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INTERVENTIONAL

Comparison between the application of microcoil and hookwire for localizing pulmonary nodules

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Abstract

Objectives To compare the efficacy and safety of localization of small pulmonary nodules with microcoil and hookwire prior to surgical resection.

Methods A total of 112 patients who underwent preoperative computed tomography (CT)-guided localization of small pulmonary nodules were enrolled in this single-center retrospective non-randomized cohort study between June 2016 and June 2017. Seventy-nine patients who underwent percutaneous localization with microcoils formed the microcoil group; the remaining 33 patients underwent percutaneous localization with hookwires (hookwire group). The primary outcomes were the success and complication rates of the procedure. Student's *t* test was used for continuous variables, whereas chi-square analysis and logistic regression were used for dichotomous variables.

Results Video-assisted thoracoscopic surgery (VATS) was successfully performed in all cases, without conversion to thoracotomy. The localization success rate was 94.9% (75/79) in the microcoil group and 93.9% (31/33) in the hookwire group ($p = 0.836$). Hookwire group ($p = 0.000$) and nodule location of the lower lobe ($p = 0.012$) were associated with an increased incidence of pneumothorax. Hookwire group ($p = 0.027$) and decreased nodule diameter ($p = 0.024$) were associated with an increased incidence of moderate to severe chest pain, as well as an increased incidence of overall complications.

Conclusions Although the deployment of the microcoil was more complex and required more time than hookwire placement, microcoil localization was associated with fewer complications.

Key Points

- *CT-guided percutaneous localization using a microcoil and that using a hookwire are equally effective for localizing small pulmonary nodules prior to resection with video-assisted thoracoscopic surgery.*
- *Lung nodule localization using a microcoil was associated with fewer complications than localization using a hookwire.*

Keywords Pulmonary nodules · Nodule localization · Video-assisted thoracoscopic surgery · Computed tomography

Abbreviations

CT	Computed tomography
VATS	Video-assisted thoracoscopic surgery

Introduction

The advent of lung cancer screening with low-dose computed tomography (CT) has increased the detection of indeterminate pulmonary nodules [1]. Small indeterminate pulmonary nodules can be characterized by either needle biopsy or surgical excision; however, a needle biopsy is associated with sampling error [2]. Video-assisted thoracoscopic surgery (VATS) is a minimally invasive method for excisional biopsy, which can remove the entire nodule without sampling error. However, previous studies showed that up to 54% of the small pulmonary nodules could not be observed or palpated at the time of VATS. This is true for nodules with a diameter of less than 10 mm that are located more than 5 mm from the pleural surface, especially if they are pure ground glass. Some were

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difficult to locate even with traditional thoracotomy [3, 4]. Developing a technique for accurately locating small pulmonary nodules in VATS would permit definitive resection when possible and would avoid extensive resection in patients with small pulmonary nodules, which would benefit the prognosis of patients with early-stage lung cancer [5].

Several localization methods have been reported with hookwire localization, microcoil localization, and liquid material being the most widely used methods [6]. Localization with a hookwire is the oldest and probably the most common method of nodule localization [6, 7]. Preoperative CT-guided microcoil localization was more recently reported by Powell et al [8]. CT-guided localization using liquid materials, including methylene blue dye [9], contrast medium [10, 11], and radionuclides [12], has also been described. Pneumothorax and pulmonary hemorrhage are commonly associated complications. Serious adverse events are uncommon [6]. Each localization method has its own risks and benefits, however, and it remains controversial which localization method is best. Several studies [13, 14] compared hookwire localization and localization using liquid materials (methylene blue dye and human albumin serum labeled with 99mTc). A meta-analysis [6] on hookwire localization, microcoil localization, and lipiodol localization has also been reported. However, there is no study directly comparing microcoil localization and hookwire localization. Therefore, this study was conducted to compare the efficacy and safety of preoperative localization technique using a microcoil and a hookwire for small pulmonary nodules.

