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Original Research

# Reevaluation of the efficacy of preoperative computed tomography-guided hook wire localization: A retrospective analysis

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ABSTRACT

*Background:* Small pulmonary nodules (SPNs) often cannot be accurately located during video-assisted thoracoscopic (VATS) resection, and preoperative computed tomography (CT)-guided localization performed using hook wire placement can be helpful. However, recent studies revealed a trend towards more frequent and severe complications occurring in association with hook wire insertion. The aim of this study is to reevaluate the safety, and reliability of the preoperative CT-guided hook wire localization technique and also identify the risk factors for localization-related pneumothorax.

*Methods:* This retrospective study enrolled 95 patients (with 105 pulmonary nodules) who underwent preoperative CT-guided hook wire localization and followed VATS resection from January 2013 to September 2016. Univariate and multivariate logistic regression analyses were used to identify factors associated with localization-related pneumothorax.

*Results:* All the 105 nodules were successfully localized. Two (1.9%) hook wires dislodged before VATS resection. Mean largest diameter of the nodules was 10.1 mm (range, 3–19 mm). Mean depth from the nearest pleural surface was 11.2 mm (range, 2–38 mm). Mean needle insertion depth was 24.3 mm (range, 4–49 mm), and mean procedure time was 17.3 min (range, 7–48 min). Asymptomatic pneumothorax was observed in 18 patients (18.9%) and hemorrhage in 7 patients (7.4%). Multivariate logistic regression analysis revealed the number of needle insertions (OR 8.893, $p = 0.019$) as the only significant independent risk factor of pneumothorax.

*Conclusions:* CT-guided hook wire localization is a safe, reliable and convenient technique and can be applied widely to facilitate the resection of SPNs. Simultaneous localization for multiple nodules in ipsilateral lung may be associated with a higher risk of localization-related pneumothorax.

## 1. Introduction

The widespread use of high-resolution and thin-section computed tomography (TSCT) has made it possible to detect markedly small pulmonary nodules (SPNs) [1]. However, small benign lung nodules cannot be confidently differentiated from small malignant lung nodules with CT imaging features, thus, a precise histopathologic diagnosis for the nodule highly suspicious for malignancy is required [2]. With the advantages in decreasing postoperative morbidity and shortening hospital length of stay, lung biopsies are increasingly done by video-assisted thoracoscopic surgery (VATS) [3]. However, because it is difficult to palpate the lung, the small nodules cannot be located accurately during VATS, especially when the nodule is with a ground-glass opacity component or deep to the pleural surface [4]. In a study conducted by Suzuki et al., the probability of failure to detect a nodule during VATS is 63% if the nodule is $>$ 5 mm deep to the pleural surface and $\leq$10 mm in size [5]. Accordingly, various localization techniques have been reported to reduce the possible thoracotomy conversion rate associated with VATS [6]. Each localization technique has its own benefits and risks, but percutaneous hook wire placement, which requires no specialized equipment or expertise, is considered as one of the most convenient techniques. However, recent studies revealed a trend towards more frequent and severe complications occurring in association with hook wire insertion [7,21].

Since 2013, we have introduced the CT-guided hook wire localization technique in preoperative SPN localization. Here, we present a retrospective study to reevaluate the safety, reliability, and convenience of this technique and also identify the risk factors for localization-related pneumothorax, which has been reported as the most common complication.

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## 2. Patients and methods

### 2.1. Patients

From January 2013 to September 2016, percutaneous localization of 105 pulmonary nodules in 95 patients were performed with CT-guided hook wire localization technique at our institution. A written informed consent had been taken beforehand from all patients. This study was approved by the Institutional Review Board of our institution. The work has been reported in line with the STROCSS criteria [25]. The study was conducted in accordance with the Declaration of Helsinki principles.

In our institution, preoperative CT-guided hook wire localization was potentially indicated for patients who had indeterminate pulmonary nodules with diameter less than 10 mm and/or the distance from the pleural surface more than 10 mm. In certain cases, the surgeon might choose to perform preoperative localization when both the surgeons and radiologists considered that the nodules were not likely to be visualized during VATS. The surgical indications for these patients included nodule enlargement and persistence of a nodule with a solid component of 5 mm or more on the follow-up CT images [2].

All patients underwent a preoperative TSCT scan. The largest diameters of pulmonary nodules, distance between the nodule and pleura and consolidation/tumor (C/T) ratio were measured by two attending radiologists on TSCT. The pure ground-glass nodules (GGNs), part-solid GGNs, and solid nodules were defined as nodules with a C/T ratio on TSCT of 0, $> 0$ and $< 1.0$, and 1.0, respectively.

