DIAGNOSTIC NUCLEAR MEDICINE

A Comparison of Brain Imaging with Gamma Camera, Single-Photon Emission Computed Tomography, and Transmission Computed Tomography: Concise Communication

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We have evaluated the utility of a single-photon axial tomographic scanner (ECT) in brain imaging, using routine tracers in 238 patients. When compared with routine delayed gamma-camera images (DGCI), there was agreement in 191 negative studies and 39 positive studies. Four patients had positive DGCI and negative ECT studies, and four had positive ECT and negative DGCI. In the 102 patients in this series who also had transmission CT (TCT) studies, there were five who had positive emission studies and negative TCT, and 38 with an abnormal TCT and normal ECT. The ECT was occasionally helpful in distinguishing brain and skull metastases, in better portrayal of deep lesions, and in resolving equivocal DGCI findings. For the ECT to become clinically rewarding, however, we feel that it will need development of new tracers that will provide functional information in addition to that already attainable by routine gamma-camera images.

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We are currently evaluating a single-photon tomographic brain scanner. Of particular interest to us is the question of how much its use would add to the information obtained from our standard gamma-camera images or transmission computerized cranial tomograms (TCT). We report here the results with our first 238 patients.

MATERIALS AND METHODS

The ECT unit* uses 12 detectors arranged in a circular array. Each detector has a focused collimator (focal length 15 cm), NaI crystal (8 × 5 × 1 in.), light pipe, photomultiplier tube, amplifier, and pulse-height analyzer. Each detector scans half of the field of view and, with its mate on the opposite side of the ring, makes a rectilinear scan. Six such scans are made simultaneously through the same plane. The image produced is a reconstruction formed by combining the six scans. The input is corrected for off-axis radiation by a mathematical "filter." The resulting image is then presented, along with a more smoothed image derived from the same input (*1*). For clinical studies we used an upper window of 91%, no contrast enhancement, and 30% background subtraction. Scanning time was 4–5 min for each of six to eight adjacent slices. ECT imaging was begun immediately upon completion of the delayed gamma-camera images (DGCI).

The radiopharmaceuticals used were $^{99m}TcO_4^-$ and Tc-99m glucoheptonate (GH). Two early cases were done with Tc-99m DTPA. The adult dose was 20 mCi of Tc-99m, and appropriate reductions, based on weight, were made for children.

Our routine studies included a radionuclide cerebral angiogram done in the AP projection with a frame rate of 2 sec using a high-sensitivity parallel-hole collimator. The delayed gamma camera images (DGCI) were started 60–90 min after injection of Tc-99m GH or 180 min after pertechnetate. An information density of 2000

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TABLE 1. COMPARISON BETWEEN ECT AND DGCI

		DGCI +	DGCI −
ECT	+	39	4
	−	4	191

TABLE 2. COMPARISON BETWEEN TCT AND DGCI

		DGCI +	DGCI −
TCT	+	23	38
	−	3	38

TABLE 3. COMPARISON BETWEEN TCT AND ECT

		ECT +	ECT −
TCT	+	22	39
	−	4	37

was acquired over the cranium, and the images were recorded on transparent film using a triple-lens camera. The DGCI included anterior, posterior, both lateral, and vertex views. For the delayed images, a high-resolution parallel-hole collimator was used. A current-generation, 37-phototube camera was used for all of these studies.

Transmission computerized tomograms were done either EMI 1005 at 140 kvp† or at 120 kvp‡. Routinely studies were done with and without contrast. The window level was +36 and the window width 100 EMI units. Most of the TCT studies were done within 2 days of the radionuclide studies. None of the cases in which there was disagreement between the ECT studies and TCT were done more than 4 days apart.

The patient population is neither a random nor a successive series. Initially patients were referred for evaluation with known intracranial lesions. Subsequently we have tried to include an emission computed tomographic study in the evaluation of all patients referred to the nuclear medicine laboratory for brain scans, but some have been missed because of ECT down time or conflicts with outpatient scheduling.

RESULTS

The comparison between routine DGCI and ECT studies is shown in Table 1. There was agreement in 191 negative studies and 39 positive studies. Four studies were read as positive (or "possible increased uptake") on the routine DGCI and negative by ECT. Two were cases with skull lesions, one of metastases seen also on TCT and one uptake in a solitary lesion seen as a lucency on plain skull films and assumed benign. Two recent CVA lesions were also confirmed by TCT.

