Subxiphoid Uniportal VATS for Thymic and Combined Mediastinal and Pulmonary Resections – A Two-Year Experience

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Compared to the intercostal approach, subxiphoid uniportal video-assisted thoracoscopic surgery (VATS) is considered to be less invasive as it may cause minimal postoperative pain. Besides, it provides an excellent view of the bilateral pleural cavities. In this paper, we describe our technique and overview a 2-year experience results in this approach for the surgical treatment of anterior mediastinal and pulmonary lesions. In a retrospective study of data collected prospectively between October 2014 and December 2016, 38 patients underwent surgery for an anterior mediastinal tumor or myasthenia gravis at our institution. Intraoperative factors like duration of operation and amount of blood loss were analyzed as well as postoperative ones, including duration of chest drains, amount of postoperative fluid drainage, and length of hospital stay. The median age of patients was 59 years (36–80 years) with 19 females (50%). Overall, 28 patients (74%) underwent extended thymectomy. Seven patients (19%) experienced a combined lung resection and extended thymectomy, 3 (7%) a resection of pericardial (2) or bronchogenic (1) cysts. The median diameter of the lesions was 2.93 cm (1.2–7.7 cm). Postoperatively, 30-day mortality was 0%. Subxiphoid uniportal VATS is a convenient approach for minimally invasive mediastinal surgery. The excellent exposure of the anterior mediastinum and the possibility of conducting complex procedures, such as extended thymectomies and combined mediastinal and pulmonary resections with good results of minimal morbidity, represent the strong points of this technique. Thoracic surgeons experienced in VATS can safely perform subxiphoid uniportal VATS for mediastinal surgery.

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Subxyphoid uniportal VATS technique may play a major role in future mediastinal surgery.

Central Message

Subxyphoid uniportal VATS for thymic and combined mediastinal and pulmonary resections is an emerging technique. This technique has several advantages and that good results could be achieved.

Perspective Statement

This article describes our experience in a new and promising technique for resecting the mediastinal tumors in 38 patients. We have described our own technique in this article in an easy way, which we hope will help surgeons in conducting this type of surgery in the future.

Abbreviations: CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease, FEV1, forced expiratory vital capacity; ICJ, innominate-caval junction; VATS, video-assisted thoracoscopic surgery

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INTRODUCTION

Traditional trans-sternal thymectomy has long been accepted as the standard surgical approach for anterior mediastinal masses. Recently, minimally invasive techniques, such as video-assisted thoracoscopic surgery (VATS) and robotic-assisted thoracoscopic surgery were adopted as a preferred approach in many centers around the world. More recently, uniportal VATS through intercostal or subxiphoid approach has gained increased popularity among thoracic surgeons, especially in Asia, due to the reduction of postoperative pain and the cosmetic benefit.[1] Considering these advantages, we have adopted the subxiphoid uniportal technique as a standard in our practice. Herein, we present the results of our 2 years' experience in this technique for anterior mediastinal mass resection simply through uniportal VATS subxiphoid approach without the need to use retractors or insufflation of carbon dioxide. We hope that our paper will help surgeons conducting this type of surgery in the future.

METHODS AND MATERIALS

Patients

We conducted a retrospective review of a prospectively maintained departmental database of all anterior mediastinal procedures performed by the same surgical team at Shanghai Pulmonary Hospital, a high-volume referral center and teaching hospital between October 2014 and December 2016. Demographic, histopathologic, surgical, perioperative, and postoperative variables were analyzed. In the last 2 years, we have utilized the subxiphoid approach in the majority of our operations even in the most complex cases. The excluded patients were inoperable either in other techniques. Therefore, no exclusion criteria for our approach except patients with severe comorbidities such as severe congestive heart failure or chronic obstructive pulmonary disease who cannot tolerate surgical intervention. Redo operations and large tumors "larger than 10 cm" were excluded as well as tumors involving aorta or vena cava. Some of the postoperative information was collected by contacting the patient by telephone. The results of our initial experience (October 2014—February 2015) have been published before Wu et al[27] are included in this study. The Ethics Committee of our institution approved this study and waived the requirement for informed consent.

