Precise localization of small pulmonary nodules using Pre-VATS with Xper-CT in combination with real-time fluoroscopy-guided coil: report of 15 patients

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ABSTRACT

Purpose: This study aimed to evaluate the value of precise localization of nodules using pre-video-assisted thoracic surgery (VATS) Xper–CT in combination with real-time fluoroscopy-guided coil in the resection of pulmonary nodules using VATS.

Materials and Methods: Precise localization of nodules using Xper-CT in combination with real-time fluoroscopy-guided coil and wedge resection using VATS were conducted on 15 patients with 17 small pulmonary nodules (diameter 0.5–1.5 cm) from April 2015 to January 2016. The value of localization was evaluated in terms of procedure time, type of coils, associated complications of localization, and VATS success rate.

Results: The success rate of coil localization was found to be 100% in the primary stage (as shown by the CT scan), and the average procedure time was 30–45 min (35.6 ± 3.05 min). No deaths or major complications occurred. Minor complications included five incidents of pneumothorax (the morbidity was 29.4%, 5/17; no patient required chest tube drainage). The dislocation of coil was found in one patient. The results of pathological examination of 17 small pulmonary nodules revealed 11 primary lung cancers, 1 mesenchymal tumor, 3 nonspecific chronic inflammations, 1 hamartoma, and 1 tuberculosis. Two patients with primary lung cancer underwent lobectomy with mediastinal lymph node dissection.

Conclusion: The preoperative precise localization of small pulmonary nodules using Xper-CT-guided coil is an effective and safe technique. It helps in the resection of nodules using VATS. It increases the rate of lung wedge resection with few complications and allows for proper diagnosis with a low thoracotomy conversion rate.

Keywords: CT-guided coil localization; pulmonary nodule; video-assisted thoracic surgery

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Conflict of interest: The authors declare that they have no conflict of interest.

Funding: The study was supported by Shanghai Medical Image Institute.

Ethical approval: Not applicable.

Informed consent: Informed consent was obtained from all individual participants included in the study.

Journal of Interventional Medicine 2018;1(2): 102-105.

INTRODUCTION

With the widespread clinical use of computed tomography (CT), numerous small pulmonary nodules are frequently detected during lung cancer screenings or routine examinations for chronic diseases (1). Approximately 40%–50% of these nodules are malignant. Therefore, a rapid and precise histological diagnosis and treatment are necessary. Video-assisted thoracic surgery (VATS) is commonly used for definitive diagnosis and therapy because of low morbidity rate and short hospitalization (2). However, the intraoperative identification of deep nodules may be difficult using VATS because these nodules are difficult to be palpated or seen, especially deeply located small pulmonary nodules, ground-glass opacities (GGOs), and lesions localized in emphysematous lung or surrounded by dense pleural adhesions. Consequently, some surgeons have switched to thoracotomy from VATS (3, 4). Precise localization of nodules before performing VATS has become extremely important. Presently, the most commonly reported preoperative localization of small pulmonary nodules is CT-guided hook-wire positioning (4, 5). In the present study, 17 small pulmonary nodules in 15 patients who underwent VATS between April 2015 and January 2016 were retrospectively reviewed. The small pulmonary nodules were precisely localized using Xper-CT in combination with real-time fluoroscopy-guided coil on the day the VATS was performed, which yielded satisfactory results.

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MATERIALS AND METHODS

Patients

From April 2015 to January 2016, 17 pulmonary nodules from 15 patients (2 patients had 2 simultaneous nodules each) were localized using Cook coil (80–100 mm in length and 5–10 mm in diameter).

The study included seven males and eight females. The average age was 62.04 ± 10.60 years (range 40–77 years). The diagnosis was not confirmed pathologically in all nodules. The nodules included 6 solid nodules and 11 GGOs. All nodules were cases of thoracic surgery under VATS, which were difficult to locate.

The diameter of the nodules ranged from 5 to 15 mm (mean 9 ± 2.3 mm). Two cases of chest CT scan prompted two nodules in each patient; the rest were single nodules. Of the 17 nodules, 7 were in the right lung and 10 in the left lung. The distance from the outer margin of the nodule to the nearest pleural surface was 5–30 mm (mean 20 ± 6.5 mm).

Equipment

The study involved the following equipment: Philips Allura Xper FD20 digital subtraction angiography (DSA) machine (Fig. 1), 3D Work stations, and surface locator (SeeStar® Guiding Device, AprioMed Incorporated, Sweden ; Fig. 2).

