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Coil localization assisted wedge resection for pulmonary nodules in patients with malignant history

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Abstract

We describe the clinical efficacy of coil localization (CL) assisted video-assisted thoracoscopic surgery (VATS) wedge resection (WR) for pulmonary nodules (PNs) in patients having a history of malignancy.

In a total of 16 patients having PNs and malignant history, treatment was carried out using computed tomography (CT)-guided CL and subsequent VATS-guided WR procedures from November 2015 to December 2019. Technical success of CL, WR, and long-term outcomes was analyzed.

A total of 21 PNs were localized (1.3 PNs per patient). A 100% technical success rate was achieved in this study for CT-guided CL. Each PN was localized with 1 coil. Two and 2 patients experienced pneumothorax and hemoptysis, respectively. VATS-guided WR also achieved a 100% technical success rate. Additional lobectomy was performed in 2 patients due to the invasive adenocarcinoma. The final diagnoses of these 21 PNs were adenocarcinoma (T1N0M0, n=8), adenocarcinoma in situ (n=2), pre-cancerosis (n=1), metastasis (n=2), and benign (n=8). All patients underwent CT follow-up for 6 to 48 months. All patients were alive during the follow-up. The cumulative 6-, 12, and 24-month disease-free survival rates were 100%, 92.9%, and 47.3%, respectively. The median disease-free survival was 27.9 months.

Pre-operative CT-guided CL can be safely and conveniently used to facilitate a high success rate of VATS-guided WR for PNs in patients with a malignant history. Among the PNs in patients with malignant history, primary lung cancer also occupied approximately half of the PNs.

Abbreviations: CL = coil localization, CT = computed tomography, GGN = ground-glass nodule, PN = pulmonary nodule, VATS = video-assisted thoracoscopic surgery, WR = wedge resection.

Keywords: coil, localization, malignant history, pulmonary nodule

1. Introduction

Because of the extensive usage of reduced-dose computed tomography (CT) in the detection of the pulmonary nodules (PNs). In this view, the rate of PN screening has been elevated.[1–5] Diagnosis of PNs is challenging, especially for patients with a previous malignant history. Except for the multiple diffused PNs, the solitary PN in patients with malignant history is hard to diagnose. Previous studies demonstrated that primary lung cancer could account for 38% to 57% of patients with solitary PNs and malignant history.[6–8]

To make a definite diagnosis of PNs, the video-assisted thoracoscopic surgery (VATS)-guided wedge resection (WR) procedure has been widely used due to its minimally invasive nature.[9–12] Pre-operative CT-guided localization is commonly employed to facilitate the VATS-guided diagnostic WR of PNs, achieving high rates of successful localization (89.6%–100%) and WR (97%–100%), with a low complication rate (8.8%–12.6%).[9–12] Localized materials usually include methylene blue, hook-wire, coils, and radio-labeling agents.[12] Compared with hook-wire, coil localization (CL) usually yielded a lower complication rate.[12] In relation to the injections of methylene-blue, the CL might be congenial with a long-standing interval between the localization and VATS invasive techniques.[13] In addition, CL did not require intraoperative fluoroscopic guidance that can result in radiation damage.[12]

CL assisted VATS-guided WR for diagnosing accidental PNs in healthy populations had been commonly reported.[9,12–14] However, the studies regarding VATS-guided diagnostic WR for PNs in patients with malignant history are still lacking.

Herein, the existing study describes the clinical consideration of CL assisted VATS-guided WR for PNs in patients having a history of malignancy.

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The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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2. Materials and methods

2.1. Study design

A retrospective study of a single-center was carried out and the approval for this study was provided by the Ethics Committee of Xuzhou Central Hospital. Patient consent was not given because the Institutional Review Board renounced the requirement of written informed consent. Moreover, the existing study was non-interventional retrospective design, no human subjects or personally identifying information used, and all data were analyzed anonymously.

In a total of 16 patients having PNs and malignant history, treatment was carried out using CT-guided CL and subsequent VATS-guided WR procedures from November 2015 to December 2019.

