JBUON 2019; 24(1): 267-272
ISSN: 1107-0625, online ISSN: 2241-6293 • www.jbuon.com
E-mail: editorial_office@jbuon.com

ORIGINAL ARTICLE

Percutaneous computed tomography-guided localization of pulmonary nodules with hook wire prior to video-assisted thoracoscopic surgery

Stamo Manouvelou[1]*, Eftychia Mosa[1]*, Maria Tolia[2], Nikolaos Tsoukalas[3], Michail Nikolaou[4], Georgios Nikolaou[5], Apostolos Dountsis[6], Efthymios Andriotis[1], Konstantinos Vasilikos[6], George Kyrgias[2]

[1]Radiology Department, St. Savvas Anticancer Hospital of Athens, Athens, Greece; [2]University of Thessaly, School of Health Sciences, Faculty of Medicine, Department of Radiotherapy, Biopolis, Larissa, Greece; [3]2nd Department of Medical Oncology, St. Savvas Anticancer Hospital of Athens, Greece; [4]Oncology Clinic, Hippokration University Hospital of Athens, Athens, Greece; [5]2nd Department of Surgery,General Hospital of Nikaia 'Agios Panteleimon',Nikaia,Piraeus,Greece; [6]Department of Thoracic Surgery, St. Savvas Anticancer Hospital of Athens, Athens, Greece.

*These authors contributed equally to this study.

Summary

Purpose: *To evaluate the use of percutaneous computed tomography (CT)-guided localization of suspicious intrapulmonary nodules with hook wire prior to video-assisted thoracoscopic surgery (VATS).*

Methods: *From April 2010 to February 2011, 15 patients with suspicious subpleural pulmonary nodules underwent preoperative CT-guided hook wire localization of the lesions, prior to VATS.*

Results: *Histological analysis of the resected suspicious pulmonary nodules revealed malignancy in 12 cases, 2 cases with granulomas and 1 case with bronchiolitis obliterans organizing pneumonia (BOOP). Better results were achieved with the double-thorn hook wire. Conversion to thoracotomy was necessary in the patient with BOOP, due to limited hemorrhage at the site of the lesion.*

Conclusion: *Preoperative CT-guided nodule localization using hook wire fixation is a useful and safe technique that helps in the precise localization of suspicious lesions, reduces the operation time, the postoperative complications, and the hospitalization.*

Key words: *CT-guided, hook-wire localization, nodule, VATS*

Introduction

Video-assisted thoracoscopic surgery (VATS) is a development in the field of thoracic surgery [1-3]. It plays an important role in the diagnosis and treatment of pleural and pulmonary lesions. In the last decade it has been used in the management of patients with a single nodular lesion. This is due to the fact that VATS is a minimally invasive procedure with little postoperative complications. Compared to conventional thoracotomy, VATS has lower morbidity rates and is more cost-effective since it decreases hospitalization. Furthermore, if the frozen biopsy reveals primary cancer and patient's performance status allows the intervention, this method offers the possibility of a direct lobectomy and lymph node dissection.

Resection of the suspected lesion with the VATS method offers safer results compared to percutaneous FNA. Up to 29% of the patients who had

Correspondence to: Maria Tolia, MD, PhD. University of Thessaly, School of Health Sciences, Faculty of Medicine, Department of Radiotherapy, Biopolis, Larissa 411 10, Greece.
Tel: +30 2413502055, +30 2413502054, E-mail: mariatolia@med.uth.gr
Received: 29/10/2018; Accepted: 17/11/2018

underwent FNA of a pulmonary nodule and whose condition was not diagnosed as malignant, were ultimately found to have carcinoma [4]. Since VATS can be performed with minimal patient discomfort, it can become a method of choice. Usually, the localization of the lesion is performed directly via monitor and/or palpation by the thoracic surgeons. The discoloration and the folds of the surface of the pleura, which are created by the presence of the mass, can lead the surgeon to the location of the lesion. If the nodule cannot be identified visually, the surgeon may use palpation.