Operative Technique

We perform all mediastinal subxiphoid uniportal VATS procedures with the patient under general anesthesia and single-lung ventilation achieved by double-lumen endotracheal tube. The patient is routinely in the supine position with a roll placed beneath the thoracic spine to elevate the thoracic cage and to hyperextend the patient's neck (Fig. 1). The operating surgeon is usually positioned at the right side of the patient while the assistant is constantly placed at the left side of the patient with the scrub nurse positioned next to the operating surgeon (Fig. 2). Depending on the width of the angle between

Figure 1. Patient positioning in supine position for subxiphoid thymectomy surgery (notice the roll beneath the thoracic spine and marking the subcostal margins and the xiphoid process).

the subcostal margins, a 3—5 cm transverse or vertical incision is made just over the prominence of the xiphoid process. When the angle between the 2 costal margins narrow (<90°), we preferred the vertical incision, while the transverse incision was chosen when the angle is wide (>90°). The same way of creating the incision is used either if the intended operation is a pure thymectomy or combined with pulmonary resection without any additional modifications. The subcutaneous tissue is dissected and the insertions of the rectus muscles to the both costal arches are divided along the midline. The cartilaginous xiphoid process is excised using surgical scissors. At this point, a collapse of the right lung is induced. The anterior mediastinum is opened below the sternum, and a retrosternal tunnel is created by blunt finger dissection. A wound protector is commonly placed through which a 30° 10 mm video thoracoscope and all thoracoscopic instruments are introduced into the anterior mediastinum and both pleural cavities. The operations conducted through the same uniportal VATS subxiphoid

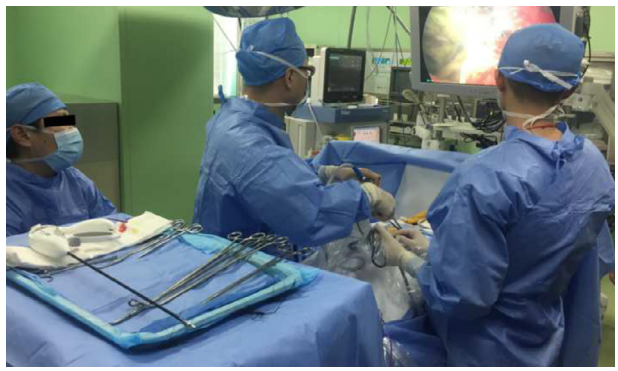


Figure 2. Positioning of the surgical team during the subxiphoid thymectomy operation (note that the main surgeon stands to the right side of the patient while the assistant who hold the camera stands at the left side).