Materials and methods

Patient population

Between June 2016 and June 2017, a total of 124 consecutive patients underwent localization and subsequent thoracoscopic resection at an academic hospital. The necessity and feasibility of preoperative localization of each pulmonary nodule was confirmed by thoracic surgeons and interventional radiologists before the localization procedure. Criteria for localization included the presence of a small pulmonary nodule, less than 20 mm in maximal diameter, located within 4 cm of a pleural surface or fissure, deemed amenable to thoracoscopic wedge excision, with a path for percutaneous puncture. Included nodules were categorized as either (1) pure ground-glass nodules, (2) part-solid nodules with a solid portion ≤ 1 cm and a distance to the visceral pleura ≥ 0.5 cm, and (3) solid nodules with a diameter ≤ 1 cm and a distance to visceral pleura ≥ 0.5 cm. Twelve patients with two or more pulmonary nodules requiring simultaneous localization were excluded. Finally, 112 patients with 112 small pulmonary nodules were included in this single-center retrospective cohort study. Of these, 79 patients who underwent the CT-guided percutaneous localization with microcoils formed the microcoil group; the remaining 33 patients who underwent the CT-guided percutaneous localization procedure with hookwires formed the hookwire group. Patients did not undergo CT-guided percutaneous localization with a microcoil or hookwire randomly. It depended on the time between the localization procedure and VATS. If the time interval between localization procedure and VATS was less than 2 h, a hookwire was used; otherwise, a microcoil was placed. This study was approved by the review board of the institution, and the requirement for informed consent for the use of patients' medical record was waived.

Interventional equipment

A 64-row multidetector CT (LightSpeed VCT, GE Healthcare) and a 256-row multidetector CT (Revolution CT, GE Healthcare) were used. The CT scan parameters were as follows: scan type, helical; slice thickness, 1.25 mm; reconstruction interval, 1.25 mm; and pitch, 0.948:1.

A 70-mm-long, 0.018-in.-diameter fiber-coated platinum microcoil (Cook) costing $200 and a percutaneous introducer kit (PBN Medicals) costing $200, including a 15 cm × 21G Chiba needle and an 80 cm × 0.018 in. Nitinol guidewire, were used in the microcoil group. The microcoil placed in the loading cannula could be pushed into the Chiba needle using the stiff end of the guidewire. A 7.8-cm-length 20G puncture trocar loaded with a hookwire (C. R. Bard, Inc.) costing $100 was used in the hookwire group.

Interventional procedure

All localizations were performed or closely supervised by two interventional radiologists with 10 years and 20 years of experience, respectively. Localization with microcoils in this study was based on the method reported by Powell et al [8]. The specific steps of the procedure were as follows:

I. An appropriate patient position (supine, prone, and lateral decubitus) for the procedure was determined according to the location of the targeted nodule using previously obtained CT scans.
II. The targeted nodule was imaged using spiral CT, and a reasonable puncture path was selected according to the intraprocedural CT images while avoiding blood vessels, fissures, and the liver (Fig. 1a).
III. A crease was made to mark the pusher wire at the length necessary to eject the entire 70-mm-long microcoil from the loading cannula through the Chiba needle into the lung parenchyma. After providing local anesthesia, the

