The purpose of this study is to review the computed tomography (CT) appearances of the lung diseases including lung carcinoma, non-cancerous diseases and pulmonary tuberculosis. Thirty one patients with 15 cases of lung carcinoma and 16 cases of non-cancerous diseases (including 10 cases of tuberculosis) were evaluated based on the CT findings of mass (or large nodule), consolidation, intralesional cavitation, intrallesional necrosis, nodular opacities, lobar or segmental distribution, extension to the mediastinum, encasement of great vessels, mediastinal lymphadenopathy and pleural effusion. The results were compared between lung carcinoma and non-cancerous disease and between lung carcinoma and tuberculosis using Fisher’s Exact test. Our results show that mass (or large nodule) and necrosis are more common in lung carcinoma while consolidation and cavitation are more frequently found in non-cancerous diseases and tuberculosis. Nodular opacities are more specific for tuberculosis. We conclude that CT is important in differentiating lung malignancy and non-tumoral lung diseases, especially tuberculosis.

Key words: lung neoplasms; tuberculosis; lung, CT

Pleura-contiguous lung diseases may be malignant [1-6], inflammatory or infectious [7-12]. Accurate diagnosis is important due to different treatments for different disease processes. The final diagnosis can be made by percutaneous image-guided biopsy, bronchoscopy and/or laboratory analysis. Computed tomography (CT) is frequently performed for the evaluation of lung diseases [1-5, 7-12]. Various CT appearances were found in different lung parenchymal diseases. The purpose of this study is to evaluate different lung diseases with various CT appearances and differentiate them by some characteristic findings.

MATERIALS AND METHODS

Thirty one patients (19 males and 12 females) of 33 to 88 years of age (mean age of 62.7 years) suffering from lung diseases contiguous to the pleura were evaluated by CT. The disease entities included 15 cases of lung carcinoma (4 small cell carcinoma, 5 squamous cell carcinoma, 4 adenocarcinoma, 1 bronchioloalveolar carcinoma and 1 non-small cell, poorly-differentiated carcinoma), 10 cases of pulmonary tuberculosis, 1 case of lung abscess, 1 case of necrotizing pneumonia, 2 cases of chronic inflammation and fibrosis, 1 case of granuloma and 1 case of foreign body in the bronchus. All the cases were proved by image-guided biopsy (totally 24 cases: of which 19 cases approached by CT-guidance and 5 cases by sonographic guidance), bronchoscopy (5 cases), sputum culture (1 case) or therapeutic diagnosis (1 case). All but two patients received intravenous contrast administration. All the patients were scanned by CT starting from the inlet of the thoracic cage to the upper pole of the kidneys with slice thickness and interval of 10 millimeters respectively. Soft tissue (window level at 30 H.U.; window width at 300 H.U.) and lung window (window level at – 530 H.U.; window width at 1200 H.U.) settings were both obtained.

The following CT appearances were evaluated: mass (or large nodule), consolidation, intrallesional cavitation, intrallesional necrosis, associated nodular...
opacity, segmental or lobar distribution, extension to the mediastinum, encasement of the great vessels, mediastinal lymphadenopathy and associated pleural effusion. A large nodule is a round opacity more than 1 cm in caliber while a mass is defined as a nodule greater than 3 cm in diameter [13]. A consolidation is the increased lung attenuation with obscuration of the lung vessels. Cavitation means the presence of air cavity inside the lesion while necrosis is the area of attenuation lower than that of the soft tissue on CT. Nodular opacities are multiple acinar, lobular or patchy lesions, and nodular lesions of various sizes [11].

Three categories were analysed based on the aforementioned CT appearances: lung carcinoma (15 cases), non-cancerous diseases (16 cases; including the tuberculosis cases) and tuberculosis (10 cases). The CT appearances were compared between lung carcinoma and non-cancerous diseases, and between lung carcinoma and tuberculosis. The data was analysed by the Fisher’s Exact test.

RESULTS

Lung carcinoma is more likely a mass (or large nodule) as compared with tuberculosis (80% versus 30%; p=0.0167) and non-cancerous disease (80% versus 44%; p=0.0369) (Figure 1)(Table 1). On the other hand, pulmonary tuberculosis and non-cancerous disease present as a consolidation more frequently than carcinoma does (70% versus 20%; p=0.0167 and 56% versus 20%; p=0.0369 respectively) (Figure 2). Cavitation is more specific for tuberculosis and non-cancerous disease than for carcinoma (60% versus 0%, p=0.0012 and 56% versus 0%, p=0.0006 respectively) (Figures 2-4). Lung carcinoma reveals a higher incidence of interior necrosis than tuberculosis (80% versus 10%, p=0.0009) and non-cancerous disease (80% versus 13%; p=0.0002) (Figures 1, 5). Also, nodular opacities are present more frequently in tuberculosis (Figure 3) than in carcinoma (Figure 5) (60% versus 13%; p=0.0204). Analysis of the subtypes of lung carcinoma is not performed due to small case number of the subtypes. One case of small cell carcinoma reveals mediastinal lymphadenopathy (Figure 6). Another case of adenocarcinoma shows invasion and destruction of the rib and vertebral body (Figure 7). One case of obstructive pneumonitis caused by tuberculosis-induced scar formation and occlusion of the right upper lobe bronchus shows the CT-angiogram sign (Figure 8). A case of obstructive

