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HOW I DO IT

How I do it: angiography-assisted full endoscopic treatment of spinal dural arteriovenous fistula

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Abstract

Background Spinal dural arteriovenous fistula (sDAVF) is a rare vascular malformation that leads to serious neurological symptoms. We treat a 52-year-old man with sDAVF in the thoracic segment exhibiting uncoordinated gait.

Method Thoracic MRI of the lesion indicated myelomalacia and dilated blood vessels, while DSA revealed the right T6 radicular artery as the feeding arteriole. A full endoscopic obliteration of the lesion was performed under angiography guidance in a hybrid operation room.

Conclusion The case underscores the importance of a multidisciplinary and individualized approach to successfully manage sDAVF using a fully endoscopic approach.

Keywords Spinal dural arteriovenous fistula (sDAVF) · Angiography-assisted surgery · Endoscopic spine surgery (ESS)

Relevant surgical anatomy

Spinal dural arteriovenous fistula (sDAVF) involves an abnormal shunt between the arteries and veins of the spinal cord within the dura mater, leading to venous hypertension and resulting in neurological symptoms like gait disturbance, weakness, and sensory deficits [6, 7]. It usually involves a single feeder and is mostly found in the thoracic region [6]. Accurately identifying and surgically closing the shunting segment results in the lowest chance of recurrence [1]. We propose that specific cases may be amenable to treatment using a full endoscopic approach with angiography assistance.

After identifying a potential case using MRI, a full presurgical angiography consisting of the radicular artery 4 levels above and below the suspected site along with relevant spinal arterial feeders such as the vertebral arteries and the artery of Adamkiewicz were checked for additional fistulas. For the full endoscopic approach to work, the problematic connection must be identified as intradural dorsal arteriovenous fistulas according to Spetzler's classification [6]. Successful closure of the shunting segment through coagulation can be confirmed with intraoperative angiography or, alternatively, by making a small durotomy and visually confirming it [5]. The trajectory used is similar to the one used for subarticular lesions [3]. An over-the-top contralateral approach akin to those used for dorsolateral lesions was used. If there is no preexisting stenosis, a

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partial preservation of the ipsilateral lamina at the entry point (in this case, the left side) was used.

Description of the technique

Preparation

The authors used a full endoscopic approach with real-time angiography in a hybrid operation room to approach and obliterate the lesion. The patient was first placed under general anesthesia and positioned supinely. An experienced neuroradiologist performed angiography from the right femoral artery, identifying a T6 right radicular artery feeder (Fig. 1). The patient was then positioned prone for standard endoscopic spine surgery, and the lesion's precise location was marked under fluoroscopy before surgery.

Procedure

After confirming the spinal level, a thoracic endoscopic contralateral interlaminar approach was planned with a left paramedian incision approximately 2 cm from the midline to access the right T6-7 interlaminar space (Fig. 2). Angiography identified the lesion level (Fig. 3a), and the operation was conducted using the SpineEndos System (SPINENDOS

