Pulmonary nodules, masses and infiltrates with specific semiology: when diagnosis is based on imaging

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Authors: M. L. L. Rodriguez Rodriguez; Murcia/ES
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Purpose

To describe the semiological findings of conventional radiography or computerised tomography (CT) that lead to a single diagnosis or reduced range of possible diagnoses of lung shadows.

Methods and Materials

The detection of a pulmonary nodule, mass or infiltrate normally implies a wide-ranging differential diagnosis. The patient's clinical context is the main factor that narrows down the number of possibilities. The need for additional diagnostic tests, perhaps invasive, is always a consideration.

For this reason, we make a retrospective study (1998 - 2010) of diagnoses provided for lung lesions that showed specific semiological or highly suggestive evidence, which led to a single disorder or a small group of related disorders.

Results

This presentation reviews these "imaging-specific" opacities of the lung.

Congenital malformations

Pulmonary arteriovenous malformation (PAVM)

PAVM is an abnormal direct communication between a pulmonary artery and a pulmonary vein. It is usually a congenital abnormality. The condition is twice as common on women than men. 75% of lesions are solitary.

70% of patients with multiple PAVMs will usually have a Rendu-Osler-Weber's syndrome. May also be associated with congenital, especially cardiac, alterations.

The probability of developing symptoms depends on the size and number of lesions.

Imaging findings
Radiography: well defined nodule with lobulated outline of 1-5 cm diameter. Afferent arteries and drainage veins are evident in the PAVMs located near lung periphery. Multiple MAVPs may be confused with metastases.

Multidetector CT (MDCT) confirms the diagnosis of PAVM by showing the nutritional artery and drainage vein around the abnormal arteriovenous connection (Fig. 1 on page 10).

MDCT provides information as regards the size and number of afferent vessels, which is essential for planning the embolization of the PAVM.

**Bronchopulmonary sequestration**

Bronchopulmonary sequestration is an area of disorganized pulmonary parenchyma without normal pulmonary arterial or bronchial communications. Irrigation occurs by means of an anomalous artery from the descending thoracic aorta, from the abdominal aorta or some of its branches. Venous draining may occur via pulmonary or systemic means.

Located in the basal segments (within or adjacent to the posterobasal segment) of the lower lobes. Can be classified into **INTRALOBAR** (contained within the pleural visceral layer) and **EXTRALOBAR** (pleura itself).

**Extralobar sequestration**

It's a congenital anomaly usually detected during infancy. Extralobar sequestration can be associated with other congenital anomalies: diaphragmatic hernia, cardiopathy, cystic adenomatoid malformation, etc. Antenatal diagnosis is possible by ecography.

Covered by their own serosa, they have a vascular pedicle that may suffer torsion, resulting in hydrothorax by intrauterine tension, which may affect the venous return to the heart (foetal hydropsia).

**Intralobar sequestration**

Intralobar sequestration is the more common of these two malformations. Some authors suggest that intralobar sequestration may be an acquired lesion as a result of chronic infection within the lung. Mainly occurs in young adults. Normally produces symptoms as a result of infection.

**Imaging findings**
**Extralobar**: mass adjacent to the mediastinum, of uniform density and well defined lateral edge (pleural envelope).

**Intralobar**: may contain air and has a less defined outline, simulating a pneumonia or abscess ([Fig. 2](#) on page 11).

CT shows a cystic component ([Fig. 3](#) on page 12). Visualisation of systemic arterial anomalous supply for the sequestered lung (CT or IMR) is the key diagnostic factor ([Fig. 4](#) on page 13).

The infection of the pulmonary sequestration conditions hydroaerial levels and poorly defined edges resulting from the inflammatory changes of the adjacent lung that simulate a pneumonia or simple pulmonary abscess. Suspicion should arise from: (a) the basal (medial or posterior) location of the lesion and (b) a history of recurrent infections in the same place ([Fig. 5](#) on page 14 and [Fig. 6](#) on page 15).

Some sequesters (especially extralobar) may look like neurogenic tumours or a meningocele. Key diagnostic factor: absence of pressure-induced erosions in vertebrae and ribs.

**Congenital cystic adenomatoid malformation (CCAM)**

CCAM is a rare congenital lesion. It's a multicystic mass of pulmonary tissue with an abnormal proliferation of bronchial structures. 3 types:

**TYPE I** (55% of cases): contain one or multiple cysts of varying diameters with the presence of at least one predominant cyst of 2 cm or more.

