CHEST

Chest CT Signs in Pulmonary Disease
A Pictorial Review

Shine Raju, MD; Subha Ghosh, MD; and Atul C. Mehta, MD, FCCP

CT scanning of the chest is one of the most important imaging modalities available to a pulmonologist. The advent of high-resolution CT scanning of the chest has led to its increasing use. Although chest radiographs are still useful as an initial test, their utility is limited in the diagnosis of lung diseases that depend on higher resolution images such as interstitial lung diseases and pulmonary vascular diseases. Several metaphoric chest CT scan signs have been described linking abnormal imaging patterns to lung diseases. Some of these are specific to a disease, whereas others help narrow the differential diagnosis. Recognizing these imaging patterns and CT scan signs are thus vitally important. In the present article, we describe a comprehensive list of the commonly encountered metaphoric chest CT scan signs and their clinical relevance.

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KEY WORDS: CAT scan; chest imaging; CT scan; pulmonary; radiology; review; thoracic

CT imaging of the chest plays a vital role in the diagnosis of various lung diseases. Although pulmonary diseases can vary in clinical presentation, the associated imaging patterns can be grouped into a few distinct patterns. Various metaphoric signs have been described to identify and simplify these patterns. Some of these signs, which have been well described in the imaging literature, are pathognomonic for a disease, whereas others can help narrow the list of differential diagnoses. These signs also help to create a unique association between an imaging pattern and the underlying disease process.

Understanding these imaging findings, and their subsequent pattern recognition, is thus of vital importance to a pulmonologist. The present review is a pictorial essay of the important chest CT scan signs and the associated pulmonary diseases. Some of these signs have been described in chest radiographs as well as in CT imaging. We have included these signs in this review, having recognized an increasing trend of CT imaging being used as the initial imaging modality.

General Considerations: The Secondary Pulmonary Lobule

It is important to review the basic structure of a secondary pulmonary lobule (SPL) and its radiologic appearance on a high-resolution CT (HRCT) scan image before we discuss the various CT scan signs. The SPL is a fundamental unit at the

ABBREVIATIONS: GGO = ground glass opacity; HRCT = high resolution CT; PJP = *Pneumocystis jirovecii* pneumonia; SPL = secondary pulmonary lobule

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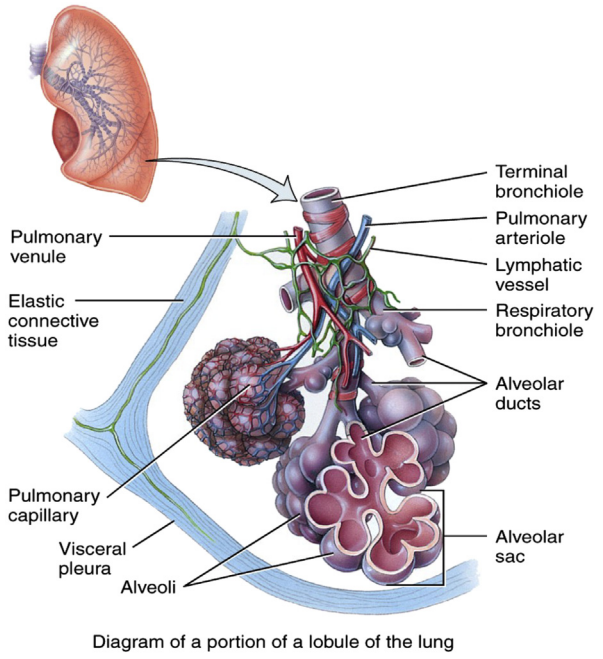


Figure 1 – *Graphic illustrating the structure of a secondary pulmonary lobule. (Reprinted with permission from Tortora and Derrickson.*[1] *© 2009 John Wiley & Sons.)*

subsegmental level of the lung (Fig 1).[1] It is surrounded by fibrous septa on all sides, known as interlobular septa.[2] The SPL is irregularly polyhedral in shape, measuring between 1 and 1.25 cm in the largest dimension and contains approximately 12 pulmonary acini. The pulmonary acini are supplied by the respiratory bronchioles and comprise the largest lung unit that participates in gas exchange. The "lobular" bronchiole (which is a preterminal or terminal bronchiole), the accompanying pulmonary arteriole, and the central lymphatics that run in the peribronchovascular interstitium form the centrilobular or core structure of the SPL. The pulmonary vein and the lymphatic channels, which drain into the subpleural plexus, are contained within the interlobular septa.

HRCT scans of the lung are able to identify the three basic components of the SPL: the lobular parenchyma, the centrilobular structures, and the interlobular septa. These structures can be differentially made prominent by various disease states to form distinct patterns. Some of these patterns have been described as

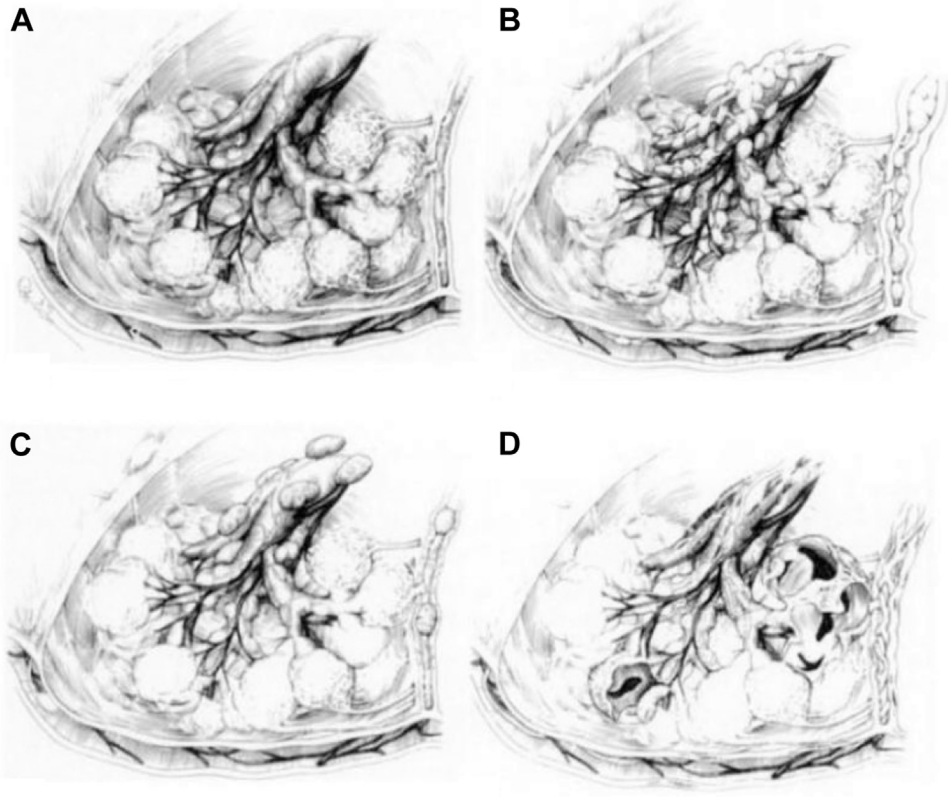


Figure 2 – *A-D, Normal secondary lobule and disease distribution in abnormal lobules. A, Normal. B, Lymphangitic carcinomatosis. C, Sarcoidosis. D, Lymphangioleiomyomatosis. (Reprinted with permission from Bergin et al.*[3]*)*

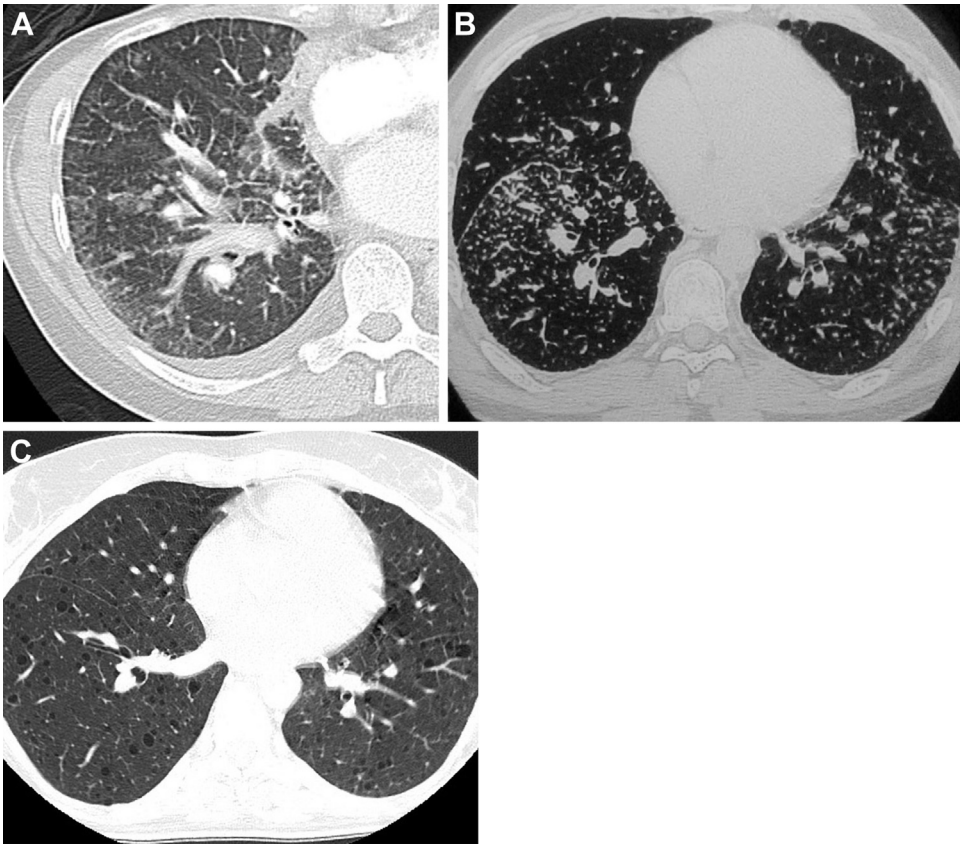


Figure 3 – *A, Lymphangitic carcinomatosis: beaded intralobular septal thickening. (Case courtesy of A. Prof Frank Gaillard, Radiopaedia.org, rID: 8530.) B, Sarcoid: with perilymphatic distribution of nodules. (Case courtesy of Dr Laughlin Dawes, Radiopaedia.org, rID: 9145.) C, Lymphangioleiomyomatosis: intralobular alveolar destruction resulting in multiple parenchymal cysts. (Case courtesy of Dr Lukas Valkovic, Radiopaedia.org, rID: 45448.)*

radiologic "signs," such as the tree-in-bud, crazy paving, and head cheese signs, whereas others have been used to describe pathology associated with specific diseases.

