

Black Pleural Effusion

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ABSTRACT

BACKGROUND: Black pleural effusions are extremely rare and have been reported in patients with infection, malignancy, and hemorrhage. However, no review articles appear to have focused on this rare clinical presentation.

PURPOSE: To classify and characterize diseases causing “black pleural effusion” based on the pathophysiological mechanisms involved.

METHODS: We searched the medical literature to find reports of “black pleural effusion” using the PubMed database.

RESULTS: We identified 8 cases and classified the underlying diseases into the following 4 entities based on pathophysiological conditions: 1) infection (*Aspergillus niger* and *Rhizopus oryzae*); 2) malignant melanoma, in which cells contain melanin pigment; 3) hemorrhage and hemolysis associated with non-small cell lung cancer or rupture of a pancreatic pseudocyst; and 4) other causes (charcoal-containing empyema). Discrimination between biliopleural fistula and pancreatico-pleural fistula, which also mimicking in color, was easily achieved by focusing on pleural amylase levels, elevation of pleural indirect bilirubin, presence of pleural glycolic acid, and the predominant site of pleural effusion.

CONCLUSION: Black pleural effusions can be divided into 4 major categories based on the underlying pathophysiological conditions.

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KEYWORDS: Biliopleural fistula; Black pleural effusion; Pancreaticopleural fistula; Pathophysiological classification

Serous (yellow) and blood-tinged (reddish) pleural effusions are the most common types of pleural fluid at thoracentesis.¹ Black pleural effusions are uncommon, and there have been no review articles on these effusions. Therefore, the previous reports of black pleural effusions were reviewed, and their characteristic findings are discussed based on pathophysiological assessment to identify clinical clues that would help a general physician or pulmonologist establish the etiology when dealing with a patient with a black pleural effusion.

EPIDEMIOLOGY

A black pleural effusion is extremely rare, and only 8 cases have been reported to date (Table 1).²⁻⁹ Therefore, the precise incidence of black pleural effusion has not yet been clarified.

Causes and Pathophysiological Classification of Black Pleural Effusion

Based on the pathophysiological conditions, the 8 cases were divided into 4 groups, as described in Figure 1.

Infection: Associated with *Aspergillus niger* and *Rhizopus oryzae*. The black color of the sputum and pleural fluid is due to the black-pigmented spores of *A. niger* (Figure 2).² Macroscopically, *A. niger* colonies on potato dextrose agar consist of a white or yellow basal felt covered by a dense layer of dark brown to black conidia (Figure 2A). The microscopic morphology of *A. niger* shows the conidial heads, which are large, globose, and dark brown to black in color, and contain the fungal spores, facilitating propagation of the organism (Figure 2B). Indeed, Kimmerling et al⁴ reported that black, friable, and gritty material was con-

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firmed by transbronchial lung biopsy in a patient with invasive aspergillosis, which showed necrotic tissue, calcium oxalate crystals, and *Aspergillus* hyphae. According to Raper,¹⁰ in 1891, Wehmer showed oxalic acid to be a fermentation product of *A. niger*. Oxalic acid was incriminated in the blood vessel destruction by identifying oxalate crystals by polarization (**Figure 2C, D**), and these crystals cause localized tissue damage or severe hemorrhage.¹¹ On partly crossed Polaroids, calcium oxalate is birefringent adjacent to black deposits (**Figure 2C**, arrow) of *A. niger* (**Figure 2C**, asterisk), whereas, on fully crossed Polaroids, calcium oxalate is more clearly identified (**Figure 2D**). The appearance of black sputum or acidic pH in pleural fluid (as low as 5.9 in previous reports), or sputum or cavitory washings containing *A. niger* should suggest the presence of *A. niger* infection or invasion.

Regarding *Rhizopus oryzae*, only one report has been published.⁵ This mold has a characteristic colonial appearance (whitish-to-yellowish cotton candy-like colonies grown on Sabouraud dextrose agar at 25°C for 3 days), and microscopic examination shows broad hyphae without septa and the presence of rhizoids where the stolons and long sporangiophores meet. The mechanism of generating a black pleural effusion associated with *R. oryzae* infection was thought to be due to necrotic debris caused by the *R. oryzae* infection⁵ or to liquefaction of old blood from a previous thoracentesis in the presence of underlying coagulopathy.

