Surgical treatment of tentorial arteriovenous malformations draining into the subarachnoid space

Report of four cases

FRANÇOIS GRISOLI, M.D., FRANÇOIS VINCENTELLI, M.D., SYLVAINE FUCHS, M.D., MARIO BALDINI, M.D., CHARLES RAYBAUD, M.D., TOUSSAINT A. LECLERCQ, M.D., AND ROBERT PIERRE VIGOUROUX, M.D.

Departments of Neurosurgery and Neuroradiology, C.H.U. La Timone, Marseilles, France, and Department of Neurosurgery, Rhode Island Hospital and St. Joseph Hospital Providence, Rhode Island

Four patients with tentorial arteriovenous malformations (AVM's) were treated surgically. The operative findings in the first case suggested that clipping of the draining vein close to the AVM may result in complete cure. The three subsequent cases were treated with this technique. The clinical and radiological implications are discussed.

KEY WORDS • dural arteriovenous malformation • posterior fossa • subarachnoid hemorrhage • tentorium • draining vein

To our knowledge, the first observation of dural arteriovenous malformation (AVM) was reported by Sachs in 1946. In 1962, Verbiest described the first case treated surgically. Different series have been compiled since then, but the incidence of such lesions is difficult to establish due to the marked variation of percentages in published reports. In the posterior fossa, the frequency of such lesions has been estimated at 3% (P Galibert, unpublished data), 7% by Czorny, and 15% by Newton, et al.

Aminoff and Kendall first differentiated AVM's with drainage anteriorly to the cavernous sinus from those draining into the lateral sinus. In 1976, Castaigne, et al., suggested classification of AVM's according to their mode of drainage rather than their anatomical location. They identified three kinds of AVM draining patterns: 1) directly into a sinus, 2) into a dural "sac," and 3) through cortical veins into the subarachnoid space. This classification appeals to us because it carries fruitful therapeutic implications. Indeed, once the type of drainage has been identified, indications for surgery and surgical approaches may vary widely. We have managed four cases that belong to the third group of Castaigne's classification (AVM drainage through cortical veins into the subarachnoid space).

The surgical technique proposed in this paper is both simple and efficacious.

Case Reports

Case 1

This 36-year-old man was hospitalized after two episodes of subarachnoid hemorrhage (SAH) occurring 12 days apart.

Examination. The patient showed mild meningeal signs without focal findings. No history of trauma could be elicited. Lumbar puncture revealed mildly xanthochromic cerebrospinal fluid (CSF). Angiographic studies (Fig. 1) showed an AVM of the tentorium, lateralized to the right, and fed by an enlarged tentorial artery and recurrent branches of the middle meningeal artery. Drainage took place through a voluminous subarachnoid vein. This vein, after travelling over the superior aspect of the left cerebellar hemisphere, continued over the anterior surface of the middle cerebellar peduncle, the lateral aspect of the brain stem, and the inferior part of the vermis cerebelli, to join the straight sinus. The straight sinus and lateral sinuses were not visualized. This drainage pattern can be compared to that reported by Pecker, et al.

Operation. Following a subtemporal approach, the lesion was found near the edge of the tentorium. As suspected from the angiograms, many dilated meningeal arteries were found feeding the malformation. The only draining vein proceeded toward the cerebellar...
FIG. 1. Case 1. Preoperative external and internal carotid artery angiograms showing the arteriovenous malformation on the inferior aspect of the tentorium. It is fed by tentorial branches of the internal carotid artery (white arrow) and by recurrent branches of the external carotid artery (black arrow). The draining vein (open arrow), after wrapping around the brain stem, terminates as an inferior vermian vein in the straight sinus.

Case 1

hemisphere. Occlusion of the vein with bipolar forceps resulted in marked decrease in the size of the malformation. Although this observation was noted by the surgeon, a decision was made to totally excise the lesion. This was accomplished by clipping and coagulating the feeding meningeal arteries, and the AVM was removed in toto.

Postoperative Course. The postoperative course was uneventful and an angiogram confirmed total removal of the AVM (Fig. 2). The patient remains asymptomatic 2 years after surgery.

Case 2

This 64-year-old man was admitted with left-sided hemiparesis. No history of trauma was present.

Examination. Lumbar puncture revealed fresh bleeding. Computerized tomography (CT) scanning showed a hemorrhagic lesion in the right suprathalamic area (Fig. 3), with blood in the choroid fissure. A four-vessel angiographic study was performed (Fig. 4). The lesion was fed by a tentorial artery and by a meningeal branch of the occipital artery on the left side. On the right, the blood supply originated from a posterior meningeal branch of the ascending pharyngeal artery. A meningeal anastomosis appeared to arise from an artery running along the superior aspect of the vermis. The draining vein ran along the superior aspect of the vermis cerebelli toward the vein of Galen. The inferior longitudinal sinus as well as the internal cerebral vein filled in a retrograde fashion. The straight and both lateral sinuses were not visualized.

FIG. 2. Case 1. Postoperative angiogram showing total disappearance of the lesion.

