

Complications During Endoscopic Ear Surgery

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ABSTRACT

Complications in endoscopic ear surgery and microscopic ear surgery can appear in both techniques. Whether complications occur more often in endoscopic ear surgery or microscopic ear surgery depends mostly on the skills and learning curve of the surgeon. Endoscopic ear surgery is a safe surgical technique with few reported complications hence the importance of understanding them to prevent and manage them. Nevertheless, intraoperative and postoperative complications may occur, including neurosensory deafness, direct injury to the ossicles, facial nerve palsy, labyrinth fistula, and dura injury.

Keywords: Endoscopic middle ear surgery, thermal effects, direct ossicle injury, facial nerve palsy, jugular bulb injury, dura mater injury

Bleeding

Bleeding is more of an inconvenience than a complication except in cases of external auditory canal (EAC) skin injury or trauma to the jugular bulb.¹⁻³ Good knowledge of vascular anatomy is a prerequisite (Figure 1).⁴

In the confined space of the EAC and the middle ear (ME), control of bleeding is essential in endoscopic surgery. This is probably the main charge made by opponents of endoscopic surgery for whom microscopic surgery frees up 1 hand to provide a dry surgical field by blood suction.

How to prevent bleeding?

- Procline patient position to lower venous pressure (anti-Trendelenburg position) and ipsilateral shoulder lowered for easy access.⁵
- Infiltration of the posterosuperior part of the EAC with vasoconstrictors mixed with a local anesthetic and use of diluted epinephrine (1:20 000, 2% mepivacaine),⁴ 1% ropivacaine, and 1:50 000 adrenaline.⁷
- Good understanding with the anesthesiologist to keep blood pressure low and use of intravenous clonidine premedication.⁴

How to control it?

- Monopolar cautery at its lowest intensity to elevate the tympano-meatal flap,
- Topical application of cottonoids soaked in a 1:1000 epinephrine,
- Saline flush,
- Washing with hydrogen peroxide (H₂O₂),
- Electrocoagulation with bipolar forceps at reduced intensity (10%),
- Wait.

Ansuetz⁴ reports his results on a study of 104 patients in whom he measured a bleeding score during endoscopic ear surgery (EES) for various pathologies. He concludes that bleeding is statistically more abundant in cases of inflammatory pathology and high mean blood pressure. Comorbidities according to the American Society of Anesthesiology, ASA scale, do not influence bleeding. In the EAC, bleeding is more frequent in the posterior superior part in 40%, whereas in the ME, outside the pathology, it is at the level of the anterior malleolar ligament which is more frequent (20%).

Quantifying bleeding remains very subjective and surgeon dependent. The Modena team proposes a score to assess the quality of the operating field, the Modena Bleeding Score⁵ (Table 1).

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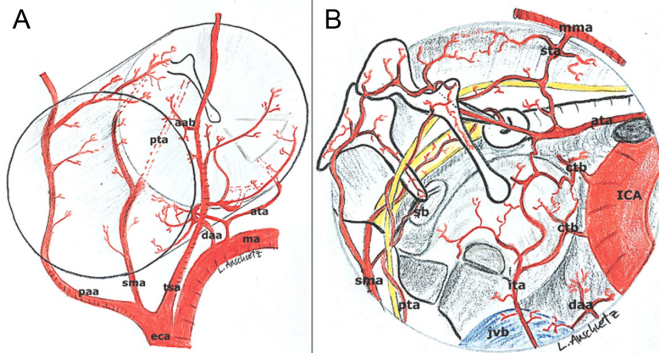


Figure 1. Schematic illustration of the vascular supply for the external auditory canal (A) and middle ear cleft (B). aab, anterior auricular branches; ata, anterior tympanic artery; ctb, carotid tympanic branches; daa, deep auricular artery; eca, external carotid artery; ICA, internal carotid artery; ita, inferior tympanic artery; jvb, jugular vein bulb; ma, maxillary artery; mma, middle meningeal artery; paa, posterior auricular artery; pta, posterior tympanic artery; sb, stapedia branch (from sma); sma, stylomastoid artery; sta, superior tympanic artery; tsa, temporal superficial artery. Lukas Anschuetz.

