European Journal of Cardio-Thoracic Surgery 49 (2016) i54–i58
doi:10.1093/ejcts/ezv338 Advance Access publication 14 October 2015

ORIGINAL ARTICLE

Cite this article as: Suda T, Hachimaru A, Tochii D, Maeda R, Tochii S, Takagi Y. Video-assisted thoracoscopic thymectomy versus subxiphoid single-port thymectomy: initial results. Eur J Cardiothorac Surg 2016;49:i54–i58.

Video-assisted thoracoscopic thymectomy versus subxiphoid single-port thymectomy: initial results[†]

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Received 29 May 2015; received in revised form 19 August 2015; accepted 25 August 2015

Abstract

OBJECTIVES: Compared with conventional median sternotomy, approaches used in thymectomy for myasthenia gravis and anterior mediastinal tumours have become much less invasive in recent years. We previously developed a surgical technique called single-port thymectomy (SPT) to excise the thymus through a single opening made below the xiphoid process. In this study, to show the utility of SPT, we compared factors contributing to low surgical invasiveness between SPT and conventional video-assisted thoracoscopic surgery (VATS) thymectomy.

METHODS: Between January 2005 and December 2014, 146 patients underwent surgery for anterior mediastinal tumour or myasthenia gravis at our hospital. After excluding patients diagnosed with tumour invasion of nearby organs or those who had undergone concurrent removal of nearby organs, 81 patients were enrolled in this retrospective study as subjects. Patients were divided into the VATS thymectomy group (VATS group, $n = 35$) and the SPT group ($n = 46$). Surgical duration, blood loss, duration of hospital stay and the amount and duration of postoperative oral analgesics were compared between the groups.

RESULTS: Operating time did not vary significantly between the VATS and SPT groups ($P = 0.0853$). The amount of blood loss was higher in the VATS group than in the SPT group ($P < 0.0001$). The duration of hospital stay was longer in the VATS group than in the SPT group ($P = 0.0008$). The amount of postoperative oral analgesics was significantly higher in the VATS group than in the SPT group ($P = 0.0092$). Similarly, the duration of postoperative oral analgesics was significantly longer in the VATS group than in the SPT group ($P = 0.0312$).

CONCLUSIONS: Compared with VATS thymectomy, SPT required a similar operating time, was associated with less blood loss and enabled postoperative analgesics to be discontinued earlier. Therefore, it could be considered a less invasive surgical approach.

Keywords: Thymectomy • Video-assisted thoracoscopic surgery • Single-port • Subxiphoid approach

INTRODUCTION

Compared with conventional median sternotomy, approaches used in thymectomy for myasthenia gravis and anterior mediastinal tumours have become much less invasive in recent years. Representative examples are the lateral intercostal approach in video-assisted thoracoscopic surgery thymectomy (VATS thymectomy) and robot-assisted thymectomy, cervical incision in transcervical thymectomy and the infrasternal approach [1–5]. Of these, VATS thymectomy is currently the most frequently performed surgical procedure, but it has some drawbacks. When approaching from the side of the chest, it is difficult to identify the contralateral phrenic nerve or to secure a sufficient operative field in the neck region. In addition, because of the intercostal approach, intercostal nerve impairment develops along at least three incision sites for port insertion. We previously developed a surgical technique called single-port thymectomy (SPT) to excise the thymus through a single opening made below the xiphoid process [4]. With no incision in the sternum or intercostal space, this subxiphoid approach does not cause intercostal nerve paralysis or neuralgia and is aesthetically excellent.

In this study, to show the utility of SPT, we compared factors contributing to low surgical invasiveness between SPT and VATS thymectomy.

