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**Intraarterial digital subtraction angiography of spinal arteriovenous malformations.**

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# Intraarterial Digital Subtraction Angiography of Spinal Arteriovenous Malformations

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Intraarterial digital subtraction angiography (DSA) in two patients with spinal dural arteriovenous fistulas demonstrated the major feeding arteries and the venous drainage of the respective malformations. However, the dural component of the malformations—which distinguishes them from intradural malformations—could not be recognized, nor was normal cord vasculature demonstrated. In a patient with an intradural arteriovenous malformation (AVM), only major arterial feeders were demonstrated. Intraarterial DSA provides essential anatomic information with an increased margin of safety in spinal AVMs, but supplemental selective arteriography, conventional or digital, also is currently required.

The surgical treatment of spinal arteriovenous malformations (AVMs) requires the preliminary angiographic demonstration of all arterial feeders [1]. In addition, the relation of the malformation to the cord (dural vs. intradural, intramedullary vs. posterior) must be established in order to determine the feasibility and risks of resection. Furthermore, many neurosurgeons like to know the origin of the artery of Adamkiewicz when approaching malformations in the lower thoracic region. Formerly, selective catheterizations of costocervical, intercostal, and lumbar arteries were required to provide this information, resulting in lengthy, tedious procedures and large doses of contrast media. We investigated in three patients the possibility of substituting nonselective intraaortic digital subtraction angiography (DSA) for multiple selective catheterization in order to simplify the workup and lessen the risk.

## Subjects and Methods

Two dural arteriovenous fistulas [2–4] and one posterior intradural AVM at the cervico-thoracic level were studied. All patients had characteristic myelographic filling defects. Intraarterial DSA was performed by injecting 20 ml (10 ml/sec × 2) of methylglucamine iothalamate (Conray 60; Mallinckrodt, St. Louis) through a 5 French pigtail catheter positioned in the proximal descending thoracic aorta, in the mid–descending thoracic aorta, and in the upper lumbar aorta. In one patient with feeders arising from the highest intercostal artery, smaller injections (10 ml/sec × 1) into the innominate and left subclavian arteries were also performed. A Polydiagnost C U-arm system (Philips, Shelton, CT) with a 9 inch (22.9 cm) image intensifier was used. Multiple-frame integration provided two images/sec. Anteroposterior or slightly left posterior oblique projections were routinely used. Lateral filming was attempted in one patient in an effort to demonstrate the relation of the intradural malformation to the spinal cord.

At a subsequent procedure, the findings of intraarterial DSA were verified by selective injections of the appropriate feeders, along with a generous screening of adjacent intercostal and lumbar arteries.

