

CT of Focal Benign Lung Lesions

Diagnosis please!



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Objectives:

- 1) To learn the imaging features of several benign focal lung lesions whose diagnosis can be specifically made by CT.
- 2) By using a QUIZ format, the authors will illustrate various entities that have specific appearances on CT.

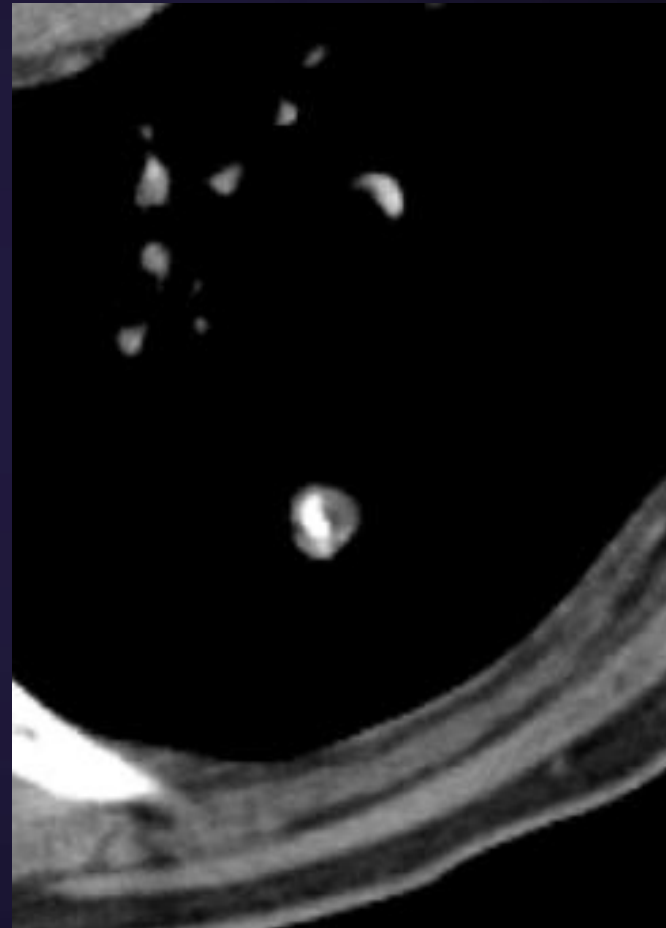
In the first “slide” of each case there is a short clinical summary and the relevant CT images.

In the subsequent slides the images are explained, followed by only the most important key ideas (we don't want to make a exhaustive review of each entity).

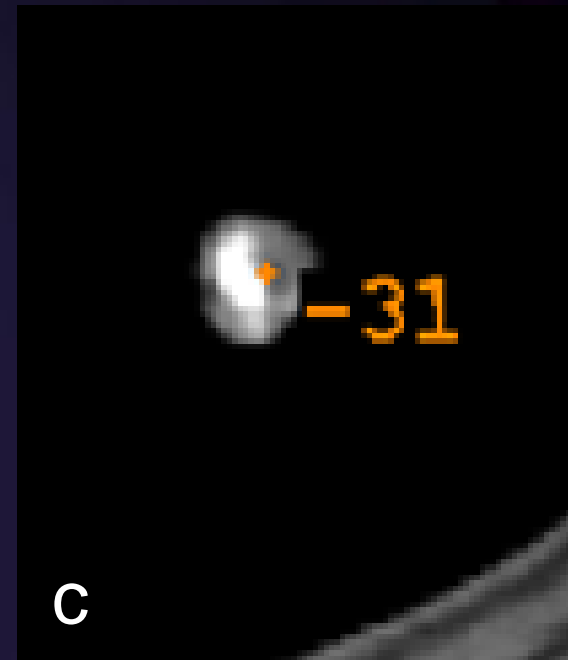
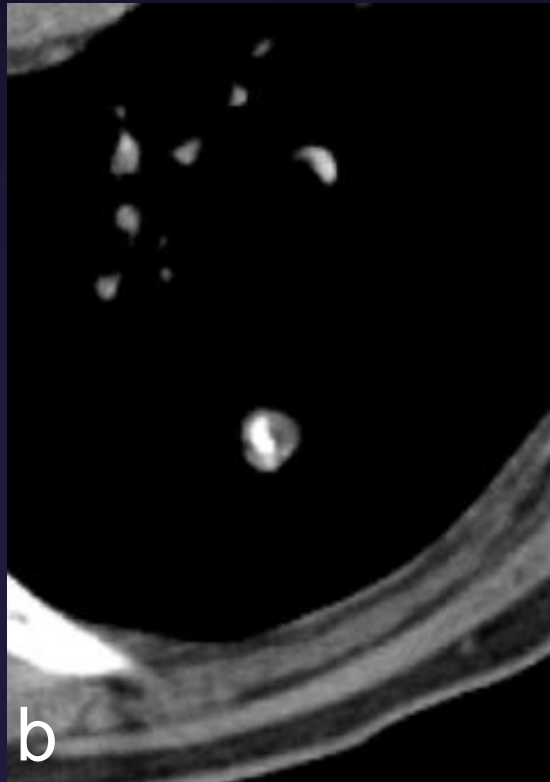
Good luck!

CASE Nº 1 – *Diagnosis please!*

45 year-old male with a solitary pulmonary nodule incidentally discovered in a routine chest x-ray, come to our institution to “rule out neoplasm”.



CASE N° 1 – *Hamartoma!*

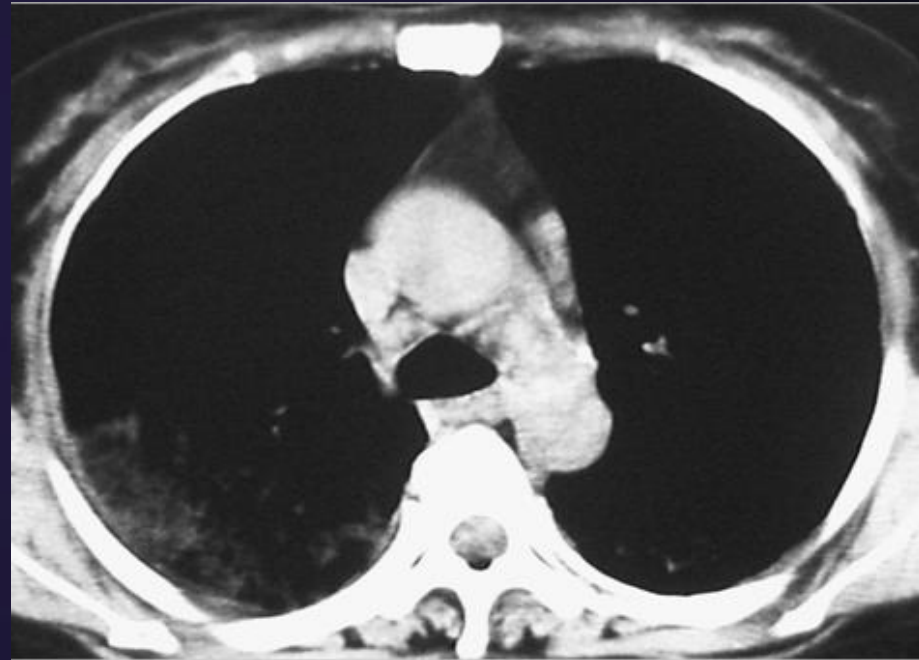
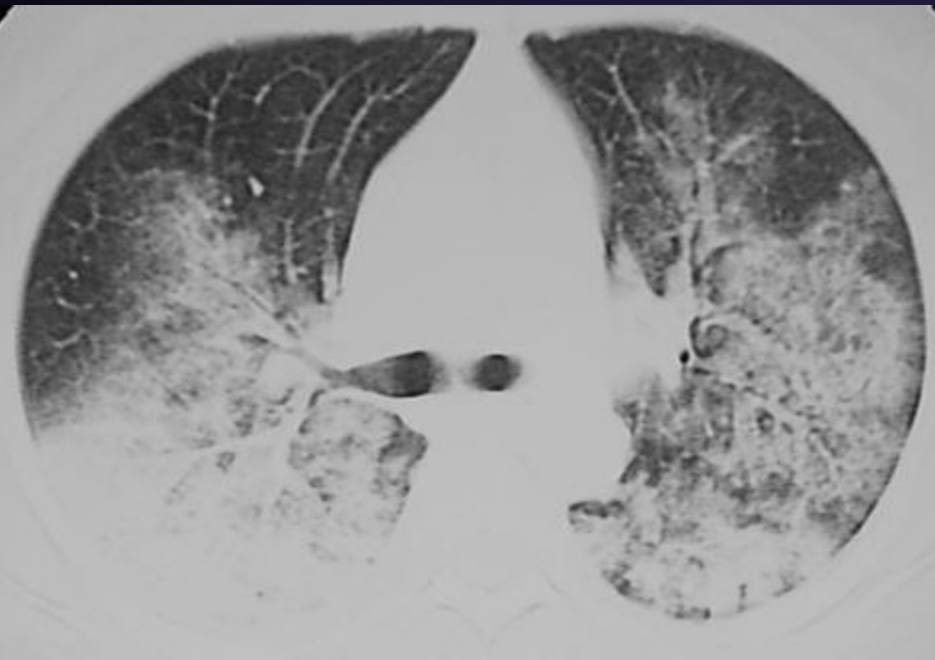


a) CT with a lung window shows a round and sharply nodule in the left lower lobe. b) and c) High-resolution CT with a soft tissue window shows that the nodule has a focal eccentric calcification. However, adjacent to the calcification there is a low attenuation area (-31 HU), consistent with accumulation of fat. **The combination of fat and calcium are diagnostic of hamartoma.**

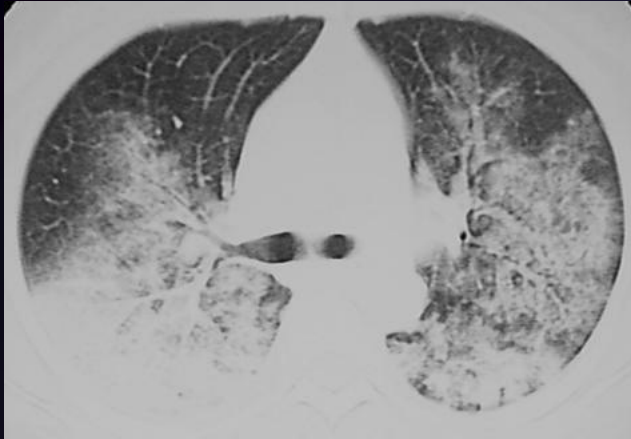
- > 85% of cases appear as a solitary pulmonary nodule.
- **Nearly 65% of hamartomas may be diagnosed using high-resolution CT because of visible fat, either focal or diffuse or a combination of fat and calcium.**
- The presence of fat in a nodule may be diagnosed accurately only on HRCT (-30 to -120 HU)
- Conglomerate or “popcorn” calcification is characteristic of hamartomas and is rarely seen with other lesions.

CASE Nº 2 – *Diagnosis please!*

47 year-old smoker, using oily nasal drops for his chronic sinusitis, presented with subacute dyspnea and abnormal chest radiograph.



