha (48). One popular solution was a hard rubber drain introduced by Adam Politzer of Vienna in 1868 (49). William Henry Winslow of Pittsburgh characterized its advantages and disadvantages:

“Politzer’s eyelet is the best and only thing now used for maintaining an opening in the membrane. . . it is difficult to fix the eyelet in place, more difficult to maintain it in position, and most difficult to keep its opening clear of mucus and epithelium. It sometimes occasions severe neuralgic pain, and may fall into the tympanum and excite violent inflammation. For these reasons Politzer’s little invention is now seldom used (50).”

Similar accounts of these difficulties were chronicled in the AOS transactions, with Henry D. Noyes (AOS President 1870–1873) describing its employment with great flourish: “The patient sat beside a window, at which I could employ direct sunlight. . . I guided [the eyelet] down to the place of incision, but could not see it when close to the drum-membrane, because the meatus was fully occupied by the forceps. I was, therefore, obliged to trust the sense of touch in engaging the eyelet in the slit (51).” He went on to describe one of the more frustrating complications:

“When I supposed it to have been put in place, I withdrew the forceps, expecting to find the eyelet either in the slit or in the meatus. But I had not brought it out; it was not in the meatus; it was not in the membrana tympani. The disagreeable conviction forced itself on my mind that I had lodged the eyelet in the cavity of the tympanum.”

“To do this much had been painful, and tested the patient’s endurance severely. He was greatly alarmed at the accident, and submitted to prolonged and futile efforts for its removal with such courage as he could, but with extreme difficulty, oftentimes compelling me to desist because of his sufferings (51).”

After treating the patient’s pain for several days with morphia and leeches, and following multiple subsequent attempts at retrieval, Noyes eventually put the patient under chloroform to extract the tube with a hook, and, “brought it safely and triumphantly out (51).” Following this ordeal, he was left to conclude, “to maintain a permanent opening is the problem not yet solved. Prof. Politzer’s eyelet has not conquered the difficulty, although it may deserve a yet longer experience (51).”

Another design for an open tubular ring made of gold was developed in Poland. This device, known as Voltolini’s ring, after its inventor Friedrich Eduard Rudolf Voltolini, was fixed via two incisions in the tympanic membrane on either side of the handle of the malleus and fixed directly onto the malleus with pliers (48). It did not enjoy the same popularity in the United States, with Burnett noting the potential risk for necrosis of the malleus, stating: “it would seem that this procedure could not be of universal application. . . though the conception of the plan must be considered brilliant (5).”

Leading otologists voiced their frustration with tympanostomy tubes of the time. Bacon noted that for most tubes, “it has been found impossible to keep this in place (2).” Roosa diplomatically proclaimed in his textbook, “[t]he published experience of those who have performed this operation do not commend it as a successful procedure, and I believe that it is now very seldom performed (3).” Despite the failures of the late 19th century, it is remarkable that many of the same principles that govern contemporary tympanostomy tubes were understood at the time. These included the need for a permanent opening to allow for ventilation of the middle ear space, the need for flanges to keep the tube in place, and the development of proper instrumentation to properly visualize and deploy the tubes. Indeed, these same principles were elucidated nearly a century later by the American Beverly Armstrong who



FIG. 6. Placement of a Eustachian tube catheter (5).

reintroduced the method, now the most common ear operation, reportedly without knowledge of the work done by his predecessors (52).

Eustachian Tube

Treatment of the middle ear via the Eustachian tube was a major part of late 19th century otological practice. It included the use of catheterization, insufflation, auscultation, dilation, cauterization, and instillation of therapeutic powders and liquids (53). Eustachian tube catheters, introduced during the 18th century, were made of a variety of materials, including metal, vulcanite, or rubber. Rubber catheters would not corrode like those of silver or nickel alloys, were less expensive, and would not uncomfortably heat up with steam (6,54). However, their shape was less easily manipulated than those made of metal (6). Following the introduction of the catheter into the Eustachian tube orifice transnasally, the surgeon would proceed to insufflate the ear through either the application of “the surgeon’s mouth. . . to a rubber tube attached to the catheter” or by using the Politzer air-bag (6,55) (Figs. 6–8). More

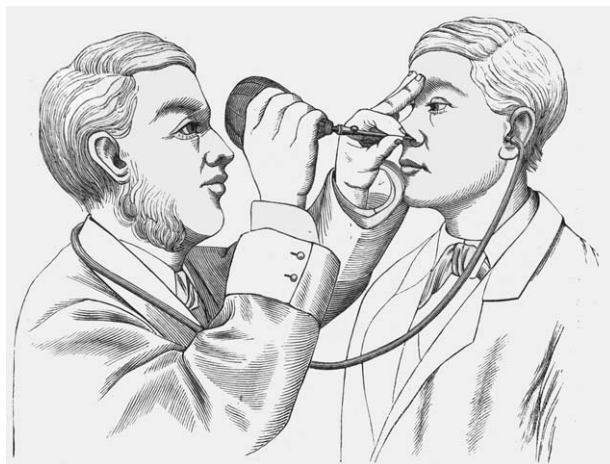


FIG. 7. Verifying the position of a Eustachian tube catheter via insufflation with the otologist listening for the verifying sound of inflation via a Toynbee tube (5).

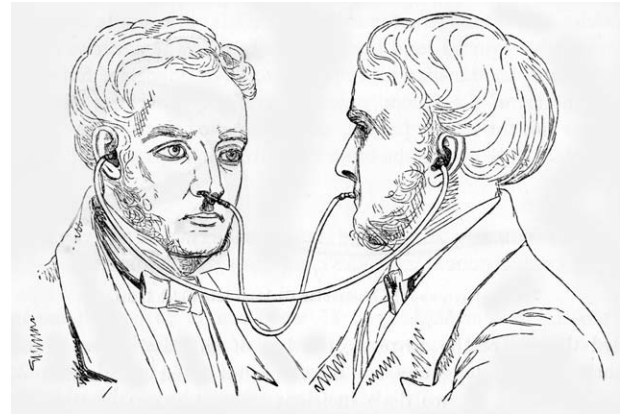


FIG. 8. Inflation of the middle ear via Eustachian tube catheter. The otologist provides both the air for insufflation and listens via a Toynbee tube for the sound of air passing through the Eustachian tube. The potential for contamination of the patient’s ear by the examiner’s oral flora is evident (55).

powerful means of inflating the middle ear were also advocated, including improbably large pumps (Fig. 9) (56).

Although Eustachian tube catheterization was widely used, it was not without complication, especially given the blind placement of the instrument. Pomeroy described that:

“Great care needs to be taken not to lacerate the mucous lining of the pharynx by the catheter, for on attempting to inflate subsequently, a very annoying and possibly dangerous emphysema may result. I have reason to believe that I once lacerated the mucous membrane in attempting to introduce a catheter, and subsequently on inflating the ear I produced emphysema of the cellular tissue surrounding the posterior pharyngeal space. . . The patient could not breathe well for some minutes, and he was fearful that suffocation might result (6).”

J.S. Prout (AOS President 1886–1889) described a specialized long specula developed to view the nasopharynx transnasally which could be employed during Eustachian tube catheterization, but these were not widely used (57). Catheters were used not only for insufflation, but also for the introduction of irrigation fluid or medications (58). Solutions of saline,



FIG. 9. Powerful insufflation of the Eustachian tube with a device which would seem to deliver an improbably large volume of air (56).

