Imaging and differential diagnosis of chronic lung consolidation

Poster No.: C-0767
Congress: ECR 2010
Type: Educational Exhibit
Topic: Chest
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Keywords: lung consolidation, chronic lung diseases, CT
DOI: 10.1594/ecr2010/C-0767

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Learning objectives

To review the conditions leading to subacute or chronic lung consolidation and the key radiological findings for correct diagnosis and management.

The different diseases are reviewed individually stressing the radiological signs that may lead to a correct diagnosis.

Background

Lung consolidation is a very commonly encountered abnormality on chest radiology and can be secondary to multiple causes, rendering this sign highly nonspecific.

Nevertheless, the wide range of differential diagnosis can be shortened if one takes into consideration if the consolidation is acute or chronic, viewed in conjunction with not only the radiological appearance but with the patient's clinical situation.

Definitions

Before proceeding with a more detailed analysis of the conditions that may appear as chronic lung consolidation is important to settle what we consider consolidation and how long it takes to become chronic.

For the first definition, the one dealing with the concept of lung consolidation, the answer comes from the Fleischner Society glossary of thoracic imaging terms. The definition provided for lung consolidation is:

"Consolidation appears as a homogeneous increase in pulmonary parenchymal attenuation that obscures the margins of vessels and airway walls. An air bronchogram may be present. The attenuation characteristics of consolidated lung are only rarely helpful in differential diagnosis."

This term should not be mistaken for the less specific term "parenchymal opacification", also included in the Fleischner Society glossary as an increased density area that may or may not obscure the definition of the vessels and airway walls. So this term includes both
lung consolidation (no vessels or airway walls visualization) and ground glass opacity (visualization of vessels and airway walls).

![Image of normal lung with ground glass opacity and lung consolidation]

**Fig.:** Normal lung. Ground glass opacity and lung consolidation

**References:** O. Persiva Morenza; Department of Radiology, Vall d'Hebron, Barcelona, SPAIN

This presentation will discuss conditions where lung consolidation is the prominent characteristic, keeping in mind that in some occasions lung consolidation will come along with some other signs, including ground glass opacities.

The definition of **chronicity** is far trickier than the definition of lung consolidation. No Fleischner Society glossary help and little consensus or vague definitions in the radiological literature with a span of time ranging from weeks to months.

In this poster a lung consolidation will be considered chronic or persistent if it lasts for more than a month since first diagnosed and correctly treated.

**Management of lung consolidation**
Whenever lung consolidation is considered by any radiologist the first differential that comes to mind is the consolidation in an acute setting, by large the most frequent in general practice.

In these cases, chest x-ray (CXR) continues to be the most important tool for the correct management of these patients. Not only CXR will be the first diagnostic test but a perfectly suitable and cost-efficient examination to monitor the evolution and the treatment response. Needless to say, follow-up CXR must be performed in any patient with lung consolidation to document total clearing.

Pulmonary edema and hemorrhage will show consolidation areas in CXR rapidly resolving in days or even hours. Whereas lung contusion or pneumonia may take longer to resolve, ranging from weeks to months. This evolution may be securely assessed with CXR alone with no other radiological examinations needed.

The existence of a persistent consolidation, not resolving or reducing in size in CXR, or consolidation in a patient with chronic symptomatology brings forward a completely different differential, including some conditions that may benefit a CT examination in order to narrow the list of diagnostic possibilities.

Non-enhanced CT is usually performed in our institution to evaluate this set of patients, even though contrast enhanced examinations may be performed if a neoplastic condition is suspected clinically or after the evaluation of the non-enhanced images.

CT examination is helpful as it can further delineate the distribution and extent of disease, provide clues to narrow the differential diagnosis and aid in guidance for invasive diagnostic procedures, such as bronchoscopy or surgical biopsy.

Another point of prime importance is the evaluation of the case with every single previous examination available. The chronological evolution of the consolidation areas may become very important in some conditions as will be shown later and may render unnecessary new examinations.

As long as the list of pathological entities showing persistent consolidations include some rare conditions the general radiologist may be not very acquainted with, we have considered interesting to make a brief review of them stressing the radiological key facts that may lead, in some occasions only, to the correct diagnosis.
Given the heterogenous bunch of entities considered, the different conditions will be grouped regarding its infectious, inflammatory, neoplastic or treatment related origin.

