

Clinical Article

Spinal Dural Arteriovenous Fistulas : Clinical Experience with Endovascular Treatment as a Primary Therapeutic Modality

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Objective : The aim of this study was to evaluate the efficacy of endovascular therapy as a primary treatment for spinal dural arteriovenous fistula (DAVF).

Methods : The authors reviewed 18 patients with spinal DAVFs for whom endovascular therapy was considered as an initial treatment at a single institute between 1993 and 2006. NBCA embolization was considered the primary treatment of choice, with surgery reserved for patients in whom endovascular treatment failed.

Results : Surgery was performed as the primary treatment in one patient because the anterior spinal artery originated from the same arterial pedicle as the artery feeding the fistula. Embolization was used as the primary treatment modality in 17 patients, with an initial success rate of 82.4%. Two patients with incomplete embolization had to undergo surgery. One patient underwent multiple embolizations, which failed to completely occlude the fistula but relieved the patient's symptoms. Spinal DAVF recurred in two patients (one collateral development and one recanalization) during the follow-up period. The collateral development was obliterated by repeated embolization, but the patient with recanalization refused further treatment. The overall clinical status improved in 15 patients (83.3%) during the follow-up period.

Conclusion : Endovascular therapy can be successfully used as a primary treatment for the majority of patients with spinal DAVFs. Although it is difficult to perform in some patients, endovascular embolization should be the primary treatment of choice for spinal DAVF.

KEY WORDS : Spine · Dural arteriovenous fistula · Therapeutic embolization.

INTRODUCTION

Spinal dural arteriovenous fistulas (DAVFs) are caused by abnormal blood flow between the dural artery, which supplies the dural root sleeve and adjacent spinal dura, and the medullary vein, which drains the coronal venous plexus^{11,12}. This abnormal shunting leads to venous hypertension and the development of clinical symptoms^{7,14}. Although advances toward a better understanding of the pathophysiology of this lesion have been made, the optimal initial treatment strategy remains a matter of debate. Some clinicians have advocated microsurgical interruption of the

fistula as the primary treatment of choice, while others have advocated the use of endovascular embolization^{1,4-6,8,13}. Endovascular therapy is less invasive than microsurgery, and it allows both diagnosis and treatment in a single session.

We reviewed 18 patients for whom endovascular embolization was considered as the initial treatment for spinal DAVF in order to evaluate the efficacy of endovascular therapy as an initial treatment for this condition.

MATERIALS AND METHODS

Patient selection

The clinical records of all patients with angiographically diagnosed spinal DAVFs for which endovascular embolization was considered as the primary treatment modality at our institution between June 1993 and March 2006 were retrospectively reviewed. Twenty-one patients were iden-

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tified, but three patients were excluded from the study because the follow-up period was less than 12 months. Thus, a total of 18 patients were enrolled in this study.

Treatment modality

Endovascular embolization was planned as the primary treatment in all patients. N-butyl 2-cyanoacrylate (NBCA) was used for all embolizations. After angiographic identification of the fistula, a mixture containing 30% NBCA and lipiodol was used as a liquid adhesive embolic agent delivered through a variable stiffness microcatheter after superselective catheterization of the involved segmental radicular branch.

Microsurgery was suggested in cases of failed embolization or if embolization was not feasible (e.g., for anatomical reasons, such as sharing a common trunk between the anterior spinal artery and the artery feeding the fistula). Microsurgery included laminectomy at the predetermined level of the fistula, followed by coagulation and excision of the intradural draining vein. Intradural vessel shrinkage was observed intraoperatively.

Follow-up

The treatment results were confirmed by immediate post-treatment angiography in all patients, and the clinical symptoms of the patients were evaluated during regular visits to our outpatient clinic. Follow-up magnetic resonance imaging (MRI) was recommended for all patients. Follow-up spinal angiography was recommended for patients with increased cord edema as well as those who reported aggravated symptoms but showed no changes on follow-up MRI. The clinical status of each patient was evaluated according to the Aminoff and Logue disability scale (Table 1)³⁾. Up-to-date information was gathered by outpatient review and telephone interview.

