December 2017 Imaging Case of the Month

Michael B. Gotway, MD

Department of Radiology
Mayo Clinic Arizona
Scottsdale, AZ USA

Clinical History: A 57-year-old woman with a past medical history remarkable only for hyperlipidemia undergoing statin therapy presented with a history of slowly progressive dyspnea on exertion for at least months, possibly longer. The patient denied cough, hemoptysis, and chest pain.

Physical examination was largely unremarkable and the patient’s oxygen saturation was 96% on room air while resting. The patient’s vital signs were within normal limits.

Laboratory evaluation was unremarkable. Quantiferon testing for Mycobacterium tuberculosis was negative, and testing for coccidioidomycosis was unrevealing.

Frontal and lateral chest radiography (Figure 1) was performed.

![Frontal chest radiography.](image)

Figure 1. Frontal chest radiography.

Which of the following statements regarding the chest radiograph is **most accurate**?

1. The chest radiograph appears normal
2. The chest radiograph shows bilateral, symmetric lower lobe reticulation suggesting fibrotic disease
3. The chest radiograph shows left upper lobe collapse
4. The chest radiograph shows linear right lower lobe opacity suggesting scarring
5. The chest radiograph shows numerous small miliary nodules
Correct!

4. The chest radiograph shows linear right lower lobe opacity suggesting scarring

The frontal chest radiograph shows linear right lower lobe opacity with some architectural distortion and volume loss, consistent with scarring, but without similar findings in the left lung base to suggest a more widespread fibrotic process. The right hilum also appears prominent. Miliary nodules are not seen. The left upper lobe is well-aerated- there is no evidence of collapse, which would be suggested by hazy left upper thoracic opacity obscuring the left cardiac border associated with decreased left lung volume.

A comparison chest radiograph from three years earlier (Figure 2) was located.

![Figure 2. A: Frontal chest radiography performed three years earlier. B: Most recent chest radiography for comparison.](image)

Which of the following statements regarding the chest radiograph is **most accurate**?

1. The comparison chest radiograph appears normal
2. The comparison chest radiograph shows a right-sided pneumothorax
3. The comparison chest radiograph shows bilateral lower lobe consolidation
4. The comparison chest radiograph shows the linear right lower lobe opacity suggesting scarring and is new from the presentation chest radiograph
5. The comparison chest radiograph shows the same linear right lower lobe opacity suggesting scarring and is unchanged from the presentation chest radiograph
Correct!

5. The comparison chest radiograph shows the same linear right lower lobe opacity suggesting scarring and is unchanged from the presentation chest radiograph.

The frontal chest radiograph performed three years earlier (Figure 2A) shows the same linear right lower lobe opacity associated with architectural distortion and volume loss visible on the presentation chest radiograph (Figure 2B). The right hilum also again appears prominent. No consolidation or pneumothorax is present.

The patient underwent pulmonary function testing which showed mild restriction and decreased diffusion capacity for carbon monoxide, and these findings seemed disproportionately mild compared to her shortness of breath and dyspnea on exertion.

Which of the following represents **the most appropriate next step for the management** of this patient?

1. $^{133}$Xe-ventilation – $^{99m}$Tc-perfusion scintigraphy
2. $^{68}$Ga-citrate scintigraphy
3. Catheter pulmonary angiography
4. High-resolution CT
5. Thoracic MRA
Correct!

1. $^{133}$Xe-ventilation – $^{99m}$Tc-perfusion scintigraphy

$^{133}$Xe-ventilation – $^{99m}$Tc-perfusion scintigraphy would be the best choice among the various tests listed. High-resolution chest CT (HRCT) is a reasonable choice as well and may play a role in the evaluation of this patient, but the chest radiographic findings do not suggest diffuse lung disease, which is the typical indication for HRCT. Furthermore, the clinical symptoms of shortness of breath out of proportion to the pulmonary function testing results, and the decreased diffusion capacity for carbon monoxide, in the context of mild chest radiographic abnormalities, raise the possibility of pulmonary embolism, and pulmonary embolism cannot be assessed using unenhanced HRCT technique. Additionally, while HRCT could provide some information regarding the hilar enlargement apparent at chest radiography, this finding would be better assessed with dedicated enhanced thoracic CT. Clearly catheter pulmonary angiography could be employed to diagnose or exclude pulmonary embolism, but this test is needlessly invasive at this point and the possibility of pulmonary embolism could be non-invasively addressed with contrast-enhanced pulmonary CT angiography, but this option was not provided above. $^{68}$Ga-citrate scintigraphy is rarely employed for the assessment of diffuse lung disease, particularly acute diffuse infections in immunocompromised patients, but this situation does not apply to this patient. Thoracic MRA, if conducted in a fashion to address the possibility of pulmonary embolism, could prove useful for this patient, but commonly thoracic MRA for pulmonary embolism is employed when contraindications to CT pulmonary angiography exist, which is not the situation for this patient. Furthermore, thoracic MRA would provide little information regarding the lung parenchymal abnormalities.