**Imaging findings OR Procedure details**

**INFECTIOUS**

**Pulmonary aspergillosis**

Aspergillosis is a mycotic disease caused by *Aspergillus* species, usually *A fumigatus*, *A flavus* and *A niger*, the three most frequent species reported as causative agents of opportunistic infections in man.

The manifestations of pulmonary aspergillosis highly depend on the patient's immune condition and the virulence of the organism. Five categories of pulmonary aspergillosis have been classically described:

1. Saprophytic aspergillosis (aspergilloma)
2. Allergic bronchopulmonary aspergillosis
3. Semi-invasive or chronic necrotizing aspergillosis
4. Airway-invasive aspergillosis
5. Angioinvasive aspergillosis

Only two of these presentation forms typically show chronic lung consolidation as a prominent and characteristic sign: Semi-invasive or chronic necrotizing aspergillosis and Angioinvasive aspergillosis.

**Semi-invasive or chronic necrotizing aspergillosis**

This form of pulmonary aspergillosis is usually seen in patients with chronic debilitating illness, COPD, malnutrition, alcoholism, diabetes mellitus and immunosuppression.

Chronic cough, constitutional symptoms and mild fever are the most frequent symptoms. All of them are nonspecific and may last for weeks or months. Hemoptysis has been described in 15% of patients.
Radiologic manifestations include segmental areas of consolidation that may be bilateral. Cavitation and pleural thickening may be present. Multiple nodular areas may appear in association with consolidation zones.

![Radiologic images of chronic lung consolidation](image)

**Fig.**: Evolution of chronic lung consolidation in the right lung in patient with alcoholism and malnutrition history. Semi-invasive aspergillosis

**References:** O. Persiva Morenza; Department of Radiology, Vall d'Hebron, Barcelona, SPAIN

Final diagnosis requires microbiologic demonstration of *Aspergillus* infection and presence of tissue necrosis and granulomatous inflammation similar to that seen in tuberculosis at histologic analysis.

**Angioinvasive aspergillosis**

Angioinvasive aspergillosis is almost exclusively seen in immunocompromised patients with severe neutropenia, oncologic patients under chemotherapy and after allogenic bone marrow transplantation. The level of neutropenia is not necessarily related to the total...
count of neutrophils because high-dose steroid therapy may interfere with the neutrophils function in a patient with a normal blood count.

Symptoms are similar to those of the chronic form and therefore nonspecific, so a high index of suspicion is needed for early diagnosis and to reduce the high mortality rate.

The radiological findings at CT are nodules of variable size surrounded by ground-glass attenuation ("halo sign") and areas of pleura based wedge-shaped consolidation.

The "halo sign" is described as a zone of ground-glass attenuation surrounding a solid nodule or mass. The explanation for this appearance is found at the pathologic examination, the solid part represents areas of infarction and the surrounding ground-glass rim results from alveolar hemorrhage. The presence of the "halo sign" is relatively high in the early stages of the disease but becomes progressively less frequent with time.

**Fig.:** "Halo sign" (top left image) in a patient with bilateral peripheral lung consolidations and bone marrow transplantation history. Angioinvasive aspergillosis

**References:** O. Persiva Morenza; Department of Radiology, Vall d'Hebron, Barcelona, SPAIN

Even though this sign is not pathognomonic for aspergillosis infection (it has been described only occasionally in eosinophilic pneumonia, organizing pneumonia, MAC infection, some other fungal and viral pneumonia, Kaposi sarcoma, hemorrhagic metastases and Wegener granulomatosis) is highly suggestive of invasive aspergillosis in a patient with neutropenia and fever.

The peripheral consolidation represents the existence of areas of hemorrhagic infarction secondary to obstruction of distal lung vessels due to aspergillus invasion.
Fig.: Bilateral lung nodules and consolidations with associated GGO in a patient with bone marrow transplantation. Images on the right show good evolution after treatment. Angioinvasive aspergillosis

References: O. Persiva Morenza; Department of Radiology, Vall d'Hebron, Barcelona, SPAIN

Another radiological sign usually seen during convalescence period (2-3 weeks after initiation of treatment, and therefore of little significance in early diagnosis) is the air crescent sign produced by separation of fragments of necrotic lung from adjacent lung parenchyma resulting in an crescent air image similar to that of mycetomas.
Histologic confirmation is not usually needed. Typical radiological pattern in a neutropenic patient with fever is considered enough to initiate anti-fungal therapy.

