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Technical Note

Transfrontal sinus approach for an anterior cranial fossa, ethmoidal, dural arteriovenous fistula

Elsa Magro, Doortje Engel, Michel W. Bojanowski

Division of Neurosurgery, Department of Surgery, Centre Hospitalier de l'Université de Montréal - Hôpital Notre-Dame, Montreal, Quebec, Canada

E-mails: Elsa Magro - elsa.magro@chu-brest.fr; Doortje Engel - Doortje.Engel@kssg.ch; *Michel W. Bojanowski - michel.bojanowski.chum@ssss.gouv.qc.ca
*Corresponding author

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Abstract

Background: Ethmoidal dural arteriovenous fistulas (eDAVFs) are usually approached via a pterional or a frontal craniotomy. A more direct route to the fistula is possible through a purely transfrontal sinus approach. The aim of this report is to illustrate the interest of transsinus frontal approach for eDAVFs.

Case Description: The transfrontal sinus approach is described and illustrated in a case of an ethmoidal arteriovenous fistula. This approach is the most direct when treating an eDAVF surgically, allowing preserving neural structures with minimal to no brain manipulation.

Conclusion: For eDAVFs, the purely transfrontal sinus approach is highly worth considering in cases of large frontal sinuses.

Key Words: Ethmoidal, dural arteriovenous fistula, transfrontal sinus approach, surgical treatment

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INTRODUCTION

Ethmoidal dural arteriovenous fistulas (eDAVFs) are known for their grim natural history leading to a high risk of hemorrhage.[5,22,25] Surgery has remained the most successful treatment[1,2] since an endovascular approach is often associated with failure.[1,14,24] Access to these fistulas has been described by pterional, orbitozygomatic or subfrontal craniotomies, whether uni- or bilateral, as well as through a transsphenoidal route.[2,12,14,17] However, the transfrontal sinus approach offers a more direct route reducing the distance between the site of entrance and the lesion itself, thus obviating the need for brain manipulation. Therefore the authors would like to highlight the appropriateness of a transfrontal sinus approach using an illustrative case.

METHODS/RESULTS

Illustrative case description

A 59-year-old male was seen by an ophthalmologist for a diplopia due to a hypotonic left small oblique muscle, which had occurred several months earlier. The neurological examination was normal. A fortuitous finding on an orbit computed tomography (CT) scan revealed large tortuous veins on the left gyrus rectus just above the cribriform plate and intraorbital dilated venous suggesting an eDAVF [Figure 1a]. An angio CT scan showed large abnormal left ophthalmic and ethmoidal arteries [Figure 1b and c]. An angiogram showed a DAVF vascularized by the left anterior and posterior ethmoidal arteries originating from the left ophthalmic artery [Figure 2a] and by anastomosis arising from the right ophthalmic artery [Figure 2b] and from the left

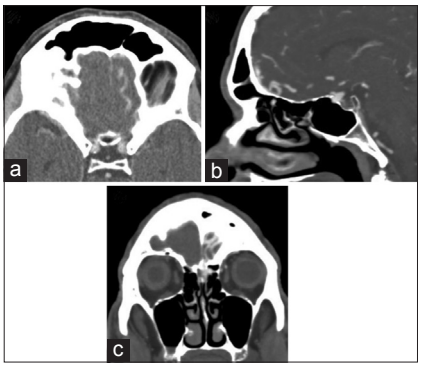

Figure 1: (a) Orbit CT scan with contrast showing tortuous veins in the left gyrus rectus; (b) and (c) CT angiogram showing large abnormal left ophthalmic and ethmoidal arteries and abnormal cortical venous drainage

