Computed tomography-guided patent blue vital dye localization of pulmonary nodules in uniportal thoracoscopy

Mong-Wei Lin, MD, PhD,[a] Yao-Hui Tseng, MD,[b] Yee-Fan Lee, MD,[b] Min-Shu Hsieh, MD,[c] Wei-Chun Ko, MD,[b] Jo-Yu Chen, MD,[b] Hsao-Hsun Hsu, MD, PhD,[a] Yeun-Chung Chang, MD, PhD,[b] and Jin-Shing Chen, MD, PhD[a]

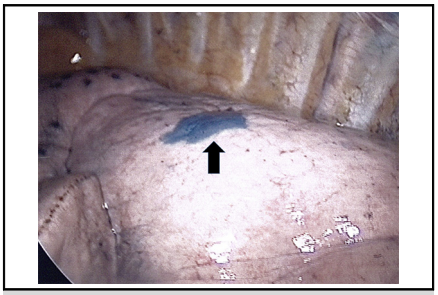
ABSTRACT

Objective: Due to the limitations of the small single incision, an ideal preoperative localization technique is essential for surgical resection of small pulmonary nodules by uniportal video-assisted thoracoscopic surgery (VATS). The aim of this study is to evaluate the usefulness and safety of preoperative computed tomography (CT)-guided patent blue vital (PBV) dye localization in patients with small indeterminate pulmonary nodules who have undergone uniportal VATS for lung resection.

Methods: In this retrospective study, 177 consecutive patients (196 pulmonary nodules) who underwent preoperative CT-guided PBV dye localization and uniportal VATS from January 2013 to September 2015 were enrolled.

Results: The CT-dye localization procedure was performed successfully and correctly for 99.5% (195/196) of the nodules within a mean procedure time of 30 minutes. The mean size of the nodules was 7.8 mm, and their mean depth from the pleural surface was 18.3 mm. Most of the nodules (78.6%, 154/196) were pure ground-glass nodules (GGNs) and part-solid GGN with ground-glass opacity (GGO) of 50% or more. Asymptomatic pneumothorax occurred in 29.4% (52/177) of patients after the localization procedure, but none required invasive treatment. All nodules were successfully resected using uniportal VATS without any conversion to thoracotomy. The postoperative course was smooth, with a short mean hospital stay (3.3 ± 1.2 days) and a low morbidity rate (0.6%, 1/177).

Conclusions: Preoperative CT-guided PBV dye localization is a feasible, safe, and accurate procedure. It makes uniportal VATS easy for small, poorly located pulmonary nodules with GGO predominance and synchronous multiple nodules. (J Thorac Cardiovasc Surg 2016;■:1-10)



Thoracoscopic view of the indeterminate lung nodule localized by CT-guided PBV dye.

Central Message

CT-guided PBV dye localization for uniportal VATS is safe and feasible, and results in a short hospital stay and low morbidity rate.

Perspective

Preoperative CT-guided patent blue vital dye localization is a feasible, safe, and accurate procedure. It makes uniportal video-assisted thoracoscopic surgery easy for small, poorly located nodules, those with ground-glass opacity, and synchronous multiple nodules, and results in a smooth postoperative course with a short hospital stay (3.3 ± 1.2 days) and low morbidity rate (0.6%, 1/177).

THOR

Advances in high-resolution computed tomography (CT) imaging and the availability of low-dose CT screening for lung cancer detection in asymptomatic patients are increasing the detection rate for small pulmonary nodules in the peripheral lung parenchyma.[1,2] Most of these CT-detected pulmonary nodules are indeterminate, including lesions characteristic of pure ground-glass nodules

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From the Departments of [a]Surgery, [b]Medical Imaging, and [c]Pathology, National Taiwan University Hospital and National Taiwan University College of Medicine, Taipei, Taiwan.

Y.-C. Chang and H.-H. Hsu contributed equally to this work.

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Address for reprints: Yeun-Chung Chang, MD, PhD, Department of Medical Imaging, National Taiwan University Hospital and National Taiwan University College of Medicine, No. 7, Chung-Shan South Rd, Taipei 10002, Taiwan (E-mail: ycc5566@ntu.edu.tw). Or: Hsao-Hsun Hsu, MD, PhD, Department of Surgery, National Taiwan University Hospital and National Taiwan University College of Medicine, No. 7, Chung-Shan South Rd, Taipei 10002, Taiwan (E-mail: ntuhsu@gmail.com).

