Review Article

Recent developments in minimally invasive surgery for biopsy of small pulmonary nodules

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Contributions: (I) Conception and design: None; (II) Administrative support: None; (III) Provision of study materials or patients: None; (IV) Collection and assembly of data: None; (V) Data analysis and interpretation: None; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

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Abstract: Following the development of radiological technology, there has been an increase in the number of pulmonary nodules found. The management of pulmonary nodules represents a specific challenge to thoracic surgeons. Pulmonary nodules are small, focal, rounded radiographic opacities that may be solitary or multiple. The definite histopathologic diagnosis is crucial in determining management ranging from interval imaging to surgical resection. The choice of a particular biopsy technique depends on the risks/benefits of the procedure, the diagnostic yield, and local expertise. Surgical lung biopsy has been reported as an accurate approach when less-invasive diagnostic methods have been unsuccessful. During the last decade, there have been huge developments of new minimally invasive techniques in thoracic surgery. In the present study, we will review both surgical and anesthetic techniques in surgical lung biopsy.

Keywords: Minimally invasive surgery; pulmonary nodule; video-assisted thoracoscopic surgery (VATS); non-intubated VATS; spontaneous ventilation

Submitted Nov 12, 2017. Accepted for publication Dec 20, 2017.
doi: 10.21037/jtd.2018.01.08
View this article at: http://dx.doi.org/10.21037/jtd.2018.01.08

Introduction

With increasing availability and accessibility of advanced radiological investigations such as high-resolution computed tomography (HRCT) and positron emission tomography (PET), the incidence of newly diagnosed pulmonary nodules is on the rise. A pathologic confirmation by a lung biopsy specimen remains essential whenever there is any doubt regarding the diagnosis or prognosis (1). Noninvasive or minimally invasive diagnostic procedures such as bronchoalveolar lavage, CT-guided or ultrasound guided transthoracic biopsy, or transbronchial definitive diagnosis of some lung lesions cannot always be made with these procedures; due to for example, inaccessibility of the lesion or inadequate sampling (2,3).

Surgical lung biopsy has been considered the gold standard diagnostic modality when less-invasive diagnostic methods have been unsuccessful, generally used as a final approach due to its association with potential morbidity and mortality, even with the surgical and anesthetic techniques (3). Recent advancements in thoracic anesthesia and minimally invasive surgical techniques have contributed to the management of pulmonary nodules.

Surgical techniques in pulmonary biopsy

Video-assisted thoracoscopic surgery (VATS) has been used with satisfactory results to obtain biopsies of pleural, pulmonary, and mediastinal masses, for evaluation and treatment of spontaneous pneumothoraxes, and for

resection of lung tissue (4). VATS lung biopsy has become an increasingly accepted approach for the diagnosis of patients with indeterminate pulmonary nodules (5,6). Although other diagnostic alternatives, such as CT-guided needle biopsy, can determine malignancy accurately, identification of specific benign diagnoses can be unreliable, with a sensitivity of 18% and false-negative rate of 29%, when compared with the sensitivity and specificity of VATS lung biopsy (7). The previous study showed that VATS lung biopsy was as safe and effective as open lung biopsy. And the postoperative recovery period, complications, and hospital stay were substantially reduced in those undergoing VATS compared with open surgery (8).

The use of VATS in the extra-anatomic wedge resection of undiagnosed pulmonary nodules (<3 cm) is the best alternative method to thoracotomy or "wait and watch" approach. Mack and colleagues demonstrated the safety and effectiveness of VATS excision of indeterminate solitary pulmonary nodules by performed VATS lung biopsy in a total of 242 patients. A definitive diagnosis was obtained in all cases. During these procedures, only two required open lung biopsy because the unreached location of the nodules. There was no mortality or major morbidity, and minor complications occurred in 3.6% patients. The average hospital stay was 2.4 days. As a result, by comparing with open lung biopsy, patients undergoing VATS had shorter length of hospital stay and recovery better (9).

