RADIOLOGIC NOTES IN CARDIOLOGY

Fleischner Lines and Pulmonary Emboli

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SUMMARY

Fleischner lines are often the only roentgen evidence of pulmonary embolization, particularly when the emboli are small. The linear shadows are cast by focal areas of atelectasis viewed on end. The atelectasis is an indirect manifestation of the vascular occlusion and is due to obstruction of a subsegmental bronchus by retained secretion or by hemorrhagic exudate. Although Fleischner lines are not seen in every case of pulmonary embolization, when present, and especially when bilateral, they are definitely suggestive of the diagnosis.

The diagnosis of pulmonary embolization is often very difficult to establish, especially when the emboli are small and major branches of the pulmonary artery are not obstructed. The small emboli are not visible radiologically, and they rarely produce recognizable areas of infarction. They impact in peripheral arteries and, although the local vascular pattern is altered, the area involved is so small that it cannot be detected on routine chest films. The emboli are almost always multiple and involve both lungs. Nevertheless, only a minor portion of the total pulmonary arterial bed is occluded, and the roentgen manifestations of pulmonary hypertension are rarely seen. Thus, there are no roentgen signs that are directly produced by the vascular occlusions. However, in many cases of embolization, pulmonary secretion is increased and some of the smaller bronchi are obstructed. The resulting areas of focal atelectasis, although not pathognomonic of the disease, are highly suggestive of the diagnosis.

Focal, or discoid, atelectasis results from obstruction of the small bronchus that supplies a pulmonary subsegment or one of its divisions. The lung collapses in such a way that it assumes a flattened, platelike shape. When the plate is oriented parallel to the X-ray beam, it is projected on end and casts a relatively dense, well-demarcated, linear shadow (fig. 1). However, because the atelectatic plate is only a few millimeters thick, if it lies perpendicular to the X-ray beam and is viewed en face, its shadow is usually too faint to be appreciated on the chest film. Between these two extremes, the roentgen appearance of the area of focal atelectasis will vary, depending on the degree of its obliquity in reference to the X-ray beam (fig. 1). The further it is from the parallel, the fainter the shadow and the less demarcated its borders.

When projected on end, the areas of focal atelectasis cast relatively straight, linear shadows. Our understanding of the nature and importance of these shadows is due largely to the work of Dr. Felix Fleischner\(^1\) and they are commonly referred to as Fleischner lines. The lines usually measure from 2 to 7 cm in length and between 2 and 7 mm in thickness. Since the entire subsegment beyond the obstructed bronchus is collapsed, a Fleischner line always reaches a pleural surface. The line never crosses an interlobar fissure. Mesially, the
Figure 1

Focal areas of atelectasis following pulmonary embolization, frontal projection. Several streak-like shadows (arrows) are present in the right lower lung. These represent areas of discoid atelectasis, viewed at different angles. The effect of the projection on the appearance of the atelectatic plate is well demonstrated by the upper Fleischner line. The mesial portion (M) is thin and sharply outlined because this portion of the plate lies parallel to the X-ray beam. The outer portion (L), however, is twisted so that it lies obliquely and therefore appears broader and less dense.
extent of the line is variable. It rarely reaches the pulmonary hilum because the subsegments originate from the segmental bronchus rather than from the root of the lung.

Because of the varying orientation of the different pulmonary subsegments, Fleischner lines can course in almost any direction, although they are always perpendicular to a pleural surface. If the area of discoid atelectasis is not viewed on end, a Fleischner line may not be visible, and collapse of a pulmonary subsegment can go undetected (fig. 2, left). For this reason, a single frontal film of the chest cannot be considered adequate to exclude the presence of such areas of atelectasis. Some Fleischner lines are seen only in the oblique or lateral projections and, occasionally, in the lordotic view. The oblique views, in addition, are usually required for examination of the basal segments of the lower lobes, especially of those portions that are tucked into the anterior and posterior costophrenic sulci (fig. 2, top right). Fleischner lines in these areas are often obscured in the frontal projection by the diaphragm. In some cases, these lines may be first detected on films of the abdomen, being seen through the shadow of the liver.

Fleischner lines at the lung bases are often oriented on a horizontal plane and, as they involve the peripheral portion of the lung, may be mistaken for Kerley B lines (fig. 2, bottom right). However, the lines representing areas of focal atelectasis are longer and broader than the septal lines, are usually not parallel to each other, and tend to be less numerous. It may not be possible to differentiate a fresh Fleischner line from a fibrous scar in the lung without the aid of previous chest films. In general, scars tend to be thinner and more sharply margined than the lines of discoid atelectasis, but these are not reliable distinctions.

Fleischner lines result from obstruction of small bronchi regardless of the cause and are not a specific sign of pulmonary embolization. They are not uncommonly found on routine chest films of asymptomatic patients, being caused by small mucous plugs in the bronchi. They may also be seen following aspiration or in relation to an area of pneumonia. One or more Fleischner lines can often be identified distal to a peripheral carcinoma of the lung. Focal atelectatic streaks in both lungs have a more specific diagnostic significance. In a hospital population, they are most commonly found in relation to intraabdominal conditions causing peritoneal irritation, or as a result of pulmonary emboli.

