We found a cervical bruit in all 12 patients with marked stenosis of the internal carotid artery and in 1 of the 5 patients with an occluded internal carotid artery (felt to be due to increased flow through ipsilateral external carotid artery). The major deficiencies of screening patients by auscultation for a cervical bruit is the high incidence of false positives (12% in our series) and inability to detect an individual with a nonstenotic ulceration or occlusion of internal carotid artery.

Acknowledgment

The authors wish to thank Lee D'Alessandro and Betty Gamoke for their excellent technical assistance.

References


Technique for Multi-View Radionuclide Angiography

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SUMMARY A new method utilizing computer subtraction allows 2 separate radionuclide angiograms to be performed during a single laboratory visit. Two separate intravenous injections of the radionuclide are given so that the patient's head can be imaged in 2 different projections. Background activity from the first injection is subtracted by the computer to allow good resolution of blood flow following the second injection. A static brain scan is performed after the second injection. Although single-view radionuclide angiography is widely in the diagnostic evaluation of the brain, the addition of a second projection provides additional important diagnostic information. The views obtained, however, must be determined individually for each patient on the basis of the clinical history and neurologic signs. The selection of appropriate views, the diagnostic quality of the studies, and the practical clinical application of this technique are illustrated by 2 case reports.

SINGLE-VIEW radionuclide angiography is widely used in the diagnostic nuclide evaluation of the brain. However, the performance of radionuclide angiography in 2 different projections of the head provides further diagnostic information and is more helpful than a single view. We present a method utilizing computer subtraction which allows 2 separate nuclide angiograms to be performed during a single visit to the laboratory.

Collection and Processing of Scintigraphic Data

A catheter with a 3-way stopcock was inserted into the patient's antecubital vein. The patient was then positioned under a scintillation camera (Pho/Gamma IV, Model 6406, G. D. Searle and Co., Des Plaines, Ill.) for an anterior Townes, lateral, or vertex view. A rapid bolus (10-20 mCi) of the nondiffusible radionuclide 99mTc-DTPA was injected through the catheter. Flow data were collected by a computer (DEC PDP-11/45) in 1.25-second histograms (64 x 64 matrix) for 50 sec following the injection.
The patient received a total of 30 mCi of Tc-DTPA during the course of 2 flow studies: 10 mCi were administered for the first flow study, and 20 mCi for the second. The use of a larger second dose markedly improved the quality of the flow images of the second injection. This dosage was empirically determined by comparing the quality of images obtained with different dose combinations, although no direct comparison of different fractionation was made in the same patient. We believe that the diagnostic advantages of high spatial resolution in multiple views fully justify the use of 30 mCi instead of the 15 to 20 mCi amount that is commonly used.

In order to have good dynamic replay images, a minimum of 30 min between the 2 flow studies was required. Forty-five to 60 min was preferable but tended to unduly prolong the patient's sojourn in the laboratory. Satisfactory static images were obtained 30 min after the second flow study, with no increase in the usual imaging time.

Acquisition and Subtraction of Imaging Data by Computer

For clinical review, a "movie-like" dynamic playback of consecutive images was displayed in color on the video screen of the computer. Each image was the sum of four 1.25-sec frames; the time between images was 1.25 sec.

The playback was a series of images pre-scaled to an absolute maximum and minimum count, determined by the computer operator for each individual study and independent of the maximum and minimum count of the individual frames. The count rate was indicated by a "rainbow" color scale* ranging from deep blue (0% of maximum count rate) to white (100%). Colors were automatically assigned to span the range from zero to 100% of the maximum count rate observed in an individual patient study. Only a relative scale such as this, applied to each study individually, was appropriate since the present method cannot be standardized to yield cerebral blood flow in absolute terms. (This is in contrast to regional cerebral blood flow maps (rCBF) using intraarterial 133Xe, where it is possible to use the same color throughout to represent a value for rCBF in ml/100 g brain/min).

Preparation of the second flow "movie" differed only in that an image representing background activity from the first flow study was subtracted from each image of the second study before the image was stored as a frame in the playback buffer. The background image was the sum of the first 4 frames of the second study before the isotope bolus appeared in the carotid arteries.

