

Air in the Pleural Cavity Enhances Detection of Pleural Abnormalities by CT Scan



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Detection of pleural abnormalities on CT scan is critical in diagnosis of pleural disease. CT scan detects minute parenchymal lung nodules, but often fails to detect similar-sized pleural nodularity. This is likely because the density of the visceral/parietal pleura and pleural fluid is similar. We hypothesize that an air-pleural interface enhances detection of pleural abnormalities. We describe six patients with pleural abnormalities that were not (or barely) detected on initial CT scan. However, pneumothorax (either ex vacuo or from a genuine air leak) after pleural fluid drainage permitted the visualization of small pleural abnormalities on CT scan, which would be amenable to imaging-guided biopsies. This case series provides proof-of-principle evidence that the sensitivity of CT scan detection of pleural abnormalities is dependent on adjacent tissue density and can be enhanced by intrapleural air. Future studies of the potential for artificial pneumothorax to improve the diagnosis of pleural disease are warranted.

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Exudative pleural effusions are common clinical presentations. Malignant pleural effusion (MPE) is the most common cause of recurrent exudative effusions and affects 250,000 patients a year in the United States alone.¹ Differentiating benign from malignant pleural disease and confirming the exact etiology is critical.²

Pleural tissue biopsy is often necessary, either because pleural fluid cytology is not

diagnostic, or to assist further molecular analysis.³ The parietal pleura covers an estimated area of 1 m². Malignant and other pleural diseases typically cause pleural nodularity or thickening. Sampling error is common with blind biopsy techniques, whereas imaging-guided (eg ultrasound, CT scan) and direct visual-guided thoracoscopic biopsies of abnormal pleura have shown better yield.^{4,5} Imaging-guided biopsy has potential advantages over the thoracoscopic

ABBREVIATIONS: MPE = malignant pleural effusion

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approach, especially in elderly patients with comorbidities.^{6,7} However, it is only feasible if there are imaging-detectable pleural abnormalities.

CT is routinely used in most centers for investigation of undiagnosed pleural effusions. It is highly sensitive in detecting pleural fluid, chest wall invasion, and abnormalities of lung parenchyma. Although CT can detect nodules as small as 2 to 3 mm readily within the lung parenchyma, CT often fails to pick up early pleural abnormalities which are easily visible on direct inspection during subsequent thoracoscopy.⁸ The low sensitivity of CT in detecting pleural tissue abnormality also makes monitoring of disease progression difficult.

We hypothesize that CT have a low sensitivity to detect subtle pleural abnormalities because the apposed pleura or adjacent pleural effusion share a similar density. This differs from lung nodules, which are surrounded by aerated lung which allows their easy detection.

We support this hypothesis with six cases where air within the pleural cavity from incidental etiology or postprocedural pneumothorax enabled identification of previously undetected pleural nodularity, demonstrating that air in the pleural space can provide a useful density separation on CT.

The Sir Charles Gairdner Hospital pleural service is a specialist tertiary referral unit that maintains a database of patients investigated for MPE as previously described.⁹ CT imaging is frequently indicated in patient workup. It may also be necessary postdrainage if the initial CT scan precludes thorough examination of the lung parenchyma (eg, because of a massive effusion) or when a pneumothorax is encountered to exclude iatrogenic injury. CTs are also frequently used for assessment during chemotherapy to assess treatment response.

In their clinical course, six patients with pleural diseases were observed to have pleural nodularity that was undetectable or ill-defined prior to the presence of air in the pleural space during CT imaging. These cases are reported in this proof-of-concept, observational study. All patients consented to publication of their unidentifiable data and images as part of consent for entry into ongoing studies of MPE. These studies were approved by the Sir Charles Gairdner and Osborne Park Healthcare Group Human Research Ethics Committee (reference No. 2009-104, 2012-005 and 2014-079).

