Early Conquest of the Rock: Julius Lempert's Life and the Complete Apicectomy Technique for the Treatment of Suppurative Petrous Apicitis

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Abstract

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- ▶ skull base

Julius Lempert (1891–1968) was one of the most revolutionary and innovative neuro-otologists of the 20th century. He had a remarkable role in advancing the field of otolaryngology to its modern shape and form, especially through his groundbreaking introduction of the fenestration procedure for the treatment of otosclerosis. Although he is highly celebrated by many neuro-otologists for his contributions to our surgical and anatomical understanding of the petrous bone, he is not well known to the neurosurgical community. In this article, we give a detailed account of Dr. Lempert's life and discuss his invaluable contribution to skull base petrous bone anatomy and surgery through his pioneering work on the complete apicectomy for the treatment of suppurative petrous apicitis.

The concept of a “petrous” approach is intimately tied with the names of the skull base pioneers who expanded and perfected surgery within and around the petrous bone to gain access to difficult intracranial spaces. In 1970, King¹ popularized the transtentorial modification to the transpetrosal approach, and House and Hitselberger² introduced their transcochlear complete petrosectomy approach with transposition of the facial nerve in 1976. Subsequently, in 1980, Jenkins and Fisch³ introduced a modified total petrosectomy approach in which the facial nerve was skeletonized in its canal to mitigate the chance of postoperative facial nerve palsy. King's transpetrosal approach was expanded by Hakuba et al⁴ with a combined infra- and supratentorial exposure that served as a predecessor to the more modern labyrinth-sparing posterior petrosal presigmoid retrolabyrinthine approach introduced by al-Mefty et al.^{5,6} Kawase et al⁷ introduced the extradural anterior petrosectomy approach to the petroclival region allowing access to the prepontine and interpeduncular cisterns in 1985 with a

landmark article detailing the use of the approach for the treatment of two patients with basilar tip aneurysms.

We duly honor these surgeons for their contributions to our understanding of petrous bone anatomy and surgery, but we forget to commemorate the much earlier ideas, concepts, and works of a man who explored the petrous bone in a most meticulous and calculated manner. By completing his explorations via a different route, Julius Lempert broadened and enhanced our understanding of petrous bone surgical anatomy and its relationship to nearby vital neurovascular structures. Lempert was one of the most colorful pioneering neuro-otologists, whose contributions to refining and enhancing our surgical and anatomical understanding of the petrous bone are not well known to the neurosurgical community. In this article, we give a detailed account of Lempert's life and discuss his invaluable contribution to skull base petrous bone anatomy and surgery through his pioneering work on the complete apicectomy for the treatment of suppurative petrous apicitis.

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Fig. 1 Photograph showing a young Julius Lempert shortly after his arrival in the United States (left). Photograph showing Lempert with his headlight in hand (right). (Reproduced with permission from http://www.michaelglasscockiii.com/21/Julius_Lempert.htm)

Julius Lempert's Early Years

Julius Lempert was born in Lublin, Russia (now Poland), on July 4, 1890 (► **Fig. 1**). In 1905, because of rising unrest there, the family moved to New York City, settling on the Lower East Side of Manhattan.⁸ Many of his friends growing up became famous entertainers, such as the songwriter/Broadway producer Billy Rose, and Lempert later married Flo Kennedy of the Ziegfeld Follies (a series of elaborate theatrical productions on Broadway from 1907 through 1931) in 1930.

Julius went directly from high school to Long Island Medical School. After graduation, he spent his time visiting the Manhattan Eye and Ear Infirmary and New York University residency programs but did not have a formal residency. By 1924, he had overstayed his allotted time and was asked to stop visiting those institutions.^{8–10} He opened an otolaryngology/ear, nose, and throat (ENT) practice and offered to pay out half of any fee collected back to the referring physicians, which immediately made him the busiest ENT surgeon in New York City. At the time, ENT consisted mostly of a practice resembling an assembly line of adenoidectomies, tonsillectomies, and mastoidectomies.