The bilateral areas of focal atelectasis associated with inflammatory disease in the abdomen or following abdominal surgery occur because of retention of secretion in the lower lobes. Diaphragmatic excursion is usually limited, diminishing the respiratory motion of the lung and impairing the clearing of secretion from the smaller bronchi. Fleischner lines secondary to pulmonary emboli are also due to bronchial obstruction. They are seen most often in the basal segments of the lower lobes but can occur anywhere in the lungs. The subsegmental bronchi may be obstructed by retained secretion, related to splinting of the diaphragm, or by an outpouring of hemorrhagic exudate related to the congestion of the bronchial mucosa caused by the local stasis of blood.

Because the Fleischner line is a relatively nonspecific roentgen finding, its significance must be evaluated with reference to the patient's clinical picture. Bilateral Fleischner lines, in themselves, are suggestive of pulmonary emboli. If the patient does not have asthma or chronic bronchial disease, both of which predispose to the formation of mucous plugs, and if there is no evidence of disease below the diaphragm, the likelihood of pulmonary emboli is greater. If, in addition, the clinical history is suggestive of pulmonary emboli such as a sudden onset of chest pain or of dyspnea, or hemoptysis, the presence of Fleischner lines in both lungs confirms the diagnosis (fig. 3). Fleischner lines in one lung and a pleural effusion on the opposite side have the same significance (fig. 2). The effusion is usually not large and is probably due to a small subpleural infarct that cannot be recognized.
Figure 2

Pulmonary embolization: Fleischner lines and contralateral pleural effusion. The frontal chest film (left) shows only a slight indistinctness of the right lateral costophrenic sulcus. When the patient is viewed in the right anterior oblique position (top, right), a small collection of fluid (arrow) is seen in the posterior right costophrenic sulcus. In the opposite oblique (bottom, right), two definite Fleischner lines (arrows) are present at the left base. These are hidden by the shadow of the diaphragm in the frontal view.

An area of consolidation in one lung and focal atelectatic streaks in the other can occur with a pneumonia and spillover infection, or with bilateral emboli. The consolidation then represents a true infarct. The lack of a septic course and the absence of purulent sputum favor the diagnosis of embolization.

Discussion
Obstruction of a subsegmental bronchus will not result, by itself, in atelectasis in a normal lung. The lung distal to the obstruction tends to remain aerated because of collateral respiration from alveoli in adjacent subsegments through the pores of Kohn. The
presence of a Fleischner line indicates a lack of aeration of the surrounding alveoli as well as occlusion of a bronchus. If these alveoli are collapsed or filled with secretion, they are no longer radiolucent and contribute to the shadow of the Fleischner line, in some cases accounting for much of its thickness.

There is some disagreement regarding the other factors involved in the formation of a Fleischner line. Fleischner felt that the line actually represented the atelectatic portion of lung. He postulated that the discoid shape of the atelectatic area is due to collapse of the pulmonary subsegment only in a craniocaudal direction. The subsegment cannot collapse in other directions because it cannot retract from the pleura on its anterior, posterior, and lateral surfaces, and it is fixed mesially by its bronchus. This may be true in some cases, but in others the pathogenesis of the Fleischner line seems to be somewhat different.

When a subsegment becomes atelectatic, it can retract mesially toward the obstructed bronchus. The visceral pleura, which is

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**Figure 3**

*Pulmonary embolization: bilateral Fleischner lines. Films made in the right oblique (top) and left oblique (bottom) projections show Fleischner lines (arrows) at both lung bases. The films were made shortly after the patient noted the onset of chest pain and had a small hemoptysis. The lines subsequently disappeared and a repeat chest film 1 week later was clear.*

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intimately attached to the lung, is drawn inward as the subsegment collapses. In this manner, a fissure is formed in the lung, lined on both sides by visceral pleura (fig. 4). It is this double layer of pleura, sometimes enclosing a small amount of fluid, that forms most of the shadow of the Fleischner line. (C. B. Rabin: Unpublished observations.) The surrounding, uninvolved lung becomes hyperaerated and fills the space relinquished by the collapsed subsegment. If the lung is examined in the inflated state, a cleft can be identified on its pleural surface. This represents the site at which the pleura is drawn inward. At the base of the cleft lies the atelectatic pulmonary subsegment.

When the secretion in the bronchus is expectorated, air once more enters the subsegment, and it rapidly reexpands. The chest film returns to normal. If the collapsed subsegment is infarcted, it eventually becomes fibrotic, and the atelectatic streak persists indefinitely. Similarly, the Fleischner line will persist if the two layers of infolded visceral pleura become adherent while the lung is collapsed. Even though the bronchial obstruction is relieved, the fused pleural layers cannot be separated and thus entrap the lung, preventing it from expanding. The disease in the alveoli of the adjacent subsegments usually clears, and the Fleischner line is converted into a thinner and more sharply demarcated fibrous scar.

Reference

1. Fleischner F, Hampton AO, Castleman B: Linear shadows in the lung (interlobar pleuritis, atelectasis and healed infarction). Amer J Roentgenol 46: 610, 1941
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