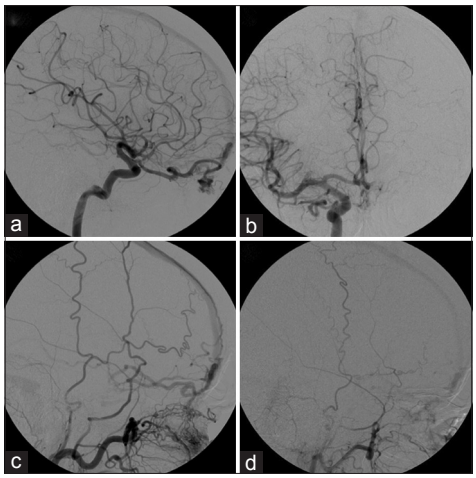

Figure 2: Conventional angiogram. (a) lateral view of the left ICA: DAVF vascularized by the left anterior and posterior ethmoidal arteries originating from the left ophthalmic artery; (b) Anteroposterior view of the right ICA showing anastomosis arising from the right ophthalmic artery; (c) lateral view of the left ECA showing anastomosis; and (d) lateral view of the right ECA showing anastomosis. The venous drainage through a large vein arising from the cribriform plate, which drains into frontal cortical orbital veins, which drains into the superior sagittal sinus. Additionally, the DAVF drains into subfrontal veins, which then drain into the deep venous system. DAVF: Dural arteriovenous fistula, ICA: Internal carotid artery, ECA: External carotid artery

and right external carotid arteries [Figures 2c and d]. The venous drainage was through a large vein arising from the cribriform plate. It drained into frontal cortical orbital veins, which drained into the superior sagittal sinus. It also drained into subfrontal veins, which then drained into the deep venous system. Because of cortical venous drainage and its related risk of hemorrhage, we recommended treatment. Because of the risk of blindness related to endovascular treatment, we opted for surgery.

Surgical technique

The patient is in supine position, with a lumbar drain in place. The head is straight, slightly elevated, with a mild extension. A bicoronal incision is made following minimal shaving, prepping, sterile draping, and the administration of antibiotics. The periosteum is exposed and preserved for use as a pediculate periosteal graft during dural closure. However, directly over the superior border of the frontal sinus, the periosteum is incised and reflected with the flap; the incision is no more than 2 cm lateral to the nasion in order to protect the supraorbital nerve bilaterally. The margins of the frontal sinus are localized [Figure 3a] with the aid of the head CT scan. The neuronavigator can be used for this purpose. The anterior wall of the frontal sinus is cut obliquely using an oscillating saw, beginning at the nasion, proceeding in superior direction, without any need for a burr hole. The mucosa from the frontal sinus is removed and the nasofrontal canals are closed with Surgicel and muscle tissue from the temporal muscle. The thin dorsal wall of the frontal sinus is then removed with drill and rongeur. The dura is opened and retracted, in this case only on the left side, revealing a totally relaxed brain. The arterialized veins on the surface of the frontal lobe can be easily identified [Figure 3b]. Without retraction, under the surgical microscope, the relaxed brain is gently retained, allowing exposure of the cribriform lamina, which is in close proximity. The draining vein of the fistula exiting from the anterior aspect of the cribriform lamina is plainly visible [Figure 3c]; it is coagulated with a bipolar and divided [Figure 3d]. This result in a darkening of the previously arterialized veins. The olfactory bulb and tract are not disturbed at all. The dura is closed in a primary fashion. A piece of bone from the former dorsal wall of the frontal sinus is applied over the muscle tissue already in place covering the nasofrontal canals. The pediculate periosteal flap is laid over the bone opening and sutured to the dura to separate the nasal compartment from the intracranial one. The craniotomy is closed with the original anterior wall of the sinus [Figure 3e]. The skin is closed in two layers. No drain is left subcutaneously. Antibiotics are continued for 24 h postoperatively.

Postoperative course

The patient showed no clinical complications and his sense of smell was normal. The postoperative CT scan also revealed no abnormalities and the postoperative angiogram showed complete disappearance of the fistula [Figure 4]. The patient was discharged 3 days after surgery.

DISCUSSION

eDAVFs of the anterior cranial fossa are rare lesions located at the cribriform plate. They are acquired and evolve over time, leading to an increasing risk of bleeding. The arterial supply is from the ethmoidal branches of the ophthalmic artery, usually bilaterally, but may also come from the middle meningeal artery. These fistulas drain via frontal cortical veins into the

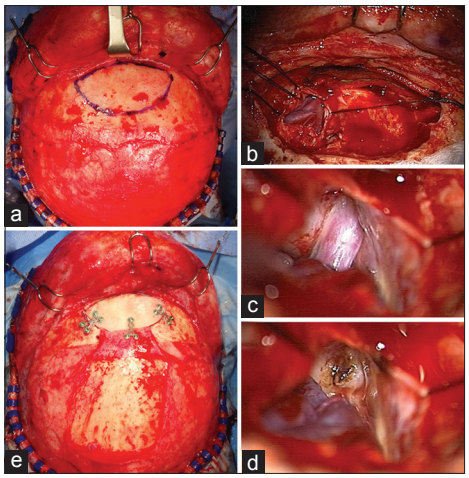

Figure 3: Perioperative images. (a) Margins of the frontal sinus. (b) Tortuous veins after opening of the dura. Pay attention to the short distance between of the skull opening and the actual target of the operation. (c) Large vein exiting the cribiform plate. (d) The large vein seen in c has been coagulated and cut. (e) Closure with the anterior wall of the sinus

