VATS Resection of Anterior Mediastinal Disease: Superiority of Subxiphoid Approach Comparing to Lateral Intercostal Approach

He Gengxu (✉ hegengxu@aliyun.com)

The First Affiliated Hospital of Hebei North University

Tong Yao

The First Affiliated Hospital of Hebei North University

lei zhao

The First Affiliated Hospital of Hebei North University

hong geng

The First Affiliated Hospital of Hebei North University

qiang ji

The First Affiliated Hospital of Hebei North University

kun zuo

The First Affiliated Hospital of Hebei North University

Luo Yuanzhi

The First Affiliated Hospital of Hebei North University

Zhou Kai

The First Affiliated Hospital of Hebei North University

Research Article

Keywords: video-assisted thoracic surgery (VATS), anterior mediastinal tumor, subxiphoid approach, lateral intercostal approach

Posted Date: February 7th, 2022

DOI: <https://doi.org/10.21203/rs.3.rs-1270771/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Abstract

Background & Aim: Optimal approaches for video-assisted thoracoscopic surgery (VATS) resection of anterior mediastinal diseases remain controversial. The present study was designed to compare subxiphoid approach with lateral intercostal approach, together with perioperative indices.

Methods: Patients diagnosed with anterior mediastinal diseases between January 1, 2018 and October 31, 2019 were prospectively randomly assigned to two groups, to receive lateral intercostal approach vs. subxiphoid approach for VATS resection. Intraoperation PaCO₂, SaO₂, PaO₂ and circulation changes were recorded. Perioperative outcomes, including clinical and surgical parameters such as operation time and blood loss, postoperative complication, neutrophil-to-lymphocyte ratio, and postoperative pain scores were compared.

Results: A total 59 patients diagnosed with anterior mediastinal tumors or myasthenia gravis underwent VATS resection. 31 patients treated with subxiphoid approach and 28 patients treated with lateral intercostal approach had comparable baseline characteristics. Intraoperation PaCO₂ was increased significantly whereas SaO₂ remained stable in subxiphoid group. By contrast, PaCO₂ was increased significantly whereas SaO₂ was decreased in lateral intercostal group, and operations were more frequently interrupted due to hypoxia or circulation disturbance during thymus dissection in the lateral intercostal approach. Compared with lateral intercostal group, patients in subxiphoid group experienced less inflammation reaction, while yielded lower pain scores and shorter postoperative hospital stay. There were no significant differences in postoperative complications between the two groups. All these patients recovered well when discharged. There were no perioperative deaths.

Conclusion: Subxiphoid approach may influence pulmonary and circulation lesser than lateral intercostal approach. Procedure may be safer and easier for subxiphoid approach, as an ideal choice for anterior mediastinal diseases.

Introduction

With rapid development of minimally invasive techniques, video-assisted thoracic surgery (VATS) has been widely applied in thymectomy for myasthenia gravis and early-stage thymoma [1–4]. For thymectomy, involved soft tissues in pre-vascular plane of anterior mediastinum between phrenic nerves should be removed. How to choose an optimal approach remains controversy. VATS thymectomy could employ lateral intercostal, transcervical or subxiphoid approach [2, 5–9]. Lateral intercostal approach is the most frequently performed, however, this approach does have some disadvantages such as challenges for exposure and increased risk of intercostal nerve injury, which results in postoperative chronic incision pain¹⁰. In recent years, subxiphoid approach has attracted more and more attention. Advantages of subxiphoid approach over lateral intercostal approach include sufficient operative view of cervical and bilateral pleural cavities, less pain and a better cosmetic effect. In this study, we

prospectively evaluated potential superiority of subxiphoid approach to lateral intercostal approach from different aspects.

1. Method

1.1 Study design

This study was approved by Ethics Committee of The First Affiliated Hospital of Hebei North University (Protocol # 2017021). The patients diagnosed with anterior mediastinal tumor or myasthenia gravis with or without thymoma who received surgery were randomly assigned to two groups, subxiphoid approach vs. lateral intercostal approach. Individual surgery was carried out by experienced surgeons through lateral intercostal approach (routine) or subxiphoid approach (exploratory).

