Acquired Whole-lung Mismatched Perfusion Defects on Pulmonary Ventilation/Perfusion Scintigraphy

Abstract

Despite the increasing use of computed tomography pulmonary angiography to evaluate for pulmonary embolism (PE), ventilation/perfusion (V/Q) scintigraphy is still a fairly common examination. A rare finding on V/Q scintigraphy is whole-lung mismatched perfusion defect. Although this finding can occur with PE, it has an important, limited differential diagnosis. In this pictorial essay, we describe different causes of acquired whole-lung mismatched perfusion defect.

Keywords: *Fibrosing mediastinitis,lung transplant,pulmonary embolus,ventilation/perfusion*

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Introduction

Pulmonary ventilation/perfusion (V/Q) scintigraphy is often performed to evaluate for pulmonary embolism (PE) and to provide global and semi-quantitative data about pulmonary function. Many disease processes affect pulmonary ventilation and perfusion and may result in abnormal findings on pulmonary V/Q scintigraphy. One particularly striking finding is absent or severely decreased unilateral whole-lung perfusion, which is seen on approximately 2% of V/Q scans and can occur with normal or abnormal ventilation.[1] However, only about 2% of pulmonary emboli present as a whole-lung mismatched perfusion defect, so alternative diagnoses should be considered. The goal of this pictorial essay is to review the differential diagnosis for acquired whole-lung mismatched perfusion defect on V/Q scintigraphy. These illustrative cases include the diagnoses of large PE, fibrosing mediastinitis, hilar malignant tumor, pulmonary vein stenosis, and pulmonary fibrosis.

Pulmonary embolism

PE, which is part of the spectrum of venous thromboembolic disease, is caused by a venous blood clot that typically forms in the lower extremities, migrates into a pulmonary artery, and limits the flow of deoxygenated blood into the lungs. A large embolus that obstructs all flow in the pulmonary artery of one lung may lead to whole-lung perfusion defect with preserved ventilation [Figure 1].

PE is common and may become life-threatening if not diagnosed and treated quickly.[2] Clinically, PE may present with shortness of breath, chest pain, or tachycardia; however, patients are often asymptomatic. PE can occur in all age groups. Factors that increase its likelihood include prolonged immobilization, recent surgery, hypercoagulable state, cancer, trauma, and pregnancy. Although computed tomography pulmonary angiography (CTPA) has become the radiologic diagnostic test of choice for PE, V/Q scintigraphy is a popular alternative test if CT is contraindicated. According to the modified criteria of prospective investigation of PE diagnosis II, findings on V/Q scan are considered highly suggestive of PE if two or more segments show perfusion scan–chest radiograph mismatch.[3] Although it is rare for a large PE to obstruct flow to an entire lung unilaterally, it must always be considered in the case of a whole-lung V/Q mismatch [Figure 1].

In general, PE is initially treated with anticoagulation, but more invasive approaches, such as percutaneous thrombectomy, can be considered if the patient's condition is sufficiently critical.

Fibrosing mediastinitis

Fibrosing mediastinitis is a benign, progressive proliferation of acellular collagen and fibrous tissue throughout the mediastinum.[4] As the tissue progresses, it

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may eventually encase and compress the normal structures of the mediastinum, including the pulmonary arteries and veins. Asymmetric compression of the pulmonary artery, veins, or both may lead to whole-lung perfusion defect with preserved ventilation [Figure 2].

Fibrosing mediastinitis typically occurs in patients over a wide range of ages with a mean age of approximately 40 years, and the most common causes of fibrosing mediastinitis are granulomatous infections, especially those caused by *Histoplasma capsulatum* and *Mycobacterium tuberculosis*. Two types of fibrosing mediastinitis – focal and diffuse – have been described. The focal type is more common and is generally localized to one region of the mediastinum. The less common diffuse type is more proliferative. Clinical presentation depends on the affected mediastinal structures. Reported symptoms and signs include dyspnea and hemoptysis. The clinical course may be highly variable, and the overall mortality rate is reportedly as high as 30%.[4]

If fibrosing mediastinitis is suggested, the diagnosis is typically confirmed with CT or magnetic resonance imaging. On CT, fibrosing mediastinitis appears as a calcified soft-tissue mass that is usually near the hilum of the lung. The characteristics of fibrosing mediastinitis may be difficult to identify on magnetic resonance imaging because of its poor sensitivity for detecting calcium, but fibrosing mediastinitis generally manifests as abnormally enhancing tissue with heterogeneous T1- and T2-weighted signal near the hilum of the lung [Figure 2d and e].