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Abbreviations and Acronyms

CT = computed tomography
GGN = ground-glass nodule
GGO = ground-glass opacity
ICU = intensive care unit
PBV dye = patent blue vital dye
VATS = video-assisted thoracoscopic surgery

(GGNs), part-solid GGNs, and pure solid nodules.[1,2] A histopathologic diagnosis is required, especially when the nodule persists and has a solid component ≥5 mm, or the nodule has enlarged on follow-up CT scans.[3]

The accurate early diagnosis of these nodules is challenging. Performing CT-guided percutaneous biopsy of these indeterminate nodules is often difficult when the nodule size is 2 cm or less, has predominantly ground-glass opacity (GGO), or is located in a site that is difficult to reach.[4,5] Surgical open-lung biopsy used to be the gold-standard diagnostic modality, both for curative resection and diagnostic procedures. However, with the advances in video-assisted thoracoscopic surgery (VATS) in the 1990s, lung biopsies are increasingly done by VATS because of shorter hospital stays, less tissue injury, and better cosmetic results.[6,7]

Recently, uniportal VATS for major lung resections has been used in the treatment of lung tumors.[8,9] Gonzalez-Rivas and colleagues[8] reported the first uniportal VATS lobectomy in 2011. Since then, more complicated procedures including segmentectomy, pneumonectomy, and sleeve resection have been reported.[9] The procedure is done through only one 3- to 4-cm incision.[9] In cases of complicated anatomic lung resection, it may be more difficult to resect a small or deeply located pulmonary nodule with a predominantly GGO component by uniportal VATS. This is because the nodule may be thoracoscopically invisible and impalpable with uniportal VATS. Therefore, preoperative localization of these nodules is mandatory for successful uniportal VATS lung resection.

Various localization techniques for traditional 3-port VATS for pulmonary nodule resections have been reported. These techniques include intraoperative digital palpation of nodules elevated by thoracoscopic instruments, intraoperative ultrasonographic localization, and preoperative localization with CT-guided methods.[10-27] With uniportal VATS, intraoperative digital palpation and intraoperative ultrasonography are difficult to perform via a small 3- to 4-cm incision. Thus, preoperative localization is essential. There are several preoperative CT-guided methods for localization using various materials.[10-27] Each method has its advantages and disadvantages. CT-guided hookwire localization has been widely used because of its safety and efficacy.[15-18] However, the major drawback is frequent dislodgment of the hookwire from its perinodular location.[15-18] The hookwire may dislodge when lung atelectasis occurs as part of the biopsy process as well as when 1 lung ventilates during the operation. In the era of uniportal VATS, dislodgement sometimes occurred during lung manipulation because of the limitations of a single incision and simultaneous use of multiple thoracoscopic instruments. Therefore, CT-guided hookwire localization is not ideal for use with uniportal VATS.

In our institute, we routinely used CT-guided hookwire localization for indeterminate small pulmonary nodules before starting uniportal VATS, and then we shifted to CT-guided PBV dye localization when we began to perform uniportal VATS in 2013. The efficacy and safety of CT-guided PBV dye localization with uniportal VATS has not been reported previously. Thus, we conducted this retrospective study to evaluate the usefulness and safety of preoperative CT-guided PBV dye localization of 196 small, indeterminate pulmonary nodules in 177 patients who underwent uniportal VATS lung resection.

MATERIALS AND METHODS

Patients

The medical records of 1075 consecutive patients who underwent thoracoscopic surgery for pulmonary resection by a single thoracic surgical team using the same clinical protocols, care patterns, and perioperative orders at National Taiwan University Hospital from January 2013 to September 2015 were reviewed retrospectively. Of these, preoperative CT-guided dye localization for undiagnosed pulmonary nodules was performed in 283 patients and, of them, 177 who underwent uniportal VATS lung resection were enrolled in the study (Figure 1 shows the algorithm for patient selection). The Research Ethics Committee of the National Taiwan University Hospital approved this study (project approval number 201510121RIND).

At our institute, preoperative CT-guided dye localization was potentially indicated for patients with incidentally found, small, undiagnosed pulmonary nodules, including pure GGNs, part-solid GGNs, and solid nodules. The surgical indications for these patients included enlargement of the nodule size on follow-up CT images and persistence of a nodule with a solid component of 5 mm or more on the follow-up CT images. In patients with stationary nodules with a solid component less than 5 mm, tumor excision was performed at the patient's request due to anxiety but only after 1 year of follow-up. This preoperative localization procedure was performed when both the surgeons and radiologists considered that these nodules were not likely to be visualized intraoperatively during thoracoscopy. All patients stopped taking anticoagulant drugs at least 5 days before surgery, had normal prothrombin and activated partial thromboplastin times, and had platelet counts of more than $80 \times 10^3/\mu L$.

Clinical parameters, including age, gender, smoking status, nodule size, nodule site, nodule numbers, preoperative CT-guided localization-related parameters, surgical procedure (wedge resection, segmentectomy, or lobectomy), anesthetic method (intubated anesthesia or nonintubated anesthesia), operation duration, operative blood loss, lengths of postoperative intensive care unit (ICU) and postoperative hospital stays, postoperative chest tube duration, and in-hospital morbidity and mortality were collected from patients' charts. The histopathology of the resected nodules was classified according to the criteria set by the World Health Organization in 2015. The GGO percentage of a nodule was determined by comparison with a standard picture archive and communication system using a commercially available viewer (IMPAX 5.2; Agfa HealthCare, Mortsel,