



## Clinical Study

## Surgical management of spinal dural arteriovenous fistulas



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## ABSTRACT

Spinal dural arteriovenous fistulas are the most common type of spinal arteriovenous malformations. Treatment options consist of microsurgical exclusion and/or endovascular embolization. We retrospectively identified all patients who benefited from surgical treatment at our tertiary center between January 2001 and December 2008. Clinical and imaging data were collected from patient files, including pre- and post-operative formal neurological examination, complete spine MRI and spinal digital subtraction angiography. Of our 30 patients, 25 were men and five were women with a median age of 62 years (range 24–76). The average delay between symptom onset and clinical diagnosis was 27 months (range 1–90). Complete cure of the fistula was obtained in all patients in a single surgical session with no procedural complications and no surgical morbidity. After a mean follow-up period of 32 months (range 14–128), 25 patients (83%) had improved, four were stable and one worsened. Despite recent advances in endovascular techniques and materials, there is a subgroup of patients for which surgery remains the best treatment option. Careful patient selection, a multidisciplinary approach and standardized surgical techniques can lead to excellent results with virtually no complications.

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## 1. Introduction

Spinal dural arteriovenous fistulas (SDAVF) account for approximately 70% of all vascular spinal malformations [1,2]. The diagnosis is often delayed because of the non-specific and insidious nature of the presenting symptoms. Without formal treatment, patients are at risk for paraplegia or even tetraplegia, depending on the level of the lesion [3]. Moreover, rehabilitation outcomes are significantly correlated to the delay between the onset of symptoms and treatment [4].

Recent advances in endovascular and microsurgical techniques have significantly improved operative outcomes [5–14]. We report our experience of open surgical management in a large series of consecutive patients with SDAVF.

## 2. Material and methods

## 2.1. Patient description

We retrospectively identified all patients who were diagnosed with SDAVF and who benefited from open surgical treatment at our center between January 2001 and December 2008. Patients with intracranial dural arteriovenous fistulas with peri-medullary venous drainage were excluded from the current study.

The following selection criteria are used in our institution to consider patients for an open surgical approach: (1) contraindication to endovascular treatment due to the presence of an anterior spinal artery originating from the radicular artery feeding the SDAVF; (2) contraindication to endovascular treatment due to extensive atherosclerotic lesions; (3) failure of endovascular treatment due to difficulties in catheterization of the arterial feeder; and (4) fistula recurrence after embolization.

According to our protocol, all patients underwent pre- and post-operative neurological examination; clinical symptoms were scored using the modified Aminoff Logue Grading Scale for

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myelopathy (Table 1). All patients underwent spinal digital subtraction angiography (DSA) (Advantix; GE Healthcare, Little Chalfont, Buckinghamshire, UK) before and after treatment. In addition, standard pre- and post-operative MRI with and without contrast were obtained (1.5 Tesla, GE Healthcare).

## 2.2. Statistical analysis

A statistical analysis of different pre-operative variables was conducted to determine the relationship with the final outcome in our study groups using a paired *t*-test for quantitative parameters. The two-sided significance level was established at 5%.

## 3. Surgical technique

Laminectomy was performed in 10 patients (during the initial 3 years). The remaining 20 patients were treated by hemilaminectomy followed by fistula disconnection/exclusion. In selected patients, dural feeding arteries were specifically identified under microscopic magnification and coagulated with bipolar cautery. Disconnection of the draining vein just distal to the fistula was considered the definitive operative cure.

Following laminectomy (or hemilaminectomy) the dura was opened in a standard longitudinal fashion and the intradural arterial vein was identified near the nerve root where the former goes out through the dura; obviously, pre-operative DSA was often checked to match radiological and anatomical findings. Then sharp dissection of the vein was carried out. When the entire vein was mobilized, it was cauterized with bipolar forceps and, if possible, sharply divided. Next, inspection and cauterization of the inner dural layer was usually the final step.

In selected patients, at the beginning of our experience, intra-operative confirmation of the fistula was obtained by peri-operative injection of methylene blue dye. Intra-operative angiography was also a very useful adjunct in some cases. Somatosensory evoked potential monitoring during surgery was rarely used until 2007 due to unavailability; however, it became a routine practice afterwards.

