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Case study

Microsurgical treatment and outcomes of spinal arteriovenous lesions: Learned from consecutive series of 105 lesions

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ABSTRACT

Spinal arteriovenous lesions (SAVLs), arteriovenous fistulas (AVFs) and arteriovenous malformations (AVMs), are rare and can devastatingly impair spinal cord function. This study aimed to evaluate clinical outcomes after microsurgical treatment with the aid of intraoperative indocyanine green video-angiography (ICG-VA) in a large series of patients with SAVLs. We retrospectively reviewed the cases of 95 consecutive patients with 105 SAVLs (77 spinal AVFs, 28 spinal AVMs) who had been treated surgically during 2010–2016 in two hospitals by the same experienced surgeon. All patients had undergone magnetic resonance imaging and digital subtraction angiography preoperatively and were assessed using the modified Aminoff and Logue Scale (mALS). All lesions were resected or occluded using ICG-VA. No ICG-VA-related complications occurred. Compared with AVF, patients with AVM tended to be younger ($p < 0.001$) and were at higher risk of an associated aneurysm ($p = 0.021$), hemorrhage ($p < 0.001$), pain ($p < 0.001$) and abrupt onset ($p < 0.001$). SAVLs were most common in the lower thoracic region (45.71%), and their most common clinical presentation was paresthesia (89.52%). At a mean follow-up of 33.3 months, mALS indicated significant improvement in patients with spinal AVFs ($p < 0.001$) and AVMs ($p = 0.002$) compared with their status preoperatively. An improved, stable clinical status was noted at the last follow-up in 93.51% of those with AVFs and 89.28% of those with AVMs. Thus, microsurgical treatment of SAVLs produced a lasting positive clinical outcome in a large cohort of consecutive patients. ICG-VA proved to be an efficient intraoperative tool during resection of these lesions, especially in patients with an AVF.

1. Introduction

Spinal arteriovenous lesions (SAVLs) are rare, complex lesions that, if not treated properly, could lead to severe morbidity with progressive spinal cord symptoms [4–6,9,12]. With the advancement of neuroimaging technologies—spinal angiography and intraoperative indocyanine green video-angiography (ICG-VA)—and microsurgical and endovascular techniques during the last decades, the understanding and treatment of these lesions have dramatically improved. Various classifications, (e.g., American/British/French connection classification and Spetzler classification), and multiple treatment modalities, including microsurgical resection, endovascular embolization and combined therapies, have been reported [2–6,8–10,12,14,16–18].

It is still difficult to treat SAVLs properly because of their rarity and complexity, even with the evolution of the diagnostic tools and treatment modalities. ICG-VA has been proposed as an intraoperative procedure to define angioarchitecture for microsurgical resection of SAVLs during the last decade—because of its safe repeatability and dynamic visualization of blood flow during the resection [3,7,12,17]. The advantages and disadvantages of intraoperative ICG-VA has been discussed in detail, however, researches about the application of this method in large cohorts of consecutive patients are still rate. We therefore reviewed our 7-years of microsurgical treatment of these lesions with the aid of ICG-VA, evaluated their clinical characteristics, and analyzed their outcomes.

Abbreviations: AVFs, arteriovenous fistulas; AVMs, arteriovenous malformations; ICG-VA, indocyanine green videoangiography; mALS, modified Aminoff and Logue Scale; MRI, magnetic resonance imaging; SAVLs, spinal arteriovenous lesions.

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2. Methods

2.1. Patient population

We retrospectively reviewed 95 consecutive patients with 105 spinal vascular malformations who were treated with the assistance of intraoperative ICG-VA at the Beijing Tsinghua Changgung Hospital and Beijing Tiantan Hospital between January 2010 and December 2016 and who were entered prospectively into our database. The institutional review board approved the study. Patients were screened based on the following inclusion criteria: (1) the diagnosis was based on spinal angiography findings; (2) patients were treated by microsurgery with or without preoperative endovascular embolization; (3) complete clinical data were of adequate resolution for the analysis; (4) the patient or a close relatives consented to inclusion in the study. The following patients were excluded: (1) those whose lesions were treated by endovascular treatment only; (2) those whose images or clinical data were incomplete or not of adequate resolution for the analysis.

