Surgical interruption of intradural draining vein as curative treatment of spinal dural arteriovenous fistulas

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To establish if interruption of the intradural draining spinal vein or surgical excision are curative treatments for spinal dural arteriovenous fistulas (AVFs), the medical records and radiographic studies of 19 patients with spinal dural AVFs and progressive myelopathy were reviewed. Spinal arteriograms were obtained before and within 2 weeks after surgery in 19 patients, and after a delay of 4 months or more in 11 patients. The mean clinical and arteriographic follow up was at 37 and 35 months, respectively. In the 11 patients who underwent excision of the dural AVF there was no evidence of a residual lesion upon immediate or delayed postoperative arteriography. Surgery in eight patients consisted of simple interruption of the intradural draining vein as it entered the subarachnoid space. In six of these patients the vein draining the AVF intrathecally provided the only venous drainage of the AVF. In these six patients there was no immediate (six of six) or delayed (four of six) arteriographic evidence of residual or recurrent flow through the AVF. Two patients had an AVF with both intra- and extradural venous drainage: after intradural division of the draining vein there was residual flow through the AVF into the extradural venous system. In one of these two patients intrathecal venous drainage was reestablished, which required additional therapy. In the other patient the extradural AVF spontaneously thrombosed and was not evident on delayed follow-up arteriography.

In patients with spinal dural AVFs with only intrathecal medullary venous drainage, which includes most patients with these lesions, surgical interruption of the intradural draining vein provides lasting and curative treatment. In patients with both intra- and extradural drainage of the AVF, complete excision of the fistula or interruption of the intra- and extradural venous drainage of the fistula is indicated. In patients in whom a common vessel supplies the spinal cord and the dural AVF, simple surgical interruption of the vein draining the AVF is the treatment of choice, as it provides lasting obliteration of the fistula and it is the only treatment that does not risk arterial occlusion and cord infarction. Simple interruption of the venous drainage of a spinal dural AVF provides lasting occlusion of the fistula, as it does for cranial dural AVFs, if all pathways of venous drainage are interrupted. This result provides further evidence that the venous approach to the treatment of dural AVFs can be used successfully.

KEY WORDS • spinal cord • dural arteriovenous fistula • outcome • spinal arteriography

S PINAL dural arteriovenous fistulas (AVFs) are the most common type of spinal arteriovenous malformation (AVM) and are the most amenable to curative treatment. In the past two decades significant advances have been made in the understanding of the anatomy, pathophysiology, classification, and management of these lesions. Ideal treatment of them should permanently eliminate venous congestion of the spinal cord without damaging the spinal cord or its blood supply. Although currently recognized management options include interruption of the intradural draining vein, complete excision of the dural AVF, and embolization, the optimum management of spinal dural AVFs is unproven. Furthermore, the permanency of occlusion of the AVF after interruption of the intradural draining vein or excision of the fistula remains to be determined. We reviewed the clinical records and spinal arteriograms of 19 patients who underwent surgery for a spinal dural AVF. We sought to establish if surgical excision of the AVF or interruption of the intradural draining spinal vein was a curative treatment for these lesions.
Surgery for spinal dural AVFs

TABLE 1

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>No. of Patients (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>sensory dysfunction</td>
<td>19 (100)</td>
</tr>
<tr>
<td>paresis</td>
<td>18 (95)</td>
</tr>
<tr>
<td>bladder disturbance</td>
<td>17 (89)</td>
</tr>
<tr>
<td>bowel dysfunction</td>
<td>13 (68)</td>
</tr>
<tr>
<td>sexual dysfunction</td>
<td>8 (42)</td>
</tr>
<tr>
<td>back pain</td>
<td>6 (32)</td>
</tr>
</tbody>
</table>

Arterialized vein draining the AVF was identified as it entered the intrathecal space near the dural penetration of the posterior nerve root. The patient was treated only by division of the arterialized medullary draining vein as it entered the subarachnoid space. This procedure was followed if the spinal dural AVF had multiple feeding vessels that would require extensive dural resection or sacrifice of an important functional nerve root, or if a medullary artery provided blood supply to the spinal cord and the spinal dural AVF, as determined by preoperative arteriography. Patients without these features received either the same treatment or complete excision of the AVF. For those undergoing excision, after coagulation of the AVF and excision of the dura investing the nidus, the nerve root was transected, if it was intricately involved with the nidus and if loss of it would not compromise motor or important sensory function, and the draining vein was interrupted intradurally. The clinical outcome and the results of immediate and delayed postoperative arteriography were examined.

