EVALUATION OF FEASIBILITY AND SAFETY OF NON-INTUBATED ANESTHESIA VIDEO-ASSISTED THORACOSCOPIC THYMECTOMY FOR MYASTHENIA GRAVIS

Trinh Ke Diep[1,2,3], Pham Huu Lu[1,2], Nguyen Quoc Kinh[1,3]
Nguyen Thi Thuy[1], Duong Duc Hung[1,3,✉]

[1]Viet Duc University Hospital
[2]Hanoi Medical University
[3]VNU University of Medicine and Pharmacy

Video-assisted thoracoscopic surgery (VATS) thymectomy is a well-established treatment for Myasthenia gravis (MG). However, traditional VATS thymectomy uses general anesthesia with endotracheal intubation, which can worsen MG symptoms. This study evaluated the feasibility and safety of non-intubated anesthesia VATS for patients with MG to solve this issue. It was a prospective, descriptive study involving six patients aged 18 to 60, ASA I, II, who underwent VATS thymectomy under non-intubated anesthesia and local anesthesia at Vietduc University Hospital between May 2022 and December 2023. The induction time was short, ranging from 3 to 4.5 minutes. The median of Peak PaCO2 and EtCO2 were 42.5 mmHg (range 33-49 mmHg) and 46.4 mmHg (range 44-48 mmHg), respectively. The median values of PaO2 and SpO2 during one-lung ventilation were 161.1 mmHg (range 82-206.9 mmHg) and 98% (range 93-99%). The lungs collapsed well, and breathing and circulation remained stable. No complicationarose, and all patients recovered well. These initial findings suggest that non-intubated anesthesia is a safe and straightforward option for MG thymectomy

Keywords: Non-intubated, Video-assisted thoracoscopic surgery, Myasthenia gravis.

I. INTRODUCTION

Myasthenia gravis, an autoimmune condition, causes muscle weakness and fatigability of skeletal muscles. This disease occurs due to a malfunction at the neuromuscular junction, where nerves communicate with muscles. In MG, antibodies attack proteins crucial for this communication, leading to muscle weakness.[1] The thymus gland, which is behind the breastbone, is often implicated in MG. Sometimes, the thymus harbors abnormal cells or antibodies, triggering the autoimmune response. Thymectomy, surgical removal of the thymus, is a well-established treatment for MG, particularly in younger patients with generalized weakness.[2,3]

Minimally invasive video-assisted thoracoscopic surgery (VATS) has become the preferred approach for thymectomy due to its smaller incisions, reduced pain, and faster recovery. However, traditional VATS relies on endotracheal intubation. Intubation can worsen MG symptoms by further impairing neuromuscular transmission. Additionally, muscle relaxants used during surgery can exacerbate postoperative weakness in MG patients and need prolonged respiratory support during the postoperative period.[4]

Non-intubated VATS (NI-VATS) thymectomy is an emerging technique that avoids these

Corresponding author: Duong Duc Hung
Viet Duc University Hospital
Email: duongdh38@yahoo.com
Received: 09/05/2024
Accepted: 08/07/2024

drawbacks. NI-VATS utilizes advanced anesthesia techniques to maintain spontaneous breathing throughout the procedure.[5,6] This anesthesia method could minimize the risk of worsening MG symptoms and allow faster recovery. Airway management during non-intubated anesthesia includes cannula oxygen, face mask, High-flow nasal cannula (HFNC), and Laryngeal mask airways (LMA). We chose LMA for the following reasons: better airway management, accurate tidal volume (VT) and End-tidal carbon dioxide (ETCO2) measurement, and use of anesthetic gas, ventilation, and intubation when needed.

This case series presents the successful application of NI-VATS thymectomy in six patients with MG. We then evaluate the possibility of a non-intubated method in anesthesia VATS for patients with Myasthenia gravis.