**INFLAMMATORY**

**Cryptogenic organizing pneumonia**

Cryptogenic organizing pneumonia (COP) is now considered the preferred term, also in the US, for the idiopathic bronchiolitis obliterans organizing pneumonia. Most cases are idiopathic as the term cryptogenic suggests but a COP-like reaction may also be seen in organizing pneumonia due to infection, drug reaction, collagen vascular disease and Wegener granulomatosis.

Symptoms are usually subacute with respiratory symptomatology including cough, progressive dyspnea, mild fever, sputum production and constitutional symptoms.

The main radiographic finding of COP is patchy consolidation with or without air bronchogram (80% of cases) and ground-glass opacities (up to 60% of cases) along with nodular and linear opacities. The distribution of these abnormalities is typically peripheral and perilobular although a mass-like form has also been described.
This radiological appearance is, by no means, pathognomonic and is present in other conditions to be reviewed in this presentation as chronic eosinophilic pneumonia, sarcoidosis and lymphoma.

Fortunately, there are two radiologic characteristics that may be extremely helpful to get the correct diagnosis: the migrating nature of the consolidations and the "reverse halo" sign.

Serial radiographs or CT examinations may show a migratory nature of the consolidations that may completely disappear in one zone only to reappear in the next follow-up imaging in another location in the same or contralateral lung. Obviously, the availability of previous examinations proves to be of paramount importance in this particular diagnosis. Nevertheless, it should not be forgotten that wandering consolidations have also been described in conditions as eosinophilic lung diseases, psittacosis and foreign body aspiration. Anyway, in a correct clinical setting is a very helpful sign to differentiate COP from the rest of entities discussed in this poster.

**Fig.**: Migrating lung consolidations in a patient with subacute respiratory symptoms and mild chronic fever. Cryptogenic organizing pneumonia

**References:** O. Persiva Morenza; Department of Radiology, Vall d'Hebron, Barcelona, SPAIN
The "reverse halo" sign is an even more powerful sign for the diagnosis of COP. It is defined as central ground-glass opacity surrounded by denser consolidation of crescentic (forming more than 75% of a circle) or complete ring shape of at least 2 mm in thickness.

The main drawback with this sign is the low frequency of appearance, being estimated in 15-20% of cases.

Although it was once considered almost pathognomonic for COP it has been described to date in pulmonary zygomycosis, paracoccidiomycosis, tuberculosis, lymphomatoid granulomatosis and Wegener’s granulomatosis. Anyway, these reports are anecdotal and the sign continues to be specific enough and very useful if COP is suspected.
**Fig.**: Migrating consolidations in a patient with cryptogenic organizing pneumonia. Notice reverse halo sign at the upper left image

**References:** O. Persiva Morenza; Department of Radiology, Vall d'Hebron, Barcelona, SPAIN
Fig.: Close-up image of the reverse halo sign in a patient with cryptogenic organizing pneumonia

References: O. Persiva Morenza; Department of Radiology, Vall d'Hebron, Barcelona, SPAIN

Chronic eosinophilic pneumonia

Chronic eosinophilic pneumonia (CEP) is an idiopathic condition characterized by chronic infiltration of the lung with eosinophils. It is usually associated with an increased number of eosinophils in the circulating blood but it is not an absolute requirement. Peripheral blood
eosinophilia, if present, is usually mild or moderate but occasionally is severe. Increased serum IgE levels are seen in two-thirds of patients. The erythrocyte sedimentation rate is usually elevated. The percentage of eosinophils in the BAL fluid is very high.

There is a female preponderance in CEP, with a peak incidence in the 5th decade; the onset is insidious with weight loss, cough, and dyspnea. The association with asthma reaches 50% of cases.

In more than 50% of cases, the chest radiograph shows non-segmental air-space consolidation confined to the outer third of the lung, the "photographic negative of pulmonary edema". This characteristic appearance is more easily depicted on CT images where virtually every patient showed bilateral consolidations and up to 85% of them proved to be peripheral. This pattern, when associated with blood eosinophilia, is characteristic enough to allow a confident diagnosis. It has been described migratory consolidations also in this condition, similar to those of COP so differential diagnosis when blood eosinophilia is not present may be tricky and require lung biopsy to assess the presence of eosinophilic infiltration of the lungs.

