Focal dependent pleural thickening at MDCT: Pleural lesion or functional abnormality?

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Abstract
Purpose: To describe the characteristics of reversible focal pleural thickening (PTs) mimicking real plaques, that firstly suggest asbestos exposure or pleural metastasis; to propose an imaging strategy and propose an explanation for their mechanism of formation.

Patients and methods: Retrospective review of data from 19 patients with PTs fitting the description of pleural plaques at chest computed tomography (CT) and presenting modifications (clearance or appearance) of at least one PT in an additional chest examination in prone position.

Results: A total of 152 PTs were recorded on the first chest CT examinations with a range of two to 19 pleural opacities per patient. All PTs had a posterior distribution in the lower lobes. On the additional acquisitions, 144 PTs disappeared. Seventeen patients presented complete regression of PTs and two patients presented persistence of eight PTs.

Conclusion: Additional low dose acquisition in prone position should be performed in all patients presenting with focal PT in a dependent and basal location. This may allow to exclude a pleural plaque in case of asbestos exposure but also a pleural metastasis in oncologic patients. These reversible dependent PTs could be related to physiological focal accumulation of lymphatic fluid in subpleural area.

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Chest computed tomography (CT) is routinely performed on patients lying in supine position, which compresses posterior lung areas and may cause false positive readings in healthy individuals. Presence of subpleural opacities in those dependent portions without proven lung disease has been well described. In this situation, additional CT examinations in prone position can help discriminating functional gravity-related changes from fixed structural lung parenchyma abnormalities [1,2].

To our knowledge, focal pleural thickenings (PTs) mimicking pleural plaques in supine examinations that are reversible in prone position have not been reported in the literature. However, in routine clinical practice, distinguishing such benign and reversible findings from real organic lesions is critical in order to avoid diagnosis hazards that may change patient management and prognosis in some conditions. Actually, in oncologic patients, pleural metastasis may appear as PT mimicking pleural plaques.

The purpose of our study is to describe the characteristics of such reversible PTs, to propose an imaging strategy to identify them and to hypothesize about their pathophysiological mechanisms.

Patients and methods

Patient selection and computed tomographic (CT) protocols

Between January 2005 and May 2007, we retrospectively identified patients with non-calcified focal PTs fitting the description of asbestos-related pleural plaques [3] exclusively located in dependent areas. Patients presenting with any additional typical pleural plaques in other locations, especially costovertebral, anterolateral or juxta-dipahragmatic area were excluded.

Nineteen patients (12 females, seven males) were included. Mean age of patients was $53.7 \pm 14$ years. Patients underwent chest CT examination for various indications, including history of collagen vascular disease ($n=4$), prior asbestos exposure ($n=3$), malignancies ($n=3$), granulomatosis ($n=3$), lymphoproliferative disorders ($n=2$), chronic obstructive pulmonary disease ($n=2$) and pulmonary nodule ($n=2$).

Chest CT examinations were volumetric acquisitions performed in inspiration and supine position. Due to the presence of dependent opacities in the 19 patients, an additional volumetric acquisition was performed with ultra low dose (120kV, 15 mAs) in prone position focused on those abnormalities, according to the routine practice in our department in order to verify the persistent or reversible characteristics of these opacities.

CT examinations ($n=19$) were performed on a 64-slice MDCT scanner (Philips, Brilliance 64, The Netherlands) with a slice thickness of 0.8 mm every 0.4 mm.

Data analysis

Three readers (G.B., D.T and C.B. respectively with 4, 7 and 15 years of experience) studied the two datasets of initial and additional CT examinations. Images were analyzed on Extended Brilliance Workspace (v.3) workstation (Philips, The Netherlands) in both mediastinal (width, 350; center 10 HU) and lung (width, 1600; center, −600 HU) window settings.

The first reader (G.B.) was blinded to the patient personal information, randomly red the two datasets (supine with normal dose, prone with low dose), and determined the characteristics, location and size of each PT.

