The CT Findings of Pulmonary Sarcoidosis

MANABU HASHIMOTO, OSAMU WATANABE, KIMIHiko SATO, KUMIKO ENDO, JYOUICHI HEIANNA, ISAMU ITOH and JIRO WATARAI

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HASHIMOTO, M., WATANABE, O., SATO, K., ENDO, K., HEIANNA, J., ITOH, I. and WATARAI, J. The CT Findings of Pulmonary Sarcoidosis. Tohoku J. Exp. Med., 1996, 179 (4), 259-266 —— We analyzed the CT findings in 35 patients with pulmonary sarcoidosis. Twenty-seven patients had biopsy-proven sarcoidosis; in eight patients the diagnosis was made clinically. In all the 35 patients, 10-mm collimation scans were available. In seven patients, high-resolution CT was also obtained. Twenty-eight patients had lymphadenopathy associated with pulmonary infiltration; two patients had pulmonary infiltration without lymphadenopathy, five patients had lymphadenopathy alone. The most frequent parenchymal features on CT were small nodules (100%), and irregularly thickened bronchovascular bundle (90%). Other frequent CT findings were pleural or subpleural thickening (83%), septal lines (73%), and ground-glass attenuation (63%). In all cases, small nodules were associated with other lesions. The authors conclude that in patient with sarcoidosis, CT is a valuable technique to visualize the findings in the pulmonary parenchyma characteristic enough to allow confident diagnosis. While high-resolution CT is superior in the assessment of linear opacities and cysts, conventional CT is superior in demonstrating small nodular opacities. We believe that both should be combined in the examination of patients with sarcoidosis. ——— sarcoidosis; lung; CT

Sarcoidosis is a systemic disorder of unknown cause characterized by the presence of noncaseating granulomas in affected tissue, which may resolve spontaneously or progress to fibrosis. Most of the morbidity and mortality is due to pulmonary disease (Crystal et al. 1984). The severity of lung disease as assessed on radiograph, however, correlates poorly with the clinical and functional impairment (Carrington et al. 1976). Recent reports suggest that computed tomography (CT) may be superior to chest radiography in assessing the presence and extent of parenchymal abnormalities in diffuse lung disease (Mathieson et al. 1989; Grenier et al. 1991). The aim of this study is to describe the CT appearances of lung abnormalities in cases of sarcoidosis.

Patients and Method

Thirty-five patients with sarcoidosis whose CT scans of the chest were

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obtained were included in this study. There were 14 men and 21 women, ranging in age from 22 to 71 years (mean, 40). All patients were examined between 1989 and 1994.

Twenty-seven patients had biopsy-proved sarcoidosis. Histopathologic confirmation was obtained by means of transbronchial lung biopsy \((n=15)\), biopsy of lymph node \((n=6)\) or of a skin lesion \((n=6)\). In the remaining eight cases, the diagnosis was made by clinical findings; these patients had bilateral hilar and mediastinal lymphadenopathy, uveitis, and increased serum angiotensin-converting enzyme (ACE) level. Under these circumstances, histologic proof is not required for diagnosis of sarcoidosis (Hillerdal et al. 1984).

The CT scans were performed on a 9200 (five patients) or 9800 (30 patients) scanner (GE Medical System, Milwaukee, WI, USA) with the use of 10-mm collimation at a 10 mm interval through the lungs. All scans were obtained at end-inspiration. All images were reviewed at windows appropriate for lung parenchyma (mean levels, -600 to -700 HU; width, 1,500-2,000 HU) and mediastinum (mean levels, 30-50 HU; width, 250-300 HU), using standard algorithm. In seven patients, additional 1.5 mm collimation scans were obtained using a high-spatial-resolution algorithm (bone-detail algorithm).

CT scans were interpreted by means of consensus by two radiologists (M.H., O.W.). The presence of the following findings in the lung parenchyma and lymph nodes was recorded.

**Lung parenchyma**

On the basis of previous reports (Brauner et al. 1989, 1992; Müller et al. 1989; Nishimura et al. 1993), the following abnormalities were assessed: micronodules of less than 3 mm in diameter, nodules of 3-10 mm in diameter, large nodules of more than 10 mm in diameter, thickened bronchovascular bundle, areas of ground-glass attenuation, pleural or subpleural thickening, linear opacities, lung distortion, bulla, and honeycomb cysts. Thickened bronchovascular bundle was defined as irregularly enlarged vessels and/or thickened bronchial wall. Ground-glass areas were defined as slightly hyperattenuated areas in which vessels and bronchi remained visible. We classified linear opacities into septal and nonseptal lines. Nonseptal lines were visible as linear areas of attenuation developing on peripheral or mediastinal pleura, and along fissures, vessels and bronchi. Lung distortion was defined as abnormal displacement of pulmonary vessels, bronchi and fissures.

