Cavitary Lung Lesions: Are there holes in our approach?

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Objectives

- Review the pathophysiology of pulmonary cavitation.
- Review imaging predictors and features of malignancy and benignity described in the literature and discuss the limitations of this approach.
- Application of the described features in pathology or culture proven cases.
- Provide a suggested algorithm for evaluating cavitary pulmonary lesions.
- Provide an opportunity to test yourself.
Cavitary Lesion DDX

**Malignant**
- Bronchogenic carcinoma
- Metastases

**Infectious**
- Cavitating/necrotizing pneumonia
- Septic emboli
- Tracheobronchial papillomatosis
- Aspergillosis and other fungi

**Inflammatory**
- Sarcoidosis
- Rheumatoid nodules
- Vasculitides

**Other**
- Congenital – CPAM, Sequestration
- Post traumatic pulmonary laceration
- Post pulmonary infarction
- Mimics
Pulmonary cavitation occurs when nodules or regions of consolidated lung undergo central necrosis or liquefaction and become air-filled. This is usually through communication with the bronchial tree, but rarely gas forming organisms can fill a cavity with gas. Fleischner defines a cavity as a “gas-filled space, seen as a lucency or low-attenuation area, within pulmonary consolidation, a mass, or a nodule”.

A wall thickness of less than 4mm has been used to differentiate thin walled cysts from pulmonary cavities, but this often ignores the underlying pathophysiology of the lesion; it is not always possible to reliably differentiate cysts from cavities by imaging. The Fleischner Society defines a cyst as “any round circumscribed space that is surrounded by an epithelial or fibrous wall of variable thickness”. Fraser and Paré include complicated cysts in their definition of a cavitary lesion; in many cases the pathologist will be required to differentiate the true cysts from the cavities.
CT Features:
A precise description does not equate to a precise prediction

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Prospective data correlating thickness of a cavitary lesion with the likelihood of malignancy is primarily derived from plain film radiography. CT based data is lacking; the more rigorous studies show low inter-reader agreement, significant overlap between benign and malignant features, and low predictive power. **Radiologists should be wary in predicting the likelihood of malignancy or benignity based on CT features alone.**

History: 66 year old male with known UIP presents with worsening cough.

Features: Single cavitary lesions with thick, irregular inner walls, lobulated margins, and a “notch” sign. There is a background of UIP-related changes.

Diagnosis: Squamous cell carcinoma.

Both primary and metastatic squamous cell carcinoma are common causes of malignant cavitation.

Several studies have examined potential correlations between ILD and development of malignancy. There is good evidence to suggest that there is an increased risk of malignancy, (especially squamous cell carcinoma), in older males who smoke with a history of UIP.

Colour Code: Malignant, indeterminate, benign features
**History:** 58 year old male presents with general weakness.

**Features:** Multiple cavitary lesions with thick, irregular walls, spiculated margins and additional solid nodules. The largest contains an air-fluid level with surrounding ground glass.

**Diagnosis:** Non-small cell lung cancer with metastases.

Primary and metastatic squamous cell carcinoma is a common cause of cavitation. The presence of an air-fluid level may indicate superinfection, which in some cases, may be the presenting complaint. In older patients and those with risk factors for malignancy, equivocal cases should be followed closely with a low threshold for more aggressive work-up.

**Colour Code:** Malignant, indeterminate, benign features
History: 61 year old female with a right tonsilar mass.

Features: Two cavitary lesions with thin, irregular walls, spiculated outer margins. Both lesions demonstrate avid FDG uptake on PET.

Diagnosis: Metastatic squamous cell carcinoma.

Malignant cavities with little solid component or low FDG avidity may result in a false negative PET study.

Colour Code: Malignant, indeterminate, benign features
History: 60 year old male presents with flank pain and night sweats. Follow-up CT 2 months after starting chemotherapy for renal cell carcinoma.

Features: Multiple solid pulmonary lesions have undergone central cavitation. The walls are thin to moderate thickness, demonstrate smooth contours, and variable solid components. There is an absence of ground glass. Note the associated right pneumothorax.

Diagnosis: Treated metastatic renal cell carcinoma.

Colour Code: Malignant, indeterminate, benign features
History: 44 year old male with scrotal mass.

