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Intracranial dural arteriovenous fistula successfully treated by combined open—endovascular procedure

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ABSTRACT

Intracranial dural arteriovenous fistulas constitute a rare though potentially devastating disease. Because the arterial (high-pressure) blood flow drains directly into the low-pressure venous system, there is a high risk of bleeding and associated neurological deficit. The classifications by Borden and Cognard underline the correlation between bleeding risk and venous drainage pattern of the fistula. There are different treatment options for this vascular pathology, which always poses a challenge for the physicians involved to offer the optimal treatment for an individual patient. This case report illustrates how combining forces between the neurosurgical and endovascular team benefits outcome. Simultaneously, this contributes to the growing amount of evidence that a new endovascular technique with transarterial ONYX embolisation enables complete obliteration of the vascular malformation.

INTRODUCTION

Dural arteriovenous fistulas (dAVF) are a well-known, though rare, vascular pathology.[1 2] The fistulas of the superior sagittal sinus are even more exceptional.[1 3] This disorder carries great risks for the patients involved, especially when bleeding occurs with potentially devastating neurological consequences.[3 4] The classifications by Borden *et al*[5] and Cognard *et al*[6] reflect that the bleeding risk of a fistula is determined not by its anatomical localisation per se but by the venous drainage pattern (table 1). Therefore, a digital subtraction cerebral angiography is needed in all cases. Treatment is necessary in Borden type II and III fistulas because of the high bleeding risk involved, even in asymptomatic patients.[7] Various surgical and endovascular techniques are described in the literature. This report elaborates on a combined neurosurgical—endovascular approach.

PATIENTS, MATERIALS AND METHOD

A 47-year-old male was referred to our centre because of an apparent vascular lesion on MR imaging. The patient had no complaints, except for a single attack of dizziness. Years ago, he suffered from a migraine-type headache. There was no history of significant head trauma. The clinical examination was normal.

MR imaging revealed a small vascular lesion in the right centroparietal region. The MR angiographic images suggested a dilated right middle meningeal artery (MMA), with otherwise normal cerebral vascular structures. The digital subtraction cerebral angiography demonstrated an obvious dAVF with multiple arterial feeders of which the right MMA was the most significant (figure 1). To a lesser extent, branches of both the occipital arteries and the left MMA also contributed to it. The fistula had a direct cortical venous drainage, without venous ectasia but with retrograde drainage through the bridging veins. The superior sagittal sinus was patent. So, the fistula was classified as a Borden type III, which constitutes a lifetime risk of haemorrhage of 80—100%.[7]

Under general anaesthesia, a transfemoral transarterial superselective catheterisation of the right MMA to embolise the dAVF with ONYX was started. However, due to proximal tortuosity of the MMA, appropriate distal catheterisation could not be reached (figure 2). The application of different types of microcatheter was not helpful. Injection of ONYX or even glue from the achieved proximal position in the MMA would most probably lead to proximal feeder occlusion, leaving the fistula site open for collateral supply (ie, the occipital artery feeders). Therefore, the procedure was stopped to discuss treatment strategy. It was decided to create a direct surgical access to the MMA, as already described in the literature.[2 8–10]

Preoperatively, the arterial sulcus of the MMA on the right side of the scalp was outlined with the aid of fluoroscopy. We placed a vertical incision of about 6 cm length, posterior to the coronary suture. Two burr holes on either side of the preoperatively marked position of the sulcus arteriosus were made and interconnected by the Kerrison rongeur. In this way, the artery was easily exposed and dissected to ensure a craniocaudal exposition of about 5 cm (figure 3). Next, a direct puncture of the hypertrophic MMA was performed with a 20G standard intravenous infusion needle (20G intravenous catheter with wings-Insyte W, Vialon, Spain) which, after removal of the steel punction needle, allowed the introduction of a 0.018-inch hydrophilic guidewire (Radifocus, Terumo, B) into the artery. After removal of the 20G cannula, a 4 French polyurethane 18G 20 cm long catheter with tapered tip (Leader-Cath 4F, Vygon, Ecouen, France) was first fetched through the scalp from outside to inside, using a tunnelling cannula (AD Tech, CAPN-1X, Racine, Wisconsin) and then gently pushed over the guidewire into the MMA, a manoeuvre similar to the classical Seldinger catheterisation technique (figure 4). This catheter then served as the guiding catheter for the coming microcatheter. The 4F catheter was secured in the MMA by a standard 4.0 Prolene suture and proximally to its entry point the MMA was ligated. The entry point in the vessel was