The indication of a preoperative hook wire nodule localization is when the lesion is not located near the surface of the pleura, and/or it has very small dimensions to be palpated. The diameter of the nodule must not exceed 1cm [5]. However, nodules greater than 1 cm with ground glass opacity can also be selected for this method. Additionally, the distance from the nearest pleural surface has to be more than 1cm [5]. The evaluation of the patients who will finally undergo this procedure is usually decided by the thoracic surgeons.

Complications of preoperative CT guided nodule localization using hook wire fixation are not of major significance. Minor non-symptomatic pneumothorax can occur. This usually does not require any intervention. A mainly limited local hemorrhage may follow the procedure. Furthermore, the patient may complain about pain during or after the hook wire nodule localization.

The main aim of the present study was to evaluate the use of percutaneous CT-guided localization of suspicious intrapulmonary nodules with hook wire prior to VATS.

Methods

The indications for needle localization included the following: small nodules inaccessible to fine needle aspiration biopsy (FNAB) because of subcostal or paracardiac location; nodules previously non-diagnostic with FNA; and planned resection of a known small peripheral tumor. All patients had had prior chest CT according to routine protocol and a coagulative profile. They were informed about the procedure and they all had to sign a consent form before the intervention. The pre-hook wire localization CT scan was studied in order to evaluate the shortest and most direct intercostal approach of the nodule.

According to their shape, two types of hooks were used, that of double thorn and that of a Kopan type. The targeting lesion was confirmed by obtaining a transverse CT scan with 5 mm collimation. Each patient was placed on the CT table in such a position as to allow the shortest possible direct access route for hook wire placement. There were instructed not to talk, cough, or move. After antisepsis of the area of interest and administration of a local anesthetic, we inserted the tip of the cannula to at least 1cm beneath the pleural surface. Only after optimal placement of the cannula tip was confirmed with CT scanning, was the pusher fully advanced to eject the hook wire. When the Kopan type hookwire was used, it was advanced within 0-2 cm of the lesion so as not to injure the pathologic specimen of the lesion. When the double thorn hook wire was used, the edge passed through the nodule and captivated the lesion. Once the hook wire was just free from the cannula, the introducer system was carefully withdrawn. The site of incision was covered with sterile gauze. A CT scan was obtained to confirm that the hook wire was placed in the planned position. Following this procedure, the patients were transferred to the surgical room for thoracoscopic resection. An Institutional Review Board approval and informed consent from all patients were obtained.

Results

From April 2010 to February 2011, 15 patients with suspicious subpleural pulmonary nodules underwent preoperative CT-guided hook wire localization of the lesions, prior to VATS. The patient age ranged from 45 to 72 years. All patients were active or passive smokers. Eight of the patients had a known prior history of cancer. The diameter of the lesions ranged from 1 to 3 cm and their distance from the nearest pleural surface ranged from 3 to 5 cm. The location of the nodules (Table 1) included the right upper lobe (n=7), the right middle lobe (n=1), the right lower lobe (n=4) and the left lower lobe (n=3). The lesions were small nodules inaccessible to FNAB (n=5); nodules previously nondiagnostic with FNA (n=8); and planned resection of a small peripheral tumor (n=2). The selected route included posterior (n=7), posterolateral (n=3), anterior (n=4) and anterolateral (n=1) approach (Figure 1).

The placement of the hook was successful in all patients. The mean time needed to position the hook was 10 min (Figures 2-4). No major complications were experienced. No patient complained for severe pain during or after the intervention. Histological analysis of the resected suspicious pulmonary nodules (Table 2) revealed malignancy in 12 cases, 2 cases with granulomas and 1 case