The following were some significant inclusion criteria for the existing study: a patient with a history of resection of malignant tumor; a PN diameter ≤3 cm (ground glass PN ≤3 cm; solid PN ≤1.5 cm); a lesion-pleura distance ≤2 cm; and the number of PNs ≤3. While exclusion criteria for the existing study were as follows: a PN diameter <4 mm; a distinctive benign PN, including calcifications as well as nodules that decreased in size upon follow-up; and any active bleeding, abnormal coagulation function, active infection, or severe cardiopulmonary reserve.

2.2. CT-guided CL

A chest interventional radiologist with 15 years of experience in CT-guided interventions conducted all procedures under a 16-slice CT device.

After the application of local anesthesia, an 18 G coaxial needle was used to puncture the lungs (Precisa, Roma, Italy). The tip of the needle was maintained near the nodule (within 1 cm), after which we inserted a 0.038 diameter coil which was 50 mm long (Cook, Bjaeverskov, Denmark) via the underlined needle into the lung parenchyma. The needle was then gradually removed while allowing the tail of the coil to remain detectable over the visceral pleura (Fig. 1).

Postoperative CT scanning was performed to evaluate patients for problems related to the procedure.

2.3. VATS-guided WR

VATS-guided WR was regularly conducted in 24 hours following CT-guided CL. The tail of the coil was visualized to guide the WR

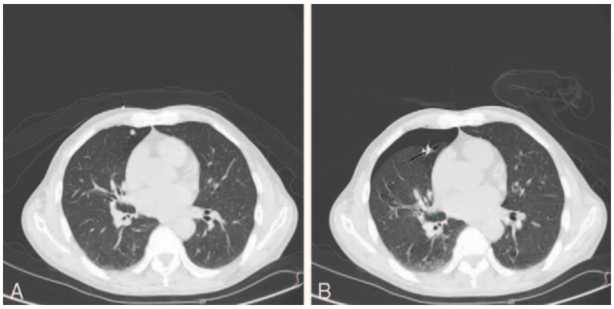

Figure 1. (A) The chest CT demonstrated the PN (metastasis) in the right middle lobe, and this patient previously underwent resection of melanoma. (B) The PN (short arrow) was localized by a coil (long arrow). CT = computed tomography, PN = pulmonary nodule.

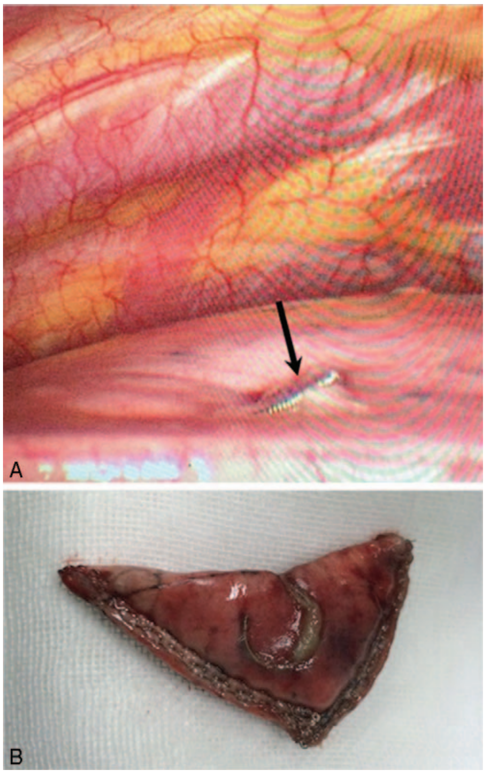

Figure 2. (A) The coil tail (arrow) was used to guide the VATS-guided WR. (B) The photo of the resected wedge pulmonary tissue. VATS = video-assisted thoracoscopic surgery, WR = wedge resection.

and the surgical area edge was 2 cm or more from the coil, as depicted in Figure 2. In those cases, where the coil was not observable, attempts were being made to locate it via palpation. When the underlined efforts were unsuccessful, lobectomy was performed as an alternative approach.