Thermal Effects

Complications secondary to the introduction of a heat source in a confined space such as the ME were unknown to the ear surgeon using the microscope, whereas they are feared by sinus surgeons. The tip of the endoscope can reach high temperatures within seconds and cause intralabyrinthine disorders by denaturation of collagen such as sensorineural hearing loss, vertigo, and tinnitus. Some transient facial paralysis could be as a result of heat exposure.² Thermal effects on human temporal bone models maintained at a temperature of 36°C with different sources, such as xenon and light-emitting diode (LED), have been well studied.⁸

Here are their conclusions:

- an endoscope maximally powered by xenon or LED source resulted in a fast temperature rise to 46°C within 0.5-1 mm from the tip of the endoscope within 30-124 seconds (Figure 2),
- elevated temperatures occurred up to 8 mm from the endoscope tip,
- temperature decreased rapidly within 20-88 seconds of turning off the light source or applying suction.

Ito et al⁹ have compared the tip temperatures of different endoscope diameters 2.7 and 4 mm powered by both xenon

Main Points

- Good knowledge of the endoscopic anatomy of the middle ear is an evident prerequisite, but knowing the tools and instruments and their harmful effects is necessary.
- Respecting the limits, indications, and contraindications of this approach is obvious.
- Knowledge of the possible complications during this surgery allows to anticipate their management and ensure safety for the patient.
- Endoscopic ear surgery is a safe technique with a low complication rate.

Table 1. Modena Bleeding Score

	Scoring
No bleeding	1
Bleeding easily controlled by suctioning, washing, or packing without any significant modification or slowing of surgical procedure	2
Bleeding slowing surgical procedure	3
Most of the maneuvers dedicated to bleeding control	4
Bleeding that prevents every surgical procedure except those dedicated to bleeding control	5

and LED sources in a 3D temporal bone model (Figure 3). The temperature of a 2.7 mm endoscope rose to 41.2°C with a 100% LED output, while it reached 110.1°C with a 100% xenon output. The admitted recommendation for a good practice of endoscopic surgery is an LED source at 50% power, use of a 2.7-3 mm endoscope, frequent cleaning of the tip, and a close suction to the tip. Richard Salzman¹⁰ describes a clinical case of a possible serious intracranial complication such as multiple venous thromboses after endoscopic surgery of the stapes with a 2.7 mm steadily held endoscope powered by a 60% LED source and mentions a potential thermal effect of the endoscope.

Direct Injuries

Trauma or direct injuries can occur especially at the beginning of the use of the endoscope and especially with 30° or 45° endoscopes (Figure 4). For this reason, it is not recommended

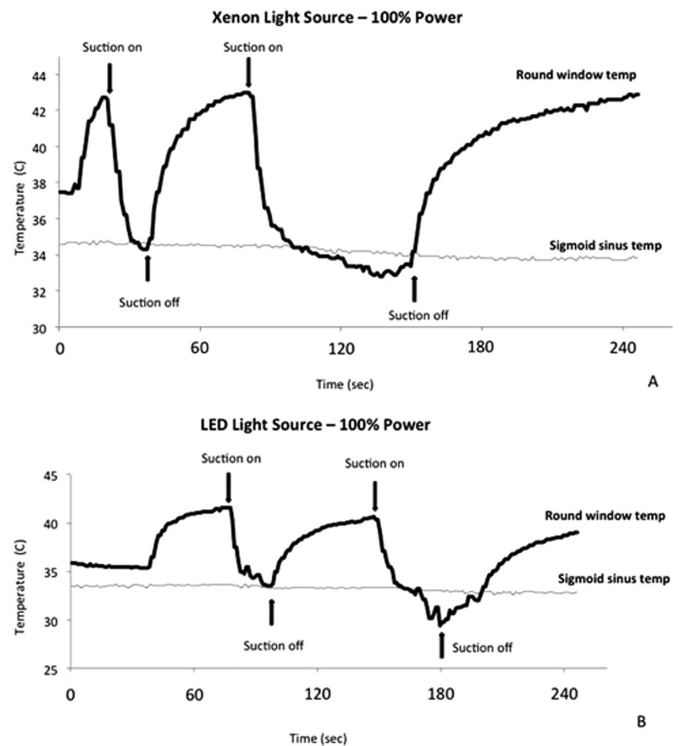


Figure 2. Thermal effects of endoscopy in a human temporal bone model. Implications for endoscopic ear surgery. Adapted from Kozin et al⁸.