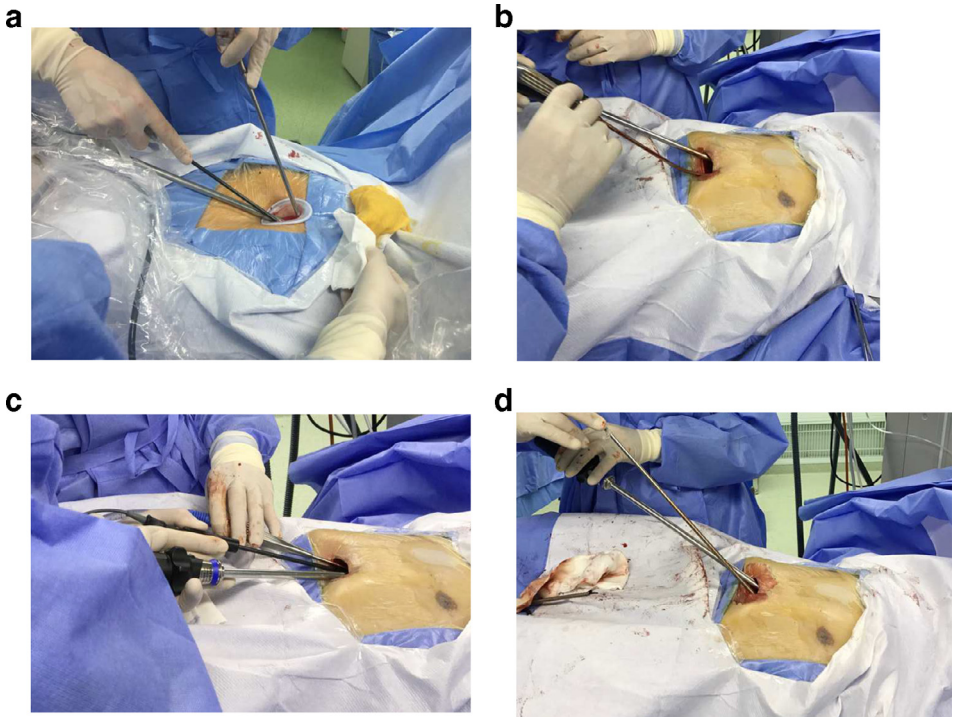


Figure 3. Placement of instrumentation (a) the thoracoscope lies at the inferior part of the vertical incision, (b–d) the thoracoscope is moved between the 2 lateral angles of the transverse incision.

incision without the need to use retractors or CO_2 insufflation in the vertical incision, in order to avoid crowding and instrumental interference, the video thoracoscope was placed at the most inferior part of the wound during the operation. Conversely, the video thoracoscope is alternatively placed at the 2 lateral angles when the incision is transverse (Fig. 3). Most of the thymic tissue dissection is performed using a long endoscopic curved tip spatula in addition to LigaSure energy device (Medtronic) and long curved tip instruments specifically designed for subxiphoid procedures (Fig. 4). The mediastinal pleura is bilaterally cut near the sternal surface up to the level of the right and left internal thoracic vein. Bilateral opening the pleura from the start provides the distinct advantage of facilitating the separation of the anterior mediastinum from the sternum since it moves posteriorly thus allowing for better exposure and broader space for instrumentation. The pericardial fat, the thymus gland, and right and left epiphrenic fat pads are dissected from the pericardium and diaphragm using a long spatula and ring forceps (Video 1). Dissection proceeds cephalad under the thoracoscopic visualization in an en bloc fashion. The phrenic nerves from both sides represent the lateral margin of dissection. The dissection continues superiorly until the innominate vein is visualized. The most crucial part of this operation is the dissection of the adipose tissue from the innominate vein in order to expose the thymic veins. At this point, the operating table is rotated to the left side with an elevation of the right side, improving access to the innominate-caval angle thereby improving exposure and safety of the dissection. The right thymic horn is dissected and pulled to

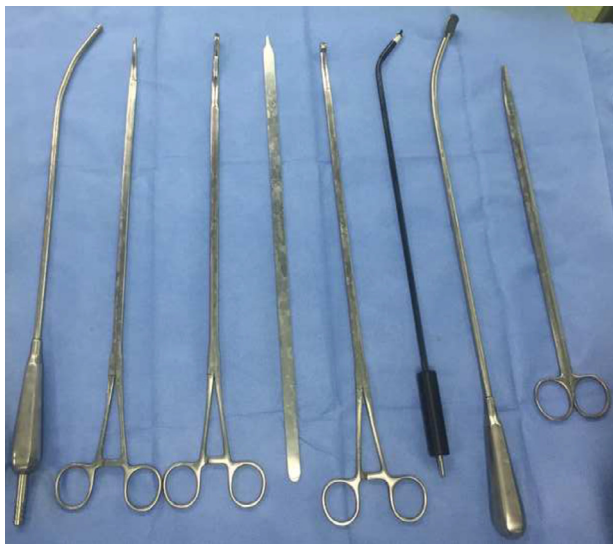


Figure 4. Long thoracoscopic instruments with curved tip specially designed for subxiphoid operations. From left to right: metal suction, long fine dissector, long ring forceps, stapling probe, long lymph nodes grasper, long curved tip spatula, diaphragmatic retractor, long scissors.