Features: Multiple cavitary lesions with thin, smooth walls, thin septations, lobulated outer margins and a “notch sign”, and associated solid components containing calcium. Large mediastinal nodal mass containing calcium. Absence of ground glass.

Diagnosis: Metastatic testicular teratoma.

Some metastases cavitate prior to therapy. Fast growing lesions will often outpace angiogenesis, leading to central necrosis and cavitation.

Colour Code: Malignant, indeterminate, benign features
History: 76 year old male with a history of colon cancer treated with chemotherapy.

Features: Single cavitary lesion with spiculated outer margins, moderate wall thickness, irregular inner margins. There is an absence of ground glass.

Diagnosis: Treated metastatic colon adenocarcinoma.

Colour Code: Malignant, indeterminate, benign features
**History:** 53 year old male, presents with cough.

**Features:** Right upper lobe, large, **thick walled**, cavitary lesion with **irregular inner margins**, peripheral **spiculations**, surrounding **ground glass** and multiple spiculated **satellite nodules**.

**Diagnosis:** Sarcoidosis

Cavitation occurs in approximately 2.2% of cases of sarcoidosis. Cavities average 2cm in size, and are typically multiple. A thick wall may reflect superimposed infection.

**Colour Code:** Malignant, indeterminate, benign features
**History:** 17 year old female with history of ulcerative colitis, pancreatitis, oral ulcers and multisystem vasculitis.

**Features:** Single cavitary lesion in the right upper lobe with moderate wall thickness, irregular internal and external margins, surrounding ground glass. There are discrete pulmonary nodules, separate regions of subpleural opacity and a right pleural effusion.

**Diagnosis:** Pulmonary involvement of Behcet’s syndrome.

With vasculitis, cavitation typically occurs in areas of hemorrhage and consolidation.

Behcet’s is a complex disorder of multisystem vasculitis. In addition to areas of hemorrhage, infarct and occasionally cavitation, the thoracic findings of Behcet’s include aortic and pulmonary arterial aneurysms, and pulmonary emboli. Cavities are thought to result from thrombus-related ischemia due to Behcet’s involvement of the pulmonary vessels.

**Colour Code:** Malignant, indeterminate, benign features
History: 23 year old male with a history of ulcerative colitis, anemia, lower GI bleed and mild abdominal pain.

Features: Two large pleural based ovoid opacities with focal irregular areas of central cavitation, smooth outer walls, surrounding ground glass.

CT for PE was performed 30 months later showing resolution of the lesions and a new left pleural effusion.

Diagnosis: Granulomatosis with polyangiitis.*

The cavitating nodules and masses in granulomatosis with polyangiitis result from necrotizing granulomatous inflammation.

*Formerly known as Wegener’s
**History:** 54 year old female with a history of smoking and COPD presents with hemoptysis, productive cough, fever and chills with general malaise.

**Features:** Right upper lobe, thin walled, irregular cavitary lesion with surrounding ground glass and linear margins. PET/CT was performed; SUV max of 4.

**Diagnosis:** The patient underwent a lobectomy. Pathology results were consistent with necrotizing aspergillosis.

**Colour Code:** Malignant, indeterminate, benign features
**History:** 58 year old male cruise ship staff presents with fever and cough.

**Features:** Bilateral upper lobe intermediate to thick walled, irregular cavitary lesions with surrounding ground glass and bronchial thickening. PET/CT demonstrated avidity in the left upper lobe.

**Diagnosis:** The patient underwent a lobectomy. Culture results were positive for Mycobacterium tuberculosis.

**Colour Code:** Malignant, indeterminate, benign features
**History:** 54 year old HIV+ male presents with multiple spontaneous pneumothoraces.

**Features:** Left upper lobe thick walled cavitary lesion with spiculated margins and surrounding ground glass shows interval worsening before eventual improvement.

**Diagnosis:** Mycobacterium avium complex diagnosed by bronchial lavage. The patient was treated with antibiotics and followed by serial CT studies.

Immunocompromised patients are at higher risk for specific organisms including mycobacterial, and fungal infections.

Malignant, indeterminate, benign
**History:** 17 year old male with backpain. On steroids for autoimmune disorder.

**Features:** Left upper lobe, peripheral, **solitary** cavitary lesion with smooth inner and outer margins, mild associated pleural thickening, mild ground glass and tree-in-bud nodularity. CT and MRI demonstrates lytic bone lesions with associated enhancing soft tissue components involving a thoracic vertebral body and the right sacrum.

