

# Non-Intubated Anesthesia Video-Assisted Thoracic Surgery for Subxiphoid Anterior Mediastinal Tumor Resection

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## Research article

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# Abstract

## Objective

Subxiphoid approach for mediastinal tumor resection was reported to provide a better view and less postoperative pain. Non-intubated video-assisted thoracic surgery (NI-VATS) without muscle relaxant would decrease the possibility of postoperative airway collapse for anterior mediastinal mass operation. Herein, we sought to describe the use of NI-VATS through subxiphoid approach for anterior mediastinal tumor resection.

## Methods

Patients that underwent subxiphoid VATS resection for anterior mediastinal tumor between December 2015 and September 2019 were retrospectively included for analysis. Patients were divided into two groups according to airway management: NI-VATS and intubated VATS (I-VATS). Intraoperative and postoperative variables were compared.

## Results

A total of 40 patients were included. Among them, 21 patients received NI-VATS (52.5%) and 19 were treated with I-VATS (47.5%). In total, intraoperative (4/21 vs. 2/19;  $p = 0.446$ ) and postoperative complications (5/21 vs. 7/19;  $p = 0.369$ ) were similar between NI-VATS and I-VATS group. The anesthesia time (231.76 vs 244.71 min;  $p = 0.218$ ), the operation time (152.35 vs 143.64 min;  $p = 0.980$ ) and the length of stay (9.47 vs 10.57 day;  $p = 0.970$ ) were similar between the two groups. Chest tube duration was shorter in NI-VATS groups (1.81 vs 1.84 day;  $p = 0.008$ ), however, the total volume (351.95 vs 348.00 ml;  $p = 0.223$ ) was similar. The post-operative pain scores (2.79 vs 2.93,  $P = 0.413$ ) were comparable between two groups.

## Conclusions

NI-VATS for mediastinal tumor resection via subxiphoid approach is a safe and technically feasible option. This technique leads to comparable perioperative clinical outcomes when compared with I-VATS via subxiphoid approach.

## Introduction

Surgical resection is the main treatment for mediastinal neoplasms, both in malignant and benign tumors. Conventional median sternotomy is considered as the standard therapy, but video-assisted thoracic surgery (VATS) has gradually taken the place in decades.[1] The trans thoracic approach is the most common choice via VATS, however, the subxiphoid approach for anterior mediastinal tumor

resection was reported to provide an excellent view of the bilateral pleural cavities and also be associated with reduction of the postoperative pain compared with trans thoracic approach.[2]

General anesthesia might increase the postoperative risks for anterior mediastinal tumor resection.[3] The most feared complication is the airway collapse after intubation and muscle relaxation, which would potentially cause prolonged extubation after surgery.[4, 5] Several studies have demonstrated that without using muscle relaxant and intubation, non-intubated VATS (NI-VATS) might solve this problem. [6]

However, NI-VATS is rarely reported in subxiphoid approach for mediastinal tumor patients, which would limit the use of subxiphoid surgery when surgeon performing NI-VATS. In this study, we reported our initial experience and explored the feasibility and safety of NI-VATS management in anterior mediastinal tumor resection via subxiphoid approach.

## **Materials And Methods**

### **Study design and patient inclusion**

The data of all patients who underwent subxiphoid anterior mediastinal tumor resection at the first affiliated hospital of Guangzhou Medical University between December 2015 and September 2019 were identified and consecutively collected through electronic medical records. The study protocol and methods were reviewed by the institutional ethics committee of hospital. Informed consents were obtained from every patient. Exclusion criteria: cases that underwent median sternotomy, cases that underwent trans thoracic approach surgery, malignant cases with obvious invasion to the surrounding organs. All patients were evaluated by thoracic surgeons before operation. Computed tomography (CT) scans of all patients were performed to confirm the size and position of lesions by two independent radiologists. Prior to the surgery, anesthetists visited each patient to judge who could be potentially received non-intubated surgery. Patients who underwent NI-VATS comprised the experimental group, and patients who received intubated VATS (I-VATS) comprised the control group.