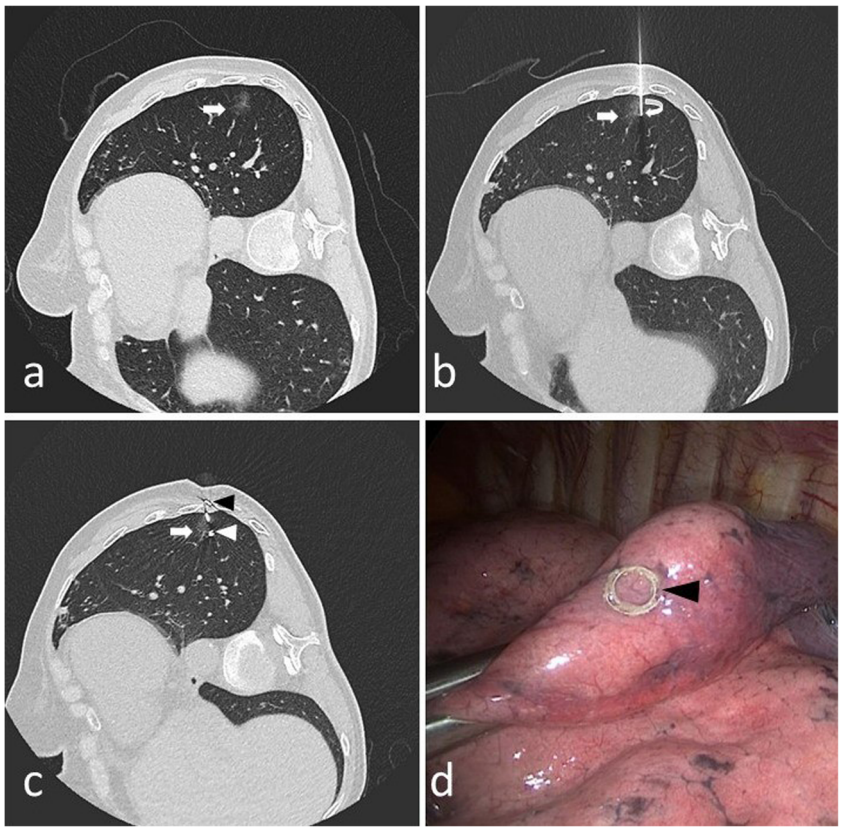

Fig. 1 A 70-year-old female with a 16-mm pure ground-glass nodule in the left lower lobe underwent thoracoscopic wedge resection. **a** Axial computed tomography image shows the lesion (straight arrow) in the left lower lobe. **b** Introducer needle (curved arrow) was inserted into the lung and positioned next to the lesion (straight arrow). **c** The microcoil was released with the superficial end of the microcoil (black arrowhead) beyond the visceral pleura and the deep end (white arrowhead) coiled in the lung parenchyma adjacent to the lesion (straight arrow). **d** Superficial end of the microcoil (black arrowhead) was visualized using a thoracoscope to guide wedge resection

Chiba needle was percutaneously inserted along the planned path using CT guidance. The pulmonary parenchyma tissue within a 1-cm radius around the pulmonary nodule was targeted.

IV. After the successfully positioning the tip of the Chiba needle (Fig. 1b), the distance from the introducer needle tip to the pleura was measured using the electronic caliper function on the CT scanner console, which was defined as distance A. Distance A plus 5–10 mm was defined as distance B. A small curved vascular clamp was used to mark the guidewire at distance B from the crease described above.

V. The loading cannula was connected to the introducer needle, and the microcoil was pushed into the lung using the guidewire. After the guidewire was pushed into the loading cannula and the needle at the point marked with the small curved vascular clamp, the clamp was removed. With the guidewire fixed, the introducer needle and loading cannula were withdrawn together, until the microcoil was released. The proximal end was extended into the pleural space, about 5–10 mm beyond the visceral pleura, whereas the distal part was embedded in the pulmonary parenchyma (Fig. 1c).

VI. A postprocedural CT scan was obtained to confirm the final location of the microcoil relative to the nodule and visceral pleura and to evaluate for complications (Fig. 1c).

The specific steps for localization with a hookwire were as follows: the puncture process was the same as for the microcoil group (Fig. 2a). Following the puncture (Fig. 2b), the hookwire was released from the puncture trocar, and the puncture trocar was withdrawn. The proximal end of the hookwire was implanted in the lung parenchyma adjacent to the pulmonary nodule (Fig. 2c), and the distal end was cut off at the skin level so that no part of the marker was protruding.

Thoracoscopic surgery

The patients underwent VATS resection of pulmonary nodules within 2 h after hookwire localization and within 24 h after microcoil localization. The localization of the nodule was first attempted by visualizing the superficial end of the microcoil or hookwire beyond the visceral pleura (Figs. 1d and 2d). If visualization failed, palpation was performed to find the microcoils or lesions through the operating port. If the location of the nodule was confirmed, wedge resection was performed under the guidance of the microcoil or hookwire. The incisal edge of the resected specimen should be no less than the diameter of the lesion or greater than 2 cm. The resected specimens were submitted to the pathologist for frozen-section diagnosis. The rest of the surgery was performed according to