**Results**

There were 17 men and two women. The average age at diagnosis was 56 years. The clinical presentation in all patients was characteristic for these lesions: a gradual onset and progressive deterioration of neurological function, including paresis, sensory disturbances, and bowel and bladder dysfunction (Table 1). The average duration of symptoms before diagnosis was 22 months (Table 2). One patient with rapidly progressive myelopathy (Foix-Alajouanine syndrome) received preoperative embolization during diagnostic arteriography. Most patients were Grades 1 to 3 according to the functional classification scheme of Aminoff and Logue3 (Table 3). The mean clinical follow-up interval was 37 months (range 1 to 78 months). After surgery, eight patients had neurological improvement, and 11 patients had stabilization of signs and symptoms (Table 3). One patient complained of worsening paresthesia of the lower extremities, although clinical examination revealed no evidence of neurological deterioration.

Selective spinal arteriography revealed vessels supplying a dural AVF in the lower thoracic or lumbar region in 18 patients and in the sacral region in one patient (Table 2). Five of the 19 dural AVFs had more than one feeding vessel. The vascular nidus was lateral to the spinal cord and the blood flow in the intradural spinal veins was in a rostral direction in most patients. Eleven patients had delayed (at least 4 months after surgery) follow-up selective spinal arteriography: in 10 patients it was at least 7 months after surgery and in eight patients it was 1 year or more after surgery. The mean delayed arteriographic follow-up examination was 35 months (range 4 to 78 months; median 24 months).

The 11 patients who underwent excision of the dural AVF had only intradural venous drainage of the spinal dural AVF on preoperative arteriography. In these patients, 11 had immediate and five had delayed arteriography, and no residual filling of the spinal dural AVF was demonstrated. The mean clinical and arteriographic follow-up interval in this subgroup of patients was 27 and 21 months (median 24 and 15 months), respectively.

Eight patients received only interruption of the intradural draining vein. In six, the vein draining the AVF intradurally provided the only venous drainage that was visible at arteriography. In these six patients, postoperative spinal arteriography (immediate in six; delayed in four patients) demonstrated no abnormal residual flow. In contrast, preoperative arteriography demonstrated both intradural venous drainage of the AVF in two patients. In these two patients, arteriography shortly after surgery demonstrated residual flow through the AVF. However, now the venous drainage went solely into the extradural venous system. In one of these patients the AVF spontaneously disappeared, and there was no abnormal extradural or intradural venous drainage evident on arteriography 9 months after surgery. The other patient developed recurrent myelopathy 6 months after surgery. Arteriography revealed that the AVF had reestablished intradural medullary venous drainage a few levels above the original site of intrathecal drainage (Fig. 1). The AVF was embolized with particles of polyvinyl alcohol (PVA) to complete the obliteration. Arteriography 6 years after...
embolization demonstrated no residual filling of the AVF. The mean clinical and arteriographic follow-up interval in this subgroup of eight patients was 51 and 39 months (median 52 and 52 months), respectively.

**Discussion**

In patients with spinal dural AVFs, venous hypertension leads to progressive spinal cord injury and myelopathy. The goal of treatment is to eliminate venous congestion of the spinal cord before irreversible neurological injury occurs.1,11,12,15,16,20 The prognosis of patients who receive prompt diagnosis and treatment is quite good.11,12,15,16,20 Treatment alternatives include interruption of the intradural draining vein, complete excision of the AVF, and transarterial embolization. Surgery is adequate therapy for most patients;12,16,20 however, prior reports combine different surgical techniques (complete excision or intradural interruption of the vein draining the AVF) and do not distinguish patients according to the specific treatment they received. Furthermore, there are no reports that include delayed follow-up arteriography to assess the permanency of occlusion of the AVF or that compare the outcomes after either simple intradural interruption of the arterialized draining vein or complete excision of the AVF. Thus, due to the lack of long-term arteriographic follow up and the variability of the surgical techniques used, the optimum treatment for these lesions remains unclear. Also the question of whether the simpler technique, interruption only of the intradural draining vein, provides transient or lasting elimination of the fistula, remains unresolved.

