Preoperative localization of small peripheral pulmonary nodules by percutaneous marking under computed tomography guidance

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Received 18 January 2011; received in revised form 19 March 2011; accepted 28 March 2011

Abstract

The outcome of computed tomography (CT)-guided percutaneous marking for the preoperative localization of small peripheral pulmonary nodules was analyzed retrospectively. This procedure, in which 21-gauge markers were placed near nodules under local anesthesia on the day of surgery, concerned the patients who received video-assisted thoracoscopic surgery as a primary operative technique. The study included all the 57 patients who underwent CT-guided percutaneous marking before pulmonary resection. The mean nodule size was 1.1 cm. Pneumothorax and pulmonary bleeding were observed in 28 and 17 patients, respectively. Other complications included pain (four), subcutaneous bleeding (two) and dislodgment of the marker (one). Wedge resection during thoracotomy was necessary in seven patients because of severe adhesions (four), multiple wedge resections (one), dislodgment of the marker (one) and difficulty in identifying a nodule (one). Pathological studies revealed 24 metastatic lung tumors, 19 bronchioloalveolar carcinomas (BACs), five adenocarcinomas with mixed subtypes, three granulomas, two atypical adenomatous hyperplasias and six miscellaneous others. Wedge resection for malignancy was performed in 39 patients with 41 lesions. The median follow-up period was 46 months. A positive surgical margin and recurrence at the surgical stump were observed infrequently.

Keywords: Tomography scanners, X-ray computed; Thoracic surgery, video-assisted; Lung neoplasms; Surgical procedures, minimally invasive; Preoperative care

1. Introduction

As a result of the latest technological advances in radiological detection and the prevalence of computed tomography (CT) screening for lung cancer in Japan, small nodules in the periphery of the lung are often subject to surgery. Some lesions are so faint with a ground-glass opacity (GGO) appearance that they are difficult to palpate and identify during video-assisted thoracoscopic surgery (VATS), and in some cases even during open thoracotomy. The purpose of this retrospective study was to evaluate both the safety of percutaneous marking with CT guidance for preoperative localization, and the outcome of surgical resection of such nodules based on appropriate follow-up data from a single institution.

2. Materials and methods

This retrospective study included a total of 57 patients who were eligible for VATS and who underwent initial VATS pulmonary resection, followed or not by open thoracotomy, between January 1998 and December 2007 after CT-guided percutaneous marking of small peripheral pulmonary nodules at our institution. This study was approved by the Institutional Review Board, which waived the requirement for individual consent. Clinical and pathological parameters were obtained by reviewing each patient’s medical record, and pathological diagnoses were based on the 2004 World Health Organization classification of tumors [1].

Percutaneous marking under CT guidance for preoperative localization was indicated if both of the following criteria were met: first, the pulmonary nodule was small and located in the periphery of the lung without a pleural finding, such as pleural indentation on a CT-scan; and second, finger palpation to identify its location through the port sites during VATS was considered to be difficult.

Localization was performed on the day of surgery, and a 21-gauge marker (Hakko Medical, Tokyo, Japan) (Fig. 1a) [2] was placed near the nodule under CT guidance after local anesthesia by board-certified radiologists (Fig. 1b). Markers were placed near nodules, but without piercing them in order to prevent the possible dissemination of tumor cells. Another chest CT-scan was repeated as soon as the procedure was finished to confirm that the marker was placed in an appropriate position. Each patient subsequently rested in bed receiving oxygen to minimize pneumothorax until it was time for surgery.
The patient was laid in the recumbent position with one-lung ventilation during surgery. A thoracoscope was inserted into the thoracic cavity, and second and third ports were then added. The suture penetrating the visceral pleura of the lung was observed (Fig. 1c); the lung parenchyma in which the nodule was presumably to be found was then grasped by ringed forceps (Fig. 1d), and a wedge resection was completed using mechanical staplers with adequate margins from the forceps. We confirmed that the specimen contained the marker. We submitted a frozen section to pathology in cases of suspected primary lung cancers and proceeded with a lobectomy during either VATS or a thoracotomy if necessary in accordance with the pathological findings.

### 3. Results

Our study included 57 patients with 59 nodules and represented approximately 3% of the total number of thoracic surgeries performed during this period. Two markers were placed during a single procedure in two patients, each of whom had two nodules located on the ipsilateral side. The patient characteristics are shown in Table 1.

Complications during CT-guided percutaneous marking are shown in Table 2. None of the cases required treatment before surgery. Dislodgment of the marker was experienced in one early case. In one case with two nodules on the ipsilateral side, only one marker was placed since marking...

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**Table 1. Patient characteristics**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>Mean</td>
</tr>
<tr>
<td></td>
<td>S.D.</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>40</td>
</tr>
<tr>
<td>Female</td>
<td>17</td>
</tr>
<tr>
<td>Nodule size (cm)</td>
<td>Mean</td>
</tr>
<tr>
<td></td>
<td>S.D.</td>
</tr>
<tr>
<td>1 cm or less</td>
<td>34</td>
</tr>
<tr>
<td>Distance from pleura (cm)</td>
<td>Mean</td>
</tr>
<tr>
<td></td>
<td>S.D.</td>
</tr>
<tr>
<td>History of ipsilateral thoracotomy</td>
<td>5</td>
</tr>
</tbody>
</table>

S.D., standard deviation.
for the second nodule was canceled because of pneumothorax.

VATS wedge resection was performed for a total of 48 patients, including three and two patients, respectively, who subsequently underwent VATS lobectomy and open lobectomy following wedge resection. Open wedge resection was performed in seven patients, followed by lobectomy in one patient, open lobectomy in one after pleural effusion had been diagnosed to contain cancer cells during VATS, and open segmentectomy in one because the nodule was located near the hilum. The reasons for these seven cases of open wedge resection are listed in Table 3.