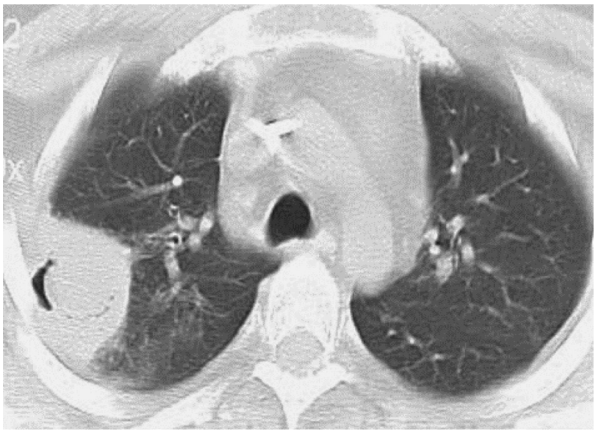


Figure 4 – *Air crescent sign in a patient with invasive aspergillosis.*

Examples include smooth or beaded interlobular septal thickening described in lymphangitic carcinomatosis, irregular perilymphatic distribution of nodules in sarcoidosis, and intralobular cyst formation seen in lymphangioleiomyomatosis (Fig 2, 3A-C).[3]

The chest CT signs described in the present essay can be broadly categorized into four groups based on anatomical distribution: parenchymal, airway, vascular, and pleural-based signs.

Parenchymal

Air Crescent Sign: The air crescent sign has been described as a complete or partial circumferential rim of radiolucent airspace within a parenchymal consolidation or nodular opacity (Fig 4). It has classically been associated with invasive aspergillosis and can be visualized in chest radiographs as well as CT scans.[4] The aspergillus hyphae invade the pulmonary vasculature and cause arterial thrombosis, pulmonary

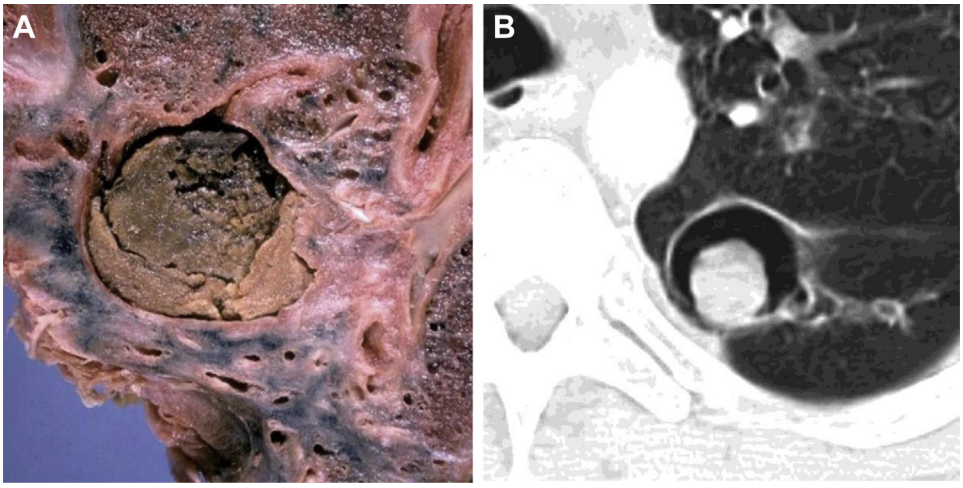


Figure 5 – *A, Gross pathology specimen showing a cut surface of lung with an aspergilloma. (Case courtesy of Dr Yale Rosen, Radiopaedia.org, rID: 8634.) B, CT chest axial cuts showing the Monod sign in a case of pulmonary aspergilloma. (Case courtesy of A. Prof Frank Gaillard, Radiopaedia.org, rID: 8679.)*

infarction, and surrounding hemorrhage. The air crescent is formed as a result of separation of the devitalized necrotic center from the surrounding opaque rim of hemorrhagic tissue. Clinically, in an appropriate setting, presence of an air crescent marks the recovery phase of the disease and portends a favorable prognosis. Gefter et al[5] reported that 67% of patients with acute leukemia and the air crescent sign had increased survival compared with 8% of those without the sign. The air crescent sign can be seen in other conditions such as pulmonary TB, pulmonary abscess, and bronchogenic carcinoma. This sign should not be confused with the Monod sign, described next.

Monod Sign: The Monod sign, first described by Pesle and Monod in 1954,[6] refers to air surrounding a fungal ball in a preexisting pulmonary cavity that falls to a gravity-dependent location of the cavity. It is an important sign that helps distinguish a "mass within a preexisting cavity" such as an aspergilloma (Figs 5A, 5B) vs a "cavitary mass." It is used interchangeably, although incorrectly, with the air crescent sign, which is seen in invasive aspergillosis and indicates a favorable prognosis (Table 1). CT scans can be performed in different positions to elicit mobility of the mass within the cavity.

Halo Sign: The halo sign is a CT scan chest finding describing a solid pulmonary nodule surrounded by a circumferential ground glass opacity (GGO).[7] These have classically been described in angioinvasive fungal infections such as invasive pulmonary aspergillosis (Figs 6A-C) and pulmonary mucormycosis in immunocompromised hosts. Histopathologically, the central nodule represents a focus of pulmonary infarction, and the surrounding GGO corresponds to

TABLE 1] Differences Between the Air Crescent Sign and the Monod Sign

Variable	Air Crescent Sign	Monod Sign
Description	Crescentic or circumferential rim of radiolucent airspace within a parenchymal consolidation	Air surrounding a fungal ball in a preexisting pulmonary cavity
Differential diagnosis	Invasive aspergillosis, bronchogenic carcinoma	Aspergilloma
Mobility of mass	Nonmobile	Mobile mass within the cavity
Positional change	None	Mass gravitates to the dependent areas of the cavity
Patient profile	Usually immunocompromised	Immunocompetent

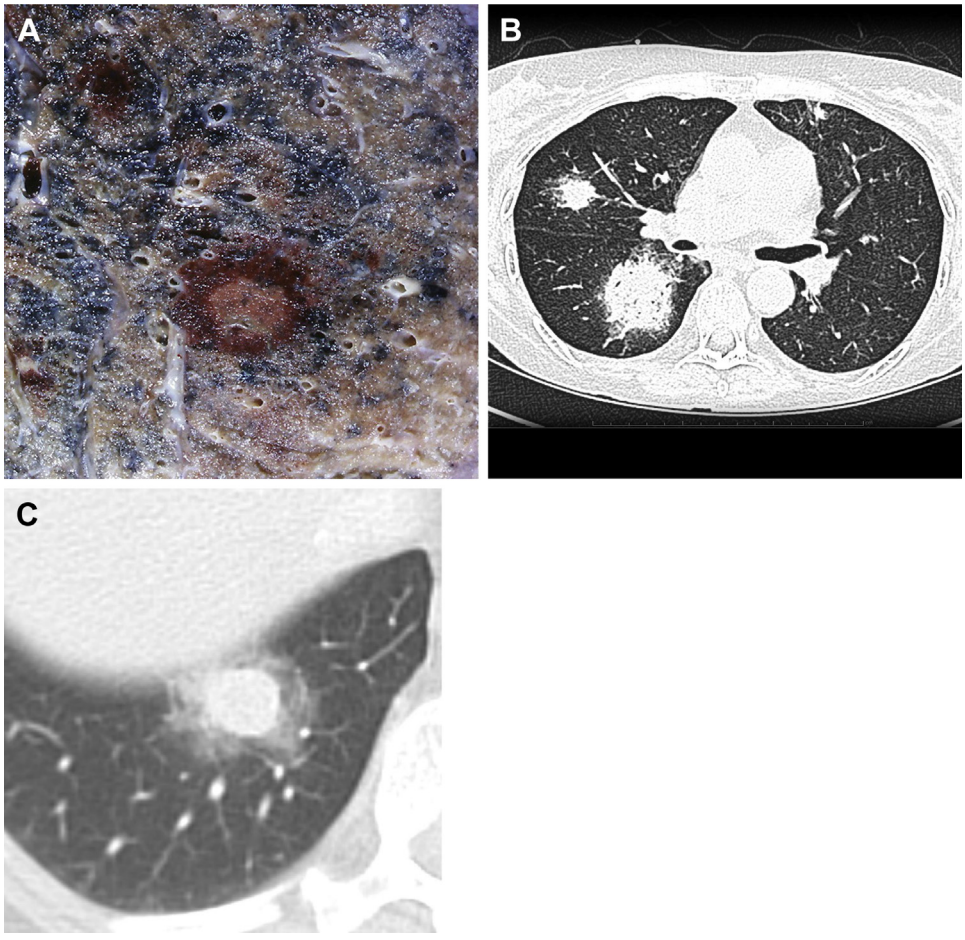


Figure 6 – *A, Gross specimen of lung in a patient with angioinvasive aspergillosis. (Case courtesy of A. Prof Frank Gaillard, Radiopaedia.org, rID: 8538.) B, Halo sign in a patient with invasive aspergillosis. (Case courtesy of A. Prof Frank Gaillard, Radiopaedia.org, rID: 8675.) C, Halo sign in a patient with peritumoral hemorrhage. (Case courtesy of Dr Charlie Chia-Tsong Hsu, Radiopaedia.org, rID: 19972.)*

areas of pulmonary hemorrhage,[8] attributed to the angioinvasive nature of the fungus. The incidence of the halo sign among patients with invasive pulmonary aspergillosis is particularly high during its early stages and tends to disappear over time. Adenocarcinoma in situ can manifest with the halo sign in

