The spectrum of diseases associated with crazypaving pattern

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Learning objectives

To identify a crazy-paving pattern appearance on high-resolution CT.

To review the conditions associated with crazypaving pattern and the key radiological findings which may lead to correct diagnosis.

Background

The crazy-paving pattern is a common finding at thin-section computed tomography (CT) of the lungs. The term crazy-paving is used because the sign resembles the appearance of paths made with broken pieces of stone or concrete (Fig 1).

Crazy-paving pattern consists of scattered or diffuse ground-glass attenuation with superimposed interlobular septal thickening and intralobular lines.

Ground-glass opacity is defined as a hazy increase in lung density with preservation of airway and vessel margins. Ground-glass opacity occurs when there is a mild decrease in the amount of air in the airspaces and a filling of the airspaces with fluid, cells or other material, thickening of the alveolar walls or thickening of the interstitium.

The linear component of this pattern can be caused by a thickening of the interlobular septa (septal lines) and a thickening of the intralobular septa, the intralobular interstitium (intralobular reticular pattern and intralobular branching lines) or a linear deposition of material within the airspaces at the borders of the acini (periacinar pattern) Fig 1- Fig 4.

The crazy-paving pattern was initially described as a pathognomonic sign of alveolar proteinosis; however, nowadays, this pattern has been reported in a variety of acute and chronic diseases. This finding has a variety of causes, including infectious, neoplastic, idiopathic, inhalational, and sanguineous disorders. Specific disorders that can cause the crazypaving pattern include Pneumocystis jirovecii pneumonia, mycoplasma pneumonia, obstructive pneumonia, tuberculosis, adenocarcinoma in situ, pulmonary alveolar proteinosis, sarcoidosis, nonspecific interstitial pneumonia, organizing pneumonia, exogenous lipoid pneumonia, adult respiratory distress syndrome, and pulmonary hemorrhage syndromes Table 1. Knowledge of the many causes of this pattern can be useful in preventing diagnostic errors. In addition, although the causes of this pattern are frequently indistinguishable at radiologic evaluation, differences in the location of the characteristic attenuation in the lungs, as well as the presence of additional radiologic findings, the patient's history, and the clinical presentation, can often be useful in suggesting the appropriate diagnosis.
In this poster, we review the most important entities that can manifest as the crazypaving pattern at thin-section CT. Where appropriate, the pathologic basis for this appearance is emphasized. Helpful clues for appropriately narrowing the differential diagnosis and for directing patient care are discussed.

**Infectious**

**Pneumocystis jirovecii**

*Pneumocystis jirovecii* pneumonia is a common pulmonary infection in the severely immunocompromised patient. Symptoms include dry cough, dyspnea, and low-grade fever. As described by Rossi et al. histologic features contributing to the ground-glass attenuation include the foamy nature of the alveolar exudates and thickening of the alveolar walls by edema and cellular infiltrates.

**Chest X ray**

- Chest radiographs are normal in up to 18% of patients.
- The typical radiographic manifestations are bilateral, perihilar reticular and poorly defined ground-glass opacities with superimposition of lines, which can be associated with interlobular septal thickening, which often progress to alveolar consolidation in 3-4 days.

**Highresolution CT**

- Usually reveals patchy groundglass opacities central, perihilar, or upper lobe predominance that can be associated with interlobular septal thickening and reticulation (Fig 6).
- Thick-walled septate cavities; thin-walled cysts
- Consolidation
- Small nodules, centrilobular or diffuse
- Bronchiectasis or bronchiolectasis

**Idiopathic Disorders**
Pulmonary alveolar proteinosis

Initially described in 1958, pulmonary alveolar proteinosis manifests as filling of the alveoli by a proteinaceous material that is positive at periodic acid-Schiff staining and rich in lipid, in association with an inflammatory response in the adjacent interstitium. Pulmonary alveolar proteinosis is most common in adults between 20 and 50 years of age, although it has been reported in a wide range of ages. Dyspnea and nonproductive cough are the most common associated symptoms, whereas pleuritic chest pain, malaise, and low-grade fever are less common. The diagnosis is established with bronchoalveolar lavage (Fig 8).

Chest X ray

- The classic radiographic finding is bilateral, symmetric alveolar consolidation or ground-glass opacity, particularly in a perihilar or hilar distribution resembling pulmonary edema.

High-resolution CT

- Typically shows diffuse ground-glass opacities with superimposed intra- and interlobular septal thickening, often in polygonal shapes representing the secondary pulmonary lobule.

Sarcoidosis

Sarcoidosis is a systemic entity characterized by the development of noncaseating granulomatous inflammation. Although the most common parenchymal findings include irregular thickening of the bronchovascular bundles and small nodules along vessels, alveolar sarcoidosis can manifest as ground-glass attenuation and crazy-paving attenuation (Fig 9). The linear pattern is caused by interstitial fibrosis.