Early Improvements

While the rest of the ENT community ostracized him, Lempert was amassing great wealth for himself and gaining great expertise. Lempert opened his own hospital near Lenox Hill Hospital, which he called the Lempert Institute of Endaural Surgery. There, he did hundreds of mastoid operations using both postauricular and endaural incisions. Lempert was a visionary who made countless improvements to the field of ENT. Among them is the one-step fenestration technique for treating otosclerosis.¹¹ He also was the first ENT surgeon to

use a personalized headlight while others continued to use overhead lights. In addition, he substituted a dental drill for the crude chisel-and-mallet method of performing a mastoidectomy and wore magnifying loops for improved visualization (► **Fig. 2**). He had an inventive and creative sense with an artistic mind that allowed him to be innovative and incorporate different tools and methods while maintaining a safe practice.

Before the development of the one-step fenestration of the lateral semicircular canal to restore conductive hearing loss, patients were given large and ghastly hearing aids that barely made any difference.^{9–12} With the one-step fenestration technique, Lempert reported 23 cases of hearing restoration.^{13,14} Two years earlier, in 1936, he had introduced the

Fig. 2 Photograph showing Julius Lempert being gowned for surgery at the Lempert Institute of Endaural Surgery. (Reproduced with permission from http://www.michaelglasscockiii.com/21/Julius_Lempert.htm)

complete apicectomy approach in a detailed methodical form delineating all the faces of the petrous pyramid with an anatomical description of the location of the internal carotid artery (ICA) as it courses through the apical carotid portion of the petrous bone as well as the location of the labyrinth.^{15,16} As other surgeons recognized the success of these procedures, Lempert developed the very first organized temporal bone courses to share his techniques (→ Fig. 3).

The partial hearing restoration that Lempert's fenestration procedure offered lost luster after Rosen's introduction of the stapes mobilization technique that offered immediate hearing restoration in a larger number of cases with near-perfect hearing.¹⁷ Shea's stapedectomy and strut placement for the treatment of otosclerosis would hand Lempert's technique a final blow.^{18,19}

Complete Apicectomy for Suppurative Apicitis

Lempert's complete apicectomy for the treatment of suppurative petrous apicitis was another progressive technique. Suppurative petrous apicitis is the purulent infection and inflammation of the petrous apex that usually result from ventral extension of purulent mastoiditis. Its clinical syndrome (Gradenigo syndrome) consists of periorbital unilateral pain related to trigeminal nerve involvement, diplopia due to sixth nerve palsy, and persistent otorrhea associated with bacterial otitis media.²⁰ Although it is seldom encountered today because of advancement in imaging and more effective antimicrobial therapy, petrous apicitis was a common ailment in the 1930s.

The type of surgery necessary to eradicate petrous apicitis was the subject of much discourse and controversy. Whereas simple drainage was accepted as the conventional way of treating petrous apicitis, Lempert advocated full exenteration of the petrous bone including its very apical portion. He fought the mainstream way of thinking and criticized the proponents of drainage for their lack of understanding of petrous bone anatomy. Lempert wrote about his distaste with the status quo: "[There is a] disorganized application of nomenclature to the anatomic structures of the petrous portion of the temporal bone and to the disease of its various portions... Today, when disease within different portions of the petrous pyramid is recognizable and specific surgical

measures for the relief of localized pathologic processes are possible, the anatomic descriptions of the petrous pyramid to be found in anatomic text books are inadequate for the requirement of surgical intervention."¹⁶

Lempert had a strong intuition that drainage was inadequate and that there was a need for full exenteration of the petrous bone that depended on a robust understanding of petrous bone anatomy. He made a clear distinction between congestive and suppurative apicitis. Whereas the former can be watched and treated with antibiotics, the latter, comprising ~20% of cases, necessitated surgical intervention because there is a tendency for intracranial extension and subsequent meningitis.^{20,21} Lempert contended that surgeons who believed that suppurative apicitis could be treated by a simple mastoidectomy and drainage of more posterior portions of the petrous bone at the petrous-mastoid junction had falsely made that attribution because in many cases they were in fact treating congestive apicitis, which could have been treated conservatively. According to Lempert, roentgenologic evidence of suppuration should push the surgeon to perform aggressive surgery.¹⁵

