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DELAYED BRAIN SCANNING WITH ^{99m}Tc PERTECHNETATE
FOR IMPROVED TUMOR DETECTABILITY

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SYNOPSIS - ABSTRACT

This investigation describes the results of 99m Tc pertechnetate brain scans performed during the first hour following tracer injection and of rescanning selected patients one to twenty four hours later. Eighty brain tumors were found among the nearly 1500 patients who had brain scans performed during the two year period 1968-69. Seventy four had a tissue diagnosis and in the remaining six, diagnoses were established by clinical, scan and neuroradiological findings. Forty had both early and delayed scan examinations and in 15 the early scans were normal or equivocal. Fourteen of these 15 became positive upon delayed examination. Twenty six nondiagnostic to moderately positive early scans increased in their degree of abnormality upon delayed examination. The detectibility of brain tumors improved from 80 percent with routine early scanning to 93 percent by rescanning selected patients later. The optimal time for delayed scan examination is three-four hours following tracer injection.

INTRODUCTION

For several years delayed brain scanning has been advocated for better definition of tumors not clearly demonstrated or missed altogether on scans obtained soon after the injection of various radioactive test materials. The optimal interval between administration of the test agent and the onset of scanning varies with the test material and the tumor type. Recent studies with ^{99m}Tc pertechnetate have demonstrated maximum tumor to background ratios at about three hours (1,2). This report from a 550 bed community hospital presents the results of routine brain scanning with pertechnetate and demonstrates the value of delayed scan examinations in selected cases for improving the detectability of both primary and metastatic tumors.

CLINICAL MATERIAL

Tumor cases were selected mainly from the 1500 brain scans performed in the nuclear medicine department during the two year period 1968-1969. Others were obtained from hospital records of patients discharged with the diagnosis of brain tumor and from the continuing in-service diagnostic follow-up of patients undergoing brain scan examinations. The total of 80 tumor cases was equally divided between primary and metastatic types. A tissue diagnosis was made in 74 patients; in the remaining six, clinical data, brain scan results and neuroradiological findings provided strong evidence of brain tumor but surgery or autopsy were refused.

TECHNIQUE AND SCAN CLASSIFICATION

All patients were examined during the first hour after injection of a 15 mCi dose of ^{99m}Tc pertechnetate using either a single* or multiprobe** scanner. Scans were graded as negative, equivocal, moderately positive or strongly positive. An equivocal scan was characterized as having one or more lesions with ill-defined boundaries and slight, if any, increases in radionuclide concentration. A moderately positive scan had one or more lesions visible on two or more views with concentrations of radioactivity well above those in normal brain areas. Strongly positive scans had one or more lesions present on two or more views with radionuclide concentrations far above those in surrounding normal brain. Grading was not based on the size or number of lesions.

Forty of the 80 tumor patients had delayed scans. The latter were obtained when early scans were negative or equivocal and when the patient's history and clinical findings were highly suggestive of a brain tumor. Postponed scans were also performed to look for additional metastatic lesions in patients with an already positive early study. Fifteen of the 40 patients in whom delayed scans were performed had negative or equivocal early scans. The number of negative and/or equivocal scans obtained with each of the two scanning instruments was proportional to its use in the overall study.

* Magnascanner V (Picker)

* Dynapix (Picker)

RESULTS

Fourteen of the 15 negative or equivocal scans performed during the first hour became positive during the delayed study, 12 within one to seven hour and two within 18 to 24 hours following tracer injection. The one false negative scan examination was in a patient with a chondrosarcoma at the base of the brain which was not visible in either the immediate or delayed scans but was demonstrated subsequently with an ^{85}Sr study. In no instance did any delayed scan image appear less positive than its early scan counterpart. Twenty-six nondiagnostic to moderately positive early scans increased in grading upon repetition of the examination. Twenty five of these delayed scans were obtained between one and seven (average 3-4 hours) after ^{99m}Tc administration. One patient having undergone early as well as three and twenty four hour studies showed the maximum concentration of radioactivity in the lesions at the three hour examination and greatly decreased concentration by 24 hours (Figure 1).

