Technique for Myasthenia Gravis: Subxiphoid Approach

Beatrice Aramini, MD, PhD, Jiang Fan, MD, PhD*

KEYWORDS
- Subxiphoid thymectomy • Myasthenia gravis • VATS thymectomy • Minimally invasive surgery
- Open thymectomy • Sternotomy

KEY POINTS
- Surgical resection of thymoma has been recommended as the principal treatment, and completeness of resection is considered the most important determinant of the long-term survival in thymomas.
- Recent studies have reported thymectomy for myasthenia gravis and anterior mediastinal tumors using a minimally invasive approach rather than conventional median sternotomy.
- Video-assisted thoracic surgery (VATS) is widely used in thoracic surgery for anterior mediastinal tumors or myasthenia gravis (MG).
- The subxiphoid approach led to less-invasive thymectomy and extended the indications for VATS for invasive anterior mediastinal tumors.
- The subxiphoid approach improves patient satisfaction, reduces pain, and offers superior aesthetic outcomes.

INTRODUCTION
Currently, surgical techniques that are less invasive than conventional median sternotomy are used for thymectomy in the treatment of myasthenia gravis (MG) and anterior mediastinal tumors, so no sternal incision is required (Videos 1–4).1–8 Among the minimally invasive approaches, 3 are widely used for thymectomy. Although the first thymectomy was performed transcervically by Sauerbruch in 1912,9 transsternal access gained popularity in the 1980s following the results of Jaretzki and colleagues,10 who recommended a “maximal transcervical-trans-sternal thymectomy” for non-thymomatous MG patients. Since then, the trans-sternal approach has been used and described with different modifications.11 In 1988, Cooper and colleagues12 described an extended transcervical approach using a dedicated self-retaining sternal retractor to lift the sternum. This technique offered the advantage of causing minimal pain because it does not involve access through the intercostal space. However, the surgical operability and field of view are very poor; thus, this technique is not widely used.13 The second approach is lateral thoracotomy, which is currently the most widely used technique, especially for large anterior mediastinal masses or infiltrating tumors. Even if the traditional approach to thymectomy by median sternotomy or lateral thoracotomy is based on the assumption that it is the best means to achieve adequate

Disclosure Statement: The authors have nothing to disclose.

a Division of Thoracic Surgery, Department of Medical and Surgical Sciences for Children and Adults, University of Modena and Reggio Emilia, Modena 41124, Italy; b Department of Thoracic Surgery, Shanghai Pulmonary Hospital, Tongji University School of Medicine, Shanghai 200433, China

* Corresponding author.
E-mail address: drjiangfan@yahoo.com

https://doi.org/10.1016/j.thorsurg.2018.12.010
1547-4127/19/© 2018 Elsevier Inc. All rights reserved.
resection margins, complete removal of the thymus and clearance of the anterior mediastinal fat, Landreneau and colleagues14 in 1992 removed an anterior mediastinal tumor under thoracoscopy. Recently, video-assisted thoracoscopic surgery (VATS) thymectomy has been gaining acceptance as a means to achieve adequate oncologic results and symptomatic improvement of myasthenic symptoms with less impact on the patient. This approach is also commonly used in robot-assisted thymectomy.15,16

The third minimally invasive technique reported by Kido and colleagues17 in 1999 is the subxiphoid approach. This approach offers a better view from the midline of the body that permits identification of the location of the superior pole of the thymus and bilateral phrenic nerves. This approach avoids intercostal nerve damage with minimal pain and excellent cosmetic outcomes.

Various surgical modifications currently used for thymectomy have been suggested.18–23

SURGICAL TECHNIQUE
Pre-operative Planning

Patient selection for the subxiphoid VATS thymectomy approach is recommended based on the good field of view provided this procedure, which is indicated in patients with MG and/or anterior mediastinal tumors who do not require surgical suturing. In the event that the mass infiltrates anatomic structures that require more attention and working space, that is, pericardium infiltration, additional ports or open surgery should be considered. However, for advanced operable stages, especially after radiation therapy, median sternotomy, or lateral thoracotomy should be planned.

