Iatrogenic dural arteriovenous fistula and aneurysmal subarachnoid hemorrhage

SUDHAKAR VADIVELU, D.O., XIN XIN, B.S., TINA LOVEN, D.O., GUILLERMO RESTREPO, P.A.-C., DAVID J. CHALIF, M.D., AND AVI SETTON, M.D.

Division of Neurosurgery and Interventional Neuroradiology, Hofstra North Shore–Long Island Jewish School of Medicine, and North Shore–Long Island Jewish Health System, Manhasset, New York

The authors present the case of a patient who presented acutely with aneurysmal subarachnoid hemorrhage (SAH) and a contralateral iatrogenic dural arteriovenous fistula (DAVF). Diagnostic angiography was performed, revealing a right-sided middle cerebral artery (MCA) aneurysm and a left-sided DAVF immediately adjacent to the entry of the ventriculostomy and bur hole site. A craniotomy was performed for clipping of the ruptured MCA aneurysm, and the patient subsequently underwent endovascular obliteration of the DAVF 3 days later. The authors present their treatment of an iatrogenic DAVF in a patient with an aneurysmal SAH, considerations in management options, and a literature review on the development of iatrogenic DAVFs.

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KEY WORDS • arteriovenous malformation • subarachnoid hemorrhage • pial reflux • trauma • iatrogenic injury • twist drill • bur hole • ventriculostomy

Case Report

History. This 42-year-old woman with an unremarkable medical history developed in a sudden onset the worst headache of her life. A head CT scan was obtained at her local emergency department, demonstrating diffuse SAH (Fig. 1A). On clinical examination, the patient appeared increasingly lethargic and was intubated for airway protection. An emergency bedside twist-drill ventriculostomy was placed at the other facility prior to transfer to our institution.

Examination. An emergency CT angiogram revealed a 4-mm right MCA bifurcation aneurysm. Subsequent diagnostic angiography performed the following day confirmed an MCA aneurysm (Fig. 1D) and unexpectedly revealed a DAVF (Fig. 1C) draining to a dural vein that directly communicated to a pial vein, with distal drainage to the vein of Labbé. This fistula was associated with the entry site of the ventricular catheter (Fig. 1B).

Operations. The patient was taken directly to the operating room after the angiogram for open clipping of the MCA aneurysm. Postoperatively, she progressed well and
underwent a follow-up angiogram on posthemorrhage Day 4. The MCA aneurysm was demonstrated to be completely clipped (Fig. 1E). The DAVF persisted, and we decided to obliterate the lesion by embolization using a coaxial technique (Fig. 2). With a 5-Fr guiding catheter in the external carotid trunk, a microcatheter was navigated supraselectively into the MMA. Beyond the pterional segment, the microcatheter was posterior and just proximal to the dural shunt, and NBCA was injected, using the continuous column technique. We achieved complete obliteration of the dural shunt and the lead pedicle. Control angiographic studies confirmed complete obliteration without residual early venous shunting.

**Postoperative Course.** The patient progressed through careful inpatient observation during the ensuing course of vasospasm and hydrocephalus and was successfully weaned from her ventriculostomy. The ventriculostomy was removed at the bedside approximately 1 week later, and shortly thereafter the patient was discharged from our hospital neurologically intact.

**Discussion**

An iatrogenic DAVF is most commonly found secondary to intracranial surgery. In our literature search, we found 14 cases of DAVF developing after ventriculostomy, bur hole, craniotomy, or craniectomy.1–3,5,7–10,12,15,17 Four cases appeared to be directly related to the site of surgery (Table 1).5,10,13 Of those cases, only 2 were caused by trauma directly to dural vessels.5,12 Mechanisms leading to the formation of DAVF include venous sinus thrombosis,7 trauma to dural vessels,5,12 and indigenous dural arteriovenous shunts opened and enlarged under the influence of a change in intracranial pressure after surgery.1–3,8,9,14,15 Other mechanisms include fistulous development after apposition of the scalp or muscle blood vessels to the dura,10 and postoperative thrombus formation in the sinus.15