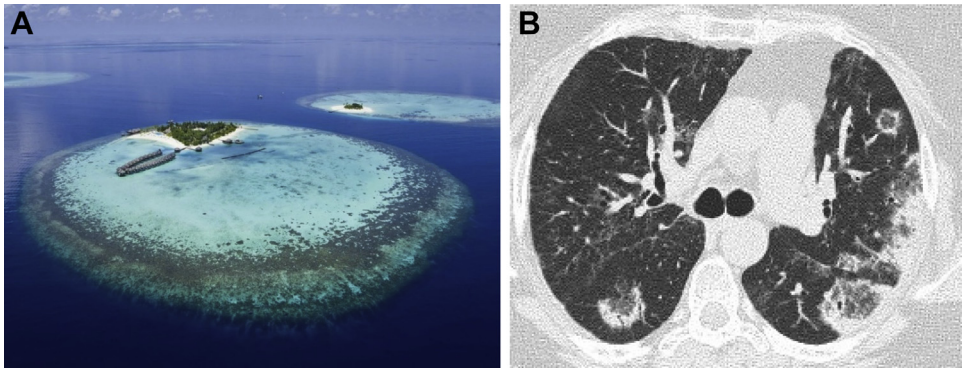


Figure 7 – A, *A coral atoll in the Maldives. (Image courtesy of Steven Heath, The Geographer Online, http://www.thegeographeronline.net.) B, Atoll sign or reverse halo sign in a patient with cryptogenic organizing pneumonia.*

immunocompetent patients.[9] Other noninfectious causes include granulomatosis with polyangiitis, amyloidosis, sarcoidosis, and metastatic cancers.[9,10]

Atoll Sign (Reverse Halo Sign): The atoll sign, also known as the reverse halo sign, is characterized by a central GGO surrounded by crescentic or circumferential rim of dense consolidation. It derives its name due to its similarities to a coral atoll (Fig 7A). It has been classically described in cryptogenic organizing pneumonia but is not specific for the disease (Fig 7B).[11] The central GGO of the reverse halo sign corresponds to alveolar septal inflammation and cellular debris, whereas the peripheral consolidation represents organizing pneumonia within the alveolar ducts.[12] It can also be seen in a wide range of pulmonary diseases, including invasive fungal infections, *Pneumocystis jirovecii* pneumonia (PJP), lymphomatoid granulomatosis, granulomatosis with polyangiitis, lipoid pneumonia, sarcoidosis, and lepidic-predominant adenocarcinoma of the lung.[13]

Cheerios Sign: The Cheerios sign, also called the open bronchus sign, is characterized by a pulmonary nodule with a lucency at its center resembling the Cheerios breakfast cereal (General Mills) (Fig 8A).[14,15] It occurs due to proliferation of neoplastic or nonneoplastic cells around a patent airway, seen in conditions such as lung adenocarcinoma and pulmonary Langerhans cell histiocytosis, respectively (Figs 8B, 8C).[16,17] The Cheerios sign is more commonly seen in the lepidic-predominant adenocarcinoma because it classically maintains the alveolar architecture and luminal patency.[18] This sign can also be occasionally seen in cavitary lesions of the lung, such as fungal infections, primary and metastatic lung cancers, lymphoma, rheumatoid nodules, and granulomatosis with polyangiitis.

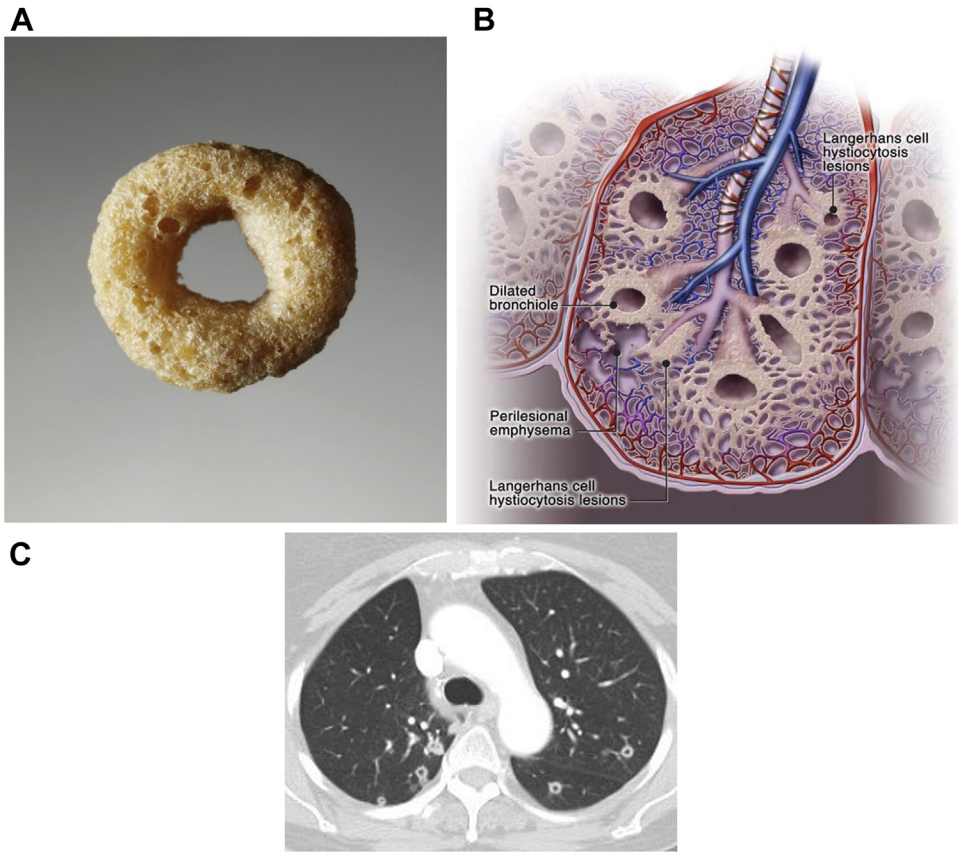


Figure 8 – A, *Photograph of a Cheerios breakfast cereal. (Image courtesy of Evan Dion, www.evandion.com.) B, Artist's rendition of the pulmonary Langerhans cell histiocytosis lesions with proliferation of Langerhans cells around dilated bronchioles, showing the Cheerios sign. (Reprinted with permission from Chou et al.[15] © Wolters Kluwer Health, Inc.) C, Cheerios sign seen on chest CT scan in a patient with biopsy proven pulmonary adenocarcinoma. (Image courtesy of Dr Subha Ghosh.)*

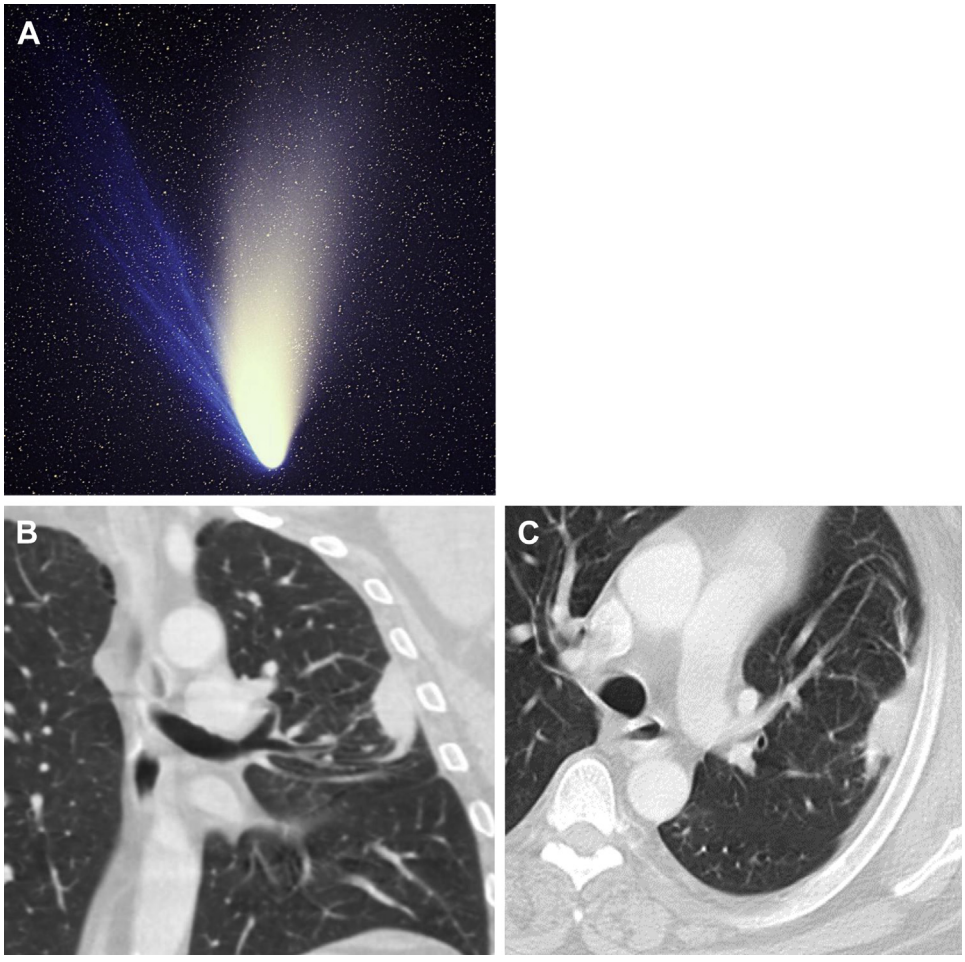


Figure 9 – *A, Image showing comet Hale-Bopp (by E. Kolmhofer, H. Raab; Johannes-Kepler-Observatory, Linz, Austria [http://www.sternwarte.at] [CC BY-SA 3.0 (http://creativecommons.org/licenses/by-sa/3.0)]), via Wikimedia Commons. B and C, Image showing comet tail sign in coronal and axial CT images, respectively, in a patient with rounded atelectasis.*