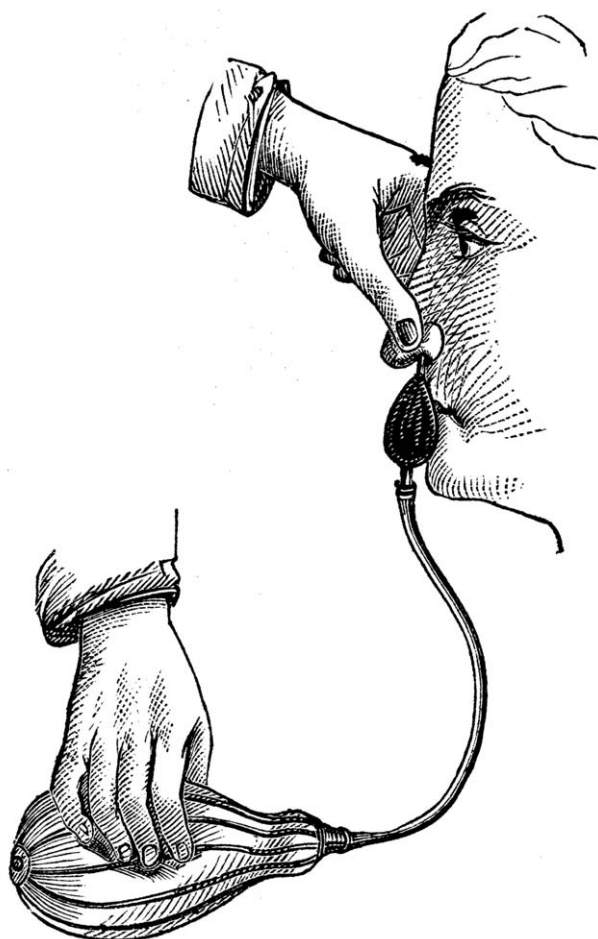


FIG. 10. Insufflation of the middle ear via a Politzer bag (3).

nitrate of silver, camphor, and ferric alum were used, as were vapors of steam, chloroform, ammonia, iodine silver compounds, and even honey (53,59–61).

Politzer's method of "inflating the drum-head" was a significantly simpler means of insufflating the ear as compared with catheterization (62) (Fig. 10). Instead of introducing an instrument into the Eustachian tube, the procedure involved placing a hand-held air bag into the anterior nasal cavity (63). Several practitioners presented their modifications of Politzer's original instrumentation. For example, Green's insufflation bag was smaller and therefore more portable. It was easier to operate, especially for, "mothers and nurses whose hands were not large and strong enough to grasp the whole bag" of Politzer's device (64,65).

Bougies were used for both therapeutic and diagnostic purposes (62). They were introduced through the lumen of Eustachian tube catheters (66). Made of luminaria, catgut, or whalebone they ranged in size from 1/3 mm to "Nos. 2 to 5 of the French scale (58,66)." Bougies were used to assess for areas of tube stricture, and also to perform tube "dilatation (67)." Medicated bougies were sometimes employed, with nitrate of silver most commonly described (66).

Assessment of Eustachian tube function was performed using Toynbee's tube (55) (Fig. 7). This instrument consisted of rubber tubing with ear-pieces at either end: one for the patient, and the other for the surgeon. With the tube in position, the surgeon could auscultate whether there was the normal entrance of air through a

functional Eustachian tube. A normal Eustachian tube, "may be best described as breezy, while that produced by more or less stenosis is squeaky and high-pitched. It is always well to use this when using the Eustachian tube and inflation bag because it is unsafe to rely on the patient's word (68)." Others felt the tube was less useful: "The diagnosis tube was used somewhat, but not relied upon as proof of inflation, it requiring too much time and practice to distinguish exactly between the sounds made in the throat and those in the tympanic cavity (60)."

With the rise of tympanostomy in the mid-20th century, focus upon instrumentation of the Eustachian tube declined markedly. The recent innovations of Eustachian tube endoscopy and balloon dilation have begun to reverse this trend.

Tympanic Membrane Perforation

Although an understanding of the mechanism of the middle ear was emerging among contemporary scientists such as Hermann von Helmholtz, many late 19th century American otologists had a poor grasp of the role of the tympanic membrane (69). In 1888, Richey opined:

"The primary purpose of the tympanic membrane is that of protection to the tympanic cavity from the influence of the air; to prevent parching and stiffening of the membrana secundaria, the joints of the ossicula, the tendons of the tympanic muscles, and to prevent loss of labyrinthine fluid by evaporation (70)."

In discussing S.O. Richey's article, Dr. Samuel Theobald dissented with the general consensus regarding the primary protective function of tympanic membrane to argue for amplification function:

"The intricate structure of the ossicles, the attachment of the handle of the malleus to the tympanic membrane, and the peculiar concavity of the latter, all point to the fact that. . . [t]he primary and most important function of the tympanic membrane, it seems to me, is to aid in the transmission of sound to the labyrinth (70)."

The significance of tympanic membrane perforations with respect to hearing was also misunderstood, with Burnett remarking that a rupture was, "not directly inferring greatly with the function of hearing (5)." Rather than a loss of the conduction apparatus, hearing impairment was thought to occur secondary to loss of the protective functions of the tympanic membrane, which would expose, "the mucous lining of the tympanic cavity to the direct irritation of the external air, and thus lead secondarily to inflammation and loss of hearing (5)."

The capacity of the tympanic membrane to heal was recognized. Burnett stated that, "[t]he drum-head. . . has great power of healing and restoration" and "tympanic disease behind the perforated drum-head should receive more attention than the simple perforation, which is but the vent for the hypersecretion resulting from disease in the middle ear (5)." Management focused on conservative measures. This included measures such as iodine of potash, pilocarpine injections, leeches, and electric currents (2). One such treatment algorithm postulated by Bacon included, "that the instillation of all drops and syringing the ear should be carefully avoided," that the patient "be kept quiet, and placed on a low diet (2)," and that inflammation be controlled.

Artificial Eardrum

The artificial eardrum came into regular otological practice in the mid-nineteenth century after seminal work advocating its

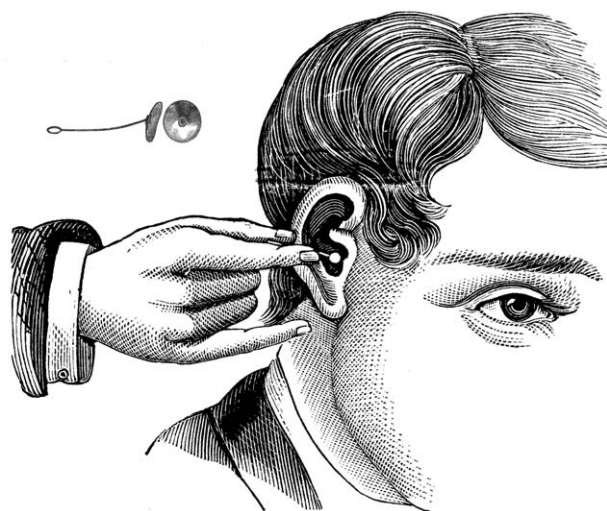


FIG. 11. Placement of an artificial tympanic membrane consisting of a wire and a rubber disk of the Toynbee design. Inset is Toynbee's device (3,55).

use by British otologists James Yearsley (1848) and Joseph Toynbee (1853) (71).

Yearsley's 1849 article "A New Mode of Treating Deafness" described his cotton pellet artificial tympanic membrane (TM), and one of his first patients stated, "To my utter astonishment I heard every sound so loud, that I felt I had never know what it was to hear until that moment (72)." This was followed shortly thereafter by Toynbee's India-rubber disk presentation (71,73) (Fig. 11).

While Yearsley stated that he "can offer nothing that is conclusive" regarding why his artificial TM improved hearing, Toynbee (who is widely viewed as the father of scientific otology) made a thoughtful conjecture:

"...it occurred to me, that as an orifice in the membrana tympani, by preventing the sonorous undulations, owing to their diffusion in the meatus, from being concentrated upon the membranes of the labyrinth, might be a direct cause of diminution of hearing power, so it was probably that increase of that power would follow an artificial closing of that orifice (55)."

Modifications included various materials (cotton-wool, rubber, collodion, silver foil, vitelline membrane of an egg, etc.), insertion tools, and wetting agents. As patients were expected to insert and remove the device after the initial fitting by the surgeon, Roosa opined that patient should, "be an adult, and possessed of a considerable amount of intelligence. . . [i]t is not of any use in the case of children, or of unusually heedless or stupid adults (3)." During the height of its popularity, the efficacy in improving hearing due to covering the perforation was widely accepted, however controversy began to arise regarding indications and contraindications for its use in a draining ear. In 1879, Hackley recommended their use only in cases with limited or no discharge, an intact ossicular chain, and patent Eustachian tube (74). By the late 19th century enthusiasm for artificial TMs gradually waned. Pomeroy stated, "Like all 'new methods' it was rather extravagantly extolled, and after a few years fell somewhat into disuse (6)."

