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Embolization of Spinal Cord Vascular Malformations via the Anterior Spinal Artery

M. C. Riché,[1] J. P. Melki, and J. J. Merland

During a 3 year period, 21 patients with spinal cord vascular malformations involving the anterior spinal artery were treated by embolization through this artery. Of four cases of extramedullary arteriovenous fistula, two patients embolized at an early stage showed excellent results, whereas results were mediocre in two patients who were paraplegic at embolization. Of 17 cases of intramedullary arteriovenous malformation (AVM), nine patients showed clinical improvement either with or without radiologic evidence of residual malformation; three patients had complications that led to clinical worsening; in the other five patients, results were mixed or inconclusive. Angiomyelotomography is recommended to diagnose extramedullary arteriovenous fistulae involving the anterior spinal artery. Pretherapeutic evaluation of intramedullary AVMs must consider the spinal cord level at which the malformation occurs. Angiotomography and temporary occlusion tests permit identification of collateral anastomoses before embolization. Respective criteria for surgery and embolization are defined. In cases where embolization is indicated, short-term results can generally be predicted.

Spinal cord vascular malformations fed by the anterior spinal artery are of two types: extramedullary arteriovenous fistulae with anterior spinal artery participation, which are usually located around the conus terminalis and comprise a direct shunt between the anterior spinal artery and the medullary vein; and intramedullary arteriovenous malformations (AVMs), which are usually multipediculated but always involve the anterior spinal artery. Embolization via the anterior spinal artery has always been regarded as a dangerous procedure because serious neurologic deficits result from its occlusion. However, recent advances in neuroradiologic technology have allowed us to embolize 21 cases of spinal cord AVM through this artery. Among the new techniques, angiotomography and angiomyelography play a major role in mapping these malformations in order to identify and minimize potential risks in treatment. Innovations involving the use of coaxial catheters and temporary occlusion and detachable balloons have also helped to make embolization a safer procedure [1].

Subjects and Methods

During a 3 year period, 21 patients with spinal cord vascular malformations at Lariboisière Hospital were treated by embolization via the anterior spinal artery. Four patients had extramedullary fistulae involving the anterior spinal artery and 17 patients had inoperable intramedullary AVMs (nine cases of cervical malformation and four cases each of dorsal and dorsolumbar malformation). Pretreatment studies were performed in all patients. Methods of evaluation included angiography, myelography, angiotomography, and angiomyelotomography. Eighteen of the patients were treated in two to four sessions at intervals ranging from 3 weeks to 3 months. At 6 months postembolization, follow-up studies were performed in all except the three most recent patients. Particulate solids (dura mater, coagulum, gelatin sponge) were used for the embolus in 17 cases. Isobutyl-2-cyanoacrylate adhesive (bucrylate) was used alone or in association with particulate material in two cases. Detachable balloons were used in two cases.

Results

Extramedullary Arteriovenous Fistulae

Patients with extramedullary fistulae who were embolized at an early stage in the course of their disease are distinct from those who were already paraplegic. Two patients embolized at an early stage showed excellent results. However, when embolization was used to treat two patients who were already paraplegic, the results were mediocre.

Intramedullary AVMs

The 17 patients with intramedullary AVMs treated by embolization through the anterior spinal artery had all been judged inoperable according to criteria of eligibility for surgical treatment (discussed

Fig. 1.—Angiomyelotomography confirms diagnosis of extramedullary arteriovenous fistula with anterior spinal artery participation.

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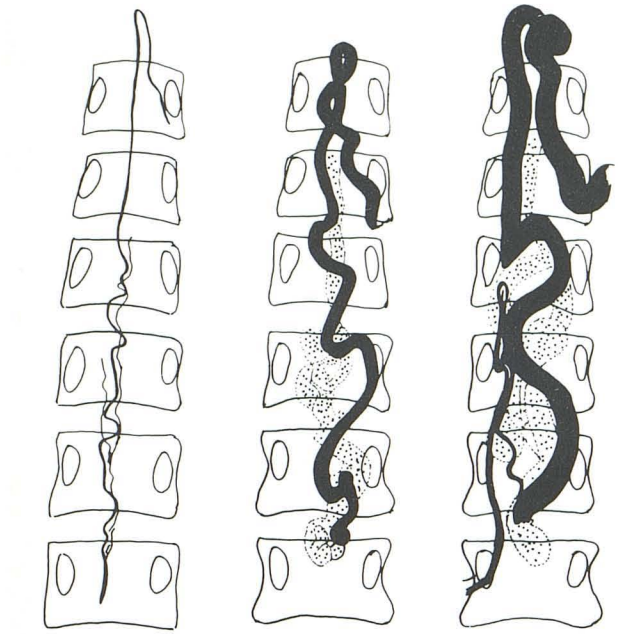

Fig. 2.—Three types of extramedullary fistulae involving anterior spinal artery. Small fistula (*left*) is indication for surgical treatment. Enlargled anterior spinal artery and dysplastic venous pouch at site of shunt (*center*) permit either surgery or embolization. Very large fistula (*right*) calls for detachable balloon occlusion.

later). They are classified according to the spinal level affected [2].