Both patients with dural arteriovenous fistulas underwent surgical excision of the dural component without resection of the medullary venous drainage [5]. Intraarterial DSA and selective arteriographic studies were repeated 8–10 days after surgery to document complete excision of the fistula and nonfilling of the enlarged posterior veins. The third
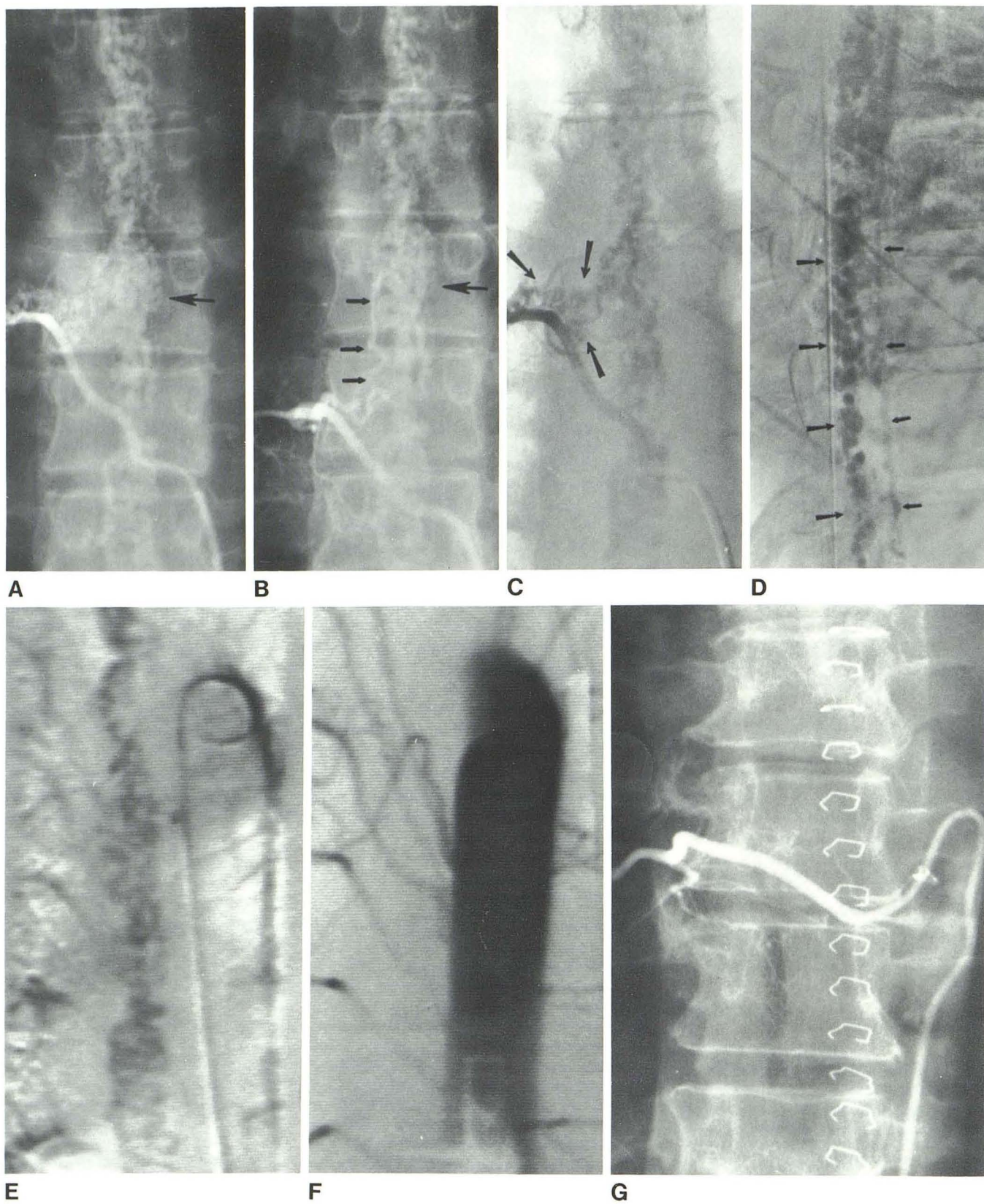
Fig. 1.—Case 1. Feeders arise from T7 (**A**) and T8 (**B**, *small arrows*) to opacify AVM at T7 level (**A** and **B**, *large arrows*). **C**, Subtraction of T7 arteriogram demonstrates dural nidus (*arrows*) which was totally excised. **D**, Posterior (*large arrows*) and anterior (*small arrows*) draining veins were left undisturbed. Intraaortic DSA (**E**) demonstrates both feeders and draining subarachnoid veins, but not dural nidus. Postoperative DSA (**F**) and selective T7 arteriogram (**G**) show no filling of malformation.