the left side by a ring forceps then divided at its most cranial point. The thymic veins (usually 1–4) are clipped and divided close to the left innominate vein (Video 2) using an energy device. At this point, a collapse of the left lung is induced while the right lung is reventilated. The left remaining pericardial fat is dissected free from the pericardium while all adipose tissues

are removed from the aortopulmonary window. The left thymic horn is dissected and divided in its most cranial point after retracting it caudally and to the right side. The specimen is extracted from the same incision after placing it in a retrieval bag. Caution should be taken when large tumors are removed, in case of compressing the heart impact of tamponade or arrhythmia may occur. In this case, the sample should be returned to the thoracic cavity immediately and the wound widened slightly before extracting it again. Hemostasis is ensured then one or two 24−28 Fr chest tubes are inserted through the same incision (according to the size of the procedure, air leak, and bleeding tendency). A mediastinal drain is constantly placed, and additional pleural drain is usually placed in the pleural space if lung resection was performed. Bilateral lung ventilation is resumed, and the wound closed in layers.

RESULTS

Demographic and Patients' Characteristic Data

Between October 2014 and December 2016, 38 patients were subjected to surgery for anterior mediastinal tumor or myasthenia gravis at our institution by the same surgical team. Median age of the 19 male patients was 61 years, whereas for the 19 females the median age was 59 years. Nearly one-third of the patients were smokers, and median FEV1 was 82% of predicted (53−110%). About half of the patients were asymptomatic when their tumor was incidentally discovered during routine radiological screening examination. Among symptomatic patients, chest pain was the most commonly reported (Table 1). Only 2 patients had mild muscles weakness due to myasthenia gravis.

Surgical Results and Characteristic Data

The procedure was performed by 1 surgical team. The first surgeon and first assistant were highly experienced in intercostal and subxiphoid uniportal VATS approaches. The operations have been conducted through a vertical incision in over than two-third of the patients, whereas a transverse incision was used in the rest of the patients. Overall median operative time ranged between 55 and 230 minutes. In combined procedures, median operative time was 127.5 minutes (range 88−230 minutes), while the median operative time in pure mediastinal procedures was 115 minutes (range 55−210 minutes). Operative and postoperative details are summarized in Tables 2 and 3. One instance of significant bleeding (400 mL) due to a vascular accident (injury of innominate vein) occurred; the tear was controlled and repaired through an additional 3 cm left anterior incision with no need for sternotomy (Video 2). No other intraoperative complications or conversions in our series. Overall, the median diameter of the lesions was 2.9 cm (1.2−7.7 cm). Final pathology showed a range of heterogeneous mediastinal lesions (Table 4) with the most frequent primary diagnosis being a thymic cyst (42%). There were no other perioperative complications or 30 days' mortality, except for 1 patient who needed mechanical ventilatory support for 48 hours due to

Table 1. Demographic and Patients' Characteristic Data

Characteristic	*N* (%)
Age (in years, mean ± SD)	59 ± 12.5
Sex	
Male	19 (50)
Female	19 (50)
Smoking history	12 (31.5)
Symptoms	
Asymptomatic	20 (53)
Myasthenia gravis	2 (5)
Cough	6 (15)
Chest pain	8 (21)
Hemoptysis	1 (3)
Fever	1 (3)
FEV1 (% of predicted, mean ± SD)	82 ± (28)