Computerized tomographic (CT) scanning is routinely performed in patients before surgery and after tumor resection to screen for thymoma recurrence. If MG or other symptoms arises, CT could be the first choice (Fig. 1). However, CT is a morphologic examination; before surgery, patients with anterior mediastinal mass should undergo physical and neurologic examination, electromyography, and acetylcholine receptor antibody blood test.

Positron emission tomography (PET)-CT could compensate for the limitations of CT by measuring the metabolic rate of tissue, which improves the diagnostic accuracy. The overall sensitivity of CT for detecting the mediastinal recurrence and pleural dissemination of thymomas is 71%, and its specificity is 85%. Regarding PET-CT, the overall sensitivity and specificity for thymoma recurrence are 82% and 95%, respectively.24

Preparation and Patient Positioning

The patient is placed in the supine position (Fig. 2). The operator stands between the patient’s legs and the surgical assistant with the camera stands to the right of the patient to operate the 30° camera scope. A monitor is positioned at the patient’s head (Fig. 3).

Mechanical ventilation with a double-lumen endotracheal tube is used, with the patient under general anesthesia for one-lung ventilation. The peripheral intravenous drip route is secured to the right upper or lower limb, making it possible to clamp the innominate vein in the event of injury to this vein.
**Surgical Approach**

A vertical 4-cm skin incision approximately 1-cm caudal to the xiphoid process (Fig. 4A), and an additional 2-cm skin incision between the fourth and fifth intercostal anterior axillary line on the right side, are used for camera placement; these surgical access points are used at the end of the operation for the placement of chest drains (Fig. 4B). A surgical assistant is typically placed to the right of the patient; however, the camera may be moved to the other side if necessary (Fig. 5A). A 1-cm incision is generated for the placement of hooks, which are tightened by 2 retractors (Fig. 5B, C).

**SURGICAL PROCEDURE**

**Step 1: Surgical Access**

Caution should be exercised given that it can be difficult for the forceps to reach the posterior aspect of the sternum if the skin incision is made too close to the xiphoid process. To guarantee better access and exposure of the anatomic structures in the anterior mediastinum, a hook is placed at the level of the jugular process behind the manubrium of the sternum, and another hook is placed behind of the lower portion of the sternum after resection of the subxiphoid process. Thereafter, a 4-cm vertical incision is made on the fascia of the rectus abdominis without opening the peritoneum, and a space is created to insert the port. An Alexis wound retractor (Applied Medical, Rancho Santa Margherita, CA, USA) is used to protect the access during the operation (Fig. 6). There is no need to dissect the xiphoid process.

**Step 2: Thymus Isolation**

The surgeon detaches the thymus from the posterior aspect of the sternum to the neck using the HARMONIC ACE+7 (Ethicon, Cincinnati, OH, USA) device. Bilateral incisions are generated in the mediastinal pleura, and the thoracic cavity is exposed bilaterally. Next, the locations of the bilateral phrenic nerves are identified. The location of the left phrenic nerve on the caudal side in the thoracic cavity can be verified by either pulling the pericardial adipose tissue to the right or by displacing the heart with cotton swabs for thoracoscopic surgery. The pericardial adipose tissue and thymus are detached from the pericardium in an anterior manner from the bilateral phrenic nerves. To prevent collateral damage to the adjacent organs when using a vessel-sealing device, the device should be used only once the dissected thymus is at a safe distance and is sufficiently detached from vital structures, such as the pericardium and brachiocephalic vein. The surgeon

---

**Fig. 3.** Surgeon and operative room during subxiphoid thymectomy.

**Fig. 4.** (A) Surgical ports access is established before the operation. (B) Chest drain placement after surgery.
proceeds along the innominate vein with the closure of the thymic veins (1–5 thymic veins are typically noted) with vascular clips (hemlock) until the left internal thoracic vein (left mammary vein) is visualized. The dissection proceeds cranially with closure and division of the lower thyroid veins in the same manner as that used for thymic veins. The dissection further proceeds along thymic poles (horns) until the lower portion of the thyroid is clearly visualized. During the dissection, structures, such as the innominate, the brachiocephalic trunk artery, the common carotid, and the trachea, are always visualized. The laryngeal recurrent and vagus nerves are preserved.