superior sagittal sinus.[3,4,25] Treatment of DAVF is indicated, if cortical venous drainage is present.[2,10,11] Both surgical and endovascular methods have been described for treatment of DAVFs.[2,18-20,28] In the case of an eDAVF, which is supplied by the ethmoidal artery from the ophthalmic artery, endovascular treatment has a high risk of failure because of the difficulty of selective catheterization of the ethmoidal arteries and because of the risk of occlusion of the central retinal artery, a branch of the ophthalmic artery, and the consequence of blindness associated with it.[18,20,27] Surgical treatment has a higher success rate.[2,14,18] Several approaches have been described: bifrontal, low subfrontal, pterional, and unilateral modified orbitozygomatic.[2,6,11,12,14,17] However, a frontal and a bifrontal craniotomy, including the low subfrontal craniotomy described by Suzuki for an anterior communicating aneurysm,[13] besides opening the sinus, all require the removal of a full thickness of the frontal bone with the subsequent risk of damage to the dura and the underlying veins including those enlarged by the fistula. In addition, such craniotomies when in close proximity to or crossing the midline may injure the venous sinus itself, which drains the arterialized veins. Moreover, because these craniotomies expose a large surface of the frontal lobes and expose the olfactory bulb and tract, they put these structures at risk. In the pterional approach, the route to the fistula is longer, thus requiring the exposure of a larger area of the frontal lobe and of the olfactory apparatus. Even with this large lateral exposure, visibility to the midline is limited, inciting some to extend this approach through an orbitozygomatic opening, which may lead to complications to the orbit and the temporal muscle.

The purely transfrontal sinus approach is well known for its use in anterior skull base tumors. It was implemented

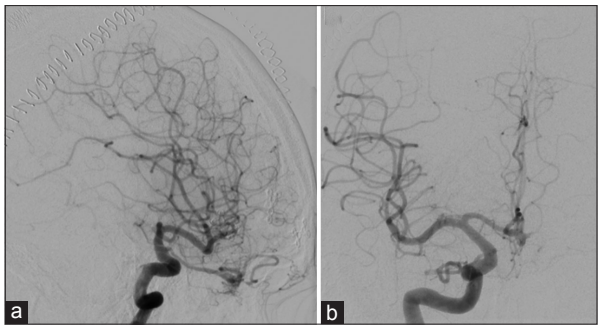

Figure 4: Conventional angiogram. (a) Lateral view of the left ICA, the early drainage into the large vein is no longer present. (b) Anteroposterior view of the right ICA showing disappearance of the anastomosis. ICA = Internal carotid artery

by Frazier in 1913 as an approach to pituitary lesions.[8] Throughout the years, several modifications were made.[15,16,21,23] However, this approach has not been described in the treatment of eDAVFs. From an anatomical point of view, the transfrontal sinus approach is the most direct route with maximal exposure of the draining vein from the fistula. The thin posterior layer of the frontal sinus bone adjacent to the dura can be drilled away carefully. The risk of dural tears is minimized, protecting the underlying veins. Also important is the fact that the frontal lobes are minimally exposed. Nor is pressure applied to the frontal lobe, olfactory bulb, or optic nerve, as retractors are unnecessary. Complications related to infection or cerebrospinal fluid fistula have not been reported to be higher than in standard craniotomies.[7,9,14,18,24] The presence of chronic sinusitis is not a contraindication because the mucosa is resected and the sinus is cranialized.[7,26] Obviously, a hyploplastic frontal sinus is a contraindication to this approach. In such a case or in the absence of the sinus, a frontal craniotomy is an option.

CONCLUSION

The purely transfrontal sinus approach for eDAVFs offers a direct and short route to the lesion while minimizing brain manipulation and avoiding injury to the olfactory bulb and tract. It serves as an excellent surgical approach for eDAVFs.