CASE Nº 2 – *Exogenous Lipoid Pneumonia!*



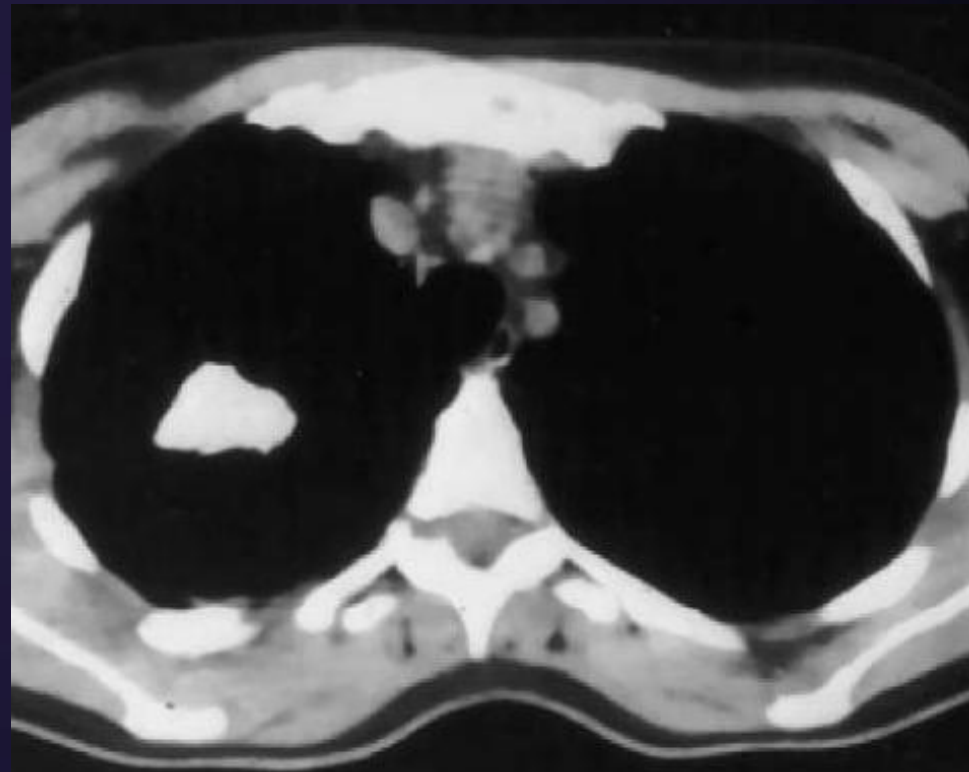
a) CT (lung window) shows ill-defined parahilar ground-glass opacity and areas of consolidation in the posterior lung. b) Soft-tissue window scan at the same level, shows areas of low attenuation (arrows) within the consolidation. This low attenuation is similar to the mediastinum fat (*).



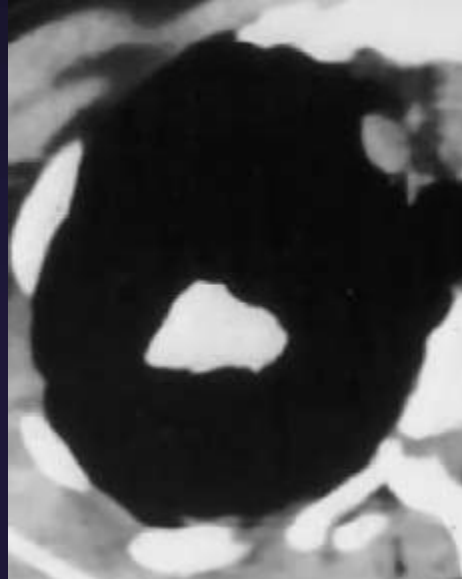
- Results from the chronic aspiration or inhalation of animal, vegetable, or petroleum-based oils or fats.
- CT shows masses that may be well-defined or ill-defined, or areas of consolidation.
- **If large amount of lipid has been aspirated, CT can show areas of low-attenuation (-35 to -75 HU).**
- These areas tend to have a lower-lobe predominance and are often bilateral.
- A dependent location is also typical.
- Ground-glass opacity in association with interlobular septal thickening and intralobular lines ("crazy paving") or centrilobular nodules may also be seen on CT.

CASE Nº 3 – *Diagnosis please!*

40 year-old patient with tuberculosis in the past, appears with a mass on chest radiograph.



CASE Nº 3 – Tuberculoma!



a) Chest film shows a homogeneous nodule with high density in the right upper lobe.
b) CT confirms a well defined and totally calcified nodule with 4 cm in the right upper lobe. The findings are consistent with granuloma (in this case a tuberculoma).

Generally the following four patterns of calcification can be used to predict the presence of a benign lesion:

1. Homogeneous calcification
2. Dense central (“bull’s eye”) calcification
3. Concentric rings of calcium (“target” calcification)
4. Conglomerate foci of calcification involving a large parte of the nodule (“popcorn” calcification)

BENIGN PATTERNS OF CALCIFICATION



DIFFUSE



**CENTRAL
(BULLS EYE)**

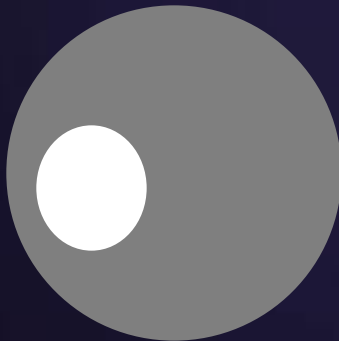


**LAMINAR
(CONCENTRIC)**

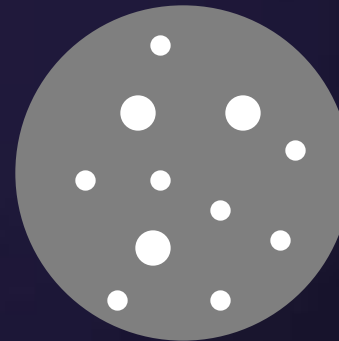


POPCORN

INDETERMINATE PATTERNS OF CALCIFICATION



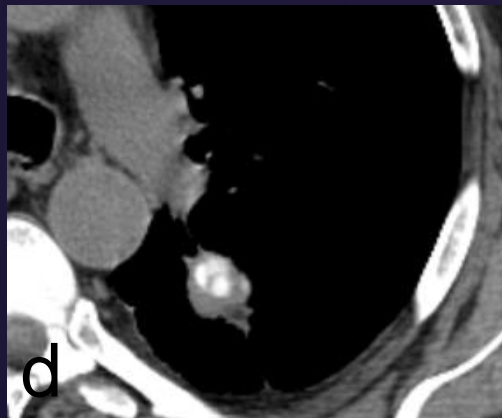
ECCENTRIC



SMALL FLECKS

- With rare exceptions, benign patterns of calcification indicate the presence of a benign lesion.
- Indeterminate patterns of calcification may be seen in benign or malignant lesions.
- In the scheme images, gray color represents soft tissue and white color represents calcification.

CASE N° 4 – *Calcification pitfall!*

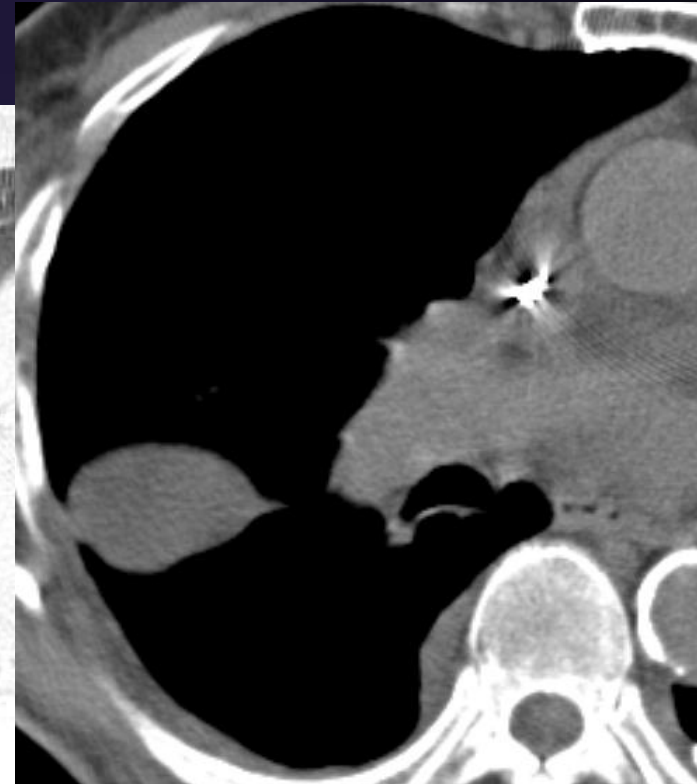
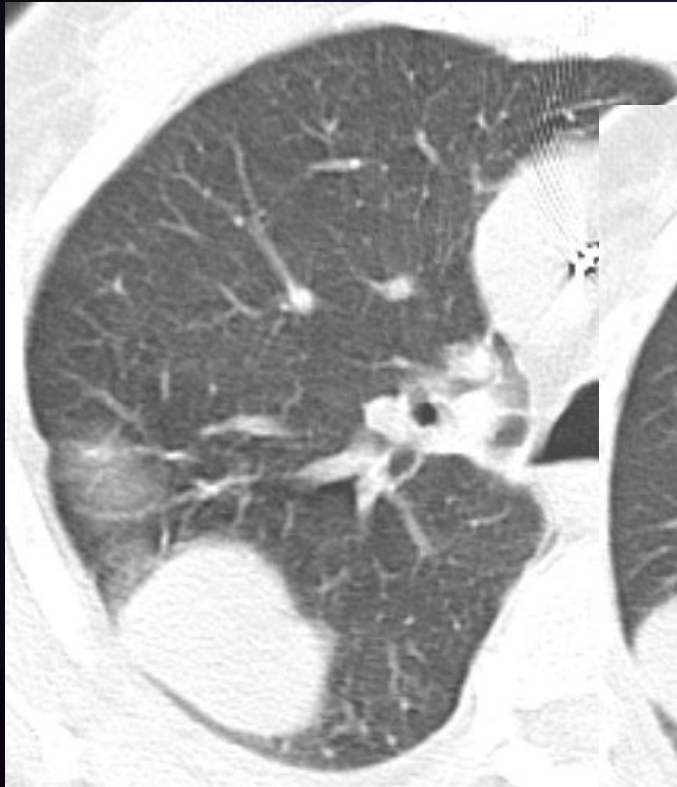


a) and b) CT in 2006 shows a totally calcified nodule in the left lower lobe, consistent with a healed granuloma. There is a pleural tail (arrow), a nonspecific finding that can be seen in peripheral granulomas. c) and d) In the follow up CT two years later, the nodule was larger and had a soft tissue component. This is an example of a carcinoma engulfing a preexisting granuloma.

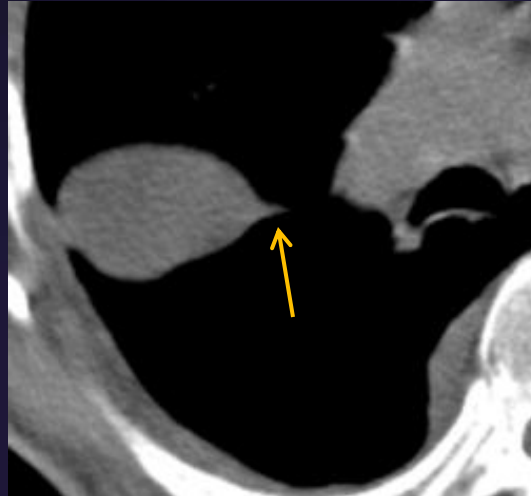
- Stippled calcification or eccentric foci of calcification may be seen in benign nodules but are also visible in as many as 10% to 15% of cancers; these patterns must be considered indeterminate.
- Calcium in a tumor may reflect dystrophic calcification, engulfing of a preexisting granuloma, or calcification of the tumor itself (mucinous adenocarcinoma or osteogenic sarcoma).

CASE Nº 5 – *Diagnosis please!*

68 year-old patient with congestive heart failure presented with a mass on chest radiography.



