MULTIPLE-VIEW LUNG SCANNING

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In the short period since its introduction, lung scanning has become an important tool for diagnostic and physiologic studies of chest disorders (*1–6*). Its most valuable clinical application is in the diagnosis of pulmonary embolic disease. The importance of early diagnosis makes it necessary to scan the lung during the acute phase of pulmonary embolism when patients are frequently seriously ill. The simplicity and safety of the method make it particularly well-suited for use in this situation. A limiting factor, however, is the long time necessary to perform the study by conventional methods.

Initially it was believed that a single view, anterior or posterior, was sufficient for diagnosis, but subsequent experience has shown that multiple views are needed to study completely the pulmonary vasculature (*7,8*). Anterior and posterior scans were therefore obtained in *sequential* fashion. Completeness of the scan, however, was attained at the expense of still greater scanning time, generally 40–60 min. The further addition of one or two lateral views virtually became prohibitive in dyspneic patients. It became apparent then that improved methods were necessary to provide complete lung scans without unduly prolonging the procedure.

The purpose of this report is to describe a high-speed dual-detector method of lung scanning and to emphasize the importance of multiple views in studying the pulmonary circulation.

MATERIALS AND METHODS

The dual-detector system consists of two 5-in. crystals mounted in scanning probes exactly opposite each other with separate electronic and recording systems for each detector.* Scanning speeds of 500 cm/min (200 in./min) are possible, but in practice scanning was performed at 450 cm/min (180 in./min) or less. A dose-weight schedule of 5 μc/kg body weight of ^{131}I macroaggregated human serum albumin (MAA)† (total not to exceed 400 μc) was adopted to keep scanning time reasonably short and constant. *Simultaneous* anterior and posterior views could be obtained within 7–14 min, with bilateral views requiring several minutes less. Oxygen was administered by nasal prongs to dyspneic patients during scanning.

All patients received ^{131}I MAA in the supine position to insure adequate blood flow to the apices. Scanning was begun immediately after injection. Upon completion of the anterior-posterior views, the patient was placed in the right or left lateral position (arms extended overhead), the upper collimator was focused to the level of the nipple line, and simultaneous bilateral views were obtained. The instrument settings were unchanged for the lateral scans. All scans were obtained with 67-hole coarse-focusing collimators with a radius of resolution of 1.25 cm (½ in.). Line spacing was set at ⅛ in. Because of the satisfactory counting rates (30–45,000 cpm), background erase or suppression was set at 2–4,000 cpm, and no contrast enhancement was employed.

OBSERVATIONS AND COMMENTS

Normal four-view scans. The usual anterior scan is readily recognized by the heart and mediastinal silhouette (Fig. 1). Generally the level of the lung bases are approximately equal unless the heart is enlarged, in which case the reduction in radioactivity at the left base is proportional to the degree of enlargement. Posteriorly, less lung is obscured by the vertebral column, and unless cardiac enlargement is massive, the heart silhouette is not seen. The lung bases are also at equal levels posteriorly and are not influenced by the mediastinal structures. The lateral

* Ohio Nuclear Model 54 FD Body Scanner.

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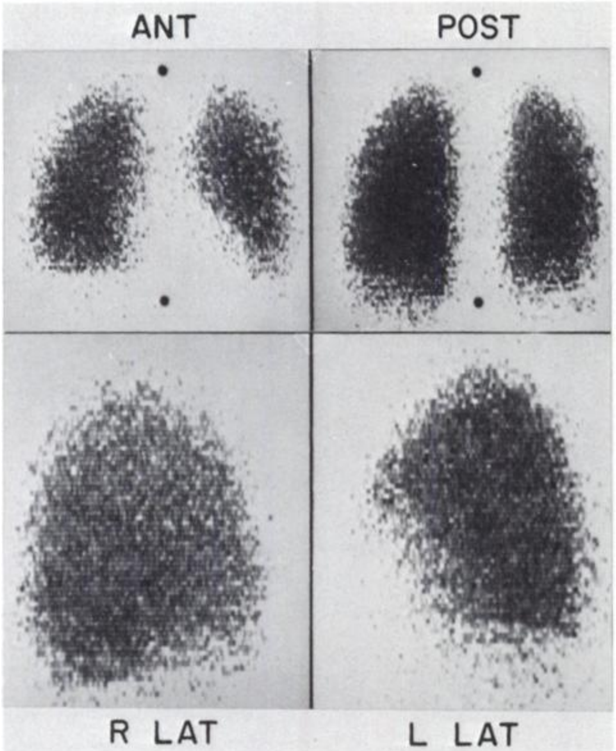


