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Internal carotid artery injury during functional endoscopic sinus surgery and its management

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Abstract Rupture of the internal carotid artery (ICA) during functional endoscopic sinus surgery (FESS) is a rare complication, which can potentially result in death. Only a few cases have been reported in the literature thus far. We present four cases with an ICA bleeding during sphenoidotomy. The treatment is discussed and an emergency plan to manage the heavy arterial bleeding is presented.

Keywords Endoscopic sinus surgery · Sphenoid sinus · Complications · Internal carotid artery injury

Introduction

Functional endoscopic sinus surgery (FESS) has become the standard technique for the treatment of chronic polypoid sinusitis. According to the literature, complications of sinus surgery, such as orbital lesion, dural or intracranial injury and damage to the internal carotid artery range from 1.3 to 9.3% [1, 2, 3, 4, 5]. Intraoperative injury to the internal carotid artery (ICA) during FESS is a rare complication, which is often fatal. In the literature, only very few reports can be found on this kind of complication [6, 7, 8, 9, 10]. In the event of a traumatic injury to the ICA during sphenoid sinus exploration, hemorrhage is massive, and access to the sphenoid sinus and vision are strongly limited. Con-

trolling the bleeding, which is very difficult, can even become fatal for many patients within minutes.

In our department, over 16,000 endoscopic sinus procedures were performed over the last 30 years. We experienced four cases of internal carotid artery bleeding following sphenoidectomy. Three cases were operated on in our department; one was referred from elsewhere. Out of the four patients, one patient, who was operated on in the 1980s, died in the operating room, whereas the other three survived without any visual or neurological deficits. Based on our experience, we wanted to present our emergency plan, which has proved to be helpful for the management of this rare but life-threatening complication.

Case reports

Case 1

In 1988, a 62-year-old man with nasal polypoid sinusitis underwent complete ethmoidectomy and sphenoidectomy. A pre-surgical CT scan was omitted in this case, since they were not performed on a routine basis in our institution at the time. After puncturing the sphenoid sinus with a suction tip, heavy arterial bleeding occurred from the left internal carotid artery. When the bleeding first occurred, the surgeon failed to compress both common carotid arteries (CCA). Immediate packing of the sphenoid sinus and insertion of a Belloque Tamponade into the nasopharynx stopped the arterial bleeding. However, the patient later died from the sequelae of a transient arterial hypotension. At autopsy the patient demonstrated a bulging ICA, which was not covered with bone.

Case 2

In 1994, a 54-year-old man with bilateral nasal polyposis and headache was admitted for bilateral middle meatal

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antroostomy, bilateral infundibulotomy and complete sphenothmoidectomy. A preoperative CT scan revealed a bulging ICA, covered with a thin layer of bone. Due to the thick, bony anterior wall of the sphenoid sinus, a perforator was used to enter the sphenoid sinus. Under endoscopic control, the anterior wall was perforated with a short but vigorous push, causing massive arterial bleeding from the left ICA. Immediate compression of both CCAs by an assistant and suction cleared the operating field. The ostium of the sphenoid sinus was then enlarged with a puncher. Using a curette, as much mucosa as possible was removed from the sphenoid sinus to prepare it for a muscle-fascia graft. The graft was harvested from the right quadriceps muscle and used to seal the damaged ICA. In the meantime, the sphenoid sinus was packed with a gauze tamponade to stop the bleeding. The tamponade was held in place with forceps by an assistant to prevent being flushed out by the arterial pressure of the ICA. Under compression of both CCAs in the neck, the gauze was removed, followed by the insertion of the muscle-fascia graft. Additionally, an antibiotic impregnated gauze tamponade (tetracyclin HCl 3% ointment) was induced for reinforcement. Ten days later, the tamponade was removed under general anesthesia. No bleeding occurred, and the patient was discharged 3 days later. Postoperatively, the patient experienced no recurrence of bleeding. Three weeks later, an angiogram revealed a normal left ICA with adequate flow. A computed tomography of the sphenoid sinus, which was done 3 months later, showed the muscle-fascia graft in the left sphenoid sinus (Fig. 1). Until now, there have been no neurological deficits encountered in the follow-up examinations.