RESULTS

Clinical data

Eighteen patients satisfied the inclusion criteria. Sixteen of the patients were men and two were women; their mean age was 55.7 ± 11.6 years (range 23-72 years). The mean duration of follow-up was 49.1 ± 39.3 months

(range 12-160 months). The Aminoff and Logue disability scale was used to assess each patient preoperatively, postoperatively and at the last follow-up examination (Table 2). The mean interval between symptom onset and diagnosis was 14.4 months. One patient died from trauma, and one patient was lost during the follow-up period. Motor weakness was the most common initial symptom (61%), while sensory deficit was the most common symptom at diagnosis (89%) (Table 3).

In 17 patients, MRI at admission revealed cord edema or

Table 1. Aminoff & Logue's scale of disability

Gait		
1.	Restriction of walking	
2.	Restricted exercise tolerance	
3.	Requires on stick or some support for walking	
4.	Requires crutches or normal leg power, stance and gait	
5.	Leg weakness with no two sticks for walking	
6.	Requires a wheelchair	
Micturition		
1.	Urgency, frequency and/or hesitancy	
2.	Occasional incontinence or retention	
3.	Persistent incontinence of retention	
Bowel		
1.	Mild constipation, responding well to aperients	
2.	Occasional incontinence or persistent constipation	
3.	Persistent incontinence	

Table 2. Clinical data and level of disability

Case No.	Sex/Age	Duration of symptoms (mo)	Duration of follow-up (mo)*	Location of the DAVFs	Treatment	Aminoff & Logue scale		
						Preop.	Postop.	Last follow-up
1	F/23	6	12	L2, left	Embo.	2	1	1
2	M/52	4	13	T5, left	Embo.	9	3	2
3	M/62	10	13	L3, left	Embo.	10	10	10
4	M/57	11	16	T6, right	Embo.	6	5	3
5	M/66	1	21	C2, left	Embo.	5	4	3
6	M/52	24	21	T6, left	Embo.	12	12	7
7	M/52	8	26	T5, left	Embo.	10	2	10
8	M/51	4	33	S2, left	Embo.	1	1	1
9	M/45	48	39	T5, left	Embo.	11	8	6
10	M/45	6	63	T12, right	Embo.	3	1	1
11	M/61	30	72	T6, right	Embo.	6	5	2
12	M/63	4	76	T11, left	Embo.	4	1	1
13	M/72	3	80	T7, left	Embo.	5	4	1
14	M/51	48	102	L1, right	Embo.	3	1	1
15	M/59	21	160	T11, left	Embo.	8	8	4
16	F/39	3	24	S1, left	Embo. & Op.	7	7	2
17	M/68	24	43	T7, both	Embo. & Op.	9	8	9
18	M/60	4	67	T10, left	Op.	4	2	1

*Duration of follow-up (mo), the duration from treatment to the last follow-up period. Embo : endovascular embolization. Op. : microsurgical operation, Preop : preoperative disability score, Postop : postoperative disability score

Table 3. Symptom distribution on initial evaluation and at diagnosis

Symptoms	No. of patients (%)	
	Initial symptoms	Symptoms at diagnosis
Back pain	3 (17)	6 (33)
Root pain	5 (28)	5 (28)
Leg weakness	11 (61)	15 (83)
Sensory deficit	9 (50)	16 (89)
Micturition disorder	7 (39)	14 (78)
Defecation disorder	4 (22)	12 (67)
Sexual dysfunction	0 (0)	1 (6)

the presence of perimedullary vessels, thus confirming the diagnosis of spinal DAVF. MRI did not detect cord edema in one patient (Case 5) who had a spinal DAVF in the upper cervical area, but it did show a subarachnoid hemorrhage in the posterior fossa. The most common fistula location on spinal angiography was at the level of T₆, with 12 fistulas located at the thoracic level, three at the lumbar level and two at the sacral level. One patient (Case 17) had a bilateral spinal DAVF supplied by the right and left seventh intercostal arteries. The fistulas was located on the left side in 14 patients and on the right side in five.

