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Intravenous Video Arteriography of the Intracranial Vasculature:
Early Experience

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A computerized fluoroscopic apparatus developed by members of the University of Wisconsin Medical Physics Section was used for 12 months to perform intravenous video arteriography. In previous papers, the apparatus was described and its use was illustrated for performing time subtraction intravenous video arteriography of the extracranial carotid arteries, the arteries of the abdomen and extremities, as well as angiocardiography. In this report, the use and current limitations of this technique for evaluation of the intracranial vasculature are described and illustrated.

Until recently, it has been impossible to achieve satisfactory visualization of the intracranial vasculature following intravenous administration of contrast medium [1–3]. New digital electronic techniques permit processing of the video signal from a conventional image-intensified fluoroscopic system for isolation of the small iodine signal produced after the intravenous injection of contrast medium. Logarithmic amplification combined with subtraction can increase the ratio of the iodine signal to the signal variation of normal anatomic structures by a factor of greater than 100. This type of image processing ensures uniform visualization of the iodine as it passes from the heart to the arteries of the neck and into the cranial vault. Our experience in demonstrating the intracranial arteries with this new method is described.

Materials and Methods

For examination of intracranial vascular structures, mask mode radiography is employed. An image is obtained before arrival of the contrast medium and is stored in one of two memories. As the iodinated contrast medium passes through the vasculature of the skull and brain, serial images are collected in a second memory, subtracted from the mask, and are then stored on a video disk and video tape. For examination of the intracranial vasculature, the exposure factors are 300 mA, 1/15 sec at 65–85 kVp. Images are generated at the rate of 1/sec. Further details of this imaging sequence have been reported previously [4–6].

Since our initial clinical reports [7, 8], our technique for intravenous injection of contrast medium has been modified. Previously, we injected 40–60 ml of contrast medium at the rate of 12–14 ml/sec through a 16-gauge, 5-cm-long Angiocath inserted into a basilic vein. While using this technique for over 300 intravenous video arteriograms, we encountered three instances of extravasation of the contrast medium at the injection site. To eliminate this potential complication and to obtain a more consistent contrast bolus, we now use a percutaneously introduced 5 French catheter with an end hole and four side holes, positioning the tip in the central innominate vein or superior vena cava.

For examination of the petrous, cavernous, and supraclinoid parts of the internal carotid artery, a projection which positions the top of the petrous bones in the center of the orbit seems to provide the best results. Such a projection is also satisfactory for visualization of the distal segments of the vertebral arteries and of the major part of the basilar artery. Because our resolution is currently limited by focal spot size (over 1.1 mm during the exposures), and a large magnification factor (greater than 1.5) caused by an under-the-

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table tube position, we have not made a systematic effort to design projections for visualization of arteries above the circle of Willis. Nonetheless, image quality is sufficient to allow, in many instances, evaluation of the proximal parts of the middle and anterior cerebral arteries. These arteries are well seen in the projection described for examination of the intracranial segments of the internal carotid artery.

Results

Because development and improvement of our computerized fluoroscopic apparatus is still ongoing, we have not felt it appropriate to carry out a study to compare intravenous video arteriograms with standard techniques. At this time, definitive study of the intracranial vasculature usually requires conventional intraarterial catheter techniques. Nonetheless, in some circumstances, the image quality with intravenous video arteriography is sufficient to allow decisions regarding diagnosis and management.

