

Nonintubated video-assisted thoracoscopic surgery for management of indeterminate pulmonary nodules

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Abstract: Indeterminate pulmonary nodules are common findings in clinical practice, especially after widespread use of high-resolution computed tomographic scans for cancer screening. To determine whether the nodule is malignant or not, surgery is usually required for either diagnostic or therapeutic purposes in the early stages. Current development in minimally invasive surgery and anesthesia using video-assisted thoracoscopic surgery without tracheal intubation (nonintubated VATS) are feasible and safe for resection of peripheral lung nodules, including nonintubated needlescopic or uniportal approaches. In addition, nonintubated VATS may offer high-risk patients for intubated general anesthesia opportunities to receive surgery. Therefore, nonintubated VATS can provide an attractive alternative for early diagnosis and treatment of indeterminate lung nodules.

Keywords: Thoracoscopy/VATS; lung nodules; anesthesia; tracheal intubation; minimally invasive surgery

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Authors' introduction:

Professor Chen (middle right) and Professor Cheng (middle left) lead the nonintubated thoracoscopic surgery program in National Taiwan University Hospital since 2009 with core team members, Dr. Hsu (left) and Dr. Hung (right) (*Figure 1*).

Introduction

Pulmonary nodules are approximately round lesions that are defined as less than 3 cm in diameter and that are completely surrounded by lung parenchyma, without other abnormalities (1). An incidental finding of pulmonary nodules on a chest radiography is one of the most common scenarios faced by clinicians, with a reported incidence of 0.1% to 0.2% of all chest radiographs (2). Since the introduction of helical computed tomography (CT) and multi-detector row CT in 1990s and their widespread use for lung cancer screening programs, the detection of



Figure 1 From left to right: Dr. Hsu, Prof. Cheng, Prof. Chen and Dr. Hung.

focal rounded pulmonary nodules as small as 1 to 2 mm in diameter are becoming routine (3).

The most relevant issue in managing an incidentally found solitary pulmonary nodule is to diagnose whether the lesion is malignant or benign. While early diagnosis

of malignancy facilitates timely treatment for best chance of survival in lung cancer patients, unnecessary repeated radiological examinations or invasive thoracic procedures with inherent risks should be avoided for benign lesions. Various modalities have been evaluated to aid in the early differential diagnoses of indeterminate pulmonary nodules, including flexible bronchoscopy, sputum cytology, endobronchial and transbronchial biopsy, CT-guided percutaneous, fine needle aspiration biopsy, high-resolution CT, and positron emission tomographic scanning (3-5). However, in the absence of a definite diagnosis, surgery remains the only option, which offers both diagnostic and therapeutic purposes at the same time.

The role of surgery for management of indeterminate pulmonary nodules is not concluded yet, especially in small lung nodules. Recommendations are focusing on the probability of malignancy to warrant surgery or not, which is predicted by nodule size, growth rate on serial follow-up studies, radiologic characteristics, and presences of relative risks (e.g., age, history of smoking, family history of lung cancer) (3). Recent advancements in minimally invasive thoracic surgery, both in surgical approaches and anesthetic techniques, may impact on the evaluation of risks and therefore on the decision management of indeterminate pulmonary nodules (6-16). In this article, we review current use of video-assisted thoracoscopic surgery without tracheal intubation (nonintubated VATS) for management of indeterminate pulmonary nodules.

Rationale for a nonintubated VATS

In the last 2 decades, thoracic operation by VATS has been well demonstrated as an effective and safe surgical approach for various thoracic diseases (17). Conventionally, intubated general anesthesia with one-lung ventilation by a double-lumen endotracheal tube or an endobronchial blocker is deemed mandatory for pulmonary VATS resections (17,18). However, adverse effects after intubated general anesthesia and one-lung ventilation are not negligible, including intubation-related airway trauma, residual neuromuscular paralysis, pulmonary atelectasis and ventilator-induced lung injury, arterial desaturation, impaired cardiac performance and postoperative nausea and vomiting (19-21). Avoidance of tracheal intubation can thereby prevent inherent risks of an intubated general anesthesia and reflect in a faster and smoother postoperative recovery with early return of daily activities and shorter hospital stay (6). In addition, compromised patients with impaired cardiopulmonary

function may therefore get a chance to have surgical therapy by nonintubated VATS (22,23).