Table 1 Classification according to Borden *et al*[5] and Cognard *et al*[6] of intracranial dural arteriovenous fistulas; correlation with lifetime bleeding risk

Borden	Cognard	Bleeding risk (%)
Type I: DVS/MV outflow only	Type I: DVS/MV outflow only Type II A: DVS/MV outflow only (retrograde)	≤2
Type II: DVS/MV outflow and RLVD	Type II B: DVS/MV outflow (anterograde) and RLVD Type II A+B: DVS/MV outflow (retrograde) and RLVD	40
Type III: RLVD only	Type III: RLVD only (no venous ectasia) Type IV: RLVD only (with venous ectasia) Type V: RLVD only (into spinal perimedullary veins)	80–100

DVS, dural venous sinus; MV, meningeal vein; RLVD, retrograde leptomeningeal venous draining.

marked with a clip. The wound was then sutured in layers. The catheter in the MMA was connected to a saline–heparin infusion in order to maintain patency. The patient, still under general anaesthesia, was brought to the angiography room, the wound being covered with a sterile wound dressing.

Then, the right external carotid artery was catheterised with a 5F-Headhunter (Cook, Bloomington, Indiana) catheter via a left femoral approach which confirmed the occlusion of the MMA by the positioned suture and filling of the fistula via collateral feeders from the occipital artery. Other minor feeders branched from the contralateral MMA and occipital artery (figure 5). Injection of contrast through the surgically placed catheter in the MMA confirmed the accurate position and revealed the fistula about 2 cm downstream. An Ultraflow 1.5F (Micro Therapeutics, Irvine, California) microcatheter was positioned through the

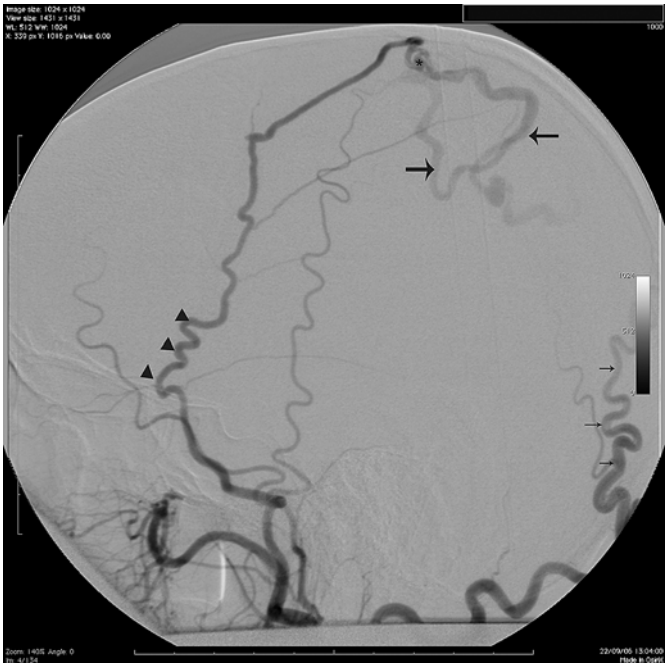

Figure 1 Right external carotid digital subtraction angiography (lateral view) showing a hypertrophic right middle meningeal artery feeding the parasagittal dural arteriovenous fistulas (asterisk) with draining cortical veins (arrows). Note the proximal tortuosities of the middle meningeal artery (arrowheads), precluding distal microcatheterisation (see figure 2), and the hypertrophic occipital arteries which help to feed the dural arteriovenous fistulas in a later arterial phase (small arrows).