In nine cases of cervical malformation, three patients experienced complete recovery accompanied by satisfactory radiologic results; two patients showed good clinical improvement but had radiologic evidence of significant residual malformation; and two patients had very good radiologic results but inconclusive clinical assessments. (One of the latter had presented with simple subarachnoid hemorrhage and had therefore no deficit; the other patient showed little improvement, but had been triplegic for many years. Embolization was successful in reversing a recent exacerbation of this patient's condition, however.) Finally, two patients had complications that led, respectively, to transient triplegia followed by surgery and quadriplegia followed by death. These are discussed later.

In four cases of dorsal malformation, one patient showed good clinical improvement but had radiologic evidence of residual malformation; one patient remained clinically unchanged despite radiologic disappearance of the malformation; and two paraplegic patients showed only mild clinical improvement.

In four cases of dorsolumbar malformation, one patient had a complete clinical recovery accompanied by nearly complete radiologic disappearance of the malformation; two patients showed good clinical improvement but had residual radiologic malformation; and one patient's condition worsened despite radiologic disappearance of the lesion.

Discussion

The short-term results of embolization can be predicted in most cases after careful study of the malformation by current radiologic means, with special emphasis on identifying the collateral vessels of the anterior spinal artery. The use of temporary occlusion balloons or coagulum can permit identification of collateral networks that are not otherwise detectable radiologically. These techniques can also be employed during embolization procedures by temporarily occluding an artery that is to be left unharmed, in order to increase the potential area for embolization in another artery or arteries. Temporary embolization using coagulum offers another advantage in that the material is resorbable. Because of this, in cases where embolization via the anterior spinal artery appears to be dangerous, trial embolization can be performed with coagulum. If clinical improvement is seen, permanent embolization using nonresorbable material can be performed 3 weeks later.

Although isobutyl-2-cyanoacrylate adhesive has been used quite often in the treatment of dural extramedullary fistulae with medullary venous drainage, this material is very rarely used for embolization

