MINI- REVIEW

Nonintubated video-assisted thoracoscopic pulmonary resections

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Summary Video-assisted thoracoscopic surgery (VATS) has become a common and globally accepted mode of resection of pulmonary tumors. One-lung isolation using double-lumen endobronchial tubes or endobronchial blockers has been traditionally considered mandatory for VATS. However, recent reports showed that VATS pulmonary resections can also be performed safely using regional anesthesia without tracheal intubation. Mostly, nonintubated VATS pulmonary resections are performed using regional anesthesia, either a thoracic epidural anesthesia or intercostal blocks, in a spontaneously breathing state after an iatrogenic open pneumothorax. Conscious sedation is usually necessary for longer and intensively manipulating procedures. Intraoperative cough reflex can be effectively inhibited by ipsilateral intrathoracic vagal blockade to facilitate major pulmonary resections. The early outcomes of nonintubated VATS pulmonary resections include a faster postoperative recovery and a lower complication rate as compared with its counterpart of intubated general anesthesia, which may be translated into a fast track VATS program. The future directions of nonintubated VATS should focus on its long-term outcomes, especially on oncological perspectives and overall survival in lung cancer patients.

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1. Introduction

Since its introduction in the 1990s, video-assisted thoracoscopic surgery (VATS) has become a common and globally accepted treatment of choice in managing various thoracic diseases involving the lungs, pleura, and mediastinum. Compared with traditional thoracotomy, VATS is demonstrated to be superior in shortening the length of hospital stay, alleviating postoperative pain, improving postoperative lung function, and reducing overall morbidities after surgery. Because a quiet, optimally visualized surgical environment is a vital prerequisite during VATS, intubated general anesthesia with one-lung isolation, and the use of a double lumen endobronchial tube or an endobronchial blocker, was considered mandatory in the past. However, complications and adverse effects following intubated one-lung ventilation are inevitable, including intubation-related airway trauma, ventilation-induced lung injury, residual neuromuscular blockade, impaired cardiac performance, and postoperative nausea and vomiting.

To avoid intubation-related complications and to facilitate a smoother postoperative recovery, interests and efforts have been recently focused on adopting a thoracoscopic technique without tracheal intubation (i.e., awake or nonintubated VATS). Satisfactory results are accumulating not only from sporadic case reports of difficult and high-risk patients not suitable for an intubated general anesthesia, but also from systemic applications of this technique to various VATS procedures, including various pulmonary resections (wedge resection, segmentectomy, and lobectomy), management of pneumothorax, excision of mediastinal tumors, and lung volume reduction surgery. Encouragingly, the safety and feasibility of nonintubated VATS were well established in these studies.

As lung cancer is still the leading cause of cancer death worldwide and also in Taiwan, and current low-dose computed tomography screening programs identify increasing numbers of indeterminate small lung nodules, a combination of minimally invasive surgery and a less invasive anesthetic technique would be appealing and is expected in the armamentarium of thoracic surgery. It may serve either a diagnostic or a therapeutic purpose and increase patients’ chances of being surgically treated. In this article, we revisit the current literature of nonintubated VATS focusing on pulmonary resections for lung cancer or undiagnosed lung tumors. We also summarize our experiences on nonintubated VATS.

2. Nonintubated VATS for pulmonary resections

Surgical treatment of lung tumors includes wedge resection, anatomical segmentectomy, lobectomy, or pneumonectomy with or without mediastinal lymph node dissections, depending on the nature of the lung tumors.

2.1. Wedge resection

Traditional pulmonary resections via a thoracotomy approach were in fact performed under regional anesthesia without tracheal intubation in the 1940s. After the introduction of a double-lumen endobronchial tube, however, tracheal intubation with one-lung isolation in modern thoracic surgery has widely been considered mandatory, especially in the era of minimally invasive thoracoscopic surgery. In 2004, Pompeo et al were among the first pioneers to re-evaluate the feasibility of thoracoscopic surgery without tracheal intubation for pulmonary resections. Thirty patients with solitary pulmonary nodules underwent VATS wedge resection under sole thoracic epidural anesthesia. Compared 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 calls/day vs. 4 calls/day) and shorter in-hospital stay (2 days vs. 3 days). Nonetheless, there were two awake patients who had their anesthesia converted to intubated general anesthesia because of lung cancer requiring lobectomy via a thoracotomy approach. They further reported similar results in patients with metastatic lung tumors using awake VATS metastasectomy, but some patients experienced anxiety or panic which necessitated conscious sedation. Additionally, awake thoracoscopic laser resection of subpleural nodules in 28 patients under local anesthesia only were also reported by Lesser. Three of them were converted to have intubated general anesthesia because of lung cancer requiring further lobectomy.