As disfavor grew among otologists, the American public continued to invest their hope in artificial TMs for their incurable hearing loss. Supposedly miraculous "artificial eardrums" were heavily advertised to the general public in newspapers by quacks and hucksters. It was only prosecution of mail-order frauds by state and federal authorities that dissuaded unscrupulous charlatans from defrauding the American public (71).

When Blake introduced the concept of paper patching in 1888, it started a trend that would continue through the latter portion of the 19th century and early 20th century towards the introduction of microsurgical tympanoplasty in 1952 (75). At the 23rd annual meeting of the AOS in 1890, Robert Barclay recounted a series of cases to those assembled, which he claimed, "demonstrated that the paper dressing has these therapeutic advantages already claimed [over other forms of artificial TMs] (76)."

Complications of Otitis Media

Complications arising from otitis media were prominently featured during the first 25 years of the AOS. At the 4th meeting of the society in 1871, Morland presented a case of cerebellar abscess following trauma in a diseased mastoid, proposing a route of disease, "through the mastoid foramen, either directly, or by means of the circulation, the inflammation which resulted so destructively," concluding "It adds, also, another to the long list of fatal results, arising sometimes from ignorance, but too often from the culpable negligence or mistaken advice of even experienced and intelligent practitioners (77)."

Roosa shared a similar case of a cerebral abscess from suppurative disease of the middle ear, proposing that "[t]he inflammation extended to the brain through the roof the tympanum, and the cerebral abscess, which may have existed for months, had its origin from this point (78)." He cautioned others faced with similar clinical cases, lamenting, "I had neglected to embrace the opportunity to evacuate a cerebral abscess, an opportunity which if availed of might have saved a life (78)."

Merrill cautioned how rapidly diseases of the ear could spread in certain circumstances when presenting a fatal case only four days after the onset of aural symptoms, offering that, "[t]he fatal termination of the case was evidently due to the direct extension of the inflammation to the membranes of the brain through the roof of the middle ear, which in this patient was not a solid plate of bone, but cribriform in appearance (79)."

Holt presented a case of facial paralysis following otitis media, demonstrating an understanding of the relationship between the anatomy of the facial nerve through the tympanum as well as the method of insult. He stated that in cases of facial paralysis, "An examination of the ear is too often neglected and the cause of the paralysis is recorded 'a cold' or 'rheumatic (80).'" He continued: "[c]onsidering how frequently the cavity of the tympanum is subject to catarrhal inflammation, so familiarly known as earache, and how often it is neglected and forgotten, and remembering that the Fallopian canal is separated from this cavity only by mucous membrane and a thin plate of bone which is often deficient, is it not reasonable to suppose that in many cases the inflammation extends to this canal, thus exposed, and produces paralysis of the facial nerve in cases whose etiology is ascribed to indefinite causes?" (80)

Blake was faced with a similar case of a patient with purulent inflammation of the middle ear accompanied by facial paralysis, and he remarked, "a slight drawing of the angle of the mouth was noticed. A week later this paralysis was greater, and there was some difficulty in speaking - 'as if the tongue were swollen (81).'" The purulent disease improved with typical

treatment of the time, which included “the use of astringent instillations with gentle syringing, forcible syringing being not only unnecessary, but causing severe vertigo; application of the muriate tincture and of persulphate of iron to the mass (81).” For the patient’s persistent facial paralysis, Blake referred her for electric-based diagnostic and therapeutic management; “the Faradic reaction entirely gone and the galvanic reaction retained only in a few muscles about the angle of the mouth. Under continued use of the galvanic current, the muscles began to respond somewhat better (81).”

Burnett presented a case of fatal “pyaemia induced by long continued purulent disease in the middle ear and mastoid cavity. The embolic elements passed by the brain to lodge in the lung and liver, an unusual course in pyaemia from ear disease (82).” He used this case as validation for performing mastoid trephination in similar clinical scenarios, weighing the relative safety profile of surgery with potential complications of untreated disease, concluding, “in chronic purulent otitis media, on the other hand, should incline us to regard, in many cases, a prompt opening of the outer mastoid wall as the one great chance of saving the patient’s life (82).” Kipp agreed, stating he “would rather operate and not find pus than to allow the case to go on and the patient die with pus in the mastoid cells, that could have been removed readily by an operation (82).”

The intimate relationship of the emissary veins of the mastoid and the lateral sinus was well understood, with Green presenting a case of phlebitis due to untreated otitis, providing “...confirmative evidence that tenderness over the vein was due to inflammation of the vein, and that the inflammation was due to trouble in the lateral sinus (83).” Sexton quipped that, “Grave and even fatal ear disease in early life is of much more frequent occurrence, probably, than is generally suspected” when he presented cases of infant death from untreated ear disease (84). He offered, “Acute aural inflammation in children often gives rise to symptoms well calculated to puzzle the general practitioner, and hence its presence is liable to be unsuspected.” (84)

With the countless examples of complications arising from untreated otitis media, the AOS membership continued to dispel myths that aural disease was best left undiagnosed and untreated. As Sexton put it, “[t]he experience derived from the study of the treatment of this class of persons points to the necessity of the prompt liberation of pent up secretions (85).”

Mastoidectomy

In 1905, Whiting wrote:

“As a life-saving measure few surgical procedures rival and none surpass in efficiency the modern mastoid operation, the meritorious achievements of which very properly entitle it to the approbation and esteem of the appreciative public. Brilliant as are the triumphs of surgery, no brighter page ornaments its records than that which chronicles the recent remarkable progress in the diagnosis and treatment of mastoid and intracranial infective disease in the development of which the otologist, we are proud to say, has borne a by no means inconspicuous part (86).”

There is a rich and interesting history of mastoid surgery beginning with the incision and drainage of swollen, red, hot, and painful abscesses behind the ear by early barber-surgeons. But it was not until the mid-nineteenth century that it became a major part of otologic practice (87). European surgeons are credited with much of the earliest records of mastoid operations.

ON CERTAIN TECHNICAL DETAILS RELATING TO PERFORATION OF THE MASTOID PROCESS, AND THE AFTER-TREATMENT.

BY ALBERT H. BUCK, M. D., *New York, N. Y.*

In a series of communications to the “Archiv für Ohrenheilkunde”, Professor H. Schwartze, of Halle, Prussia, lays down in very clear and positive language what he believes to be the best manner of perforating the mastoid



process and of conducting the after-treatment. As is well known to members of this society, he very much prefers small gouges and chisels to the drill in accomplishing the desired object. While I hesitate, with my comparatively small experience, about disputing the correctness of the conclusions drawn by one who has already perforated the mastoid process one hundred times, I am satisfied that, so far as the form of drill commonly employed in this country is concerned, Schwartze’s condemnation is unjust. My impression is that his remarks have reference to some form of drill or boring instrument totally different from that which is pictured here and which

FIG. 12. Article by Albert Buck from American Otological Society Transaction of 1886 describing hand drill technique for penetrating the mastoid (88).

There was, however, great enthusiasm among American otologists to perform and refine surgical techniques. Mastoid surgery progressed from simple postauricular incision (Wilde’s incision) through trephination, chisel and curette, and ultimately mechanical and electric drills (88–90) (Figs. 12–14).

Buck provides some of the more detailed accounts of standard practice at the time in his textbook, where he presented 47 cases of acute inflammation of the mastoid (4). Common practice at the time would include noninvasive measures, as he wrote, “the application of heat and moisture, in the form of poultices, will often be found useful. . .they mitigate the pain in an appreciable degree (4).” Burnett preferred treatment with hydrogen peroxide through a perforation in the tympanic membrane, which he presented at the 19th meeting of the AOS in 1886 (33). Additional therapy might include the use of medicinal leeches: “[l]ocal depletion by means of leeches exerts a direct restraining influence upon the inflammation (4).”

In cases that failed to recover with these more conservative measures, it was widely accepted that the purulence of the middle ear and mastoid required drainage, as Buck stated, “[t]he establishment of an opening in the mastoid process constitutes undoubtedly the most effective procedure thus far discovered for checking an inflammation in this region, or for preventing it from spreading to important organs in the neighborhood (4).” There was, however, controversy regarding the best means by which this was accomplished, and the meetings of the AOS were often the setting of great debates.