II. PATIENTS AND METHODS

1. Study Design

A prospective, descriptive study was conducted on 6 consecutive patients diagnosed with MG who underwent NI-VATS thymectomy at the Center of Anesthesia and Surgical Intensive Care, Viet Duc University Hospital, between May 2022 and December 2023.

2. Patients

Patients: Aged 18 - 60 years. American Society of Anesthesiologists (ASA) is no more than III. The respiratory and circulatory systems work well (EF above 50% and FEV1% above 50% of the expected value), and all essential organs function normally.

Exclusion criteria: Decline the surgery and anesthesia protocols. Associated severe acute pulmonary infection or tuberculosis. BMI >30. Coagulopathy, elevated risk of aspiration (<6 hours of fasting), hypoxemia (PaO_2 <60 mmHg), or hypercapnia ($PaCO_2$ >50 mmHg) preoperatively; neurological disorders. Persistent cough or high airway secretion, complex airway management. Extensive pleural adhesions, inexperience, and poorly cooperative surgical team. Previous ipsilateral surgery. Patients with Myasthenia Gravis Foundation of America (MGFA) clinical classification between III and V.

Research Sampling and Sample Size:

Convenient Convenience sampling, we selected all patients eligible for the study. Six patients meet this criterion of the study during the study period.

***Anesthesia Setting*:**

Erector Spinae Plane block with 20 ml ropivacaine 0.25% was performed before anesthesia. *Induction of anesthesia:* Target-controlled infusion (TCI) of propofol 2–4.0 µg/mL and fentanyl 1– 2 µg/kg was selected. Laryngeal mask airways LMA ProSeal (Teleflex) was inserted when the BIS value was between 40 and 60. muscle relaxants were not included. *Maintenance of anesthesia:* TCI of Propofol and fentanyl 1-2 µg/kg was adjusted to keep index (BIS) at 40–60. Propofol was stopped immediately after the beginning of closing the chest wall. Oxygen (FiO_2 adjusted between 50% and 100%) was provided through the LMA at 4 l/min. During the anesthesia period, if SpO_2 gradually decreased to below 90% or $PaCO_2$ was ≥60 mmHg, the infusion rates of anesthetics was adjusted first, followed by low-pressure support (8 $CmHO_2$); if hypoxemia or hypercapnia persisted despite the above treatment, intubation would be initiated; Intraoperative physiologic monitoring includes blood gas analysis, continuous monitoring of electrocardiogram (ECG), heart rate (HR), blood pressure (BP), pulse oxygen saturation (SpO_2), respiratory rate (RR), and pressure of end-tidal carbon dioxide ($EtCO_2$) machine to enable spontaneous breathing. Oxygen (4–5 L/min). Support ventilation (PSV) was used to prevent lung collapse and support breathing at the end of the operation'. Propofol was discontinued immediately after skin closure and patients were extubate when the tidal volume of spontaneous breathing was above 5 ml/kg (ideal body weight), and BIS was above 80.

Surgical Technique:

All procedures were performed with a 5 cm skin incision in the right mid-axillary line to access the chest cavity. Thoracoscopic instruments and a video camera were inserted through this incision to visualize the thymus gland. The thymus was carefully dissected and removed entirely. The surgical field was inspected for any bleeding, and chest tubes were placed for drainage before closing the incision.

***Data Collection**:*

Patient demographics: Age, American Society of Anesthesiologists (ASA), sex, weight, height, medical history; MG severity: Myasthenia Gravis Foundation Classification (MGFC) score; Ventilation and blood oxygenation status: PO_2, PCO_2, $EtCO_2$ levels, lactate; anesthesia details: Induction time, Lung collapse score, intraoperative complications; Postoperative outcomes: Length of hospital stay, postoperative pain scores, complications (e.g., bleeding, infection, myasthenic crisis).