**TYPE II** (40% of cases): smaller more uniform cysts of less than 2 cm in diameter.

**TYPE III** (5% of cases): contain microscopic cysts (less than 3-5 mm). Macroscopically, it has a solid in appearance. These are large lesions with a poor prognosis due to their association pulmonary hypoplasia.

Clinical presentation depends on the size and the prognosis of the histological subtype.

**Imaging findings**

Depend on the subtype. The presence of a solid mass in children suggests type III CCAM.

Types I and II CCAMs show multicystic masses. Cysts may contain air, liquid or air-fluid levels ([Fig. 7](#) on page 16 and [Fig. 8](#) on page 17).
They may affect one lobule, which is usually swollen, having a mass effect on neighbouring lobules: the key feature for diagnosis (Fig. 9 on page 18).

Infections of specific appearance

Calcified granuloma

Most frequent cause of lung nodules. Three characteristic calcification patterns: a) complete and uniform (Fig. 10 on page 19), b) central and c) concentric rings.

6-14% of lung carcinomas show calcification. It has been published that experienced radiologists may interpret more than 7% of non-calcified nodules as being calcified.

Indeterminate nodules should be examined by CT without administration of intravenous contrast to detect some of the patterns of benign calcification.

Air-crescent sign of invasive fungal infections

Aspergillus infection causes symptoms that depend on the patient's immunological state. Two findings are very characteristic of fungal infection: 1) Air-crescent sign in the invasive forms and 2) the presence of an intracavitary mycetoma in the chronic non invasive form.

Lung macrophages and circulating monocytes are the primary immune mechanism for combating this germ. Invasive aspergillosis is produced in neutropenic patients or who have been treated with systemic corticosteroids: recipients of solid organs or bone marrow, patients with leukaemia / lymphoma, patients treated by suppressing chemotherapy.

The air-crescent sign is a manifestation of pulmonary infarction that occurs in the invasive forms of aspergillosis. Peripheral retraction and reabsorption of the necrotic tissue lead to air occupying the space between this dead tissue and the usually haemorrhagic adjacent parenchyma, with resulting radiodensity (Fig. 11 on page 20). This is a sign of a good prognosis.

Imaging findings.

The fungus invades the pulmonary vasculature, causing hemorrhage, thrombosis, and infarction. With time, the peripheral necrotic tissue is reabsorbed by leukocytes and air fills the space left peripherally between the devitalized central necrotic tissue and normal lung parenchyma. (Fig. 12 on page 21 and Fig. 13 on page 22).

Intracavitary mycetoma
The most common form of aspergillosis is the mycetoma or fungus ball. The fungus ball consists of aspergillus hyphae, mucus, and cellular debris developing within a pre-existing cyst, cavity, bulla or area of bronchiectasis. It grow as a saprophytic organism and is usually noninvasive.

Diagnosis established from the images: rounded mass (the mycetome itself) within pre-existing cavity. Usually located in upper lobes or apical segments of the lower lobes (most are secondary to sarcoidosis or TBC).

The mass only occupies the cavity partially, and air can be seen between the fungal ball and the wall: sign of "air meniscus". By turning the patient, CT shows the mobility of the aspergilloma (Fig. 14 on page 23).

**Infections invading the thoracic wall or across fissures**

Most pneumonias are confined by the pleura. They rarely cross the pleura to invade the neighbouring lobe or thoracic wall. When this does occur, it is a manifestation of one of a few infections. These include **actinomycosis, mucormycosis, blastomycosis and tuberculosis**.

**ACTINOMYCOSIS**

Actinomyces israelii (filamentous gram+, anaerobic bacteria) is a common normal oral flora. The infection is produced when bacteria reaches devitalized or infected tissue, facilitating its growth. Not an opportunistic infection. It affects alcoholic patients with poor oral hygiene but not the immunosuppressed.

**Imaging results:** persistent air-space opacity with irregular margins, similar to any bacterial pneumonia. Occasionally the opacity may have a masslike appearance. Infection may form cavities. It may be confused with pulmonary carcinoma and TBC.

**MUCORMYCOSIS**

Mucormycosis is an uncommon, often fatal infection of fungi belonging to the Mucorales group. It is seen almost exclusively in certain groups of immunocompromised patients: diabetics, patients with renal failure, and patients with hematologic disorders (leukemia, lymphoma, myeloma, aplastic anemia).