Our group has employed nonintubated VATS using thoracic epidural anesthesia to perform wedge resections for peripheral lung nodules since 2009. In contrast to the awake technique, we prefer to sedate the patients under the guidance of the Ramsay sedation score (target at level III: patients are sedated but retain response to commands) and yielded a 4.3% conversion rate of tracheal intubation by a needlescopic approach. After applying thoracoscopy-guided intercostal blocks to replace thoracic epidural anesthesia and bispectral index monitoring to precisely target the sedation level, the conversion rate was further improved and the duration of anesthesia induction was also shortened. Our method was also applied to simultaneous bilateral VATS for indeterminate pulmonary nodules in both lungs. Similar results were also reported by Dong and his colleagues (Table 1).

2.2. Anatomical major pulmonary resections, including segmentectomy and lobectomy

For surgical management of primary lung cancer or central located benign tumor, anatomical pulmonary resections such as segmentectomy or lobectomy with or without mediastinal lymph node dissection are usually necessary. However, these procedures are associated with a longer operating time, frequent lung traction, and intense hilar manipulation, which can trigger a cough reflex in awake patients. The reactivity of the coughing response can be further exaggerated when thoracic epidural anesthesia is used alone, because of an unbalanced parasympathetic activity after sympathetic block. While stellate ganglion block has been applied to attenuate the cough reflex, our group used thoracoscope-guided intrathoracic vagal block to achieve effective inhibition of the cough reflex. In addition, intravenous opioid and propofol were titrated...
with monitoring of anesthesia depth to further control the respiratory rate and alleviate anxiety of patients. Using our nonintubated methods, nonintubated VATS segmentectomy or lobectomy with mediastinal lymphadenectomy for early stage non-small cell lung cancer could be safely performed. The rates of conversion to intubated general anesthesia were reported to be between 2.8% and 10.0%, depending on the type of procedure and which could be further decreased as the learning curve progressed. In addition to being feasible and safe, nonintubated thoracoscopic lobectomy for lung cancer using regional anesthesia also offered better postoperative pain control, lower rates of a sore throat (6.7% vs. 40.0%, \( p = 0.002 \)) and earlier resumption of oral intake (mean, 4.7 hours vs. 18.8 hours, \( p < 0.001 \)), and shorter length of hospital stay (mean, 5.9 days vs. 7.1 days, \( p = 0.078 \)) with better noncomplication rates (90% vs. 66.7%, \( p = 0.057 \)) when compared to its counterpart of intubated general anesthesia, especially in geriatric lung cancer patients with less postoperative delirium. By thoracic epidural anesthesia, intrathoracic vagal blockade, and targeted sedation, Dong et al and Guo et al also reported satisfactory results in nonintubated VATS segmentectomy and lobectomy (Table 1).

### Table 1: Relevant literature findings in nonintubated video-assisted thoracoscopic surgery (VATS) pulmonary resections.