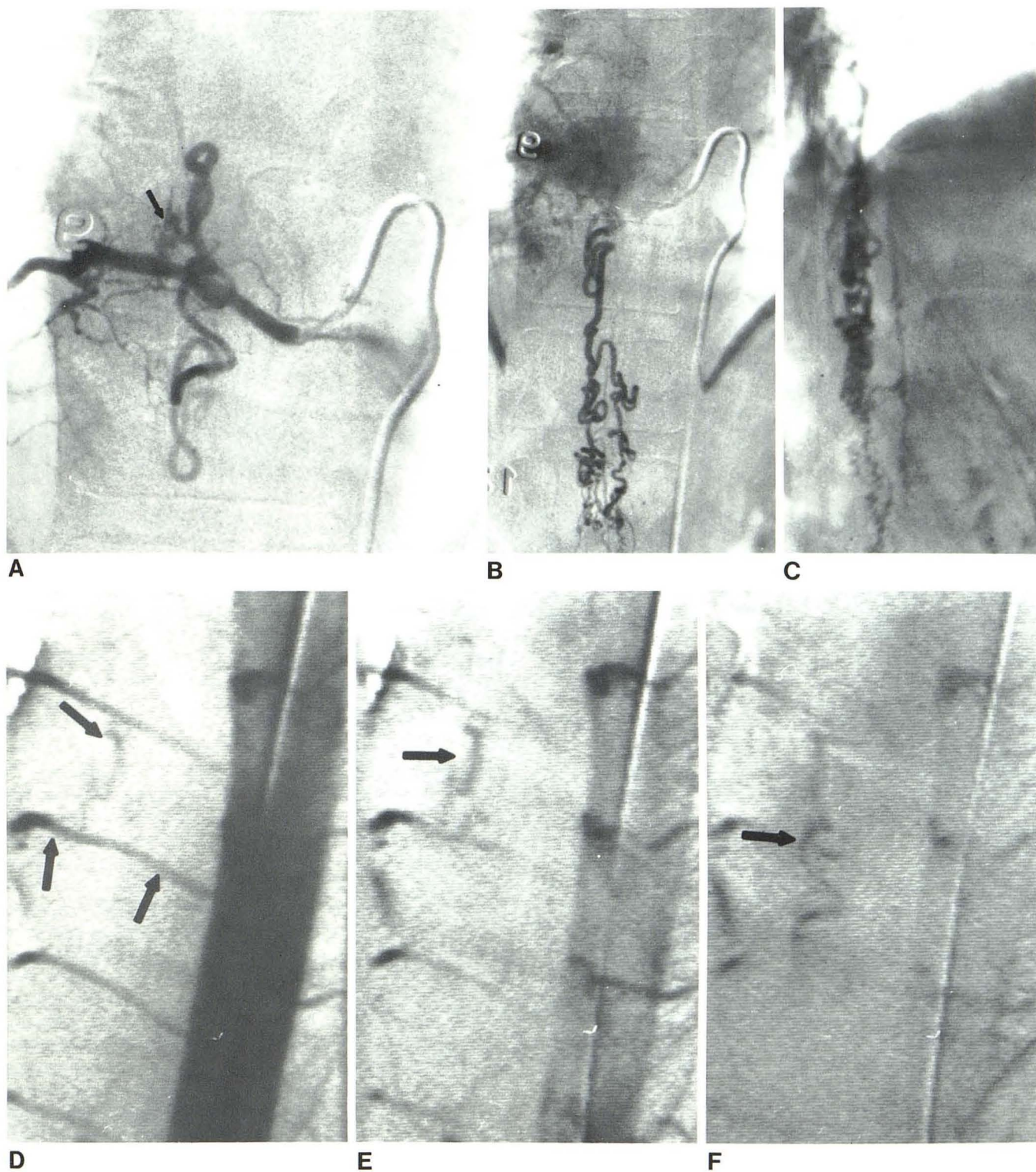Fig. 2.—Case 2. **A,** Selective right T9 arteriogram demonstrates dural nidus (*arrow*) draining into extensive subarachnoid venous plexus (**B**) involving posterior spinal veins (**C**). **D,** Digital subtraction