Case Reports

Case 1

A 45-year-old woman presented with a large pleural effusion, and her CT showed only possible anterior pleural

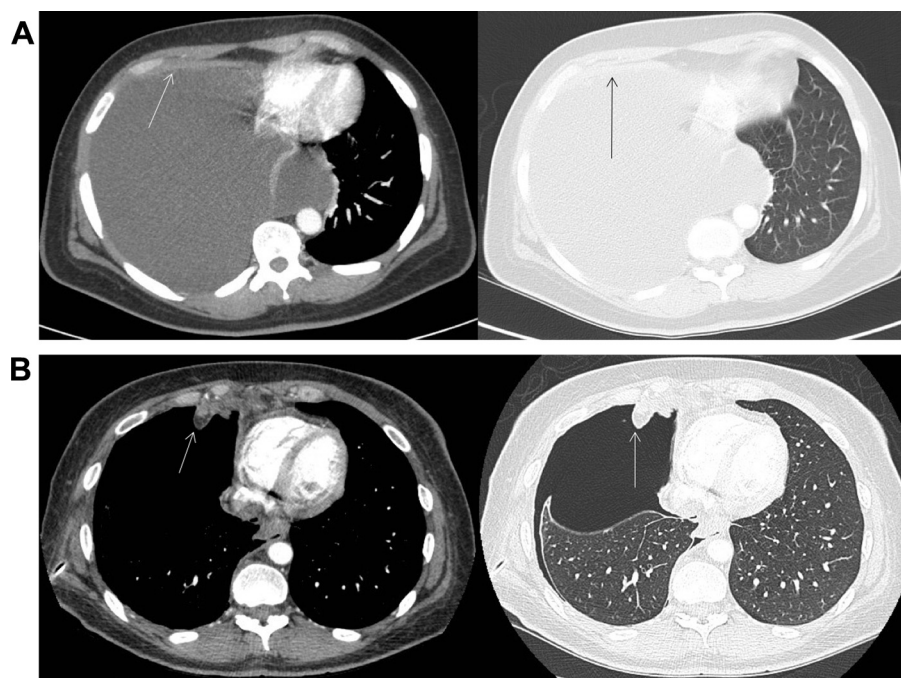


Figure 1 – A, CT imaging showing large pleural effusion with possible anterior pleural thickening (arrow). B, Axial CT images of the thorax showing unexpanded lung revealing marked pleural nodularity (arrows).

thickening (Fig 1A). On drainage of the pleural effusion, significant parietal pleural nodularity became apparent in the presence of a pneumothorax on CT scan (Fig 1B). Pleural biopsy of this area confirmed malignant mesothelioma.

Case 2

An 83-year-old man presented with increasing dyspnea and a large left-sided pleural effusion and indistinct, possible pleural thickening (Fig 2A). Postaspiration imaging revealed trapped lung, with pneumothorax accentuating extensive nodular pleural thickening (Fig 2B). Pleural fluid cytology revealed mesothelioma, and confirmatory tissue biopsy was not required, especially with the typical findings on the second CT scan and a clinical history of asbestos exposure.

Case 3

A 61-year-old man known to have mesothelioma developed a symptomatic MPE. A CT scan was performed before and after pleural fluid drainage (Fig 3). Before drainage, there was a large pleural effusion with atelectatic lung and no visible pleural abnormality. The small trapped lung postdrainage showed significant pleural nodularity not seen in the predrainage CT scan. Further biopsies were unnecessary because the diagnosis had been confirmed already with cytology and the postdrainage imaging findings were consistent with mesothelioma.

Case 4

A 67-year-old man with mesothelioma and trapped lung underwent serial CT imaging to assess disease progression. The initial scan showed a large pleural effusion and barely visible anterior and mediastinal pleural nodules (Fig 4). His effusion was drained and the postdrainage CT scan revealed pleural nodularities on the parietal and mediastinal pleura, not visible on the predrainage images. As a result of these findings the patient was referred to an oncologist and treated with cisplatin and pemetrexed chemotherapy.

