

# Imaging Findings of Focal and Multiple Cystic and Cavitory Lung Lesions



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## Abstract

Cystic and cavitory lung lesions constitute a spectrum of pulmonary diseases diagnosed in both children and adults. Cysts and cavities are commonly encountered abnormalities on chest radiography and chest computed tomography. High-resolution computed tomography (HRCT) of the chest frequently helps define morphologic features that may serve as important clues regarding the nature of cystic and cavitory lesions of the lung. Occasionally, the underlying nature of the lesions can be readily apparent as in bullae associated with emphysema. Cystic and cavitory lung lesions can be diagnostic challenge. Although many patients with cystic and cavitory lung lesions have a known underlying disease, in many cases the considerable overlap in morphologic features of these lesions tunders transthoracic needle biopsy necessary to establish the correct diagnosis.

**Key words:** Radiography, CT scan, cyst, lung, cavitory

## Fokal ve Multipl Kistik ve Kaviteli Akciğer Lezyonlarında Radyolojik Bulgular

### Özet:

Kistik ve kaviteli akciğer lezyonları çocuklarda ve yetişkinlerde görülen akciğer hastalıklarının bir spektrumunu oluşturur. Kistler ve kaviteler akciğer radyografisinde ve bilgisayarlı toraks tomografisinde yaygın olarak görülen lezyonlardır. Yüksek çözünürlüklü bilgisayarlı tomografi (YÇBT) sıklıkla akciğerin kistik ve kaviteli lezyonları hakkında önemli ipuçları vererek morfolojik özelliklerini tanımlamaya yardım eder. Bazen, amfizem ile birlikte bül gibi, lezyonların altta yatan nedeni açıkça görülebilmektedir. Kistik ve kaviteli akciğer lezyonlarında tanısal zorluklar halen devam etmektedir. Kistik ve kaviteli akciğer lezyonları bulunan birçok olguda altta yatan bilinen bir sebep olmakla birlikte, birçoğunda bu lezyonların morfolojik özelliklerinde belirgin örtüşme olması nedeniyle doğru tanıyı koymak için transtorasik iğne biyopsisi gerekmektedir.

**Anahtar sözcükler:** Radyografi, BT, kist, akciğer, kavite,

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## INTRODUCTION

The cysts and cavities are seen as foci of decreased lung density with definable walls (1). In contrast, emphysematous airspaces usually lack such perceptible walls (bullae and blebs are exception). The presence or absence of a wall around a radiolucent area can be accurately depicted by high resolution computed tomography (HRCT), if it is not apparent on chest radiography. The term cyst, cystic air space and cavity have overlapping meanings and sometimes used interchangeably. The terms cyst and cavity convey different meanings and ranges of diagnostic possibilities to clinicians (1). In the literature, the term cyst is used to mean a clearly defined air-containing space surrounded by a relatively thin ( $\leq 4$  mm) wall. In contrast, the term cavity is used to refer to an air-containing lesions with a relatively thick ( $\geq 4$  mm) wall or within an area of a surrounding infiltrate or mass. Cystic lesions in the lungs are rarely malignant. However, malignancy is commonly the first diagnosis to consider for a cavitory lesion, particularly in a middle-aged or older adult with a history of cigarette smoking. Some cystic and cavitory lesions may be filled with fluid or solid contents. For example, a bronchogenic cyst may be filled with fluid and appear as a mass lesion on chest radiography. The presence of an air-fluid level does not correlate well with benignity or malignancy (1). Solid contents within a cavity may be seen in infectious processes (e.g. invasive aspergillosis), and in necrotic tumors. The location of focal lesions may be of help in narrowing the differential diagnosis (e.g. propensity of tuberculosis to affect the upper lobes of

the lung) (1). Chest radiograph remains the first imaging technique in the evaluation of cystic and cavitory lung lesions. However, computed tomography (CT) and high resolution CT (HRCT) can show the size, shape and precise location of cysts and cavities when these lesions are not apparent on chest radiography. The purpose of this review is to describe the characteristic radiologic findings of focal and multiple lung cystic and cavitory lesions.

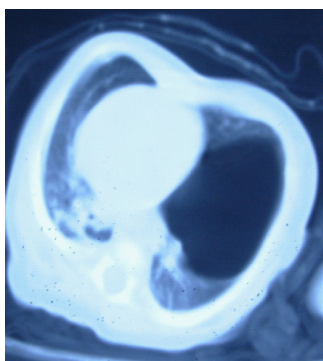
### *Congenital abnormalities*

#### **Congenital lobar emphysema**

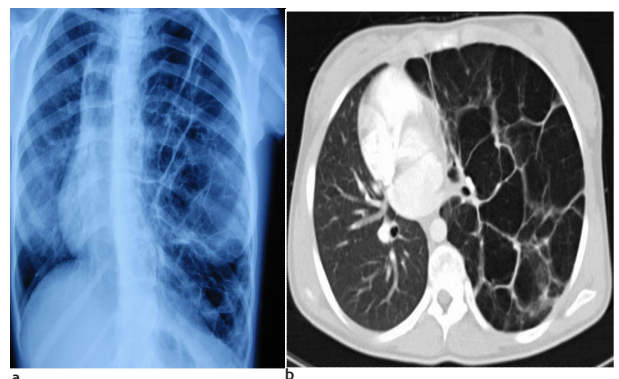
Lobar emphysema can be either acquired, or secondary or congenital. CLE refers to progressive overinflation of a pulmonary lobe secondary to air trapping clinically, most infants with CLE present within the first 6 months of life, with symptoms and signs of respiratory distress. Bilateral or multifocal involvement is rare. With severe overdistention of a lobe, contralateral lobar compression results and there is cardiomeastinal shift (Figure 1). CT scan demonstrates which lobes or segments are involved. The affected lobe is overdistended and hypodense, with attenuated vascular markings (Figure 1) (1,2).