Less common findings include ground-glass opacities, nodules, and reticulation. These less common findings predominate in the later stages of CEP. CT performed more than 2 months after the onset of symptoms shows linear band-like opacities parallel to the pleural surface. Pleural effusion is observed in less than 10% of cases.

**Fig.**: Non-segmental peripheral consolidations in both lung. Notice "pulmonary edema negative" on CXR. No GGO associated. Patient with blood eosinophilia. Chronic eosinophilic pneumonia

**References**: O. Persiva Morenza; Department of Radiology, Vall d'Hebron, Barcelona, SPAIN
Churg-Strauss syndrome, another of the eosinophilic lung diseases, may also present homogeneous peripheral lung consolidation with a chronic course but in Churg-Strauss syndrome consolidation has a tendency toward lobular distribution (non-segmental in CEP) and is often associated with centrilobular nodules within the ground-glass opacities.

**Sarcoidosis**

Sarcoidosis is a systemic disorder of unknown cause that is characterized by noncaseating granulomas with proliferation of epithelioid cells.

Young and middle-aged patients are more commonly affected with a slightly higher prevalence in women. There is a well-known racial and geographic distribution with African-Americans and Scandinavians presenting the highest prevalence.

Clinical symptoms are, once again, nonspecific and include constitutional symptoms and, in a minority of cases, mild fever. The clinical course is very variable with a tendency to wax and wane, though this course correlates with the mode of onset and the extent of the disease. So, patients with acute onset with erythema nodosum or bilateral hilar lymphadenopathy usually portends a self-limiting course with spontaneous resolution, whereas insidious onset, especially with parenchymal lung involvement may be followed by progressive fibrosis of the lung.

Thoracic involvement is reported in 90% of patients and with mediastinal and bilateral hilar ganglionar involvement as the most frequent manifestation, followed by parenchymal anomalies. Five radiological stages are described:

Stage 0 - Normal chest radiograph
Stage 1 - Lymphadenopathy only
Stage 2 - Lymphadenopathy with parenchymal infiltration
Stage 3 - Parenchymal disease only
Stage 4 - Pulmonary fibrosis

The parenchymal disease may be clearly depicted with HRCT showing small nodules in a perivascular distribution and with irregular thickening of bronchovascular bundles and septa with a upper lobes predominance.
Fig.: Typical lung parenchyma involvement by sarcoidosis. Micronodular pattern with perilymphatic distribution

References: O. Persiva Morenza; Department of Radiology, Vall d'Hebron, Barcelona, SPAIN

This is the commonest presentation, but many atypical variants have been described including forms mimicking lymphoproliferative disorders with no upper lobes predominance and patients with coalescing granulomas that may appear as irregular areas of high attenuation that may contain air bronchogram. True alveolar consolidation and ground-glass opacities may also be found in this condition but more probably reflects inflammatory lesions that will clear or reduce in follow-up studies. It has been suggested that patients with predominant ground-glass opacity and consolidation patterns seen on the initial CT scan had a worse prognosis and were susceptible to developing severe respiratory insufficiency.
**Fig.**: Bilateral consolidation in patient with calcified hilar and mediastinal lymph nodes. Silicosis

**References:** O. Persiva Morenza; Department of Radiology, Vall d'Hebron, Barcelona, SPAIN

The combination of bilateral hilar and right paratracheal lymph node enlargement is a characteristic and common manifestation. Calcification of these lymph nodes is also characteristic, specially when it resembles the egg-shell calcification pattern also described in silicosis.
Fig.: Symmetric hilar, subcarinal and paratracheal lymph node enlargement with peripheral (egg-shell) calcification. Sarcoidosis

References: O. Persiva Morenza; Department of Radiology, Vall d'Hebron, Barcelona, SPAIN

Despite this wide range of possible appearances, the simultaneous presence of small nodules with a perivascular or subpleural distribution and symmetric hilar and mediastinal ganglionar involvement can raise suspicion for sarcoidosis.

Cystic formation with honeycomb pattern and distortion of the lung parenchyma, which represent irreversible findings, are seen in patients with long-standing sarcoidosis.

Wegener’s granulomatosis

Wegener's granulomatosis is a multisystemic necrotizing vasculitis that most commonly occurs in whites and affects men and women equally. The mean age at diagnosis is 40 years, but the disease can develop at any age.