Table 1. Location of the nodules in the lung parenchyma

Location of the lesions	*n (%)*
Right upper lobe	7 (46.6)
Right middle lobe	1 (6.7)
Right lower lobe	4 (26.7)
Left upper lobe	3 (20)

with *bronchiolitis obliterans organizing pneumonia (BOOP)* (Figures 5 and 6). From the nodules that were proved to be malignant, seven were adenocarcinomas, one was squamous cell carcinoma and four were metastatic. The metastatic lesions were in concordance with the clinical history of the patient, thus two nodules derived from breast cancer, one from colon and one from bladder carcinoma. Regarding the characteristics of the nodules, solid appearance was present in all cases except one that showed ground glass opacity. That particular case was diagnosed as BOOP. Better results were achieved with the double-thorn hook wire, as dislocation occurred once when the Kopan type hook wire was used. Conversion to thoracotomy was necessary in that case, due to limited hemorrhage at the site of the lesion. Later on, the histopathological analysis revealed BOOP. Dislocation occurred once, in the surgeon's effort to bring the lesion near the chest wall, in order to resect it. The site of the lesion was identified by the small hemorrhage and the incision present at the surface of the lung.

Postoperatively, minor asymptomatic pneumothorax occurred in two cases, with no necessary treatment needed and a patient with local pain and bradycardia that was treated conservatively. Overall, the mean time of hospitalization was reduced from 7 days when conventional thoracotomy was performed, to 1 day with VATS.

Discussion

VATS is an excellent procedure for diagnosis and treatment of peripheral pulmonary nodules. It is a procedure that permits to perform biopsies of the thoracic cavity without the need of a thoracotomy. Nodules of small dimension or of distant location from the pleural surface are not visible during thoracoscopic surgery. In this case localization is indicated. There are three different types

Figure 1. A CT scan is done before positioning the hook wire in order to evaluate the shortest route to access the nodule. Histological analysis revealed metastasis from primary carcinoma of the colon.

Table 2. Histopathologic findings of resected nodules

Histopathologic findings of the lesions	*n (%)*
Malignancies	12 (85.7)
Adenocarcinoma	7 (46.7)
Squamous cell carcinoma	1 (6.7)
Metastasis	4 (26.6)
Breast	2 (13.3)
Colon	1 (6.7)
Bladder	1 (6.7)
Benign lesions	3 (20)
Granulomas	2 (13.3)
Bronciolitis obliterans organizing pneumonia	1 (6.7)

Figure 2, 3, 4. After CT-guided hook-wire localization of the lesion, the patients were immediately transferred to the operation room and VATS were performed.

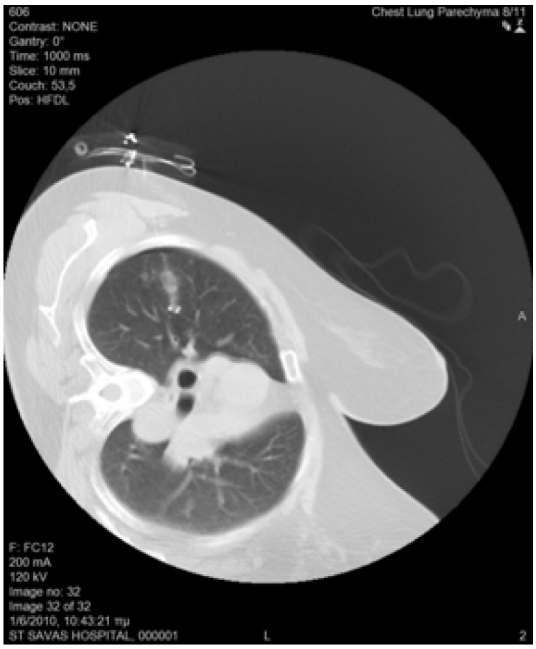

Figure 5. Hook wire localization of a ground glass nodule.

