

February 2019 Imaging Case of the Month: Recurrent Bronchitis and Pneumonia in a 66-Year-Old Woman

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Clinical History: A 66-year old woman presented with complaints of a non-productive cough worsening over the previous several weeks. She complained that her cough had also occurred several months earlier, but resolved, and then subsequently returned.

The patient indicated that she has had bouts of bronchitis off and on for many years. Her smoking history included only 3 cigarettes / day for two years, quitting 20 years earlier. She did not note any allergies and her list of medications included only vitamin supplements, baby aspirin, omeprazole, and lisinopril. Her surgical history was remarkable only for remote tonsillectomy and hysterectomy.

Her physical examination was largely unremarkable, although some coarse breath sounds were detected over the medial right base. Her vital signs showed normal pulse rate and blood pressure, breathing at 12 breaths / minute. Her room air oxygen saturation was 97%.

Frontal chest radiography (Figure 1) was performed.

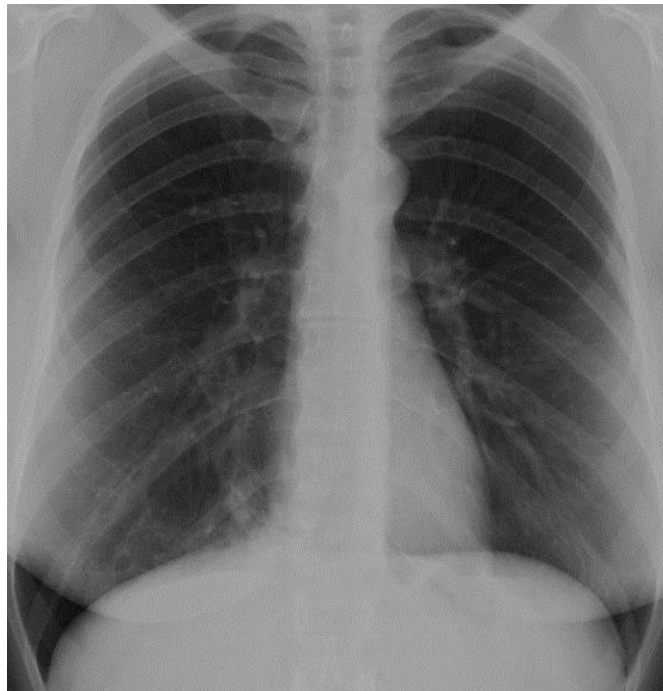


Figure 1. Initial frontal chest x-ray.

Which of the following represents **the most accurate assessment** of the chest radiographic findings?

1. Chest radiography shows a vague solitary pulmonary opacity
2. Chest radiography shows basilar fibrotic opacities
3. Chest radiography shows cavitary pulmonary lesions
4. Chest radiography shows marked cardiomegaly
5. Chest radiography shows numerous small nodular opacities

Correct!

1. Chest radiography shows a vague solitary pulmonary opacity

The frontal radiograph shows a vague nodular opacity overlying the medial right base, perhaps with some streaky opacity just superior to the nodular opacity (Figure 2).

