Nonintubated thoracoscopic lung resection: a 3-year experience with 285 cases in a single institution

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ABSTRACT

Objective: Tracheal intubation with one-lung ventilation is considered mandatory for thoracoscopic surgery. This study reported the experience of thoracoscopic lung resection without endotracheal intubation in a single institution.

Methods: From August 2009 through July 2012, 285 consecutive patients were treated by nonintubated thoracoscopic surgery using epidural anesthesia, intrathoracic vagal blockade, and sedation for lobectomy, segmentectomy, or wedge resection in a tertiary medical center. The feasibility and safety of this technique were evaluated.

Results: The final diagnosis for surgery were primary lung cancer in 159 patients (55.8%), metastatic lung cancer in 17 (6.0%), benign lung tumor in 104 (36.5%), and pneumothorax in 5 (1.8%). The operative methods consisted of conventional (83.2 %) and needlescopic (16.8%) thoracoscopic surgery. The operative procedures included lobectomy in 137 patients (48.1%), wedge resection in 132 (46.3%), and segmentectomy in 16 (5.6%). Collapse of the operative lung and inhibition of coughing were satisfactory in most of the patients. Fourteen (4.9%) patients required conversion to tracheal intubation because of significant mediastinal movement [5], persistent hypoxemia [2], dense pleural adhesions [2], ineffective epidural anesthesia [2], bleeding [2], and tachypnea [1]. One patient (0.4%) was converted to thoracotomy because of bleeding. No mortality was noted in our patients.

Conclusions: Nonintubated thoracoscopic lung resection is technically feasible and safe in selected patients. It can be a valid alternative in managing patients with pulmonary lesions.

KEY WORDS Anesthesia; tracheal intubation; lobectomy; lung cancer; thoracoscopy; segmentectomy; wedge resection

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Introduction

Since the introduction of the double-lumen endotracheal tube, intubated general anesthesia with one-lung ventilation has been considered mandatory in both open and video-assisted thoracoscopic surgery (VATS) (1). However, adverse effects of intubated general anesthesia occur after the operation and they include intubation-related complications, ventilator-induced lung injury, impaired cardiac performance, and postoperative nausea and vomiting (2-5). In order to reduce the adverse effects of tracheal intubation and general anesthesia, thoracoscopic surgery without tracheal intubation has been recently employed for management of pneumothorax (6-8), resection of pulmonary nodules (9-12), resection of solitary metastases (13), lung volume reduction surgery (14), and even performing lobectomy (15). The results achieved for these early surgeries are encouraging.

Although the feasibility of thoracoscopic surgery via nonintubated anesthesia was demonstrated in some reports, most of them are limited to small number of cases. In this study, we reported our experience of 285 consecutive patients undergoing nonintubated VATS or nonintubated needlescopic VATS in a 3-year period of time to evaluate the feasibility, safety, and indication of this innovative technique.

Patients and methods

Study design and patients

The medical records of all patients who underwent nonintubated

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VATS at National Taiwan University Hospital and National Taiwan University Hospital Yun-Lin Branch, a 3,200-bed tertiary medical center, from August 2009 to July 2012, were retrospectively reviewed. The thoracic surgical team, both surgeons and anesthesiologists, selected the cases upon review of the medical records. Patients considered appropriate for nonintubated VATS met the same criteria as for intubated VATS. Patients with American Society of Anesthesiologists (ASA) scores of greater than 3, bleeding disorders, sleep apnea, or unfavorable airway or spinal anatomy were contraindicated for nonintubated VATS in our hospital. Patient consent was obtained after explaining the type of anesthesia and the surgical procedure.

During this period of time, nonintubated thoracoscopic lung resections were performed in 285 patients, including wedge resection, segmentectomy, and lobectomy. The operation methods used were conventional VATS or needlescopic VATS. All patients were managed by a single thoracic surgical team using the same clinical protocols, care patterns, and perioperative orders.

Anesthetic setting, induction, and maintenance

Anesthetic techniques were described previously (10,11,15). Patients were pre-medicated with fentanyl 50-100 μg intravenously (IV) and were continuously monitored electrocardiographically, along with pulse oxymetry, respiratory rate, blood pressure, body temperature, and urine output. Monitoring of central venous pressure was optional. Thoracic epidural anesthesia was performed by insertion of an epidural catheter at the T5/6 thoracic interspace to achieve a sensory block between the T2 and T9 dermatomes, and was maintained by continuous infusion of 2% lidocaine. End-tidal carbon dioxide ($ETCO_2$) was continuously monitored by insertion of a detector into one nostril. The patient was then asked to turn him or herself into the lateral decubitus position. Sedation was then started by intravenous infusion of propofol (10 mg/mL) using a target-controlled infusion method, with incremental fentanyl injection to maintain the patient in a mildly sedated, but communicable and cooperative level (Ramsay sedation score III), responding to commands only (16).