We also evaluated a vertical topographic predominance in the distribution of lesions by means of visual inspection. We classified it according to whether the lesions were predominantly in the upper (upper and/or middle zones) or lower lung field (lower zones). The upper zones were above the level of the carina, the middle zones were between the level of the carina and that of the inferior pulmonary vein, and the lower zones were below the level of the inferior pulmo-
nary vein (Brauner et al. 1989).

**Lymph nodes**

Signs of hilar or mediastinal lymphadenopathies with diameters (short axis) of more than 10 mm were noted.

**Results**

Hilar and/or mediastinal lymphadenopathies were recognized in 33 of the 35 patients (94%). Five patients had lymphadenopathy only. Twenty-eight patients had lymphadenopathy associated with pulmonary infiltration. There were only two patients (6%) with CT findings of pulmonary infiltration without lymphadenopathy.

Pulmonary abnormalities (Figs. 1–4) were observed at CT in 30 patients (Table 1). Nodular areas of attenuation were seen in all cases: micronodules in 30 (100%), nodules in 19 (63%), large nodules in 10 (33%). Many large nodules observed at CT had irregular margins. Of the 10 patients who had large nodules, three had patchy areas with air bronchograms, and four had excavated nodules. Nodules were associated with other lesions in all cases. Peribronchovascular thickening was observed in 27 (90%) cases. Ground-glass areas of attenuation were observed in 19 (63%) cases. Pleural and/or subpleural thickening was

![CT scan of right lung](image)

**Fig. 1.** CT scan of right lung of a 24-year-old woman shows peribronchovascular thickening, micronodules mainly in the subpleural region and irregularly marginated nodules (arrowhead).
Fig. 2. CT scan obtained in a 30-year-old man shows a large parenchymal nodule with irregular margin in the right lower lobe. Thickening and irregularity of the peripheral pleural surface are also present.

Fig. 3. CT section through the lung base shows ground-glass areas of attenuation, micronodules, septal lines (black arrowheads), and nonseptal line (white arrowhead) in a 23-year-old man.
Fig. 4. CT scan at the level of the aortic arch in a 30-year-old woman. The involvement of lung parenchyma consists of poorly defined opacity with lung distortion and dilated bronchi. Also seen are a bulla (arrowhead), nonseptal line (arrow) in a peripheral location, and nodules.

<table>
<thead>
<tr>
<th>Lesions</th>
<th>No.*</th>
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<tbody>
<tr>
<td>Nodules</td>
<td>30 (100)</td>
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<tr>
<td>Micronodules</td>
<td>19 (63)</td>
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<td>Nodules</td>
<td>10 (33)</td>
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<td>Peribronchovascular thickening</td>
<td>27 (90)</td>
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<td>Ground-glass attenuation</td>
<td>19 (63)</td>
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<td>Pleural and/or subpleural thickening</td>
<td>25 (83)</td>
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<tr>
<td>Septal lines</td>
<td>22 (73)</td>
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<tr>
<td>Nonseptal lines</td>
<td>7 (23)</td>
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<tr>
<td>Lung distortion</td>
<td>8 (27)</td>
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<td>Bulla</td>
<td>2 (9)</td>
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<td>Honeycomb cysts</td>
<td>5 (17)</td>
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*Percentages in parenthesis
detected in 25 (83%) cases. Septal lines were observed in 22 patients (73%), and nonseptal lines were seen in seven patients (23%).

The following topographic predominances were observed: upper lung field predominance, $n = 21$ (70%); lower lung field predominance, $n = 4$ (13%). Two patients had diffuse lesions without any topographic predilection. In the remaining three patients, pulmonary lesions were scant and randomly scattered throughout the parenchyma.

