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†

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Abstract

OBJECTIVES: To present the new technique of minimally invasive extended thymectomy performed through the subxiphoid-right video-thoracoscopic (VATS) approach with double elevation of the sternum and the early results of resection of thymomas with the use of this technique.

METHODS: Operative technique: whole dissection was performed through a 4- to 7-cm transverse subxiphoid incision, and a single 5-mm port was inserted into the right chest cavity for the video thoracoscope and subsequently for the chest tube. The sternum was elevated with two hooks connected to the sternal frame (Rochard bar, Aesculap-Chifa, Nowy Tomysł, Poland). The lower hook was inserted through the subxiphoid incision, and the superior hook was inserted percutaneously after the mediastinal tissue including the major mediastinal vessels was dissected from the inner surface of the sternum. The fatty tissue of the anterior mediastinum and the aorta-pulmonary window was completely removed.

RESULTS: There were 24 patients operated on for the Masaoka Stage I–III thymoma in the period from 1 January 2009 to 30 March 2012. There was no mortality and complications occurred in 1 patient necessitating revision for bleeding (morbidity rate 4.2%). The median operative time was 105.0 (range 70–195) min. In 2 patients it was possible to completely resect Masaoka Stage III tumour infiltrating the right lung, which was resected with the use of an endostapler. The dimensions of the thymomas ranged from 1.8 × 1.5 × 1.5 to 12 × 9 × 5 cm.

CONCLUSIONS: In our opinion, the presented technique is probably the least invasive and the most complete technique of VATS thymectomy with excellent cosmetic results and is a valid alternative to sternotomy approach for the Masaoka Stage I–III thymomas.

Keywords: Thymectomy • Mediastinum • Thymoma

INTRODUCTION

The standard technique of thymectomy for thymomas is still a trans-sternal approach. During the last two decades, minimally invasive techniques of thymectomy for Myasthenia Gravis (MG) have been developed, mainly for the treatment of non-thymomatous MG. The minimally invasive techniques are those that utilize operative approaches without sternotomy or thoracotomy. These techniques include transcervical, video-thoracoscopic (VATS), subxiphoid approaches or a combination of these approaches. The advantages of minimally invasive techniques include less pain in the early postoperative period, pulmonary function less compromised, better cosmetic results and total avoidance of the risk of disruption or infection of the sternotomy wound [1, 2]. Disadvantages of VATS approach included insufficient completeness of removal of the upper poles of the thymus with unilateral or bilateral VATS approach and risk of chronic pain after thoracoscopy in 10% of patients [2, 3]. There is a very limited worldwide experience with the use of minimally invasive thymectomy in thymomas, with only one report including >50 patients with thymoma and follow-up of at least 5 years [4] (Table 1). The aim of this article is to present a new minimally invasive technique of thymectomy performed through a limited subxiphoid incision combined with single-port right VATS and a 2-mm puncture for insertion of the sternal hook.

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Table 1: Minimally invasive thymectomy series for thymoma, including >10 patients [6]

