Case of the Quarter

Eugene M. Volz and Paul E. Christian

University of Utah Medical Center, Salt Lake City, Utah

Case History

A 35-year-old white man was presented to the emergency room complaining of increased weakness, shortness of breath, coughing up blood, and pleuritic chest pain of one week's duration. The patient had a history of heart disease but did not know what type. Physical exam revealed a chronically ill man who appeared short of breath and cyanotic. His pulse rate was 90/min and regular, and the respiratory rate 22/min. Chest examination revealed distant breath sounds with some dullness to percussion. Examination of the extremities was normal except for clubbing of the fingers.

Arterial blood gases revealed a $pO_2$ of 32 and a $pCO_2$ of 37. With the history of sudden onset of pleuritic chest pain and hemoptysis and the low arterial $pO_2$, pulmonary embolism was considered. A ventilation perfusion study was requested.

A posterior ventilation study was performed using 15 mCi of xenon-133 (Fig. 1). A continual wash-in (WI) image was obtained for 3 min while the patient re-breathed the radioactive gas and serial wash-out images were obtained while the patient breathed room air. The perfusion study (Fig. 2) was obtained following the intravenous administration of 4 mCi of Tc-99m macroaggregated albumin (MAA) containing approximately 100,000 particles.

The ventilation study revealed areas of decreased wash-in in the hilar areas and left apex. Wash-out of the radioactive gas showed retention in both upper-zone areas through 5.0 min. The perfusion study revealed decreased perfusion in the hilar and upper-zone areas in the regions of decreased or absent ventilation while the remaining areas revealed irregular, nonsegmental abnormalities. Of particular interest was the activity noted outside the lungs.

The radiopharmaceutical located outside the lungs on the perfusion study is related to which of the following:

(1) Free [99mTc] pertechnetate injected with the Tc-99m MAA.
(2) Incorrect photopeak setting with instrument nonuniformity.

For reprints contact: Eugene M. Volz, Div. of Nuclear Medicine, 50 N. Medical Dr., Salt Lake City, UT 84132.
FIG. 3. Chest radiograph revealing markedly enlarged pulmonary arteries with some calcification and left upper-lobe infiltrate.

(3) A right-to-left cardiac shunt.
(4) Severe chronic obstructive lung disease.
(5) Blood clots injected with the Tc-99m MAA.

Solution and Discussion

After the patient’s chart and a chest radiograph (Fig. 3) were obtained, it was found that the patient had a history of a large ventricular septal defect with subsequent development of pulmonary hypertension and reversal of the intracardiac shunt from a left-to-right to a right-to-left shunt. The areas of absent ventilation and perfusion corresponded to the large central pulmonary arteries noted radiographically.

A good method for determining if the activity outside the lung is free $[^{99m}Tc]$ pertechnetate or Tc-99m MAA is to obtain a lateral view of the head (Fig. 4). If the activity is pertechnetate, an image similar to a routine brain scan should be obtained. If the activity is particulate, then the brain itself will retain the activity in its pre-capillary arterioles and capillaries, as demonstrated in this patient. Furthermore, with particulate activity, the renal parenchyma will be identified in the images of the kidney and not the collecting system. Radiochromatography of this preparation of Tc-99m MAA revealed greater than 97% of the activity bound to the MAA.

The photopeak setting was checked and was unchanged. The daily flood field revealed acceptable uniformity. If the camera was calibrated below the photopeak, scattered photons could give the appearance of activity outside the lungs. Severe camera nonuniformity can give apparent defects but these defects should appear in the same location within the field of every image. Although the lung perfusion may be markedly irregular and decreased with severe chronic lung disease, activity should not be noted outside the lungs. Lastly, blood clotting in the syringe at the time of injection may give “hot spots” in the lung but activity in the kidneys and brain would not be expected.

Severe reactions, including death, have occurred in patients with severe pulmonary hypertension (1). In such patients, the minimum number of particles that can be injected without introducing statistical artifacts should be administered slowly. The number of particles necessary for good images in normal humans has been demonstrated to be at least 60,000 (2,3).

Labeled particles have been used to evaluate right-to-left shunts in children and coronary perfusion in adults without demonstrable adverse effects (4,5). Again, the smallest number of particles to avoid statistical artifacts should be administered to increase the safety factor. Thus, in patients with pulmonary hypertension or right-to-left shunts, lung perfusion imaging with particles can be performed, but the potential risks must be realized and minimized by controlling the number of particles injected.

References

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