Application of imaging postprocessing of spiral CT in the staging of lung cancer

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Abstract Objective: To evaluate the role of spiral CT imaging postprocessing techniques in preoperative TNM staging of lung cancer. Methods: 106 patients with pathologically confirmed lung cancer received spiral CT examinations with a new revised TNM staging method of lung cancer which was taken as criterion of diagnosis. The images were reconstructed by using different postprocessing techniques such as MPR, MIP, SSD, VR, and their TNM staging capabilities were assessed by using postprocessing imaging and the results with axial CT images were compared. Results: In T staging, the accurate rates of axial CT images in T1–T4 staging were 77.3%, 60.6%, 60.7%, and 60.3% respectively; for postprocessing images, the accurate rates were 86.4%, 90.9%, 89.3%, and 87.0% respectively. In N staging, the accurate rates of axial CT images were 84.6%, 68.1%, 63.6%, and 64.2% in N0–N3 staging, respectively; but they were 92.3%, 90.9%, 90.9%, and 85.7% in postprocessing images, respectively. The postprocessing images were superior to axial CT images in T1–T3 and N1–N3 staging of lung cancer but there were no significant differences in T1 and N0 staging. For metastasis, the postprocessing images may be helpful for the TNM staging of lung cancer. Conclusion: The postprocessing techniques of the spiral CT could improve the accurate rates of TNM staging of lung cancer, and represent a useful complement to the axial CT.

Key words: spiral CT; imaging postprocessing; lung cancer; TNM staging

Abbreviations: MPR = multiplanar reformation; MIP = maximum intensity projection; VE = virtual endoscopy; SSD = surface shaded display; VR = volume rendering; SCT = spiral CT; UICC = international union against cancer; AJCC = American joint committee on cancer

CT is considered to be the main staging method of lung cancer, which is the prerequisite for treatment. The conventional CT has some limitation to a certain extent; however, the spiral CT, due to its widespread complication, is considered to be not only faster in scanner speed and wider in coverage but also possess more scanning modes and more methods of image reconstruction and processing, which represent a useful complement to the conventional CT and meet the requirement of TNM staging of lung cancer as well. This study was designed to evaluate the role of spiral CT imaging postprocessing techniques in preoperative TNM staging of lung cancer and compare it with the conventional CT.

Materials and methods

Clinical information

106 patients diagnosed as lung cancer without radiotherapy or chemotherapy before surgery were collected for this study. All of them had complete information in pathology and radiology. Of the 106 patients, 86 were males and 20 were females. They ranged in age from 34 to 82 years, with an average age of 59 years. In the pathological grading of lung cancer, 48 of them were squamous cell carcinoma, 56 adenocarcinoma and 2 adenosquamous carcinoma.

Imaging technology

Contrast-medium enhanced scan
All the patients underwent a contrast-medium enhanced scan. The contrast medium, which was no-ion, was injected into the brachial vein at a speed of 3.0 mg/s by the high-pressure syringe which was special for CT. Its
dose was 1.5 mL/kg diluted to 300 mg/mL. About 20–25 seconds after the injection the arterial phase was scanned, and its portal phase was scanned 30 seconds later.

**Image reconstruction and image postprocessing**

The data of image were imported into the GE ADW4.0 and Sensation 16 workstation to finish the image reconstruction. Image postprocessing consisted of MPR, MIP, VE, SSD and VR. SSD included two threshold scopes, one being the soft tissue lump ranging from 210 to 200 HU, and the other being the tracheobronchial tree ranging from -202 to 700 HU.

**Image judgement and diagnosis criteria**

Images obtained by plain scan and contrast-medium enhanced scan were judged and their TNM staging was determined by 3 experienced radiologist doctors who were blind for the pathological diagnosis of the patients.

The diagnosis criteria: TNM staging criteria published in 1997 by UICC and AJCC [1].

Criteria about positive lymph node: Lymph node with the diameter ≥ 1.0 cm or mediastinal lymph node with low density umbra were considered to be positive.