#### **Bronchopulmonary dysplasia and Wilson-Mikity syndrome**

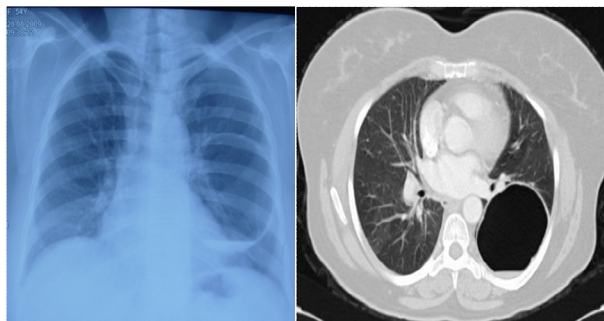
In the neonatal period, several disease entities, such as bronchopulmonary dysplasia and Wilson-Mikity syndrome are associated with respiratory distress. Bronchopulmonary dysplasia results infantile respiratory distress syndrome and respiratory therapy with high oxy-



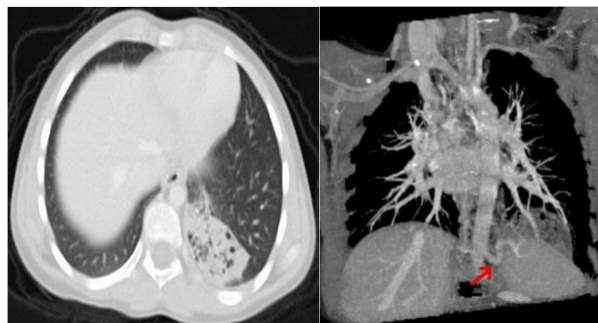
**Figure 1.** Congenital lobar emphysema. CT scan shows a large hyperlucent area in the left hemithorax. There is marked overinflation in the left hemithorax and the mediastinal structures are shifted to the right side and the lower lobe is compressed



**Figure 2.** Type I congenital cystic adenomatoid malformation a. chest radiograph shows thin walled cysts with multiple internal septa expand left lung and displace diaphragm and mediastinum b. CT scan shows replacement of the left lung by cystic lesions of varying sizes.



**Figure 3.** Bronchogenic cyst a. Chest radiograph shows a bronchogenic cyst in the left lung with an air filled level b. CT scan (lung window) shows a unilocular air-filled bronchogenic cyst on the left lung



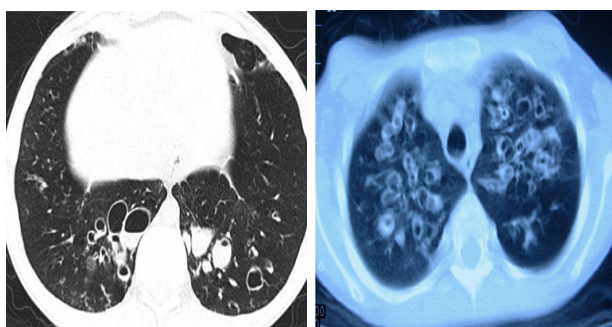
**Figure 4.** Intralobar sequestration in a child with recurrent pneumonia in the lower lobe. a. CT scan shows a large multicystic mass b. The arterial supply to the sequestered segment (arrow) arises from the descending aorta as demonstrated on the surface rendered 3-D image

gen concentrations. Multiple lung cysts reflect air trapping due to broncholitis or areas of destroyed lung surrounded by fibrous tissue. Lesions are typically bilateral. Wilson-Mikity syndrome or pulmonary dysmaturity, has a radiologic appearance similar to that of bronchopulmonary dysplasia, but is not associated with infantile respiratory distress syndrome (3).

#### Congenital cystic adenomatoid malformation of the lung

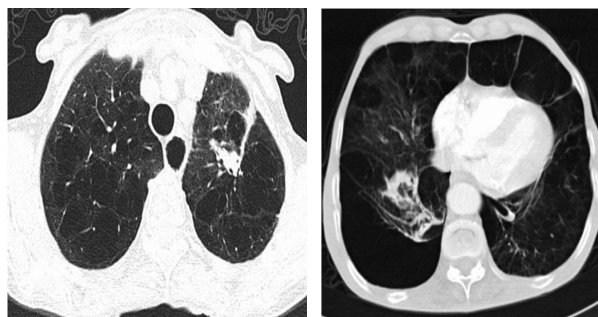
Congenital cystic adenomatoid malformation of the lung (CCAM) is an uncommon developmental abnormal-

ity. CCAM is usually discovered in neonates, because of respiratory distress and may occasionally be discovered in older children or adults who have recurrent infection (2-4). Stocker et al. (5) classified into three types based on clinical, gross and microscopic criteria. In type 1 CCAM, lesions consist of multiple large cysts (2-10 cm in diameter). Type 2 lesions have numerous smaller, more uniform-sized cysts (0.5-2 cm in diameter, rarely larger). Type 3 lesions are bulky solid lesions that usually involve an entire lobe or lung (2,4,6). Typical radiographic finding in patients with CCAM is a large air-filled multicystic lesion. However, variable radiographic features can