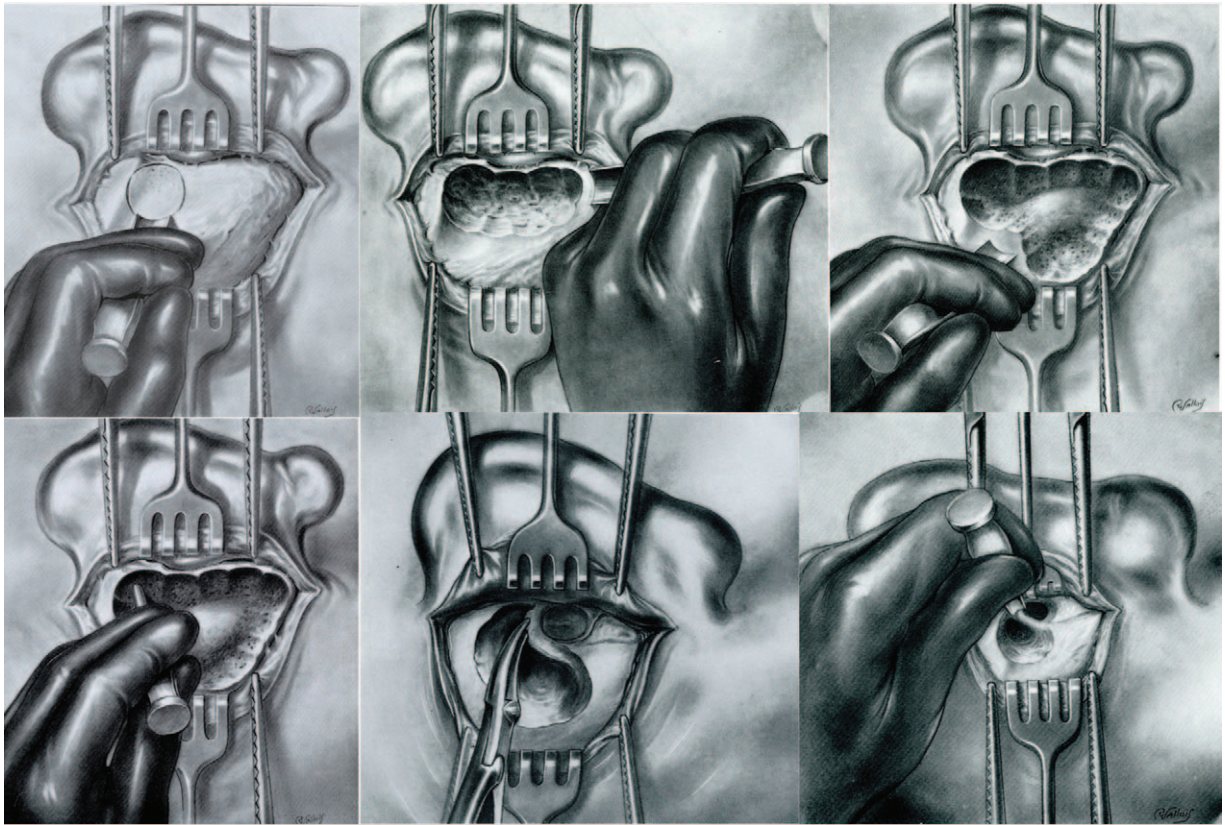


FIG. 13. Mastoidectomy performed with mallet, gouge, and rongeur. While less controlled than an electric drill, surgeons skilled with this technique were capable of anatomically precise mastoid surgery (89).

One such method would be carried out via an eponymous postauricular incision named for Sir William Wilde of Dublin, the father of author Oscar Wilde, followed by entry into the mastoid process, often via trephination with a gouge or chisel. At the 3rd annual meeting of the AOS in 1870, Agnew presented a case of mastoid trephination and remarked, “I am convinced...that mastoid-cell disease is very common in ear-diseases in adults, that it may escape and does escape attention except when the physical symptoms of its presence are very grave and conspicuous, and that we often lose time by not making an early opening” (91).

Buck presented the results of 24 of his own cases at the 19th annual meeting in 1886, 71% of which he claimed to have cured, to advocate for use of the drill over the chisel (88). It is important to distinguish contemporary otologic drills which principally use burrs from the penetrating hand drill in use at the time.

Dr. Knapp countered, “[t]he advantage of the chisel lies in the fact that at every step of the operation you can satisfy yourself of the nature of the tissue before you (88).” For the reader who considers the chisel to be a crude surgical instrument, keep in mind that it was the implement used by Michelangelo to sculpt the David. In the hands of an expert 19th century surgeon, chisels and gouges could be used with craftsmanship and relative precision. To eschew concern, “raised by surgeons in this country...that in the use of the drill there is danger of plunging it into the lateral sinus, into the brain, or into some other important part,” Buck recommended specific technical guidance that the “forefinger of the hand which guides the

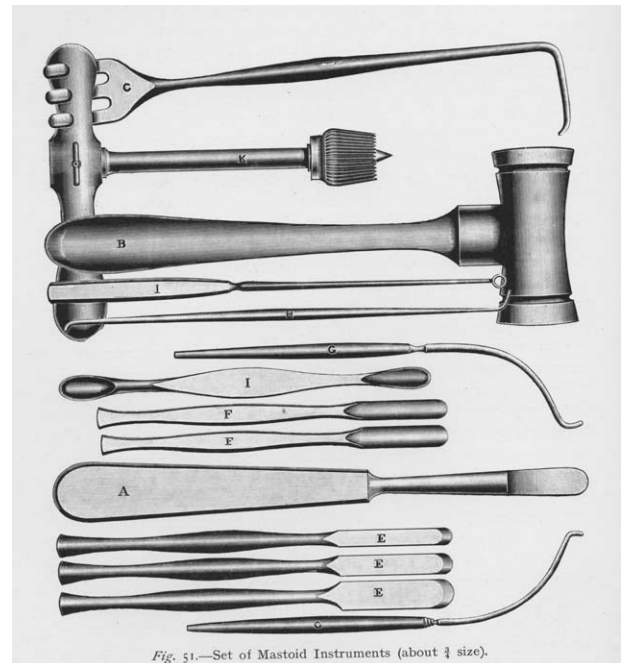


Fig. 51.—Set of Mastoid Instruments (about 1/2 size).

FIG. 14. Instruments used in mastoid surgery during the era of mallets, chisels, and gouges (90).

drill should rest firmly against the bone. If this precaution be taken, there will not be the slightest danger of our sudden plunging the sharp point of the drill into parts which might thereby receive serious damage (88)."

Sexton presented data from 2366 selected cases from over 20,000 cases of acute and chronic purulent inflammation of the middle ear and concluded, "I have never been convinced of the advantage of any trephining operations which opened up only the healthy cellular structure of the mastoid process (85)." Instead, he "favored keeping open the outlet through the tympanum into the canal rather than through the cortex of the mastoid (85)."

Later American contributions to the development of modern mastoid surgery include William Bryant of New York who reported on the notion of the modified radical mastoidectomy procedure in the AOS Transactions of 1906 around the same time as Austrian Gustave Bondy, who is generally credited as the pioneer of the procedure. Bryant failed to garner widespread acceptance for his procedure (and the credit that comes with it), likely because he failed to open the antrum while leaving the ossicles, tympanic membrane, and a portion of the superior canal wall potentially harboring disease (87,92).

Perhaps Burnett best summarized the enthusiasm for mastoid surgery towards the end of the 19th century by a quote from his 1884 textbook:

"It becomes, therefore, the duty of every conscientious practitioner of medicine to be carefully observant of the onset of an inflammation in the mastoid cavity, and prompt to relieve it; for, by so acting, he will in all probability save life, where, in similar cases, there is every reason to know that death has occurred, simply because the true nature of the mastoid disease was not recognized, and, consequently, no rational means of relief resorted to (5)."

