Review Article

Subxiphoid thymectomy—technical variants

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Abstract: The aim of this article is to review technical variants of minimally invasive extended thymectomy performed through the subxiphoid approach. These approaches include the sole subxiphoid with use of Video-Assisted-Thoracic Surgery (VATS) technique or the subxiphoid incision might be combined with the transcervical, intercostal, subcostal single or bilateral VATS. The use of CO_2 insufflation or the elevation of the sternum are the options to facilitate an access to the chest. The technical details of all these variants are described in detail. The advantages of the subxiphoid approach in comparison to the other approaches for thymectomy including a transcervical approach, unilateral VATS, bilateral VATS, VATS combined with transcervical incision, are analyzed. The operative technique of the new procedure, subxiphoid uniportal extended thymectomy with double elevation of the sternum is described.

Keywords: Subxiphoid; thymoma; thymectomy; myasthenia gravis (MG); mediastinum

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Introduction

There are two most important principles in the surgical treatment of non thymomatous myasthenia (MG). One of these, is the necessity of removal the whole thymus gland, without leaving any part of the gland in the mediastinum, or in the neck, which is currently often the case in VATS thymectomy (1). The other rule, which is generally accepted by the majority of thoracic surgeons is the need of performance of thymectomy in an extended technique, with removal of the adipose tissue surrounding the thymus gland (1,2). In case of myasthenia associated with thymoma the need for extended thymectomy is less clear with no strong data supporting such an aggressive approach. There are virtually no recommendations regarding the extent of surgery in case of thymomas associated with MG. The need for removal the whole thymus gland has been questioned for thymomas without MG. The role of thymectomy is totally unclear in case of the other thymic pathologies like the thymic cysts. Thymectomy should not be performed in patients with the thymic hyperplasia without MG. In the beginning of the 1990. the right and left uniportal VATS were introduced and practiced with the growing popularity. In the end of the same decade several authors independently from each other started to use the subxiphoid approach for thymectomy, with the results published in 1999 and afterwards (3-8). Currently, the use of a subxiphoid incision is increasing not only for thymectomy, but also for VATS pulmonary resections. In this review the technical variants of a subxiphoid approach are described and their advantages and disadvantages in comparison to the other minimally invasive approaches for thymectomy are discussed (*Table 1*).

Table 1 Technical variants of the subxiphoid thymectomies

Type of the subxiphoid thymectomy	Author
Simple subxiphoid approach	Kido *et al.* (3)
Transcervical-subxiphoid-VATS	Zieliński *et al.* (4)
Uniportal subxiphoid plus elevation of the skin with a wire suture	Suda *et al.* (8)
Subxiphoid-robotic	Suda *et al.* (9)
Subxiphoid-right VATS with double elevation of the sternum	Zieliński *et al.* (10)
Subxiphoid-bilateral VATS plus double elevation of the sternum	Zieliński *et al.* (11)
Subxiphoid-bilateral subcostal with CO_2 insufflation	Zhao *et al.* (12)
Subxiphoid-bilateral subcostal with double elevation of the sternum	Zieliński *et al.* (13)
Uniportal subxiphoid with CO_2 insufflation	Suda *et al.* (14)
Uniportal subxiphoid with double elevation of the sternum	Zieliński *et al.* (current article)

Variants of techniques of thymectomy with use of subxiphoid approach

A longitudinal, transverse or subcostal incision

Originally, a transverse incision was used (3-7). A longitudinal incision was introduced afterwards by the other several authors (8,15). There have been no studies comparing these two incisions. The advantage of the transverse incision is probably the better access to the chest, especially if the elevation of the sternum is used. In such case the incision is round-shaped, which facilitates introduction of the instruments to the chest and extraction of the specimen in an endo-bag. It must be stressed that a similar effect can be achieved in case of a longitudinal subxiphoid incision if the round-shaped wound retractor is used. The advantage of a longitudinal incision is an avoidance of incision of the medial edges of the rectus abdominal muscle, which theoretically might lead to occurrence of postoperative hernia. The third variant of this approach is a subxiphoid-subcostal incision placed unilaterally in aim to improve an access to one pleural cavity. This approach has probably no role in case of thymectomy necessitating an access to both pleural cavities.