Ours is the second reported case of a DAVF caused by an emergency twist-drill ventriculostomy. It is well known that trauma to the MMA at the grooves of the inner aspect of the skull can result in formation of DAVFs;
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skull fractures and penetrating injuries that cross these grooves are the most common causes of traumatic DAVF. The importance of accurate location for emergency twist-drill craniotomies cannot be stressed enough; the bur hole in our case appeared to have been placed too posteriorly, near the coronal suture and near a common trajectory of the MMA. The important aspect of this traumatic DAVF is the venous drainage. The natural history of an aggressive DAVF is predicated by its venous drainage; lesions with cortical venous reflux have high risk for bleeding or intracranial hypertension. Typically, the fistula in a traumatic DAVF is between the MMA and the accompanying dural vein, and rarely a diploic vein. However, 1 case of DAVF developed after placement of a bur hole, presenting 9 days postoperatively as an acute subdural hematoma. In the single documented case of a DAVF caused by a ventriculostomy, the venous drainage was to the MMV, and it was immediately embolized. However, in our case,

**TABLE 1: Literature review of iatrogenic DAVF induced from direct surgical site trauma**

<table>
<thead>
<tr>
<th>Authors &amp; Year</th>
<th>Primary Diagnosis</th>
<th>Presumed Mechanism of DAVF Formation</th>
<th>Arterial Supply</th>
<th>Venous Drainage</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nabors et al., 1987</td>
<td>2 cases of MVD for trigeminal neuralgia</td>
<td>fistulous dev after apposition of scalp or muscle blood vessels to dura mater</td>
<td>1) rt OA &amp; MMA; 2) OA, ascending PhA, &amp; MMA</td>
<td>rt sigmoid sinus; jugular vein</td>
<td>embo w/ PVA particles in both cases</td>
</tr>
<tr>
<td>Pappas et al., 1992</td>
<td>subdural hematoma</td>
<td>direct trauma to dural vessels</td>
<td>AMA</td>
<td>parallel vein</td>
<td>coagulation of dural vessels &amp; resection of dura involved by fistula</td>
</tr>
<tr>
<td>Sasaki et al., 1995</td>
<td>trigeminal neuroma</td>
<td>postop thrombus formation in sinus—fistulous dev after apposition of muscle blood vessels to dura</td>
<td>lt OA, lt STA transverse sinus</td>
<td>observation</td>
<td></td>
</tr>
<tr>
<td>Field et al., 2002</td>
<td>ventriculostomy for IVH</td>
<td>direct trauma to dural vessel</td>
<td>MMA</td>
<td>MMV</td>
<td>embo w/ microfibrillar collagen &amp; coils</td>
</tr>
<tr>
<td>present study</td>
<td>ventriculostomy for acute HC after SAH</td>
<td>direct trauma to dural vessels</td>
<td>MMA</td>
<td>cortical vein</td>
<td>embo w/ NBCA</td>
</tr>
</tbody>
</table>

*AMA = anterior meningeal artery; dev = development; embo = embolization; HC = hydrocephalus; IVH = intraventricular hemorrhage; MVD = microvascular decompression; OA = occipital artery; PhA = pharyngeal artery; PVA = polyvinyl alcohol; STA = superficial temporal artery.
the venous drainage was to a posteriorly directed dural vein, with direct communication to a pial vein distally contributing to the vein of Labbé and in the setting of an aneurysmal SAH, thus making management of this traumatic DAVF of significant concern.

The DAVF in our case is unique in that the patient had suffered an SAH, which was an important consideration for treatment. Because a DAVF can alter the flow dynamics of cerebral perfusion,\(^1\) this can become an important factor in the face of vasospasm associated with SAH. Alteration of flow dynamics caused by a DAVF may make treatment of potential vasospasm more difficult and unpredictable. Because of the proximity of the venous drainage to the DA VF, there is also an increased risk of hemorrhage during removal of the venous catheter. With the aneurysm completely secured by surgical clipping, we proceeded toward treatment of the DA VF early in the postoperative course (posthemorrhage Day 4) and prior to the patient entering into a period of higher risk for vasospasm (6–7 days post-SAH).\(^2\) Furthermore, this allows for a safer removal of the venous catheter at a later time and eliminates the development of any adverse event related to treatment of the DAVF.

Conclusions

This is the second documented case of a DAVF caused by an emergency twist-drill ventriculostomy, and the first documented case in a patient with an aneurysmal SAH. We recommend early embolization of a venous-artery-venous associated DAVF with concurrent aneurysmal SAH.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: Vadivelu, Setton. Acquisition of data: Vadivelu, Xin, Setton, Restrepo. Analysis and interpretation of data: Setton. Drafting the article: Vadivelu, Xin, Loven. Critically revising the article: Vadivelu, Setton, Reviewed submitted version of manuscript: Vadivelu, Setton, Restrepo. Approved the final version of the manuscript on behalf of all authors: Vadivelu. Administrative/technical/material support: Chalif. Study supervision: Chalif, Setton.

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