CASE Nº 5 – *Cisural pleural effusion!*

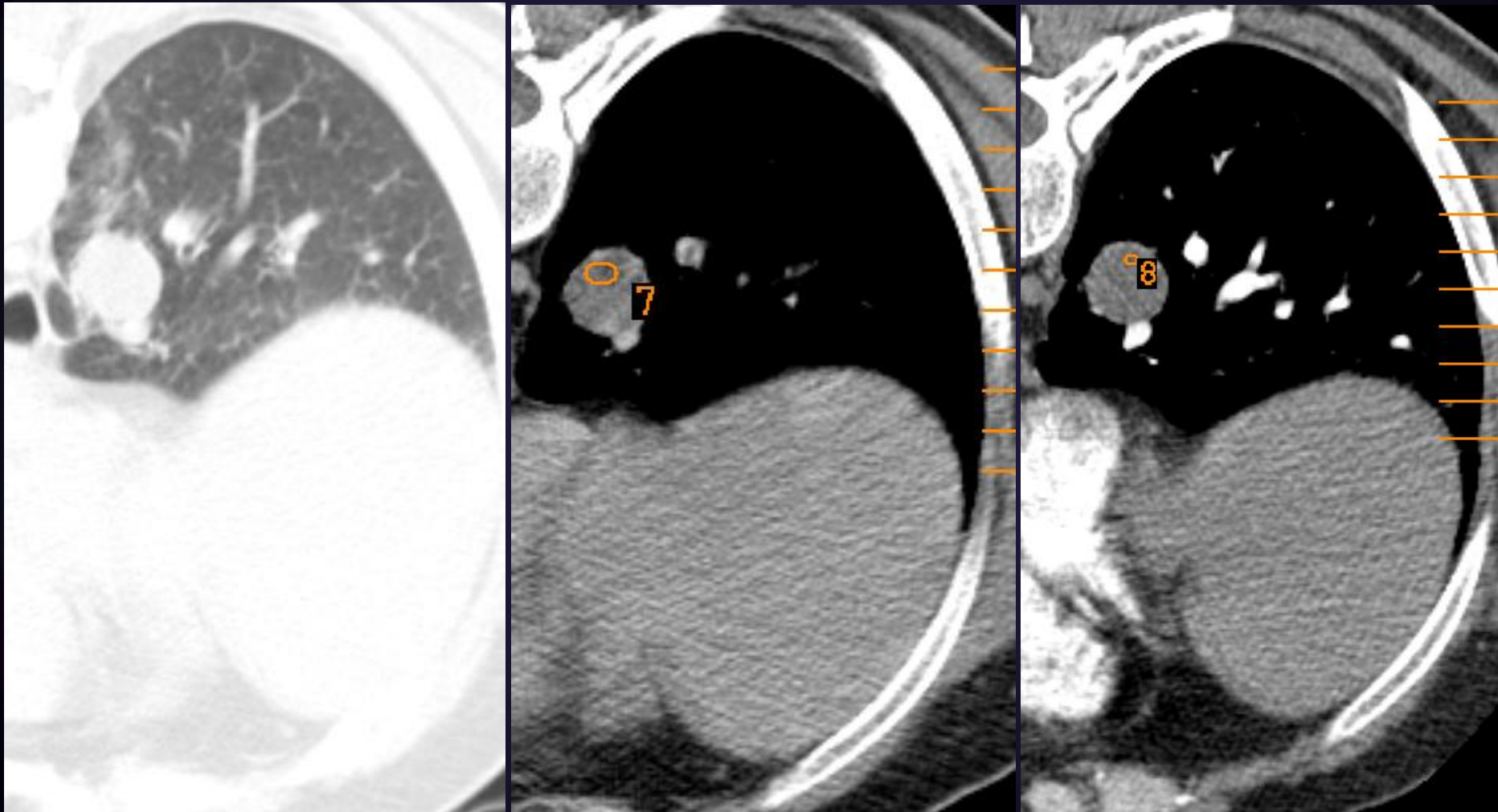


a) There is an aparent parenchymal mass in the right lung. **b)** Analysis of sequential images showed a lenticular shape and the relationship of the opaque mass to the plane of the fissure. A beak is visible medially (arrows) and the pseudolesion is of homogeneous fluid attenuation.

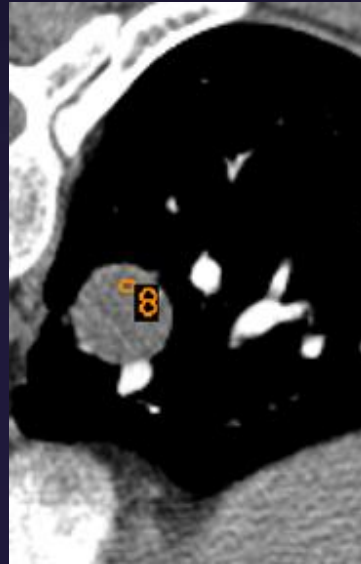
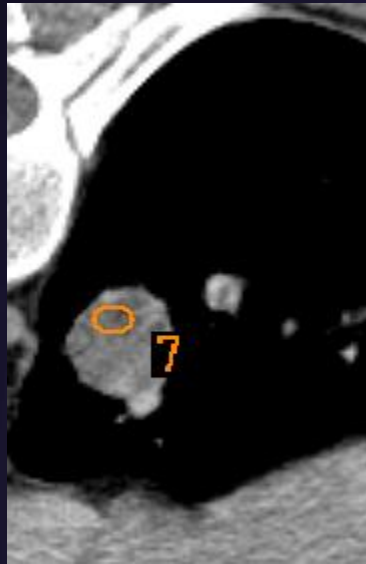
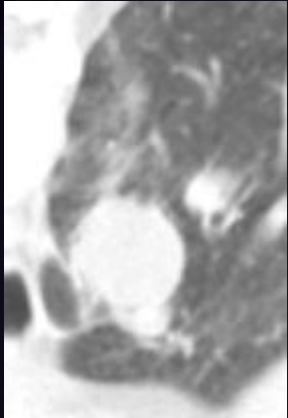
- A focal or loculated collection of pleural fluid in a major or minor fissure can have a confusing appearance on CT images and can be misinterpreted as a parenchymal mass.
- Careful analysis of sequential images usually will confirm the relationship of the opaque mass to the plane of the fissure.
- If the abnormality is of fluid density the diagnosis becomes more likely.
- The edges of the mass may taper to conform to the fissure, forming a beak.

CASE Nº 6 – *Diagnosis please!*

Smoker patient that was referred for CT guided lung biopsy (note the patient is in prone position).



CASE Nº 6 – *Pulmonary Bronchogenic cyst!*



a) A sharply marginated round nodular opacity is visible in the right lower lobe. **b)** The nodule has fluid attenuation (7 HU). **c)** There is no enhancement after contrast administration. The findings are typical of a fluid-filled bronchogenic cyst.

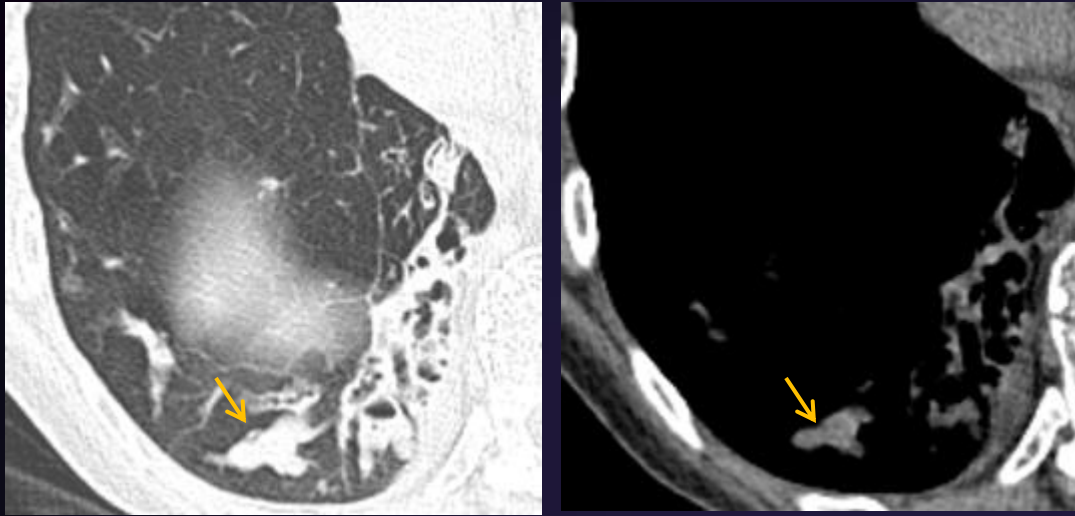
- They are less common than mediastinal bronchogenic cysts and are most common in the medial lung and the lower lobe.
- Fluid contents can be serous, hemorrhagic, or highly viscous and gelatinous because of its high protein content.
- Their wall is invisible on CT or appears very thin.
- When dense may be difficult to distinguish from solid lesions. **An important clue to the diagnosis can be their lack of enhancement following intravenous contrast infusion.**

CASE Nº 6 – *Diagnosis please!*

37 year-old patient with several episodes of broncho-pulmonar infections.



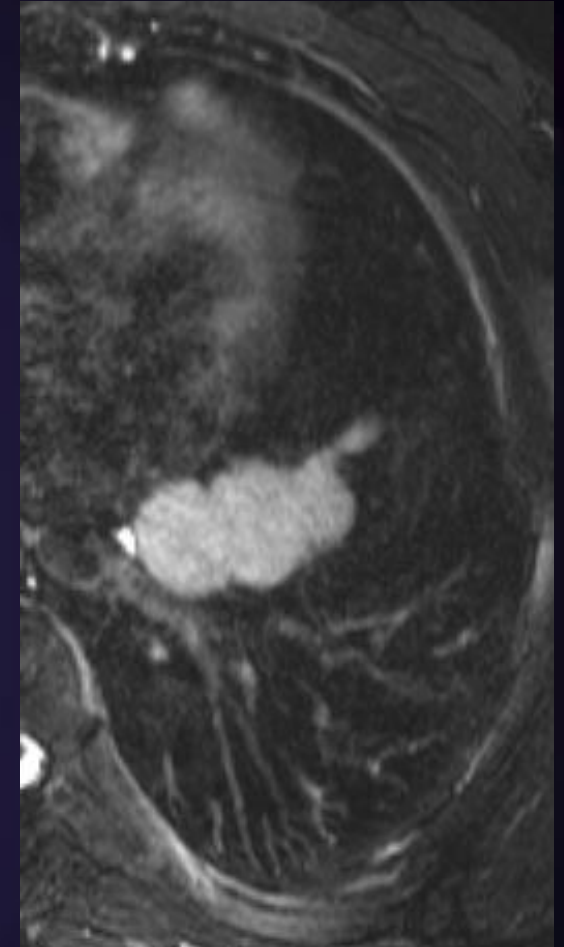
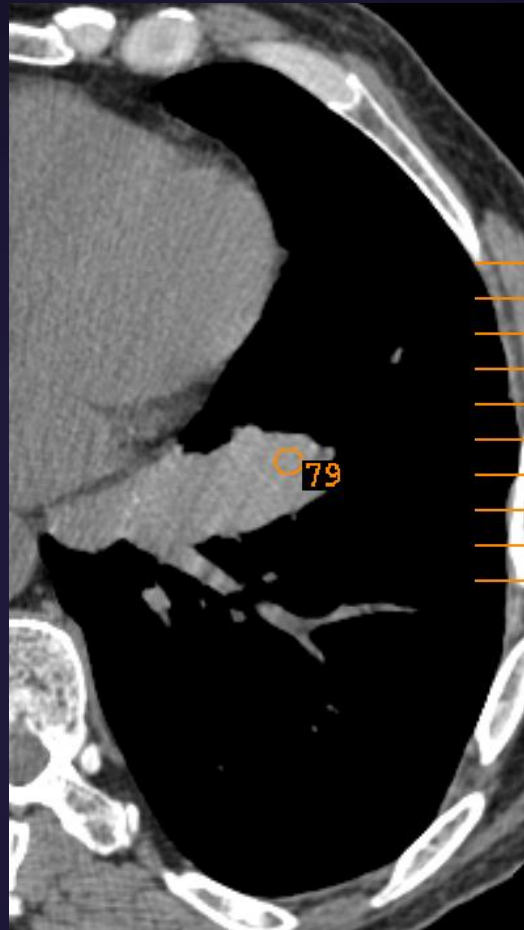
CASE Nº 6 – *Bronchocele!*



There are several bronchiectasis in the right lower lobe. There is also a branching tubular opacity (arrow), whose appearance is similar to that of a gloved finger or the shape of the letters V or Y. This is the typical appearance of a bronchocele.