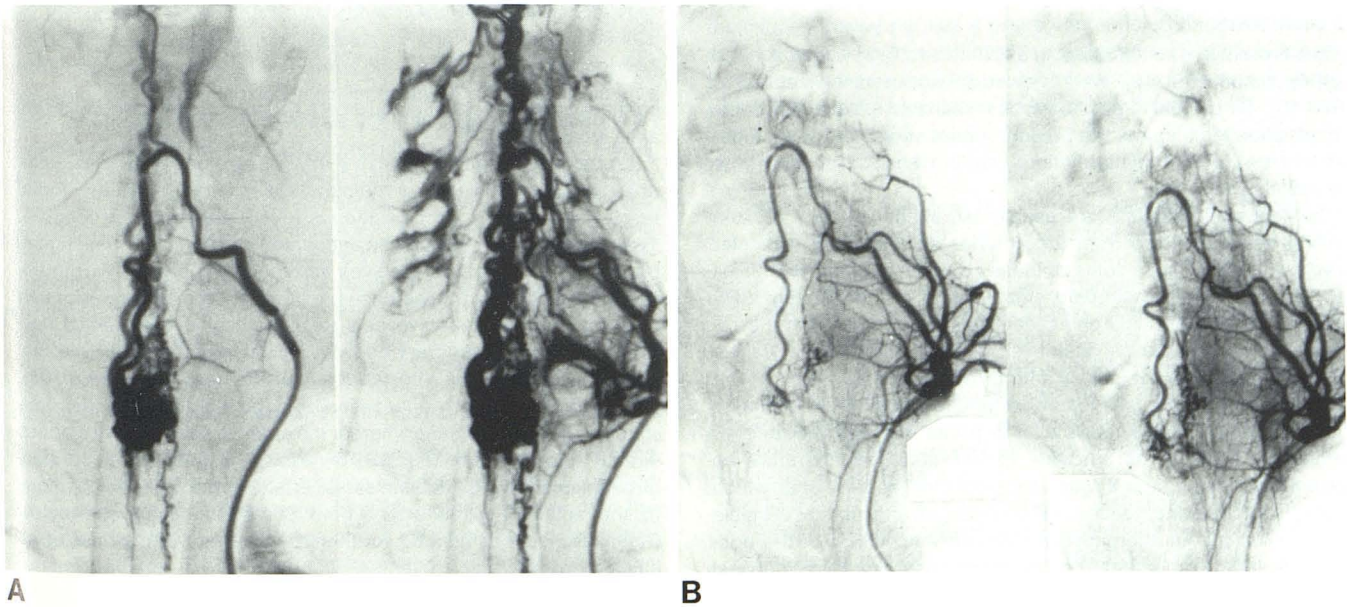

Fig. 3.—Cervical intramedullary AVM supplied primarily by anterior spinal artery. Arteriograms before (**A**) and 6 months after (**B**) embolization.

via the anterior spinal artery. One patient in our series worsened after embolization with this product. Controlled embolization with particulate solids appears to be much safer.

Extramedullary Arteriovenous Fistulae with Anterior Spinal Artery Participation

These fistulae were first described by M. Djindjian [3]. They continue to be poorly understood since they are often confused with intramedullary AVMs. However, the fistula differs fundamentally from the intramedullary AVM in two respects: its location outside the spinal cord and the existence of a direct shunt between the anterior spinal artery and its draining vein. Clinically, these malformations appear in persons 20–30 years of age with the onset of a slowly progressive myeloradicular syndrome. Frequently, the patient's medical history reveals an episode of subarachnoid hemorrhage. Diagnosis is made essentially by angiomyelotomography (fig. 1). This examination generally confirms the extramedullary position of the malformation by demonstrating the normal aspect of the spinal cord and conus terminalis, with occasional displacement of the latter. It also permits visualization of the entire malformation in the perimedullary spaces. Prognosis is generally unfavorable as lack of intervention results in paraplegia.

Three principal types of extramedullary arteriovenous fistulae involving the anterior spinal artery can be distinguished (fig. 2): In the first type, the fistula is small and the anterior spinal artery is long and thin. Embolization is contraindicated, but surgery can be performed. In the second type, the anterior spinal artery is enlarged and there is a dysplastic venous pouch at the site of the shunt. Treatment may be surgical and is facilitated by a temporary occlusion balloon, which is placed at the origin of the anterior spinal artery and inflated while the surgeon ligates the shunt. Embolization with macroemboli may also be performed. Another possiblility is embolization with a calibrated-leak balloon. In the third type, the fistula is very large and surgery is contraindicated. The exact location of the shunt is sometimes problematic but can be determined by identifying the juncture of the accessory arterial feeders (specifically, the posterior spinal arteries). The optimum treatment is occlusion by a detachable balloon.

Intramedullary AVMs

The first case of embolization of a spinal cord AVM was described by Doppmann et al. [4]. We reviewed 38 cases embolized up to 1977 [5]. Since that time, numerous changes have occurred in embolization techniques. We present a brief survey of recent techniques used in such malformations, again classified according to the spinal level.

Cervical malformations are usually intramedullary and contain several feeders arising from the anterior and posterior radicular arteries (fig. 3A). Since some of these radicular arteries stem from the vertebral artery, adequate embolization is difficult (fig. 3B). However, there are numerous collateral anastomoses with the radicular arteries at the cervical level, making embolization via the anterior spinal artery relatively safe provided that the trunk of the anterior spinal artery itself is not occluded. Since the emboli must reach the angiomatous network, it is preferable that the anterior feeders be as large as possible. Embolization can therefore be performed in steps, first through the posterior feeders, after which procedure the anterior feeders will be enlarged and more accessible to embolization. An alternative is temporary occlusion of the posterior feeders. Finally, in a very complex case of a lower cervical intramedullary AVM supplied by the anterior spinal artery and arising from the top of a vertebral artery, we were able to selectively catheterize this artery after surgical exposure of the vertebral artery at its loop at C1–C2.