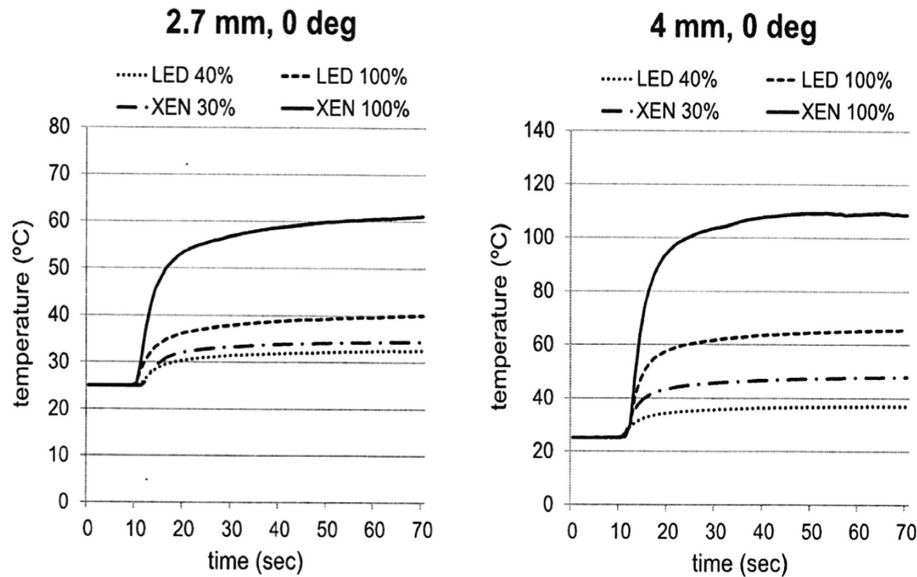


Figure 3. Temperature change curves at the tip of 0-degree endoscopes. The endoscopes were heated up dramatically when using a xenon light source set at 100%. Safety of heat generated by endoscope light sources in simulated transcanal endoscopic ear surgery. Ito T, Kubota T, Takagi A, Watanabe T, Futai K, Furukawa T, Kakehata S.

to use them before acquiring good skills with a 0° endoscope. Trauma concern the ossicles and especially the stapes, labyrinth but also the facial nerve if it is exposed and dehiscent. Under these conditions, Anshuetz⁴ does not recommend the topical use of epinephrine to not interfere with neuronal microvascularization.

Taste Disturbances

In some types of surgery, like stapedotomy, removal of the scutum is needed to have a better exposure of the stapes and oval window. Consequently, there is a risk of damage to the chorda tympani, especially in microscopic stapedotomy, where curetting of the posterosuperior bony canal is almost mandatory to visualize the incudostapedial joint. In endoscopic stapedotomy, curetting the scutum or posterosuperior bony canal is rarely needed; therefore, temporary impairment of taste and

dysgeusia is less frequent: 7% compared to 25% in the microscopic group.¹¹

Potential Ototoxicity of Antifog Solution

Nomura et al¹² showed that there could be a potential ototoxic effect from the use of an antifog solution at the tip of the endoscope. This effect was demonstrated in guinea pigs where increased Auditory Brain Response (ABR) thresholds were seen after the use of Ultrastop Antifog in the ME. Ultrastop and other liquid antifog solutions usually contain a combination of alcohol, surfactants, glycerine, and water. Ethanol has ototoxicity for both the middle and inner ear. In the study by Nomura et al.¹² the bulla was filled with Ultrastop and closed without removal of the solution, a protocol that is not likely to appear during EES. It is advised to apply minimal antifog solution to the tip of the endoscope.

