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SELF-STUDY TEST

Pulmonary Nuclear Medicine

Questions are taken from the *Nuclear Medicine Self-Study Program I*, published by The Society of Nuclear Medicine

DIRECTIONS

The following items consist of a heading followed by numbered options related to that heading. Select those options you think are true and those that you think are false. Answers may be found on page 70.

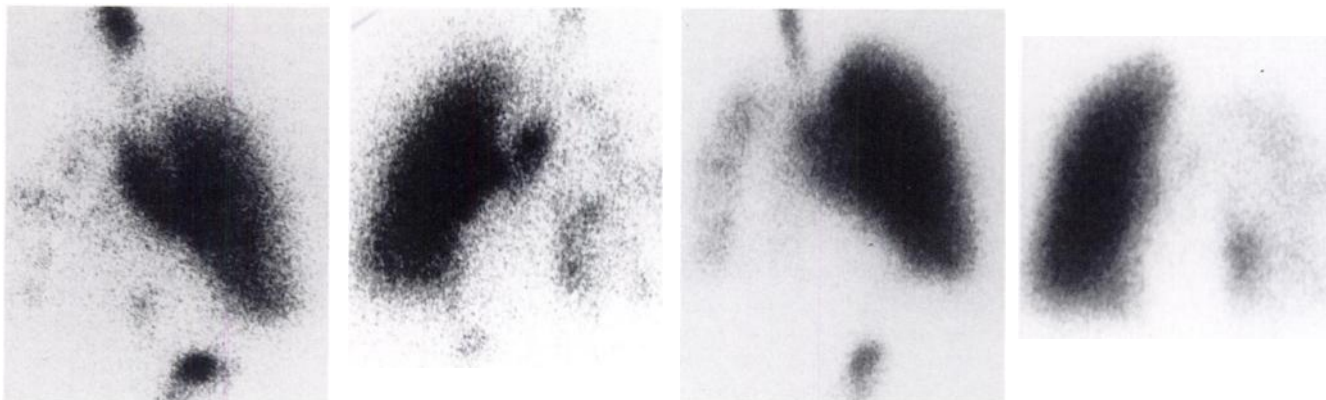


FIGURE 1.

The ^{99m}Tc DTPA aerosol and ^{99m}Tc MAA perfusion images shown in Figure 1 were obtained from a 65-yr-old woman who had increasing shortness of breath. The aerosol images (each 100,000 counts requiring about 150 sec of imaging time) were obtained immediately before the perfusion images (each 400,000 counts requiring about 60 sec). True statements concerning these images include:

1. The central airways deposition indicates that the aerosol droplets were too large to penetrate into the periphery of the right lung.
2. The medial right lower lobe activity seen on the perfusion image probably is "shine-through" from right lower lobe aerosol deposition.
3. The scintigraphic findings are typical of those seen in patients who have undergone irradiation of the right hemithorax for lung cancer.

True statements regarding sarcoidosis include:

4. It is a systemic disorder associated with abnormalities of the immune system's response to an infectious agent.
5. Most patients with sarcoidosis develop progressive deterioration in pulmonary function as a result of extensive pulmonary fibrosis.
6. The pathologic finding in the lungs of patients with early sarcoidosis that is most directly related to pulmonary ^{67}Ga uptake is alveolitis with granuloma formation.
7. Pulmonary function tests generally show progressive deterioration of lung reserve in patients with normal ^{67}Ga pulmonary scintigrams.
8. The magnitude of ^{67}Ga uptake in the lungs of patients with sarcoidosis has been shown to correlate with both the severity of pulmonary function abnormality and the radiographic severity of pulmonary fibrosis.

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SELF-STUDY TEST

Pulmonary Nuclear Medicine

ANSWERS

ITEMS 1-3: Unilateral Pulmonary Hypoventilation and Hypoperfusion

ANSWERS: 1, F; 2, F; 3, F

Central pulmonary airway hyperdeposition of radioaerosols is frequently associated with poor peripheral penetration of activity. In fact, prior to the development of convenient methods to produce submicronic radioaerosol droplets, central "hot spots" secondary to impaction of large particles commonly led to poor delineation of peripheral air spaces. The anterior and posterior radioaerosol images shown in Figure 1 reveal a substantial amount of radioaerosol activity at and just above the carina. This activity extends laterally into the region of the left central bronchi. However, there is excellent uniform peripheral penetration of radioaerosol activity in the left lung. Only the right lung shows markedly diminished aerosol activity, with a patchy distribution. Radioaerosol activity, however, does reach the lung periphery in several areas. There is no central right-sided aerosol hyperdeposition, nor are "hot spots" seen in more peripheral zones of the right lung. The lack of right-sided central airway hyperdeposition and the excellent penetration of activity to the outer zones of the left lung and the peripheral location of whatever activity has reached the right lung suggest that the aerosol particles were small enough to reach the lung periphery. The findings suggest that intrinsic pulmonary disease, present to a much greater extent in the right lung than the left, is responsible for the asymmetric deposition of activity, rather than central obstruction or central airflow turbulence. The central hyperdeposition in the trachea probably was caused by turbulent airflow, perhaps secondary to excessive mucus in the airways. The findings also demonstrate that centrally turbulent airflow will not prevent good penetration of submicronic radioaerosols to a well-ventilated lung in the absence of significant airway blockage.

