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Case Report

Non-intubated Uniportal Subxiphoid Video-Assisted Thoracoscopic Surgery for Extended Thymectomy in Myasthenia Gravis Patients: A Case Series

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Minimally invasive strategies are increasingly popular in patients with myasthenia gravis (MG)-associated thymomas. Within the context of video-assisted thoracoscopic surgery (VATS) as a widely known minimally invasive option, the most recent achievement is uniportal subxiphoid VATS. In MG patients, it is mandatory (1) to minimize perioperative interference with administered anesthetics to avoid complications and (2) to achieve a complete surgical resection, as the prognosis essentially depends on radical tumor resection. In order to fulfill these criteria, we merged this surgical technique with its anesthesiologic counterpart: regional anesthesia with the maintenance of spontaneous ventilation via a laryngeal mask. Non-intubated uniportal subxiphoid VATS for extended thymectomy allowed radical thymectomy in all MG patients with both rapid symptom control and fast recovery.

Keywords: Non-intubated surgery, Uniportal video-assisted thoracoscopic surgery, Subxiphoid approach, Thymectomy, Myasthenia gravis, Case report

Case report

Since minimally invasive surgical strategies are becoming increasingly popular, traditional surgical approaches are gradually being replaced. For thymectomy, the transsternal approach has long been accepted as the standard surgical method, but video-assisted thoracoscopic surgery (VATS) techniques are a powerful emerging option [1]. The latest trend is uniportal subxiphoid VATS, which (1) provides a cinematographic view of the anterior mediastinum and therefore enables radical thymectomy, (2) avoids intercostal nerve damage and therefore reduces postoperative pain, and (3) leads to a faster recovery and therefore lowers expenses [2,3]. In patients with myasthenia gravis (MG)-associated thymomas, it is not only mandatory to achieve complete surgical resection—as the prognosis essentially depends on anatomical radicality—but also to minimize perioperative interference with the administered anesthetics [4,5]. In order to further enhance the beneficial effects of minimal invasiveness, we merged this surgical technique with its anesthesiologic counterpart (regional anesthesia with the maintenance of spontaneous ventilation via a laryngeal mask). Herein, we present our initial experience with this novel combination.

Patients' preoperative data are presented in Table 1. All patients were diagnosed with generalized MG roughly 3 months preoperatively. During the course of the diagnostic process, a chest computed tomography scan revealed a mass in the anterior mediastinum (Fig. 1A). The patients were thoroughly evaluated preoperatively by thoracic surgeons, neurologists, and anesthetists. The main exclusion criteria were bleeding disorders, sleep apnea, body mass index >30 kg/m^2, abnormal blood gases (partial pressure of CO_2 or O_2), American Society of Anesthesiologists grade >II, Masaoka stage >2, preoperative treatment with evidence of potential pleural adhesions, and a possibly difficult airway situation for intubation. Patient consent was obtained.

Anesthesia was performed using (1) dexmedetomidine with an initial dose of 3 μg/kg/hr for 10 minutes followed by a maintenance dose of 1 μg/kg/hr, (2) propofol (2–5 mg/kg/hr), and (3) remifentanil (0.01–0.05 μg/kg/min). The depth of anesthesia was measured using a bispectral index (BIS)

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Table 1. Perioperative data

Characteristic	Patient #1	Patient #2	Patient #3
Preoperative findings			
Age (yr)	20	41	35
Sex	Female	Female	Female
Body mass index (kg/m^2)	29.7	22.6	26.2
FEV_1 (%)	100.3	107.7	75.3
MGFA clinical classification	IIA	IIA	I
Anti-AchR antibodies (nmol/L)	41.50	0.93	84.50
MuSK antibodies	Negative	Negative	Negative
Titin antibodies	Negative	Negative	Negative
Accompanying illnesses	None	pSS	None
Preoperative QMGS	6	5	3
Intraoperative findings			
Operative time (min)	156	122	104
Lowest detectable mean SpO_2 (mm Hg)	83.7	77.1	81.3
Mean peak $EtCO_2$ (mm Hg)	43.7	41.8	42.5
Intraoperative blood loss (mL)	90	75	50
Postoperative findings			
Duration of chest tube drainage (day)	2	1	2
Duration of ICU-stay (day)	1	1	1
Amount of pleural effusion (mL)	600	100	520
Postoperative stay (day)	5	5	5
NRS (postoperative day 1)	7	5	4
NRS (postoperative day 3)	2	2	2
NRS (postoperative day 7)[a]	0	0	0
Follow-up (mo)	12	12	8
QMGS (on follow-up)	1	2	1
Histopathological findings			
Weight of resected specimen (g)	179	172	88.7
Maximum diameter of the tumor (cm)[b]	6.5/6.0/1.8	5.5/5.7/1.5	8.5/5.5/1
Maximum extent of the specimen (cm)[b]	22.0/14.5/2.0	26.0/16.6/1.5	17.5/8.5/2.2
Tumor biology	LTH	LTH	LTH

