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Intraarterial Digital Subtraction Spinal Angiography

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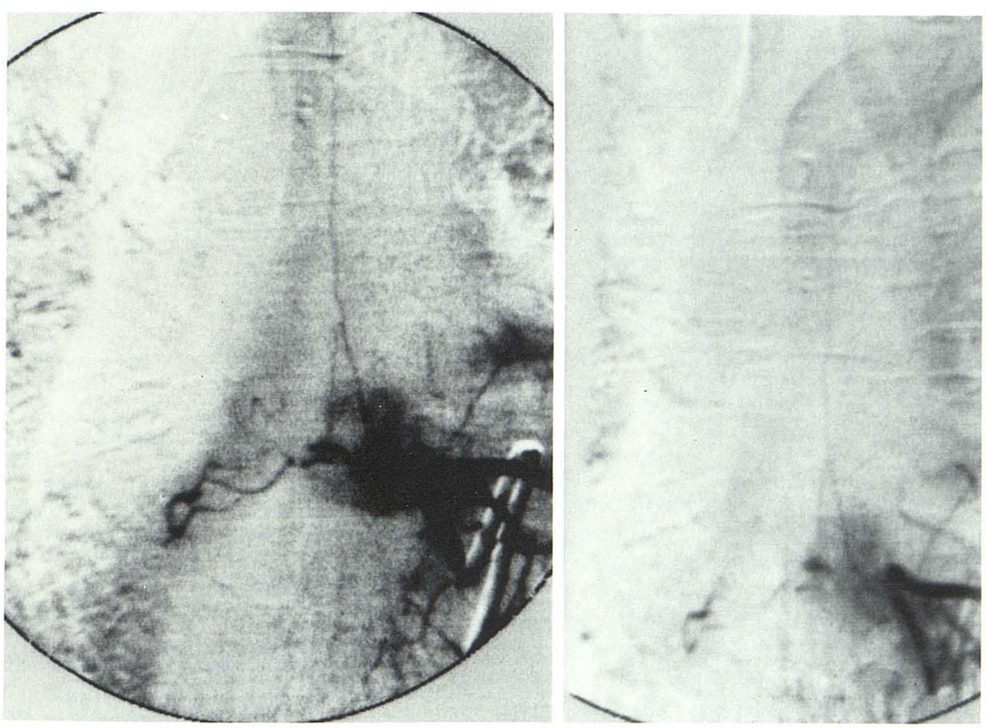
Intravenous digital subtraction angiography (DSA) is already a well accepted procedure for studying a wide spectrum of vascular structures. As with other initially "noninvasive" tests, radiologists soon find a way to make them more invasive [1]. Intraarterial DSA is a logical extension of this new technology and can be particularly useful for procedures, such as spinal arteriography, which are arduous for both the physician and patient. This application of DSA greatly facilitates the speed and efficiency of an otherwise long and cumbersome search for a spinal arteriovenous malformation (AVM).

Materials and Methods

The study was performed in an angiographic suite equipped with an LU/A arm (General Electric) with both digital fluoroscopy and cut-film capability (Puck film changer 14 × 14 inch [35.6 × 35.6 cm]). The digital fluoroscopy system (General Electric DF3000) was integral to the angiographic equipment.

The spinal arteriogram was obtained in the usual fashion using a Mikaelson catheter (6.7 French). After each individual intercostal and lumbar artery catheterization, imaging was done by digital fluoroscopy rather than by serial cut-films. This imaging process was extremely rapid in that centering was accomplished under fluoroscopy at the time of test injection with the actual imaging sequence following immediately thereafter. Because the catheter was connected directly to the power injector via a universal joint, the next vessel could be catheterized and the test injection/imaging sequence repeated until the injector syringe had to be refilled with contrast medium. The amount of "dead time" between vessel catheterization and imaging (filming) was dramatically reduced. The imaging sequence was programmable up to 10 frames/sec (pulsed x-ray mode), but the usual program consisted of one image/sec for 6 sec. Each individual imaging sequence consisted of a mask (the



A B

Fig. 1.—Intraarterial DSA of left T9 intercostal artery. **A**, 6 inch (15.2 cm) mode. Artery of Adamkiewicz with small descending branch and larger ascending branch. **B**, 9 inch (22.9 cm) mode shows entire extent of artery of Adamkiewicz, but there is poorer spatial resolution.

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image before the power injection) and subsequent subtracted images; these were immediately available for viewing, eliminating delays caused by film processing. In each individual vessel imaging sequence, the mask film and two subtracted images showing vessel opacification to best advantage were recorded on multiformat film as the study progressed in order to facilitate the "bookkeeping" process. The mask was necessary because the subtraction process was often so complete that anatomic landmarks were not visible on the subtracted images.

The field sizes available for digital fluoroscopy systems (9 inch [22.9 cm] mode being the largest in this system) could be a problem for imaging extensive AVMs (i.e., long draining veins). It was our intent to use the cut-film capability selectively at those sites where abnormal vessels were identified. Both anteroposterior and lateral cut-films were available and could be used to delineate the entire AVM once it was localized. Some slow-filling AVMs may require an extended interval of time, on the order of 20–50 sec, to fill completely. This can pose problems for a DSA examination because of its reliance on temporal subtraction. Motion and, therefore, degraded images will be inevitable over such a long time interval. Again, the capability of alternatively performing conventional film arteriography could prove important in circumventing this problem. Alternatively, reconstituting the original image, mask plus subtraction image, will eliminate the motion problem. Software for this image processing should be available. The 6 inch (15.2 cm) field of view was used as the standard field of view with the 9 inch (22.9 cm) and 4 inch (10.2 cm) modes reserved for either a larger field or magnification as dictated by the findings. The radiographic factors were: 85–90 kVp, 1,000 mA, and 15–70 msec exposure time.

Different imaging processing techniques were available on-line and used during the study. The remasking capability was often used to improve the quality of the subtracted image. This technique alone was sufficient to demonstrate all of the major feeders to the anterior spinal artery. Another reprocessing technique that integrates multiple images for both the "mask" and the "contrast" images was available; this integrated image technique reduced noise and further improved the diagnostic quality by demonstrating vessels of very small diameter to better advantage.

An important question regarding this application of DSA was whether the spatial resolution afforded by the system was sufficient for diagnosis. The 512 × 512 matrix in conjunction with 9, 6, and 4 inch (22.9, 15.2, and 10.2 cm) image intensifier field sizes was sufficient to identify the artery of Adamkiewicz and other, smaller arterial feeders of the anterior spinal artery (fig. 1). For most types of spinal AVM the arterial feeders would be expected to be enlarged. The large tortuous draining veins would be easily visualized by this system. Depiction of arterial anatomy can be enhanced by electronic magnification and also by video processing techniques, such as remasking and integration. The latter technique yielded low noise images with excellent anatomic detail. It is necessary to have these video processing techniques on-line.

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