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Stripe sign in pulmonary embolism: A review of the causes

Eser Lay ERGUÑ, Bilge VOLKAN and Biray CANER

Department of Nuclear Medicine, Hacettepe University, Faculty of Medicine, Ankara, Turkey

The most common indication for radionuclide imaging of lungs is the evaluation of suspected pulmonary thromboembolism (PE). Scintigraphically PE classically produces ventilation/perfusion mismatch, that is perfusion defects in areas showing normal ventilation. Stripe sign refers to the visualization a stripe at normally perfused lung interposed between a defect and adjacent pleural surfaces as originally described by Gottschalk.

In the present case the authors describe a patient with a ventilation/perfusion scan suggesting PE. She also had a stripe sign on the perfusion scan with normal ventilation. On the follow-up perfusion scintigraphy, normal perfusion was seen in the corresponding area. The literature on stripe sign is also reviewed.

Key words: stripe sign, pulmonary embolism, ventilation/perfusion scintigraphy

INTRODUCTION

VENTILATION/PERFUSION (V/Q) scintigraphy is the non-invasive screening procedure of choice in the evaluation of patients with suspected pulmonary embolism (PE). Studies that show homogeneous V/Q patterns have long been accepted to exclude PE for practical purposes. V/Q mismatch is the hallmark of PE. Modified PIOPED criteria or the modified Biello criteria are generally used for the interpretation of V/Q scintigraphy.[1]

A significant modification of Biello criteria is the use of stripe sign as described by Sostman and Gottschalk.[2,3] This sign indicates a perfusion defect that has normally perfused lung tissue at the pleural surface. Although the defects demonstrating stripe sign are rarely indicative of PE in the affected region, there is still a theoretical possibility that a stripe sign could occur in the case of PE.

Here we present a patient with a stripe sign on perfusion scan, but also review the possible causes of the stripe sign.

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For reprint contact: Bilge Volkan, M.D., Department of Nuclear Medicine, Hacettepe University, Faculty of Medicine, 06100 Sıhhiye, Ankara, TURKEY.

E-mail: bilgev@hacettepe.edu.tr

CASE REPORT

A 56-year-old woman complaining of cough and back pain for 2 months, had worsening complaints in the last 3 days. She described a pleuritic chest pain referring to her back, in addition to which and besides she had palpitations and hemoptysis for 2 days. On physical examination there was bilateral leg edema and in addition bilateral crackles were found on auscultation of the lungs. She had diabetes mellitus and hypertension for 5 years.

Her chest X-ray showed infiltrates in the lower zone of the bilateral lungs, more prominent on the right (Fig. 1). PaO_2 and $PaCO_2$ values were found to be in the normal ranges (PaO_2: 95 mmHg, $PaCO_2$: 41 mmHg). Bilateral lower extremity venous Doppler US showed no abnormality. D-dimer value was found to be elevated (3.62 ng/m*l*; normal range = 0–0.5 ng/m*l*).

Ventilation/perfusion scintigraphy was performed for the evaluation of suspected PE. Perfusion scintigraphy was carried out by a slow i.v. injection of 185 MBq ^{99m}Tc-labeled macro-aggregated albumin (500,000 particles). Ventilation scintigraphy was performed by the inhalation of (1.48 GBq) aerolized ^{99m}Tc-DTPA on the following day. Posterior, anterior, left and right posterior oblique, left and right lateral views were obtained with a gamma camera (ADAC Cirrus, USA) equipped with an LEGP collimator. Perfusion scan revealed multiple segmental perfusion defects in the lower lobes of both lungs

