RADIOLOGICAL INVESTIGATION IN CASES OF CEREBROVASCULAR DISEASE*

BY

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It is only in the last decade that radiology has played a part in the investigation of cerebrovascular diseases. This has come about as a direct result of the development of percutaneous cerebral angiography. Paradoxically, before this time the diagnosis of the commoner cerebrovascular lesions was represented to the student as being fairly straightforward. Not many cases of "stroke" were seen in the wards of a teaching hospital, and only a minority of those admitted were examined at necropsy. Thus there was little opportunity of confirming or refuting diagnoses, and faith in the textbooks remained unshaken.

The tidy clinical pictures of cerebral haemorrhage, thrombosis, and embolism were most convincing; and the same might be said of subarachnoid haemorrhage.

Ten years' experience of cerebral angiography in the investigation of cases of this type has taught me how uncertain is clinical diagnosis. Until angiographic, operative, or necropsy evidence is available, the old-fashioned term of "stroke" probably cannot be bettered. Any more specific diagnosis is apt to be misleading. The *Oxford English Dictionary* defines a stroke as "an apoplectic or paralytic seizure, formerly 'the stroke of God's hand.' Doctors," the dictionary goes on to say, "speak of cerebral haemorrhage, etc."

I have no figures for the morbidity of "strokes," but the mortality is very heavy. In 1945 471,274 people died in England and Wales from all causes, and 52,557 (11.1%) of these were listed as suffering a cerebrovascular death. The numbers have crept up annually, and in 1955, 11 years later, 74,152 out of 518,864

FIG. 1.—Showing total deaths in England and Wales, 1945 and 1955, and the percentage of deaths from "strokes." Strokes are indicated by black rectangles.

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(14.5%), or over one in seven, died from a similar cause (Registrar-General, 1947-56) (Fig. 1). If the figures are broken down a little one finds some startling changes over the years in the ratio of the different types of "stroke" causing death (Fig. 2). Thus the figures for cerebral haemorrhage have remained virtually unchanged, while those for embolus and thrombosis (lumped together by the Registrar-General) have roughly doubled. Subarachnoid haemorrhage was not listed before 1949, but the numbers have risen annually since that date. "Other and ill-defined vascular lesions affecting the central nervous system" have more than doubled.

The Registrar-General's figures for cerebral tumour deaths have also been added in Fig. 2. They have risen by some 33% over this 11-year period. Tumours have been included because in my opinion it is often impossible to differentiate them clinically from "strokes."

One must remember that most of the cases collected by the Registrar-General have not been investigated

FIG. 2.—Ratio of different types of stroke causing death, 1945 and 1955.

radiologically, surgically, or by necropsy examination of the brain. Without the aid of one or more of these procedures it is often impossible to make an accurate diagnosis. It is certainly difficult to imagine that some unknown factor has crept in slowly over the last decade, causing the deaths from embolus and thrombosis to double, while those for haemorrhage have remained stationary (Fig. 3). Furthermore, there is no doubt in my mind that very many cerebral tumours are hidden in the figures given for "haemorrhage" and "embolus and thrombosis."

At the moment—and probably for many years to come—economics preclude a complete investigation into the cause of death of some 75,000 selected persons every year. If a "stroke" centre were to be started in some small district in which all deaths attributed to "stroke" were checked by a careful necropsy of both the central nervous system and the supplying arteries down to their origins in the neck, as advocated by Hutchinson and Yates (1957), we would have a background of figures which could perhaps reasonably be interpolated for the

whole population. Comparison of such figures with those of the Registrar-General would undoubtedly be instructive.

FIG. 3.—Mortality of cerebrovascular diseases, 1945-55 (Registrar-General's figures).

Radiology

Plain x-ray films of the skull should always be taken. In practice they are not often helpful, but occasionally they provide invaluable clues. Features such as the following should be sought. (1) *The position of the pineal gland*, if it is calcified. Its displacement may help to lateralize the lesion when physical signs are absent or unconvincing. Thus the appropriate carotid tree can be investigated. (2) *Calcification of aneurysms*: It was formerly thought that aneurysms calcified not infrequently. This is true of carotid aneurysms in the cavernous sinus, but they seldom give rise to "strokes." Moreover, they represent only about 5% of intracranial aneurysms. Aneurysms within the subarachnoid space very seldom calcify. (3) *Angiomas*: About 7% of subarachnoid haemorrhages are caused by angiomas. About 15% calcify and a further 30% show other plain x-ray changes, such as abnormal vascular markings, which may or may not enable a specific diagnosis to be made. (4) *Cerebral haemorrhage, thrombosis, and embolism*: The plain x-ray films are nearly always normal. (5) *Tumours*: The cause of some "strokes" is found ultimately to be a tumour. Gliomas represent some 50% of intracranial tumours, and about 10% of them calcify.

Thus valuable information regarding the location and pathology may occasionally be obtainable from plain x-ray films.

