Asbestos related pleuro-pulmonary disease: a pictorial essay on CT imaging manifestations

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Learning objectives

The purpose of this pictorial essay is to provide the general radiologist, trainees in radiology as well as other clinicians interested in thoracic radiology with a comprehensive overview of the CT imaging manifestations of asbestos related pleuro-pulmonary disease.

Background

Asbestos refers to a group of naturally occurring silicate minerals which have been traditionally used in building materials and household products due to many favourable properties such as thermal resistance. They are primarily divided into two major categories, serpentine (chrysotile) and amphibole (amosite, crocidolite, tremolite, anthophyllite, and actinolite) fibres. The fibres are insoluble in water/inorganic solvents and are largely chemically inert. Inhalation of asbestos fibres, however, has been associated with adverse health outcomes, with the disease manifestations principally affecting the thorax. There can be a considerable latency period between exposure and the development of disease (may span many decades).  

Amphibole asbestos fibres are considered more hazardous to the human body with their fine, straight fibres having greater capability for deposition in smaller, more distal airways. Similarly, the smaller finer Amphibole particles are more prone to inhalation as they are more easily mobilised from their source. Serpentine fibres are broader and mostly get deposited in larger airways. This allows the body’s natural defence mechanisms (i.e mucociliary clearance) to better clear these fibres.

Almost all the thoracic imaging features of asbestos related pleuro-pulmonary pathology are best appreciated on thoracic CT (ideally high resolution CT imaging). Hence, the focus of this essay will be on the imaging manifestations of this modality.

Findings and procedure details

1. Benign pleural and parenchymal lung disease

1.1 Pleural effusions (Benign asbestos related pleural effusions - BAPE)
A benign pleural effusion (Fig. 1 on page 6 and Fig. 2 on page 7) is often one of the earliest manifestations of past asbestos exposure. The effusions can vary in size and composition. Exudative effusions are more common than transudative effusions. Pleural effusions typically occur within 10 years of the exposure. Although they can occur bilaterally, many tend to be unilateral. Most effusions resolve over weeks to months, are macroscopically haemorrhagic and upon resolution can result in pleural thickening. Intermittent recurrence is common. A benign pleural effusion secondary to asbestos exposure must be distinguished from a pleural effusion secondary to malignant effusions from entities such as mesothelioma (which tends to have varying combinations of pleural thickening, nodularity and pleural based mass lesions).

A benign pleural effusion secondary to asbestos exposure is often difficult to diagnose, as many people are not aware of their previous exposure to the asbestos fibres. It is also difficult to differentiate from pleural effusions arising from an unrelated cause.

1.2 Diffuse pleural thickening

Diffuse pleural thickening (Fig. 1 on page 6 and Fig. 3 on page 8) is another benign pleural manifestation that can occur secondary to asbestos exposure. They tend to occur secondary to pleural irritation. When irritated, the visceral pleura will often undergo a fibrotic reaction and adhere to the parietal pleura. In the context of asbestos related lung disease, it tends to occur secondary to the irritative nature of exudative pleural effusions. Whilst a feature of asbestos related lung disease, diffuse pleural thickening on its own is non-specific and may result from any cause of exudative pleural fluid.

Diffuse pleural thickening can be distinguished from distinct pleural plaques as:

1. Plaques are rarely seen involving the costophrenic angles and apices.
2. Whilst pleural plaques may calcify, it is rare for diffuse pleural thickening to calcify.
3. Plaques tend to be well defined whereas diffuse pleural thickening tends to be irregular.
4. Pleural plaques rarely extend over more than four rib spaces.
5. Pleural plaques primarily affect the parietal pleura and will rarely involve the interlobar fissures. As diffuse pleural thickening primarily involves the visceral pleura, it may extend into the interlobar fissures.

1.3 Pleural plaques

Pleural plaques (Fig. 1 on page 6) often appear long after asbestos exposure (20-30 years). They are the most common sequelae of fibre exposure and almost always arise...
from the parietal pleura. Pleural plaques are mostly asymptomatic although some patients may have associated pain.\textsuperscript{8}

They primarily occur along the posterolateral chest wall and to a lesser extent the mediastinal and diaphragmatic pleura. The costophrenic recesses and apices are rarely involved.