Case 5

A 75-year-old man with rheumatoid arthritis, emphysema, and previously resected buccal squamous cell carcinoma developed a spontaneous hydropneumothorax, which was successfully drained. Pleural fluid analysis revealed no malignant cells. Subtle pleural thickening was detected on CT scan at follow-up, which was considered unsuitable for biopsy (Fig 5A). PET scan revealed no extrapleural disease and nonspecific low-grade pleural enhancement. Two weeks later, symptomatic hydropneumothorax recurred, prompting repeat CT imaging. Extensive pleural nodularity was revealed in this setting (Fig 5B). The pneumothorax was drained and repeat pleural fluid testing again did not show malignant cells. The patient

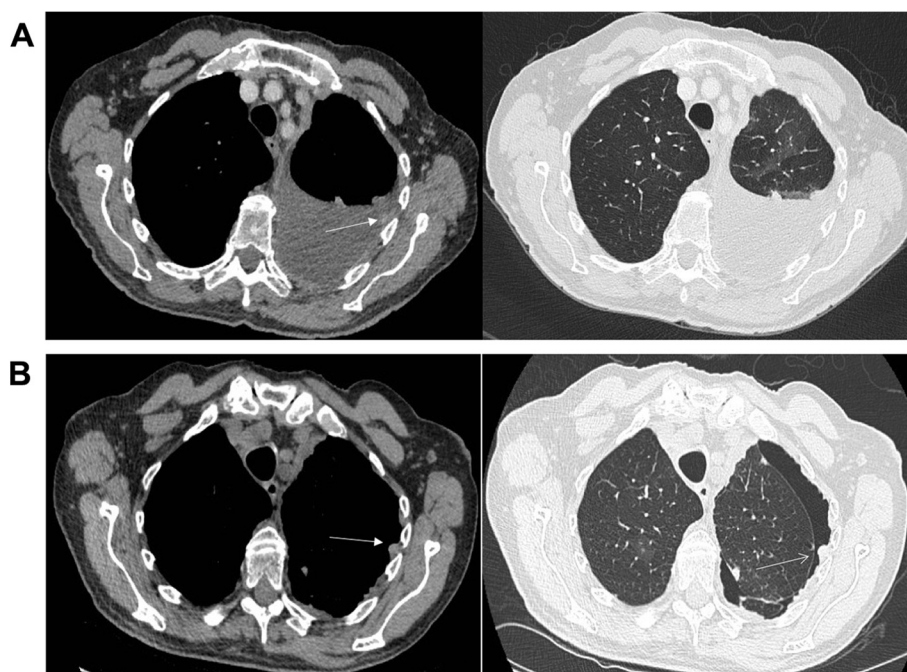


Figure 2 – A, Axial CT imaging of the thorax above the aortic arch, showing a large left-sided pleural effusion with possible parietal pleural thickening (See arrow. mediastinal and lung windows included for comparison purposes with B). B, Postaspiration pneumothorax (visible on lung windows, right) reveals marked nodular parietal pleural thickening with possible sites for biopsy shown (arrows).

