VALUE OF CEREBRAL ANGIOGRAPHY

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Introduction

CEREBRAL ANGIOGRAPHY was first described by Egas Moniz in 1927, when ventriculography was the method of choice in the localisation of brain tumours. His development of this new technique was probably motivated by the introduction of cholecystography at that time by Graham who successfully opacified the biliary system on intravenous injection of tetra-iodophenolphthalein, and noted few untoward side effects to the patient. Moniz realised that the first step was to look for an ideal contrast medium that would permit good opacification of the cerebral vasculature, with few side effects. After having experimented with various substances, he finally decided on 25% freshly prepared Na I, which appeared to satisfy his criteria to some extent. By 1931, he had performed over 300 examintations, but his technique of open dissection was not widely accepted and was generally regarded as rather dangerous and experimental. Loman and Myerson in 1936 introduced the percutaneous technique but it was not seriously considered nor practised and, as recently as 1945, some workers in the United States still dismissed it as "not a formidable procedure, but one that requires skill." However, Scandinavian workers helped by the use of Diodone, which had few side effects, persisted with this percutaneous method and by 1944, it had gained general acceptance. In England, Bull (1949) performed some 500 percutaneous carotid angiograms and although three deaths occurred in his series, there was no certain proof that any of them was directly due to the procedure. Engeset and his co-worker (1960), in reviewing 1,000 cerebral angiograms, found no complications attributable to the contrast medium or the arterial puncture. By this time, new and improved contrast media, the diatrizoate compounds, had been developed. To-day, cerebral angiography is widely accepted as a safe and invaluable diagnostic procedure.

Technique

The procedure is performed under local anaesthesia on the sedated patient. In children under 16 years of age, and in apprehensive and unco-operative subjects, a general anaesthetic may be necessary.

With the patient supine and his head slightly extended on an A.O.T. changer, the common carotid artery is punctured as low down in the neck as possible, using an 18-G Cournand needle. Both walls of the artery are impaled and the needle is then withdrawn until its tip re-enters the arterial lumen, as evidenced by a vigorous flow of blood from the hub. The advantage of the Cournand needle lies in its having a blunt stylet which may be inserted after removal of the sharp stylet. It is then possible to advance the needle tip within the lumen of the artery without fear of perforating the posterior wall. A test injection of 4 — 5 mls. of 45% Hypaque shows the relationship of the tip of the needle to the arterial lumen and the presence or otherwise of an abnormality at the carotid bifurcation. If necessary, the tip of the needle in

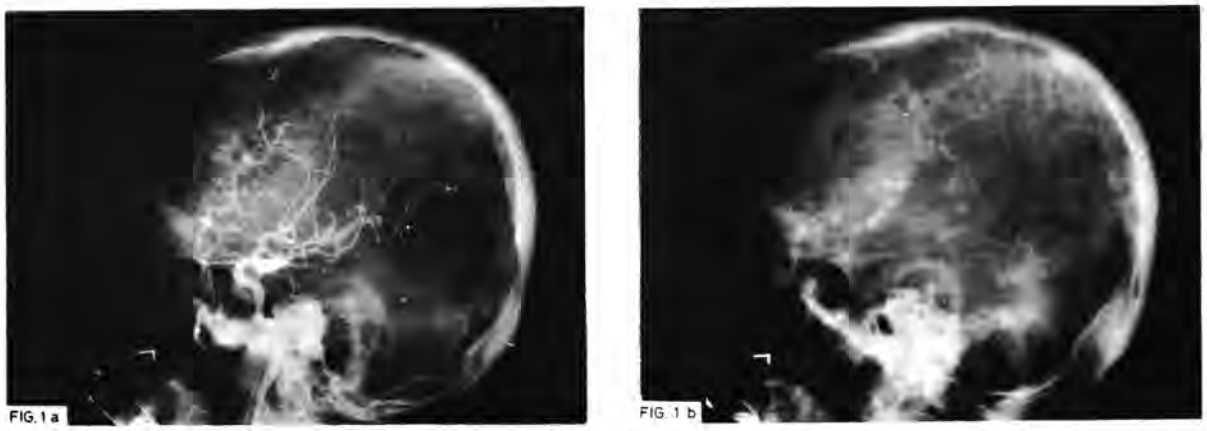

Figure 1. Left carotid angiogram showing frontal meningioma with (a) characteristic sunburst appearance in the arterial phase and (b) tumour blush in the venous phase.

