Preoperative coil marking to facilitate intraoperative localization of spinal dural arteriovenous fistulas

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Abstract Considering surgical treatment of spinal dural arteriovenous fistulas, the major difficulty is to localize them reliably during surgery. Usually the affected spinal level is sought by counting of bony structures using fluoroscopy. However, quite frequently, anatomical particularities impede adequate counting resulting in surgery performed at erroneous spinal levels. The objective of this study was therefore to evaluate the potential benefits of preoperative coil marking in order to facilitate intraoperative localization of spinal dural arteriovenous fistulas. After detection of the fistula with spinal angiography, selective catheterization of the feeding vessel was performed, and a GDC coil was detached in the lumen of the vessel adjacent to the respective bony pedicle. Coil marking was effected in 8 patients (group A), 20 patients were operated without such a marking (group B). The data of both groups of patients were compared with regard to accurateness of the surgical approach, duration of surgery, and dosage of intraoperative fluoroscopy. In all patients of group A, the coil was easily identified by intraoperative fluoroscopy. A partial hemilaminectomy was sufficient for localization and microsurgical treatment of the spinal dural arteriovenous fistula in each patient. In patients of group B, the correct spinal level was approached in 12 patients (60%), in 8 patients (40%) surgery was performed initially at an erroneous level ($P = 0.048$). Mean duration of surgery was

130 min in group A and 177 min in group B ($P = 0.031$). Likewise, mean dosage of intraoperative fluoroscopy was higher in group B (119.5 vs. 394.3 cGy/cm²; $P = 0.036$). Preoperative coil marking allows exact intraoperative localization of spinal dural arteriovenous fistulas. Thus, surgery at erroneous spinal levels is avoided, and it is feasible to perform a straightforward, minimally invasive surgical approach. This reflects in significant reduction of duration of anesthesia and surgery. Moreover, radiation exposure of the patient is significantly reduced.

Keywords Spinal dural arteriovenous fistula · Coil marking · Intraoperative fluoroscopic localization

Introduction

Spinal dural arteriovenous fistulas (SDAVFs) effectuate venous congestion within the spinal cord that most probably will be followed by progressive myelopathy. On this account, these spinal vascular malformations should be treated aggressively aiming at obliteration of the fistula point. This can be accomplished by either endovascular or surgical measures.

Endovascular therapy, however, still has lower occlusion rates than surgical treatment [6] and failure rates up to 39% [3]. Furthermore, after endovascular therapy, patients have to be subjected to repeated angiography and probably embolization [8] as recanalization after successful embolization [1] may occur. For these reasons, surgery is widely considered as first-line therapy for SDAVF and treatment of choice [5, 7, 8].

From the surgical point of view, the operative management of a SDAVF usually is not a serious problem once the fistula is visualized. The major difficulty with SDAVFs,

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however, is to localize them reliably during surgery [4]. Typically, the affected spinal level is sought by counting of bony structures such as ribs or vertebral bodies from above and below using fluoroscopy. In doing so, the correct level will be approached in the majority of patients. However, quite frequently, anatomical particularities impede adequate counting. This fact inevitably results in a considerable number of procedures performed initially at erroneous spinal levels. To meet this problem, Britz and co-workers [2] proposed endovascular preoperative coil marking of the relevant spinal level.

The purpose of the present study was to evaluate the significance of such a measure in order to facilitate intraoperative localization of the SDAVF. We, therefore, studied the accurateness of the surgical approach in a series of patients in whom preoperative coil marking of the relevant spinal level was performed and compared the results with those obtained in another group of patients who were subjected to surgery without such a marking. Additionally, we compared both groups of patients with regard to duration of surgery and dosage of intraoperative fluoroscopy.

Patients and methods

A total of 28 consecutive patients with symptomatic thoracolumbar SDAVFs treated surgically between 2001 and 2007 were included in this study. There were 4 women and 24 men aged 45–82 years (mean 66.7 years). Spinal level involvement was thoracic in 20 patients (D5–D12) and was lumbar (L1 and L2) in 8 (see Table 1).

Preoperative coil marking was achieved in the course of spinal angiography confirming the tentative diagnosis of SDAVF. Angiographic detection of the SDAVF was followed by superselective catheterization of the segmental artery carrying the radicular artery to the fistulous point. A microcatheter was placed close to the origin of the radicular artery feeding the fistula, just below the bony pedicle. A GDC coil with a length of 3 cm and a diameter slightly above the caliber of the segmental artery was introduced and detached after reaching a stable position.