Figure 1. Xper-CT digital subtraction angiography machine.

Figure 2. Surface locator: SeeStar.

Technology

Localization using Xper-CT in combination with real-time fluoroscopy-guided coil was performed on the day of VATS in the DSA room. A radiologist performed the procedure under local anesthesia. The patient was placed in the supine or prone position or laid on the side depending on the location of the nodule. The Xper-CT scan was performed. The target nodule was detected on the Xper-CT scan. Then, the puncture plan was made. The surface point nearest to the nodule was selected, and the path line was not blocked as the puncture point. The puncture path guide line could connect the puncture point to the nodule. Respiration training was conducted in advance. The patient was asked to breathe consistently, followed by the puncture.

SeeStar locators were placed in the patient's puncture point and adjusted so that the SeeStar axis coincided with the center hole. Combining the puncture path guide line and the real-time video fluoroscopy of the DSA, a 19-gauge coaxial needle (Cook Medical Incorporated，USA) was punctured into the position near the nodule through the SeeStar. The needle was aligned with the puncture guide line, along its direction or parallel to it. Once the needle tip was identified to be just in contact with the nodule, the stylet was removed from the needle. For localization, the coil was completely loaded in the needle and then introduced into the place just near the nodule by pushing down the wire. A coil of diameter 5–10 mm and length 50–100 mm was selected. The coil should be in the pulmonary parenchyma near the nodule and the coil formation should be good, and should not easily fall off. Additional Xper-CT images were routinely obtained to assess the position of the coil relative to the nodule and visceral pleural surface, and to identify any complications (Fig. 3. a–d). The patient was moved to the ward and then to the operating room for wedge resection using VATS.

Thoracoscopic surgery was performed 24 h after precise positioning. The surface of the visceral pleura was searched by eye, or palpated by finger if necessary, to detect the coil around the nodule so as to identify a generous margin for the thoracoscopic resection during VATS (Fig. 4). Most of the needle puncture sites on the visceral pleura were identified on the thoracoscopic view, and the inserted parenchymal coils were clearly visualized. The resected lung containing the coil was withdrawn into an endoscopic retrieval bag. The specimen was sent to the pathologist for frozen-section pathological examination. The next step in the treatment program was decided based on the pathology results. If the nodule was determined to be a benign or completely resected metastatic nodule, the operation was completed. If the nodule was a non-small-cell lung cancer that was surgically resectable, a lobectomy with mediastinal lymph node dissection was performed.

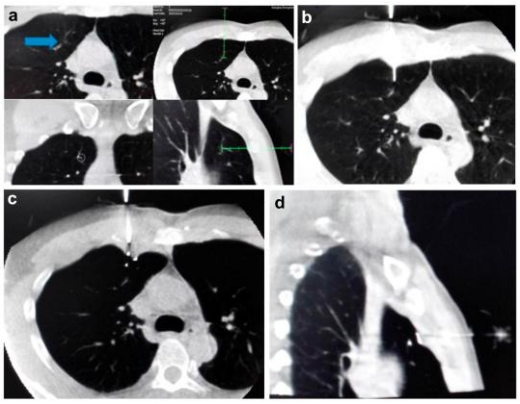

Figure 3. a: GGO in the right upper lung and the planning line. b: Needle tip near the GGO. c: Coil in CT scan. d: coil in CT scan.

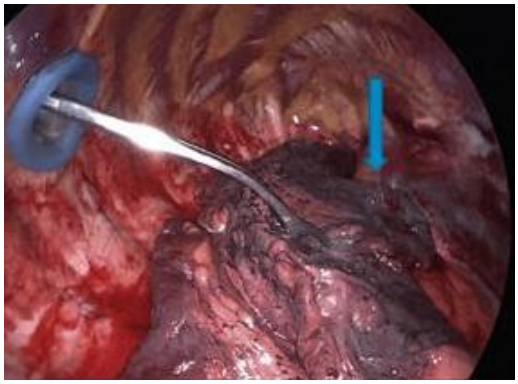

Figure 4. The coil can be easily seen under the VATS.

Statistical analysis

All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS) software (version 12.0).