Contraindications to NI-VATS: American Society of Anesthesiologists (ASA) class 4 or greater, body mass index (BMI) 30 or greater, severe heart disease (e.g., ischemia, arrhythmia, etc.), hemodynamic instability, coagulopathy, asthma and sleep apnea syndrome.<sup>[7]</sup>

All patients met the criteria were asked whether they would like to receive new technique of NI-VATS, patients who refused would get the conventional intubated surgery.

### **Surgical procedures**

The surgical process is the same between NI-VATS and I-VATS groups via mediastinal approach (Fig. 1). Details of the surgical procedure have been already reported elsewhere.[8] A 3-cm incision was made 2 cm below the lower edge of the xiphoid for setting the thoracoscope. Two 5 mm extra pleural thoracic ports were created at the midclavicular line intersecting with the bilateral costal arch to introduce a thoracoscopic grasping forceps and a harmonic scalpel. A pneumomediastinum was created by an 8 cm

H<sub>2</sub>O positive pressure carbon dioxide (CO<sub>2</sub>) insufflation to enlarge the retrosternal space and facilitate dissection of the tumor. Both the right-sided and left-sided mediastinal pleura were opened. The incision in the chest wall could cause collapse of the lungs. The tumor and surrounding tissue were resected and removed through the subxiphoid port. Finally, the air in the chest cavities was evacuated by inflating the lungs. A drainage tube was inserted into the mediastinum through the subxiphoid incision. If necessary, the process was changed from the subxiphoid approach to the trans thoracic approach or open thoracotomy.

## Anesthesia management

I-VATS: Sufentanil 0.3 ~ 0.6ug/kg, target-controlled infusion (TCI) of propofol plasma concentration of 2.0 ~ 3.0ug/ml and cis-atracurium 0.2 mg/kg were injected intravenously for induction. A double-lumen tube (DLT) was inserted, the placement of bronchial tube was affirmed by bronchoscopy. For anesthesia maintain, inhaled sevoflurane 0.8 ~ 1.5 times minimum alveolar concentration (MAC), TCI of propofol plasma concentration 0.5 ~ 1.0 ug/ml, remifentanil 0.05 ~ 0.15 ug/kg/min, dexmedetomidine 0.05 ~ 0.10 ug/kg/min and cis-atracurium 0.2 mg/kg/h were administered. One lung ventilation was applied during the surgery, ventilation parameters were adjusted as: tidal volume (VT) 6 ~ 8 ml/kg, respiration rate (RR) 10 ~ 15 times/min in volume-controlled ventilation (VCV) mode. The lung recruitment maneuvers were performed after operation completion, maintaining the maximum artificial pressure not exceeding 20 cmH<sub>2</sub>O for 5 seconds. The neostigmine and atropine were routinely given for antagonism; the patient's respiratory rate, tidal volume and SpO<sub>2</sub> were carefully observed to reach the clinical stage.

NI-VATS: Sufentanil 0.1 ~ 0.3ug/kg and TCI of propofol plasma concentration 2.0 ~ 3.0ug/ml were injected intravenously. Muscle relaxants were not used in the entire process of surgery. A laryngeal mask (FORNIA, Disposable Laryngeal Mask) was placed after anesthesia induction. For anesthesia maintain, TCI of more propofol plasma concentration 2 ~ 3ug/ml, remifentanil 0.05 ~ 0.15ug/kg/min and dexmedetomidine 0.05 ~ 0.10 ug/kg/min were administered. During the surgery, ventilation parameters were adjusted as: VT 3–8 ml/kg, RR 10–15 times/min in synchronized intermittent mandatory ventilation (SIMV) mode.

## Data collection and Statistical analyses

Baseline characteristics including age, BMI, gender, tumor size, histology and myasthenia gravis status were extracted to observe the balance between two groups. The clinical data included intraoperative blood loss, anesthesia time, operation time, hospital duration after surgery, postoperative chest tube duration, postoperative drainage volume and pain evaluation. Continuous data are presented as mean and standard deviation and were analyzed with 2-sample Student t tests for independent data.

