The use of multi-detector computed tomography and ultrasonography for evaluation of pleural lesions

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Abstract Background and objective: Multidetector CT (MDCT) and ultrasonography (US) are of increasing importance for assessment of many pulmonary disorders. Our aim was to evaluate their role in diagnosis of pleural diseases.

Methods: Patients from Tanta University Hospital who were suspected to have pleural lesions (symptoms, signs and/or suggestive chest X-ray) during one year period were enrolled in the study. US and MDCT were done for all of them, then data were reported and analyzed.

Results: Seventy-one patients were included, sixty of them had evident pleural lesions. Chest pain was the commonest presenting symptom. Malignancy represented 36.7% of pleural lesions, a percentage similar to lesions due to infection etiology. Free pleural effusions were the most common pleural lesions followed by pleural thickening. US was diagnostic in 72% of pleural lesions detectable by MDCT. Multiplanar reconstruction (MPR) images had an additional value than axial images in 39% of pleural lesions, mostly in cases of pleural thickening, free pleural effusion, pleural masses, encysted pleural effusions and pleural plaques. On the other hand, the MPR images had the same value as axial images in empyema and pneumothorax cases.

Conclusion: MDCT is an important noninvasive imaging tool in accurate detection and characterization of pleural lesions with complementary MPR images that solve many diagnostic problems. Ultrasonography is a safer alternative but with less diagnostic value.

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Introduction

The pleura is derived embryologically from the mesenchyme [1]. It serves an important role in lung function in that it acts as a cushion for the lungs and allows for smooth movement of the lungs within the chest cavity [2].
Pleural diseases (as pleural effusions, pneumothorax, pleural plaques, diffuse pleural thickening and pleural tumors) affect over 3000 subjects per million population each year. They can originate from a broad spectrum of pathologies.[3,4] Pleural plaques are deposits of hyalinized collagen fibers in the parietal pleura. They are indicative of asbestos exposure and typically become visible twenty or more years after the inhalation of asbestos fibers, although latency periods of less than ten years have been observed [5].

Imaging of the pleura can be challenging and it plays an important role in the diagnosis and subsequent management of patients with pleural diseases. The presence of a pleural abnormality is usually suggested following a routine chest X-ray, with a number of imaging modalities available for further characterization [6].

Computed tomography (CT) may show abnormalities of the pleura at an earlier stage than do other imaging techniques. It is also useful in the distinction of pleural from parenchymal lung disease, in determining the precise location and extent of pleural disease, and in certain instances it permits characterization of tissue density within a lesion by means of analysis of attenuation coefficients [7].

Multislice (or multi-detector array) CT scanners are capable of acquiring several tomographic slices in a single rotation of the X-ray tube and detector assembly. It reduces examination times presenting advantages, particularly in examinations where voluntary or involuntary patient motion is a problem [8].

Multi-detector CT (MDCT) is currently considered as a better modality for the diagnosis of pleural lesions as it provides excellent image quality, it allows excellent visualization during the different stages of contrast enhancement, thereby facilitates detection of small pleural lesions and 3D multiplanar reformatted images can be used to solve different diagnostic problems and to help communicate findings to clinicians [9].

Trans-thoracic ultrasound (US) is an easily performable, feasible and reliable diagnostic tool, very helpful toward diagnosing pleural disorders. Lack of ionizing radiation and ability to be done at bedside have been emphasized as advantages of this diagnostic procedure [10]. Apart from having a higher sensitivity when confronted with the conventional radiography, the US is able to differentiate solid from cystic lesions [11]. Thus, it is able not only to detect a pleural effusion, but also it might be helpful in precisng a point to perform aspiration.

The aim of this work was to assess the role of both multi-detector CT (MDCT) and trans-thoracic US in diagnosis and evaluation of pleural lesions.

Methods

The current study has been conducted during the period from October 2012 to October 2013. Patients who were clinically suspected to have or provisionally diagnosed as having pleural diseases during the study period were included in the study. Patients were selected from those attending to Tanta University Hospital, Egypt. Patients were first evaluated in the Pnumology clinic of Chest Department and then referred to the radiologist.

Study design

We performed a prospective cross sectional study. It was conducted according to the guidelines of ethics committee of our university and was approved by our institutional ethics committee and review board; all patients gave us a written informed consent to be included and imaged in our study.