Case 3

In 1996, a 48-year-old man was referred with a history of nasal obstruction on both sides, due to nasal polyposis and chronic sinusitis. The preoperative CT scan showed a normal anatomical course of the ICA separated from the sphenoid sinus by a thin overlying bone. The patient underwent polypectomy with ethmoidal infundibulotomy, supratubinal fenestration of the maxillary sinus and complete ethmoido-sphenoidectomy. While taking down the anterior wall of the sphenoid sinus laterally with a curved cup forceps, heavy arterial bleeding occurred from the left lateral wall of the sphenoid sinus. Compression of both CCAs in the neck, a gauze tamponade and a muscle-fascia graft controlled the bleeding. Ten days later, while removing the tamponade from the sphenoid sinus, the muscle-fascia graft, which had adhered to the tamponade, was accidentally pulled out. The defect in the now closed arterial wall was identified with no bleeding. To prevent relapse bleeding, a new muscle graft was harvested from the right quadriceps muscle and reinserted into the sphenoid sinus. An angiogram, carried out 3 weeks later, revealed a false aneurysm of the C3 segment of the left ICA lateral to the

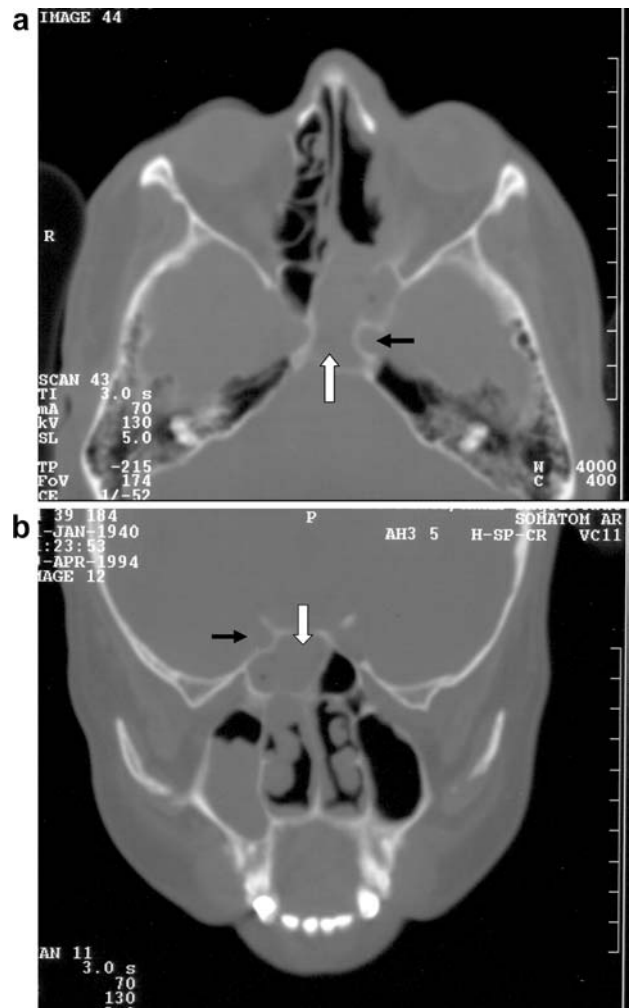


Fig. 1 Postoperative axial (a) and coronal (b) CT scan of the paranasal sinuses of the same patient. It shows the muscle-fascia graft (white arrow) in the left sphenoid sinus. The ICA, which is bulging into the sphenoid sinus (black arrow), can be identified more easily on axial than on coronal sections

sphenoid sinus, which was clipped by the neurosurgeon, using a transfrontal approach (Fig. 2). The further postoperative course of the patient was uneventful. No visual or neurological defects were observed.