In the primary brain tumor group, acoustic neuromas and astrocytomas were histologic types in which visualization was improved by delayed scanning (Table 1). Postponed views disclosed two of the three acoustic neuroma cases which otherwise might well have been missed. In the metastatic brain tumor series (Table 2), detection of breast lesions was improved more by delayed scanning than other tumors. Three of six metastatic breast carcinomas required postponed scanning to establish an abnormality at all. Visualization of metastatic lung carcinomas, adenocarcinoma of unknown origin and reticulum cell

sarcoma was also enhanced by delayed scanning. Occasionally, when initial scans showed only solitary abnormalities, delayed studies demonstrated the metastatic nature of the disease by disclosing additional lesions (Figure 2).

There were five patients with falsely negative early scans in whom delayed studies were not done because of the patient's inability to return for re-examination. Their lesions were: astrocytoma, chromophobe adenoma, chondroma, angioblastoma and metastatic lung carcinoma. The chromophobe adenoma was obscured by abnormalities secondary to occlusion of the right internal carotid artery and probably would not have been demonstrated with delayed scanning. However, it is likely that two of the remaining four tumors, namely, the astrocytoma and the metastatic lung carcinoma might have been visualized.

With delayed scanning the accuracy for detection of brain tumors was 93% in this series. Furthermore, had delayed scanning been done in the five patients with falsely negative initial scans who could not return for delayed examinations, tumor detectability could have been higher. The improved detection efficiency from delayed examinations is definitely not related to instrument choice. Figures 1 and 2 show typical examples of the superiority of delayed scans with both the single and multiprobe scanners. Furthermore, the multiprobe instrument has been shown to produce scans comparable in information to those obtained with single probe rectilinear scanners (3).

DISCUSSION

Several radioactive test materials are satisfactory for brain scanning. However, ^{99m}Tc pertechnetate is currently regarded as the agent of choice because of its nearly ideal physical properties (4, 5).

The optimum interval between administration of a radionuclide and the onset of scanning is dependent upon both the test agent and the nature of the lesion. Schlesinger (6), using ^{131}I human serum albumin, reported that visualization of lesions with abundant vascularity such as arteriovenous malformations and angioblastic meningiomas was best at 24 hours, and gliomas and cystic lesions at 48 hours. Economos (7), using ^{203}Hg chlormerodrin reported that maximum visualization of meningiomas occurred in one to two hours and gliomas at 24 hours. Recommendations for both immediate (8-13) and delayed (1, 14-17) ^{99m}Tc pertechnetate scanning exist. This agent equilibrates with the extracellular space in approximately 15 minutes and is then removed from the blood with a half time of approximately three hours (9). This blood removal rate probably contributed to McAfee's recommendation (14) that scans should be performed one to three hours after administration because ^{99m}Tc blood levels are more stable at that time. The advantage of delayed scanning which is attributed to improvement in tumor to background ratios for selected tumors was recently demonstrated by Hand (2). Utilizing serial scanning with a scintillation camera for 120 minutes after the injection of ^{99m}Tc pertechnetate, Handa showed progressive uptake in gliomas, metastatic carcinomas and sarcomas with consequent increases in the ratios of tumor to normal brain radioactivity

with time. Contrariwise, a continuous regression of radioactivity occurred in arteriovenous malformations, meningiomas and angiomas with a concomitant decrease in the ratio of tumor to normal brain radioactivity with time. Computerized evaluation of scanning with ^{99m}Tc pertechnetate by Tauxe and Thorsen (1) demonstrated that a three hour post injection interval is best for visualizing meningiomas, astrocytomas, vascular lesions and hemangioendotheliomas.