MATERIALS AND METHODS

In our department, extended thymectomy, which involves the removal of all adipose tissue anterior to the phrenic nerve, is performed for myasthenia gravis. For anterior mediastinal tumours in the absence of myasthenia gravis, thymectomy is performed to remove the tumour as well as the entire thymus. In January 2005,

[†]Presented at the 3rd Asian Single Port VATS Symposium & Live Surgery, The Chinese University of Hong Kong, Hong Kong, China, 26–27 March 2015.

we converted from median sternotomy to VATS thymectomy with an intercostal approach from one side or both sides of the chest as the standard approach for thymectomy that does not involve the removal of other organs. Subsequently in March 2011, we converted from VATS thymectomy to SPT with an approach via a single skin incision made 3 cm below the xiphoid process. Between January 2005 and December 2014, 146 patients underwent surgery for anterior mediastinal tumour or myasthenia gravis at our hospital. After excluding patients diagnosed with invasion to nearby organs or those who had undergone concurrent removal of nearby organs, 81 patients were enrolled in this retrospective study as subjects. SPT was performed by a single surgeon (Takashi Suda). VATS thymectomy surgeries were performed by two surgeons, including Takashi Suda. We also excluded a case where SPT was switched intraoperatively to VATS thymectomy because of the difficulty of the surgical procedure due to preexisting mediastinitis, and 2 cases where an additional port was inserted into the right thoracic cavity because of difficulty of the operation. In both groups, 15 mg intramuscular injections of pentazocine or 50 mg diclofenac sodium suppositories were administered on the day of surgery and the day after according to the patient's wishes, but from postoperative day 2, none of the patients were administered loxoprofen or opioids for analgesia. Catheterization for epidural anaesthesia was performed preoperatively only in the VATS group, and epidural bupivacaine 0.125% was administered continuously for 2 days after surgery. In all patients, 60 mg of oral loxoprofen three times daily was started on postoperative day 1 and continued as long as requested. Patients were divided into the VATS thymectomy group (VATS group, $n = 35$) and the SPT group ($n = 46$), and surgical duration, blood loss, duration of hospital stay and the amount and duration of postoperative oral analgesics were compared between the groups. No significant differences were observed in patient characteristics, including thymoma staging based on the Masaoka classification [6], and body mass index between the two groups (Table 1). None of the patients had a positive tumour margin or were postoperatively diagnosed with thymic carcinoma based on the World Health Organization Classification. In addition, no postoperative chemotherapy or radiotherapy was performed. This study was approved by the Ethics Committee of Fujita Health University.

Table 1: Patient characteristics

	VATS thymectomy	Subxiphoid approach	*P*-value
Sex (male/female)	15/20	23/23	0.52[a]
Age (mean, years)	49.7 ± 17.8	53.9 ± 14.4	0.17[b]
BMI	21.8 ± 3.6	23.1 ± 2.9	0.09[a]
Tumour size (cm)	3.09 ± 1.63	2.92 ± 1.66	0.54[b]
Myasthenia gravis	10 (28.8%)	11 (23.9%)	0.63[a]
Anterior mediastinal tumour	27 (77.1%)	11 (82.6%)	0.46[a]
Thymoma	8 (22.9%)	11 (23.9%)	0.91[a]
WHO histological type (A/AB/B1-3/C/other)	2/2/4/0/0	0/7/3/0/1	
P-Masaoka stage (I/II)	6/2	7/4	0.59[a]

BMI: body mass index; WHO: World Health Organization; VATS: video-assisted thoracoscopic surgery.
[a]χ^2 test.
[b]Mann–Whitney *U* test.

SURGICAL TECHNIQUE

Video-assisted thoracoscopic surgery thymectomy

In VATS thymectomy, thoracoscopic thymectomy was performed with patients placed in a supine position and three 1-cm skin incisions were made on the anterior axillary line in the third intercostal space and on the midaxillary line in the third and sixth intercostal spaces. The anterior mediastinal tumour was approached from the side of the right chest in most cases, but when the tumour was predominantly located on the left side, the approach was from the left chest. In patients with myasthenia gravis, the lateral intercostal approach was made from both sides to remove all adipose tissue anterior to both phrenic nerves.