To support his seemingly radical stance on the surgical treatment of petrous apicitis, Lempert likened surgery on the petrous apex for apicitis to that on the mastoid bone for mastoiditis. To that end, he wrote, "Apicitis, like mastoiditis, doesn't always become suppurative. ... This type of apicitis does not require surgical intervention in the petrous pyramid any more than congestive mastoiditis needs surgical intervention within the mastoid process. When definite suppuration ... is recognized clinically and roentgenologically, there is an imperative need for immediate surgical intervention within the apical carotid portion. ... I am profoundly convinced that ... there is to be no middle course. Surgery is the only treatment to avoid suppurative meningitis."¹⁶

Lempert felt that avoiding surgery on the petrous bone with the aim of complete eradication of infection was "a surgical sin of omission." He wondered which portions of the petrous bones were actually being targeted with myringotomy and simple mastoidectomy, and during which stage of disease most ENT surgeons were performing this. In essence, two very simple beliefs led him to disagree with the mainstream strategies. The first was the basic principle that for

Fig. 3 Photographs showing visiting students attending Lempert's annual temporal bone course (left) and Lempert lecturing in his laboratory (right). (Reproduced with permission from http://www.michaelglasscockiii.com/21/Julius_Lempert.htm)

suppurative apicitis, the target should be the petrous apex rather than the mastoid. The second was his strong conviction that a surgeon should not wait for signs and symptoms of impending intracranial involvement before intervening surgically, just as one should not wait with acute suppurative mastoiditis in which the chances for intracranial extension were even more remote.¹⁶ Criticizing the accepted conventional method of treating petrous apicitis via simple mastoidectomy and drainage, Lempert remarked, "Those procedures ... do not permit a complete exenteration of the lesion within the apical carotid portion of the petrous pyramid, nor do they afford a means of approach for drainage of an epidural abscess ... Furthermore, these procedures do not permit a full inspection of the entire interior of the apical carotid portion or the petrous pyramid."¹⁶

Approach to the Petrous Apex

Lempert's conviction about the importance of getting to the petrous apex and being able to explore its walls fully and adequately to treat suppurative petrous apicitis came about through what he described as several stages of evolution in mindset. According to Lempert, he was first caught in a laissez-faire attitude masquerading as conservative otology because of a simple lack of knowledge. The second stage of evolution consisted of a rationalizing self-defensive conservatism with a comprehension of what was needed but not knowing how to approach it. The final stage involved an understanding and acknowledgment of the works of Koptetzky and Almour for the drainage of petrous apicitis and comprehending the limitations of the technique.^{15,16,22,23}

Lempert divided his approach into several stages. The first stage involved performing a complete mastoidectomy to expose the base of the petrous pyramid.²⁴ This involved drilling the mastoid bone until the lateral semicircular canal was exposed. Stage 2 consisted of the severance of the petrous base from the mastoid process by removing the inner bony table of the mastoid process covering the sigmoid sinus, exposing the dura of the middle fossa, removing the bony table roofing the tympanic cavity, and exposing the dura of the posterior fossa through the Trautman triangle. Inspection of the labyrinthine portion of the petrous bone constituted

the third stage. This involved gently separating the posterior fossa dura from the posterior surface of the petrous bone, which allowed the basal labyrinthine portion of the petrous bone internal and anterior to the posterior semicircular canal to be inspected for pathologic change. The superior surface of the basal labyrinth was simultaneously inspected by gently elevating the temporal middle fossa dura, which also allowed for examination of the tegmen tympani. The last and fourth stage involved creating an approach to the apical carotid portion of the petrous pyramid.¹⁶