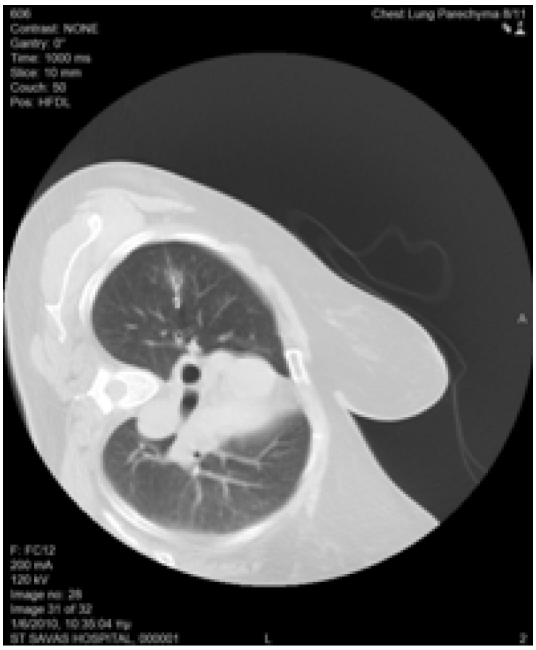

Figure 6. A minor pneumothorax after hook wire localization of the previous ground glass nodule (Figure 5). Histology revealed a bronchiolitis obliterans organizing pneumonia (BOOP).

of localization. The first type is localization with imaging modalities during thoracoscopy. This includes intraoperative ultrasonography [6] and CT fluoroscopy [7]. The second type is preoperative localization with injection of dyes [8], contrast media [9], radionuclides [10] or colored adhesive agents [11]. The third type is preoperative localization with hook wire fixation [1,12-17]. The latter two types of preoperative localization usually are performed with CT guidance. Hook wire localization is probably the oldest and the most commonly used.

In the Dendo et al. study [5], the surgeon's requirement for localization with this technique was that the diameter was less than 10mm and/or the distance from the pleural surface was more than 10mm. Lesions with a diameter of more than 10mm but with a ground glass appearance can also be an indication for hook wire localization. VATS is being performed more often in lesions with ground glass opacity, as shown on thin-section CT scans that cannot be palpated easily during thoracoscopy. These lesions are often a typical adenomatous hyperplasia, or primary adenocarcinoma, including bronchioloalveolar carcinoma [18,19]. Whenever they are proved to be primary lung malignancy by means of intraoperative frozen pathologic examination, lobectomy with lymph node dissection also can be performed with VATS [20]. The wider the application of VATS for pulmonary lesions becomes, the more preoperative localization will be needed [5]. The necessity for preoperative localization will probably not decrease. Suzuki et al [12] revealed that preoperative localization of small pulmonary lesions should be considered when the distance to the nearest pleural surface is more than 5mm in cases of lesions of 10mm. The contraindications consist of the absence of patient's collaboration, the incapacity to maintain apnea during the intervention and coagulation disorders. As a modality, hook wire localization may lead to some minor complications, such as pneumothorax, limited hemorrhage at the site of incision and nerve injury. The incidence of pneumothorax or hemorrhage in the lung is not any higher than that in other reports of localization or CT-guided needle biopsy [3,21]. Wire dislodgement and pain during or after the procedure are probable [14,16]. According to Mullan et al. [17] a wire generally dislodged at one of three times during: transportation of the patient to the surgical room, during surgical deflation of the lung, or during resection, when the surgeon will often apply gentle retraction on the wire. Shallowness of insertion is the most common cause of hook wire dislodgement.

Jeon et al. showed that in stage I NSCLC patients with chronic obstructive pulmonary disease (COPD), VATS lobectomy was associated with a lower incidence of pulmonary complications vs. lobectomy by thoracotomy. In a total of 283 patients, 160 underwent VATS lobectomy and 123 underwent thoracotomy/lobectomy. Patients following VATS had shorter operation time (165 vs 201 min;$p<0.01$), shorter length of stay (6.0 vs 9.0

days;p=0.04) and less pulmonary complications (1.1 vs 12.1%; p<0.01) [22].

Mun et al. performed VATS segmentectomy in frail, older NSCLC cases, with poor pulmonary function and with severe comorbidities [23].

Perhaps the technique of single-incision VATS can create less postoperative chest pain [24,25].