FEV_1, forced expiratory volume in 1 second; MGFA, Myasthenia Gravis Foundation of America; AchR, acetylcholine receptor; MuSK, muscle-specific tyrosine kinase; pSS, primary Sjögren's syndrome; QMGS, quantitative myasthenia gravis score; SpO_2, saturation of peripheral oxygen; $EtCO_2$, end-tidal CO_2; NRS, Numerical Rating Scale; LTH, lympho-follicular thymic hyperplasia.
[a]Values measured in outpatient area. [b]Length/width/height.

monitoring system with a target BIS value of 45–60. In order to maintain continuous oxygen saturation >95%, a laryngeal mask was inserted for spontaneous ventilation with 100% inspired oxygen (4–5 L/min). Along with epidural anesthesia with 0.2% ropivacaine, the intended skin incision field was infiltrated with 0.375% ropivacaine and 1.00% lidocaine (mixing ratio 1:1). After incision of the pleura, 10 mL of 2% lidocaine was sprayed on the lung surface under thoracoscopic guidance.

Briefly, the surgical approach, which has been described in more detail elsewhere [6], involved the following steps (Fig. 1B): (1) making a 3-cm vertical subxiphoid incision; (2) removing the xiphoid process; (3) performing blunt manual dissection of the anterior mediastinum; (4) placing a sternal retractor underneath the sternum to elevate the sternum from below and hence facilitate enhanced access; (5) using a flexible wound retractor to keep the incision open; (6) opening the right-side mediastinal pleura; (7) dissecting the pericardial and epiphrenic fat pad, with the phrenic nerve being the dorsal boundary of dissection; (8) proceeding upwards to the level of the internal thoracic vein in an en-bloc fashion, avoiding any attempt to dissect the thymus gland separately (Fig. 1C); (9) skeletonizing the superior vena cava, both innominate veins, and the aorta; (10) dividing the upper poles close to the thyroid gland; (11) dissecting along the left phrenic nerve similarly; (12) placing the specimen in an Endobag and removing it via the subxiphoid incision (Fig. 1D); and (13) inserting a chest tube (Fig. 1E).

