# A systematic approach to a cystic pattern in the lungs

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## Keywords:
lung cysts, Bulla, cavity, lymphangioleiomyomatosis

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Cystic lung disease is a broad term used to describe pathological process in the lungs, characterized by the presence of cysts in the lung parenchyma.

**A cyst** is any round circumscribed space that is surrounded by an epithelial or fibrous wall of variable thickness.

## Radiographs and CT scans

A cyst appears as a round parenchymal lucency or low-attenuating area with a well-defined interface with normal lung [1].

Cysts have variable wall thickness but are usually thin-walled (<2 mm) and occur without associated pulmonary emphysema. Cysts in the lung usually contain air but occasionally contain fluid or solid material.

The term is often used to describe enlarged thin-walled airspaces in patients with lymphangioleiomyomatosis or Langerhans cell histiocytosis; thickerwalled honeycomb cysts are seen in patients with end-stage fibrosis [1].

**A cavity** is a gas-filled space, seen as a lucency or low-attenuation area, within pulmonary consolidation, a mass, or a nodule. In the case of cavitating consolidation, the original consolidation may resolve and leave only a thin wall. A cavity is usually produced by the expulsion or drainage of a necrotic part of the lesion via the bronchial tree. It sometimes contains a fluid level. Cavity is not a synonym for abscess [1].

**A pseudocavity** appears as an oval or round area of low attenuation in lung nodules, masses, or areas of consolidation that represent spared parenchyma, normal or ectatic bronchi, or focal emphysema rather than cavitation. These pseudocavities usually measure less than 1 cm in diameter. They have been described in patients with adenocarcinoma, bronchioloalveolar carcinoma, and benign conditions such as infectious pneumonia [1].

**Figure 1.** *In this image are presented a cyst (left), a cavity (center), a pseudo-cavity (right)*

**A pneumatocele** is a thin-walled, gas-filled space in the lung. It is most frequently caused by acute pneumonia, trauma, or aspiration of hydrocarbon fluid and is usually transient.

The mechanism is believed to be a combination of parenchymal necrosis and check-valve airway obstruction. A pneumatocele appears as an approximately round, thin-walled airspace in the lung [1].

**A bleb** is a small gas-containing space within the visceral pleura or in the subpleural lung, not larger than 1 cm in diameter.

A bleb appears as a thin-walled cystic air space contiguous with the pleura. Because the arbitrary (size) distinction between a bleb and bulla is of little clinical importance, the use of this term by radiologists is discouraged [1].

**Bulla** is an airspace measuring more than 1 cm—usually several centimeters—in diameter, sharply demarcated by a thin wall that is no greater than 1 mm in thickness. A bulla is usually accompanied by emphysematous changes in the adjacent lung.

A bulla appears as a rounded focal lucency or area of decreased attenuation, 1 cm or more in diameter, bounded by a thin wall. Multiple bullae are often present and are associated with other signs of pulmonary emphysema (centrilobular and paraseptal) [1].

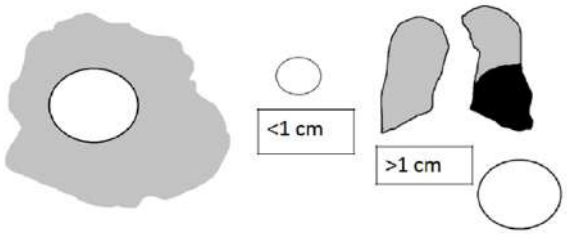



**Figure 2.** *In this image are presented a pneumatocele (left), bleb (center), bull (right)*

**An air crescent** is a collection of air in a crescentic shape that separates the wall of a cavity from an inner mass.

The air crescent sign is often considered characteristic of either Aspergillus colonization of preexisting cavities or retraction of infarcted lung in angioinvasive aspergillosis. However, the air crescent sign has also been reported in other conditions, including tuberculosis, Wegener granulomatosis, intracavitary hemorrhage, and lung cancer [1].