Comet Tail Sign: The comet tail sign has been classically described in rounded atelectasis of the lung.[19] It consists of a curvilinear opacity that originates from a pleural-based opacity toward the ipsilateral hilum. The opacities resemble a comet tail (Fig 9A) and comprise vessels and adjoining airways that get pulled into a

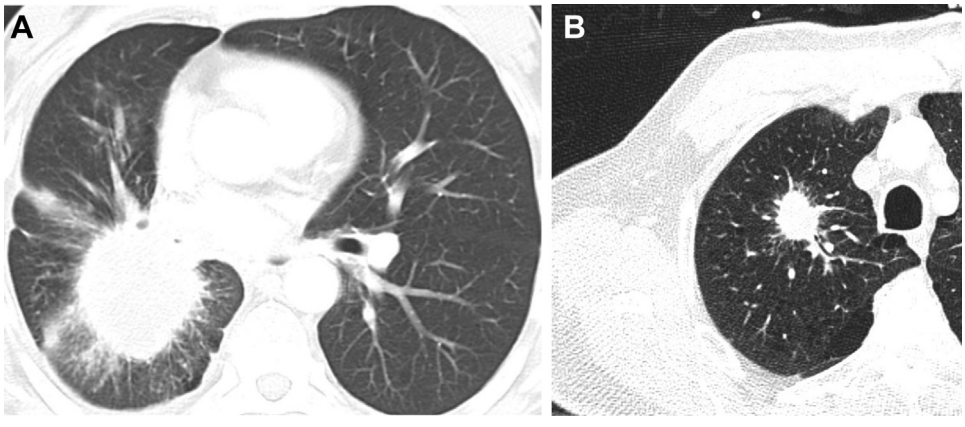


Figure 10 – *A, CT chest scan showing the corona radiata sign in a patient with non-small cell lung cancer. B, CT chest scan showing the corona radiata or sunburst sign in a patient with moderately differentiated squamous cell carcinoma.*

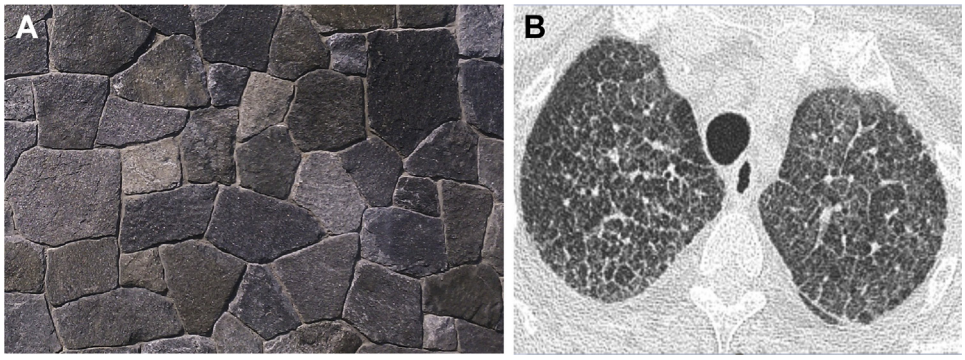


Figure 11 – *A, Graphic depicting stones arranged in a crazy-paving pattern. (Image courtesy of www.stonefarmliving.com.) B, Crazy-paving pattern seen on chest CT scan in a patient with pulmonary alveolar proteinosis.*

mass-like opacity as the lung collapses (Figs 9B, 9C). Overlying pleural thickening is also invariably seen on the CT scan. The bronchovascular bundle can at times be seen entering the mass from all sides and is referred to as the talon sign.[20] Rounded atelectasis of the lung is benign, does not require specific treatment, often reduces in size, and occasionally resolves spontaneously.[21] The main differential diagnosis includes bronchogenic carcinoma.

Corona Radiata Sign: The corona radiata, also called the sunburst sign, is used in reference to a solitary pulmonary nodule or mass (Figs 10A, 10B), with spiculated and irregular margins, and distortion of surrounding blood vessels. It is highly suggestive of a lung malignancy.[22,23] It should be differentiated from the galaxy sign in sarcoidosis, which refers to tiny satellite nodules at the periphery of a pulmonary nodule, giving the appearance of a galaxy. The latter favors a benign diagnosis.

Crazy Paving Sign: Crazy paving of the lung is seen on HRCT images of the lung and represents thickened interlobular septae, often associated with scattered or diffuse GGOs, which indicate a concomitant alveolar filling process.[24] The term "crazy paving" is used because the pattern resembles paths made from broken pieces of stone or concrete (Fig 11A). It is a nonspecific finding, which has been classically described in pulmonary alveolar proteinosis (Fig 11B).[25] It can also be seen in pulmonary edema, lymphangitic spread of malignancy, mucinous adenocarcinoma, sarcoidosis, exogenous lipoid pneumonia, pulmonary hemorrhage, and PJP, among others.[26,27]

Galaxy Sign: The galaxy sign, also called the sarcoid galaxy, is used to describe pulmonary parenchymal nodules seen in sarcoidosis that is composed of several smaller interstitial nodules.[28] The appearance of a

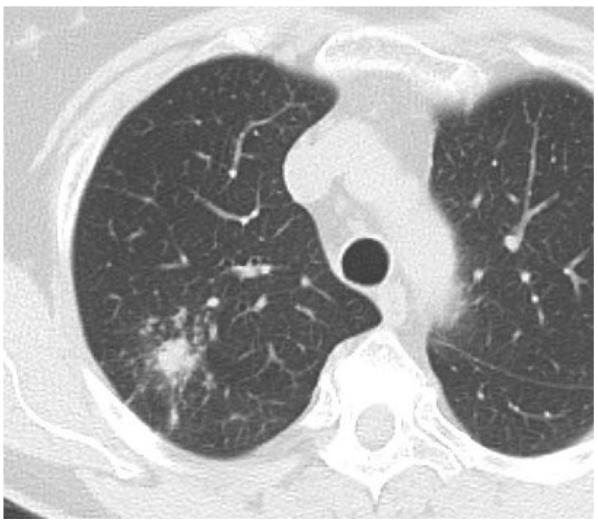


Figure 12 – *CT chest scan demonstrating the galaxy sign in sarcoidosis.*

TABLE 2] Causes of Mosaic Attenuation

Variable	Vessel Size	Inspiration/ Expiration CT Scanning
Small airways disease	Decreased size and number in lucent lung	Air trapping
Pulmonary vascular disease	Decreased size and number in lucent lung	No air trapping
Diffuse infiltrative disease	Similar size and number throughout lung	No air trapping

Reprinted from McLoud and Boiselle.[34]

