Video-assisted thoracoscopic microthymectomy

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There are many techniques for performing video-assisted thoracoscopic (VATS) thymectomy. This article describes one particular technique that we employ in thymectomies as well as lobectomies. The principles of both operations are as follows, and have been presented in greater detail for lobectomies previously: (I) the use of ports no greater than 5-mm in the intercostal spaces; (II) the use of a 12-mm subxiphoid port; (III) subxiphoid removal of the specimen; (IV) carbon dioxide (CO_2) insufflation; (V) vision enabled through a 5-mm camera; (VI) in microlobectomies, the use of a 5-mm stapling device. These principles are particularly suited to thymectomy, as there are no large vascular structures that require stapling and a large number of the instruments required for thymectomy are already 5-mm in diameter, including energy devices, graspers, clip applicators and suction devices. We believe that this technique, which eliminates the need for large incisions in the intercostal spaces, is less painful than other techniques that we have employed, including intercostal uniportal surgery. It also allows the use of CO_2 insufflation, which is very useful indeed in endoscopic thymectomies. Furthermore, microthymectomy is technically easier than subxiphoid-only techniques, in that it requires little modification compared to a more conventional VATS thymectomy. We describe this technique in detail in this article.

Keywords: Thymoma; video-assisted thoracoscopic (VATS)

Introduction

There is a wide range of techniques that may be employed in order to achieve a minimally invasive thymectomy. In our journey through the range of techniques available, we had at the core of our ethos the principles laid out by the International Thymic Malignancy Interest Group (ITMIG) in 2011, which requires an *en bloc* thymectomy for all thymomas, including perithymic fat and cervical poles. Furthermore, patients with myasthenia gravis are required to undergo an extended thymectomy must be performed, including the mediastinal pleura, pericardiophrenic fatty tissue and dissection of the aorto-pulmonary window (1). The Myasthenia Gravis Foundation of America have also graded the completeness of thymectomy and provided a classification system, ranging from a T1. We are mindful of the need to achieve at least a T2b video-assisted thoracoscopic (VATS) extended thymectomy for myasthenic patients (2). In addition, we have been particularly impressed by subxiphoid approaches to thoracic surgery. Early descriptions in thoracic surgery were described by Mineo and colleagues (3,4) for metastasectomy, where two ports were placed in the intercostal spaces. The xiphisternum was then resected and an 8-cm vertical incision was made in the linea alba allow entry of the surgeons hand into the hemithorax in order to palpate the whole lung for metastases, as well as the contralateral hemithorax. More recently this approach has been replicated but with a single subxiphoid approach, avoiding all incisions between the intercostal spaces and using a Covidien single incision laparoscopic surgery (SILS) port and carbon dioxide (CO_2) to perform bilateral metastasectomy (5). Cardiac surgery has also been performed using a subxiphoid-only approach by Mark Levinson, including multi vessel off pump coronary bypass and atrial septal defect repairs, using a 7-cm
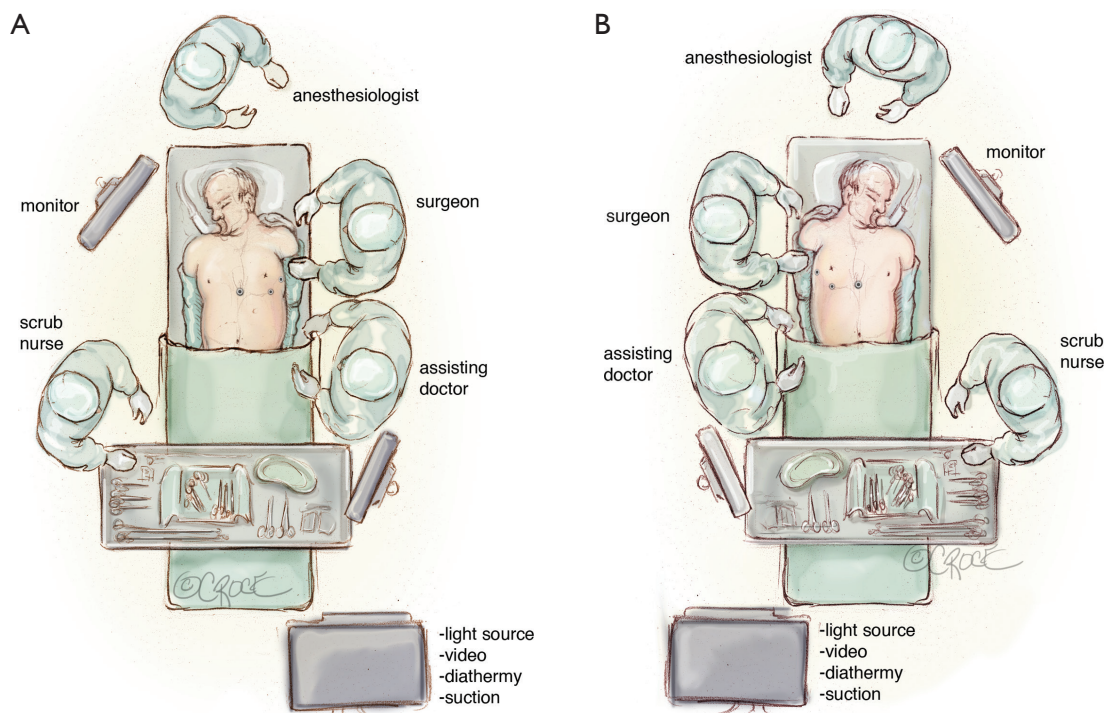
Figure 1 (A) The positioning for a left sided microthymectomy. This approach is used for thymomas that are predominantly on the left side of the mediastinum and those that are likely to be near to the left phrenic nerve; (B) the positioning for a right sided microthymectomy. This approach is the usual approach for non-thymomatous myasthenia gravis resections, and thymomas or anterior mediastinal masses that are predominantly to the right of the midline.