**Cystic bronchiectasis** is irreversible localized or diffuse bronchial dilatation, usually resulting from chronic infection, proximal airway obstruction, or congenital bronchial abnormality.

Morphological criteria for CT scans include bronchial dilation relative to the accompanying pulmonary artery, lack of bronchial constriction, and visualization of the bronchi within 1 cm of the pleura surface [1].

**Honeycombing** represents destroyed and fibrotic lung tissue containing numerous cystic airspaces with thick fibrous walls, representing the late stage of various lung diseases, with complete loss of acinar architecture.

The cysts range in size from a few millimeters to several centimeters in diameter, have variable wall thickness, and are lined by metaplastic bronchiolar epithelium. On chest radiographs, honeycombing appears as closely approximated ring shadows, typically

3–10 mm in diameter with walls 1–3 mm in thickness, that resemble a honeycomb; the finding implies end-stage lung disease. On CT scans, the appearance is of clustered cystic air spaces, typically of comparable diameters on the order of 3–10 mm but occasionally as large as 2.5 cm.

Honeycombing is usually subpleural and is characterized by well-defined walls. It is a CT feature of established pulmonary fibrosis. Because honeycombing is often considered specific for pulmonary fibrosis and is an important criterion in the diagnosis of usual interstitial pneumonia, the term should be used with care, as it may directly impact patient care [1].

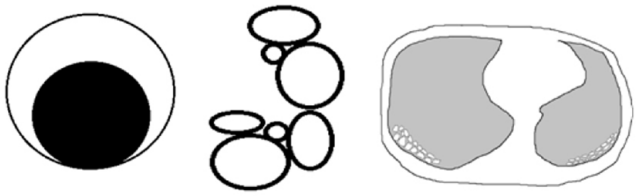


**Figure 3.** *In this image are presented a air crescent sign (left), cystic bronchiectasis (center), honeycomb lung (right)*

The authors of Maffessanti and Dalpiaz distinguish certain types of cystic changes or patterns characterized by multiple areas of low density with smooth contours in relation to normal pulmonary parenchyma.

For example, such as:

- Cystic changes in the type of grape cluster.
- Cystic changes in the type of pearl thread.

**Cystic changes in the type of grape cluster** - close to each other brush along the bronchi vascular pedicle, usually localized in the upper and middle zones. This type of changes is typical for cystic bronchiectasis, cystic fibrosis [1].

| | |
|---|---|
| **Distribution:** | Uni- or Bilateral |
| **Axial plane:** | Central or the peripheral zones |
| **Craniocaudal plane:** | Upper and middle zones |
| **Certain diagnosis:** | Cystic bronchiectasis<br>Cystic fibrosis |

**Cystic changes along the string of pearls** are characterized by the location of one row of cysts in the subpleural zones, usually in the upper and middle zones, which is characteristic of paraseptal emphysema [1].

| | |
|---|---|
| **Distribution:** | Uni- or Bilateral |
| **Axial plane:** | Peripheral and subpleural areas |
| **Craniocaudal plane:** | Upper and middle zones |
| **Certain diagnosis:** | Paraseptal emphysema |

**Honeycomb lung,** detected by CT, is a specific change in pulmonary fibrosis and is an important criterion in the diagnosis of usual interstitial pneumonia (UIP), so the term should be used with caution, as it can directly affect the tactics of patient management. Depending on additional symptoms such as traction bronchiectasis, reticular changes, pleural plaques, subpleural changes, either the UIP pattern, asbestos, collagenosis is suspected [1].

| | |
|---|---|
| **Distribution:** | Bilateral |
| **Axial plane:** | Peripheral and subpleural zones |
| **Craniocaudal plane:** | Basal, peripheral zones |
| **Differential diagnosis:** | UIP, Asbestosis, Collagenosis |

**A cystic pattern with a random cyst distribution** is visualized as cysts arranged arbitrarily. For the differential diagnosis it is also necessary to evaluate the distribution in the craniocaudal direction with the assessment of the costal-diaphragmatic angles [2].