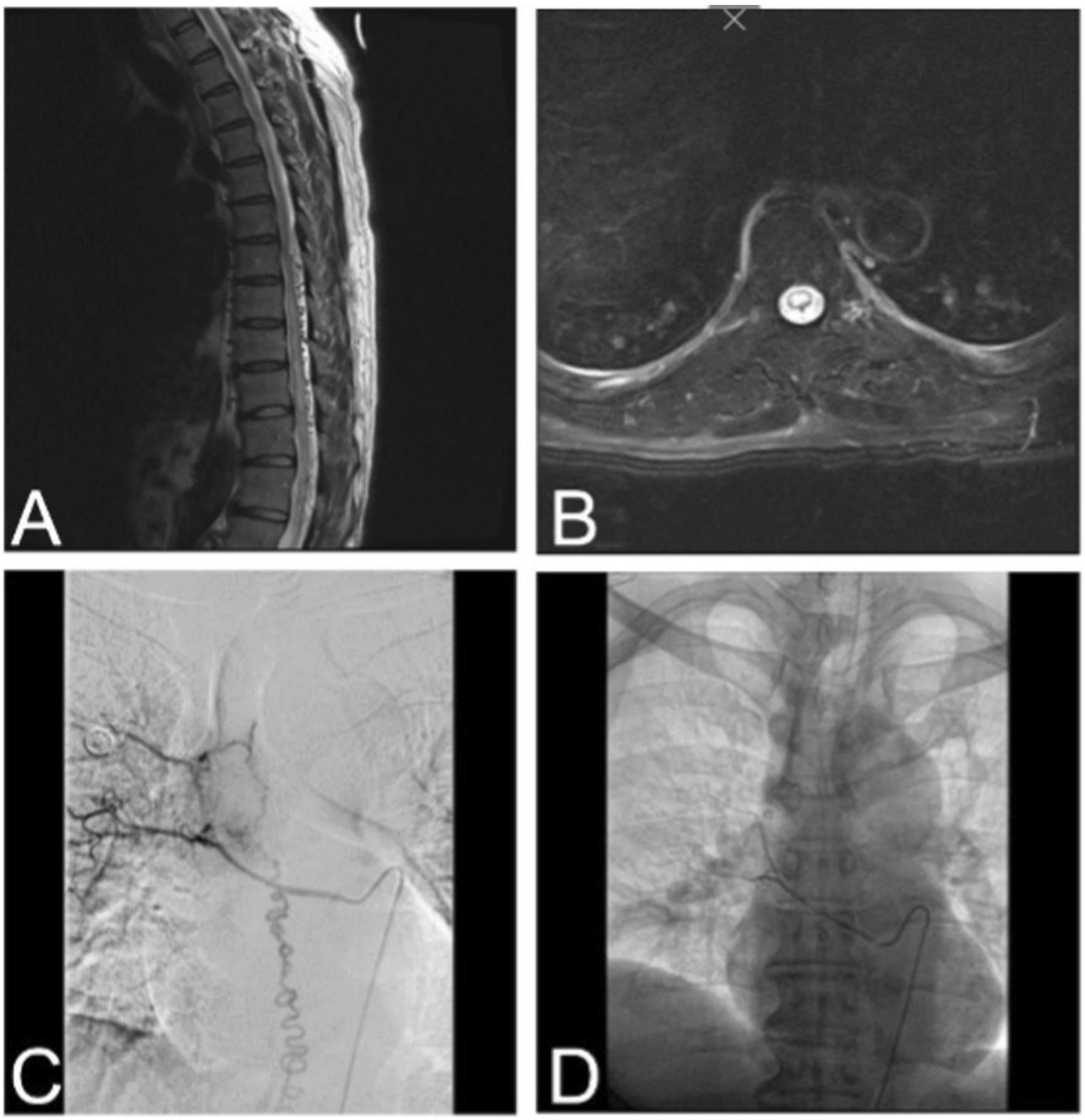

Fig. 1 **A** Sagittal T2WI of thoracic spine showing prominent coils of redundant serpentine veins typical of a spinal dural arteriovenous fistula. **B** Axial view of T2 image at T6 level of the cord showing hypointensity in the cord indicative of severe cord edema. **C** PreOP angiography showing a radicular artery that highlights to location of the fistula in the level above from the right side. Patient was laying supine in this image. **D** The level of the lesion was marked with a radiopaque sticker or paper clip as needed with the help of a C-arm