Statistical Analysis:

The researchers used SPSS version 22.0 to analyze their data. All data were looked at using quantitative and categorical data qualitative. Tests like t-tests and Pearson correlation coefficients were used for quantitative variables. For qualitative variables, we used Chi-Square tests, Fisher's exact tests (for small samples), Phi coefficient, and Cramer's V to determine if there were any significant associations. A P-value less than 0.05 was considered a statistically significant difference between values.

3. Ethical Issues in Research

The research has the purpose of protecting and improving patients' health and has no other purpose; it was conducted with the patient's consent. They will be treated (if there are unwanted effects) and consulted about research issues, and we will keep confidential the information provided by patients. The study was approved by the ethics committee of Viet Duc University Hospital (Mars 21st, 2022) and Hanoi Medical University (Ref 659/GCN-HĐĐĐNCYSH-ĐHYHN dated June 7th, 2022).

III. RESULTS

Table 1. Clinical Characteristics of the Patients

	Patient 1	**Patient 2**	**Patient 3**	**Patient 4**	**Patient 5**	**Patient 6**	**Value N (%)/ Median (Min-Max)**
Myasthenia gravis classification (MGFA) (before operation)	I				I	I	3 (50%)
		IIa		IIa			2 (33.3%)
			IIb				1 (16,7%)

	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Patient 6	Value N (%)/ Median (Min-Max)
Sex Female	+		+	+	+		4 (66.7%)
Male		+				+	2 (33.3%)
Age	54	58	48	28	43	28	45.5 (28-58)
Smoking status	No	No	No	No	No	No	6 (100%)
BMI (Body mass index) (kg/m^2)	19.7	22.0	23.1	17.2	21.9	21.6	21.8 (17.2-23.1)
ASA score		1		1	1		3 (50%)
	2		2			2	3 (50%)

Table 1 shows thatmost patients (3, or 50%) have MGFA class I (only eye muscle weakness), 2 patients (33.3%) have Class IIa (mild generalized weakness), and 1 with Class IIb (moderate generalized weakness), a slight majority (4, or 66.7%) of female patients. The median age is 45.5 years (range 28–54 years). All 6 patients (100%) are non-smokers. The average BMI is 21.8 kg/m^2 (range 17.2- 23.1 kg/m^2). Almost all patients fall within the normal BMI range (18.5 to 24.9 kg/m2). Three cases (50%) have an ASA score of 2, indicating mild systemic disease. The other 3 patients (50%) have an ASA score of 1, indicating no systemic disease.

Table 2. Anesthetic Procedures

	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Patient 6	Value N (%)/ Median (Min-Max)
Anesthetic induction duration (min)	3.5	3	3	3	4	4.5	3.3 (3-4.5)
In-room SpO_2 (%)	97	99	97	98	98	98	98 (97-99)
Average intraoperative FiO_2	58.2	62.8	56.4	57.3	55.8	56.3	56.9 (55.8-62.8)
Lowest SpO_2 during operation, %	98	93	98	99	97	99	98 (93-99)
Highest FiO_2 during operation, %	60	80	60	50	65	60	60 (50-80)
Peak $EtCO_2$ during operation, mmHg	44	48	45	47	48	46	46.5 (44-48)