Representative Case Reports

Case 1

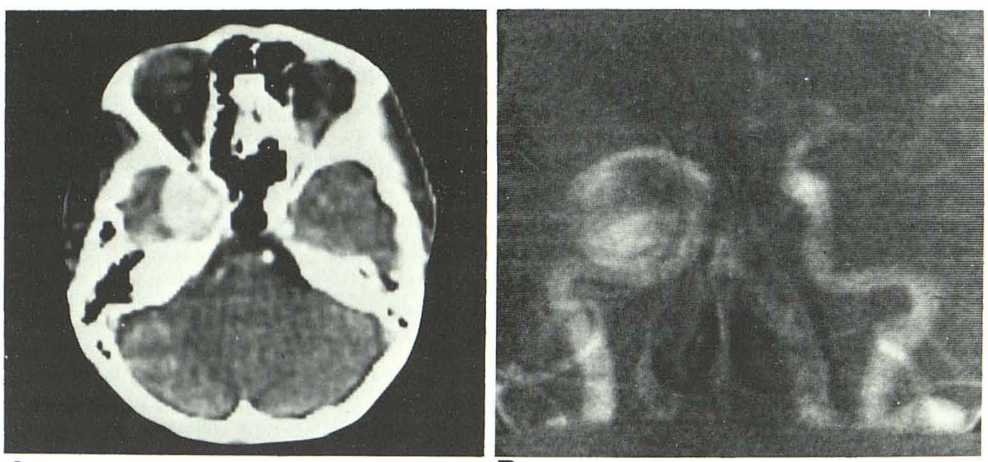
An 82-year-old woman had a right cavernous sinus syndrome. While computed tomography (CT) (fig. 1A) suggested a giant carotid artery aneurysm, the diagnosis could not be made with certainty. An intravenous video angiogram (fig. 1B) clearly shows a giant aneurysm of the cavernous segment of the right internal carotid artery. The intravenous examination obviated conventional arteriography.

Case 2

This patient had a giant aneurysm of the cavernous segment of the right internal carotid artery. Carotid and vertebral arteriography 5 years before had shown this lesion and several other aneurysms (fig. 2A). Surgery was not performed. Because of an increase in right extraocular muscle dysfunction, it was considered prudent to determine whether the giant carotid aneurysm had undergone significant change in size or configuration. The intravenous video arteriogram (fig. 2B) was of sufficient quality to allow this determination, thus sparing the patient conventional arteriography.

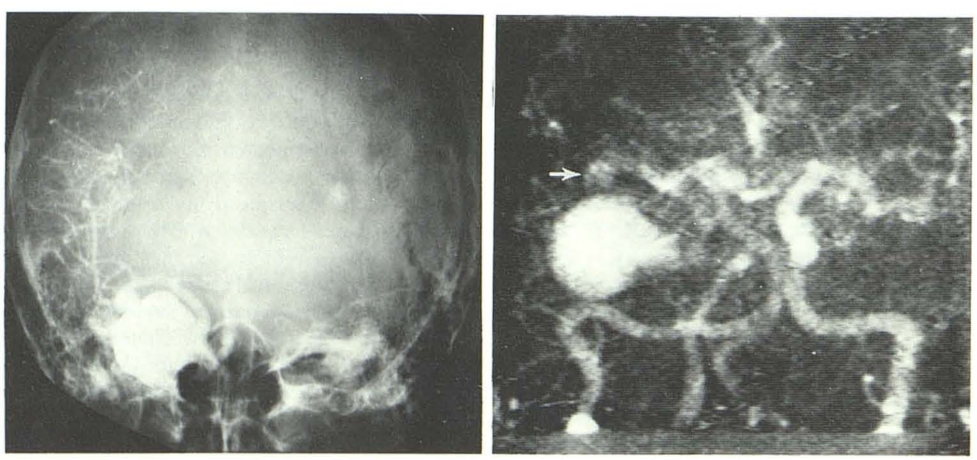
Case 3

In this patient, CT (fig. 3A) was interpreted as being consistent with an aneurysm of the right middle cerebral artery. An intravenous video arteriogram (fig. 3B) confirmed this diagnosis. Because other medical considerations precluded surgery, conventional arteriography was not performed.