Reports

Patient No. 1

An 80-year-old woman had an onset of dizziness and inability to talk, followed by loss of consciousness without seizure activity or incontinence. She was admitted to the hospital where a general physical examination showed congestive heart failure, mitral stenosis, and an irregular pulse. The electrocardiogram showed a chaotic atrial rhythm with multiple premature ventricular contractions. A neurologic examination revealed a loss of speech without loss of comprehension, right central facial weakness, and a right hemiparesis which was more prominent in the arm than in the leg. There was no visual field defect or sensory loss. During the first few hours of hospitalization, her speech returned but she had mild expressive difficulty. The hemiparesis improved to a mild monoparesis of the right hand. She was observed for several days in the cardiac care unit. There was no evidence of myocardial infarction; her syncopal episode was thought to have resulted from an arrhythmia. The neurologic deficit was presumed to be of cardiac embolic origin or to be secondary to hypoperfusion during an arrhythmia. A radionuclide angiogram was performed 6 days after the onset of her ictus. The anterior Townes projection showed greater flow to the left hemisphere than to the right. The left lateral projection showed a focal area of increased perfusion in the left parietal region (fig. 1). A static nuclide scan showed a blood–brain barrier defect in the left parietal region. The combined angiogram and static nuclide studies therefore demonstrated a cerebral infarction with luxury perfusion even though her neurologic deficit had largely resolved. Because of her advanced age and poor cardiac status, cerebral angiography was not performed and she was not anticoagulated. She was discharged on cardiac medication and has had no further neurologic deficit in 13 months follow up.

Patient No. 2

A 42-year-old man experienced the sudden onset of left hand twitching followed by loss of consciousness and urinary incontinence. He had a postictal confused state for approximately 45 minutes. He had had a prior major seizure with focal onset in the left hemisphere (arrow) than to the right. (B) left lateral projection, computer image without subtraction. There is a focal area of increased blood flow to the left parietal region.
hand 1½ years earlier but had not sought medical attention. He reported having had 5 to 15 episodes of isolated left hand twitching for 45 seconds over the past 15 years. He denied having headache, personality change, or interictal neurologic symptoms. The general physical and neurologic examinations were normal. An electroencephalogram showed a mild bilateral frontotemporal slowing. Radionuclide angiography in the anterior Townes projection demonstrated a prominent vascular lesion in the right hemisphere that received blood from the right anterior cerebral artery (ACA). The right lateral projection showed that the lesion was in the right frontoparietal region and demonstrated right middle cerebral artery (MCA) blood supply (fig. 2). Cerebral angiography confirmed the presence of a hypervascular mass, 4 by 4 cm, in the right hemisphere which received blood from both the right ACA and MCA. The arteriovenous malformation was judged to be inoperable and the patient was treated with anticonvulsant medication. He continued to have occasional seizures.

**Discussion**

In our laboratory, multiple flow studies in the same patient were first done using the Anger 80-lens oscilloscope camera attached to the scintillation camera console. While this device provided excellent spatial and temporal resolution, it had disadvantages for multiple studies. The second study had to be performed the following day in order to avoid interference from background activity remaining from the first injection. The computer technique described in this paper obviates the need for the patient to make a second trip to the laboratory and makes the performance of multiple flow studies a practical clinical diagnostic evaluation.

At present, we still examine the 80-lens image for the first view, relying on a computer subtracted image for the second study. Our present computer system video output has slightly less spatial resolution than the 80-lens camera; however, we believe that the technique of using camera and computer alone is very promising. Our computer images, using a 64 X 64 matrix, are already of nearly comparable diagnostic quality. In addition, dynamic acquisition in a 128 X 128 matrix will soon be available to us, and the resolution provided by this matrix is already included in some commercially available systems.

The clinical application of multiple flow studies can best be appreciated by considering specific disease entities. In cerebral infarction, in the distribution of the ACA and MCA, multiple views of the head become especially useful. The views obtained must, however, be determined individually for each patient on the basis of the clinical history and neurologic signs. For example, in suspected left MCA infarction, the left lateral projection should be combined with an anterior Townes or vertex projection. In Patient No. 1, the flow study showed a focal area of hyperperfusion corresponding to the left parietal blood-brain barrier defect on the static scan (fig. 1). The hyperperfusion represented luxury perfusion in the infarcted tissue. The location of the abnormality on the flow study was compatible with the patient's neurologic defect. The focal nature of the blood flow defect could only be appreciated in the lateral projection. The anterior projection showed only asymmetry between the 2 hemispheres.