Nonspecific interstitial pneumonia

Nonspecific interstitial pneumonia (NSIP) is a term used to describe interstitial inflammation and fibrosis with temporal and spatial uniformity that does not fulfill clinicopathologic criteria for usual interstitial pneumonia, desquamative interstitial pneumonia, or acute interstitial pneumonia. The initial concept of NSIP as a mixture of entities has evolved into the concept of NSIP as a clinicopathologic entity. The clinical presentation is similar to that of interstitial pulmonary fibrosis, although NSIP is associated with a much better prognosis.
Chest X ray:
Chest radiographic findings of bilateral pulmonary opacities, which are mainly localized in the middle and lower zones, are the predominant feature.

High-resolution CT:
- The most common CT abnormality is ground-glass opacities.
- The ground-glass opacities is usually bilateral and symmetric with a tendency to subpleural and basal predominance.
- Other findings include consolidation and irregular reticular lines that can be superimposed on a background of ground-glass attenuation (Fig 10).
- Honeycombing is typically absent; this characteristic can be useful in narrowing the differential diagnosis with the other interstitial pneumonias.

Organizing pneumonia

Organizing pneumonia is a chronic inflammatory process characterized by focal plugs of granulation tissue (Masson bodies) in the lumina of distal small airways, often extending into the alveolar spaces, associated with intraalveolar foamy macrophages and an interstitial cellular response. Most cases of organizing pneumonia are idiopathic (cryptogenic organizing pneumonia). An association with collagen-vascular diseases (rheumatoid arthritis, mixed connective-tissue disease), infection, and toxic effects of drugs (bleomycin, methotrexate, cyclophosphamide, gold salts, topotecan, amiodarone) has been reported. Patients usually present with cough, dyspnea, fever of several weeks duration, and leukocytosis. Response to steroid therapy is typical.

Chest X ray:
- Chest radiographs show scattered and asymmetric consolidation bilaterally.
- In over one-half of patients, the consolidation is predominantly peripheral.

High-resolution CT:
- Show scattered and asymmetric consolidation bilaterally.
- In over one-half of patients, the consolidation is predominantly peripheral.
- Shows commonly subpleural as well as peribronchovascular consolidation.
- The crazy-paving pattern is uncommon (Fig 11).

**Inhalational Disorders**

**Exogenous lipoid pneumonia**

Exogenous lipoid pneumonia is a pulmonary disorder resulting from chronic aspiration or inhalation of animal, vegetable, or petroleum-based oils or fats. Predisposing factors such as structural abnormalities of the pharynx, esophageal disorders (achalasia, Zenker diverticulum, hiatus hernia, and reflux), neurologic defects, and chronic illness are common. However, in many cases, no predisposing condition is found. Histopathologically, exogenous lipoid pneumonia manifests acutely as intraalveolar macrophages containing abundant cytoplasmic lipoproteinaceous material within normal-appearing alveoli. Subacute manifestations include larger vacuoles within the alveoli, often surrounded by macrophages, and inflammatory infiltrates of alveolar walls and interlobular septa. Repeated episodes of aspiration can result in pulmonary fibrosis. Symptoms include cough, mild fever, shortness of breath, and chest discomfort.

Diagnosis can be difficult, since many patients do not recall a history of ingestion or inhalation of mineral oil substances. Bronchoalveolar lavage, transbronchial biopsy, or open lung biopsy combined with a history of oil ingestion and radiographic studies are usually diagnostic (Fig 13).

*Chest X ray:*

- Usually nonspecific, demonstrating bilateral lower-lobe air-space opacities, mixed alveolar and interstitial opacities.

- Occasionally poorly marginated focal masslike lesions that mimic pulmonary neoplasms.

*High-resolution CT:*

- Usually reveals consolidation that is characteristically low in attenuation (-35 to -75 HU), indicating the presence of lipid deposition.

- Exogenous lipoid pneumonia can also manifest as geographic ground-glass opacities associated with interlobular septal thickening within areas of ground-glass attenuation (Fig 12).

**Hypersensitivity pneumonitis**
Hypersensitivity pneumonitis, also known as extrinsic allergic alveolitis, is an allergic lung disease caused by the inhalation of antigens contained in a variety of organic dusts.

Histologic abnormalities are alveolar interstitial thickening by mononuclear infiltrate, bronchiolitis (small bronchioles down to the proximal respiratory bronchioles) and small granulomas in the peribronchiolar interstitium. Proteinaceous exudates may be present.