FIG. 1. Simultaneous normal anterior and posterior lung scans (upper) and simultaneous normal right and left lateral scans (lower). Upper dot marks suprasternal notch; lower marks xiphoid process.

views are recognized by the rounded apices, anterior, posterior and oblique diaphragmatic surfaces (Fig. 2). The posterior projection of the heart constitutes a fifth surface on the left lateral view and is anterior and inferior (see arrows). On all views, the slightly diminished radioactivity at the apices and bases due to respiratory excursions is slightly enhanced by high-speed scanning. Sufficient detail is present, however, to eliminate false cold areas. When MAA is administered to patients in the supine position, slightly greater activity is noted posteriorly, reflecting greater blood flow.

With the present dual-detector system, bilateral views are made in either lateral decubitus position. The dependent or "down" lung appears to have greater concentration of radioactivity than the superior or "up" lung due to the effects of gravity which compresses the "down" lung (Fig. 2). This difference is not very obvious in the normal, but is exaggerated in patients with diminished blood flow to the "up" lung.

Normally with ^{131}I there is a spill-over of radioactivity from the opposite lung which contributes to the photoscan image. Although this contribution is not detectable in well-perfused lungs, it becomes obvious on lateral scanning in patients with absent blood flow to one lung when radioactivity is detected through the nonperfused lung (Fig. 3). This spill-over, which is probably due to the relatively large half-value layer of ^{131}I, may be prevented by using ^{99m}Tc which has a smaller half-value layer.

Abnormal four-view scans. The characteristic regional "cold" area or crescent-shaped perfusion deficit on the lateral edge of either lung in pulmonary embolism can also be seen on the lateral views (Fig. 4). The extent and configuration of these deficits can be estimated more accurately by these three-dimensional evaluations. Although the anterior and posterior scans yield information about the length and width of regional pulmonary blood-flow abnormalities, the depth of these perfusion deficits cannot be estimated without the lateral scans.

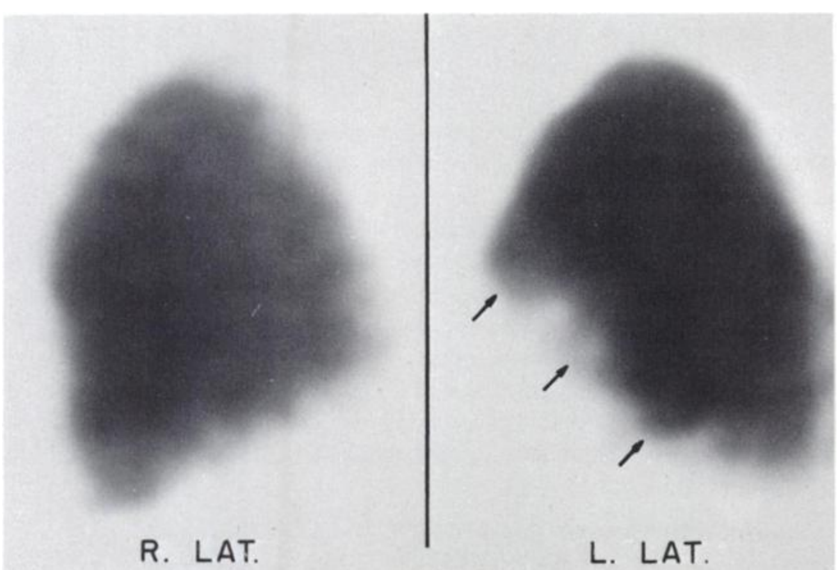


FIG. 2. Simultaneous normal right and left lateral scans. Blended photorecordings show distribution of blood flow more clearly. Note increased concentration of radioactivity in left lateral view when subject was scanned in left lateral decubitus position (see text). Arrows point to infero-anterior surface made by posterior projection of heart.