Table 2. Operative and Postoperative Characteristic Data

Characteristic	*N*
Overall operative time (in min), median	121 (55−230)
Operative time (in min), median in pure mediastinal operations	115 (55−210)
Operative time (in min), median in combined mediastinal and pulmonary operations	127.5 (88−230)
Intraoperative blood loss (in mL)	92.6 (range, 20−400)
Chest tubes drainage after 24 h (in mL)	235 (range, 10−600)
Postoperative hospital stay (in d, mean ± SD)	3.8 ± 2.6

Table 3. Type of Operation

Surgery	*N* (%)
Thymectomy with resection of the pericardial fat	28 (74)
Combined thymectomy with lung resection − total	7 (19)
Thymectomy with left lower lobectomy	1 (2.6)
Thymectomy with right lower lobectomy	1 (2.6)
Thymectomy with right middle lobectomy	1 (2.6)
Thymectomy with right segment (6) segmentectomy	1 (2.6)
Thymectomy with wedge resection of left lower lobe	1 (2.6)
Thymectomy with wedge resection of right upper lobe	2 (5)
Pericardial cyst	2 (5)
Bronchogenic cyst	1 (2)

Table 4. Final Pathologic Diagnosis

Pathologic diagnosis	*N* (%)
Bronchogenic cyst	5 (14)
Thymic cyst	16 (42)
Pericardial cyst	2 (5)
Ectopic goiter	1 (2.6)
Tuberculoma	1 (2.6)
Combined thymic cyst with fibrous hyperplasia of lung	1 (2.6)
Combined thymic cyst with adenocarcinoma of lung	2 (5)
Combined thymic cyst with squamous cell carcinoma of lung	1 (2.6)
Thymic hyperplasia	1 (2.6)
Thymoma	
AB	4 (10)
AB combined with AIS	1 (2.6)
B2	1 (2.6)
B2 combined with AIS	1 (2.6)
B3	1 (2.6)

exaggeration of myasthenia gravis symptoms. This patient recovered smoothly after treatment with mestinon bromide. This patient had mild ocular symptoms before the surgery and was under treatment of 60 mg mestinon per day. No readmissions were recorded.

DISCUSSION

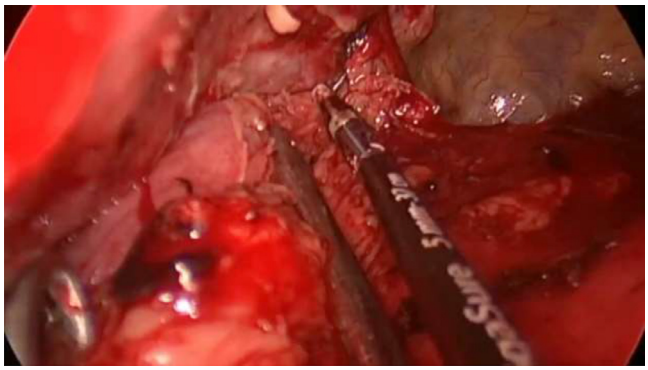
In this study, authors collected data on the results of subxyphoid uniportal VATS operations performed on a number of cases of anterior mediastinal tumors, some of which were coupled with lung resections. These operations were performed undividedly through a single subxiphoid incision with no utilization of CO_2. From the author's point of view, this approach can provide an excellent "panoramic" view to the anterior mediastinum and both pleural spaces.

Before the era of thoracoscopic surgery, the standard surgical approach to thymectomy was through a midline sternotomy, thoracotomy, or a cervical collar incision.[2,3] In spite of the risk for sternal dehiscence and infection of the mediastinal space along with significant postoperative pain and the potential for a more lengthened recovery period, median sternotomy has long been considered the most effective approach.[3,4] Partial sternotomy was subsequently introduced in to reduce the morbidity of sternotomy and for cosmetic purposes.[5] Due to its limited surgical exposure, the alleged difficulty in achieving hemostasis in case of major bleeding, and its association with high incidence of leaving thymic remnants, the transcervical approach did not gain widespread popularity.[6,7] In the early 1990s, with the development of thoracoscopic surgery, several authors described an extended thymectomy performed by a combined cervicotomy and thoracoscopic approach.[8,9] With the development of the thoracoscopic techniques and instrumentations, VATS thymectomy was started to be performed either unilaterally or bilaterally, from the right or left side.[10–12] Zielinski et al were the first to report the safety and the efficacy of the combination of a subxiphoid incision with a cervical approach.[13,14] Similar techniques were reported by Takeo et al, Kido et al, and Uchiyama et al.[15–17]