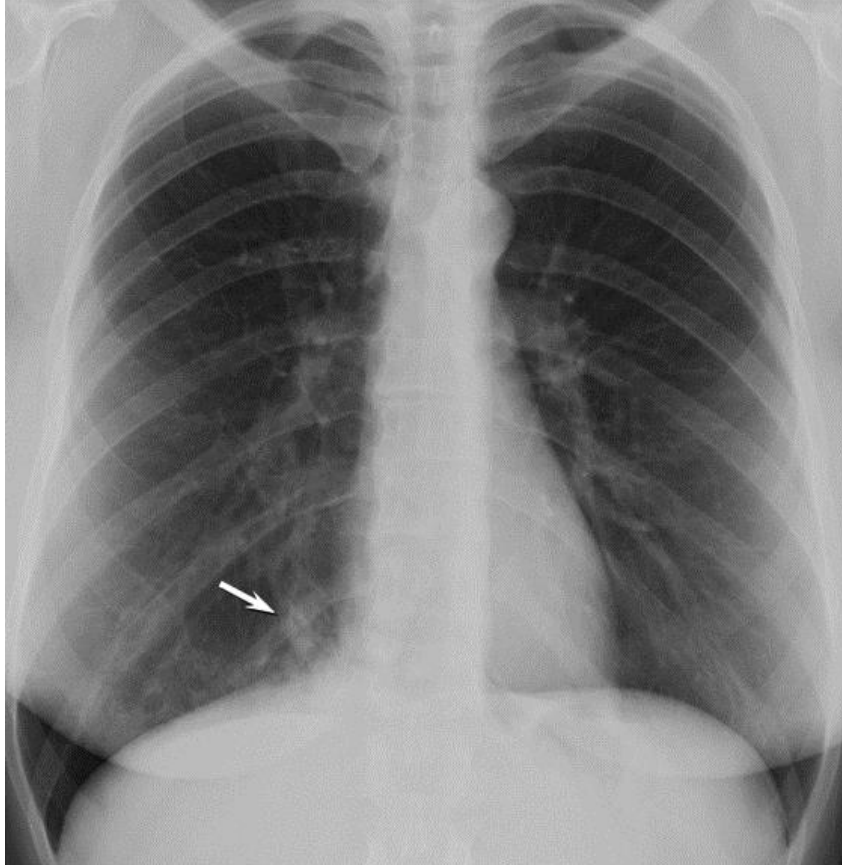


Figure 2. Frontal chest radiography shows a poorly defined nodular opacity (arrow) projected over the medial right lung base. No pleural abnormality or lymph node enlargement is present and the left lung is clear.

The lungs appear relatively clear otherwise. There is no evidence of cavitation, the heart size is normal, the lung volumes are normal, and there is no evidence of fibrotic disease.

At this point, which of the following represents the **most appropriate step** in this patient's management?

1. ¹⁸FDG-PET scan
2. Check coccidioidomycosis titers
3. Obtain prior imaging for comparison
4. Pulmonary function testing
5. More than one of the above

Correct!

5. More than one of the above

More than one answer listed is correct- it is appropriate to check for titers suggesting coccidioidomycosis infection given that the patient resides in an endemic region. Obtaining prior imaging for comparison is always an expedient choice when confronted with abnormalities at imaging, particularly in the context of a possible indeterminate solitary pulmonary nodule in an adult patient. Pulmonary function testing is also a reasonable procedure to perform when an adult patient presents with respiratory complaints. However, ^{18}F FDG – PET scan is premature at this point. It is usually more rewarding to obtain chest CT for characterization of pulmonary opacities, as well as first determine if prior imaging or medical records can clarify the nature of a potentially indeterminate focal lung opacity, before obtaining expensive, advanced non-invasive tissue characterization procedures.

The patient was empirically treated with broad-spectrum antibiotics for several weeks, but without improvement. Pulmonary function testing showed an FEV1 of 1.57L (80% predicted), DLCO = 133% of predicted, and normal oxygenation at rest and with exercise. No prior imaging for comparison could be located, and testing for coccidioidomycosis infection was unrevealing.

Which of the following represents the **most appropriate step** in this patient's management?

1. ^{18}F FDG-PET scan
2. ^{68}Ga -Dotatate scan
3. CT pulmonary angiography
4. Unenhanced thoracic CT
5. Unenhanced thoracic MRI

Correct!

4. Unenhanced thoracic CT

Unenhanced thoracic CT is the most appropriate choice among those listed. While some recent data suggest MRI can detect and characterize pulmonary nodules, MR is more costly, takes longer, and is generally less efficacious than CT for this purpose. Typically indeterminate nodular opacities at thoracic CT are characterized using unenhanced CT, although one can employ intravenous contrast injection utilizing a specific nodule enhancement protocol for characterization, but injecting intravenous contrast according to a CT pulmonary angiography is not an appropriate protocol as the nodular opacity cannot be characterized properly with that protocol, and neither the patient's presentation nor the chest radiographic findings are suggestive of pulmonary thromboembolic disease. As noted above, ^{18}F FDG – PET scan is premature at this point. Finally, ^{68}Ga – PET – CT dotatate scanning is typically used for neuroendocrine malignancies, and could play some role in this patient's assessment if neuroendocrine malignancy is subsequently diagnosed, this study is not appropriate at this point in the patient's assessment.

