

# Thymic minimally invasive surgery: state of the art across the world—Europe

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**Abstract:** In this brief review of selected peer-reviewed literature on thymic minimally-invasive surgery (MIS) we sought to identify if there is a unique approach to thymic MIS on the European continent.

**Keywords:** Thymectomy; minimally-invasive surgery (MIS); robotic surgery; thoracoscopy

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## Introduction

The landscape of different surgical approaches for the surgical treatment of thymic malignancies is rapidly changing and—as it historically did—still harbors a wide range of different possible approaches. The choice of surgical approach is influenced by the evolution of evidence based advances in thymic surgery but also historical development of the institutional technique, technological advances, socioeconomic constraints and the surgeons' skills, previous experiences and personal preferences.

Thoracic surgeons went with the times and incorporated technical achievements, such as video-assisted thoracic surgery (VATS) and robotic-assisted thoracic surgery (RATS) into their practice of thymic surgery. Their learning abilities for new technologies contributed to smaller incisions, better cosmetic results and patient comfort, without compromising oncologic radicality and patient safety.

International initiatives of the European Society of Thoracic Surgeons [ESTS (1)] Thymic Working Group, the International Thymic Malignancies Interest Group [ITMIG (2)] and the Japanese Association for Research on the Thymus [JART (3)] have leapfrogged the development of surgical achievements in thymic surgery. Nevertheless, the introduction of minimally invasive techniques has

brought new aspects into the ongoing debate on the “best” surgical approach for thymic malignancies. Surgeons experienced in traditional open thoracic surgery favor sternotomy or thoracotomy and express concerns about the possible risk of more recurrences because of inferior control of resection margins, damage to the capsule (desmoplastic reaction) that covers most thymomas and seeding of malignant cells with endoscopic manipulations. One might not forget that endoscopic manipulations are controlled by vision of 2D- or 3D-screens with the only tactile feedback reaching the surgeons' fingers through long instruments during VATS procedures or no tactile feedback at all during RATS surgery. Surgeons performing minimally-invasive thymic surgery always have to keep in mind that abandoning the option of viewing the operative field directly as well as having tactile feedback to their fingers from exploring the patients' tumor, nerves or great vessels with their fingertips may lead to a loss in valuable information necessary for optimal surgical judgement which may hamper patient safety, oncologic or myasthenic outcomes in advanced tumor surgery or unexpected anatomic difficulties. Many of nowadays concerns will find their answers when long term follow up data on recurrences and survival in terms of open and minimally invasive thymic surgery become available. This article focuses on the peer reviewed literature on

**Table 1** List of common terms used to describe surgical approaches for thymic MIS

Commonly used terms for thymic MIS approach	Description
Transcervical	Anatomic site
Thoracoscopic (VATS)	Technical equipment
Robotic (RATS)	Technical equipment
Subxiphoidal	Anatomic site
Combined techniques	–

MIS, minimally-invasive surgery; VATS, video-assisted thoracic surgery; RATS, robotic-assisted thoracic surgery.

minimally invasive thymic surgery published by European thoracic surgery centers.

### What is the dimension of minimally-invasive thoracic surgery in Europe?

According to the thymoma section of the ESTS annual database report 2015, 17.6% of thymic surgery was operated by VATS, 3% by VATS-robotic and 1.9% by a transcervical approach (4,5). In a cohort study of the ESTS Thymic Working group on 229 thymic carcinomas in the ESTS retrospective database from 1990 to 2010 seven percent of patients had surgery by a VATS or RATS approach (6).

We will use the common designations for the minimally-invasive procedures that were used in previous classifications for thymic surgery even anatomic descriptors (e.g., subxyphoid) are intermingled with terms of the technical equipment used for the procedure (e.g., robotic, *Table 1*). Future classifications of terms describing thymic MIS will take into account that technical equipment used for VATS or RATS can be inserted through any anatomic site (e.g., subxyphoidal or transcervical).

### Different surgical approaches published by European centers

#### *Transcervical approach*

Reports of cervical thymectomy on patients with myasthenia gravis range back to the surgeon Ernst Ferdinand Sauerbruch [1912 (7)]. After promising results were published in the early 80's (8): the cervical approach became again attractive for surgeons dealing thymic pathologies. Sternal lifting with retractors facilitated the surgical access

to the anterior mediastinum (9).

Excellent results of radical thymic resections with low operating costs and no necessity for sternal lifting were recently reported with the use of a V-shaped sternal retractor allowing partial sternotomy from the 4–5 cm cervical skin incision (10).

Another possible valid indication for transcervical approaches was described by Zieliński *et al.* regarding re-thymectomy in patients who suffered previous non complete thymic resections (11).

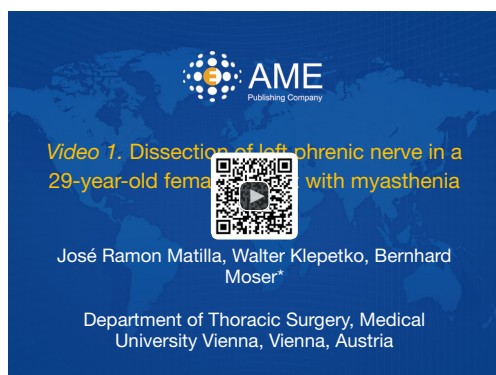
#### *VATS approach*

After the implementation of thoracoscopic procedures in General Thoracic surgery at the end of the 90's, some European centers, started successful programs including thymic resections. Most of the early published European series started their thoracoscopic thoracic surgery programs with the treatment of non-thymomatous myasthenia gravis (12,13). Not all technical refinements of VATS thymectomy over time can be mentioned here, but techniques were steadily improved, e.g., the preoperative induction of an adjuvant pneumomediastinum to ease visualization and mobilization of the thymus (14).

