

THE DIAGNOSTIC VALUE OF CAROTID ARTERIOGRAPHY

A Preliminary Report

J. CORNALL HOWARTH, M.B., Ch.B. and JOSEPH G. KLOTZ, M.D.

Department of Neurosurgery

CEREBRAL angiography is now almost universally recognized as a valuable addition to the diagnostic armamentarium of the neurologic surgeon. A clearly defined picture of the vessels of the brain, whether normal or abnormal, is most useful in helping the surgeon decide in favor of or against an intracranial operation. This is especially true in cases of vascular malformations, aneurysms, thromboses of the venous sinuses, and other lesions which do not cause displacement or distortion of the ventricular system.

The feasibility of injecting a radio-opaque medium into the arteries supplying the brain and its coverings, with a view to outlining the intracranial vessels by x-rays, was demonstrated by Egas Moniz,¹ a Portuguese neurosurgeon, in 1927. Since his original description, the methods and materials utilized have varied considerably. All modifications have been made with the intention of obtaining clearer and more diagnostic pictures, with a minimum of risk to the patient.

Many elaborate technics have been developed in order to obtain certain specific views of the cerebral circulation; these have recently included the use of the x-ray motion picture camera. However, it is unnecessary to use complicated equipment in taking cerebral angiograms. Usually only single posteroanterior and lateral views are required to establish the presence or absence of the suspected lesion. Variations in the timing of the exposures may be helpful, as the arterial, capillary and venous phases of the circulation may be photographed at will.

Injection of one vertebral artery will outline the vessels in the posterior fossa bilaterally if the circulation is normal, including also the posterior communicating arteries in some patients. Injection of the internal carotid artery in the neck causes filling of the anterior and middle cerebral circulations on the same side, often showing the posterior communicating and posterior cerebral groups as well. Variations in the over-all picture may occur; i. e., both anterior cerebral arteries may fill from a single injection. Both the internal carotid and vertebral arteries may be approached and injected by either open operation or a percutaneous route.

Moniz, in his original description of carotid arteriography, described the open technic in which the internal carotid artery was exposed in the neck by operation, and radio-opaque material was injected under direct vision. He used two media for injection, 30 per cent strontium bromide and 25 per cent

sodium iodide,¹ in volumes varying from 6 to 15 cc. Common complications of these injections, carried out under local anesthesia, were the initiation of convulsions, and frequent delayed reactions to the bromide or iodide. Davies² subsequently observed that sodium iodide was a dangerous substance to inject into atheromatous vessels.

In 1933, Moniz^{3,4} described the use of thorium dioxide (thorotrast) in volumes of 10 to 16 cc. as a more suitable medium for injection. The larger quantity was injected when it was desired to outline the venous phase of the circulation. Many workers^{5,6,7} have used thorotrast since the original report, and there are various descriptions of its toxic effects. Because of the slight degree of radioactivity exhibited by the salt, the danger of damage to the reticulo-endothelial system must be considered, a point stressed by Davis² in 1937. At the same time he indicated that the volume injected in cerebral angiography is considerably less than the 60 to 70 cc. used to outline the spleen radiographically. In 1942 King⁸ reported enthusiastically on the use of thorotrast, and detected no permanent toxic side effects when the total volume injected was maintained below 25 cc. Linden⁷ described the use of thorotrast arteriography in diagnosing three intracranial aneurysms in 1936, and List and Hodges⁹ referred to it in the diagnosis of intracranial expanding lesions.

Thorotrast is not the ideal contrast medium to use in cerebral arteriography; its ill effects have been described as ranging from transient rashes through temporary hemiplegia and convulsions, to liver damage and possible sarcogenesis. This latter complication was discussed by Ingraham and Cobb¹⁰ in 1947.

Although thorotrast is still used, diodrast, an organic iodine compound introduced into the literature by Shimidzu¹¹ in 1937, appears to be a safer medium. Shimidzu probably was the first to use the closed or percutaneous technic for approaching the internal carotid artery. He had utilized the method since 1932, having injected such media as thorotrast, uroselectan β and parabrodil.

Apparently the first direct recommendation for the use of diodrast was made in 1939 by Gross,¹² who used the open technic for injecting the dye into dogs and humans. He observed a transient cutaneous flush, sweating, and an elevation of the systolic blood pressure following each injection.

The use of radio-opaque substances other than thorotrast and diodrast has been generally discontinued. While the radio-opacity of diodrast in the usual 35 per cent concentration is significantly less than that of thorotrast, this disadvantage is counteracted by the decreased danger of toxic side reactions.

Anesthesia is an important factor in the making of good arteriograms. The sudden injection of a radio-opaque dye into the internal carotid artery, under local anesthesia, causes the patient to experience a sudden surge of pain in the corresponding side of the head. This has been described by one of our patients who underwent the examination elsewhere, as "like the flame of a blowtorch." Such severe discomfort may cause movement, thereby ruining an x-ray picture. Even under light pentothal anesthesia a patient will react by generalized muscular spasm after each injection, and move his head if not

restrained. General anesthesia is preferred as it is more comfortable for the patient and more conducive to satisfactory radiography.