Single-port thymectomy using a subxiphoid approach

SPT was performed without epidural or local anaesthesia in patients lying supine with their legs spread apart. Differential lung ventilation was not necessary in most patients. The surgeon stood between the patient's legs, and an assistant standing on the right side of the patient operated the camera. First, a 3-cm transverse incision was made 1 cm distal to the inferior margin of the xiphoid process. We performed xiphoidectomy in our first case, but not in subsequent cases as we have noted that surgery can be performed without the procedure. Detachment of the thymus from the back of the sternum was performed blindly using a finger, and a longitudinal 1-cm incision was made on the fascia of the rectus abdominis for creating enough space for inserting a port for single-port surgery. The port used in this study was an SILS™ Port (Covidien, Mansfield, MA, USA), X-gate (Akita Sumitomo Bakelite Co., Akita, Japan) or GelPOINT Mini (Applied Medical, Rancho Santa Margarita, CA, USA). Currently, we use a GelPOINT Mini Advanced Access Platform. Because the platform for the GelPOINT Mini is made from a soft gel, the range of instrument movement is extended and interference between neighbouring instruments is reduced. Three mini-ports were inserted into the main port, one of which was used for a camera scope. The most common camera scope used in this study was a 30°, 5-mm rigid scope. We used a flexible camera scope for the earlier cases, but currently we use a 30° oblique view rigid scope. This is because we became accustomed to using rigid scopes, but the procedure can be performed with either type. We do not believe that there was increased interference between instruments due to the use of a rigid scope, compared with a flexible scope. To ensure the safety of the surgery, equipment is required to prevent the screen from darkening with use of the 5-mm camera scope. CO_2 insufflation was performed at 8 mmHg. In addition to the detachment of the thymus from the back of the sternum, the positive pressure of CO_2 insufflation opened up a space for the operation. The mediastinal pleura was opened bilaterally to connect the two thoracic cavities in many patients. This incurs the risk of intrathoracic dissemination of the tumour. In cases where it was possible that the tumour had infiltrated only one side of the pleural cavity, we made the decision not to open the mediastinal pleura on the unaffected side in order to prevent pleural dissemination of the tumour. It is possible to perform this surgery without opening the mediastinal pleura. When confirming the identification of the left and right phrenic nerves, confirmation of the inferior part of the left phrenic nerve was possible by applying traction to the adipose

Video 1: Confirmation of the right and left phrenic nerves. Confirmation of the inferior part of the left phrenic nerve was possible by applying traction to the adipose tissue above the pericardium to the right, but sometimes this was not easy.

tissue above the pericardium to the right, but sometimes this was not easy (Video 1). En bloc resection of the thymus and thymoma was performed by wielding the Autonomy grasper (Cambridge Endo, Framingham, MA, USA) in the left hand and the LigaSure™ V or LigaSure™ Maryland vessel sealing device (Covidien, Mansfield, MA, USA) in the right hand (Fig. 1, Video 2).

Statistics

Statistical analysis was performed using StatView version 5.0 software package (SAS Institute, Inc., Cary, NC, USA). We performed a comparative analysis using the χ^2 test for the 0–1 data and the Mann–Whitney *U* test for ordinal data and continuous data. Patient background data (Table 1) are shown as mean values with standard deviation, while the degree of surgical invasiveness is shown as a median and 25th–75th percentile interval. In all analyses, significance level was set at $P < 0.05$.