<table>
<thead>
<tr>
<th></th>
<th>(A) Lung carcinoma (subtotal=15)</th>
<th>(B) Non-cancerous diseases* (subtotal=16)</th>
<th>(C) Tuberculosis (subtotal=10)</th>
<th>p value: (A) compared with (B)</th>
<th>p value: (A) compared with (C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Mass (or large nodule)*</td>
<td>12 (80)</td>
<td>7 (44)</td>
<td>3 (30)</td>
<td>0.0369</td>
<td>0.0167</td>
</tr>
<tr>
<td>(2) Consolidation*</td>
<td>3 (20)</td>
<td>9 (56)</td>
<td>7 (70)</td>
<td>0.0369</td>
<td>0.0167</td>
</tr>
<tr>
<td>(3) Intralobular cavitation*</td>
<td>0 (0)</td>
<td>9 (56)</td>
<td>6 (60)</td>
<td>0.0006</td>
<td>0.0012</td>
</tr>
<tr>
<td>(4) Intralobular necrosis*</td>
<td>12 (80)</td>
<td>2 (13)</td>
<td>1 (10)</td>
<td>0.0002</td>
<td>0.0009</td>
</tr>
<tr>
<td>(5) Nodular opacities*</td>
<td>2 (13)</td>
<td>6 (38)</td>
<td>6 (60)</td>
<td>0.1066</td>
<td>0.0204</td>
</tr>
<tr>
<td>(6) Segmental or lobar distribution</td>
<td>4 (27)</td>
<td>3 (19)</td>
<td>1 (10)</td>
<td>0.2907</td>
<td>0.2569</td>
</tr>
<tr>
<td>(7) Extension to mediastinum</td>
<td>8 (53)</td>
<td>8 (50)</td>
<td>6 (60)</td>
<td>0.2756</td>
<td>0.3032</td>
</tr>
<tr>
<td>(8) Encasement of great vessels</td>
<td>2 (13)</td>
<td>2 (13)</td>
<td>2 (20)</td>
<td>0.4004</td>
<td>0.3735</td>
</tr>
<tr>
<td>(9) Mediastinal lymphadenopathy</td>
<td>4 (27)</td>
<td>2 (13)</td>
<td>2 (20)</td>
<td>0.2225</td>
<td>0.3468</td>
</tr>
<tr>
<td>(10) Pleural effusion</td>
<td>6 (40)</td>
<td>3 (31)</td>
<td>4 (40)</td>
<td>0.2582</td>
<td>0.3215</td>
</tr>
</tbody>
</table>

*Statistically significant (p<0.05) between (A) and (B) and between (A) and (C)

*Statistically significant (p<0.05) between (A) and (C)

*Non-cancerous diseases include all the cases of tuberculosis
atelectasis results from obstruction of the left upper lobe bronchus by a foreign body (Figure 9).

The case of lung abscess was diagnosed and treated by CT-guided insertion of a pigtail catheter for closed drainage purpose (Figure 4).

**DISCUSSION**

CT is frequently used to evaluate lung parenchymal diseases [1-5, 7-12]. Peripheral lung diseases can be diagnosed with high sensitivity by either CT-guided [14] or sonography-guided [15] core-needle biopsy. These procedures have low rate of minor complications, including pneumothorax, hemoptysis or pleuritis. Treatment of lung abscess can also be performed by image-guided percutaneous drainage with good result [16,17]

Imaging analysis of different cell types of lung carcinoma has been described [1-3]. Adenocarcinoma may be a solitary pulmonary nodule or a mass in peripheral location and has well-marginated, lobulated, irregular or poorly defined border. It may directly invade the pleura or chest wall (Figure 7). Air bronchogram or bronchiologram may be present inside the tumor [1,2]. Bronchioloalveolar carcinoma is a subtype of adenocarcinoma. The most common imaging finding is a well-circumscribed peripheral solitary pulmonary nodule or mass with or without cavitation. Multiple nodules or extensive consolidation involving one or more lobes may be present. CT angiogram sign was first described in bronchioloalveolar carcinoma [4] but may also be found in many
frequently associated with enlarged or conglomerated mediastinal lymph nodes, which cause mediastinal widening on chest radiograph and can be easily evaluated with CT [1,3].

In pulmonary tuberculosis, cavitation may occur when the areas of caseous necrosis erode into the bronchi (Figure 2 and 3) [7]. The wall of the cavity may be thick or thin and smooth or irregular [7-10]. Cavitation may also occur in pneumonia progressing to lung abscess [17].

Figure 5. In a case of adenocarcinoma of lung, post-contrast CT scan shows a segmental consolidation with interior necrosis in right upper lobe, extending to the mediastinum (a). Multiple small nodules are noted in both lungs in lung window setting, indicating intrapulmonary metastases (b).