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Commentaries

The authors have described a transfrontal sinus approach for an anterior cranial fossa, ethmoidal region dural arteriovenous fistula. The transfrontal sinus approach is not a novel skull base approach and is often used to repair traumatic frontal sinus fractures and remove tumors of the anterior skull base. In these cases, as with the ethmoidal region dural arteriovenous fistula, the potential to use this approach depends on the size of the patients frontal sinuses. If a patient has no or very small frontal sinus, this is not indicated. Therefore to me, this case report highlights the fact that each patient is different and we as surgeons have multiple tools that we can use, and selecting the right tool for each individual patient will result in the best outcome. Ethmoidal region dural arteriovenous fistulas can be fed from the ophthalmic artery and in the vast majority of those cases, endovascular therapy is not indicated as embolization may result in blindness. In these cases, selecting the least invasive, simple, and direct approach or surgical corridor is the best.

Gavin W. Britz

Director, Cerebrovascular Center, Cerebrovascular/Endovascular Neurosurgery, Skull Base Surgery, DUMC Box 3807, Durham, NC 27710, USA
E-mail: Gavin W Britz - gavin.britz@duke.edu

How much exposure is necessary to treat properly an anterior cranial fossa dural arteriovenous fistula (AVF) or malformation or any intracranial lesion for that matter? The simple answer is that the neurosurgeon should obtain as much exposure as he or she needs, no less and no more. Inadequate exposure can compromise the surgeons' ability to visualize properly the relevant anatomy while an overly generous opening puts normal brain tissue at unnecessary risk. Of course, in most cases, it is impossible to tailor the opening perfectly, and each surgeon will

require a slightly different amount of exposure to treat a given lesion successfully. When treating vascular lesions in particular, the surgeon must always be mindful of the potential for troublesome bleeding and should therefore be sure that if such bleeding does occur, that he/she will be able to properly control the bleeding through the opening that has been created.

In the accompanying nicely written case report, the authors describe an anterior cranial fossa dural AVF treated through a frontal sinus approach. I suspect many vascular neurosurgeons (including myself) have taken advantage on occasion of a large frontal sinus to treat such a lesion just as the authors did here. The sinus does need to be generous to allow for safe approach to these lesions using exclusively a trans-frontal sinus route. The potential for delayed mucocele development and infection must also be considered when intentionally utilizing an approach that violates the frontal sinus, and the surgeon must know how to properly address the sinus mucosa and fronto-nasal ducts in this setting.

The real message here is that neurosurgeons should maintain flexibility in the operating room and take advantage of the opportunities presented by natural anatomical variations to optimize the treatment of their patients as the authors did in this case.

Eric S. Nussbaum

Director, National Brain Aneurysm Center, John Nasseff Neuroscience Institute, United Hospital, Saint Paul, Minnesota, USA
E-mail: Eric S. Nussbaum - lnussbaum@comcast.net

Magro and colleagues describe an interesting case report of a 59-year-old patient with diplopia who showed on CTA an ethmoidal dAVF with intraorbital dilated compressive vein operated on by a transfrontal sinus approach. Ethmoidal dAVFs are challenging lesions due to their high likelihood of rupture and their difficult endovascular approach.[1] Even in the best endovascular hands, this treatment approach is risky, since it involves accessing the ophthalmic artery past the central retinal artery to the ethmoidal branches. Once the ethmoidal branches are reached, injection of embolization material in the form of micro-particles, glue, or Onyx is indicated to occlude the fistula. Agid *et al*., in their multicentric retrospective analysis from three large experienced centers, analyzed 24 patients of which 11 underwent endovascular treatment. The cure rate by this endovascular approach was only 63.6% and the remaining patients had to undergo open surgery. Open surgery is very effective in achieving a high cure rate for these lesions, however, there is no universal consensus regarding the optimal surgical approach. Approaches include frontal, bifrontal, pterional, orbitozygomatic, and a mini-approach by eye-brow incision. Magro and colleagues present here their experience with a transfrontal sinus approach. This approach offers the most direct access to the anterior skull base and exposure of the fistulous point and draining vein with minimal brain retraction. While this is a historic approach, concerns remain with this approach relating to infectious complications from traversing the frontal sinus and possible cerebrospinal fluid (CSF) leaks. The authors stress that these complications may not be more prevalent with this approach and think that only future experience will show. The authors think that their case and the images displayed underline the elegance of the approach and is a valuable part in any surgeon's armamentarium for anterior skull base lesions.

Phil Taussky

Department of Neurosurgery, 175 North Medical Drive East, University of Utah Health Care, Salt Lake City, Utah 84132, USA
E-mail: Phil Taussky - philipp.taussky@hsc.utah.edu

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