Determination of the Pleural Edge by Gamma-Ray Transmission Computed Tomography

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A technique is described for transaxial imaging of the thorax during pulmonary perfusion study. The contours of the air-containing lungs were obtained by gamma-ray transmission data from a Tc-99m plane flood source. These images were overlaid on the emission tomogram of the pulmonary blood flow obtained with Tc-99m MAA. It permits reliable detection of peripheral perfusion defects. Use of the results from these measurements can be applied to evaluate marginal hypoperfusions of the lungs.

J Nucl Med 22: 815–817, 1981

Delineation of the lung margin is always a frustrating clinical problem in the study of distribution of pulmonary blood flow with Tc-99m macroaggregates of human serum albumin (MAA). Central or segmental defects are rather easily demonstrated by comparison with adjacent normal segments, but marginal hypoperfusions are not definitive, either in plain images or by emission CT (ECT) studies (*1*).

A new approach to delineate the lung margin is attempted by using a transmission computerized tomogram (TCT) from a Tc-99m plane flood source in conjunction with the ECT. The 140-keV gamma emission of Tc-99m is less absorbed in the lungs filled with air than in the surrounding organs, which permits visualization of the rib cage (*2–4*). In this method, the cross-sectional images of the rib cage can easily be overlaid on those of the perfusion study without any dimensional corrections, since the patient does not have to be moved.

METHOD

Transmission images were obtained by using a Tc-99m plane flood source rotating around the patient. The source consisted of a Plexiglas vessel, inner diameter 50 cm and thickness 2 cm, filled with a solution containing 20–30 mCi of Tc-99m. The source was fixed to the camera carriage, on the opposite of the patient, as shown in Fig. 1. Transmission images were taken at 64 equally spaced angles around the patient, with 10 sec for each step. After the TCT study, the source was removed, care being taken not to move the patient, then 3–5 mCi of Tc-99m MAA was administered intravenously, and the patient was imaged at the same 64 angles used for the transmission images.

The total study time, including both transmission and emission imaging, was approximately 30 min. After the reconstructions, the TCT and ECT images were superimposed by the computer. The computer processing time for each transverse section image

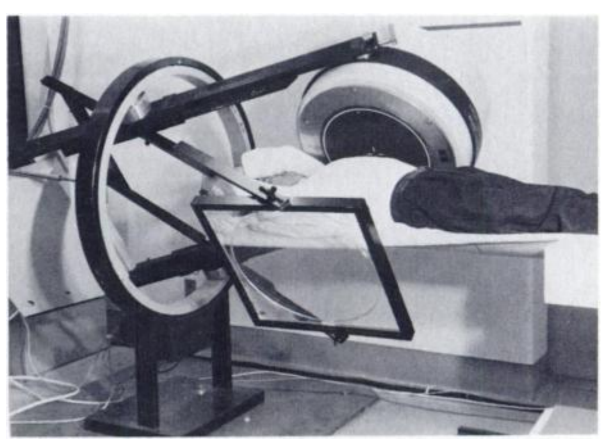

FIG. 1. Arrangement for transmission imaging. Plane flood source (Plexiglas vessel) and camera are attached to the rotating ring.

Received Jan. 29, 1981; revision accepted May 11, 1981.

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FIG. 2. Transverse TCT image of thoracic cage in a patient with pneumonia. Top is ventral side of thorax. This transverse section is about 17 cm below apex of lung.

FIG. 3. Pulmonary perfusion section by ECT at same level as shown in Fig. 2.

FIG. 4. Overlay of TCT and ECT images shown in Figs. 2 and 3. Wedge-shaped defect on lateral aspect of right lower lobe and hypoperfusion along pleural edge of left lung are delineated.

was 1 min, and time for superimposing ECT and TCT was 30 sec.

The determinations of the edges were carried out using the threshold method (*5*). Our phantom studies showed that thresholding of 20% for the thoracic cage and 35% for the perfusion study gave satisfactory results. Changing the threshold from 15 to 20% for the thorax and from 30 to 40% for the perfusion study did not materially influence apparent separations of the two pleural surfaces. After definition of the edge, nine-point smoothing (*5*) was used to reduce random noise.