Case 4

In 2002, a 48-year-old man was referred from an outside hospital with packing of the nose and nasopharynx, after experiencing heavy arterial bleeding during sinus surgery. Due to nasal obstruction on both sides with nasal polyposis, the patient had undergone polypectomy, intranasal bilateral ethmoidectomy and septoplasty. Six units of blood had already been administered. The patient was immediately taken to the operating room, where the tamponade was removed under general anesthesia. While removing the tamponade, immediate massive arterial bleeding occurred from the left sphenoid

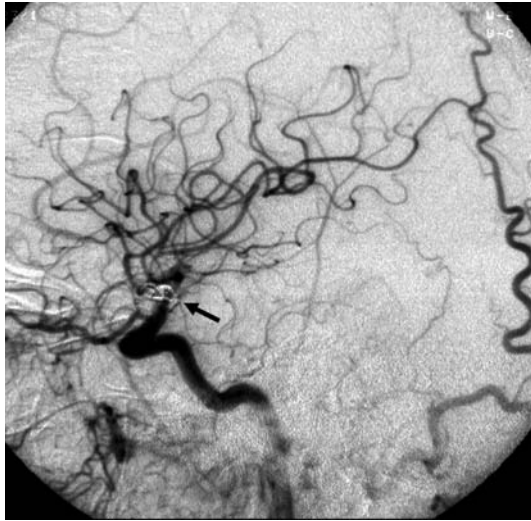


Fig. 2 Digital subtraction angiogram showing the left ICA after the aneurysm was clipped at the C3 segment lateral to the sphenoid sinus (arrow). A normal cerebral perfusion distally to the left ICA is provided

sinus, which was identified as bleeding from the left ICA. Under compression of both CCAs in the neck and suction, a muscle-fascia graft, harvested from the right quadriceps muscle, was introduced into the sphenoid sinus together with a tamponade, which stopped the bleeding. An attempt to remove the tamponade from the sphenoid sinus 10 days later failed because of heavy recurrent bleeding. A new muscle-fascia graft had to be inserted. An angiogram, which was carried out 5 days later, showed a false aneurysm underneath the muscle-fascia graft in the sphenoid sinus (Fig. 3). A second attempt to remove the tamponade 10 days later was also unsuccessful, due to the heavy bleeding. To obtain further treatment options, the patient was brought to the



Fig. 3 Digital subtraction angiogram showing the left ICA after inserting the muscle-fascia graft. A false aneurysm has formed underneath the muscle graft (arrow)

Department of Neuroradiology. A balloon occlusion of the ICA was considered the best treatment. An angiogram revealed a sufficient collateral circulation from the contralateral ICA and the vertebral artery system. A 3-cm long, detachable balloon was placed at the level of the laceration, and a successful closure of the leak was achieved (Fig. 4). The follow-up time was for over 1 year without any visual or neurological deficits.

Discussion

Endoscopic sinus surgery has become the standard treatment of chronic sinusitis. Since 1972, over 16,000 endoscopic sinus procedures have been performed in our department by different surgeons. Anatomical and technical knowledge, gained from cadaver sections as well as surgical experience, have helped to prevent complications. Complications, such as a CSF leak with meningitis, brain injury, orbital hematoma or carotid artery bleeding, are rarely seen today.

In the sphenoid sinus, it has been demonstrated that the internal carotid artery can be located close to the lateral wall, bulging into the sinus in over 70% of the cases [11]. Fujii et al. found that in 88% the bony wall overlying the internal carotid artery is less than 0.5 mm thick and therefore not sufficient to protect the artery [12]. In 4–22% of the cases, the bony wall is dehiscent, the ICA being separated from the sphenoid sinus only by dura and mucosa [11, 12, 13]. A CT scan is therefore absolutely mandatory prior to endonasal sinus surgery in order to detect such anatomical variations. Axial scans provide more positional information about the ICA than coronal scans (Fig. 1). One of the patients with ICA bleeding (case 1) was operated on during a time in which preoperative CT scans were not performed routinely prior to sinus surgery.