- Mucous plugs mimicking the appearance of a lung nodule (or nodules) may be seen in a variety of conditions.
- **Usually the characteristic branching appearance of the mucoid impaction allows it to be distinguished from other causes of a lung nodule (gloved finger or the shape of the letters V or Y).**
- Mucous plugs often appear low in attenuation on CT, being less dense than the bronchial wall.
- High attenuation mucous plugs may be seen on CT in patients with allergic bronchopulmonary aspergillosis (ABPA) and bronchial atresia, most likely due to calcification.

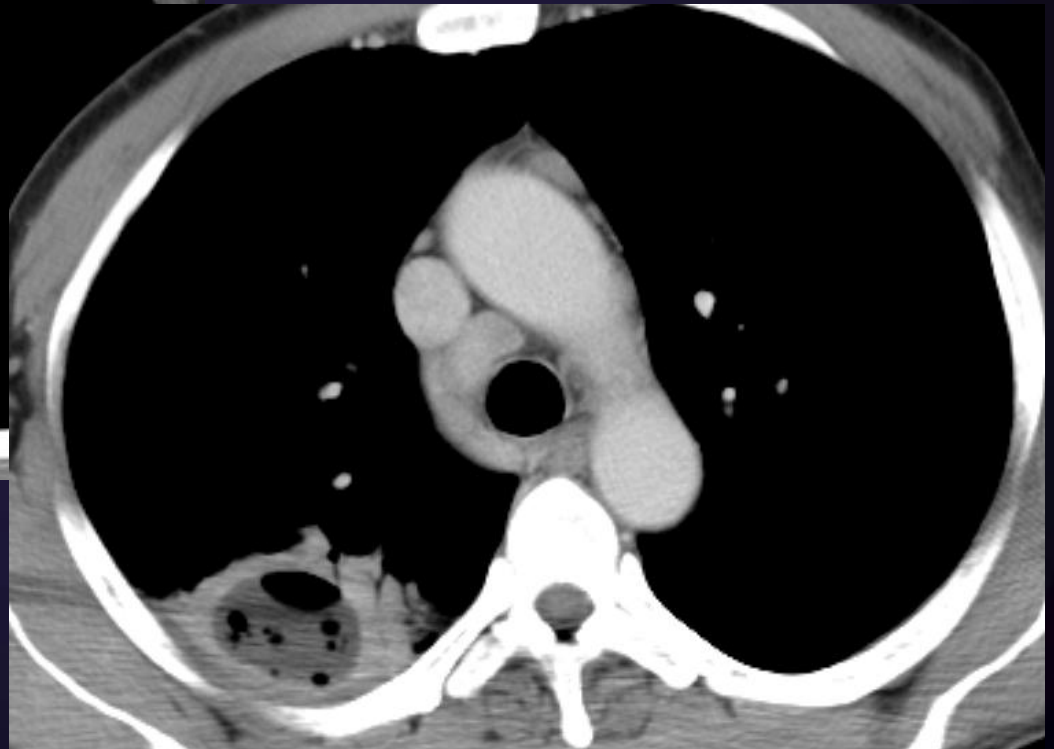
CASE Nº 6 – *Bronchocele!*



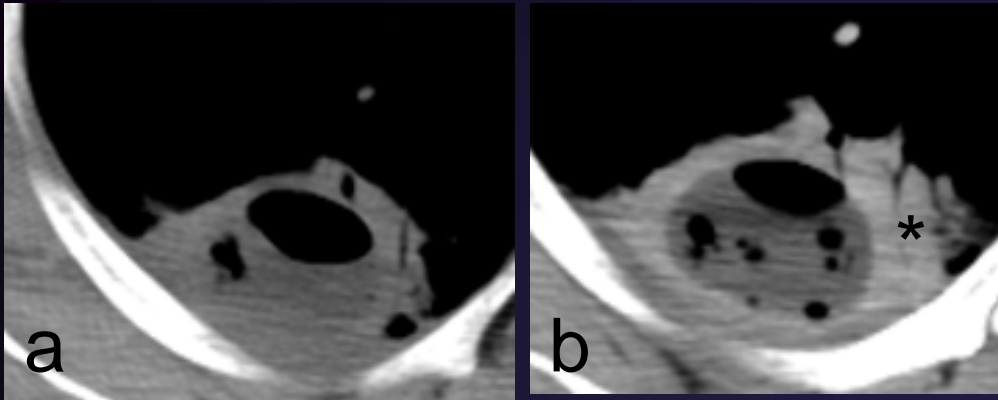
Bronchial atresia with bronchocele. **a) and b)** CT shows a left central para-hilar tubular/ovoid density due to mucus accumulation within dilated bronchi distal to the atretic segment. The contents of this bronchocele have high attenuation, which may be seen in bronchial atresia (as this case) or ABPA. **c)** MR (T2 fast SE, FS) shows a tubular structure that is hyperintense . On T1 (not shown) it has intermediate signal, consistent with proteinaceous contents.

CASE Nº 7 – *Diagnosis please!*

57 year-old diabetic patient, with fever, cough, dyspnea and foul expectorations.



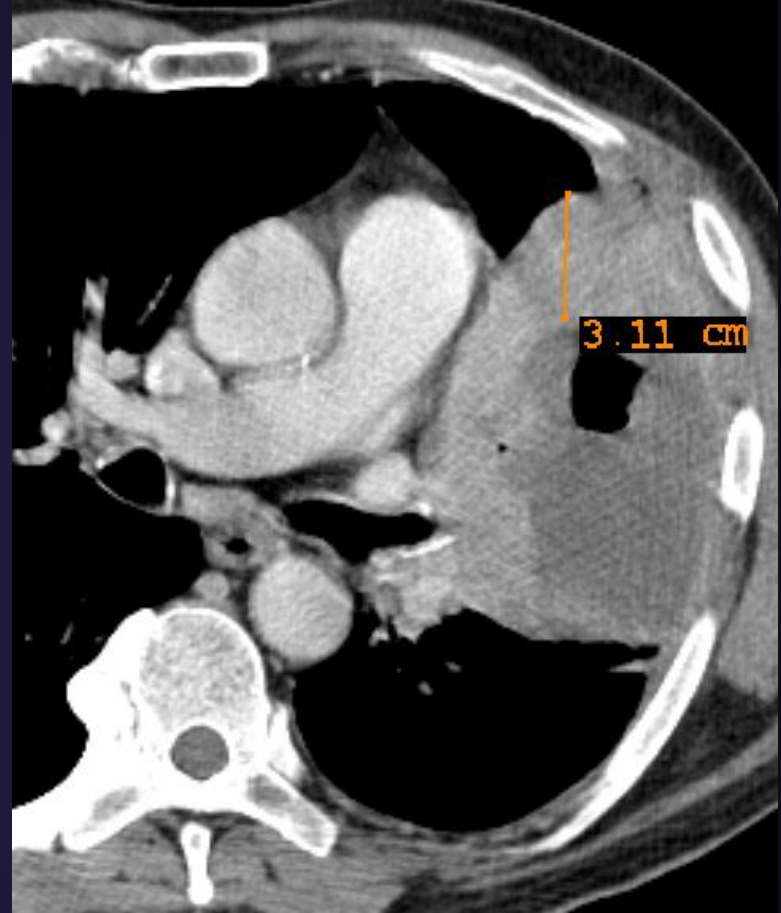
CASE Nº 7 – Lung abscess!



a) A fluid-filled abscess is visible on the right lung. There are small amounts of air inside it. b) There is an enhancing wall after contrast administration and there is surrounding consolidated lung (*), a clue to the inflammatory etiology of this lesion.

- A lung abscess represents a localized infection that undergoes tissue destruction and necrosis.
- When a communication with the tracheobronchial tree is present, cavitation and an air-fluid level may be evident.
- **The inner wall of an abscess varies from smooth to shaggy and irregular, and maximum wall thickness usually ranges from 5 to 15 mm.**
- Sometimes the outer wall is obscured by surrounding consolidation.
- The contents of a lung abscess appear low in attenuation and typically show a densely enhancing wall.

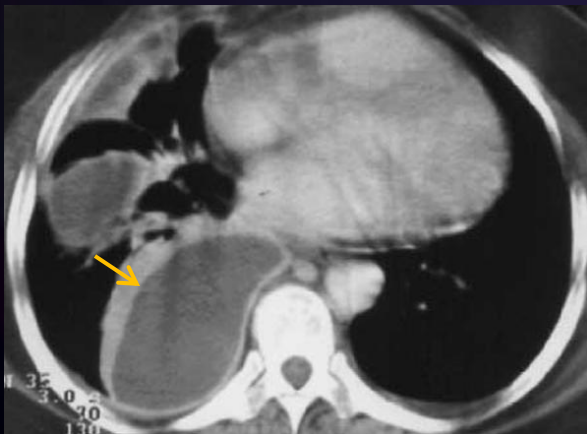
CASE Nº 8 – *Lung abscess pitfall!*



Necrotic adenocarcinoma. There is a mass in the left lung with fluid attenuation and gas in eccentric location. This could mimetize an abscess, but the enhancing wall is too thick (3,11 cm) and the eccentric location of fluid and gas is also atypical for abscess. The maximum wall thickness of an abscess usually ranges from 5 to 15 mm.