Feasibility of nonintubated VATS for indeterminate pulmonary nodules

Previously reported nonintubated VATS using locoregional anesthesia were mostly applied in high-risk patients for an intubated general anesthesia who receive pleural treatments (24-28). In 2004, Pompeo *et al.* were among the first pioneers to evaluate the feasibility of nonintubated VATS for resections for pulmonary nodules (6,8). They included 30 patients with solitary pulmonary nodules undergoing conventional VATS under sole thoracic epidural anesthesia without conscious sedation (awake VATS). Comparing to patients with intubated general anesthesia, their results showed that the awake technique was safe and feasible with more patient satisfaction, less requirement of postoperative nursing care (2.5 *vs.* 4 calls per day) and shorter in-hospital stay (2 *vs.* 3 days). In surgical perspective, the operated lung collapsed satisfactorily with an excellent surgical feasibility score in awake spontaneously breathing patients. Nonetheless, there were two awake patients who required intraoperative conversion to intubated general anesthesia because of lung cancer approved by frozen examination and requiring lobectomy via a thoracotomy approach (6). They further reported similar results in patients with metastatic lung nodules using awake VATS metastasectomy, but some patients experienced anxiety or panic, which necessitated conscious sedation (8). In addition, Lesser *et al.* also reported awake thoracoscopic laser resection of subpleural nodules in 28 patients under local anesthesia (9). On the same reason for a definite treatment of lung cancer, three of them were converted to intubated general anesthesia for further lobectomy.

Our group has employed nonintubated VATS using thoracic epidural anesthesia to perform wedge resections for diagnoses and treatments of peripheral lung nodules since 2009 (29). In contrast to the awake technique, we prefer to sedate our patients (non-awake technique). Since the undetermined nature of their pulmonary nodules, intraoperative frozen examinations are mostly necessary to confirm malignancy or not. Patients are usually anxious about the final results and opt for amnesia during the process. We believe that a sedative adjunct will facilitate a nonintubated VATS procedure to alleviate the cooperability of the patients, in particular when further lobectomy and lymphadectomy for primary lung cancer can be a lengthy

and uncomfortable procedure, if necessary (30). It is important to note that creating an surgical pneumothorax inevitably induce a hypoventilative status in a spontaneously breathing patient (10,30). Therefore, non-awake technique using sedative and/or opioid analgesics can also help to attenuate the tachypneic response of an open pneumothorax, but over-sedation should be meticulously avoided. Excessive sedation can further inhibit ventilation and oxygenation of the nonintubated VATS patients and jeopardize their safety (30,31). Depth of sedation can be titrated according to a Ramsay sedation score (target at level III: patients are sedated but retain response to commands) in awake patients (32), but a bispectral index using electroencephalographic analysis (target at levels between 40 and 60) will be more a convenient tool to spare the caring anesthesiologist for more vigorously observing the respiratory patterns of patients on surgical videos and capnographic monitor (16).

Intense traction of lung parenchyma and hilar manipulation may be necessary to treat deeply located nodules, by which may trigger a coughing response. Unexpected or intractable cough not only interfere with surgical manipularities but also cause dangerous complications, which may require emergency conversion to tracheal intubation and thoracotomy (32). To abolish the afferent input of a cough reflex, we found that a simple intrathoracic vagal blockade is effective without affecting the heart rate, breathing rate, and blood pressure (32). An effective vagal blockade also decreases the requirement of opioid analgesics to attenuate the tachypneic responses resulting from surgical pneumothorax and coughing reflex, thereby alleviate the risks of symptomatic hypoventilation (30). The combinations of a sedative technique and vagal block enable us to convert from a wedge resection of indeterminate pulmonary nodules to more extensive anatomical resections such as segmentectomies or lobectomies with mediastinal lymph node dissections under the same type of anesthetic management without conversion to tracheal intubation, once frozen pathological results show primary lung cancer (13,23,32). Our nonintubated VATS method was also feasible to perform simultaneous bilateral VATS wedge resections of indeterminate pulmonary nodules in both lungs (33).

