Comparison of the Anger Tomographic Scanner and the 15-in. Scintillation Camera for Gallium Imaging

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The Anger longitudinal emission multiplane tomoscanner and a 15-in. Anger camera with multipeak spectroscopic capability were compared in a series of 51 patients. The tomoscanner was preferred in 49%, the camera in 12%, and 39% were equivalent. The tomoscanner preference is statistically significant ($p < .025$). These data support the conclusion that the Anger multiplane tomographic scanner is the instrument of choice for gallium-67 imaging.

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The Anger tomographic multiplane scanner† is a relatively new gamma-imaging device that provides three-dimensional information. Its detectors consist of Anger cameras with NaI(Tl) crystals 8½ in. in diameter and 1 in. thick, seven 3-in. photomultiplier tubes, and a focused collimator. The standard scintillation camera's positioning electronics produce two-dimensional information in the X and Y axes. Planar localization along the Z (depth) axis is made possible through the movement of image elements horizontally across the camera face as the detector traverses the scanning field in rectilinear fashion. By correlation of detector speed with the direction and speed of movement of activity across the cathode-ray tube, the depth of the source can be determined. These data are assimilated electronically and used in the simultaneous production of 12 pictures, each of which is in sharp focus at a different depth plane (*1*).

The tomographic capabilities of the multiplane scanner offer several theoretical advantages. Longitudinal section scanning should enable the delineation of deep structures despite the intervening superficial activity that might otherwise obscure underlying anatomy. It should provide more precise localization of both normal and diseased structures; and it should increase lesion detectability, since the contrast is improved over a wide range of depths.

Although gallium-67 citrate is currently the agent of choice for tumor and abscess scanning, it is far from an ideal radionuclide for imaging with current instrumentation. Gallium-67 has four principal gamma emissions: 93 keV (40%), 184 keV (24%), 290 keV (22%), and 388 keV (7%). The use of the higher-energy peaks for imaging is desirable not only to increase sensitivity, but to improve resolution, since they include less scatter. The 1-in.-thick crystal of the tomoscanner is more efficient at the 290- and 388-keV peaks of gallium than the thinner crystal in conventional cameras.

After i.v. administration, approximately 30% of gallium in the blood is protein-bound. This significantly impedes blood clearance, and about 10% is still in the plasma at 24 hr. Twenty-five percent of the total dose is excreted in the urine in 24 hr and 10% in the stool in the first week. At 48–72 hr after injection—generally considered the optimum time for scanning—significant concentrations of gallium are still present in the liver, spleen, kidney, and bone (*2*). The high blood background, and concentration in normal structures, frequently obscures abnormalities. Tomographic capability thus is of particular potential benefit in these instances (*3*).

To see whether the tomoscanner achieves this potential, the present study was designed to evaluate clinically the relative merits of the tomoscanner and the 15-in. scintillation camera with multiple windows. We agree with Hoffer et al. that the latter

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instrument provides as good Ga-67 images as any commonly used device (*4*), and thus is an effective comparison standard.

MATERIALS AND METHODS

Patient selection. From October 1, 1976, to March 31, 1977, 51 subjects were entered into the study. The series was not consecutive, since entry depended upon availability of both tomoscanner and 15-in. camera. In addition, each patient must be well enough to tolerate, without undue discomfort, the additional time necessitated by duplicate imaging. Since all data analysis was performed only after completion of both studies, however, we know of no selection bias other than the patient's ability to cooperate. Patient consent was routinely obtained.

Method. Each subject was injected intravenously with gallium-67 citrate. The dose administered was based on the clinical indication for the study: 6 mCi for infection and 10 mCi for tumor. The patients were routinely imaged initially at 48 hr, unless an infection was suspected, in which latter case earlier imaging 6 or 24 hr) was occasionally done. Repeat studies were done on subsequent days if necessary (e.g., inadequate bowel preparation, confirmation of suspicious area, etc.). Although the tomographic examination was usually a wide-area body survey (e.g., chest and abdomen for abscess; head to upper thigh for tumor), the area of the body to be compared on the 15-in. camera were limited to the specifiic regions of interest as determined by the nuclear medicine physician in light of the clinical symptoms and tomoscanner image. Multiple views of all areas of interest were obtained on the camera. The comparison studies on the tomoscanner and camera were performed within 1 hr of each other. These logistics dictated that the tomo examination preceded the companion camera study in virtually all cases except those in which the patient was being reexamined and the area of interest was known.