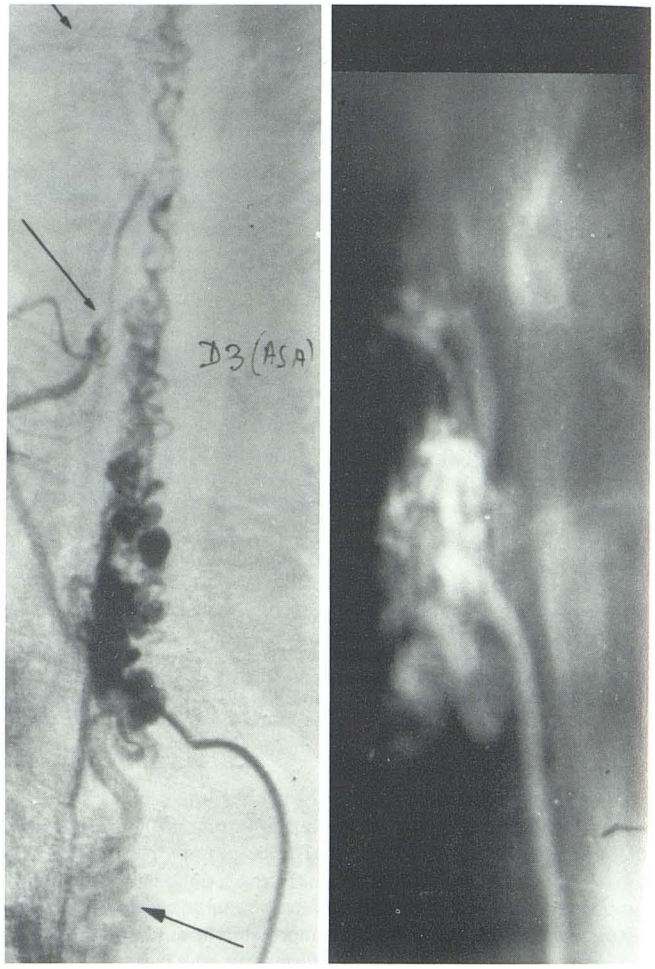

Fig. 4.—**A**, Inoperable, laterally situated dorsal intramedullary AVM supplied primarily by anterior spinal feeders at T3 and T7 (*long arrows*). Normal anterior spinal artery supply above AVM (*short arrow*). **B**, Angiotomography via T7 (lateral view). Opacified anterior spinal artery empties directly into AVM, indicating feasibility of embolization.

Dorsal malformations always carry a very poor prognosis since only one collateral vessel, a radicular artery, is present at the dorsal level. Consequently, embolization is a very dangerous procedure. Two types of situations may be encountered: The malformation may be a "mixed" type that receives its blood flow primarily from the posterior feeders. In these cases, embolization may be performed through these posterior vessels after increasing preferential flow through them by temporary balloon occlusion of the anterior spinal artery. In other cases, the predominant feeders are anterior (fig. 4A). Angiotomography that visualizes the anterior spinal artery shunt is used to determine whether the anterior spinal artery empties directly into the AVM (fig. 4B) or involves significant blood-steal through enlarged sulcocommissural arteries. Anastomotic channels to the anterior spinal artery from above (cervical) and below (Adamkiewicz) can also be scrutinized, possibly with the use of an inflated balloon.

Dorsolumbar malformations may be of several types. Frequently the posterior spinal arteries provide anastomotic channels at the

