ORIGINAL ARTICLE

Experience with the "da Vinci" robotic system for early-stage thymomas: Report of 23 cases

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Abstract

Background: The aim of this study was to report a single referral center experience in robotic extended thymectomy for clinical early stage thymomas, evaluating its safety, feasibility and efficacy, with special regard to oncological outcomes.
Methods: Between January 2009 and December 2012, we retrospectively selected patients who underwent robotic extended thymectomy for clinical early stage thymomas. Operative time, morbidity, mortality, duration of hospitalization, and overall and disease-free survival were analyzed.
Results: There were 23 patients (15 males, eight females) with a mean age of 49.3 years (range 20–66). There were no intra-operative complications, and no mortality. The mean operative time was 85.2 minutes (range 60–180). No patient underwent conversion to open surgery. All post-operative complications (4.3%) were conservatively treated. The mean post-operative stay was 3.6 days (range two to nine). The pathological analysis revealed Masaoka stage I (21 cases) and II (two cases). No disease recurrence occurred at a mean follow-up of 24.8 months.
Conclusions: Robotic thymectomy is a safe and feasible technique, with a short operative time and low morbidity. Even on a small series with short follow-up, robotic extended thymectomy for thymoma appeared to be an effective treatment for early-stage thymomas.

Introduction

Thymomas are rare intrathoracic neoplasms of the thymus with an annual incidence of approximately 0.15 per 100 000 person-years.[1] Surgical intervention remains the only curative treatment, traditionally performed through a median sternotomy, with complete resection of the tumor, thymus, thymic cervical extensions, and the surrounding perithymic fat.[2,3] With the advent of improved optics and computer-assisted surgical systems, minimally invasive thymectomies by video assisted or robotic techniques are becoming increasingly popular.[4] In the present study, we present our operative method of unilateral robotic-assisted thoracoscopic surgery (RATS) thymectomy for the treatment of Masaoka stage I and II thymoma. The main aim of this study was to assess the safety and feasibility of robotic thymectomy for an early-stage thymoma. The secondary aim was the evaluation of the oncological outcomes.

Materials and methods

We retrospectively reviewed our experience with thymectomy for the treatment of stage I and II thymomas at the Shanghai Chest Hospital, Shanghai Jiaotong University. Between January 2009 and December 2012, 584 patients presented with primary thymic tumors that were resected with curative intent. Of these, 23 (15 men and eight women) patients with a pathological diagnosis of Masaoka stage I and II thymoma who underwent RATS were selected for study. One patient suffered from myasthenia gravis (MG). RATS was approved by our local ethics committee, and informed consent was obtained from all patients.

The thymoma was considered suitable for a complete robotic removal if the diameter was <5 cm, with no evidence of extracapsular extension or contiguous structure infiltration. The presence of early stage thymoma observed via computed tomography (CT) scan indicated thymectomy.

Neurologists determined a diagnosis of thymoma with MG based on clinical criteria, electromyography, and the titre of acetylcholine receptor antibodies, and it was stratified according to the Myasthenia Gravis Foundation of America (MGFA) classification.[5] The correct timing of thymectomy for MG was established according to our neurologists. Additionally, patients with clinical evidence of pleural adhesions, with previous thoracic intervention, previous chemotherapy or previous radiotherapy of the chest were not referred for the robotic approach. Moreover, additional parameters, observed during the pre-operative evaluation course, had to be satisfied (Table 1). We followed the guidelines of the International Thymic Malignancy Interest Group (ITMIG) for minimally invasive resection of thymoma ("no touch technique").[6]

During the RATS procedure, a patient was positioned left or right side up at 30°. The first incision was generally performed in the fifth intercostal space at the anterior–axillary line. Thus, the camera was inserted to explore the chest cavity, and CO_2 was inflated (ranging between 4 and 8 mmHg) to enlarge the operating space and safely perform the other port incisions: at the anterior–axillary line at the third intercostal, and at the fifth intercostal space at the mid-clavicular line. The right arm had ultrasonic shears to perform dissection, whereas the left arm had a Cadiere forcep (EndoWrist; Intuitive Surgical, Sunnyvale, CA, USA), an atraumatic instrument for grasping the normal thymus. The 30° scope permitted an excellent visualization of normal thymic tissue and the thymoma capsule. The normal thymic tissue and perithymic fat were used for grasping and for traction of the tumor, avoiding direct manipulation of the tumor, to minimize the risk of capsule damage. If the tumor location was in the middle or the right side of the body, we chose the right side for RATS resection of the thymoma. If the tumor location was in the left side of the body, we chose the left side for RATS resection of the thymoma. In patients without MG, whose contralateral pericardial fat could not be approached, we dissected the perithymic fat. Bilateral RATS was performed on the patient who suffered from MG.