EMPYEMA VS LUNG ABSCESS ON CT

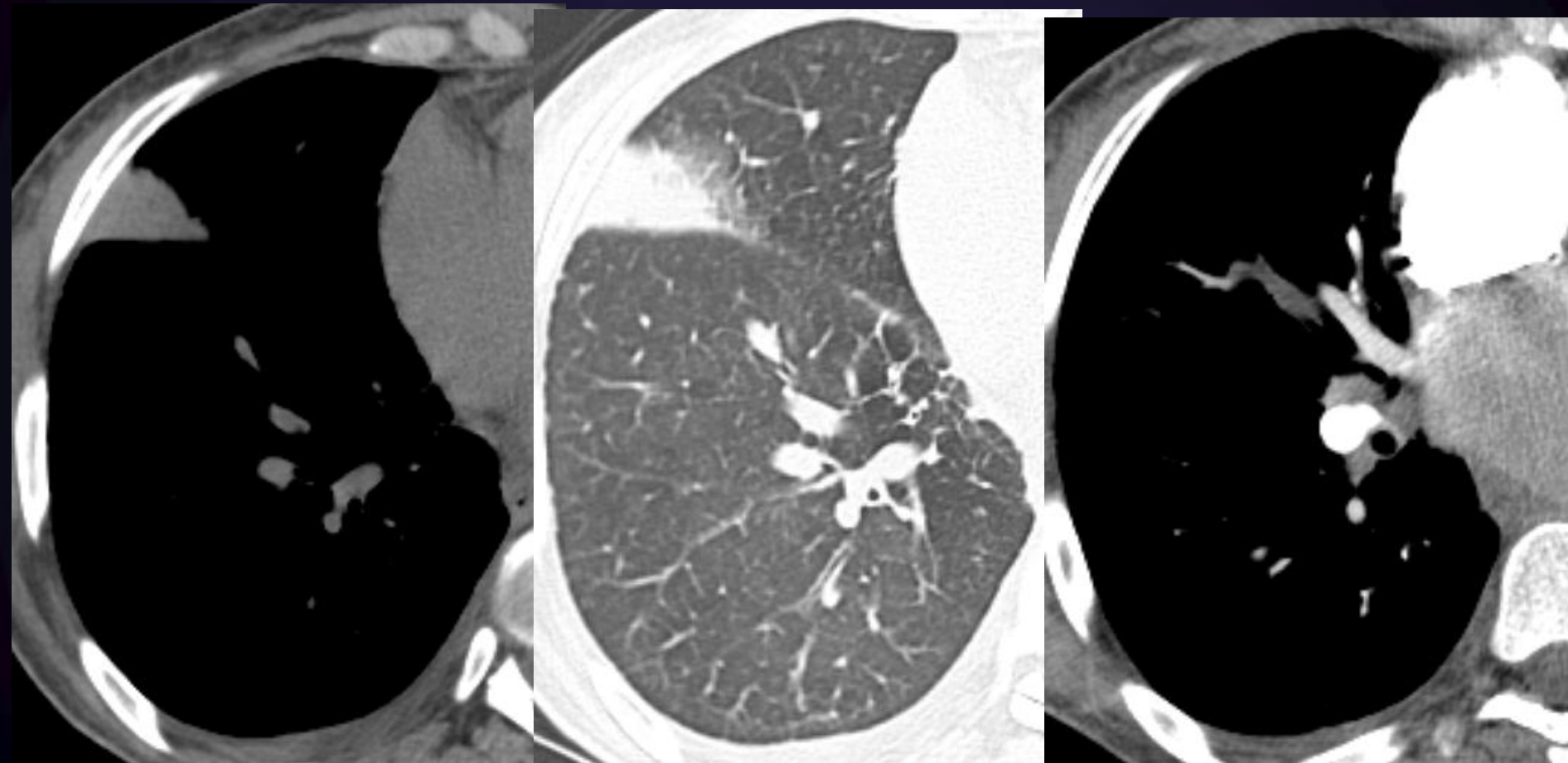
<u>Feature</u>	<u>Empyema</u>	<u>Abscess</u>
<u>Shape</u>	Oval <u>Oriented longitudinally</u>	<u>Round</u>
<u>Margin</u>	<u>Thin, smooth (“split pleura” sign)</u>	<u>Thick, irregular</u>
<u>Angle with chest wall</u>	<u>Obtuse</u>	<u>Acute</u>
<u>Effect on lung</u>	<u>Compression</u>	<u>Consumption</u>
<u>Treatment</u>	<u>External drainage</u>	<u>Antibiotics</u> <u>Postural drainage</u>



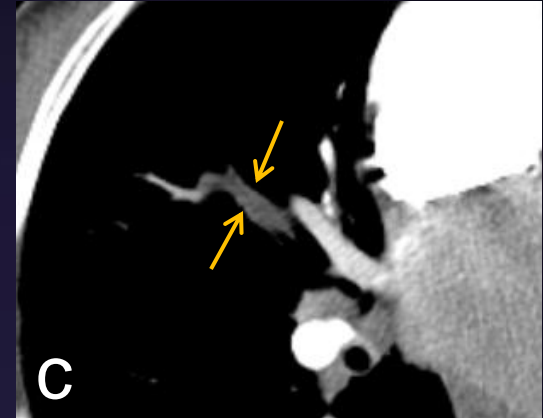
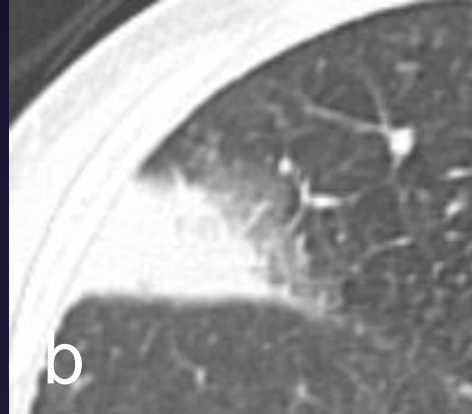
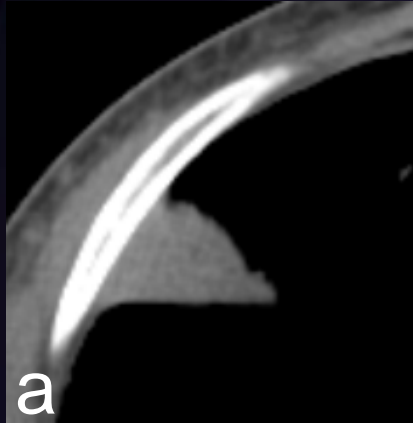
Enhanced CT shows an oval pleural fluid collection with enhancing visceral and parietal pleural layers representing an **empyema**.

CASE Nº 8 – *Diagnosis please!*

70 year-old patient with dyspnea and right sided pleuritic pain.



CASE Nº 8 – *Pulmonary Infarction!*



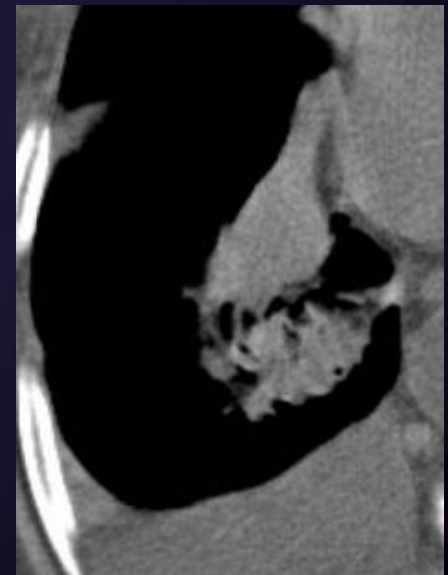
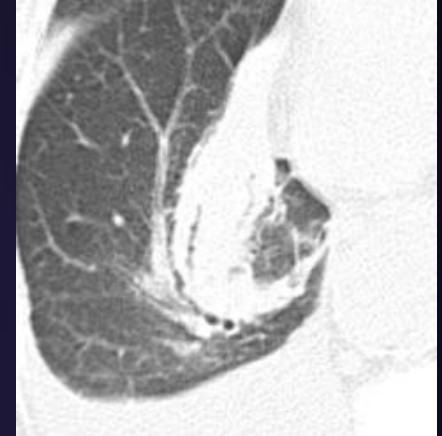
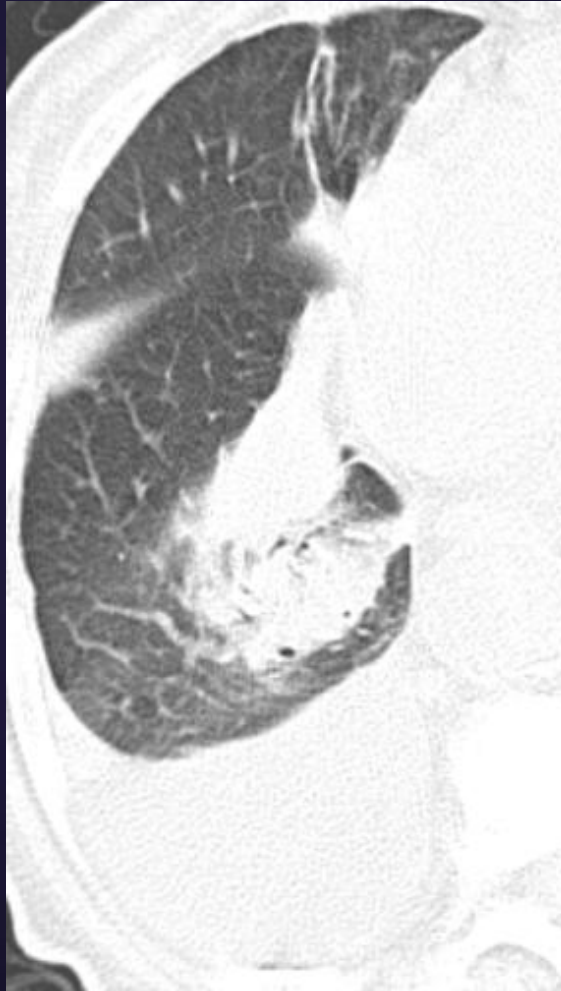
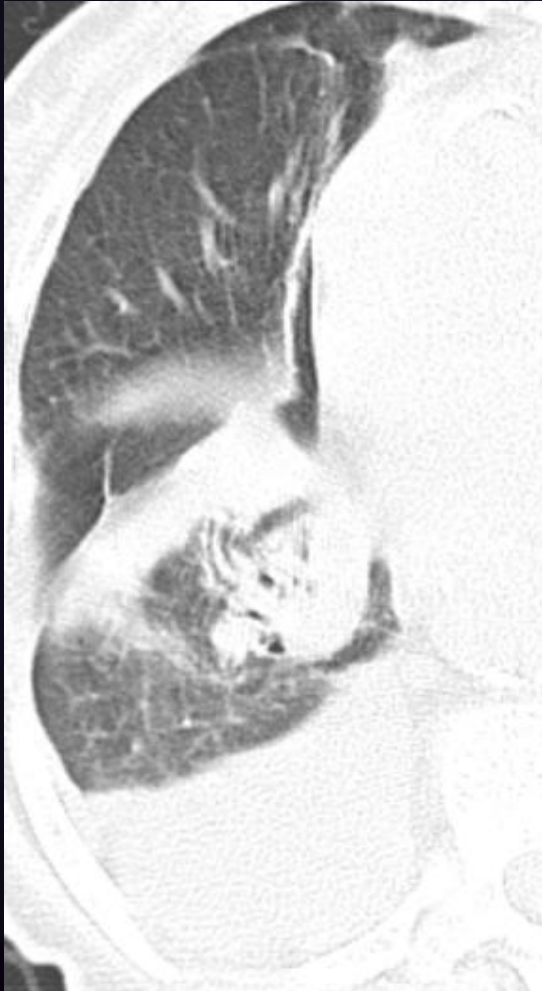
a) and b) A wedge-shaped opacity is visible in the peripheral lung, contacting the pleural surface and associated with surrounding ground-glass opacity (halo sign), consistent with adjacent hemorrhage. **c)** angio-TC shows a pulmonary embolus in the lateral segmentar artery of the medium lobe (arrows). So this is a **pulmonary infarction in a patient with pulmonary embolism**.

