

Noninvasive computed tomography-guided marking technique for peripheral pulmonary nodules

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Background: Identification of the exact location of small peripheral pulmonary nodules during thoroscopic wedge resection (TWR) is crucial. We describe a new method of computed tomography (CT)-guided marking without puncturing the visceral pleura (VP) for minimally palpable pulmonary nodules.

Methods: Preoperative CT scans were performed 1 day before TWR with the patient in the lateral decubitus position. Under CT guidance, we marked the skin over the pulmonary nodule. During TS, an indwelling catheter was inserted perpendicular to the marked skin surface and put a mark with gentian violet (Pyoktanin blue[®], Wako Pure Chemical Industries, Osaka, Japan) onto the VP. We palpated the nodules near the mark(s) and performed TWR.

Results: Between October 2012 and April 2016, we performed CT-guided marking in 54 patients (24 males and 30 females, median age 65 years). Cases included 39 primary lung cancers, 10 metastatic lung tumors, and 5 benign tumors. The mean diameter of the nodules was 10 mm (range, 3–26 mm), and the mean distance of the nodule from the VP was 4 mm (range, 0–17 mm). The mean time of intraoperative marking was 3.5 min (range, 1–4.5 min). The mean distance from the nodule to the marking point was 7.0 mm (range, 0–30 mm). We were able to identify the location of the nodule using this procedure in 53 patients (98%). Hematoma of the chest wall after marking was observed in one patient. There were no other complications.

Conclusions: This marking technique is a simple, economic, and effective procedure to locate small peripheral pulmonary nodules during TWR.

Keywords: Thoroscopic surgery; computed tomography (CT); solitary pulmonary nodule; multiple pulmonary nodules

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Introduction

Peripheral small pulmonary nodules such as ground glass opacities (GGO) and possible lung metastases require a tissue diagnosis. Minimally invasive thoroscopic wedge resection (TWR) is a good therapeutic option for these peripheral pulmonary nodules. However, in some cases, it is difficult to identify the exact location of a small peripheral, but not subpleural, nodule during TWR. In such cases, preoperative marking is often employed (1-5). Although preoperative

CT-guided marking techniques are the most common, most of them require puncture of the visceral pleura (VP). CT-guided hookwire placement before resection has been performed, but is subject to complications such as pneumothorax, hemothorax, and air embolism from puncture of the VP (6,7). A CT-guided marking technique that does not puncture the VP is less prone to these complications. We developed and performed a marking technique using CT guidance that does not involve VP puncture, based on the report of Nishida *et al.* (8).