Perioperative data are listed in Table 1. The mean overall

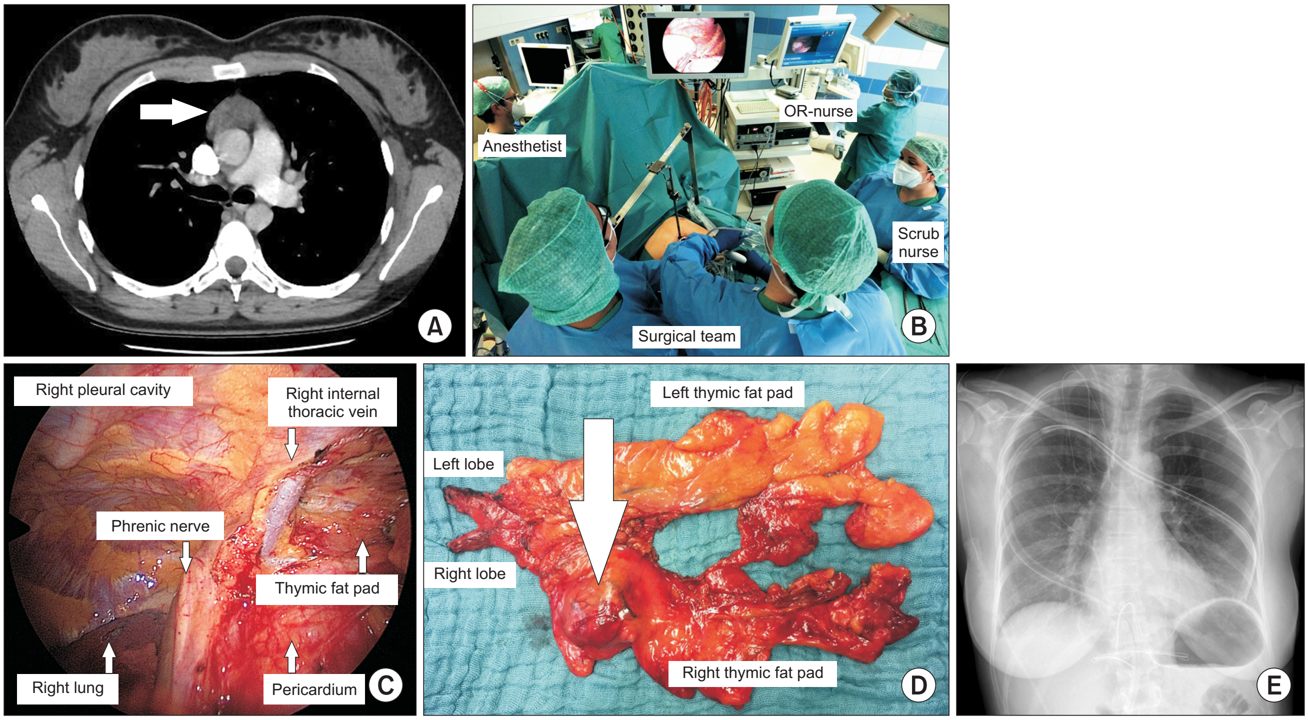

Fig. 1. (A) Representative preoperative computed tomography scan presenting the thymic mass (arrow). (B) Arrangement of the surgical team (surgeon with the assistant on the patient's right, scrub nurse on the opposite side). (C) Thoracoscopic image: dissecting the pericardial fat pad alongside the phrenic nerve, offering straight access to the junction between the innominate vein and the superior vena cava in order to dissect and divide the thymic veins. (D) Representative thymic mass (arrow) and surrounding thymic fat tissue. (E) Representative postoperative X-ray demonstrating the position of the chest tube, which makes a sweeping arc from the right into the left chest cavity.

operative time was 127 minutes (range, 104–156 minutes). The lowest detectable intraoperative saturated oxygen level was 77.1 mm Hg, with a mean peak end-tidal carbon dioxide of 41.8 mm Hg. No conversion to intubated ventilation was required. Intraoperative blood loss was negligible. The mean chest tube duration was 1.7 days. The postoperative pain intensity was low. The overall hospital stay was 5 days. A histological examination revealed lympho-follicular thymic hyperplasia in all patients, and extended thymectomy was confirmed by the volume of the resected specimens. Quantitative MG scores decreased with improved MG status during follow-up. Short-term follow-up was uneventful, with neither tumor recurrence nor myasthenic crisis.

The patients provided written informed consent for the publication of their clinical details and images.

Discussion

Merging surgical and anesthesiologic minimally invasive strategies in MG patients has various benefits. A prerequisite for any resection of thymic tissue is a thorough knowledge of its ectopic occurrence. A special emphasis is placed on (1) the broad distribution pattern of ectopic thymic tissue (i.e., anterior mediastinal fat, pericardiophrenic angles, aortopulmonary window, and cervical region with pretracheal fat) and (2) the lack of effective preoperative imaging techniques to localize ectopic thymic tissue [4]. Radical thymectomy should therefore target complete removal of all possible thymic tissue containing mediastinal fat tissue, as the course of MG might remain unchanged with persisting symptoms due to incomplete surgical resection.

The uniportal subxiphoid approach allowed exceptional thoracoscopic visualization of the entire anterior mediastinum up to the lower cervical area, facilitating radical resection of all potential thymic tissue holding fat tissue [3,7]. The sternum retractor is an impeccable tool for achieving broad vision with no need for additional CO_2-insufflation, as the latter carries its own risks in non-intubated VATS procedures [8]. Access to the junction between the innominate vein and superior vena cava is straightforward, enabling safe isolation and division of the thymic veins. No concomitant surgical damage, such as unintended vessel laceration or phrenic nerve injury, occurred. As this approach avoids impairment of the intercostal neurovascular

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bundle, the postoperative pain intensity was low, and patients' recovery was therefore accelerated. Separate from the question of surgical convalescence alone, quantitative MG scores decreased with improved MG status during follow-up.

To guarantee both adequate access and visualization for non-intubated uniportal subxiphoid VATS thymectomy, it is necessary to create a bilateral iatrogenic pneumothorax. Opening both pleural cavities inevitably leads to (1) hypoventilation, (2) decrease of pulmonary perfusion, (3) decrease of functional residual capacity, and (4) hypercapnia [9]. An inserted laryngeal mask can mitigate these adverse effects by (1) administering a higher concentration of inspired oxygen, (2) enhancing the monitoring of end-tidal carbon dioxide and facilitating its removal, and (3) providing pressure-support ventilation [10].