The tables below show two different types of cystic pattern with random cysts:

| | |
|---|---|
| **Distribution:** | Bilateral, symmetrical |
| **Axial plane:** | Uniform distribution |
| **Craniocaudal plane:** | Upper, middle zones |
| **Differential diagnosis:** | Centrilobular emphysema, Langerhans cell histiocytosis |

| | |
|---|---|
| **Distribution:** | Bilateral, symmetrical |
| **Axial plane:** | Uniform distribution |
| **Craniocaudal plane:** | Diffuse |
| **Certain diagnosis:** | **Lymphangioleiomyomatosis** |

**Further in the review are not considered:**

- Single air cysts – e.g. pneumatocele
- Fluid-filled cysts – e.g. echinococcal cyst
- Honeycomb lung / end-stage fibrosis
- Cystic bronchiectasis

**Cysts, as a dominant sign on CT**, are characteristic of many diseases [2]:

1. Langerhans cell histiocytosis
2. Lymphangioleiomyomatosis
3. Lymphoid interstitial pneumonia
4. Centrilobular emphysema
5. Tracheobronchial papillomatosis
6. gren
7. Follicular bronchiolitis
8. Cystic fibrosis
9. Asbestos-induced pneumoconiosis
10. Neurofibromatosis
11. Syndrome Berta-Hogan-Dube (rarely)
12. Pulmonary mesenchymal cystic hamartoma (rarely)
13. Light chain disease
14. Subacute hypersensitive pneumonitis

**Cysts, as an additional sign**, occur in the following pathologies [2]:

1. Cystic bronchiectasia
2. Desquamative interstitial pneumonia
3. Cell light in the pattern of the IPR
4. Lung injury
5. Pneumocystis pneumonia
6. Sarcoidosis
7. Pulmonary metastases (squamous/adenocarcinoma)
8. Cystic fibrohistiocytoma lung tumor
9. Cystic mesenchymal
10. Necrobiotic nodules (final stage)

When assessing cystic changes in the lungs, the following signs should be taken into account:

- Distribution (craniocaudal, axial plane)
- Number
- Uni-, bilateral changes.
- Additional typical changes typical of other nosologies
- Changes in surrounding parenchyma
- Form of cystic changes

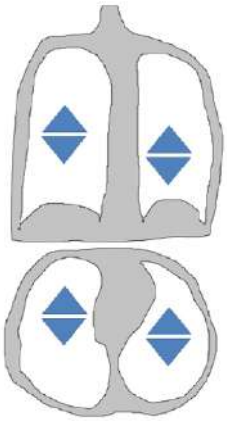
Particular attention should be paid to clinical manifestations, as sometimes the assumption of a diagnosis is out of the question, if there is no clinical data, even better when there is pathomorphological verification.

**Lymphangioleiomyomatosis.**

Lymphangioleiomyomatosis is a tumor growth of smooth muscle fibers in the interstitial.

Options: local form (leiomyoma) and diffuse form (cysts)

Clinical symptoms: first of all – it is shortness of breath.



More often affects women of childbearing age, receiving estrogen therapy, the connection of shortness of breath with menstruation, pregnancy, combination with uterine myoma.

Additional symptoms - spontaneous pneumothorax (50-80%), chylous pleurisy (– 20-40%), pericarditis, ascites.

The function of external respiration (spirometry) – norm or obstructive changes.

Radiography – mesh deformation, sometimes visible air cysts, pleurisy, pneumothorax.

According to CT data, cysts are usually visualized without clearly visible walls against the background of an unchanged pulmonary parenchyma. However, nodes are not typically rendered.

Additional signs include pneumothorax, lymphadenopathy, pleural effusion and others, such as renal angiolipoma.

Uniform distribution of cysts, less pronounced in the tops of the lungs.