subxiphoid incision and a sternal elevator (6,7). Subxiphoid surgery has been extended to lobectomy of every lobe by Liu *et al*. from Taiwan using a sternal elevator rather than CO_2 (8). They have also performed segmentectomies in this fashion. Resection of anterior mediastinal masses have been described with a subxiphoid incision (9) and thymectomy has also been performed using a single subxiphoid approach (10). This has been achieved using the SILS port and CO_2, but also required a Kirschner wire in the upper sternum for sternal elevation.

Therefore, we aimed to reduce the magnitude of our own incisions both in lobectomy and thymectomy by using a subxiphoid utility port. However, subxiphoid-only surgery is technically very demanding as it is a considerable change compared to our usual multiport approach. In addition, we felt that this compromised safety and vision significantly in our hands. Subsequently, we have replicated our traditional VATS approaches but with a subxiphoid utility incision, which has allowed us to restrict ourselves to 5-mm ports rather than our usual 12-mm ports.

Operative techniques

Positioning

The patient is supine and the surgeon and assistant are by the patient's side. If the patient has a thymoma that is more on the left side or near the left phrenic nerve, then we will start the operation on the left side (*Figure 1A*). However, for patients with non-thymomatous myasthenia gravis and in general, we will typically start the procedure in the right hemithorax (*Figure 1B*).