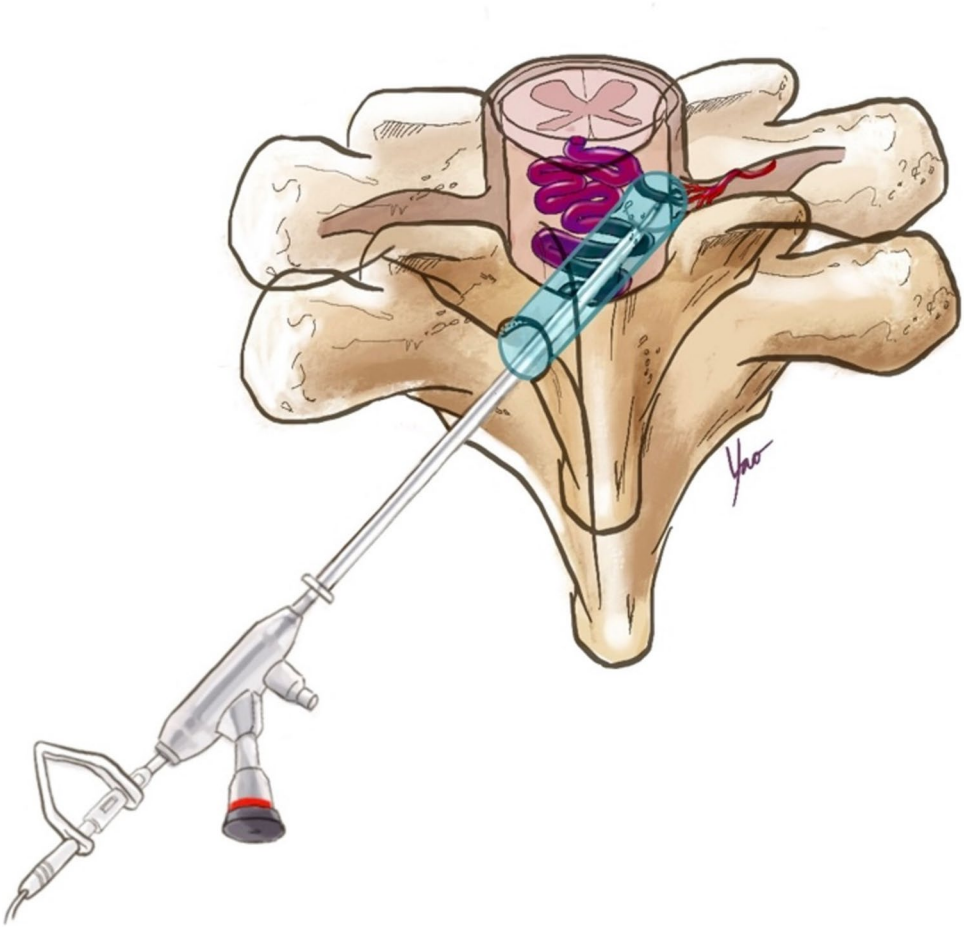

Fig. 2 An illustration of the angle of the scope towards the lesion from the contralateral side, from the spinolaminar junction. A tunnel was made from the patient's left to the lesion site towards the right

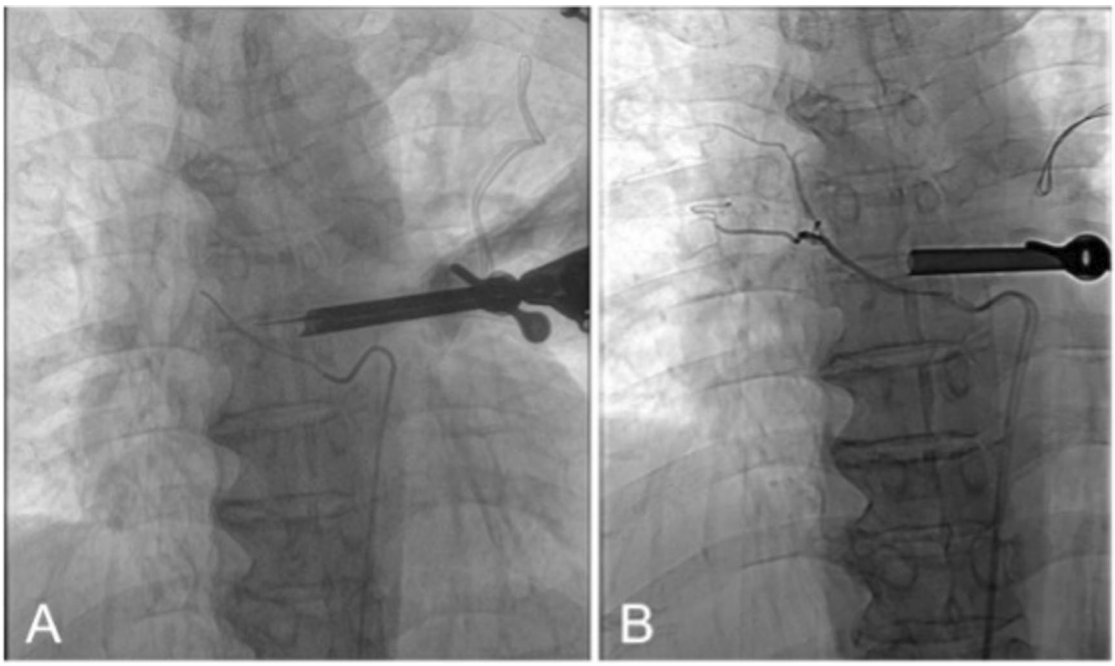

Fig. 3 **A** The endoscope sheath was inserted from the contralateral side with a pointer inserted pointing towards the target lesion. **B** Immediate post treatment intraoperative angiography in the hybrid OR showing obliteration of the sDAVF lesion

GmbH, Munich, Germany). A standard 8-mm × 8-mm laminotomy was performed from the left spinolaminar junction towards the right T6 lateral recess and subarticular space over the lesion site (Fig. 4). After coagulation of the arteriovenous fistula from the right T6 radicular artery, intraoperative angiography confirmed obliteration (Fig. 3b). More specifically, the target is the proximal arteriole shunting zone of the AV fistula, including possible extensions to the inner side of the dura.

