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Far lateral craniotomy for disconnection of vertebral dural arteriovenous fistula: how I do it

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Abstract

Background Craniocervical junction (CCJ) vascular abnormalities can be challenging to treat because of the surrounding density of critical neurovascular anatomy. Although most dural arteriovenous fistulas (dAVFs) are now treated with endovascular surgery, dAVFs near the CCJ are often better suited for microsurgical obliteration with precise vascular control.

Methods We describe our microsurgical approach to treating dAVFs at the CCJ. This includes a far-lateral approach with a small incision centered over the transverse process of the atlas and circumferential skeletonization of the vertebral artery in addition to clipping the fistula to limit lesion recurrence.

Conclusions Definitive microsurgical treatment of CCJ dAVFs can be accomplished using a minimally invasive approach.

Keywords Dural arteriovenous fistula · Craniocervical junction · Vertebral artery · Microsurgical approach

Abbreviations

CCJ	Craniocervical junction
dAVFs	Dural arteriovenous fistulas
CVR	Cortical venous reflux
VA	Vertebral artery
ICG	Indocyanine green
CSF	Cerebrospinal fluid

Relevant surgical anatomy

Dural arteriovenous fistulas (dAVFs) are vascular abnormalities characterized by pathologic connections between arteries and veins within the dura [1]. The presence of cortical venous drainage/reflux (CVR) is associated with a greater propensity to rupture and is used to classify dAVFs as aggressive. Cognard type IIb-V arteriovenous fistulas fit this classification. The mortality rate is > 30% after initial hemorrhage, and the risk of rebleed is up to 35% within the first 2 weeks if CVR is present [1]. Thus, prompt diagnosis and treatment are necessary to mitigate the risk of complications.

dAVFs of the craniocervical junction (CCJ) represent 1–2% of intracranial or spinal dAVFs [2]. They frequently cause CVR and present high risks of myelopathy from venous congestion or severe neurologic injury due to intramedullary hemorrhage [2]. The deep-seated location and tortuosity of the vessels that supply these dAVFs complicate diagnosis and endovascular treatment strategies [9].

Many cerebrovascular malformations are now treated endovascularly. In CCJ dAVFs, vertebral artery (VA) involvement can complicate endovascular procedures with the risk of embolization reflux to the anterior spinal artery and other vessels. Given the anatomic challenges and complex angioarchitecture, microsurgery remains a favorable treatment with good outcomes [8, 9].

The far-lateral approach provides ideal access for the treatment of CCJ dAVFs. Using a lateral incision over the transverse process of C1, the superficial muscles are dissected in a layered fashion to expose the suboccipital triangle (bordered by the rectus capitis posterior major and the inferior and superior oblique muscles) [3]. The dorsal ramus of the C1 nerve and the V3 segment of the VA lie on the floor of the triangle [3, 6]. After running in the vertebral groove in the posterior arch of the atlas, the VA turns anterosuperiorly and then pierces the dura and atlantooccipital membrane. Attention to the surrounding neurovascular structures is critical when dissecting the VA, including the C1 ventral ramus, which runs anterior to the VA,

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the venous plexus encasing the horizontal portion of the VA, and small VA perforating branches [3, 6]. The posterior aspect of the atlantooccipital joint may be resected to achieve a greater working corridor and to allow for a circumferential dural incision around the VA entry site.

Description of technique (video)

An 83-year-old woman with a past medical history of a left middle cerebral artery stroke, right lower-extremity plegia, and a known cervicomedullary dAVF presented with worsening lower-extremity weakness and upper-extremity contractures. She had recently lost the ability to walk and stand and was experiencing progressive speech difficulties. Imaging work-up (Fig. 1) revealed a T2-weighted/short tau inversion recovery intramedullary signal abnormality within the cervical spinal cord likely from venous congestion and edema due to the dAVF. The main dAVF feeding artery originated from the right VA, inferior to the origin of the posterior inferior cerebellar artery, and drained to a perimedullary vein, consistent with a Cognard type V dAVF. Because of the high grade with subacute myelopathy, the patient was offered surgery to obliterate the dAVF.