Details of imaging. Although two different cameras with 15-in. field of view were used, most of the patients were examined with the Searle LFOV with Microdot and a medium-energy parallel-hole collimator. Three 20% pulse-height windows accepted the energy peaks at 93, 184, and 296 keV, with 500,000 counts per image. Alternatively, a Picker 4/15 with a high-energy parallel-hole collimator was used, with the two 20% windows, at 184 and 296 keV, and 400,000 counts per view. With the tomoscanner, a 380-keV, medium-resolution collimator with 3.5-in. focal length was used; 20% windows covered the 184- and 296-keV peaks, the scan speed was 250 cm/min, and the line spacing 3 mm. The width setting for the focal plane was determined by patient thickness.

Data analysis. Two experienced nuclear medicine physicians with prior knowledge of the clinical history examined the readouts from the two different instrument systems together for each individual case. A subjective evaluation of the image was based on the comparative clarity of anatomic topography, whether normal or abnormal. The images were classified into three categories: 1. tomoscan image preferred; 2. 15-in. camera image preferred; 3. the two images considered equivalent. The subjects were subdivided into normal or abnormal on the basis of the scan interpretation. The results were tabulated and subjected to statistical analysis by means of a chi-squared test.

Results. In the group of 18 normals, the tomoscanner appeared to be more frequently preferred than the camera, but this was not of statistical significance, possibly due to the small size of the population. For the 33 abnormals, a statistically significant ($P = .05$) preference for the tomoscanner occurred. Since the preference distribution within the three categories was similar in both normals and abnormals, the two groups were consolidated and analyzed. In the total group of 51 cases, the tomoscanner was favored in 25 and the camera in six; the remaining 20 were considered equivalent (Table 1). This preference was statistically significant ($P < .025$).

DISCUSSION

By nature of its physical properties and biologic distribution, gallium-67 is difficult to image with current imaging devices. The tomographic capability of the multiplane scanner is particularly suited to gallium imaging.

For all tomographic studies, our study protocol designated a fixed scanning speed, which is appropriate for imaging over the thorax and abdomen at 48 hr postinjection. Therefore, in areas of lower count rates, diminished information density, with resultant image degradation, may be anticipated. The camera in preset-count mode, on the other hand, compensates for low count rates by increasing imag-

TABLE 1

	Normal	Abnormal	Total
Tomoscan preferred	7 (39%)	18 (55%)	25 (49%)
Camera preferred	2 (11%)	4 (12%)	6 (12%)
Equivalent	9 (50%)	11 (33%)	20 (39%)
Total	18	33	51
Significance	N.S.	$P = .05$	$P < .025$

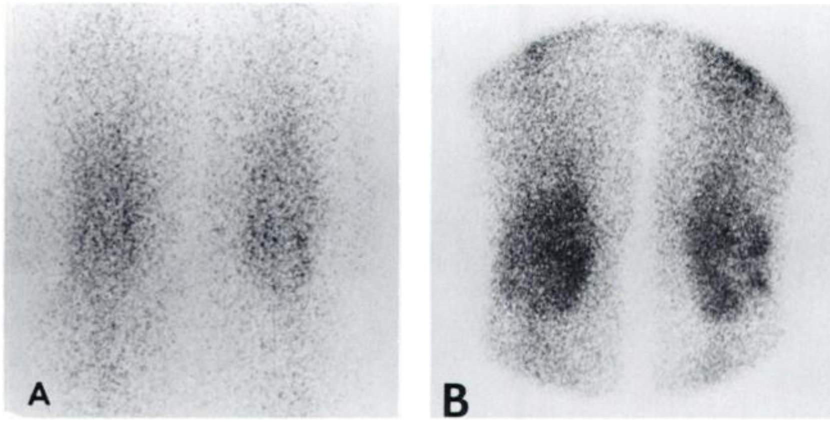

FIG. 1. Since tomoscanner technique was optimized for thorax and abdomen, extremities were often poorly imaged. Camera, in preset-count mode, has no such limitation. (A) Tomoscan of knees. (B) Fifteen-inch camera view of same area. Camera clearly shows more anatomic detail.

ing time. Review of the six cases in which the camera is superior shows that five of them involved the scanning of low-activity regions—either examination of the extremities (three patients), or significantly delayed imaging (two patients). In the former instance, the ability of the camera to view with ease multiple projections of thin, easily placed extremities makes it eminently suitable for visualization of the peripheral skeleton. Thus we believe the camera is still the best device for the imaging of the extremities (see Fig. 1).