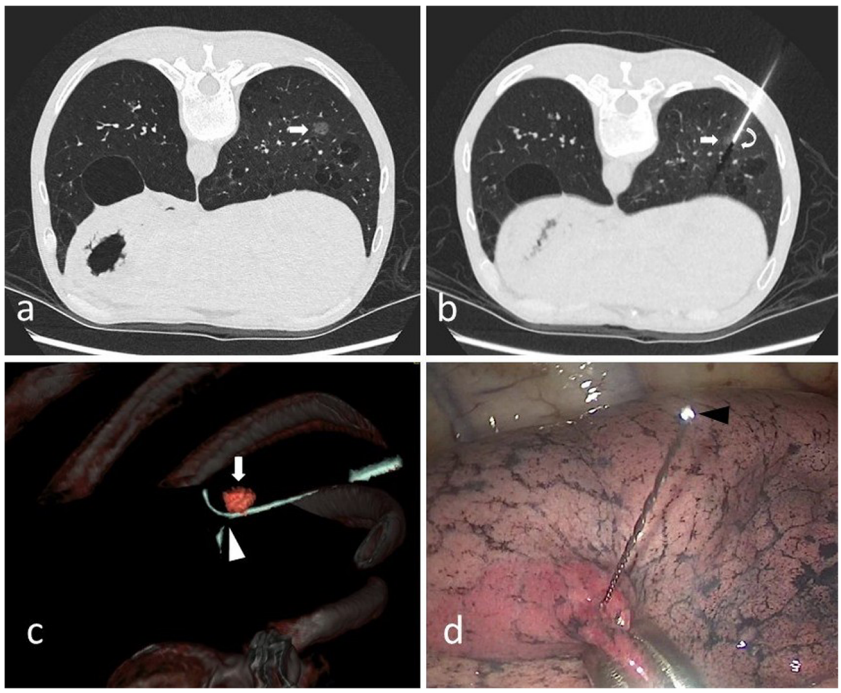

Fig. 2 A 52-year-old male with an 11-mm pure ground-glass nodule in the right lower lobe underwent thoracoscopic wedge resection. **a** Axial computed tomography image shows the lesion (straight arrow) in the right lower lobe. **b** Puncture needle (curved arrow) was inserted into the lung and positioned next to the lesion (straight arrow). **c** Reconstruction demonstrates the hookwire (white arrowhead) implanted in the lung parenchyma adjacent to the lesion (straight arrow). **d** The superficial end of the hookwire (black arrowhead) was visualized using a thoracoscope to guide wedge resection

the standard of care. Each lesion underwent a final histopathological examination after the surgery.

Data collection and statistical analyses

Clinical data, imaging data, interventional procedure and surgical data, and data on postoperative pathological diagnosis, including age, sex, nodule location, attenuation, diameter, distance between lesion border and visceral pleura, duration of localization procedure (defined as the time between acquiring the scout image and acquiring the last CT image), and complications of localization, were collected from the electronic medical record and picture archiving and communication system. Complications were confirmed using postprocedural CT, and chest pain was evaluated using a numerical rating scale [15]. All values were recorded as means ± standard deviations. SPSS (version 20, IBM) was used to perform all statistical analyses. Student's *t* test was used for continuous variables, and chi-square analysis and logistic regression were used for dichotomous variables. A result was considered to be significant at $p < 0.05$.

Results

In the microcoil group, targeted lesions consisted of 67 pure ground-glass nodules, seven part-solid nodules, and five solid nodules. In the hookwire group, all lesions were pure ground-glass nodules. The patient and nodule characteristics are listed in Table 1. Age, sex, mean maximal transverse diameter, mean distance from the most superficial edge of the nodule to the visceral pleura, and lesion location did not differ significantly between the two groups.

VATS was successfully performed in all cases, without conversion to thoracotomy. The localization success rate was 94.9% (75/79) in the microcoil group and 93.9% (31/33) in the hookwire group ($p = 0.836$). The localization success rate showed no significant difference between the two groups (Table 3). The superficial end of the microcoil was not beyond the visceral pleura in three of the four failed cases in the microcoil group. In these instances, palpation of the microcoil allowed for localization of the nodule, and VATS was successfully performed. In one of the

Table 1 Patient and nodule characteristics

	Microcoil group	Hookwire group	*p*
Number	79	33	
Age (year)	53.9 ± 11.0	52.6 ± 8.7	0.553
Sex			
Male	34 (43.0%)	13 (39.4%)	0.722
Female	45 (57.0%)	20 (60.6%)	
Mean maximal transverse diameter (mm)	8.7 ± 4.0	8.0 ± 3.7	0.362
Mean distance from the most superficial edge of the nodule to the visceral pleura (mm)	9.4 ± 6.4	7.9 ± 7.4	0.307
Nodule location			
Upper and middle lobes	51 (64.6%)	26 (78.8%)	0.139
Inferior lobe	28 (35.4%)	7 (21.2%)	

Student's *t* test was used for continuous variables and chi-square analysis for dichotomous variables