PTs were classified as typical pleural plaques or indeterminate focal PTs, according to published guidelines [3,4]. Pleural plaques were considered in case of PT presenting a quadrangular shape with sharp borders. Focal PTs not fitting these criteria were classified as indeterminate PTs.

Size of the PT was measured in its great axis, along the pleura surface, on images displayed with lung window settings, by using an electronic calliper on the workstation monitor.

Thereafter, the two other readers (D.T., C.B.) determined in consensus the PT disappearance, persistence, modification in size between the first and second acquisitions. Apparition of new PTs on the second acquisition was also recorded. Disappearance or persistence of PT between both acquisitions was tested using McNemar tests. Modification in size of persistent PT between the first and second exam were analyzed using the Wilcoxon sign rank test and $p$ value < 0.05 was considered statistically significant.

Results

The mean dose length product (DLP) of the two acquisitions was $330.1 \pm 148.8$ mGy $\times$ cm. The dose delivered specifically by the low dose prone acquisitions varied from 35 to 40 mGy $\times$ cm.

On the supine acquisitions, 152 PTs were recorded, including 44 typical and 108 indeterminate (Table 1 and Figs. 1, 2 and 3). The number PTs per patient was in the range of two to 19 PTs per patient (mean: 8.3). All PTs had a posterobasal distribution. They were unilateral in three patients and bilateral in the remaining 16 patients. Size of typical and indeterminate PTs were $9.4 \pm 3.4$ mm and $6.9 \pm 3.4$ mm respectively.

On the additional acquisitions on prone position, a total of 144 initial (43 typical and 101 undetermined) PTs disappeared (95%, $p<0.001$). Eight initial PTs (one typical and seven indeterminate) persisted in two patients, and 17 patients presented complete regression of initial pleural abnormalities (Figs. 1, 2 and 3). Of the seven persistent indeterminate PTs, four decreased in size. Five new indeterminate PTs were observed in five patients. No PT change from one type to another (typical and indeterminate) was noted.

Of the three patients with history of prior asbestos exposure, two presented a complete regression of PTs and the other had three persistent indeterminate PTs. The four typical pleural plaques found on the first CT exam were not observed on the second. The three patients with history of malignancies showed complete regression of PTs.

The mean size of the eight persistent indeterminate PTs decreased from $6.9 \pm 4.4$ mm to $5.8 \pm 2.6$ mm ($p=0.3$). The size of the only persistent PT fitting the criteria of typical pleural plaque decreased from 7 to 5 mm. The mean size of the five new PTs was $7.2 \pm 2.4$ mm.
Discussion

Focal PT may be related to several diseases, including pleural plaques secondary to asbestos exposure or pleural metastasis. Similar findings may express as subpleural parenchymal disease mimicking plaques (pseudo-plaques), particularly in case of silicosis or sarcoidosis. Nevertheless, when these findings are seen strictly in a postero basal location in patients examined on supine position, these abnormalities may be purely functional and disappear on prone CT scans as demonstrated in this study.

We described pleural lesions that have typical appearance of asbestos-related pleural plaques in patients without or with prior asbestos exposure and that are reversible in prone position (Figs. 1, 2 and 3). In the same study, performing an additional prone acquisition in oncologic patients with PTs allowed us to definitely exclude pleural metastases and therefore preclude invasive diagnostic procedures.

The second acquisition with low dose parameters (120 kV, 15 mAs) focusing on the abnormal area appears therefore useful, with a minimal increase of radiation dose to the patient. In our study, the choice of volumetric acquisition in prone position focused on the abnormal area was justified by the fact that a formal diagnosis of persistence or disappearance of a PT requires an analysis of the whole loco-regional environment, taking into account changes related to position.