After inspection of the thymus gland and the thymoma, dissection generally started from inferiorly, first from the left side, at the pericardiophrenic angle. It then continued on the right side, from the retrosternal area, finding the right mediastinal pleura and the right phrenic nerve, permitting a safe dissection of the right inferior horn under direct vision of the nerve. Consequently, the dissection continued upward to the neck until the superior horns were identified. The thymic veins were identified, and separately clipped. The lesions were removed with endoscopic pouches from the cavity through the port incision in the mid-axillary region. If necessary, the incision was enlarged (3 cm maximum). No additional utility incision was used. A drainage tube was inserted, generally 32Ch. All thymus and perithymic fat was dissected, according to the Masaoka criteria,[7] and the completeness of the thymectomy was assessed by macroscopic inspection of the thymic bed and specimen.

Table 1 Additional selection criteria for the robotic approach

Entry criteria	Mean	Range
FEV1% (Act/Pred%) (≥80%)	95%	80–110%
Age > 18 years	49.3	20–66
PO2 value > 75 mmHg	93	80–100
BMI < 30 kg/m^2	25	20–29
ASA score < II		
I	15	
II	8	

Act/Pred%, Actuality/Predicted; ASA, American Society of Anaesthesiologists; BMI, body mass index; FEV1, forced expiratory volume in 1 s; PO2, oxygen partial pressure.

The safety assessment included identification of treatment related complications occurring within 30 days of treatment. Recurrence of thymoma was evaluated by CT of the chest at three and six months after surgery and once yearly thereafter. Additionally, a neurologist followed up the patient with MG, and the post-operative status of MG was stratified according to MGFA classification.[5]

Statistical analysis was performed using SPSS 16.0 statistical software (SPSS Inc., Chicago, USA). The demographic data of patients' age, gender, comorbidities, operative time, docking time, conversion rate, mortality, morbidity, and length of stay were collected. Statistical analysis was expressed in terms of frequency, mean and range. The Student's t-test was used to compare the distributions of continuous data. A probability value of <0.05 was considered statistically significant. Disease-free survival was defined as the time from surgery to the first diagnosis of recurrence. Overall survival (OS) was defined as the period of time from treatment to death or last follow-up.

Results

There were 23 patients: 15 males and eight females. The mean age was 49.3 years (range 20–66). One patient with thymoma suffered from MG. In this study, 17 patients were approached from the right thoracic cavity, and six patients were approached from the left.

No intra-operative complications occurred. No patient underwent conversion to open surgery. The mean operating time was 85.2 minutes (range 60–180), with a mean docking time of 13 minutes (range 10–15), the mean duration of post-operative drainage was 1.3 days (range one to three), and the mean post-operative stay was 3.6 days (range two to nine). No mortality occurred. No surgical complications, such as massive bleeding, were observed in this series, except for one case of pulmonary atelectasis, which appeared in a male patient two days after surgery and was treated and resolved with medical therapy.

Table 2 Thymectomy learning curve: analysis of operative time and docking time of all thymectomies, and comparative analysis between the first 10 and the last 10 thymectomies

	All procedures	First 10	Last 10	*P*-value
Operative time (minutes)				
Mean	85.2	105.3	80.4	<0.05
Range	60–180	90–180	60–170	
Docking time (minutes)				
Mean	13	14.9	11.8	<0.05
Range	10–15	13–15	10–14	

With regard to learning curve, operative time and docking time were separately investigated. The mean operative time and docking time were 85.2 minutes (range 60–180) and 13 minutes (range 10–15), respectively. If we separately analyzed the first and the last 10 thymectomies, significant reductions in mean operative time and docking time were observed (Table 2).

The mean size of the thymomas was 31.2 mm (range 1.9–4.3 cm). The Masaoka stages were I in 21 cases and II in two cases. The World Health Organization classifications were: A in nine cases, AB in six cases, B1 in four cases, B2 in three cases and B3 in one case. Two patients underwent adjuvant radiotherapy. No patient was lost at follow-up. At the time of analysis (mean follow-up 24.8 months, range one to 48), no patients had local or pleural disease recurrence. For the patient affected by MG, at the time of analysis, the MGFA change in status results improved.