The ECT study was positive (or suggestive) in four cases where the DGCI were normal. Three were cases of CVA that were confirmed by TCT (Fig. 1). One was a case of encephalitis in which the routine DGCI and TCT were normal but the ECT showed increased activity in the left temporal lobe. There were no true-positive results on the vertex view not demonstrated by routine four-view DGCI and ECT.

Of the 102 patients in these series examined by TCT, (Tables 2 and 3), 61 were positive and 41 were negative.

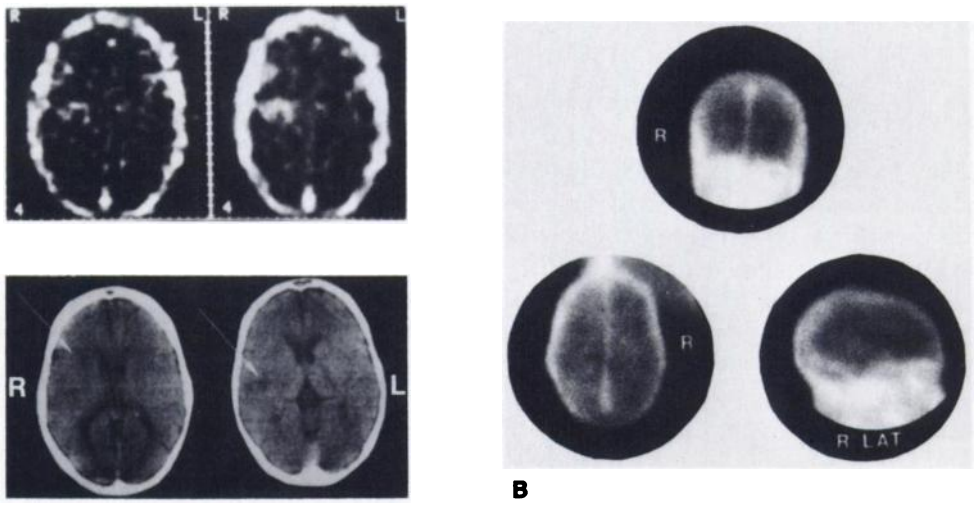

FIG. 1. (A) ECT study above with increased uptake corresponding to area of decreased density (arrow) on TCT study below. (B) Normal DGCI.

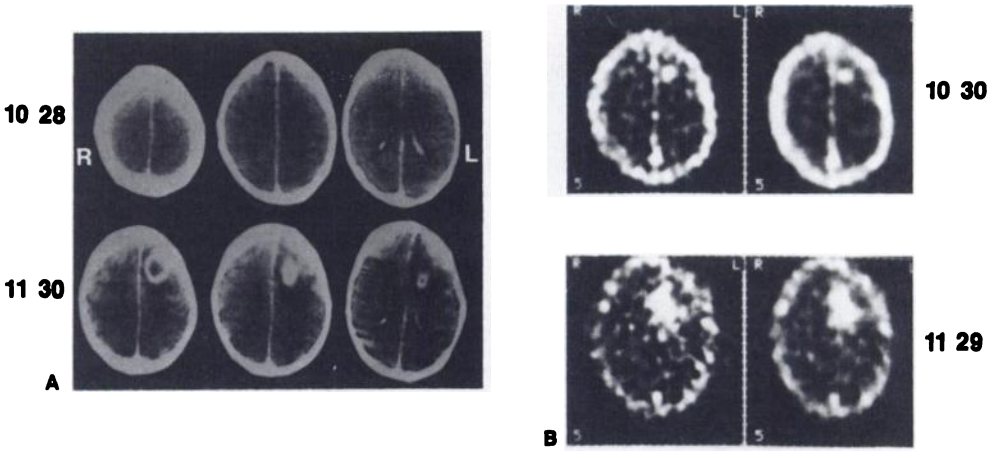

FIG. 2. (A) TCT studies both with infusion of contrast. Negative study 10/28, positive 11/30. (B) ECT studies at approximately same time. Positive on both studies.