Patients may present with respiratory signs and symptoms, including cough, hemoptysis, and dyspnea. Elevation of serum c-ANCA titers frequently occurs in patients with Wegener's granulomatosis and can be used to assess disease activity.

Even though the presence of nodules and masses are the most common manifestation in this condition (40-70% of patients), lung consolidation along with area of ground-glass opacities have also been described in up to one third of the patients. This areas of consolidation are usually related with hemorrhagic lesions or may be secondary to lung infarcts or organizing pneumonia. When consolidation is present in isolation may be initially misdiagnosed as pneumonia and Wegener’s granulomatosis is only considered when consolidation persist despite proper treatment.

Alveolar proteinosis

Pulmonary alveolar proteinosis is a rare disease characterized by abnormal intraalveolar accumulation of surfactant-like material. Idiopathic form accounts for more than 90% of cases with an incidence of 0.36 new cases per million per year. Congenital and secondary to industrial exposure forms are exceedingly rare.
Symptomatology includes moderate respiratory involvement with cough and progressive dyspnea. Mean age at diagnosis is about 40 years with a strong association with smoking habit (up to 75% of patients are smokers).

CXR usually reveals bilateral central and symmetric opacifications with relative sparing of apices and costophrenic angles. Opacities range from a ground-glass appearance to distinctive consolidation with air bronchograms. A striking fact is the notable clinicoradiologic discrepancy in these patients with mild symptoms and an eye-catching imaging. Abnormalities at chest radiography might persist or evanesce over months or years.

The CT appearance of "crazy-paving", defined as a network of smoothly thickened septal lines superimposed on areas of ground-glass opacity, was first described in this condition and is highly suggestive for the diagnosis, being present in 75% of the patients. These areas are typically widespread and bilateral, often with sharply margined areas of geographic or lobular sparing. Areas of clear consolidation are not always present and usually appear in association with ground-glass opacities in up to 45% of the cases. Extent and degree of CT ground-glass opacity or consolidation appear to correlate directly with severity of compromised pulmonary functional parameters.

Fig.: Irregular consolidation areas in both lung on CXR. CT images show the typical "crazy-paving" pattern. Alveolar proteinosis

References: O. Persiva Morenza; Department of Radiology, Vall d'Hebron, Barcelona, SPAIN

Although the CT finding of crazy-paving is highly characteristic of alveolar proteinosis, it is also been described in several conditions including left heart failure, pneumocystis pneumonia, alveolar hemorrhage, bronchoalveolar carcinoma, lymphangitic carcinomatosis, adult respiratory distress syndrome, radiation- or drug-
induced pneumonitis, lipoid pneumonia, hypersensitivity pneumonitis, and pulmonary veno-occlusive disease.

**Lipoid pneumonia**

Lipoid pneumonia results from accumulation of lipids in the alveoli and can be either exogenous or endogenous, based on the source of the lipids. Exogenous lipoid pneumonia is caused by inhalation or aspiration of animal fat or vegetable or mineral oil. Endogenous lipoid pneumonia is usually associated with bronchial obstruction.

The acute form is very uncommon and is caused by an episode of aspiration of a large quantity of a petroleum-based product, typically occurring in children due to accidental poisoning, but also seen in fire-eaters who use liquid hydrocarbons for flame blowing.

Chronic exogenous lipoid pneumonia results from repeated episodes of aspiration or inhalation of oils over an extended lapse of time. It typically occurs in older patients, but has been reported in children with a predisposition to aspiration and in patients without swallowing impairment but with a history of chronic use of mineral oil lubricants and decongestants such as Vaseline, Vicks VapoRub, lip gloss and laxatives, specially in young patients with alimentary disorders such as anorexia nervosa or bulimia. It has also been described after occupational exposition.

Acute form is usually asymptomatic whereas chronic lipoid pneumonia may present with cough, dyspnea, fever, and weight loss.