The patient underwent unenhanced thoracic CT (Figure 3).

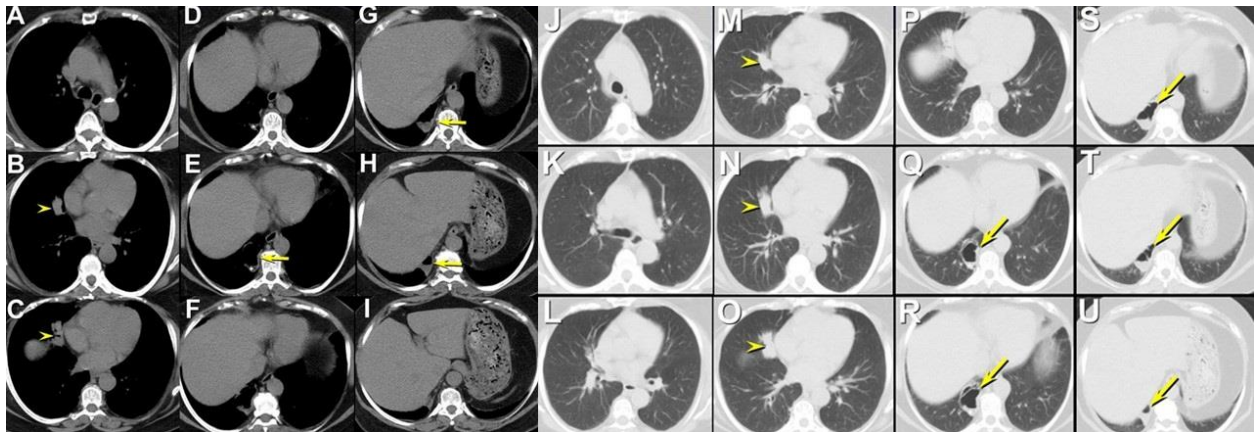


Figure 3. A-I: Axial unenhanced thoracic CT displayed in soft tissue windows. J-U: Axial unenhanced thoracic CT displayed in lung windows.

Which of the following represents ***the most accurate assessment*** of the chest CT findings?

1. Chest CT shows a poorly defined, non-calcified, right lung nodule
2. Chest CT shows basilar fibrotic lung disease
3. Chest CT shows multifocal bilateral pleural thickening
4. Chest CT shows multifocal bronchiectasis
5. Chest CT shows patchy, multifocal areas of ground-glass opacity and consolidation

Correct!

1. Chest CT shows a poorly defined, non-calcified, right lung nodule

The unenhanced chest CT shows a poorly defined, non-calcified nodule in the right middle lobe (arrows and arrowheads on Figure 3). No lymphadenopathy or pleural disease is present. There is no areas of ground-glass opacity to suggest alveolitis nor is there bronchiectasis or features of fibrotic lung disease. An incidentally noted cystic lesion is seen in the extreme medial right lung base, containing a small gas-fluid level. Testing for *Mycobacterium tuberculosis* was negative.

Which of the following represents the **most appropriate step** in this patient's management?

1. ¹⁸F-DG-PET scan
2. High-resolution chest CT (HRCT)
3. Perform contrast-enhanced thoracic CT using a solitary pulmonary nodule protocol
4. Thoracic MRI
5. Ventilation – perfusion scintigraphy

Correct!
1. ¹⁸FDG-PET scan

Among the choices listed, ¹⁸FDG-PET scanning may represent the least invasive, most effective approach to nodule management for this patient. Performing contrast-enhanced thoracic CT using a nodule enhancement protocol could prove useful—negative findings, typically defined as less than 15 HU enhancement within the nodule at all of 4, 1-minute time points, compared to baseline unenhanced imaging nodule attenuation, strongly predicts that the nodule is benign. However, false positive results are not uncommon and may occur with infectious granulomas (a consideration for this patient), and the nodule should be followed anyway to exclude growth even if the contrast-enhanced CT results are negative, limiting the utility of this approach. In contrast, positive ¹⁸FDG-PET scanning results may prompt tissue sampling, whereas negative results predict that a solitary nodule is likely benign; furthermore, ¹⁸FDG-PET scanning can detect additional findings that may impact the differential diagnostic considerations and also reveal abnormal findings that would be more readily accessible to a tissue diagnosis than the pulmonary nodule. Should the nodule prove to represent a bronchogenic malignancy, ¹⁸FDG-PET scanning is of proven value for lung cancer staging as well. Surgical lung biopsy would no doubt be diagnostic, but is needlessly invasive at this point. As noted previously, thoracic MRI has limited utility for the assessment of a solitary pulmonary nodule, and ⁶⁸Ga – PET – CT dotatate scanning, typically used for neuroendocrine malignancies, is premature at this point.