Bronchovascular trunk is stored in the walls of cysts (may resemble bronchiectasis) [2].

| | |
|---|---|
| **Distribution:** | Bilateral, symmetrical |
| **Axial plane:** | Uniform distribution |
| **Craniocaudal plane:** | Diffuse |
| **Differential diagnosis:** | Lymphangioleiomyomatosis |

# Langerhans cell histiocytosis

Langerhans cell histiocytosis is a term for a group of diseases with unexplained etiology, in which pathological immune cells, called histiocytes, and eosinophils actively multiply, especially in the lungs and bones, which causes the formation of scar tissue.

Morphology – proliferation in organs and tissues of Langerhans cells

– Consolidation around bronchioles and arterioles include lymphocytes, neutrophils and eosinophils

- Symptoms: fatigue, weight loss, fever, dry cough
- Additional symptoms: smokers (70-95%), predominantly male (4:1), spontaneous pneumothorax (15-25%)
- Respiratory Function – a combination of obstruction and restriction
- Radiography – nodes/reticulation in the upper lobes – tuberculosis

CT-picture depends on the stage of the process

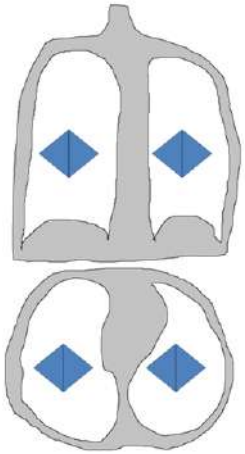
- Initial stage – centrilobular nodes in upper and middle

lung sections – respiratory bronchiolitis (open biopsy)

- At a late stage – lung cysts – irregular shape, outlined

the walls are combined with micro foci (typical pattern) as presented in the middle images

The lower images show additional features of centrilobular nodules less than 10 mm in diameter with cavitations, to the right of the pneumothorax proper [2].



| | |
|---|---|
| **Distribution:** | Double-sided, symmetrical |
| **Axial plane:** | Uniform distribution |
| **Craniocaudal plane:** | Upper, middle |
| **Differential diagnosis:** | Lymphangioleiomyomatosis,<br>Centrilobular emphysema,<br>Cystic bronchiectasis |

# Lymphoid interstitial pneumonia, or LIP

LIP is a rare disease characterized by diffuse pulmonary lymphoid proliferation with predominant interstitial involvement. It is included in the spectrum of interstitial pneumonias and is distinct from diffuse lymphomas of the lung.

Features include diffuse hyperplasia of bronchus-associated lymphoid tissue and diffuse polyclonal lymphoid cell infiltrates surrounding the airways and expanding the lung interstitium. LIP is usually associated with autoimmune diseases or human immuno-deficiency virus infection.

Ground-glass opacity is the dominant abnormality, and thin- walled perivascular cysts may be present. Lung nodules, a reticular pattern, interlobular septal and bronchovascular thickening, and wide-spread consolidation may also occur.

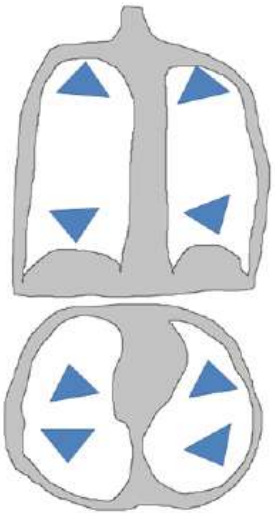
Clinical manifestations – shortness of breath, dry cough (50%), fatigue (80%), fever (40%), arthralgia (30%), weight loss (30%)

Physical signs – crepitation (70%), drumsticks (10%)

FVD – restrictive type, reduced diffusion capacity

Radiography – possible reticular changes in the basal regions.

According to CT data, single pulmonary cysts, which can be combined with a symptom of frosted glass (reversible) or be the only manifestation of the disease.