### 2.2. CT-guided hook wire localization

The localization was performed with a multidetector-row helical CT scanner, and the hook wire with a 21-gauge 10-cm-long cannula was produced by Argon Medical Devices, Inc, Athens, TX (Fig. 2A). The CT-guided hook wire placement was performed in the morning of surgery. Each patient was placed on the CT table in such a position as to allow the shortest distance between the skin and the nodule. A guiding CT scan was performed with a radio-opaque grid mesh placed on the appropriate region of the chest wall. Based on the guiding CT scan, the optimal puncture site was determined and the appropriate insertion depth of the introducer needle was calculated. After administration of a local anesthetic, the introducer needle was inserted into the lung parenchyma (generally $< 15$ mm from the nodule and at least 10 mm beneath the pleural surface). After confirming the optimal placement of the introducer needle with CT scanning, the hook wire was released. Once the hook wire was free from the introducer needle, the introducer needle was carefully pulled out. A postprocedural CT scan was obtained to confirm the final position of the hook wire and to assess the possible postprocedural complications. The hook wire protruding from the skin was trimmed and covered with sterile gauze pad. Multiple hook wire placements were simultaneously performed in 10 patients with double nodules in ipsilateral lung. The patient was then transferred back to the general ward to await surgery.

### 2.3. VATS procedure

All patients underwent VATS procedure on the same day of hook wire localization. The operative technique of VATS was similar to our previous report [8]. The patients were placed in the lateral decubitus position. The procedures were performed under general anesthesia with single-lung ventilation. Based on visualization of the end tail of the hook wire above the visceral pleura, wedge resection or segmentectomy (the nodule shows a C/T ratio of less than 50% [9]) was performed (Fig. 1). All surgical specimens were sent for frozen-section analysis. If nodules were diagnosed as atypical adenomatous hyperplasia (AAH), adenocarcinoma in situ (AIS), minimally invasive adenocarcinoma (MIA), metastatic tumor or benign lesion, no additional resection was performed. Lymph node sampling or systemic lymph node dissection was performed for these patients diagnosed as MIA. If diagnosis was primary lung cancer with an invasive component, lobectomy with mediastinal lymph node dissection was performed following initial resection. Histological classification was determined according to the 2011 IASLC/ATS/ERS classification [10].

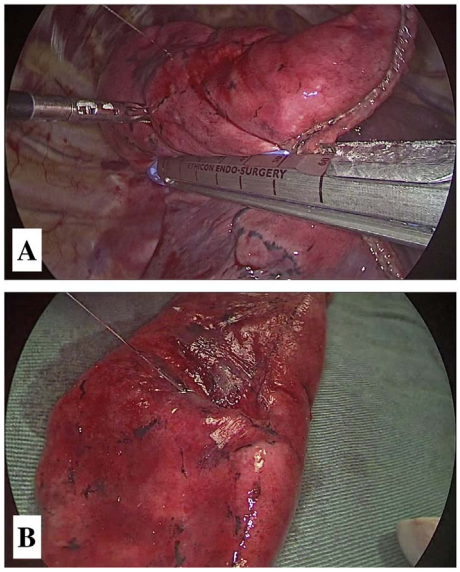


**Fig. 1.** (A): The wedge resection of the pulmonary nodule, including the hook wire (arrow). (B) Hook wire (arrow) localization of the nodule on the lung specimen.

### 2.4. Evaluation of the clinical outcomes

Data that were extracted from the medical record system included patient age, sex, pulmonary function testing, smoking status, presence of emphysema on the CT scan, BMI, carcinoembryonic antigen (CEA), nodule site, image characteristics, CT nodule dimensions, localization procedure duration, insertion depth from pleura, duration from localization to surgery (defined as the time from the end of the localization to the first incision of the skin), localization-related complications, type of initial resection, pathologic diagnosis, type of final resection based on diagnosis, conversion (defined as conversion to minithoracotomy or thoracotomy due to nodule localization failure during VATS), postoperative hospital stay, and 30-day mortality. We classified pneumothoraces as small or large according to the 2010 British Thoracic Society guidelines [11]: the distance of the lung margin from the chest wall was less than 2 cm or 2 cm or more, respectively.

### 2.5. Statistics

Variables were analyzed as proportions, or mean ± standard deviation (SD) with range, as appropriate. Univariate and multivariate logistic regression analyses were performed to identify the independent risk factors for pneumothorax. Those variables with $p < 0.10$ from univariate analyses were included in the multivariate logistic regression analyses. The results of multivariate logistic regression analyses were expressed as odds ratios (OR) with a 95% confidence interval (CI) and $p$ value. All statistical analyses were carried out with SPSS for Mac (version 22.0, IBM, New York, USA). Differences were considered significant for $p < 0.05$ (two-sided).

## 3. Results

### 3.1. Patient characteristics

For the present cohort, 95 patients with 105 nodules underwent CT-