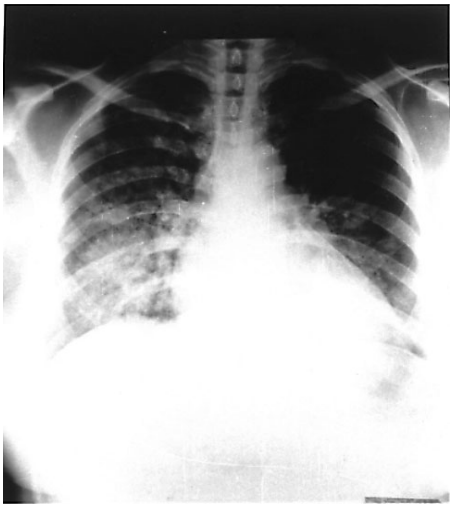

Fig. 1 Posteroanterior chest X-ray; obtained on the same day with the initial perfusion scintigraphy, demonstrates bilateral infiltrates in the lower zones of the both lungs, more prominent on the right.

including a stripe sign defect in the lower lobe of the right lung. Most of these perfusion defects except for that in the anterior medial basal segment of the left lung were ventilated, producing a V/Q mismatch (Figs. 2–4). These findings were highly suggestive of PE.[1] Then, the patient received anticoagulant therapy with low molecular weight heparin.

Fifteen days after the first V/Q scintigraphy a follow-up perfusion scan was requested and revealed that most of the perfusion defects (including the stripe sign area) shown on the initial perfusion scan had disappeared on the follow-up scintigraphy (Fig. 5). A perfusion defect remained on the posterior view in the left lower lobe, in the medial basal segment.

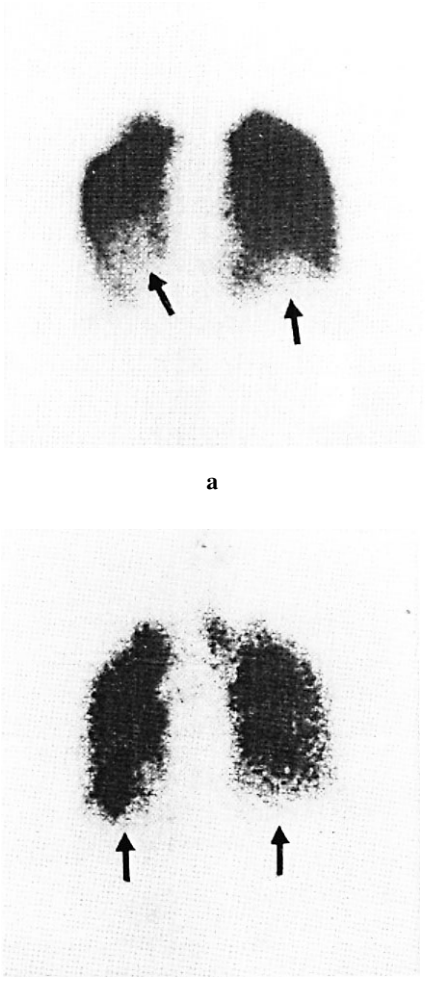

Fig. 2 a: Posterior view of ^{99m}Tc-MAA perfusion study; demonstrating multiple perfusion defects in both lungs, particularly in basal segments (*arrows*). b: ^{99m}Tc-DTPA ventilation scintigraphy (Posterior view); Normal ventilation was observed in lower lobes of both lungs except for medial basal segment in the left lung (*arrow*), leading to a high probability interpretation of V/Q scan.

DISCUSSION

The stripe sign, seen on lung perfusion scintigraphy, is described as an area of hypoperfusion separated from the peripheral lung border by a stripe of normal parenchyma. Pathologies resulting in stripe sign are uncertain. It has been shown that, defects demonstrating stripe sign are rarely indicative of PE in that region, and should be considered in the interpretation of the study, resulting in a more descriptive interpretation. In a study by Gottschalk and Sostman, 93% of the cases demonstrating the stripe sign failed to have the diagnosis of PE.[2] The authors suggested that although a stripe sign is generally indicates a low probability for PE, it was still possible occur in some cases of PE. If the patient has a high probability V/Q scan, the presence of stripe sign does not change the diagnosis as seen in our case. However, it moves the intermediate or low probability readings to move to a lower category.[3]

Stripe sign in a high probability V/Q scan may also show the reperfusion of an embolic segment.[4] Findings in our patient may support the above contention since the interval between the appearance of her symptoms and admission to the hospital (first V/Q scan) was rather long. The patient had a history of symptoms for 2 months that had shown further worsening in the last 3 days prior to hospitalization. In our opinion the worsened symptoms might be due to a resolving PE in the stripe sign area, leading to fragmentation of the emboli and perhaps a secondary PE in other territories of the lungs.