2.4. Definitions

A solid PN was defined as a PN which was presented as the soft-tissue density.[3] A ground-glass nodule (GGN) was defined as a PN which was presented as the hazy increased lung opacity.[4] A mixed GGN had a solid component within the ground-glass component.[3] The technical success of CT-guided CL was revealed as if the coil could be visualized during the VATS. WR was considered successful when the nodule of interest was detectable within the resected wedge of lung tissue. The duration of VATS procedure was calculated (Reviewer 2, Question 1). Disease-free survival was defined as the duration between VATS resection and the point when recurrence (including recurrence of PN or extra-pulmonary tumors) was detected or the patients' death. Overall survival was defined as the duration between VATS resection and the death of the patients.

2.5. Statistical analysis

All statistical testing was conducted with SPSS v16.0 (Inc., IL). Continuous variables were shown with mean ± standard deviation while categorical variables were represented as a percentage (number/total). Kaplan-Meier curves were employed to assess survival.

Table 1

Baseline data of the 16 patients.

	Age (yrs)/ gender	Tumor history	Interval between primary tumor and PN detection	Chemotherapy/ radiotherapy before VATS	Number of nodules	Nature	Diameter (mm)	Lesion-pleura distance (mm)
1	61/male	Renal cancer	48 mos	No	1	Solid	8	5
2	65/male	Lung cancer	11 mos	Yes	1	Solid	5	0
3	66/male	Melanoma	29 mos	No	1	Solid	5	3
4	64/male	Esophageal cancer	26 mos	No	1	Solid	4	4
5	76/male	Lung cancer	50 mos	Yes	1	Solid	8	19
6	65/female	Oral cancer	6 mos	Yes	1	mGGN	15	2
7	47/male	Lung cancer	36 mos	Yes	1	GGN	4	15
8	69/male	Lung cancer	23 mos	Yes	1	Solid	5	0
9	66/female	Lung cancer	35 mos	No	1	Solid	4	5
10	69/female	Breast cancer	9 mos	Yes	1	GGN	18	11
11	59/male	Lung cancer	19 mos	No	2	GGN, GGN	12, 15	2, 2
12	54/female	Lung cancer	25 mos	Yes	1	GGN	10	10
13	61/female	Lung cancer	30 mos	Yes	2	GGN, solid	6, 4	12, 4
14	52/female	Lung cancer	31 mos	Yes	3	GGN, GGN, GGN	4, 5, 7	0, 1, 0
15	50/male	Liver cancer	58 mos	No	2	GGN, solid	8, 10	2, 16
16	51/male	Lung cancer	9 mos	No	1	Solid	6	10

GGN = ground-glass nodule, mGGN = mixed ground-glass nodule, PN = pulmonary nodule, VATS = video-assisted thoracoscopic surgery.

3. Results

3.1. Baseline data

Baseline data for the 16 patients (6 females and 10 males) were shown in Table 1. The average age was 60.9 ± 8.1 years (in the range of 47–76 years). Twelve patients had 1 PN, 3 patients had 2 PNs, and 1 patient had 3 PNs. Ten (62.5%) of the 16 patients had lung cancer history. The remaining 6 patients had a history of renal carcinoma, melanoma, oral carcinoma, esophageal carcinoma, liver carcinoma, and breast carcinoma, respectively. The interval between primary tumor and PN detection was 27.8 ± 15.3 months (6–58 months). Eight patients underwent chemotherapy and 1 patient underwent radiotherapy before VATS resection, respectively.

A total of 21 PNs were localized (1.3 PNs per patient). The mean diameter and lesion-pleura distance of the 21 PNs were 7.8 ± 4.2 mm and 5.9 ± 5.9 mm, respectively. The 21 PNs contained 10 solid PNs, 10 GGNs, and 1 mixed GGN.