Cholesteatoma

The term cholesteatoma was coined in 1838 by Müller and appears sporadically in the AOS Transactions of the period (93). A number of articles in the transactions refer to perforation in Shrapnell's membrane, inflammation of the attic, or desquamative inflammation (94–96). Randall pointed to the frequency of attic disease and stressed that it could be easily overlooked at otoscopy: "... my special purpose is to lay stress upon the point that perforation in Shrapnell's membrane is far from infrequent, and to claim that constant vigilance in this direction will bring to light an unexpectedly large number of cases, and in so doing will clear up not a few instances of difficult diagnosis and of exasperating and enigmatical obstinacy (95)." An understanding of the relationship between attic disease and cholesteatoma was not clearly articulated by most authors and, hampered by limitations in otoscopy at the time, the distinction between squamous pocket and actual tympanic membrane perforation was not made. In discussions of his article it was noted that Shrapnell's perforation seldom whistled, suggesting to the commentator that they are cut off from the tympanic cavity. Dr. Knapp commented that, "Cheesy masses may be located in the mastoid, which are at the bottom of these relapses (94)."

Stapedectomy

The story of stapedectomy in the United States should rightly begin in Boston, where Blake was appointed Chief of the Aural Service at the recently opened Massachusetts Charitable Eye and Ear Infirmary in 1888, and Frederick Lafayette Jack (AOS

President 1909–1910) served as his Assistant Aural Surgeon. Blake's intention was to "avail himself of the clinical material afforded by the Aural clinic" to perform stapedectomy (97). Unfortunately, he suffered an accident which led to the temporary loss of the use of his right hand, and he called upon Jack to perform these operations. These procedures were generally performed with an ear speculum, hand-held lens for magnification, and head mirror for illumination under local anesthesia, which was administered via the insufflation of 10% cocaine solution in the middle ear through a transnasal Eustachian tube catheter (97). These early procedures were performed via an incision of the tympanic membrane rather than by elevation of a flap.

"...After the incision of the membrana tympani, the incudo-stapedal articulation should be divided by means of the angular knife, the principal cutting being done from behind forward, the pressure in this direction being made against the pull of the stapedius muscle. The tendon of the stapedius muscle may be next divided, and the straight knife used for the purpose also passed around the niche of the stapes, in order to divide any adhesions; the stapes may then be extracted either by means of the hook forceps, curved forceps or by a blunt hook passed beneath the head of the stapes between the crura (98)."

The above excerpt from Blake was among the first reports of stapedectomy in the United States, which he presented to the AOS in 1892 at the same meeting that Jack reported on his own experiences (99,100) (Figs. 15 and 16). Blake ultimately attempted the procedure on 21 patients, the results of which appears in his 1906 text *Operative Otolaryngology: Surgical Pathology and Treatment of Diseases of the Ear* (7). He detailed his outcomes and noted that hearing improved in only three patients while six developed new onset of vertigo. While initially being a proponent of the procedure, these results lead him to remark: "The operation of stapedectomy, while very simple in itself, is open to question as to its advisability, because of the varied consequences which may follow invasion of the cavity of the internal ear, and because of its doubtful value for the purpose for which it is usually demanded, amelioration of an extreme degree of deafness" (7). In describing the pathology of otitis media insidiosa (otosclerosis) Blake recognized that the disease sometimes affects the inner ear in ways not remediable by surgery: "[i]t should be borne in mind, however, that the fixation which causes extreme symptoms, either of deafness or vertigo, is not infrequently only secondary to a hyperostotic process in the labyrinthine capsule, which removal of the stapes cannot relieve" (7).

Jack presented a number of cases at the same meeting of the AOS in 1892 and subsequently in 1893 and 1894, and while he noted, "there were absolutely no bad results," he ultimately concluded that the results of the procedure were not consistently beneficial (101). After compiling nearly 70 cases, Jack suggested that it was better to: "mobilize the stapes rather than remove it" and he admonished that: "most operations for mobilizing the stapes must be looked upon as largely experimental (99)."

There are obvious reasons offered for the poor initial stapedectomy outcomes including limitations in visualization and instrumentation as well as the unavailability of a replacement prosthesis. Due to poor results, stapes surgery for otosclerosis never really caught on during the 19th century and was relegated to obscurity for over 50 years. Its revival in the early era of

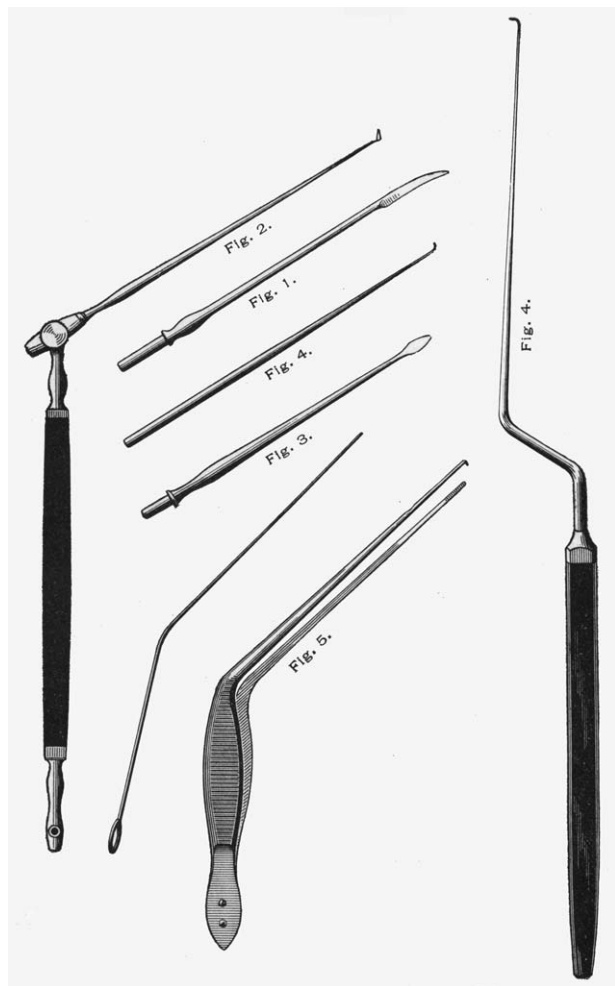


FIG. 15. Instruments used by Frederick L. Jack in performing stapedectomy in the early 1890s (99).

microsurgery came with stapes mobilization by Samuel Rosen (1952) and stapedectomy (with prosthesis) by John Shea Jr. (1956) (97,102,103). It remains an important part of the otosurgical armamentarium today.

Sensory Hearing Loss

Hearing loss has always been an integral part of the practice of otology. As expected, understanding and treatment options were limited in the nineteenth century. Presbycusis had long been observed and understood to be a part of the normal aging process, as Roosa put it at the 18th meeting of the AOS in 1885, "A certain degree of impairment or diminution of hearing power, is, I think, inevitably an accompaniment of old age, or even of life after fifty years (104)." Age fifty may seem early by today's standards, but keep in mind that the average lifespan of Americans in 1900 was 46 years for men and 48 years for women.

As otologists saw increasing number of cases, other etiologies of hearing loss were better characterized. During this early part of the industrial age hearing protection was seldom, if ever, practiced. For example, Holt examined 40 men from steam-boiler shops in Portland, Maine and deduced that they suffered:

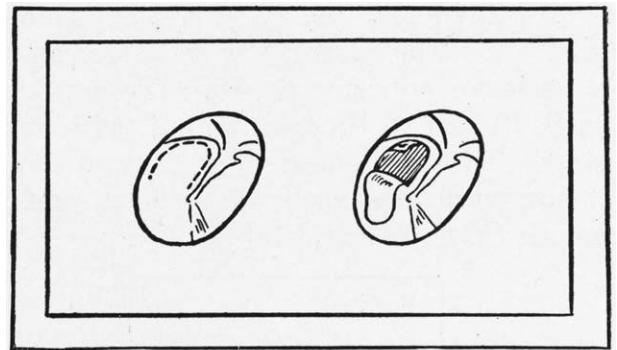


FIG. 146.—Diagrams showing line of incision, and the resulting flap, deflected.

FIG. 16. Tympanic membrane flap used for early stapes surgery (100).

"loss of hearing from constant concussions of the air produced by striking one substance against another," an affliction known as, "Boiler-maker's disease (105)."