aortogram demonstrates T9 feeder (*arrows*) but not dural nidus. Venous drainage (**E** and **F,** *arrows*) poorly visualized by DSA as compared with selective arteriography (**A–C**).
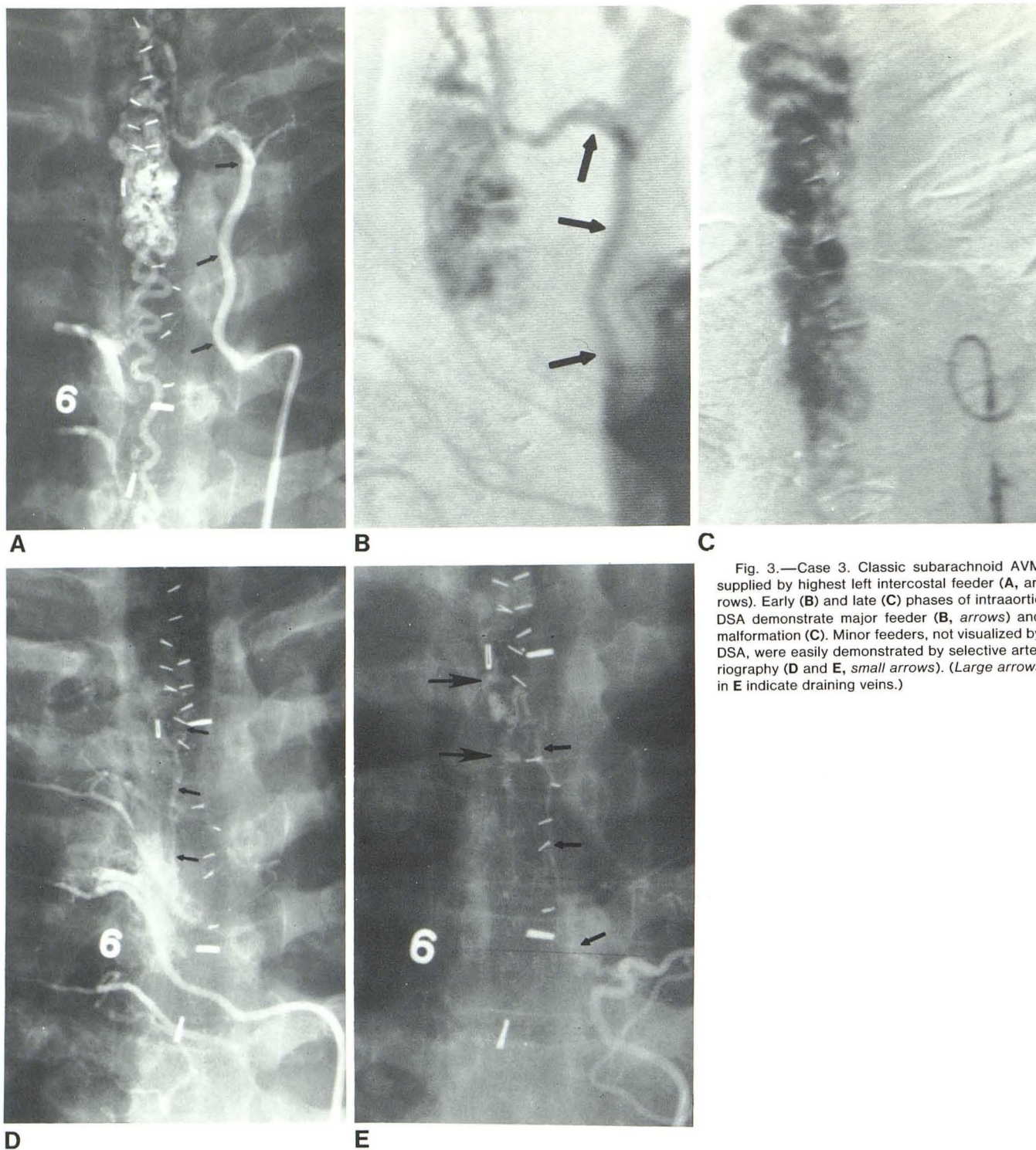
**A**   **B**   **C**