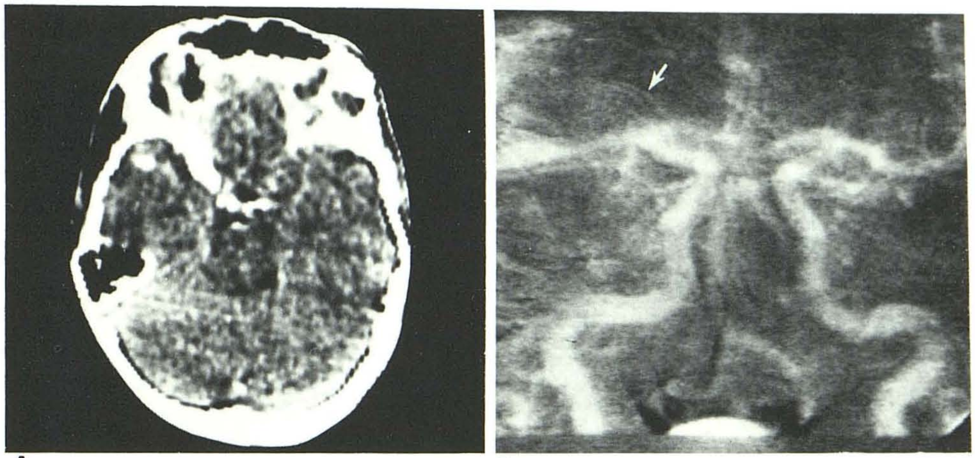
A B

Fig. 1.—Case 1. **A**, CT scan after administration of intravenous contrast. Enhancing mass lesion in right middle cranial fossa. Differential diagnosis was giant carotid aneurysm versus sphenoid wing meningioma. **B**, Intravenous video arteriogram with 40 ml Renografin-60 (11.6 g I). Giant carotid aneurysm clearly demonstrated as contrast swirled in aneurysm pouch. Normal cavernous and petrous segments of left internal carotid artery well seen.



A B

Fig. 2.—Case 2. **A**, Selective right internal carotid arteriogram. Giant aneurysm of right internal carotid artery and right middle cerebral artery aneurysm. **B**, Intravenous video arteriogram with 40 ml Renografin-60 (11.6 g I). Giant aneurysm of cavernous segment of right internal carotid artery. Also, aneurysm of right middle cerebral trifurcation (*arrow*). Overlap of vasculature at base of brain obscures vascular details of circle of Willis.



A B

Fig. 3.—Case 3. **A**, CT scan. Area of abnormal enhancement along course of right middle cerebral artery was seen on two adjacent sections. Presumptive diagnosis was middle cerebral artery aneurysm. **B**, Intravenous video arteriogram with 40 ml Renografin-60 (11.6 g I) confirms aneurysm of right middle cerebral artery. Lenticulostriate arteries visualized on right (*arrow*).

Case 4

Intravenous video arteriography (fig. 4) in a candidate for transphenoidal hypophysectomy provided information of sufficient quality to obviate conventional arteriography. The internal carotid arteries are well visualized and the cavernous segments are clearly seen not to extend into the operative field.

Case 5

Arch arteriography (figs. 5A and 5B) and an intravenous video examination (fig. 5C) of a patient with severe extracranial occlusive disease showed right internal and external carotid arteries fill in a retrograde manner. With conventional techniques, it could not be determined at which level the internal carotid artery was reconstituting. The intravenous video examination clearly showed that the intracranial part of the right internal carotid artery was patent and grossly normal. This information showed that a surgical procedure aimed at revascularization of the right cerebral hemisphere was feasible.

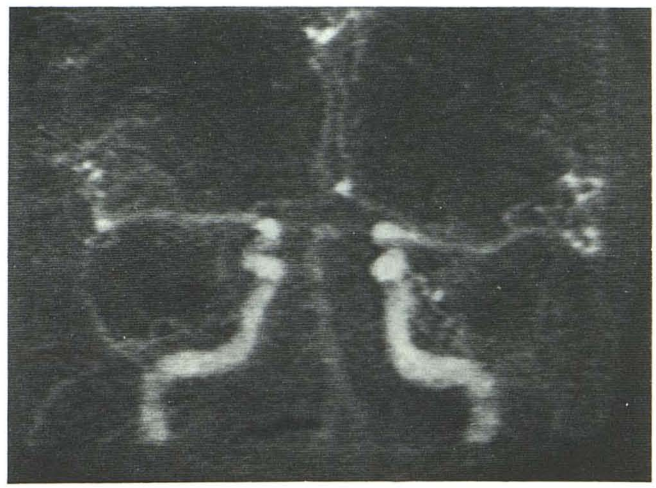


Fig. 4.—Case 4. Intravenous video arteriogram with 40 ml Renografin-60 (11.6 g I). Petrous and cavernous segments of internal carotid arteries in normal position and do not intrude into sphenoid sinus. Good visualization of proximal anterior and middle cerebral arteries.

