Multiple cerebral venous thrombosis after endoscopic stapedotomy: A potential role of endoscope-produced heat

Richard Salzman, Ivo Stárek and Jan Heřman
Department of Otorhinolaryngology, University Hospital Olomouc, Palacký University, Olomouc, Czech Republic

ABSTRACT
Authors present the very first case of cerebral venous thrombosis (CVT) after endoscopic stapedotomy. A 37-year-old female underwent routine endoscopic stapedotomy using 18-cm long 30° endoscope with 2.7-mm diameter, attached to Storz Power LED light source with 60% intensity. On day 5, she returned with vertigo, tinnitus without any sign of inflammation. After a slight improvement, she started to complain about left hand paresis. The magnetic resonance angiography showed venous thrombosis of superior sagittal, right transverse and right sigmoid sinuses, and thrombosis of central veins. The patient received full anticoagulation therapy. Six months later, imaging confirmed complete recanalization of all cranial sinuses. She has fully restored her mobility. She is only left with moderate right-sided sensoneural hearing loss and tinnitus. The authors hypothesize that the exposure to steadily held endoscope resulted in higher amount of heat spreading within the middle ear cleft that could have caused a small middle ear venule thrombosis which further spread to cerebral sinuses in the high-risk patient of spontaneous CVT due to her smoking and oral contraceptives use. A temperature of 104°C can be measured at the tip of a "cold" light endoscope. The direct thermal tissue damage is induced when the temperature rises above 50°C. Even smaller temperature elevation can, however, irritate vestibular functions. More studies looking at heat production and subsequent complications in endoscopic ear surgery are necessary. For now, we suggest detailed description of type and intensity of light source to be included in all papers on endoscopic ear surgeries.

Introduction
Currently, stapes surgeries are performed by most surgeons worldwide using traditional microscopic technique. Since the advent of endoscopic ear surgery, the list of publications looking at results of various endoscopic techniques has grown. Majority of them study cholesteatomas. The number of papers on endoscopic stapes surgery is still very limited. Unsurprisingly, this minimally invasive surgical technique is associated with very few complications [1]. Our literature review failed to identify even a single case of cerebral sinus thrombosis following any ear surgery.

Objective
The authors present the very first case report of multiple cerebral venous thrombosis following endoscopic ear surgery and discuss a potential role of endoscope-produced heat.

Case report
A 37-year old female with slowly progressive right-sided hearing loss since her pregnancy 11 years ago, with no other medical problems was seen in the outpatient clinic of our institution. She had been serologically diagnosed with Lyme disease and treated with antibiotics 2 years earlier. Her medication included daily use of oral contraceptives and frequent use of triptans for migrainous headaches. She had known allergies against paracetamol, iodine disinfection solutions, and gold contact dermatitis. She admitted to be smoker and occasional alcohol consumer. Clinical examination prior to her stapes surgery was completely unremarkable. The audiogram showed Carhart's notch with otherwise normal bone conduction threshold and air bone gap of 30–50 dB. The results of blood tests (including clotting) were found to be within normal range.

The patient was referred with suspected otosclerosis for middle ear exploration and stapedotomy.

CONTACT Richard Salzman richard.salzman@fnol.cz Department of Otorhinolaryngology, University Hospital Olomouc, Palacký University, I.P. Pavlova 6, Olomouc 775 20, Czech Republic © 2017 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.
The explorative tympanotomy under purely endoscopic control using 18-cm long 30° endoscope with 2.7-mm diameter, attached to LED light source (Storz PowerLED 175) with 60% light intensity setting, confirmed immobile stapes due to an anterior otosclerotic focus. The stapes footplate was opened using 0.6 mm perforator. A 0.4 × 4.25 mm Titanium Vario Piston type Loop was crimped on the long process of incus. Despite multiple attempts to fix the piston firmly, the surgeon decided to cement it on the incudal long process. It resulted in very good restoration of the ossicular chain mobility. It is noteworthy that, in our department, all female patients on contraceptives receive anticoagulant treatment, i.e. low-molecular weight heparine. The nadroparin in a dose of 0.3–0.4 ml based on the patient’s weight, is administered 12 h prior to procedure and then once daily till the patient’s mobility returns to normal (usually postoperative day 2). Treatment with a low-molecular weight heparine is accompanied by the elastic lower limb compression.