## Emphysema

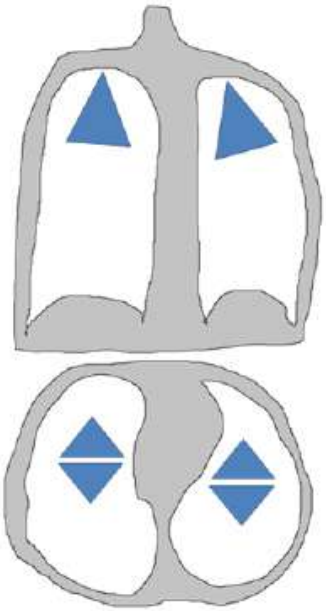
Emphysema is a permanent and irreversible pathological expansion (usually destruction) of air-containing spaces distal to terminal bronchioles without concomitant fibrosis.

Classification

- Proximal acinar emphysema
  – Centrilobular and focal
- Distal acinar (paraseptal) emphysema
- Panacinar emphysema

Changes in x-ray is manifested by the local depletion of lung pattern and avascular areas, architectural distortion For panacinar emphysema is characterized by diffuse expansion of acinus, the merger of intra-lobular structures into a single airspace with predominant localization in the lower lobes of the lungs.

Additional signs are thickening of the bronchial wall, signs of pulmonary hypertension, intraluminal changes in the trachea, lymphadenomegaly, which are caused by chronic inflammation [1].

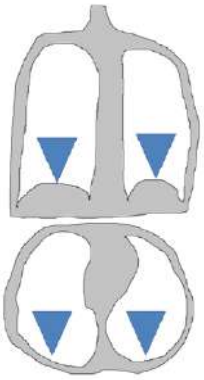


## Asbestos-induced pneumoconiosis

Asbestos is a form of pneumoconiosis that develops as a result of long-term inhalation of asbestos-containing dust and is characterized by diffuse fibrosis of the pulmonary tissue. This pathology is also characterized by visualization of cysts from 2 to 10 mm, which are usually located in the posterior subpleural areas forming a cellular lung. Usually, in this pathology, the lungs are reduced in volume, the changes are bilateral against the background of bronchial and bronchiolectasis [1].

From other indications I would also like to acknowledge the presence:

- reticular changes,
- subpleural lines and bands,
- pleural plaques,
- thickening of the pleura.



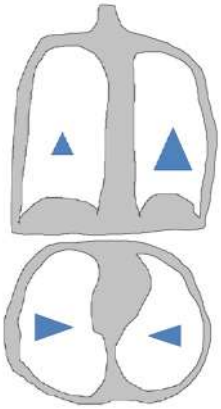
## Cystic fibrosis

Cystic fibrosis is a systemic hereditary disease caused by a mutation of the gene of the transmembrane regulator of cystic fibrosis and characterized by damage to the glands of external secretion, severe violations of the functions of the respiratory organs.

According to CT data in the axial plane changes are usually centrally arranged in pairs, but it is also worth paying attention to the peripheral zones. Cranio-caudal distribution predominance in the upper lobes and dorsal segment of the lower lobes, especially on the right.

Additional changes in the form of changes in the type of mosaic density and cylindrical bronchiectases filled with air [3].

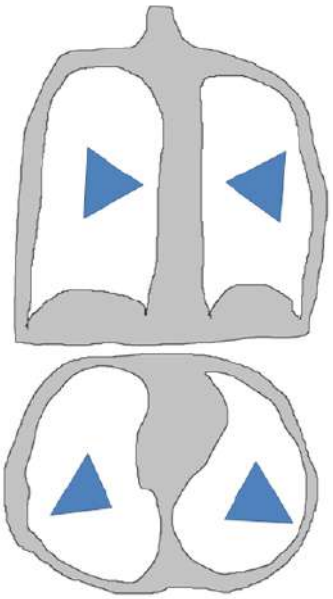
| | |
|---|---|
| **Distribution:** | Bilateral |
| **Axial plane:** | Central perihilar but also periphery |
| **Craniocaudal plane:** | Predominance in the upper lobes and dorsal segment of the lower lobes, especially in the right lung |
| **Differential diagnosis:** | Allergic bronchopulmonary aspergillosis<br>Langerhans Histiocytosis<br>Tracheobronchomalacia |



## Tracheobronchial papillomatosis

Tracheobronchial papillomatosis is characterized by the appearance of multiple squamous papillomas in the trachea and bronchi. This is an unusual manifestation of recurrent respiratory papillomatosis (RRP), which in itself is a rare phenomenon in which HPV-associated papilloma is localized along the respiratory, digestive tract.