Figure 6. In small cell carcinoma of lung, post-contrast CT scan shows an irregular mass in left hilar region and left peripheral lung. Conglomerated mediastinal lymph nodes are found at higher level (not shown).

Figure 7. Adenocarcinoma of lung with bony destruction. Post-contrast CT scan shows a heterogeneous enhanced soft tissue mass is present in the posterior segment of right upper lobe. Invasion and destruction of right fourth rib and the fourth thoracic vertebral body are illustrated.

In small cell carcinoma, hilar or perihilar mass is frequently associated with enlarged or conglomerated mediastinal lymph nodes, which cause mediastinal widening on chest radiograph and can be easily evaluated with CT [1,3].

In pulmonary tuberculosis, cavitation may occur when the areas of caseous necrosis erode into the bronchi (Figure 2 and 3) [7]. The wall of the cavity may be thick or thin and smooth or irregular [7-10]. Cavitation may also occur in pneumonia progressing to lung abscess [17].

Nodular opacities are present in tuberculosis. They include acinar, lobular or patchy lesions (Figure 2) and nodular lesions of various sizes (Figure 3).[11].
In bronchogenic spread of pulmonary tuberculosis, the typical CT findings are centrilobular branching linear structure (tree-in-bud appearance), relatively poorly defined centrilobular peribronchiolar nodules 2-3mm in size, acinar shadows 4-10mm in size and large lobular consolidations [10,12]. Miliary tuberculosis results from the hematogeneous spread. Diffuse, discrete nodules of 1-2mm in size are noted [7,9,12]. High-resolution CT (HRCT) using slice thickness of 1mm to 1.5mm with various slice intervals is sensitive to detect the nodular densities [7-12].

It is difficult to make differential diagnoses between nodules of pulmonary tuberculosis, satellite nodules of lung carcinoma and metastatic lung nodules when only nodules are taken into consideration. Other nodular opacities (acinar, lobular or patchy pattern), if present, are valuable to narrow the differential diagnoses. Foreign body in the bronchus may cause obstructive emphysema, pneumonia or atelectasis (Figure 9)[20]. Symptoms of cough, fever, dyspnea and recurrent pneumonia may occur. Bronchoscopy should be performed for prompt diagnosis and removal of the endobronchial foreign body.

Pulmonary consolidations associated with bronchial obstruction may have various CT appearances (Figures 5, 8 and 9). Consolidation caused by lung carcinoma may have irregular margin with outward bulging and heterogeneous density (Figure 5).

When CT-angiogram sign is present in the consolidation (Figure 8), a wide range of differential diagnoses, including bronchioloalveolar cell carcinoma, lymphoma, pneumonia and obstructive pneumonitis, is considered, although the associated bronchial obstruction may favor the latter disease [4, 18, 19]. When the consolidation has a homogeneous density with a wedge-shaped and concave margin, and extends from the pulmonary periphery to the central location, atelectasis caused by bronchial obstruction is diagnosed with high confidence (Figure 9).

The drawback of our study is that no HRCT is performed to better evaluate the nodular opacities of the lung diseases. However, the statistically significant difference in the higher percentage of nodular opacities in tuberculosis than in the carcinoma (60% versus 13%) using routine 10mm-10mm slice thickness-interval CT scans hints that even though no HRCT is performed, the routine slice parameters can be used to evaluate the nodular opacities and make differential diagnosis between malignancy and benignity in high confidence. HRCT may even decrease the p value and therefore increase the statistical significance. Further study with large number of cases using HRCT is necessary to verify this difference.

In conclusion, pleura-contiguous lung diseases can be diagnosed frequently by image-guided biopsy. Mass (or large nodule) and intralesional necrosis are more common in lung carcinoma while consolidation and intralesional cavitation are more frequent in non-tumoral disease and tuberculosis. Associated nodular opacities are more specific for tuberculosis. CT is a
good imaging modality for differentiation of these various lung diseases.

REFERENCES

電腦斷層掃描術對於肋膜相鄰的肺臟疾病之評估

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本研究主要目的為探討肺部疾病於電腦斷層掃描術（CT）中各種表徵。疾病包括肺癌，非癌症疾病及肺結核。本研究共有三十一位病人，其中十五例為肺癌、十六例為非癌症疾病（其中包括十例肺結核），並評估各種疾病是否具有下列CT中的表徵：塊狀（或大的小結）、堅實、病變內的空洞化、病變內的壞死、小結性濁斑、肺葉或分節之分佈、延伸至縱膈腔、包圍大血管、縱膈腔淋巴腺病及肋膜間積水等。所得到的結果以 Fisher's Exact test來比較肺癌和非癌症疾病的關係以及肺癌和肺結核的關係。結果顯示，塊狀（或大的小結）及壞死較容易出現於肺癌，另外堅實及空洞化較常出現在非癌症疾病及肺結核的病例，而小結性濁斑於肺結核較具特異性。所得到的結論為CT對於肺部惡性腫瘤及非癌症疾病（尤其對肺結核而言）的鑑別非常重要。

關鍵詞：肺癌；肺結核；肺部電腦斷層掃描