Occasionally an extensive wedge lesion seen on the lateral scan may not be apparent on the frontal or posterior view. Generally located on the anterior or posterior surface, the long axis of this type of lesion is parallel to the frontal or posterior plane with the short axis or width being less than twice the focal length of the detecting collimator. Unless viewed in relief by lateral scans, these avascular areas are obscured on anterior or posterior views by the radioactivity from surrounding normal lung tissue (Fig. 5). In the patient in Fig. 5 who had both chronic obstructive pulmonary and embolic diseases there is little anteriorly to suggest any perfusion deficit except for irregularity in distribution of radioactivity. Posteriorly, only generalized diminution in radioactivity is noted. The lateral views, however, show these large wedge defects clearly. Selective pulmonary arteriography showed bilateral obstruction to these areas.

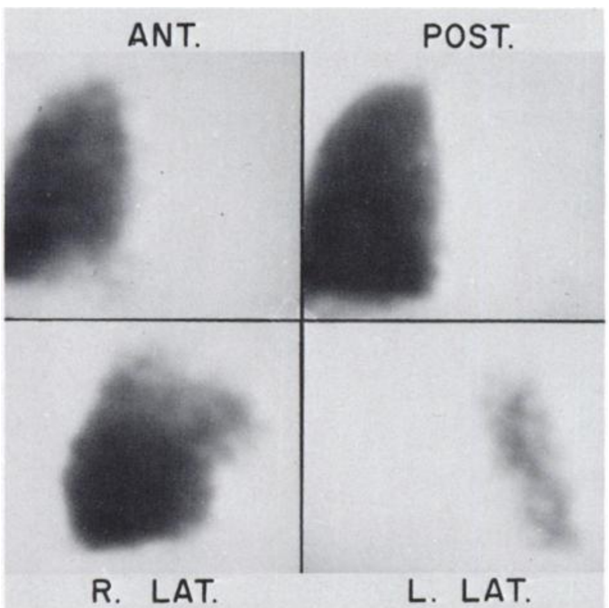


FIG. 3. Blended scans from patient with fibrotic disease of left lung. Although no radioactivity is noted on anterior or posterior views, minimal activity is seen on left lateral view due to spill-over from right lung (see text). Anterior projection on right lateral view represents increased amount of perfused lung anterior to mediastinum.

In patients with chronic obstructive pulmonary disease, multiple views have proved useful in estimating the degree of uneven perfusion. As shown in Figs. 6A and B, the unevenness is diffuse and sufficiently gross in some areas to simulate pulmonary embolism. Little MAA will accumulate in these regions of lung where pulmonary vasoconstriction and diminished blood flow has resulted from poor ventilation. Administration of oxygen before injection of MAA will tend to correct the hypoxia, relieve pulmonary vasoconstriction and allow MAA

FIG. 4. Lung scans from patient with pulmonary embolism. On right there is moderate diminuation and narrowing of radioactivity, especially in mid-portion of lung. This is due to wedge defect as shown on right lateral view (lower left). Aside from small lateral wedge defect of left anterior scan, there is little to suggest in anterior or posterior views extent of perfusion deficit as shown on left lateral scan.

to flow into these regions. In some patients with severe obstructive or bullous emphysema, however, the alveolar air exchange with respiration may be so minimal in some areas that 15 min of oxygen