Bendixen et al. [25] in a randomised controlled trial investigated the postoperative pain and quality of life in early stage lung cancer after lobectomy via four-port VATS or anterolateral thoracotomy. The authors compared 102 patients in the VATS group and 99 in the thoracotomy group. In stage I, NSCLC patients, VATS was associated with less postoperative pain during the first 24 hrs (VATS 38%, 95% CI 0.28-0.48 vs thoracotomy 63%, 95% CI 0.52-0.72, p=0.0012) and during 52 weeks of follow-up (p<0.0001). A better quality of life was found for the VATS for the first postoperative year (p=0.014) [25].

Al-Ameri M et al. compared VATS lobectomy to open thoracotomy lobectomy in early stage NSCLC patients. The authors evaluated long-term overall survival and postoperative complications as the 30- and 90-day mortality. 1,601 patients underwent open (n=1,316) and VATS (n=285) lobectomy. Following VATS lobectomy compared to open thoracotomy lobectomy, they found less postoperative complications (83% vs. 86%, p=0.41) and better overall survival at 1 and 5 years [92% vs. 97% and 63% vs. 78%; HR (95% CI): 0.47 (0.33-0.68)] [26].

VATS represents a minimally invasive, safe and oncologically efficient procedure [27-29]. In the cases of a) suspicious pulmonary nodules [30] previously localized by a CT-guided hook wire system and b) early-stage lung NSCLC. VATS offers several advantages over traditional open thoracotomy [28].

VATS is related to a low conversion thoracotomy rate, a short operation time, and few postoperative complications, and it is well suited for the clarification of pulmonary nodules of unknown etiology.

Conflict of interests

The authors declare no conflict of interests.

References

1. Mack MJ, Aronoff RJ, Acuff TE, Douthit MB, Bowman RT, Ryan WH. Present role of thoracoscopy in the diagnosis and treatment of diseases of the chest. Ann Thorac Surg 1992;54:403-8.
2. Miller DL, Allen MS, Trastek VF, Deschamps C, Pairolero PC. Videothoracoscopic wedge excision of the lung. Ann Thorac Surg 1992; 54:410-3.
3. Kaiser LR, Shrager JB. Video-assisted thoracic surgery, the current state of the art. AJR Am J Roentgenol 1995;165:1111-7.
4. Calhoun P, Feldman PS, Armstrong P et al. The clinical outcome of needle aspirations of the lung when cancer is not diagnosed. Ann Thorac Surg 1986;41:592-6.
5. Dendo S, Kanazawa S, Ando A et al. Preoperative localization of small pulmonary lesions with a short hook wire and suture system: experience with 168 procedures. Radiology 2002;225:511-8.
6. Greenfield AL, Steiner RM, Liu JB et al. Sonographic guidance for the localization of peripheral pulmonary nodules during thoracoscopy. AJR Am J Roentgenol 1997;168:1057-60.
7. Akamatsu H, Sunamori M, Katsuo K. Thoracoscopic lung resection for extremely small nodular lesions using simultaneous intraoperative real-time computed tomography. Thorac Cardiovasc Surg 2000;48:34-5.
8. Lenglinger FX, Schwarz CD, Artmann W. Localization of pulmonary nodules before thoracoscopic surgery: value of percutaneous staining with methylene blue. AJR Am J Roentgenol 1994;163:297-300.
9. Choi BG, Kim HH, Kim BS, Kim KT, Shinn KS, Moon SW. Pulmonary nodules: CT-guided contrast material localization for thoracoscopic resection. Radiology 1998;208:399-401.
10. Chella A, Lucchi M, Ambrogi MC et al. A pilot study of the role of TC-99 radionuclide in localization of pulmonary nodular lesions for thoracoscopic resection. Eur J Cardiothorac Surg 2000;18:17-21.
11. Horio H, Nomori H. Thoracoscopic wedge resection of small pulmonary nodules: evaluation of endofinger and colored collagen injection techniques for localization of pulmonary nodules. Nippon Kyobu Geka Gakkai Zasshi 1996;44:1059-64.
12. Suzuki K, Nagai K, Yoshida J et al. Video-assisted thoracoscopic surgery for small indeterminate pulmonary nodules: indications for preoperative marking. Chest 1999;115:563-8.
13. Thaete FL, Peterson MS, Plunkett MB, Ferson PF, Keenan RJ, Landreneau RJ. Computed tomography guided wire localization of pulmonary lesions before thoracoscopic resection: results in 101 cases. J Thorac Imaging 1999;14:90-8.
14. Plunkett MB, Peterson MS, Landreneau RJ, Ferson PF, Posner MC. Peripheral pulmonary nodules: preoperative percutaneous needle localization with CT guidance. Radiology 1992;185:274-6.
15. Shah RM, Spirn PW, Salazar AM et al. Localization of peripheral pulmonary nodules for thoracoscopic excision: value of CT-guided wire placement. AJR Am J Roentgenol 1993;161:279-83.

