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November 2021 Imaging Case of the Month: Let's Not Dance the Twist*

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History of Present Illness: An 82-year-old man presented to his physician for general health maintenance as well as a complaint of persistently poor quality sleep and poor appetite with weight loss. The patient had undergone robotic-assisted radical left nephroureterectomy and cystectomy with pelvic lymph node dissection and urinary diversion for left clear cell renal cell carcinoma (staged T2a, grade 2) and transitional cell carcinoma of the bladder (carcinoma in situ at surgery), approximately 9 months earlier. The patient's bladder malignancy was initially treated with transurethral resection, with histopathology at that procedure showing high-grade papillary urothelial malignancy with lamina propria invasion, but no muscular invasion; this procedure was followed by formal complete resection approximately 3 months later. The patient's post-operative course was complicated by significant bleeding which required transfusion of 3 units of blood. He had

undergone inferior vena caval filter placement prior to surgery when preoperative testing revealed lower extremity deep venous thrombus and pulmonary embolism.

Past Medical History: The patient's past medical history was remarkable for atrial fibrillation treated with anticoagulation and hypertension. He also had a history of coronary artery disease and myocardial infarction with moderate systolic dysfunction. His medical list included warfarin (for his atrial fibrillation), acetaminophen, vitamin supplementation, hydrochlorothiazide, atorvastatin, ramipril, metoprolol, and zolpidem. He denied allergies. The patient was a former smoker, previously smoking 2 packs-per day for 35 years, quitting over 30 years prior to presentation.

His past surgical history was remarkable for laminectomy in addition to the recent

urinary surgery. He also had a history of rectal laceration complicating previous prostatectomy for prostate carcinoma (Gleason 3 + 4, T2).

Physical Examination: showed the patient to be afebrile with normal heart and respiratory rates and blood pressure. Her room air oxygen saturation was 99%. The physical examination did not disclose any salient abnormalities.

Initial Laboratory: The patient's complete blood count and serum chemistries showed largely normal values, with the white blood cell count was normal at $6.7 \times 10^9 /L$ (normal, $4-10 \times 10^9 /L$). His liver function testing and renal function testing parameters were also within normal limits. Echocardiography showed mildly decreased left ventricular systolic function, but this finding was stable. The patient underwent frontal chest radiography (Figure 1A).

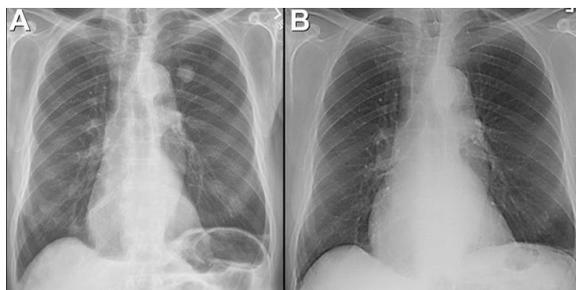


Figure 1. A: Frontal chest radiography. **B:** Frontal chest radiography performed just over 1 year prior to A shows no specific abnormalities.

Which of the following represents **an appropriate interpretation** of his frontal chest **radiograph**?

1. Frontal chest radiography shows no specific abnormalities
2. Frontal chest radiograph shows a nodule
3. Frontal chest radiography shows bilateral interstitial thickening

4. Frontal chest radiography shows bilateral pleural effusions
5. Frontal chest radiography shows mediastinal and peribronchial lymph node enlargement

Correct!

2. Frontal chest radiograph shows a nodule

The frontal chest radiograph (Figure 1) shows a circumscribed left upper lobe nodule. No pleural effusion, interstitial lung abnormality, or intrathoracic lymph node enlargement is evident.

Which of the following represents **an appropriate next** step for the patient's management?

1. Comparison to prior chest radiography
2. Chest MRI
3. Lateral decubitus chest radiography
4. ^{18}F FDG-PET scan
5. Contrast-enhanced chest CT

Correct!