Port insertion for microthymectomy

The intercostal spaces range in size from 7-10 mm, and therefore large ports and instruments may easily cause damage to intercostal nerves, causing post-thoracostomy pain. Most large stapling devices require either a 12-mm or a 15-mm port for access, and thus in a standard VATS lobectomy 12 mm ports routinely used. Once a subxiphoid port is utilized, it may quickly be found that there is no
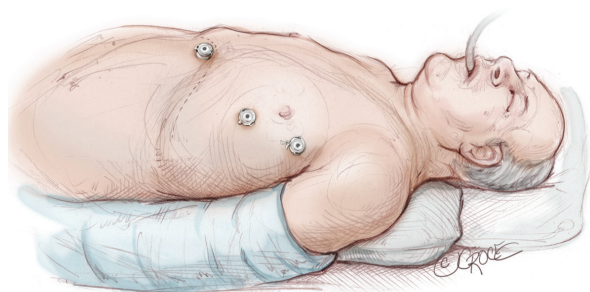
Figure 2 Port placement for a left microthymectomy. Two 5-mm ports are placed in the 5th and 7th intercostal spaces. Once the mediastinal fat is cleared from the subxiphoid space the Subxiphoid port is created.

necessity for large ports in the chest. In addition, high quality 5-mm cameras are now available and there is therefore no longer any need for 10-mm cameras in routine practice. Thus, our approach is as follows.

The computed tomography (CT) scan is assessed and this guides the placement of the two 5 mm intercostal ports. *Figure 2* demonstrates the position of the left sided ports. However, in non thymomatous myasthenia gravis or in more right-sided thymomas, we prefer to approach from the right hemithorax due to the increased space on this side (*Figure 3*). The patient is positioned supine, often with a support under the left scapula in a left sided approach. A single lumen tube is used, as we use CO_2 to create space in the anterior mediastinum bilaterally, so that single lung isolation is not required. The CO_2 is set at 8 mmHg at a maximum flow rate of 8 litres per minute and reduced if there is hypotension, high airway pressures or hypercarbia. As a finger cannot be first inserted into the chest for a 5-mm port, we use a disposable plastic 5-mm port, which has a clear central trocar to enter the chest. (*Figure 4*). The CO_2 is attached to the side arm and a 5-mm straight camera is inserted into the trocar. An incision is made over the skin of the 5th space in the anterior axillary line, and under screen vision and CO_2 insufflation, the trocar is pushed into the chest once ventilation has been paused. The pleura and then the lung are seen on the screen and further advancement is paused as the lung is pushed away by the CO_2. The port is then inserted safely into the chest. We have a camera cover that facilitates easy exchange with the straight and 30 degree cameras, and thus we now change to the 30 degree camera for the remainder of the procedure. After CO_2 insufflation has pushed the diaphragm inferiorly, a second port is
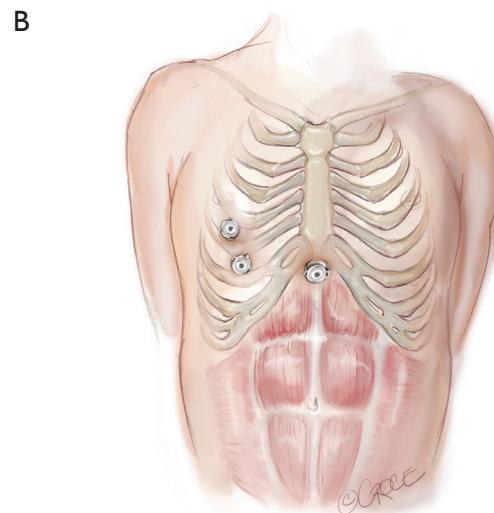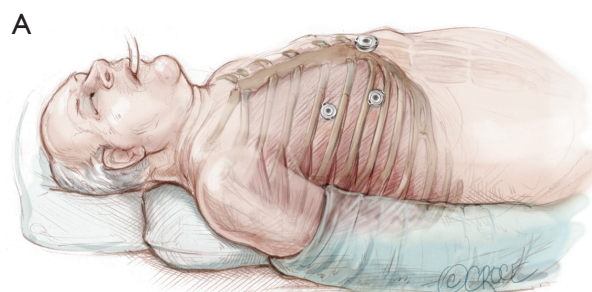

Figure 3 (A) Demonstration of port placement for a right sided microthymectomy. Exact port placement is sometimes dependent on the size and shape of the patient. Here a subxiphoid port is shown with ports in the 4th and 6th intercostal spaces; (B) anteroposterior view of the port placment for a right sided microthymectomy.

