RADIONUCLIDE ANGIOGRAPHY IN THE DIAGNOSIS OF CEREBROVASCULAR DISEASE

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A comparison between radiocontrast and radionuclide angiography was made in 272 patients with cerebrovascular disease. The radionuclide studies showed a 58% true-positive rate and 11% false-positive rate. The true-positive rate for patients with unilateral carotid artery disease was 66%. These results were similar to those of other reported series (63% true positive and 11% false positive). Therefore, radionuclide angiography is not recommended as the major screening procedure in cerebrovascular disease.

Radionuclide cerebral angiography has been used widely since its introduction in 1966 (*1–5*). There are several good reviews of this subject that describe angiographic results in neurological conditions including tumors and cerebrovascular disease (*6–10*). If this procedure is to be a significant addition to the diagnostic and screening procedures available for the study of cerebrovascular disease, it should be accurate enough to record the presence of vascular abnormalities in a high percentage of patients with clinically significant diseases. As yet, there are insufficient numbers of cerebrovascular cases reported in specific literature series to give an accurate appraisal of true-positive and false-positive rates obtainable from this radionuclide procedure. The purpose of this study is to compare the results of radionuclide angiography with radiocontrast angiography in the diagnosis of disease in the major arteries of the head and neck. A retrospective chart review of hospitalized patients referred for radionuclide cerebral angiography and brain imaging resulted in 272 cases that could be used for this comparison study.

MATERIALS AND METHODS

The chart review was of patients referred to the Methodist Hospital Radioisotope Dept. for radionuclide imaging of suspected intracranial pathology. The radionuclide cerebral angiography was performed with ^{99m}Tc-pertechnetate, 1 mCi/10 lb weight. No choroid plexus blocking agent was given. A Nuclear-Chicago Pho/Gamma III was set for the ^{99m}Tc photopeak with a 15% window. Either the standard 4,000-hole or the high-resolution collimator was used. The patients were positioned for an anterior view of the head and neck. The ^{99m}Tc-pertechnetate was injected intravenously, usually in a small volume (<0.5 ml). To minimize the length of the bolus, a fast-dose delivery was used combined with a postinjection tourniquet release. Immediately after the injection, three Polaroid pictures were obtained of the CRT. The counting rate was used to determine the duration of each exposure. The first picture (0-5K) generally detected the flow through the carotid and vertebral arteries. The vertebral arteries were not visually separable from the carotids. The second picture (5-10K) usually recorded the flow in the middle and anterior cerebral arteries and the diffuse activity throughout the cerebrum as the bolus entered smaller vessels. The third picture (10-25K) generally showed the superior and lateral venous sinuses. Pictures adequate for study were obtained 98% of the time. Thirty minutes or more after the injection, the static brain imaging pictures were obtained.

The classification of the 500 charts reviewed are shown in Table 1. Of these 500, 356 cases had a radiocontrast cerebral angiogram; the following were excluded from the comparison study: tumors, hematomas, A-V malformations, aneurysms, and six of the infarctions. The six infarctions were excluded because no vessel involvement was found by the contrast angiography.

The radiocontrast angiograms performed for the 272 patients included in the comparison study were as follows: both carotids and both vertebral arteries—86; both carotids and one vertebral artery—36; both

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TABLE 1. DIAGNOSTIC CLASSIFICATION

Patients with radiocontrast cerebral angiogram*		
Tumor	58	
Hematoma: subdural (5); intracerebral (6)	11	
A-V malformation (7); aneurysm (2)	9	
Infarction	20	
Cerebrovascular disease	121	
Arterial irregularity	18	
Normal	119	
Total	356	
Patients without radiocontrast cerebral angiogram:		
Discharge diagnosis—stroke		16
No cerebrovascular disease		116
Unsatisfactory radionuclide angiogram		12
Total number of charts reviewed		500

* A radionuclide angiogram was performed for all 500 patients.

TABLE 2. ABNORMAL INTRACEREBRAL ARTERIES WITH NORMAL CAROTIDS

Radionuclide	Radiocontrast	Number of Patients
Abnormal	Abnormal	11
Abnormal	Normal	9
Normal	Abnormal	7
Normal	Normal	7
Normal	Abnormal	8*

* It would not be expected that the involved arteries (vertebral, basilar, and posterior cerebral) would be seen in an anterior angiogram. Generally, the contrast angiograms were lateral projections whereas the radionuclide angiograms were anterior projections.