RESULTS

Operating time did not vary significantly between the VATS and SPT groups (median 150.0, 25th and 75th percentiles 128.0 and 202.0 vs 139, 25th and 75th percentiles 108.0 and 174.0 min, respectively; $P = 0.0853$) (Fig. 2). The amount of blood loss was higher in the VATS group than in the SPT group (median 20.0, 25th and 75th percentiles 3.0 and 50.0 vs 2, 25th and 75th percentiles 2.0 and 3.0 g, respectively; $P < 0.0001$) (Fig. 3). Duration of hospital stay was longer in the VATS group than in the SPT group (median 5.0, 25th and 75th percentiles 4.0 and 7.0 vs 4.0, 25th and 75th percentiles 3.0 and 5.0 days, respectively; $P = 0.0008$) (Fig. 4). The amount of postoperative oral analgesics was significantly higher in the VATS group than in the SPT group (median 41.0, 25th and 75th percentiles 21.0 and 53.0 vs 28, 25th and 75th percentiles 21.0 and 40.0 tablets, respectively; $P = 0.0092$) (Fig. 5). Similarly, the duration of postoperative oral analgesics was significantly longer in the VATS group than in the SPT group (median 14.0, 25th and 75th percentiles 7.0 and 26.8 vs 10, 25th and 75th percentiles 7.0 and 13.0 days, respectively; $P = 0.0312$) (Fig. 6). One

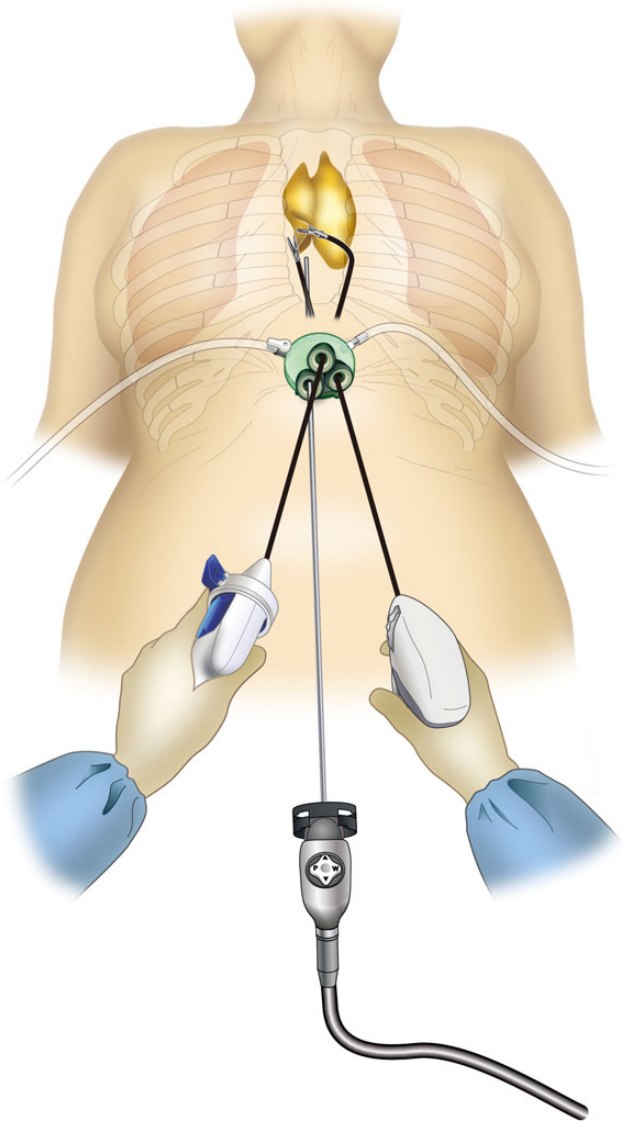
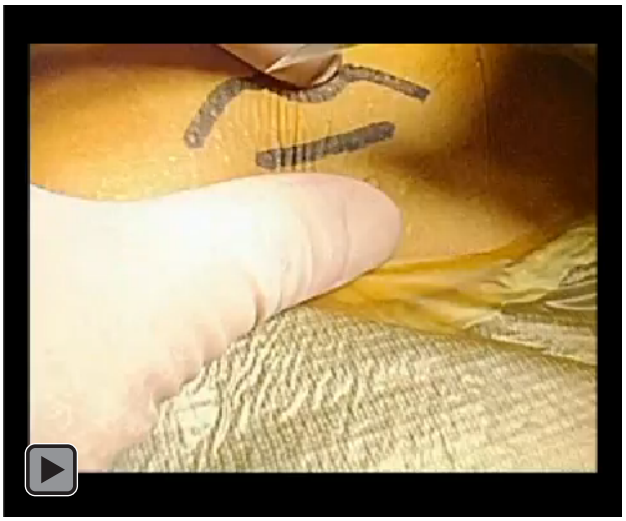


Figure 1: The operator performs all procedures through a 3-cm wound made below the xiphoid process.