**High-resolution CT:**
- Patchy, diffuse ground-glass opacities
- Ground-glass centrilobular nodules
- Air trapping and mosaic perfusion
- Centrilobular branching lines
- Upper lobes can be more involved
- Intralobular reticular pattern, irregular interlobular septal thickening, traction bronchiectasis and honeycombing when progressing to chronic stage

**Sanguineous Disorders**

**Adult respiratory distress syndrome**

Adult respiratory distress syndrome is a form of pulmonary edema characterized by refractory hypoxemia and respiratory distress. Numerous causes have been reported, including shock, contusion, infection, sepsis, aspiration, drug abuse, and inhalation of noxious substances. Diagnosis is based on impaired diffusion capacity (Dlco), reduced compliance of the lung, and typical radiologic findings. Histologic features include edema of the alveoli and perivascular spaces with filling of the alveoli by a protein-rich fluid.

**Chest X ray:**
- Typically show bilateral homogeneous pulmonary opacities.
- Cardiomegaly and upper-lobe blood diversion are usually absent in these patients.

**High-resolution CT:**
- Reveals bilateral extensive ground-glass opacity with or without consolidation that tend to involve mainly dependent lung regions
- Other findings such as reticular and linear attenuation can be seen (Fig 14).
Adult respiratory distress syndrome may progress to architectural distortion, consolidation with bronchiectasis, and honeycombing.

**Pulmonary Hemorrhage Syndromes**

Pulmonary hemorrhage syndromes include a wide spectrum of diseases, including idiopathic pulmonary hemosiderosis, Wegener granulomatosis, Churg-Strauss syndrome, Goodpasture syndrome, collagen-vascular disease (systemic lupus erythematosus, rheumatoid arthritis, systemic sclerosis, polymyositis, and mixed connective-tissue disease), drug-induced coagulopathy, and hemorrhage associated with malignancy. Diffuse parenchymal bleeding may be secondary to either hemodynamic modifications of the capillary pulmonary blood flow or pathologic changes in the alveolar wall. Patients typically present with hemoptysis, dyspnea, and anemia. The diagnosis can be established by recovery of blood with bronchoalveolar lavage or evaluation of the iron content of alveolar macrophages. Diffuse pulmonary hemorrhage occurs in up to 2% of patients with systemic lupus erythematosus, typically in the context of established disease associated with extrapulmonary manifestations such as glomerulonephritis. Half of the patients do not have hemoptysis at presentation.

Chest radiographic and CT manifestations are symmetric acinar and ground-glass opacities or attenuation and the crazy-paving pattern (Fig 15).

**Neoplasm**

**Adenocarcinoma in situ**

Adenocarcinoma in situ formally known as bronchoalveolar carcinoma and minimally invasive adenocarcinoma in lung are relatively new classification entity. The terms BAC and mucinous and non-mucinous BAC are no longer used. Adenocarcinoma in situ (AIS) (# 3 cm formerly BAC) has a number of subtypes. The most common subtype is non-mucinous and rarely mucinous or mixed subtypes. Histology pattern - no growth patterns other than lepidic and no feature of necrosis or invasion. Minimally invasive adenocarcinoma (MIA) # 3 cm, describes small solitary adenocarcinomas with either pure lepidic growth or predominant lepidic growth with # 5 mm of stromal invasion.

Two invasive adenocarcinomas previous termed non-mucinous and mucinous BAC are no longer used.
Lepidic predominant adenocarcinoma describes invasive adenocarcinoma with a predominant lepidic pattern with > 5 mm invasion. Formerly known as non-mucinous BAC.

Invasive mucinous adenocarcinoma is a variant invasive adenocarcinoma previously known as mucinous BAC.

Chest X ray:
- Ill-defined consolidation or ground-glass opacities that occur in a focal or multilobar distribution.
- Lymphadenopathy and pleural effusion occur occasionally.

High-resolution CT
- The appearance of bronchoalveolar carcinoma on CT depends on its pattern of growth
- Alveolar consolidation and ground-glass opacities, which occasionally manifest as a crazy-paving pattern (Fig 16).
- Peripheral nodule, commonest appearance typically solitary and well circumscribed the nodule may be surrounded by a halo of ground glass opacity the so called fried egg sign
- Pseudocavitation (presence of bubble like lucencies) is recognised
- Overt cavitative changes rarely occur (~ 7 %)
- Cavitating pulmonary metastases may occur (Cheerios sign)
- Hilar, mediastinal adenopathy and pleural effusion are uncommon
- Air bronchograms may be seen (also known as open bronchus sign)
- CT angiogram sign.
Fig. 1: Crazy paving

References: filterforge.com
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**Table 1**: Crazy paving differential diagnosis

**References**: Radiology, UZ Brussel, UZ Brussel - Brussel/BE

**Imaging findings OR Procedure details**
Fig. 2: Diagram depicting a secondary pulmonary lobule and related structures. 

References: Author: Frank Gaillard License: CC-NC-BY-SA
Fig. 3

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Fig. 4

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Fig. 5

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Fig. 14: ARDS in a 28-year-old woman. CT scan MIP (A) and axial (B) shows areas of ground-glass attenuation with interlobular lines and intralobular lines.