The patient underwent ¹⁸FDG-PET scanning (Figure 4).

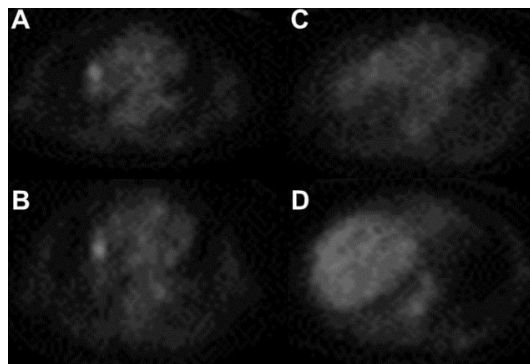


Figure 4. ¹⁸Axial FDG-PET images.

Which of the following represents **the most accurate assessment** of the ¹⁸FDG-PET scan findings?

1. ¹⁸FDG-PET is marred by artifact and is non-diagnostic
2. ¹⁸FDG-PET scintigraphy shows focal tracer uptake within the right middle lobe
3. ¹⁸FDG-PET shows focal photopenia within the right middle lobe lesion
4. ¹⁸FDG-PET shows no tracer utilization within the right middle lobe lesion but does show focal tracer uptake at the site of the medical right basal cystic lesion
5. ¹⁸FDG-PET shows normal findings

Correct!

2. ¹⁸FDG-PET scintigraphy shows focal tracer uptake within the right middle lobe

The ¹⁸FDG-PET scan shows mild increased tracer utilization within the right middle lobe nodule, but without focal tracer uptake within the medial right base cystic lesion. No hypermetabolic lymphadenopathy is present.

At this point, which of the following represents the **most likely diagnosis** for this patient's condition?

1. Coccidioidomycosis
2. *Mycobacterium tuberculosis* infection
3. Organizing pneumonia
4. Primary bronchogenic malignancy
5. Primary lymphoma of lung

Correct!

4. Primary bronchogenic malignancy

The differential diagnosis for a solitary pulmonary nodule in an adult patient is broad, but when one notes that the nodule is poorly defined, unaccompanied by any laboratory data suggesting an infectious etiology, and the nodule shows elevated tracer utilization at ¹⁸F¹⁸FDG-PET scan, the leading diagnostic consideration is primary bronchogenic malignancy.

At this point, which of the following represents the **most appropriate step** in this patient's management?

1. Follow the lesion for growth
2. Perform cryobiopsy of the right middle lobe lesion
3. Perform pleuroscopy
4. Perform surgical lung biopsy of the right middle lobe lesion
5. Plan to resect the right middle lobe lesion

Correct!

5. Plan to resect the right middle lobe lesion

Given the leading consideration of primary bronchogenic malignancy, absent surgical contraindications, the best chance of long-term cure is through surgical resection. Continuing to follow the lesion for growth with serial imaging is not appropriate. Cryobiopsy is an emerging technique that may increase the diagnostic yield for patients with diffuse lung disease compared with bronchoscopy, yet is less invasive than surgical lung biopsy, but is not generally utilized for the diagnosis of focal nodular lesions in the lung. As part of the pre-operative evaluation, the patient underwent bronchoscopy with endobronchial ultrasound and sampling of both the right middle lobe lesion, which was found to occlude the medial segmental bronchus of the right middle lobe, and level 4 (right paratracheal) and level 10 (right hilar) lymph nodes on the right side. These tissue sampling procedures showed that the right middle lobe lesion was adenocarcinoma, but the mediastinal and peribronchial lymph nodes sampled were negative for malignancy.