Of these 41 negatives, 37 were also negative by DGCI and ECT. Of the three positive by DGCI and negative by TCT, two had skull lesions, one a metastasis (positive also on ECT), and one a clinically benign lesion that appeared as a lucent area on plain skull films (negative on ECT). In addition, there was one glioblastoma (Fig. 2) that was positive on both DGCI and ECT but was negative 24 hr earlier on TCT with and without infusion. The two additional cases in which the ECT was positive and the TCT negative were: (a) a CVA that was negative by TCT 3 days before but positive 3 days after the ECT (DGCI was negative at the time the ECT was positive); and (b) the case of encephalitis, which was negative by TCT 3 days before and 4 days after the radionuclide studies.

Of the 61 positive TCT studies, 22 were positive on ECT and 23 on DGCI. The negative radionuclide studies associated with positive TCT scans are listed in Table 4. Most of these represent lesions that one would not expect to detect with current radionuclide imaging.

The experience with brain tumors, including primary and metastatic lesions, is given in Table 5. The two cases missed by both radionuclide studies were on high-dose steroids at the time of the studies. Of the 17 tumor patients scanned by TCT, there was one false negative. The scans were done both with and without infusion and were negative even in retrospect. The lesions was readily demonstrable by TCT 1 mo later.

The experience with recent CVAs (scanned within 21 days of onset of symptoms) is tabulated in Table 6. There were six negative studies with DGCI and five negatives on ECT. Of the false-negative emission studies, one is explained by the patient's having been on steroids. In three of the other five recent CVA studies negative by DGCI, the ECT was positive. Two of the negative ECT studies had positive DCGI studies. The two cases in

TABLE 4. NEGATIVE RADIONUCLIDE SCAN WITH POSITIVE TCT

	DGCI	ECT
Atrophy	6*	7
Remote infarct	11	11
Communicating hydrocephalus	5	5
Tumor	2†	2†
CVA (recent)	6	6
Base-of-skull lesions	2	2
Other	5	5
False-positive TCT	1	1

* One false-positive due to hot PM tube.
† On steroids at time of scan.

TABLE 5. COMPARISON OF IMAGING TECHNIQUES IN TUMOR CASES

	Positive	Negative	Not done
DGCI	23	2*	0
ECT	23	2*	0
TCT	16	1	8

* On steroids.

TABLE 6. COMPARISON OF IMAGING TECHNIQUES IN RECENT CEREBROVASCULAR ACCIDENTS

	Positive	Negative
DGCI	6	6*
ECT	7	5*
TCT	12	0

* One patient on steroids.

TABLE 7. COMPARISON OF VERTEX-VIEW DGCI WITH ROUTINE DGCI

		DGCI +	DGCI −
Vertex	+	25	0
	−	11	191

TABLE 8. COMPARISON OF VERTEX-VIEW DGCI WITH ECT

		ECT +	ECT −
Vertex	+	39	1*
	−	4	191

* False-positive due to hot PM tube.

which both the DGCI and ECT studies were negative can be explained by early imaging after the CVA (2 and 3 days). No proven CVAs were missed by TCT.

There were two patients with chronic subdural fluid collections. Both were seen on ECT and DGCI. One was not detected initially on TCT but was apparent in retrospect.

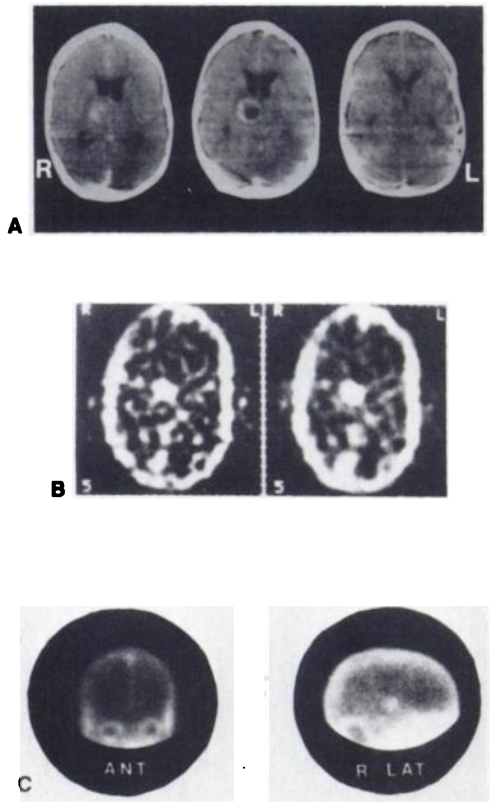

FIG. 4. (A) TCT study with infusion. (B) ECT study showing depth of lesion as well as TCT study. (C) Lesion apparent on lateral DGCI but depth uncertain.