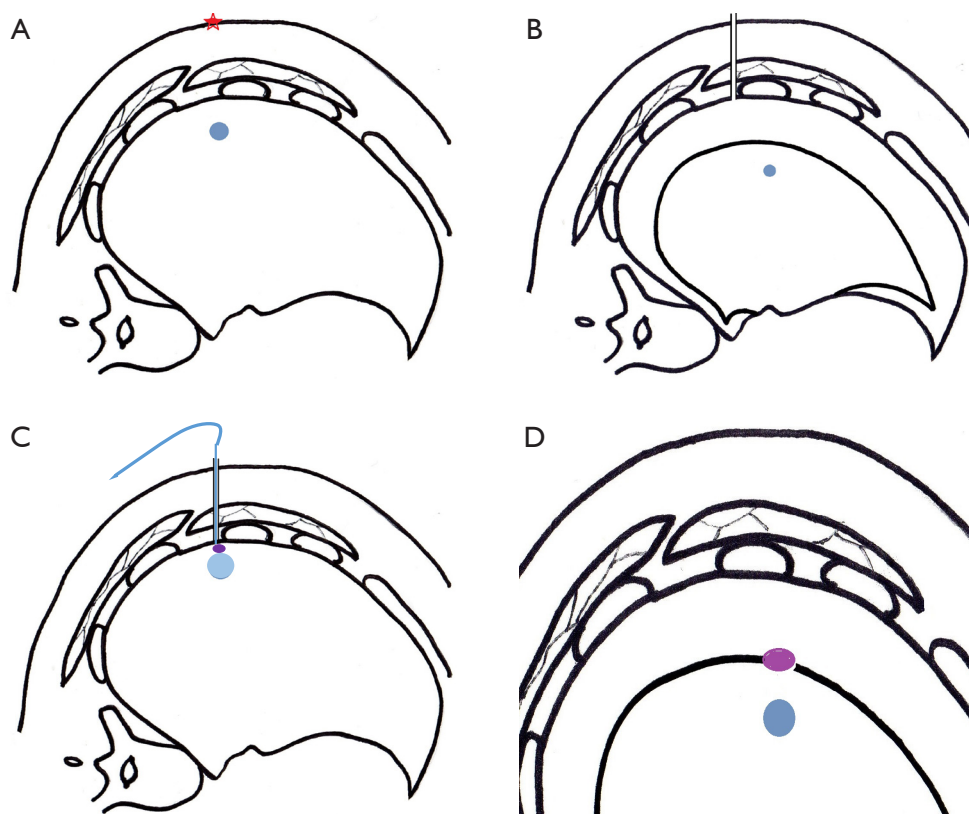


Figure 1 Technique of noninvasive CT-guided marking. (A) A skin mark representing the shortest distance to the pulmonary nodule; (B) under single ventilation, an indwelling catheter was inserted vertically from the skin mark through the chest wall and into the thoracic cavity; (C) after inflation of the lung, gentian violet pigment was stamped using an epidural catheter; (D) the visceral pleura was pigmented near the pulmonary nodule.

Methods

This study was an exploratory, single-armed study approved by the ethics committee of our institution (No. 1114), and written informed consent was obtained from each patient. The indication for marking was a histologically undiagnosed peripheral pulmonary nodule or nodules ≤ 20 mm in diameter designated for TWR. Fifty-four patients were enrolled in this study from October 2012 to April 2016.

Technique

Our hospital is a referral center, so the patients had undergone initial CT scanning at other institutions. Patients with small peripheral pulmonary nodules are generally followed for at least 3 months using thin-section CT (TSCT). TWR is reserved for nodules. Preoperative CT scans were performed 1 day before the operation. Patients were placed in the lateral decubitus position to best

approximate their position during TWR, using radiopaque markers on the body surface. Scans were acquired in the maximal expiratory phase. A mark was placed on the patient's skin at the shortest distance from the nodule (*Figure 1A*). At operation, patients received general anesthesia and were placed in the lateral decubitus position with the side to be operated uppermost. After the relevant lung was collapsed and the thoracic cavity was entered through either one or two trocar ports, a 16-gauge indwelling catheter (Surflo[®], Terumo Corporation, Tokyo, Japan) was inserted perpendicular to the skin surface through the chest wall at the mark and into the thoracic cavity (*Figure 1B*). The needle was removed and the external catheter hub was fixed to the thoracic wall. After reinflating the lung, a ϕ 1.0 mm epidural catheter (Hakko Medical, Tokyo, Japan) containing gentian violet dye was inserted through the indwelling catheter. The tip of the catheter touched and tattooed the VP of the inflated lung (*Figure 1C*), which was identifiable