A right far-lateral approach with partial C1 laminectomy was performed for disconnection of the dAVF. Intraoperative neuromonitoring was placed, and the patient was situated in the lateral position. The patient was prepped at the craniocervical site as well as the right lower abdominal quadrant for the harvesting of a fat/fascia graft. A curvilinear incision was marked over the transverse process of C1, avoiding the excess tissue disruption required for an L-shaped midline incision. After muscular dissection, the V3 segment was identified within the suboccipital triangle using a Doppler ultrasound probe. A retrosigmoid craniectomy and an ipsilateral C1 hemilaminectomy were performed. Additional bony removal to visualize the dural entry site of the VA was achieved with the drilling of the posterior occipital condyle and the medial portion of the C1 lateral mass. After dural opening, the early draining arterialized vein was identified and confirmed with video indocyanine green (ICG) angiography. A temporary clip was placed, and neuromonitoring was stable. A permanent clip was replaced on the proximal vein, and a second clip was placed where it coursed anterosuperiorly to ensure complete occlusion. Finally, the dura was cut circumferentially around the VA dural entry site to completely disconnect any arterial supply from the fistula. Video ICG angiography confirmed the absence of abnormal venous drainage.

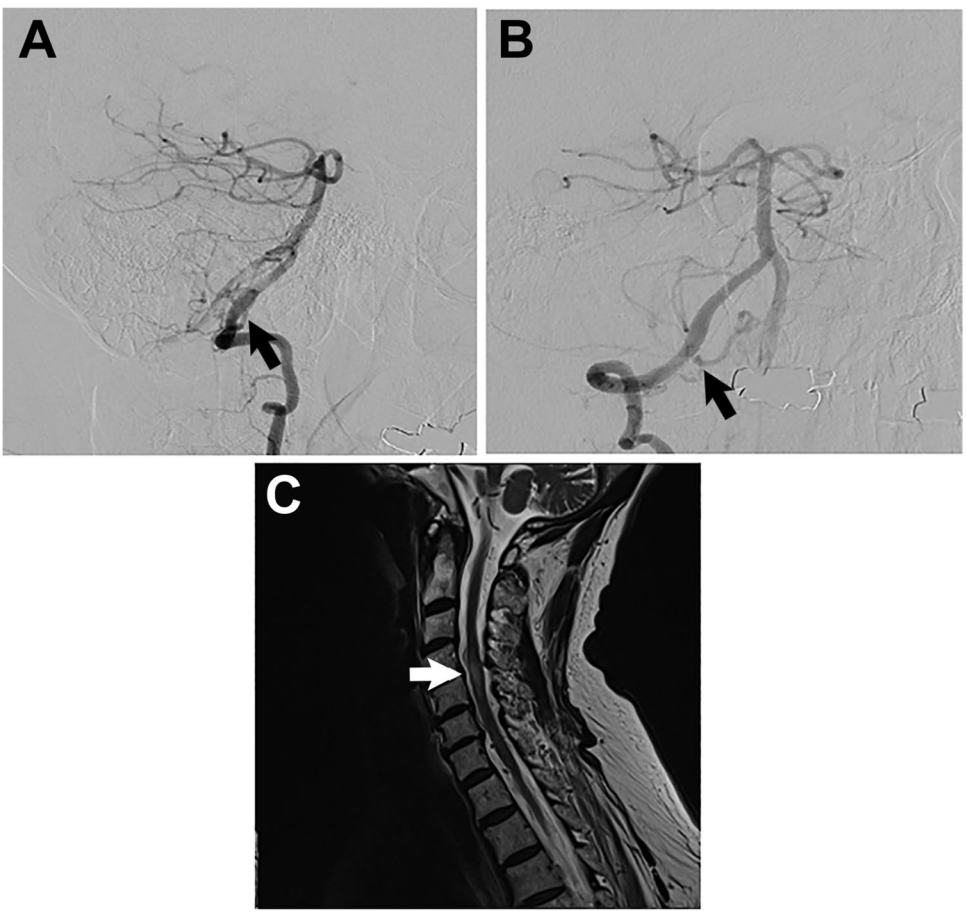

Fig. 1 Preoperative imaging. An 83-year-old woman presented with worsening bilateral lower-extremity weakness from a known dAVF. Digital subtraction angiography demonstrated a Cognard type V dAVF with arterial supply from a right posterior meningeal branch arising from the VA and drainage into a single perimedullary vein. **A** lateral and **B** anteroposterior injections of the right VA (black arrows highlight the draining vein). **C** T2-weighted/fluid-attenuated inversion recovery MRI of the cervical spine displayed hyperintensities at the level of C4, with edema due to spinal venous congestion (highlighted by the white arrow). The patient underwent a successful far-lateral approach for fistula disconnection

The dura was closed in a watertight fashion (an autologous fascia or allogenic graft can be used as needed), followed by a fat graft to fill the dead space and decrease the risk of a cerebrospinal fluid (CSF) leak. The wound was closed in a layered fashion. A postoperative angiogram demonstrated complete fistula obliteration (Fig. 2). On a 1-month follow-up, the patient had improved speech and extremity motor function.

