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ORIGINAL ARTICLE

Comparison of hook wire versus coil localization for video-assisted thoracoscopic surgery

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Keywords

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Abstract

Background: A hook wire has been most widely used for computed tomography (CT)-guided localization before video-assisted thoracoscopic surgery (VATS). However, microcoils have been suggested to replace wires. The purpose of this study was to compare the efficacy, VATS procedure time, and excised volume of specimens of CT-guided localization using a hook wire and microcoil.

Methods: The medical records of 106 patients with 110 pulmonary nodules who underwent CT-guided localization using a hook wire (group A) or microcoil (group B) before VATS performed between March 2013 and January 2017 were retrospectively reviewed.

Results: The procedure success rate was 100% in both groups. Dislodgement occurred in four patients in group A and not in group B. Patient pain score was significantly lower for group B than group A (4.0 vs. 6.3; $P < 0.001$). The VATS success rate was higher in group B than in group A (98.1% vs. 91.1%; $P = 0.174$). The VATS procedure time was significantly shorter for group B than group A (18.8 vs. 23.6 minutes; $P = 0.004$). The excised volume of surgical specimens was significantly smaller for group B than group A (8.5 vs. 11.7 cm^3; $P = 0.043$). No major complications related to the localization procedure were noted in either group.

Conclusions: This study showed similar effectiveness of VATS localization between groups. However, microcoil is superior to hook wire for localization of pulmonary nodules in terms of VATS procedure time and excised volume of surgical specimens, with the advantages of no dislodgement and less patient pain.

Introduction

With computed tomography (CT), the detection rate of small pulmonary nodules has increased in clinical practice.[1] Diagnosis is challenging because of the variable diagnostic accuracy, sensitivity, and specificity of CT and positron emission tomography with radiolabeled (18F)-2-fluoro-deoxy-D-glucose/CT.[2] To complement this, video-assisted thoracoscopic surgery (VATS), a minimally invasive method, was adopted to diagnose and treat clinically suspicious malignant pulmonary nodules.[3] The vast majority of VATS can be performed without CT-guided localization. However, preoperative localization has been proven to be beneficial in terms of a higher success rate for VATS and efficient nodule excision for patients.[4,5]

A number of pulmonary nodule localization methods have been used, including barium,[6] lipiodol,[7] hook wire,[4,8,9] Tc-99m radionuclide,[10] intraoperative ultrasonography,[11] and metallic coil marking.[12–14] Hook wire localization is probably the oldest method for VATS.[4,8,9] It has an advantage in that the wire deployed in the lung can be used to retract the lung during VATS.[8] However, it also has disadvantages including wire dislodgement, and pleural pain during and after insertion.[8,9] The cause of dislodgement was poor anchorage of the hook wire in the lung parenchyma, possibly due to patient movement, clothing, surgical drapes, or lung deflation.[8,12] After localization with a hook wire, the patient's position should be maintained while moving from the CT room to the operating room. Therefore, there is a limitation in patients who cannot maintain a specific position, such as the prone or lateral decubitus position. Although microcoil is more expensive than hook wire, the coil was recently introduced as a localizer, and CT-guided microcoils were reported to be a safe and effective tool for easy and fast VATS.[13] Also, the localization technique is known to not impede histopathological processing or interpretation of the specimens, and pathologists can find the nodule adjacent to the coil using palpation, which increases the accuracy of pathological diagnosis.[14,15] It is also possible for the coil to dislodge after it reverts to its original shape.[14] However, coil dislodgement due to respiratory movement or surgical procedure is rare. Furthermore, metal materials can be easily discovered before and after surgery with fluoroscopy.[13,15]

A hook wire has been most widely used for CT-guided localization before VATS.[8,9] However, of late, microcoils have been suggested to replace hook wires for localization.[12–14]

Therefore, the aim of this study was to compare the efficacy, VATS procedure time, and excised volume of surgical specimens of a hook wire and microcoil for CT-guided localization before VATS.

