A 71-year-old man presented to the emergency room with chest pain, dry cough, shortness of breath and night sweats for 10 days. He had no fever, flu-like symptoms, sputum production or haemoptysis. There was no history of recent travel or sick contacts. A general review of systems was remarkable for subjective weight loss and malaise. He was an active smoker with a 100 pack-years smoking history and a past medical history of rectal squamous cell carcinoma (SCC). His cancer was treated with chemoradiotherapy and had been in remission for 8 years before the presentation. He was also known to have COPD, Global Initiative for Chronic Obstructive Lung Disease (GOLD) category B, well-controlled, with no recent hospitalisations or exacerbations over the past year.

Upon initial examination, arterial blood pressure was 123/75 mmHg, heart rate was 81 beats per min, respiratory rate was 24 breaths per min, and oxygen saturation was 93% on room air. Arterial blood gases showed partial oxygen pressure 73 mmHg, carbon dioxide tension 45 mmHg and pH 7.43. There were decreased breath sounds on the right side, up to the upper lung zone with dull percussion note and reduced tactile vocal fremitus on chest examination. The physical examination was unremarkable otherwise. The patient had a chest radiograph, which showed a right-sided pleural effusion (figure 1).

**Task 1**
What is the most likely diagnosis?
- a) Community-acquired pneumonia (CAP)
- b) Malignancy
- c) Tuberculosis (TB)
- d) Pulmonary embolism

**Figure 1** Chest radiograph depicting right-sided pleural effusion.
The most likely diagnosis is malignant pleural effusion due to significant smoking history and prior history of malignancy. CAP and pulmonary TB are differentials. The patient received intravenous antibiotics for possible CAP.

**Task 2**
What is the most appropriate investigation to undertake next?

a) Thoracentesis
b) Order a computed tomography (CT) scan
c) Perform bronchoscopy
d) Quantiferon Gold for TB

A diagnostic thoracentesis is needed to establish appropriate diagnosis. Under ultrasound guidance, a diagnostic and therapeutic thoracentesis yielded 1200mL of fluid. Shortness of breath and tachypnoea improved post-procedure.

The fluid analysis results showed straw-coloured lymphocytic, exudative effusion, a negative Gram stain, and malignant cells, consistent with malignant pleural effusion (table 1). The pleural fluid analysis was not suggestive of complicated parapneumonic effusion or empyema.

On day 2 of admission, the patient developed worsening shortness of breath and desaturation. A follow-up examination revealed tracheal deviation to the left side, with decreased vocal fremitus and reduced breath sounds on the right side.

**Task 3**
What is expected on a repeat chest radiograph?

a) Reaccumulating pleural effusion
b) New consolidation
c) Lung collapse
d) Pneumothorax

**Table 1** *Pleural fluid analysis*

|                          | Day 1 (at admission)                  | Day 16 (immediately post-thoracoscopy) |
|--------------------------|---------------------------------------|----------------------------------------|
| Colour                   | Straw-coloured                        | Black                                  |
| Appearance               | Turbid                                | Black                                  |
| pH                       | 7.46                                  | 7.29                                   |
| Glucose mmol·L⁻¹          | 4.5                                   |                                        |
| Protein g·L⁻¹             | 40.2                                  |                                        |
| Serum protein g·L⁻¹       | 71                                    |                                        |
| Albumin g·L⁻¹             | 20.6                                  |                                        |
| LDH U·L⁻¹                 | 358                                   | 980                                    |
| Serum LDH U·L⁻¹           | 271                                   |                                        |
| WBC cells·µL⁻¹            | 328                                   | 1125                                   |
| Neutrophils %             | 3                                     | 87                                     |
| Lymphocytes %             | 93                                    | 7                                      |
| Monocytes %               | 4                                     | 6                                      |
| RBC cells·µL⁻¹            | 613                                   | 15375                                  |
| Gram stain               | Negative                              | Gram-negative bacilli                  |
| Culture                  | Negative                              | *Pseudomonas aeruginosa* and *Klebsiella pneumoniae* |
| Fungal culture           | Negative                              | Negative                               |
| TB PCR, smear, and culture| Negative                              | Not done                               |
| Cytology                 | Abnormal large cohesive cells with nuclear polymorphism and vacuolated cytoplastom suspicious of malignant infiltration | Malignant cells present |
| Special characteristics   | Abundant mesothelial cells present    | Prominent RBCs⁷                        |
| Effusion characterisation| Lymphocytic, exudative, malignant effusion | Empyema in a malignant effusion |

LDH: lactate dehydrogenase; WBC: white blood cell; RBC: red blood cell; ⁷: RBC content declined successively over the following days.
A repeat chest radiograph revealed iatrogenic pneumothorax on the side of the pleural effusion (figure 2).

Task 4
What should be the next step in the management of the patient?
- a) Oxygen supplementation and observation
- b) Needle aspiration
- c) Chest tube insertion
- d) High-flow nasal oxygen

Answer 4
c.

The patient has a >2 cm iatrogenic pneumothorax and is symptomatic. Hence a chest tube was inserted and connected to the underwater seal (figure 3).

The patient’s shortness of breath progressed despite chest tube insertion. The chest tube was functioning appropriately, as evidenced by swinging fluid levels and bubbling. CT of the chest was performed (figure 4).