1.2 Surgical technique

1.2.1 Subxiphoid procedure:

All patients were anesthetized and intubated with a single-lumen endotracheal tube and placed in supine position on operating table. Surgeon and an assistant stood on the right and left side, respectively. A 2-3 cm transverse observational port was made below the lower edge of xiphoid. Then, rectus abdominis muscle was separated vertically, and retrosternal space was bluntly separated with surgeon's finger as extensively as possible. Afterwards, two 5-mm thoracic ports under bilateral costal arches were created at midclavicular line, and Trocar was inserted into working space guided by surgeon's finger. A 10-mm, 30° oblique view rigid thoracoscope was inserted through observation ports. Carbon dioxide (CO₂) with 8-10 mmHg positive pressure was insufflated into anterior mediastinum, to enlarge retrosternal space. An ultrasonic scalpel and thoracoscopic grasping forceps were introduced into bilateral operation ports. Then, pleural cavity was opened bilaterally, to create bilateral pneumothorax. The primary surgical steps were as follows (Figure 1). First, pleural space was opened bilaterally. The anterior border of the thymus was gradually dissected along the retrosternal space to thoracic outlet vertically. Second, in the right pleural cavity, adipose anterior to phrenic nerve was removed. The thymic horn was dissected from underlying innominate vein. Thus, innominate vein and superior vena cava junction were fully visualized. The thymic vein draining into innominate vein was ligated using ultrasonic scalpel. Third, in the left pleural cavity, surrounding adipose tissue along the anterior left phrenic nerve was removed to the junction of the left intra thoracic vein and the left innominate vein. Then, the upper part of the thymus was dissected in the superior space of the left innominate vein. Finally, the freed thymus and any attached mediastinal fat were placed into a specimen bag and removed via subxiphoid observation port. For a specimen with large volume, transverse observation incision could be extended along subcostal space. A chest tube was inserted into one subcostal arch port for drainage after surgery as described previously²⁹.

1.2.2 Lateral approach:

After intravenous induction, the patient was anesthetized and intubated with a double-lumen endotracheal tube. The patient was placed at 30-45° in a semi-supine position. Anterior mediastinal tumor was approached from the right or left chest according to tumor site. A 3-port system was applied, with one observation port and two main operation ports. An observation port of 1.0 cm was typically made in the 6th intercostal space at the anterior axillary line. This port was primarily used to insert trocar lens of thoracoscope into thoracic cavity, which was retained for chest tube placement. Two main operation ports were placed in the 3rd intercostal space at the anterior whereas in the 5th intercostal space at the midclavicular line, respectively. An ultrasonic scalpel was used for resection. In most cases, both thymus and adipose tissue in the mediastinum were resected, including the left and right cardio-diaphragm angle.

1.3 Evaluation of the procedure

1.3.1 Intraoperation blood gas analysis:

The arterial blood was collected at four time points, immediately after anesthesia, 15 minutes and 30 minutes after initiation of operation and 15 minutes after operation. The PaCO_2 , SaO_2 , PaO_2 were recorded.

1.3.2 Intraoperation hemodynamic index:

Hemodynamic status, dynamic changes in blood pressure and cardiac arrhythmia were recorded. Interruptions of operation procedure due to hypoxemia, hemodynamic disturbance and arrhythmia were recorded.

1.3.3 The inflammatory indices:

Peripheral blood was obtained on the day before surgery, on the first and the third postoperative day, respectively. Neutrophil-lymphocyte ratio was calculated by dividing the absolute count of neutrophils by that of lymphocytes. C reactive protein (CRP) was detected routinely.

1.4 Postoperative management

The majority of patients were extubated immediately postoperatively. For pain management, an opioid-sparing multimodal analgesic regiment was used. All patients received patient-controlled analgesia with 0.2 mg/kg/h fentanyl and 0.1 mg/kg/h tramadol for 24-48 h. Postoperative pain score at 6, 12, 24, and 48 h, respectively, was assessed. Paracetamol oxycodone was administered as a rescue analgesic when requested by a patient with an NRS over 4. The chest tube was removed when drainage was less than 100 ml/day with no air leakage. A patient who was able to mobilize independently and appeared normal on chest radiography was discharged after chest tube removal.