Treatment data

Microsurgery was performed as the primary treatment modality in one patient (Case 18) because the anterior spinal artery originated from the same artery pedicle as the artery feeding the fistula (Fig. 1).

Endovascular therapy was used as the primary treatment in 17 patients. Spinal angiography was performed immediately after embolization in all patients. The initial embolization therapy was failed in three patients (Cases 5, 16, and 17). The initial success rate of endovascular therapy was 82.4% (14 of 17 patients). Patient 5 had multiple feeders in the craniocervical area and underwent endovascular embolization four times. Though his headache was disappeared, complete occlusion was not achieved. Patient 16, who had a spinal DAVF in the sacral area, underwent three embolizations but showed no improvement. Microsurgery was eventually performed, and the patient was symptom-free after the procedure. Patient 17, who had a bilateral spinal DAVF at the T₇ level, underwent embolization therapy. The right spinal DAVF was completely occluded, but embolization of the left spinal DAVF failed. The patient then underwent microsurgery for the left spinal DAVE, and follow-up angiography showed no evidence of a spinal DAVE. An endovascular complication occurred following transient aortic intimal dissection in one patient.

Follow-up imaging data

The treatment results and follow-up strategies for 18

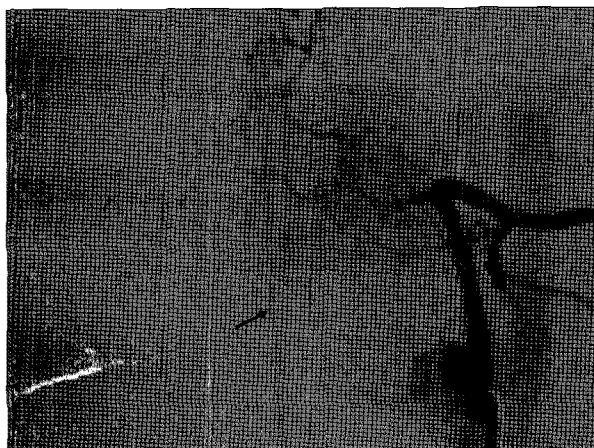


Fig. 1. Case 18 : Selective intercostal arteriogram reveals that the artery of Adamkiewicz shares the same arterial pedicle as the radiculodural branch supplying the fistula (open arrow). Closed arrow indicates the anterior spinal artery. Endovascular treatment could not be performed in this case and the fistula was excised by microsurgery.

patients in whom embolization therapy was considered as the initial treatment for spinal DAVFs are summarized in Fig. 2.

Four patients (Cases 5, 11, 13 and 14) whose symptoms improved after treatment refused follow-up MRI. Fourteen patients underwent both pre-intervention and follow-up spinal MRI examinations for two to 24 months (mean 6.2 ± 6.4 months) after treatment. In ten patients with symptom improvement, follow-up MRI showed the complete disappearance of perimedullary vessels or decreased T₂ signal intensity in the spinal cord.

Three patients (Cases 3, 15, and 17) showed no improvement. Patient 3 showed improvement on follow-up MRI at 3 months after embolization. In Patient 15, who showed no change on follow-up MRI, repeat angiography revealed the collateral development of a spinal DAVE, which was successfully treated with re-embolization. No change was observed on follow-up MRI in Patient 17, who underwent embolization and microsurgery, even though this patient's symptoms did not change. However, no remaining spinal DAVF was detected on follow-up angiography.

Patient 7's clinical symptoms recurred at 11 months after the initial embolization. No changes were observed on MRI obtained 12 months after embolization, and he refused to undergo further treatment or angiography. Although the follow-up angiography could not be performed, we attributed the lack of change on the follow-up MRI and the recurrence of clinical symptoms to the recanalization of a spinal DAVE.

The rates of obliteration and recurrence after embolization for spinal DAVF were 76.5% (13 of 17 patients) and 11.8% (2 of 17 patients, one collateral development and one recanalization), respectively.