Treatment depends on the degree of fibrosis and the structures involved. Mild cases may respond to corticosteroid or antifungal therapy. Severe cases may require vascular or airway stenting. Surgical resection may be considered but is generally associated with substantially greater morbidity and mortality rates.

Hilar malignant tumor

Perihilar tumor is an important consideration in the differential diagnosis of whole-lung mismatched perfusion defect.[5] The most common tumors are lung carcinoma and metastatic hilar adenopathy; lymphoma is less likely. If concomitant hypoxia is present, these masses may decrease ipsilateral lung perfusion by direct vascular invasion or reflex vasoconstriction [Figure 3].

Lung cancer is the most commonly diagnosed cancer worldwide, and as many as 90% of cases are associated with tobacco use.[6] Lung cancer typically affects patients older than 50 years and is often clinically asymptomatic until it becomes advanced. Patients with advanced lung cancer may have postobstructive pneumonia, hemoptysis, cough, and dyspnea.

Perihilar tumor is most commonly diagnosed on the basis of findings on chest CT, which typically presents as a spiculated parenchymal opacity [Figure 3d]. Confirmation requires percutaneous or endobronchial biopsy. When the diagnosis is established, staging is typically performed with positron emission tomography with CT. Prognosis depends on the disease stage and the specific histologic type of cancer.

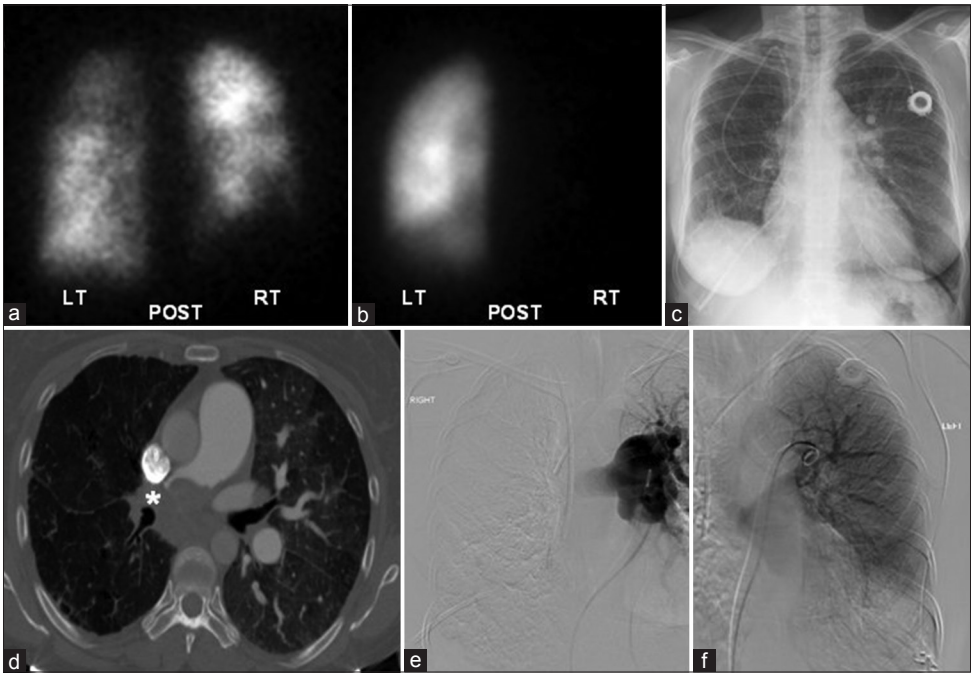

Figure 1: Large right pulmonary embolism. (a and b), Ventilation (a) and perfusion (b) images obtained with ventilation/perfusion scintigraphy: Mildly heterogeneous ventilation without perfusion to the right lung. (c) Chest radiograph: Mild interstitial thickening. (d) Computed tomography pulmonary angiogram: Right pulmonary artery occlusion secondary to pulmonary embolus (*) and decreased perfusion throughout right lung. (e and f), Conventional pulmonary angiograms: right pulmonary artery occlusion (e) and hypoperfusion of the lingula (f). LT: Left; POST: Posterior; RT: Right