Preoperative coil marking of the relevant spinal level was performed in 8 patients (group A), 20 patients were operated without such a marking (group B). The charts of all patients were reviewed retrospectively in order to assess whether intraoperative localization of the SDAVF was prompt or whether surgery was performed initially at erroneous level(s) with the necessity to extend the surgical approach. In addition, all charts were analyzed for duration of surgery and dosage of intraoperative fluoroscopy.

The data obtained from both groups of patients were compared with regard to prompt locating of the SDAVF using Student's *t* test and χ^2 test for independent samples.

Table 1 Summary of 28 patients with SDAVF

	Group A (<i>n</i> = 8)	Group B (<i>n</i> = 20)	<i>P</i>
Mean age (range of years)	68.2 (58–82)	62.1 (45 – 76)	
Male:female	6:2	18 : 2	
Spinal level of the SDAVF			
Thoracic (<i>n</i>) (%)	6 (75)	14 (70)	
D5	–	1	
D6	2	3	
D7	1	3	
D8	–	–	
D9	1	–	
D10	–	3	
D11	1	1	
D12	1	3	
Lumbar (<i>n</i>) (%)	2 (25)	6 (30)	
L1	2	3	
L2	–	3	
Mean duration of surgery (min)	133	170	0.031
Mean dosage of intraoperative fluoroscopy (cGy/cm ²)	119.5	394.3	0.036
Correct level approached promptly (<i>n</i>) (%)	8 (100)	12 (60)	0.048

Mann–Whitney *U* test was used for univariate comparison of duration of surgery and dosage of intraoperative fluoroscopy. A probability value of <0.05 was considered to be significant in the statistical analysis of all data.

Results

All patients were operated via a posterior approach, and the SDAVF could be identified in all patients. In each case, microsurgical closure of the fistula point was performed by intradural selective venous disconnection of the shunting vein.

In all patients of group A, the coil was easily identifiable with the aid of intraoperative fluoroscopy (Fig. 1). A minimally invasive tailored approach by means of a partial hemilaminectomy was sufficient for prompt localization and microsurgical treatment of the SDAVF in each patient (Fig. 2). In patients of group B, the appropriate spinal level was sought in the usual manner by counting the vertebral bodies from above and below using fluoroscopy. In doing so, the correct level was approached promptly via a hemilaminectomy in 12 of 20 patients (60%). In eight patients (40%), no SDAVF was encountered at the exposed level necessitating an extension of the approach. In seven of these patients one additional level and in one patient two additional spinal levels had to be exposed in order to

Fig. 1 The coil is easily identified with intraoperative fluoroscopy

Fig. 2 Postoperative roentgenogram showing the clips used for skin closure and the extent of the minimally invasive approach (arrows)

localize the SDAVF. This difference in the accurateness of the initial surgical approach of both groups of patients was statistically significant ($P = 0.048$).

Mean duration of surgery was 130 min in group A and was 177 min in group B ($P = 0.031$). Likewise, mean dosage of intraoperative fluoroscopy was higher in group B (119.5 vs. 394.3 cGy/cm²; $P = 0.036$). The results are outlined in Table 1.

Discussion

Most of the SDAVFs are encountered in the thoracic and upper lumbar region. Once the fistula is visualized, its surgical closure generally does not constitute an intricate surgical problem. Its adequate intraoperative localization, however, sometimes might prove to be a real challenge.

Usually, the appropriate spinal level is determined by counting of ribs or vertebral bodies from above and below using fluoroscopy. However, adequate counting might be hampered by anatomical particularities such as cervical ribs, spinal deformity, pronounced scoliosis, marked degenerative reduction of disc heights, or an abnormal number of lumbar vertebrae with either sacralization or lumbarization. Besides, it may be impeded particularly in obese patients due to poor visualization of bony structures. But even in patients without these specials, it is not impossible to unfathomably expose initially an incorrect level in spite of all diligence. Taking into consideration all these different possibilities of miscounting, the correct level was approached in only two-thirds of our patients of group B. In one-third of these patients, the initial spinal exposure was performed at an erroneous level necessitating an extension of the approach. This proportion of surgery performed at unnecessary levels appears to be very high, but revealing data referring thereto are not to be found in the pertaining literature.