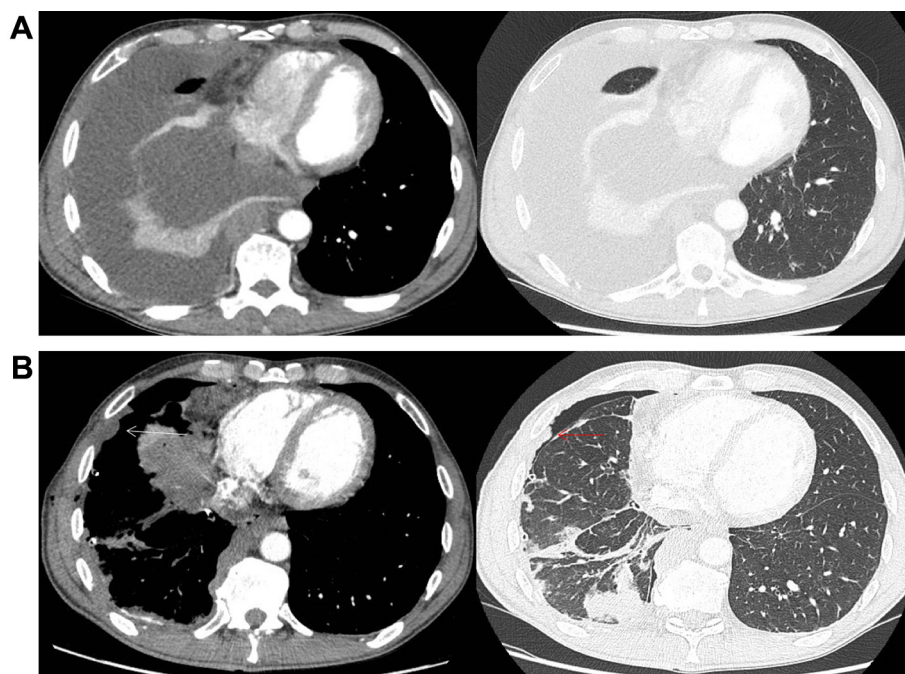


Figure 3 – A, Axial CT image showing large pleural effusion and atelectatic lung, without detectable pleural nodularity. B, The same patient after drainage. Trapped lung reveals significant parietal pleural nodularity (arrows) that was not apparent prior to drainage.

declined biopsy of the nodules, and instead talc pleurodesis was performed. One year later, there was no clinical evidence of malignancy and no further drainage

procedures have been required despite a persistent, small pneumothorax, revealing underlying pleural thickening (Fig 5C).

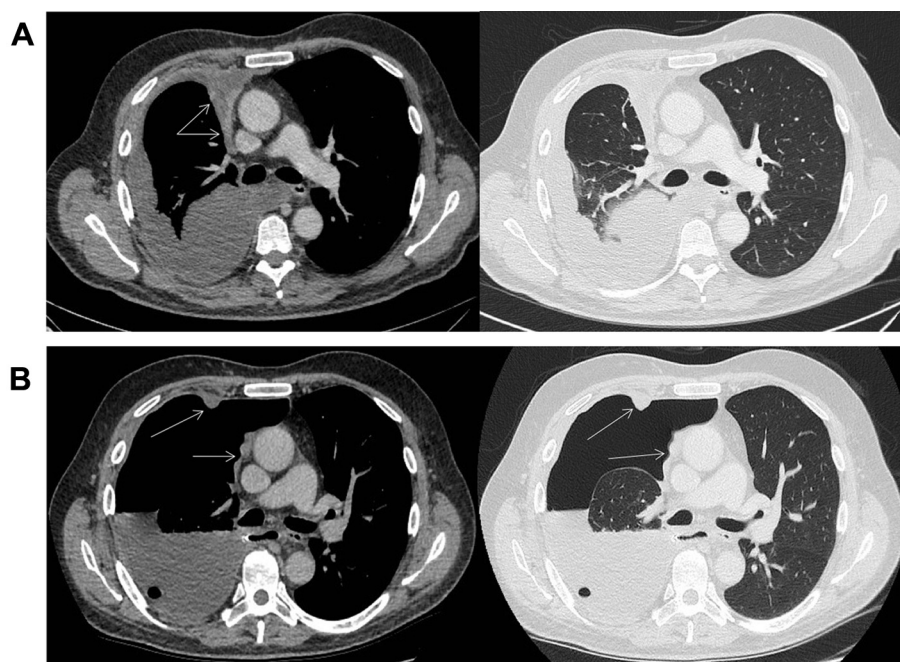


Figure 4 – A, Axial CT images just below the level of the main carina show reduced right hemithorax volume with pleural effusion and barely visible anterior and mediastinal pleural nodules (arrows). B, Drainage of the pleural fluid with resultant pneumothorax (visible on lung windows) highlights prominent areas of pleural thickening (arrows).



Figure 5 – A, CT chest revealed insignificant pleural thickening (arrows), unsuitable for biopsy. B, Two weeks later, a large pneumothorax revealed significant parietal and visceral pleural nodularity. C, Subsequent CT scanning shows that even a small pneumothorax can effectively reveal pleural nodularity (arrows).