Jugular Bulb Injury

Ferri et al¹³ presented 2 cases of accidental jugular bulb (JB) injury, with massive bleeding blinding the surgical field. The first case appears during cauterization and drilling to remove a glomus tympanicum, and the second injury of the JB occurs during the elevation of the tympanomeatal flap. In both cases, bleeding was controlled by suction, topical epinephrine (1:1000)-soaked cottonoid application, and pressure with Tambotamp® (Ethicon®) and Spongostan® (Ethicon®) without converting to microscopic surgery. They remember the importance of accurate analysis of preoperative imaging to detect vascular abnormalities of the internal carotid artery and dehiscence of the JB. More recently Amorosa et al¹⁴ proposed an interesting video report on the management of JB injury during transcanal endoscopic tympanoplasty (<http://links.lww.com/MAO/B280>).

Only experienced surgeons can claim to manage these types of complications endoscopically. Failing to convert to a microscopic approach could be lethal in inexperienced hands. Table 2 details the steps in the management of JB injury.

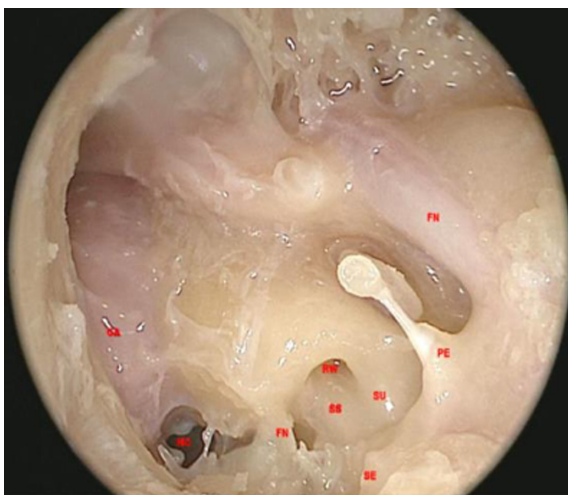


Figure 4. Cadaveric left ear. 0° endoscope view Livio Presutti, Daniele Marchinoni. Endoscopic Ear Surgery Principles, Indications and Technique Textbook ©2015 by Georg Thieme Verlag KG Thieme Publishers Stuttgart.

Table 2. Gaetano Ferri et al's Management of Jugular Bulb Injuries During Endoscopic Ear Surgery: Our Experience

Adrenalized cottonoid on to the vascular injury
Suction on to the cottonoid and mechanic compression
Enlargement of the surgical (+/-) 3-hand technique
Oxidized cellulose and/or gelatin absorbable sponge placement on the jugular bulb injured area
Completion of surgical procedure (if possible) avoiding the removal of the hypotympanic packing

Dural Injury

To our knowledge, there are no reported cases of injury to the dura mater during endoscopic ME surgery. Brandon Isaacson mentions a possible endoscopic cerebrospinal leakage repair on his UTSouthwestern Medical Center® website (<http://www.utswmed.org>).

I experienced an induced dural injury to the dura mater of the tegmen tympani during an endoscopic approach for an attic cholesteatoma. She is a 25-year-old woman who has been followed for several years for left hearing loss. On otoscopy, she presents an attic retraction pocket with progressive atticotomy, suggesting an epitympanic cholesteatoma (Figure 5). The audiogram confirms moderate conductive hearing loss, and the temporal bone computed tomography (TBCT) scan shows an opacity limited to the epitympanic space with limited bone erosion (Figures 7 and 8).

According to the attic cholesteatoma staging proposed by Marchinoni and Presutti,⁶ this is a type A case allowing an exclusive endoscopic approach (Figure 9).

Tanscanal Endoscopic Ear Surgery (TEES) is proposed to the patient. After removing the bone of the scutum and resection of the incus, the injury occurred while cleaning the roof of the posterior epitympanic space with a curved microtip with a dripping cerebrospinal fluid (CSF). At that moment, the question of a conversion to a microscope was raised. Under endoscopy the fissure was sealed using the technique described in sinus surgery,¹⁵ sealing with perichondrium, fibrin glue, and Surgicel® (Ethicon®). After a few scares and a little patience, the CSF leak was under control and the surgery could be continued (cf. video).