<table>
<thead>
<tr>
<th>No</th>
<th>Author and publication</th>
<th>Technique of thymectomy</th>
<th>No. of patients No. of patients with MG</th>
<th>Masaoka stage</th>
<th>Follow-up</th>
<th>Effect on MG (% of complete remission—CR)</th>
<th>No. (%) of recurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Roviaro et al. [7]</td>
<td>Bilateral VATS</td>
<td>22/ns</td>
<td>I ns</td>
<td>ns</td>
<td>Ns</td>
<td>Ns</td>
</tr>
<tr>
<td>2</td>
<td>Papatestas [8]</td>
<td>Transcervical basic</td>
<td>64</td>
<td>I–III ns</td>
<td>ns</td>
<td>Ns</td>
<td>Ns</td>
</tr>
<tr>
<td>3</td>
<td>Deeb et al. [9]</td>
<td>Transcervical</td>
<td>14/14</td>
<td>I–5 ns</td>
<td>Mean 48 months (3–96)</td>
<td>Ns</td>
<td>Ns</td>
</tr>
<tr>
<td>4</td>
<td>Uchiyama et al. [10]</td>
<td>Substernal VATS</td>
<td>16/11</td>
<td>I–13 ns</td>
<td>Mean 19.2 (2–33) months</td>
<td>11.1%</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>Cheng et al. [11]</td>
<td>Unilateral VATS subtotal/12 Trans-sternal 10</td>
<td>22/ns</td>
<td>II ns</td>
<td>33.9 ± 19.7 months</td>
<td>Ns</td>
<td>0, no difference in survival</td>
</tr>
<tr>
<td>6</td>
<td>Sakamakiet al. [12]</td>
<td>Unilateral VATS subtotal/11; Infrasternal mediastinal total/19</td>
<td>30/13</td>
<td>NS</td>
<td>48</td>
<td>NS</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>Maggi et al. [4]</td>
<td>VATET/71, Extended tras-sternal/126</td>
<td>197/197</td>
<td>I–IV ns</td>
<td>Mean 7.69 ± 6.0 years</td>
<td>CR 9.64%</td>
<td>9.64% (no difference between VATET and trans-sternal)</td>
</tr>
<tr>
<td>8</td>
<td>Agasthian [13]</td>
<td>Unilateral VATS subtotal</td>
<td>58/32</td>
<td>I–IVA ns</td>
<td>Mean 4.9 (1.9–10) years</td>
<td>21%</td>
<td>2/58</td>
</tr>
<tr>
<td>9</td>
<td>Odaka et al. [14]</td>
<td>Unilateral VATS subtotal</td>
<td>22/0</td>
<td>I–II ns</td>
<td>Mean 21.6 (5–40) years</td>
<td>No difference in CR</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>Ruckert et al. [15]</td>
<td>Unilateral VATS robotic/30 Trans-sternal/44</td>
<td>74/ns</td>
<td>Ns</td>
<td>No difference in CR</td>
<td>No difference in survival</td>
<td>0</td>
</tr>
</tbody>
</table>

Ns: not stated; VATS: video-thoracoscopic; VATET: video-assisted thoracoscopic extended thymectomy; CR: complete remission; MG: Myasthenia Gravis.
Surgical technique

The operative technique of this procedure is as follows: a 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 selective lung ventilation during the latter part of the procedure.

The subxiphoid part of the operation: a transverse 4- to 6-cm incision is made above the xiphoid process. The subcutaneous tissue is cut and the medial parts of the rectus muscles are cut near the insertions to the costal arches. The xiphoid process is removed or divided transversely and left without removal. The selective left-lung ventilation is started resulting in the collapse of the right lung. The anterior mediastinum is opened from below the sternum. A sternal retractor connected to the traction frame (the same as one that is used for traction of the manubrium) is placed under the sternum, which is elevated to facilitate access to the anterior mediastinum from below. A thoracoscopic port for a 5-mm, 30° oblique thoracoscopic is inserted into the right pleural cavity in the sixth intercostal space in the anterior axillary line. The position of a patient and the general idea of the technique of the procedure are shown in Fig. 1. The right mediastinal pleura is cut near the sternal surface up to the level of the right internal thoracic vein which is left intact. The prepericardial fat and the right epiphrenic fat pads are dissected from the pericardium and diaphragm with bipolar cautery (Bi-Clamp, ERBE Medical, Germany). Alternatively, such devices as a harmonic knife, LigaSure or vascular clips can be used to secure the vessels throughout the procedure. Dissection of the prepericardial fat containing the thymus gland proceeds upwards under the control of the video-assisted thoracoscopic surgery camera in an en bloc fashion, without any attempt to dissect the thymus gland separately. The right phrenic nerve is a margin of dissection. After dissection of the mediastinal tissue from the inner surface of the sternum, a 2-mm puncture is performed over the sternal notch and a single-tooth hook is inserted percutaneously under the sternal manubrium, while the mediastinal structures are protected with a peanut sponge pressing the mediastinum in the direction of the spine. The second hooks improves exposure of the superior mediastinal and the lower neck regions facilitating considerably the performance of the procedure and enabling visualization of the whole upper poles of the thymus and the lower part of the thyroid (Fig. 2).