Categorical variables are given as a count and percentage of patients and compared with the X<sup>2</sup> or Fisher exact test. All statistical tests were 2-sided. P values of less than 0.05 were considered significant. SPSS software (SPSS version 25.0; IBM Corp, Armonk, NY) was used for all data analysis.[9]

## Results

### Patients characteristics

A total of 40 patients between December 2015 and September 2019 underwent subxiphoid VATS anterior mediastinal tumor resection were consecutively included in this analysis. (Fig. 2) Among them, 21 patients received NI-VATS (52.5%) and 19 patients were treated under I-VATS (47.5%). The baseline characteristics were summarized in Table 1. Baseline demographic and clinical variables were well balanced between the two groups.

Table 1  
Demographic characters of study

	NI-VATS(n = 21)	SD/%	I-VATS(n = 19)	SD/%	P
<b>Age (year)</b>					0.16
Mean	43.90	15.18	54.26	11.64	
<b>Gender</b>					0.751
Male	11	52.38%	10	52.63%	
Female	10	47.62%	9	47.37%	
<b>BMI (kg/m<sup>2</sup>)</b>					0.12
Mean	23.01	3.64	23.49	2.52	
<b>FVC (L)</b>					0.38
Mean	3.55	0.79	3.16	0.94	
<b>FEV1 (L)</b>					0.24
Mean	2.86	0.68	2.46	0.87	
<b>ASA status class</b>					0.52
I	10	47.62%	11	57.89%	
II	11	52.38%	8	42.11%	
<b>Tumor size (cm)</b>					0.24
Mean	4.81	1.49	5.26	1.56	
<b>Myasthenia gravis</b>					0.92
Yes	2	9.52%	2	10.53%	
None	19	90.48%	17	89.47%	
<b>Pathology</b>					0.16
Thymoma	10	47.62%	5	26.31%	
Cysts	6	28.67%	4	21.05%	
Fibroma	5	23.71%	10	52.64%	
NI-VATS, non-intubated video-assisted thoracic surgery; I-VATS, intubated video-assisted thoracic surgery; BMI, body mass index; FVC, forced vital capacity; FEV1, Forced Expiratory Volume In 1 second; ASA, American Society of Anesthesiologists; SD, standard deviation;					

## Operative results and postoperative recovery

No surgery-related deaths occurred. In total, operative/anesthesia related intraoperative complications were similar in NI-VATS groups and I-VATS (2/21 vs. 4/19;  $p = 0.446$ ). Specifically, two patients in the I-VATS group and one patient in NI-VATS group were converted to the trans thoracic approach due to an excess of fat tissues. Two patients in the I-VATS group and one patient in NI-VATS group were switched to median sternotomy due to the pleural adhesions.

The incidence of post-operative complication was less in the NI-VATS and NI-VATS group, although without significant statistical (5/21 vs 7/19;  $p = 0.369$ ). No nerve damage or prolonged extubation owing to airway collapse occurred in both groups. All perioperative complications were summarized in Table 2.

Table 2  
Perioperative complications between NI-VATS group and I-VATS group

	NI-VATS (n = 21)	%	I-VATS (n = 19)	%
<b>Intraoperative complications</b>				
Total	2	9.5%	4	21.1%
converted to the trans thoracic approach	1	4.8%	2	10.5%
converted to median sternotomy	1	4.8%	2	10.5%
<b>Postoperative complications</b>				
Total	5	23.8%	7	36.8%
Fever	2	9.5%	1	5.3%
Vomiting	0	0%	1	5.3%
Dizziness	1	4.8%	1	5.3%
Sore throat	0	0%	3	15.8%
Incision pain	4	19.0%	4	21.1%
Dyspnea	0	0%	1	5.3%
<b>Total Perioperative complications</b>	<b>7</b>	<b>33.3%</b>	<b>11</b>	<b>57.9%</b>
NI-VATS, Non-intubated video-assisted thoracic surgery; I-VATS, Intubated video-assisted thoracic surgery.				

The anesthesia time (231.76 vs 244.71 min;  $p = 0.218$ ), the operation time (152.35 vs 143.64 min;  $p = 0.980$ ), operative bleeding (34.74 vs 38.47 ml;  $p = 0.267$ ) and the length of stay (9.47 vs 10.57 day;  $p = 0.970$ ) were all similar between the two NI-VATS and I-VATS group. Chest tube duration was shorter in NI-VATS groups (1.81 vs 1.84 day;  $p = 0.008$ ), however, the total volume (351.95 vs 348.00 ml;  $p = 0.223$ ) was similar in two groups.