Because inhalation and imaging of the $^{99\text{m}}\text{Tc}$ -labeled radioaerosol generally is performed before injection and imaging of the $^{99\text{m}}\text{Tc}$ MAA, the possibility always exists that $^{99\text{m}}\text{Tc}$ aerosol activity could contribute to and degrade the perfusion images. When both studies are properly performed, however, this is not a clinical problem. On the average, only about 700-800 μCi of radioaerosol is deposited in the lungs after a typical inhalation period of 2-3 minutes. A typical $^{99\text{m}}\text{Tc}$ MAA dose of approximately 4 mCi yields a perfusion image to aerosol image count-rate ratio of about 5:1. Under these circumstances, only areas of focal aerosol hyperdeposition are likely to be seen on the "combined" aerosol-perfusion image, and even these areas usually are not prominent. In Figure 1, note that the count rate for the aerosol images alone was 100,000 counts per 150 sec (about 660 counts/sec). After $^{99\text{m}}\text{Tc}$ MAA injection, the count rate was 400,000 counts per 60 sec (about 6660 counts/sec). Hence, the net count rate from $^{99\text{m}}\text{Tc}$ MAA was 6000 counts/sec. In this patient, the count rate contributed by $^{99\text{m}}\text{Tc}$ MAA was nearly ten times the aerosol count rate, making significant "shine-through" of the aerosol activity most unlikely. It has been shown that such "shine-through" is not a problem even when the $^{99\text{m}}\text{Tc}$ MAA to $^{99\text{m}}\text{Tc}$ DTPA count-rate ratios are as low as 4:1 or 5:1. In this example, the left central

airway activity still can be seen faintly on the perfusion images, as can tracheal activity and swallowed activity in the gastric fundus. The medial right lower lobe radioaerosol activity is not as intense as these foci on the original aerosol images. Accordingly, it is unlikely to be visible on the perfusion images. Thus, medial right lower lobe activity on the perfusion images more likely represents a region of maintained perfusion than an artifact caused by $^{99\text{m}}\text{Tc}$ aerosol activity.

The irregular and incomplete reduction of perfusion seen in this patient's right lung is not at all typical of postradiation change. In irradiated patients, perfusion is reduced in uniform fashion throughout the irradiated region, which usually has a well-defined geometric shape. At the radiation doses usually employed for bronchogenic carcinoma (≥ 5000 rads midplane cumulative dose), perfusion is markedly reduced due to radiation-induced microvascular obliteration. Ventilation also may be reduced in the irradiated area, but usually it is much less affected than perfusion. When abnormal, ventilation studies typically reveal effects of reduced lung volume, and show a more uniform pattern of hypoventilation than seen in this image.

In this patient, Swyer-James' syndrome (unilateral hyperlucent lung) had been diagnosed many years previously. The origin of her disease was not known precisely, although she did report several episodes of bronchitis in childhood. Her chest radiograph revealed a moderately hyperlucent right lung and a normal-appearing left lung. The hypoventilation of her right lung was considered to be secondary to diffuse small airways obstructive disease on the right.

ITEMS 4-8: Sarcoidosis

ANSWERS: 4, F; 5, F; 6, T; 7, F; 8, F

Sarcoidosis is a systemic disorder characterized by enhanced local immune processes, which cause the most significant morbidity through their effects on the pulmonary parenchyma. Although the etiology of sarcoidosis is still unknown, and no direct relationship to an infectious agent has been shown, there appears to be a temporal association between the presence of an initial alveolitis and the subsequent development of granulomas and fibrosis. In most patients disease is self-limited and is associated with a good prognosis. Patients who present with symptoms of dyspnea are those who have more advanced disease, the greatest extent of pulmonary fibrosis, and who show the poorest response to therapy. Prognosis is partially determined by the appearance of the disease on chest roentgenograms. Nonetheless, many patients with persistently abnormal roentgenograms show no clinical evidence of progressive disease.

Although granulomas are the characteristic pathologic feature of the disease, the initial lesion in the lung is probably an alveolitis from which the granulomas eventually are derived. As a granuloma matures, there is an increase in the number of fibroblasts, which may lead to roentgenographically evident parenchymal fibrosis. The sarcoid granuloma either resolves, leaving no morphologic changes, or it undergoes an obliterative

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SELF-STUDY TEST **Pulmonary Nuclear Medicine**

ANSWERS

fibrosis, a process leading to widespread interstitial fibrosis, bronchiolectasis, and distortion of pulmonary architecture.

Gallium-67 images of the lungs are frequently abnormal in patients with pulmonary sarcoidosis. There is evidence from in vitro experiments that the macrophages associated with the alveolitis and granulomas of the active disease become labeled with more ⁶⁷Ga on a per-cell basis than do normal macrophages. Furthermore, this increased macrophage uptake of ⁶⁷Ga in vitro correlates with the presence of positive ⁶⁷Ga scintigrams.

Although the role of ⁶⁷Ga scintigraphy, as a means to stage or monitor the disease is controversial, patients with normal studies generally have stable pulmonary function, suggesting that their diseases are quiescent. Conversely, positive ⁶⁷Ga studies have been associated with deterioration of pulmonary function in most, but not all, patients. Furthermore, several authors have demonstrated a close correlation between positive gallium scintigrams and responsiveness to therapy. Most authors seem to agree that corticosteroid therapy is unlikely to benefit a patient with sarcoidosis who has a negative ⁶⁷Ga study. On the other hand, it appears that positive ⁶⁷Ga scintigrams do not reliably distinguish patients

who will improve spontaneously (without treatment) from those who require medical intervention.

Thus, it appears that ⁶⁷Ga uptake marks the presence of one or more components of the disease stages associated with active alveolitis and granuloma formation. Gallium-67 localization has not been associated with pulmonary fibrosis per se, and hence may not correlate closely with pulmonary function or with the appearance of the chest roentgenogram. Patients who have pulmonary fibrosis but no ⁶⁷Ga localization are unlikely to benefit from corticosteroid therapy, which appears to be most successful during the inflammatory phase of the disorder.

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For further in-depth information, refer to the syllabus pages in Nuclear Medicine Self-Study I.

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