The surgery was only complicated with slightly prolonged crimping (lasting about 10 min) and need for additional piston fixation. However, the footplate perforation and the piston insertion were very smooth.

After the surgery, the patient experienced only very mild vestibular symptoms, with no nystagmus or fever. She lateralized Weber tuning fork test toward her operated ear. She was discharged from the hospital on day 3 after surgery as it is a common practice in the Czech Republic. She returned early for a follow-up on postoperative day 5 with 1 day history of nausea, vertigo, dizziness, right-sided tinnitus without any ear discharge, or other signs of inflammation. Despite her instability, she still manifested no nystagmus. She consistently kept pointing towards her operated ear during Weber tuning fork testing. Intravenous corticosteroids (dexamethasone 16 mg once daily) and vasodilators (vinpocetine 20 mg once daily) were administered for suspected acute labyrinthitis. The ear pack was removed and greyish, partly transparent ear drum confirmed immobile stapes due to an anterior otosclerotic focus. The stapes footplate was opened using 0.6 mm perforator. A 0.4 × 4.25 mm Titanium Vario Piston type Loop was crimped on the long process of incus. Despite multiple attempts to fix the piston firmly, the surgeon decided to cement it on the incudal long process. It resulted in very good restoration of the ossicular chain mobility. It is noteworthy that, in our department, all female patients on contraceptives receive anticoagulant treatment, i.e. low-molecular weight heparine. The nadroparin in a dose of 0.3–0.4 ml based on the patient’s weight, is administered 12 h prior to procedure and then once daily till the patient’s mobility returns to normal (usually postoperative day 2). Treatment with a low-molecular weight heparine is accompanied by the elastic lower limb compression.

The surgery was only complicated with slightly prolonged crimping (lasting about 10 min) and need for additional piston fixation. However, the footplate perforation and the piston insertion were very smooth.

After the surgery, the patient experienced only very mild vestibular symptoms, with no nystagmus or fever. She lateralized Weber tuning fork test toward her operated ear. She was discharged from the hospital on day 3 after surgery as it is a common practice in the Czech Republic. She returned early for a follow-up on postoperative day 5 with 1 day history of nausea, vertigo, dizziness, right-sided tinnitus without any ear discharge, or other signs of inflammation. Despite her instability, she still manifested no nystagmus. She consistently kept pointing towards her operated ear during Weber tuning fork testing. Intravenous corticosteroids (dexamethasone 16 mg once daily) and vasodilators (vinpocetine 20 mg once daily) were administered for suspected acute labyrinthitis. The ear pack was removed and greyish, partly transparent ear drum without any inflammatory signs noted. Pure tone audiogram showed dropped bone conduction on the affected side to 40–50 dB. Cranial nerves function was found to be normal. Two days later, the patient felt slight improvement. Her dizziness manifested only after rapid head movement. Her tinnitus persisted. The electroneystagmography revealed no nystagmus. Consequently, suspicion for other etiology than acute labyrinthitis was raised.

On the following day, she started to complain about progressive paraesthesia and paresis of her left hand. A consultant neurologist reported left hemiparesis with complete plegia of left upper extremity, photophobia, headache, and neck stiffness. The urgently indicated brain magnetic resonance imaging (MRI) scan for suspected cerebral stroke revealed two hypersignal foci in the right frontal and left frontoparietal region. The magnetic resonance angiography (MRA) confirmed patent artery circle of Willis, but showed thrombosis of superior sagittal, right transverse and right sigmoid sinuses and central veins. The subsequent CT scan revealed venous infarctions in right frontal and left frontoparietal region. The patient was transferred to neurological intensive care unit (Neuro ICU), where she received full anticoagulation therapy. On day 1, at the Neuro ICU, she had two epileptic seizures. The repeat imaging a week later confirmed reduction of venous infarctions with partially reduced venous thrombosis of superior sagittal, right transverse, and right sigmoid sinuses. She was advised against continuation of oral contraceptives, and was started on oral anticoagulant (warfarin), anti-convulsant (valproate), and rehabilitation therapy. The patient was found not to be factor V Leiden mutation carrier. The repeat MRI and MRA 6 months later, revealed normal intracranial picture including complete recanalization of all cranial sinuses. Six months from the onset of her neurological symptoms, she has slowly, but fully, restored the function of her left-sided extremities and is left with moderate sensorial hearing loss and permanent tinnitus in her right ear.