Two forms: a) infection of the upper airway (paranasal sinuses), and b) pulmonary mucormycosis in immunosuppressed patients (recipients of bone marrow).
Image of pulmonary mucormycosis: lobar, multilobar or focal consolidation, with the appearance of a mass / nodule. Due to its angioinvasive nature, a "halo sign" may appear or cavities may be formed.

Invasion of the thoracic wall or adjacent lobule is infrequent but is a diagnostic clue (Fig. 15 on page 24).

**Imaging specific neoplasms**

**Pulmonary hamartoma**

The name *hamartoma* implies a malformation composed of tissues normally present within the organ it is found. However, most authors believe that this lesion represents a benign neoplasm of connective tissue. It will contain varying degrees of cartilage, bone, fat, and fibrous tissue.

Most are asymptomatic, and they are incidentally detected in image studies.

Hamartoma are usually well defined pulmonary nodule between 1 and 3 cm in diameter. They are round or oval, often with lobulations.

Thorax radiography reveals calcification in 15% of cases. "Popcorn" cartilage configuration confirms diagnosis (Fig. 16 on page 25). The presence of fat may lead to central transparency that could be confused with cavitation in chest radiographs (Fig. 17 on page 26).

CT facilitates calcium and fat identification. Most calcifications on chest CT will be of a nonspecific appearance. However, those cases with calcifications resembling popcorn can be confidently diagnosed as hamartoma. Calcification in conjunction with fat will be detected by CT in 25% of hamartoma. This appearance is strongly suggestive of a pulmonary hamartoma (Fig. 18 on page 27).

Only pulmonary chondroma and exogenous lipoid pneumonia contain areas of lipid or fat.

**Other disorders**

**Radiation pneumonitis and radiation fibrosis**

Radiotherapy of pulmonary or mediastinic tumours may produce an acute radiation pneumonitis or lead to the presence of a fibrosis several months after radiation. This follows a series of phases according to pathological, clinical and radiological criteria.

Such lesions are characteristically confined to the radiation field and their edges coincide with the radiation portal (Fig. 19 on page 28).
Lesion of the endothelial cells and type I pneumocytes leads to an increase in capillary permeability, causing interstitial and alveolar edema: radiation pneumonitis.

**Imaging findings**

Pneumonitis caused by radiation is confined to the radiation field. Lung shadows have a geometric shape and the demarcation between affected and healthy lung is lineal.

This appearance of nonanatomical boundaries between normal and abnormal lung is virtually pathognomonic of radiation pneumonitis and fibrosis (Fig. 20 on page 29).

CT may show opacity outside the radiation field, the cause of which is controversial. At present, it is considered to be induced by lymphocytic alveolitis of immunological origin.

**EARLY CHANGES:**

Consolidation of the air space with air bronchogram with opaque vascular margins. Diffuse consolidations may converge. CT shows opacity of “ground-glass” or consolidation.

**LATE CHANGES:**

Lineal or reticular opacities. Retraction with distortion of adjacent structures (e.g., hilar vessels). Atelectasis and scar fibrosis. Presence of bronchiectasis resulting from fibrosis (Fig. 21 on page 30).

**EVOLUTION**

The signs appear 6-8 weeks after beginning treatment, reaching a maximum at 3-4 months after the end of radiotherapy. The lesions mature and become quiescent after 12-18 months. Changes beyond this time suggest an alternative diagnosis, probably tumoral recurrence.

**Rounded atelectasis**

Rounded atelectasis is an infrequent cause of a lung mass. Although described as a manifestation of asbestos exposure, any exudate-type pleural effusion behind pleural fibrosis could cause rounded atelectasis. Exposure to asbestosis still the most common cause (86% of some series). No symptoms; it is discovered incidentally in image studies.

**Imaging findings**
Chest radiographs will demonstrate diffuse pleural thickening, seen as a smooth opacity separating the lung from the chest wall. A diagnosis of rounded atelectasis should not be made in the absence of identifiable pleural thickening. Rounded atelectasias may appear as a rounded, oval, lenticular or irregular mass adjacent to the pleura, with angles acute to the pleural images, indicating its intrapulmonary localisation (Fig. 22 on page 31). They are usually solitary and found in the lower lobes.