The tomographic scanner is most helpful in the abdomen and the thorax, where the tomographic effect is valuable. In this series, the identification of deep structures by the tomoscanner is definitely superior to that of the camera. Indeed, normal pulmonary hila and kidneys are fairly consistently seen only with the tomographic unit. In addition, the ability to localize in the anteroposterior direction proves to be of greatest value in the abdomen and thorax, particularly in the postsurgical patient where recent incisions can be extremely confusing (see Fig. 2). Finally, the problems associated with colonic gallium or the superposition of two lesions are decreased with tomography. This is especially true in or near the mid-line where lateral views are least helpful with the gamma camera.

In summary, we believe that the Anger tomographic multiplane scanner is the instrument of choice for gallium scanning. Its tomographic capability, allowing separation of superposed structures with improved contrast at depth, is particularly valuable in the abdomen and the thorax.

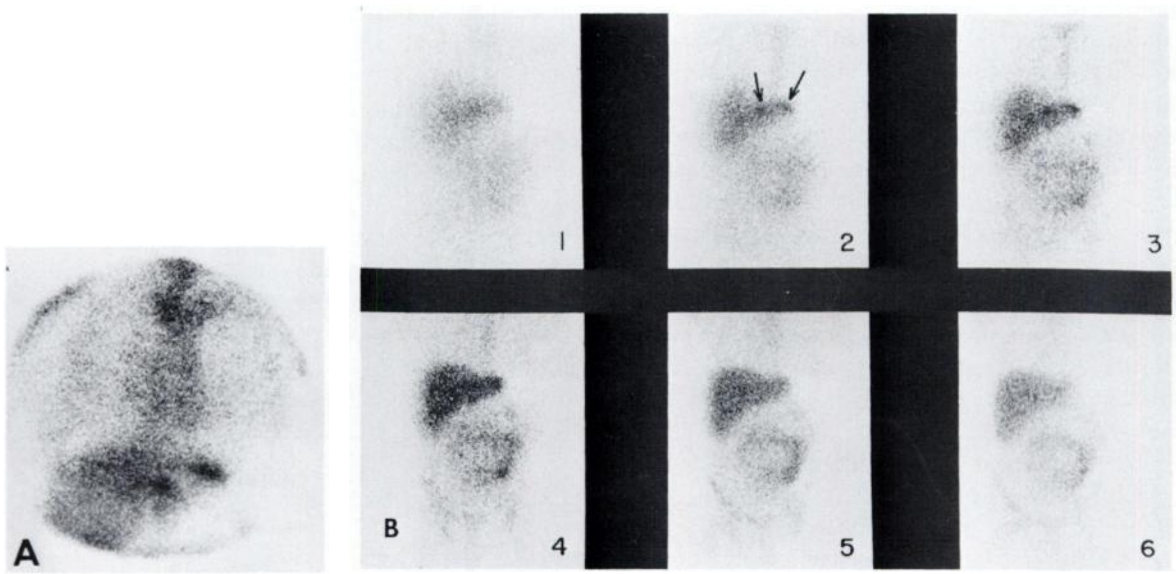

FIG. 2. Patient was referred 1 wk postsurgery for ruptured duodenal ulcer with suspected abdominal abscess. (A) On this anterior camera view, two foci of increased uptake, in region of left lobe of liver, could easily be interpreted as hepatic abscesses. (B) Tomoscan clearly demonstrates that uptake lies anterior to the liver, since it is in best focus in Plane 2 (arrows), whereas liver begins to come into focus in Plane 3 and is in best focus in Planes 4–6. In fact, lesions correspond to sites of uppermost retention sutures. Two weeks later, repeat examination showed no uptake in these areas.

FOOTNOTE

† Searle Radiographics/Pho Con, Des Plaines, Ill.

REFERENCES

1. ANGER HO: Tomographic gamma-ray scanner with simultaneous readout of several planes. In *Fundamental Problems in Scanning*, Gotttschalk A, Beck RN, eds, Springfield, Ill, Charles C Thomas, 1968, pp 195–211

2. LARSON SM, MILDER MS, JOHNSTON GS: Tumor-seeking radiopharmaceuticals: Gallium-67. In *Radiopharmaceuticals*, Subramanian G, Rhodes BA, Cooper JF, Sodd VJ, eds, New York, Society of Nuclear Medicine, 1975, pp 413–434

3. WINCHELL HS, SANCHEZ PD, WATANABE CK, et al: Visualization of tumors in humans using ^{67}Ga-Citrate and the Anger whole-body scanner, scintillation camera and tomographic scanner. *J Nucl Med* 11: 459–466, 1970

4. HOFFER PB, SCHOR RA, ASHBY D, et al: Comparison of Ga-67 citrate images obtained with rectilinear scanner and large-field Anger camera. *J Nucl Med* 18: 538–541, 1977