TABLE 3. ABNORMAL CAROTID ARTERIES

	Number of abnormal angiograms	
	Radio-contrast	Radio-nuclide
Complete unilateral occlusion	24	23
Partial unilateral occlusion	25	10
Unilateral arterial plaque	7	4
Complete bilateral occlusion	5	1
Complete unilateral occlusion with contralateral narrowing	15	15
Bilateral disease without occlusion	17	5

TABLE 4. CLINICALLY SIGNIFICANT CEREBRAL VASCULAR DISEASE NOT FOUND

Radiocontrast findings	N	Radionuclide angiograms: Number of abnormal
Normal	119	15
Marginal arterial irregularity	18	0

carotid arteries—113; and one carotid artery—37. Of these patients, 43 eventually had surgical repair of their carotid lesions.

The radiocontrast angiogram was accepted by us as the definitive test proving the presence or absence of cerebral vascular disease. The exception was in 16 patients who had normal radiocontrast angiograms classified as abnormal because clinical or autopsy evidence was diagnostic of cerebrovascular disease. The true-positive and false-positive rates were calculated by the Lusted method (*11*) and as outlined and applied to nuclear medicine procedures by Haynie, et al (*12*).

RESULTS

In Table 2 are shown the results in patients who had abnormal intracerebral vessels with normal carotids. Because the radionuclide studies were of the anterior view, a separate category is shown for the eight patients who had involvement only in the vertebral, basilar, or posterior cerebral vessels. If these 8 were excluded, there would have been 14 false-negative radionuclide studies and 16 false-negative radiocontrast studies. These 16 false-negative studies were patients classified as having cerebrovascular disease on the basis of diagnostic clinical findings and/or autopsy.

The results shown in Table 3 are from the studies of patients who had carotid artery abnormalities. The patients were classified by unilateral or bilateral involvement and by the extent of the occlusion. When there was complete unilateral occlusion, the number of abnormal studies was almost identical for both types of angiograms. This is true whether the contralateral artery was normal or narrowed. The radionuclide study did not detect partial occlusion or equal involvement bilaterally nearly as well as did the radiocontrast study.

The results of the radionuclide angiograms in patients in whom no significant stenosis was found by contrast angiogram are shown in Table 4. There were 15 false-positive results with the radionuclide studies. There could be no false-positive radiocontrast angiography because it was the definitive study for the presence of cerebrovascular disease.

The true-positive and false-positive rates are shown in Table 5. We have assumed that the patients in Tables 2 and 3 had clinically significant cerebral vascular occlusive disease and the patients in Table 4 did not have clinically significant vascular occlusive disease. In bilateral carotid occlusive disease, we have considered the results a true positive even when the radionuclide angiogram showed involvement of

TABLE 5. TRUE-POSITIVE AND FALSE-POSITIVE RATES

	Radionuclide angiogram	
	Normal	Abnormal
Intracerebral artery abnormality	22	20
Carotid artery abnormality	35	58
No cerebral vascular abnormality	122	15

$$\text{True-positives} = \frac{78}{135} = 58\%$$

$$\text{False-positives} = \frac{15}{137} = 11\%$$

TABLE 6. PATIENTS WITH CEREBROVASCULAR DISEASE*

Reference number	Table number	Radionuclide angiogram Normal	Radionuclide angiogram Abnormal	Total	% True positives
6	3	6	14	20	70
7	3	7	14	21	67
8	2	2	6	8	75
9	1	8	17	25	68
10	1	18	18	36	50
	Total	41	69	110	63
	This series	57	78	135	58

* The true-positive rates of this series compared with the combined results from five articles in the medical literature.

TABLE 7. PATIENTS WITHOUT CEREBROVASCULAR DISEASE*

Reference number	Table number	Radionuclide angiogram Normal	Radionuclide angiogram Abnormal	Total	% False positives
6	3	26	3	29	10
7	3	4	3	7	43
8	2	2	0	2	0
10	1	43	3	46	7
	Total	75	9	84	11
	This series	122	15	137	11

* The false-positive rates of this series compared with the combined results from four articles in the medical literature.

only one carotid artery. The radionuclide angiogram had a 58% true-positive rate and an 11% false-positive rate.

There were 16 patients who did not have radiocontrast angiography but whose case histories indicated a recent stroke and by other findings that made a diagnosis of cerebrovascular disease the most likely of all other diagnostic possibilities. Eleven of these patients showed a decreased intracerebral flow in the radionuclide angiogram and five showed a decreased flow in one carotid. Their static brain imaging results were normal.

Contrast angiography was not performed because of the patient's clinical state. If these 16 stroke patients were added to the series, the true-positive rate for the radionuclide angiogram would have been 62%.