Malignant Cells Containing Melanin Pigment Associated with Melanoma. Libshitz and North¹² reported that metastatic malignant melanoma constituted about 5% of all secondary malignancies of the lung, and Chen et al¹³ reported that only 2% of patients with malignant melanoma metastatic to the thorax had pleural effusions. Malignant melanoma with thoracic metastases can cause a black pleural effusion. Mohan and Gowrinath⁷ reported that, on cytological examination of pleural effusion, cytoplasmic pigment was stained black with Fontana Masson's stain, highlighting the presence of cytoplasmic melanin within the tumor cells. However, the degree of melanin pigment in their cytoplasm varied in individual cases, which might explain why melanin pigment was seen in only 25% of cytology specimens of fluids (pleural, ascitic, cerebrospinal, and other fluids) in another report.¹⁴

Hemorrhage and Hemolysis Associated with Non-small-cell Lung Cancer or Rupture of a Pancreatic Pseudocyst.

Rojas-Solano et al⁶ reported a black pleural effusion occurring in a patient with non-small-cell lung cancer, subtype adenocarcinoma, stage IIIB (T4, N1, M0). This case suggests that the black color of the pleural fluid was the result of hemolysis, which was confirmed by the presence of large quantities of hemosiderin-laden macrophages on Prussian blue staining following massive bleeding into the pleura.

Rupture of a pancreatic pseudocyst is one of the causes of a black pleural effusion.⁹ The development of a pseudocyst was preceded by pancreatitis (90%) or pancreatic trauma (10%). Sankaran and Walt¹⁵ reported that alcoholism was the most common cause of pancreatitis, and 3% of patients with a pancreatic pseudocyst developed a pancreaticopleural fistula, but the precise incidence of pancreaticopleural fistula is difficult to ascertain because of its rarity.¹⁶ A pancreatic pleural effusion develops due to a pancreaticopleural fistula expanding

mainly in 2 directions. Anterior disruption of a pancreatic pseudocyst into the peritoneal cavity results in pancreatic ascites,¹⁷ and posterior disruption causes a retroperitoneal fistula track into the pelvis (**Figure 3**, route 1) or superiorly through a natural hiatus in the diaphragm into the mediastinum (esophageal or aortic hiatus) (**Figure 3**, routes 2 and 3). The predominant left-sided pleural effusion would be noted as route 2 when a retroperitoneal fistula spreads via a natural hiatus owing to the anatomical proximity. Another mechanism is direct penetration through the dome of the diaphragm, ignoring normal fascial planes (**Figure 3**, route 4).^{18,19}

Uchiyama et al²⁰ reported that only 20% of patients complained of abdominal pain, and most complained of dyspnea and chest pain; because the pancreatic secretions drain into the pleural cavity, abdominal pain and peritonitis may not develop. We reported a massive left pleural effusion in a patient with a pancreaticopleural fistula with a pancreatic pseudocyst caused by chronic pancreatitis⁹ (**Figure 4**). The pleural fluid was black in color, and the fluid analysis was consistent with an exudative pleural effusion (lactate dehydrogenase 784 IU/L, total protein 4.4 g/dL, glucose 115 mg/dL). The mechanism of the black fluid color was due to hemolysis of the blood that entered the chest from thoracic bleeding. This etiology was confirmed by further fluid analysis, including marked elevations of amylase (5292 IU/L), total bilirubin (7.3 mg/dL; indirect bilirubin 6.5 mg/dL), and a pleural fluid-to-serum bilirubin ratio of 24:3, along with the presence of iron (223 mg/dL). Cytology

CLINICAL SIGNIFICANCE

- We divided black pleural effusions into 4 classifications based on their pathophysiology.
- Infection (*Aspergillus niger* and *Rhizopus oryzae*), malignant melanoma, hemorrhage and hemolysis, and other cause (charcoal-containing empyema) were the main etiologies for black pleural effusion.
- Discrimination of greenish dark or straw-colored bilious pleural effusion from a black or blood-tinged pleural effusion associated with pancreaticopleural fistula is a critical issue for general physicians.

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