1. Comparison to prior chest radiography

Whenever a lesion is discovered at chest imaging, comparison to older chest imaging studies is of paramount importance. If a chest lesion can be shown to be stable for a significant length of time, the evaluation of a chest lesion may be tempered, saving expense, potential radiation exposure, patient anxiety, and possibly even complications. Further evaluation with cross sectional imaging or ^{18}F FDG-PET may occasionally be averted with this approach, the latter typically employed after a nodule at chest radiography has been evaluated with chest CT and found to be indeterminate. In this case, ^{18}F FDG-PET may not be required if the nodule is shown to be stable for a long period of time. Similarly, chest CT may also

be avoided if prior chest radiographs show long-term nodule stability. Furthermore, nodule evaluation with CT is typically performed without use of intravenous contrast, unless a specific pulmonary nodule enhancement protocol is used. Lateral decubitus chest radiography is employed to further characterize pleural effusion [mobile vs. loculated or pleural thickening] or for the detection of pneumothorax, and hence does not play a role for the evaluation of this patient.

A chest radiograph performed just over one year earlier, prior to the patient's urologic surgery, was located for comparison (Figure 1B).

Given this comparison, which of the following represents the **less likely consideration** for the patient's presentation chest radiographic findings?

1. Bronchogenic malignancy
2. Coccidioidomycosis
3. Hamartoma
4. Metastasis
5. Tuberculosis

Correct!
3. Hamartoma

Infectious etiologies, especially fungal infections, and possibly tuberculosis, are certainly considerations when a new nodule becomes apparent at chest imaging. Among the differential diagnostic considerations listed, hamartoma is unlikely to account for the new nodule as such lesions grow slowly, and the nodule would probably be visible on the chest radiograph performed one year earlier. Bronchogenic malignancy is overall unlikely when chest radiography just over one year earlier showed normal findings, but a rapidly growing cancer remains possible. An isolated metastatic lesion is certainly a

possibility given the patient's recent urologic malignancies, although the upper lobe location is atypical and both malignancies were localized.

Which of the following represents an **appropriate next step** for the patient's management?

1. Perform unenhanced chest CT
2. Perform lateral decubitus chest radiography
3. Perform ⁶⁸Ga-Dotatate scan
4. Perform ¹⁸F-FDG-PET scan
5. Perform contrast enhanced thoracic MR

Correct!

1. Perform unenhanced chest CT

Unenhanced chest CT is typically the diagnostic study of choice when a new indeterminate nodule is encountered in an adult patient. As noted previously, lateral decubitus chest radiography is reserved for assessment of layering pleural effusion (with the affected side dependent) or pneumothorax (with the affected side non-dependent). PET scanning with ⁶⁸Ga-Dotatate is typically used for the evaluation of neuroendocrine malignancies, and could play a role for this patient if that diagnosis is subsequently confirmed, but is as yet premature. Thoracic MR is not commonly employed for the assessment of new pulmonary nodules; chest CT is generally more rewarding for that application).

The patient underwent enhanced chest CT (Figure 2).

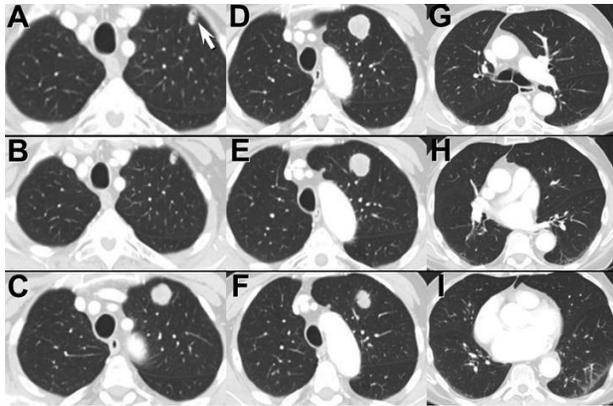


Figure 2. Axial enhanced CT.

Which of the following represents *an appropriate interpretation* for this examination?

1. Chest CT shows a solitary left upper lobe nodule
2. Chest CT shows several pulmonary nodules
3. Chest CT shows extensive interlobular septal thickening
4. Chest CT radiography shows peribronchial and mediastinal lymphadenopathy
5. Chest CT radiography shows multifocal ground-glass opacity and consolidation

Correct!

1. Chest CT shows a solitary left upper lobe nodule

The enhanced chest CT shows a lobulated, non-calcified left upper lobe nodule corresponding to the chest radiographic abnormality. However, another smaller subpleural cavitory nodule in the left apex is present as well. No interlobular septal thickening, ground-glass opacity, or consolidation is evident. No definitely peribronchial or mediastinal lymph node enlargement is seen.

Testing for coccidioidomycosis infection and tuberculosis was negative.

Which of the following represents *an appropriate next step* for the evaluation of this patient?