The patient underwent mediastinoscopy followed by surgical resection of the right middle lobe lesion without complications. The lesion was staged as T1bN0M0. The patient recovered uneventfully and was discharged from the hospital. Approximately 6 months later, the patient underwent routine follow up unenhanced thoracic CT (not shown) which showed no evidence of lesion at the right middle lobe bronchial stump as well as no lymph node enlargement, and the cystic lesion at the right base was unchanged.

The patient did well overall for the next several years, although she complained of intermittent cough, presumably bronchitis, at various clinical encounters, treated with board-spectrum antibiotics. Slightly over 2 years after her surgical procedure, she developed a productive cough with fever, which prompted chest radiography (Figure 4).

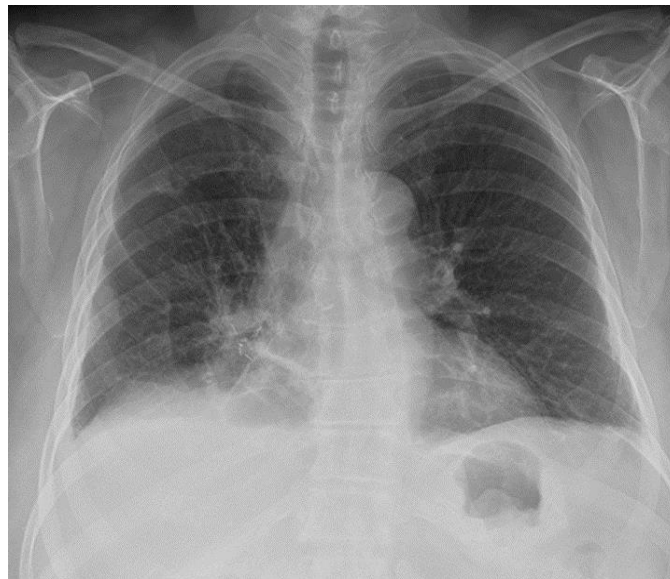


Figure 5. Frontal chest radiography 2 years after initial presentation.

Which of the following represents **the most accurate assessment** of the chest radiography (Figure 5) findings?

1. Frontal and lateral chest radiography shows a pneumothorax
2. Frontal and lateral chest radiography shows new bilateral pulmonary nodules
3. Frontal and lateral chest radiography shows new mediastinal lymph node enlargement
4. Frontal and lateral chest radiography shows only normal post – right middle lobectomy findings
5. Frontal and lateral chest radiography shows right basilar consolidation

Correct!

5. Frontal and lateral chest radiography shows right basilar consolidation

Frontal and lateral chest radiography shows expected post-surgical changes following right middle lobectomy, but with some patchy medial basal opacity on the right, associated with mild blunting of the right lateral costophrenic angle. No evidence of new lung nodules or mediastinal lymph node enlargement is seen. There is no evidence of pneumothorax.

The patient was presumed to have right lower lobe pneumonia and was treated with broad-spectrum antibiotics, but without symptomatic improvement.

At this point, which of the following represents the **most appropriate step** in this patient's management?

1. ¹⁸F₁₈FDG – PET
2. Bronchoscopy
3. Repeat chest CT
4. Repeat pulmonary function testing
5. Thoracic MRI

Correct!
3. Repeat chest CT

Given the appearance of pneumonia on the chest radiograph and the previous history of lung carcinoma, and the patient's lack of clinical response to presumably appropriate therapy, repeat chest CT is appropriate. Bronchoscopy could be considered as well, but may be better directed in light of information obtainable by chest CT. Given the suggestion that the chest radiographic abnormalities and the patient's complaints reflect an acute lung disorder, both pulmonary function testing and ¹⁸F-FDG-PET scan are not appropriate tests at this point. As noted previously, thoracic MRI has a very limited role for the evaluation of pulmonary disorders, particularly acute lung abnormalities.

The patient underwent contrast-enhanced thoracic CT (Figure 6).