relation to the arterial lumen can be altered. Filming is then carried out with an automatic serial changer. For routine purposes, five films are obtained covering a period of seven seconds which will include the arterial, capillary and venous phases. For the frontal and lateral projections, an injection of 10 mls. of Hypaque 45 given by hand is adequate to render good opacification of the cerebral vascular tree. Not more than three injections are given on one side except under special circumstances where oblique and per orbital views are required to display, for example, the exact locality of an aneurysm. An interval of 10 minutes is allowed to lapse between successive injections. This is done to reduce any adverse effects of the contrast on the brain. When the procedure is completed and the needle withdrawn, firm pressure should be applied to the puncture site for at least 10 minutes.

Complications

The diatrizoate compounds possess characteristics that match the ideal contrast medium in many respects. Used in small quantities and low concentrations, their toxicity is very low. Their relatively high viscosity gives good visualisation of very small vessels. Although with these modern contrast media and other refinements in technique complications are uncommon, they do occasionally occur. These manifest commonly as an aggravation of neurological signs, usually transient and not severe. Evaluation of deterioration of the neurological state of the patient is often made difficult by the concommittant effects of general anaesthesia and sedation. The common local complications include subintimal and peri-arterial injections of contrast material. Haematoma formation at the site of puncture occurs quite frequently and it is important to recognize it before it becomes large enough to compress the trachea. Recently, Ansell (1968) reported complications in 9.6% of patients requiring more than four attempts at puncture, with subintimal and peri-arterial injections accounting for 7.1%. Bull (1960) noted a 10% incidence of complications in 80 cases of clinically recognised strokes submitted to carotid angiography. It is obvious, therefore, that apart from careful use of contrast material, skill is required of the operator in reducing complications to a minimum.

Indications

(1) Tumour Demonstration and Diagnosis

It is now generally accepted that carotid angiography is the method of choice in investigating space occupying lesions of the cerebral hemisphere. The pathology of some tumours can be identified with a fair degree of certainty by their vascular pattern and "staining" characteristics. Many meningiomas show a typical "sunburst" appearance in the arterial phase, with the contrast material lagging behind in the venous phase in the form of a uniform, homogenous, well-defined "blush". These features are well illustrated in the following patient.

Case (1)

T.A.J., a 40-year-old school teacher, complained of headache of 4 years' duration, progressively getting worse during the past 6 months. For the past one