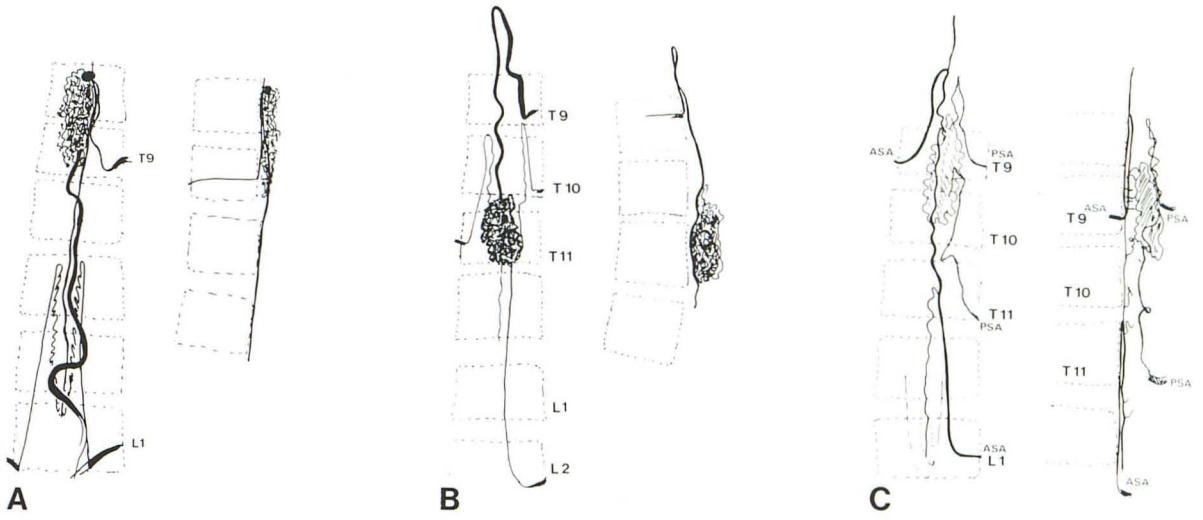

Fig. 5.—Three types of dorsolumbar intramedullary AVM. **A**, Inoperable AVM supplied by artery of Adamkiewicz arising from left T9 is diffuse, lateralized with ectasia, and adherent to anterior spinal artery (lateral view, *right*). Normal posterior spinal arteries at L1 level supply conus terminalis and anterior spinal artery, creating favorable situation for embolization. **B**, Posterior spinal arteries empty into AVM, while anterior spinal artery is sole supplier for conus terminalis. Embolization via anterior spinal artery calls for precautionary measures. **C**, Artery of Adamkiewicz supplies AVM by superior branch and conus by inferior branch. Optimum treatment is temporary balloon occlusion of artery of Adamkiewicz during embolization of posterior spinal artery feeder. ASA = anterior spinal artery; PSA = posterior spinal artery.

level of the conus terminalis (fig. 5A). In such cases, embolization through the anterior spinal artery is possible. On the other hand, if radiologic studies reveal that the posterior spinal arteries contribute to the malformation, the situation is similar to that of dorsal level malformations and necessitates important precautionary measures (fig. 5B). A third possibility is a "mixed" malformation (fig. 5C).

Complications

We encountered complications in embolizing two patients with cervical AVMs and one patient with a dorsolumbar AVM. In the latter case, the AVM was supplied both by the anterior spinal artery and by the two posterior spinal arteries, leaving no protection for the conus (fig. 5B). Embolization through the anterior spinal artery led to transient worsening which could have been foreseen today according to our current embolization criteria. Of the two patients with complicated cervical malformation, one had an AVM supplied by radicular arteries arising from both vertebral arteries; in this case, one feeder was catheterized and embolized with isobutyl-2-cyanoacrylate. A transient triplegia resulted, and the second feeder was surgically clipped. In the other patient, the malformation comprised a huge venous pouch occupying the cervical canal, which was also enlarged. A single fistula was supplied by three feeders arising from the left vertebral artery. Embolization resulted in quadriplegia and death after 48 hr. This event may have been caused by hemodynamic alteration in the local medullary circulation (vacuum effect of sudden depletion of the pouch).

Respective Roles of Surgery and Embolization

Surgery is indicated in cases of intramedullary AVM, according to M. Djindjian [3], if the malformation is focal and midline, supplied by long sulcocommissural arteries, partly ectatic, shorter than the height of two vertebrae, and has only a minor element of posterior venous drainage. These criteria are sometimes difficult to elucidate. Still, many malformations do not meet the above criteria and thus are not considered operable.

Embolization is indicated if the AVM has a short preangioma afferent feeder, large sulcocommissural arteries, collateral blood supplies for the anterior spinal artery both above and below the malformation, and lacks extensive venous drainage.

Although the short-term results of embolization can now be predicted in most cases, neither the long-term prognosis nor the eventual fate of embolized malformations has yet been clarified; it is possible that intramedullary cavities may develop as a result of thromboses or compressive fibrosis may result from a thrombosed venous ectasia. However, since the natural course of these malformations is always unfavorable, therapy is essential. The first step in treatment is careful consideration of the various therapeutic possibilities. The progress achieved in neuroradiology and embolization techniques during the last 4 years has enabled neurosurgeons at our institution to select embolization as the treatment of choice and to perform surgery only as a complementary measure in cases where embolization has failed or is contraindicated.

REFERENCES

1. Merland JJ, Djindjian M, Chiras J, Djindjian R. Recent advances in spinal cord arteriography. *Neuroradiology* **1981**;21:111–121
2. Riché MC, Modenesi-Freitas J, Djindjian M, Merland JJ. Arterio-venous malformations (AVM) of the spinal cord in children. *Neuroradiology* **1982**;22:171–180
3. Djindjian M. *Les malformations artério-veineuses de la moëlle épinière* (thesis). Université de Paris VI, Pitié Salpétrière, **1976**
4. Doppmann JL, Di Chiro G, Ommaya A. Obliteration of spinal cord arterio-venous malformation by percutaneous embolization. *Lancet* **1968**;2:477
5. Djindjian R, Merland JJ. Place de l'embolisation dans le traitement des malformations artério-veineuses médullaires. A propos de 38 cas. *Neuroradiology* **1978**;16:428–429