then placed in the mid clavicular line, usually in the 7th intercostal space. A 5-mm dissecting peanut is then used to push the mediastinal tissue away from the back of the inferior sternum in preparation for the subxiphoid incision. A 2-cm vertical incision is then made below the xiphisternum and down to the linea alba. The linea alba is divided by electrocautery for 2 cm and then a finger is inserted and pushed up vertically under the xiphisternum and body of the sternum. The finger is then moved towards the camera in the chest and is easily seen. Once the finger has entered the chest cavity, it is replaced by a 10-mm CO_2 port. The subxiphisternal port is then used for a hook diathermy, 5-mm SILS endo dissector or 5-mm peanut to clear the thymus from the retrosternal space, with a three-port approach.
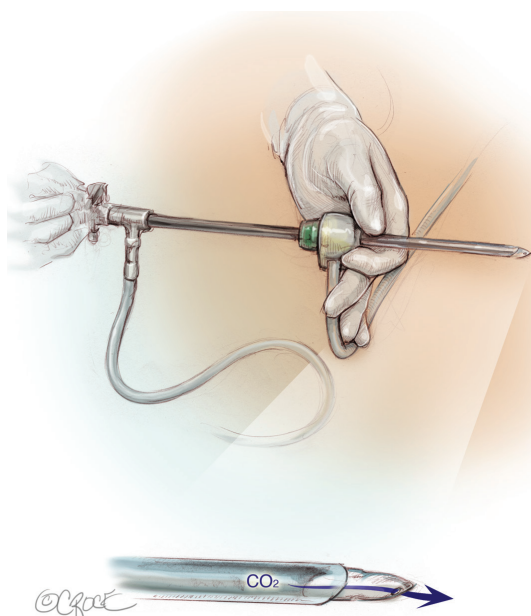
Figure 4 The 5 mm camera is placed into the clear trocar in the middle of the 5 mm port. We advocate the use of a port such as the Allied medical Kii-Fios first entry port with a clear central trocar so one is able to watch chest entry. Also, this trocar has a fenestration 2 mm from the tip for CO_2, so insufflation to push the lung away occurs almost immediately.

Conduct of the thymectomy

With the 30 degree camera in the lower 5-mm port, the other two ports are used to dissect the thymus away from the sternum by following a line just medial to the internal mammary artery (IMA), up to the IMA vein. The thymus and thymic fat are removed from the diaphragmatic surface and the phrenic nerve closest to the camera is released using bipolar cautery. Further specifiers could be provided or 5 mm endoscopic scissors. The thymus is lifted anteriorly and released from the pericardium. A very low threshold exists for obtaining a disc of pericardium with the sample, especially in older patients or larger thymomas where the tumor may be more invasive in nature. If approaching from the left hemithorax, the left IMA (LIMA) vein is followed superiorly and then posteriorly until it inserts into the innominate vein (*Figure 5*). The thymus is then stripped off the innominate vein as far as is convenient. The left superior horn can also be followed above the LIMA vein. If approaching from the right hemithorax, the thymus is first stripped off the right phrenic nerve (*Figure 6*). The superior vena cava (SVC) is followed up to the right IMA (RIMA)
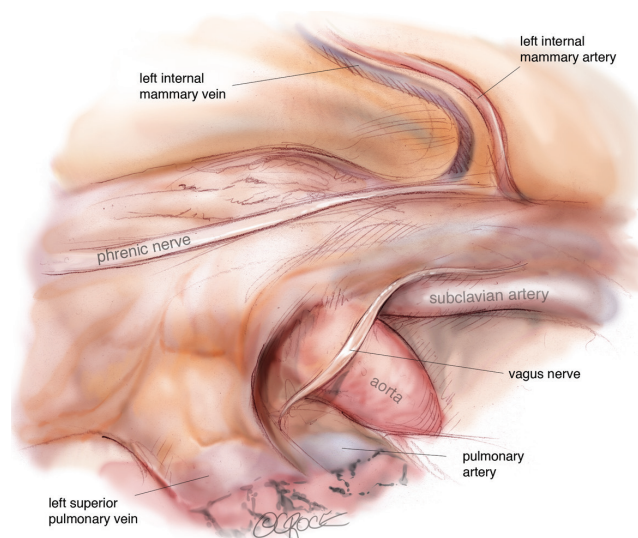