# Postoperative analgesia medication

Comprehensive data of 31 patients (17 NI-VATS, 14 I-VATS) were available for the post-operative pain score analysis. The visual analogue scale score was evaluated on the postoperative day one of each patient. A similar level of VAS score was observed in NI-VATS group compared with I-VATS group ( $2.79 \pm 1.42$  vs  $2.93 \pm 1.83$ ,  $P = 0.413$ ). In addition, the patient number of using postoperative opioid analgesia was similar in NI-VATS group compared with I-VATS groups (17.64% vs 29.41%,  $P = 0.368$ )

## Discussion

This is the first cohort study on subxiphoid NI-VATS mediastinal tumor resection, which indicated that NI-VATS was a safe and feasible procedure via subxiphoid approach. Although statistically significant was not observed because of small sample size, NI-VATS might potentially decrease perioperative complication compared with I-VATS (7/21 vs 11/19). It can be considered as an alternative to I-VATS when lateral approach is not available or when surgeons preferred subxiphoid surgery.

Compared with the trans thoracic approach, the most prominent advantages of subxiphoid approach for mediastinal tumor are more visual and less postoperative pain.[10] A complete resection of tumor is the primary aim. With the help of a camera scope inserted from the midline of the body, it would be convenient to look over the bilateral mediastinum clearly and confirm the location of important blood vessels and nerves nearby. [11] However, there are still some shortcomings of subxiphoid approach. First, a surgical team familiar with the subxiphoid approach procedure is needed. Second, it's hard to play when severe adhesions are existing. Third, the tumor size also need to be limited because of the narrow space.[8] Therefore, the application of the subxiphoid approach may be restricted in some conditions.

The anesthesia process of the I-VATS group in subxiphoid approach is almost the same as it in other thoracic surgeries. [12] When using a double-lumen tube for one-lung ventilation, contralateral lung collapse is easy to achieve via gentle press by a surgeon and air suction by an anesthesiologist. Nonetheless, the anesthesia process of the NI-VATS group under subxiphoid approach is a novel attempt. There was only one case report about subxiphoid NI-VATS for thymectomy in 2017; the patient was selected carefully, which indicating that NI-VATS in subxiphoid approach was still under exploring.[13] The present study indicated that NI-VATS under subxiphoid approach was a feasible procedure with similar intraoperative and postoperative outcomes with conventional I-VATS group, which

Spontaneous ventilation during surgery relies on the integrality of at least one side of pleura. The way of three-port subxiphoid approach in our study cuts bilateral mediastinal pleuras, causing collapse of both sides of lungs, which made complete spontaneous ventilation impossible. When there is bilateral pneumothorax at the same time, mediastinal swing would stop, followed by a continuous deflation and inflation of bilateral lungs, which would bring great challenge to the surgeon. To alleviate this problem, we adopted a small tide volume (3-4L/min) ventilation through SIMV mode, which would not only maintain the oxygen supply but also minimize the impact on the operation.

Non-intubated anesthesia management for subxiphoid approach actually includes laryngeal mask airway general anesthesia (without muscle relaxant) in SIMV mode, combined with vagus and intercostal nerve blocking. The laryngeal mask could potentially avoid intubation-associated complications, including postoperative sore throat, hoarseness and irritating cough. Besides, the difficult intubation is not uncommon in thymoma patients, rendering a laryngeal mask the preferred option.[6, 7]

Not using muscle relaxants is benefit for myasthenia gravis patients, which can avoid the residual effects of muscle relaxants, achieve faster recovery of respiratory muscle function and lower the incidence of difficult postoperative extubation.[14] The benefits of omitting muscle relaxants are not limited in myasthenia gravis patients, it was reported that the use of muscle relaxants was associated with an increased risk of postoperative pulmonary complications, which cannot be reduced by the administration of reversal agents like sugammadex.[15] In addition, muscle relaxants during large anterior mediastinal tumor resection would cause airway collapse, NI-VATS would potentially avoid this situation. [6] Although no airway collapse or prolonged extubation case occurred in our study, it could happen when the mediastinal mass is big. One of the important meanings of this study is to prove the feasible and safety of NI-VATS under subxiphoid approach. When surgeons confront a situation when convention I-VATS may have the high risk of causing airway collapse, he/she could also use NI-VATS via subxiphoid approach.