Angiography

Not only has this procedure improved diagnosis and thus made the treatment of "stroke" more rational, but retrospective analysis has sharpened our ability to make a correct diagnosis clinically. Two examples may be quoted: angioma and internal carotid thrombosis. Ten years ago doctors in the neurological field seldom mentioned either condition in differential diagnosis, while to-day both are frequently considered.

Percutaneous cerebral angiography is fairly simple and safe in experienced hands. There are practically no contraindications or reasons for delay. A "stroke" may be just as much an emergency as an abdominal catastrophe, and in appropriate cases cerebral angiography should be withheld no more and delayed no longer than, for example, intravenous pyelography in excluding or confirming the presence of a urinary calculus in a case of acute abdomen.

Contrast media developed in the last two or three years are possibly safer and certainly cause less discomfort and sensation of heat to the patient, and give brighter images of the blood vessels than the diodone contrast media. These factors have added to the value of the investigation.

Indications for Angiography in Subarachnoid Haemorrhage

In subarachnoid haemorrhage—which incidentally, like haemoptysis, is a sign and *not* a diagnosis—there is an absolute indication. Often there are no localizing or lateralizing signs. In such cases my practice is to start by investigating the carotid tree supplying the non-dominant hemisphere. As a rule both carotid trees should be investigated, particularly in cases of aneurysm, for quite often they are multiple and may be situated on both trees. Yet further aneurysms may also be situated on the vertebral tree.

Before angiography is undertaken each carotid artery should be compressed for about 10 minutes. If compression cannot be tolerated it is clear that the circle of Willis is not functioning adequately. In such cases the patients are probably not in a fit state to undergo arteriography. It has been shown angiographically that spasm of the main cerebral vessels often occurs for a few days after a subarachnoid haemorrhage—presumably a natural compensatory mechanism. It is also thought that the contrast substance sometimes induces further spasm. An adequate cross-circulation through Willis's circle is most important, and in the absence of this cross-flow it would be dangerous to consider the ligation of one carotid artery.

Following the teaching of James Collier, it was assumed for many years that the great majority of spontaneous subarachnoid bleeds are caused by a leaking aneurysm. We now know that this is only an approximation to the truth.

It is very difficult to give accurate figures in percentages of the causes of subarachnoid haemorrhage. This is partly because lumbar puncture is performed so much more often to-day in cases of various types of cerebral catastrophe. Thus, for example, the predominating clinical picture may be of cerebral haemorrhage, but, none the less, blood is present in the C.S.F. Many such bleeds are not initiated by aneurysms. On the other hand, the bleed which occurs mainly into the subarachnoid space is much more likely to result from a ruptured aneurysm. As there is a tendency to-day to submit a wider spectrum of cases to angiography, the percentage of aneurysms found is dropping. Thus at the neurosurgical unit (Atkinson Morley's Hospital) at St. George's, an analysis of 250 recent cases with blood in the cerebrospinal fluid, investigated angiographically, has revealed an aneurysm in only 50.8% of cases; angiomas were found in 5.2%, intracerebral haematoma in 12.8%, and thrombosis of a major artery in 0.8%. No angiographic abnormality was found in 30.4%.

McKissock and Walsh (1956) have shown that subarachnoid haemorrhage from aneurysm alone is often associated with other complicating haemorrhages: (1) intracerebral, (2) intracerebral and intraventricular, (3) subdural, (4) intracerebral and subdural. Out of 225 cases of subarachnoid bleed from aneurysm they found 59 (26%) with complicating haemorrhages. These complications can frequently be recognized by angiography and/or pneumography. Thus radiology has helped to show that the morbid anatomical picture of subarachnoid haemorrhage is more complex than was formerly believed.

More work needs to be done in clarifying the cause of subarachnoid haemorrhage in cases where no lesion is found following bilateral carotid angiography. With this in mind it has been our practice for more than a year now to proceed to vertebral angiography in such cases.

In this recent consecutive series of 250 cases (see Table), no abnormality was found in either carotid arterial tree at angiography in 79. Of these 79, 71 were submitted to vertebral angiography, the remaining eight cases either refusing the investigation or being too ill to tolerate the procedure.

Positive findings were made in 8 of the 71 cases—two were supratentorial angiomas derived from the posterior cerebral artery, the remaining six lesions lying in the posterior fossa (see Table).

250 Cases of Subarachnoid Haemorrhage, September 1, 1956, to June 4, 1957

Bilateral Carotid Arteriography

99	Aneurysms, single
24	Aneurysms, multiple
10	Angiomas
1	Angioma plus aneurysm
31	Intracerebral haematoma
2	Middle cerebral thrombosis
4	Examination unsatisfactory
79	No abnormality. (Vertebral arteriography: 3 aneurysms; 4 angiomas (2 supratentorial); 1 haematoma (posterior fossa); 60 normal; 3 unsuccessful; 8 no examination.)