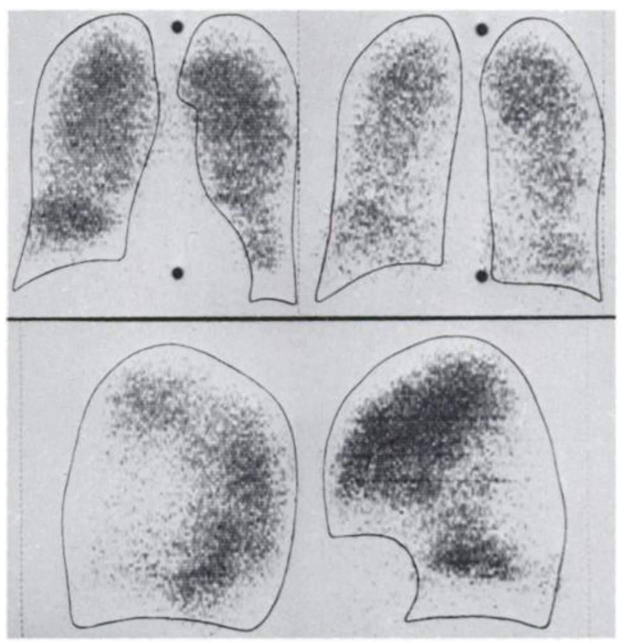
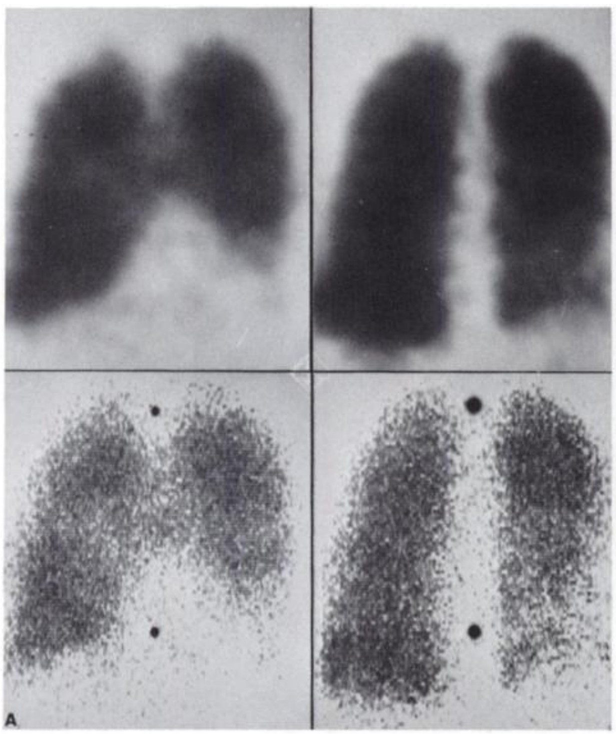
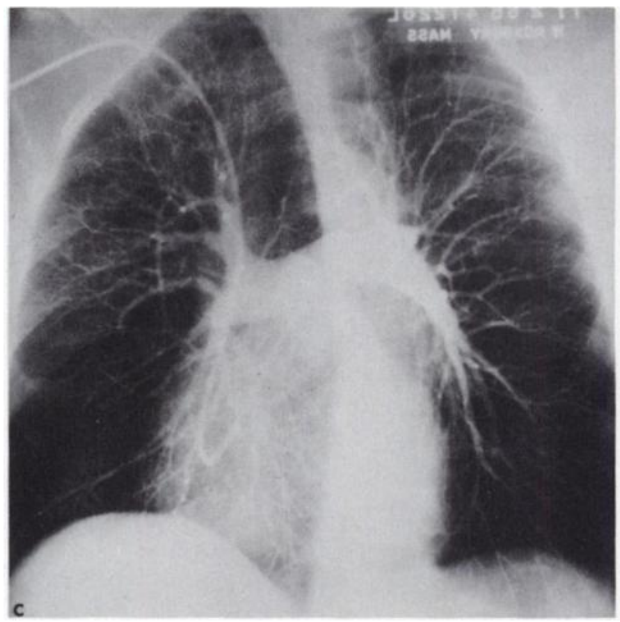


FIG. 5. Scans from patient with chronic pulmonary emphysema and embolic disease. Although there is diminution of perfusion to right lung, especially posteriorly, nature of lesion is best appreciated on right lateral view (lower left). Similarly, nonspecific diminution perfusion on posterior view is clarified by left lateral scan (lower right). Pulmonary arteriography showed embolic occlusions.

inhalation may not relieve the local hypoxia. The scan may show these areas as spurious perfusion defects which resemble pulmonary embolism. In this situation, only selective pulmonary arteriography will aid in diagnosis (Fig. 6C).