	Patient 1	**Patient 2**	**Patient 3**	**Patient 4**	**Patient 5**	**Patient 6**	**Value N (%)/ Median (Min-Max)**
Arterial blood gas (ABG) data before one-lung breathing							
pH	7.5	7.47	7.47	7.47	7.46	7.35	7.4 (7.35 - 7.5)
PaO2 (mmHg)	278.4	190.9	227.3	348	534.1	317.9	298.2 (190.9-534.1)
PaO_2/FiO_2	463.9	381	378.9	580	593.4	529.8	496.85 (381-593.4)
$PaCO_2$ (mmHg)	30	37	32	32	39	40	34.5 (32-39)
Lactate (mmol/l)	2.1	2.2	1.7	1.6	2.4	1.7	1.9 (1.6-2.4)
Arterial blood gas data during one-lung breathing							
pH	7.48	7.34	7.4	7.4	7.41	7.35	7.4 (7.34-7.48)
PaO_2 (mmHg)	170.8	82	88.1	206.9	151.4	282	161.1 (82-206.9)
PaO_2/FiO_2	284.7	164	304.5	345	256.6	470	294.6 (164-470)
$PaCO_2$ (mmHg)	34	45	33	42	49	43	42.5 (33-49)
Lactate (mmol/l)	2	1.6	1.8	1.1	2	0.7	1.7 (0.7-2)
Post-operative data of arterial blood gas							
pH	7.5	7.4	7.41	7.42	7.41	7.36	7.4 (7.36-7.5)
PaO_2 (mmHg)	269.9	86	84	165.3	249.8	201.9	183.6 (84-269.9)
PaO_2/FiO_2	770.3	409.5	405.6	787.1	711	966.3	740.7 (405.6-966.3)
$PaCO_2$ (mmHg)	33	40	36	38	38.5	39.5	38.3 (33-40)
Lactate (mmol/l)	2	1.6	1.3	0.8	1.5	0.8	1.4 (0.8-2)

The anesthetic induction time was short, with a median of about 3.3 minutes and a range (of 3-4.5 minutes). All patients maintained good oxygen saturation (SpO_2) above 97% preoperation (Table 2).

Arterial blood gas data changed clearly during the anesthesia process. $PaCO_2$ increased (Highest 49 mmHg) when one lung was breathing, and PaO_2 decreased (lowest 82 mmHg). Median of lactate tended to decrease (from 1.9 (1.6-2.4) to 1.7 (0.7-1.6)) when one-lung was functionning. All data was in the safe range, and the parameters were almost identical as in preoperation (table 2). The median of the highest level of FiO_2 intraoperative was 60% (range 50 - 80%). The median of the lowest SpO2 during the operation of 6 patients was 98% (range 93-99%). The median of the highest $EtCO_2$ during operation was 46 mmHg (range 44- 48 mmHg).