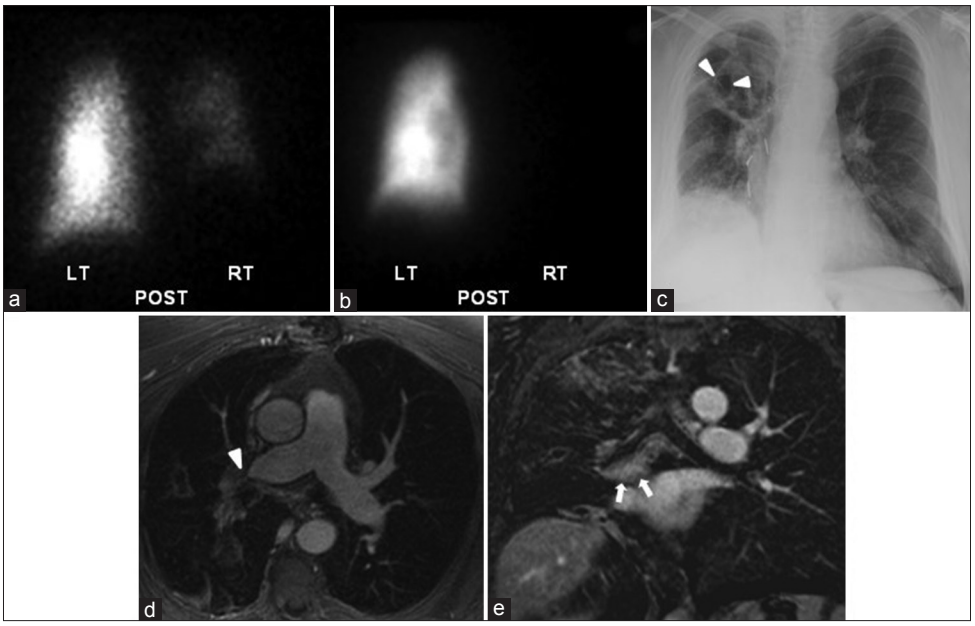

Figure 2: Fibrosing mediastinitis. (a and b), Ventilation-perfusion scans: Severely decreased ventilation (a) and no perfusion (b) to right lung. (c) Chest radiograph: right lung decreased volume, surgical clips, nodules, band-like opacities, and cavities (arrowheads). (d and e), T1-weighted postcontrast (gadofosveset) magnetic resonance images. Axial fat-saturated image (d): Narrowing and distal occlusion of the right pulmonary artery (arrowhead). Coronal motion-corrected subtraction image (e): Abnormally enhancing soft tissue encasing carina and right mainstem bronchus (arrows). LT: Left; POST: Posterior; RT: Right

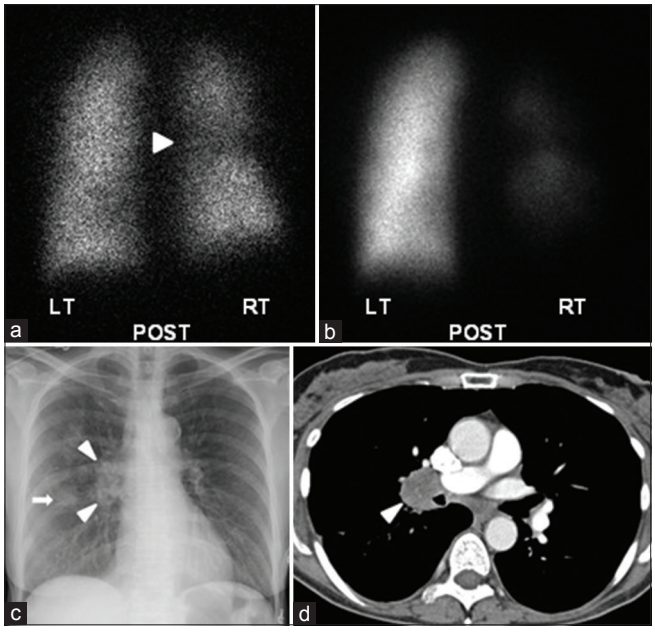

Figure 3: Right hilar malignant tumor. (a) Ventilation image showing a small ventilation defect in the right hilum (arrowhead); ventilation is otherwise preserved. (b) Perfusion image showing severely decreased perfusion to the entire right lung. (c) Chest radiograph showing a right hilar mass (arrowheads) and a round parenchymal nodule in the right midlung (arrow). (d) Axial contrast-enhanced computed tomography image showing a right hilar mass (arrowhead). LT indicates left; POST, posterior; RT, right

In our experience, perihilar tumors more often cause whole-lung matched perfusion defects than mismatched defects on V/Q scans. By the time a tumor is large enough to obstruct the central pulmonary vasculature and the perfusion of an entire lung; it usually has obstructed most of the central airways. Indeed, we have found that whole-lung mismatched perfusion defects are more often secondary to fibrosing mediastinitis and pulmonary vein stenosis than cancer.