Additionally, an intentional durotomy was performed to inspect the perimedullary vein's alignment and the complete obliteration of the shunting segment from the dura after coagulating the arteriovenous fistula. Subsequently, the dural defect was packed with two layers of dural substitute (Duragen plus, Integra) and reinforced with fibrin sealant (Tisseel, Baxter). The microscope and microscopic instruments were on standby throughout the procedure in case of complications. A lumbar drain was placed postoperatively at the L4-5 level and removed within 24 h.

The endoscopic management of sDAVF involves careful planning of the trajectory and necessary laminectomy. The patient was anesthetized and positioned to optimize access to the affected spinal level. Real-time angiography confirmed the lesion's precise location and aided navigation. The feeding arteriole was identified and completely coagulated to obliterate the fistula. The durotomy created during the procedure was repaired using dural substitutes and fibrin sealants. A follow-up DSA confirmed total sDAVF resolution 4 months after the operation (Fig. 5).

Indications

Application of a full endoscopic approach for managing spinal dural arteriovenous fistula (sDAVF) mainly depends on evaluating the lesion and considering the anatomy. In this instance, the neuroradiologist assessed that the offending vessel had a high risk of potential recurrence from other neighboring arteriole after endovascular treatment due to its extended shunting zone. It is crucial to carefully assess the location of the anastomosis in the spinal vasculature, with a preference for cases where a single feeder vessel is visible on the dorsal or dorsolateral side. Although around 85% of sDAVFs originate from a single feeder [7], it is important to recognize that there can be variations, including cases with arterial feeders coming from multiple locations or even from both sides, and some may even present as single feeder initially [2]. More complex cases may pose challenges for endoscopic techniques, especially when there is bleeding during the operation [2]. In situations with multiple feeders or lesions located at different levels, the endoscopic approach may be less effective due to restricted visualization, highlighting the importance of selecting the right cases [4].

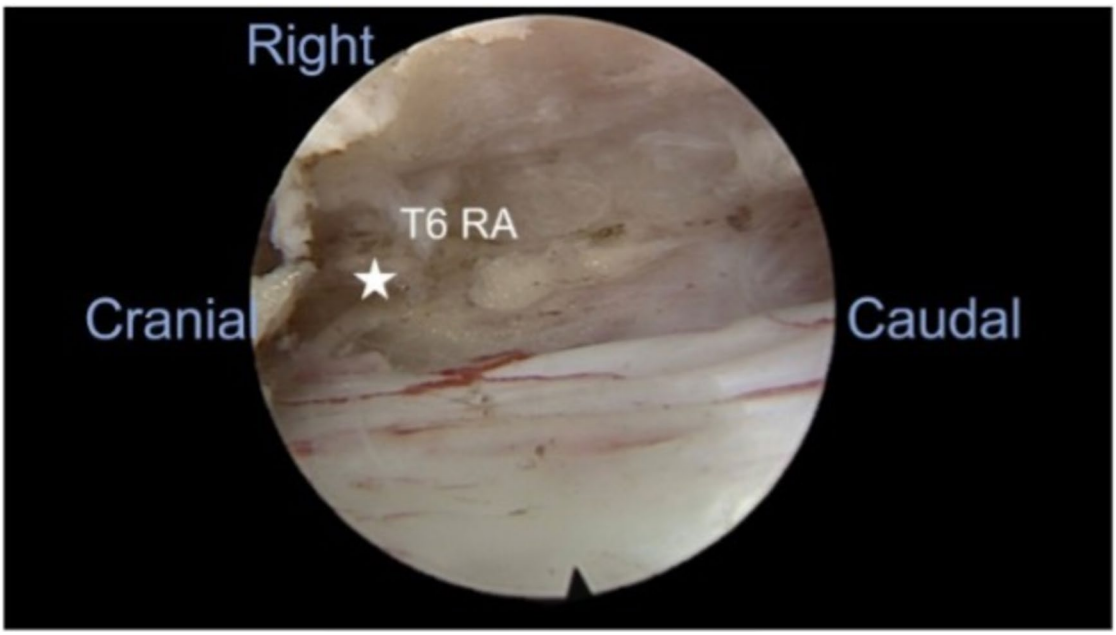

Fig. 4 Under the endoscope, view of the contralateral side of the dorsal region of the thecal sac was visualized; the T6 radicular feeding artery can be seen on the left of the screen (marked as: asterisk T6 RA). Figure is available in color online only