The left lobe of the thymus is pulled toward the right of the patient by bending the forceps of the left hand to the right. At this point, the surgeon crosses hands to detach the left lobe with the HARMONIC device (Ethicon). The right lobe of the thymus is pulled toward the left of the patient by bending the forceps to the left. The surgeon does not need to cross hands for this step. The lower pole of the thymus is detached from the pericardium. A trick to perform this surgery well is to firmly grasp the thymus near the detachment site with the forceps in the left hand and pull. To safely expose the distal side of the left brachiocephalic vein, the superficial adipose tissue is slowly and gradually detached from the area near the left brachiocephalic vein. The proximal side of the left brachiocephalic vein is close to where this vein joins the right internal thoracic vein. Similar to the distal side, the proximal side is exposed by slowly and gradually detaching superficial adipose tissue from the area thought to be near the left brachiocephalic vein. Once the proximal side of the left brachiocephalic vein is exposed, the area of the confluence of the brachiocephalic veins is exposed. Thereafter, the neck portion is detached, and the thin membrane above the thymus is dissected. Although the right internal thoracic vein is not typically dissected, it can be dissected if it hinders the operation. Although exercising caution to not injure the left brachiocephalic vein, the superior pole of the thymus is grasped using grasper forceps and pulled caudally to push the left brachiocephalic vein and expose a good field of vision of the neck. The superior pole of the thymus and the cervical adipose tissue are dissected from the right brachiocephalic vein on the right side, the thyroid at the upper end, the brachiocephalic artery and trachea on the posterior aspect, and the left brachiocephalic vein on the left side. Due care should be exercised to not damage the inferior thyroid vein. Finally, the thymus is pulled to either the right or left and dissected from the innominate vein. In the sequential order of the procedure, the thymic vein is dissected using the HARMONIC device, and thymectomy is completed. The liberated upper horns of the

Fig. 5. Hooks are inserted in the jugular and subxiphoid incision and tightened by 2 retractors (A, B). Hooks and 30° camera (C).
thymus are grasped and pulled caudally, enabling dissection of the thymus from the pericardium and the left mediastinal pleura, which is partially resected. Finally, the thymus is pulled to either the right or left and dissected from the innominate vein (Fig. 7). The thymus is finally placed in the plastic bag and removed through the subxiphoid incision (Fig. 8). Dissection of the aorta-pulmonary window is completed. Hemostasis is assessed. VATS ports are removed. The resected thymus is placed in an endobag in the mediastinum and removed from the body through the subxiphoid incision. Two chest drains (variable from 20Fr to 28Fr, depending of the patient’s size) are placed, 1 inserted through the subxiphoid incision in the left thoracic cavity and 1 inserted through the right access in the right pleural space, or both into the subxiphoid incision, and the surgical incision is closed.

**Immediate Postoperative Care**

After surgery, patients with no complications are monitored in the thoracic surgery unit. A chest radiograph and blood test are performed on the day of the operation. Patients with a preoperative MG diagnosis are placed preventively in the intensive care unit for 24 hours. The chest drainage is removed the day after surgery. Patients are typically discharged from the hospital after 2 to 3 days.

**Rehabilitation and Recovery**

Patients are typically assessed 1 week after surgery and undergo chest radiography. Follow-up for thymoma and thymic carcinoma is set by current guidelines. In our surgical experience, the mean observation period after thymectomy for thymoma was 10.1 months (range: 0.5–26.0 months after operation). No mortality was reported in this period.