1. Short-term follow up CT
2. ¹⁸F¹⁸FDG-PET scan
3. Bronchoscopy with transbronchial biopsy
4. Cryobiopsy
5. CT-guided percutaneous lung biopsy

Correct!

5. CT-guided percutaneous lung biopsy

Given the history of urinary malignancy and the appearance of a new indeterminate lung nodule, short-term follow up CT, usually obtained to assess for growth as a proxy for aggressiveness, is not appropriate. Similarly, ¹⁸F¹⁸FDG-PET scan would not provide management-altering results negative ¹⁸F¹⁸FDG-PET results (highly unlikely) would be difficult to reconcile with the clinical situation, and positive ¹⁸F¹⁸FDG-PET results would prompt a tissue diagnosis, so a tissue diagnosis is required regardless. Bronchoscopy with transbronchial biopsy is not inappropriate, but probably stands a lower chance than percutaneous transthoracic needle biopsy. Cryobiopsy is generally reserved for evaluation of diffuse lung disease and not used to evaluate pulmonary nodules.

The patient's warfarin was held and he underwent percutaneous transthoracic lung biopsy (Figure 3).



Figure 3. Axial unenhanced chest CT performed during percutaneous transthoracic needle biopsy. Note that the nodule has enlarged (now 3.9 cm) only 22 days after the presentation chest CT (2.8 cm, Figure 2)

Histopathological analysis showed poorly defined adenocarcinoma with necrosis consistent with urothelial malignancy, showing a morphology identical to the patient's bladder malignancy. Repeat CT of the abdomen and pelvis showed post-surgical changes related to left renal and adrenal resection and ureteral resection and cystectomy with ileal conduit information, but no evidence to suggest recurrence of malignancy.

Which of the following represents **an appropriate next step** for the patient's management?

1. Perform ^{18}F FDG-PET scan
2. Begin chemotherapy
3. Surgical consultation for possible metastectomy
4. Perform stereotactic radiation to the left upper lobe lesions
5. Perform percutaneous radiofrequency ablation of both left upper lobe lesions

Correct!

3. Surgical consultation for possible metastectomy

Because the patient has been adequately staged, ^{18}F FDG-PET scan would play little role in the management of this patient. Either chemotherapy or local radiotherapy are appropriate considerations, but left upper lobe resection to achieve metastectomy, give the apparently isolated nature of these metastatic lesions, may offer a survival benefit compared with either local radiotherapy or systemic treatment alone. Percutaneous radiofrequency ablation is a viable approach for local malignancy control in selected patients, although typically for primary lung malignancy and not metastatic lesions, but the spatial separation of the two lesions renders this approach untenable.

The patient was reviewed at a multidisciplinary conference attended by radiation oncology, medical oncology, radiology, pulmonary medicine, and thoracic surgery, and left upper lobe resection was recommended. Preoperative pulmonary function testing showed relative normal results, with preserved diffusion capacity and no features to suggest either restrictive lung disease or significant air flow obstruction. The patient underwent left upper lobe resection without difficulty.

The plan for the patient on the first post-operative day (Figure 4) was to optimize pain management, discontinue intravenous fluids, maintain the thoracostomy tube on water seal, transition to oral medication, and ambulate the patient.



Figure 4. Frontal chest radiography immediately following left upper lobe resection shows the expected left-sided volume loss with poorly defined left base opacity. A small amount of left pleural effusion may be present with a thoracostomy tube over the left apex, but no visible pneumothorax.

On post-operative day 2 (Figure 5), the patient was afebrile, tolerating diet well, and the thoracostomy tube was removed and the patient was transferred from surgical intensive care to the floor, with the intention to discharge the patient home later in the day.

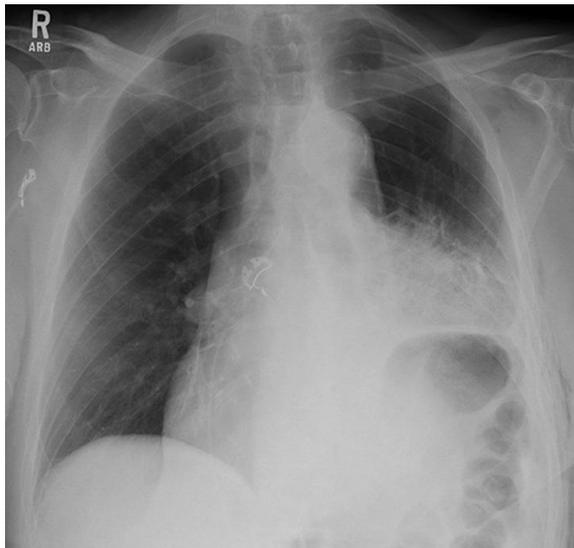


Figure 5. Frontal chest radiography postoperative day 2 following left upper lobe resection shows the expected left-sided volume loss with increase in the poorly defined left base opacity, although left lung volume has decreased compared with the immediate post-operative study (Figure 4). No pneumothorax is visible and no enlarging pleural effusion is present. The thoracostomy tube has been removed.