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**Fig. 6**: Pneumocystis jirovecii pneumonia, High-resolution CT scan shows diffuse ground-glass attenuation with intra- and interlobular lines most pronounced posteriorly.  
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![Image](image_url)

**Fig. 7**: Alveolar proteinosis in a 65-year-old man with. (A) Posteroanterior chest radiograph shows bilateral reticular areas of increased opacity, which occur predominantly in the lower zones especially on the left side. (B) High-resolution CT scan shows diffuse geographic ground-glass attenuation with superimposed intra- and interlobular septal thickening. Note the polygonal appearance, which represents the secondary pulmonary lobule.  
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Fig. 8: Same patient as in Fig 15 histological specimen from a transbronchial biopsy show alveolar spaces filled by a dense, eosinophilic, granular proteinaceous material (black arrow) that is positive for periodic acid-Schiff stain, normal alveolar spaces (red arrow) and alveolar septa (bleu arrow).

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**Fig. 11:** Infection-induced organizing pneumonia in a 57-year-old man. (A) Chest X-ray shows patchy distribution of areas with consolidation and groundglass opacity. There is also a fine reticular pattern, most pronounced in the periphery of both lungs. (B) High-resolution CT scan shows ground-glass attenuation and scattered areas of focal consolidation peripherally on the right side and diffuse ground-glass attenuation on the left side. Note the interlobular lines and intralobular lines superimposed on the ground-glass attenuation.

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**Fig. 12:** Lipoid pneumonia in a 74-year-old man presented with progressive dyspnea and a dry cough. (A) Posteroanterior chest radiograph shows areas of increased opacity in the air space on the right side, which have a predominantly lower lobe distribution. (B) High-resolution CT scan shows ground-glass attenuation in association with interlobular thickening and intralobular lines on the right side. The results of bronchoalveolar lavage and transbronchial biopsy were diagnostic.

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**Fig. 15:** Acute diffuse pulmonary hemorrhage in a 53-year-old woman with systemic lupus erythematosus and massive hemoptysis. High-resolution CT scan shows geographic areas of ground-glass attenuation with interlobular septal thickening.  
**References:** November 2003 RadioGraphics, 23, 1509-1519
Fig. 10: Amiodarone-induced NSIP in an 88-year-old man with severe dyspnea. High-resolution CT scan shows bilateral diffuse ground-glass attenuation and inter- and intralobular lines. Note the traction bronchiectasis and bronchiolectasis.

**Fig. 9:** Sarcoidosis in a 25-year-old asymptomatic man. High-resolution CT scan shows scattered bilateral areas of ground-glass attenuation associated with inter- and intralobular lines.

Fig. 16: CT scan shows typical crazy-paving ground-glass attenuation associated with septal thickening surrounding the mass, which is perihilar. Adenocarcinoma with surrounding pulmonary hemorrhage was confirmed at surgery.


Images for this section:
Fig. 1: Crazy paving
**Fig. 2:** Diagram depicting a secondary pulmonary lobule and related structures.
Fig. 3

The reticular pattern: thickening of the interlobular septa

Pulmonary vein

Pulmonary artery

Acinus

Thickening of the interlobular septa
The reticular pattern: Centrilobular interstitial thickening

Fig. 4
Fig. 5

The reticular pattern: perilobular pattern
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![Image of chest radiograph and high-resolution CT scan showing alveolar proteinosis]

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![Image of histological specimen]
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![Image](image1.png)

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![Image](image2.png)
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**Table 1:** Crazy paving differential diagnosis
Conclusion

-The crazy-paving pattern consists of scattered or diffuse ground-glass attenuation with superimposed interlobular septal and intralobular lines.

-The appearance can also be caused purely by airspace disease, in which case the appearance is owing to linear deposition of material within the airspaces.

-The frames of the networks are situated at the borders of unit structures such as acini or pulmonary secondary lobules.

-Often considered to have a limited differential diagnosis-pulmonary alveolar proteinosis, lipoid pneumonia, bronchioloalveolar cell malignancy-this pattern is now recognized as a CT manifestation of many diverse entities.

-Although causes of this pattern are frequently indistinguishable at radiologic evaluation, differences in the location of the characteristic opacities or attenuation in the lungs as well as presence of additional radiologic findings, together with the history and clinical presentation, can often be useful in suggesting the appropriate diagnosis.

References


**Personal Information**