**Discussion**

The venous drainage of the brain runs predominantly via the cerebral veins communicating with dural sinuses. Superficial cerebral veins empty into the superior sagittal sinus which continues to the transverse and sigmoid sinuses from which blood drains into the internal jugular vein. Deep cerebral veins communicate with the inferior sagittal and straight sinuses [2]. The occlusion of any cerebral vein or sinus is called cerebral venous thrombosis (CVT). Numerous causes were described in the literature. They can be broadly grouped into endocrine, haematological, inflammatory, and neoplastic. The etiopathogenesis is usually either by the prothrombotic state due to direct disturbance of venous flow, by inflammation of venous wall or by altered blood coagulability [2]. Our patient was at increased risk of CVT as contraceptive pills and smoking are recognized as etiological factors of spontaneous CVT. Inflammatory etiology is unlikely as our patient gave no signs of
acute otitis media or mastoiditis. Thrombophlebitis of middle ear and mastoid venules might be another possible cause as they are the most likely starting points for the growing thrombi from superior petrous and sigmoid sinuses [3]. This could explain delayed manifestation of symptoms.

Stapedotomy has stood the test of time as a successful microsurgical operation [4]. Complications are infrequent, however, if arise, they are often associated with severe consequences, such as sensoneural hearing loss; tinnitus; vertigo resulting from serous labyrinthitis due to direct trauma or spread of infection to the inner ear; meningitis. Other complications include chorda tympani injury; bleeding from the ear canal; and middle ear or ear canal infection. [5]

The number of papers on endoscopic stapes surgery is very limited. Unsurprisingly, this minimally invasive surgical technique is associated with very few complications [1]. In his work, Kanona described two complications (out of 11 cases) after stapedotomy – a postoperative mastoiditis and a labyrinthitis [6]. A case of late facial paralysis (out of 15 patients) was reported in the study by Kojima [7]. The study on 15 patients by Naik and another study on 20 patients by Nogueira described no serious postoperative complication [8,9]. Only one of Nogueira's patients temporarily suffered from reduced taste sensation [9].

Papers describing other types of endoscopic ear surgeries again revealed only a few complications. Two (out of 30) cases of iatrogenic tympanic membrane cholesteatoma after endoscopic cartilage myringoplasty were seen by Ayache. These cholesteatoma pearls were limited in size as they could be easily removed at the office [10]. Migirov dealt with two (out of 30) cases of sensoneural hearing loss after major cholesteatoma removal [11].

Finally, we reviewed literature on complications after microscopic stapes surgeries. Our review failed to identify a single case of cerebral venous sinus thrombosis following microscopic or endoscopic stapedotomy.

With the development of visualization systems, light sources used in endoscopy are manufactured more powerful, to provide better peroperative view. The more powerful light sources produce more heat, thus carry higher risk of thermal injury [12]. Aksoy warns us that even so-called “cold light sources” generate certain amount of heat [12]. MacKeith recorded a temperature of 104°C at the tip of 4-mm 18-cm long 0° endoscope [13]. The direct thermal tissue damage is induced when the temperature rises above 50°C [14]. Even smaller temperature elevation can, however, irritate vestibular functions [15]. Larger diameter endoscopes produce more heat [16]. Similarly, Xenon produces more heat than halogen or LED sources [12,17,18]. Even the LED light associated with lower temperature increment, still leads to 10°C increase of the middle ear temperature [19].

In his study on guinea pigs, Aksoy [13] found the decrease in vestibular function right after continuous 5-min shining of endoscope within the middle ear cleft. Interestingly, a 1-min of exposure did not lead to any vestibular deficit. Botrill showed that even low diameter otoendoscopes increase temperature in lateral semicircular canal in human temporal bones [16].