Discussion

The open surgical approach was generally accepted as the gold standard for the resection of thymomas. However, over the last decades, both thoracoscopic and, more recently, robotic approaches have been introduced into the thoracic field and also applied to thymectomy. Several studies have been published regarding minimally invasive thymectomy reporting interesting outcomes, emphasising less operative trauma, shorter hospital stay, preserved pulmonary function, and cosmetic results.[8–11] However, only a few major series have reported the surgical results of RATS surgery for thymoma.[12–14]

In fact, case reports regarding the application of the robotic system for thymectomy[15,16] and for the removal of a posterior-mediastinal mass[12,17] were reported by several authors at the beginning of this century, emphasizing its safety and feasibility. As a result, several authors reported their outcomes on a small series of patients affected by mediastinal lesions. In 2012, Mussi *et al.* utilized the robotic system for the exeresis of 14 thymectomies, reporting a short operating time and a low conversion rate (14.3%).[10] Rea *et al.*[8] reported interesting results on 33 cases of thymectomy for MG with a short operating time and no conversion to sternotomy. In a recent study, Fleck *et al.*[9] described their experience of 18 thymectomies treated with the robotic system, with a mean operating time of 175 minutes and an acceptable conversion rate (5%). In our series, the mean operating time appeared to be comparable with those reported in the literature, ranging between 120 and 175 minutes.[8,9,12] No intra-operative complications occurred, and the conversion rate was zero.

An important point is that we use ultrasonic devices in RATS. Great care must be taken to avoid vascular and nervous injuries. Bleeding is the most serious complication and should be kept in mind during this operation. Special attention must be paid because venous drainage of the gland to the innominate vein involves thin vessels; each must be isolated for the thymic veins and clipped and cut with the ultrasonic device so as to minimize the amount of bleeding. In our series, no patients experienced conversion to an open procedure. Although it is small, this tool is excellent in terms of handling and is indispensable for this operating method.

In our study, the mean docking time and the mean operative time were adequately low. Unfortunately, there is little comparable research focusing solely on robotic thymectomy for thymomas. Bodner *et al.*[12] and Savitt *et al.*[14] reported a similar operative time on a heterogeneous series of resections of mediastinal lesions, including thymomas. However, the operative time was similar to those reported in other studies for robotic thymectomy in the case of MG,[8,9] and for video-assisted thoracoscopic surgery (VATS) thymectomy in the case of thymomas.[17,18] Moreover, in our series, the resulting morbidity rate was low compared to the 6–10% reported for robotic thymectomy for MG.[8,9] Agasthain *et al.*, reported one case of phrenic nerve injury, on a large series of VATS thymectomies, which, however, was not observed in other papers,[9,19,20] nor in this study.

Nevertheless, with regard to oncological outcomes, some criticisms of minimally invasive approaches still exist. The possibility of the tumor spreading into the chest cavity has been reported in a number of studies.[21,22] Pennathur *et al.*[20] reported a local recurrence rate of 3.4% in patients who underwent VATS thymectomy for thymoma, while two recent papers compared the VATS and the open approaches for thymomas. Cheng *et al.*[19] observed no local or pleural disease recurrence for stage II thymoma, either in the open or in the VATS groups, and similar results were published by Pennathur *et al.*[20] in a larger comparative study, reporting no significant difference in disease recurrence and OS between the two groups. In our small series, even though the follow-up period was short, we observed no local or pleural recurrence. We believe that the robotic system facilitates differentiation of the thymoma from normal thymic tissue, allowing safe manipulation. The dimension of the lesion probably represents an important factor that affected the success of the minimally invasive approach. In our series, the mean thymoma dimension was 31.2 mm in RATS, similar to those reported in the above-mentioned comparative studies.[9,14] However, the indolent nature of thymomatous disease requires a long follow-up[23] – 10 years – in order to evaluate survival and disease-free rate, thus, further multi-institutional studies on larger series, are necessary.

Transsternal thymectomy (TST) is the traditional gold standard for the treatment of thymoma, and VATS thymectomy is increasing in popularity because it is technically feasible and safe, and less invasive than TST, with a shorter duration of surgery, less intraoperative blood loss, less postoperative pleural drainage, a shorter duration of postoperative pleural drainage, and a shorter postoperative hospital stay. Oncological outcomes were comparable between the TST, VATS, and RATS.

The present study has some limitations, including its retrospective nature, which may have resulted in a selection bias. Moreover, the study sample was small, with a short follow-up period. However, this is an initial experience, resulting from gained skill in robotic surgery for thymoma, and the main aim was to analyse the safety and the technical feasibility of the robotic approach for early-stage thymomas. In fact, few studies regarding the robotic approach focusing on thymoma have been published, and our small series is the largest one to our knowledge.

Conclusion

This preliminary study demonstrates the safety and feasibility of robotic thymectomy for thymoma, with no mortality, low morbidity, and no nerve or vessel injury. Nevertheless, it is hoped that randomized multi-institutional trials with long follow-up will be designed to compare the transsternal, VATS, and robotic approaches, and evaluate the oncological outcomes.

Disclosure

No authors report any conflict of interest.

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