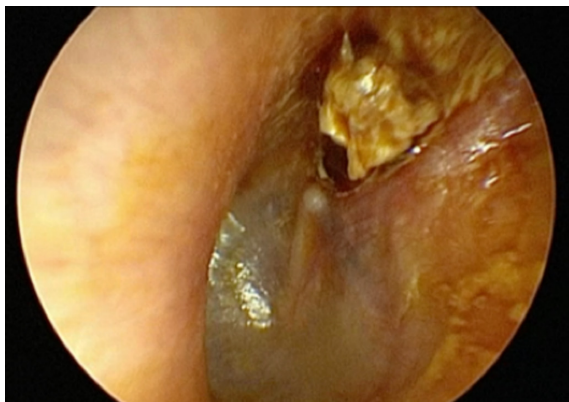


Figure 5. Left ear otoscopy, epitympanic cholesteatoma.

The lessons, in this case, are multiple:

- The importance of an accurate analysis of the coronal TBCT to detect a tegmen dehiscence
- Limited dehiscence of the tegmen tympani is not an absolute contraindication¹⁶

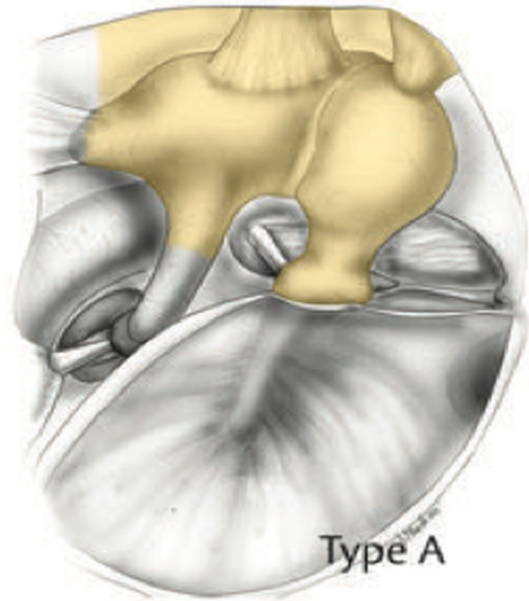


Figure 6. Type A according Attic cholesteatoma staging Marchinoni, Presutti.

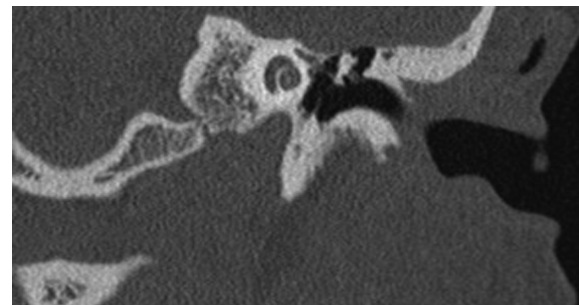


Figure 7. Temporal Bone Computed Tomography (TBCT) Coronal view, limited attic cholesteatoma. Note the tegmen dehiscence.

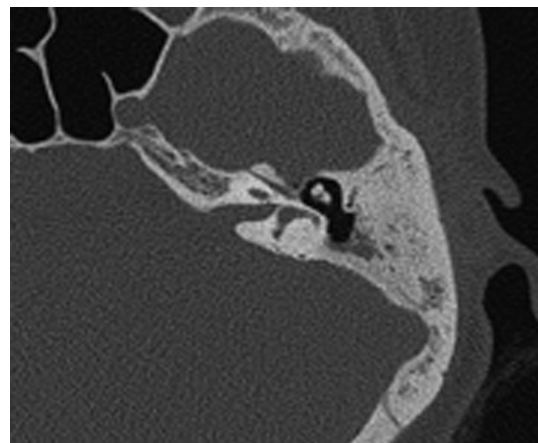


Figure 8. Temporal Bone Computed Tomography (TBCT) axial view.