SPT patient and 2 VATS patients developed left phrenic nerve palsy postoperatively. Paroxysmal atrial fibrillation developed temporarily in 1 SPT patient, but no deaths occurred in this study.

COMMENTS

In recent years, minimally invasive approaches have replaced median sternotomy in thymectomy for thymoma or myasthenia gravis. After being introduced for the first time in 1993 by a surgical team in Boston, USA, VATS thymectomy with a lateral intercostal approach has spread globally and together with the robot-assisted procedure, VATS thymectomy is currently the most frequently performed thoracoscopic procedure [7]. The incision wound in VATS thymectomy is relatively less noticeable because of the small size and lateral location. However, one of the drawbacks is the difficulty in identifying the contralateral phrenic nerve and in ensuring a sufficient operative field in the neck region. In patients with myasthenia gravis, we always remove all adipose



Video 2: The technique for single-port thymectomy used the subxiphoid approach.

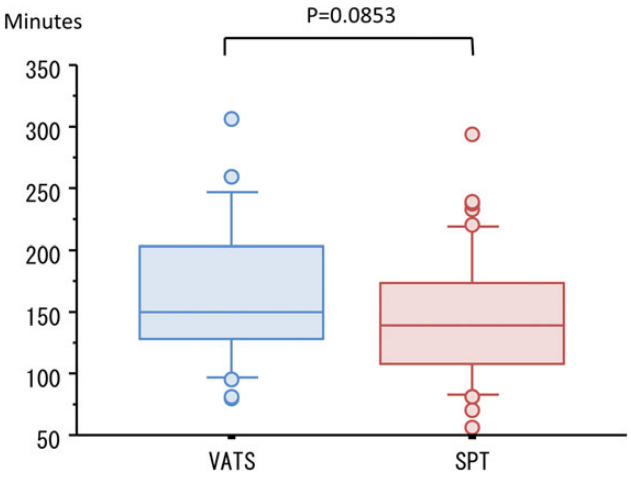


Figure 2: Operating time (min) did not differ significantly between the VATS and SPT groups. VATS: video-assisted thoracoscopic surgery; SPT: single-port thymectomy.

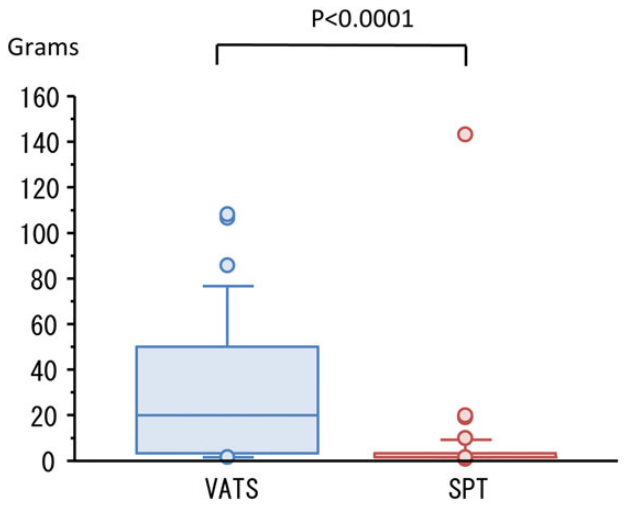


Figure 3: The amount of blood loss (g) was higher in the VATS group than in the SPT group. VATS: video-assisted thoracoscopic surgery; SPT: single-port thymectomy.