Chest X-ray is also important in the interpretation of V/Q scintigraphy in both the PIOPED and Biello criteria. In our case the chest X-ray demonstrated bilateral infiltration which was more prominent in the right lung. According to PIOPED criteria, a crystal clear radiogram is

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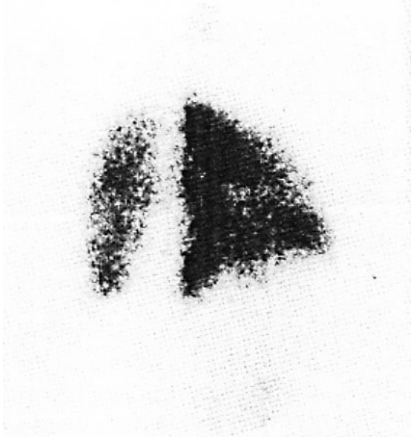

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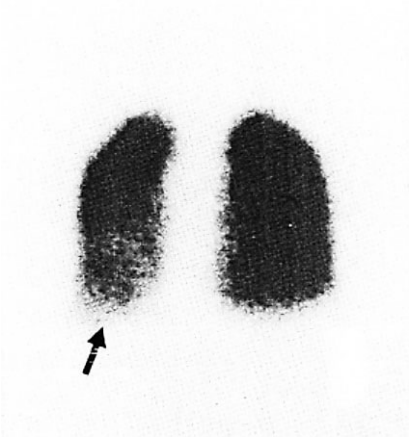
Fig. 3 a: Right posterior oblique view of the right lung on the perfusion scan; the stripe sign defect is shown (*arrow*). b: ^{99m}Tc-DTPA ventilation study; the stripe sign area seen in the lower lobe of the right lung has normal ventilation.



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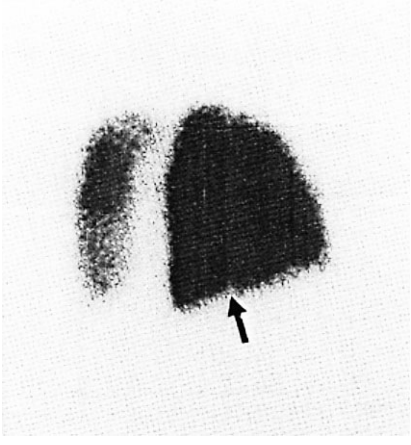

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Fig. 5 The follow-up perfusion scan; displays normal perfusion in both lungs except for medial basal segment in the left lung (*arrow*). Posterior (a) and right posterior oblique (b) images show the resolution of the embolic segments and the stripe sign, respectively.

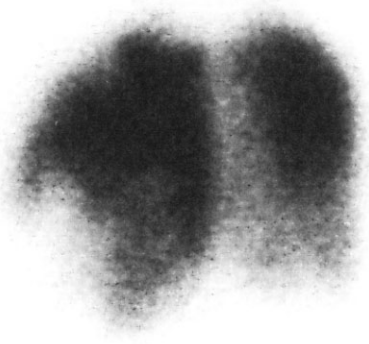

Fig. 4 The left posterior oblique view showing large perfusion defect inferior lobe of the left lung.

strongly indicative of PE, in the presence of wedge shaped perfusion defects. However, chest X-ray may also reveal nonspecific findings such as elevation of hemidiaphragm, area of subsegmental athelectasis, infiltrates (as seen in our patient) or pleural effusions in the case of PE.[1] Infiltrations might be indicative of pulmonary infarction. The preserved ventilation at the perfusion defective areas, except for the medial basal segment of the left lung (besides infiltrates on X-ray) also supports PE in the patient. The persistent V/Q defect in the medial basal segment of the left lung can be considered as an infarction which may be seen in 10% of the cases.[1] The smaller perfusion defects that are observed on control perfusion scan may be due to infarct areas secondary to PE.