On CT, pulmonary infarctions are characterized by the following features:

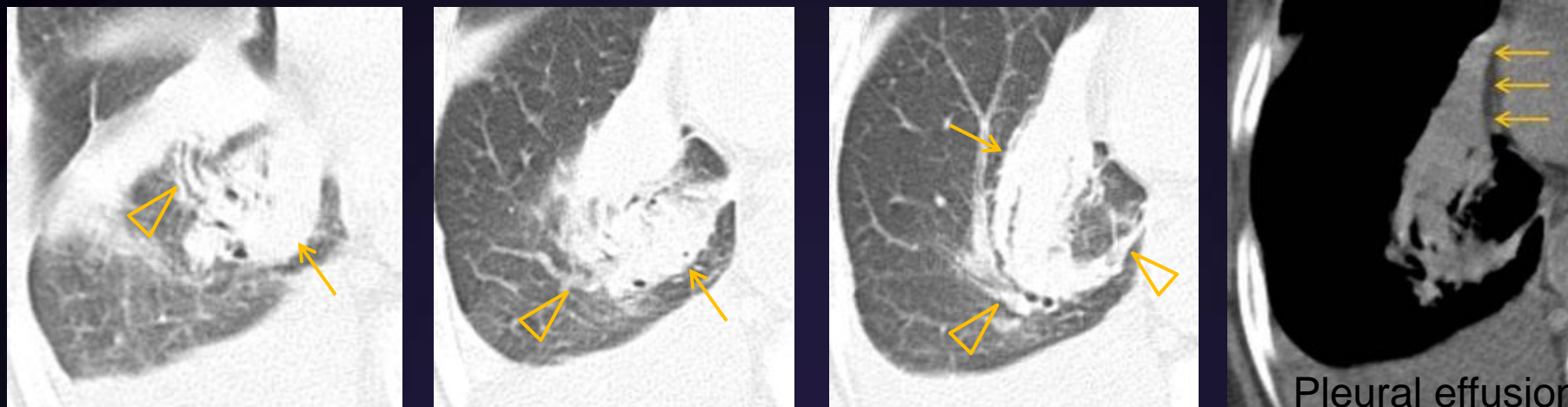
- A wedge-shaped opacity (sometimes with a truncated apex).
- Contact with the pleural surface.
- Convex borders.
- A linear opacity directed from the apex of the density toward the hilum (i.e., its feeding vessel).
- Scattered areas of low attenuation (necrosis) within the lesion.
- A halo sign due to adjacent hemorrhage.

CASE Nº 9 – *Diagnosis please!*

A chest radiography made outside our institution showed a mass lesion and pleural effusion on the right lung.



CASE Nº 9 – *Rounded Atelectasis!*



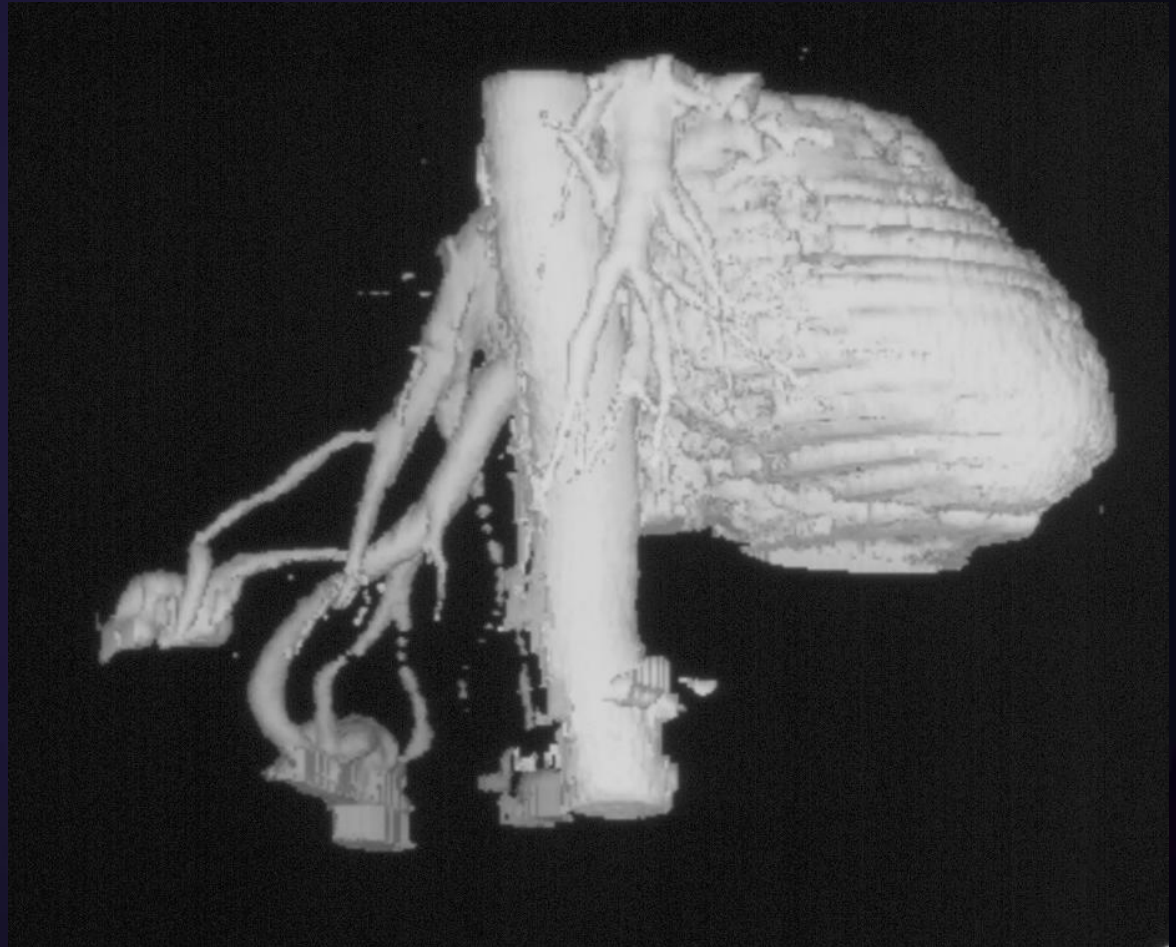
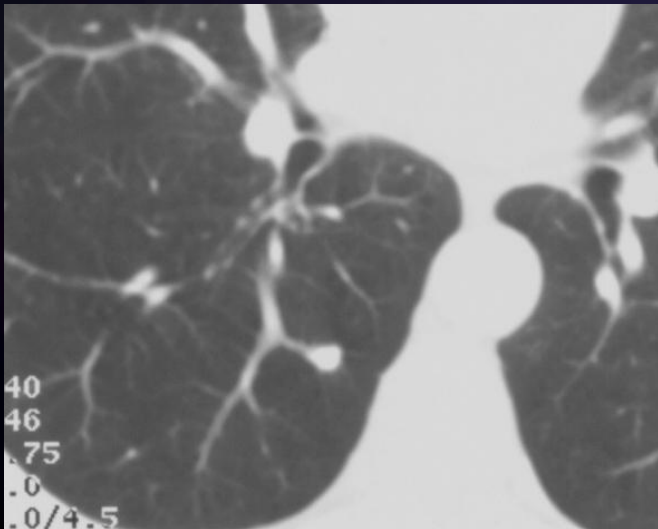
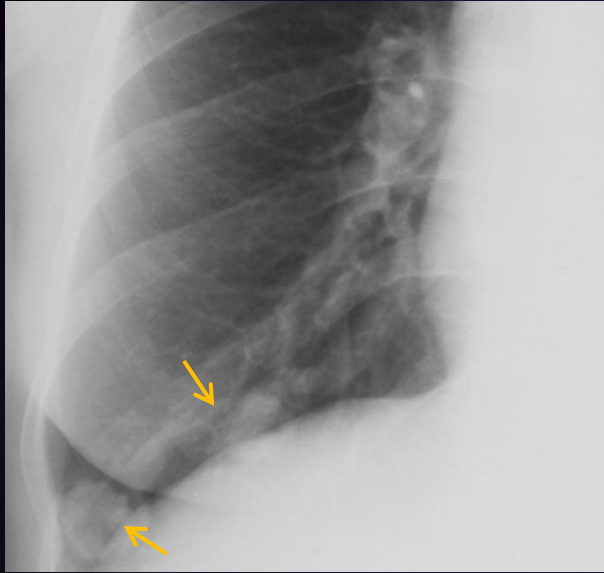
Typical rounded atelectasis associated with pleural effusion. **a), b) and c)** CT scans of three adjacent levels show characteristic findings of rounded atelectasis. An elliptical opacity is visible (arrows), which has significant contact with the mediastinal pleural surface. Vessels and bronchi curve into the edge of the lesion – “comet-tail sign” (arrowheads). In cine mode it was perceptible a whorled appearance, produced by the crowding of the bronchovascular bundle. **d)** The opacity has soft tissue attenuation with significant contact with the mediastinal pleura (arrows). Note also the presence of air bronchogram.

To suggest the diagnosis of rounded atelectasis on CT, the opacity should be:

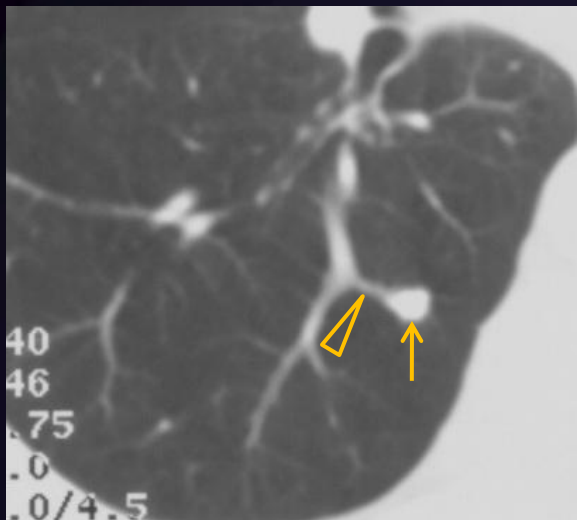
1. Round or elliptical
2. Associated with an ipsilateral pleural abnormality, either effusion or pleural thickening
3. Peripheral in location, having significant contact with the abnormal pleural surface
4. Associated with curving of pulmonary vessels or bronchi into the edge of the lesion (“comet-tail sign”)
5. Associated with volume loss in the affected lobe
6. Associated with significant enhancement following the intravenous injection of contrast agents

CASE Nº 10 – *Diagnosis please!*

A 37 year-old patient with hereditary hemorrhagic telangiectasia has a chest radiography with some nodules in the right lung.