**Figure 5.** The HRCT shows bilaterally mucoid impaction and cystic bronchiectasis in both lower lobes.

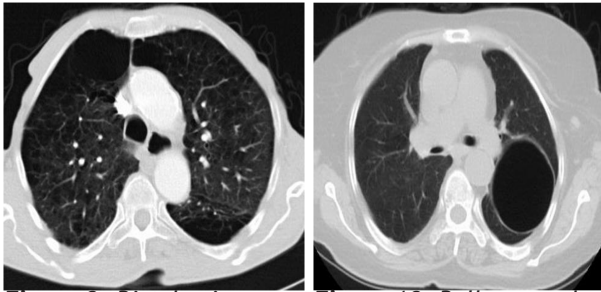
**Figure 6.** The CT scan shows bronchial wall thickening and bronchiectasis involving all of the lobes. Mucus plugs are seen with in several of the dilated bronchi (Cystic fibrosis)



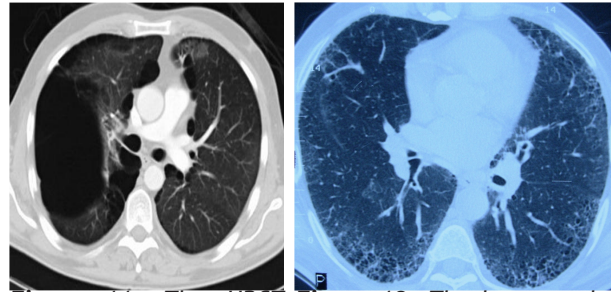
**Figure 7.** Centrilobular emphysema. The HRCT shows multiple areas of low attenuation with minimal or no perceptible walls consistent with centrilobular emphysema and finding pulmonary fibrosis

**Figure 8.** Panlobular emphysema. The HRCT shows the panacinar emphysema lesion that is seen in both lower lobes.





**Figure 9.** Distal acinar emphysema. The HRCT shows distal acinar emphysema in both lung and absence of emphysema in the lung.



**Figure 11.** The HRCT shows a large bullae on the right and presence of fibrosis. The HRCT shows distal acinar emphysema in both lungs.

**Figure 12.** The honeycomb cysts with a distinct predominance in the peripheral and subpleural regions.

make diagnosis difficult (Figure 2). CT demonstrates the air-filled or fluid-filled cystic lesions with thin walls and air-fluid levels in cysts or a combination of these findings (Figure 2).

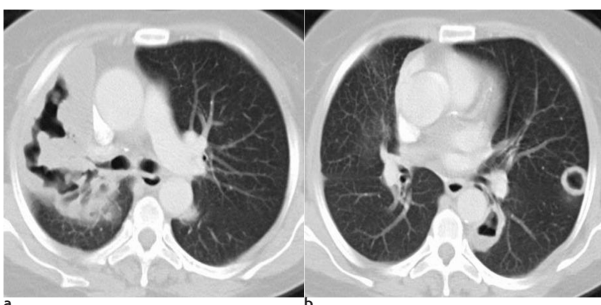
**Bronchogenic cysts**

Bronchogenic cysts are found most frequently in the mediastinum or lungs, but they can develop in extrathoracic locations, such as neck, pericardium or abdominal cavity (2,4). On chest radiography, an intrapulmonary bronchogenic cyst may appear as well-defined, noncalcified lung mass with water density or air-space cysts with air-fluid levels (Figure 3). CT often demonstrates a cyst not visible by conventional radiographic techniques. CT density of bronchogenic cysts can vary from typical water density (0 to 20 HU) to high density (89 to 99 HU). CT provides

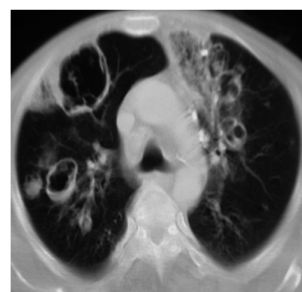
optimal demonstration of cyst location, morphology and contents (Figure 3) (7,8).

**Pulmonary sequestration**

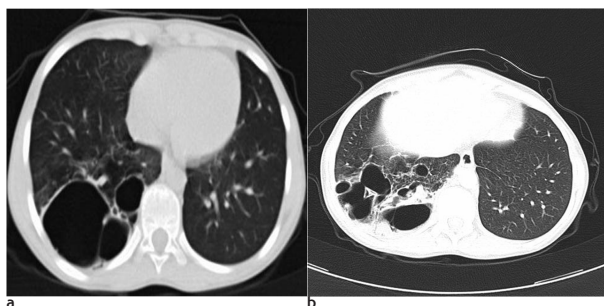
Classically, two forms of pulmonary sequestration (PS) have been described: intralobar (ILPS) and extralobar (ELPS). ILPS is a segment of pulmonary tissue that shares the visceral pleural covering of normal adjacent lung tissue and are usually located in the posterobasal portion of the lower lobes. The arterial supply is typically from thoracic or upper abdominal aorta and most drain by way of the pulmonary venous system to the left atrium. ELPS is entirely separate segment of pulmonary tissue that is invested in its own pleural layers. ELPS may also be located in the mediastinum, pericardium and within or below the hemidiaphragm (2,9). The abdominal or thoracic aorta



**Figure 13.** Wegener granulomatosis. a; The CT shows a large cavitating mass associated with consolidation in the right upper lobe. b; Cavitating nodules in the left subpleural region.