3.2. Localization procedures

The CT-guided CL had a 100% technical success rate. Each PN was localized with 1 coil. The mean time of CT-guided CL was 15.0 ± 3.8 minutes for each nodule. The mean time of CT-guided CL was comparable between the nodules with different lesion-pleura distance (<10 mm: 15.1 ± 4.2 minutes; ≥10 mm: 14.7 ± 3.3 minutes, $P = .846$).

Two (12.5%) and 2 (12.5%) patients experienced CL-related pneumothorax and hemoptysis, respectively (Table 2). These complications did not affect the subsequent VATS. However, the CL-related complications significantly prolonged the time of CT-guided CL (with CL-related complication: 20.0 ± 3.7 minutes; no CL-related complication: 13.8 ± 2.8 minutes, $P = .037$).

Table 2

Details of CT-guided localization and VATS procedures.

	Values
Technical success of localization	100%
Duration of CT-guided procedure for each nodule (min)	8–25 (Mean: 15.0 ± 3.8)
Pneumothorax	2 (12.5%)
Hemoptysis	2 (12.5%)

CT = computed tomography, VATS = video-assisted thoracoscopic surgery.

3.3. VATS procedures

The technical success rate of VATS-guided WR was 100% (Table 3). The mean time interval between the CL and VATS procedures was 8.4 ± 8.3 hours (range: 1–20.5 hours). No patient was converted to thoracotomy. The mean VATS procedure time and blood loss were 35.6 ± 25.9 minutes and 93.8 ± 64.4 mL, respectively. No VATS-related complication occurred. The final diagnoses of these 21 PNs were invasive adenocarcinoma (T1aN0M0, n = 8), adenocarcinoma in situ (n = 2), atypical adenomatous hyperplasia (n = 1), metastasis (n = 2), and benign (n = 8). All malignant nodules were “R0” resected. All of the

Table 3

Details of VATS procedures.

	Values
Technical success of wedge resection	100%
Types of surgery	
Wedge resection	14
Wedge resection + lobectomy	2
Duration of VATS procedure (min)	15–100 (Mean: 35.6 ± 25.9)
Blood loss (mL)	20–200 (Mean: 93.8 ± 64.4)
Final diagnoses	
Invasive adenocarcinoma (T1aN0M0)	8
AIS	2
Atypical adenomatous hyperplasia	1
Metastasis	2
Benign	8

AIS = adenocarcinoma in situ, VATS = video-assisted thoracoscopic surgery.

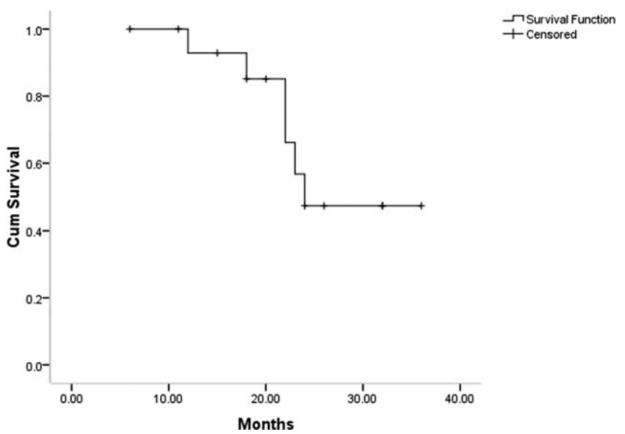

Figure 3. The patients' disease-free survival rates.

adenocarcinomas were well differentiated. The 8 benign nodules were inflammation (n=7) and lymph node (n=1).

Among the 8 patients with invasive adenocarcinoma, additional lobectomy was performed in 2 patients. The remaining 6 patients did not undergo lobectomy at this time because they had the history of lobectomy for lung cancer.

3.4. Follow-up

All patients were CT follow-up for 6 to 48 months. The follow-up protocol was 1, 3, 6, 12 months, and every 12 months after VATS. All patients were alive in the follow-up. Five patients suffered from the recurrence of PN and 1 patient experienced hilar lymph nodule metastasis. The cumulative 6-, 12, and 24-month disease-free survival rates were 100%, 92.9%, and 47.3%, accordingly (Fig. 3). The median disease-free survival was 27.9 months.