2. Results

Totally, 59 patients were enrolled onto our study. 31 patients received subxiphoid procedure and 28 patients received lateral intercostal approach, including 22 patients with right-lateral intercostal approach and 6 patients with left-lateral intercostal approach (Table 1).

Table 1
Clinical/demographic characteristics and operation approach

Variables	Subxiphoid approach (n=31)	Lateral intercostal approach (n=28)	P value
Clinical/demographic information			
Age (years)	49±10.2	51±11.2	0.95
Male	19	18	0.79
Tumor size (≥5 cm)	6	3	0.66
Operation time (min)	110±23.4	120±19.8	0.08
Blood loss (ml)	58 (16.1)	60 (14.3)	0.61
Conversion to thoracotomy	0	1	0.97
Delayed extubation	3 (10.7)	2 (8.9)	0.88
Total drainage (ml)	491±173.4	509±214.6	0.72
Hospital-stay after operation (days)	5±3	7±4	0.03
Pulmonary infection	2 (6.45%)	3 (10.71%)	0.42
Phrenic nerve paresis	3 (9.67%)	2 (7.14%)	0.88
recurrent laryngeal nerve damage	1 (3.22%)	0 (0)	0.95
Postoperative pain score			
24h post-operation	4.2±0.69	6.1±0.79	<0.001
48h post-operation	4.1±0.53	6.3±0.61	<0.001
72h post-operation	4.4±0.49	5.9±0.89	<0.001
Pathological diagnosis	19 (61.29%)	21 (75.00%)	0.62
Thymoma	5 (16.12)	4 (14.29%)	0.84
Thymic hyperplasia	5 (16.12)	3 (10.71)	0.87
Thymic cyst			
Thymic carcinoma	2 (6.47%)	0 (0)	0.63

Intraoperation PaCO₂ was elevated significantly after bilateral artificial pneumothorax was created through insufflating carbon dioxide (CO₂) with 8 mmHg positive pressure in subxiphoid group, where SaO₂ was maintained stably. By contrast, SaO₂ was lowered significantly whereas PaCO₂ was elevated in lateral intercostal group with unilateral lung ventilation (Table 2). Among 9 patients (32.1%), operation procedure was interrupted because of hypoxemia where SaO₂ was lowered more than 85% when unilateral lung ventilation was carried out in lateral intercostal group. However, this event happened only in one patient (3.2%) in subxiphoid group. As for hemodynamic effects, operation procedure with lateral intercostal approach was interrupted in 5 patients (17.9%) ecause of hypotension or cardiac arrhythmia. This event was resulted from cardiac decompression during dissection of the right or left cardio-diaphragm angle adipose from the opposite lateral intercostal incision when carrying out extensive thymus resection. In sharp contrast, only one patient (3.2%) in subxiphoid approach group suffered from blood fluctuation at initiation of artificial pneumomediastinum, while operation procedure was carried out smoothly in other 30 patients.

Table 2 Intraoperative gas analysis at different time points

Variables	Subxiphoid approach n=31	Lateral intercostal approach (n=28)	P value
PaCO ₂			
After anesthesia	36±11	39±10.2	0.28
15 minutes intraoperation	46±13.5*	48±12.9	0.56
30 minutes intraoperation	42±8.9*	46±13.2	0.17
15 minutes post-operation	38±10.4	41±10.8	0.28
PaO ₂			
After anesthesia	133±38	129±39	0.69
15 minutes intraoperation	246±41*	145±37	<0.001
30 minutes intraoperation	302±51*	187±40	<0.001
15 minutes post-operation	109±48	91±42	0.13
SaO ₂			
After anesthesia	98±1.9	97±2.8	0.10
15 minutes intraoperation	95±4.1	92±7.9	0.06
30 minutes intraoperation	96±3.9	95±4.1	0.06
15 minutes post-operation	95±4.9	93±4.6	0.11

In subxiphoid group, 6 patients had a tumor size larger than 5 cm. Two patients with stage III thymoma invading right pulmonary underwent concomitant pulmonary wedge resection (Figure 2). In lateral intercostal approach, 3 patients had a tumor size larger than 5 cm. One patient was converted to upper sternotomy because the tumor adhered to innominate vein. Exposure of tumor was more efficient and easily in subxiphoid group.