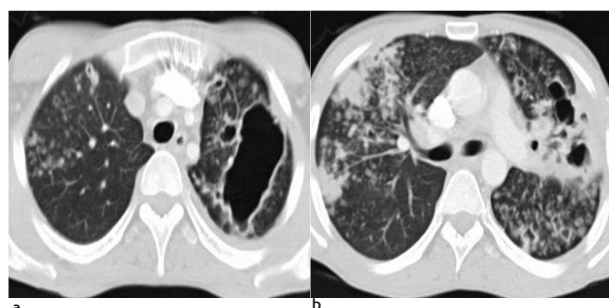


**Figure 14.** Staphylococcal pneumonia. The CT scan shows multiple cavitation in the right and left lobes

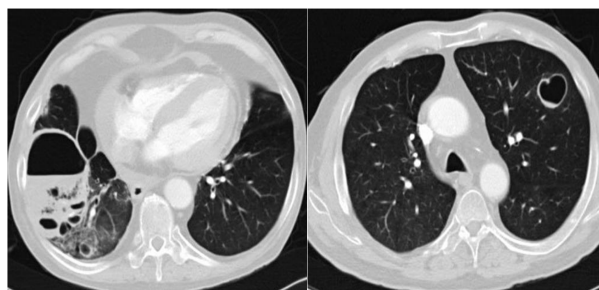


**Figure 15.** Pneumotocele formation in staphylococcal pneumonia a-b .The CT scan show multiple pneumotoceles with thin walled in right lower lobe pneumonia.

usually supplies the arterial vessels. In 80 % of cases, venous drainage is to the systemic circulation , usually by way of azygous system or IVC. It is difficult to distinguish between an ILPS and ELPs on plain radiograph alone. CT or MRI provide a more global assessment of sequestration and are in general, recommended for full evaluation. CT images shows an ILPS as a more irregular outline and also a heterogenous appearance. Cysts and cavities with air-filled levels may be seen (Figure 4). CT images show an ELPs as a homogenous, well-circumscribed areas of soft tissue attenuation (2). With its multiplanar capability, MR imaging can successfully demonstrate the systemic feeding vessels of an intralobar sequestration (Figure 4). MR imaging can also depict the pulmonary venous return of the lesion and the relationship of the draining vein to the cardiac chambers. MR imaging can also reveal the cystic nature of many intralobar sequestrations, as well as the



**Figure 17.** Active cavitory pulmonary tuberculosis.a. The HRCT shows an irregular small and large thick-walled cavity in the left upper lobe.b. CT scan obtained at level of carina shows thicked walled cavities associated with segmental consolidation and scattered nodules and clusters of nodules that are typical of endobronchial spread of infection (three-in-bud appearance)



**Figure 16.** Pulmonary abscess. The CT scan shows consolidation with cavitation and air- fluid level in the right lobe and cavitating lesion on the left.

variable solid, fluid, hemorrhagic and mucus-containing components (9).

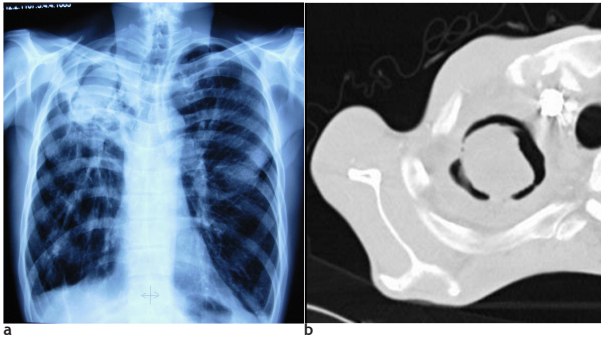
#### Airway abnormalities

##### Bronchiectasis

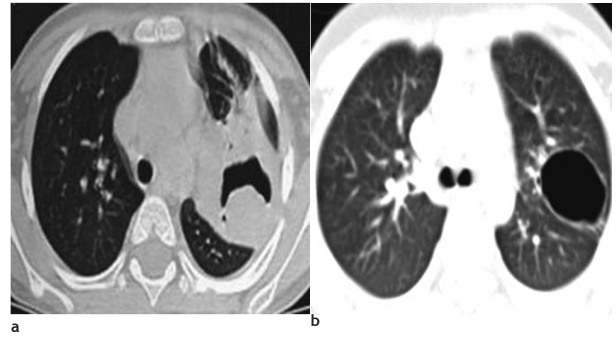
Bronchiectasis is a disease process characterized by abnormally dilated bronchi with thickened bronchial walls, and which has a number of potential underlying causes. Ninety percent of bronchiectatic patients have some abnormalities on chest radiograph as follows: focal opacifications, scattered irregular opacities, linear or plate-like atelectasis or dilated and thickened airways that appear as ring-like shadows (10) (Figure 5). HRCT has now become the best tool for diagnosis. Typical findings on chest CT scan tend to correlate with type of bronchiectasis present (e.g. cylindrical, saccular or varicose), although



**Figure 18.** Cystic pneumocystis carinii pneumonia.The HRCT shows poorly marginated air-space nodules and foci of ground glass opacification scattered through out the upper lobes and small thin-walled cavities.