In devising his approach to the apical carotid pyramid, Lempert had the following important goals in mind: (1) Creating a practical and adequate spacious field of view to permit free instrumentation and surgical manipulation under direct vision aided by proper illumination; (2) reducing the distance existing between the apical carotid portion and the outermost edge of the wound to a minimum; and (3) fully exposing the petrous internal carotid artery as a guide to work through the apical carotid portion of the petrous pyramid. Lempert performed the approach with microsurgical technique that he borrowed from his fenestration procedure, using the electric drill and under loop magnification. According to Shambaugh, "the fenestration operation played a vital role in the birth and development of microsurgery of the temporal bone."¹²

After the mastoidectomy was completed and the basal labyrinth was inspected through a retroauricular incision (→Fig. 4A), the incision was supplemented with either an endaural incision overlying the squamous temporal bone that stretches from the uppermost part of the anterior wall of the external auditory canal along the entire line of attachment until it emerges from the external auditory canal at the junction of the inferior and anterior canal walls (→Fig. 5A) or with an extension of the original retroauricular incision anteriorly over the squamosal portion of the temporal bone (→Fig. 5B). The auricle was then retracted posteriorly or anteriorly depending on whether an endaural or retroauricular extension was performed, respectively. Next, the entire posterior root of the zygoma was removed all the way to the anterior superior wall of the external auditory canal with an electrical round burr. The tegmen tympani was then completely removed with a curette until the mouth of the

Fig. 4 Illustrations from Lempert's paper detailing (A) the mastoidotomy disclosing the tegmen of the sigmoid sinus posterior fossa, middle fossa, lateral semicircular canal, oval window, round window, and the facial ridge. (B) Further exposure of the middle fossa dura, removal of the entire posterior root of the zygoma, removal of the peri-eustachian tube cells, and destruction of the semicanal for the tensor tympani muscle. (C) The tympanic ascending portion of the internal carotid canal is exposed by removing the tympanic bony wall of the posterior nonarticular surface of the mandibular fossa. (Reproduced with permission from Lempert.¹⁶)

Fig. 5 Illustrations showing Lempert's supplementary incisions for apicectomy. (A) The endaural incision in the anterior wall of the external auditory canal and the incision over the squamosal portion of the temporal bone. (B) Extension of the existing postauricular incision (labeled AB) over the squamosal temporal bone. (Modified with permission from Lempert.¹⁶)

eustachian tube and the semi-canal of the tensor tympani muscle were exposed. The lower border of the squamosal temporal bone was removed to allow for easy access to the middle fossa floor to allow some retraction of the temporal lobe affording added space for instrumentation with the apical carotid portion (► **Fig. 4B**). The peri-eustachian tube cells were exenterated, and the mouth of the eustachian tube was widened before the tensor tympani muscle was removed. Finally, the outer wall of the anterior bony surface of the external auditory canal was accessed posterior to the mandibular surface and the adjacent soft tissue was carefully dissected anteriorly toward the mandible. The entire tympanic bony part of the anterior wall of the external auditory canal was then removed in a piecemeal fashion along with as much of the tympanic bony wall of the posterior nonarticulating part of the mandibular fossa as possible to reach the petro-tympanic fissure (► **Figs. 6 and 7**). In doing so the entire tympanic ascending portion of the ICA lying in its bony canal

Fig. 6 Illustration from Lempert's paper demonstrating the existing surgical space between the nonarticular posterior part of the mandibular fossa and the mandible. A indicates the space between the mandible and the tympanic bony anterior canal wall; B indicates the nonarticular part of the mandibular fossa; C points to the petrotympanic fissure. (Reproduced with permission from Lempert.¹⁶)

anterior and internal to the promontory was exposed (► **Fig. 4C**).