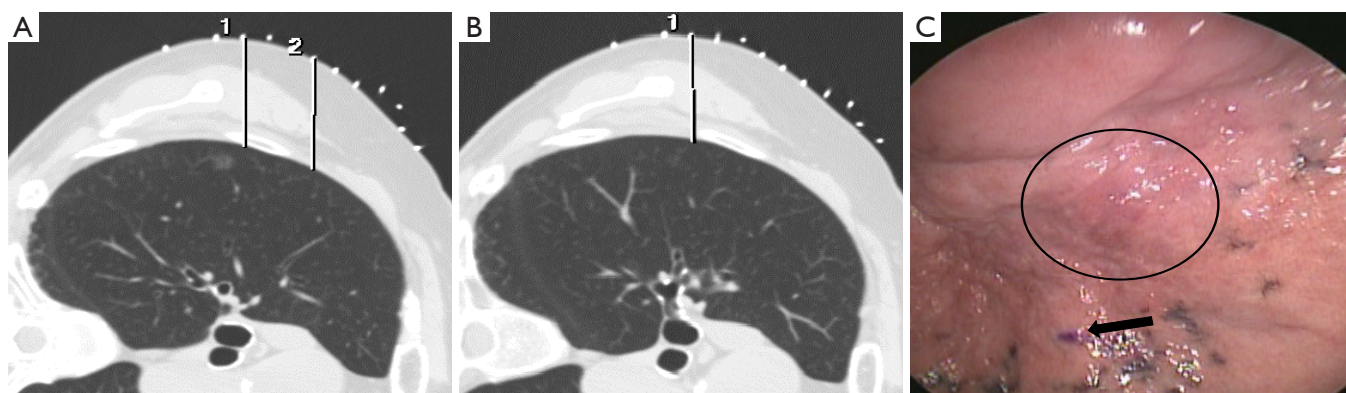


Figure 2 Procedure of 1-point method. (A) A small pure ground glass nodule was located in right upper lobe; (B) skin mark was set 2.5 mm below the nodule to avoid the rib; (C) the visceral pleura was pigmented with gentian violet (bow) near the nodule (circle).

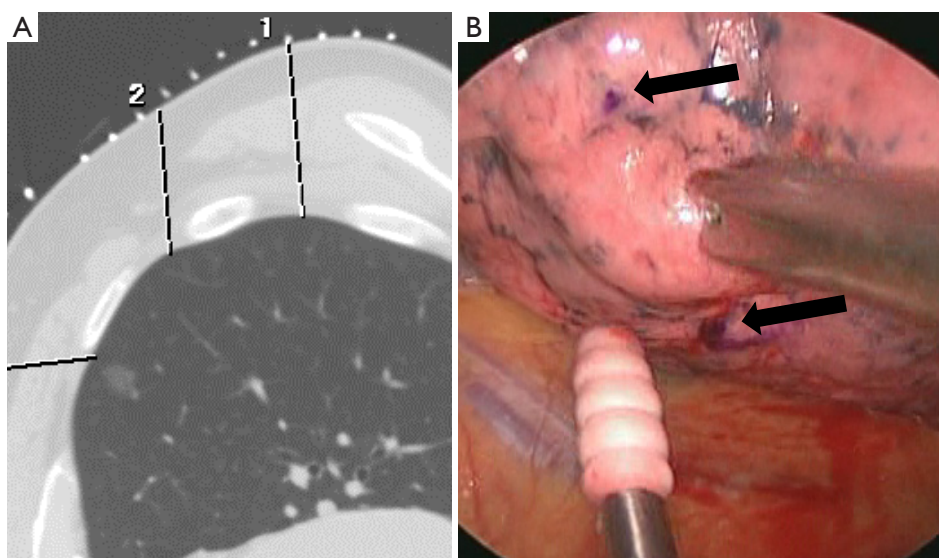


Figure 3 Procedure of 2 points method. (A) Pulmonary nodule is located beneath the rib. Two skin marks were placed at the same axial line; (B) two marks were observed on the visceral pleura (two bows). Target nodule could be palpated on the line extending to these two points.

after deflation of the lung (*Figure 1D*). We usually palpated around the marking point using endoscopic instruments and fingers through the port site, and then TWR was performed using endoscopic staplers.

During the preoperative CT, we usually put one mark on the VP for one pulmonary nodule (one-point method, *Figure 2*). However, if the nodule was located beneath the scapula or ribs, the shortest distance to the nodule may not be a straight vertical line. In such situations, we performed a two-point method. Two marks were placed on the patient's skin in the same axial plane in the CT examination and the VP tattooing followed. During the operation, the two tattoo

points were identified, and we palpated the nodule along the line connecting these two points (*Figure 3*).