The CT appearance of rounded atelectasis is usually sufficiently characteristic to make a diagnosis. The CT features of rounded atelectasias are the same as those of the chest radiographs: (1) diffuse pleural thickening, (2) domelike mass adjacent to the pleural thickening, and (3) vessels which swirl toward the center of the mass.

The vessels and bronchia curving towards the center of the mass: "comet tail" sign is a characteristic sign (Fig. 23 on page 32). Rounded atelectasis will typically densely enhance following administration of intravenous contrast, like most atelectasis (Fig. 24 on page 33). They can show air bronchogram.

**Exogenous lipid pneumonia**

Exogenous lipid pneumonia is an unusual granulomatous pneumonitis secondary to chronic aspiration of mineral oils or other lipids.

Groups at risk: elderly patients with deglution problems or hiatus hernia and those who use mineral oils as laxatives or nasal drops. It may also be caused by occupational exposure to spraying of paint.

Most patients are asymptomatic. Recurrent aspiration may cause fibrosis manifested by severe or gradual dyspnea.

**Imaging findings**

Three patterns: (1) Diffuse consolidation of the air space in patients suffering breathing difficulty after acute aspiration of a large quantity of oil (rare), (2) Focal or multifocal consolidations, predominantly in the lower lobes of asymptomatic patients with low level chronic aspirations, and (3) Presence of one or more masses in asymptomatic patients. In this case, differential diagnosis with bronchogenic carcinoma advisable.

CT will also demonstrate a focal area of consolidation or mass formation in the lower lobes of the lung. In the majority of the cases, CT imaging will demonstrate internal areas of low attenuation (-50/-100 UH) consistent with lipid. This is a very particular diagnostic finding (Fig. 25 on page 34), but in 14-33% of cases it is not possible to observe macroscopic fat. A "crazy paving" pattern has been described.
Amiodarone pulmonary toxicity

Amiodarone is an iodated benzofuran-derivate used to treat cardiac arrhythmias. Its toxicity depends on the accumulated dose.

Dyspnea is the usual symptom. One third of all patients have a fever or symptoms that suggest an infectious process. Delays in diagnosis are frequent and may be fatal.

Imaging findings

A variety of image manifestations have been described. Frequently, multiple peripheral consolidations that look like the consolidations observed in hypersensitivity pneumonitis (Fig. 26 on page 35). A diffuse, nonspecific interstitial abnormality will often be present (Fig. 27 on page 36).

Given the high iodine content and the fact that it accumulates in the lung and liver, attenuation in the CT of these tissues may increase in patients receiving this drug. The chest CT manifestation of amiodarone toxicity is characteristically one or multiple focal areas of lung opacifications. These infiltrates are higher attenuation than nearby muscle in unenhanced CT (Fig. 28 on page 37).

Although probably a marker of exposure to the drug, increased hepatic attenuation or pulmonary consolidations suggest amiodarone pulmonary toxicity in the correct clinical context.