**D**   **E**

Fig. 3.—Case 3. Classic subarachnoid AVM supplied by highest left intercostal feeder (**A**, arrows). Early (**B**) and late (**C**) phases of intraaortic DSA demonstrate major feeder (**B**, *arrows*) and malformation (**C**). Minor feeders, not visualized by DSA, were easily demonstrated by selective arteriography (**D** and **E**, *small arrows*). (*Large arrows* in **E** indicate draining veins.)

patient, who had an extensive cervicothoracic AVM and long-standing paraplegia, was not offered surgery.

## Results

Figures 1 and 2 compare the nonselective intraarterial DSA studies and selective arteriograms in the patients with dural arteriovenous fistulas. All arteries feeding the dural malformations were demonstrated on the digital studies. However, the dural nidus could not be recognized in either case and therefore the important distinction between dural and intradural malformations was not made [2–4]. Moreover, the normal artery of Adamkiewicz and anterior spinal artery could not be recognized on the digital studies in either patient, but were clearly displayed on the selective arteriograms.

The principal feeding artery in the case of the intradural cervicothoracic AVM (fig. 3) was demonstrated by intraarterial DSA, but four small feeders and the normal anterior

| Case No.: Type, Site of AVM | Intraaortic DSA | | | Selective Arteriography | | |
| --- | --- | --- | --- | --- | --- | --- |
| | AP/LPO | | Lateral* | AP/LPO | | Lateral* |
| | Feeders | ASA | | Feeders | ASA | |
| 1: Dural, right T6–T7 ......... | + | − | ... | + | + | ... |
| 2: Dural, right T7–T8 ......... | + | − | ... | + | + | ... |
| 3: Posterior extramedullary, left T3–T4 ................. | +/−† | − | − | + | + | + |

Note.—DSA = digital subtraction angiography; AVM = arteriovenous malformation; AP/LPO = anteroposterior/left posterior oblique projections; ASA = anterior spinal artery; + = vessel(s) visualized; − = vessel(s) not visualized.

* Lateral filming was attempted only in case 3.

† Major feeders visualized; minor feeders not visualized.

spinal artery at this level were identified only on the selective arteriograms. The lateral digital study at the cervicothoracic level failed to demonstrate the malformation in this patient, who was quite obese; however, the malformation was demonstrated on the lateral projection of the selective arteriogram.

The two patients with dural arteriovenous fistulas underwent total excision of the nidus and have shown dramatic short-term clinical improvement. There was no evidence of filling of the remaining medullary veins on either the postoperative digital or the postoperative selective studies. Dynamic computed tomography (CT), which was grossly positive in both patients preoperatively, was negative after resection of the dural fistulas. Table 1 summarizes the clinical and angiographic findings in all three cases.

## Discussion

Our initial experience [6] with intravenous DSA in spinal arteriovenous malformations was disappointing. Small malformations were not seen, and although the intraspinal component of large malformations usually could be demonstrated, feeding arteries never were recognized. We concluded that a negative intravenous DSA study does not exclude a small spinal AVM. The most sensitive intravenous screening method seems to be dynamic CT [6, 7], provided an appropriate level can be selected on the basis of myelographic findings.

Since feeding vessels are never demonstrated by intravenous DSA, assessment of operability and surgical planning require an intraarterial study. But multiple selective catheterizations are technically complex and entail some risk of further spinal cord damage. Because of the potentially shorter procedure time and lower contrast dose directed to the cord, intraarterial DSA was evaluated in three patients and found to be a satisfactory but not a perfect substitute. All malformations and their major feeding arteries were demonstrated by injection into the aorta or major branches. Contrast doses to the spinal cord were reduced and undiluted intracostal injections were avoided. In the two patients with spontaneous lower-leg spasms, satisfactory digital studies could be obtained by intraarterial DSA, since opacification of the malformation generally occurred before commencement of spasms; this was not generally the case with intravenous studies.

However, in the two dural arteriovenous fistulas, the normal cord vasculature was not demonstrated. This information is useful for the surgeon who is planning excision and essential for the angiographer considering embolization. (If the malformation and the artery of Adamkiewicz are supplied by the same intercostal artery, embolization is contraindicated.) In addition, small feeders to malformations were not visualized by intraarterial DSA, but their demonstration is not critical provided all major feeders are identified.

In both midthoracic lesions (cases 1 and 2), the feeding vessels were right-sided. Inspection of the digital studies suggests that left-sided feeders may be more difficult to identify because they are obscured by the thoracic aorta. We deliberately chose to inject small boluses of concentrated contrast medium to avoid prolonged aortic opacification, but we suspect superposition of the opacified aorta will obscure left-sided feeders in the mid and lower thoracic levels. Perhaps the safest angiographic combination would be intraaortic DSA (for demonstrating the malformation and major feeders) followed by selective digital subtraction arteriography (to identify the normal cord vasculature and minor feeders). The lower contrast dose required for selective digital arteriograms would greatly reduce the risk of spinal cord damage.

Ultimately, improved resolution of new DSA imaging systems may eliminate the need for selective arterial studies: Low-volume, rapid, nonselective (intraaortic) injections through small-bore, high-flow catheters may demonstrate all the pathology. However, it is doubtful that intravenous DSA will provide enough information to replace intraarterial studies in the foreseeable future.

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