There are several limitations in our study, including small sample size, short follow-up and retrospective nature. Because the process is relatively novel, the steps are unfamiliar, and good cooperation is needed between the surgeons and the anesthesiologists, this new approach was not commonly performed.

## Conclusion

In summary, this study reveals that NI-VATS mediastinal tumor resection is a safe and technically feasible option. This technique leads to comparable postoperative outcomes when compared with I-VATS.

## Abbreviations

Video-assisted thoracic surgery (VATS), Intubated video-assisted thoracic surgery (I-VATS), Non-intubated video-assisted thoracic surgery (NI-VATS), Computed tomography (CT), American Society of Anesthesiologists (ASA), Body mass index (BMI), Carbon dioxide (CO<sub>2</sub>), Electrocardiogram (ECG), Heart rate (HR), Non-invasive blood pressure (NIBP), Pulse oxygen saturation (SpO<sub>2</sub>), End-tidal carbon dioxide partial pressure (PETCO<sub>2</sub>), Targett-controlled infusion (TCI), Double-lumen tube (DLT), Minimum alveolar concentration (MAC), Tidal volume (VT), Respiration rate (RR), Volume-controlled ventilation (VCV), Thoracic epidural blockade (TEB), Synchronized intermittent mandatory ventilation (SIMV)

## Declarations

### Conflict of interest

None

## Data sharing statement

For original deidentified individual patient data please contact [drjianxing.he@gmail.com](mailto:drjianxing.he@gmail.com). Data will be made available for a period of 5 years after the publication date.