After an epidemic of meningitis, Knapp noted high rates of profound deafness in survivors. Through his examination of various specimens, he found that in those whose hearing did not recover: "the affection that ends in total and irrecoverable loss of hearing which we notice so frequently – in about ten per cent of our latest epidemic—is an essential symptom, a homogeneous extension of the original morbid process, namely a suppurative inflammation in the labyrinth (106)." He made note that: "[t]he prognosis of the deafness consequent on epidemic cerebro-spinal meningitis, is, as far as my own experience teaches me, hopelessly unfavourable (106)."

Many other etiologies of hearing loss were considered. Morland treated several women who reported hearing loss immediately after miscarriage or childbirth, and postulated that "anaemic deafness" could be caused by excessive blood loss during labor (107). Obesity too was suspect, with a theory that: "adipose deposit, by diminishing the patency of the nasal passages as well as by pressing upon the membranous walls of the Eustachian tubes, should cause a loss of equilibrium of the atmospheric pressure within and without the membrana tympani, and consequently the symptoms . . . can be readily understood, and that a general treatment directed to the removal of the corpulence should be the remedy for the aural symptoms, follows as a matter of course (108)." Another prevalent thought of the time was that "habitual use of the telephone would be prejudicial to the hearing in many cases where the hearing was already impaired (109)."

Hearing Devices

Numerous clever hearing devices were invented in the pre-electric era including horns, trumpets, speaking tubes, pinnae inserts, and various other forms of sound collection (110,111). Due to the stigma associated with hearing impairment, many were camouflaged to fit under clothing (e.g., hats), disguised within hair or beard, within carried items (e.g., fans, parasols, walking sticks, canteens, bouquet holder), or even incorporated into furniture such as the arms of chairs (112).

During the latter part of the 19th century interest was growing in hearing devices not only among otologists but among influential inventors of the time. At the 18th meeting of the AOS in 1885, Sexton presented in conjunction with



FIG. 17. A binaural device to enable hearing impaired individuals to hear their own voice as well as that of others (117).

Alexander Graham Bell on binaural conversation tubes to assist deaf children in comparing their own voice with that of a teacher's to help acquire speech by imitation (113) (Fig. 17). This was followed by an address by Bell to the AOS President and those assembled where he applauded physicians for raising awareness of the use of hearing aids. In his experiments in schools for deaf-mutes, he noted:

“[w]e had no idea until within a year or two how large a proportion of the so-called deaf mutes in our institutions were only hard of hearing; the number is especially large among the congenitally deaf. A child is born with partial hearing, but not sufficient to enable him to acquire speech by imitation. It is now found that with artificial aides to hearing, such children can be taught to speak, and when so taught, they are only hard of hearing. . .

I think that all [deaf mutes] should be examined by competent aurists, simply for the information, if nothing more, to determine if anything can be done to benefit the hearing (114).”

Bell, whose mother and wife were both deaf, considered himself to be an educator of the deaf. His motivation in inventing the telephone was, at least in part, as an aid to the hearing impaired. His 1884 article titled, “Memoir upon the Formation of a Deaf Variety of the Human Race,” described the propagation of the disability via deaf-deaf marriages (115). Bell espoused a eugenic viewpoint manifest in support of oral education to mainstream hearing impaired children as a means of discouraging separate deaf culture and thus the trend toward intermarriage. Among the deaf community, his advocacy for assimilation was met with much controversy and consternation (116).

Pneumomassage

Massage of the ear, typically delivered through the ear canal either by compressed air or direct mechanical pressure on the malleus, was common in the later part of 19th century (117–119) (Figs. 18 and 19). In 1899, Houghton wrote:

“Aural massage is based on the same science as general massage, and implies the same art in use.



FIG. 18. Noebel's ear pneumomassager powered by a hand crank which was used for a wide variety of ear disorders (118).

Given rigid articulations, tense ligaments, wasted muscles, impeded venous or arterial circulation, dull, torpid nerve centres or terminals, then the law, the guiding rules, fixed by experience, give the indications by which the art is practiced (120).”

Houghton likened the rationale to that of traditional massage, noting: “We know that general massage gives mobility to rigid articulations, gives freedom to capsular or intercapsular ligaments, restores wasted muscles, overcomes stasis, increases destructive metamorphosis, aids nutrition, and lastly, but most vital, energizes the nerve at the centre and terminal (120).” Pneumomassage was administered by delivering alternating high and low pressure air via a sealed ear canal. There was hope that such techniques could relieve a litany of conductive

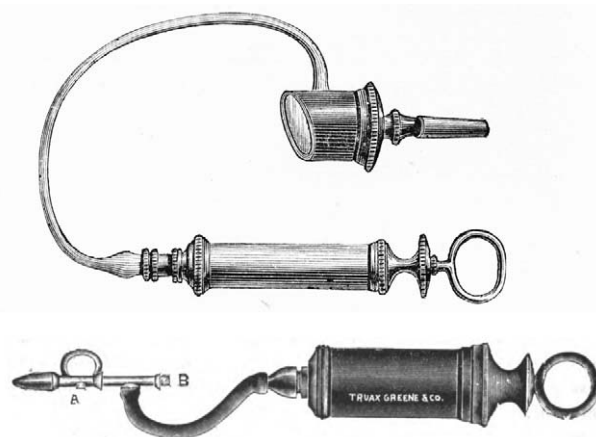


FIG. 19. Hand pump pneumatic otomassagers. Using a Siegle otoscope allows visualization of the tympanic membrane during the therapy (3,119).

forms of hearing loss, many of which were later recognized as otosclerosis. Hydrotherapy, or aural douching, was predominantly performed to clear cerumen or infectious debris but sometimes as a means of aural massage. Some proponents of hydrotherapy went so far as to recommend it as a cure for deafness (121).

While French and German otologists were the first to widely employ tympanic membrane masser, there were skeptics among the ranks of American aurists. At the 19th annual meeting in 1886 Theobald posed: "Have any of the members had favorable results from the use of any form of apparatus for rarefying and condensing the air in the auditory canal, with the idea that the drum-membrane would be moved in and out and thus rigidity of the ossicles be lessened? (122)" To this question Sexton replied: "an apparatus, consisting in a large glass ball to fit over the entire auricle, to which a little pump was attached and it was intended to accomplish the same purpose of the other rarefaction instruments. . .[i]t was the device of a charlatan well known fifty years ago (122)."

Randall, on the other hand, having presented on the subject numerous times was among the more vocal proponents. In 1901, he argued that the failure of others to obtain good results with massage was most often due to lack of air within the tympanum, for which he recommended concurrent tympanic insufflation, for which he recommended concurrent tympanic insufflation. He also argued that Siegle's otoscope was the best appliance of pneumatic massage, noting that its chief advantage was allowing the otologist to view the drum-head during treatment, thus ensuring positive results. He pragmatically remarked: "the dramatic value of electric or compressed-air manipulation will always appeal to some classes of patients and tempt the aurist who must be up to date (123)."

As an increasing number of American otologists gained experience with the practice, more began to question its indication and efficacy. In 1904, Emil Amberg argued that: "I think that it is the time to call a halt to the indiscriminate treatment of nonsuppurative middle ear affections without proper indication, or without a thorough knowledge, and consequently often with disastrous results. The subject which I am referring to is the inflation and massage of the middle ear...this massage carries with it a certain danger to the hearing, by producing a flabby membrane and perhaps by loosening the joints between the ossicles (124)."

Randall himself came to this conclusion when confronted with the indiscriminate explosion of so many massage devices, including motor driven apparatuses that he believed could lead to noise-induced hearing loss. In remarks given to the AOS in 1910, he reiterated, "so it is well to recall that the ideal form of massage is that by the voice, even though few will undertake to use it rightly (125)."