Table 1 Baseline characteristics of patients and nodules

Variables	Wire group (n = 45) n (%)	Coil group (n = 54) n (%)	*P*
Mean age (years)	63.6 ± 8.0	62.2 ± 10.6	0.487
Gender			0.657
Male	26 (57.8)	29 (53.7)	
Female	19 (42.2)	25 (46.3)	
Nodule			
Mean size (mm)	13.0 ± 6.9	12.6 ± 16.3	0.881
Feature			0.862
Solid	23 (51.1)	25 (46.3)	
Part-solid	12 (26.7)	14 (25.9)	
Ground glass	10 (22.2)	15 (27.8)	
Location			1.000
Right upper lobe	12 (26.7)	15 (27.8)	
Right middle lobe	4 (8.9)	3 (5.6)	
Right lower lobe	14 (31.1)	18 (33.3)	
Left upper lobe	6 (13.3)	6 (11.1)	
Left lower lobe	9 (20)	12 (22.2)	
Mean distance (mm)†	9.1 ± 7.7	9.4 ± 7.4	0.884

†Mean distance is the distance from the pleura surface to the superficial margin of the nodule.

Methods

Patients

The institutional review board approved this retrospective study. For the study, 106 patients with 110 suspicious malignant pulmonary nodules underwent CT-guided localization using a hook wire (group A) from March 2013 to December 2014 or microcoil (group B) from January 2015 to January 2017 before VATS, and 99 of these patients were enrolled.

The inclusion criteria were as follows: single pulmonary nodule, ≤30 mm in maximal pulmonary nodule long-axis diameter, and nodule abutting a pleural surface. The exclusion criteria were as follows: patients with insufficient medical records, and nodules that invaded the adjacent chest wall or central pulmonary arteries or veins. Three patients who each had insufficient medical records and four patients who each had two suspicious malignant pulmonary nodules were excluded. Patient age ranged from 42 to 80 years (mean age 63 years; 55 men and 44 women). Patient and nodule characteristics are summarized in Table 1.

We assessed the success rate of CT-guided localization, the VATS success rate, likelihood of conversion to standard thoracotomy, procedure-related complications, procedure time, fluoroscopy time, operation time, VATS procedure time, and excised volume of surgical specimens. The excised volume of lobectomy was not included in the excised volume of surgical specimens.

When a frozen specimen had been diagnosed as a primary lung cancer, VATS lobectomy was performed first, and thoracotomy was performed when this was not possible; these cases were excluded when comparing conversion to thoracotomy between groups, as this reason is unrelated to the localization procedure used.

VATS success was defined as complete excision of the nodule using VATS without conversion to thoracotomy. Procedure time was the time required to localize a hook wire or coil in or near the pulmonary nodule under CT guidance. Operation time was the time required for VATS to remove the pulmonary nodule in the operating room. VATS procedure time was the time from skin incision to completion of wedge resection.

Patient pain associated with the procedure was evaluated in terms of pain score. Each patient completed a questionnaire after CT-guided hook wire or microcoil localization to assess the severity of pain with a visual analog scale from 0 (no pain) to 10 (worst possible pain).[16]

The pathology of excised specimens was as follows: chronic granulomatous inflammation (n = 23), intrapulmonary lymph node (n = 4), organizing pneumonia (n = 3), hemangioma (n = 1), hamartoma (n = 1), fibrosis (n = 1), primary lung malignancy (n = 36), and metastasis (n = 30). Primary lung malignancy consisted of invasive adenocarcinoma (n = 10), adenocarcinoma *in situ* (n = 23), and adenomatous hyperplasia (n = 3).

CT-guided localization

An intervention radiologist (YG) with 15 years' experience performed CT-guided hook wire localization (21-G, 10-cm cannula; 20-cm calibrated wire with a thorn; Cook, Bloomington, IN, USA) and Tornado Coil localization (MWCE-35-3-4, diameter: 3 mm; 0.018-inch diameter, 3 cm, fiber-coated, stainless steel; Cook). Patients were placed on a CT table in a suitable position (supine, prone, or lateral) to obtain the shortest needle insertion route for their initial CT scan. Next, a coaxial needle with a 20-G trocar tip (Medax Medical Devices, Poggio Rusco, Italy) was introduced percutaneously into or near the pulmonary nodule. If the needle tip was visualized at the planned site, the inner stylet of the needle was removed, and the hook wire or microcoil was inserted through the trocar. All CT images were obtained using a 128-detector row CT scanner (Somatom Definition AS$^+$; Siemens Medical Solutions, Forchheim, Germany). CT images were acquired using a picture archiving and communications system (PACS-Marosis; Infinitt, Seoul, Korea) and a three-dimensional workstation (Aquarius Intuition; Terarecon, San Francisco, CA, US). Follow-up CT was performed to identify the exact location of the hook wire or microcoil and to identify any procedure-related complications, such as pneumothorax or hemorrhage (Figs 1–2). After undergoing CT-guided localization, patients were transferred to the operating room for VATS. At this time, patients using the hook wire were transferred as they were in localization, and patients using the coil were transferred to a comfortable posture.