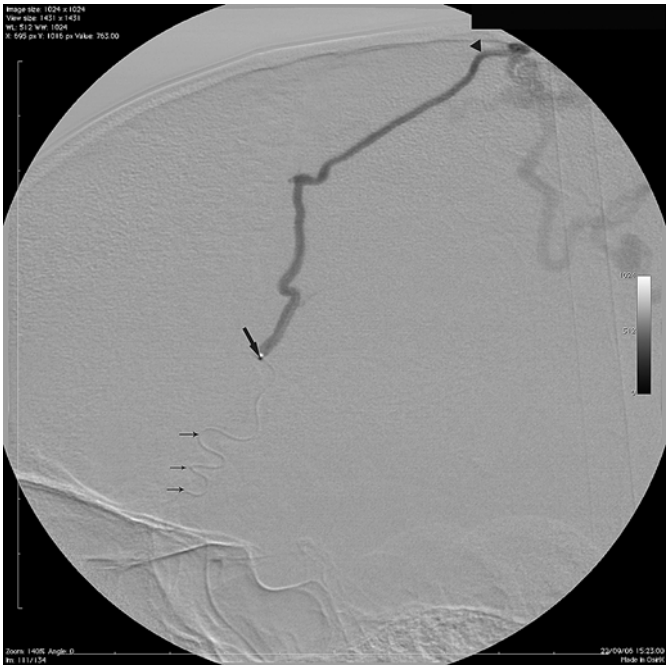

Figure 2 Microcatheter digital subtraction angiography of the middle meningeal artery (lateral view) showing the tip of the microcatheter (arrow), far from an ideal distal position (arrowhead). Tortuosities are faintly visible by shadow of microcatheter (small arrows).

catheter inside the fistula itself (figure 6). Embolisation could now be performed with ethylene vinyl alcohol copolymer (ONYX 34, Micro Therapeutics). The fistula pouch was slowly filled with ONYX for about 45 min (figure 7). The embolisation was completed by inducing reflux down the 4F catheter entry point (figure 8). After waiting a couple of minutes for the ONYX to solidify, the guiding and microcatheter were then gently removed. Control angiography of both external carotid arteries and vertebral arteries confirmed obliteration of the fistula. To avoid gluing in the ONYX, the surgically placed guiding catheter was removed directly after the embolisation by cutting the

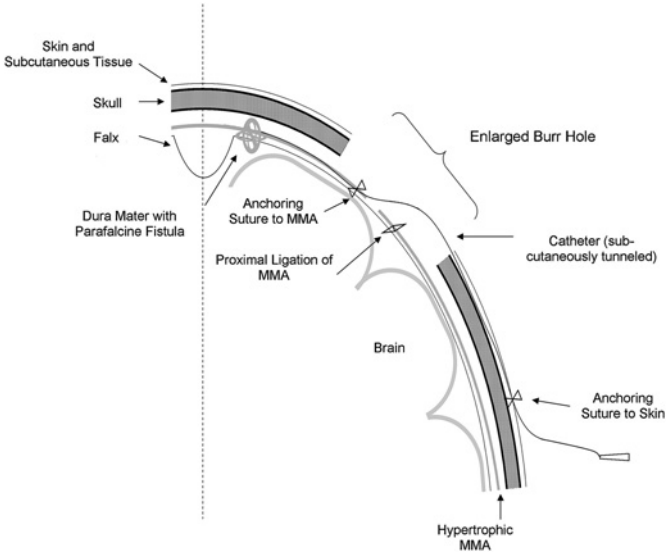

Figure 3 Schematic overview of the surgical access to the middle meningeal artery (MMA) and direct catheterisation of the vessel. Note the subcutaneously tunnelling of the catheter in order to maintain a safe distance from the wound to avoid infection.