Indications

Although the natural history of dAVFs at the CCJ has not been well elucidated, progressive myelopathy is a common presentation. In a patient with myelopathy of unknown origin, a workup for DAVF may be warranted [8]. In the absence of definitive guidelines, patients with symptomatic or high-grade dAVFs of the CCJ should be considered for treatment.

Limitations

The use of a minimally invasive lateral incision for the far-lateral approach is often limited by unfamiliarity with the local anatomy. It is favored by the senior author because it avoids extensive medial-to-lateral dissection and cervical muscle disruption, which can cause significant postoperative discomfort and pseudomeningocele formation. A thorough understanding of the course of the VA and its surrounding neurovascular structures is critical to the safe adoption of this technique, which has a dissection plane directly onto the artery [5].

How to avoid complications

The far-lateral approach using a lateral incision centered over the C1 transverse process minimizes tissue disruption and postoperative pain. Resection is limited to the posteromedial aspect of the occipital condyle, which adequately exposes the VA dural entry site without sacrificing CCJ stability while facilitating the circumferential cutting of the dura around the VA. Circumferential excision of the dura around the VA entry site, in addition to fistula clipping, ensures complete dAVF detachment and minimizes the chance of recurrence. As the VA pierces the dura, the connective tissue layers of these structures become contiguous [4]. Leaving a dural cuff on the artery (rather than complete skeletonization) confers protection from vascular injury while achieving complete dAVF disconnection. Fat with or without fascia grafts can help prevent postoperative complications. This technique has been used by the senior author, who previously reported a 1.9% CSF leak compared with rates up to 20% from other retrospective analyses [7].

Specific perioperative considerations

Collaboration with an experienced anesthesiology team is vital for blood pressure control. Optimal perfusion of tissue at risk of ischemia must be simultaneously met with mitigation of hemorrhagic risk before dAVF disconnection. Patients should be closely monitored postoperatively in the intensive care unit, and an intra- or early post-operative angiogram should be performed.

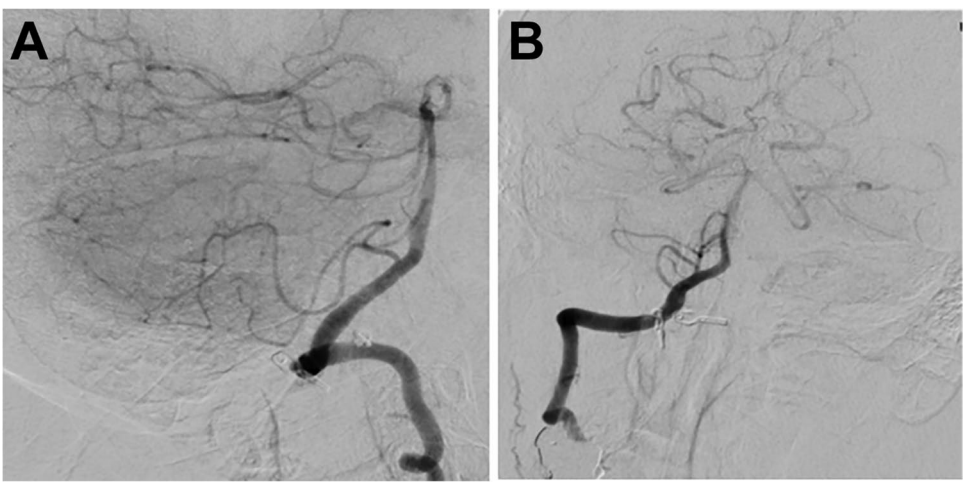

Fig. 2 Postoperative imaging. A postoperative angiogram confirms no abnormal early venous drainage and complete resolution of the dAVF. **A** lateral and **B** anteroposterior injections of the right VA

Specific information for the patients

Although previous studies suggest myelopathy due to venous hypertension can be reversed with early treatment, persistent hypoxia can lead to a permanent infarct and disability that is intractable to surgery [8]. Common risks of surgery include CSF leak, pseudomeningocele formation, and infection. Nevertheless, obliteration of a dAVF is warranted in symptomatic and asymptomatic patients at greater risk for complications. Patients should be aware of the risks of dAVFs, including hemorrhage and myelopathy, and milder symptoms including headache and pulsatile tinnitus.