4. Discussion

This study showed the clinical value of CL assisted VATS-guided WR for PNs in patients with a malignant history. Exact the differentiation of benign and malignancy is essential for patients with incidental PNs.[15] However, for patients with malignant history, differentiation of primary and metastasis tumors is also important because the subsequent treatment options are different.[6]

CT-guided lung biopsy is a commonly used diagnostic strategy for PNs with an overall diagnostic accuracy >90%.[16–18] However, many patients with malignant history usually undergo anticancer treatment. Therefore, there may be much necrosis tissue in the PNs and it may cause diagnostic failure. Furthermore, the CT-guided biopsy technique for the small (<20 mm) PNs is also challenging.

VATS-guided WR is the standard criterion of diagnosis of the PNs.[9] In order to increase the success rate of WR, pre-operative CT-guided CL can decrease the need for thoracotomy or VATS anatomic resection when diagnosing PNs when compared to cases in which localization is not employed.[19] In this study, the technical success rate of CT-guided CL is 100%, which is consistent with previous studies regarding CL for PNs.[9,19] CL for PNs has several advantages. First, the coiled tail might be readily detected in VATS. Importantly, if the coil is accidentally fully inserted into the lung, it can still be readily palpated during the VATS procedure.[9] Furthermore, immediate surgery does not need to be conducted following coil insertion and localization.[9]

The mean time of CT-guided CL (15.0 ± 3.8 minutes) was comparable to that (14.3–15.7 minutes) in the previous studies regarding CT-guided CL for PNs.[9,13,14] We found that the time of CT-guided CL was not influenced by the lesion-pleura distance. In this study, the lesion-pleura distance was smaller than 2 cm in all PNs, the PNs within such lesion-pleura distance might have no significant difference in the lesion locations. Therefore, it was reasonable that lesion-pleura distance did not influence the time of CT-guided CL. The result that CL-related complications prolonged the time of CT-guided CL was reasonable.

The WR was successfully performed in all patients under the CL in this study. Only 2 patients underwent subsequent additional lobectomy due to invasive adenocarcinoma. These results indicated that CL assisted VATS-guided WR can preserve the patients' maximum pulmonary function. In this study, 10 of the 16 patients previously underwent resection of lung cancer, therefore, the WR demonstrated its biggest value in these patients.

The final diagnoses of the 21 PNs included 10 primary lung cancers. This result is attributed to the 11 PNs that were present with GGNs. However, there were only 2 (12.5%) metastatic PNs. This rate was lower than those (39.6%–62.8%) in previous studies regarding PNs in patients with a malignant history. This result is attributed to the limited size of this study.

The cumulative 6- and 12-month disease-free survival rates of 100% and 92.9% demonstrated that WR could provide an excellent short-term outcome for patients with PNs and malignant history.[6–8] However, the cumulative 24-month disease-free survival rate decreased to 47.3%. This result may indicate that tumor occurrence usually happened after 1 year. The median disease-free survival was 27.9 months, which was shorter than that (3.7 years) in a previous study.[6] This result may be attributed to the shorter follow-up period and limited sample size.

The present study has some shortcomings. First, a single-center retrospective analysis was carried out that is therefore susceptible to selection bias. Secondly, our sample size was limited, making it challenging to draw any definitive conclusions concerning this approach. Furthermore, we did not include a control group in these analyses, and as such future randomized controlled trials will be necessary to confirm our findings.

In conclusion, pre-operative CT-guided CL can be carefully and conveniently used to achieve a highly successful rate of VATS-guided WR for PNs in patients with a malignant history. Among the PNs in patients with malignant history, primary lung cancer also occupied approximately half of the PNs.

Author contributions

Data curation: Tao Wang, Wei Cao.
Formal analysis: Qing-Song Xu.
Methodology: Tao Wang, Wei Cao.
Supervision: Pan-Hao Rong.
Writing – original draft: Qing-Song Xu.
Writing – review & editing: Pan-Hao Rong.

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