The dissection of the thymus proceeds along the left innominate vein with closure with vascular clips and division of the thymic veins (usually there are 1–5 thymic veins) until the left internal thoracic vein (left mammary vein) is visualized (Figs 3 and 4). The left phrenic nerve located close to these veins is dissected with a peanut and protected from injury. Dissection proceeds cranially with closure and division of the lower thyroid veins, performed in the same way as in the case of the thymic veins. Further dissection proceeds along the thymic poles until the lower part of the thyroid is clearly visualized. At this point, the upper poles are divided close to the thyroid. During the dissection, such structures as the innominate, the right and left carotid arteries and the trachea are clearly visualized (Figs 5 and 6). No attempt is made to perform extended resection of the adipose tissue of the lower neck and visualization, the laryngeal recurrent and vagus nerves are not performed. The liberated upper poles of the thymus are grabbed and pulled caudally enabling dissection of the thymus from the pericardium and the left mediastinal pleura, which is generally left intact. The thymus containing the thymoma and the adipose tissue are finally placed in the plastic bag and removed through the subxiphoid incision. Dissection of the aorta-pulmonary window is completed. Haemostasis is checked, the VATS port is removed and a single 24–28 chest tube is inserted into the right pleural cavity.
through the incision made for insertion of the port. In case of opening of the mediastinal pleura, the second chest tube is inserted into the left pleural space. Ventilation of the right lung is resumed. The subxiphoid incision is closed in the standard manner, and a puncture incision is closed with a peristrip. Generally, a patient is extubated immediately after the operation.

MATERIALS AND METHODS

Generally, patients with clinical Masaoka Stage I thymoma were operated on; however, a large size of thymoma was not an excluding factor. In case of infiltration of the pericardium, the mediastinal pleura, the adipose tissue or the marginally infiltrated lung, we tried to perform a radical resection of these structures. Extensive infiltration of the mediastinal structures was considered an indication for conversion to median sternotomy. However, in cases of the limited infiltration of the lung, mediastinal pleura or pericardium, an attempt was made to perform radical en bloc resection. Successful procedures, conversions to sternotomy and the thymectomies for thymomas and non-thymomatous MG performed through the other approaches were reported.

RESULTS

There were 24 patients with thymomas operated on in the period from 1 January 2009 to 30 June 2012, with the use of the subxiphoid right VATS approach with double elevation of the sternum. In 1 patient, conversion to sternotomy was necessary because of advanced Masaoka Stage III, World Health Organization (WHO) Type B1 tumour (conversion rate 4.2%). There were 3 other patients who underwent rethymectomy with the use of the subxiphoid right VATS approach, with the double elevation of the sternum for suspected recurrence of thymoma previously resected through the trans-sternal approach. During the same period, 15 other patients with thymoma were operated on with the use of other approaches (sternotomy—10 patients, including 1 in whom pleuropneumonectomy was performed, transcervical incision—1 patient and transcervical subxiphoid VATS—in 4 patients). During that period, there were 111 other patients operated on for non-thymomatous MG with the use of the transcervical subxiphoid VATS approach, which is a standard in our institution. We have used the presented technique of thymectomy in 3 patients with non-thymomatous MG. Patient characteristics, including Masaoka stages and WHO histological
types for the resected lesions, are listed in Table 2. In 2 patients, it was possible to completely resect Masaoka Stage III tumour infiltrating the right lung, which was resected with the use of an endostapler. The median diameter of the thymomas was 4.5 cm, ranging from 1.8 × 1.5 × 1.5 to 12 × 9 × 5 cm. In 15 patients, tumours were ≥4 cm, and in 7 patients tumours were ≥6 cm. The median operative time was 105.0 (range 70–195) min. There was no mortality and complications occurred in 1 patient necessitating revision for bleeding 48 h after the first operation (morbidity rate 4.2%). During the follow-up period (3–41 months, mean—29.9 months), no recurrence of thymoma was noted.