### Excision of Dural AVF

The patients in this study who underwent excision of the dural AVF had no arteriographic evidence of residual or recurrent flow through the AVF, and their clinical course improved or stabilized. On the other hand, our results also indicate that recanalization is unlikely after simple interruption of the intradural draining medullary vein, if the spinal dural AVF has only intrathecal drainage. Clinical signs and symptoms improved or stabilized in this subgroup of patients, with no recurrence, and delayed arteriography revealed no evidence of residual flow through the AVF. However, in the two patients with arteriographic evidence of both intra- and extradural venous drainage, there was persistence of flow through the AVF into the extradural venous system after division of the intradural draining vein. In one patient the AVF subsequently spontaneously disappeared. In the other patient, due to the persistence of the AVF via flow into the extradural venous system, intrathecal drainage was reestablished a few levels above the original site of intradural drainage and produced recurrent myelopathy. The AVF was then occluded with particulate emboli. Six years later arteriography demonstrated no residual flow through the AVF.

There exist special circumstances in which complete excision of the AVF should not be attempted. In approximately 15% of patients with spinal dural AVFs the segmental artery that supplies the AVF also supplies the spinal cord and, because of the entanglement of the AVF and the origin of the medullary artery, removal of the nidus is not feasible without risking compromise of the blood supply of the spinal cord.4,7,17,18 In addition, because...
spinal dural AVFs are predominantly located in the lower thoracic and lumbar spinal segments, functionally important nerve roots may be covered by the same nerve root sleeve into which the AVF is embedded, preventing excision of the AVF without risking nerve root injury or interruption. Furthermore, excision of the dural nerve root sleeve investing the nidus requires more extensive surgery and may require dural grafting to prevent a cerebrospinal fluid leak.

**Interruption of the Vein Draining an AVF**

Our observations suggest that treatment limited to sim-
ple interruption of the vein draining the AVF is a safe, effective, and lasting treatment for patients in whom the only drainage of the AVF is into the intradural medullary veins (17 of 19 patients reported here). Furthermore, simple interruption is the only treatment that should be considered in patients with a common blood supply to the spinal cord and the AVF or when the AVF is at the same level as functionally important nerve roots. In contrast, surgical treatment of patients with intra- and extradural venous drainage should include complete excision of the AVF or interruption of both the intra- and extradural venous drainage of the AVF, because persistence of extradural venous drainage can keep the AVF open and it can reestablish intradural medullary venous drainage at a different level and produce recurrent myelopathy.

Embolization of the AVM

With the advancement of interventional techniques, embolization of spinal AVMs has become an alternative to surgery. However, embolic occlusion with biologically inert particulate matter, such as PVA, only provides temporary occlusion. Early recanalization and recurrent myelopathy have been the rule rather than the exception. Recanalization after embolic occlusion of the AVF with PVA occurred in one patient in the current series. Isobutyl-2-cyanoacrylate (IBCA), a liquid polymerizing agent, is used at some centers as primary treatment in patients with spinal dural AVFs. However, due to the minimal clinical and arteriographic follow-up studies that have been performed, the incidence of recanalization is unknown. Furthermore, unpublished studies in laboratory animals implicate IBCA as a potential carcinogen, which has limited its clinical use in the United States. Spinal embolization is contraindicated in patients in whom a segmental artery supplies the spinal cord and the fistula. On the other hand, in patients with rapidly progressive myelopathy (Foix-Alajouanine syndrome) embolization provides immediate reduction in venous hypertension and temporarily halts spinal cord injury until surgery is performed. In addition, dural AVFs with both intra- and extradural venous drainage may require excision of the fistula as initial therapy, or after surgical division of the intradural draining vein the patient may be treated with vein embolization to eliminate residual flow through the AVF. Because of the high incidence of recanalization of spinal dural AVFs after embolization with particulates we do not routinely recommend its use as the only treatment for spinal dural AVFs.

Conclusions

We have shown that simple interruption of the intradural venous drainage of spinal dural AVFs provides lasting occlusion by retrograde thrombosis and fibrosis of the fistula, as it does for cranial dural AVFs. This holds true as long as all pathways of venous drainage are interrupted, and provides further evidence that the venous approach to the treatment of dural AVFs can be used successfully.

References


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