Based on the previous animal models studies, we hypothesize that increased temperature produced by otoendoscope might play a role in the etiology of some vestibular complications after endoscopic ear surgeries. It is not clear if the endoscope use played any role in the development of the intracranial complication in our patient. She manifested no signs of vestibular irritation early after surgery or on re-admission 5 days later. However, we cannot rule out a heat-induced thrombophlebitis of a middle ear venule which would otherwise leave no clinical consequences, to continuously spread to cerebral venous sinuses in the high-risk patient. This would explain relatively late manifestation of symptoms. Kim [20] described a case of cerebral venous thrombosis mimicking unilateral vestibulopathy including rotational vertigo and tinnitus without nystagmus. Given similar manifestation, we suspect similar etiology in our patient.

It is noteworthy that most studies on the thermal effect of endoscope used in the temporal bone, used models very different from a real middle ear. Several authors studied heat spread in animal temporal bone models, others used fresh or dry human temporal bones. So far, we lack a study describing temperatures in realistic in vivo human models with frequent endoscope repositioning and wiping with anti-fog solution.

In our department, in accordance with the International Working Group for Endoscopic Ear Surgery recommendations, we use only 50–60% intensity setting on the LED light source in order to reduce the risk of heat damage to surrounding structures. The recorded length of the whole procedure was 65 min. Therefore, the heat exposure was unlikely too intense during the procedure of an average duration.

Previous studies revealed that endoscope tip temperature returns rapidly to room temperature after switched off [19,21]. The temperature in the vestibule decreases rapidly after the endoscope is removed from the middle ear (e.g. for cleaning). Therefore, frequent
endoscope repositioning within the middle ear and withdrawal from the ear canal prevents dangerous rise of middle ear temperature. Kozin even suggests that using suction significantly drops the middle ear temperature [19].

In order to avoid thermal injury during endoscopic ear surgery, the International Working Group for Endoscopic Ear Surgery recommends not to apply endoscope in the middle ear for too long; it should be frequently repositioned within the middle ear and should be pulled from the ear canal for cleaning and cold irrigation; a LED light source and 2.7-mm endoscopes should be preferred; submaximal light intensity should be preferred; the endoscope tip should never come in the direct contact with any tissue; and it should be kept at least 5 mm away from the promontory [12,19]. All these recommendations were followed during the presented procedure.

In clinical setting, there are numerous parameters affecting amount of heat produced and spreading during middle ear surgery. Let us summarize that, first, it is instrumentation: (1) the endoscope size; (2) number of broken light fibres depends on the endoscope and light cable age; (3) type of, and (4) intensity set on light source. Second, a surgical technique affects heat exposure: (1) frequent endoscope repositioning within the middle ear and in and out of the middle ear; (2) wiping a endoscope tip with a gauze sponge soaked with antifog solution; (3) use of suction; (4) use of middle ear washout. Third, there are factors on a patient’s side: (1) individual anatomy and (2) intensity of perioperative bleeding.

Interestingly, not a single author of a paper on endoscopic ear surgeries in humans considered the type and setting of the light source important enough to include it in their methodology. We suggest that the detailed description of type and intensity of light source to be included in all papers on endoscopic ear surgeries in order to find the safe maximum light intensity.

Conclusions

The authors cannot clearly identify the cause of very severe intracranial complication after endoscopic stapes surgery in their patient. Even though a spontaneous cerebral venous thrombosis is sometimes seen in female smokers on contraceptives, they hypothesize that the heat produced by the “cold” light of endoscope could have played a role as well. Prolonged crimping associated with extended exposure to steadily held endoscope resulted in higher amount of heat spreading within the middle ear cleft that could have caused a small middle ear venule thrombosis which further spread to cerebral sinuses at the high-risk patient of spontaneous CVT due to her smoking and oral contraceptives use. More studies looking at heat production and subsequent complications in endoscopic ear surgery are necessary. For now, we suggest detailed description of type and intensity of light source to be included in all papers on endoscopic ear surgeries.