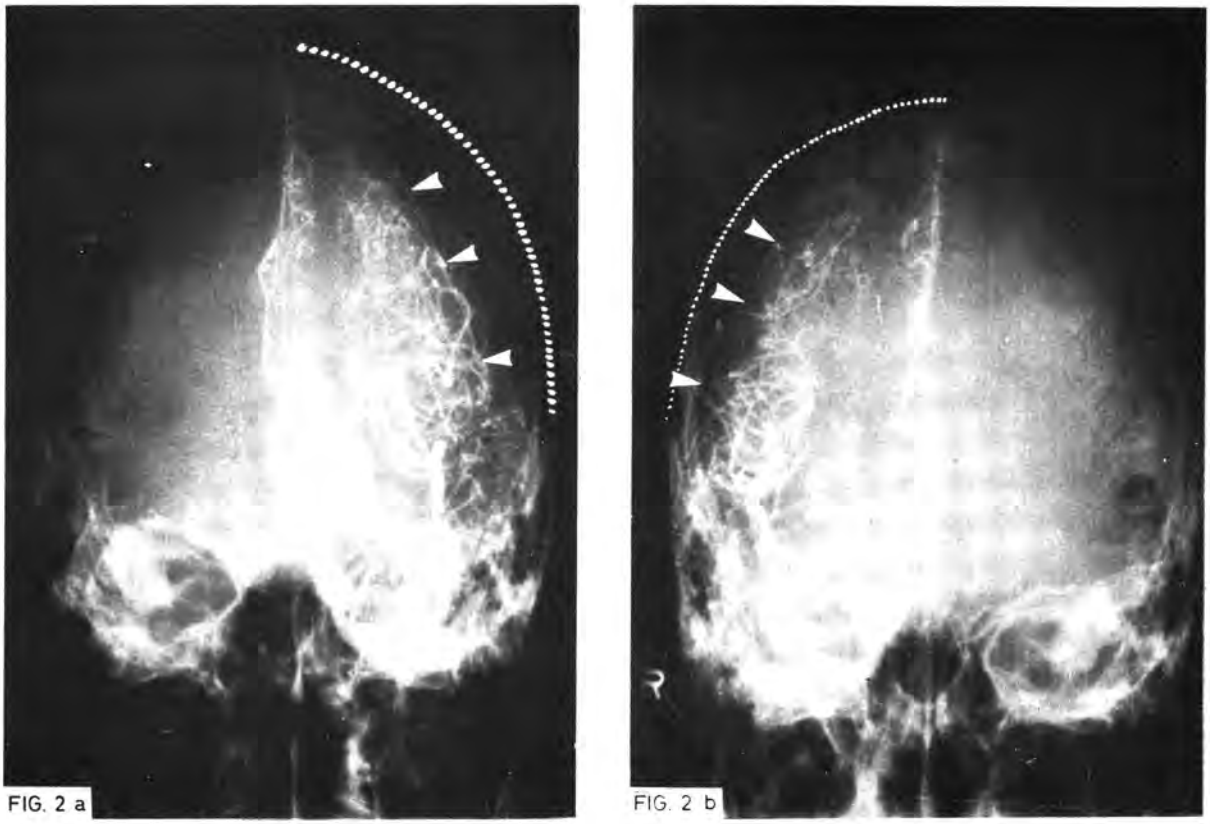

Figure 2. Bilateral carotid angiogram showing (a) left subdural and (b) right subdural collections (arrows).

year, he had also noticed loss of libido and progressive blindness. At the same time, he was noticed to be forgetful and often unintelligible. The clinical findings pointed to a left frontal lobe tumour. Plain skull radiographs showed thinning of the floor of the sella turcica consistent with prolonged raised intra-cranial pressure. A left carotid angiogram **(Fig. 1)** showed a huge tumour in the frontal lobe extending backwards to the supra-sellar region. The tumour was supplied by a hypertrophied, tortuous anterior branch of the middle meningeal artery and had the characteristic "sunburst" appearance of a meningioma. A typical tumour blush was noted in the venous phase. The patient was successfully operated on in another hospital, where the angiographic diagnosis was confirmed.

(II) Post Traumatic Sequelae

The typical avascular lenticular appearance of a subdural collection may be found in most standard radiological textbooks. In an elderly patient with a history of head injury, it may be impossible clinically to distinguish between subdural haematoma and a cerebro-vascular accident due to cerebral arteriosclerosis. Angiography enables the correct diagnosis to be made. Where a shift of the mid-line structures does not correspond to the size of the subdural collection on one side, the opposite side must be investigated.