Results

Patient characteristics are shown in *Table 1*. In this study, ground-glass nodules (GGNs) on preoperative TSCT findings were observed in forty patients (74%). Cases included 39 primary lung cancers, 10 metastatic lung tumors, and 5 benign tumors. The mean tumor size was 10 mm (range, 3–20 mm) and the mean distance of the tumor from the VP was 4 mm (range, 0–17 mm). The one-point method

Table 1 Patient characteristics

| Characteristics | (N=54) |
|---|------------------|
| Gender (male/female) | 24/30 |
| Age, years* | 65 [36–78] |
| Preoperative CT findings (GGN/solid) | 40/14 |
| Tumor size, mm** | 10 [3–20] |
| Distance from visceral pleura, mm** | 4 (0–17) |
| Body mass index, kg/m ² | 22.5 (17.6–30.3) |
| Thickness of chest wall, mm* | 34 [6–80] |
| Histology | |
| Primary lung cancer/metastatic tumor/benign | 39/10/5 |
| Marking points (one/two) | 41/13 |
| Intraoperative marking time, min** | 3.5 (1–4.5) |
| Distance from the nodule to the marking point, mm** | 7.0 (0–30) |
| Complication*** | 1 (1.8%) |

*, values are presented as median (range); **, values are presented as mean (range); ***, hematoma of chest wall. CT, computed tomography; GGN, ground glass nodule.

was performed in 41 patients and the two-point method was performed in 13 patients. The mean distance from the nodule to the marking point was 7.0 mm (range, 0–30 mm). The mean intraoperative marking time was 3.5 min (range, 1–4.5 min). Complications of this procedure were seen in one patient, who developed a hematoma of the chest wall because of injury to an intercostal artery. We could not detect a nodule in one patient because of insufficient collapse of the lung. In the other 53 patients (98%), we detected the nodules and performed successful TWR.

Discussion

Indications for surgical resection of small pulmonary nodules have been increasing due to recent advancements in CT screening. TWR is a minimally invasive approach to obtain a pathologic diagnosis and may be curative. However, sometimes the target nodule is not readily palpable and time is required to detect it. Preoperative marking allows quick intraoperative identification.

There are two preoperative marking techniques, CT-guided and bronchoscope-guided (3,8). In CT-guided marking technique, percutaneous hookwire placement is the most

common procedure (4,5). Hookwire placement is relatively easy for nodule localization. However, puncture of the VP is an associated hazard that may result in complications such as air embolism (6,7). Similar techniques using insertion of pigment or contrast media may carry the same risk because of puncture of the VP. To avoid these complications, several marking techniques without VP puncture have been reported (8,9). We already reported the efficacy and feasibility of CT-guided nodule marking in 2015 (10). Compared with contrast media, gentian violet is easy to see with the naked eye, obviating the need for exposure of radiation during surgery.

Bronchoscope-guided marking techniques can also be performed without puncturing the VP (3,11). However, these marking techniques need both expensive equipment and expert skills. In addition, these techniques are more painful and invasive than CT-guided techniques. Preoperative marking techniques for peripheral pulmonary nodules require a balance among accuracy, technical ease, and minimal invasiveness.

In our experience, NICTM has two limitations. One is that there is no information on the depth of the nodule from the VP. For nodules located >30 mm from the VP, thoracoscopic segmentectomy is necessary to obtain appropriate surgical margins. The other limitation involves the inflation of the lung before tattooing the VP. In this study, we missed one nodule during surgery because of the marking was slipped off from the nodule. We have been waiting >1 minute after inflating the lung to achieve full expansion before tattooing. In addition, sufficient collapse of the lung is important to palpate nodules after marking, requiring close collaboration with the anesthesiologist.

Conclusions

Noninvasive CT-guided marking without puncturing the VP is a feasible and effective procedure to localize peripheral pulmonary nodules prior to TWR.

Acknowledgements

None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: This study was an exploratory, single-

armed study approved by the ethics committee of our institution (No. 1114), and written informed consent was obtained from each patient.

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