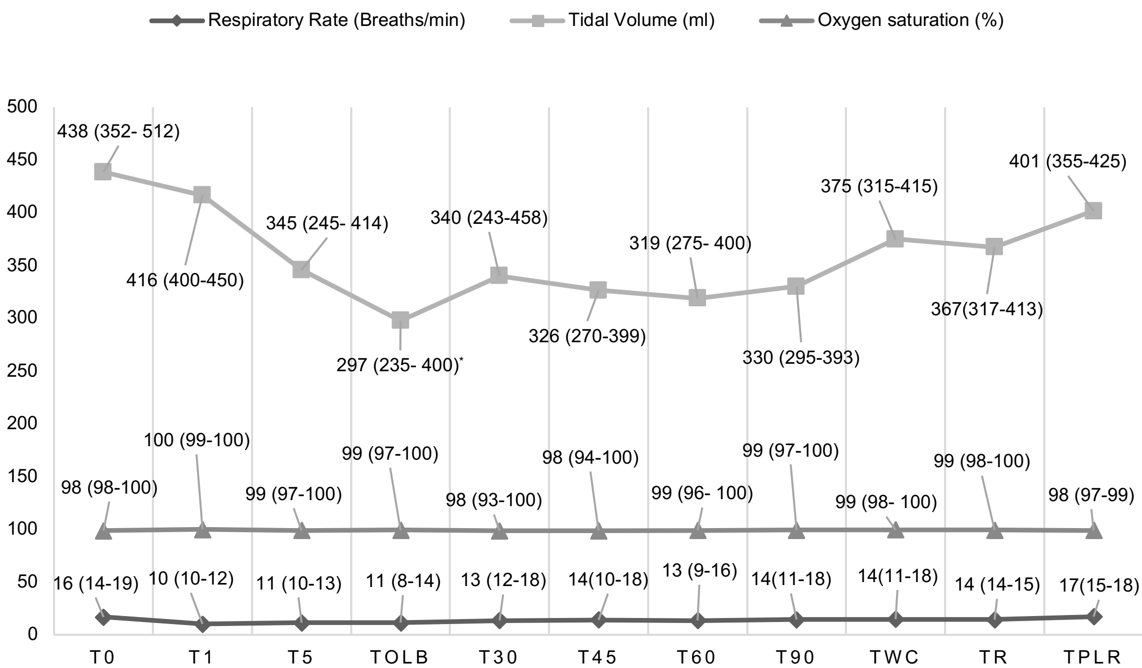

Figure 1. Changing in breathing frequency, tidal volume, and SpO2 intraoperative

Continuous data are presented as mean (Min-Max), T0= Preoperation, T1= Before LMA insertion, T5= 5 minutes after LMA Insertion, TOLB- One lung breathing, T30= 30 minutes after one lung breathing, T45= 45 minutes after one lung breathing, T60= 60 minutes after one lung breathing. T90= 90 minutes after one lung breathing, TWC= Wound closure, TR= Before LMA Removal, TPLR= 5 mins Post LMA Removal, *P < 0.05. Tidal volume (VT) was reduced after one-lung breathing and two-lung ventilation (before LMA insertion) (< 0.05). Respiratory rate (RR) and SpO2 were within allowable limits and did not change statistically significantly between time points (Figure 1).