The plaques comprise of bundles of tightly woven collagen that contain asbestos fibres arranged parallel to the pleural surface. The exact mechanism behind their formation is unclear.

**Calcified pleural plaques** (Fig. 1 on page 6 and Fig. 4 on page 8)

Approximately 10-15% of asbestos-related pleural plaques can be calcified as a whole.\textsuperscript{6} Their prevalence may however increase over time as pleural plaques can calcify with time. The presence of calcification makes their detection easier. Pleural calcification from other causes such as a response to a previous pleural infection or haemorrhage can occasionally mimic calcific pleural plaques.

**Non calcified pleural plaques**

The majority of pleural plaques attributable to asbestos exposure are non-calcified.\textsuperscript{9} CT has been shown to be more sensitive than plain radiographs in the detection of non calcific pleural plaques by allowing the distinction between pleural disease and extrapleural fat.\textsuperscript{9}

**Hairy pleural plaques** (Fig. 5 on page 9)

This is a term given to a specific morphological appearance of some pleural plaques. When pleural plaques arising from the visceral pleura are associated with abnormalities of the adjacent lung parenchyma, they then cause short interstitial fibrotic lines that radiate out from the plaque, giving rise to a "hairy" appearance.\textsuperscript{9}

**1.4 Rounded atelectasis**

**Rounded atelectasis** (Fig. 6 on page 10) refers to an atypical form of peripheral lung collapse that usually occurs adjacent to a scarred pleural surface.\textsuperscript{10} Exposure to mineral dust, including asbestos fibres is the most common cause of rounded atelectasis.\textsuperscript{11} The exact pathogenesis of rounded atelectasis is unclear but is thought to relate to inflammation and fibrosis of the superficial pleural layer.\textsuperscript{9} They appear as a subpleural
round or oval mass with a "comet tail" of bronchovascular structures entering it. They are usually located in the lower lobes, middle lobe and lingula. The adjacent pleura is thickened and there may be associated volume loss. An important imaging differential diagnosis is lung cancer. In fact, asbestos-related rounded atelectasis is also known as "asbestos pseudotumour" or Blesovsky syndrome. Regions of rounded atelectasis may remain stable, reduce or even increase over time.

1.5 Asbestosis related pulmonary fibrosis

The term asbestosis (Fig. 7 on page 10 and Fig. 8 on page 11) refers to pulmonary fibrosis as a result of exposure to asbestos dust. It predominantly affects the lower lobes in a subpleural distribution, but may extend to involve the middle lobe and lingula. In advanced cases, apical involvement is also seen.

High resolution CT is more sensitive than chest radiography in detecting asbestosis. Subpleural curvilinear opacities and band-shaped opacities projecting in from the pleura can be early radiological features. Other findings include interlobular septal thickening, ground glass opacification and less commonly, honeycombing. HRCT features of asbestosis have been reported to correlate well with clinical and functional restriction.

2. Malignant pleural and parenchymal lung disease

Asbestos exposure has been linked to a number of malignancies, and in particular, thoracic malignancies such as mesothelioma and bronchogenic carcinoma. Extrathoracic malignant associations include carcinoma of the larynx, gastrointestinal tract and kidneys as well as mesothelioma arising from outside the pleura.  

2. 1 Malignant pleural mesothelioma

Malignant pleural mesothelioma (Fig. 9 on page 12 and Fig. 10 on page 13) is a primary pleural tumour associated with asbestos exposure. It is refractory to many medical treatments and generally carries a poor prognosis. The occurrence of such malignancy is strongly related to the cumulative dose of asbestos exposure, the type of asbestos fibre and time elapsed from first exposure.