Fig. 4 Lateral view of the skull base confirming the detachable balloon positioned at the level of the damaged left ICA (arrow)

For the large number of FESS performed each year, there are very few cases reporting an injury to the internal carotid artery. However, it must be assumed that there is probably a greater number of unknown cases. May et al. reviewed 2,108 of their own cases with no intraoperative laceration of the carotid artery [4]. Wigand et al., Hudgins et al. and Isenberg et al. each noted one case of severe hemorrhage, secondary to carotid bleeding, during endoscopic sinus surgery [6, 7, 8]. Maniglia and Weber reported three and two cases, respectively, with an ICA bleeding during sphenoidotomy or sphenoidectomy [9, 10]. Injury to the internal carotid artery during sinus surgery happens unexpectedly and is associated with massive bleeding, leading to a loss of vision and orientation in the operating field. Therefore, when such a life-threatening complication occurs, prompt intervention is necessary to save the patient's life. Any surgeon who performs sinus surgery should be familiar with an emergency plan to stop the bleeding (Table 1). As soon as a laceration of the ICA is realized as the cause of the bleeding, the first steps to control the hemorrhage should be carried out as quickly and vigorously as possible, since the patient can exsanguinate within a few moments. The initial treatment should include compression of both CCAs in the neck; however, this does not stop the bleeding completely, since the ICA is collateralized via the circle of Willis. Additional suction is necessary to provide a sufficient view into the sinus. Concomitant packing with gauze will stop the bleeding. After these steps have been taken, the surgeon has gained some time for planning the definitive treatment.

Due to the heavy arterial bleeding and the restricted transnasal access to the sphenoid sinus, it is impossible surgically to repair the ICA, and some surgeons may believe there is no alternative but to perform an emergency ligation of the artery in the neck. As Liskey et al.

Table 1 Emergency protocol for management of internal carotid artery injury in endoscopic sinus surgery

1. Compression of both CCAs in the neck, time limited to 2 min, done by an assistant
2. During compression: enlargement of the ostium of the sphenoid sinus, resection of the mucosa, insertion of a gauze tamponade and pressure exertion on the tamponade with forceps
3. Careful decompression first of the contralateral, then of the ipsilateral CCA, checking for bleeding from the sphenoid sinus
4. Maintaining pressure on the tamponade with forceps, while harvesting an autologous muscle fascia graft from the quadriceps muscle
5. Preparing the instruments including suction, gauze tamponade, impregnated with antibiotic ointment, and the muscle fascia graft with fibrin glue
6. Recompression of both CCAs in the neck
7. Removing the tamponade carefully, followed by insertion of the muscle graft into the sphenoid sinus. Insertion of the additional tamponade into the sphenoid and the ethmoid sinus for reinforcement
8. Releasing both CCAs gently, starting with the contralateral side

reported in their literature review, abrupt internal carotid occlusion is associated with a stroke rate of up to 26% and a mortality rate of 12% [14]. Roski et al. had a 16.6% incidence of strokes in their long-term follow-up (average 12.5 years) after ligation of the ICA for an ICA aneurysm [15].