In addition, postoperatively inflammatory indices N/L ratio and Hs-CRP were significantly higher in lateral intercostal group comparing with subxiphoid group during postoperative period (Table 3).

Table 3
Postoperative inflammatory indices at different time points

Variables	Subxiphoid approach (n=31)	Lateral intercostal approach (n=28)	P value
Hs-CRP			
Pre-operation	1.21±0.23	1.31±0.27	0.12
D1 post-operation	3.2±1.23	4.9±1.86	0.00
D5 post-operation	2.2±1.23	3.1±1.32	0.00
D7 post-operation	1.34±0.48	2.1±0.69	0.81
N/L	2.32±1.58	2.41±1.39	0.00
Pre-operation	5.41±2.08	12.89±3.78	0.00
D1post-operation	3.44±1.98	7.32±2.15	0.00
D5 post-operation	2.44±1.43	4.36±1.62	0.00
D7 post-operation			

There was no significant difference in the mean operative time or median intraoperative blood loss between the two groups. In fact, if the 6 patients with a tumor size large than 6 cm who required more time than others in subxiphoid group were excluded from analysis, the mean operative time was shorter than that in lateral intercostal group. Simultaneously, learning curve of an experienced thoracic surgeon in grasping subxiphoid approach technique was recorded. An experienced surgeon became familiar with this technique after operation on 2 patients. The mean operation time would be significantly shorter than that in lateral intercostal approach.

All 59 patients recovered smoothly. In subxiphoid group, phrenic nerves encapsulated in the tumor were damaged in 3 patients during tumor dissection. The left recurrent laryngeal nerve was damaged in 1 patient during dissection of the tumor adhered to aorta-pulmonary artery window, who recovered after 3 months. In lateral intercostal group, phrenic nerves were damaged in 2 patients during tumor dissection.

There was statistically significantly difference with respect to postoperative pain between the two groups. In addition to primary endpoints, patients treated with subxiphoid approach had less pain compared with lateral approach.

3.discussion

Complete resection has been well-accepted as standard treatment of thymoma and myasthenia gravis. However, appropriate surgical approaches remained debated. Considering wide distribution of ectopic thymic tissues in the anterior mediastinum, most thoracic surgeons would recommend to resect completely soft tissues in pre-vascular plane of the anterior mediastinum between the left and right

phrenic nerves, especially for patients with gravis myasthenia, regardless of thoracoscopic or open approaches^{10–12}. In open surgery, transsternal approach is recognized as standard procedure for extended thymectomy. However, different approaches have emerged for thoracoscopic thymectomy, including unilateral (right- or left-side), bilateral, transcervical or a combination approach^{2,13–22}. Recently, subxiphoid approach has become more and more investigated with its superiority more and more accepted.

In our study, arterial blood gas was analyzed at different time points. Intraoperative gas exchange and hemodynamic change were compared during surgical procedure between two approaches. PaCO₂ was significantly elevated and remained stable within an accepted range in subxiphoid group, while SaO₂ was maintained. By contrast, elevation of PaCO₂ occurred along with reduction in SaO₂ during unilateral lung ventilation. Operation was interrupted in 7 patients, so that the anesthetist had to ventilate bilateral lungs to alleviate hypoxia. These changes indicated that subxiphoid approach with artificial pneumothorax on pleural cavity bilaterally under 8 mmHg CO₂ pressure would not affect pulmonary ventilation and ventilation/blood flow ratio. However, in lateral intercostal approach group, unilateral lung ventilation and lateral position would affect pulmonary ventilation and ventilation/blood flow ratio more severely. As for hemodynamic effect, 5 patients suffered from blood loss and arrhythmia when surgeons dissected adipose fat tissue of the contralateral cardiac-diaphragmatic angle, however, only 1 patient exhibited decrease in blood pressure when pneumomediastinum was created at the beginning of operation. Notably, complete exposure of tumor or thymus in the anterior mediastinum was more easily and clearly through subxiphoid approach, so there is less influence on circulatory intraoperatively. In sharp contrast, in lateral intercostal approach, it is difficult to expose the contralateral side and to remove mediastinal fat tissues, especially at cardiac-diaphragmatic angle. During the exposure of the contralateral side tissues, the heart would be influenced severely, even hypotension or arrhythmia might happen.