**Figure 19.** Pulmonary aspergilloma (mycetoma) a. Chest radiograph shows pulmonary cavity in the right upper lung surrounded by circumferential pleural thickening and containing aspergilloma. b. CT scan shows a right intracavitary aspergilloma with associated pleural thickening.



**Figure 20.** Invasive pulmonary aspergillosis with acute leukemia. a. active early lesion of invasive pulmonary aspergillosis with CT halo sign. b. Four months later, lesion are healed. CT shows residual thin-walled cyst.

patterns may be mixed. HRCT findings of bronchiectasis include increased bronchoarterial ratio, lack of appropriate airway tapering, bronchial wall thickening and irregularity, mucoid impaction and mosaic perfusion with air trapping (Figure 5). Bronchial dilatation is considered to be present when the bronchus is larger than the adjacent pulmonary artery (signet ring sign) or when bronchi are visible within 1 cm of the pleura (10-12).

### Cystic fibrosis

Cystic fibrosis is transmitted as an autosomal recessive trait. The CT findings of cystic fibrosis include bronchial wall thickening, bronchiectasis and mucus plugs within the bronchi (Figure 6). The abnormalities are usually most

severe in the upper lobes. The bronchiectasis is most often cylindrical, but varicose and cystic bronchiectasis can be seen in advanced cases (12).

### Emphysema

Emphysema is defined as a condition of the lung characterised by permanent, abnormal enlargement of the airspaces distal to the terminal bronchiole, accompanied by destruction of the airspace walls (11,13). The HRCT findings of emphysema include centrilobular (centriacinar), panlobular (panacinar) and distal acinar (paraseptal). Centrilobular emphysema (Figure 7) is found most commonly in the upper lobes and manifests as multiple small areas of low attenuation without a perceptible wall,

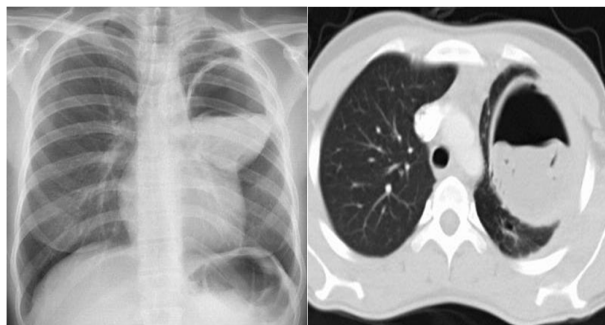


**Figure 21.** Allergic bronchopulmonary aspergillosis in a 50-year-old asthmatic patient a. The HRCT shows fungus ball with in multiple dilated bronchi in the left upper lobe and b. lower lobe.

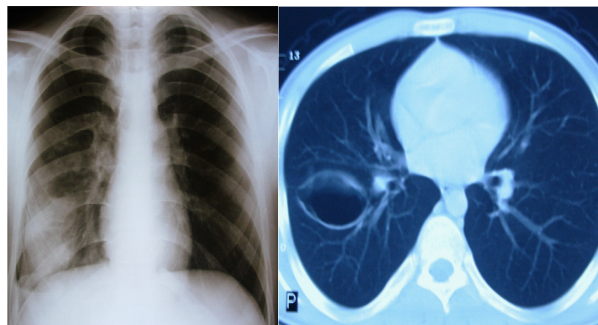


**Figure 22.** Hydatid cyst. CT scan shows a hypodense crescentic sign (meniscus sign)





**Figure 23.** Hydatid cyst. Chest radiograph and CT scan shows the water lily sign created by collapsed and crumpled endocysts floating freely in the most dependent part of the cyst.



**Figure 24.** Hydatid cyst. Chest radiograph shows a large homogenous solid mass in the right lower lung. CT scan shows an “empty cyst” after complete evacuation parasitic membranes (1 year after).

producing a punched-out appearance. In contrast to centrilobular emphysema, panlobular emphysema is histopathologically characterized by complete destruction of the entire pulmonary lobule. On HRCT panlobular emphysema appears as extensive low attenuation that manifests as diffuse simplification of pulmonary architecture (Figure 8) and the pulmonary vessels appear stretched and attenuated in the presence of panlobular emphysema (11,13). Distal acinar or paraseptal emphysema appears on HRCT imaging as multiple areas of low attenuation with thin, definable, uniform walls distributed in the subpleural regions of lung (Figure 9).

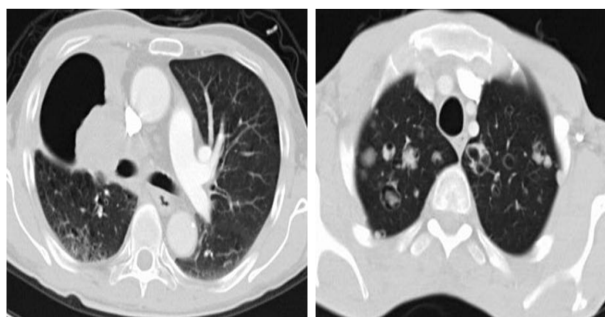
### Bullous emphysema

Bullous emphysema is the most common cause of multi-

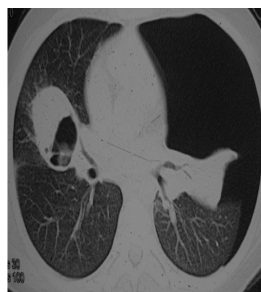
ple lung cysts. Bullae can occur in otherwise normal lung (Figure 10), but are often associated with emphysema (Figure 11). Pathologically, bullae are filled spaces lined by pleura, connective tissue septa or emphysematous lung. The walls of bullae appear hair-thin (Figure 11). CT scan may be necessary to demonstrate the walls and establish the presence of bullae (13).