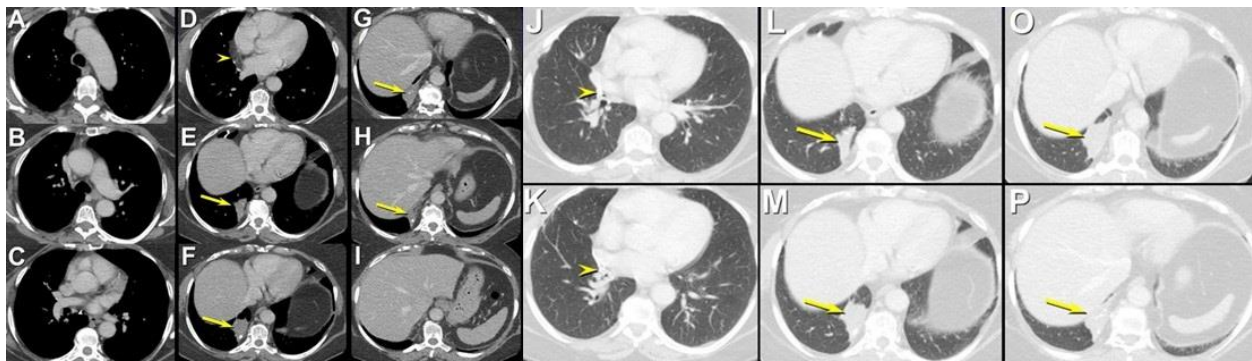


Figure 6. A-I: Axial enhanced thoracic CT displayed in soft tissue. J-P: Axial enhanced thoracic CT displayed in lung windows.

Which of the following represents **the most accurate assessment** of the thoracic CT findings?

1. Expected right middle lobectomy findings only
2. New mediastinal lymphadenopathy is present
3. The previously noted cystic medial right basal lesion has resolved
4. The previously noted cystic medial right basal lesion has significantly enlarged
5. The previously noted cystic medial right basal lesion now appears solid

Correct!

5. The previously noted cystic medial right basal lesion now appears solid

The previously noted cystic medial right basal lesion on the pre-operative CT (Figure 3) is still present, but now appears solid. No new peribronchial or mediastinal lymph node enlargement is present.

The patient appeared somewhat toxic and was admitted to the hospital and intravenous antibiotics were begun.

At this point, which of the following represents the **most appropriate step** in this patient's management?

1. Perform CT aortography
2. Perform CT pulmonary angiography
3. Perform percutaneous transthoracic fine needle aspiration biopsy
4. Perform repeat bronchoscopy
5. Perform surgical lung biopsy

Correct!

1. Perform CT aortography

Surgical lung biopsy could be considered for the right lower lobe lesion, but the relatively indolent nature of this lesion, despite its recent apparent change, suggests a more conservative approach is in order. Bronchoscopy could also be considered, but the lesion is relatively peripheral and not clearly associated with an airway. If a tissue-sampling procedure is desired, percutaneous transthoracic fine needle aspiration biopsy would be the best approach for this lesion. However, the medial basal location and morphology raise the possibility of a particular diagnosis that could be readily evaluated with CT aortography. Of note, the CT protocol of most use in this situation is CT aortography, not CT pulmonary angiography- the latter technique would provide optimal contrast enhancement in reference to the pulmonary arteries, not the aorta and branch vessels, as is desirable in this circumstance.

After a week the patient underwent repeat CT (Figure 7), but not with CT aortography technique.