Figure 5 View from the left hemithorax. The left phrenic nerve is anterior to the hilum and it is followed up in the dissection until the left internal mammary vein is found and then medially along the innominate vein.

vein and then across the innominate vein, with clipping of the thymic vein.

The camera is then changed to the subxiphoid port, which facilitates an excellent view of the opposite phrenic nerve. In the case of an initial left chest approach, instruments are still used from the two left-sided 5 mm ports. One is used to elevate the thymus, and a hook diathermy or energy device is used to remove the thymus from the right phrenic nerve. This plane of dissection is followed up the SVC to the RIMA vein and across to the innominate vein. A 5-mm clip may be applied to the thymic vein, which invariably arises from the mid-point of the innominate vein. Vessels arising from the IMA, internal mammary vein, thyrothymic ligament and inferiorly from pericardiophrenic vessels are usually small enough to be divided by diathermy or an energy device. Finally, the right superior horn is released. Additional tissue under the innominate vein is also removed and the view of this process and of the cervical superior horns from the subxiphoid port is excellent. The key vascular anatomy of the thymus is demonstrated in *Figure 7*.

Removal of the thymus

After release of the thymus, it is placed in the left hemithorax, and the area is checked for bleeding. Intercostal nerve
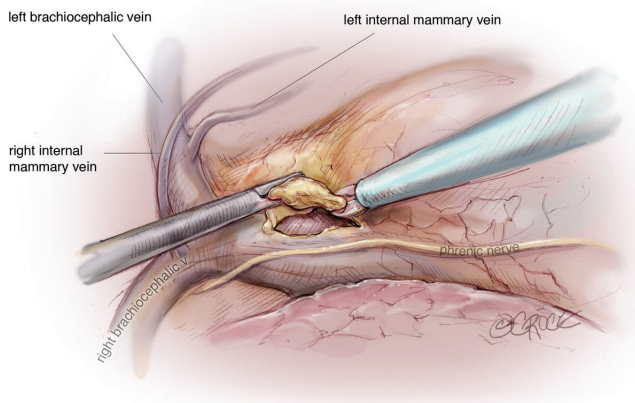
Figure 6 View from the right hemithorax. The first step is to remove the thymus off the right phrenic nerve from inferior to superior, following the superior vena cava until the right internal mammary vein is identified, then the innominate vein is followed across the midline.
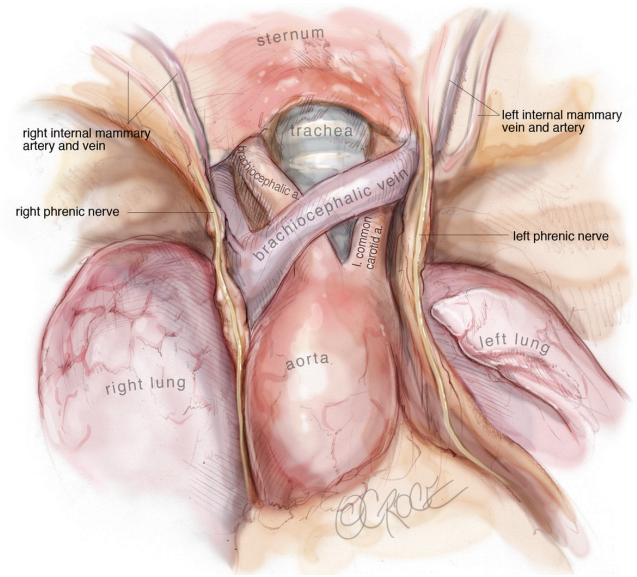

Figure 7 Anterior view of the thymus, demonstrating the vascular supply and the position of the thymic lobes and superior and inferior horns.