Criteria about metastasis: Grade 0 (−): There were fat diastema and normal lung tissues between the tumor and vascular. Grade 1 (±): The fat diastema disappeared or was abnormal, no matter whether the vascular moved smoothly or not. Grade 2 (+): The contact surface between the tumor and vascular was larger than 50% of the vascular cycle, or one of the lateral walls of the vascular became flattened, or the vascular was anomalous slightly. Grade 3 (++): Both of the lateral walls of the vascular were pathologically changed (≥ 2/3 of the vascular cycle), and the borderline between the tumor and vascular was serration. The lumens stenosis entad or eccentricity. Grade 4 (+++): The lumen of the vascular was obliterated or the filling defect was seen.

**Statistical analysis**

The coincidence rates between plain scan and contrast-medium enhanced scan were assessed and the staging results judged by postprocessing and pathology were also compared. The χ² test by SPSS 12.0 software was used to analyze the data and P value below 0.05 was considered significant.

**Results**

**Results of pathological staging**

The results of post-operative pathological staging: of 106 patients, 4 cases were in the stage T1N0M0, 5 T2N0M0, 10 T1N1M0, 8 T2N1M0, 10 T3N0M0, 12 T2N2M0, 12 T3N1M0, 7 T4N0M0, 8 T2N3M0, 9 T4N1M0, 6 T3N3M0, 5 T4N1M0, and 2 T4N2M1. On the other hand, 4 cases were in the stage Ia, 5 Ib, 10 Ila, 18 IIb, 32 IIIa, 35 IIIb, and 2 IV. One of the patients in stage IV had metastasis in his homonymy adrenal gland, and the other one had it in his homonymy lobes of lung.

**Comparison between axial CT and image postprocessing in T staging**

For T1 staging, the accuracy of postprocessing images had no significant difference from axial CT images (P > 0.05). However, for T2, T3 and T4 stagings, postprocessing images were superior to axial CT images (Table 1).

**Comparison between axial CT and image postprocessing in N staging**

All the patients had undergone the lymph node biopsy. And the lymph node with diameter ≥ 1.0 cm or the mediastinal lymph node with low density umbra were considered to be positive. Compared with the axial CT, although the image postprocessing had no difference in N0 staging, it was better both in sensitivity and specificity (Table 2).

**Comparison between axial CT and image postprocessing in M staging**

Metastasis tumor often encroached on the brain, adrenal gland, liver, skeleton, etc. SCT could scan more widely one time, which was helpful to discover the metastasis tumor earlier. In this group, one patient had cerebellar metastasis, one had tumor in his homonymy lobes of the lung. The latter was confirmed by the postprocessing

**Table 1** The accurate rate of diagnosing T staging by cross-sectional image and postprocessing image

<table>
<thead>
<tr>
<th>Image</th>
<th>T1 stage</th>
<th>T2 stage</th>
<th>T3 stage</th>
<th>T4 stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross-sectional image (CI)</td>
<td>77.3% (17/22)</td>
<td>60.6% (20/33)</td>
<td>60.7% (17/28)</td>
<td>60.3% (14/23)</td>
</tr>
<tr>
<td>Postprocessing image (PI)</td>
<td>86.4% (19/22)</td>
<td>90.9% (30/33)</td>
<td>89.3% (25/28)</td>
<td>87.0% (20/23)</td>
</tr>
</tbody>
</table>

Note: for T1, PI had no significant different from CI (P > 0.05); for T2, T3 and T4, PI had significant different from CI (P < 0.05)

**Table 2** The accurate rate of diagnosing N staging by cross-sectional image and postprocessing image

<table>
<thead>
<tr>
<th>Image</th>
<th>N1 stage</th>
<th>N2 stage</th>
<th>N3 stage</th>
<th>N4 stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross-sectional image (CI)</td>
<td>84.6% (22/26)</td>
<td>68.1% (30/44)</td>
<td>63.6% (14/22)</td>
<td>64.2% (9/14)</td>
</tr>
<tr>
<td>Postprocessing image (PI)</td>
<td>92.3% (24/26)</td>
<td>90.9% (40/44)</td>
<td>90.9% (20/22)</td>
<td>85.7% (12/14)</td>
</tr>
</tbody>
</table>

Note: for N0, PI had no significant different from CI (P > 0.05); for N1, N2 and N3, PI had significant different from CI (P < 0.05)