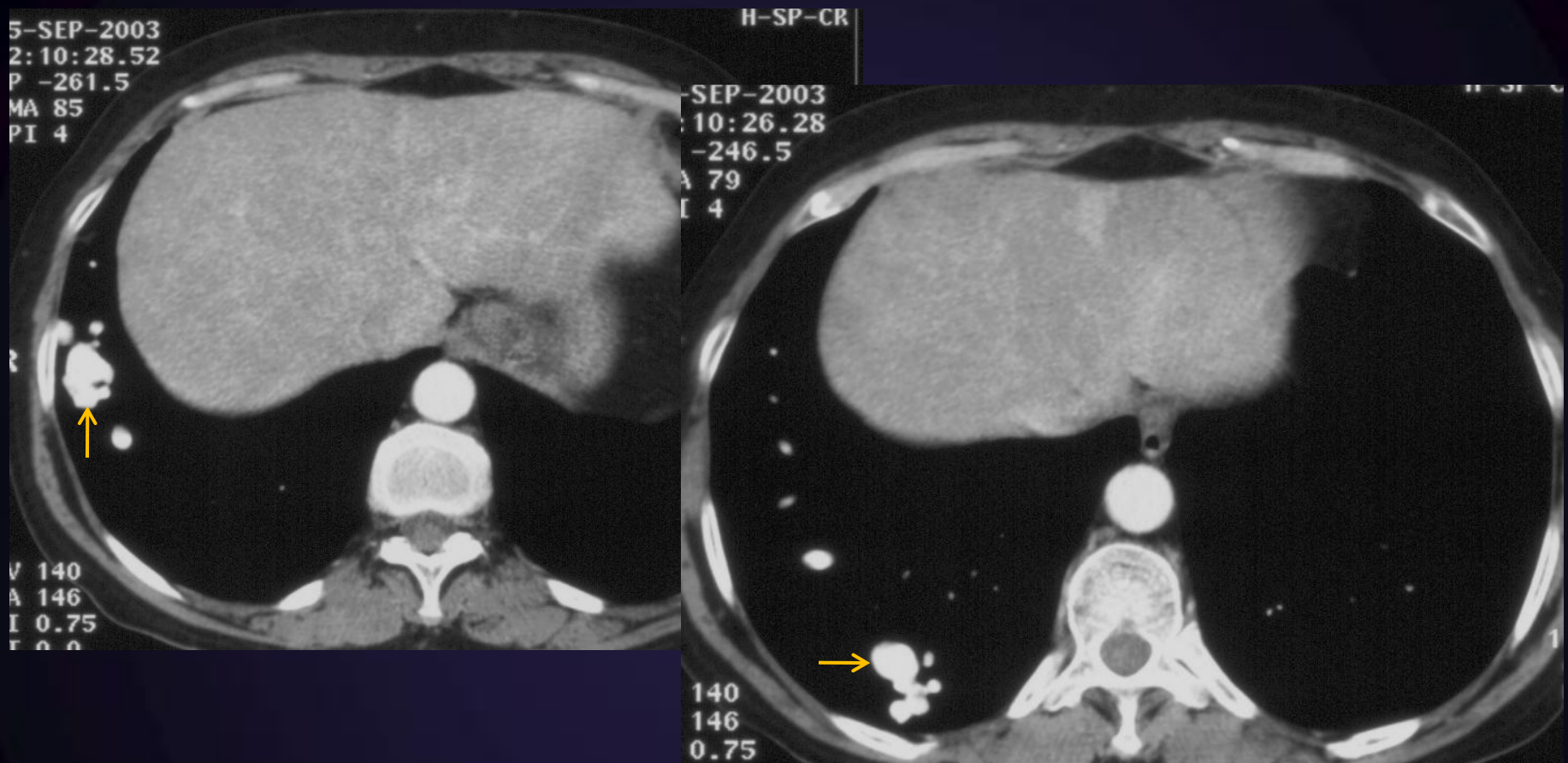
CASE Nº 10 – Pulmonary arteriovenous malformation (MAV)!



a) CT showing the feeding artery (arrowheads) of a small MAV (arrows). **b)** CT (3D, SSD) shows the feeding and draining vessels, confirming that the nodules are AVMs. **c)** Pulmonary arteriography of another patient, showing a simple arteriovenous malformation. A single artery (arrow) supplies a simple malformation drained by a single vein (arrowhead).

- 35%-67% associated with Osler-Weber-Rendu syndrome.
- A simple AVM is a single, dilated vascular sac connecting one artery and one vein (most common).
- Complex AVMs, which have more than one feeding artery, are rare.
- **At CT, a simple AVM is visible as a smooth, sharply defined, round or elliptical nodule, almost always in a subpleural location.**
- Arteriovenous fistulas characterized by a tangle of tortuous, dilated vessels are seen as lobulated, serpiginous masses.
- The feeding pulmonary artery branch and draining pulmonary vein are dilated, and with fistulas of significant size (larger than 1 to 2 cm) the feeders are easily recognizable.
- **Pulmonary AVMs show rapid contrast opacification and washout, occurring in phase with opacification and washout of the main pulmonary artery and the right ventricle.**

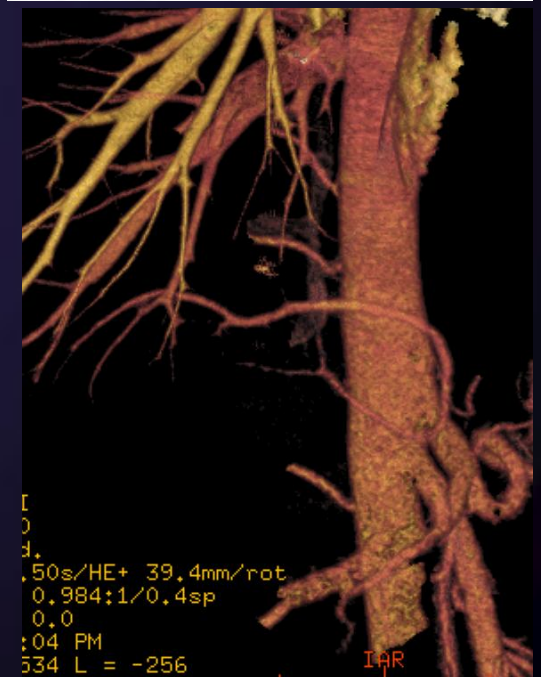
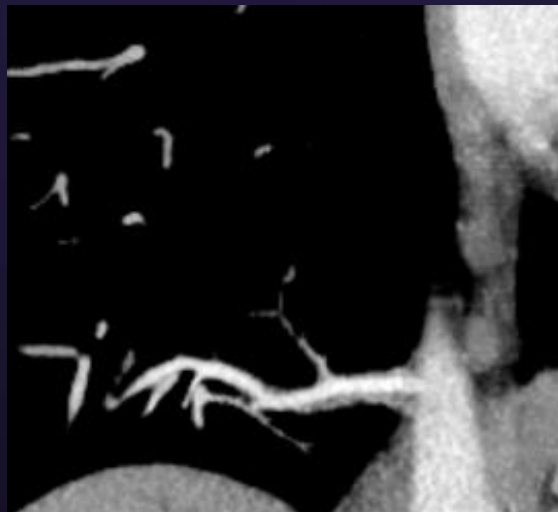
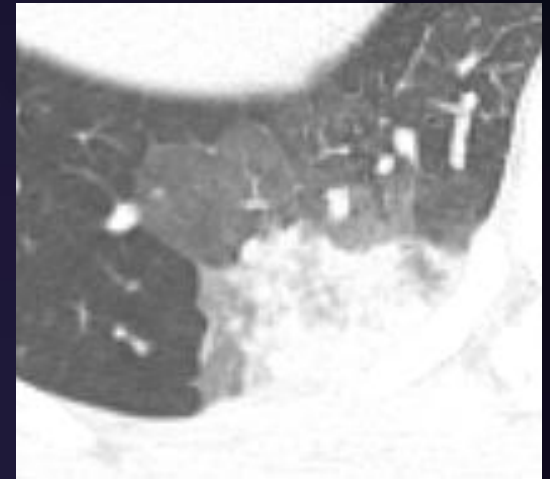
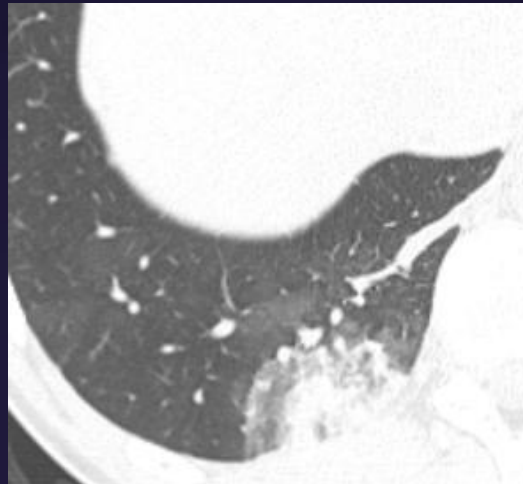
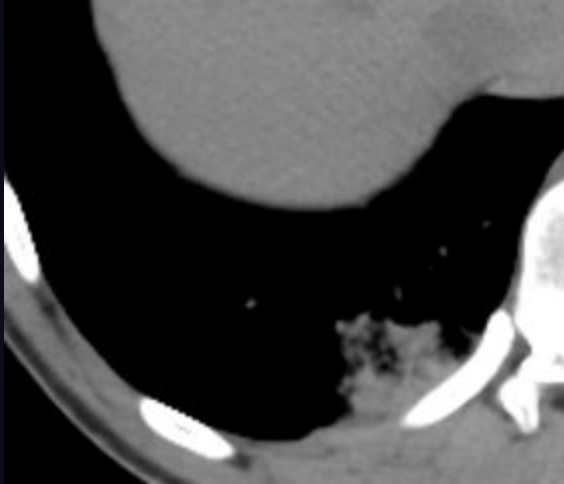
CASE Nº 10 – *Pulmonary arteriovenous malformation!*



Multiple AVMs in another patient with Osler-Weber-Rendu syndrome. Arteriovenous fistulas (arrows) characterized by a tangle of tortuous, dilated vessels that are seen as lobulated, serpiginous masses. With contrast injection, dense opacification of the fistulas is seen.

CASE Nº 11 – *Diagnosis please!*

33 year-old patient with recurrent hemoptysis.



CASE N° 11 – *Bronchopulmonary sequestration!*



CT shows at the posterior basal segment of right lower lobe, a consolidation/mass (arrow) with a systemic feeding artery (arrowheads). There is ground glass attenuation surrounding the consolidation due to hemorrhage. The abnormal systemic feeding artery (arrowheads) is seen to arise from the abdominal aorta, just adjacent to the celiac axis (CA).

CASE Nº 11 – *Bronchopulmonary sequestration!*

- This congenital abnormality results from the independent development of a portion of the tracheobronchial tree that is isolated from the normal lung and maintains its fetal systemic arterial supply.
- Pulmonary sequestration is divided into intralobar and extralobar forms.
- These patients most often present with recurrent pneumonia from infection in the sequestered lung.

	<u>Intralobar sequestration</u>	<u>Extralobar sequestration</u>
<u>Frequency (of all sequestrations)</u>	<u>Common (75%)</u>	<u>Uncommon (25%)</u>
<u>Age at presentation</u>	<u>Young adult</u>	<u>Neonate / infant</u>
<u>Mode of presentation</u>	<u>Recurrent pneumonia</u>	<u>Asymptomatic</u>
<u>Location</u>	<u>Left lower lobe (60%)</u> <u>Right lower lobe (40%)</u>	<u>Left lower lobe (90%)</u> <u>Right lower lobe (10%)</u>
<u>Pleural covering</u>	<u>Within visceral pleural</u>	<u>Separate pleural layer</u>
<u>Associated congenital anomalies</u>	<u>Rare</u>	<u>Common</u> <u>(diaphragmatic eventration / hernia)</u>