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Ramesh Grandhi: methodology, writing—original draft, visualization.

William T. Couldwell: conceptualization, resources, supervision, project administration, writing—review and editing.

Data availability Not applicable.

Code availability Not applicable.

Declarations

Ethical approval Approval from the institutional review board is waived for case reports. All procedures performed in studies involving human participants were in accordance with the ethical standards of the University of Utah Institutional Review Board and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Consent to participate The patient consented to participate.

Consent for publication The patient consented to the publication of the case in this paper.

Conflict of interest The authors declare no competing interests.

References

1. Ghobrial GM, Marchan E, Nair AK, Dumont AS, Tjoumakaris SI, Gonzalez LF, Rosenwasser RH, Jabbour P (2013) Dural arteriovenous fistulas: a review of the literature and a presentation of a single institution's experience. World Neurosurg 80:94–102. https://doi.org/10.1016/j.wneu.2012.01.053
2. Hiramatsu M, Sugiu K, Ishiguro T, Kiyosue H, Sato K, Takai K, Niimi Y, Matsumaru Y (2018) Angioarchitecture of arteriovenous fistulas at the craniocervical junction: a multicenter cohort study of 54 patients. J Neurosurg 128:1839–1849. https://doi.org/10.3171/2017.3.JNS163048
3. Liu JK, Couldwell WT (2005) Far-lateral transcondylar approach: surgical technique and its application in neurenteric cysts of the cervicomedullary junction. Report of two cases. Neurosurg Focus 19:E9. https://doi.org/10.3171/foc.2005.19.2.10
4. Rennert RC, Powers MP, Steinberg JA, Fukushima T, Day JD, Khalessi AA, Levy ML (2021) Histology of the vertebral artery-dural junction: relevance to posterolateral approaches to the skull base. J Neurosurg 134:131–136. https://doi.org/10.3171/2019.9.JNS191394
5. Rennert RC, Stephens ML, Palmer AW, Rodriguez A, Kazemi N, Morris TW, Pait TG, Day JD (2022) Basilar decompression via a far lateral transcondylar approach: technical note. Acta Neurochir (Wien). https://doi.org/10.1007/s00701-022-05312-9
6. Rhoton AL (2000) The far-lateral approach and its transcondylar, supracondylar, and paracondylar extensions. Neurosurgery 47:S195-209. https://doi.org/10.1097/00006123-200009001-00020
7. Scoville JP, Mazur MD, Couldwell WT (2020) Unique far-lateral closure technique: technical note. Oper Neurosurg (Hagerstown) 18:384–390. https://doi.org/10.1093/ons/opz168
8. Wang JY, Molenda J, Bydon A, Colby GP, Coon AL, Tamargo RJ, Huang J (2015) Natural history and treatment of craniocervical junction dural arteriovenous fistulas. J Clin Neurosci 22:1701–1707. https://doi.org/10.1016/j.jocn.2015.05.014
9. Zhao J, Xu F, Ren J, Manjila S, Bambakidis NC (2016) Dural arteriovenous fistulas at the craniocervical junction: a systematic review. J Neurointerv Surg 8:648–653. https://doi.org/10.1136/neurintsurg-2015-011775

Key Points

Dural AVFs at the CCJ are rare, but can cause severe symptoms from brainstem irritation.

Myelopathy secondary to a CCF dAVF is often due to venous congestion.

In a patient with myelopathy of unknown origin, a diagnostic work-up for dAVF may be warranted.

Cognard classification type IIb-V arteriovenous fistulas are aggressive, and treatment should be considered to avoid complications.

CCJ dAVFs are often better suited for microsurgical rather than endovascular treatments.

The far-lateral suboccipital approach provides direct access to CCJ dAVFs.

Knowledge of the involved anatomy is imperative.

The use of a lateral incision minimizes tissue disruption.

Clip ligation followed by circumferential excision of the dura around the VA entry site ensures complete dAVF disconnection.

Dural closure with fat/fascia grafts can reduce the risk of complications.