The patient underwent $^{133}$Xe-ventilation – $^{99m}$Tc-perfusion scintigraphy (Figure 3).

Figure 3. $^{133}$Xe-Ventilation (top two rows) – $^{99m}$Tc-perfusion (bottom two rows) scintigraphy.
Which of the following statements regarding the $^{133}$Xe-ventilation – $^{99m}$Tc-perfusion scintigraphy is **most accurate**?

1. The $^{133}$Xe-ventilation – $^{99m}$Tc-perfusion scintigraphy is not normal but shows no specific findings
2. The $^{133}$Xe-ventilation – $^{99m}$Tc-perfusion scintigraphy shows findings suggesting pulmonary embolism
3. The $^{133}$Xe-ventilation – $^{99m}$Tc-perfusion scintigraphy shows normal findings
4. The $^{133}$Xe-ventilation – $^{99m}$Tc-perfusion scintigraphy shows systemic embolization of tracer consistent with shunting
5. The $^{133}$Xe-ventilation – $^{99m}$Tc-perfusion scintigraphy shows the “stripe sign”
2. The $^{133}$Xe-ventilation – $^{99m}$Tc-perfusion scintigraphy shows findings suggesting pulmonary embolism

The $^{133}$Xe-ventilation – $^{99m}$Tc-perfusion scan shows relatively normal perfusion bilaterally but with multiple areas of clear perfusion defects, representing "mis-matched" ventilation and perfusion, consistent with pulmonary embolism. The scan is abnormal, and, while the presence of ventilation and perfusion mis-matching is not entirely specific for pulmonary embolism, the scan is suggestive of that disorder and therefore is not merely non-specifically abnormal. The "stripe sign" at $^{133}$Xe-ventilation – $^{99m}$ Tc-perfusion scintigraphy represents a rim of tracer uptake peripheral to a perfusion defect, indicating that lung is present between a defect and the pleura, which is not a pattern consistent with pulmonary embolism and indicates a non-embolic cause for a perfusion abnormality- perfusion defects related to pulmonary emboli extend to the lung periphery. The $^{133}$Xe-ventilation – $^{99m}$Tc-perfusion scan does not show features indicating systemic shunting- this situation is indicated by tracer uptake in the kidney or brain, neither of which are seen in Figure 3.

The $^{133}$Xe-ventilation – $^{99m}$Tc-perfusion was interpreted as “high probability” for pulmonary embolism. Because the patient’s clinical history indicated a prolonged course for the development of her shortness of breath, and she had no known thromboembolic risk factors, the pre-test probability for acute pulmonary embolism was estimated as low. Therefore, the possibility of chronic thromboembolic disease was considered.

Which of the following represents the most appropriate next step for the management of this patient?

1. $^{18}$FDG-PET
2. Catheter pulmonary angiography
3. Echocardiography bubble study
4. High-resolution CT
5. Thoracic MRI and MRA
Correct!