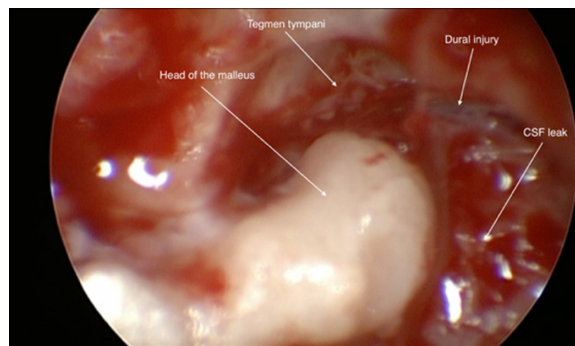


Figure 9. 30° endoscopic view of the epitympanum after resection of the incus. Note the linear induced injury of the dura.

- as soon as the CSF leak was detected, convert to a microscopic approach
- the use of less sharp instruments to clean this space
- need to cut the head of the malleus for better control of the anterior and posterior epitympanic space

Fortunately, at the 1-year follow-up visit, the otoscopy showed no sign of recurrence (Figure 10), the hearing was improved, and the diffusion magnetic resonance imaging showed no recurrence.¹⁷ These mistakes are due to my lack of experience at that time. Find below a 3 minute video on the surgery, double click on the image to view.

Complications are uncommon in experienced hands, and Table 3 shows the complication rates in 825 patients undergoing EES in Modena and Verona hospitals, between 2008 and 2016, the largest series ever published.² They report only 4.1% of intraoperative and 1.3% of early complications.

They have no injury of the dura mater.

Many articles in the literature attempt to improve endoscopic surgery safety.

Most recently, Tolisano et al¹⁸ propose the Antrum–Malleus–Tegmen score as preoperative radiographic predictors for transcanal endoscopic cholesteatoma dissection. After analysis of the preoperative TBCT, the opacity of the antrum, the erosion of the malleus and the tegmen tympani are scored to determine the feasibility of an entirely endoscopic cholesteatoma dissection.



Figure 10. One year post-operative otoscopy.

Table 3. Complication Rates

	Number of Patients (%) [*]
Intraoperative complications	34 (4.1)
Iatrogenic labyrinthine fistula	0
Inner ear injury	3 (0.4)
Sensorineural hearing loss ^a	10 (1.2)
Injury to other anatomical structures	21 (2.5)
Ossicular chain	1 (0.1)
Tympanic membrane	2 (0.2)
Transient facial palsy	2 (0.2)
Persistent facial palsy	0
Vascular structures	0
Chorda tympani ^b	16 (1.9)
Dura	0
Early complications	11 (1.3)
Infection and otorrhea	7 (0.8)
Impaired wound healing	4 (0.5)
Delayed complications	8 (<1)
Prosthesis extrusion ^c	3 (0.4)
Iatrogenic cholesteatoma	0
Persistent iatrogenic eardrum perforation	5 (0.6)

^{*}Total number of patients: 825.

^aDefined as a decrease equal to or higher than 30 db Hearing Level (HL) on at least 1 frequency.

^bOnly in patients who underwent myringoplasty, stapedoplasty, and tympanoplasty for dry chronic otitis media in a sterile ear cavity in whom chorda tympani was anatomically intact.

^cOnly for ossiculoplasty and stapedoplasty.

Conclusion

Endoscopic ear surgery is a safe technique with very low complication rates as long as we respect the limits, indications, and contraindications, but always remember the possible complications and how to manage them.

Only with this in mind can we fully enjoy all the benefits of this minimally invasive surgery.

“We all learn from our clinical cases.” Daniele Marchioni.

Data Availability Statement: The data that support the findings of this study are available on request from the corresponding author.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – J.V.; Design – J.V., I.F.; Supervision – J.V.; Materials – J.V.; Data Collection and/or Processing – J.V.; Analysis and/or Interpretation – J.V., I.F.; Literature Review – J.V., I.F.; Writing – J.V., I.F.; Critical Review – J.V., I.F.

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Supplementary Video: Repair of a meningeal breach with CSF leak from the tegmen tympani by transcanal endoscopy.

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