Rocks in the lungs: High attenuation pulmonary lesions

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Learning objectives

1) To review the computed tomography (CT) findings of common and uncommon high-attenuation pulmonary lesions

2) To present a classification scheme of the various entities that can result in high-attenuation pulmonary abnormalities based on the pattern and distribution of findings on CT.

Background

High-attenuation pulmonary abnormalities can result from a variety of different conditions. They can result from the deposition of calcium or, less commonly, other high-attenuation material such as talc, amiodarone, iron, mercury and barium sulfate. CT is highly sensitive in the detection of areas of abnormally high-attenuation in the lung parenchyma, airways, mediastinum, pleura and blood vessels. Calcifications in the thorax are frequently manifestations of previous infectious processes. However, they may be due to benign and malign neoplasms, metabolic disorders or occupational exposure. The cause of the calcifications and other high-attenuation conditions may be determined by means of the location and pattern of the abnormalities within the lung parenchyma and knowledge of the associated clinical features.

Imaging findings OR Procedure details

We have presented a diagnostic approach based on the presence and distribution of five main patterns of high-attenuation conditions on CT:

1) Diffuse small hyperdense nodules:

Small hyperdense nodules refer to nodular opacities measuring less than 10 mm in diameter, showing focal or diffuse distribution in the lung parenchyma. Small hyperdense nodules most commonly are secondary to dystrophic calcification in previously damaged lung parenchyma. Small calcified parenchymal nodules most commonly are a result of infection diseases. Other causes of small hyperdense nodules are pulmonary metastases, chronic hemorrhagic conditions, occupational diseases, deposition diseases, talcosis and idiopathic disorders such as pulmonary alveolar microlithiasis (1,2,3).
Calcified parenchymal nodules are frequently seen in tuberculosis. Sequela dystrophic calcification follows caseation, necrosis, or fibrosis. These nodules are frequently seen well circumscribed parenchymal calcifications with fibrosis on CT scan (Fig. 1 on page 5). Most patients with pulmonary nodular calcifications secondary to tuberculosis have calcified hilar or mediastinal lymph nodes, known together as the Ranke complex. Histoplasmosis and varicella infections less commonly may lead to parenchymal calcified nodules (1). Widespread micronodular calcification can be seen in late period of varicella infection.

Metastatic pulmonary calcification is consequence of calcium deposition in normal pulmonary parenchyma. This condition can occur in a variety of benign and malignant disorders such as primary and secondary hyperparathyroidism, chronic renal failure, sarcoidosis, vitamin D intoxication, IV calcium therapy, multiple myeloma, and massive osteolysis caused by metastases (4). High-resolution CT (HRCT) findings are characterized by centrilobular fluffy ground-glass nodular opacities which contain foci of calcification (Fig. 2 on page 6 and fig. 3 on page 7). Metastatic pulmonary calcification typically is most marked in the upper lobes.

Idiopathic pulmonary hemosiderosis is an uncommon cause of alveolar hemorrhage that occurs predominantly in infants and young adults. This disorder is characterized by recurrent episodes of alveolar hemorrhage. HRCT shows dense centrilobular nodular opacities due to recurrent hemorrhage. Secondary hemosiderosis due to mitral stenosis may present with small calcified nodules.

Diffuse small calcified nodules, often associated with egg-shell calcification of hilar or mediastinal lymph nodes, can occur in silicosis and coal workers' pneumoconiosis. Silicosis is caused by inhalation of free silica particles, usually during occupational exposure such as mining, sandblasting, and masonry (5). HRCT findings of silicosis include diffuse and randomly distributed small well-defined nodules that are most prominent in the upper lobes (6). These calcified nodules are commonly seen with massive fibrosis (Fig. 4 on page 8).

Multiple dense nodular opacities are rarely seen in siderosis, stannosis, and baritosis, in which iron, tin, and barium, respectively, are deposited in the lungs. HRCT shows extremely dense opacities due to barium aspiration in baritosis, usually locating in basal segments of lower lobes (Fig 5 on page 9).

Alveolar microlithiasis, a rare disease of unknown origin, is characterized by diffuse sendlike calcifications within the alveoli. This disorder may be detected incidentally on chest radiographs obtained for other reasons. Characteristic HRCT findings consist of multiple innumerable tiny sandlike calcified micronodules which tend to confluence throughout both lungs. Other findings include calcified interlobular septa and small subpleural cysts.
Another feature seen on HRCT scans includes a very low attenuation line alongside the pleura, called "black pleural line" (Fig. 6 on page 10).

Talcosis is seen in workers exposed to talc during extraction of magnesium silicate from mines and grinding. Another form of talcosis can be seen in drug users who inject talc for medication. HRCT findings consist of numerous high-attenuation well-defined micronodules or diffuse ground-glass opacities.

2) Large calcified nodules or masses

Calcification can be seen in a variety of benign and malignant tumors such as hamartomas, chondromas, plasmositomas, carcinoid tumors, and bronchial carcinomas (7). Hamartoma is the most common benign tumor of the lung. Calcification can be detected at CT in over 30% of cases. Hamartomas have characteristic popcorn-like or diffuse calcification (Fig. 7 on page 11). Bronchogenic carcinoma may rarely contain calcification, usually eccentric in location (Fig. 8 on page 12).