<table>
<thead>
<tr>
<th>Study</th>
<th>Patients</th>
<th>Preoperative diagnosis</th>
<th>Anesthesia</th>
<th>Sedation level</th>
<th>Medications</th>
<th>Intubation conversion rate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wedge resection</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pompeo et al (2004)</td>
<td>30</td>
<td>Solitary pulmonary nodules</td>
<td>TEA</td>
<td>Awake</td>
<td>Not available</td>
<td>6.7%</td>
</tr>
<tr>
<td>Pompeo et al (2007)</td>
<td>14</td>
<td>Metastasectomy</td>
<td>TEA</td>
<td>Awake, some need sedation</td>
<td>Propofol</td>
<td>0%</td>
</tr>
<tr>
<td>Lesser TG (2012)</td>
<td>28</td>
<td>Subpleural nodules</td>
<td>LA</td>
<td>Awake</td>
<td>Not available</td>
<td>10.7%</td>
</tr>
<tr>
<td>Tseng et al (2012)</td>
<td>46</td>
<td>Peripheral lung nodules</td>
<td>TEA</td>
<td>RSS-III</td>
<td>Propofol</td>
<td>4.3%</td>
</tr>
<tr>
<td>Dong et al (2012)</td>
<td>13</td>
<td>Pulmonary nodules</td>
<td>TEA</td>
<td>BIS: 50–70</td>
<td>Propofol</td>
<td>0%</td>
</tr>
<tr>
<td>Hung et al (2014)</td>
<td>50</td>
<td>Lung tumors</td>
<td>ICB</td>
<td>BIS: 40–60</td>
<td>Propofol</td>
<td>0%</td>
</tr>
<tr>
<td>Liu et al (2014)</td>
<td>48</td>
<td>Wedge resection</td>
<td>TEA</td>
<td>BIS: target not defined</td>
<td>Propofol</td>
<td>2.1%</td>
</tr>
<tr>
<td><strong>Segmentectomy</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hung et al (2013)</td>
<td>21</td>
<td>Lung tumors</td>
<td>TEA</td>
<td>BIS: 40–60</td>
<td>Propofol</td>
<td>4.8%</td>
</tr>
<tr>
<td>Guo et al (2014)</td>
<td>15</td>
<td>Lung tumors</td>
<td>TEA</td>
<td>BIS: 40–60</td>
<td>Propofol</td>
<td>0%</td>
</tr>
<tr>
<td>Hung et al (2014)</td>
<td>12</td>
<td>Lung tumors</td>
<td>ICB</td>
<td>BIS: 40–60</td>
<td>Propofol</td>
<td>8.3%</td>
</tr>
<tr>
<td>Chen et al (2011)</td>
<td>30</td>
<td>Non-small cell lung cancer</td>
<td>TEA</td>
<td>RSS-III</td>
<td>Propofol</td>
<td>10.0%</td>
</tr>
<tr>
<td>Wu et al (2013)</td>
<td>36</td>
<td>Non-small cell lung cancer, geriatric</td>
<td>TEA</td>
<td>RSS-III</td>
<td>Propofol</td>
<td>2.8%</td>
</tr>
<tr>
<td>Liu et al (2014)</td>
<td>31</td>
<td>Lobectomy</td>
<td>TEA</td>
<td>BIS: not defined</td>
<td>Propofol</td>
<td>16.1%</td>
</tr>
<tr>
<td>Hung et al (2014)</td>
<td>43</td>
<td>Non-small cell lung cancer</td>
<td>ICB</td>
<td>BIS: 40–60</td>
<td>Propofol</td>
<td>4.7%</td>
</tr>
</tbody>
</table>

BIS = bispectral index; ICB = intercostal blocks; LA = local anesthesia; RSS = Ramsay sedation scale; TEA = thoracic epidural anesthesia.

3. **Nonintubated uniportal VATS pulmonary resection**

Conventional VATS is widely performed via a two- or three-port approach. Recently, uniportal or single-access VATS was introduced and has been shown to reduce postoperative pain, residual paresthesia, and hospital stay compared with conventional multi-port VATS. Therefore, a combination of a uniportal approach and nonintubated anesthesia would be appealing for less invasive VATS. In 2010, Rocco et al were the first to employ an awake uniportal VATS wedge resection of a right middle lobe nodule in an ambulatory setting. Interestingly, they inserted a Fogarty balloon to occlude the right middle lobe bronchus via a flexible bronchoscope to obtain lung exclusion. Moreover, Galvez et al also performed an awake uniportal VATS metastasectomy in a nasopharyngeal cancer patient with potential difficult airway management after chemoradiotherapy. Although this method may resolve the facing difficult airway to achieve effective one-lung isolation, it is worthy to note that despite a conversion protocol, well-prepared, emergent management of a difficult airway in such patients may be more challenging with increasing risks of airway morbidity or mortality, which may outweigh the benefits of nonintubated VATS, especially in a lateral decubitus position.

