Angiographic Characteristics and Treatment of Cervical Spinal Dural Arteriovenous Shunts

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SUMMARY: Spinal DAVSs of the cervical level are rare lesions. The purpose of this study is to describe the clinical and angiographic characteristics of cervical spinal DAVSs. From a prospectively collected database including 449 cases of brain and spinal DAVSs, lesions located at the cervical level were selected. The clinical presentation, angiographic characteristics, and treatment outcome were assessed. Twelve cases of spinal DAVSs were identified at the level of the cervical spinal canal (male to female ratio = 8:4; mean age = 56.5 years). Five patients (41.7%) presented with hemorrhage including SAH (n = 4) and cerebellar hemorrhage (n = 1). Coincidental spinal DAVSs with cranial DAVSs or brain AVMs were noted in 5 cases (41.7%). The spinal DAVS was the symptomatic lesion in 10 cases and was incidentally discovered during evaluation for SAH from a coincidental lesion in 2 cases. Combined endovascular and surgical resection resulted in symptomatic improvement in 10 patients. In conclusion, DAVSs of the cervical spine are rare lesions which often present with hemorrhage and are frequently associated with complex coincidental vascular lesions. Combined endovascular and surgical treatment will result in good outcome.

Materials and Methods
From a prospectively collected database including 449 cases of brain (n = 358) and spinal (n = 91) DAVSs, lesions located at the cervical level were selected. The database has been collected prospectively since 1989 by a team of both neuroradiologists and neurosurgeons in a multidisciplinary clinic. The evaluations included a detailed medical history, full neurologic examination, and imaging findings.

Cervical spinal DAVS is defined as a communication between a dural arterial feeder or converging arterial feeders and a radicular or leptomeningeal vein with an identifiable shunt surgery zone located between the C1 and C8 spaces. All diagnoses were confirmed with DSA.

Endovascular treatment was the first choice and was attempted in all patients with the aim of obliteration of the shunt and the initial venous segment. The treatment results were confirmed by angiography, preferably during the same hospital stay. The patients were followed clinically on a regular 3- to 6-month basis. Additional imaging was performed in any case of delayed recovery or clinical suspicion of recurrent disease.

The DSA images were evaluated for the feeders, shunt location, drainage routes, and accompanying angiographic features such as aneurysms or other vascular diseases. The age, sex, clinical presentation, drainage routes, and accompanying angiographic features such as aneurysms or other vascular diseases. The age, sex, clinical presentation, results were assessed. Institutional review board approval was obtained with a waiver of informed consent.

Results
The characteristics of the patients are summarized in the Online Table. Twelve cases of cervical spinal DAVSs were identified in 8 men and 4 women. The mean age was 56.5 years with a range of 36–76 years.

The main feeders were the vertebral (n = 10), thyrocervical (n = 1), and costocervical (n = 1) arteries. Ten cases were...
located at the upper cervical level (C1 through C2). Two cases were located at the lower cervical level (C8) with feeders arising from the segmental radicular branches of the costocervical (case 3) and thyrocervical (case 10) arteries. The main feeder of the lesion was located on the right side in 10 patients (83.3%). Five patients (41.7%) presented with SAH (n = 4) and cerebellar hemorrhage (n = 1). The spinal DAVS was the symptomatic lesion in 10 cases. In 2 cases, the spinal DAVS was incidentally discovered during evaluation for SAH from a coincidental vascular lesion (cases 1 and 2). Venous aneurysms associated with the DAVS were identified in 3 cases (cases 9, 10, and 11). All sources of hemorrhage were discovered on the initial DSA except in 1 patient (case 10). In this case, the DAVS associated with a venous aneurysm with the main feeder from the C8 radicular branch of the right thyrocervical trunk was discovered on the second angiogram after an initial negative finding on cerebral DSA.

The main intradural venous drainage routes were rostral in 6 cases, caudal in 4 cases, and bidirectional in 2 cases. All the SAHs in the upper cervical spine were associated with a rostral intracranial venous drainage.