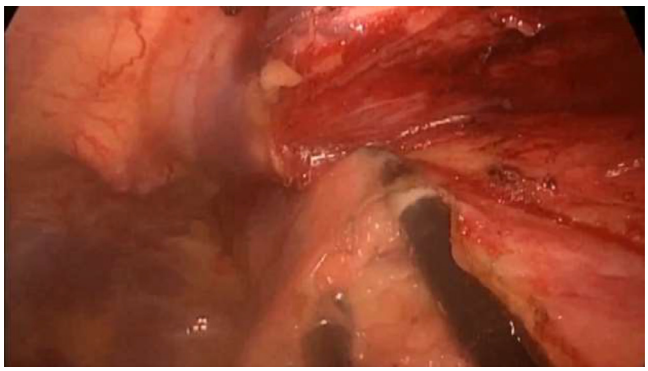
However, in the last 2 decades, thoracoscopic and robotic thymectomy had been increasingly used in selected patients to reduce pain and recovery time while maintaining the quality of thymectomy demonstrated by comparable remission and asymptomatic disease rates compared to other minimally invasive and open techniques.[10,12,18] Several approaches to thoracoscopic thymectomy have been described, including the right, left, bilateral, or bilateral with a cervical incision.[11,12] The right thoracoscopic approach seems to have gained the favor of the majority of surgeons due to better visualization of the innominate-caval junction and the thymic veins. One other aspect to be considered is lack of room on the left side for thoracoscopic stratagems and instrumentation due to the presence of the heart.[11] After the demonstration of the feasibility and safety of uniportal VATS through a single intercostal incision initially used for a variety of intrathoracic conditions, including lung cancer,[19–22] this approach was recently used for mediastinal lesions.[23–25] Simultaneously and as a natural development of intercostal uniportal VATS technique, the subxiphoid approach was introduced for anterior mediastinal surgical procedures. The technique was described for the first time by Suda et al that reported the use of a subxiphoid approach in performing a thymectomy for a patient with myasthenia gravis.[26] Subsequently, our group published in 6 patients subjected to thymectomy for different pathologies, including 1 case for myasthenia gravis.[27] More recently, Suda et al[28] described the use of CO_2 insufflation and several technical devices used to facilitate subxiphoid VATS. In our practice, we found that CO_2 insufflation is unnecessary, as opening the pleura bilaterally at the beginning of the surgery will let the mediastinum fall posteriorly providing a good space for instrumentation. We conclude that our preliminary experience demonstrates that subxiphoid uniportal VATS surgery is a convenient approach due to an excellent panoramic "phrenic to phrenic" exposure of the anterior mediastinum and the feasibility of complex procedures, including combined mediastinal and parenchymal lung resections through the same incision with minimal morbidity and short hospital stay. This approach should be used by experienced surgeons in extended VATS thymectomy practicing in relatively high-volume centers. We hope that we can describe and clarify the new technique for surgeons to be able to adopt and develop them more to reach the ideal approach for this type of surgery. Larger numbered studies and long-term follow-up with a comparison group will be necessary to clarify the role of subxiphoid uniportal VATS for thymectomy and complex procedures in the future.

SUPPLEMENTARY MATERIAL

The following is the supplementary data to this article:



Video 1. Subxyphoid uniportal VATS extended thymectomy.



Video 2. Management of intraoperative bleeding during subxyphoid uniportal VATS thymectomy by adding accessory port.

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