Uniportal subxiphoid VATS or robotic technique

An uniportal subxiphoid thymectomy is possible only with use of VATS technique. A subxiphoid robotic approach necessitates a Multiportal approach (9). In the future, with possible introduction of a new generation of robots able to work through a single incision it might be possible to develop new techniques of thymectomy including a uniportal subxiphoid thymectomy.

A subxiphoid approach with bilateral subcostal VATS

This approach was described by Zhang *et al.* who performed a longitudinal 3 centimeter incision and two 5 millimeter bilateral subcostal incisions and used an additional CO_2 insufflation for resection of the Masaoka stage III thymomas (10).

A subxiphoid approach plus elevation of the skin

This approach was introduced by Suda *et al.* (8). The authors performed a 3.5 centimeter subxiphoid incision with a Single Incision (SILS) port introduced to the wound, which enabled the use of CO_2 insufflation. To facilitate the visualization of the mediastinum a 2-mm Kirschner wire was introduced subcutaneously transversely at the level of the sternal angle between manubrium and gladiolus, and the skin was lifted upward by a Kirschner wire using the Laparolift system. Specially designed instruments with bendable tips are useful for operation in the narrow surgical field.

A subxiphoid approach with elevation of the sternum and right-sided VATS

This approach was reported by our team in team especially

for resection of thymomas (11). In that time, in cases of thymomas we did not strive for as extensive thymectomy as for nonthymomatous MG. In this operation the whole dissection was performed through the right pleural cavity and the left pleural cavity was not opened.

A subxiphoid approach with elevation of the sternum and bilateral VATS

Subsequently, the policy of our team for the treatment of thymomas has changed and currently we try to perform a maximally extended thymectomy with opening of both pleural cavities and dissection proceeded up to the level of the lower poles of the thyroid gland and laterally—from one phrenic nerve to another. The right and left epiphrenic fat pad are resected en-bloc with the specimen. The tissue from the aorta-pulmonary window is removed separately (12).

A subxiphoid approach with elevation of the sternum and bilateral subcostal VATS

This technique was introduced by our team in 2013 and it was described recently (13). The procedures includes a 5 cm transverse subxiphoid incision, elevation of the sternum from the upper sternal notch and lower angle of the sternum with use of the Rochard frame and bilateral subcostal incision for insertion of the bariatric laparoscopic extra-long ports (standard, shorter ports might not reach the pleural cavity in case of obese patients). Due to the elevation of the sternum the whole thymus with the surrounding fatty tissue can be resected extensively from the level of the lower poles of the thyroid down to the diaphragm.

A uniportal subxiphoid approach

This approach was introduced by Suda, who used the subxiphoid approach and single-incision laparoscopic surgery (SILS) port combined with CO_2 insufflation (14)

The operation is performed with the patient in the supine position and the surgeon standing between a patient's legs and an assistant standing on the patient's right ride to operate the camera. First, a 3-cm transverse incision is made 1 cm caudal to the xiphoid process. After blind detachment of the sternum using a finger, a 0.5-cm longitudinal incision is made on the fascia of the rectus abdominis to create enough space to insert a SILS port.

One of three mini-ports inserted into the main port is used for the camera scope. CO_2 insufflation in the mediastinum was performed at 8 mmHg. The positive pressure of CO_2 insufflation, together with detachment of the thymus from the sternum creates a space sufficient for the surgeon to proceed with dissection. The mediastinal pleura is opened bilaterally. For detachment in the neck region, grasper forceps are used to grab and pull the superior pole of the thymus towards the caudal end in order to push the brachiocephalic vein and create a good operative field.

A uniportal subxiphoid approach with double elevation of the sternum—this new approach introduced recently by our team will be described in detail in next part of this article.

The patient

A uniportal subxiphoid extended thymectomy presented on the videos was performed in a patient with a large thymic cyst without MG. The indications for surgery in patients with thymic cyst without MG are not clear with no publications on this particular issue. In our patient the dimensions of the cyst (95 milimeters × 40 milimeters × 30 milimeters) were decisive. In our opinion there was a risk of a pressure of the cyst on the mediastinum and a development of possible infection of the cyst. Due to the lack of thymoma and MG we made no effort to dissect the upper thymic poles up to the level to thyroid, as is our usual practice in patients with thymoma and/or MG (16). The aim of surgery was to remove the whole thymus without rupturing of the capsule of the cyst to avoid its subsequent recurrence.