Calcification in pulmonary metastases is rare and can result from either sarcomas (osteosarcomas, chondrosarcomas, and synovial sarcomas,) or carcinomas (mucin producing carcinomas, thyroid carcinomas, and treated metastatic choriocarcinomas). Osteosarcoma may lead to multiple, calcified parenchymal and pleural metastases (Fig. 9 on page 13).

Parenchymal calcified nodules or consolidation may be seen in pulmonary amyloidosis.

3) High-attenuation linear or reticular pattern,

Diffuse pulmonary ossification is associated with a variety of pulmonary, cardiac, and systemic disorders. It may be localized or distributed widely (8).

Linear calcification through the lung interstitium is occasionally seen in idiopathic pulmonary fibrosis.

Long standing mucus plugging may progress to linear or nodular calcification (Fig. 10 on page 14).

4) High-attenuation consolidation

Deposition of iodine can occur within the lung parenchyma as a result of treatment with amiodarone, a triiodinated antiarrhythmic drug. The most common CT findings include septal thickening, interstitial fibrosis, and high attenuation consolidations (Fig. 11 on page
16). The association of dense lung air-space consolidations with high density of the liver and spleen is characteristic of amiodarone exposure.

Chronic atelectasis can be rarely seen as calcified consolidation (Fig. 12 on page 16).

5) High attenuation extraparenchymal lesions

Teeth aspiration may be seen after trauma. CT scan shows high-attenuation endobronchial lesions (Fig.13 on page 17).

Pleural calcifications occur most often as the result of long standing inflammatory diseases, like empyema, hemothorax or tuberculosis (Fig. 14 on page 18). Pleural calcification is also a common manifestation of asbestos exposure (9). Empyema necessitans is a rare complication of pleural space infections and occurs when the infected fluid dissects spontaneously into the chest wall from the pleural space (10). Tuberculosis is more likely to form an empyema necessitans than are pyogenic organisms (Fig.15 on page 19).

Lymph node calcifications result from healed granulomatous infection, usually tuberculosis or histoplasmosis (Fig. 16 on page 20). Eggshell calcification is highly suggestive of silicosis or coal workers' pneumoconiosis, but it has been described also in sarcoidosis, Hodgkin’s disease or infections like histoplasmosis or blastomycosis.

Images for this section:
Fig. 1: Residual postprimary pulmonary tuberculosis. Axial CT scan shows multiple calcified granulomatous lesions in left upper lobe.
Fig. 2: Metastatic pulmonary calcification in 24 year old man who had known chronic renal failure. Axial CT scan(mediastinal window) demonstrates bilateral centrilobular fluffy ground-glass nodular opacities which contain foci of calcification.
Fig. 3: Metastatic pulmonary calcification in 24 year old man who had known chronic renal failure (same patient shown in fig.2). Axial CT scan (parenchymal window) demonstrates bilateral centrilobular fluffy ground-glass nodular opacities which contain foci of calcification.
Fig. 4: Silicosis. Axial CT scan obtained using mediastinal window settings shows multiple calcified nodules with conglomerate mass of fibrosis in upper lobes.
Fig. 5: Barium aspiration. Axial CT (lung window) shows extremely dense opacities in both lower lobes.
**Fig. 6:** Pulmonary alveolar microlithiasis. Axial CT scan shows diffuse numerous dense micronodules with calcific thickening of interlobular septa and subpleural cysts.
Fig. 7: Hamartomas. Axial CT scan shows popcorn calcification in benign solitary pulmonary nodule.
Fig. 8: Lung carcinoma. Axial CT scan shows eccentric calcification in malignant mass, invading mediastinum and right hilar region.
**Fig. 9:** Metastatic osteosarcoma. Axial CT scan shows parenchymal and pleural calcified metastatic lesions in both hemithorax.
**Fig. 10:** Mucus plugging. Axial CT scan (lung window) shows calcified linear bronchial opacity in right upper lobe.

**Fig. 11:** Amiodarone toxicity. Axial unenhanced CT scan (mediastinal window) shows dense lung consolidations in both lower lobe. Bilateral pleural effusion and pericardial effusion also are seen.
Fig. 12: Calcified atelectasis. Axial unenhanced CT scan (mediastinal window) shows high-attenuation consolidations in both upper lobes.
Fig. 13: Endobronchial teeth secondary to trauma. Axial CT scan (bone window) demonstrates teeth in right main and upper lobe bronchus.
Fig. 14: Pleural calcification secondary to empyema. Axial CT scan shows pleural calcification at right hemithorax.
Fig. 15: Empyema necessitans after tuberculous empyema. Axial CT scan shows a diffuse calcified pleural mass, extending extrapleural structures at right hemithorax.
**Fig. 16:** Lymph node calcification. Axial CT scan shows right paratracheal calcified lymph nodes secondary to tuberculosis.
Conclusion

Some high-attenuation pulmonary abnormalities have characteristic CT findings suggesting the correct diagnosis. In other diseases, a combination of clinical features and radiologic findings can significantly improve diagnostic accuracy.

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References