Coincidental vascular lesions associated with the cervical spinal DAVSs were noted in 5 patients (41.7%). These included a spinal pial AVF (Fig 1, case 1), a cerebellar pial AVM (case 2), an intracranial DAVS (cases 6 and 9), and a coincidental contralateral spinal DAVS and an epidural AVF (Fig 2, case 7). The intracranial DAVS lesions were not associated with cortical venous drainage.

Angiographic cure of the lesion was achieved with n-BCA in 2 patients (16.7%, cases 3 and 11). One patient showed
spontaneous occlusion of the main vertebral artery feeder; thus, a small residual feeder from the occipital artery lesion was then occluded with PVA. However, recanalization was demonstrated on 2-month follow-up DSA; the recurrence was then treated by surgery (case 5). No significant complications were noted related to the embolization procedures. Surgical resection was performed in 7 patients because of embolization failure (n = 4; cases 1, 4, 7, and 8) or residual/recurrent shunt (n = 3; cases 5, 6, and 10). Clinical follow-up showed symptomatic improvement in 10 patients (mean, 15.9 months; range, 2–53 months).

Discussion
The results of our study revealed some unique distinguishing features of cervical spinal DAVSs compared with the typical lesions located in the thoracolumbar area. Five of the 12 patients (42%) presented with hemorrhage as the initial feature. In 3 cases, the spinal DAVS was the main lesion responsible for the hemorrhage. All the SAHs in the upper cervical spine (C1-C2) were associated with a rostral intracranial venous drainage. Hemorrhagic presentation of a thoracolumbar DAVS is considered extremely rare.7 However, previous reports have shown that cervical spinal DAVSs may be more frequently associated with hemorrhage.3,4,6,8,10 According to a review of the literature by Aviv et al,4 approximately 45% of patients with cervical DAVSs presented with SAH as their initial symptom. However, many of these patients had DAVSs at the foramen magnum level (37%; 15 of 41 reviewed cases), which were not true cervical spinal DAVSs. The higher flow rate in the lesions of the cervical area compared with the thoracolumbar area has been proposed as a mechanism for increased bleeding tendency.11 Also, due to the anastomosis of medullary and pontomesencephalic veins, rostral venous flow of the shunt may drain the shunted flow into the cranium.3,4,7 Thus, the relatively high flow of shunted blood into the pial veins of the posterior fossa may be a cause of SAH.

Another distinguishing feature in our series of cervical spinal DAVSs, which has not been elaborated previously, was the high incidence of association with a coincidental vascular lesion in the vicinity of the cervical spinal DAVS. Multiplicity is considered a possibility in patients with favorable vascular anatomy may be a safe and effective strategy. In cases of failure or residual lesion, the patient may be subsequently treated by surgical resection.20,21 For patients who present with hemorrhagic coincidental vascular lesions, the main goal of treatment should always include, first of all, eradication of the symptomatic lesion.

The angiographic differentiation of spinal DAVSs from radicular AVMs is a pertinent issue. Even though radicular AVMs are very rare, composing only 0.6% of the spinal cord vascular malformations, these lesions should be differentiated from spinal DAVSs.22 Radicular AVMs are arteriovenous shunts located on the nerve root and show a conglomerate of abnormal nidal vessels around the nerve root with relatively fast flow. Spinal DAVSs will have a shunting zone along the dura with radicular feeding vessels converging onto the draining radicular or leptomeningeal vein with relatively slow flow. Patients with radicular AVMs often present with radicular pain and only rarely show congestive venous myelopathy.23 In
terms of the relationship between spinal and intracranial DAVSs, the spinal DAVS lesions probably are the embryologic homolog of the intracranial DAVSs draining into the petrosal vein or bridging veins of the medulla. These lateral epidural shunts are characterized by male predominance, later age of onset, and the presence of cortical venous reflux, which has also been shown in our series. However, the frequent association of the multiple coincidental vascular lesions in the cervical spinal DAVSs seems to be a feature distinguishing them from the intracranial lateral epidural type of lesion.

Conclusions
Cervical spinal DAVSs are rare lesions with distinguishing features, compared with the more common lesions located in the thoracolumbar area. The lesions are characterized by a high incidence of hemorrhagic presentation, right-sided location, and also frequent association with multiple coincidental vascular lesions. Multidisciplinary endovascular and surgical treatment should be directed to the symptomatic lesion and will result in good outcome.

References