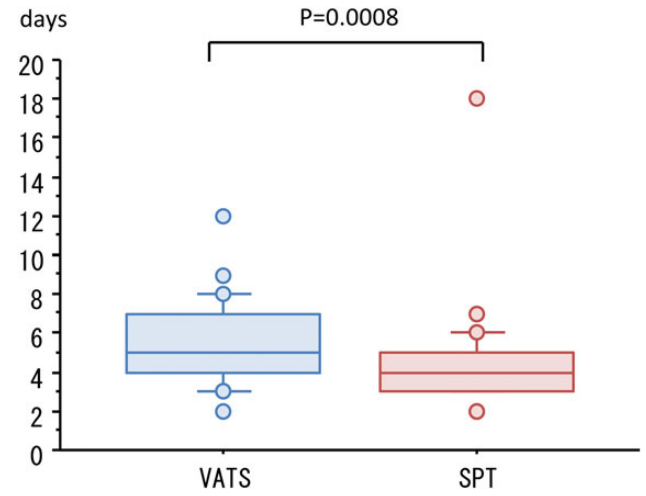


Figure 4: The duration of hospital stay (days) was longer in the VATS group than in the SPT group. VATS: video-assisted thoracoscopic surgery; SPT: single-port thymectomy.

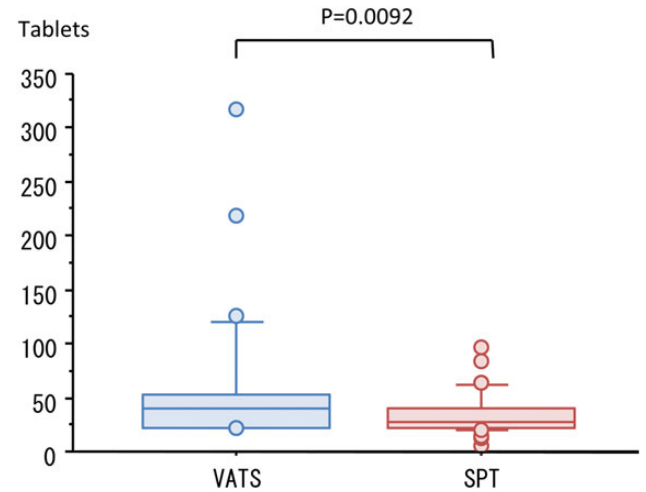


Figure 5: The amount of postoperative oral analgesics (tablets) was significantly higher in the VATS group than in the SPT group. VATS: video-assisted thoracoscopic surgery; SPT: single-port thymectomy.

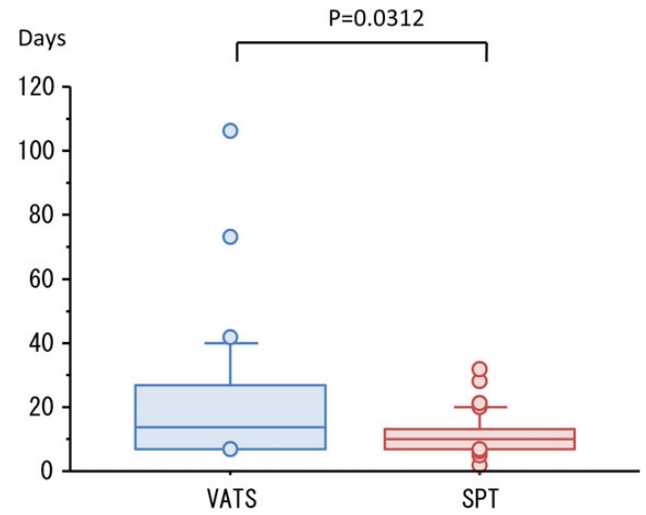


Figure 6: The duration of postoperative oral analgesics was significantly longer in the VATS group than in the SPT group. VATS: video-assisted thoracoscopic surgery; SPT: single-port thymectomy.