During the procedure, patients breathed O_2 through a ventilation mask, keeping oxygen saturation above 90%. An iatrogenic pneumothorax was made by creating incisions through the chest wall for thoracoscopy and the ipsilateral lung collapsed gradually. To inhibit coughing during thoracoscopic manipulation in selected patients, intrathoracic vagal blockade was produced by infiltration of 2 mL of 0.25% bupivacaine adjacent to the vagus nerve at the level of the lower trachea for right-sided operations and at the level of the aortopulmonary window for left-sided operations, under direct thoracoscopic vision. This procedure effectively inhibited the cough reflex for 3 or more hours and was mandatory for lobectomy and segmentectomy, especially before anatomical dissection of the pulmonary hilum. Repeated bupivacaine infiltration was occasionally needed in prolonged operations. During the thoracoscopic procedure, the respiration rate was 12-20/min.

During wound closure and chest tube insertion, propofol infusion was stopped. After the patient was fully awake, the patient was asked to breathe deeply and cough to re-expand the collapsed lung. The epidural catheter was used for postoperative pain control during the following days.

Technique of thoracoscopic surgery

The detailed surgical setting and procedures performed in our group were described before (10,15). Thoracoscopic lobectomy, segmentectomy, or wedge resection was performed using a 3-port method, as described by McKenna (17). In brief, the patient was positioned in the full-lateral decubitus position, with slight flexion of the table at the level of the mid-chest. The thoracoscope was placed into the seventh or eighth intercostal space in the midaxillary line. A working port was placed in the sixth or seventh intercostal space in an auscultatory triangle, and an anterior 3 cm incision was placed anteriorly in the fifth intercostal space. After collapse of the lung, incomplete fissures, pulmonary vessels, and bronchi were divided with endoscopic stapling devices. The resected specimen was removed in an organ retrieval bag through the utility incision. After staging mediastinal lymph node dissection, a 28-French chest tube was placed through the lowest incision. Rib spreading, rib cutting, and retractor use were avoided in all patients, except when conversion to thoracotomy was required. Conversion from nonintubated anesthesia to intubated general anesthesia or from thoracoscopic surgery to thoracotomy was decided by the attending surgeon and anesthesiologist. Conversion from nonintubated to intubated anesthesia was performed when epidural anesthesia was ineffective, hypoxemia persisted (S_pO_2 <80%), hemodynamic status was unstable, or intraoperative bleeding requiring thoracotomy. When conversion was indicated, the surgical wounds were sealed with transparent waterproof dressings (Tegaderm Film, 3M Health Care, Neuss, Germany) after insertion of a chest tube to re-expand the lung. A single-lumen endotracheal tube was inserted under the guidance of a bronchoscope, followed by insertion of a bronchial blocker without changing the patient's position.

After the operation, chest radiography was performed immediate or the next morning. Drinking and meal intake were resumed 2-4 hours after surgery. The chest tube was removed if no air leak was present and drainage was less 200 mL in a 24-hour period.

Technique of needlescopic VATS

Needlescopic VATS was mainly used for biopsy of undiagnosed

peripheral lung nodules. The technique was described previously (10). Briefly, of Two sets of independent video-thoracoscopic equipment and monitors (HD Endoscopy System, Karl Storz, Tuttlingen, Germany), one for needlescopic videothoracoscopy and the other for 10-mm videothoracoscopy, were used simultaneously to save time switching scopes (18,19). An incision of about 15 mm in length was made in the sixth intercostal space on the midaxillary line and a 12-mm thoracic port was inserted through the incision. Two or three small skin punctures were made and mini-ports were inserted for the needlescopic instruments (3-mm instruments, Olympus, Tokyo, Japan). Initially, the 10-mm telescope and two mini-endograspers were used to identify the nodule. Once the nodule was identified, it was stabilized using the mini-endograsper. The mini-endograsper in the other mini-port was withdrawn and a needlescope was introduced to visualize the tumor. The 10-mm telescope was then withdrawn and a 45-mm endoscopic stapler was introduced for partial lung resection including the nodule. Resected tissue was placed into a bag inserted through the 12-mm port and was taken out of the thoracic cavity. Upon completion of the procedure, a chest tube was inserted via the 12-mm port.

