Vascular Malformations of the Spinal Cord
The Anatomic and Therapeutic Significance of Arteriography

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Ever since the studies of Virchow, a distinction has been made between tumors and vascular malformations in the central nervous system. Although described since the end of the 19th century, the study of vascular malformations of the spinal cord entered a new era with the advent of angiography. In fact, angiography not only shows spinal angiomas much better than was previously possible by surgical or anatomical examinations, but also encourages the hope of a logical treatment.

In 1936, Henson and Croft first reported a cervical arterio-venous aneurysm visualized with vertebral arteriography. In 1954, R. W. and C. W. Rand had succeeded in visualizing a malformation of the dorsal-lumbar junction by means of aortography. Subsequently, Höök and Lidwall and Morris published 2 cases of cervical malformations injected by means of vertebral arteriography.

Since 1962, when Djindjian et al. reported their first case of opacification by aortography, we have been able to collect 15 cases of vascular malformations of the spinal cord studied by means of angiography. This number may seem surprising. We think that the frequency of spinal cord malformations will become more apparent with the increased use of the spinal angiography, just as has been the case with cerebral angiography. The diagnosis may also be made earlier, that is to say, with the first signs of the abnormality.

It is interesting to note that in the 15 cases of our series, the first symptoms appeared in 11 cases prior to the age of 12 (twice before 3 years, 4 times between 3 and 7 years, and 5 times between 7 and 12 years). However, in 4 cases the first symptoms appeared much later; we recall that in the case of cerebral arterio-venous aneurysms, although 70 per cent of the cases become symptomatic before the age of 30 years, 5 per cent appear after the age of 50.

Classical diagnostic procedures are undeniable helpful in identifying a vascular malformation of the spinal cord. However, the identification on plain x-rays or tomographs of the spine, of an enlargement of the central canal, or an erosion of its walls is only presumptive evidence. Positive contrast myelography (Lipiodol, Pantopaque) suggests the diagnosis of a vascular malformation in about 75 per cent of cases by characteristic images described in 1925 by Guillaum and Alajouanine, but, as Gross and Ralston pointed out, small malformations can probably escape this relatively elementary method of diagnostic study.

Like other authors such as Svien and Baker, and Tavares, we had expected big things from trans-osseous phlebography. But it is not reliable in demonstrating a dilatation of the venous plexus surrounding the spinal cord. It shows merely the increased pressure existing distal to the arterio-venous shunt which is characteristic of vascular malformations of the spinal cord as they appear with arteriography.

Technique of Arteriography

Arteriography is in fact the fundamental examination necessary to determine the existence of a vascular malformation, and precisely to define its position, its dimensions, and its afferent and efferent vessels. A rigorous technique is absolutely essential in order to avoid accidents, and to obtain clear x-rays. We therefore wish to emphasize certain technical points which seem to us important.

1. The use of general anesthesia.
2. The selection of the technique, vertebral or aortic, appropriate for the presumed site of the malformation.
3. The choice of a catheter of minimum length and maximum diameter in order to increase the concentration of the contrast medium.
4. Monitoring the position of the catheter on a television screen in order to avoid the introduction of the catheter into a major spinal artery.

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5. The use of a tri-ioded contrast medium the viscosity of which decreases when it is heated to a temperature of about 37°C.

6. Selection of the right quantity of medium injected, depending on the location of the injection.

7. The use of automatic injection under controlled pressure.

8. The use of serigraphic technique in making the exposures.

9. The rigorous maintenance of apnoea while making the arteriographic exposures as well as while taking 2 plain x-rays prior to the injection, permitting one to obtain at different times in the serigraphy, the subtraction x-rays so important for the interpretation of these often complex studies.

**Anatomical Study**

Like malformations of the brain, spinal vascular malformations appear to be nothing more than arterio-venous aneurysms, their main characteristic being the existence of an arterio-venous communication without an intermediate capillary network. From one or several arteries, comes a group of vessels, more or less important, which open into the venous system by one or several veins, thus creating a malformation of variable size and volume, from the simple arterio-venous fistula, to the large cirsoid malformation.

1. *The Malformation*. This appears where the identification of artery and vein ends but it is supplied by a normal vascular system. Angiography studied in its time sequences show successively the opacification of one or more arterial pedicles supplying the malformation, the mass of abnormal vessels composing the arterio-venous shunt, and the venous pedicles draining the malformation.

A. The arteries supplying the malformation come from one or more pedicles and may be unilateral or bilateral. These arteries are often of important size and at times are really monstrous. On the other hand, although abnormal in appearance and size, they are of normal topography; that is, their origin, course and point of penetration of the vertebral canal is normal.

B. These arteries do not divide into a capillary network but terminate their course in the malformation as a mass of distended and sinuous vessels. This mass is probably nothing other than a vestigial vascular network. The malformation itself is difficult to isolate on the angiogram. The venous pedicles of drainage, in fact, are very quickly confounded with the malformation itself, and it is difficult if not impossible in this diffuse opacity, to differentiate which is related to the afferent pedicle, to the arterio-venous malformation, or to the pedicle of drainage.

C. Drainage veins are more numerous and larger when the malformation is larger and supplied by more pedicles. We believe, however, that here again it is not a question of topographically abnormal vessels, but of abnormally developed local veins.

One fact concerning these veins is very striking and should be emphasized. These veins may travel far from the arterio-venous shunt, upwards as well as downwards; this explains how some malformations seem to extend along the whole length of the spinal cord, and may form a mass much larger than the true malformation. This fact is of great practical value. These venous dilatations may produce a pressure syndrome at some distance from the malformation itself and myelograms may show, at this level, a picture of complete obstruction simulating that of a tumor.

Thus the malformation is really an arterio-venous shunt. In order to understand its importance, it would be necessary to study the blood flow in the malformation, just as has already been done in the brain, with the aid of gas measurements or by cine-angiography. Such a study would be difficult to accomplish since rates for normal blood flow in the spinal cord have not yet been established. Moreover arteriography of the spinal cord is not yet a simple, routine examination. However, we may say regarding cervical aneurysms injected by vertebral angiography, that their opacification appears more rapidly than the opacification of the vertebral system usually studied.

2. *The Size of the Malformation*. This is probably better defined by angiography than by anatomical examination. We have seen that drainage veins may extend some distance from the malformation and that they may at this point be mistaken for the main anomaly. The angiograms differentiates between the venous pedicles and the malformation itself, the size of which varies from a