Comparative study of diffusion-weighted magnetic resonance imaging and PET-CT to detect non-small cell lung cancer and its nodal involvement.

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Purpose

Diffusion-weighted magnetic resonance imaging (DWI) makes it possible to detect malignant tumors based on the difference in the diffusion of water molecules among tissues. The aims of this study are to examine the usefulness of DWI compared to PET-CT in the assessment of lung cancer, and the relationships between the apparent diffusion coefficient (ADC) value and several pathological factors.
Methods and Materials

Patients

Sixty-three patients with primary non-small cell lung cancer were enrolled in this study. They underwent DWI and PET-CT examinations before pulmonary resection with nodal dissection from May 2009 to October 2010. Forty-one patients were male and 22 were female. There were 42 adenocarcinomas, 19 squamous cell carcinomas, one large cell neuroendocrine carcinoma and one carcinosarcoma.

MR Imaging

All MR images were obtained with a 1.5 T superconducting magnetic scanner with two anterior six-channel body phased-array coils and two posterior spinal clusters (six-channels each). Conventional MR images and DWI were acquired during the same procedure. DWI using a single-shot echo-planar technique were performed under SPAIR (spectral attenuated inversion recovery) with respiratory triggered scan (b values of 0 and 800 s/mm$^2$).

PET-CT

PET-CT scanning was performed with a dedicated PET camera. The $^{18}$F-FDG (18-fluoro-2-deoxy-glucose) (185 MBq) was administered intravenously. After a 60- min uptake period, an emission scan was acquired for 3 min per bed position and a whole-body scan was performed on each patient.

Statistical analysis

The sensitivity, specificity, and accuracy of DWI versus PET-CT for N staging and diagnosing each lymph node station were compared by using McNemar test. A P value of < 0.05 was considered statistically significant.
Results

The receiver operating characteristics (ROC) curve for the ADC value for diagnosing lymph node metastasis in DWI revealed the optimal cutoff value was $1.70 \times 10^{-3}$ mm$^2$/sec. The ROC curve for the SUVmax for diagnosing lymph node metastasis in PET-CT revealed the optimal cutoff value was 2.40. Findings of chest CT, DWI, and FDG-PET of a squamous cell carcinoma are shown in Figure 1-3.

The detection rate (0.97 (61/63)) by DWI was significantly higher than that (0.86 (54/63)) by PET-CT ($p=0.0207$) (Table 1).

<table>
<thead>
<tr>
<th></th>
<th>DWI</th>
<th>PET-CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detectable</td>
<td>61 lung cancers</td>
<td>54 lung cancers</td>
</tr>
<tr>
<td>Not detectable</td>
<td>2 lung cancers</td>
<td>9 lung cancers</td>
</tr>
<tr>
<td>Detection rate</td>
<td>0.97</td>
<td>0.86</td>
</tr>
</tbody>
</table>

Table 1.

The accuracy for N staging (0.81 (51/63)) by DWI was not significantly higher than that (0.71 (45/63)) by PET-CT ($P=0.0703$) (Table 2).

<table>
<thead>
<tr>
<th></th>
<th>Correct</th>
<th>Incorrect</th>
<th>Total cancers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Overstaging</td>
<td>Understaging</td>
<td></td>
</tr>
<tr>
<td>DWI</td>
<td>51 (81%)</td>
<td>3 (5%)</td>
<td>9 (14%)</td>
</tr>
<tr>
<td>PET-CT</td>
<td>45 (71%)</td>
<td>4 (6%)</td>
<td>14 (22%)</td>
</tr>
</tbody>
</table>

Table 2.

Of the 319 lymph node stations examined, 44 had metastases, and 275 did not. The sensitivity (0.75 (33/44)) for metastatic lymph node stations by DWI was significantly higher than that (0.48 (21/44)) by PET-CT ($P=0.00049$) (Table 3a).