Inclusion criteria

- Presence of one or more of symptoms of pleural diseases as cough, dyspnea, talepnea, pleuritic or dull aching chest pain or chest heaviness, with or without palpitation, fever, weight loss, night fever or night sweat.
- Presence of one or more of signs of pleural diseases as unilateral bulge or retraction of the chest wall, unilateral decreased chest expansion, mediastinal shift, diminished tactile vocal fremitus, diminished vocal resonance, change in percussion note (tymanitic resonance, impaired note, dullness or stony dullness), diminished intensity of breath sound, or pleural rub.

All patients were submitted to

1. Careful history taking:
   With emphasis on the onset, course and duration of the presenting complaint and the risk factors (e.g. asbestos exposure, T.B), and past history of previous operation or receiving chemotherapy or radiotherapy for any malignancy and its site.
2. Thorough clinical examination:
3. Laboratory investigations:
   Routine laboratory investigations were done to all patients that included: complete blood picture, blood urea and serum creatinine.
   Other investigations were needed in some cases to help diagnosis as tuberculin skin test, sputum analysis for tuberculosis, investigations for collagen diseases, liver function tests, or pleural effusion analysis (chemical, culture and sensitivity, adenosine deaminase, or cytological examination). In some cases, the diagnosis was confirmed by doing pleural biopsy and histo-pathological examination.
4. Chest X-ray:
   For all cases in Postero-anterior view and for some cases in Lateral view.
5. Ultrasonography (US):

   It was done for all patients. Transthoracic gray-scale chest US examination was performed with a 3.5 MHz curvilinear probe that allowed visualization of the deeper structures, and the sector scan field allowed a wider field of view through a small acoustic window. The pleura was surveyed with the curvilinear probe. Once an abnormality has been identified, a high-resolution 7.5 MHz linear probe was used to provide detailed depiction of any chest wall, pleural, or peripheral lung abnormality.
Patients were asked to raise their arms above their heads to increase the rib space distance and facilitate scanning with the patient in erect or recumbent positions. The posterior chest was best imaged with the patient sitting upright, while the anterior and lateral chest were assessed in the lateral decubitus position.

6. Multi-detector Computed tomography (MDCT):

The examination was done at the CT unit of Tanta University Hospital with 16 slice multi detector CT with scan time about 4 s.

In general, the pleura was best evaluated using the standard technique CT of the chest.

- Patient preparation:

Usually no preparation was recommended in CT pleural examination except for the patient being fasting for 6 h for the possibility of contrast media administration.

- Patient position:

Patients were usually scanned in the supine position. To prevent streak artifacts from appearing on skeletal structures of the upper extremity, patients were scanned with arms elevated above the head.

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Table 3  Distribution of cases according to types of pleural lesions detected by MDCT, ultrasound, and Chest X-ray.

<table>
<thead>
<tr>
<th>Types of pleural lesions</th>
<th>MDCT No. of cases</th>
<th>MDCT %</th>
<th>US No. of cases</th>
<th>US %</th>
<th>Chest X-ray No. of cases</th>
<th>Chest X-ray %</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free pleural effusion</td>
<td>24</td>
<td>100.0</td>
<td>20</td>
<td>83.3</td>
<td>16</td>
<td>66.7</td>
<td>0.008 *</td>
</tr>
<tr>
<td>Encysted pleural effusion</td>
<td>10</td>
<td>100.0</td>
<td>6</td>
<td>60.0</td>
<td>4</td>
<td>40.0</td>
<td>0.014 *</td>
</tr>
<tr>
<td>Empyema</td>
<td>4</td>
<td>100.0</td>
<td>4</td>
<td>100.0</td>
<td>2</td>
<td>50.0</td>
<td>0.090</td>
</tr>
<tr>
<td>Pneumothorax</td>
<td>2</td>
<td>100.0</td>
<td>1</td>
<td>50.0</td>
<td>2</td>
<td>100.0</td>
<td>0.301</td>
</tr>
<tr>
<td>Pleural thickening</td>
<td>20</td>
<td>100.0</td>
<td>14</td>
<td>70.0</td>
<td>2</td>
<td>10.0</td>
<td>0.090</td>
</tr>
<tr>
<td>Pleural calcification or plaque</td>
<td>10</td>
<td>100.0</td>
<td>6</td>
<td>60.0</td>
<td>4</td>
<td>40.0</td>
<td>0.014 *</td>
</tr>
<tr>
<td>Pleural nodule or mass</td>
<td>12</td>
<td>100.0</td>
<td>8</td>
<td>66.7</td>
<td>2</td>
<td>16.7</td>
<td>0.0001 *</td>
</tr>
<tr>
<td>Total lesions</td>
<td>82</td>
<td>100.0</td>
<td>59</td>
<td>72.0</td>
<td>32</td>
<td>39.0</td>
<td>0.00001 *</td>
</tr>
</tbody>
</table>