The CT features of mesothelioma can be variable and non-specific (dependant on factors such as location and extent). Described imaging features associated with mesothelioma include: focal pleural thickening, pleural nodules or irregular and bulkier plaques; pleural effusions, and circumferential pleural encasement. At later stages, nodal involvement...
and invasion into the ipsilateral chest wall, diaphragm, contralateral pleural cavity and peritoneal seeding can also be detected. Histological analysis is required for a definitive diagnosis of malignant pleural mesothelioma. There are three distinct histological subtypes: epithelial, sarcomatoid and biphasic type (mixed epithelial and sarcomatoid), which cannot be differentiated with imaging alone.\textsuperscript{17}

\subsection*{2.2 Mesothelioma outside pleura (rare)}

**Peritoneal mesothelioma** (Fig. 11 on page 14) is rare, and while not directly relating to either pleura or lung parenchyma, it is discussed in this essay since some peritoneal mesotheliomas close to the diagramatic pleural surface can on occasion mimic intrathoracic disease. The incidence is approximately one per million while one fifth to one third of all mesotheliomas are peritoneal.\textsuperscript{18} Approximately 30\% of all mesotheliomas arise solely from the peritoneum and in only a minority of such cases will the patient have a history of significant asbestos exposure.\textsuperscript{19} CT appearances of peritoneal mesothelioma are non-specific and insufficient for a definitive diagnosis on its own. It does, however, have a role in the detection, characterisation and staging of peritoneal masses.\textsuperscript{14} Peritoneal mesothelioma may present in three ways:\textsuperscript{15}

1. "Dry painful" type: Most common. A solitary mass or multiple small peritoneal masses in a single quadrant in the absence of ascites
2. "Wet" type: Ascites without a distinct solitary mass
3. "Mixed" type

\subsection*{2.3 Bronchogenic carcinoma}

As with malignant mesothelioma, the risk of development of asbestos related bronchogenic carcinomas is dose dependant (Fig. 12 on page 15). This related to all histological subtypes. The radiographic appearance of asbestos-related bronchogenic carcinomas have no distinguishing features to differentiate them with non-asbestos-related lung cancers.\textsuperscript{20} Correspondingly, the prognosis for individuals with asbestos related lung cancers is similar to those without asbestos exposure. However, due to the concurrent restrictive lung disease caused by asbestosis, diagnosis of asbestos related bronchogenic carcinoma can often be missed, leading to poorer outcomes for these patients.\textsuperscript{20}

Images for this section:
**Fig. 1:** Spectrum of benign pleural abnormalities associated with asbestos exposure.

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Fig. 2: Pleural effusions (Benign asbestos related pleural effusions - BAPE). 86 year old male with history of asbestos exposure. CT scan shows a moderate pleural effusion at the right base with associated pleural plaques.

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Fig. 3: Diffuse pleural thickening. 72 year old male with diffuse pleural thickening on a background of known asbestos exposure.

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Fig. 4: Calcified pleural plaques. 73 year old male with history of asbestos exposure. CT shows multiple calcified pleural plaques.

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**Fig. 5:** Hairy pleural plaques. 88 year old female with history of asbestos exposure. CT shows a partially calcified pleural plaque with interstitial fibrotic lines extending into the lung parenchyma giving the "hairy plaque" like appearance.

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**Fig. 6:** Rounded atelectasis. (diagram of rolled atelectasis shown on the left) 70 year old male with a history of asbestos exposure and pleural plaques on chest x ray. CT shows an area of rolled atelectasis in the right lower lobe.

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Asbestosis related pulmonary fibrosis

Fig. 7: Asbestos related pulmonary fibrosis.

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Fig. 8: Progressive asbestos related pulmonary fibrosis. 76 year old male with known asbestos exposure. The initial CT images are shown at the top, the repeat CT images at the bottom at an 8 month interval show progressive pulmonary fibrosis.

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Fig. 9: Malignant pleural mesothelioma.

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Fig. 10: Malignant pleural mesothelioma. 60 year old female with nodular pleural thickening proven on biopsy to be mesothelioma.

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Fig. 11: Mesothelioma arising from outside pleura (i.e. peritoneum). 85 year old male presents with abdominal pain and ascites. CT shows a nodular peritoneum with irregular thickening. Cytology of ascitic fluid confirmed peritoneal mesothelioma.

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Fig. 12: Bronchogenic carcinoma. 80 year old male with known prior asbestos exposure with subsequent development of metastatic small cell lung carcinoma. Selected CT slices show primary lung malignancy, pleural plaques and liver metastases.

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Conclusion

We hope review of this presentation will aid the reader in a better understanding the full CT imaging spectrum of asbestos related pleuro-pulmonary disease, aiding in better and more refined detection in day to day practice.

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