Figure 8 The final subxiphoid view after thymus removal. For complete thymectomy the space above the innominate should be clear of thymus and thymic fat. You will then be able to see the right brachiocephalic, the innominate artery, the trachea and occasionally the left carotid artery. The phrenic nerves will demarcate the lateral borders of the resection.
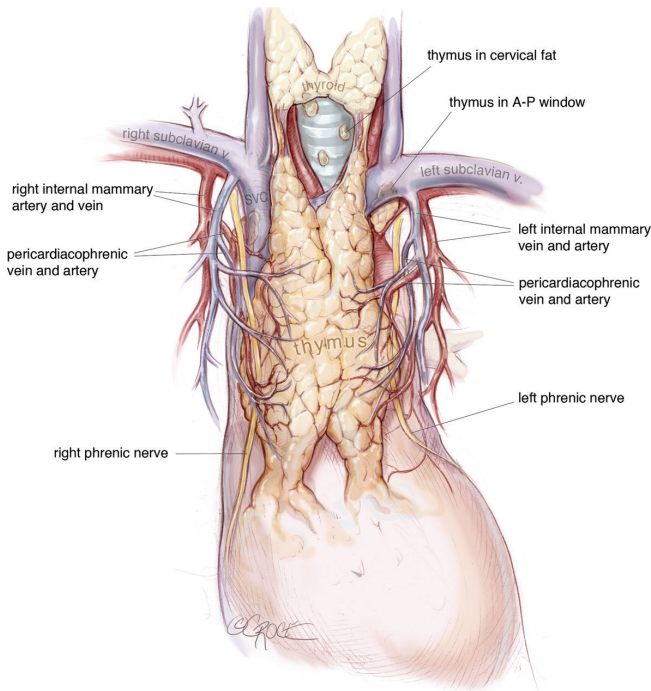
blocks are placed using a long needle under vision from the subxiphoid port. The sample is only removed as the final intraoperative step, as CO_2 insufflation will be lost once the subxiphoid port is extended to remove the thymus in a retrieval bag. Once removed in a bag, a single size 24 French drain is inserted into the mediastinum. We find that two drains are unnecessary. In addition, the drain establishes the absence of a pneumothorax, as bleeding is invariably minimal with this technique. Once the thymus has been removed in full, one should be able to visualize the remaining anatomy very clearly from the subxiphoid port and fully evaluate the extent of resection (*Figure 8*).

Safety considerations

Throughout the operation, there is a 5-mm suction irrigator available for use. We also have 5-mm dissecting

peanuts and 5- and 10-mm endoclip applicators available. If a larger vessel bleeds, then pressure can be applied and the suction irrigator can be used to identify the source of bleeding, which can then be grasped prior to application of a clip. If the innominate vein is damaged, then it must be remembered that this is a low pressure vessel and the patient can be placed in a reverse Trendelenberg position to further reduce the venous pressure. Additional CO_2 insufflation can also collapse small low pressure veins to provide more time to identify the location of bleeding.

Comments

The most important consideration in VATS thymectomy is that the same quality of resection must be achieved as by an open operation. Challenges include adequate visualization of both phrenic nerves and of the superior horns above the innominate vein. If an equivalent resection is achieved as that possible by sternotomy, then the VATS technique will significantly reduce pain compared to sternotomy and speed up recovery. Microthymectomy achieves many of these aims. The subxiphoid port allows an excellent view of both phrenic nerves and the superior horns of the thymus. It also allows painless removal of the sample at the end of the operation. The 5-mm ports allow the surgeon to use a multiport approach that may be more familiar than a uniportal subxiphoid approach. We encourage surgeons to try this approach as one method of performing VATS thymectomy.

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Footnote

Conflicts of Interest: The author has no conflicts of interest to declare.

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