DISCUSSION

Radionuclide angiography can easily be combined with a static brain image study. This combination adds slightly to patient discomfort, does not require an additional injection, and does not add to the patient's radiation exposure. It complements the static brain study by detecting abnormalities otherwise not visible as lesions in the static images. As an example, an abnormality was present in the static image in 20 of the 356 cases in this series whereas a positive radionuclide angiogram was found in 119.

Similar to the static study, a radionuclide angiogram is easily performed on an outpatient basis. For these reasons radionuclide cerebral angiography would be an ideal screening test for patients suspected of having cerebral vascular disease. It should have even greater utility in cerebrovascular diagnosis of patients for whom a contrast angiography is not possible.

The 58% true-positive rate and the 11% false-positive rate found in this series is not adequate for a clinically useful screening test. Even if the true-positive rates were increased to 62% by including the 16 stroke patients who did not have contrast angiography, the figures from this series are still below the true-positive rate usually reported for other radionuclide imaging procedures (*12,13*).

It might be argued that the relatively poor resolution of the camera would preclude accurate diagnosis of intracerebral disease and therefore radionuclide angiography should be used only for diseases confined to the relatively large carotid arteries. However, even for unilateral carotid artery disease, the true-positive rate in this series increased only to 66%.

The technique used to perform the radionuclide angiograms reported here used a predetermined number of accumulated counts to determine the duration of each picture's exposure rather than the more usual technique of predetermined postinjection elapsed time. The fact that the results are not peculiar to this series of patients or this methodology can be seen in the results cited from the references shown in Tables 6 and 7. The results selected from the references were of patients for whom both radionuclide and radiocontrast angiographies were performed, thus confirming the presence or absence of cerebrovascular disease. The combined results of the series reported in the literature are nearly identical with the true and false-positive incidence of this series. This occurred even though different techniques were used to perform this procedure, and it is likely that different angiographic criteria were used to establish these diagnoses.

If radionuclide cerebral angiography is to be of greater clinical usefulness, a way must be found to improve the accuracy of the method in the diagnosis of cerebrovascular disease. Whether techniques such as computer readout, different patient positions, or multiple views will help is still unknown.

Until techniques are available which can improve the diagnostic accuracy of this procedure, caution should be exercised when interpreting the results of a radionuclide angiogram. At the present time, it would not seem advisable to consider using radionuclide cerebral angiography as the major screening procedure in the diagnosis of suspected cerebrovascular disease.

REFERENCES

1. Owens G, Bender MA, Blau M: Radioisotope (gamma) cerebral angiography. *J Neurosurg* 27: 466–470, 1967

2. Burke G, Halko A: Cerebral blood flow studies with sodium pertechnetate Tc 99m and the scintillation camera. *JAMA* 204: 109–114, 1968

3. Fish MB, Pollycove M, O'Reilly S, et al: Vascular characterization of brain lesions by rapid sequential cranial scintiphotography. *J Nucl Med* 9: 249–259, 1968

4. Maynard CD, Witcofski RL, Janeway R, et al: Radioisotope arteriography as an adjunct to the brain scan. *Radiology* 92: 908–912, 1969

5. Rosenthall L, Chan J, Sidhu R, et al: Combined radiocontrast and radionuclide cerebral angiography. *Radiology* 92: 1223–1228, 1969

6. Griep RJ, Wise G, Marty R: Detection of carotid artery obstruction by intravenous radionuclide angiography. *Radiology* 97: 311–316, 1970

7. Moses DC, James AE, Strauss HW, et al: Regional cerebral blood flow estimation in the diagnosis of cerebrovascular disease. *J Nucl Med* 13: 135–141, 1971

8. Fischer RJ, Miale A: Evaluation of cerebral vascular disease with radionuclide angiography. *Stroke* 3: 1–9, 1972

9. Stemmer EA, Leins PA, Bodfish RE, et al: Radioisotopic angiography in the selection of patients for cerebrovascular reconstructive surgery. *Amer J Surg* 120: 166–172, 1970

10. Meschan I, Lytle WP, Maynard CD, et al: Statistical relationship of brain scans, cervicocranial dynamic studies, and cerebral arteriograms. *Radiology* 100: 623–629, 1971

11. Lusted LB: Decision-making studies in patient management. *New Eng J Med* 284: 416–424, 1971

12. Haynie TP, Jhingran SG, Jahns MR: Sources of error in diagnostic scintigrams of the thyroid, liver, and brain. *Texas Med* 68: 132–136, 1972

13. Wagner HN, ed: *Principles of Nuclear Medicine.* Philadelphia, WB Saunders Co, 1968, p 676