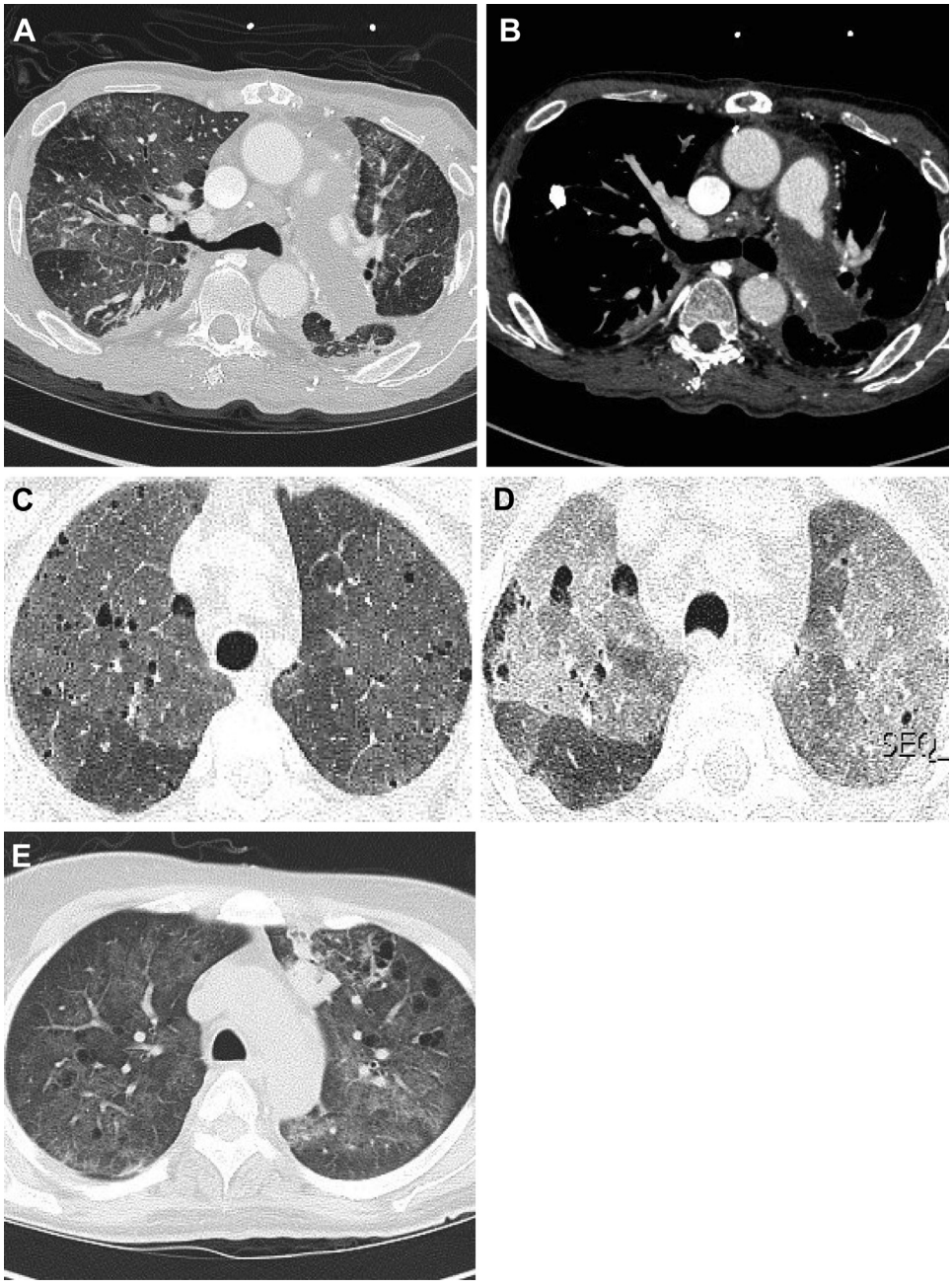


Figure 13 – *A,B, chronic thromboembolic pulmonary disease. CT images showing mosaic perfusion due to thrombus in the main pulmonary artery. C and D, Subacute hypersensitivity pneumonitis. C, Inspiratory films: low attenuation areas showing mosaic perfusion pattern. D, Expiratory film showing air trapping and accentuation of low perfusion areas. E,* Pneumocystis jirovecii *pneumonia: mosaic attenuation due to patchy ground glass opacities.*

central dense mass with tiny peripheral satellite nodules is akin to a galaxy cluster. The unique contribution of a CT scan is to show the innumerable tiny nodules along the edge of the nodule (Fig 12). This sign can also be seen in progressive massive fibrosis and in active pulmonary TB.[29] Clinically, the identification of a galaxy sign favors a benign diagnosis. The satellite nodules must be distinguished from spiculated lung nodules typical of malignancy. The presence or absence of lymphadenopathy can be very useful in this setting. Sarcoidosis causes hilar lymphadenopathy, with or without mediastinal lymphadenopathy, in 95% of patients with the disease.[30] Contrary to this outcome, extensive mediastinal and bilateral hilar lymphadenopathy is rarely seen in non-small cell lung cancer, especially in lesions < 3 cm.[31,32] Calcification within hilar and mediastinal lymphadenopathy also favors sarcoidosis and is rare in untreated malignancy.

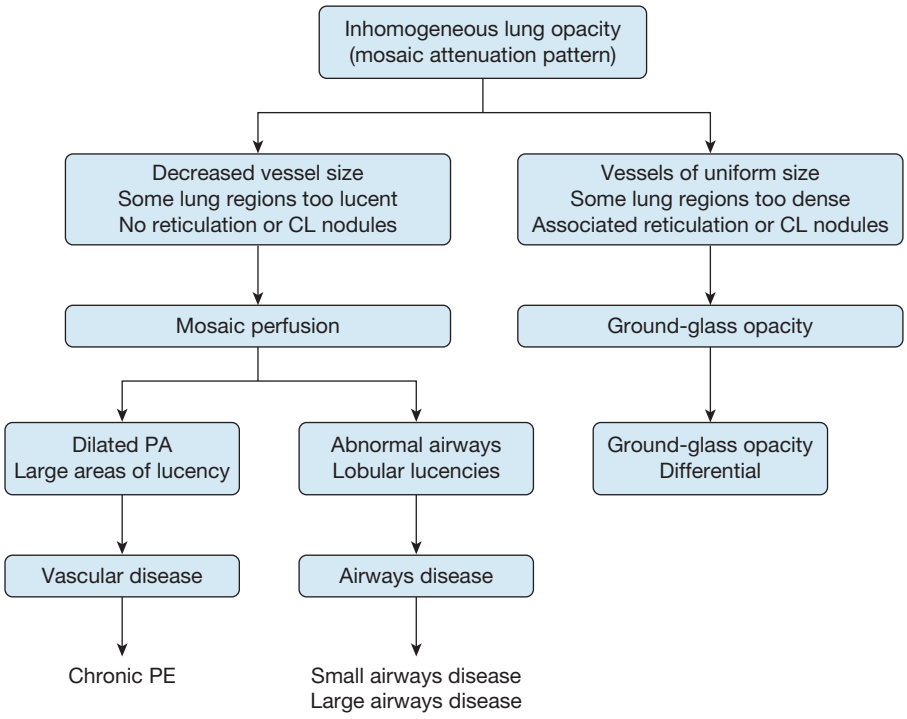


Figure 14 – *Algorithmic approach to mosaic attenuation pattern. CL = centrilobular; PA = pulmonary artery. (Reprinted with permission from Webb et al.*[37] *© Wolters Kluwer Health.)*

Mosaic Attenuation: Mosaic attenuation refers to areas of variable attenuation seen on a chest CT scan in a lobular or multilobular distribution. It derives its name from the word "mosaic," which describes a composition made from different pieces of stone or tiles. It can be seen in three predominantly broad categories of lung diseases: small airways disease, vascular lung disease, and infiltrative lung disease (Table 2).[33,34] In vascular lung disease such as chronic thromboembolic pulmonary disease, there is paucity of vascular markings (both size and number of vessels) in the low attenuation areas, and the term used is "mosaic perfusion" or "mosaic oligemia" (Figs 13A, 13B). In small airways disease such as bronchiolitis obliterans, there is mosaic perfusion in the low attenuation areas; however, these areas are accentuated in a chest CT scan performed during expiration, suggestive of lobular air trapping (Figs 13C, 13D).[35] Infiltrative diseases can present with GGOs in infections such as PJP (Fig 13E), chronic eosinophilic pneumonia, hypersensitivity pneumonitis, and cryptogenic organizing pneumonia. They have a higher attenuation compared with the surrounding normal parenchyma, which has a relatively lower attenuation.[36] It must be reemphasized that air trapping can only be elicited on an expiratory CT film. The algorithmic approach to identifying mosaic lung attenuation on a HRCT scan is shown in Figure 14.[37]

Head Cheese Sign: Head cheese is a type of terrine made from pieces of meat obtained from various parts of different animals, such as a calf or pig (Fig 15A). The head cheese sign is characterized by the juxtaposition of distinct radiographic areas of low, normal, and high attenuation.[38] The CT scan image bears close resemblance to the cut surface of a head cheese and hence the name. It was considered pathognomonic for subacute hypersensitivity pneumonitis (Fig 15B), but, more recently, it has been described with other conditions such as sarcoidosis, respiratory bronchiolitis, and atypical infections (eg, *Mycoplasma pneumoniae*).[39,40] It represents areas of consolidation (high attenuation), interspersed with areas of low attenuation, suggestive of mosaic perfusion and normal lung parenchyma (normal attenuation) typically seen with mixed infiltrative and obstructive conditions such as bronchiolitis. The low attenuation areas typically accentuate on expiratory CT films to denote air trapping within distinctly identifiable secondary pulmonary lobules (Figs 15C, 15D). The areas of consolidation and GGOs seen as high attenuation areas are indicative of the infiltrative parenchymal process accompanying the underlying disease.[41]

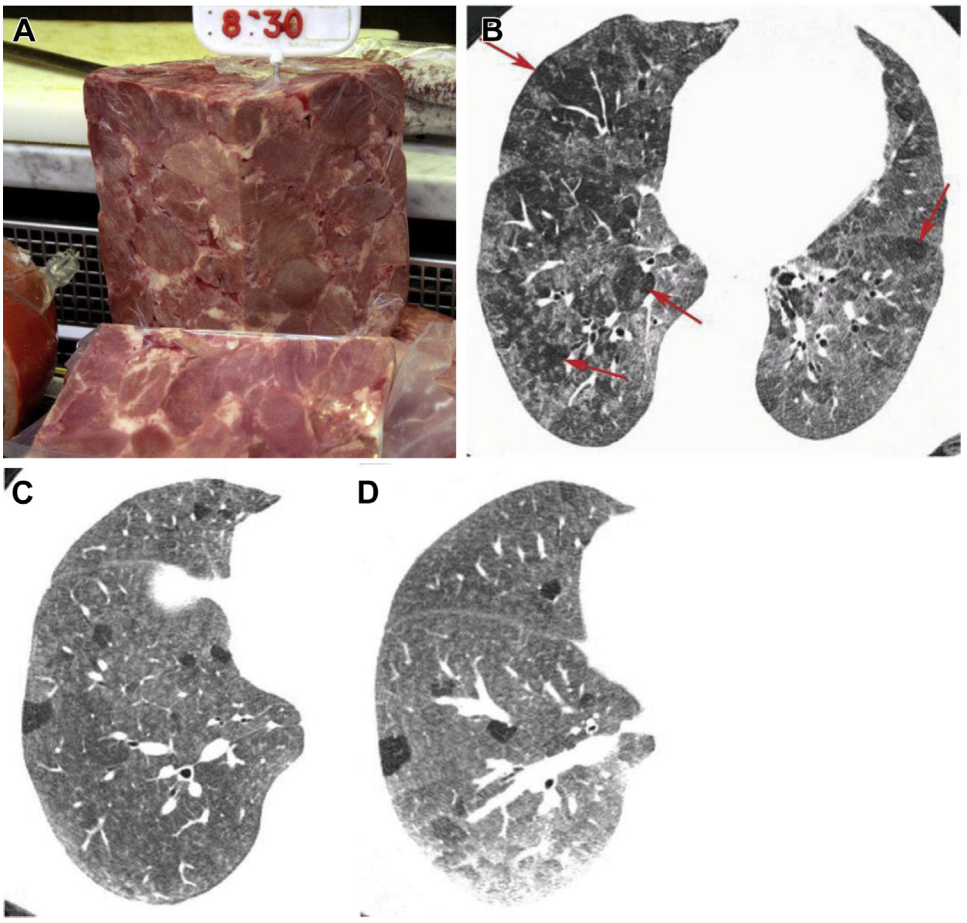


Figure 15 – *A, Graphic showing a cut piece of a head cheese. (Case courtesy of A. Prof Frank Gaillard, Radiopaedia.org, rID: 8767.) B, The head cheese sign seen in a patient with hypersensitivity pneumonitis. Note the areas of ground glass opacities interspersed between normal and hypo-attenuated lung fields. C and D, Head cheese sign in hypersensitivity pneumonitis. Low attenuation areas showing mosaic perfusion on the left and expiratory images demonstrating air trapping on the right.*