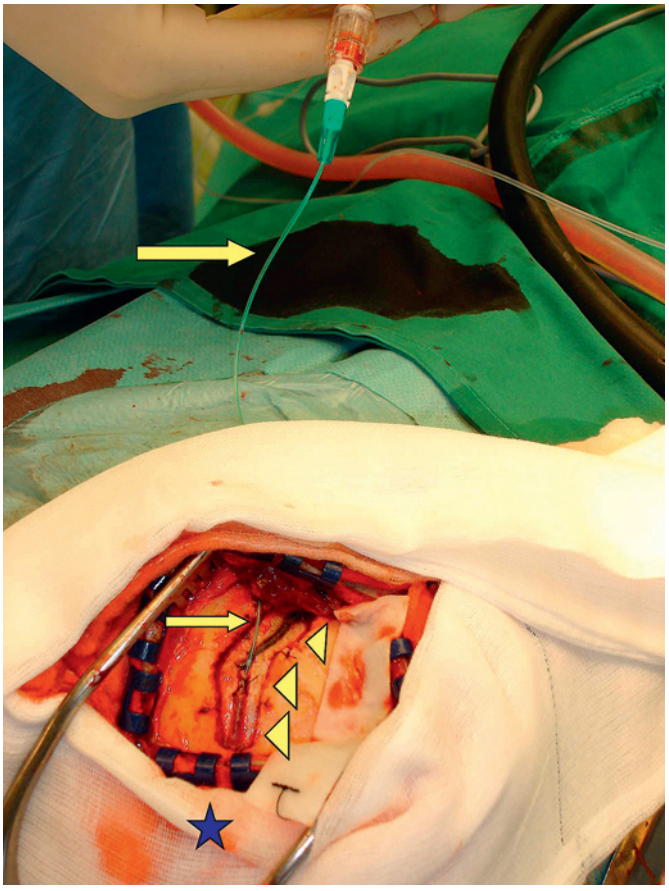

Figure 4 Peroperative picture illustrating the enlarged burr hole (arrowheads) with the hypertrophic middle meningeal artery, in which the catheter has been placed and tunnelled (arrows). *Cranial.

anchoring suture and retracting the catheter percutaneously. During this combined neurosurgical–endovascular procedure, no anticoagulation was used. There were no complications.

The patient was then returned to the operating theatre. The wound was reopened, and inspection of the MMA showed no bleeding. The enlarged burr hole was filled up with methyl methacrylate antibiotic bone cement (Antibiotic Simplex, Stryker, Howmedica Osteonics, Limerick, Ireland). After repeated antiseptic measures, the wound was meticulously closed again.

The patient woke up without any complaints or neurological deficit. MRI the next day demonstrated the resolution of the high flow signals in the dilated cortical veins. No haemorrhagic or ischaemic complications were found. After a further observational period of 2 days, he was discharged. A week later, he returned to work. Digital subtraction angiography of the carotid and vertebral arteries after 6 months confirmed the complete obliteration of the fistula (figure 9).

DISCUSSION

A Borden type II or III dAVF requires treatment, because the lifetime risk of haemorrhage and associated neurological damage is high.[4 7 11] Our patient did not show any clinical or radiological signs of bleeding.

The surgical obliteration of the fistula was the first treatment modality described in the literature and is still frequently used today. However, depending on the type of the fistula on the one hand and on the location of the lesion on the other hand, the surgical risks can be elevated.[12] Given the eloquent region in

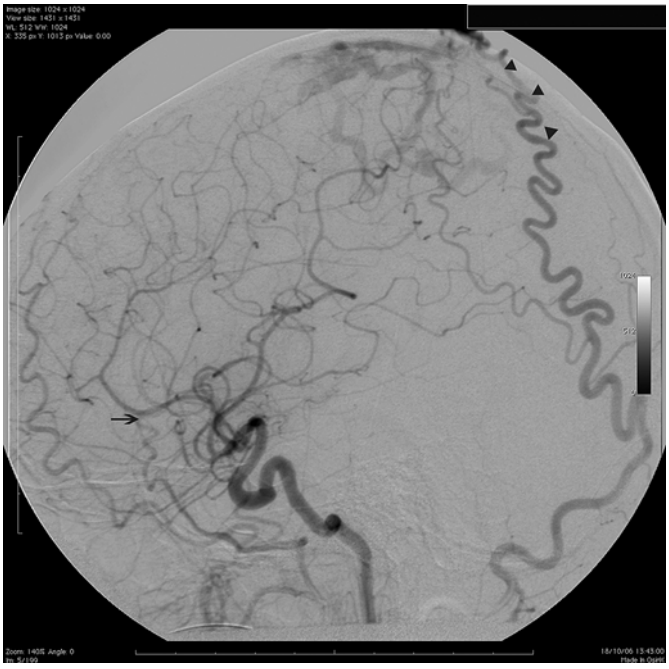

Figure 5 Right carotid digital subtraction angiography (lateral view) showing proximal occlusion of the ligated middle meningeal artery (arrow), but also collateral supply of the dural arteriovenous fistulas by the occipital artery (arrowheads). The other minor supply arises from the contralateral middle meningeal artery, occipital artery and posterior meningeal artery.

which the present lesion was located, the surgical option was kept as a last resort.