Each image consisted of a 64 × 64 matrix of 6-mm squares. In the transmission image typical count rates fall from 40 cps per pixel from the naked source to about 7 cps/pixel through the lungs and ~3 cps through more compact organs. The reconstructed transverse image had a resolution of about 2.4 cm at FWHM. Each slice was 1.2 cm thick.

The radiation exposure to the patient from the source was approximately 30 mR/hr at the chest, so this procedure was considered reasonably safe.

RESULTS AND DISCUSSION

Figure 2 shows a Tc-99m TCT cross section of the thorax, and Fig. 3 an ECT perfusion study, from a 54-yr-old patient with pneumonia, the sections being 14 cm below the apex. The sides are as shown, and the sternum is at the top. Figure 4 shows the combined overlay. The thoracic cage and the mediastinal images are clearly delineated by the air-filled lungs of Fig. 2. A marginal defect was suspected at the right pleural edge in Fig. 3; this defect was more readily apparent in Fig. 4, where a diffuse hypoperfusion along the lateral margin of the left lung also became evident.

Figure 5 illustrates reconstructed pulmonary images at different levels from a 40-yr-old female with pulmonary fibrosis. Each slice has a thickness of 1.2 cm. The image at upper left is 5 cm below the apex and that at lower right is about 3 cm above the base of the lung. Shrinkage and peripheral perfusion defects were detected near the base of the left lung.

We adopted the transmission method to delineate the edges of the lung. Techniques have been proposed to display the margins, including x-ray CT (*6*) and ECT with rebreathing of a radioactive gas in a closed circuit. With x-ray CT, positional and dimensional corrections are indispensable, because the images of the pulmonary perfusion study are usually collected in a different facility. With the radioactive gas method, these corrections are not required,

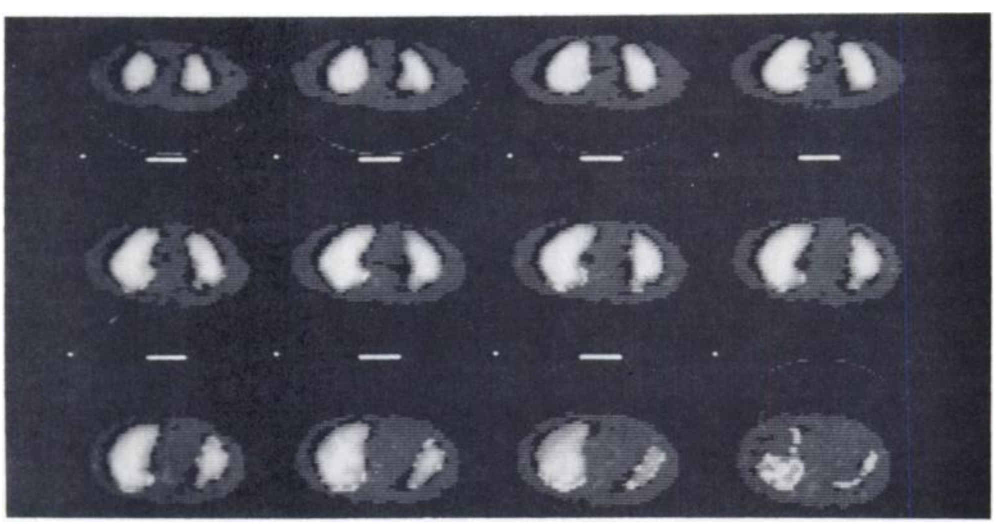

FIG. 5. Overlaid TCT and ECT images at different levels of lungs in patient with pulmonary fibrosis. Slice thickness is 1.2 cm. Images start at ~5 cm below apex (upper left) and end at 3 cm below base (lower right).

although a lung margin derived from ventilation does not always coincide with the anatomical edge. By using TCT in conjunction with ECT, marginal defects could be clearly delineated without any dimensional corrections.

Our preliminary studies showed a significant clinical potential for this simple technique. Thus, it can provide a powerful tool for detecting marginal hypoperfusions of the lung on routine lung scan. A further interesting application of this overlay approach is in the study of pulmonary physiology.

ACKNOWLEDGMENT

Grateful thanks go to Dr. K. Horiuchi for her kind supervision of our manuscript.

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