Table 2 Procedural success rate, complications, and duration for the two groups

	Microcoil group ($n = 79$), n (%)	Hookwire group ($n = 33$), n (%)	p
Procedure success	75 (94.9)	31 (93.9)	1.000
Pneumothorax	12 (15.2)	16 (48.5)	0.000
Pulmonary hemorrhage	6 (7.6)	8 (24.2)	0.015
Moderate and severe chest pain	5 (6.3)	8 (24.2)	0.007
Overall complications	20 (25.3)	22 (66.7)	0.000
Duration for localization procedure (min)	29.8 ± 4.8	23.9 ± 5.3	0.000

The chi-square analysis was used for dichotomous variables and Student's t test for continuous variables. Univariate analysis might be affected by selective bias, which could be eliminated by multivariate logistic regression (Table 3)

four failed cases in the microcoil group, the distal end of the microcoil had dislodged and was fixed to the chest wall. In this instance, nodule localization was guided by the small hematoma caused by the puncture. In the two failed cases of the hookwire group, the proximal hook of the hookwire was pulled back into the pleural space. The localization of the nodule was guided by the hematoma at the puncture site. The duration of the localization procedure was longer in the microcoil group than in the hookwire group (Table 2). Pneumothorax was observed in 12 of 79 (15.2%) patients of the microcoil group and 16 of 33 (48.5%) patients of the hookwire group. Hookwire group ($p = 0.000$) and nodule location in the lower lobe ($p = 0.012$) were associated with an increased incidence of pneumothorax (Table 3). Patients with pneumothorax remained asymptomatic and did not require additional intervention. Pulmonary hemorrhage was observed in 6 of 79 (7.6%) patients of the microcoil group and 8 of 33 (24.2%) patients of the hookwire group. The incidence of pulmonary hemorrhage was lower in the microcoil group than in the hookwire group, but this was not statistically significant (Table 3). Patients with pulmonary hemorrhage showed mild symptoms and did not require additional intervention. Two patients in the hookwire group experienced both pneumothorax and mild pulmonary hemorrhage. No aeroembolism was observed in both groups. Immediately following the localization, a total of 74 in the microcoil group and 25 patients in the hookwire group had mild chest pain (1/3).Three patients in the hookwire group experienced severe chest pain (7/10) which required 10 mg morphine hydrochloride by hypodermic injection. No severe chest pain was observed in the microcoil group. Five patients each in the microcoil and hookwire groups had moderate chest pain (4/6). Patients with mild and moderate chest pain did not require intervention, and all chest pain caused by localization procedure was eliminated after VATS. Hookwire group ($p = 0.027$) and decreased nodule diameter ($p = 0.024$) were associated with an increased incidence of moderate and severe chest pain (Table 3). Any complication (pneumothorax, pulmonary hemorrhage, moderate or severe chest pain) was observed in 20 of 79 (25.3%) patients in the microcoil group and 22 of 33 (66.7%) patients in the hookwire group. Hookwire group ($p = 0.000$) and decreased nodule diameter ($p = 0.010$) were associated with an increased incidence of any complication (Table 3). The pathology of the targeted lesions is shown in Table 4. The final pathological result was in agreement with the pathological results of frozen sections in all instances.

Table 3 Multivariate logistic regression of procedural success, pneumothorax, pulmonary hemorrhage, moderate and severe chest pain, and overall complications

	Procedural success		Pneumothorax		Pulmonary hemorrhage		Moderate and severe chest pain		Overall complications	
	OR(95%CI)	p	OR(95%CI)	p	OR(95%CI)	p	OR(95%CI)	p	OR(95%CI)	p
Group										
Microcoil group	1	0.836	1	0.000*	1	0.059	1	0.027*	1	0.000*
Hookwire group	0.82 (0.12–5.46)		8.43 (2.79–25.52)		3.28 (0.96–11.23)		4.50 (1.19–17.04)		7.66 (2.82–20.83)	
Age (years)	0.98 (0.90–1.06)	0.535	0.98 (0.93–1.04)	0.549	0.97 (0.91–1.03)	0.319	0.96 (0.90–1.03)	0.213	0.98 (0.94–1.03)	0.361
Sex										
Male	1	0.367	1		1	0.200		0.264	1	0.685
Female	0.35 (0.04–3.40)		0.46 (0.16–1.34)	0.154	2.46 (0.62–9.72)		2.35 (0.53–10.47)		0.82 (0.32–2.10)	
Diameter (mm)	0.94 (0.76–1.17)	0.591	0.87 (0.74–1.01)	0.063	0.87 (0.71–1.06)	0.164	0.75 (0.58–0.96)	0.024*	0.83 (0.73–0.96)	0.010*
Distance (mm)	1.07 (0.90–1.26)	0.449	0.99 (0.92–1.07)	0.844	1.06 (0.97–1.16)	0.233	0.98 (0.88–1.09)	0.695	1.01 (0.94–1.09)	0.738
Nodule location										
Upper and middle lobes	1	0.372	1	0.012*	1	0.151	1	0.847	1	0.126
Lower lobe	0.44 (0.07–2.66)		4.31 (1.38–13.48)		0.30 (0.06–1.55)		0.87 (0.21–3.65)		2.16 (0.81–5.76)	

