Ventilation/Perfusion Mismatch Caused by Positive Pressure Ventilatory Support

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In a patient with lobar atelectasis who was on positive pressure ventilatory support, ventilation and perfusion images showed absent ventilation and normal perfusion (reverse mismatch) in the region of the atelectasis and normal ventilation and decreased perfusion (true mismatch) not caused by pulmonary embolism in another lung zone. We report this case to emphasize that the lung scan findings in patients on positive pressure ventilatory support be carefully interpreted for the diagnosis of pulmonary emboli.

J Nucl Med 30:1268–1270, 1989

Pulmonary embolism (PE) is often difficult to diagnose because the symptoms and signs can be nonspecific or subtle. Lung ventilation/perfusion (V/P) scintigraphy is the principal noninvasive imaging modality for its diagnosis. We report a case demonstrating both classical V/P mismatch (false positive for PE in this case) and reverse V/P mismatch (absent ventilation and normal perfusion, therefore negative for PE) in a patient on positive end-expiratory pressure (PEEP) mechanical ventilatory support.

CASE REPORT

A 4-mo-old black girl was initially treated at the age of 5 wk for presumed pneumococcal meningitis. She was readmitted with respiratory distress, requiring intubation and assisted ventilation. She was thought to have an aspiration pneumonia that responded to antibiotic therapy. Although extubation was possible after 10 days, the patient required supplemental oxygen. Clinical assessment suggested an anoxic encephalopathy, and computed tomography (CT) showed a calcification at the base of the brain as well as cerebral atrophy. Repeated episodes of respiratory distress occurred that required increasing oxygen therapy. Chest radiographs revealed migratory atelectasis and infiltrates. Intubation was required to facilitate reexpansion of the lung. Although the patient was placed on PEEP sustained at 10 cm H_2O, there was no improvement. Computed tomography of the chest showed bilateral lower lobe atelectasis (Fig. 1). PEEP was increased progressively from 10 to 18 cm H_2O with worsening of hypoxemia and hypercapnea. At this stage a PE was clinically suspected and a V/P scan obtained. The study was performed with krypton-81m (^{81m}Kr) for the ventilation and technetium-99m (^{99m}Tc) macroaggregated albumin (MAA) for the perfusion, and showed classical V/P mismatched lobar defects to suggest PE as well as reverse V/P mismatch (Fig. 2). There was a significant reduction of perfusion in the right upper and middle lobes and possibly a mild reduction of perfusion in the left upper lobe, while relatively increased ventilation was present in these portions of the lung. An additional remarkable finding was relative hyperperfusion and no ventilation in atelectatic bilateral lower lobes.

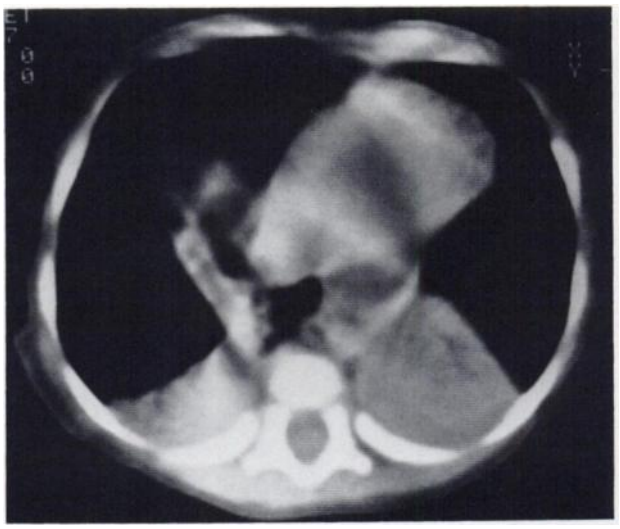

FIGURE 1
Chest CT shows bilateral lower lobe atelectasis.

Received Nov. 14, 1988; revision accepted Feb. 1, 1989.