Pulmonary vein stenosis

Pulmonary vein stenosis is the narrowing of a pulmonary vein and typically occurs at its insertion site to the left atrium. Most commonly, pulmonary vein stenosis develops as a complication of radiofrequency catheter ablation to treat atrial fibrillation, but it can also develop after lung transplant and, much less often, in patients with congenital heart disease.[7] Among radiofrequency ablation-related cases, the incidence of pulmonary vein stenosis depends on the radiofrequency technique and operator experience. A single stenotic pulmonary vein is frequently asymptomatic; however, a whole-lung perfusion defect may develop if both veins that drain the same lung are stenotic and impede pulmonary circulation [Figure 4]. Symptoms associated with pulmonary vein stenosis are typically vague, including shortness of breath, cough, hemoptysis, and pleuritic chest pain. Symptoms can easily mimic those of PE.

Pulmonary vein stenosis is most commonly diagnosed with electrocardiography-gated CT angiography. Mild cases demonstrate narrowing of the pulmonary vein ostium and occasionally soft-tissue thickening around the ostium. As the stenosis becomes more severe, there may be decreased contrast opacification of the blood pool in the affected vein, eventually leading to venous thrombosis and/or chronic occlusion. A small percentage of pulmonary vein stenoses

will progress, and a similar percentage will spontaneously improve.

When clinically significant, pulmonary vein stenosis can be treated with balloon angioplasty and stent placement. As many as 50% of stented veins develop restenosis. The decision to treat asymptomatic, high-grade pulmonary vein stenosis is controversial.[8]

Pulmonary fibrosis

Parenchymal lung disease, when sufficiently advanced, often has associated perfusion defects on pulmonary scintigraphy. These defects are often symmetric, but a whole-lung perfusion defect may result if the lungs have substantially different degrees of disease involvement. This is particularly evident in patients with unilateral lung transplant [Figure 5]. The transplanted lung may perfuse normally, whereas the fibrotic native lung may have little to no measurable perfusion.[5]

Pulmonary fibrosis can be diagnosed with chest radiography, but chest CT is more typically used. Modern CT scanners and acquisition protocols typically preclude the need for high-resolution reformatted images of the chest, but these can still be obtained if clinically necessary. A careful review of medical history, particularly whether the patient is a lung transplant recipient, is critical to the evaluation of a whole-lung perfusion defect in a patient with a history of pulmonary fibrosis. Knowing the side of the transplant is also important because vascular compromise of the transplanted lung may cause paradoxical whole-lung perfusion defect on the side of the transplant.