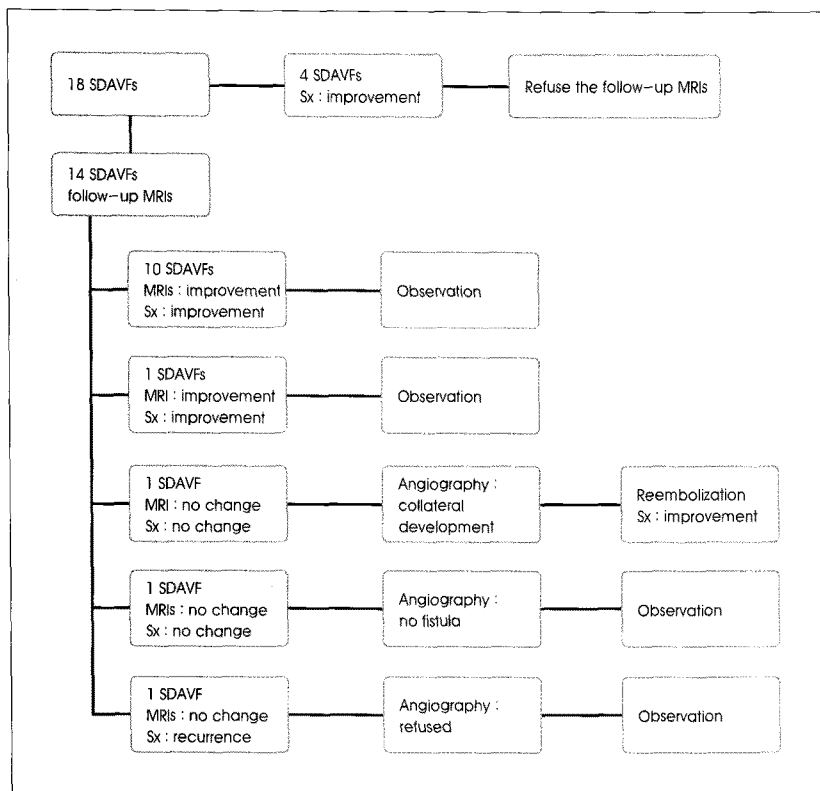


Fig. 2. Flow chart showing the treatment results and follow-up strategy in 18 patients with spinal dural arteriovenous fistula. Sx.: symptom.

Table 4. Change of Aminoff and Logue's scale of disability following embolization & operation

Treatment modality	Aminoff grade at diagnosis	Aminoff grade at last follow up
Embolization and/or operation (18 patients)	6.4 ± 3.3*	3.6 ± 3.3*
Initial embolization (17 patients)	6.5 ± 3.3†	3.8 ± 3.3†
Embolization alone (15 patients)	6.3 ± 3.5‡	3.5 ± 3.3‡

*p=0.001, †p=0.001, ‡p=0.002

Clinical outcome

The mean duration of follow-up was 49.1 ± 39.3 months (range 12-160 months). A good outcome was achieved in Patient 18, who underwent surgery as the primary treatment. The 17 patients who underwent NBCA embolization for spinal DAVF showed improvement or no change in disability score at the last follow-up examination. Improved outcomes were achieved in 15 patients (83.3%, 15 of 18 patients). Three patients (Cases 3, 7 and 17, 16.7%, 3 of 18 patients) remained stable without further deterioration. In quantitative terms, the mean Aminoff and Logue scale score improved significantly in the entire study cohort and in the NBCA-embolization group (6.4 ± 3.3 vs. 3.6 ± 3.3, p=0.001 and 6.5 ± 3.3 vs. 3.8 ± 3.3, p=0.001) (Table 4).

DISCUSSION

Endovascular management

Spinal DAVF appears to be particularly amenable to endovascular techniques^{5,10,13}. One advantage of endovascular therapy is the ability to diagnose and treat the lesion in a single session; however, more than one session may be necessary for some patients. Although endovascular therapy is potentially less invasive and associated with less morbidity and earlier mobilization than surgery, endovascular therapy has been associated with a lower initial success rate and higher rate of recurrence than microsurgical therapy¹⁹. However, recent reports have shown that liquid adhesive materials, such as NBCA, are superior to polyvinyl alcohol, which showed a recanalization rate of 83%. Another report showed that NBCA embolization was a successful primary treatment in 75-90% of patients with

spinal DAVFs, with a recurrence rate of 15% to 20%^{6,15}. In other words, the problem with embolization therapy was that, although the development of embolic materials provided a higher success rate, the long-term recurrence rate was still higher than that observed with microsurgical therapy. However, our study had a longer follow-up period and lower recurrence rate than those of other studies^{6,15,20}.