Surgical Technique of a uniportal subxiphoid approach with double elevation of the sternum

The patient is positioned supine on the operating table with a roll placed beneath the thoracic spine to elevate the chest and to hyperextend the patient's neck. Under general anaesthesia an endobronchial tube is inserted to conduct possible selective lung ventilation during the latter part of the procedure.

A transverse 5–7 cm subxiphoid incision was made above the xiphoid process. The subcutaneous tissue and the medial parts of the rectus muscles were cut near the insertions to the costal arches. The xiphoid process was removed. In this case we did not used a selective ventilation of one lung but proceeded with two lung ventilation with anesthesiologist trying not to hyperextend of the lungs. In this patient a hypoventilation and permissive hypercarbia was avoided,

Figure 1 Subxiphoid incision, elevation of the sternum, opening of the right mediastinal pleura, dissection of the mediastinal tissue from the sternum, introduction of the percutaneous hook elevating the sternal manubrium (17).
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Figure 2 Dissection of the thymus and the surrounding mediastinal tissue from the neck, the mediastinal vessels and the pericardium (18).
Available online: http://www.asvide.com/articles/1373

however such a slight risk must be considered in this type of operations.

The anterior mediastinum was opened from below the sternum. A sternal retractor connected to the traction frame (Rochard bar, Aesculap-Chifa, Nowy Tomysl, Poland) was placed under the sternum, which was elevated to facilitate access to the anterior mediastinum from below (*Figure 1*). The whole dissection was performed through the subxiphoid incision under control of a videothoracoscope inserted alternatively to the right and left pleural cavities.

The right mediastinal pleura was cut near the sternal surface up to the level of the right internal thoracic vein, which was left intact with the use of bipolar cautery (Bi-Clamp, ERBE). Alternatively, such devices as a harmonic knife, LigaSure or vascular clips can be used to secure the vessels throughout the procedure. After dissection of the mediastinal tissue from the inner surface of the sternum a 2–3 mm puncture was performed over the sternal notch and a single-tooth hook was inserted percutaneously under the sternal manubrium. The second hook improved exposure of the superior mediastinal and the lower neck regions facilitating considerably performance of the procedure and enabling visualization of the whole upper poles of the thymus and the lower part of the thyroid. The prepericardial fat was dissected from the pericardium and diaphragm. Dissection of the prepericardial fat containing the thymus gland proceeded upwards in en bloc fashion under control of thoracoscopy, without any attempt to dissect the thymus gland with the cyst separately. The right phrenic nerve was a margin of dissection. The dissection of the thymus proceeded along the left innominate vein with closure with vascular clips and division of the thymic veins, until the left internal thoracic vein (left mammary vein) was visualized (*Figure 2*). The left mediastinal pleura was opened at the relatively early stage of dissection, enabling the maneuver of transferring of the dissected specimen obscuring plane of dissection from the right to the left pleural cavity. This maneuver facilitated dissection substantially due to improved exposure of the rest of the thymus. Dissection proceeded cranially with closure and division of the lower thyroid veins, performed in the same way as in the case of the thymic veins. The liberated upper poles of the thymus were grabbed and pulled caudally enabling dissection of the thymus from the pericardium. Dissection of the specimen along the left phrenic nerve was performed, the same as was done on the right side (*Figure 3*). The specimen containing the thymus and the adipose tissue was placed in a plastic bag and removed. Haemostasis was checked and single chest tubes were inserted into both pleural cavities through the subxiphoid incision. The anaesthesiologist hyperexpanded both lungs. The subxiphoid incision was closed in the standard manner, a puncture incision was closed with a single 5/0 suture, which was replaced with a Peri Strip on the next day. The patient was extubated immediately after the operation.