RESULTS

All patients underwent localization of nodules using Xper-CT in combination with real-time fluoroscopy-guided coil and wedge resection using VATS. The success rate of coil localization was 100% in the primary stage (as shown in the CT scan), and the average procedure time was 30–45 min (35.6 ± 3.05 min). No deaths or major complications occurred. Venous air embolism is a life-threatening complication occasionally reported after the puncture. However, this complication was not observed previously. Minor complications related to localization using Xper-CT in combination with real-time fluoroscopy-guided coil included five incidents of pneumothorax (the morbidity was 29.4%, 5/17; no patient required chest tube drainage). The dislocation of the coil was found in one patient. However, VATS resection was successfully accomplished in the patient by locating the needle puncture sites on the visceral pleura, lung puncture site, and some parenchymal hemorrhage. The final success rate of the localization technique was 94.12% (16/17). The subcutaneous emphysema was found in 1 patient (occurrence rate 5.9%; no patient needed clinical treatment). Resections of nodules guided by the coil were successfully performed using VATS (success rate 100%). No unplanned conversion thoracotomy occurred. The procedure time for VATS wedge resection was 20–45 min. The results of pathological examination of 17 small pulmonary nodules revealed 11 primary lung cancers, 1 mesenchymal tumor, 3 nonspecific chronic inflammations, 1 hamartoma, and 1 tuberculosis. Two patients with primary lung cancer underwent lobectomy with mediastinal lymph node dissection.

DISCUSSION

VATS has become a useful tool for the diagnosis and treatment of indeterminate pulmonary nodules, especially small pulmonary nodules. It is a faster, effective, and minimally invasive method for the diagnosis and treatment of small pulmonary nodules. One important element that can affect the quality of VATS is locating the nodule quickly and accurately. However, identification of deep nodules may be difficult using VATS because the nodules, especially deeply located small pulmonary nodules, are difficult to be palpated or seen during VATS (2, 3). Without the precise localization before VATS, the thoracic surgeon had to locate the nodule by preoperative CT scan or palpate the nodule by finger. Although most of the nodules could be found and removed, still some nodules could not be found due to the changes in nodule location caused by intraoperative atelectasis and few nodules could not be distinguished from the surrounding lung tissue in terms of color, density, and hardness. Hence, conversion thoracotomy could not be avoided (3).

Since the 1990s, a variety of methods have been devised, such as CT-guided insertion of the localizer to mark lung nodules for easier identification of small nodules and help guide resection. Pleural marking with methylene blue dye injection, cyanoacrylate adhesive injection, hook-wire localization system, and coil localization system facilitated precise localization of small pulmonary nodules before VATS (6).

Preoperative methylene blue injection works well for nodules close to the pleura, but if the distance between the nodules and the visceral pleura is more than 1.5 cm, locating the nodules using this method is difficult. Methylene blue injection carries the risk of spreading the colorant on the pleural surface. Identification of the nodules in patients with extensive anthracotic pigments is difficult because of the patients' respiratory motion. This situation also occurred when the patients were old or smoked a lot because the color of their lung surface was too dark to identify any nodules. This technique is associated with a failure rate of 13% (7, 8).

Cyanoacrylate adhesives have a certain smell. If the

injection speed is too fast, the odor may cause coughing. Also, cyanoacrylate adhesive injection leads to pulmonary artery embolism (9).

The hook-wire technique showed a varied success rate ranging from 58% to 97.6% in various series with relatively higher failure rate due to unhooking reaching up to 47%. Because of the sharp barbed hook needle, unhooking can occur often during pulling back of the wire, especially near the pleural nodule. Unhooking can also cause hemothorax and pneumothorax, even air embolism (1). The patient should undergo VATS as soon as possible to avoid unhooking. Sometimes if the wire is cut off and remains in the body, conversion thoracotomy cannot be avoided (10). Sometimes the nodule is close enough to the pleura for the wire to hook onto; therefore, methylene blue is used in combination, leading to wastage of time.

The coils placement is similar. The small nodules can be resected precisely because of coil placement guided by preoperative Xper-CT in combination with real-time fluoroscopic guidance. The coil is a spiral steel wire; it can take a circular shape. Consequently, dislodgement because of respiratory movement or surgical procedure can be avoided. In the present study, 94.1% of patients had successful localization. At the same time, the metal material can be easily discovered during VATS, so the resection range is ensured.

The preoperative precise localization of small pulmonary nodules using Xper-CT-guided coil is an effective and safe technique. It helps in the resection of nodules using VATS. It increases the rate of lung wedge resection with few complications and allows for proper diagnosis with a low thoracotomy conversion rate.

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