Several factors need to be considered when selecting endovascular therapy for the treatment of spinal DAVF. A spinal DAVF usually consists of multiple dural arterial vessels with a single draining vein¹¹. Thus, occlusion of a feeding arterial vessel may lead to recanalization or collateral development in the early postoperative period. Recanalization occurred in Patient 7 in our study, and NBCA embolization failed to occlude the proximal draining vein. Another important consideration is the identification of patients with conditions that would make them unsuitable for endovascular therapy. Embolization therapy may not be feasible if the arterial feeder is too small to catheterize and arterial damage due to catheter manipulation is likely, as in patients with severe arteriosclerosis, or if the anterior spinal artery of Adamkiewicz and feeding artery of the fistula originate from the same segmental artery¹⁸. Microsurgical obliteration is necessary in such cases. In our study, microsurgery was initially performed in

Patient 18 because the anterior spinal artery originated from the same arterial pedicle as the artery feeding the fistula.

Combined multidisciplinary management

Technological advances have made it possible to use a combined approach for the management of spinal DAVFs^{15,19,20}. In the present study, embolization was performed as the primary treatment modality, and surgery was reserved for patients in whom embolization was deemed dangerous and those in whom embolization had failed or could not be performed. Clinical status improved in 15 patients (83.3%, 15 of 18 patients, 14 embolizations and 1 surgery) during the follow-up period. There were significant differences between functional status at diagnosis and at the last follow-up in the entire patient group.

Follow-up strategy

We believe that follow-up spinal angiography is a definitive tool for evaluating the results of treatment during the early follow-up of patients who undergo embolization for spinal DAVF. However, spinal angiography is invasive and associated with several risks². Recanalization or collateral development should be considered and confirmed by spinal angiography in patients whose symptoms recur or become aggravated during the early follow-up period after embolization therapy. Follow-up spinal angiography may not be necessary if no symptom recurrence or aggravation is observed during the immediate follow-up period, and follow-up spinal MRI is recommended for the long-term evaluation of these patients. In our study, follow-up spinal MRI was recommended for all patients, and follow-up spinal angiography was performed in patients whose clinical symptoms and MRI findings did not change.

Many reports have stated that failure to occlude the draining vein at the site of the spinal DAVF is the main cause of spinal DAVF recurrence^{9,11,16}. Fistula recurrence was observed in 15% of patients in whom NBCA failed to occlude the proximal draining vein¹⁶. Although there are few articles concerning the follow-up treatment after failure of endovascular treatment in patients with spinal DAVFs, the feasibility of filling the draining vein via the microcatheter is considered the main factor for determining the need for repeat embolization therapy⁹. However, it is important to consider the fact that repeat embolization therapy is associated with several potential hazards, such as repeat angiography, radiation exposure, risk of inadvertent embolization of the spinal vasculature, and risk of morbidity.

Although the duration of the follow-up period was less than two years in some patients, the mean duration of follow-up in this study was longer than that in most reports

concerning the treatment of spinal DAVFs^{9,15-17}. Until now, surgery has a higher obliteration rate than endovascular therapy for the treatment of spinal DAVF. However, the important findings of this study are that the recurrence rate tends to decrease after endovascular therapy when liquid embolization material is used and that endovascular therapy provides a reasonable chance of achieving complete obliteration in most patients. These findings suggest that embolization therapy should be considered as the initial treatment of choice for patients with spinal DAVFs.

CONCLUSION

In our study, acceptable initial success and recurrence rates were achieved with endovascular therapy involving the use of liquid embolization material, and most patients showed improved clinical outcomes during the follow-up period. Thus, although it is difficult to perform in some patients, endovascular therapy should be tried before surgical treatment in patients with spinal DAVFs.

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