MDCT: multi-detector computed tomography. US: ultrasound. No.: number. N.B: more than one type of lesion may be detected in one case.
* Statistically significant.

Table 4  Additional diagnostic value of multiplanar reconstruction (MPR) in the studied cases compared to axial images.

<table>
<thead>
<tr>
<th>Types of pleural lesions</th>
<th>Diagnostic value of MPR images</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Same diagnostic value</td>
<td>Additional diagnostic value</td>
</tr>
<tr>
<td></td>
<td>No. %</td>
<td>No. %</td>
</tr>
<tr>
<td>Free pleural effusion (24)</td>
<td>16</td>
<td>66.7</td>
</tr>
<tr>
<td>Encysted pleural effusion (10)</td>
<td>6</td>
<td>60.0</td>
</tr>
<tr>
<td>Empyema (4)</td>
<td>4</td>
<td>100.0</td>
</tr>
<tr>
<td>Pneumothorax (2)</td>
<td>2</td>
<td>2.5</td>
</tr>
<tr>
<td>Pleural thickening (20)</td>
<td>11</td>
<td>55.0</td>
</tr>
<tr>
<td>Pleural calcification or plaque (10)</td>
<td>6</td>
<td>60.0</td>
</tr>
<tr>
<td>Pleural nodule or mass (12)</td>
<td>5</td>
<td>41.7</td>
</tr>
<tr>
<td>Total lesions (82)</td>
<td>50</td>
<td>61.0</td>
</tr>
</tbody>
</table>

MPR: multiplanar reconstruction.
* Statistically significant.

**Figure 1**  Case number 1: A 60 year old male patient, presented with left sided chest pain. A: Axial cuts mediastinal window. B: Axial cuts pulmonary window. C: Coronal reconstruction cuts mediastinal window. D: Sagittal reconstruction cuts mediastinal window. E & F: US images showing polypoidal soft tissue pleural mass with mild effusion. Contrast enhanced MDCT & US showing a large ill defined soft tissue mass encasing the left lung along the course of costal and mediastinal pleura associated with mild pleural effusion. Biopsy results came as malignant mesothelioma.
Results

Patients who were eligible to be included the study and agreed to share were seventy-one. Eleven of them were excluded because after doing chest X-ray, chest ultrasound and chest CT, no pleural lesions were found (five cases of pneumonia with no pleural involvement, four had pulmonary fibrosis without pleural lesion, 2 cases of lung abscess with no pleural involvement). So, sixty patients (39 males & 21 females) were included. Their ages ranged from 12 to 67 years with a mean age of 50.5 ± 7.8 years.

Demographic data, presenting symptoms, and site of the lesions are described in Table 1. Etiologies of pleural lesions are described in Table 2.

Thirty-eight patients (63.3%) had benign pleural lesions and twenty-two (36.7%) patients had malignant pleural lesions (Table 2).

Different types of pleural lesions detected by MDCT, ultrasound (US), and Chest X-ray in the studied cases are shown in Table 3. Eighty-two lesions (100%) were detected by MDCT, fifty-nine lesions (72%) were detected by ultrasound and thirty-two lesions (39%) were detected by chest X-ray.

MPR images had an additional value than axial images in 32 pleural lesions (39%), mostly in nine cases of pleural thickening, eight cases of free pleural effusion, seven cases of pleural masses and four cases in both encysted pleural effusion and pleural plaque. On the other hand, the MPR images had the same value as axial images in empyema and pneumothorax cases (Table 4).

Five of our cases are presented in Figs. 1–5. MDCT images, MPR images (coronal and sagittal), and US images are shown.