**DISCUSSION**

Recent publication of Toker et al. [5] presented the standard terms, definition and policies for minimally invasive resection of thymoma. This article formed the basis for the further analyses of this area. Several surgical teams started to use less-invasive approaches, including the transcervical incision with elevation of the sternal manubrium with mechanical retractor, unilateral VATS approach, bilateral VATS approach, transcervical approach or infrasternal approach for the treatment of the early-stage thymomas [6–15]. With continuous accumulation of the patients with thymomas operated on with minimally invasive techniques, it becomes clear that the results of such operations are equivalent to the classic trans-sternal thymectomies, with no increase of late recurrences during follow-up. However, up to now, there has been only one reported series of minimally invasive thymectomy for MG associated with thymomas, including >50 patients with a mean follow-up exceeding 5 years [4]. The technique presented in this paper is a combination of the infrasternal and right VATS approaches with elevation of the sternum, both from the manubrium and the inferior angle of the sternum. Such a double elevation enabled an optimal view of the anterior mediastinum and visualization of the lower part of the thyroid gland and the whole upper poles of the thymus. In our opinion, any technique of thymectomy omitting visualization of the thyroid leads to retaining of the parts of the upper poles of the thymus as was convincingly showed by Shigemura et al. [2], who found residual thymic tissue in >70% of VATS thymectomies. The presented technique is the only one VATS technique of thymectomy with documented visualization of the thyroid gland, which means that this is the only one fully complete VATS technique of thymectomy performed without additional transcervical incision. In our opinion, all other VATS techniques including bilateral VATS and robotic thymectomy are not complete in regard to removal of the whole upper poles of the thymus. However, contrary to non-thymomatous MG, subtotal thymectomy in thymomas might not be critically important if the whole tumour is completely resected. In our opinion, the supine position for VATS thymectomy is more useful than a semilateral position used for most of thoracic surgeons due to the easy access to both sides of the mediastinum, especially for good access for the aorta-pulmonary window area from the right VATS approach. The aorta-pulmonary area contains the ectopic foci of the thymic tissue in the substantial number of patients with MG [16].
prefer to use the right VATS approach, because we found it more convenient than the left one. Due to elevation of the sternum and supine position of the patient, there was no problem in reaching the left side of the mediastinum with our technique. It is possible, however, to combine subxiphoid incision with the left VATS approach as well, if any surgeon feels more familiar with operating from the left side. Despite minimal invasiveness, it was possible to perform extended resection of the thymoma infiltrating the right lung in 2 patients and to perform rethymectomy in 3 patients after previous trans-sternal thymectomy for thymoma. In our opinion, however, most of advanced stage thymomas should be still operated on with the use of traditional complete sternotomy approach. The use of dissection under control of a video thoracoscope inserted through the single right VATS port with simultaneous elevation of the sternum enabled omission of the injury of the left innominate vein, which is very vulnerable during rethymectomy. A percutaneous insertion of the single-tooth hook for elevation of the manubrium was always performed secondary to the dissection of the mediastinal tissue from the inner surface of the sternum and after visualization by VATS of the movements of the operator’s finger pressing the neck just above the sternal notch, assuring that no major vascular structure could be injured by the hook. Hsu et al. [17] described the technique of thymectomy through the subxiphoid and VATS approach for non-thymomatous MG; however, they did not use the elevation of the sternum. Takeo et al. [18] used a combination of the transcervical and subxiphoid incisions and three-port VATS for resection of thymomas. Their approach was similar to ours, but was more invasive. The origin of postoperative bleeding in one of our patients necessitating revision was a tiny branch of the left mammary vein. This patient was revised through the original incisions, and the bleeding vessel was clipped. Most thoracic surgeons agree that minimally invasive procedures should be limited to relatively small thymomas, easily removable from the chest, with low risk of injury of the capsule. A maximal diameter of 4 cm has been proposed for such less-invasive techniques by Roviaro et al. [7]; however, Odaka et al. [14] removed thymomas of the diameter 44 ± 18.9 mm and Agasthan et al. [13] removed thymomas of the diameter 40 ± 20.8 mm and 56.6 ± 18.2 mm, with/without the use of harmonic scalpel, respectively. We were able to remove even bigger thymomas (the maximal dimensions were 12 × 9 × 5 cm) in the endobag, without any special problems. The subxiphoid incision with elevation of the sternum enabled convenient removal of the considerable size thymomas in the endobag. We found the bipolar coagulation system very useful in performing any minimally invasive procedures. The combination of the subxiphoid incision and single-port VATS with a 5-mm thoracoscope is a minimally painful approach and there is no risk of disruption or infection of the sternotomy wound. Our results confirm safety of this procedure with no mortality and 4.2% morbidity. There is also a clear cosmetic advantage with no visible scar in the cervical/upper chest area. Up to date, there has been no recurrence in any patient of the presented series; however, it must be stressed that the mean time interval from thymectomy to occurrence of the local recurrence of thymoma is >7 years, so this is too early to estimate the real oncological value of this approach [6]. We have used the presented technique of thymectomy only in 3 patients with non-thymomatous MG because with exception of these 3 patients, all other patients who were proposed to be operated on with this approach refused this technique and chose the transcervical subxiphoid VATS maximal thymectomy, due to the possibly more radical removal of the adipose tissue of the neck and mediastinum with the latter technique, which might affect the final outcome of MG. Therefore, we have very limited experience in the use of the subxiphoid single-port right VATS thymectomy in non-thymomatous MG. However, it must be underlined that the need for extended removal of the adipose tissue of the lower neck has never been proved in case of thymomas. In our opinion, the subxiphoid single-port right VATS thymectomy is much more complete than the widely used unilateral VATS thymectomies or the robotic thymectomy, mostly in regard to the excision of the upper poles of the thymus.