Diameter means maximal transverse diameter, and distance means the distance from the most superficial edge of the nodule to the visceral pleura

* marks the p values that are statistically significant

Table 4 Pathology of the lesions in the microcoil and hookwire groups

Pathology	Microcoil group, *n* (%)	Hookwire group, *n* (%)
Fibrous hyperplasia	2 (2.5)	4 (12.1)
Granulomatous inflammation	2 (2.5)	
Atypical hyperplasia	7 (8.9)	6 (18.1)
Adenocarcinoma in situ	16 (20.2)	5 (15.1)
Minimally invasive adenocarcinoma	27 (34.1)	9 (27.3)
Invasive adenocarcinoma	25 (31.6)	9 (27.3)

Discussion

The localization success rate was 94.9% (75/79) in the microcoil group and 93.9% (31/33) in the hookwire group. Hence, localization using a microcoil and that using a hookwire were equally effective in directing VATS resection. Microcoil localization performed in this study was based on the method reported by Powell et al [8], but with some modifications. The superficial end of the microcoil needed not be deployed exactly in the pleural space to reduce the CT scan times and complexity of the localization procedure. It could be deployed about 5–10 mm beyond the visceral pleura without increasing patient discomfort [16]. As most of the microcoil was embedded in the pulmonary parenchyma, the superficial end of the microcoil prolapsed from the chest wall to the pleural cavity, with the physiological movement of respiration or the collapse of the affected lung after single-lung ventilation was initiated at the time of VATS. In some cases, the superficial end of the microcoil might still hang on the chest wall with the deep end coiled in the pulmonary parenchyma following lung collapse leading to VATS. It could be easily pulled out of the chest wall into the pleural space using the grasper, without additional injury. If the superficial end of the microcoil was not beyond the visceral pleura, visual localization would fail and the nodule localization would be guided by palpation of the microcoil. In case palpation fails, fluoroscopy could be used to identify the location of the microcoil, which would localize the nodule. Localization with the hookwire could also direct VATS resection by the visual inspection of the distal end of the hookwire.

Deploying a microcoil was more complex than releasing a hookwire, which explains why the procedure duration was longer in the microcoil group than in the hookwire group. Compared with localization using a hookwire, microcoil localization required measuring the distance from the introducer needle tip to the visceral pleura, calculating the length that the guidewire needed to be advanced and deploying the microcoil with the superficial end beyond the visceral pleura. A few studies reported that the puncture did not affect the pathological analysis or cause tract seeding [16, 17]. Seo et al [18] demonstrated that the puncture did not pass through the lesion. Also, the target area was the normal lung tissue in a 1 cm range around the lesion. This approach precluded the possibility of damaging the lesion and tract seeding. Also, it did not affect the excision because the edge of wedge resection was usually at least 2 cm beyond the edge of the lesion.