Surgical procedure

Patients were placed in the lateral decubitus position and were ventilated with a double lumen endotracheal tube while under general anesthesia. Three-port thoracoscopy was performed using two 5-mm ports and one 12-mm port. Group B patients also received intraoperative C-arm fluoroscopy. The resected specimen was submitted for pathological assessment.

Statistical analysis

Statistical analysis was carried out with SAS software, version 10.1 (SAS Institute, Cary, NC, USA). Results are presented as mean and SD (range). Independent t-tests for continuous variables and Pearson's χ^2-test or Fisher's exact test for categorical variables were used to compare groups A and B. Statistical significance was defined as $P < 0.05$.

Results

Lung nodules had a mean maximal transverse diameter of 13.0 ± 6.9 mm (range 4.4–30 mm) for group A and 12.6 ± 16.3 mm (range 4–30 mm) for group B. The mean distance from pleura to superficial nodule margins was 9.1 ± 7.7 mm (range 0–27.5 mm) for group A and 9.4 ± 7.4 mm (range 0–26 mm) for group B.

In both groups, the success rate of CT-guided localization was 100%. The VATS success rate was 91.1% for group A and 98.1% for group B (P = 0.174). Four patients in group A and one patient in group B required conversion to standard thoracotomy. No microcoils became dislodged, but four hook wires did (0% vs. 8.9%; P = 0.04). The causes leading to conversion were pleural adhesion (2 patients) and a dislodged hook wire (2 patients) among group A patients, and pleural adhesion (1 patient) among group B patients.

The mean patient pain score based on the visual analog scale was 6.3 and 4.0 for groups A and B, respectively (P < 0.001). The asymptomatic pneumothorax rates were 33.3% and 29.6% (P = 0.637), and the pulmonary parenchymal hemorrhage rates were 28.9% and 25.9% (P = 0.807) in groups A and B, respectively. The VATS procedure times were 23.6 and 18.8 minutes for groups A and B, respectively (P = 0.004). Excised volume of surgical specimens was 11.7 and 8.5 cm^3 for groups A and B, respectively (P = 0.043). The mean fluoroscopy time was 3.1 minutes (range 1.8–6.2 minutes) in group B. Localization procedure time and operation time were similar across groups. No preoperative hook wire or microcoil localization-related major complications were noted (Table 2).

Discussion

The current study confirmed the results of previous studies, indicating that pulmonary nodules can be successfully localized by CT-guided placement of hook wire or coils.[4,8,9,12–14]

Previous studies have reported conversion rates to standard thoracotomy ranging from 1.9% to 7.5% after CT-guided hook wire localization for VATS[8,9,12,13] and 0–6.6% after CT-guided coil localization.[12–14] The present study yielded conversion rates of 9% (4 patients) and 2% (1 patient) for the hook wire group and the coil group, respectively. The most common causes of conversion are pleural adhesion and dislodgement. If pleural adhesion or dislodgement was present, VATS lobectomy was