DISCUSSION

Although the manifestations of sarcoidosis on the chest radiographs have been well described (Heitzman 1984), the radiologic findings are non-specific or atypical in 25–30% of cases (Hamper et al. 1986). As in other interstitial lung diseases, CT depicts in detail the morphologic derangements of sarcoidosis and has been proved superior to chest radiography in the diagnosis (Mathieson et al. 1989; Grenier et al. 1991). The aim of this study was to analyze the CT appearance of abnormalities of the lung in patients with sarcoidosis. Unfortunately, pathologic findings were not correlated with CT findings in pulmonary sarcoidosis for the following reasons: Open lung biopsy is rarely performed in patients with sarcoidosis in our institute. Moreover, biopsy provides information only from a small area of lung, while sarcoidosis is non-uniform in distribution.

In the present study, the most frequent CT features were small nodules (100%) and thickened bronchovascular bundles (90%). Other frequent CT findings were pleural or subpleural nodules and ground-glass attenuation. We consider these findings are the main features of parenchymal sarcoidosis. While small nodules were seen in all cases, large nodules were less common. In the present study, large nodules had ill-defined contours. Sometimes, an air bronchogram or excavated appearance was present within a large nodule; the former aspect corresponds to the radiologic “alveolar or pseudoalveolar sarcoid” (Heitzman 1984). Nishimura et al. (1993) demonstrated that large nodules correspond to accumulated granulomatous lesions. Although not observed in our study, large nodules may be solitary (Rose et al. 1985). They must be differentiated from metastatic neoplasm or primary lung cancer. Thickened bronchovascular bundles reflect the presence of granulomas distributed along the lymphatic system in the peribronchovascular interstitial space (Nishimura et al. 1993). However, this CT finding is not specific to sarcoidosis. It also occurs in patients with lymphangitic carcinomatosis. Both conditions cause a beaded appearance of the bronchovascular bundles and of the interlobular septa (septal lines). Septal lines are scant in sarcoidosis, whereas they are prominent in lymphangitic carcinomatosis (Brauner et al. 1989; Müller et al. 1989). In the present study, they were few, even when present. In contrast to sarcoidosis, nonseptal lines are not features of lymphangitic carcinomatosis (Bergin et al. 1989). Although it has been suggested that the appearance of ground-glass attenuation is related to active alveolitis,
Nishimura et al. (1993) proved that it represents an accumulation of many granulomatous lesions in the interstitium of peripheral lung tissue, that is, in the alveolar septa and around blood vessels or bronchioles.

Signs of distortion, bulla and honeycomb cysts, easily detectable on CT, were considered to reflect fibrosis. Parenchymal distortion and cysts are seen in both usual interstitial pneumonia (UIP) and sarcoidosis (Bergin et al. 1989). However, cysts are generally smaller, more numerous, and peripheral in distribution in UIP. In UIP, distortion usually affects peripheral structures except in severe, advanced disease. In contrast to UIP, sarcoidosis more commonly affects the central and middle lung compartment (Bergin et al. 1988). In the present series of patients, fibrosis appeared to be more marked along the bronchovascular bundle and associated with distortion of lung, displacing major vessels and bronchi. It is conceivable that the CT appearances may not be as characteristic in patients with advanced disease, although patients in our study who had fibrosis had a relatively early stage of disease.

In the majority of the present cases, the pulmonary abnormality was upper zonal predominance. This topographic preference was already well established in radiographic studies (Heitzman 1984). In patients in whom the disease is confined largely to the upper lung field, their CT finding may not be different from that of pulmonary tuberculosis. In our limited series, when parenchymal abnormalities were either mild or extensive, the imaging diagnosis of sarcoidosis was difficult.

High-resolution CT allowed better assessment of parenchymal detail, especially in the detection of the septal lines and small cystic areas of honeycombing. However, it did not detect any abnormality in areas where conventional CT at the same level was normal. Furthermore, even with high-resolution CT, small nodules were easily missed between CT sections. When present, they were difficult to be distinguished from blood vessels. The beaded appearance of the bronchovascular bundle was also much easier to assess with conventional CT. High-resolution CT is superior in the assessment of linear opacities, whereas conventional CT is superior in the assessment of small nodular opacities. Therefore, we believe that both should be used in the examination of patients with sarcoidosis.

In conclusion, no single parenchymal abnormality was predictive of sarcoidosis. In addition to the nodal involvement, however, the diagnosis of sarcoidosis can be made with a high degree of accuracy if we take into account a combination of parenchymal CT features. These include nodules, thickened bronchovascular bundles, pleural and/or subpleural thickening, ground-glass attenuation, linear opacities and distortion.

References