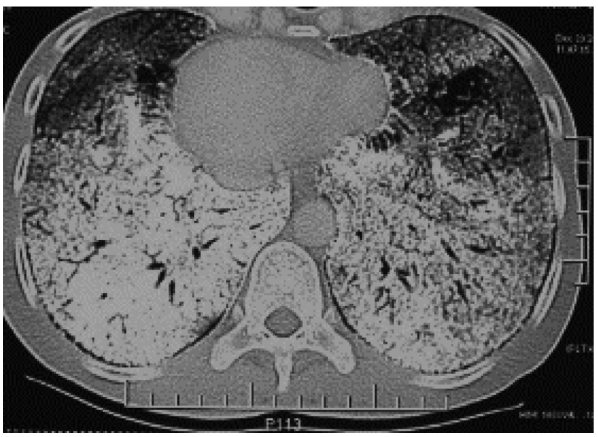


Figure 16 – *Sand storm sign seen in pulmonary alveolar microlithiasis. Note the prominent black pleural line sign.*

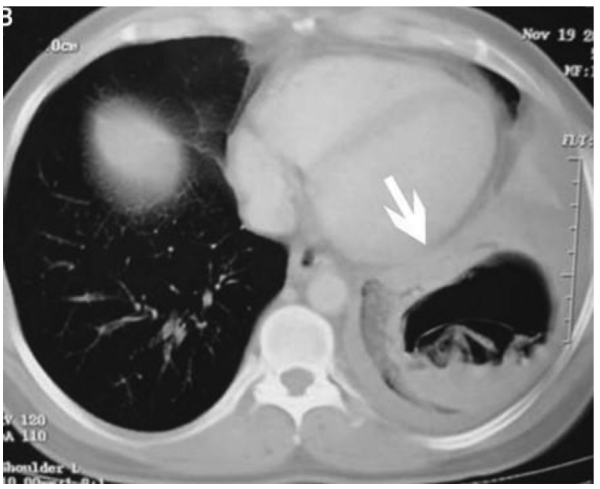


Figure 17 – *Contrast-enhanced CT chest scan showing a cyst in the left lower lobe of the lung containing a freely floating endocyst (the "water lily sign"). (Reprinted with permission from Khanna et al.*[46] *© Copyright 2007 The Medical Journal of Australia)*

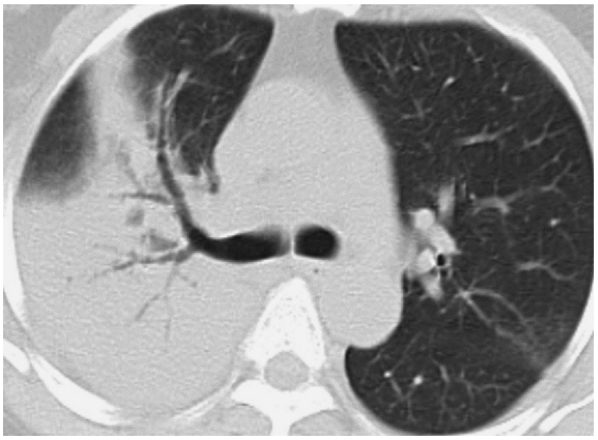


Figure 18 – *CT chest scan showing air bronchograms.*

Sand Storm Sign: The sand storm sign, seen in both chest radiographs and CT scans, has been used to describe diffusely dense micronodular calcifications seen in pulmonary alveolar microlithiasis (Fig 16). Pulmonary alveolar microlithiasis is a rare disease of both sporadic and familial occurrence, characterized by diffuse deposition of calcium phosphate microliths, measuring up to 3 mm (called calcipherites) in the alveolar spaces and along a peribronchial distribution.[42] The pleural margin appears as a black lucent line between the ribs and the surrounding calcified parenchyma. This margin has been described as the black pleural sign. Associated HRCT findings include GGOs, interlobular septal calcifications, "sand storm" appearance, and crazy paving pattern.[43,44]

Water Lily Sign: The water lily sign is also known as the camalote sign. Although rarely seen, it is pathognomonic for cystic echinococcosis, caused by the hydatid tapeworm, *Echinococcus granulosus*.[45] It can be seen on both chest radiographs and chest CT scans. It comprises a hydatid cyst in the lung with a free-floating endocyst, which collapses and floats in the cystic fluid, similar to a water lily (Fig 17).[46] A pleural effusion can be seen in close proximity.

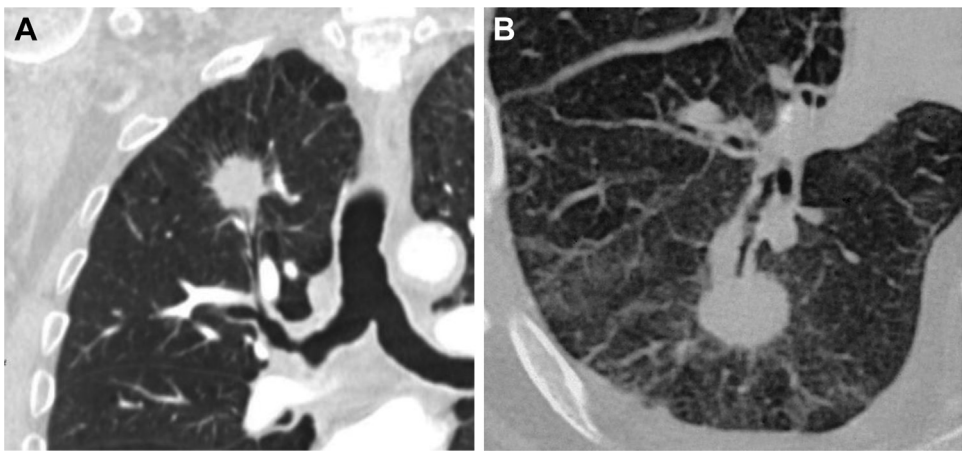


Figure 19 – *A, Bronchus sign seen in the coronal plane with the airway leading into a lung mass, diagnosed as moderately differentiated squamous cell cancer. B, Bronchus sign in a patient with non-small cell lung cancer.*

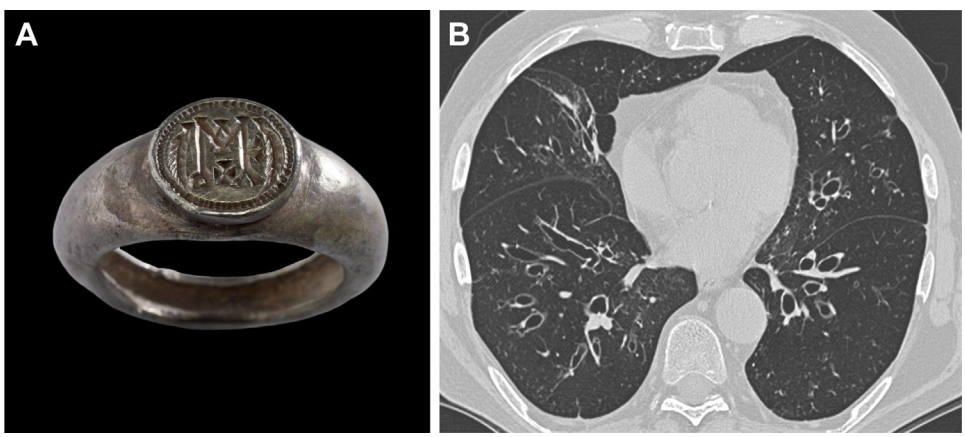


Figure 20 – *A, Image of a signet ring. (Image courtesy Wikimedia Commons.) B, Note classic signet ring sign on axial CT images in a patient with cystic fibrosis. Also note the tram-track sign.*

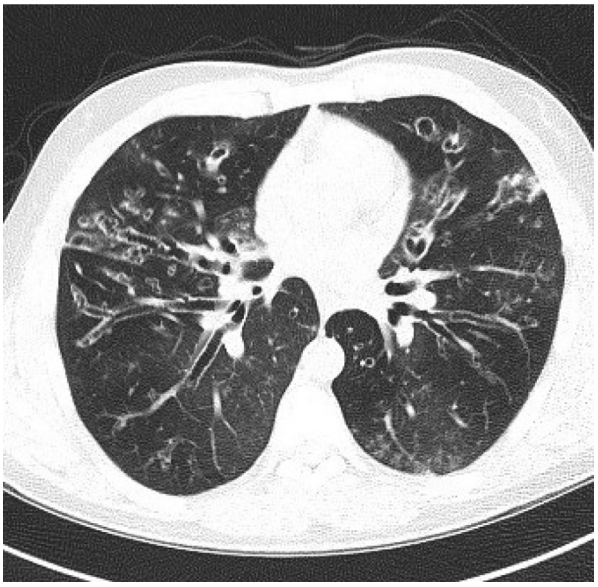


Figure 21 – *Tram-track sign seen in cylindrical bronchiectasis on the chest CT scan in a patient with advanced cystic fibrosis.*

Diagnosis is usually confirmed by positive serologic findings.