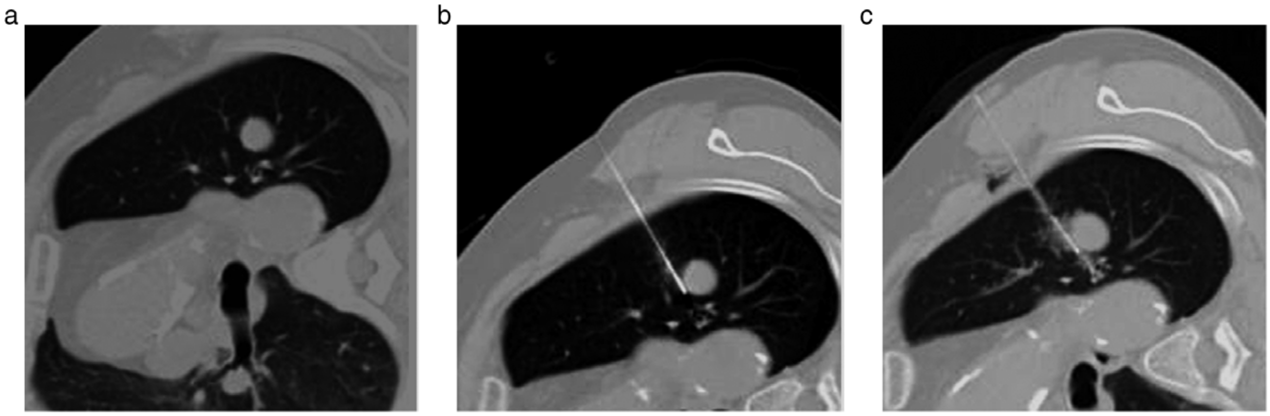

Figure 1 A hook wire was inserted beside the target nodule. Axial, non-enhanced chest computed tomography images show (**a**) a pulmonary nodule (**b**) during and (**c**) after hook wire insertion with a right lateral decubitus position.

performed first; if not, thoracotomy was performed. In our study, three out of four cases with pleural adhesion were converted to thoracotomy. Considering the high prevalence of pulmonary tuberculosis and tuberculous pleurisy in Korea,[17] tuberculosis-induced pleural adhesion can be a challenge during thoracic surgery.

In this study, the average patient pain score, as assessed with a visual analog scale, was significantly lower in group B than in group A before VATS resection. The cause is that the hook wire is placed in the lung parenchyma and extended out through the chest wall. Because wires are used to fix the lung to the overlying chest wall, they prevent the physiological sliding of the visceral pleura on the parietal pleura and thus cause pain.[12] However, the microcoil does not extend out. In addition, patients in group A could feel discomfort by trying to maintain a specific position (supine, prone, lateral decubitus) while in the CT-scanner suite and while moving to the operating room before VATS resection. In contrast, group B patients experienced a more convenient procedure, and could remain in a comfortable position between CT-guided localization and VATS. The relevance of this procedure to the clinical practice of further reducing patient pain is in the reduction of required analgesics, the friendly approach to the procedure, and the quality of the patient's experience in relation to the procedure.

The most commonly reported complications of CT-guided hook wire or coil localization are asymptomatic pneumothorax and pulmonary parenchymal hemorrhage.[4,13] In a prospective randomized controlled trial conducted in 2015, hook wire localization was associated with a high frequency of pneumothorax.[5] Also, Nakashima *et al.* reported that wire dislodgement was associated with pneumothorax, hemorrhage, and pleural pain.[18] A pilot study conducted in 2013 used microcoils made of stainless steel with attached synthetic fibers to promote thrombogenicity, which decreased bleeding.[13] Although complications can arise from both types of localization procedures, in the present study, the complication rates were not significantly different between groups A and B.

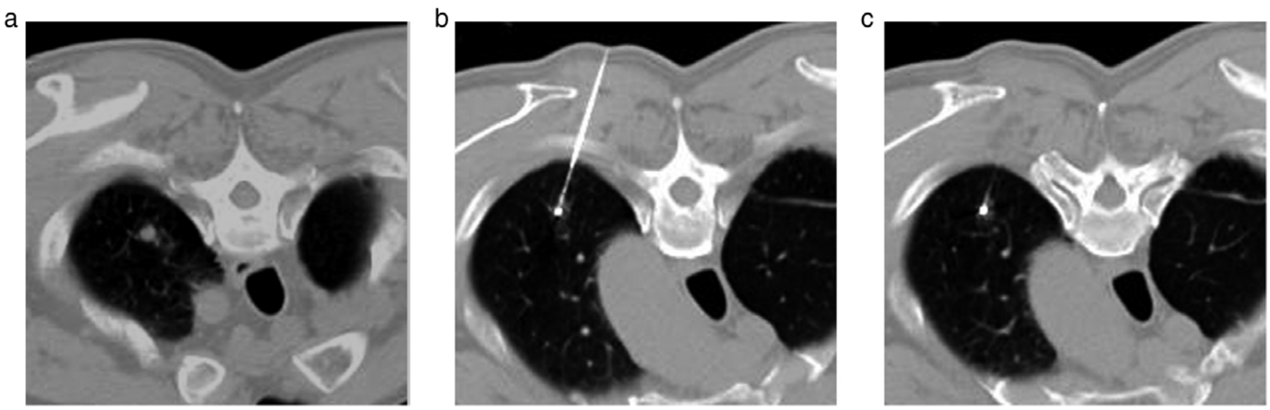

Figure 2 A coil was inserted through the target nodule. Axial, non-enhanced chest computed tomography images show (**a**) a pulmonary nodule (**b**) during and (**c**) after coil insertion with a prone position.