The endovascular treatment of this vascular pathology is well known, either via a transvenous route or via a transarterial approach. The transvenous route is reported to be a safe

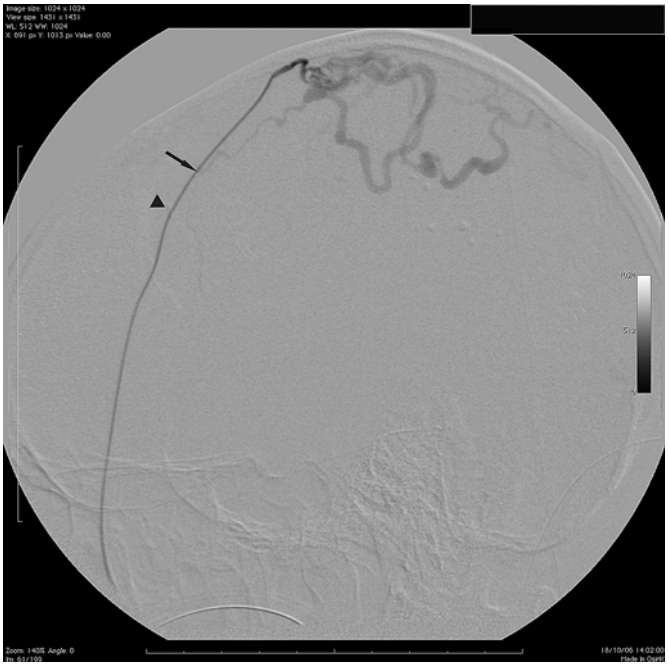

Figure 6 Superselective digital subtraction angiography of the distal middle meningeal artery (lateral view) via the directly implanted 4F polyurethane catheter. Note the entry point (arrow), with proximally ligated middle meningeal artery (arrowhead). A 1.5F microcatheter was then introduced through the 4F catheter and pushed into the fistula (see text).

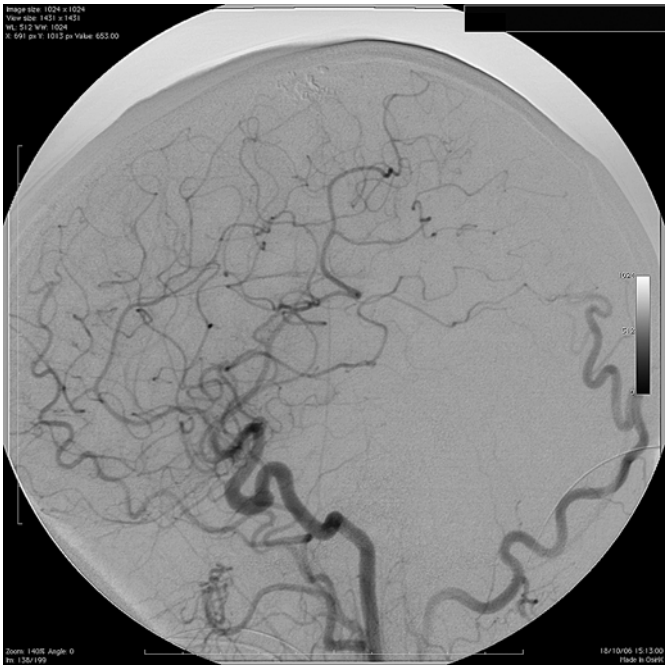

Figure 7 Right carotid digital subtraction angiography (lateral view) after occlusion of the dural arteriovenous fistulas with 0.7 cm^3 of ONYX-34.

procedure,[13] but unexpected, potentially fatal, complications can occur as also demonstrated in our own experience (unpublished data). One has to mention the risk of thrombosis of the superior sagittal sinus and subsequent venous infarction, or the thrombosis of the draining cortical veins with serious consequences even at a distance from the fistula.