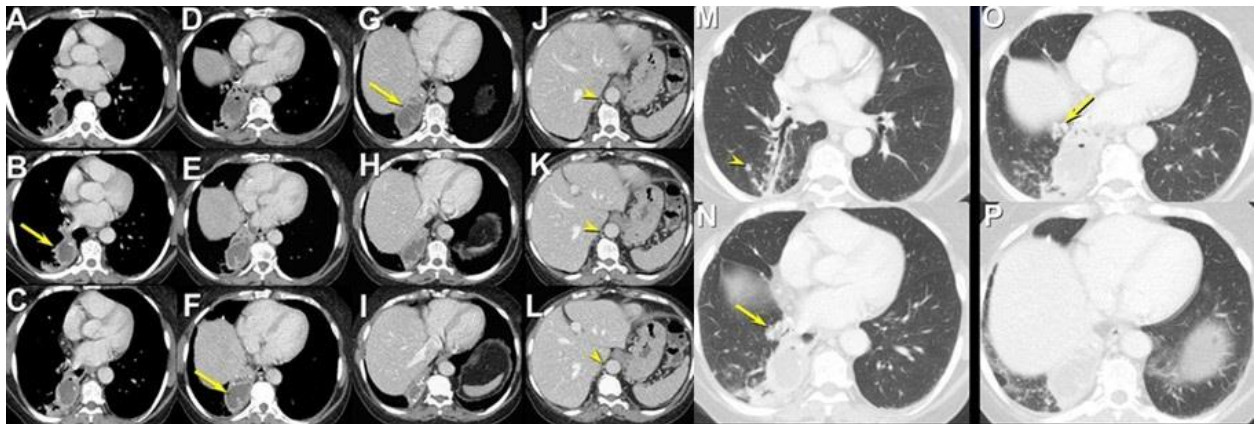


Figure 7. A-L: Axial enhanced thoracic CT displayed in soft tissue windows. M-P: Axial enhanced thoracic CT displayed in lung windows.

Which of the following represents **the most accurate assessment** of the thoracic CT findings?

1. A new large right pleural effusion is present
2. New left lung consolidation is present
3. The cystic right medial basal lesion has diminished in size
4. The cystic right medial basal lesion is grossly fluid-filled
5. The previously noted cystic medial right basal lesion has greatly enlarged

Correct!

4. The cystic right medial basal lesion is grossly fluid-filled

The cystic medial right basal lesion has neither regressed nor enlarged, but is now grossly fluid-filled, with new nodular opacities and peribronchovascular thickening in the vicinity of the right basal lesion. No pleural effusion is seen on either side and no significant left lung opacity is present.

The CT was subsequently repeated using CT aortography technique (Figure 8) several weeks later, after the patient was successfully treated with antibiotics and discharged from the hospital.