Airway

Air Bronchogram Sign: The air bronchogram sign refers to patent airways seen through opacified lung (Fig 18). The airways appear as air-filled, hyperlucent tubular structures made prominent by the opacification of the surrounding alveoli. This sign has been described both in chest radiographs and on CT imaging. It is most commonly seen in consolidative processes of the lung such as pneumonia but can also be seen in pulmonary edema, severe interstitial lung disease,[47] neoplasms such as adenocarcinoma,[48] and in nonobstructive atelectasis. Clinically, the presence of an air bronchogram indicates patency of the bronchial lumen; however, a partial endoluminal obstruction cannot be excluded.

Figure 23 – *CT angiogram seen on the CT chest scan in a patient with pulmonary lymphoma. (Case courtesy of Dr Mohammad Taghi Niknejad, Radiopaedia.org, rID: 21271.)*

Positive Bronchus Sign: The bronchus sign on a chest CT scan is representative of an airway leading directly to a peripheral lung nodule or mass (Figs 19A, 19B).[49] It is a powerful clue in predicting the success of a transbronchial lung biopsy and brushing with endobronchial ultrasound.[49] Gaeta et al[50] reported a 90% success rate of transbronchial biopsy and brushing when a positive bronchus sign was identified at the level of the fourth-order bronchi in this series.

Signet Ring Sign: The signet ring is a commonly described CT chest sign in bronchiectasis. The dilated airway is prominently larger than its accompanying pulmonary artery on axial images, resembling a signet ring (Fig 20A). Normally, the airway and the blood vessel must be of equal caliber. A bronchoarterial ratio > 1 is suggestive of bronchiectasis.[51,52] Associated findings include the tram-track sign, which represents dilated, nontapered bronchi extending into the lung periphery (Fig 20B).

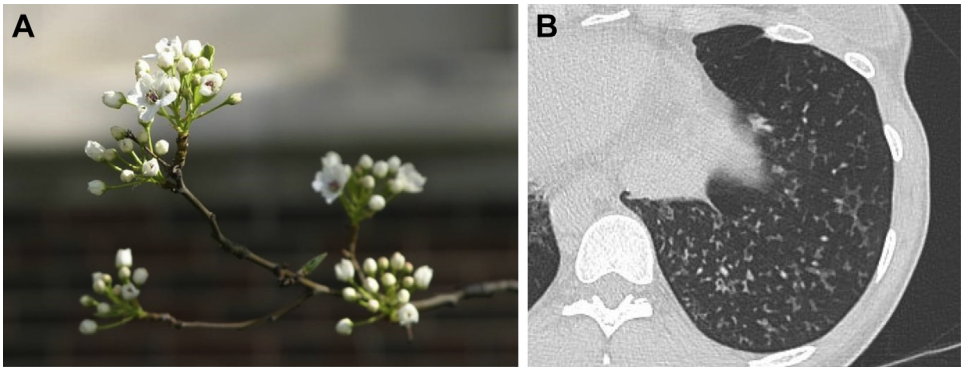


Figure 22 – *A, Image showing a tree branch with buds. (Case courtesy of Dr Ruslan Esedov, Radiopaedia.org, rID: 8231.) B, Tree-in-bud opacities seen on the chest CT scan in a patient with* Mycobacterium avium *infection.*

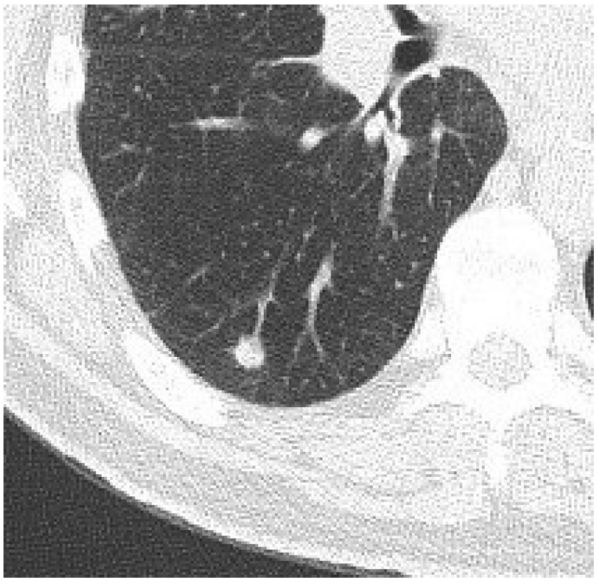


Figure 24 – *Feeding vessel sign in a patient with metastatic disease of the lung.*

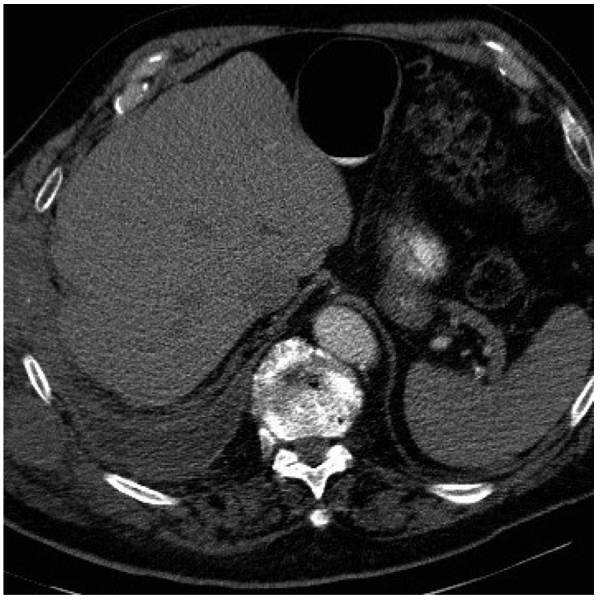


Figure 26 – *CT chest scan showing the split pleura sign in a patient with empyema.*

Tram-track Sign: The tram-track sign has been described in both chest radiographs and chest CT scans and refers to the parallel, nontapering airways seen extending to the lung periphery in cylindrical bronchiectasis.[53] The bronchial walls are always thickened, denoting airway inflammation, and accompanying radiographic findings include the signet ring sign on cross-sectional view. These signs are seen in diseases such as cystic fibrosis (Fig 21), interstitial lung disease, allergic bronchopulmonary aspergillosis, and congenital disorders such as Kartagener's syndrome and ciliary dysmotility syndrome.[54,55]

Tree-in-bud Sign: The tree-in-bud sign refers to the presence of multiple centrilobular nodules arranged in a linear branching pattern, as in buds on a tree (Fig 22A). Clinically, the tree-in-bud pattern is indicative of endobronchial spread of inflammation or bronchiolar infection in the vast majority of cases. This feature is best appreciated on HRCT images. They are typically seen within 1 cm of the pleural surface and are between 2 and 4 mm in size. The sign was first described in endobronchial tuberculosis, but is now recognized in a variety of lung disorders.[56] Focal bronchiolitis is the most commonly encountered pattern.[57] Infections such as nontuberculous mycobacteria (Fig 22B) and viral and

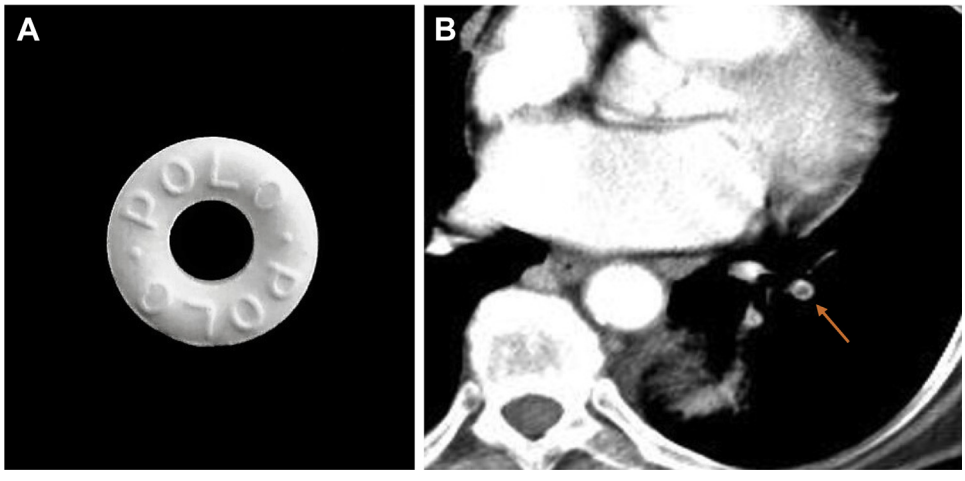


Figure 25 – *A, Image of a Polo mint (Nestlé). (Image courtesy © 2016 Shine Photography.) B, CT scan with contrast showing the Polo mint sign. (Case courtesy of Dr Prashant Mudgal, Radiopaedia.org, rID: 11839.)*

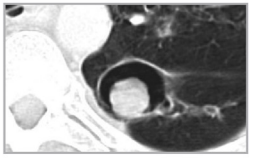
TABLE 3] Tabular Summary of Common CT Signs on Pulmonary Imaging

Air crescent sign

- Crescentic or circumferential rim of radiolucent airspace within a parenchymal consolidation or nodular opacity
- DDx: Invasive aspergillosis, bronchogenic Ca

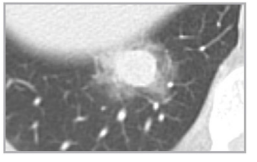
Monod sign

- Air surrounding a fungal ball in a preexisting pulmonary cavity.
- DDx: Aspergilloma



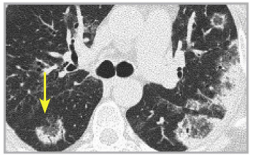
Halo sign

- SPN or mass surrounded by a circumferential GGO
- DDx: invasive pulm aspergillosis, pulm mucormycosis, GPA, amyloidosis, sarcoidosis, mets to the lung



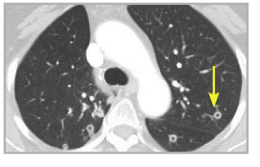
Atoll sign (reverse-halo sign)