The radiological appearance is very distinctive with ground-glass opacities or consolidations with a peribronchovascular distribution and predominant involvement of the lower lobes. CT can reveal areas of fat attenuation as low as -30 HU within the consolidations, a finding diagnostic of lipoid pneumonia.
Fig.: Persistent consolidation in a young woman with mild fever and history of anorexia-bulimia. Notice fat-attenuation consolidation in both lungs. Clinical history disclosed use of oily laxatives. Exogenous lipoid pneumonia

References: O. Persiva Morenza; Department of Radiology, Vall d'Hebron, Barcelona, SPAIN

Resolution of opacities is variable in acute forms and usually occurs within 2 weeks to 8 months. On the other hand, architectural distortion associated with persistent consolidations has been reported in chronic lipid pneumonia. Thickening of interlobular septa or fibrosis in the adjacent parenchyma can occur in the later stages due to the transportation of oils from the alveoli into the lung interstitium. Crazy-paving pattern with a basilar predominance and single or multiple nodules that may or may not contain fat have also been described. The diagnosis of these nodules may be challenging because its radiological appearance and an increased $^{18}$F-FDG on PET scans make them indistinguishable from lung cancer.

Endogenous lipid pneumonia is an obstructive pneumonitis with a histopathologic diagnosis made on the basis of its appearance due to the accumulation of lipid in the alveoli. Radiologically it is presented with thickened septa and ground-glass opacities distal to the obstruction but without the characteristic low attenuation consolidations of the exogenous form.
Bronchioloalveolar carcinoma

Bronchioloalveolar carcinoma (BAC) represents 1.5%-6.5% of all primary pulmonary neoplasms. Most patients are middle-aged (40-70) and as with other adenocarcinomas it presents a relatively high prevalence in women (30-50%). Only one third of the patients with BAC were heavy smokers.

The localized form of BAC is usually asymptomatic and even disseminated forms may persist asymptomatic or with mild and nonspecific symptoms as cough, shortness of breath or weight loss. Hemoptysis is seen in 10% of the patients.

From a histologic point of view BAC is an adenocarcinoma with tendency to spread using the lung structure as a stroma (lepidic growth) with preservation of the underlying pulmonary architecture. Lymphogenous or hematogenous dissemination occurs in 50% of cases.

Two main cytologic forms are considered: mucinous, more likely to be multicentric and with a worse prognosis and nonmucinous, usually localized and with a good prognosis.

BAC manifests radiologically in three different ways:

- Solitary nodule (45%)
- Consolidation (30%)
- Multiple nodules (25%)

Our discussion will be centered in the BAC appearing as a area of consolidation. The consolidative form of BAC accounts for approximately 30% of all BAC tumors and corresponds to a mucinous histological subtype. In this subtype there is filling of alveolar spaces by mucus, resulting in gelatinous consolidation in the lung parenchyma. The preservation of lung architecture and the alveolar occupation by mucus of the alveoli are responsible for two classical radiological signs: the "leafless tree" sign and the angiogram sign.
The "leafless tree" sign describes the appearance of air-filled bronchi within a pulmonary consolidation. The bronchi are stretched and the branching is sparse as seen in a leafless tree. This appearance reflects the pattern of growth, as the tumor seldom obliterates the original architecture of the lung. As tumor fills the alveolar spaces and infiltrates the alveolar septa and bronchial walls, the bronchus becomes narrowed, stretched and rigid.

**Fig.**: Leafless tree sign. Stretched bronchus with sparse branching more evident in sagital view. Bronchioloalveolar carcinoma

**References:** O. Persiva Morenza; Department of Radiology, Vall d'Hebron, Barcelona, SPAIN

The angiogram sign is caused by the homogeneous low attenuation of the consolidation due to the presence of copious amounts of mucin. This lower attenuation allows vessels to be clearly seen even in non-enhanced CT. Obviously, the angiogram sign is not useful after intravenous contrast administration because vessels will always have higher attenuation regardless of the high or low attenuation of the consolidation.

These signs were once regarded as specific for neoplastic infiltration of the lung but time has proved them not very reliable as they can also be seen in many other diseases including: lymphoma, lipoid pneumonia, pulmonary infarction, pulmonary edema, amyloidosis...

CT findings include a combination of ground-glass opacities, consolidation, nodules, centrilobular nodules, peripheral distribution and air bronchograms. The combination of
consolidation, nodules (with centrilobular nodules) and remote areas of ground-glass attenuation are characteristic of diffuse BAC.