Case (2)

O.S., aged 68, was a chronic depressive undergoing treatment in a psychiatric ward. On 14.4.69, he fell while in the toilet and lost consciousness for half an hour. Physical examination showed exaggerated reflexes, and plantar response was extensor on the left side. A bilateral carotid angiogram showed a suggestion of a thin subdural collection over the left convexity. No other abnormality was seen. The patient apparently recovered the next day and was discharged, later to be followed up. On 9.7.69, he was brought back to the hospital in a comatose state. Bi-


FIG. 3 a


FIG. 3 b

Figure 3. (a) and (b) Left carotid angiogram showing aneurysm at origin of posterior communicating artery.

lateral carotid angiogram showed a huge lenticular avascular area on the left side **(Fig. 2)** and a similar lesion of smaller size on the right. Surgery confirmed the diagnosis of bilateral chronic subdural haematoma.

(III) Subarachnoid Haemorrhage

The excellent paper by Bull (1962) and the figures reported by Sutton (1962) leave little doubt as to the role of cerebral angiography in the investigation of subarachnoid haemorrhage. In Sutton's series, a lesion was demonstrable in 75% of cases by bilateral carotid angiography and the percentage of positive findings rose to 96% when bilateral vertebral angiograms were done as well. The proportion of arteriovenuous malformations in relation to cerebral aneurysms increased when the posterior fossa was thus investigated.

Case (3)

L.D.K., a 58-year-old female patient, was admitted on 9.8.69 with a history of loss of consciousness for 5 hours. There was marked neck rigidity and right-sided weakness; plantar responses were extensor. A lumbar puncture showed blood-stained C.S.F. and the diagnosis of subarachnoid haemorrhage was made. Her condition remained unchanged for 4 days and on 13.8.69 a bilateral carotid angiogram was done **(Fig. 3).** This showed an aneurysm, measuring 1.2 cm. in diameter, at the origin of the posterior communicating artery on the left side. No vascular spasm nor evidence of a haematoma was seen. On the right side, two smaller berry aneurysms were noted, one arising from the trifurcation of the middle cerebral artery and the other from the bifurcation of the internal carotid artery.

Intracranial and Extracranial Occlusive Vascular Lesions

The segmental nature and multiplicity of these occlusive or stenotic lesions causing cerebral vascular insufficiency have been well established in the past three decades. Following on the work of Hutchinson and Yates (1957) who pointed out the frequency of involvement of the vertebro-basilar system by atherosclerosis, it is now accepted that these vessels should be investigated in patients presenting with manifestations of carotico-basilar insufficiency. The current accepted practice is to study the origins and course of the head vessels by arch aortography and to supplement this examination by carotid angiography where necessary. Recent advances in corrective vascular surgery and the limited success of anti-coagulant therapy have made it almost mandatory to investigate the carotid systems, particularly in young patients presenting with the stroke syndrome.

FIG 3 c

FIG. 3 d

FIG. 3 e

(c), (d) and (e) Right carotid angiogram showing two berry aneurysms, one at trifurcation of middle cerebral artery and the other at bifurcation of internal carotid artery (arrows).

Case (4)

I.K., a 49-year-old truck driver, had been well except for mild hypertension for the past 2 years. For the past 3 months, he had noticed right-sided weakness, blurring of vision, and difficulty in speaking. Examination showed a blood pressure of 160/110. There was nominal aphasia. He also had right hemiparesis and homonymous hemianopia. The clinical impression was thrombosis of the middle cerebral artery, although an internal carotid artery occlusion had to be excluded. A left carotid angiogram was performed. A preliminary film of the neck following injection of 4 ccs. of 45% Hypaque ruled out a stenosis or occlusion at the common carotid bifurcation. The cerebral angiogram showed an occlusion of the main trunk of the middle cerebral artery, with nonfilling of its distal branches in the arterial phase **(Fig. 4a)**. There was retrograde filling of the distal middle cerebral arteries from branches of the anterior cerebral at 4.5 seconds **(Fig. 4b)**. The diagnosis of middle cerebral artery thrombosis, with satisfactory collateral filling, was made.

FIG. 4 a

FIG 4 b

Figure 4. Left carotid angiogram. (a) Early arterial phase showing occlusion of main trunk of middle cerebral artery with non-filling of its distal branches. (b) Late arterial phase showing retrograde filling from branches of the anterior cerebral artery.