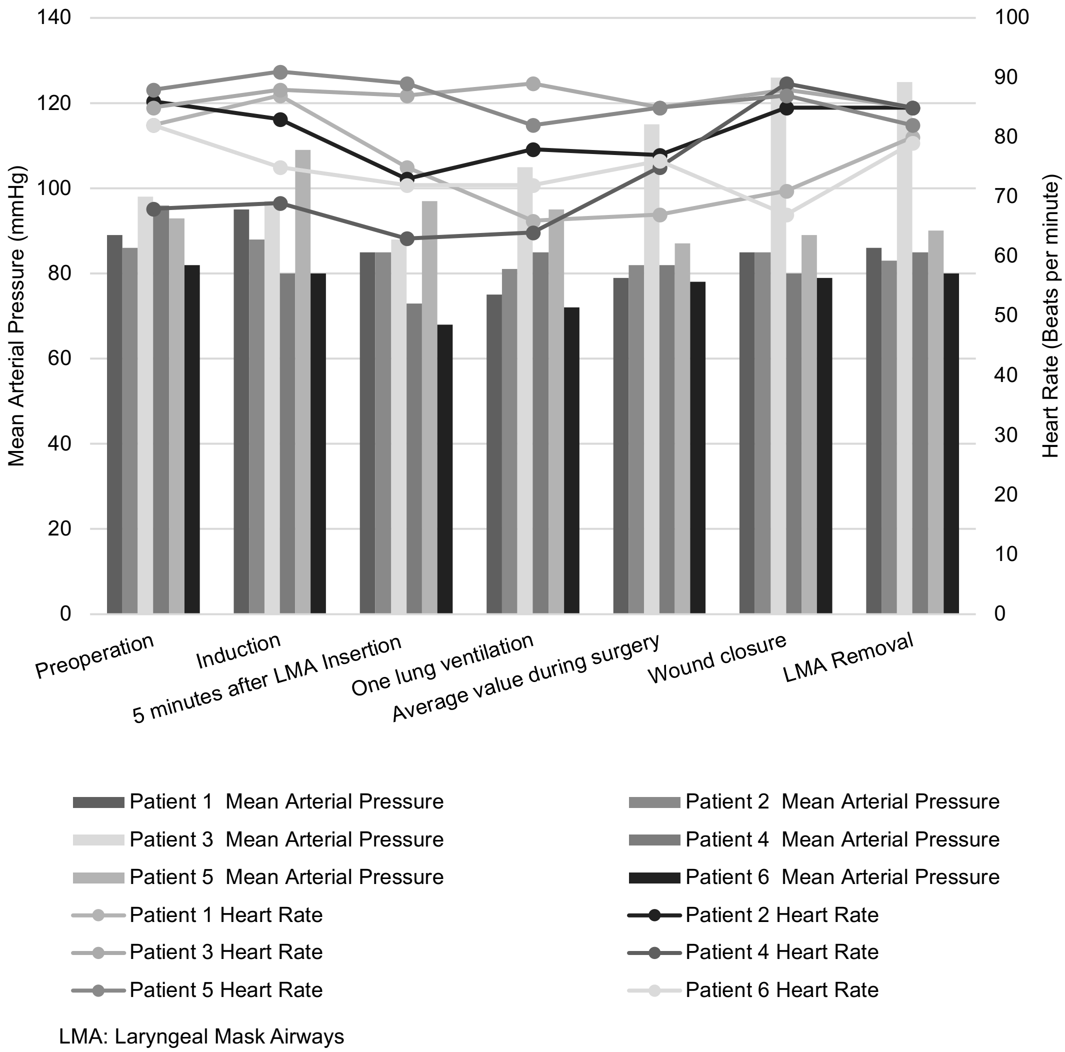

Figure 2. Heart rate and Mean Blood Pressure Intraoperative

Figure 2 shows mean arterial pressure (MAP) and heart rate (HR). Both heart rate and mean blood pressure decreased slightly during the induction phase and were stable during surgery. The measured hemodynamic parameters were within allowable limits. There was no statistically significant difference ($p > 0.05$) between stages during surgery.

Table 3. Operative Procedures

	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Patient 6	Value Median (Min-Max)
Lung collapse scores after pleural cavity opening at 10 minutes and 30 minutes							
10 min	8	7	8	6	7	6	7 (6-8)
30 min	9	9	9	8	9	8	9 (8-9)

	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Patient 6	Value Median (Min-Max)
Surgical duration (min)	75	85	61	142	55	75	75 (55-142)
Conversion to intubated	No	No	No	No	No	No	0
Conversion to thoracotomy	No	No	No	No	No	No	0

The lung collapse score shows the degree of lung collapse; the lung is a complete collapse, when the score is 10 points. Conversely, non-collapsed lungs are at zero point. The more collapsed lung, the better the operating conditions. Lung collapse scores at 10 minutes and 30 minutes after skin incision were 7 (range 6-8) and 9 (range 8-9), respectively (10 means the lung was completely collapsed) (Table 3).

Surgical duration varied significantly (median 75 minutes, range 55-142 minutes). There was no conversion to intubated ventilation or thoracotomy during surgery (Table 3).

Table 4. Postoperative Recovery and Treatment Outcomes

	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Patient 6	Value N (%)/ Median (Min-Max)
Anesthetic side effects							
Vomiting	No	No	No	No	No	No	0
Sore throat	No	No	No	No	No	No	0
Headache	No	No	No	No	No	No	0
Delirium	No	No	No	No	No	No	0
Air leak >3 days	No	No	No	No	No	No	0
The peak of post-op pain intensity on a visual analog scale							
Day 1	2	4	4	3	3	3	3 (2-4)
Day 3	2	2	2	3	2	3	2 (2-3)
Day 5	1	1	2	1	1	1	1 (1-2)
Chest tube drainage (days)	3	3	2	3	3	3	3 (2-3)
Postoperative hospital stay (days)	4	4	3	7	6	5	4.5 (3-7)

Postoperative adverse events are shown in Table 4. None of the patients experienced side effects, such as Sore throat, Vomiting, Headache, Delirium, and Air leaks for more than 3 days. Using a Visual Analog Scale (VAS) to measure patient's Pain intensity, likely ranging from 0 (no pain) to 10 (worst pain imaginable). The table shows average pain scores for each patient on Day 1, Day 3, and Day 5 after surgery. Overall, pain scores appeared moderate (between 2 and 4) and decreased over time (highest on Day 1 and lowest on Day 5). Chest tube drainage and hospital stay durations were relatively short: 3 days (range 2-3 days) and 4.5 days (range 3-7 days).