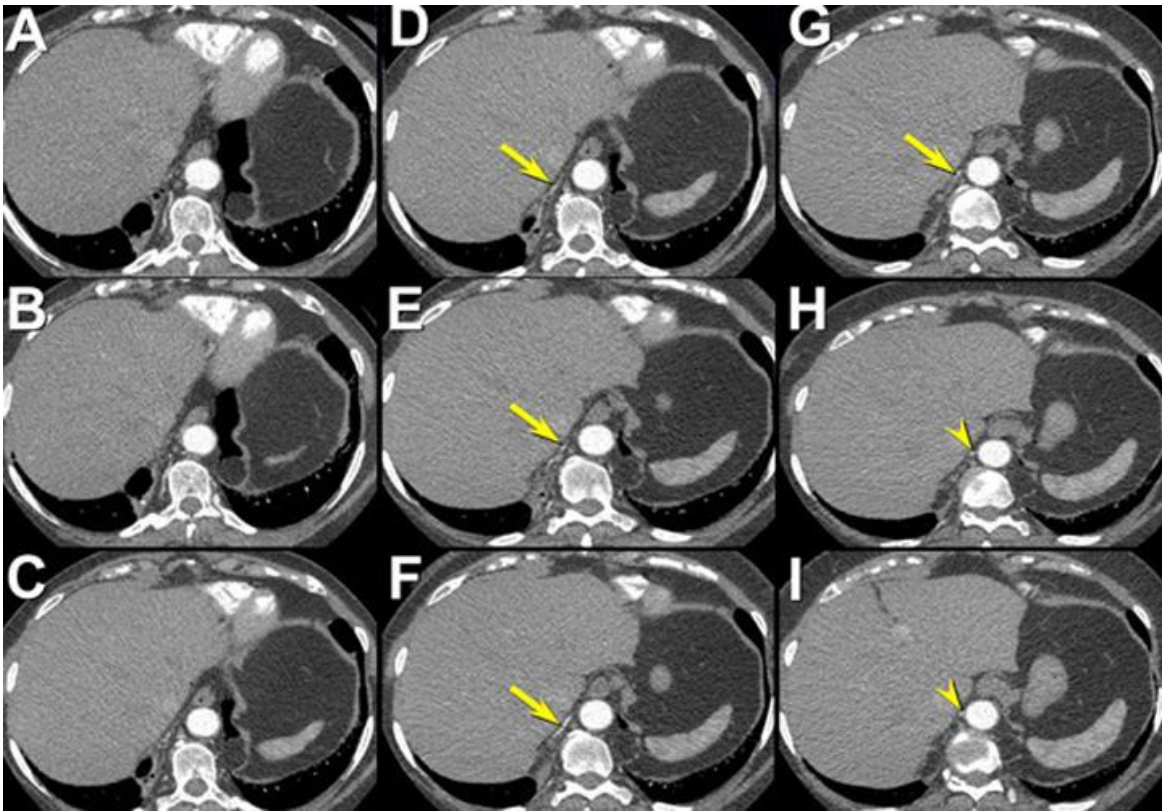


Figure 8. Enhanced axial CT aortography.

Which of the following represents **the most accurate assessment** of the thoracic CT findings?

1. CT aortography shows a pulmonary artery pseudoaneurysm
2. CT aortography shows an aberrant vessel supplying the cystic right medial basal lesion
3. CT aortography shows aorto-pulmonary arterial shunting
4. CT aortography shows intercostal artery pseudoaneurysm
5. CT aortography shows no specific findings that add to what is already known

Correct!

2. CT aortography shows an aberrant vessel supplying the cystic right medial basal lesion

CT aortography again demonstrates the cystic medial right basal lesion, now somewhat smaller and again now contains gas in addition to fluid. The CT aortography technique reveals an aberrant artery arising from the distal thoracic aorta supplying the medial right basal lesion. No intercostal artery pseudoaneurysm is evident and no evidence of direct shunting from the aorta or its branches to the pulmonary arterial circulation is seen. No aneurysm of the pulmonary artery is seen.

Based on the CT aortography findings, a specific diagnosis could be offered that lead to cardiovascular surgical consultation. As part of a pre-operative evaluation, catheter aortography (Figure 9) was performed.



Figure 9. Catheter aortography with selective cannulation of the aberrant artery arising from the distal thoracic aorta shows this artery supplying extensive vascularity to the cystic medial right lower lobe lesion.

Based on the information available from CT and the catheter pulmonary angiogram, what is the **most likely** diagnosis?

1. Bronchogenic cyst
2. Bronchopulmonary intralobar sequestration
3. Congenital pulmonary airway malformation
4. Cystic chondroid hamartoma
5. Metachronous bronchogenic carcinoma

Correct!

2. Bronchopulmonary intralobar sequestration

All of the lesions listed could cause gas-containing abnormalities in the lung. Among the choices listed, however, only bronchopulmonary intralobar sequestration would be associated with aberrant arterial blood supply derived from the aorta.

Cardiopulmonary surgical consultation recommended surgical resection of the lesion, given the evidence of recurrent infection. The patient was taken to the operating room after the aberrant vessel supplying the lesion was embolized (Figure 10).



Figure 10. Catheter aortography with selective cannulation of the aberrant artery following coil embolization of this vessel shows complete occlusion of the aberrant vessel with no residual flow to the cystic medial right lower lobe lesion.

This vessel was successfully identified in the pulmonary ligament, ligated, and the right lower lobe lesion was successfully resected (Figure 10), despite some difficulty owing to adhesions from the previous right thoracotomy.

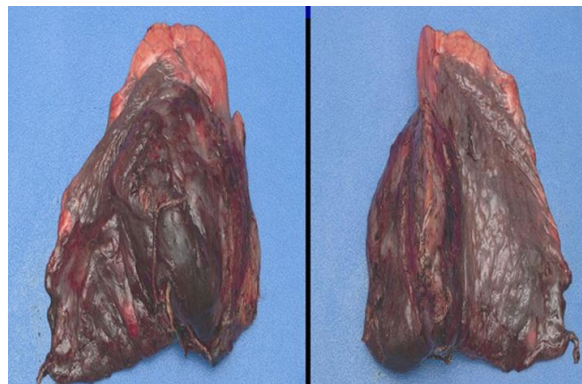


Figure 11. Gross pathological specimen of the resected cystic right lower lobe lesion.

Diagnosis: Intralobar bronchopulmonary sequestration

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