It has been argued that vertebral angiography is not justified in cases of subarachnoid haemorrhage, since if a lesion is found it is rather seldom amenable to surgery. However, if all the intracranial arterial trees are examined and nothing is found, we have now gained the firm impression that the prognosis in such cases is good. One feels that this information alone has justified the undertaking of the procedure.

Although angiography has greatly assisted in clarifying the causes of subarachnoid haemorrhage and allowing a precise diagnosis to be made in life, it must be remembered that the Registrar-General's figures (see Fig. 2) would suggest that this only scratches the surface of the whole problem of cerebrovascular disease.

Indications for Angiography in Other Conditions

Haemorrhage, Thrombosis, and Embolism.—It would be idle to pretend that angiography can differentiate these types unless the lesion is relatively gross. It must be remembered that the method is a rather crude form of investigation and allows only the largest vessels to be outlined. Thus a small cortical or capsular thrombosis, both common lesions, will not be demonstrable angiographically. However, there is no difficulty in diagnosing the grosser catastrophes such as large haemorrhages and thromboses or emboli of major vessels. This alone is a useful advance, for surgery has something to offer in some of these cases. Large intracerebral clots can be evacuated, often with benefit to the patient. In certain suitable types of carotid thrombosis, particularly when the lumen is not completely obliterated, restoration of the vessel can be achieved by the insertion of an arterial graft as Rob and Wheeler (1957) have shown.

Tumour.—Perhaps one of the most useful functions of cerebral angiography in the investigation of cases of "stroke" is in the diagnosis of brain tumours. In recent years one has been repeatedly impressed by cases of tumour which have been misdiagnosed as examples of thrombosis of the internal carotid artery or one of its main branches. Such cases have been referred to the radiologist for carotid angiography, merely in order to eliminate any doubt at all regarding the diagnosis. So confident has the clinical diagnosis sometimes been that a specific request for an angiogram of the cervical portion *only* of the carotid arteries has been made. One such case, that of an elderly woman, was seen recently. Having shown the cervical portions of the carotid arteries to be normal, the intracranial branches were examined. This examination revealed the presence of a very large astrocytoma of fairly severe malignancy (grade III Kernohan's classification) occupying most of the left cerebral hemisphere. Cases of this kind are not uncommon in my experience, and it is nowadays agreed that clinical differentiation between a vascular accident and a tumour is often quite impossible.

Subdural Haematoma.—The natural history of this condition is so pleomorphic that the diagnosis should always be borne in mind. A history of trauma is often lacking, and the occasional case presents itself which has been given

up for lost as either an inoperable tumour or a vascular catastrophe of such a severe nature as to be beyond medical help. The diagnosis can often be made quite readily by angiography, and the subsequent simple treatment of drainage through a single burr-hole may be dramatic in restoring a dying patient to complete normality.

Pneumoencephalography

There may be a tendency to assume that air studies have no place, or only a very minor place, in the investigation of cerebral vascular diseases. In fact this is not true, and sometimes the diagnosis can be reached only by this means. In many other cases pneumography gives valuable additional information to that provided by the angiograms.

The air is introduced either via burr-holes (ventriculography) or by lumbar puncture in the sitting position (encephalography). The choice of the more suitable method in any given case depends on the patient's condition and is beyond the scope of this paper. Some illustrative examples of the uses of air studies may now be cited.

If carotid angiography shows a major displacement of vessels suggesting the presence of an intracerebral haemorrhage, a more accurate picture of the size and position of the lesion may sometimes be obtained by air studies. Then, again, the recognition of a slight distortion of the ventricular system may point to the presence of a haematoma when the carotid angiogram has shown no obvious displacement of the cerebral vessels.

Intraventricular clots and intraventricular angiomas can be readily recognized by pneumoencephalography. Cerebellar haematomas have been demonstrated by air studies in some cases of cerebral vascular catastrophe when total cerebral angiography has proved negative. There may have been a suggestion of raised intracranial tension with or without clinical cerebellar signs. The diagnosis is made on the classical displacement of the aqueduct and fourth ventricle, usually accompanied by some degree of hydrocephalus. Such cases often benefit very considerably following the enucleation of the cerebellar hemisphere blood clot.

Conclusions

This brief survey is intended to indicate how radiology can help to clarify the diagnosis in many cases of "stroke." Now that neurologists with a lifetime's experience admit that the clinical diagnosis in this type of case is haphazard, it is reasonable to suppose that most doctors signing death certificates all over England and Wales have difficulty in giving the Registrar-General an accurate picture of the cause of death following a "stroke." It was Collier (1922) who said that cerebral tumours are commoner than any other type in man. Perhaps his statement, which has received some ridicule, will be vindicated by the Registrar-General's figures in, let us say, a quarter of a century hence, particularly if it is common practice by that time to investigate "strokes" more fully by radiology, surgery, or necropsy. In any event, it is safe to predict that the Registrar-General's figures will show considerable further modification by that time.

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