Discussion

Until recently, the images of intracranial arteries and veins after intravenous administration of vascular contrast medium had been of such poor quality that little clinically useful information was obtained. To our knowledge, this is the first report of clinically useful quality images of the intracranial vasculature obtained with intravenous contrast medium.

Our current method of contrast administration has made it possible to reduce the injection rate to 10–12 ml/sec and the volume to 30–40 ml. It is feasible to obtain, when necessary, three or four projections. An added benefit of this injection technique is a more uniform contrast level from patient to patient than can be achieved with a peripheral venous injection. Since adopting this method, we have not had an examination that was unsatisfactory because of insufficient intravascular contrast. The two most common reasons for unsatisfactory image quality of intravenous video arteriography of the arteries at the base of the brain have been overlying vascular structures and patient motion.

We believe that the problem of vascular superimposition will, to a significant degree, be reduced by mounting the fluoroscopic apparatus on a U-arm suspension system. This will make it possible to obtain projections designed to eliminate vascular superimposition while at the same time maintaining the patient's head in a comfortable position to minimize motion. For example, it seems likely that a true base projection of arteries at the base of the brain would eliminate the problem of superimposition. This projection would allow visualization of both internal carotid arteries, the vertebral basilar system, and the circle of Willis as well as the dural venous sinuses. All of this would be achieved with the injection of a single bolus of contrast medium.

Others have suggested stereoscopy to avoid the problem of vascular superimposition due to simultaneous opacification of all intracranial vessels [9]. In our opinion, the major disadvantage of such an approach is the inherent cost of such a device. Interfacing our apparatus with a U-arm suspension system will also reduce the magnification factor now caused by the under-the-table position of the x-ray tube. The use of a small (0.3 mm) focal spot tube will further improve image quality.

In our experience, patient motion remains the most common cause of unsuccessful intravenous video arteriography.