**Fig.**: Nodules and consolidations with a minimal area of GGO of predominantly peripheral distribution. Bottom row shows partial remission after chemotherapy. Bronchioloalveolar carcinoma

**References**: O. Persiva Morenza; Department of Radiology, Vall d'Hebron, Barcelona, SPAIN
**Fig.** Right basal non-segmental consolidation with bilateral nodules. Bottom row shows progression of the disease despite treatment. Bronchioloalveolar carcinoma

**References:** O. Persiva Morenza; Department of Radiology, Vall d'Hebron, Barcelona, SPAIN

The parenchymal consolidation may be segmental or may involve an entire lobe or lung and may mimic diffuse pneumonia. This form of presentation has a poorer prognosis than the solitary nodular form.
Fig.: Bilateral non-segmental lung consolidations with GGO areas with progression on follow-up CT. Bronchioloalveolar carcinoma

References: O. Persiva Morenza; Department of Radiology, Vall d'Hebron, Barcelona, SPAIN

Cavitation and "crazy-paving" have been described in BAC but it is not a common finding.

In summary, the presence of persistent consolidation with one of the previously described signs and the combination of diffuse nodules and consolidation should alert the radiologist to the diagnosis of BAC.

**Pulmonary lymphoma**

Lymphoma involves the lung more frequently in secondary or recurrent disease than as a primary manifestation, particularly in Hodgkin disease.

**Primary non-Hodgkin’s pulmonary lymphomas** are rare extranodal lymphomas (less than 1% of all lymphomas) that are usually low-grade B-cell types that originate from the mucosa-associated lymphoid tissue.

Primary pulmonary lymphoma is diagnosed only under the following criteria:

Lung, bronchus or both are involved
No mediastinal ganglionar involvement

No evidence of extrathoracic lymphoma or leukemia at the time of diagnosis or previously diagnosed.

No evidence of disease outside the thorax for at least 3 months after diagnosis

The most common radiologic appearance of primary non-Hodgkin's lymphoma of the lung is an area of opacification with poorly defined margins and an air bronchogram. Less common radiographic patterns of primary lymphoma of the lung include nodules, diffuse bilateral air space consolidation, and segmental or lobar atelectasis. Pleural involvement is rare.

Pseudolymphoma, a benign inflammatory lymphocytic infiltrate that can be diagnosed accurately by immunochemical staining, shows a similar appearance but with smaller and ill-defined nodules peripherally located.

Many pathologic and imaging similarities exist between primary pulmonary lymphoma and bronchioloalveolar carcinoma. Both disorders begin as a small peripheral nodule or an area of lung consolidation. Many of the lesions grow slowly, showing little change for months or even years. Characteristic of both entities is the tendency to maintain bronchial integrity despite spread of the neoplasm throughout the alveoli and the interstitium of the lung. So, differentiation of both entities may result extremely challenging and sometimes impossible by radiological means alone.
**Fig.**: Middle lobe consolidation progressing despite treatment. Pleural effusion and cavitation on the last CT images. Primary lung lymphoma

**References**: O. Persiva Morenza; Department of Radiology, Vall d'Hebron, Barcelona, SPAIN

**Fig.**: Small nodular areas of consolidation in LUL and RUL. Notice subtle air bronchogram within RUL lesion. Primary lung lymphoma

**References**: O. Persiva Morenza; Department of Radiology, Vall d'Hebron, Barcelona, SPAIN

**Secondary pulmonary lymphoma** is seen at initial presentation in 12% of patients with Hodgkin's disease and 4% of patients with non-Hodgkin's lymphoma, but may appear in any stage of the disease up to a 40% of the patients with Hodgkin's disease, being less frequent in non-Hodgkin's lymphoma.

Recurrent or secondary pulmonary involvement may result from direct mediastinal node extension, from lymphatic or hematogenous dissemination from distant sites, or from parenchymal lymphoid foci, which develop as spontaneous disease.

Various patterns are described on CXR: bronchovascular or lymphangitic with thickening of bronchovascular bundles and interlobular septa (41%), pulmonary nodules (39%), pulmonary consolidation (14%), and hematogenous or miliary with disseminated micronodules (6%).
On CT images masses and mass-like areas of consolidation are the most frequent finding along with peribronchovascular nodules and opacities. Significant ganglionar involvement and pleural effusion are also commonly seen.

It is important to keep in mind that patients with AIDS and organ transplant recipients, due to its immunosuppression show a higher prevalence of pulmonary lymphoma, rendering this diagnosis more likely in this subgroup of patients.

**TREATMENT RELATED DISEASES**

**Radiation pneumonitis**

Lung injury is commonly found after therapeutic irradiation of lung and chest wall malignancies, mainly breast cancer.