Generally, the dissection of the neck area performed during the uniportal subxiphoid VATS extended thymectomy is less extensive than in the transcervical-subxiphoid-VATS approach. Therefore, we describe the techniques without a cervical incision as the extended, contrary to the previous technique called as “the maximal”. Nevertheless, the differences of extensiveness between the

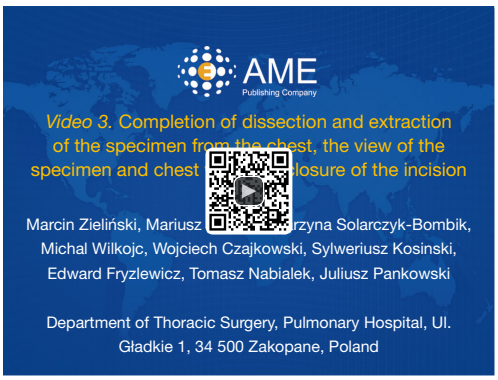

Figure 3 Completion of dissection and extraction of the specimen from the chest, the view of the specimen and chest wall after closure of the incision (19).
Available online: http://www.asvide.com/articles/1374

techniques with and without the transcervical incisions are probably slight.

Tips, tricks and pitfalls

I. The subxiphoid incision should be performed just below the junction of the lower angle of the sternum. The length of the incision depends on the patients' body habitus—in case of slim patients 3 cm could provide an adequate approach instead of the length of 5 cm, which is usually performed in the medium body habitus patients;
II. Generally, we start dissection from the right pleural cavity with completion of dissection in left one;
III. During dissection of the mediastinum from the posterior surface of the sternum the mediastinal structures are pressed posteriorly towards the spine, with the Yankauer suction tube to protect these structures from injury during percutaneous insertion of the second sternal hook elevating the sternal manubrium;
IV. The next step is dissection of the right epiphrenic fat pad from the right dome of the diaphragm and the pericardium. Dissection of the specimen containing the whole thymus gland is proceeded in the cephalad direction. In case of obese patients and especially in thymomas it is useful to open the mediastinal pleura to transfer the specimen to the contralateral left pleural cavity. This maneuver gives the clear view of the plane of dissection facilitates dissection of the specimen from the pericardium;
V. During dissection on the left it is useful to rotate an operating table to the right and to rotate it in the opposite direction during dissection on the left side;
VI. Dissection of the area cranial to the left innominate vein is the most difficult part of the procedure. The aim is to reach and visualize of lower poles of the thyroid gland to remove completely the upper poles of the thymus and the surrounding fatty tissue. The innominate artery, right and left carotid arteries and the trachea should be clearly dissected. This can be achieved with the simultaneous use of the bipolar cautery (or harmonic knife or LigaSure) and the Yankauer suction tube, which is used to dissect and retract tissue. Avoidance of injury of the left recurrent nerve might occur during dissection in the area located on the left side of the trachea.

There several advantages of the subxiphoid approach for thymectomy in comparison to the VATS approach, regardless if it is a unilateral right or left or bilateral approach. The main advantage is an access to both side of the mediastinum through a one incision with clear visualization of both phrenic nerves after opening of the mediastinal pleura on both sides. Such an access is hardly possible in case of the unilateral VATS (right or left). The access to both pleural cavities is possible partly due to a supine position of the patient undergoing a subxiphoid thymectomy in comparison to the lateral or semi lateral position of the patient undergoing unilateral VATS approach. In case of bilateral VATS an access to both pleural cavities is possible, but for the price of introduction of multiple intercostal ports with a risk of an increased postoperative pain. It is important to stress that, generally, a subxiphoid incision is less painful than VATS in the early postoperative period and virtually never leads to the development of a chronic postoperative pain. Theoretically, there are several complications possible after the performance of a subxiphoid access, but they are seldom encountered in the clinical practice. The only type of complication we noticed in 3 patients after performing about 600 operations through a subxiphoid incision at our hospital was an incisional hernia, which was relatively easy to repair with implantation of mesh prosthesis. To avoid occurrence of postoperative hernia after transverse subxiphoid incision we recommend to make it a little below the insertion of the xiphoid process to the lower sternal angle, due to the presence of the rectus muscles at this level, which allows for reconstruction of the fascia covering the muscle and protects the wound from dehiscence. If the incision is made to high (cephalad) there is no fascia at this level place and closure of the wound is not safe.

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