No major complications [19] were observed during and after localization using a microcoil or hookwire. The incidence of pneumothorax, moderate and severe chest pain, and overall complications was lower in the microcoil group than in the hookwire group. The microcoils used for localization were soft and pliable, causing little damage to the pulmonary parenchyma. They would not cause any additional injury with physiological respiratory motion. Moreover, animal experiments [20] have shown that the microcoil coated with hemostatic synthetic nylon fibers can induce coagulation of the surrounding pulmonary parenchyma and fill the puncture pathway, hence decreasing the incidence and severity of pneumothorax and pulmonary hemorrhage. In comparison, the hookwires are stiff and have a sharp end shaped like a hook, preventing the physiologic relative movement between the visceral and the parietal pleura, which results in torsional stress in the pulmonary parenchyma. This might lead to the increased incidence of hookwire prolapse from the lung in case of prolonged time between the localization procedure and VATS. Therefore, the interval time between hookwire localization procedure and VATS should be as short as possible. Moreover, if a pneumothorax develops, the stiff hookwire fixed to the chest wall prevents the lung from collapsing, causing pulmonary parenchymal laceration, possibly hemothorax, and failed localization [16, 21, 22]. Gagliano et al [20] compared microcoils with hookwires in ex vivo goat lungs and observed that microcoils caused minimal tissue damage when they were dislodged. These differences in material properties and technical details might explain why localization with microcoil was associated with a lower incidence of complications. The lower lobes experience a greater range of respiration motion, so puncture needle caused greater torsional stress around the pulmonary parenchyma, explaining why nodules located in lower lobes were associated with an increased incidence of pneumothorax. As the nodule diameter decreased, the difficulty in puncturing increased, leading to multiple punctures. Hence, decreased nodule diameter contributed to an increased incidence of moderate or severe chest pain and overall complications.

The advantages of a short 10-mm-long hookwire with suture material attached to the non-hook bearing end have been reported [23–25]. The suture material provides a less rigid attachment of the lung parenchyma to the chest wall. The reported incidence of complications with this method ranged from 43.9 to 60.7% [23–26], which were lower than complications associated with hookwire localization as described in this manuscript but higher than those of microcoil localization. A meta-analysis [6] on hookwire localization, microcoil localization, and

lipiodol localization showed that the three methods yielded similarly highly successful targeting rates; microcoil localization yielded the lowest complication rates, which was consistent with the findings of the present study. A study [14] comparing methylene blue injection and hookwire insertion indicated that both techniques had statistically equivalent efficacy for preoperative pulmonary nodule localization. Higher rates of overall complications, pneumothorax, and perilesional hemorrhage in the hookwire group were not statistically significant. Methylene blue injection increased the risk of allergy [9] and was often difficult to visualize on the visceral pleural surface in patients with extensive anthracotic pigmentation. Gonfiotti et al [13] reported that the radio-guided technique resulted in fewer complications and failures compared with the hookwire technique. However, the radio-guided technique was limited by the equipment, training requirements, and radiation exposure [12]. Another study reported that microcoil localization without pleural marking decreased the procedure time and radiation dose compared with microcoil localization with pleural making [26]. However, microcoil localization with pleural marking can guide VATS by visualization of the superficial end of the microcoil without requiring intraoperative fluoroscopy, hence eliminating radiation exposure.

Several other kinds of CT-guided pulmonary localization methods are also available. For example, localization with contrast media has been reported [10, 11]. However, injection of liquid materials may trigger an allergic reaction or cerebral embolism if injected into a pulmonary vein. Some may even affect the accuracy of the pathological examination results. Localization using fiducial markers has also been reported and was associated with minor complications (25%) such as pneumothorax [27]. This technique is similar to microcoil localization without pleural marking and requires the use of intraoperative fluoroscopy and radiation exposure. Recently, the use of electromagnetic navigational bronchoscopy as a localization tool for small pulmonary nodules has been reported [28, 29]. However, results in large cohorts are not yet available. Finally, ultrasonography (US)-guided localization of lung nodules was reported in the 1990s [30, 31]. This technique is highly operator dependent and requires a complete collapse of the lung, which is often not possible in patients with emphysema.

This study had some limitations. First, a relatively small sample size and non-random grouping were used. Larger-sample randomized studies are required for validation. Second, this was a single-center evaluation and multicenter studies are needed to confirm the findings.

In conclusion, CT-guided percutaneous localization with a microcoil and that with a hookwire were equally effective for small pulmonary nodules prior to VATS resection. Although the deployment of the microcoil was more complex and required more time than hookwire placement, microcoil localization was associated with fewer complications.

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Compliance with ethical standards

Guarantor The scientific guarantor of this publication is Jian Gao.

Conflict of interest The authors declare that they have no competing interests.

Statistics and biometry Huixin Liu (Department of Clinical Epidemiology, Peking University People's Hospital, Beijing, China), PhD, provided statistical advice for this study, and she is one of the authors.

Informed consent Written informed consent was waived by the Institutional Review Board.

Ethical approval Institutional Review Board approval was obtained.

Methodology
- retrospective
- observational
- performed at one institution

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