Later that day the patient complained of pain and sputum production and atrial fibrillation with a rapid ventricular response (heart rate in 130s) was noted. Discharge was delayed and respiratory therapy was consulted to improve pulmonary toilet. On postoperative day 3 (Figure 6), the patient became hypotensive (mean arterial pressure in the 50's mmHg), unresponsive to fluids.

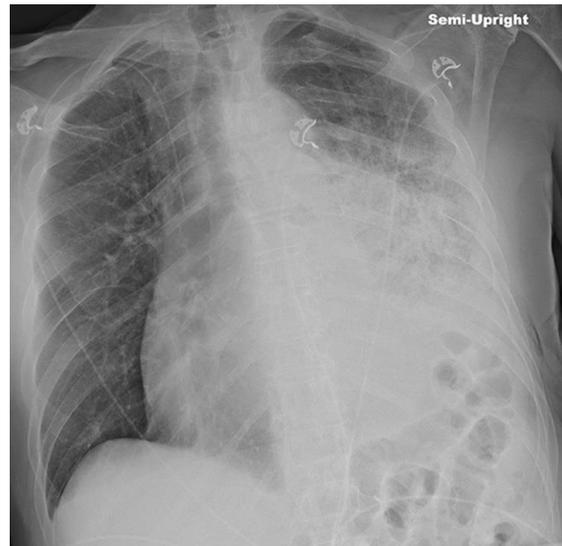


Figure 6. Frontal chest radiography postoperative day 3 following left upper lobe resection shows worsening of left lung consolidation now with a more prominent linear component, suggesting interlobular septal thickening.

Evaluation of the patient revealed copious secretions with cough and wheezing.

Laboratory data showed hyponatremia (132 mEq/L, normal 136-145 mEq/L), hypocalcemia (8.2 mg/dL, normal 8.6-10 mg/dL), mild anemia (stable), and elevated blood urea nitrogen (58 mg/dl, normal 7-22.4 mg/dl) and creatinine (2.5 mg/dL, 0.7-1.3 mg/dL; baseline pre-operative creatinine was 1.4 mg/dL). A urine culture showed *Pseudomonas*, and the patient's white blood cell count was elevated at $16.9 \times 10^9 / L$ (normal, $4-10 \times 10^9 / L$).

Which of the following represents **an appropriate next step(s)** for the patient's management?

1. Transfer to the intensive care unit
2. Consult critical care medicine
3. Begin broad spectrum antibiotics
4. Vasopressors for blood pressure support
5. All of the above

Correct!
5. All of the above

The patient was diagnosed with left-sided pneumonia and septic shock and acute kidney injury, and all of the measures were undertaken.

On post-operative day 4 (Figure 7), echocardiography showed normal left ventricular systolic function (ejection fraction= 64%) on dobutamine, with a baseline echocardiogram performed 7 months earlier showing moderate systolic dysfunction (ejection fraction= 35%).



Figure 7. Frontal chest radiography postoperative day 4 following left upper lobe resection shows continued left lung consolidation again with a prominent linear component suggesting interlobular septal thickening. Trace left subcutaneous emphysema is present. A small left pleural effusion cannot be excluded, possibly with some pleural liquid over the left apex laterally, but a large pleural effusion is not seen and no right pleural liquid is evident.

The patient maintained his blood pressure on a combination of vasopressin and dobutamine.

Which of the following represents **an appropriate next step(s)** for the patient's management?

1. Perform renal ultrasound to exclude hydronephrosis
2. Perform chest ultrasound to exclude pleural effusions
3. Consider bronchoscopy for airway secretion management
4. Vasopressors for blood pressure support
5. All of the above

Correct!
5. All of the above

All of the above are appropriate measures and were undertaken.

On post-operative day 5 (Figure 8), renal ultrasound showed no hydronephrosis and chest ultrasound showed no right pleural effusion and only trace left pleural effusion.