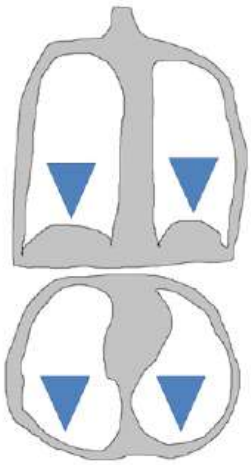
Usually CT shows thin-walled cysts with adjacent nodes of 2-3 mm in size. With a more common disease, normalization can be observed. On CT it is also possible to visualize the distal atelectasis, bronchiectasis and bronchi clogged with mucus [4].



## Sjogren's syndrome (scleroderma)

This pathology is characterized by visualization of cysts from 2 to 10 mm, which are usually located in the posterior subpleural areas, forming a honeycomb lung. Usually the lungs are reduced in volume, bilateral changes in the background of traction bronchi- and bronchiolectasis.

Among other signs: intralobular reticular changes, subpleural lines and strands, unilateral thickening of the pleura, esophageal dilation [5].

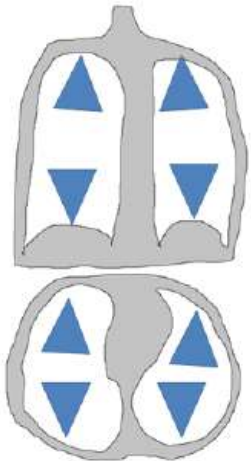


| | |
|---|---|
| **Distribution:** | Bilateral |
| **Axial plane:** | Peripheral, predominantly subpleural posterior |
| **Craniocaudal plane:** | Basal parts |
| **Differential diagnosis:** | Asbestosis<br>Collagenosises<br>UIP |

## Light chain deposition disease (BOLC)

Light chain deposition disease (BOLC) is a rare systemic disease based on the deposition of monoclonal light chains in various organs and tissues, which leads to a progressive impairment of their function.

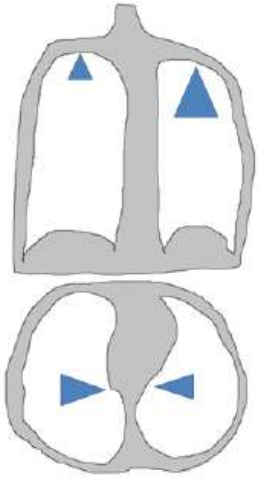
In the manifestation of the disease, the deposition of light chains on CT visualized cysts, lymphadenopathy, nodules. It is believed that the formation of the cyst comes from the wall of the small respiratory tract [6].



## Cystic bronchiectasis

Cystic bronchiectasis is irreversible localized or diffuse bronchial dilatation, usually resulting from chronic infection, proximal airway obstruction, or congenital bronchial abnormality.

Morphological criteria for CT scans include bronchial dilation relative to the accompanying pulmonary artery, lack of bronchial constriction, and visualization of the bronchi within 1 cm of the pleura surface [1].