FIG. 3. Case 2. Computerized tomography scans showing a hemorrhagic lesion at the level of the choroid fissure and the tela choroidea of the third ventricle.
Tentorial arteriovenous malformations

Fig. 4. Case 2. Upper: Left carotid angiograms revealing the arteriovenous malformation (AVM, black arrow) fed by an artery of the tentorium (white arrow) and by a meningeal branch of the occipital artery (open arrows). Lower Left: Right carotid angiogram showing a branch of the ascending pharyngeal artery (arrow) running along the straight sinus toward the AVM. Lower Right: Vertebral artery angiogram showing the venous drainage of the AVM to the vein of Galen, with reflux in the superior longitudinal sinus (arrows).

Operation. The lesion was approached through an occipital craniotomy with the patient in a sitting position. The lesion had the appearance of a strawberry attached to the tentorium near the straight sinus. A Yaşargil clip placed on the draining vein as close as possible to the malformation resulted in almost immediate collapse of the AVM.

Postoperative Course. The postoperative course was uneventful. However, progressive enlargement of the entire ventricular system required ventriculoperitoneal shunting 2 months later. An angiogram 6 months postoperatively demonstrated no residual malformation (Fig. 5).

Case 3

This 55-year-old woman presented with SAH without neurological deficit.

Examination. A hemorrhagic lumbar puncture confirmed the diagnosis of SAH. There was no history of trauma. A large infratentorial hematoma, extending

Fig. 5. Case 2. Angiogram demonstrating that the arteriovenous malformation and its feeding arteries are no longer visible.
FIG. 6. Case 3. Computerized tomography scans showing an infratentorial supracerebellar hematoma.

toward the left side, was visualized on CT scanning (Fig. 6). An AVM of the tentorium was demonstrated by angiography (Fig. 7). It was fed by arteries of the tentorium on the right, and on the left by a posterior branch of the middle meningeal artery and a posterior meningeal branch of the vertebral artery. The venous drainage was more difficult to assess but appeared to be by way of dilated veins travelling on the superior surface of the vermis. The straight sinus and both lateral sinuses were clearly injected.

Operation. An occipital craniotomy was performed. The lesion displayed aspects similar to that in Case 2 with a tentorial attachment 5 cm to the left of the straight sinus. The venous drainage, more evident than one would expect from the angiograms, took place through two dilated vermian veins. Clipping of both veins close to the AVM resulted in satisfactory collapse of the lesion.

Postoperative Course. The postoperative course was benign. An angiogram performed 6 months following surgery was normal (Fig. 8).

Case 4

This 68-year-old woman complained of increasing difficulty in gait of 4 years’ duration. Her medical history revealed a right-sided hemiplegia primarily involving the face and arm, associated with intracranial bleeding. History was negative for trauma.

FIG. 7. Case 3. Bilateral carotid and vertebral angiograms. The AVM (black arrow) is fed bilaterally by the artery of the tentorium (white arrow), by the posterior branch of the middle meningeal artery (open arrow), and by a meningeal branch of the vertebral artery (double white arrow). The straight sinus is injected (double black arrow).
Tentorial arteriovenous malformations

Examination. On admission the neurological examination revealed a bilateral pyramidal syndrome primarily affecting the lower extremities. A voluminous vascular lesion with a markedly dilated mesencephalic vein was demonstrated on CT scanning with contrast enhancement (Fig. 9). The angiographic findings are shown in Fig. 10. The huge AVM was fed by branches of the right external carotid artery: the ascending pharyngeal artery (jugular branches toward the posterior aspect of the petrous bone); the accessory meningeal artery (main feeder); recurrent branches of the middle meningeal artery; and meningeal branches of the stylomastoid artery. Neither the internal carotid artery nor the vertebral artery fed the malformation. The lesion emptied into a venous pouch in the cerebellopontine angle, which joined the vein of Galen through a mesencephalic vein. Retrograde feeding was noted in a Sylvian vein and the internal cerebral vein. No feeding of the venous system was noted in the lower brain stem. The right lateral sinus was visualized up to its junction with the superior petrosal sinus.

Operation. In a first stage, the right external carotid artery was ligated, which, from a clinical standpoint, resulted in no improvement. A CT scan performed 1 month after ligation showed the continued presence of dilated venous structures. A repeat angiogram showed that the unchanged malformation was now being fed by the meningeal branches of the vertebral system and the left external carotid artery. A right-sided occipital “mini-craniotomy” was then performed with the patient in the lateral decubitus position. The neck of the venous drainage was identified and clipped close to the tentorium.

Postoperative Course. Marked clinical improvement was noted, and the CT scan 6 months after the second operation demonstrated no residual malformation (Fig. 11). Because the CT scan showed so clearly that the AVM had disappeared, the risk of repeat angiography was not deemed indicated in this elderly patient.