**CLINICAL RESULTS IN THE LITERATURE**

Thymectomy is recommended for the treatment of thymoma. Surgical resection for thymoma is regarded as the principal treatment, and the completeness of resection is considered to be the most important determinant of the long-term survival of the patients with thymomas. In recent years, minimally invasive approaches have replaced conventional median sternotomy in thymectomy for thymoma or MG. VATS thymectomy for MG and anterior mediastinal tumors was initially reported in the early 1990s. Although sternal wound complications occasionally become problematic following sternotomy, the incidence of sternal wound complications disappeared with the use of VATS thymectomy. Although many groups have reported on the use of VATS thymectomy, the technique is not widespread based on the following hypothesized reasons. First, the thymus is surrounded by the sternum, the pericardium, and the pleura. Median sternotomy has been used for thymectomy for many years.
Many thoracic surgeons prefer sternotomy for thymectomy even if they often perform VATS operations for lung cancer. This notion could be justified based on the following reasons. Surgeons prefer to understand the anatomy of the mediastinum from the viewpoint of median sternotomy. The working space is severely limited owing to the position of the thymus, which is a gland surrounded by many organs. In addition, difficulties in the operative procedures potentially influence the use of the technique.

To overcome such difficulties, the subxiphoid approach has been used in recent years. This technique offers the following advantages: the view is similar to the view from median sternotomy and the view looking-up from the main incision using this approach is familiar to thoracic surgeons. Second, to overcome the challenge of the working space, many surgeons have increased the working spaces by lifting the sternum or using CO₂ insufflation, which beneficially compress all organs and structures, thus securing the space from the sternum to the heart.

The subxiphoid approach is not more widely used because thoracic surgeons are unfamiliar with this approach. One of the main complications during this surgery is bleeding of the main vessels. The response to that is vital, and countermeasures for bleeding from the innominate vein are important in thymectomy. If bleeding occurs, the first step is to stop the bleeding by applying pressure using the thymus or a swab for thoracoscopy. An attempt should be made to stop the bleeding by applying a fibrin sheet or other hemostatic agents to the bleeding point. If these methods do not stop the bleeding, the surgeon should promptly switch to median sternotomy, which is easy given that a subxiphoid approach is performed with the patient in a supine position. However, experience with this technique is mandatory. In 2016, Friedant and colleagues published a systematic review and meta-analysis regarding the role of minimally invasive versus open thymectomy for thymic malignancies and reported no statistically significant differences in overall R0 resections for the minimally invasive surgery (MIS) or open groups; however, the trend favored patients in the MIS group. The only statistically significant clinical outcomes observed were decreased blood loss and reduced length of hospital stay, both of which favored the minimally invasive group. No differences in operating time or complications were noted between the 2 groups.

SUMMARY

Current literature suggests that minimally invasive surgery may be as effective as or better than open thymectomy in treating small, early-stage thymic malignancies. Studies have reported comparable survival data and oncologic outcomes between the 2 procedures; however, such claims are limited by the small sample size and lack of long-term follow-up comparisons between patients who underwent MIS and those who underwent open thymectomy.

There are 2 main advantages of the subxiphoid approach: the reduction of pain after surgery and the aesthetic result. Furthermore, the subxiphoid approach uses only 1 or 2 ports for access. In fact, this technique avoids intercostal nerve...
damage due to the subxiphoid access, and the eventual small collateral incision. Suda and colleagues\textsuperscript{13,34} in 2016 published a description of monoportal VATS suxiphoid thymectomy and “multiple-ports” robotic subxiphoid thymectomy. Further steps need to be set to develop a future single-port robotic thymectomy through the subxiphoid access. However, this technique is recommended for small- to middle-sized anterior mediastinal tumors, possibly without infiltration of the main vessels and the surrounding structures. Recently, an increased incidence has been noted for small-sized anterior mediastinal tumors. This increase is presumably associated with the combination of increased radiological procedures with medical examinations.

SUPPLEMENTARY DATA

Supplementary data to this article can be found online at https://doi.org/10.1016/j.thorsurg.2018.12.010.

REFERENCES