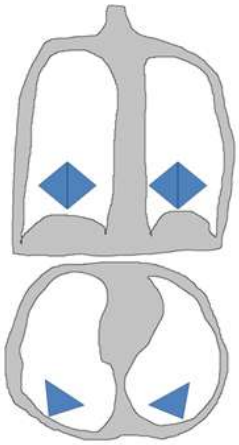
| | |
|---|---|
| **Distribution:** | Bilateral |
| **Axial plane:** | Peripheral, predominantly subpleural posterior |
| **Craniocaudal plane:** | Basal parts |
| **Differential diagnosis:** | Cavitating metastases<br>Histiocytosis Of Langerhans<br>Plasma cell pneumonia |

## Desquamative interstitial pneumonia, or DIP

Histologically, DIP is characterized by the widespread accumulation of an excess of macrophages in the distal airspaces. The macrophages are uniformly distributed, unlike in respiratory bronchiolitis–interstitial lung disease, in which the disease is conspicuously bronchiolocentric. Interstitial involvement is minimal. Most cases of DIP are related to cigarette smoking, but a few are idiopathic or associated with rare inborn errors of metabolism.

Ground-glass opacity is the dominant abnormality and tends to have a basal and peripheral distribution. Microcystic or honeycomb changes in the area of

ground-glass opacity are seen in some cases [1].

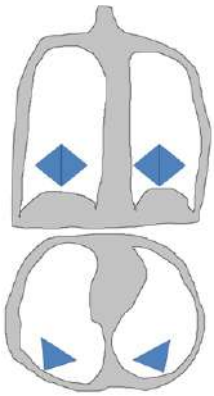


## Usual interstitial pneumonia, or UIP

Usual interstitial pneumonia in the later stages is also visualized with the presence of cysts, the manifestations of which are naturally not in the first place.

UIP is a histologic pattern of pulmonary fibrosis characterized by temporal and spatial heterogeneity, with established fibrosis and honeycombing interspersed among normal lung. Fibroblastic foci with fibrotic destruction of lung architecture, often with honeycombing, are the key findings. The fibrosis is initially concentrated in the lung periphery. UIP is the pattern seen in idiopathic pulmonary fibrosis, but can be encountered in diseases of known cause [1].

| | |
|---|---|
| **Distribution:** | Bilateral |
| **Axial plane:** | Peripheral, predominantly subpleural posterior |
| **Craniocaudal plane:** | Basal part |
| **Differential diagnosis:** | Collagenosises<br>Asbestosis<br>Sarcoidosis |



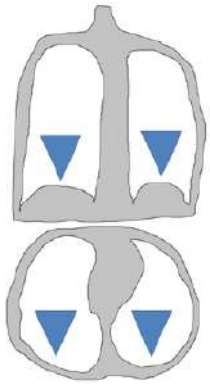
## Cystic lung cancer and metastases

Cystic metastases also have a differential diagnosis in patients with a history of cancer, which should be differentiated from cavitating metastases [7]. During the first year, 4,700 ultra-LDCT were performed in the risk group, and of 84 verified malignancies in the lungs, almost 5% had signs of pseudo-cavities according to ultra-LDCT.

## Birt–Hogg–Dubé syndrome

Birt–Hogg–Dubé syndrome is a rare autosomal dominant genetic disease caused by mutation in the FLCN gene and manifested by the development of benign tumors of the hair follicle, cysts in the lungs and an increased risk of kidney cancer and colon cancer.

On CT images, signs of manifestation of the syndrome are usually manifested by bullous emphysema, thin-walled cysts, pneumothorax [8].



Below is a CT image of this rare disease. Note the distribution of cystic changes in the lower lung and subpleural localization, as well as the absence of pneumothorax. The disease is verified by genetic tests.

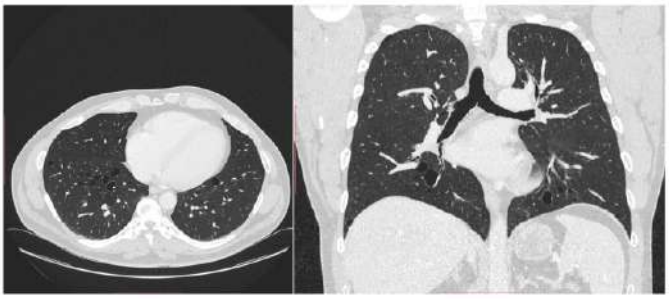


**Figure 4.** *CT scan of a patient with Birt–Hogg–Dubé syndrome.*

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