Case 6

An 88-year-old man presented with a large pleural effusion. Postdrainage imaging showed a pneumothorax. CT scan prior to complete fluid evacuation revealed vaguely perceptible pleural thickening in the setting of a large left-sided pleural effusion (Fig 6A). However, repeat scanning in the presence of air showed significant nodular thickening consistent with pleural malignancy (Fig 6B). Pleural fluid cytology was highly suggestive of mesothelioma. The patient and treating clinician agreed that further investigation was not indicated, and appropriate palliative care was instigated.

Discussion

This series of cases provides proof-of-concept data to support our hypothesis that air within the pleural cavity may be helpful in diagnosing pleural abnormalities.

Pleural thickening and nodules are common in malignant or inflammatory pleural diseases. Biopsy of these pleural abnormalities is frequently useful in establishing the diagnosis.⁷ Presence of pleural nodularity can also support a cytologic diagnosis of malignancy.¹⁰ Locating these abnormalities can streamline the differential diagnosis and, more importantly, allow imaging-guided pleural biopsy where necessary. This may in some cases negate the need for more invasive diagnostic thoracoscopy.

The presented cases demonstrate that there is reduced ability to detect pleural abnormalities because of the diminished contrast between atelectatic or consolidated lung, the pleural layers, and the chest wall. The presence of pleural air provides an interface which enhances detection of pleural abnormalities. Further prospective studies are needed to test the hypothesis that artificial

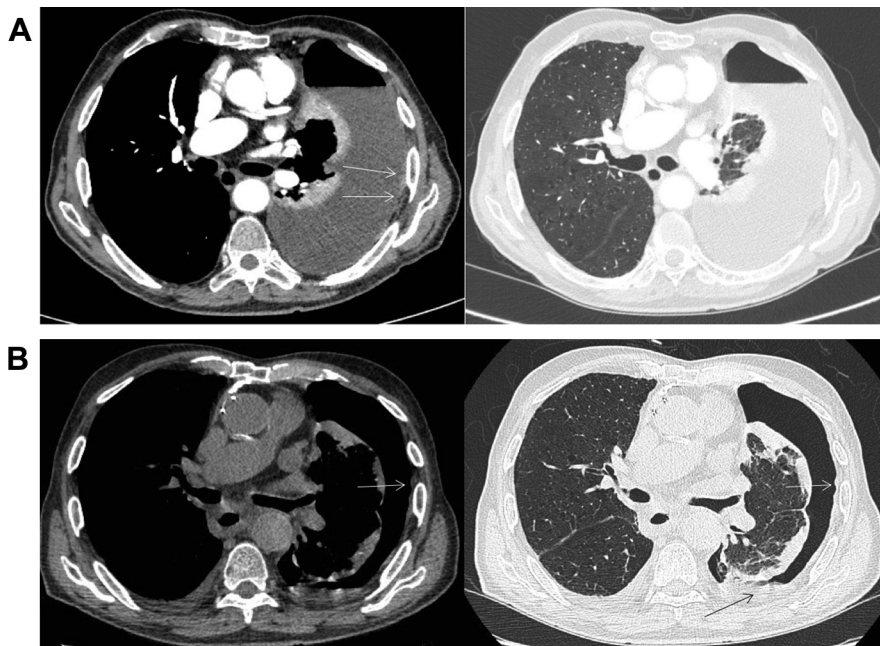


Figure 6 – A, CT image showing barely perceptible pleural thickening (arrows) in the setting of large left-sided pleural effusion. B, CT image after drainage of pleural effusion with trapped lung. Air/pleural interface shows more clearly defined nodular pleural thickening (arrows).

induction of pneumothorax may facilitate detection and subsequent percutaneous biopsy of pleural pathology, which can streamline the diagnostic pathway. Further optimization techniques should also be examined. For example, because tumor deposits are more commonly found in the posterior and inferior part of the pleural cavity, prone scanning may have a theoretical advantage over supine positioning. In patients who have a chest tube inserted before undergoing CT examination, we suggest future studies should examine if the injection of a small amount of air prior to imaging can provide more clinically relevant information.

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