This study indicates the optimal time for detecting brain tumors with ^{99m}Tc is three to four hours after injection. Astrocytomas and acoustic neuromas were primary brain tumors where visualization improved with delayed scanning. Likewise, in the metastatic category, imaging of metastases from breast and lung carcinomas, adenocarcinomas of unknown origin and reticulum cell sarcomas was improved with postponed scanning. Scanning at three to four hours is also useful in disclosing multiple metastatic lesions where the patient's initial scans revealed only a single lesion.

While ideally it might be best to scan all patients initially at 3-4 hours, this timing poses a logistical problem in a busy service. The policy in this department is still to scan all patients soon after the administration of the test material. If the results are negative or equivocal in patients with a high probability of brain tumor, scans are repeated 2-3 hours later. Only the views most likely to be positive are obtained. This regimen allows performance of a complete four or five view routine brain scan series, plus delayed examinations within half a day.

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Legends

Figure 1: Metastatic adenocarcinoma. Early scan on Dynapix instrument is equivocally positive for a right parietal lesion. Three hour delayed study on Magnascanner instrument is positive for a right parietal lesion which is subsequently only faintly visualized 21 hours later.

Figure 2: Metastatic lung carcinoma. Initial right lateral view on Magnascanner machine is positive for two lesions; anterior and posterior views equivocal for left-sided lesion. Three hour delayed examination on Dynapix scanner is positive for additional lesions.

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TABLE 1
PRIMARY BRAIN TUMORS

<u>TISSUE TYPE</u>	<u>TOTAL</u>	<u>SCAN RESULTS</u>			
		<u>Initial Studies</u> negative & equivocal (0-1 hours)	<u>Delayed Studies</u> positive 1-7 hrs.	positive 18-24 hrs.	<u>Number</u> Missed
ASTROCYTOMA (all grades including Glioblastoma Multiforme)	25	3	2	1	1
ACOUSTIC NEUROMA	3	2	2		
MENINGIOMA	1				
CHROMOPHOBE ADENOMA	2				1
OCCIPITAL HEMANGIOMA	1				
CHONDROMA	1				1
ANGIOBLASTOMA	1				1
CHONDROSARCOMA	1	1			1
EPENDYMOMA	1				
NO TISSUE DIAGNOSIS AVAILABLE (1)	4				
	40	6	4	1	5

(1) Cases in which clinical evidence, brain scan results and neuroradiological evaluation were strongly suggestive of a primary brain tumor but surgery or autopsy was refused.

TABLE II
METASTATIC BRAIN TUMORS

<u>TISSUE TYPE</u>	<u>TOTAL</u>	<u>SCAN RESULTS</u>			
		<u>Initial Studies</u> negative & equivocal (0-1 hours)	<u>Delayed Studies</u> positive 1-7 hrs.	<u>positive</u> 18-24 hrs.	<u>Number</u> <u>Missed</u>
LUNG CARCINOMA	14	2	2		1
BREAST CARCINOMA	6	3	3		
MALIGNANT MELANOMA	5				
ADENOCARCINOMA OF UNKNOWN ORIGIN	4	2	2		
POORLY DIFFERENTIATED CARCINOMA OF UNKNOWN ORIGIN	2				
RETICULUM CELL SARCOMA	2	1		1	
RECTAL CARCINOMA	1				
GASTRIC CARCINOMA	1				
SALIVARY GLAND CARCINOMA	1				
TONSILAR FOSSA CARCINOMA	1				
TONGUE CARCINOMA	1				
PRIMARY AND TISSUE TYPE UNKNOWN (2)	2	1	1		
	<u>40</u>	<u>9</u>	<u>8</u>	<u>1</u>	<u>1</u>

(2) Cases in which clinical evidence combined with brain scanning results were overwhelmingly in favor of metastatic brain disease.

Fig 1

IMMEDIATE

3 HOUR DELAY

24 HOUR DELAY

M.B., ♀, 49

99

Fig 2

IMMEDIATE

DELAYED

E.P., ♂, 58