nm/PRELIMINARY NOTE

^{99m}Tc POINT SOURCE FOR TRANSMISSION SCANNING

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Simultaneous transmission-emission scanning was introduced by Kuhl as an aid to accurate keying of the emission image to patient anatomy (*1*). The commonly used radiation sources for transmission scanning have been ^{125}I (27-keV x-rays, 60-day half-life) and ^{241}Am (60-keV gamma rays, 460-yr half-life). Transmission imaging with the scintillation camera using ^{99m}Tc (140 keV gamma rays, 6-hr half-life) as the transmission source was recently reported by Anger and McRae (*2*). The transmission source consisted of a uniform distribution of ^{99m}Tc solution covering the full field of view of the camera crystal. We have developed a technique for making point sources of ^{99m}Tc usable for transmission imaging in rectilinear scanning procedures.

MATERIALS AND METHODS

The ^{99m}Tc source activity is contained on a small column of ion-exchange resin (Dow 21K, 50–100 mesh, J. T. Baker Chem. Co., Phillipsburg, N.J.) at the center of a lead and stainless-steel holder (Fig. 1). The holder is cylindrical with an outside diameter about 2.5 cm and length about 3.2 cm. The dimensions of the resin column are 3-mm dia × 6-mm long. A piece of 150-mesh stainless-steel screen at each end of the column holds the resin in place. The chambers at the ends of the column and the column itself are sealed in an air-tight manner with rubber O-rings and diaphragms as shown in Fig. 1.

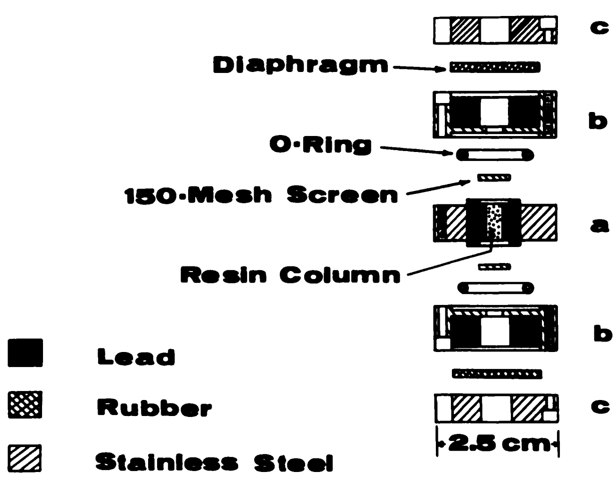

FIG. 1. Cross-section view of ^{99m}Tc point source. Piece b fastens to piece a, and piece c fastens to b, each with three Allen-head screws on common diameter.

The resin is activated by passing the eluate from a ^{99m}Tc generator (from Squibb or Neisler) through the column. Radioactive solution is injected through the rubber diaphragm and into the chamber at one end of the column with a syringe and needle and is continuously withdrawn from the chamber at the opposite end with another syringe and needle or with a needle and flexible tubing connected to an evacuated collection vial. A 30-cc sample of ^{99m}Tc solution passes through the column in about a minute when a 30-cc evacuated collection vial is used.

Lead was used in the fabrication of the source holder to reduce radiation leakage through the sides of the holder. The lead pieces are press-fitted into the stainless-steel outer shell to maintain the air-tight seal. The remaining metal components are stainless steel to eliminate rusting.

The construction of the source holder permits easy replacement of the rubber diaphragms, stainless-steel screens or the resin column itself, should this be necessary. A ^{99m}Tc transmission source of the type described has been in use in our laboratory for about 3 months. After about 20 activations it was necessary to replace the rubber diaphragms at each end of the source column, but it has not yet been necessary to replace any of the other components of the source or of its holder.