16. Templeton PA, Krasna M. Localization of pulmonary nodules for thoracoscopic resection: use of needle/wire breast-biopsy system. AJR Am J Roentgenol 1993;160:761-2.
17. Mullan BF, Stanford W, Barnhart W, Galvin JR. Lung nodules: improved wire for CT-guided localization. Radiology 1999;211:561-5.
18. Noguchi M, Morikawa A, Kawasaki M et al. Small adenocarcinoma of the lung. Cancer 1995;75:2844-52.
19. Kuriyama K, Seto M, Kasugai T et al. Ground-glass opacity on thin-section CT: value in differentiating subtypes of adenocarcinoma of the lung. AJR Am J Roentgenol 1999;173:465-9.
20. McKenna RJ Jr, Wolf RK, Brenner M, Fischel RJ, Wurnig P. Is lobectomy by video assisted thoracic surgery an adequate cancer operation? Ann Thorac Surg 1998;66:1903-8.
21. Collings CL, Westcott JL, Banson NL, Lange RC. Pneumothorax and dependent versus nondependent patient position after needle biopsy of the lung. Radiology 1999;210:59-64.
22. Jeon JH, Kang CH, Kim HS et al. Video-assisted thoracoscopic lobectomy in non-small-cell lung cancer patients with chronic obstructive pulmonary disease is associated with lower pulmonary complications than open lobectomy: a propensity score-matched analysis. Eur J Cardiothorac Surg 2014;45:640-5.
23. Mun M, Nakao M, Matsuura Y, Ichinose J, Nakagawa K, Okumura S. Novel techniques for video-assisted thoracoscopic surgery segmentectomy. J Thorac Dis 2018; 10(Suppl 14):1671-6.
24. Migliore M. Video-assisted thoracic surgery techniques for lung cancer: which is better? Future Oncol 2016;12(23s):1-4.
25. Bendixen M, Jørgensen OD, Kronborg C, Andersen C, Licht PB. Postoperative pain and quality of life after lobectomy via video-assisted thoracoscopic surgery or anterolateral thoracotomy for early stage lung cancer: a randomised controlled trial. Lancet Oncol 2016;17:836-44.
26. Al-Ameri M, Bergman P, Franco-Cereceda A, Sartipy U. Video-assisted thoracoscopic versus open thoracotomy lobectomy: a Swedish nationwide cohort study. J Thorac Dis 2018;10:3499-506.
27. Baltayiannis N, Anagnostopoulos C, Bolanos N, Tsourelis L. Thoracoscopy, bronchoscopy and mediastinoscopy in the staging of lung cancer. JBUON 2002;7:141-4.
28. Vannucci F, Gonzalez-Rivas D. Is VATS lobectomy standard of care for operable non-small cell lung cancer? Lung Cancer 2016;100:114-9.
29. Jing X, Lin Y, Zhang B, Zhang G. Video-assisted thoracoscopic lobectomy mitigates adverse oncological effects of delayed adjuvant chemotherapy for nonsmall cell lung cancer patients. JBUON 2016;21:1524-9.
30. Uchikov A, Djambazov K, Uchikova E. Video assisted thoracoscopic surgery in patients with small peripheral pulmonary tumors. JBUON 2003;8:273-5.