### Pulmonary fibrosis and honeycomb lung

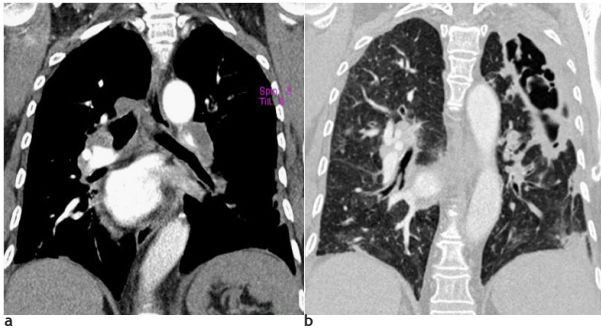
In patients with chronic interstitial fibrosis, fibrosis associated with areas of lung destruction and disorganization of lung architecture (honeycomb) results in a cystic appearance on HRCT scans. That can be characterized and localized precisely (Figure 12). Honeycombing results in cystic spaces several millimeters to several centime-



**Figure 25.** Squamous cell carcinoma of bronchus showing cavitation. The CT scan shows that cavity wall is of variable thickness and the presence of mural nodule  
**Figure 26.** Metastatic testis carcinoma. The CT scan shows multiple metastatic nodules in both lungs and there are several cavitating nodules.



**Figure 27.** Cavitating metastasis associated with pneumothorax from osteogenic sarcoma. The CT scan shows a thick walled cavity in the right lung and pneumothorax in the left



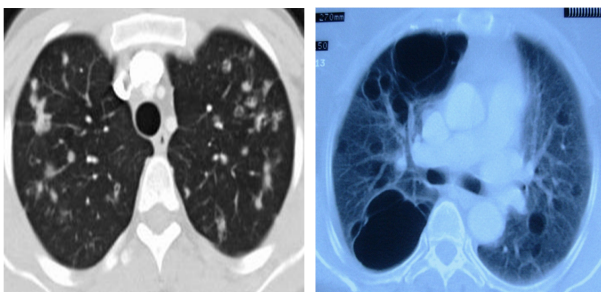
**Figure 28.** Acute pulmonary embolism with infarction  
*a.* Coronal reformation obtained along the main axis of the left pulmonary artery shows the presence of endoluminal clots within the left pulmonary artery *b.* Coronal reformat CT reveals the cavitating infarct and residual scarring of pleura in the left lung and mosaic perfusion in both lungs.

ters in diameter, which are often peripheral in location and are characterized by thick clearly definable walls. Honeycombing often is associated with other findings of fibrosis, such as septal thickening, intralobular lines and irregular pleural thickening (14). Traction bronchiectasis; In patients who have severe lung fibrosis and distortion of lung architecture, so-called traction bronchiectasis may be present. In the presence of severe fibrosis and particularly honeycombing, traction by fibrous tissue on the bronchial walls can result in areas of irregular bronchial dilatation (e.g. bronchiectasis) (14).

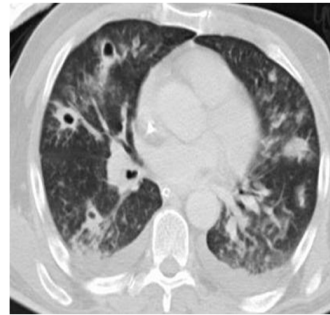
**Granulomatous diseases**

**Sarcoidosis**

The CT lesions of pulmonary sarcoidosis include nodular



**Figure 30.** Langerhans cell histiocytosis. The CT scan shows diffuse thick walled nodules and small nodular opacities.  
**Figure 31.** Lymphangiomyomatosis in a 40-year-old woman. The HRCT shows numerous discrete round, thin walled lung cysts.

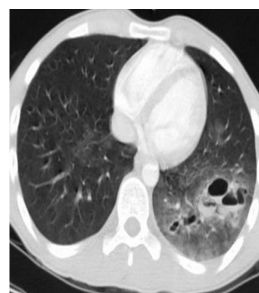


**Figure 29.** Septic pulmonary emboli in 30 years old who had bacterial endocarditis. The CT scan shows scattered mostly peripheral poorly defined foci of air-space consolidation and multiple round pulmonary cavities with thin walls. Note that a number of these cavities appear to be associated with feeding vessels.

areas of attenuation, linear areas of attenuation, alveolar or pseudoalveolar consolidations, irregular interfaces, peribronchovascular thickening, lung distortion, honeycomb cysts, cavitary nodules and traction bronchiectasis (15). CT provides a precise assessment of the pattern and distribution of the disease and it depicts cavitary lesions not shown with chest radiography (4,15).