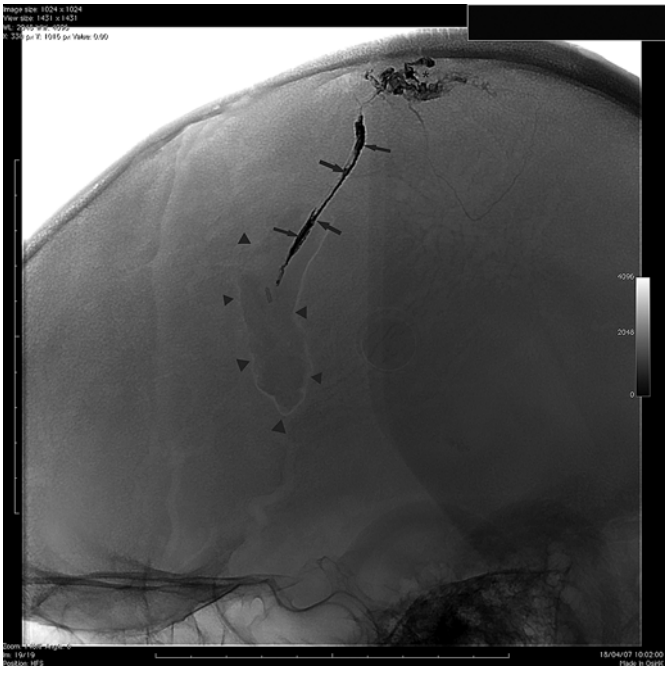

Figure 8 Plain digital image (lateral view) showing the final ONYX cast (asterisk) and the retrograde filling/reflux (arrows) of the middle meningeal artery down to the 4F catheter entry point. Note the burr hole (arrowheads), which was enlarged craniocaudally to allow easy access to the blood vessel and which was filled after the procedure with methyl methacrylate bone cement (see text).

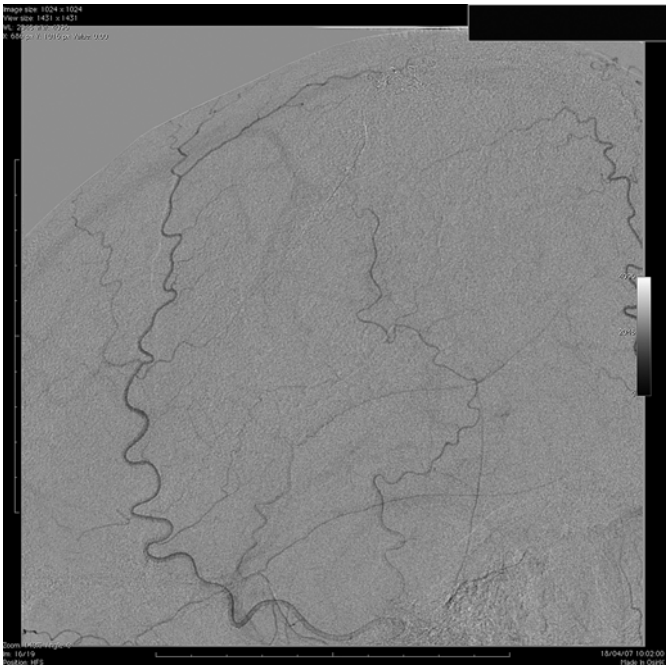

Figure 9 Control right external carotid digital subtraction angiography (lateral view) at 6 months confirming complete obliteration of the dural arteriovenous fistulas.

We decided to perform a transarterial ONYX embolisation in our patient. However, because of the tortuous course of the MMA, the wedge position of the microcatheter in the fistula site could not be reached. The transfemoral approach was abandoned, but we decided to gain arterial access through direct exposure of the MMA. This combined neurosurgical–endovascular approach is not novel and has already been described,[2 9 10] to our knowledge first by Fransen *et al*.[8] This type of rare vascular pathology requires a multidisciplinary approach. Through the whole process of diagnosis and treatment choice in this case, there was counselling and discussion between the neurosurgical and neuroendovascular teams. When the endovascular procedure met technical difficulties, a new discussion led to a combined approach with the aim of minimising the risks and optimising the odds for complete obliteration of the fistula. We believe that such cooperation will lead to the optimal treatment for an individual patient with this rare vascular pathology.[2 8–10]

The fistula was obliterated using ONYX 34. Though still a matter of debate, there is growing evidence that ONYX provides a definite treatment for dAVF.[14 15] Digital subtraction angiography after 6 months reaffirmed a complete obliteration of the fistula in our patient.

CONCLUSION

This case of a Borden type III dAVF illustrates how collaboration between neurosurgeons and interventional neuroradiologists can lead to optimal patient treatment. A direct surgical access of the main arterial feeder of the dAVF can facilitate the endovascular procedure when a transfemoral approach fails. We also contribute to the growing amount of evidence that a definitive treatment in these lesions can be obtained with transarterial ONYX embolisation.

Competing interests None.

Patient consent Obtained.

Provenance and peer review Not commissioned; externally peer reviewed.

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