2. Catheter pulmonary angiography

One could make an argument that CT pulmonary angiography should be the next appropriate step, but this test was not offered as a choice. When chronic thromboembolic disease is a leading diagnostic consideration, $^{133}$Xe-ventilation – $^{99m}$Tc-perfusion scintigraphy is often the next recommended test, serving as a screening study. If this study is abnormal, then typically catheter pulmonary angiography is recommended for the diagnosis and confirmation of thromboembolic disease. Catheter pulmonary angiography has the major advantage of combining the assessment of hemodynamic parameters with imaging to allow both diagnosis and determination of the severity of chronic thromboemboli and to as a baseline to assess therapeutic interventions. Thoracic MRI and MRA can also establish the diagnosis of chronic thromboembolic disease, and recent advancement in MR techniques have allowed the accuracy of thoracic MRI and MRA for the diagnosis of chronic thromboembolic disease to approach that of CT pulmonary angiography. If CT pulmonary angiography were considered in this patient, but was not feasible for some reason, then thoracic MRI and MRA would potentially be a correct choice and could serve as an alternative to catheter pulmonary angiography. Echocardiography is a useful test for the assessment of possible chronic thromboembolic disease as it allows determination of right heart function and estimation of pulmonary hypertension, and would be a reasonable test to obtain, but a bubble study to assess for right-to-left shunt is not specifically required in this patient.

The patient underwent catheter pulmonary angiography (Figure 4), which showed the mean pulmonary artery pressure to be 20 mmHg.
Figure 4. Catheter pulmonary angiography of the right pulmonary arterial system in the arterial (A) and venous (B) phases shows no specific abnormalities. Catheter pulmonary angiography of the left pulmonary arterial system in the arterial (C) and venous (D) phases shows complete obstruction of the left interlobar and lower lobe arterial system (arrows) with absent perfusion to the left lower lobe (between arrowheads). The left superior pulmonary vein is well visualized (double arrowhead) but the left inferior pulmonary vein is not, owing to delayed contrast transit from the left lower lobe pulmonary arterial obstruction.

There was lack of pulmonary arterial filling at the left apex and left lower lobe (Figure 4C and D), corresponding to the locations of perfusion defects seen at $^{133}$Xe-ventilation – $^{99m}$Tc-perfusion scintigraphy. Difficulty accessing the left pulmonary artery was noted during the study. The right pulmonary artery showed no evidence of occlusion, webs, or tortuosity to suggest chronic thromboembolic disease.

Which of the following represents **the most appropriate next step** for the management of this patient?

1. $^{18}$FDG-PET
2. Bronchoscopy
3. CT pulmonary angiography
4. Echocardiography
5. Thoracic MRI and MRA
Correct!

3. CT pulmonary angiography

CT pulmonary angiography represents the next most appropriate step for the evaluation of this patient. Catheter pulmonary angiography identified narrowing of the left pulmonary arterial system with upper and lower lobe vascular occlusions; the cause of these findings may be readily identified at thoracic CT. Thoracic MRI and MRA could provide information similar to enhanced thoracic CT, but CT offers superior depiction of the hilum of perivascular tissues and therefore would be preferred. Because the findings seen at catheter pulmonary angiography were vascular and perivascular in nature, bronchoscopy would not be the next test to obtain. As noted previously, echocardiography would prove useful in this patient, although probably less so now following right heart catheterization, and would not allow confident identification of the abnormalities producing the vascular findings seen at catheter pulmonary angiography. $^{18}$FDG-PET could eventually play a role in the evaluation of this patient, after the perivascular abnormalities are better characterized, but PET scan results are often more rewarding following clarification of the anatomy with CT first, so $^{18}$FDG-PET is premature at this point.

The patient underwent CT pulmonary angiography (Figure 5).

![CT images](image_url)

Figure 5. A-H: Axial enhanced CT pulmonary angiography displayed in soft tissue windows. I-P: Axial enhanced CT pulmonary angiography displayed in lung windows.
Which of the following represents the most appropriate description for the thoracic CT pattern present?

1. The thoracic CT shows features suggesting metastatic malignancy
2. The thoracic CT shows features suggesting previous granulomatous infection
3. The thoracic CT shows features suggesting pulmonary arterial vasculitis
4. The thoracic CT shows features suggesting sarcoidosis
5. The thoracic CT shows features suggestive of chronic thromboembolic disease
Correct!