Reversibility of parenchymal lesions in prone position, such as GGO and curvilinear densities, has been well described in the literature; reversible subpleural nodules have also been reported [2, 5]. Most of these abnormalities were located in the dependent part of the lungs, i.e. bases and posterior segments, where lung volume variation is the greatest. These lesions were reported to reflect alveolar collapse in the dependent parts of the lung where mechanisms responsible for keeping the small airways open are most vulnerable [6–8]. When the patient is in supine position, there may be also some defects in the collateral air drift in areas of nodular atelectasis [2]. In our study, we also observed such posterior subpleural opacities, particularly GGOs lying in front of the focal PTs that disappeared in prone position (Fig. 2). The presence of a thin layer of normal lung density intervening between some of these subpleural opacities and the focal PTs confirms the parenchymal nature of the former opacities (Fig. 3a,b); the hypothesis of the pleural nature of the underlying thickening is supported by the large base of implantation of the focal thickening with the pleura (Fig. 2).

In animal studies, it has been shown that the lymphatic system directly communicates with pleural space through stomas at the level of the parietal pleura [9, 10]. The submesothelial lymphatics drain themselves into collecting vessels to finally reach the right lymphatic trunk and thoracic duct. Autopsic and electronic microscope studies have confirmed that such stomas exist in human parietal pleura [11–14]. To date, no equivalent structures were found in visceral

<table>
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<th>Table 1</th>
<th>Focal pleural thickenings (PTs) at the first and second computed tomographic (CT) acquisition in 19 patients.</th>
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<td></td>
<td>Number of pleural thickenings fitting typical pleural plaques criteria</td>
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<tr>
<td>1st Exam (supine)</td>
<td>44</td>
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<tr>
<td>2nd Exam (prone)</td>
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Focal reversible dependent pleural thickening at MDCT

Figure 2. Basal and posterior pleural opacities at the level of the left lower lobe (arrows) in mediastinal (a) and lung (b) window settings which disappear on additional acquisition in prone position (right).

Figure 3. Multiple basal and posterior pleural thickenings (PTs) and associated subpleural ground glass opacities (white arrows) (a) which completely disappear on the additional low dose acquisition in prone position (b). Note the obtuse angle of the pleural thickenings with the adjacent pleura. The ground glass opacities facing the focal pleural thickenings correspond to alveolar collapse induced by the bulging effect of pleural thickenings.
pleura [14]. Removal of pleural fluid and particles by lymphatics occurs only at specific areas in the parietal pleura [14]. About 85% of lymphatic stomata are located in the posterobasal part of the thorax, probably explaining the posterior and basal location of the reversible PTs we observed. Prone position may induce a variation of pleural pressure and increase pleural fluid removal through the parietal pleural stomas leading to PTs disappearance. Afterwards, the parietal lymphatics, which have smooth muscles in their walls, act as small pumps to force fluid to evacuate [15]. Pleural fluid removal through lymphatics may also be increased by respiratory movements which are partly responsible for topographic differences in pleural pressure [16]. This reinforces our hypothesis that such reversible PTs are of fluid pleural nature. Of the five new PTs we observed on additional acquisitions, three were located close to their initial location. This may suggest that local pressure variations occurring in prone position can induce a physiological migration of reversible PTs.

Our study has some limitations. First, it is based on a small cohort, particularly a small sample (n = 6) of patients with prior asbestos exposure or prior history of malignancies. Secondly, we do not have histopathological correlation to prove our hypothesis that these reversible PTs originate from physiological pleural fluid accumulation. However, it would be ethically questionable to order histopathological confirmation of such reversible and probably physiological findings in asymptomatic patients.

Conclusion

In conclusion, focal pleural abnormalities mimicking pleural malignancies or plaques related to asbestos exposure may be found on chest CT scan performed in supine position. In order to identify their potential reversible nature probably related to normal lymphatic drainage, additional volumetric low dose acquisition in prone position should be performed. This may simplify the recognition of real organic pleural lesions and avoid critical misdiagnosis that may sometimes totally change prognosis and management, especially in oncologic patients.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References