- Central GGO surrounded by a crescentic or circumferential denser consolidation
- DDx: COP, IFI, PJP, LG, GPA, lipoid pna, sarcoidosis, paracoccidioidomycosis



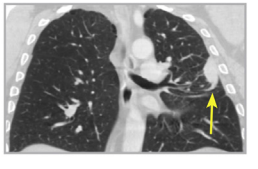
Cheerio sign (open bronchus sign)

- Pulmonary nodule with a central lucency
- DDx: Pulm adeno Ca, PLCH, primary and metastatic lung malignancy, rheumatoid nodules, GPA



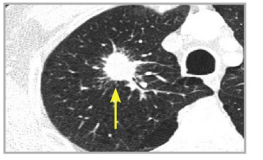
Comet tail sign

- Curvilinear pleural based opacity directed towards the ipsilateral hilum
- DDx: Rounded atelectasis



Corona radiata (sunburst sign)

- SPN or mass, with spiculated and irregular margins
- DDx: Bronchogenic Ca

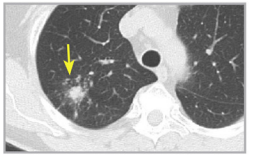


Crazy paving sign

- Thickened interlobular septa in a background of diffuse GGO's.
- DDx: PAP, pulm edema, lymphangitic spread of malignancy, pulm mucinous adeno Ca, sarcoidosis, lipoid pna, pulm hge, ARDS, PJP

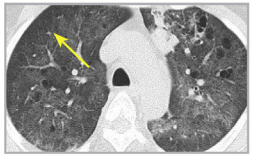
Galaxy sign

- Coalescent granuloma with a central dense mass and tiny peripheral satellite nodules
- DDx: Sarcoidosis, progressive massive fibrosis, active pulm TB.



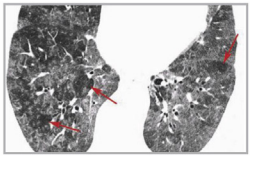
Mosaic attenuation

- Variable attenuation seen on a chest CT in a lobular or multilobular distribution.
- DDx: BO, CTEPH, PJP, CEP, HP, COP



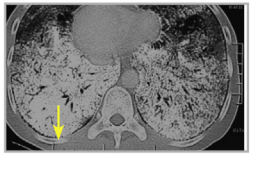
Head cheese sign

- Juxtaposition of distinct radiographic areas of low, normal and high attenuation
- DDx: sub-acute HP, sarcoidosis, RB, Mycoplasma pna



Sand storm sign

- Diffusely dense pulmonary micronodular calcifications. Note the black pleural line sign (arrow)
- DDx: PAM

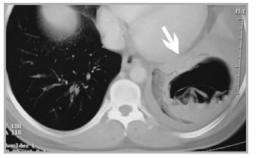


(Continued)

TABLE 3] *(Continued)*

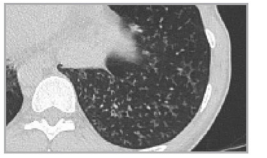
Water lily sign (Camalote sign)

- Hydatid cyst in the lung with a free-floating endocyst
- DDx: Hydatid cyst of the lung



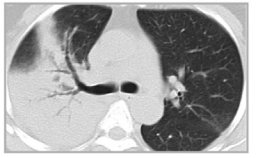
Tree-in-bud sign

- Multiple centrilobular nodules arranged in a linear branching pattern.
- DDx: NTM, atypical pna, viral bronchiolitis, aspiration pneumonitis



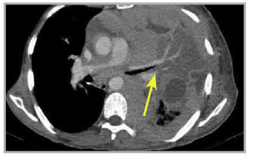
Air bronchogram sign

- Patent airways surrounded by opacified lung
- DDx: pna, pulm edema, severe ILD, pulm infarction, pulm adeno Ca, non-obstructive atelectasis



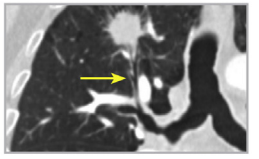
CT angiogram sign

- Prominent pulm vessels traversing through an area of prenchymal consolidation
- DDx: Pulm mucinous adeno Ca, pulm lymphoma, post-obstructive pna



Bronchus sign

- Airway leading directly to a peripheral lung nodule or mass
- DDx: Bronchogenic Ca

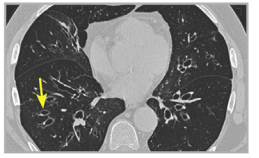


Feeding vessel sign

- Distinct pulmonary vessel leading into a lung nodule or mass.
- DDx: Septic emboli, pulm infarction, mets to the lung, pulm AVM, GPA

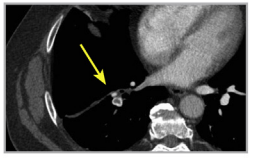
Signet ring sign

- Prominently dilated airway compared to its accompanying pulm vessel.
- DDx: Bronchiectasis



Polo mint sign

- Partial filling defect in a blood vessel surrounded by a rim contrast material in a CT angiogram.
- DDx: PE, portal vein thrombosis.



Tram track sign

- Parallel, non-tapering airways, extending to the lung periphery.
- DDx; Cylindrical or traction bronchiectasis, CF, ILD, ABPA Kartagener's syndrome

Split pleura sign

- Contrast enhancement of the parietal and visceral pleura, separated by an exudative effusion
- DDx: Empyema, malignant effusions, post-talc pleurodesis, mesothelioma

Abbreviations:
ABPA=allergic bronchopulmonary aspergillosis,AIP=acute interstitial pna,AP=anterior-posterior,ARDS=acute respiratory distress syndrome,AVM=arteriovenous malformation,BO=bronchiolitis obliterans,CEP=chronic eosinophilic pneumonia,CF=cystic fibrosis,COP=cryptogenic organizing pneumonia,COPD=chronic obstructive pulmonary disease,CT=computed tomography,CTEPH=chronic thromboembolic pulmonary disease,Ca=carcinoma,DDx=differential diagnosis,DIP=desquamative interstitial pna,FB=foreign body,GGO=ground glass opacity,GPA=granulomatosis with polyangitis,HP=hypersensitivity pneumonitis,hge=hemorrhage,IFI=invasive fungal infections,ILD=interstitial lung disease,LG=lymphomatoid granulomatosis,NSIP=non-specific interstitial pna,NTM=non-tuberculous mycobacteria infection.,PAM=pulmonary alveolar microlithiasis,PAP=pulmonary alveolar proteinosis,PE=pulmonary embolism,PJP=Pneumocystis jirovecii pneumonia,PLCH=pulmonary Langerhans cell histiocytosis,mets=metastasis,pna=pneumonia,pulm=pulmonary,RB=respiratory bronchiolitis,RCC=renal cell carcinoma,SPN=solitary pulmonary nodule,TB=tuberculosis,UIP=usual interstitial pneumonia.

aspiration pneumonia—suggested by the dependent distribution of tree-in-bud opacities—comprise the most common etiologies.

Vascular

CT Angiogram Sign: The CT angiogram sign is seen on contrast-enhanced CT scans of the chest and refers to prominent branching pulmonary vessels traversing through a homogeneous low attenuation area of lung consolidation.[58] It was originally described in mucinous adenocarcinoma of the lung and was thought to be 92.3% specific according to one series. More recently, this theory has been challenged, with similar findings reported in pulmonary lymphoma (Fig 23),[59] postobstructive pneumonia, and pulmonary edema. On a histologic note, the surrounding low attenuation consolidation was attributed to mucin-containing alveolar airspaces, specifically in reference to invasive mucinous adenocarcinoma.

Feeding Vessel Sign: The feeding vessel sign is a chest CT finding that consists of a distinct pulmonary vessel leading into a lung nodule or mass (Fig 24). It was originally described in septic emboli and was considered very specific, with a prevalence of 67% to 100% in various case series.[60-62] In addition to the feeding vessel sign, associated findings include pulmonary nodules and wedge-shaped subpleural opacities with or without cavitation. The sign has also been described in pulmonary infarctions, metastasis, and pulmonary arteriovenous malformations.[63] More recently, studies using multidetector CT scans have shown that some of these vessels pass around the nodule instead of entering it, making this sign less specific.[64]

Polo Mint Sign: The Polo mint (Nestlé) sign is used to describe a partial filling defect in a blood vessel surrounded by a rim of contrast material in a CT angiogram on images acquired perpendicular to the long axis of a vessel.[65] This appearance closely resembles a Polo mint, which is a popular candy (Fig 25A) also referred to as the "mint with a hole." This sign was described with reference to pulmonary embolism (Fig 25B), but it can be seen in venous thrombosis at other sites such as portal vein thrombosis.

Pleural

Split Pleura Sign: The split pleura sign is evident on a contrast-enhanced CT scan of the chest. It is seen in empyema and in some malignant effusions. It is considered to be one of the most reliable CT signs to differentiate an empyema from a lung abscess.[66] The split pleura sign is formed due to contrast enhancement of the parietal and visceral pleura, separated by the exudative effusion, as a result of fibrin deposition along the opposing pleural surfaces and ingrowth of blood vessels (Fig 26).[66] It is also described in malignant effusions, especially after talc pleurodesis, and mesothelioma.[67,68]

Conclusions

This article attempts to highlight some of the common chest CT signs that pulmonologists are likely to encounter in their practice (Table 3). With the increasing trend of using chest CT scans as an imaging tool to diagnose lung diseases, it is of vital importance to know and recognize these signs, not only to diagnose but also to exclude other diseases. With appropriate clinical and laboratory correlation, many of these signs can be pathognomonic for a particular disease entity. Even when they are not, the pattern recognition approach can definitely help in narrowing the differential diagnosis. We emphasize that pattern recognition is the key, and this pictorial essay should serve as a guide to help establish a correct diagnosis.

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