In the post-operative period, patients were treated for 3 to 6 months with oral anticoagulants. The rationale was to prevent thrombosis in the spinal venous system, occasionally seen due to the sudden reduction in flow velocities after surgical fistula exclusion.

## 4. Results

Between January 2001 and December 2008, a total of 142 patients with SDAVF were treated at our center. Figure 1 illustrates the patient selection diagram. One hundred and twenty patients were embolized as the first treatment. The majority of these (93.4%) were cured by embolization alone. However, two patients (1.6%) had only partial success and six patients (5%) had recurrence

of fistulas on angiographic follow-up. Both non-cured groups went on to have a second intention surgery.

A total of 30 patients benefited from open surgical treatment, either as first intention (*n* = 22) or second intention after embolization (*n* = 8). Among this group there were 25 men and five women, with a median age of 62 years (range 24–76). The majority of patients presented with ascending lower extremity symptoms with or without associated bowel and/or bladder dysfunction; detailed symptoms and clinical signs are summarized in Table 2. The typical evolution in the majority of patients was slow and progressive deterioration; only two patients presented with severe acute or subacute worsening. The most common initial referral diagnosis was spinal cord tumor in 18 patients, followed by transverse myelitis in eight patients. The average delay between symptom onset and clinical diagnosis was 27 months (range 1–90).

The diagnosis of SDAVF was made based on the initial MRI in only 18 patients. Suggestive diagnostic features consisted of increased intramedullary T2-weighted signal changes in the lower spinal cord and conus medullaris and/or abnormal dorsal spinal cord vascularity with venous dilatation.

The definitive diagnosis was achieved after spinal DSA, confirming the presence of a SDAVF in the thoracic (16 patients), lumbar (12 patients), or sacral (two patients) spine.

Among the 30 patients, 22 underwent direct surgical excision without prior embolization, six had recurring lesions (they underwent prior embolization) and in the remaining two patients, embolization was only partial. In all patients (100%), the fistula was successfully obliterated at the time of the surgical procedure. There were no intra-operative complications and no post-operative morbidity was recorded. Post-operative hospitalization ranged from 4 to 11 days; often physical therapy was initiated during the hospital stay and inpatient rehabilitation was considered depending on the degree of pre-operative disability.

Long term follow-up (median interval of 32 months, range 18–104), showed that 83% of patients (*n* = 25) clinically improved. Four of our 30 patients (13.3%) were neurologically stable when compared to the pre-operative neurological status, and one patient (3.3%) worsened. A significant change of modified Aminoff Logue Grading Scale score was observed, from a median of 5 (range 4–6) pre-operatively to a median of 2 (range 0–3) post-operatively (*p* < 0.001).

Complete cure was confirmed in all patients with post-operative angiographic evaluations.

An illustrative patient is presented in Figure 2.

## 5. Discussion

Our results indicate that, in our series of patients, open surgical treatment was very effective in curing SDAVF. Complete disconnection of the fistula was achieved in all patients during one single operative session, with no recurrences noted on angiographic evaluation during the follow-up period.

Several classifications of spinal arteriovenous malformations have been described [15,16], using various parameters, including the size and the aspect of feeding and draining vessels. All these systems are useful in clinical practice, especially with regards to risk stratification and anticipating outcome and management difficulties.

On the other hand, the use of multiple categorization systems with overlapping criteria may be occasionally misleading and confusing. We believe that the unifying concept that should help in understanding and planning treatment for SDAVF is related to the exploration of the arteriovenous shunt point and the foot of the draining vein, as well as its potential effects on the global venous drainage [14,17]. Several studies have emphasized the cardinal role of venous endothelial disorders in the pathophysiology of SDAVF, and consequently identified the draining veins as

**Table 1**  
Modified Aminoff Logue Grading Scale for myelopathy assessment

<b>Gait</b>
0 = Normal
1 = Leg weakness, abnormal gait or stance, but no restriction of activity
2 = Restricted activity
3 = Requiring one stick for walking
4 = Requiring two sticks, crutches, or walker
5 = Confined to wheelchair
<b>Micturition</b>
0 = Normal
1 = Hesitancy, frequency, urgency
2 = Occasional urinary incontinence or retention
3 = Total incontinence or persistent retention

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