Acknowledgement

Mr. George Kumsta is acknowledged for his assistance with English language revision.

Disclosure statement

The authors declare that they have no conflict of interest.

Funding

This work was supported by the institutional support grants of the Ministry of Health of the Czech Republic Nos. RVO 61989592 and RVO-FNOL 2016.

ORCID

Richard Salzman http://orcid.org/0000-0001-5705-5510

References

[1] Presutti L, Marchioni D, Mattioli F, et al. Endoscopic management of acquired cholesteatoma: our experience. J Otolaryngol Head Neck Surg. 2008;4:481–487.
[2] Martin PJ, Enevoldson TP. Cerebral venous thrombosis. Postgrad Med J. 1996;72:72–76.
[3] Levine SC, De Souza C. Intracranial complications of otitis media. In: Shambaugh GE Jr, Glasscock ME III, editors. Surgery of the ear. Philadelphia (PA): WB Saunders; 1980. p. 289–315.
[4] Shea JJ Jr. Forty years of stapes surgery. Am J Otol. 1998;19:52–55.
[5] Wiet RJ, Harvey SA, Bauer GP. Complications in stapes surgery. Options for prevention and management. Otolaryngol Clin North Am. 1993;3:471–490.
[6] Kanona H, Virk JS, Owa A. Endoscopic ear surgery: a case series and first United Kingdom experience. World J Clin Cases 2015;3:310.
[7] Kojima H, Komori M, Chikazawa S, et al. Comparison between endoscopic and microscopic stapes surgery. Laryngoscope 2014;1:266–271.
[8] Naik C, Nemade S. Endoscopic stapedotomy: our view point. Eur Arch Otorhinolaryngol. 2014;1: 37–41.
[9] Nogueira JF, Martins MJ, Aguiar CV, et al. Fully endoscopic stapes surgery (stapedotomy): technique
and preliminary results. Braz J Otorhinolaryngol. 2011;6:721–727.

[10] Ayache S, Tramier B, Strunski V. Otoendoscopy in cholesteatoma surgery of the middle ear: what benefits can be expected? Otol Neurotol. 2008;8:1085–1090.

[11] Migirov L, Shapira Y, Horowitz Z, et al. Exclusive endoscopic ear surgery for acquired cholesteatoma: preliminary results. Otol Neurotol. 2011;3:433–436.

[12] Aksoy F, Dogan R, Ozturan O, et al. Thermal effects of cold light sources used in otologic surgery. Eur Arch Otorhinolaryngol. 2015;10:2679–2687.

[13] MacKeith SAC, Frampton S, Pothier DD. Thermal properties of operative endoscopes used in otorhinolaryngology. J Laryngol Otol. 2008;7:711–714.

[14] Stoll AM, Greene LC. Relationship between pain and tissue damage due to thermal radiation. J Appl Physiol. 1959;3:373–382.

[15] Drescher DG. Noise-induced reduction of inner-ear microphonic response: dependence on body temperature. Science 1974;4147:273–274.

[16] Bottrill I, Perrault DF, Poe D. In vitro and in vivo determination of the thermal effect of middle ear endoscopy. Laryngoscope 1996;2:213–216.

[17] Brown GJ, Saunders BP. Advances in colonic imaging: technical improvements in colonoscopy. Eur J Gastroenterol Hepatol. 2008;8:785–792.

[18] Dundar R, Bulut H, Güler OK, et al. Oval window temperature changes in an endoscopic stapedectomy. J Craniofac Surg. 2015;5:1704–1708.

[19] Kozin ED, Lehmann A, Carter M, et al. Thermal effects of endoscopy in a human temporal bone model: implications for endoscopic ear surgery. Laryngoscope 2014;8:E332–E339.

[20] Kim HA, Sohn SI, Lee H. Cerebral venous thrombosis mimicking acute unilateral vestibulopathy. Neurol Sci. 2008;1:41–43.

[21] Tomazic PV, Hammer GP, Gerstenberger C, et al. Heat development at nasal endoscopes' tips: danger of tissue damage? A laboratory study. Laryngoscope 2012;8:1670–1673.