Discussion

Multi-detector CT (MDCT) allows detailed evaluation of the pleura and differentiation of benign from malignant pleural disease [12].

In our study, eighty-two lesions (100%) were detected by MDCT in sixty patients. Fifty-nine lesions (72%) were detected by ultrasound, while only thirty-two lesions (39%) were detected by chest X-ray.

In the present study, pleural effusion was the most common pleural lesion where it was reported in 34 (41.5%) lesions. This was in agreement with Rahman et al. [13] who reported that pleural effusion is the most common pleural abnormality resulting from various types of diseases “inflammatory, traumatic, cardiovascular, autoimmune, metabolic and neoplastic”.

In our study, we found that MDCT was sensitive in diagnosing all cases of pleural lesions, and this result was in accordance with Raj et al. [14] who stated that MDCT allows detailed evaluation of the pleura and differentiation of benign from malignant pleural disease. Adequate enhancement of the pleura enables differentiation of the thickened pleura from adjacent effusion or aerated or collapsed lung.

In our study ultrasound (US) diagnosed 83.3% of free pleural effusion lesions, 60% of encysted pleural effusion lesions and diagnosed all empyema lesions, however it was less sensitive in diagnosis cases with pleural plaques, calcifications,
Figure 3  Case number 3: A 62 year old female patient, presented with cough and right sided chest pain. A: Axial cuts mediastinal window. B: Axial cuts pulmonary window. C: Coronal reconstruction cuts mediastinal window. D: US picture showing mild right free pleural effusion. Contrast enhanced MDCT showing mild right free pleural effusion with multiple subpleural nodules. However US picture showing mild right pleural effusion and the nodules could not be depicted.

Figure 4  Case number 4: A 64 year old male patient, presented with chronic cough with a previous history of old TB. A: Axial cuts mediastinal window. B: Axial cuts pulmonary window. C: Coronal reconstruction cuts mediastinal window. D & E: US images. Contrast enhanced MDCT & US showing multiple calcified linear plaques associated with minimal pleural thickening & rim of effusion.
thickening and pleural nodules or masses. These results were in agreement with Koh et al. [15] who reported that trans-thoracic US of the chest is useful in the evaluation of a wide range of pleural diseases.

Also Sikora et al. [16] stated that transthoracic US serves as a more accurate imaging tool than chest radiography for the diagnosis of pleural effusions and allows discrimination of pleural effusions from other lung pathology that may appear similar on a chest radiograph. Furthermore, US can allow diagnosis of complicated pleural effusions, such as empyemas that may be associated with a higher risk for a drainage procedure.

In the current study approximately 42% of pleural collections were not diagnosed by chest X-ray. This figure is higher than what was reported by Koenig et al. [17] who conducted a study of 61 patients with pneumonia and parapneumonic effusion and showed that chest X-rays, taken as anteroposterior, posteroanterior, or lateral, all missed more than 10% of parapneumonic effusions. The difference may be because some of our patients had small pleural effusions and also because some of them had encysted effusions.

In the present study MDCT was highly sensitive in the diagnosis of all cases presented with pleural nodules or masses. This result coincided with Wang et al. [18] and Tyszko et al. [19] who stated that CT is the most sensitive modality used for the assessment of mesothelioma and pleural masses.

In our study chest radiographs were a non-sensitive imaging technique for diagnosing pleural thickening, pleural calcification or plaque and pleural nodules or masses. These results were in full agreement with Müller [9] who reported that chest radiographs are of limited utility and are non-sensitive in demonstrating pleural opacities and plaques which may extend around and encase the lung, also reduction in volume of the affected hemithorax is common resulting in shift of the mediastinum toward the lesion.

MPR images in studied cases were able to provide comparable accuracy to that of the trans-axial MDCT which could be explained by the synergic effect of MPR images in revealing the tumor extent of malignant mesothelioma as MPR images could reveal the longitudinal extent of the enhancing tumor volume. Other studies like Honda et al. [20] had the same conclusion.

Conclusion

Multi-detector CT (MDCT) is an important noninvasive imaging tool in accurate detection and characterization of pleural lesions with complementary multiplanar reconstruction (MPR) images that solve many diagnostic problems. Ultrasoundography is a safer alternative but with less diagnostic value.

Conflict of interest

None declared.

References