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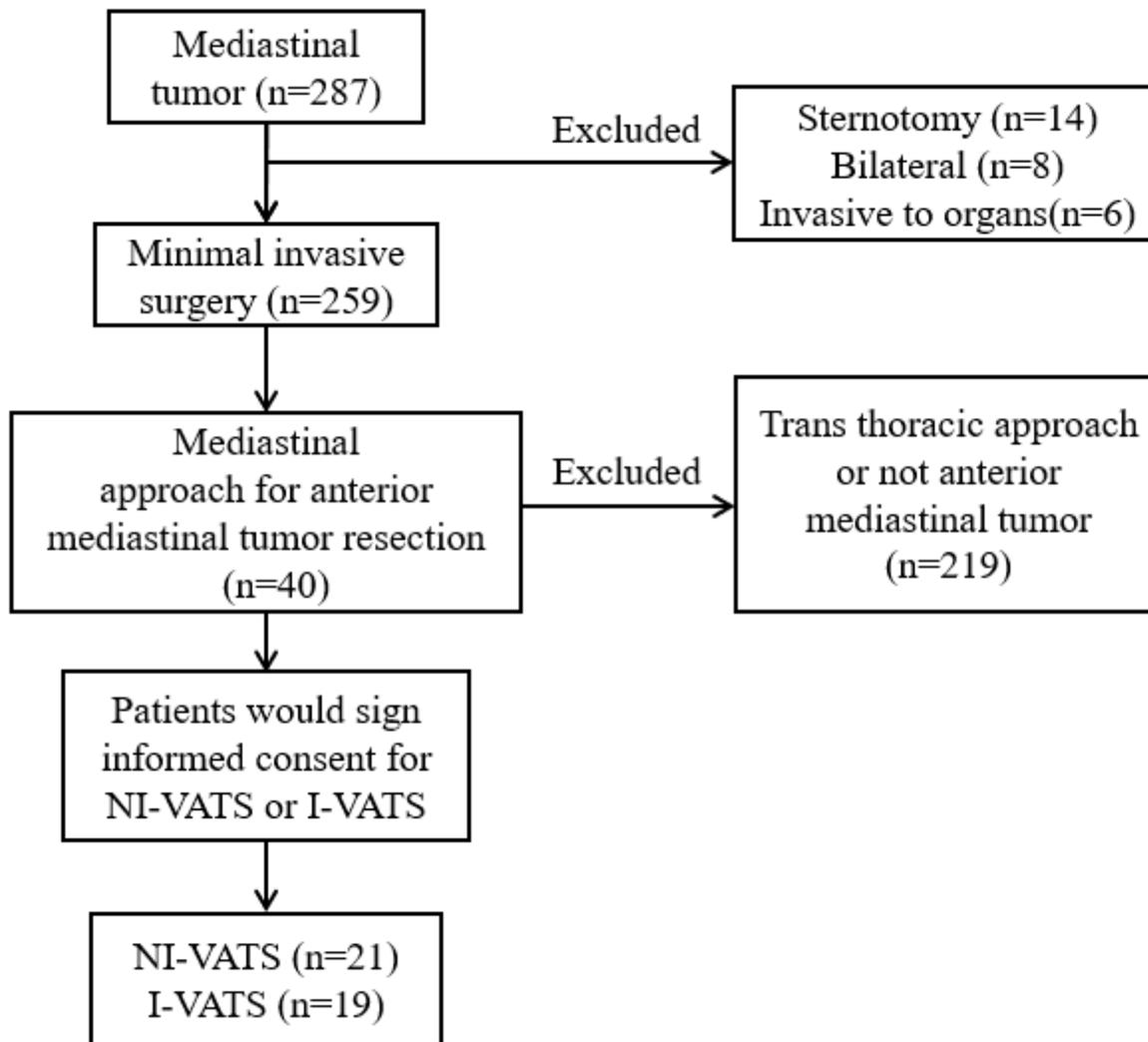
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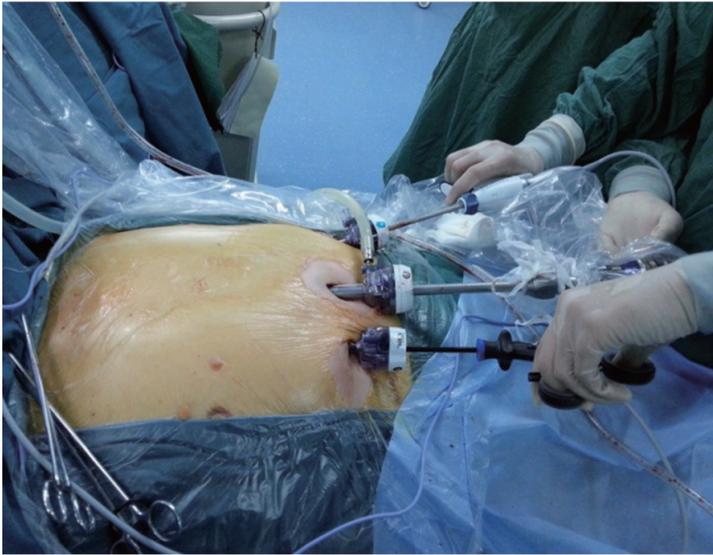
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## Figures



**Figure 1**

Surgery procedure of non-intubated video-assisted thoracoscopic surgery for mediastinal tumor resection via subxiphoid approach (A) Approach portal location of subxiphoid video-assisted thoracoscopic surgery; (B) Post-operative chest tube location; (C) Opening left pleural cavity; (D) Opening right pleural cavity.



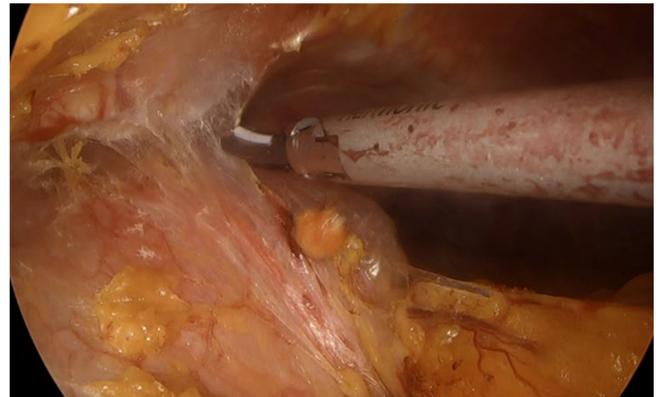
**A**



**B**



**C**



**D**

**Figure 2**

Schema of patient grouping and matching. (I-VATS, intubated video-assisted thoracoscopic surgery; NI-VATS, non-intubated video-assisted thoracoscopic surgery.)