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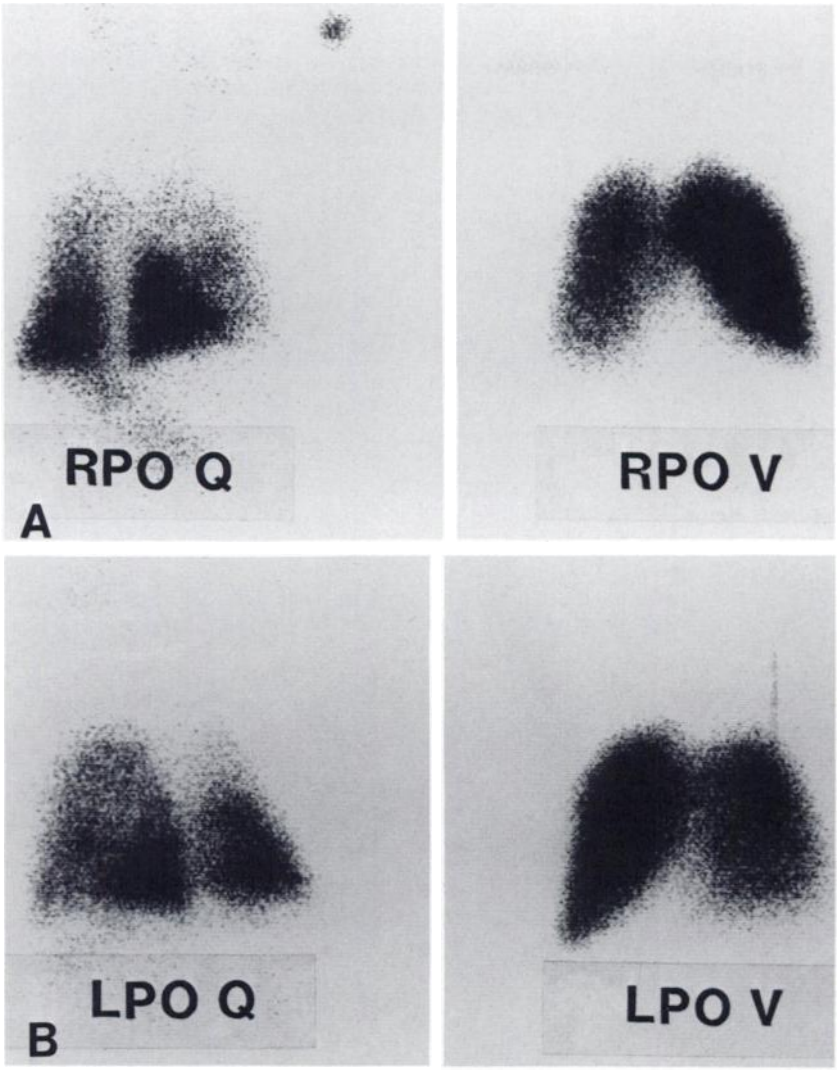

FIGURE 2
Right posterior oblique (A) and left posterior oblique (B) V/P images demonstrate significant reduction of perfusion in the right upper and middle lobes with normal ventilation, and relative hyperperfusion in bilateral lower lobes with no ventilation.

The patient's respiratory status improved dramatically following discontinuation of PEEP and vigorous chest physical therapy.

DISCUSSION

The regional distribution of pulmonary perfusion in normal persons is known to be uneven in the upright position primarily because of gravity (*1–3*). Alveolar pressure exceeds pulmonary arterial and venous pressure in the uppermost part of the upright lung, resulting in the collapse of the capillaries. There is blood flow only at the peaks of the pulsatile pressure wave in this zone (*4–6*). Alveolar pressure of normally ventilated (therefore inflated) upper and middle lobes was increased iatrogenically by positive pressure ventilatory support, and the blood flow to this portion was reduced. On the other hand atelectatic lower lobes were not inflated in spite of PEEP, so that the blood vessels were relatively protected from the pressure effect and relative hyperperfusion was seen. The result of this phenomenon was a right to left shunt of blood flow through the nonventilated lower lobes of the lungs. This finding was previously well demonstrated in closed-chest pigs (*7*) and in dogs (*8*). Other investigators reported that PEEP significantly reduced intravascular pulmonary fluid volumes along with cardiac output (*9,10*) and pulmonary arterial flow (*11*). All these factors could contribute to further decrease of PaO_2.

In a previous case report demonstrating a similar finding, the authors emphasized the need for a knowledge of the patient's clinical status and of a timely chest radiograph to compare with V/P scan (*12*). Without a complete understanding of the effect of PEEP, however, it would be difficult to accurately interpret this kind of V/P scan, even with a timely chest radiograph. Our study demonstrating marked reduction of perfusion and normal ventilation in the right upper and middle lobes could have been interpreted as having high probability for PE, since large thromboemboli may cause incomplete occlusion of large vessels.

We wish not only to describe a relative hyperperfu-

sion in nonventilated atelectatic lobes (reverse V/P mismatch) but also to emphasize that a reduction of perfusion in the artificially inflated part of the lungs (true V/P mismatch) may occur. This finding should not be interpreted as a high probability for PE. V/P lung scintigraphy may be effectively utilized to evaluate an unexplained drop of PaO_2 in the patient on mechanical ventilation.

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