**Wegener’s granulomatosis**

Wegener’s granulomatosis (WG) is an idiopathic disease characterized by a granulomatous and necrotizing vasculitis (16). The CT lesions of pulmonary WG include nodules, masses, pulmonary consolidations and ground glass opacities. Nodules are the most frequent parenchymal abnormality. In untreated disease, nodules tend to in-



**Figure 32.** Traumatic pseudocyst. The CT scan shows cystic lesions with an air-filled level and some surrounding lung contusion in the left lower lobe.



crease both in size and number and may cavitate (Figure 13). The cavitory nodules may occasionally become infected to give an air-filled level (4,16).

### Infectious diseases

Infectious diseases due to bacteria, fungi or parasites can result in cystic lesions in the lung. Staphylococcus aureus, Klebsiella and anaerobic bacteria commonly result in the development of thick or thin-walled, air-filled cystic lesions (Figure 14). Pneumatocele are thin-walled, cystic lesions commonly seen in children (Figure 15) and infrequently in adults as a sequelae of Staphylococcal pneumonia (1,4). Gram-negative, anaerobic bacteria and occasionally Streptococcus pneumoniae are responsible for the development of lung abscesses. A lung abscess is a thick-walled cavity that contains purulent material resulting from a pulmonary infection. It is believed to be less common in children than adults. Secondary lung abscesses may be seen in children at increased risk of pulmonary aspiration, immunocompromised hosts and those with underlying localized structural lung abnormalities or generalized suppurative lung disease (17). The characteristic appearance of a lung abscess on a CT image is thick-walled cavity. It contains mobile, central fluid occurring in the middle of an area of consolidated lung. An air-filled level is often apparent on the CT, even when it is not evident on the chest radiograph (Figure 16).

### Mycobacterial infection

Two forms of pulmonary tuberculosis (Tb) is known: Primary and post-primary or reactivated tuberculosis which is more frequent in the adult population. The high resolution CT findings of active post primary Tb are centrilobular lesions appearing as a nodule or a branching linear structure (tree-in-bud appearance), bronchial wall thickening, a poorly defined nodule, a cavity and lobular consolidation (18). Cavities result when areas of caseation necrosis erode into the bronchial tree, expelling liquefied debris. CT is more sensitive than plain radiograph in the detection of small cavities, particularly ones in the apices, lung bases and paramediastinal and retrocardiac locations. On CT scans, cavities due to mycobacterial disease can be thick or thin walled and smooth or irregular with or without air-filled levels (Figure 17) (18). Those caused by atypical mycobacteria are indistinguishable from those caused by M.tuberculosis. Tuberculosis may manifest with different patterns and distribution in patients with diabetes or acquired immunodeficiency syndrome (AIDS) (4).

### Pneumocystis carinii pneumonia

Pneumocystis carinii is the commonest cause of pneumonia in patients with AIDS, occurring in 60 % to 80 % patients. Radiographic and CT manifestations of P.carinii pneumonia is bilateral, central or basal, reticular or ground glass opacification, which may progress over a few days to diffuse air-space consolidation. Cavitation is rare and has been reported in 10 % of cases. Thin-walled, air-filled lung cysts occur frequently (38 % of cases) (Figure 18). They often persist after treatment. Such cavities which are often apical and subpleural may cause pneumothorax (19).

### Fungal infections

In the literature, several forms of pulmonary aspergillosis have been described, including saprophytic (aspergilloma), invasive, semi-invasive and allergic bronchopulmonary aspergillosis (ABPA) (4,20). The radiographic presentations of pulmonary aspergillosis vary depending on the form of the disease and the patient's clinical setting. At CT aspergillomas are characterized by the presence of a solid, round or oval mass with soft tissue opacity within a lung cavity. The mass is typically separated from the cavity wall by an air-space ("air crescent sign") and is often associated with thickening of the wall and adjacent pleura (Figure 19) Characteristic CT findings in invasive aspergillosis consist of nodules surrounded by a halo of ground glass attenuation ("halo sign") or pleura-based, wedge-shaped areas of consolidation (Figure 20). CT findings in allergic bronchopulmonary aspergillosis (ABPA) consist primarily of mucoid impaction and bronchiectasis involving predominantly the segmental and subsegmental bronchi of the upper lobes (Figure 21). Semi-invasive (chronic necrotizing) aspergillosis may be seen at CT as an endobronchial mass, obstructive pneumonitis or collapse or hilar mass. Only a few reports have described CT findings in aspergillus necrotising bronchitis involving the central airways (20).

### Hydatid disease

The localization of hydatid cysts in humans is mostly hepatic (55 to 75 percent), with the lungs being the second most frequent location in adults (10 to 30 percent). Radiographically, the cysts are commonly seen as spherical, homogenous masses with smooth borders surrounded by normal lung tissue. An intact cyst is filled with clear fluid (21). Cysts may rupture spontaneously (Figure 22) or due to trauma. As the cysts enlarges and erodes into the

bronchioles, air enters the potential space between pericyst and endocyst and appears as a thin lucent crescent (crescent or meniscus sign) (Figure 22). When hydatid cyst completely collapsed, the crumpled endocyst floats freely in the cyst fluid (water lily sign) (4) (Figure 23). Complicated hydatid cysts, either ruptured or infected, are also difficult to differentiate from other cavitory lesions, such as active cavitory tuberculosis (21). In cases of completely empty cysts (Figure 24), a variety of diseases that produces or mimic air-containing cavities should be considered in the differential diagnosis (21).