Data collection and analyses

The data including patient demographics, complications, and the surgical results were collected from the institutional database, anesthesia and surgical notes, and the medical and nursing records.

Results

From August 2009 through July 2012, nonintubated thoracoscopic lung resection was performed on 285 patients. The demographic data of the patients are shown in Table 1. The mean patient age was 59.2 years and 107 patients (37.5%) were male. Conventional VATS was performed in 237 patients (83.2%), while needlescopic VATS was performed in 48 patients. One patient received bilateral VATS for lesions in both lungs (11). Operation procedures included lobectomy in 137 patients (48.1%), followed by wedge resection and segmentectomy.

The operative and anesthetic results are shown in Table 2. The mean duration of anesthesia induction was 34.3 minutes. Fourteen (4.9%) patients required conversion to tracheal intubation because of significant mediastinal movement [5], persistent hypoxemia [2], dense pleural adhesions [2], ineffective epidural anesthesia [2], bleeding [2], and tachypnea [1] (Table 3). Conversion to a thoracotomy was required in one patient with blood transfusion due to bleeding during dissection of pulmonary artery. After the surgery, anesthetic side effects were noted in 23 patients (8.1%) including vomiting, sore

Table 1. Clinical characteristics of the patients.

Variable	N=285
Age [y][a]	59.2±12.3 [60,19-89]
Sex (male)	107 (37.5%)
Smoking (%)	75 (26.3%)
Operation methods	
Conventional VATS	237 (83.2%)
Needlescopic VATS	48 (16.8%)
Operation procedures	
Lobectomy	137 (48.1%)
Wedge resection	132 (46.3%)
Segmentectomy	16 (5.6%)
Pathological diagnosis	
Lung cancer	159 (55.8%)
Metastatic cancer	17 (6.0%)
Benign lung tumor	104 (36.5%)
Pneumothorax	5 (1.8%)

[a]Mean ± standard deviation (median, range); VATS = video-assisted thoracoscopic surgery.

Table 2. Treatment outcome of nonintubated thoracoscopic lung resection.

Variable	N=285
Anesthetic side effects (%)	
Vomiting requiring medication (%)	12 (4.2%)
Sore throat (%)	6 (2.2%)
Headache	5 (1.8%)
Operation complications (%)	
Air leaks >5 days	6 (2.1%)
Bleeding	2 (0.7%)
Pneumonia	3 (1.1%)
Conversion to tracheal intubation (%)	14 (4.9%)
Lobectomy	10/137 (7.3%)
Wedge resection	3/132 (2.3%)
Segmentectomy	1/16 (6.3%)
Conversion to thoracotomy (%)	1 (0.4%)
Mortality (%)	0 (0%)

Table 3. Causes of conversion to tracheal intubation.

	N =14
Significant mediastinal movement	5 (35.7%)
Persistent hypoxemia	2 (14.3%)
Dense pleural adhesions	2 (14.3%)
Ineffective epidural anesthesia	2 (14.3%)
Bleeding	2 (14.3)
Tachypnea	1 (7.1%)

throat, and headache. Operation complications were noted in 11 patients (3.9%) including air leaks >5 days, bleeding, and pneumonia. No mortality or major complications were noted.

Discussion

Since the introduction of thoracoscopic surgery, intubated general anesthesia with one-lung ventilation has been considered mandatory for lung resection. To avoid intubation-related or mechanical ventilation-associated complications, thoracoscopic surgery without endotracheal intubation has recently been tried in selected patients. However, the number of patients in the published reports is small (2,6-15). This is the first report of nonintubated thoracoscopic lung resection applied in large number of patients. Our results showed that nonintubated VATS is feasible and safe for lobectomy, segmentectomy, and wedge resection.

Some concerns might arise with the use of nonintubated epidural anesthesia for pulmonary resection, especially for patients with compromised respiratory function. First, prolonged one-lung breathing during surgery could lead to hypoxia and hypercapnia in patients with already compromised respiratory function. Secondly, epidural anesthesia-associated sympathetic blockade could lead to increased bronchial tone and airway hyperreactivity. Thirdly, lung movement and inadequate lung collapse would make hilar dissection more difficult. Fourthly, conversion to general anesthesia with intubation could be required occasionally (15).