Postoperative inflammatory indices N/L ratio and CRP were significantly higher in lateral intercostal group during postoperative period. Intraoperative unilateral lung ventilation in lateral intercostal group might induce more severely inflammatory reaction than subxiphoid group.

Thoracoscopic approach for thymectomy may be associated with several limitations. In unilateral approach, it is difficult to expose the contralateral side and to remove completely mediastinal fat tissues²⁴. Although bilateral approach provided adequate exposure of the anterior mediastinum, more incisions were required, which might increase operative trauma and postoperative pain^{13–16}. Hsu^{27,28}, Zielinski^{16,25,26}, and Suda^{21–23} reported thoracoscopic thymectomy partially or only via subxiphoid incisions. A 6-cm semi-curved subxiphoid incision was created and Kent retractor was used to lift the sternum. Two ports were created in the sixth intercostal space along bilateral anterior axillary lines. Alternatively, transcervical, subxiphoid, and unilateral incisions were performed for maximal thoracoscopic thymectomy by two surgeon teams. Several issues generated from minimally invasive thymectomy require clarification. Furthermore, single-port thymectomy with subxiphoid incision might avoid intercostal nerve damage in the field of thoracic surgery, because instruments might interfere with

each other. Therefore, dual-port thymectomy was developed. Although these approaches provided acceptable view of both sides, a few shortcomings exist. First, subxiphoid incision was huge and a retractor was applied to lift the sternum and to enlarge the anterior mediastinal space, leading to potentially greater trauma. Second, two ports in the intercostal space may injure intercostal nerves, and thus inducing postoperative pain. Third, minimally invasive procedure was applied. However, it was difficult to totally remove fat surrounding cardiac-diaphragmatic angles using single-port or dual port subxiphoid approach.

Compared with the aforementioned approaches, a few advantages regarding subxiphoid and subcostal arch intervention were as follows. First, it enables excellent visualization of the anterior mediastinum, which facilitates the removal of fat tissue and minimizes the chance of surgical injury, such as accidental vessel laceration or contralateral phrenic nerve injury. In our study, more tumors with larger sizes could be resected through subxiphoid approach, and combined lesion could be handled for excellent exposure. Second, double lumen endotracheal tube ventilation was not mandatory, as was necessary in lateral intercostal thoracoscopy. Therefore, patients with severe lung diseases or poor lung functions were intolerant to unilateral lung ventilation. In addition, young patients unable to accommodate to the smallest double-lumen tube could be included, since subxiphoid and subcostal arch approach could adequately expose the surgical field under single-lumen ventilation. Third, subxiphoid procedure induced less postoperative pain. Postoperative pain was mainly caused by chest tube-induced intercostal nerve compression or injury. In lateral intercostal approach group, intercostal nerves in at least three patients could be involved intraoperatively. By contrast, in subxiphoid and subcostal arch approach group, no intercostal nerve was compressed or injured. Therefore, postoperative pain score was far less compared with that in lateral intercostal approach³⁰.

Furthermore, for an experienced thoracic surgeon, it would take less time to master this technique. There was only a short learning curve in mastering this procedure. There was no significant difference in operation time, since there were more patients with a tumor size larger than 5 cm, which required more time to dissect these larger tumors adhered to surrounding tissues. If these patients were excluded, operation time was significantly less in subxiphoid group, as previously described^{9,30}.

Collectively, subxiphoid approach will influence pulmonary and circulation lesser than lateral intercostal approach. Subxiphoid approach may be safer and easier, as an ideal choice for anterior mediastinal diseases.

All methods were performed in accordance with the relevant guidelines and regulations by Ethics Committee of The First Affiliated Hospital of Hebei North University (Protocol # 2017021).

Abbreviations

Video-Assisted Thoracic Surgery (VATS)

Declarations

Author's contribution:

Conceptualization: Gengxu He and Tong Yao

Methodology: Gengxu He and Tong Yao

Statistical analysis: Gengxu He and Yuanzhi Luo

Investigation: Lei Zhao, Hong Geng, Qiang Ji, Kun Zuo , Yuanzhi Luo, and Kai Zhou

Writing – Original Draft: Gengxu He and Tong Yao

Writing – Review & Editing: Gengxu He and Tong Yao

Supervision: Gengxu He and Tong Yao

All authors have read and approved the final version of manuscript.