**Diagnosis:** Blastomycosis.

Pulmonary infection by *Blastomyces dermatitidis* results in cavitation in 15-35% of cases. The fungus is endemic in the Southeastern USA, Great Lakes region. AKA: “Chicago Disease”.

**Colour Code:** Malignant, indeterminate, benign features
**History:** 58 year old male with several days of night sweats, fevers and chills.

**Features:** Single cavitary lesion in the right upper lobe with thick, irregular inner walls and an abundance of surrounding ground glass.

**Diagnosis:** Pulmonary abscess.

Pulmonary abscesses should be followed with serial imaging until resolution. This can usually be accomplished with radiographs. Complications of cavitating pulmonary abscesses include bronchopleural fistulae, pneumothorax, empyema.

**Colour Code:** Malignant, indeterminate, benign features
**History:** 35 year old male IV drug user with known *S. aureus* endocarditis. Worsening respiratory status.

**Features:** Bilateral predominantly peripheral, cavitary lesions with intermediate wall thickness, air-fluid levels, variable inner margins and predominantly smooth outer margins and extensive surrounding ground glass. There are associated bilateral empyemas and a right sided pneumothorax.

**Diagnosis:** *S. aureus* septic emboli.

**Colour Code:** Malignant, indeterminate, benign features
**History:** 44 year old male with thigh abscess, weight loss, night sweats and fevers. Treated with antibiotics.

**Features:** Bilateral peripheral, cavitary lesions with variable wall thickness, air-fluid levels, variable inner margins and predominantly smooth outer margins. No associated ground glass.

**Diagnosis:** *S. aureus* septic emboli.

In contrast to the previous case, there is much less associated ground glass – likely due to response to therapy. Like a pulmonary abscess, these lesions have similar complications and should be followed with imaging to resolution.

**Colour Code:** Malignant, indeterminate, benign features
**History:** 69 year old male with a history of chronic cough, and occasional hemoptysis.

**Features:** Solitary left lower lobe cavitary lesion with thin walls that on a subsequent study is filled with soft tissue density, has moderate wall thickness and has associated surrounding ground glass. The patient was treated for presumed fungal infection and the inflammatory changes resolved on a follow-up study. Spiculated outer margins, irregular inner walls and a thin wall are noted on the latest study.

**Diagnosis:** Pathology of the wedge resection was consistent with primary squamous cell carcinoma.

Although there was improvement in the appearance of the lesion after anti-fungal therapy, persistence of the lesion with some concerning features should alert the radiologist to potential superinfection of a malignant cavity. Serial imaging and a multidisciplinary approach lead to the correct diagnosis and treatment in this case.

**Colour Code:** Malignant, indeterminate, benign features
History: 24 year old male presents after a 6 story fall.

Features: Several large, irregular cavitary lesions with thin walls, containing air-fluid levels and extensive surrounding ground glass and consolidation. There is a right sided pneumothorax with rib fractures.

Diagnosis: In the setting of trauma, the findings are consistent with pulmonary laceration.

Pulmonary laceration presents as spherical, thin walled cavitary lesions containing varying amount of fluid and air on a background of parenchymal hemorrhage and contusion. The appearance of the cavities can change rapidly, usually healing in less than a month with mild residual scar.

Colour Code: Malignant, indeterminate, benign features
History: 62 year old male presents with pleuritic chest pain despite treatment for pneumonia.

Features: Peripheral cavitary lesion with intermediate wall thickness, irregular internal walls, lobulated margins, surrounding ground glass. Filling defect in LPA consistent with pulmonary embolus.

Diagnosis: Pulmonary infarct with cavitation.

Cavitation is reported in up to 7% of pulmonary infarcts. Cavitation is hypothesized to be secondary to aseptic necrosis or secondary infection. Air-fluid levels suggest secondary infection.

Colour Code: Malignant, indeterminate, benign features
History: 29 year old male presents with cough.

Features: Multiple cavitary lesions in left lower lobe with thin, smooth walls, air-fluid levels. There is some mild surrounding consolidation with an absence of ground glass. There is focal bronchiectasis and an anomalous feeding artery on CTA.

Diagnosis: Intralobar pulmonary sequestration.