2. The thoracic CT shows features suggesting previous granulomatous infection

The thoracic CT shows abnormal soft tissue with foci of calcification surrounding the vessels and the bronchi extending from the hilar regions into the segmental regions bilaterally. This abnormal tissue narrows the right inferior pulmonary vein, the right lower lobe bronchus, and the left interlobar and lower lobe pulmonary arteries. The arterial narrowing, and bronchial artery hypertrophy, can superficially resemble chronic thromboembolic disease, but the narrowing in this circumstance is extravascular in nature, rather than caused by abnormal tissue centered on the wall of the pulmonary arteries- therefore, chronic thromboembolic disease and pulmonary arterial vasculitis are not correct answers. Metastatic malignancy can certainly result in abnormal peribronchial tissue, reflecting lymphadenopathy, but the presence of calcification argues strongly against a metastatic malignancy in this patient. Some sarcomas, notably osteogenic sarcoma and chondrosarcoma, may ossify or calcify, but sarcomas far more commonly affect the lung parenchyma, not mediastinal and peribronchial nodal tissue. Sarcoidosis commonly causes peribronchial and mediastinal lymphadenopathy, and not infrequently, these lymph nodes may show calcification. Often the calcification is less dense than seen in this patient, and lymph nodes related to sarcoidosis are commonly fairly symmetric. The abnormal calcified soft tissue in this patient is bilateral, but is rather asymmetric. Finally, although sarcoidosis is a fibrosing disease, the degree of mass effect on adjacent structures- the right inferior pulmonary vein, right lower lobe bronchus, and left interlobar and lower lobe pulmonary arteries- is atypical for the diagnosis of sarcoidosis. Rather, the presence of the calcification within the abnormal peribronchial soft tissue is strongly suggestive of previous granulomatous infection, and the mass effect suggests an associated fibrosing reaction.

Based on the data thus far, what is the most likely diagnosis for this patient?

1. Congenital interruption of the pulmonary artery
2. Fibrosing mediastinitis
3. Inflammatory myofibroblastic tumor
4. Metastatic malignancy
5. Sarcoidosis
Fibrosing mediastinitis

Inflammatory myofibroblastic tumor can result in abnormal mediastinal and/or peribronchial soft tissue that calcifies and produces mass effect, including vascular and bronchial narrowing, but the process is more likely to be focal rather than multicentric and bilateral. Sarcoidosis remains a possibility, but the appearance of the calcification and associated mass effect, as well as the absence of the typical parenchymal features of this disorder, suggest that sarcoidosis is less likely than fibrosing mediastinitis. Metastatic malignancy is also unlikely, given the presence of calcification within the abnormal peribronchial soft tissue and the absence of both lung nodules and a history of a calcifying or ossifying extrathoracic primary malignancy. Congenital interruption of the pulmonary artery could account for the small left pulmonary arterial system and the associated bronchial artery hypertrophy, but typically this process occurs on the side opposite the aortic arch (this patient’s aortic arch is left-sided, so the interruption would be present on the same side of the aortic arch), and interruption of the pulmonary artery would not account for the right-sided abnormalities or the calcified soft tissue.

Diagnosis: Fibrosing mediastinitis, due to *Histoplasma capsulatum*

The patient was diagnosed with fibrosing mediastinitis and did well without intervention for a number of years. A slight decrease in her vital capacity was noted over an 11-year period since her diagnosis, perhaps with slight progression in exercise-induced dyspnea. Subsequently, she then presented with some worsening dyspnea, which prompted chest radiography (Figure 6), which showed worsening right lower lobe opacity and increasing volume loss.

Figure 6: Frontal (A) and lateral (B) chest radiography shows worsening of right lower lobe opacity with right lung volume loss. A new small right pleural effusion is also present.
These abnormal results prompted repeat thoracic CT (Figure 7), which showed worsening atelectasis in the right lower lobe due to right lower lobe bronchial obstruction.

Figure 7. Representative images form axial unenhanced CT displayed in soft tissue windows shows that the worsening right lower lobe opacity seen at chest radiography is due to obstruction of the right lower lobe bronchus (arrowhead), just distal to the origin of the superior segment right lower lobe bronchus (arrow), with associated atelectasis. The calcification of the peribronchial soft tissue bilaterally is well-appreciated with unenhanced technique.

Severe narrowing of the right lower lobe bronchus was confirmed with bronchoscopy (Figure 8); the left-sided airways were patent.

Figure 8. Severe narrowing of the right lower lobe bronchus.

No evidence of infection was noted on bronchoalveolar lavage. Despite the apparently worsening imaging findings, the patient’s pulmonary function testing results remain stable and she remains only minimally symptomatic with exercise.
References