tissue anterior to both phrenic nerves for extended thymectomy. The lateral approach is made bilaterally because of the difficulty in identifying the contralateral phrenic nerve when approaching from only one side of the chest. In addition, because of the approach via the intercostal space, patients always develop intercostal nerve paralysis or neuralgia lasting for months, or sometimes for life as post-thoracotomy pain syndrome [8], at more than three incision sites for port insertion. The incidence rates of post-thoracotomy pain syndrome are similar in open chest surgery and thoracoscopic surgery [9, 10]. As shown in the present study, compared with SPT, which does not involve intercostal incisions, a higher amount of postoperative analgesic was prescribed for a longer period of time in patients who had undergone VATS thymectomy, presumably because of intercostal nerve impairment caused by forceps and the camera scope inserted through the intercostal space. In contrast, intercostal nerve damage is avoided in SPT because of the subxiphoid approach, which is not via the intercostal space. This approach was recently applied to metastasectomy and lobectomy [11, 12] and is expected to spread widely as an approach that does not cause intercostal nerve impairment. The length of hospital stay was shorter in the SPT group. We believe this was due to the fact that there were cases in the VATS thymectomy group in which hospital discharge was delayed because of pain, and the fact that there was less postoperative pain in the SPT group. In recent years, single-port surgery has been used for complicated surgery including lobectomy [13–15], but one of its drawbacks is poor surgical manipulability because surgical instruments inserted in a single-port interfere with each other. However, after experiencing individual learning curves, we now complete thymectomy within 2 h in most patients. As this study showed, surgical duration did not differ significantly between SPT and VATS thymectomy. We think that surgeons should master the techniques of single-port surgery in order for patients to reap benefits such as pain reduction and excellent aesthetic outcome. However, we do not recommend SPT for cases requiring sophisticated surgical manipulations, such as those with tumour infiltration into the phrenic nerve, pericardium or innominate vein, for which trans-subxiphoid robotic thymectomy [16] or median sternotomy is indicated, because concurrent resection is necessary. Intercostal nerve impairment develops after trans-sub-xiphoid robotic thymectomy because a robotic arm is inserted bilaterally via the intercostal space. However, a camera inserted via the subxiphoid incision provides an operative field that is sufficient for identifying the phrenic nerves bilaterally and the neck region, as in median sternotomy. Moreover, surgical manipulability is excellent with robot assistance. With the establishment of a single-port robotic surgery system in the near future, surgical manipulability in SPT is expected to improve further. In this study, 1 patient (2.2%) developed phrenic nerve palsy after SPT. The phrenic nerve was damaged because of difficulty in identifying the nerve as the mediastinal pleura was not opened. In endoscopic surgery, because of the relatively small operative field, it is necessary to constantly verify the location of the phrenic nerve to prevent its injury. No vascular injuries occurred in any of the study subjects during the present study, but countermeasures for vascular injuries are important. If haemorrhage occurs during surgery, the thymus tissue or a cotton finger is first used to compress the bleeding point. After compression, a fibrin sheet is pasted over the bleeding point to attempt to stop the bleeding. If haemorrhage cannot be controlled, a median sternotomy is performed, as patients are in the supine position. This study has some limitations. No randomization was performed in the study. The VATS thymectomy group was a previous historical control group. Bias occurred because of changes to surgical policies and referral patterns with the introduction of new surgical methods. In addition, it is possible that the surgeries that were performed later had superior results due to the surgeon's greater experience. Although randomization was not performed and the VATS thymectomy group was a previous historical control group, compared with VATS thymectomy, SPT required a similar operating time, was associated with less blood loss and enabled postoperative analgesics to be discontinued earlier. As such, it could be considered a less invasive surgical approach. Going forward, it will be important to investigate the long-term treatment outcomes of using SPT in myasthenia gravis and thymoma patients.

ACKNOWLEDGEMENTS

We thank Megumu Kondo for secretarial support. Statistical advice was obtained from Shuji Hashimoto, PhD.

Funding

This study was funded by the Division of Thoracic and Cardiovascular Surgery at Fujita Health University.

Conflict of interest: none declared.

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