Nonintubated needlescopic and uniportal VATS for indeterminate pulmonary nodules

Conventional VATS is widely performed through a 2- or

3-port approach with 5- or 10-mm instruments. To further reduce the postoperative chest pain and cosmetic satisfaction after conventional VATS, modifications of VATS using 3-mm needlescopic instruments or single-access approach have recently developed (34). Needlescopic VATS has rarely been tried because of several limitations, including an inferior visual field of needlescope and inadequate strength of the instruments. In 2012, Tseng *et al.* combined nonintubated technique and needlescopic VATS to treat 46 patients with peripheral lung nodules (13). In their study, two miniports were made for 3-mm endograsper and 3-mm endoscope while a 12-mm thoracic port was made for 10-mm endostapler to resect indeterminate lung nodules. Their results showed that nonintubated needlescopic VATS was feasible and safe to remove peripheral lung nodules and to obtain a definite diagnoses of the nodules. However, extension of the 3-mm incisions was required in three primary lung cancer patients for lobectomies, in three patients with unexpected pleural adhesions and in two patients with difficulty to identify or resect the nodule. In addition, conversion to tracheal intubation was only required in two patients because of pleural adhesions. Most of patients completed needlescopic VATS without conversion to conventional VATS reported very satisfied or satisfied about wounds without residual neuralgia (13).

Single-access, or uniportal VATS is another emerging trend in minimally invasive thoracic surgery and has been shown to reduce postoperative pain, residual paresthesia, and hospital stay compared with conventional multiport VATS (35). However, instrumental interferences and limited access for finger-palpation of lung nodules are concerned. To evaluate the feasibility and safety of a combination of nonintubated anesthetic management and uniportal VATS approach, Hung *et al.* recruited 32 patients with peripheral lung nodules less than 2 cm undergoing a diagnostic wedge resection (15). For very small lung nodules less than 1 cm with ground-glass opacities, they used CT-guided dye-localization to target the lesion site before surgery. In addition, two-anchoring lung sutures were made for two-directional traction to spare the single access for maneuverability of endoscopic linear cutter (36). Their results showed that peripheral lung nodules could be easily resected via their modifications of nonintubated uniportal VATS to obtain a definite diagnosis. Only one patient without preoperative CT-guided dye-localization was converted to 3-port VATS because of difficulty locating an 11-mm ground-glass opacity. For 20 patients (59%) confirmed to be primary lung cancer, further resection

for adequacy of margins and mediastinal lymph node dissections were also feasible while only three of them required conversions to multiport VATS and one of them required conversion to tracheal intubation due to limited instrumental maneuverability and vigorous mediastinal movement during nodal dissection, respectively. Not surprisingly, nearly all patients were very satisfied or satisfied (97%) with their scars (15).

Potential roles of nonintubated VATS for indeterminate pulmonary nodules

With refinements of surgical approach and anesthetic management after years of experiences on nonintubated VATS, we believe that our combination of uniportal incision and intercostal block can be a least invasive diagnostic modality for surgical management of indeterminate lung nodules. Once a definite diagnosis obtained after wedge resection and frozen examination of nodules, conversion to segmentectomy or lobectomy with mediastinal lymph node dissection for primary lung cancer can also performed under the same type of anesthesia with conventional multiport VATS, if necessary (14-16). Therefore, nonintubated uniportal VATS may increase the acceptability of surgical management of indeterminate lung nodules for early diagnosis and treatment of potential primary lung cancer.

Conclusions

Currently, increasing numbers of indeterminate lung nodules are necessitating surgery for either diagnostic or therapeutic purposes in the early stages because of the popularity of high-resolution CT and new cancer screening policies. Nonintubated VATS can provide an attractive alternative for early diagnosis and treatment of indeterminate lung nodules, especially using minimally invasive surgical and anesthetic approaches.

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