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THREE-DIMENSIONAL RECONSTRUCTION OF LUNG PERFUSION IMAGE WITH POSITRON DETECTION

D. A. Chesler, C. Hales, D. J. Hnatowich, and B. Hoop
Massachusetts General Hospital, Boston, Massachusetts

Transverse section images of the distribution of pulmonary perfusion in a canine have been obtained using microspheres labeled with the positron-emitting isotope ^{68}Ga and a three-dimensional reconstruction technique. The reconstruction method is more accurate than conventional tomographic procedures and is facilitated by the use of positron detection. The transverse sections presented demonstrate the capacity of the technique to delineate reduction in regional perfusion resulting from occlusion of the artery to the left lower lobe.

This paper demonstrates the use of three-dimensional reconstruction to obtain transverse section images in the canine lung. The reconstruction method used in the study is a convolutional technique, which has been previously described (*1,2*), and differs from conventional tomography in that images are produced without the characteristic tomographic blurring. Coincidence detection of positron annihilation radiation is particularly appropriate to three-dimensional reconstruction since (A) it is possible to compensate for photon absorption and (B) good resolution is achieved at all depths in the subject (*3*).

The three-dimensional distributions of radioactivity within a subject are obtained from a sequence of radionuclide scintigraphs taken at uniformly spaced angles around the patient. Using positron-emitting radioactivity, both a transmission image and an emission image are obtained at each angle. Each emission image is then corrected point-by-point for the effects of absorption determined from the corresponding transmission image. The corrected images are then processed on a PDP-9 computer (Digital Equipment Corp.) to provide the reconstructed transverse section images.

MATERIALS AND METHODS

Our laboratory has recently become interested in the development of radiopharmaceuticals labeled with ^{68}Ga. This radionuclide possesses a short 68-min half-life, yet is available as a generator product* by decay of its 280-day parent ^{68}Ge. The decay mode of ^{68}Ga is almost entirely by positron emission; for these reasons it is nearly ideal for use in studies employing the MGH positron camera for detection.

Human serum albumin microspheres, 10–30 microns in size, were prepared according to the procedure of Zolle, et al (*4*). In order to facilitate their labeling with ^{68}Ga, approximately 8% by weight of lanthanum was incorporated into the microspheres during their preparation.

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For reprints contact: David A. Chesler, Physics Research Laboratory, Massachusetts General Hospital, Boston, Mass. 02114.

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Images obtained in dogs following intravenous administration of the microspheres are identical to those obtained using ^{13}N-labeled molecular nitrogen for perfusion. Images obtained 6 hr after injection show that the gallium activity remains in the lungs during this period with negligible activity appearing in the liver.

The dog used in this study was anesthetized initially with 30 mg/kg of sodium pentobarbital and then ventilated 15 times per min by a Harvard Pump (Harvard Apparatus, Millis, Mass.) at a volume of 15 cc/kg. Three centimeters of positive end expiratory pressure were used to prevent collapse of the lung following the thoracotomy that allowed ligation of the pulmonary artery to the left lower lobe. After ligation of the artery, the dog was placed in the supine position between the heads of the camera and fastened securely to prevent movement.

A plane source consisting of a thin plastic vessel, large enough to cover the head of the MGH positron camera, was filled with a solution containing 1 mCi of ^{68}Ga and fixed to one face of the camera. With the dog in position for imaging, transmission images were taken at 23 equally spaced angles in a half circle about the animal. The images were stored on magnetic tape for future use in image reconstruction.

The plane source was then removed and 1 mCi of ^{68}Ga contained on 10 mg of microspheres was administered intravenously to the animal. In order to correct for lung motion during breathing, earlier studies were gated such that the animal was counted only during end tidal breath holds. However, it was found that this precaution was not necessary as tidal breathing did not significantly alter the images obtained. The animal was imaged at the identical 23 angles used to obtain the transmission images. The total study time, including both the transmission and emission imaging, was approximately 1 hr.