Any reliable screening procedure must not only be applicable to all patients but should also detect any clinically significant abnormality. The dual-detector high-speed system appears to fulfill these requirements. Simultaneous anterior and posterior views now can be obtained in less than half the time previously required for a single view, thereby permitting bilateral scans to be obtained routinely. In addition, the dual probes compensate for the inability of a single detector to "see" all of the lung. Previously, in studying patients for pulmonary embolism using a single view, one could not be certain whether a "normal" scan meant no emboli or whether the wrong view was scanned. When they are combined, anterior and posterior views provide nearly 75–80% of the total information available compared to less than 50% from a single view. The remaining 20–25% may be obtained from clear delineation of the costophrenic areas on lateral scans.





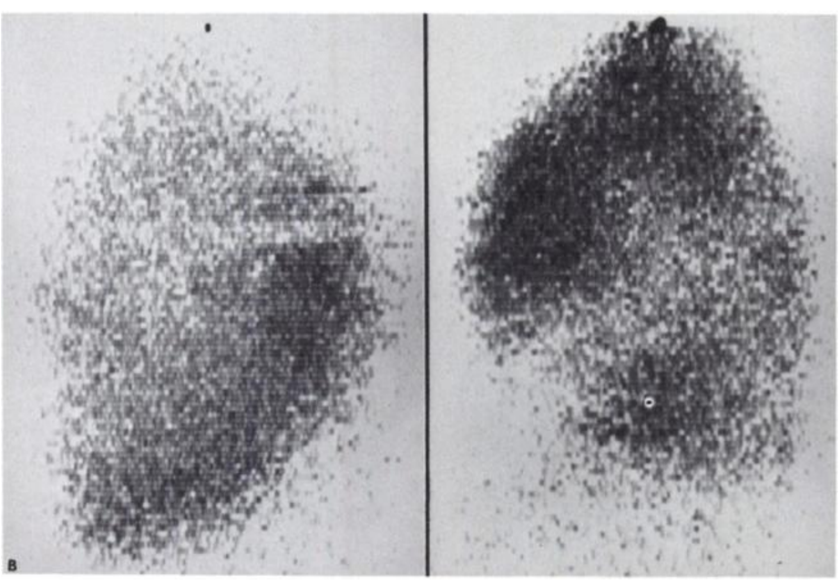


FIG. 6. A: Blended and conventional simultaneous anterior and posterior scans from patient with chronic pulmonary emphysema. Of note are elongation of lung fields, uneven distribution of radioactivity (better appreciated on blended scans) and "bridge" of radioactivity linking right and left lungs, all characteristic of chronic pulmonary disease. There is also deficit in perfusion in infero-lateral third of left lung. B: Simultaneous right and left laterals (same patient) showing striking irregularity in distribution of radioactivity. Although outline of lung is clear, there is diminished perfusion to upper half of right lung (left) and to lower half of left lung (right). Costophrenic area to left lung is abnormally light. C: Selective left anterior oblique pulmonary arteriogram (same patient) which shows no obstruction by emboli. There is, however, diminution in number of small vessels to lower left lung as well as to right, with uneven distribution of vessels characteristic of chronic emphysema.

SUMMARY

Despite its simplicity and safety, conventional lung scanning does not detect enough lung volume to serve as an accurate and consistent screening method for pulmonary embolism. Multiple sequential views make for overlong and distressful procedures in very ill patients.

This study, performed with a high-speed dual 5-in. detector system, permits simultaneous anterior and posterior scanning as well as both laterals. The total duration of all four views is frequently less than that required for one view by previous single-detector systems.

Perfusion deficits, located anteriorly or posteriorly, were occasionally undetected by the frontal or posterior scans but were well defined in the lateral views. Multiple views are therefore necessary in screening for pulmonary embolism.

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