CONCLUSIONS

(i) The subxiphoid single-port right VATS thymectomy is a minimally invasive technique enabling complete removal of the whole thymus in case of early-stage thymomas and in rethymectomies.

(ii) Further studies are necessary to prove the usefulness of this technique in the treatment of non-thymomatous MG.

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Conflict of interest: none declared.

REFERENCES

APPENDIX. CONFERENCE DISCUSSION

Dr M. Lucchi (Pisa, Italy): I have some concern about the selection criteria you used. The ITMIG Society has suggested that minimally-invasive approaches should not be used for stage III thymomas. In this study you used it for stage III and for large thymomas. You showed that you have operated on 12 cm tumours. I think that is not a good indication for any minimally-invasive approach. Also, the video you showed, in my opinion, although it is a nice technique and achieves a good view, the tumour you have just shown us is not an ideal case for a minimally-invasive approach. You have seen the tumour, you stayed very near the tumour, and in my view it is not safe. Also, the endobag you used was in the pleural cavity and not in the mediastinum, so you did not use the transpleural approach. The pleura was just used to obtain a better view. All of the operation was done through the mediastinum, but the endobag was in the pleural cavity, so the issue of seeding still remains.

So my concern is, why did you use this technique for large tumours? And why do you think it is superior to a VATS procedure, especially if you use CO2 insufflation or elevation of the sternum? I think that the view of the upper lobe is more or less similar to what you can achieve through a transxiphoid approach.

A further question is, don't you think that in case of a conversion (I read in your paper that you had one conversion,) you will move from a minimally-invasive approach to a maximally-invasive approach (because you have a transverse skin incision and then you have to do a longitudinal one)?

Dr Zielinski: Your comments are obviously correct. In case of conversion, you do not make a beautiful scar, that is correct, because it is a reverse T scar. It happens rarely. That is why we proceed with this kind of procedure.

Of course, the maximal diameter we should use is a matter for discussion. If we use this technique for stage III, as we did, we resect it with a part of the right lung with an endostapler. It was a good case and it was easy to do. That is why we didn't convert this patient. I think it is difficult to say in whom minimally-invasive thymectomy should be applied. Maybe we exaggerated a bit, I am not sure about it, but we thought it was feasible, so that is why we did it.

Dr Lucchi: You have shown that it is feasible, but with a rare disease, if you put together stage I, stage II, stage III, you cannot do so many cases. The priority at this moment is to demonstrate that the minimally-invasive approach is effective in early-stage thymoma and then we can understand our indication, but if you put all the cases together, I think that we lose a lot of time.

Dr Zielinski: Maybe.

Dr S. Alnasser (Riyadh, Saudi Arabia): Don't you think it is better, when we are applying a new technique, that we use it for benign disease rather than malignant disease? Can we apply this in a patient with myasthenia gravis who is indicated for surgery rather than to apply it in malignant disease?

I have another quick question. There is a significant lifting of the sternum on both sides, and one of the advantages of minimally-invasive surgery is the avoidance of the postoperative pain and the amount of chronic pain that has been associated with a sternotomy or other manoeuvre. Don't you think it would be better to have a postoperative pain assessment? I'm concerned with this amount of lifting the sternum that a significant strain in the costochondral joints may cause chronic pain and alleviate the advantage of minimally-invasive surgery.

Dr Zielinski: Regarding the second question, the elevation of the sternum does not add any pain. We checked it in more than 1,000 operations performed through the neck and with more than 400 operations performed with double elevation of the sternum. It doesn't add any pain.

Concerning the first question, with growing experience, we can now visualize the structures of the neck better than we did in our first patients, and probably now we will start to apply it for myasthenia, because it is a big advantage for female patients, who predominate in myasthenia, that there is no scar in the neck. They are very happy if they avoid scar in the neck. We think that this technique is an alternative to the transcervical subxiphoid VATS approach now in our institution and we will probably start to apply it for myasthenia.