IV. DISCUSSION

Table 1 shows the patients demographics in the study. Among these patients, the majority (50%) exhibited MGFA Class I, characterized by solely ocular muscle weakness, followed by 33.33% with Class IIa (mild generalized weakness) and 16.67% with Class IIb (moderate generalized weakness). This distribution aligns with the known spectrum of MG severity, with ocular manifestations predominant in the early stages. Regarding gender distribution, there was a slight predominance of female patients, comprising 66.67% of the cohort. This observation is consistent with existing literature indicating a higher prevalence of MG among women.[1]

General anesthesia with tracheal intubation is widely used in thoracic surgery because it improves surgical safety. However, this technique cannot avoid complications of tracheal intubation, and medications used, especially neuromuscular blocking during anesthesia for MG patients, may cause prolonged mechanical ventilation and failure to remove the endotracheal tube after surgery. NI-VATS can avoid the side effects of that traditional method. NI-VATS keeps the patient spontaneously breathing without needing a double-lumen tube or an endobronchial blocker, ensuring patient safety in a spacious surgical field with wakefulness, conscious sedation, or deep sedation. This method is a safe and feasible technique applied in several surgical centers. It reduces complications related to tracheal intubation and anesthetics drugs used and enhances recovery after thoracic surgery.[5,6] In our study, we performed Non-intubated thymectomy for MG patients; the anesthetic induction time was notably short, with a median value of approximately 3.3 minutes (table 2). We placed the LMA right after the BIS reaches about 40 to 60. This time was much shorter than anesthesia methods with endotracheal intubation[7] using muscle relaxants due to the waiting time necessary for the effects of muscle relaxants and technique. Insertion of an endotracheal tube, especially a double-lumen tube or bronchial blocker, is more complicated and requires extra time to determine the correct position. Short induction time contributes to short anesthesia time and may reduce the risk of complications during and after surgery.

Table 2 shows that the median of the lowest SpO_2 during the operation was 98% (range 93-99%), the median of the lowest PaO_2 and PaO_2 /FiO_2 were 161.1 mmHg (range 82- 282 mmHg) and 294.6 mmHg (range 164- 470 mmHg), the median of the highest $EtCO_2$ during the operation was 46.5 mmHg (range 44-48 mmHg), median of $PaCO_2$ was 42,5 mmHg (range 33- 49 mmHg), indicating adequate ventilation, CO_2 elimination achieved and good blood oxygenation status. Some studies comparing tubeless anesthesia and endotracheal tubes (using a double-lumen endotracheal tube or a bronchial block) have shown that blood oxygenation is improved in the tubeless group.[8] One of the reasons is when the patient breathes spontaneously in a tilted position (without using muscle relaxants), the V/Q ratio is preserved because the lower lung is better perfused due to the influence of gravity. It is also well-ventilated because of better diaphragmatic contraction and better expansion when using muscle relaxants and mechanical ventilation. Anesthesia without intubation can include a Face mask, High-flow nasal cannula (HFNC) oxygen, or the use of LMA. When using LMA, it will be advantageous when hypoxemia or excessive hypercapnia can be artificially ventilated or intubated through LMA. However, these changes are within safe limits and does not pose significant clinical concerns. Furthermore, when one lung breathes, lactate levels decrease, showing adequate tissue perfusion and even better than one lung ventilation. This can be explained according to the Bohr effect: in organs with much CO_2, HbO_2 causes more oxygen to be given to tissues, improving tissue perfusion.