Pulmonary sequestrations are abnormal segments of lung that have an aberrant arterial supply and do not communicate with the bronchial tree. Intralobar sequestrations are located within the visceral pleura with normal lung; extralobar are external to the normal visceral pleura.

Pulmonary sequestrations typically present in late childhood or in early adulthood.

Colour Code: Malignant, indeterminate, benign features
History: 18 year old female with cough. Returns 3 years later with new cough and fever.

Features: Initially, she has a solitary, thin walled lesion with tiny septations in the right lower lobe. Three years later, the lesion demonstrates thin walls, some internal irregularity, an air-fluid level and extensive surrounding ground glass.

Diagnosis: Infected congenital pulmonary airway malformation (CPAM).

CPAMs (previously known as CCAMs) are lesions whose classification and etiology is debated. They are broadly defined as heterogenous group of congenital lesions characterized by varying degrees of cystic and solid components. Infection of these lesions can result in fluid filling the cystic/cavitary portion of the lesion.

CTA should be performed to evaluate for an aberrant feeding vessel which would be suggestive of a pulmonary sequestration.

Colour Code: Malignant, indeterminate, benign features
History: 77 year old male with a history of cough and smoking.

Features: Solitary left lower lobe cavitary lesion with thin, irregular walls and associated ground glass demonstrates an increasingly large solid component over serial studies, until the cavity is filled with a large, lobulated mass with spiculated margins.

Diagnosis: Pulmonary adenocarcinoma.

Ground glass opacity associated with a cavitary lesion will typically indicate inflammation. When there are no other inflammatory findings such as a thickened cavitary wall and findings persist on follow up adenocarcinoma should be suspected.

This is not a true cavity as defined by Fleischner, rather, a mass developing around a cyst; this is included as a cavitary mimic. However, the pathophysiology of these irregular lung cysts associated with adenocarcinoma is uncertain.* If the initial imaging occurred at one of the later time points, differentiating this from a true cavity would be impossible.

*Yoshida T., et. al. Lung adenocarcinoma presenting with enlarged and multiloculated cystic lesions over 2 years. Respir Care. 2004 Dec;49(12):1522-4
Bronchiectasis can mimic pulmonary cavitation, especially when there is superimposed infection. The air filled spaces in this case can be followed back to the bronchial tree.

**History:** 77 year old male with shortness of breath

**Features:** Numerous bilateral, thin, smoothly marginated, cystic lesions with air-fluid levels that communicate with the bronchial tree.

**Diagnosis:** Infected cystic bronchiectasis.

Bronchiectasis can mimic pulmonary cavitation, especially when there is superimposed infection. The air filled spaces in this case can be followed back to the bronchial tree.

**Colour Code:** Malignant, indeterminate, benign features
Clinical Correlation Required:
The Radiologist’s Approach

Cavitary Lung Lesion

- High pretest probability of malignancy
- High pretest probability of infection
- Specific CT or clinical features
- Case by case basis

Thoracic surgery consultation

Biopsy

Therapy and short interval follow-up

1. Age, smoking, known primary malignancy, absence of infectious features
2. Fever, productive cough, immunocompromise, risk of aspiration, absence of clinical features of malignancy
3. Underlying chronic lung disease, known vasculitis, trauma

The non-specific CT features of cavitary lung lesions require the interpreting radiologist to perform detailed clinical correlation to narrow the differential diagnosis, and suggest appropriate management. Short interval follow-up in equivocal cases can minimize the morbidity associated with unnecessary biopsy and surgery while avoiding the pitfalls of delaying necessary treatment.
Which of these right lung lesions is **malignant**?
Click on an image or click [here](#) for patient history.
Which of these right lung lesions is **malignant**? Click on an image.
Regrettably, your selection was incorrect. Continue
Congratulations! Your selection was correct.

Granulomatosis with polyangiitis
Strep abscess
Aspergilloma

Strep abscess
Mucor species mycetoma
NSCLCA
Teaching Points

• Despite the classic descriptions in the radiology literature, there is considerable overlap in the CT features of both benign and malignant cavitary lung lesions.

• The clinical history is often indispensable in narrowing the differential diagnosis, guiding therapy and follow-up.

• There should be a high index of suspicion for opportunistic and fungal infections in the immunocompromised patient.

• Suspected infectious or inflammatory cavities should followed with serial imaging to resolution.
References