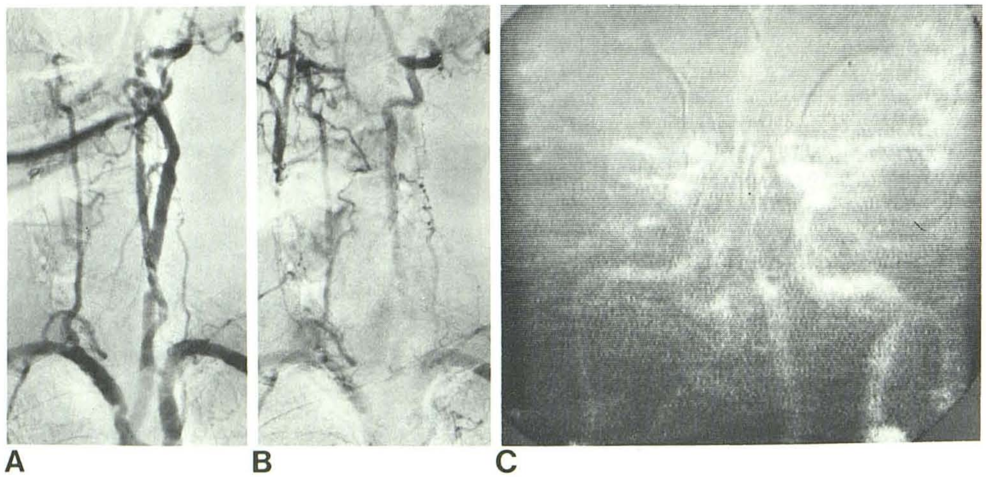


Fig. 5.—Case 5. **A**, Early arterial film from aortic arch arteriogram. Anomalous right subclavian artery with stenosis midway between its origin and origin of right vertebral artery. Right common carotid artery occluded at its origin from aortic arch. **B**, Late arterial film from aortic arch injection. Retrograde filling of right internal and external carotid artery to level of carotid bifurcation. Level of reconstitution of these vessels cannot be ascertained. **C**, Intravenous video arteriogram with 40 ml Renografin-60 (11.6 g I). Motion artifact and poor contrast level caused this image to be suboptimal. However, it is clearly seen that right internal carotid artery is patent in its petrous and cavernous segments, allowing consideration of revascularization of right cerebral hemisphere.

Fig. 6.—**A**, Mask image for intravenous video arteriogram. **B**, Arterial phase of intravenous video arteriogram with 40 ml Renografin-60 (11.6 g I). Examination is nondiagnostic because of misregistration between mask image and image taken at time of maximum arterial opacification. Bony detail present on this film. **C**, Intravenous video arteriogram on same patient after reprocessing of image was obtained by selecting alternate mask image. Bony features on **B** have disappeared because of improved registration between mask image and image at time of maximum arterial opacification.

If the examination is to be satisfactory, the patient must remain still. Swallowing, which occurs on an involuntary basis after intravenous administration of large volumes of ionic contrast medium, does not interfere with examination of the intracranial arteries and veins. However, the sensation of heat and discomfort accompanying the intravenous injection of currently available contrast media in many patients results in slight voluntary movement of the entire body. This causes slight subtraction misregistration and degradation of image quality. However, with our system, it is often possible to minimize the effect of such motion through reprocessing. This is done by selecting an alternate subtraction mask. Figure 6 is an example. We are initiating a clinical study to test our impression that the use of a nonionic contrast medium will reduce patient discomfort and thereby reduce motion artifacts.

For examination of the intracranial vasculature, intravenous video arteriography offers in some circumstances a satisfactory alternative to conventional arteriography. Intravenous examinations can be readily performed on an outpatient basis and if desirable can be repeated at selected intervals. The equipment needed is relatively inexpensive. The major risks associated with the examination are those related to intravenous iodinated contrast medium. We expect that further refinements in the instrumentation and anticipated development of new contrast media will increase its utility for the study of intracranial abnormalities.

REFERENCES

1. Bannister RG, Murray-Leslie RM. Venoangiography in the study of cerebrovascular disease. *Brain* **1963**;86:161–172
2. Scatliff I, Evans JA. Radiographic evaluation of major arteries of the neck by intravenous aortography. *Acta Radiol* (Stockh) **1963**;1:404–416
3. Steinberg I, Evans JA. Technique of intravenous carotid and vertebral arteriography. *AJR* **1961**;86:1138–1145
4. Kruger RA, Mistretta CA, Houk TL, Riederer SJ, Shaw CG. Computerized fluoroscopy in real time for noninvasive visualization of the cardiovascular system. Preliminary studies. *Radiology* **1979**;130:49–57
5. Kruger RA, Mistretta CA, Lancaster J, et al. A digital video image processor for real time x-ray subtraction imaging. *Opt Eng* **1978**;17:652–657
6. Ergun DL, Mistretta CA, Kruger RA, Riederer SJ, Shaw CG, Carbone D. A hybrid computerized fluoroscopy technique for noninvasive cardiovascular imaging. *Radiology* **1979**;132: 739–742
7. Strother CM, Sackett JF, Crummy AB, et al. Clinical applications of computerized fluoroscopy. The extracranial carotid arteries. *Radiology* **1980**;136:781–783
8. Crummy AB, Strother CM, Sackett JF, *et al.* Computerized fluoroscopy: digital subtraction technique for intravenous angiocardiography and arteriography. *AJR* **1980**;135:1131–1140
9. Christenson P, Ovitt T, Fischer HD, et al. Intravenous angiography using digital video subtraction: intravenous cervicocerebrovascular angiography. *AJNR* **1980**;1:379–386