In order to compare the images of the occluded lung with that of the normal lung, the ligature on the left lower lobe artery was removed and the animal injected with a second preparation of ^{68}Ga microspheres. Four hours were allowed between injections to reduce the level of residual ^{68}Ga activity from the first injection. The animal was again imaged at the 23 intervals.

The computer processing time for each transverse section image was 1 min.

RESULTS AND DISCUSSION

Figure 1A shows scintigrams of the distribution of lung perfusion in a prone dog with and without occlusion of the pulmonary artery to the left lower lobe. The perfusion defect in the left lower lung is readily apparent in the image on the right of Fig. 1A. Figure 1B–D shows the reconstructed transverse images taken through the planes of the lung represented by the horizontal lines in Fig. 1A. In the latter figure the left lung is on the left and the anterior aspect of the chest is at the top of the image.

Figure 1B is a reconstructed image on a transverse plane just cephalad to the perfusion defect seen in Fig. 1A. Perfusion is slightly decreased on the left side. Figure 1C represents a plane through the cephalad aspect of the perfusion defect and demonstrates loss of perfusion to all segments of the left lower lobe. Faint perfusion persists anteriorly and represents the caudal aspect of the linqula. Figure 1D is the reconstructed image on a plane through the middle of the defect and below the linqula. The perfused area behind the heart represents continued blood flow to the infracardiac lobe of the right lung.

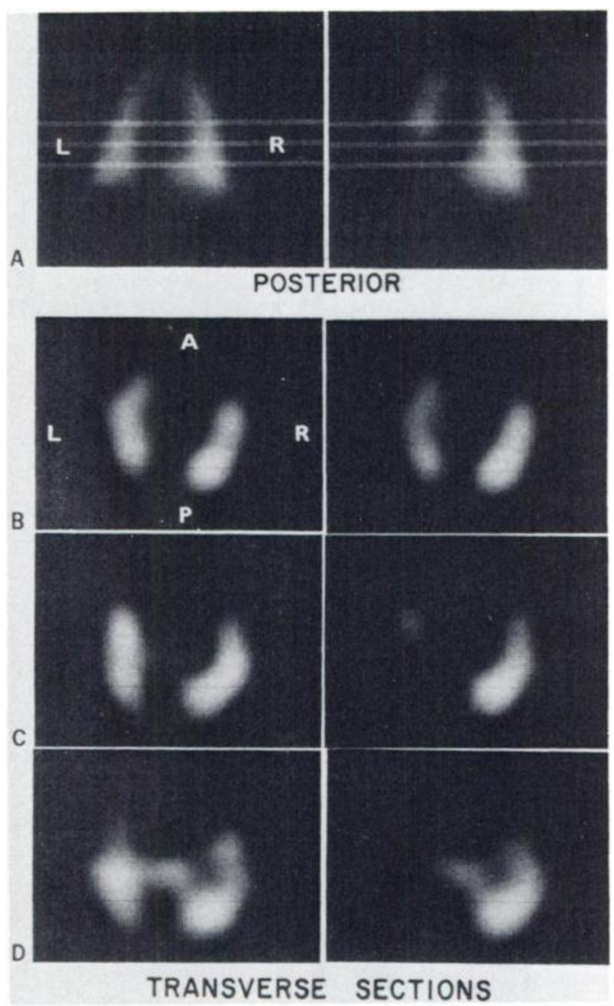

FIG. 1. Lung scintigrams with ^{68}Ga microspheres and positron annihilation coincidence detection. Images on left are of normal lungs; images on right show effect of occlusion in left lower lobe. Horizontal lines through P-A images (A) show position of transverse sections presented in (B–D).

The reconstructed three-dimensional images define distinctly the margins of the defect seen on the routine posterior-anterior view. This technique may find an application in human studies for delineating segmental from nonsegmental perfusion defects on the routine lung scans.

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