Figure 1 indicates that RR, VT, and SpO_2 were within acceptable limits during the surgery. Despite a decrease in Vt, it remained above the minimum of 4 ml/kg ideal body weight, within the permissible range. We used fentanyl during surgery, which inhibited the patient's breathing rate. As such, RR did not change when compared with 2-lung breathing.

The study shows evidence of hemodynamic stability throughout NI-VATS for MG patients undergoing thymectomy (Figure 2). We have not seen any study on non-intubated anesthesia for thoracic surgery that describes intraoperative hemodynamic changes, and there is no hemodynamic complication. Thus, the stable MAP and HR profiles observed during anesthesia and surgery underscore the safety and considerations of this approach in managing MG.

Median lung collapse scores at 10 and 30 minutes after skin incision revealed satisfactory results, with 7 (range 6-8) and 9 (8-9) (Table 3), respectively. This result was similar to Narayanaswamy et al., who used endotracheal intubation and one-lung mechanical ventilation. The author pointed out that bronchial blockers (BBs) required longer and intraoperative repositioning more often. The Arndt bronchial blockers needed to be repositioned more often than the other BBs[9] Our research group's patients used LMA, making it easy to place without needing a flexible endoscope. These findings suggest that LMA is easy and effective for lung isolation and collapse and facilitates optimal surgical exposure and access while minimizing the risk of intraoperative-related complications to lung manipulation.

The duration of surgery varied significantly among patients, with a median of 82.2 minutes (range 55- 142 minutes) (Table 3). Vo Van Hien et al. (2020) performed general anesthesia with an endotracheal tube for thymectomy in 90 patients with myasthenia gravis divided into 2 groups (using sevoflurane and propofol), 115.7 ± 33.5 minutes and 127.5 ± 25.6 minutes, respectively.[7] The surgical duration in our study is relatively short compared to the previous study, which also shows that this anesthesia method could be more effective in the surgical process. Operation duration variability may reflect differences in surgical complexity and patient-specific factors. In our study, there was a patient whose surgery time was up to 142 minutes due to damage to the arch of the Azygos vein during surgery, unrelated to surgical working conditions, and not requiring conversion to endotracheal tube or open surgery. The result shows that surgical working conditions are similar to anesthesia with intubation when performing Non - Intubated anesthesia for VATS thymectomy.

Our study demonstrates favorable postoperative outcomes following NI-VATS for MG patients undergoing thymectomy. The absence of significant side effects, effective pain management, and short hospital stays underscore the safety and considerations of this surgical approach (Table 4). This result is similar to some studies on Non-intubated anesthesia for thoracic surgery[5,8] and has fewer complications than studies on general anesthesia with intubation.[7] These findings support the broader adoption of NI-VATS as a preferred technique for thymectomy in MG patients, potentially enhancing patient outcomes and overall surgical experience.

LIMITATION

The small sample size of six patients may limit the generalizability of our findings to larger cohorts. Additionally, further research is warranted to explore the long-term respiratory and cardiovascular outcomes and potential benefits of NI-VATS compared to traditional intubated approaches in MG patients.

V. CONCLUSION

The results showed that respiratory rate, Tidal volume, SpO_2 PaO_2, $PaCO_2$, during surgery were all within normal limits. Hemodynamics through the pulse and mean arterial blood pressure was within normal limits; the surgical process was favorable, and there was a short surgical hospital stay. Notably, no patient had any complication or required conversion to traditional intubated anesthesia. It is proven that Non-intubated Video-assisted thoracoscopic Thymectomy is a safe and feasible approach for patients with Myasthenia Gravis. It demonstrates that Non-intubated Video video-assisted thoracoscopic Thymectomy can be a viable and secure approach for patients with Myasthenia Gravis.

While these results are promising, further research with a larger sample size and longer follow-up is necessary to establish NI-VATS thymectomy as a standard technique for MG patients. This approach can potentially reduce postoperative complications associated with endotracheal intubation in MG patients.

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