To prevent respiratory failure, we selected patients with good cardiopulmonary reserve during the learning curve of this cohort. In most of the patients, S_PO_2 was maintained at 90% or more during the whole operation. Hypercapnea was noted in some patients, especially when the surgery was long. Our experience showed that hypercapnia was permissive and did not affect the hemodynamics and surgical procedures, which was comparable to a recently published report by Dr. Dong *et al.* (12).

Increased bronchial tone and airway hyper-reactivity during manipulation of the pulmonary hilum was a major obstacle when performing nonintubated lobectomy or segmentectomy. Using simple intrathoracic vagal blockade, we found that the cough reflex could be effectively abolished, without affecting the heart rate, breathing rate, and blood pressure (15).

Although non-intubated thoracoscopic lung resection could provide an attractive alternative in managing patients with lung diseases, they should be cautious until judicious evaluation of the benefits and risks is complete. Fourteen patients (4.9%) in the nonintubated group required conversion to intubated one-lung ventilation because of significant mediastinal movement, persistent hypoxemia, dense pleural adhesions, ineffective epidural anesthesia, bleeding, and tachypnea. We suggest that proper patient selection, accumulated experience by performing minor non-intubated thoracoscopic procedures, and conversion to intubated general anesthesia without hesitation are mandatory to decrease the risk of emergency intubation and complications, especially at the beginning of the learning curve.

In our cohort, almost two third of the patients were women. We believe that nonintubated thoracoscopic surgery is most applicable in small body-sized female patients. These patients are prone to have small tracheal caliber and are susceptible to intubation-related complications such as sore throat, hoarseness, and subglottic stenosis, especially when double-lumen endotracheal tubes are used. Using the nonintubated technique, we found that the rates of postoperative sore throat were significantly decreased. It is reasonable to suggest that the incidence of hoarseness and tracheal injury could also have been lower, although they were not investigated in this study.

Many of our patients presented with an undetermined solitary pulmonary nodule when undergoing thoracoscopic surgery. A previous study showed that wedge resection of benign lung nodules can be performed by awake thoracoscopic surgery (9). One of the major concerns of the awake technique is that when the frozen section shows malignancy, the procedure must be converted to intubated general anesthesia for subsequent lobectomy. Using our nonintubated technique, both the diagnosis of the pulmonary nodules and curative resection of the lung cancer can be performed under the same type of anesthesia. Our technique extends the indication of nonintubated anesthetic technique to a wider application. A comparison among different types of nonintubated anesthesia techniques and applicable thoracoscopic procedures is provided in Table 4.

The anesthetic side effects were minimal in this patient cohort. In a previous study of intubated one-lung ventilation for thoracoscopic lobectomy, 40% of patients required medication for control of vomiting and 37% had a sore throat (15). In this study, the rates were 4.2% and 2.2%, respectively. We attribute these results to the avoidance of tracheal intubation and muscle relaxants.

We acknowledge that this study was limited by its retrospective design and the lack of a control group for comparison. Nonetheless, the low conversion rate from nonintubated to intubated anesthesia and the low complication rate indicate that nonintubated VATS can be safely performed in selected patients.

Conclusions

Nonintubated thoracoscopic lung resection is safe and technically feasible. Avoidance of intubation, mechanical ventilation, muscle relaxants, and routine use of perioperative epidural anesthesia in these patients was reflected in less intubation-associated discomfort, and immediate return to many daily life activities including drinking, eating, and walking. Nonintubated thoracoscopic surgery is a less invasive surgery than traditional thoracoscopy due to the combination of less

Table 4 Comparison among different nonintubated anesthesia techniques and the applicable thoracoscopic procedures [modified from works of Dr. Tseng *et al.* (10)].

Anesthetic techniques	Pleural diseases[a]	Wedge resection	Lobectomy or segmentectomy
Local anesthesia + IV sedation	+	+	–
Epidural anesthesia + IV sedation	+	+	–
Epidural anesthesia + IV sedation + vagal blockade	+	+	+

[a]Including pleural biopsy and management of pneumothorax and empyema; +, Technically feasible; –, Technically infeasible; IV, intravenous.

thoracic trauma and less invasive anesthesia. Although the long-term outcome and benefits remain unclear, we believe that it can be a valid alternative of one-lung ventilated thoracoscopic surgery in managing patients requiring lung resection.

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