The acute phase of radiation pneumonitis manifests radiologically as ground-glass opacities and consolidation in the irradiated area. Nodules and focal consolidation within the treatment port have also been reported. Although radiation pneumonitis usually occurs within the irradiated lung, radiation pneumonitis outside the treatment area may also appear. Occasionally, an ipsilateral pleural effusion, often associated with atelectasis of the lung, develops at the time of radiation pneumonitis.

The radiological abnormalities of radiation pneumonitis gradually resolve without sequelae when the injury to the lung is limited. In cases of more severe injury there is usually a progression to radiation fibrosis which manifests radiologically as a well-defined area of volume loss, linear scarring, persistent ares of consolidation, and traction bronchiectasis. A key radiological fact is that consolidation usually coalesces and typically has a relatively sharp border that conforms to the treatment zone rather than to anatomic boundaries. With the evolution of radiation fibrosis the demarcation between normal and fibrotic lung becomes more and more distinct.

Radiation pneumonitis morphology will depend on the radiation technique used. For example, the tangential-beam technique used in the treatment of breast carcinoma results in parenchymal increased attenuation confined to the anterolateral subpleural region of the lung, whereas mediastinal radiation techniques usually results in areas of increased density of paramediastinal location.
Fig.: RUL non-small cell carcinoma in a patient with previous left pneumonectomy. Radiation therapy is decided. Acute pneumonitis in the top row involving the irradiated area. Control CT show persistent consolidation with slight loss volume. Notice appearance of a focal area of opacification in RLL outside the area of irradiation (top right image, middle row) that disappears on July CT. Radiation pneumonitis

References: O. Persiva Morenza; Department of Radiology, Vall d'Hebron, Barcelona, SPAIN

The fibrotic related changes in association with the consolidation areas, along with the particular shape of the opacities and the antecedent of radiation therapy allow a confident diagnosis in most of cases.

Amiodarone lung toxicity

Amiodarone is an antiarrhythmic agent used for various types of both ventricular and atrial arrhythmias.
Pulmonary toxicity develops in around 6% of patients, presenting with subacute onset of dyspnea. The risk of lung toxicity is increased with a high cumulative dose (more than 400 milligrams per day), treatment duration longer than two months, increased age, and preexisting pulmonary disease. Anyway, lung toxicity remains unpredictable as some individuals were noted to develop pulmonary fibrosis after a week of treatment, while others did not develop it after years of continuous use.

CT images show diffuse interstitial thickening or, less commonly, subpleural consolidation reflecting areas of organizing pneumonia. One important characteristic of these consolidations derives from the chemical composition of amiodarone. Amiodarone is an iodine-containing compound; therefore, parenchymal lesions often show high attenuation, with a range from 80 to 175 H. Although this finding is helpful in suggesting amiodarone-induced pulmonary toxicity, it is not pathognomonic and may be present in other unusual diseases including metastatic pulmonary calcification occurring as the result of hyperparathyroidism from renal failure, pulmonary alveolar microlithiasis, talcosis, iodinated oil embolism, silicoproteinosis, and amyloidosis.

**Fig.**: Severe interstitial lung disease with minimal areas of high-density basal consolidation. Increased liver attenuation. Amiodarone toxicity
Increased attenuation in the liver, spleen, or both is also very common, being present in 90% of the patients. So, the combination of high attenuation within lung lesions and the liver and/or spleen is characteristic of amiodarone exposure.

Fig.: Irregular areas of GGO over both lung bases with focal area of high attenuation consolidation in LLL. Notice high attenuation of the liver parenchyma on a non-enhanced CT. Amiodarone toxicity

References: O. Persiva Morenza; Department of Radiology, Vall d'Hebron, Barcelona, SPAIN

Conclusion

The existence of a persistent lung consolidation opens a wide range of differential diagnosis that includes some rare conditions as alveolar proteinosis or lipoid pneumonia the general radiologist is not usually acquainted with. On the other hand,
bronchioloalveolar carcinoma, sarcoidosis or cryptogenic organizing pneumonia are relatively common diseases any radiologist should identify and correctly diagnose.

Some of the radiological signs and peculiar appearances presented in this poster and that this conditions usually show will help us, if not making a straightforward diagnosis, at least narrowing the differential and suggesting the next step for a correct diagnosis.

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**References**