More than 700 arteriograms have been made at the Cleveland Clinic since June 25, 1946, the vast majority by the percutaneous method, under sodium pentothal anesthesia using diodrast as the contrast medium. Both the internal carotid and the vertebral arteries have been injected and, since the first few cases, the closed route has been used exclusively. Thirty-five per cent diodrast is utilized as the routine dye, 10 cc. for the lateral pictures and 10 to 12 cc. for the posteroanterior view. Injection is made as rapidly as possible through an 18 gage needle from a 10 cc. syringe. The artery is entered with the patient under light pentothal anesthesia, and 30 to 60 seconds before the injection an additional quantity of 2 or 3 cc. of pentothal is administered to prevent movement during exposure of the film. The posteroanterior view is preferable to the anteroposterior, because of the increased clarity of visualization of the anterior portion of the anterior cerebral artery.

This report concerns 145 patients who underwent internal carotid arteriography. All cases were investigated in the early days of arteriography at the Cleveland Clinic, and include the majority subjected to the open operation. They represent a small unselected portion of the entire series of patients, on whom a further report will be made at a later date.

Complications in this small group have been minimal. No instances of postoperative convulsions, iodine sensitivity or other serious conditions have been recorded. In the early days occasional anxiety developed concerning the size of some of the hematomata which formed after withdrawal of the needle. However, evacuation of clots has never been necessary to relieve obstruction to the patients' airway, and hematoma formation can always be minimized by prolonged digital pressure over the site of puncture. Diodrast, if injected into the tissues of the neck outside the vessels, is rapidly absorbed and apparently causes no permanent sequelae. The postoperative morbidity has also been minimal, and patients demonstrating negative arteriograms usually are allowed to go home on the day following the procedure.

We believe that the absence of serious complications in our patients has been largely due to the use of sodium pentothal as the anesthetic agent.

Although we are relying more and more on arteriography in the diagnosis of intracranial lesions, we do not hesitate to follow the procedure by air studies if the arteriograms are not completely conclusive. We feel, however, that a positive arteriogram frequently gives a more accurate localization than do the air contrast pictures. Also whenever possible, we prefer to avoid the more traumatic procedures of encephalography or ventriculography.

Table 1

Cases reviewed	145
Open arteriograms	23
Age oldest patient	71
Age youngest patient	6 months

Table 2

(A) Diagnostic of site of lesion	68
(B) Diagnostic of type of lesion, i.e., tumor, aneurysm, etc.	62
(C) Confirmatory of no lesion deforming the blood vessels, i.e., tic douloureux, idiopathic convulsions, cerebral atrophy, etc.	37
(D) Total arteriograms confirming preoperative diagnosis (A) and (C)	105

Of the 68 arteriograms showing definite intracranial lesions, 62 also accurately localized the position. The 37 represented in table 2 (C) are considered as positive results because they confirmed a clinical impression of no space-occupying lesions.

Twenty-eight of the 68 positively identified lesions caused deformities or displacements of the ventricular system and could have been diagnosed conceivably by air contrast studies. This left a total of 40 lesions, 27.6 per cent of the entire series, which could not have been definitely diagnosed preoperatively.

A detailed breakdown of these 40 cases follow:

Type: (a) aneurysms	24
(b) arteriovenous malformations	11
(c) hemangioma	1
(d) internal carotid occlusions	1
(e) absence or occlusion of right anterior cerebral artery	1
(f) other vascular anomalies	2
Total	40

One case with a negative carotid arteriogram was found at surgery to have an arteriovenous malformation at the cerebellopontine angle.

Summary

1. Internal carotid arteriography using 35 per cent diodrast, under sodium pentothal anesthesia, is a safe procedure with minimal complications.

2. In the present series of 145 cases, internal carotid arteriography increased the percentage of positive preoperative diagnoses by 27.6 per cent over that obtained by other diagnostic measures alone.

References

1. Egas Moniz: Arterial encephalography, its importance in localization of cerebral tumors. *Rev. neurol.* 2:72 (July) 1927.
2. Davies, H.: Cerebral arteriography. *Brit. J. Radiol.* 10:871 (Dec.) 1937.

3. Egas Moniz: Cerebral angiography with thorotrast. *Arch. Neurol. and Psychiat.* **29**:1318 (June) 1933.
4. Egas Moniz: Cerebral angiography. *Lancet* **2**:1144 (Nov. 18) 1933.
5. Hodes, P. J., Perryman, C. R. and Chamberlain, R. H.: Cerebral angiography. *Am. J. Roentgenol.* **58**:543 (Nov.) 1947.
6. Loman, J. and Myerson, A.: Visualization of cerebral vessels by direct intracarotid injection of thorium dioxide. *Am. J. Roentgenol.* **35**:188 (Feb.) 1936.
7. Linden, L. C. E.: Cerebral arteriography. *M. J. Australia* **1**:849, 1936.
8. King, A. B.: Demonstration of basilar artery and its branches with thorotrast. *Bull. Johns Hopkins Hosp.* **70**:81 (Jan.) 1942.
9. List, C. F. and Hodges, F. J.: Angiographic diagnosis of expanding intracranial lesions by vascular displacement. *Radiology* **47**:319 (Oct.) 1946.
10. Ingraham, F. D. and Cobb, C. A., Jr.: Cerebral angiography: Technique using dilute diodrast. *J. Neurosurg.* **4**:422 (Sept.) 1947.
11. Shimidzu, K.: Beitrage zur Arteriographie des Gehirns—einfache percutane Methode. *Arch. f. klin. Chir.* **188**:295, 1937.
12. Gross, S. W.: Cerebral arteriography in dog and in man with a rapidly excreted organic iodide. *Proc. Soc. Exper. Biol. and Med.* **42**:258 (Oct.) 1939.