In recent years, as a result of the development of equipment and revolution of surgical techniques, VATS has evolved from a multiport to a single incision approach. Uniportal or single incision VATS has been shown to be tolerable, safe and efficient (10). Moreover, it has been demonstrated to reduce post-operative pain and paraesthesia incidence compared with conventional multiport VATS (11,12). The version of thoracoscopic system has developed from 2D to 3D with much more resolution. Recently, the glasses-free 3D thoracoscopic display system was developed and applied in thoracic surgery (13). Compared to the traditional 3D display system, it is advantageous to the surgeon by allowing the surgeon to see the high definition 3D image without polarized lenses changing the light and coloring of the image. We believe that all these techniques will facilitate the surgeons to better perform the lung biopsy.

Advances in anesthesiology and perioperative management

For decades, intubated ventilation was considered mandatory for VATS. As a result, the only absolute contraindication for VATS lung biopsy was the inability of the patient to tolerate a general anesthetic with single lung ventilation (SLV). Furthermore, complications after general anaesthesia and endotracheal intubation cannot be negligible. For example, deep anesthesia and intravenous analgesics (primarily opioids) have deleterious systemic side-effects associated with a higher mortality, morbidity and cognitive dysfunction postoperatively (14). Mechanical ventilation may cause airway pressure-induced injury by lung over-distension. Endotracheal intubation can also result in sore throat, mucosal ulceration and airway injury. Previous study reported that tracheobronchial rupture may carry a mortality rate as high as 22% (15).

Since the introduction of non-intubation thoracic surgery by Pompeo *et al.* (16), our center has successfully performed a range of thoracic procedures, including pulmonary resection, thymectomy and tracheal and carinal resections, under spontaneous ventilation without general anesthesia. From our studies (17-19), we found that patients operated under spontaneous ventilation had a shorter post-operative recovery time, were able to eat and mobilize earlier compared with the conventional VATS approach. In addition, two previous studies had explored the immunological response in patients after using this approach with favorite results (17,20). Until now, in our institute, we have performed more than 2,000 VATS procedures under spontaneous ventilation. We believe that this method benefits the patient by minimizing the side effects of anesthesia and allowing the patient a faster recovery.

In addition, the concept of tubeless has been put forward in thoracic surgery (21). The main reason for placement of chest tube and urinary catheter is for post-operative monitoring. However, urinary catheterization is associated with urethral trauma, discomfort, infection and can impair patient mobility, a chest drain is also a recognized cause of post-operative pain and can affect patient's post-operative mobility as well as effective chest physiotherapy. Therefore, in order to maximize the benefit of this non-intubated approach, we explored the possibility of combining it with other maneuvers that can improve patient's recovery, such as avoiding postoperative chest tube and urinary catheterization. Ultimately, our aim is to improve patient care, and allow patients to be discharged from hospital safely and quickly (21). We think that intubation, chest drainage, and/or urinary catheterization may not be necessary in all patients.

Limitations in lung biopsy

Some technical problems with VATS lung biopsy need to be addressed. Peripherally placed lesions present little problem but more deeply situated lesions may be difficult to locate and grasp thoracoscopically. Usually the lesion can be identified by puckering of overlying visceral pleura or by touching the lung surface and noting the change in texture. Some techniques such as three-dimensional reconstruction by preoperative CT can help to guide the location. However, for particularly small and deep lesions, the localization can be challenging. Currently, several localization methods exist to increase the diagnostic yield during thoracoscopy, such as percutaneous wire placement, injection of dye, intraoperative imaging with ultrasound, fluoroscopy, or other molecular imaging devices (22). Further studies need to be explored.

Conclusions

Recent advancements in minimally invasive surgical technique and thoracic anesthesia have contributed to a more effective and less invasive diagnostic method for surgical lung biopsy of small peripheral pulmonary nodules in the management of pulmonary nodules.

Acknowledgements

None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Cite this article as: Jiang L, He J. Recent developments in minimally invasive surgery for biopsy of small pulmonary nodules. J Thorac Dis 2018;10(Suppl 7):S905-S908. doi: 10.21037/jtd.2018.01.08