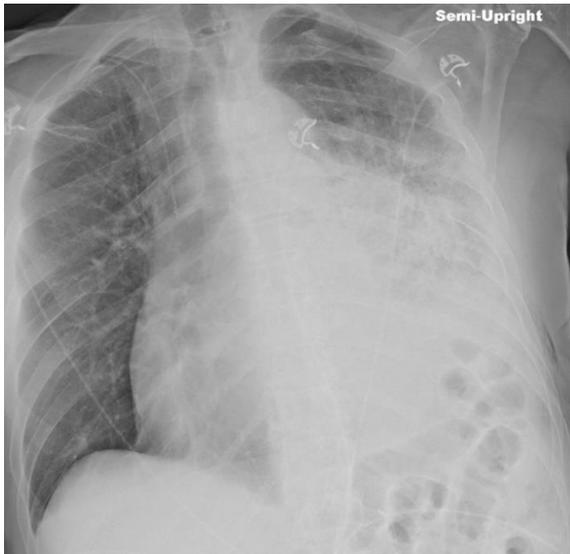


Figure 8. Frontal chest radiography postoperative day 5 following left upper lobe resection shows continued worsening of left lung consolidation and interlobular septal thickening.

The patient's white blood cell count began trending down on broad spectrum antibiotic therapy. Vascular support provided by vasopressin and Dobutamine, with the intention to wean Dobutamine, although attempts to decrease blood pressure support were not tolerated. The patient complained of left-sided chest pain, thought to be the result of presumed left lower lobe pneumonia. Pain management was optimized. Physical examination showed wheezing and the patient complained of sputum production.

Which of the following represents ***an appropriate next step(s)*** for the patient's management?

1. CT pulmonary angiography
2. Bronchoscopy for airway secretion management
3. Cardiac MRI
4. Thoracentesis
5. All of the above

Correct!
2. Bronchoscopy for airway secretion management

Chest CT is not unreasonable, but the patient's renal function precluded iodinated contrast administration. Similarly, cardiac MRI typically involves the use of intravenous gadolinium administration to assess for myocardial inflammation and scar, and the administration of gadolinium-based compounds is typically avoided in patients with worsening renal insufficiency. Furthermore, echocardiography has already been successfully employed for the management of the patient's cardiac dysfunction and inotropic support. Since chest ultrasound showed only trace left pleural effusion, thoracentesis is not required.

The progression of post-operative chest radiographic findings is shown in Figure 9.

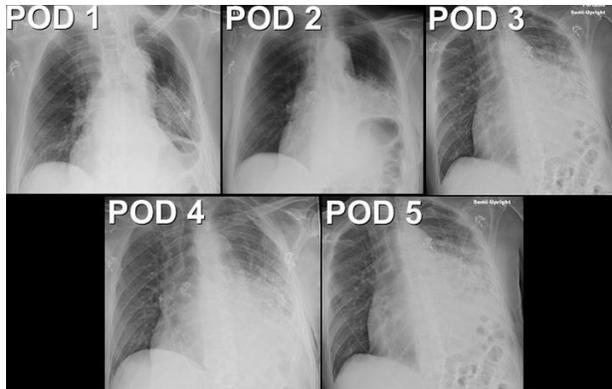


Figure 9. Frontal chest radiograph sequence following left upper lobe resection shows progressive left lung consolidation and interlobular septal thickening.

Bronchoscopy (Figure 10) was performed and showed a normal-appearing carina with bloody secretions were noted in the left mainstem bronchus.

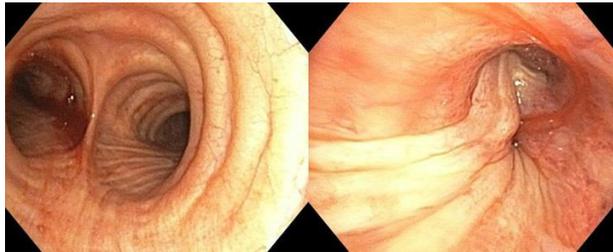


Figure 10. Bronchoscopy shows a normal appearing carina. Some bloody secretions were noted in the left mainstem bronchus.

The left upper lobe bronchial stump appeared clean and intact. The left lower lobe bronchus was severely narrowed, described as showing a “fish-mouth” appearance with edema, through which the bronchoscope could not be advanced. The right-sided airways appeared normal.

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bronchoscope could not be advanced. The right-sided airways appeared normal.