The study group consisted of 95 patients (average age 41.95 years, range 16 months to 73 years) with 105 lesions (Table 1). The lesions were divided into two groups—arteriovenous fistulas (AVFs) and arteriovenous malformations (AVMs)—according to a modified classification of SAVLs based on anatomical and pathophysiological features [8,14]. The locations of lesions were classified into cervical cord, upper thoracic cord (T1-T7), lower thoracic cord (T8-L1), and filum terminale (below the conus medullary) [10]. The lesions were most common in the lower thoracic cord (45.71%), followed by the upper thoracic cord (29.52%), cervical cord (20%) and filum terminale (4.76%). The most common clinical presentation was paresthesia (89.52%). Other symptoms included paresis or paralysis (81.90%), bowel and bladder dysfunction (71.43%), and pain (30.47%). The mean clinical follow-up was 33.30 months (range 3–68 months). Pre-treatment and follow-up spinal function was evaluated using the modified Aminoff and Logue Scale (mALS) scores (Table 2) [1], and was rated "improved" (decreased mALS scores compared with preoperative scores, deficits lessened), "stabilized" (no change in the mALS scores except for indicating excellent spinal function) and "deteriorated" (increased mALS scores, indicating neurological deterioration).

Table 2
Modified Aminoff-Logue spinal function scoring.

Classification of gait disturbance	
Grade 0	Normal gait and activity
Grade 1	Leg weakness or abnormal gait, no restricted activity
Grade 2	Grade 1 with restricted activity
Grade 3	Requires cane or similar support for walking
Grade 4	Requires walker or crutches for walking
Grade 5	Unable to stand, confined to bed or wheelchair
Classification of micturition	
Grade 0	Normal
Grade 1	Hesitance, urgency, or frequency
Grade 2	Occasional urinary incontinence or retention
Grade 3	Total urinary incontinence or retention
Classification of defecation	
Grade 0	Normal
Grade 1	Slight constipation, reacts to laxatives
Grade 2	Occasional incontinence or severe constipation
Grade 3	Total incontinence

2.2. Imaging and surgical treatment

Pre-treatment magnetic resonance imaging (MRI) and catheter angiography of the spine were conducted to evaluate the angioarchitecture, types and localizations of the SAVLs. Microsurgical procedures were performed while monitoring somatosensory evoked potentials and motor evoked potentials. All SAVLs were approached via a routine posterior midline approach laminectomy, laminotomy or laminoplasty, whichever was deemed appropriate for the surgical anatomy of the lesion.

For intraoperative ICG-VA, a 25-mg bolus of ICG dye (ICG-PULSION; PULSION medical system, Feldkirchen, Germany) was injected via the peripheral vine. For visualization, the Zeiss Pentero operating microscope (Carl Zeiss Co., Oberkochen, Germany) with

Table 1
Summarized data of patients with spinal arteriovenous lesions.

Variables	Total (n = 105)	AVFs (n = 77)	AVMs (n = 28)	*p* value*
Age, years	41.95 (18.35)	47.69 (15.65)	26.15 (15.96)	<0.001
Male: Female	75:30	59:18	16:12	NS
Associated Aneurysm, (%)	10 (9.52)	4 (5.19)	6 (21.43)	0.021
Ruptured, (%)	20 (19.05)	4 (5.19)	16 (57.14)	<0.001
Location, (%)				NS
Cervical	21 (20.00)	12 (15.58)	9 (32.14)	
Upper thoracic (T1-T7)	31 (29.52)	23 (29.87)	8 (28.57)	
Lower thoracic (T8-L1)	48 (45.71)	38 (49.35)	10 (35.71)	
Filum terminale	5 (4.76)	4 (5.19)	1 (3.57)	
Clinical Manifestation, (%)				
Pain	32 (30.47)	14 (18.18)	18 (64.29)	<0.001
Paresis/paralysis	86 (81.90)	64 (83.12)	22 (78.57)	NS
Paresthesia	94 (89.52)	70 (90.91)	24 (85.71)	NS
Bowel and/or bladder dysfunction	75 (71.43)	57 (74.03)	18 (64.29)	NS
Duration of Symptoms, months	4.00 (11.00)	6.00 (9.00)	1.00 (2.67)	<0.001
Duration of follow-Up, months	33.30 (18.21)	34.26 (18.37)	30.64 (17.83)	NS
Outcome at Last Follow-Up, (%)				NS
Improved	70 (66.67)	55 (71.43)	15 (53.57)	
Stable	27 (25.71)	17 (22.08)	10 (35.71)	
Deteriorated	8 (7.62)	5 (6.49)	3 (10.71)	
Mean mALS				
Pre-treatment	5.84 (3.37)	5.99 (3.16)	5.43 (3.91)	NS
Last follow-up	3.68 (3.26)	3.82 (3.33)	3.32 (3.09)	NS
	<0.001	<0.001	0.002	

AVF, arteriovenous fistula; AVM, arteriovenous malformation; NS, not significant.
* Comparison between AVF and AVM groups. $p < 0.05$ was considered statistically significant; NS indicates not significant.

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