Lempert had a clear understanding of the importance of exposing the petrous carotid artery: to use the carotid as a guide through the apical wall of the petrous bone because its petrous course is constant and to protect the ICA from direct injury. His understanding of the different segments including its point of entry through the skull base, its orientation within the petrous bone, and its final emergence from the anterior internal orifice at the very apex allowed him to comfortably maneuver intrapetrosally to the petrous apex while exploring and exenterating the apical pyramid walls. As he wrote,

This course of the internal carotid artery through the apical carotid portion is of great importance and assistance in the performance of a complete apicectomy. A complete exposure of the internal carotid artery and its employment as a guide is the only true way to reach and exenterate successfully every part of the apical carotid portion of the petrous pyramid, and, the best means to avoid injury to the internal carotid artery. Just as the sigmoid sinus in its course through the mastoid portion of the temporal bone acts as a guide to complete exenteration of the mastoid process, so must the internal carotid artery in its course through the apical portion of the petrous pyramid act as a guide to complete exenteration of the apical carotid portion of the petrous pyramid.¹⁶

Exposing the Petrous Internal Carotid Artery

The final part of the procedure involved exposure of the petrous carotid artery. This was performed by initial removal of the outer bony wall of the carotid canal with a sharp curette beginning with the ascending tympanic end exposing the artery along its vertical course until the canal curves forward and medial to begin its horizontal course along the anterior-superior wall of the apical carotid portion of the petrous pyramid (► **Fig. 7**). Lempert described a triangular tent-like space between the anterior-superior and posterior walls of the apical carotid petrous portion with the inferior surface as its base where the cellular structures could be found lying partly superior and mostly posterior to the horizontal portion of the carotid canal.¹⁵ According to Lempert, the cell exenteration of this spaces starts at the point where the ICA bends and begins its horizontal course forward and medially.^{15,16} With a small sharp curette, he carefully removed the outer carotid canal and exenterated each cell 1 mm at a time by curetting supero-posteriorly to the upper edge of the inner wall of the carotid canal. This was performed in a stepwise manner following the course of the petrous ICA until the entire apical portion of the carotid artery was exposed up to its upward bend where it makes its exit from the very apex of the apical carotid portion (► **Fig. 7**). Lempert described a small bony structure separating the cochlea from the intracranial ascending portion of the carotid measuring ~ 2 mm in its widest dimension, which,

Fig. 7 Postmastoidectomy and exposure of the retromandibular space. (A) The posterior arch of the zygoma has been drilled off, exposing the vertical tympanic segment of the internal carotid artery (ICA) up to its medial turn before starting its horizontal course through the petrous bone. (B) Removal of the tegmen tympani along the middle fossa floor followed by widening of the eustachian tube and drilling of the peri-eustachian air cells around the vertical and early petrous segment of the ICA to help define the petrous course of the ICA and afford extra working space. (Reproduced with permission from the Department of Neurosurgery, University of Utah.)

when removed, allowed the floor of the apex to be flush with the jugular dome. This area is most likely the anteriormost portion of the petrous apex. Lempert noted that complete apicectomy with deliberate removal of the posterior inner

wall of the petrous carotid afforded access to the dura of the posterior fossa for direct surgical drainage of the “cisterna pontis and interpeduncularis.” In fact, Lempert even remarked that this approach to the anterolateral posterior

fossa could be used for the treatment of inferior petrosal sinus thrombosis.^{15,16}

As early as 1936, Lempert was capable of methodically and meticulously reaching the very apex of the apical carotid portion of the petrous bone through the complete and elegant exposure of the entire course of the petrous ICA. In effect, he brought to light knowledge and surgical understanding of invaluable skull base anatomy and fundamental neurovascular relationships that we continue to use today. Although Lempert had an ENT perspective to his approach because he followed an exocranial intrapetrosal approach to the apex, he nonetheless could visualize the petrous carotid anatomy from an intracranial perspective and was comfortable exposing the posterior internal wall of the petrous carotid and the prepontine cistern. His experience, expertise, and temporal bone courses educated and influenced generations of neuro-otologists and neurosurgeons who continued to improve and perfect temporal bone surgery.

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