Which of the following represents **an appropriate next step(s)** for the patient’s management?

1. Chest CT
2. Decubitus chest radiography
3. Enhanced pulmonary toilet
4. Surgical consultation
5. More than one of the above

Correct!

5. More than one of the above

Decubitus chest radiography can prove useful to assess for pleural effusion (dependent side) or pneumothorax (non-dependent side), but chest ultrasound has already shown only trace pleural effusion on the left side, and thus decubitus chest radiography would probably provide no useful information. While enhanced pulmonary toilet is not a “wrong” answer as some secretions were noted at bronchoscopy, these secretions were not profound and the pattern of left lower lobe bronchial obstruction at bronchoscopy was not suggestive of a mucous plug. Other causes for left lower lobe bronchial obstruction should be considered and hence surgical consultation is advisable.

The patient underwent unenhanced chest CT (Figure 11).

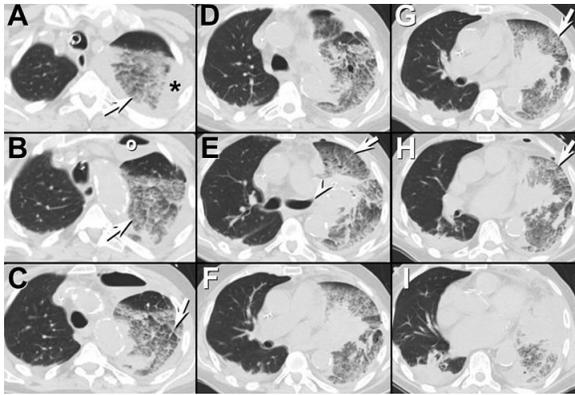


Figure 11. Axial unenhanced chest CT shows extensive left lung ground-glass opacity following left upper lobectomy associated with extensive left lung interlobular septal thickening (arrows). Dense central left lung consolidation is present associated with a truncated bronchus; the left lower lobe bronchus is not readily seen. A small anterior left upper chest pleural effusion (*) and post-operative hydropneumothorax (°) are present.

Which of the following represents *the most accurate interpretation* of this examination?

1. The chest CT findings suggest left lung infection
2. The chest CT findings suggest thromboembolic disease
3. The chest CT findings suggest bronchopleural fistula
4. The chest CT findings raise concern for pulmonary torsion
5. The chest CT findings central airway mucous impaction

Correct!

4. The chest CT findings raise concern for pulmonary torsion

While the left lung findings are not inconsistent with pulmonary infection, the extensive interlobular septal thickening is unusual for that diagnosis. Thromboembolic disease can neither be diagnosed nor

excluded given the unenhanced nature of the chest CT examination. While a small anterior upper thorax hydropneumothorax is present, this finding is consistent with the recent post-operative state and is too small to overtly suggest bronchopleural fistula. The left mainstem bronchus appears truncated or “cut-off,” which certainly can raise the possibility of mucous impaction. However, it is more typical of mucous impaction to show material within the affected airway, rather than an abrupt, tapered occlusion of the airway as seen in this circumstance. Furthermore, bronchoscopy was performed prior to this chest CT and airway mucous was removed. The abrupt, tapered occlusion of the left mainstem and left lower lobe bronchus, central consolidation, and extensive ground-glass opacity and interlobular septal thickening are features of pulmonary torsion.

The patient was taken to the operating room and thoracoscopy showed extensive hemorrhage in the remaining left lower lobe. An open thoracotomy was performed for exploration, which confirmed torsion with 360° rotation of the vascular pedicle and bronchus, and lung appeared non-viable. Completion pneumonectomy was performed (Figure 12).



Figure 12. Gross surgical specimen from left lower lobectomy.

Diagnosis: Urothelial malignancy with left upper lobe resection for metastectomy complicated by left lower lobe torsion treated with completion pneumonectomy

Which of the following statements regarding lung torsion is / are **true**?

1. The right middle lobe is most commonly affected following right upper lobectomy
2. Incomplete fissures are a risk factor
3. An incomplete or divided inferior pulmonary ligament is a risk factor
4. Risk factors include large pleural effusions or pneumothoraces
5. The diagnosis is often delayed owing to the non-specific presentation and rarity of the diagnosis
6. Lung torsion may occur without prior surgery
7. Torsion should be suspected at recent post-operative state when persistent ad progressive consolidation is present, particularly when interlobular septal thickening is seen
8. Some of the above
9. All of the above

Correct!

9. All of the above

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