The pathological findings for the 59 nodules are shown in Table 4. Wedge resection for malignancy was performed in 39 patients with 41 lesions, including 23 metastatic lung tumors and 18 primary lung cancers. Pathological examination revealed that the surgical margin was positive for one lesion (2.4%) in a patient with a past history of a right middle lobectomy who had undergone preoperative percutaneous marking followed by wedge resection for a 1.7-cm cystic lesion in the right lower lobe. The distance from the pleura was 1 cm, and thoracotomy was necessary because of severe adhesion in the thoracic cavity. The pathological findings indicated an adenocarcinoma with mixed subtypes, and lymph node recurrence was subsequently detected in that particular patient 21 months later.

The median follow-up period was 46 months. Twenty-three of the 39 patients who had undergone wedge resection for malignancy experienced recurrence, including 21 patients with metastatic lung tumors and two with primary lung cancer. The sites of recurrence, while taking into account duplication, are shown in Table 5.

The median duration until recurrence in the 21 metastatic lung tumor patients who had undergone wedge resection was 8.5 months. VATS wedge resection was performed in 15 cases involving bronchioloalveolar carcinomas (BACs) and there has been no evidence of recurrence to date in any of these patients.

4. Discussion

The VATS procedure is superior to thoracotomy for lung biopsy because it preserves respiratory function, is less painful, maintains a better patient quality of life and prevents atrophy of the latissimus dorsi muscle on the surgical side [3]. However, it can be difficult to identify the exact location of a small and/or faint nodule through the port site by finger examination, and therefore preoperative localization is mandatory. Percutaneous marking under CT guidance using wire [2–6], lipiodol [7], a platinum microcoil [8] and Technetium-99m macroaggregated albumin [9] have previously been reported.

Pneumothorax is the most frequent complication, followed by pulmonary bleeding, and hemorrhage into the pleural cavity and bloody sputum have also been observed on occasion. Dislodgment of the marker has been encountered in 0–7.5% of cases. Whereas VATS was performed in most of the previously reported cases, conversion to thoracotomy was necessary in 7.5 and 14% of the cases in two earlier studies [4, 5]. Dendo et al. used the same guidance marker system as in our study for the localization of 168 lesions in 150 patients, and reported that non-symptomatic pneumothorax was observed in 32.1% of cases, pulmonary bleeding in 14.9%, hemorrhage into the pleural cavity in 0.6% and dislodgment of the marker in 2.4% [2].

Our results are comparable to those in other previously published reports. Complications related to percutaneous marking were acceptable, and none required treatment before surgery. Although there was some limited radiation exposure from the CT-scan, our system is relatively easy to perform without the need for a fluoroscopy guide [7, 8] or radioprobe [9] during surgery. Fortunately, we did not experience any cases of systemic air embolism, which, although relatively rare, is potentially fatal [10].

As previously indicated, dislodgment of the marker was experienced in one early case. Therefore, we now take a whole-lung CT-scan after percutaneous marking is complete to ascertain the correct location of the marker in the lung, as well as to evaluate the possibility of pneumothorax and pulmonary bleeding. There have been no further cases of marker dislodgment as a result of this modified procedure. The CT-scan also enables us to determine the distance and direction from the marker to the nodule, thereby facilitat-
ing an adequate surgical margin based on accurate identification of the nodule’s location.

Wedge resection has been reported to be the optimal treatment for GGO lesions in a prospective study involving 50 patients [11]. In our retrospective study, there have been no cases of recurrence so far among the 15 BAC patients who underwent percutaneous marking under CT guidance, followed by VATS wedge resection. Therefore, this less invasive strategy is a promising means of treatment for BACs.

Most surgeries were performed during VATS, although thoracotomy was selected in four cases that involved severe adhesion in the thoracic cavity, including one case with a positive surgical margin. This suggests that we need to carefully consider the optimal approach for localizing and treating small nodules detected in patients with a previous history of thoracotomy. We also had one case of local recurrence on the stapled line during the lengthy follow-up period, and therefore we now check the distance and direction from the marker to the nodule on a CT-scan taken after percutaneous marking.

References


EComment: About the localization techniques of solitary pulmonary nodules

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doi:10.1510/icvts.2011.266932A

We read with interest the manuscript of Yoshida et al. [1] about the outcome of computed tomography (CT)-guided percutaneous marking for preoperative localization of small peripheral pulmonary nodules.

Use of a percutaneous hook-marker in the localization of solitary pulmonary nodules (SPNs) was widely used. Nevertheless, the marker can dislocate [2]. In our institution, we are able to perform radio-guided surgery (RGS) [3]. We localize SPNs by injection of a solution of human albumin serum labeled with 99m-Tc and non-ionic contrast medium with a CT-scan guide. RGS can mark SPN located in any region of the lung and the nodule location can be continuously reassessed during the operation using a gamma radio probe to confirm an accurate excisional biopsy. RGS can be successfully used for very small nodules (5 mm) and larger nodules deep in the parenchyma which could be difficult to VATS excise. It is also useful for lesions with ground-glass appearance, which may be difficult to palpate even in open procedures. The localization technique does not interfere with immediate pathological study, permitting frozen analysis of the specimen and assessment of the margins. An advantage of RGS is the use of a percutaneous hook-marker in the localization of solitary pulmonary nodules. In conclusion, RGS is a safe and simple technique for localizing SPNs difficult to identify during routine surgery, with fewer complications and failures than other techniques. This technology also supports the current practice of video-assisted thoracoscopic lung resection.

References