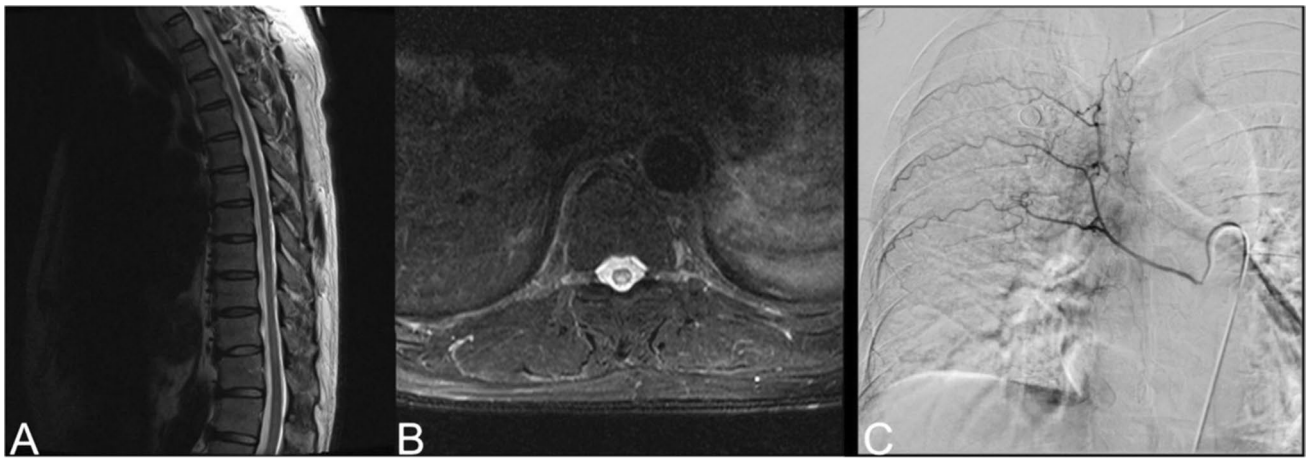

Fig. 5 **A** Post-operative T2 images showing faint to no trace of flow in dorsal tortuous veins 3 months after surgery. **B** Improved cord edema at the T6 level as compared to Fig. 1A. **C** DSA of the patient 4 months post-surgery

Limitations

While the full endoscopic approach holds promise, its limitations must be acknowledged. Its feasibility decreases when addressing multiple lesions or lesions located on different sides, levels, or angles of the spinal structure. Note that the entry point determines the cone volume of maneuverability and the visible levels of the scope, which in this case gives a view from the T6 pedicle to the top of the T7 pedicle. Additionally, the anastomosis may be hard to access with an endoscope or located near essential nerve or vascular structures [2]. Management of intradural bleeding can be tricky, and high-pressured irrigation is contraindicated on an opened dura. Gentle compression with a gelatin sponge and patiently waiting 2–5 min for clot the form can be sufficient, but be prepared to convert to open spine surgery if bleeding is profuse. These factors emphasize the need for careful patient selection and comprehensive preoperative evaluation to ascertain the suitability of a full endoscopic approach for the best outcomes.

Endpoint of the procedure

The goal of the procedure is to completely obliterate the sDAVF, confirmed by angiography or inspection of both sides of the dura. In this case, intraoperative angiography and a minor durotomy were employed to ensure no residual flow remained in the abnormal connection between the arteries and veins. Furthermore, postoperative imaging, such as MRI and DSA, can be utilized to evaluate the resolution of spinal cord edema and the absence of any remaining fistula (Fig. 5).

How to avoid complications

Detailed preoperative planning, comprehensive imaging, and multidisciplinary collaboration are essential for accurate lesion localization and assessment of anatomical variations. Real-time angiography, which assists in precise navigation, is valuable for verifying complete obliteration. Surgeons should be prepared for potential complications and have a contingency plan, such as having microscopic instruments readily available. Careful management of hydrostatic pressure and temperature during the procedure, along with meticulous repair of any durotomies, can help minimize postoperative complications.

Specific perioperative considerations

Managing patients during the perioperative period for endoscopic treatment of sDAVF involves closely watching their neurological status, blood pressure, and overall body functions. Immediate postoperative care includes caution on possible IICP signs and hypothermia, especially when durotomy was performed. It is important to keep the patient immobilized until the removal of the lumbar drain tube and watch out for possible complications like leaks of cerebrospinal fluid, infections at the wound site, or worsening neurological conditions. Long-term follow-up is essential to assess the durability of the endoscopic treatment and ensure the absence of recurrence.

Conclusion

The application of endoscopic techniques in the treatment of spinal dural arteriovenous fistulas (sDAVF) presents a promising option compared to traditional surgery or endovascular embolization. This approach is characterized by its minimally invasive nature, which can lead to a quicker recovery. However, the success of this method rests on careful patient selection and thorough preoperative planning. This case shows that collaborative efforts with endovascular experts can more fully leverage the minimally invasive nature of endoscopy, ensuring both the safety and effectiveness of the procedure.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00701-024-05997-0.

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