Acknowledgement:

We thank Professor Xiaoqun Dong at The Warren Alpert Medical School of Brown University, USA, for editorial assistance and scientific comments on this manuscript.

Funding: None.

Availability of data and materials: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate: The study was approved by the Ethical Review Board of The First Affiliated Hospital of Hebei North University (Ethical approval No. 2017–021). Written informed consent was provided by each participant.

Consent for publication: Not applicable.

Competing interests: The authors declare no competing interests.

References

1. T. Nakagiri, M. Inoue, Y. Shintani, S. Funaki, et al. Improved procedures and comparative results for video-assisted thoracoscopic extended thymectomy for myasthenia gravis, *Surg Endosc.* 2015;29(9): 2859–2865.
2. H. Numanami, M. Yano, M. Yamaji, et al. Thoracoscopic thymectomy using a subxiphoid approach for anterior mediastinal tumors, *Ann. Thorac. Cardiovasc. Surg.* 2018; 24(2):65-72.

3. Raza, E. Woo. Video-assisted thoracoscopic surgery versus sternotomy in thymectomy for thymoma and myasthenia gravis, *Ann. Cardiothorac. Surg.* 2016; 5:33–37.
4. A.P. Yim, R.L. Kay, J.K. Ho, Video-assisted thoracoscopic thymectomy for myasthenia gravis, *Chest* 1995;108:1440–1443.
5. G. Zhang, W. Li, Y. Chai, et al. Bilateral videoassisted thoracoscopic thymectomy for Masaoka stage IIIA thymomas, *Thorac. Cardiovasc. Surg.* 2015;63: 206–211.
6. C.P. Hsu, C.Y. Chuang, N.Y. Hsu, et al. Comparison between the right side and subxiphoid bilateral approaches in performing video-assisted thoracoscopic extended thymectomy for myasthenia gravis, *Surg. Endosc.* 2004;18: 821–824.
7. J. Bramis, T. Diamantis, C. Tsigris, et al. Video-assisted transcervical thymectomy, *Surg. Endosc.* 2004;18: 1535–1538.
8. M. Odaka, Y. Tsukamoto, T. Shibasaki, et al. Thoracoscopic thymectomy is a feasible and less invasive alternative for the surgical treatment of large thymomas, *Interact. Cardiovasc. Thorac. Surg.* 2017;25: 103–108.
9. M. Yano, S. Moriyama, H. Haneda, et al. The subxiphoid approach leads to less invasive thoracoscopic thymectomy than the lateral approach, *World J. Surg.* 2017;41: 763–770.
10. Aielinski M. Surgical approaches to myasthenia gravis: perspective of anatomy and radicality in surgery. *Thora Surg Clin* 2019; (29):159-164
11. A Masaoka, Y Monden, K Nakahara, et al. Follow-up study of thymomas with special reference to their clinical stages. *Cancer.* 1981; 48:2485-2491
12. A Toker, J Sonett, M Zielinski, et al. Standard terms, definition, and policies for minimally invasive resection of thymoma. *J Thorac Oncol.* 2011;6: S1739-1742
13. Caronia FP, Fiorelli A, Santini M, et al. Uniportal bilateral video-assisted thoracoscopic extended thymectomy for myasthenia gravis: A case report. *J Thorac Cardiovasc Surg* 2015; 150: e1-3.
14. Yeh CM, Chen HC, Chou CM, et al. Hybrid combination of small subxiphoid incision and thoracoscopic thymectomy for juvenile myasthenia gravis. *J Pediatr Surg* 2011; 46: 780-3.
15. Caronia F, Fiorelli A, Monte AL. Bilateral thoracoscopic thymectomy using a novel positioning system. *Asian Cardiovasc Thorac Ann* 2014; 22: 1135-7.
16. Zielinski M, Czajkowski W, Gwozdz P, et al. Resection of thymomas with use of the new minimally-invasive technique of extended thymectomy performed through the subxiphoid-right video-thoracoscopic approach with double elevation of the sternum. *Eur J Cardiothorac Surg* 2013;44: e113-9; discussion e119.
17. Varghese TK Jr, Wood DE, Farjah F, et al. Variation in Esophagectomy Outcomes in Hospitals Meeting Leapfrog Volume Outcome Standards. *Ann Thorac Surg* 2011; 91: 1003-9; discussion 1009-10.
18. Yu L, Ma S, Jing Y, et al. Combined unilateral-thoracoscopic and mediastinoscopic thymectomy. *Ann Thorac Surg* 2010; 90:2068-70.