Task 5
Can you identify the finding on the chest CT image (figure 4)?
- a) Pneumothorax
- b) Apical bleb
- c) Sub-pleural nodules
- d) All of the above
The right lung shows a sizeable pneumothorax, apical subpleural blebs and subpleural nodules. Other cuts of CT revealed multiple spiculated nodules throughout both lung fields.

**Task 6**
Considering the persistent air-leak, what is the most appropriate next step in management?

a) Perform bronchoscopy  
b) Pleurodesis  
c) Thoracoscopy  
d) Bilateral chest tube insertion

**Answer 6**
c.

The patient underwent right-sided video-assisted thoracoscopy. There was an upper lobe scar with surrounding nodules and continuous air leak. The thoracic surgery team performed an upper lobe wedge resection to fix the air leak and inserted a chest tube connected to an underwater seal. The color of the fluid draining from the chest tube noted immediately post chest tube insertion was black (figure 5).

**Task 7**
What is the most common cause of this finding?

a) Crack cocaine use  
b) Malignancy  
c) Fungal infection  
d) Pancreatic pseudocyst rupture with pancreaticopleural fistula

**Answer 5**
d.

Figure 5 Black-coloured pleural fluid draining from the chest tube.
The most common cause of the black pleural effusion is malignancy. The pleural fluid analysis was consistent with empyema secondary to *Pseudomonas aeruginosa* and *Klebsiella pneumoniae* (table 1). Multiple invasive procedures, including a thoracocentesis and chest tube insertion performed before thoracoscopy on a frail, elderly patient with underlying malignancy, could have led to an iatrogenic empyema. Pyomelanin is a brown/black extracellular pigment produced by *Pseudomonas*; however, it does not cause black discolouration of body fluids.

The patient also had neutrophilic leucocytosis, a raised C-reactive protein (324 mg·L⁻¹), and high procalcitonin (38.2 ng·mL⁻¹). He received piperacillin/tazobactam with a working diagnosis of empyema. Pyomelanin is a brown/black extracellular pigment produced by *Pseudomonas*; however, it does not cause black discoloration of body fluids.

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Table 2

| Tumour marker | Normal range | Value in patient |
|---------------|--------------|-----------------|
| CEA µg·L⁻¹    | 5.5–6.5 (smoker) 3.8–5 (nonsmoker) | 6 |
| CA19-9 Units·mL⁻¹ | 0–27 | 256 |
| AFP IU·L⁻¹    | 0–6 | 4 |
Fade to black!

Immunohistochemistry was negative for P-40 and P-63, which are the markers for SCC. This immunoreactivity excluded the possibility of recurrence of the rectal SCC. The tumour cells’ reactivity for epithelial-specific antigen (MOC-31) and BER-EP4 confirmed the epithelial origin of the tumour. Based on negative lung adenocarcinoma markers, thyroid transcription factor 1 (TTF-1) and napsin-A, a lung primary was less likely. TTF-1 immunoreactivity is highly sensitive and specific in determining pulmonary versus extrapulmonary origin of adenocarcinoma [1]. In extrapulmonary adenocarcinomas (except thyroid) it is so low (1%) that the negativity for TTF-1 may be interpreted as definitive evidence that the tumour is a primary from an extrapulmonary source. The cells were immunopositive for cytokeratin (CK)-7 expression and immunonegative for CK-20 expression (figure 6). A definitive conclusion on the origin of the tumour based entirely on the immunostaining is challenging due to the lack of additional markers of pancreatic and hepatobiliary origin.

CT of the chest, abdomen and pelvis with contrast showed a dilated common bile duct measuring 16 mm with associated dilated intrahepatic biliary radicals. CK-7 positivity and CK-20 negativity in biliary tract carcinomas are associated with intrahepatic bile duct carcinomas. Tumour markers showed normal alpha-fetoprotein (AFP) and carcinoembryonic antigen (CEA), but a raised carbohydrate antigen 19-9 (CA19-9) (table 2). The serum alkaline phosphatase, total bilirubin and aspartate aminotransferase were also elevated. The patient’s age, sex, tumour marker profile, immunohistochemical profile, liver function profile, and imaging data fit the possibility of metastasis from a hepatobiliary origin, likely intrahepatic bile duct carcinoma [2–5].

A multidisciplinary team meeting between the primary team, pulmonology, cardiothoracic surgery, oncology, onco-radiology and histopathology was conducted. The general condition of the patient made him unfit for further malignancy workup or chemotherapy. He received palliative care from thereon. He later passed away due to the progression of the disease.

### Discussion

The aetiologies of pleural effusion are varied and range from infection to malignancy and...
autoimmunity to drugs of abuse [6, 7]. Analysis of pleural fluid is essential to the diagnosis of underlying aetiology. The pleural fluid colour may vary from clear or straw-coloured to blood-tinged or frankly bloody [8]. It is incredibly unusual to have black coloured pleural effusion. The authors reviewed the literature on Medline, PubMed, Embase and Google scholar. Key terms used were (“black” and (“pleura” or pleural)) and “effusion”.

The search duration was from 1950 to June 26, 2020. The search identified 25 reported cases of black pleural effusion (table 3). There are 11 reported cases of black pleural fluid secondary to malignancy. What makes this case unique is the immunostaining being negative for lung markers and melanoma. Hence, it is the first reported black pleural effusion case thought to be secondary to hepatobiliary malignancy.

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