To meet the problem of inadequate surgical exposure, preoperative coil marking of the relevant spinal level was performed in patients of group A. During surgery, the titanium coil was easily visualized with fluoroscopy. The surgical approach could be fashioned straightforward, and in all patients the SDAVF was localized promptly. In none of the cases, surgery was performed at unnecessary levels. Thus, reliable identification of the intended surgical site and accurate intraoperative localization of the SDAVF was impressively facilitated.

Additionally, preoperative coil marking of the respective spinal level allows for less surgical exposure. Reporting on five patients, this technique was previously described by Britz and co-workers [2]. Nevertheless, they used a two-level laminectomy in one of their patients and 1.5-level laminectomies in three patients. Such extensive

approaches with all its disadvantages, however, are not necessary, and in contrast we treated all patients of group A via a minimally invasive partial hemilaminectomy.

Such tailored surgical approaches do not only imply less operative trauma, but also reflect in shorter duration of surgery. Due to accurate intraoperative localization of the SDAVF and owing to a minimally invasive approach, duration of surgery was significantly shorter in patients of group A. Accordingly, length of anesthesia could be reduced significantly likewise. This certainly is beneficial for the patient and eventually is cost-saving, too.

The last but not least point in favor of preoperative coil marking is the matter of radioprotection. Using this technique, it is possible to minimize the number of intraoperative fluoroscopic scans in order to identify the appropriate spinal level. Accordingly, the radiation dosage employed was significantly lower in patients of group A, a fact that is without doubt salutary for patient and staff.

Conclusions

Preoperative coil marking allows for prompt intraoperative localization of the SDAVF. Thus, surgery at erroneous spinal levels can be avoided reliably, and it is feasible to perform a tailored, straightforward, minimally invasive surgical approach. This reflects in significant reduction of

duration of anesthesia and surgery. Moreover, radiation exposure of patient and staff is reduced to the absolute minimum.

References

1. Birchall D, Hughes DG, West CG (2000) Recanalisation of spinal dural arteriovenous fistula after successful embolisation. *J Neurol Neurosurg Psychiatry* 68:792–793. doi:[10.1136/jnnp.68.6.792](https://doi.org/10.1136/jnnp.68.6.792)
2. Britz GW, Lazar D, Eskridge J, Winn HR (2004) Accurate intraoperative localization of spinal dural arteriovenous fistulae with embolization coil: technical note. *Neurosurgery* 55:252–255. doi:[10.1227/01.NEU.0000127883.26964.81](https://doi.org/10.1227/01.NEU.0000127883.26964.81)
3. Eskandar EN, Borges LF, Budzik RF Jr, Putman CM, Ogilvy CS (2002) Spinal dural arteriovenous fistulas: experience with endovascular and surgical therapy. *J Neurosurg* 96:162–167
4. Hassler W (2007) Personal communication
5. Huffmann BC, Gilsbach JM, Thron A (1995) Spinal dural arteriovenous fistulas: a plea for neurosurgical treatment. *Acta Neurochir (Wien)* 135:44–51. doi:[10.1007/BF02307413](https://doi.org/10.1007/BF02307413)
6. Koch C (2006) Spinal dural arteriovenous fistula. *Curr Opin Neurol* 19:69–75. doi:[10.1097/01.wco.0000200547.22292.11](https://doi.org/10.1097/01.wco.0000200547.22292.11)
7. Schaat TJ, Salzman KL, Stevens EA (2002) Sacral origin of a spinal dural arteriovenous fistula: case report and review. *Spine* 27:893–897. doi:[10.1097/00007632-200204150-00023](https://doi.org/10.1097/00007632-200204150-00023)
8. Steinmetz MP, Chow MM, Krishnaney AA, Andrews-Hinders D, Benzel EC, Masaryk TJ, Mayberg MR, Rasmussen PA (2004) Outcome after the treatment of spinal dural arteriovenous fistulae: a contemporary single-institution series and meta-analysis. *Neurosurgery* 55:77–87. doi:[10.1227/01.NEU.0000126878.95006.0F](https://doi.org/10.1227/01.NEU.0000126878.95006.0F)