In our experience, either an anterior Townes or vertex projection should always be included in order to provide a comparison of flow to the 2 hemispheres. The activity seen in the lateral projection originates primarily from blood flow to that side of the brain with one important exception. In a patient with greatly reduced flow to a single hemisphere, e.g., congenital hemiatrophy of a hemisphere, a lateral flow study will show activity from the opposite hemisphere and may be mistakenly interpreted as normal, unless a view comparing the 2 hemispheres is obtained. With our present techniques, if lateral views of both hemispheres are needed, the patient must be studied on a second visit to the laboratory. If the patient's clinical presentation is nonfocal, e.g., dizziness or headache, we routinely perform a left lateral view to visualize the dominant hemisphere, combined with an anterior Townes or vertex projection.

If a borderzone ("watershed") infarction is suspected, a vertex projection is especially useful to demonstrate the vulnerability of the circulation in the parietal-occipital cortex (unpublished result). For suspected ACA infarction, a combination of anterior Townes and vertex projections is helpful. Sagittal sinus thrombosis with venous infarction is reliably seen only in the posterior oblique projection. However, we also perform an anterior Townes or vertex view in order to compare the flow to each hemisphere.

Serial radionuclide circulation studies can be used to demonstrate the evolution of changes in an infarcted region of the brain. Immediately following an infarction there may be a focal increase or decrease in blood flow, while later studies usually show a return to

**Figure 2.** Patient No. 2, radionuclide angiogram, early arterial phase. (A) anterior Townes projection, computer subtracted image. A large vascular blush appears in the right hemisphere (closed arrow) and prominent blood supply derived from the ACA is seen (open arrow). (B) right lateral projection, computer image without subtraction. The vascular lesion is in the frontoparietal region (closed arrow) and receives blood supply from the MCA (open arrow).
more normal flow. In contrast, the radionuclide static scan or computerized tomographic scan may be negative in the first days following ischemic infarction and may become abnormal at a later time. Patients with neoplasms, arteriovenous malformations, carotid-cavernous fistulas, and fistulas in the neck have been studied in our laboratory by multi-view radionuclide angiography. The pattern of arterial feeding vessels supplying the lesion and the venous drainage channels can be identified. In Patient No. 2, the location and the prominent ACA and MCA feeding vessels were demonstrated and were confirmed by cerebral angiography (fig. 2). In some patients with neoplasms and fistulas, intracerebral steal of blood may occur, i.e., the blood flow to normal regions of the brain may be diverted to feed the vascular lesion.

Radionuclide angiography is a quick, noninvasive diagnostic tool which provides different information from computerized axial tomography. These techniques can best be used in combination to arrive at a correct clinical diagnosis.

References

Cerebral Blood Flow and Metabolism in Man Following Cardiac Arrest

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SUMMARY We measured cerebral oxygen extraction, cerebral blood flow (CBF), and cerebral metabolic rate (CMRO₂) in comatose patients during the first 60 hours after resuscitation from cardiac arrest. Each patient was studied 2 or 3 times. CBF was determined by a modification of the Kety-Schmidt method using inhaled Xenon. Over the study period jugular venous oxygen tension and saturation rose, while the oxygen content difference between arterial and jugular venous blood fell, indicating a progressive increase in the ratio of CBF to metabolism. CBF and CMRO₂ measurements confirmed this. Between 2 and 6 hours after resuscitation both measurements were severely but proportionately depressed to less than 50% of normal. After 6 hours CBF was increased disproportionately to CMRO₂ so that a relative hyperemia developed and persisted for the duration of the study.

Although regional inhomogeneity of flow and regional ischemia cannot be ruled out, we have found no evidence for global cerebral ischemia between 2 and 60 hours post-resuscitation as an explanation for failure of recovery. In man following cardiac arrest restoration of levels of global cerebral blood flow, which can be considered adequate relative to the depressed metabolic state of the tissue, is achieved within 2 hours of resuscitation.

ANIMAL STUDIES suggest that recovery of neuronal function after severe ischemic-anoxia may be impaired by either early or delayed failure of cerebral tissue perfusion. Although the evidence that this occurs in man is lacking, there is speculation that recirculation to the brain may be impaired after total cerebral ischemia, contributing to failure of neuronal recovery. We have investigated this question by measuring cerebral oxygen extraction, cerebral blood flow (CBF), and cerebral and metabolic rate for oxygen (CMRO₂) in patients during the first 60 hours after resuscitation from cardiac arrest.
Technique for multi-view radionuclide angiography.
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