DISCUSSION

Although vertex views have not been a routine part of our brain scans in the past, they were included in this study because we felt that this view might most closely approximate the ECT. As can be seen in Tables 7 and 8, many abnormal cases were not seen on the vertex view. It was not nearly as sensitive as the ECT or routine DGCI. This was probably due to the increased volume of skull and brain included in the vertex camera image and overlay of activity in oro-facial structures. In no case was the vertex view positive when the ECT or routine DGCI was negative.

When the results of ECT and DGCI are compared, the most striking result is the number of cases in which

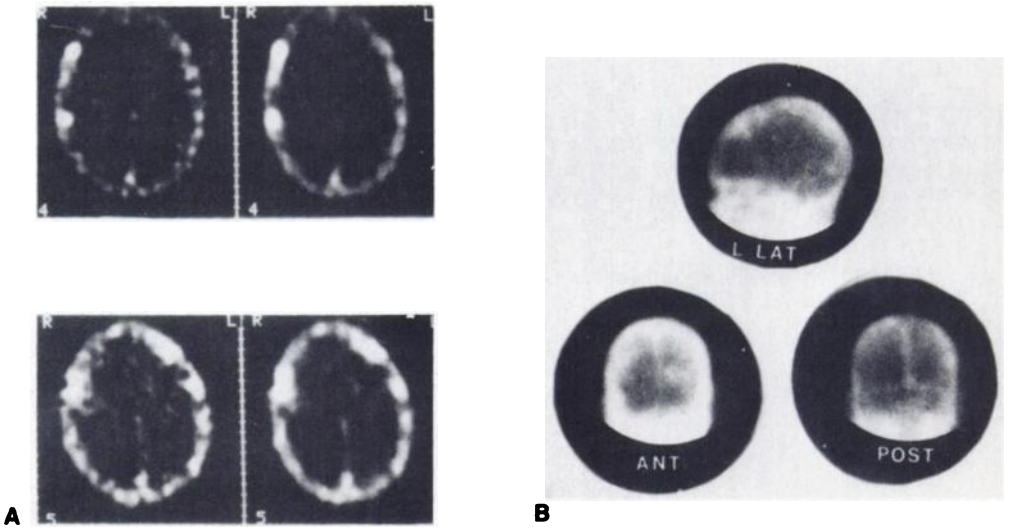

FIG. 3. (A) Multiple discrete areas of increased activity confined to skull on ECT. (B) Multiple areas of increased uptake with depth of some uncertain on DGCI.

there was agreement. There were only eight cases in which one technique was positive and the other negative. These were evenly divided between the ECT and the DGCI. There is no significant difference in detection rate when the two imaging systems are compared. It follows then that when either of the emission techniques is compared with TCT, the results will be similar. If the target-to-background ratio is high, the lesion will probably be detected by either imaging system. If not, neither will detect it.

There are some areas in which the ECT did provide useful, complementary information in addition to the four cases where it detected lesions not seen on DGCI. The most useful has been its ability to distinguish better between skull and brain metastases (Fig. 3). There were five cases in this series in which the ECT was helpful in that determination. It was also helpful in confirming the depth of an intracerebral lesion (Fig. 4). It was felt that in two patients in this series, the ECT defined the depth of the lesion more definitively than did the DGCI. In one case, the ECT was able to define a second lesion when only one was seen on the DGCI, thus suggesting the correct diagnosis (cerebral metastases) rather than a primary brain tumor. Finally the ECT has proven helpful in that very subjective realm of confidence in interpretation and is currently relied on when equivocal abnormalities are seen on DGCI. Another area in which ECT might be helpful is the earlier detection of recurrent tumor associated with a prior craniotomy. Unfortunately, our limited material has not given us enough information to decide on its utility in this area.

At present it is our impression that the ECT does not add enough clinically useful information to warrant the added cost and time its use entails. We do feel, however, that as new radiopharmaceuticals are developed that can add metabolic and physiopathologic information to the excellent anatomic information available from TCT, current ECT units have the potential for the detection and quantification that would be needed for such studies.

FOOTNOTES

* Cleon 710
† EMI 1005
‡ Delta 2020

REFERENCE

1. STRELZOFF A: The radionuclide brain imager. *Imaging Systems* 1:4-7, 1978