The extraction efficiency of the resin column was determined at each activation of the source by measuring the activity of the ^{99m}Tc solution before and after passage through the resin column. The range was 35–65%, and typically it was about 50%. There was no systematic change in the efficiency with use. Passing the eluate through the column the second time increased the over-all efficiency to about

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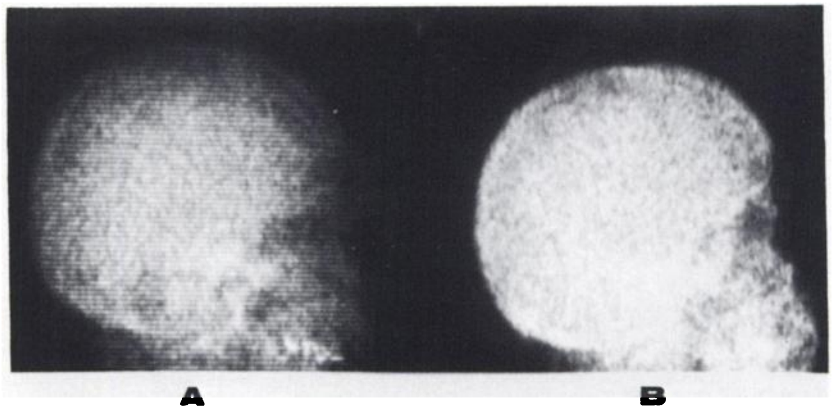

FIG. 2. Comparative transmission scans of skull with 30 mCi ^{99m}Tc (A) and 125 mCi ^{241}Am (B) on rectilinear scanner.

75%. The efficiency could be increased by using a column with a larger resin volume. In an earlier version of the source the size of the resin column was ¼-in. dia × ¼-in. long, and the extraction efficiency was consistently 80–90%. The size of the column was subsequently made smaller to improve the resolution of transmission images.

RESULTS

Comparative transmission images of the skull were obtained with a 30-mCi ^{99m}Tc source and with a 125-mCi ^{241}Am source on a conventional dual-headed rectilinear scanner (Ohio-Nuclear Model 54FD) (Fig. 2). The source-detector separation was about 30 cm for both scans. A straight-bore collimator, 3-mm dia × 50-mm long, was used on the detector for the ^{99m}Tc scan. Transmitted counting rates averaged about 15,000 cpm through the skull. The ^{241}Am source gave only about 1,000 cpm under the same conditions so the collimator aperture diameter was increased to about 6 mm for the ^{241}Am scan to give a more usable level of 4,000 cpm. The scanning speed was 250 cm/min for both scans, and the comparative information densities of the two scans were 100 counts/cm^2 (^{241}Am) and 400 counts/cm^2 (^{99m}Tc).

The information density of the ^{99m}Tc scan could be increased significantly by loading the source with more activity. Our present source was activated to 70-mCi activity without difficulty. The activity of available ^{241}Am sources is limited to about 125 mCi. This is an inherent limitation of the ^{241}Am source material because of its low specific activity and high self-absorption of 60-keV gamma rays.

The ^{99m}Tc point source was also used to obtain good-quality transmission images of the chest. However, attempts at outlining bony structures in the pelvis were not successful because of the low differential in absorption between bone and soft tissue. The usefulness of ^{99m}Tc as a transmission source thus appears to be best for outlining dense bones such as the skull and for outlining air spaces such as those in the chest.

To use ^{99m}Tc as the transmission source in conjunction with ^{99m}Tc emission scanning it would be necessary to use a dual-headed scanner with opposing detectors. A separate detector is required for each image since there would be no way of distinguishing transmitted from emitted photons with a single detector. To obtain directly superimposable transmission and emission images with a dual-probe scanner, the transmission source would be placed directly over the center holes of the focusing collimator on the emission detector. This would require careful shielding of the emission detector from the transmission source.

For this reason a 5-mm thick × 25-mm dia lead shield was made to be placed over one end of the transmission source. With this shield in place it was observed that the ^{99m}Tc source could be placed directly over the center holes of the emission-detector focusing collimator with a negligible increase in background counting rates. The focusing properties and efficiency of the collimator were somewhat disturbed in this arrangement with the efficiency of the collimated 5-in. dia emission detector being reduced by about 15%. The results suggest, however, that simultaneous transmission-emission scanning with ^{99m}Tc as the only source is possible on a dual-headed scanner.

ACKNOWLEDGMENT

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