Electro-otiatrics

The employment of electricity for a variety of medicinal purposes was a rich topic of exploration for both exploitive charlatans and legitimate physicians. Electrical stimulation of the ear began with Volta in the 18th century and by the late 19th century was well enough established that the field had a name: electro-otiatrics (126). In otology during the early years of the AOS, application of galvanic current was proffered as a treatment for ailments including hearing loss, tinnitus, otitis media, and even mastoiditis. Entire books were written on the subject of electricity for the treatment of ear disease, including one by William Franklin Coleman (Fig. 20 (127)) In it, there are descriptions of "[t]he application of electricity to the treatment of chronic catarrhal otitis media. . .based upon the well-known effect of galvanism upon chronic inflammatory processes." In

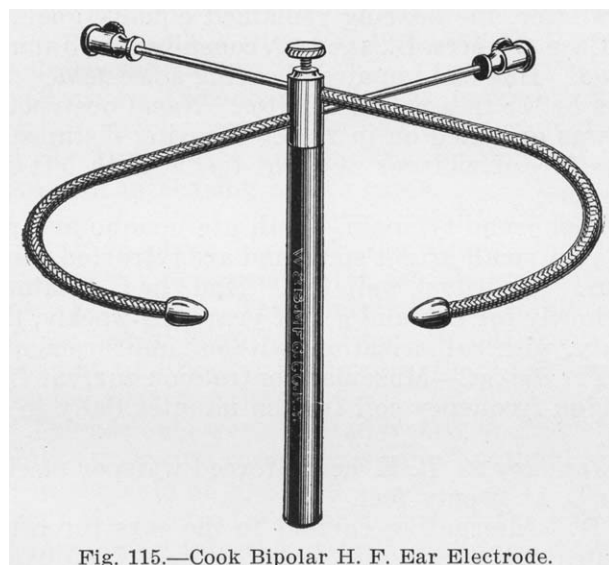


Fig. 115.—Cook Bipolar H. F. Ear Electrode.

FIG. 20. Ear electrode for delivering current in the treatment of deafness, tinnitus, and chronic inflammation (127).

diagnostic use, he recommended transillumination of the mastoid with an incandescent lamp to detect the presence of purulence or granulation, the presence of which would preclude the normal illumination expected in a healthy aerated mastoid. Coleman also described the treatment of mastoiditis with phototherapy, citing several successful cases, and concluding that, "in cases of acute mastoiditis, if caries is not present, the symptoms will yield promptly to treatment by the incandescent lamp. If they do not yield after a week or ten days' treatment, I conclude that caries exists and operate (127)."

Blake described a favorable effect of electricity upon tonal tinnitus: "the passage of the galvanic current increases not only the limit of perception of musical tones, but also the intensity of perception (128)." Often stimulation was titrated to the specific patient, with Blake advising "It will be found as a rule, that the current which diminishes the tinnitus aurium increases the hearing, and that the current which increases the tinnitus diminishes the hearing (128)." Burnett noted an effect on the opposite ear: "paradoxical formula, [which] implies a response to the electric current from the acoustic nerve of the armed as well as the unarmed ear (129)."

With increased experience, use of electricity in the treatment of ear diseases gradually faded. Robert F. Weir treated a young girl stricken deaf by an attack of measles and observed: "continuance of galvanism, however, afforded no change in the hearing (130)." Such cases led Weir and Buck to speculate that in the case of measles "the whole trouble might well be ascribed to the internal ears alone," explaining why electrical stimulation failed to benefit those patients (130). Eventually, otologists migrated away from use of electricity to treat otological diseases, but that did not deter hucksters from promoting false claims throughout the turn of the century (126).

Aural Vertigo

In 1861, Prosper Ménière noted the intermittent nature of vertiginous spells and the relation to hearing loss, which led him to conclude that dysfunction of the semicircular canals was causative (131). It was general convention in the late 19th

century to loosely apply the term Ménière's disease "to all those cases of sudden loss of hearing. . . which are associated with vertigo, tinnitus, nausea, inability to maintain one's balance, etc. (4)"

At the 7th annual meeting of the AOS in 1874, Burnett presented several cases of "so-called Ménière's disease" to expound on several points (40). He was able to observe "the various planes of the apparent motion experienced by the patient during his attacks of vertigo" and isolate it to the orientation of a particular semicircular canal. He attempted to rule out central pathology by noting that attacks of vertigo are "always accompanied, be it remembered, by perfect consciousness." He then postulated "chronic catarrh. . . induced the Ménière's disease by an extension of the proliferous disease to the semicircular canals." He concluded by stating "that, although the semicircular canals may not be devoid of acoustic functions, they seem to possess well-marked functions presiding over the pose of the head, and mediately over that of the entire body (40)."

Common treatments would include lifestyle and dietary modifications, namely "chiefly nourishing food, but avoiding excess as regards quantity of any kind of food" and the avoidance of stimulants (4). Solutions containing sodium bicarbonate and strychnine were also commonly prescribed, as well as more invasive interventions such as Eustachian tube cauterization and the application of silver nitrate to the torus of the Eustachian tube (4,5).

Due to the paroxysmal nature of aural vertigo and the apparent improvement between attacks, speculation grew that the "direct lesion cannot be in the labyrinth", but instead was due to "spasmodic affection of the muscular structures of the middle ear" causing inward pressure of the stapes onto the labyrinth fluid (5). At the 21st AOS meeting in 1888, Burnett presented a surgical intervention for relief of aural vertigo caused by Ménière's disease, which he believed was due to inward pressure on the labyrinth fluid from the ossicles and tympanic membrane. Using ether anesthesia, he excised the malleus and overlying tympanic membrane, while at the same time separating the incudo-stapedial joint and placing the incus in the attic. Two months postoperatively the patient reported "no sensation of fullness in the ear, which has so long distressed her, nor any vertigo" (41). This led him to conclude "[t]hat tinnitus and aural vertigo may be due entirely to disease in the middle ear, and therefore need not always be referred to disease of the internal ear" and more remarkably that "[w]e also see that nothing but good resulted from the operation performed in this case, and we may conclude that this would always be the result (41)."

Burnett's recommendations were immediately met with skepticism from C.J. Kipp who wrote in a comment to the article: "Lucae had performed this operation twenty-five times for the relief of tinnitus and vertigo. . . he said that he had abandoned the operation for this purpose because the results had been unsatisfactory (41)." Two years later, Burnett remained steadfast reporting that his patients sustained "permanently good results (42)." With more cases to report on by 1893, he continued, "I have long maintained the tympanic or mechanical origin of most cases of aural vertigo. . . morbid retraction of the auditory chain, and resultant cerebellar irritation, are not constant, but vary with the state of the general health and the condition of the catarrhal middle ear (43)." He postulated that, "[i]f the theory is correct that the vertigo. . . is due to the retraction of the conductors of sound and mechanical pressure upon the labyrinth fluid, then the surgical removal of

such retraction and pressure ought to relieve the tympanic vertigo (43)."

General Anesthesia in Otology

The use of local and general anesthesia was critical to allowing the early AOS practitioners to advance their craft. General anesthesia using ether, nitrous oxide, or chloroform had been in use since the 1840s, however it was not until the 1880s that local anesthesia using cocaine was developed (132,133). Ether was the most commonly used general anesthetic in aural procedures, and was "used to complete narcotism (134)." It allowed the patient to forgo the pain associated with ear surgery, and allowed the surgeon to "ensure perfect quiet of the head (135)." Chloroform was also used, but referenced much less frequently in the otologic literature. Ether inhalant anesthetic allowed otologists to progress from Wilde's postauricular incision simply to release pus to more formal mastoidectomy. According to Sexton, writing in 1876: "[A]fter the administration of chloroform, many hours' patient work with the 'American' drill" was [possible.] (136)" Nitrous oxide gas was seldom mentioned in the AOS transactions, as "owing to the spasmodic movements that usually take place when this agent is used it had to be abandoned (137)."

There was debate as to which procedures were painful enough to the patient to warrant the use of anesthesia. Some practitioners felt that all "grave operations about the ear in children should be done under anaesthetics (45)." In adults, paracentesis of the tympanic membrane to treat acute catarrh was generally not thought to be particularly painful (45). However, treatment of chronic catarrh, and in patients having operations for the "relief of deafness," general anesthesia was deemed necessary (45). Early AOS surgeons recognized the flammable potential of inhaled anesthetics, and advised that "the light afforded by an argand gas burner, or even an oil lamp, illuminates the ear sufficiently in ordinary cases; but in the more difficult ones an electric light illumination is best, especially where ether is administered, on account of the danger of its ignition from an exposed flame (24)." The comment refers to an improved oil lamp invented in 1770 by Aimé Argand which put out 6 to 10 candle power.