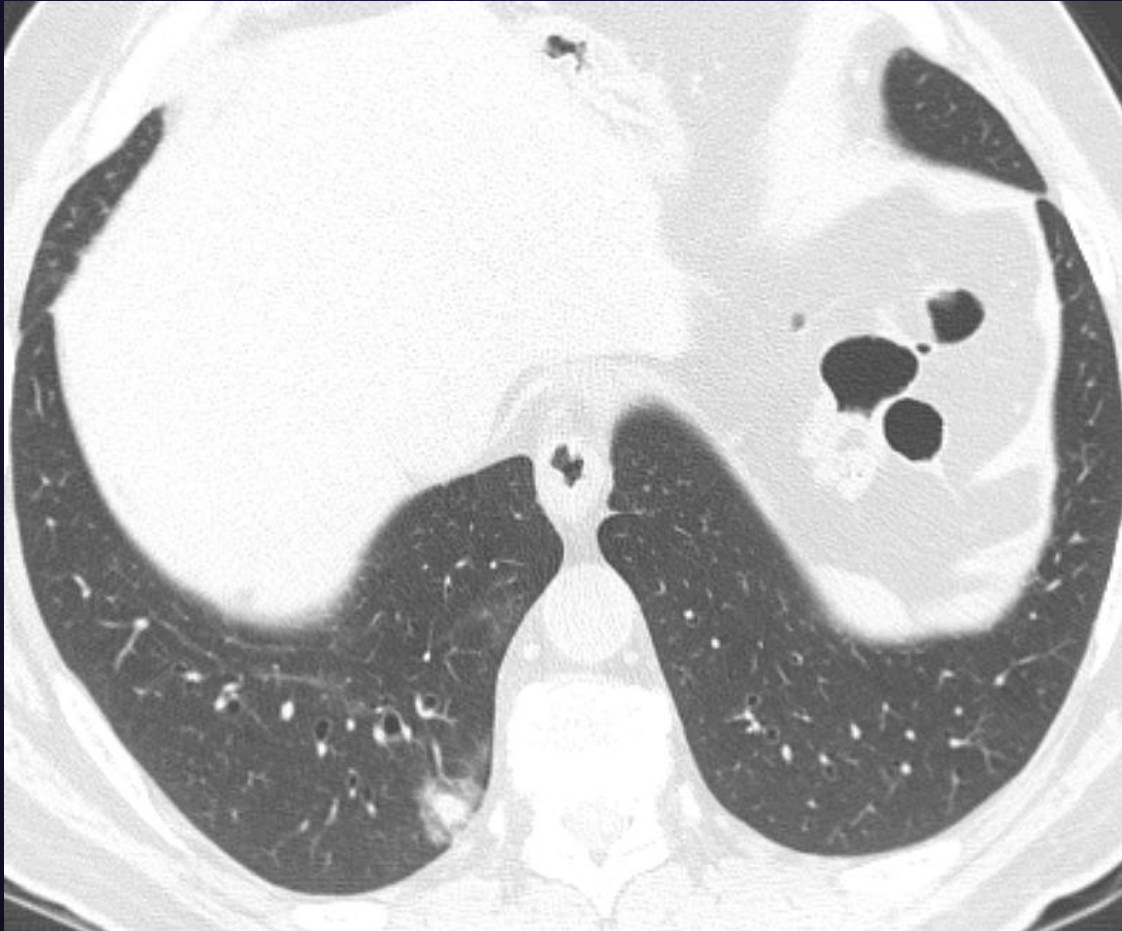
CASE Nº 11 – *Bronchopulmonary sequestration!*

	<u>Intralobar sequestration</u>	<u>Extralobar sequestration</u>
<u>Imaging appearance</u>	<ul style="list-style-type: none">• <u>Homogeneous and well-defined mass lesion</u>• <u>Cystic or multicystic air- and fluid-filled lesion</u>• <u>Hyperlucent and hypovascular region of lung</u>• <u>Combination of these</u>	<ul style="list-style-type: none">• <u>Homogeneous and well-defined mass lesion</u>• <u>May contain fluid-filled cystic areas</u>• <u>Rarely contains air</u>
<u>Arterial supply</u>	<u>Single vessel from peridiaphragmatic aorta</u>	<u>Multiple small systemic/pulmonary arteries</u>
<u>Venous drainage</u>	<u>Pulmonary veins</u>	<u>Systemic veins</u>

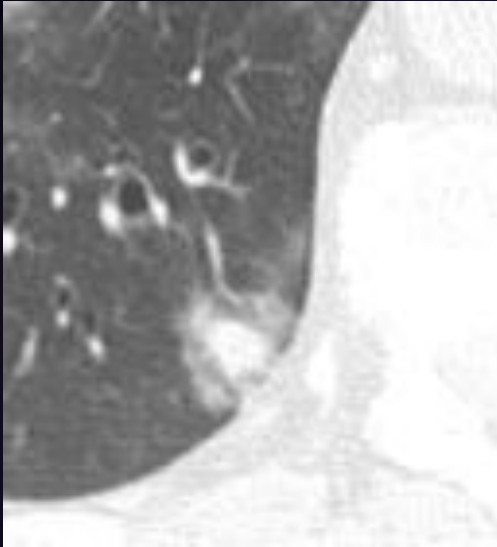
The definitive diagnosis is made by the demonstration of abnormal systemic arterial supply to the abnormal lung.

CASE Nº 12 – *Diagnosis please!*

A severely neutropenic bone marrow transplant patient with fever.



CASE Nº 12 – *Invasive aspergillosis* !

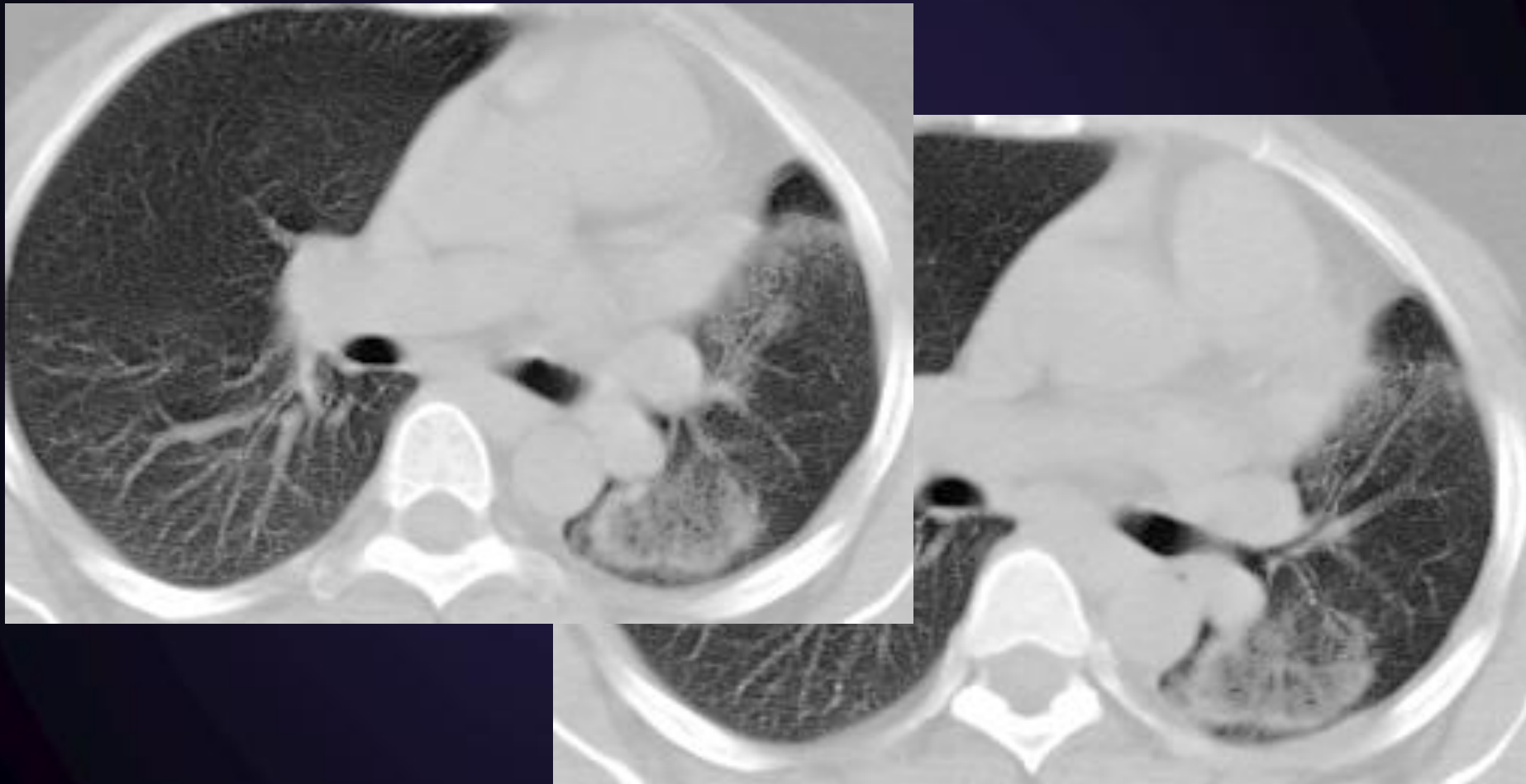


CT shows a right lower lobe nodule (circle) with surrounding ground-glass opacity. This combination represents the halo sign and in the appropriate clinical setting is very suggestive of pulmonary fungal infection.

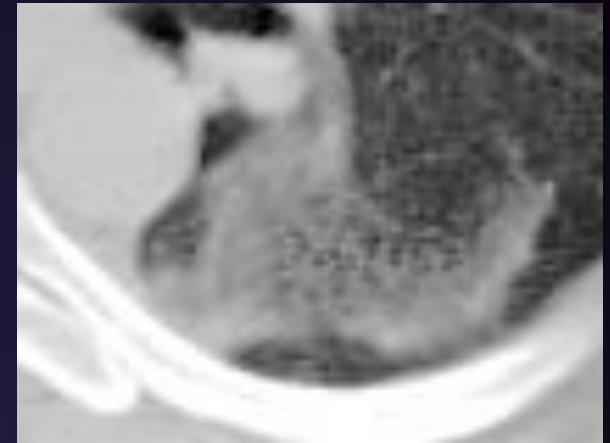
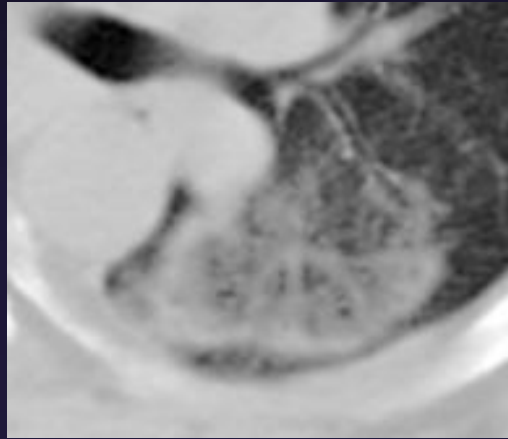
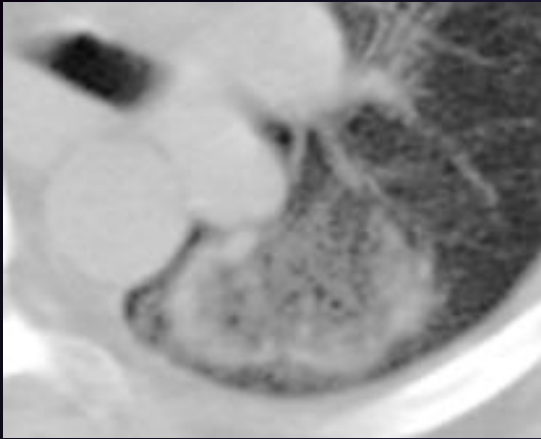
- The halo sign refers to a ring of ground-glass opacity surrounding a pulmonary nodule or mass, thought to represent parenchymal hemorrhage.
- In severely neutropenic patients, it is highly suggestive of infection by an angioinvasive fungus, most commonly aspergillus.
- Rarely, it can be seen in neoplastic diseases.
- **Notwithstanding the wide spectrum of associated diseases, this sign is a useful diagnostic clue in the appropriate clinical setting and may be the first evidence of pulmonary fungal infection.**

CASE Nº 13 – *Diagnosis please!*

A 53 year-old patient with subacute dyspnea. No fever.



CASE Nº 13 – *Cryptogenic Organizing Pneumonia!*



CT shows ground-glass opacity in the left lower lobe surrounded by a ring-shaped opacity. This represents the “atoll” sign, which is usually associated with organizing pneumonia.

- Ring-shaped or crescentic opacities are seen, often with ground-glass opacity in the center of the ring, resembling a coral atoll.

- **This finding strongly suggests the diagnosis of cryptogenic organizing pneumonia.**

- Less common:

- Wegener's granulomatosis; lymphomatoid granulomatosis; Malignant neoplasms

The radiologist must be able to recognize the specific CT findings of a wide spectrum of benign lung lesions, in order to avoid unnecessary lung biopsies or other invasive procedures in a considerable proportion of patients who present with focal abnormalities.

Thank you!