19. Shigemura N, Shiono H, Inoue M, et al. Inclusion of the transcervical approach in video-assisted thoracoscopic extended thymectomy (VATET) for myasthenia gravis: a prospective trial. *Surg Endosc* 2006; 20:1614-8.
20. Komanapalli CB, Cohen JI, Sukumar MS. Extended transcervical video-assisted thymectomy. *Thorac Surg Clin* 2010; 20:235-43.
21. Suda T, Ashikari S, Tochii D, et al. Dual-port thymectomy using subxiphoid approach. *Gen Thorac Cardiovasc Surg* 2014; 62:570-2.
22. Suda T, Sugimura H, Tochii D, et al. Single-port thymectomy through an infrasternal approach. *Ann Thorac Surg* 2012; 93:334-336.
23. Suda T, Hachimaru A, Tochii D, et al. Video-assisted thoracoscopic thymectomy versus subxiphoid single-port thymectomy: initial results†. *Eur J Cardiothorac Surg* 2016;49 Suppl 1: i54-58.
24. Louqian Z, Ming L, Feng J, et al. Subxiphoid versus lateral intercostal approaches thoracoscopic thymectomy for non-myasthenia early-stage thymoma: a propensity score-matched analysis. *Inter J Surg* 2019; (67): 13-17.
25. Zielinski M, Hauer L, Hauer J, et al. Comparison of complete remission rates after 5 year follow-up of three different techniques of thymectomy for myasthenia gravis. *Euro J Cardiothorac Surg* 2010; 37:1137-1143
26. Zielinski M, Kuzdzal J, Szlubowski A et al. Transcervical-subxiphoid-video thoracoscopic “maximal” thymectomy-operative technique and early results. *Ann Thorac Surg* 2004; 78:404-409
27. Hsu CP, Chuang CY, Hsu NY, et al. Comparison between the right side and subxiphoid bilateral approaches in performing thymectomy video-assisted thoracoscopic extended thymectomy for myasthenia gravis. *Surg Endosc* 2004; 18:821-824
28. CP Hsu, C.Y Chuang, N.Y Hsu, et al. Subxiphoid approach for video-assisted thoracoscopic extended thymectomy in treating myasthenia gravis. *Interact Cardiovasc Thorac Surg*. 2002;(1):4-8
29. Qiang L, Jinbo Zhao, Juzheng Wang, et al. Subxiphoid and subcostal arch “three pores” thoracoscopic extended thymectomy for myasthenia gravis. *J Thorac Dis* 2018; 10(3):1711-1720
30. Jiaduo L, Guoyan Q, Yaling L, et al. Meta-analysis of subxiphoid approach versus lateral approach for thoracoscopic thymectomy. *J Cardiothorac Surg*. 2020;15(1):89
31. L.A Hernadeze-Arenas, L Lin, Y. Yang, et al. Initial experience in uniportal subxiphoid video-assisted thoracoscopic surgery for major lung resections. *Eur J Cardiothorac Surg*. 2016;(50):1060-1066.

Figures

Figure 1

Procedure of subxiphoid extended thymectomy. A: dissection of the anterior border of the thymus. B: exposure of the right cardiophrenic angle. C: exposure of the left cardiophrenic angle. D: exposure of the right phrenic nerve and dissection of the anterior adipose tissue. E: exposure of the left phrenic nerve and dissection of the anterior adipose tissue. F: postoperative view of the anterior mediastinum.

Figure 2

Imaging findings. A: contrast enhanced computer tomograph identified a large tumor located in the anterior mediastinum. B: specimen of the tumor together with wedge-resected left-upper lung tissue.