### **Malignant neoplasms**

#### **Lung cancer**

Cavitation in bronchogenic carcinoma is common and occurs in about 10 % to 15 % of cases. Eighty percent of cavitating lung tumors are squamous cell carcinomas, whereas the remaining 20 % are adeno and large cell carcinomas. Bronchoalveolar carcinoma may occasionally present as multiple cavitory nodules (1,4,22). Typically, the cavity will have thick walls, nodular extensions of tumor (mural nodules) projecting into the lumen of cavity are frequent (Figure 25). Occasionally, a cavitated lung cancer will have smooth, thin walls. Rarely, a meniscus or air-crescent sign may be seen in association with a cavitated bronchogenic carcinoma (23).

#### **Metastatic disease**

Cavitating lung metastases can occur in any primary malignancy. However, previous studies have shown that they are more commonly associated with primary squamous cell carcinoma. Cavitating lung metastases have been reported with primary lung, head and neck, thyroid, breast, bone, kidney, pancreas, colon and rectum, urinary bladder, penis, testis (Figure 26), uterine, cervix and skin carcinomas (4,24). The aetiology of the formation of a cavity is not clear. Metastatic sarcomas can also cavitate and a pneumothorax can be complicated (Figure 27). Chemotherapy is known to induce cavitation. Pneumothorax occurs most frequently with an osteosarcomatous tumors. Necrosis of subpleural metastases is thought to produce a bronchopleural fistula that results in a pneumothorax. The frequency of a pneumothorax in a patient with an osteosarcoma has been reported to be approximately 5 % - 7 %. A spontaneous pneumothorax in a patient with a sarcoma should raise the possibility of occult pulmonary metastases. In such cases, CT may help detect occult pulmonary metastatic nodules (24).

### **Miscellaneous diseases**

#### **Bronchiolitis obliterans organising pneumonia**

Bronchiolitis obliterans organising pneumonia (BOOP) is an unusual condition that is characterized pathologically by the presence of polypoid granulation tissue in the lumen of bronchioles and alveolar ducts. It is usually associated interstitial and airspace infiltration by mononuclear cells and foamy macrophages (25). The most radiological appearance is that of bilateral, multifocal, non-segmental and patchy areas of consolidation. Both cavitation and hemoptysis are rare manifestations of BOOP. Focal solitary nodule or mass, which may simulate a bronchial carcinoma, and multiple nodules or masses which may also be associated with cavitation (25).

#### **Emboic diseases**

##### **Pulmonary embolism with infarction**

This is an uncommon cause of cavitory lung nodules. Pulmonary embolism causes infarction in less than 15 % of cases, and cavitation is found in only about 5 % of infarctions. Cavitory pulmonary infarction has also been reported in immunocompromised patients (1). The cavities most frequently have well-defined borders, round or oval shape and a wall thickness ranging from 1 to 2 mm which decreases overtime (Figure 28) (1).

##### **Septic pulmonary emboli**

Septic pulmonary emboli occur in patients with congenital heart diseases, endocarditis (often due to intravenous drug abuse), infected in dwelling catheters. Radiographically, the lesions appear as multiple, scattered consolidation. The pattern may change rapidly and new lesions appear as other resolve. Thin walled cavities can develop (Figure 29). Fluid levels are infrequently seen (3).

#### **Collagen vascular diseases**

Lung involvement in rheumatoid arthritis (RA) may manifest with necrobiotic nodules, pleural effusions and/or pleuritis. Rheumatoid (necrobiotic) nodules are found in up to 20 % of patients. Nodules typically range from a millimeter to centimeters in size. Nodules identified in HRCT must be distinguished from malignant and infectious lesions. Caplan's syndrome refers to conglomerations of nodules seen in patients with the combination of RA and pneumoconiosis (26).

## Diffuse lung diseases

### Langerhans cell histiocytosis

Langerhans cell histiocytosis is a proliferative disorder of unknown aetiology, that may involve many organs and tissue. Pulmonary involvement consists of small nodules and cystic air space. Nodules usually measuring less than 5 cm in diameter, are seen in most patients. Nodules are characteristic of the early stage, whereas cystic air spaces present late stage of the disease (Figure 30). The cystic air spaces usually measure less than 10 mm in diameter. CT is superior to the chest radiograph (27).

### Lymphangiomyomatosis

Lymphangiomyomatosis (LAM) is a rare hamartomatosis characterized by smooth cell hyperplasia along the terminal bronchioles, lymphatic vessels and blood vessels. It was suggested that oestrogens play a role in the patho-mechanism since LAM occurs almost exclusively in woman of child-bearing age (1,28). On CT scans LAM is characterized by the presence of diffuse distributed cysts. Cystic changes in LAM are described as multiple thin-walled cysts uniformly distributed throughout the lung (Figure 31).

### Chest trauma

Blunt chest trauma frequently produces pulmonary contusions, hematomas or effusions, but rarely leads to appearance of a cystic lesion. Cystic lesions are either a direct result of the injury itself (primary pseudocyst) or can develop after resolution of a pulmonary hematoma (secondary pseudocyst). On chest radiography an air-fluid level usually seen and the surrounding lung often shows consolidation due to pulmonary contusion. On CT posttraumatic pneumatoceles appear as round, well-circumscribed, single or multiple cavitory lesions with air and thin wall (Figure 32). They may contain blood. Radiological resolution usually occurs within 2-3 months (29).

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