<table>
<thead>
<tr>
<th></th>
<th>PET-CT True-positive</th>
<th>PET-CT False-negative</th>
<th>Total stations</th>
</tr>
</thead>
<tbody>
<tr>
<td>DWI</td>
<td>True-positive</td>
<td>21</td>
<td>12</td>
</tr>
<tr>
<td>DWI</td>
<td>False-negative</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>Total stations</td>
<td>21</td>
<td>23</td>
<td>44</td>
</tr>
</tbody>
</table>

Table 3a.
The specificities of DWI and PET-CT for the 275 non-metastatic lymph node stations were 0.99 (272/275) and 0.97 (266/275), respectively.

The accuracy (0.95 (305/319)) for all 319 lymph node stations by DWI was significantly higher than that (0.90 (287/319)) by PET-CT (P=0.000121) (Table 3b).

<table>
<thead>
<tr>
<th>Total stations</th>
<th>PET-CT Correct</th>
<th>PET-CT Incorrect</th>
<th>PET-CT Total stations</th>
</tr>
</thead>
<tbody>
<tr>
<td>DWI Correct</td>
<td>285</td>
<td>20</td>
<td>305</td>
</tr>
<tr>
<td>DWI Incorrect</td>
<td>2</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>Total stations</td>
<td>287</td>
<td>32</td>
<td>319</td>
</tr>
</tbody>
</table>

Table 3b.

There was a weak reverse relationship between ADC value and SUVmax (correlation coefficient r = 0.286) (Figure 4).

Concerning the relationship between cell types and ADC value, the ADC value (1.366 ± 0.299) of adenocarcinomas was not significantly higher than that (1.248±0.382) of squamous cell carcinomas.

ADC values increased while the cell differentiation increased. The ADC value (1.037±0.140) of poorly differentiated carcinomas was significantly lower than that (1.275±0.211) of moderately differentiated carcinomas, that (1.336±0.136) of a mixture of moderately and well differentiated carcinomas, and that (1.415±0.316) of well differentiated carcinomas (Figure 5).

The ADC value (1.125±0.181) of carcinomas with necrosis was significantly lower than that (1.413±0.335) of carcinomas without necrosis (Figure 6).
Figure 1  abcd : a: The CT presented lung cancer of 55mm in size in right upper lobe. b: DWI showed high signal intensity on primary lung cancer. c: The ADC value of the cancer was $0.979 \times 10^{-5}$mm$^2$/sec on the ADC map. d: FDG-PET showed high accumulation in primary lung cancer. The SUV max of the cancer was 16.85.

Fig. 0

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Figure 2 efg:
e: The CT showed swelling of #12u lymph node. f: DWI showed high signal intensity in #12u lymph node. The ADC value of the node was $1.264 \times 10^{-3}$ mm$^2$/sec. g: FDG-PET showed moderate accumulation in #12u lymph node. The SUV max of the node was 3.64.

**Fig. 0**

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Figure 3  hij
h: The CT showed slight swelling of #4R lymph node. i: DWI showed no signal intensity in #4R lymph node, which meant clinical n1. j: FDG-PET showed moderate accumulation in #4R lymph node. The SUV max of the node was 3.37, which meant clinical n2 disease. Pathological examination revealed pathological n1 disease. Clinical diagnosis by DWI was correct.

Fig. 0

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Figure 4. Relationship between ADC value and SUVmax

SUVmax = 14.297 – 5.641 × ADC

Correlation coefficient : \( r = 0.286 \)

**Fig. 0**

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Figure 5. Relationship between cell differentiation and ADC value in adenocarcinomas and squamous cell carcinomas.

P: poorly differentiation, M: moderately differentiation, W: well differentiation. P&M: mixture of poorly and moderately differentiation, M&W: mixture of moderately and well differentiation. ADC values increased while the cell differentiation increased.

Fig. 0

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Figure 6. Differences of ADC values between carcinomas without necrosis and carcinomas with necrosis. ADC value (1.128 ± 0.204) of carcinomas with necrosis was significantly lower than that (1.407 ± 0.347) of carcinomas without necrosis.

Fig. 0

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Conclusion

The detection rate of primary lung cancer by DWI may be better compared with that by PET-CT. The accuracy for the lymph node stations by DWI was significantly higher than that by PET-CT because of fewer false-negative results in DWI. The diagnostic efficacy of DWI is superior to that of PET-CT, and DWI can be used in assessment of lung cancer and lymph nodes instead of PET-CT.
References


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