A consequence of avoiding muscle relaxants is unaffected neuromuscular transmission, thereby decreasing the risk of perioperative respiratory failure [8,11]. None of our patients' vital parameters were compromised intraoperatively. As the acts of intubation and extubation were avoided, postoperative dysphagia, sore throat, irritating cough, and increased sputum could be prevented [5]. In addition, omitting endotracheal intubation avoided intubation-related complications, such as (1) mucosal ulceration and laryngeal/tracheal injuries, (2) shear stress of the alveoli induced by elevated airway pressure, and (3) release of proinflammatory mediators [11]. Vagus nerve blocking was not necessary. To reduce irritation of the visceral pleura and thereby keep the operative field stable, spraying 10 mL of 2% lidocaine on the lung surface was sufficient.

The general benefits and risks of both non-intubated anesthesia and uniportal subxiphoid VATS was discussed thoroughly with each patient. As non-intubated techniques require experience, preparation, and vigilance, patient selection must be carefully performed. Contraindications to non-intubated VATS can be divided into patient, anesthetic, and surgical contraindications (Table 2) [10,12]. With growing expertise in this technique, the patient population has expanded to those in whom the avoidance of mechanical ventilation is beneficial (i.e., elderly patients and those with severe emphysema, interstitial lung disease, or MG) [10]. Special attention was paid to laryngeal mask–associated complications, such as mask dislocation, gastric insufflation, or reflux. The side effects of intraoperative epidural anesthesia (i.e., sympathetic blockade-induced hypotension, bradycardia, and urinary retention) were negligible on the basis of its short-term use.

Although the risk of conversion to intubated general anesthesia is low, a conversion protocol should be prepared in advance. The main reasons for conversion include surgical factors (e.g., bleeding, poor surgical field, hypoxia, hypercarbia, or hemodynamic instability) and patient factors (e.g., cough, inadequate analgesia, or patient discomfort). The vast majority of bleeding events are controllable by simple compression. In case of uncontrollable bleeding, immediate general endotracheal anesthesia and thoracotomy might be required. As the patient is already positioned supine on the operating table, rapid intubation is no problem. Bronchial blocker placement if 1-lung ventilation is necessary is likewise straightforward. Epidural analgesia is prerequisite for any consistent pain control. The cough reflex might be stimulated by an increased airway hyper-reactivity as a result of epidural anesthesia-induced sympathectomy [10]. To resolve this issue, remifentanil and dexmedetomidine both act as antitussives and have little

Table 2. Contraindications for non-intubated video-assisted thoracoscopic surgery

	Contraindications
1. Patient	
A. Absolute	Hemodynamic instability Inability to tolerate one lung ventilation Patient noncompliance Lung isolation required to prevent contamination Coronavirus disease 2019 High risk of aspiration High intracranial pressure Patient refusal Pulmonary hypertension Uncontrolled systemic hypertension Risk for arrhythmias
B. Relative	Obesity Obstructive sleep apnea Persistent cough or secretions Resting hypoxemia or hypercarbia Neurologic conditions such as dementia
2. Anesthetic	
A. Absolute	Anticipated difficult airway Allergy to local anesthetics/sedatives
B. Relative	Coagulopathy (INR >1.5) Spinal deformities
3. Surgical	
A. Absolute	Inexperienced team Extensive pleural adhesions Prior talc pleurodesis Contralateral phrenic nerve paralysis
B. Relative	Previous thoracotomy Large, centrally located tumors Prior radiation therapy

From Gelzinis T. Curr Anesthesiol Rep 2021;11:1-9 [10].
INR, international normalized ratio.

effect on hypoxic pulmonary vasoconstriction. Using a laryngeal mask prevents most other respiratory insufficiencies [10].

Compared internationally, the postoperative hospital stay was rather extended for the following reasons: (1) the accounting system of German health insurance provides minimum and maximum lengths for in-hospital stays, and (2) German outpatient care is—again on the basis of health insurance issues—somewhat underdeveloped. Theoretically, much shorter in-hospital stays (e.g., roughly 3 days) would have been possible.

Non-intubated uniportal subxiphoid VATS for extended thymectomy in patients with MG was safely accomplished with both rapid symptom control and fast recovery. This technique might be a valuable tool to reduce the postoperative incidence of myasthenic crisis and prevent intubation-related complications. A larger sample size and longer follow-up period would be necessary to further confirm the effectiveness of this technique.

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Conflict of interest

No potential conflict of interest relevant to this article was reported.

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