Recently, we also evaluated the feasibility and safety of uniportal VATS wedge resection for peripheral indeterminate lung nodules using our nonintubated technique. Among 32 patients, uniportal VATS was successfully performed, except in four patients, for whom conversion to multi-port VATS was required to obtain more resection for adequacy of the safety margin. Conversion to tracheal intubation was only required in one patient (3%) because of vigorous mediastinal movement jeopardizing the lymphadenectomy to follow. One major concern of uniportal VATS...
for pulmonary resection of lung tumors is its difficulty to palpate the lesion via a single access, in particular for those small, nonsolid, and deeply located lesions. We used and suggested computed tomography-guided dye-localization to help identify the small and ground-glass opacity lesions. Our preliminary results showed that nonintubated VATS is technically feasible and safe in managing indeterminate peripheral lung nodules. Postoperative neuralgia that required occasional use of analgesics in 1 month was low (3%) and nearly all patients (97%) were very satisfied, or satisfied, despite the resulting scars (unpublished data).

4. Anesthetic considerations of nonintubated VATS

To be feasible and safe in performing nonintubated VATS pulmonary resections, anesthetic management should meet the criteria for management of considerable physiological derangements during the procedure, including effective analgesia, amnesia, and areflexia during lung traction or mediastinal manipulation.28 While the operated lung is collapsed spontaneously after an iatrogenic open pneumothorax, the goal of ventilatory manipulation is to maintain a smooth, effortless, and spontaneously respiratory pattern. Meanwhile, we aim at a respiratory rate >12–20 times/minute to acquire a satisfactory surgical field without jeopardizing the ventilatory adequacy.28

Major nonintubated VATS pulmonary resections, such as segmentectomy or lobectomy, usually require a longer surgical time and intensive hiliar manipulation. Therefore, appropriate conscious sedation with amnesia is required for our patients to tolerate the uncomfortable decubitus position for hours in a stress-free environment. Moreover, intraoperative thoracoscopy-guided vagal blockade has proved effective on cough reflex suppression without causing hemodynamic instability and facilitate intensive hiliar dissection and lung traction during major pulmonary resection surgery.12,16–18,28 Although hypoxemia and hypercapnia may occur in nonintubated VATS, they are usually mild and well-tolerated and oxygenation is usually satisfactorily maintained with supplemental oxygen via a facemask.15,28

Despite the extra vigilance and careful selection of nonintubated candidates, intraoperative conversion to intubated general anesthesia is occasionally inevitable because of unexpected pleural adhesions, insufficient anesthesia, uncontrollable respiratory pattern, and significant bleeding.18,28 Because intubation in the lateral decubitus position with VATS instruments in place is a technical challenge to anesthesiologists, an emergency protocol of airway management and one-lung isolation device should be well prepared in advance. Conversion to tracheal intubation should be performed decisively and early instead of in a hurry scenario to decrease the risk of emergency intubation.18,28

5. Potential advantages of nonintubated VATS and its future directions in thoracic oncology

Current studies in the literature support the feasibility and safety of nonintubated VATS for management of a variety of pulmonary diseases. Potential advantages of nonintubated VATS are faster postoperative recovery and less overall complication rates, both of which enhance a short length of hospital stay. Therefore, the use of nonintubated VATS may translate into a fast track protocol bypassing intensive care or postoperative ventilator support. For patients with high risks for an intubated general anesthesia, this technique may offer better chances for surgical treatment and postoperative recovery.21

In addition to these beneficial early outcomes, nonintubated VATS under thoracic epidural anesthesia are also demonstrated to attenuate surgical stress responses as the decreased level of stress hormones and preservation of natural killer cell functions, compared to intubated general anesthesia.29 It has recently been hypothesized that regional anesthesia and analgesia may protect cancer patients from recurrence or metastases after surgery.30 This implies that further investigation including long-term outcomes (recurrence-free survival or overall survival) by large controlled trial is needed in attempts to develop safer, more effective and less invasive surgical strategies for an optimal treatment of lung cancer patients.21

6. Conclusion

In the modern era of minimally invasive thoracic surgery, we are encouraged that tracheal intubation with a double-lumen tube or bronchial blocker is no longer regarded as a prerequisite for one-lung isolation to perform VATS in a series of reported studies. Nonintubated thoracoscopic surgery is feasible and safe to perform VATS wedge resection, segmentectomy, and lobectomy, with or without mediastinal lymphadenectomy. Although the risks and benefits of this technique are not entirely clear yet, it seems to offer an equally effective and safe alternative to those patients with high risks to intubated general anesthesia. Postoperative recovery is also faster with less complication rates. Nonetheless, further studies are still necessary to clarify the indications and true benefits of this technique and its potential beneficial role against postoperative recurrence in lung cancer patients.21

References