Images for this section:
Fig. 1: PULMONARY ARTERIOVENOUS MALFORMATION. A subpleural PAVM shows the feeding artery and draining vein in axial and coronal reconstructions (arrows). This appearance is typical of PAVMs.
Fig. 2: PULMONARY SEQUESTRATION. Persistent consolidation in a 20-years-old man with a history of recurrent right lower lobe pneumonia.
Fig. 3: PULMONARY SEQUESTRATION. CT shows a opacification with multiple small cysts with air-fluid levels in the right lower lobe. Reconstruction: An artery is seen arising from the aorta, supplying the sequestration.
**Fig. 4:** PULMONARY SEQUESTRATION. Axial and coronal CT images confirm the presence of multiple small cysts with air-fluids levels. A systemic arterial supply to the mass.
Fig. 5: PULMONARY SEQUESTRATION. Persistent infiltrate in the left lower lobe.
Fig. 6: PULMONARY SEQUESTRATION. Axial and coronal CT images demonstrate a large artery extending from the descending aorta into the left lower lobe infiltrate (arrow).
Fig. 7: TYPE I CCAM. Infiltrate in the right upper lobe with the presence of multiple cysts with air-fluid levels (arrow).
**Fig. 8:** TYPE I CCAM. After treatment, we can see the resolution of the consolidation. Cystic images persist. The affected right upper lobe is expanded.
Fig. 9: TYPE I CCAM. Axial CT images demonstrate a confluent area of opacification with multiple air-fluid levels and multiple faint cysts clustered in the right upper and medium lobes. The affected lobes are expanded.
Fig. 10: CALCIFIED GRANULOMAS. Several examples.
**Fig. 11:** AIR-CRESCEnt SIGN. Infiltrate in the right upper lobe that demonstrates a small crescent of air within it (arrows). Invasive mucormicosis.
Fig. 12: AIR-CRESSENT SIGN OF INVASIVE FUNGAL INFECTION. In November study, we see pulmonary multiple nodules. They show cavitation in January control.
Fig. 13: ANGIOINVASIVE ASPERGILLOSIS. Pulmonary infiltrates and nodules that present air-crescent sign.
Fig. 14: INTRACAVITARY MYCETOMA. A round mass partially filling a cavity. Axial prone CT image shows that intracavitary mass is mobile.
Fig. 15: CHEST WALL INVASION BY PNEUMONIA. MUCORMYCOSIS. CT images show a infiltrate that extends from the right upper lobe into the chest wall, indicating infiltrative spread of disease from the lung to the chest wall o vice versa.
**Fig. 16:** PULMONARY HAMARTOMA. Those cases with calcifications resembling popcorn can be confidently diagnosed as representing a hamartoma.
**Fig. 17:** PULMONARY HAMARTOMA. Nódule in the left lower lobe that contains areas of mature fat. The presence of mature fat strongly suggests the diagnosis of a pulmonary hamartoma.
Fig. 18: PULMONARY HAMARTOMA. A mass that contains areas of mature fat (8 or more voxels of between -40 and -120 HU), and calcifications resembling popcorn.
Fig. 19: RADIATION FIBROSIS. Because radiation is confined by portals, the radiation damage is nearly always delimited by the boundaries of the portals on both chest radiographs and chest CT. Mediastinal lymphoma.
**Fig. 20:** RADIATION FIBROSIS. The appearance of nonanatomic boundaries between normal and abnormal lung is the critical element to diagnosing radiation pneumonitis and fibrosis. See the minor fissure (arrow).
Fig. 21: RADIATION FIBROSIS. PA chest radiograph and axial CT demonstrate an area of consolidation with bronchiectasis, volume loss and distortion of surrounding structures. Note the well-defined, nonanatomic border of the area of consolidation.
**Fig. 22:** ROUNDED ATELECTASIS. PA and lateral chest radiographs demonstrate a loculated right pleural effusion. There are multiple transpulmonary bands that are a manifestation of pleural fibrosis. There is also an oval mass in the right lower lobe, that given its subpleural location and the presence of pleural thickening, the possibility of rounded atelectasis should be considered.
**Fig. 23:** ROUNDED ATELECTASIS. Oval mass adjacent to the pleura, with angles acute to the pleural images, indicating its intrapulmonary localisation (short arrow). The vessels and bronchia curving towards the center of the mass: "comet tail" sign (large arrows). Note the enhance following administration of intravenous contrast, like most atelectasis.
**Fig. 24:** ROUNDED ATELECTASIS. The vessels and bronchia are curving towards the center of the mass: "comet tail" sign. Mass enhance following administration of intravenous contrast(*).
**Fig. 25:** EXOGENUS LIPOID PNEUMONIA. A focal area of consolidation in the left lower lobe of the lung. In the majority of the cases, CT imaging will demonstrate internal areas of low attenuation (-50/-100 UH) consistent with lipid.
Fig. 26: AMIODARONE LUNG TOXICITY. Axial CT demonstrates multiple peripheral consolidations that look like the consolidations observed in hypersensitivity pneumonitis. Ground-glass opacities and reticulation also are present.
Fig. 27: AMIODARONE LUNG TOXICITY. Axial CT images demonstrate a diffuse interstitial abnormality characterized by nonspecific reticulation and ground-glass opacities: "crazy-paving" pattern.
Fig. 28: AMIODARONE LUNG TOXICITY.. Axial CT images show infiltrates, ground-glass opacities and septal reticulation. High-attenuation infiltrates in the lower lobes (arrows).
Conclusion

Knowledge of the image findings that lead to a single diagnosis or reduce differential diagnosis is essential for diminishing the number of complementary tests needed and the risk of complications involved therein.

References


Personal Information