In our reported cases, operative management of the ruptured ICA was performed in order to maintain the continuity of the vessel and to avoid neurological complications. This was done by inserting an autologous muscle-fascia graft, harvested from the quadriceps muscle, into the sphenoid sinus covering the injured ICA as a permanent tamponade. For reinforcement, a gauze tamponade was additionally introduced, providing an adequate seal for the ICA leak with a sufficient cerebral perfusion. In one patient, the leak of the ICA did not close and heavy rebleeding occurred when attempting to remove the gauze tamponade from the sphenoid sinus 10 days postoperatively. This was probably due to the large size of the laceration, as this happened again after reinserting a second muscle graft into the sphenoid sinus. An angiogram showed an adequate collateral cerebral perfusion, and a successful occlusion of the ICA was achieved by placing a detachable balloon over the arterial wall defect (Fig. 4). No neurological deficits were encountered afterwards. Detachable balloons have been the most frequently used device for endovascular occlusion and are widely accepted for the treatment of carotid cavernous fistulas, giant aneurysms, pseudoaneurysms and traumatic injuries of the carotid artery [16, 17, 18, 19]. As an alternative, detachable platinum microcoils can be used for the occlusion of major vessels such as the ICA; however, distal migration with the risk of stroke has to be avoided during the procedure by flow control. Several techniques are available for the evaluation of the collateral blood supply. In addition to an angiogram, as performed in our patient, a balloon occlusion test (BOT) of the ICA in combination with an EEG, transcranial Doppler, Xenon-CT or a SPECT have been shown to be good alternatives [20, 21]. However, passing the BOT according to the criteria above does not prevent ischemic events in all cases after occlusion of the ICA. In a literature review, Mathis et al. found that of 192 patients who passed the BOT, 4.7% developed a permanent stroke [22].

Once the bleeding has been treated with a muscle-fascia graft as a permanent tamponade and no neurological deficits have developed, it is not necessary to perform an immediate angiogram, as it would not provide any relevant information and would therefore not lead to any further treatment. However, sometimes following an operative trauma to the ICA, a pseudoaneurysm may develop, which can rupture with a delay of weeks to months [23, 24, 25, 26, 27]. Therefore, it is important to perform an angiogram a few weeks postoperatively in all cases. In an angiogram, carried out 3 weeks after the surgery, it was verified that one of the three patients described had developed such a secondary

aneurysm (Fig. 3), which was clipped by a neurosurgeon using a transfrontal approach. In all three patients, it was possible to control the emergency situation by following our protocol. In all three patients, no visual or neurological deficits were found during their follow-up period of 2 to 9 years.

It has been reported in the literature that during FESS, orbital complications occur more frequently on the right side than on the left side [28]. According to Freedman and Kern, this is related to the limited view right-handed surgeons have during surgery, when standing on the right side of the patient [2]. In the literature regarding injury of the ICA during FESS, there is no dominance of the left or the right side [6, 7, 10, 21, 28, 29, 30]. However, it should be noted that all of our ICA lacerations occurred on the left side. A possible explanation is that a right-handed surgeon, who stands on the right side of the patient, has the tendency to aim laterally while opening the sphenoid sinus, thus risking a laceration of the ICA running along the lateral wall of the sphenoid sinus. In all our reported cases, a perforator, suction tip or curved cup forceps was used to enter the sphenoid sinus. It has to be pointed out that if such devices are used, the sphenoid sinus can only be entered midline adjacent to nasal septum. It should be mentioned that a burr can alternatively be used for this purpose, which minimizes the risk of injuring the ICA by removing the anterior wall of the sphenoid sinus safely.

Conclusion

The high mortality rate of an internal carotid artery injury during sinus surgery can be decreased if the following conditions are fulfilled. (1) A preoperative CT scan should be carried out, which can detect possible anatomical variations of the bony structures, the optic nerve and the ICA. Hereby, axial sections give more positional information about the internal carotid artery than coronal sections. (2) The surgeon must be familiar with the operation technique, the anatomy of the sphenoid sinus region and its danger spots, including the variations of the course of the ICA lateral to the sphenoid sinus wall. (3) It is important to be prepared for possible complications (CSF leak, retrobulbar hematoma, ICA bleeding) and to be familiar with each necessary treatment. (4) In the event of an ICA laceration, expeditious compression of both common carotid arteries will decrease the bleeding to a great degree (it will not stop it, because of the collateral blood flow from the vertebral artery system). Insertion of a muscle graft into the sphenoid sinus with concomitant packing with a gauze tamponade will stop the bleeding. (5) Ten days postoperatively the gauze tamponade should be removed. This has to be done with caution in the operating room since rebleeding may occur. (6) A postoperative angiogram needs to be performed in order to rule out a secondary aneurysm of the ICA, which can develop after a trauma to the internal carotid artery.

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