Discussion

In our review of the literature, we found 60 cases of dural AVM’s in the posterior fossa, 16 (27%) of which drained through a cortical vein. The etiology of these lesions is poorly understood. They have been classified as posttraumatic, acquired, or congenital. In our patients, there was no history of head trauma or previous neurosurgical intervention. Castaigne, et al., proposed a venous occlusion as either the source of the AVM or as a factor “revealing” a preexisting condition. In our four cases, two venous sinuses were visible and two were not. However, postoperatively, all sinuses were successfully injected, which eliminates thrombosis as a possible etiology for these malformations. It appears, therefore, that the origin of these lesions is most likely congenital. A congenital etiology is most compatible with the fact that the malformations were located on the tentorium at its attachment on the petrous bone, which is at the border between the two vascular territories (the meningeal territory of the internal maxillary artery system and that of the pharyngo-occipital system).
Clinically, these AVM's have a rather homogeneous presentation, and differ from lesions draining in the lateral sinus, which most often result in pulsatile tinnitus. Our four cases presented with fresh bleeding in the subarachnoid space or with a history of previous bleeding episodes. Obrador, et al., found a 20% incidence of bleeding in their review of dural AVM's, and Castaigne, et al., found a 42% incidence of bleeding when drainage occurred through a cortical vein.

Because of the significant risk of bleeding in these lesions, an external carotid angiogram is indicated in cases of SAH when both internal carotid and vertebral artery angiograms do not reveal a source for the bleeding. Hemorrhage may occur near the malformation (Case 3) or distally (Cases 2 and 4), which suggests that the draining vein is most likely responsible for the bleeding episode. Computerized tomography was helpful in three of our cases. It revealed a subdural and intracerebral hematoma and, in one case (Case 4), showed the venous drainage. This study should be part of the neuroradiological workup.

The dura mater of the posterior fossa and the tentorium is vascularized by branches of the internal carotid, internal maxillary, and ascending pharyngeal arteries, as well as by branches from the occipital arteries and vertebrobasilar system. Variations are seen from one patient to another due to the complexity of embryological evolution. Therefore, angiographic studies should be as complete and as selective as possible.

The external carotid vascular system was found to feed the malformations in all of our cases. In three cases, the AVM was fed by the internal carotid artery and in two cases by the vertebral system. Afferent...
Tentorial arteriovenous malformations

vessels to the AVM are always multiple and often more numerous than one would expect from the angiograms. This probably explains some unsatisfactory results following embolization. Although a few cases of spontaneous disappearance have been reported, most will require some form of intervention: ligation of the feeding arteries (usually the external carotid artery), surgical removal of the AVM, or embolization. These three techniques may be combined.

Distal ligation of the feeding arteries most often results in failure because it does not reduce the blood flow to the AVM sufficiently to produce occlusion. Revascularization by other anastomotic channels often takes place (Case 4). Surgical approach to the AVM with interruption of the afferent vessels and direct removal of the malformation and adjacent meninges would appear to be the treatment of choice. Unfortunately, the location of the AVM near a major venous sinus may render this approach quite dangerous and sometimes impossible.

In the past 10 years, embolization of such AVM's has been proposed by many authors. Less traumatic than surgical intervention, this approach is effective provided that the malformation itself can be occluded. Unfortunately, operative findings have shown that many distal arterial feeders cannot be demonstrated angiographically, even with highly selective studies. Embolization, therefore, is not always performed distal enough to preclude revascularization. Furthermore, some arteries such as the meningeal branches of the internal carotid or the vertebral arteries are poor candidates for embolization. In a series of 17 cases of dural AVM's, Czorny was able to embolize nine cases successfully; six patients required both embolization and surgery. Postoperative angiograms revealed residual arterial feeders in all his cases.

We propose an approach which we think is less traumatic than total ablation of the AVM and more effective than embolization or distal ligation. Clipping the venous drainage close to the AVM not only interrupts the abnormal communication but results in decreased flow under direct visualization in the afferent arteries. This simple approach appears to solve all the problems related to the AVM. It is similar to the technique used by Hurth (personal communication) in dural spinal AVM's. We think that the results obtained with this benign surgical approach are satisfactory from both clinical and radiological standpoints.

Collapse of the lesion following venous clipping is contrary to the result one would expect in an AVM. These AVM's, however, are a special entity quite distinct from intraparenchymatous AVM's where interruption of the venous drainage results in swelling of the lesion. Contrary to the more frequently encountered AVM's, the cases reported above had no coiled vessels. The abnormality appeared to provide a direct communication between artery and vein. They were not embedded in the neural parenchyma, and the draining vein was free in the subarachnoid space. Another peculiarity is that there was a single venous drainage vessel, one easily identified vein, whereas in the case of intraparenchymatous AVM's the venous drainage system is more complex. The differences noted above may explain the collapse of this type of AVM following clipping of the draining vein.

Conclusions

Dural AVM's of the posterior fossa are rare and present with distinct anatomical features. Subarachnoid hemorrhage is the most frequent clinical presentation. Following complete, selective angiographic studies, we propose clipping of the draining vein close to the AVM as the treatment of choice.

References

29. Sachs E: Diagnosis and Treatment of Brain Tumors and Care of the Neurosurgical Patient. St Louis: Mosby & Cie, 1946, pp 162–166

Manuscript received April 21, 1983. Accepted in final form November 21, 1983. Address reprint requests to: François Grisoli, M.D., Neurochirurgie, C.H.U. La Timone, Bd. Jean Moulin, 13385 Marseille Cedex 4, France.