Table 2 Results of computed tomography-guided hook wire or coil localization and video-assisted thoracoscopic surgery

	Wire group (n = 45)	Coil group (n = 54)	
Variables	n (%)	n (%)	P
Procedure success	45 (100)	54 (100)	
Success of VATS	41 (91.1)	53 (98.1)	0.174
Conversion to thoracotomy	4 (8.9)	1 (1.9)	
Dislodgement	4 (8.9)	0 (0)	0.040
Pleura adhesion	2	2	
Mean pain score (VAS: 0–10)	6.3 ± 1.1	4.0 ± 1.3	<0.001
Complications			
Pneumothorax	15 (33.3)	16 (29.6)	0.637
Pulmonary parenchymal hemorrhage	13 (28.9)	14 (25.9)	0.807
Mean procedure time (min)	16.7 ± 3.5	16.4 ± 3.7	0.740
Mean operation time (min)	50.7 ± 20.6	53.8 ± 20.8	0.495
VATS procedure time (min)	23.6 ± 7.17	18.8 ± 4.77	0.004
Excised volume of surgical specimens (cm^3)	11.7 ± 7.0	8.5 ± 4.78	0.043

VAS, visual analog scale; VATS, video-assisted thoracoscopic surgery

Our study showed that VATS procedure time was significantly shorter for group B than group A (18.8 vs. 23.6 minutes; $P = 0.004$), and the excised volume of surgical specimens was significantly smaller for group B than group A (8.5 vs. 11.7 cm^3; $P = 0.043$). The longer the wasting time was from after the localization procedure to the start of the thoracoscopic resection, the more likely it was that the wire would be dropped from the targeted nodule. Also, in the case of a >2-cm-deep nodule on the pleural surface, the possibility of positional displacement of the wire relative to the targeted nodule was higher when lung deflation was performed.[15] It will also take a relatively long time to reach a deep nodule along the wire in a deflated lung. However, with the coil, as the position of the coil can be confirmed with the guidance of real-time fluoroscopy, it takes less time to excise a specimen and allows excision of a relatively small amount of specimen. Therefore, it is presumed that wedge resection with VATS using wire is relatively time-consuming and requires resection of a larger surgical specimen compared with using a coil.

We also found that differences in mean procedure time (16.7 vs. 16.4 minutes; $P = 0.74$) and operation time (50 vs. 54 minutes; $P = 0.495$) between groups A and B were not significant. Thus, we concluded that selecting either a hook wire or microcoil as a localizer did not affect procedure time or operation time for VATS.

We did find that applying C-arm fluoroscopy to group B patients resulted in radiation exposure during VATS. However, fluoroscopy time was only minutes, so we suspect that group B patients were not seriously affected by this radiation.

Other various materials have been used for percutaneous localization of nodules before VATS. These techniques shorten the time between CT-guided localization and VATS.[13] However, we believe that they can present problems. Dye, contrast media (such as lipiodol, barium), and radionuclides have a tendency to diffuse into the surrounding lung parenchyma. Therefore, rapid performance of VATS resection is required. Also, they can cause an anaphylactic reaction, aspiration into the lung, or inflammation at the marking site. An additional gamma probe is required with radionuclides during VATS. Localization with intraoperative ultrasonography is operator dependent and requires complete collapse of the lung, which is difficult to obtain in emphysematous lungs.[6,14,15]

Our study has limitations. This study was conducted at a single institution. Furthermore, one intervention radiologist (YG) with 15 years' experience performed all CT-guided localizations, which makes the study susceptible to various biases. A large-scale multicenter study is required to confirm our findings.

In conclusion, this study showed similar effectiveness of VATS localization between groups. However, microcoil is superior to hook wire for localization of pulmonary nodules in terms of VATS procedure time and excised volume of surgical specimens, with the advantages of no dislodgement and less patient pain.

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Disclosure

No authors report any conflicts of interest.

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