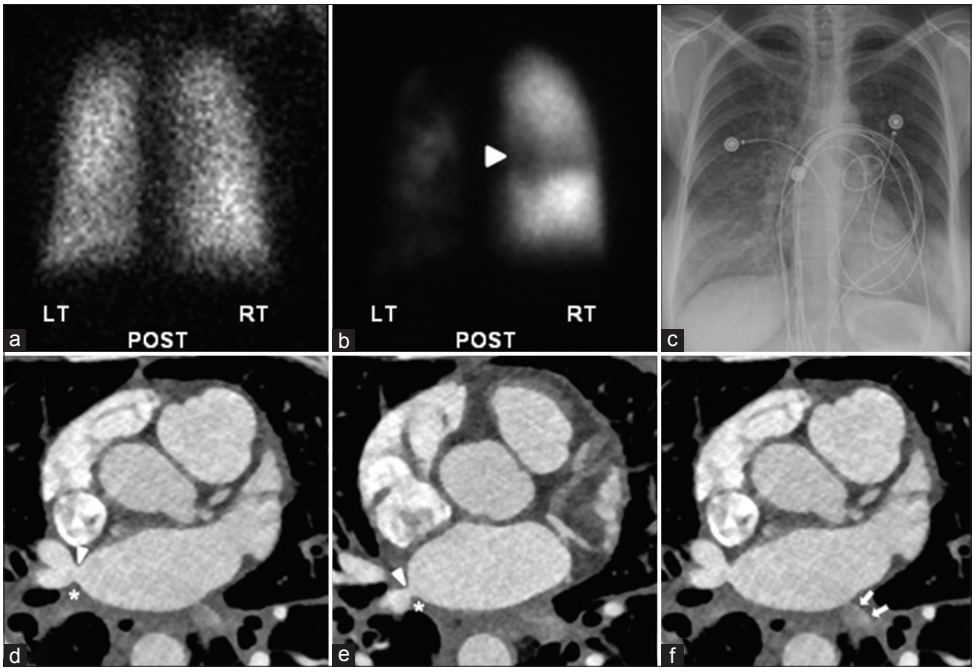

Figure 4: Pulmonary vein stenoses. (a and b), Ventilation-perfusion scans: preserved ventilation (a) and decreased perfusion (b) of the left lung and the superior segment of the right lower lobe (arrowhead). (c) Chest radiograph: Pulmonary edema. (d-f) Axial electrocardiography-gated contrast-enhanced cardiac computed tomography angiograms: (d) mild/moderate right superior pulmonary vein ostial narrowing (arrowhead) and abnormal tissue surrounding ostium (*); (e) moderate/severe right inferior pulmonary vein ostial stenosis (arrowhead) and surrounding soft tissue (*); (f) left superior pulmonary vein ostial stenosis and poor left superior pulmonary vein opacification (arrows). Note: image (d) is the same as image (f). LT: Left; POST: Posterior; RT: Right

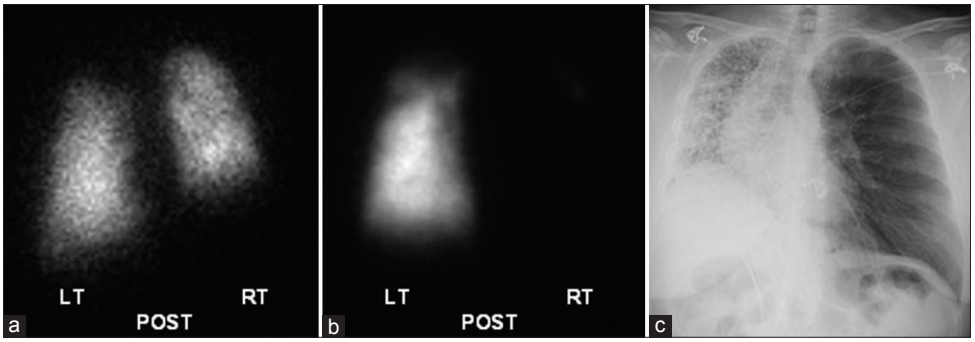

Figure 5: Pulmonary fibrosis with left lung transplant. (a) Ventilation image showing a small right lung and symmetrical ventilation. (b) Perfusion image showing no perfusion to the native right lung. (c) Chest radiograph showing fibrosis throughout the native right lung and a clear transplanted left lung. LT indicates left; POST: Posterior; RT: Right

Symptoms related to pulmonary fibrosis typically include dyspnea with exertion, which is often long-standing. Nonproductive cough is frequently reported. Signs of poor oxygenation that may be present include clubbed fingers and the need for oxygen at rest.

The treatment of pulmonary fibrosis is mainly supportive; however, the treatment of the primary condition may be beneficial if fibrosis is secondary to another disease. Many cases, however, are idiopathic and typically progress. Medical therapies often provide little benefit, and definitive treatment usually requires lung transplant.[9]

Other causes

In addition to these described causes, whole-lung mismatched perfusion defects secondary to aortic dissection have been reported.[10] This pictorial essay focused entirely on acquired causes of mismatched perfusion defect. Congenital causes, such as congenital stenosis or atresia of the pulmonary arteries or veins, may have similar findings but are exceedingly rare compared with acquired causes.

Conclusion

With advancements in the availability and quality of CTPA, the use of V/Q scintigraphy to evaluate for PE has decreased. However, V/Q scintigraphy can still be used to evaluate chronic pulmonary disease, pulmonary hypertension, and PE in patients who are unable to undergo CTPA. It is also used in presurgical planning for lung resection and transplant. Accordingly, identification and understanding of specific V/Q scan patterns remain important because these examinations continue to be used in patient care. Whole-lung mismatched V/Q defects are uncommon but are still encountered in clinical practice, and the ability to identify common causes of this finding is important. In almost all cases, the patient medical history and appropriate cross-sectional imaging will allow for an accurate diagnosis and guide appropriate treatment.

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Conflicts of interest

There are no conflicts of interest.

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