FIG. 5 a

Figure 5. (a) and (b) Late arterial phase of left carotid angiogram showing angiomatous malformation in the fronto-parietal and parieto-temporal region. Arrows indicate prematurely opacified hypertrophied draining veins.

FIG. 5 b

Angiomatous Malformations

These lesions are congenital in origin, although they usually present during adult life. The clinical presentation depends on the site of the lesion. Usually located superficially, these anomalies can shunt blood away from neighbouring areas resulting in underlying cerebral ischaemia and later atrophy. When situated over the motor cortex, the first manifestation may be that of Jacksonian epilepsy. Danger of rupture into the subarachnoid space or the brain substance makes it a neuro-surgical problem once discovered. Angiomatous malformations, once reported

as rare, are not that uncommon nowadays, with increasing use of cerebral angiography. They account for up to 15% of all cases of subarachnoid haemorrhage (Du Boulay 1967).

Case (5)

S.P.Y., a 37-year-old clerk, presented with Jacksonian epilepsy of 5 years' duration, associated with progressive weakness and hemi-anaesthesia of the right half of the body for the same period. Examination showed increased tone and reflexes of the right upper and lower limbs. The clinical impression was a focal lesion in the left parietal region. A left carotid angiogram showed a large angiomatous malformation in the left fronto-parietal and parieto-temporal region **(Fig. 5).** The vascular anomaly was supplied by branches of the anterior and middle cerebral arteries on the same side. The cerebral circulation was characteristically accelerated, with early venous filling. The presence of tortuous and enlarged draining veins is pathognomonic of this condition.

Discussion

Advances in technique and interpretation have made cerebral angiography a precise tool in the localisation and diagnosis of hemispheric lesions. Ventriculography is less frequently used on account of this but where a lesion is deeply situated near to the ventricular systems, air encephalography or ventriculography may still be necessary.

Where a tumour circulation is shown, its appearance is sometimes pathognomonic. This is illustrated in Case 1 where demonstration of a tortuous and hypertrophied middle meningeal artery and uniform, well-defined contrast staining up to 8 seconds put the issue beyond doubt. A diagnosis could have been made on plain films if attention had been directed to the prominent arterial impressions on the vault and an increase in density in the floor of the anterior and middle cranial fossae. In general, a little under 50% of meningiomas will show a tumour circulation and a meningeal arterial supply. This is particularly true of parasaggittal and high convexity tumours. Where a tumour circulation is absent, a hypertrophied meningeal artery has still to be looked for as its presence may be the only clue to the diagnosis (Banna and Appleby 1969).

Cerebral angiography has an important place in the management of subdural haematoma, particularly of the chronic varieties. Here, the angiographic findings are able to show the number, location and extent of these lesions as illustrated in Case 2.

Case 3 illustrates the difficulties the radiologist may encounter in deciding which aneurysm has bled. There was no associated vascular spasm or vessel displacement on either side to give even a suggestion, and localisation in this instance was made on purely clinical grounds.

The carotid angiogram in Case 4 was done in the hope of finding a surgically correctable lesion in the internal carotid artery. Instead, a thrombosis of the middle cerebral artery was found. Serial films up to 8 seconds had not shown any stasis of the contrast in the distal middle cerebral branches and the presence of a propagating thrombosis could be safely ruled out.

Case 5 demonstrates the typical radiological appearance of an angiomatous malformation, although operative confirmation was not available because the patient refused surgery. It must be pointed out that investigations on this patient would have been incomplete if surgery was contemplated. Multiple feeding-vessels to the lesion would have to be excluded and this would have at least required an ipsilateral vertebral angiogram with a contra lateral carotid study.

Summary

1. A technique of percutaneous carotid angiography is described.
2. The possible complications of the procedure are discussed.
3. Examples are presented to illustrate the main indications of cerebral angiography.

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