Local Anesthesia in Otology

Before the introduction of cocaine in 1884, cold (e.g., application of ice) was a common means of local anesthesia (138). In ear surgery morphine was sometimes infiltrated subcutaneously as a means of pain control after surgery (41). Cocaine was introduced to otology in the latter part of the 19th century and achieved some popularity: "Cocaine has demonstrated itself to be the most important local anaesthetic that medical science has yet discovered. But a few months old, in a therapeutic sense, its brilliancy of achievement has flashed like a meteor over the whole medical world (139)." It was less readily accepted in otology than in ophthalmologic or mucous membrane surgery (41,140). Otologists observed the hemostatic effects of cocaine: "the slight hemorrhage was checked by mopping the cut with a five per cent. solution of cocaine muriate (41)." In acute otitis it was said that: "...cocaine relieves the pain when used early and repeatedly," but it might "prolong the congestion (141)." Cocaine's side effects and abuse potential among physicians (e.g., Halsted, Freud) were also observed: "Impaired health and temporary insanity are attributed to the excessive use of this drug. . . Abuse of a remedy as potent for evil as it is powerful for good. Already the cocaine

habit has supplanted the morphine, alcohol or chloral habit (139).”

Antisepsis in Otology

Joseph Lister introduced antiseptic technique in 1867, marking a dramatic shift in the landscape of surgery that had previously been limited by the lack of sterility since the time of antiquity. Lister first described the use of carbolic acid, initially poured onto skin or by packing acid-soaked lint into wounds (142). Despite successes reported from centers across Europe, adoption was initially mixed in the United States. There have been several reasons offered for this. One prevailing thought was that American and European hospitals were intrinsically different, and that infection was due to overcrowding in European cities. John Mason Warren, an American, explained that, the “impaired hygienic condition...[was] consequent [of] crowding. . .for it is only necessary to travel a few miles into the country to find again the same favorable influences (142).”

Dismissive opinions in America were numerous and vocal. In an 1876 centennial celebration essay commemorating American influence to the field of surgery, eminent Philadelphia surgeon Samuel D. Gross, subject of a famous painting by Thomas Eakins and President of the International Medical Congress, opined: “Little, if any faith, is placed by any enlightened or experienced surgeon on this side of the Atlantic in the so-called carbolic acid treatment of Professor Lister (143).” Despite skepticism regarding the need for antisepsis and the slow rate of adoption, there were early American proponents. Edmund Andrews, a Chicago surgeon, after a tour of London in 1867 offered, “if it is a settled thing that an English hospital must not be ventilated, I think carbolic acid may be a good thing, as being, next after fresh air, the best preventative of pyaemia. It is powerfully antiseptic, and if it will prevent suppuration, it may be very valuable in cases of hectic exhaustion (142).”

Despite the slow, yet inevitable, adoption of asepsis among other surgical fields, otologists lagged behind. That is not to say there were not early adopters. In describing the removal of exostosis, Burnett referred to the use of carbolic acid, “I proceeded to remove this obstruction, as follows: First, five minims of a 5% solution of hydrochlorate of cocaine were injected hypodermatically into the concha near the exostosis; the tumor and the adjacent parts, as well as the instruments, were mopped with a 5% solution of carbolic acid (18).” One potential reason offered for the poor adoption of asepsis in otology is that during this era one of the main purviews of the aural surgeon was the treatment of grossly infected patients, often with purulent middle ears or infected mastoids. J. Holinger admitted as much in an 1896 JAMA article critical of the field of otology, stating, “there is no physician who comes so much into contact with putrid and virulently infective material as the otologist (144).” This, he argued, made aseptic technique more critical for the diagnosis and treatment of the ear. He argued that, “The principles of asepsis should be carried out in otology in the routine examinations of the ear, and especially in the seemingly unimportant details of ambulatory practice.” To further illustrate the point, he shared an old saying “As soon as you treat (with non-sterilized instruments) an acute suppuration of the ear, it becomes chronic.” He remained critical of carbolic acid, stating it was not strong enough for disinfection and useful only as a means to “lull our consciences.” He offered the following: “. . .practical rules for aural work:

1. Every instrument should be so constructed that it can be easily cleaned and examined.
2. Before every examination the instruments (speculum, probe, catheter, middle ear instruments) should be sufficiently boiled, and immediately after use they should be washed in cold water, so that the pus, mucus and blood may not coagulate and dry on them. Of course, it goes without saying that the hands must be kept clean according to the general rules of asepsis (144).”

DISCUSSION

The founder generation of the AOS saw their time as one of enormous progress during which interest in ear disease was kindled and new methods were enthusiastically explored. The latter half of the 19th century saw a transition in attitudes toward management of ear diseases from one of therapeutic nihilism to one of interventionism enabled by newly introduced anesthetic techniques which allowed less rushed and more meticulous surgical procedures. This newfound ability led to spirited and sometimes excessive use of operative approaches. For example, during this era resection of the tympanic membrane and ossicles was put forward as a highly successful “cure” for maladies as diverse as chronic otitis media, otosclerosis, tinnitus, and Ménière’s disease.

The spectrum of diseases reported upon in the Transactions focused primarily upon the external and middle ear with little attention to inner ear or the deeper regions of the temporal bone. Articles published in the AOS Transactions focused principally upon chronic otitis media, tympanic membrane perforation, mastoiditis, complications of ear infections, fatal cases of ear infections, cerumen, foreign bodies of the ear canal, and lesions of the auricle. Scant attention was focused on sensory hearing loss and vestibular disorders. In terms of surgical procedures, greatest attention was placed upon mastoidectomy, myringotomy, and destructive procedures such as resection of the tympanic membrane and ossicles. Medical therapy was principally topical, primarily application of powders, purges, and potions with few systemic therapies (e.g., arsenic, strychnine, mercury, quinine). Inflammation was sometimes countered with leeches. Overall, the primary occupation of the otologist was to fight infection, as it was for all of otolaryngology, a circumstance which would continue until the 1950s.

This was an era during which anecdote was the rule. Reports typically emanated from single surgeon’s series with no tendency to aggregate data across centers. Similar to today, reports of surgeries are often focused upon successful outcomes with few articles reporting upon techniques which were tried but failed to help the patient—or worse. The field of audiology had yet to develop and hearing testing relied upon tuning forks, whistles, whispers, and ticking watches. The lack of objective and reproducible means of recording hearing levels impaired the ability to evaluate the effectiveness of treatment upon hearing and thus the auditory implications of treatment we deemphasized.

The tonality of discourse during AOS sessions of the late 19th century was more acrimonious than today. This tendency was echoed in written scholarship, which were sometimes laced with dismissive and harshly critical opinions of colleagues bearing contrasting opinions. There was also a tendency to be more dramatic in written scholarship than typical in current style, which tends to be more formal and moderated. Case reports at the time were more comprehensive than today and often contained florid descriptions of a patient's suffering chronicled day by day with his ultimate demise despite the valiant efforts of the practitioner.

While we refer to the practice otology in America, in reality we are describing the level of practice by a mere handful of specialist practitioners in major Northeastern cities, principally New York and Boston. It was not until well into the 20th century that more advanced otological practices permeated most regions of the nation. The participation in AOS by Alexander Graham Bell, inventor of the telephone, illustrates the forward-thinking ethos of the founder generation. They were intrigued by its potential as an aid to the deaf. America did not assume a leading role in shaping otological practice until the latter half of the 20th century when innovations such as stapedectomy, cochlear implantation, and microsurgery of acoustic neuroma arose principally in the new world.

In many ways it is remarkable how much 19th century otologists were able to do without technologies central to the contemporary practice of otology such high resolution imaging, operating microscopes, high speed electric drills, standardized audiometric testing, and, of perhaps most importance, antiseptic technique and effective antimicrobials. It would be erroneous for contemporary observers to smugly conclude that our forbearers lacked understanding of pathophysiology of ear diseases and that they practiced ear medicine and surgery crudely with at most limited beneficial effect. This is all a matter of perspective. So-called "modern methods" are just that, the state-of-the-art for a given period in time.

At the tercentennial of the AOS, 150 years from now, our early 21st century advanced technology and sophisticated biological targeted therapies will appear naïve and ignorant to our late 22nd century successors. We hope that future historians of otology will be charitable, as we have attempted to be, in recognizing the achievements of the present era in their proper context.

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