In patients with PE, the presence of pulmonary arterial hypertension is not rare. Although it is a theoretical possibility; the elevated pulmonary vascular pressure in

these patients might force the particles distal to the embolus. In this case a stripe sign can be seen on perfusion scintigraphy.[1]

Arterial blood gas levels were normal in the patient. Even the classic laboratory finding of decreased PO_2 levels is not a reliable diagnostic parameter. In a PE case PO_2 levels may be normal or up to 10–15% patients with PE may present with an increased PO_2, such as >80 mmHg.[1]

In the present case, elevated D-dimer also confirms the presence of PE. D-dimer is a product of endogenous fibrinolysis, and elevated in PE and acute venous thrombosis. D-dimer is measured by ELISA (enzyme linked immunosorbent assay) method in our hospital and has a sensitivity of 99.5% and a specificity of 41%.[5] Thus it has a high negative predictive value (95%) in the diagnosis of PE.[6]

Stripe sign is rarely seen in pulmonary disorders other than pulmonary emphysema. In a prospective study by Gottschalk and Sostman, the presence of stripe sign was significantly associated with the history of smoking in 72% of the cases.[3] Suga and co-workers reported that peripheral lung tissue was less susceptible to the emphysematous changes caused by smoking. The researchers stated that because of the numerous patent side branches of the distal arterioles, central emphysematous destruction might not influence the blood supply of peripheral lung tissue.[7] Because of all these predisposing factors, smoking-related emphysematous changes might lead to a stripe sign on lung perfusion scintigraphy. Since there was no history of smoking in our case, no such relation was considered as a possible cause for the stripe sign. Moreover, rapid disappearance of the stripe sign following anticoagulation therapy strongly supported the diagnosis of PE.

Another cause of stripe sign observed on perfusion scintigraphy is the limited number of image views acquired on V/Q scintigraphy. Shine through of normally perfused tissue adjacent to a wedge shaped perfusion defect may mimic a stripe sign especially on oblique and lateral views.[8,9] Interpretation of a stripe sign should not be based solely on a lateral image. Although it is rarely seen, shine through from the contralateral lung may mislead the interpreter. Thus, SPECT imaging may increase the sensitivity and accuracy of the PE diagnosis if stripe sign is observed on planar V/Q scintigraphy. In our case there were large perfusion defects observed in the lower lobes of the left lung at LPO view (Fig. 4). Therefore, a shine through of normal perfused lung is out of the question.

In the present case, there was no history of smoking, pulmonary hypertension and pulmonary emphysema, and six image views of planar images were recorded allowing full evaluation of all lung fields. Therefore, the above mentioned causes for stripe sign were thought to be unlikely. The most likely explanation for the stripe sign in our case was the presence of a resolving PE. We have observed that the perfusion defects disappeared except for that in the medial basal segment in the left lung in the control scan, indicating that the perfusion of the surrounding tissue around the infarct area was improved. Reperfusion of the wedge shaped defects, which were present in the first perfusion scintigraphy, also supports this diagnosis.

The interval of two months between presentation of the case and the appearance of the symptoms led us to think that the event was not new. Moreover, the prompt response to anticoagulation therapy and consequent disappearance of all perfusion defects including the area with the stripe sign led us to think that a resolving embolus was responsible for the appearance of the stripe sign in our case.

In conclusion, although stripe sign is generally accepted as a rare indication of PE, it might occur in PE, especially in resolving PE. In addition, it might be observed due to pulmonary emphysema, cigarette smoking, pulmonary hypertension and because of limited image views of planar imaging.

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