VATS thymectomy was more and more proposed as a valid less invasive alternative to open approaches. Left-sided VATS thymectomy was reported to achieve improvement or remission in 95% of patients with myasthenia gravis [1993–1997, 31 patients, 4 patients had thymomas, Vergata University, Rome, Italy, and Catholic University, Leuven, Belgium (12)].

Further debates about the proper side—left or right—to perform the operation took place in the last 20 years. Many institutions preferred a tumor orientated approach—left or right sided approach depending on the predominant laterality of the thymoma (15). Others followed a bilateral thoracoscopic approach when difficulties in visualizing the contralateral side were encountered (e.g., the contralateral phrenic nerve). In a series 50 patients undergoing right-sided VATS resections for Masaoka-Koga stages I and II, a bilateral VATS approach was necessary in 6 patients [Istanbul University, Turkey (16)]. Glancing at the peer reviewed published literature one might get the impression that there is a preference for a left-sided approach in European high volume centers of thymic surgery while in large American and Asian series the right-sided approach seems more prevalent.

New concepts incorporating the latest technological



**Figure 1** Dissection of left phrenic nerve in a 29-year-old female patient with myasthenia gravis (29).

Available online: <http://www.asvide.com/articles/1519>

advances in minimally-invasive surgery pave the way for changing thymic surgery. Video-assisted thoracoscopic microthymectomy serves as a magnificent example [James Cook University Hospital, Middlesbrough, UK (17)].

### **RATS approach**

The start of a “robotic era” became reality in Europe in the beginning of the 21st century (18,19). Institutions from several European countries reported promising results in the treatment of mediastinal disorders. Early experiences of RATS on the resection of mediastinal masses including thymomas were reported from the University of Innsbruck [Austria, 2001–2003, 14 patients (20)] or thymectomy in patients with myasthenia gravis from the University of Padua [Italy, 2002–2004, 33 patients (18)].

Studies comparing RATS with sternotomy favored the RATS approach in quality of life [Antwerp University Hospital, Belgium, 2004–2008, 14 RATS *vs.* 22 sternotomies (21)], cosmetic effects, pain, and shorter hospital stays [University of Strasbourg, France, 1998–2010, 6 RATS *vs.* 15 sternotomies (22)].

A more recent report of four European thoracic surgery centers between 2002 and 2011 reported on 79 patients (University of Berlin, Germany, 39 patients; University of Padova, Italy, 14 patients; University of Pisa, Italy, 13 patients; University of Innsbruck, Austria, 13 patients) undergoing RATS on patients with early stage thymomas (size range 1–12 cm) that were operated by a left sided (82.4%), right-sided (12.6%), or bilateral approach (23). Fifty-seven percent of the patients were diagnosed with myasthenia gravis. Operating times ranged from 70–

320 minutes. Only one patient required conversion for an oncological reason (large tumor). Hospital stay ranged from 2–15 days. Postoperative complications were reported in 12.7% of patients (none of the complications required additional surgery).

A large series on patients with myasthenia gravis undergoing extended thymectomy compared 79 VATS thymectomies [1994–2002] with 74 RATS thymectomies [2003–2006] at the University of Berlin. Improved outcome in patients with myasthenia gravis who received a RATS Thymectomy compared with the previously used VATS approach was observed. After a follow-up of 42 months cumulative complete remission rates of myasthenia gravis for RATS and VATS thymectomy were reported as 39.2% and 20.3% ( $P=0.01$ ), respectively (24).

At present it seems that the robotic approach is gaining widespread acceptance in thymic and mediastinal surgery. It is the preferred approach in our own practice at the Medical University Vienna and many other European institutions (25). After a short learning curve of 15 RATS thymectomies (26) similar operating times and improved radicality can be achieved compared with VATS approaches (24).

A left sided (18,27) and a right sided (28) approach were described. In a recent multi-institutional report the left-sided approach was employed in 38%, the right-sided in 59.8% and a bilateral approach in 2.2% of patients (28). Even few of these centers started with a right-sided approach; there is a trend towards using a left-sided approach in European practice. Our own video material showing the dissection of the left phrenic nerve (*Figure 1*), thymic horns (*Figure 2*), and the thymus on the right side (*Figure 3*) via our left sided three-port RATS approach are available on the journal’s website.

### **Subxyphoid approach**

The benefits of subxyphoid video-assisted thoracoscopic thymectomy for thymoma were recently described [2015, Pulmonary Hospital, Zakopane, Poland (32)]. The subxyphoid approach provides excellent view of the anterior mediastinal space, the right phrenic nerve and both costophrenic angles. The avoidance of entering intercostal spaces may be responsible for minimal pain after closure. Proponents of the “maximal thymectomy” technique described a modification of the subxyphoidal procedure to improve exposure in the cervical region. The resection of Masaoka stage I-III thymomas with the use of minimally-invasive extended thymectomy performed through the



**Figure 2** Dissection of the thymic horns in a 22-year-old female patient with myasthenia gravis (30).

Available online: <http://www.asvide.com/articles/1520>



**Figure 3** Dissection of the thymus on the right side in a 48-year-old patient with myasthenia gravis (31).

Available online: <http://www.asvide.com/articles/1521>

subxiphoid-right or bilateral VATS approach with double elevation of the sternum allows visualization of the lower poles of the thyroid [2009–2012, 14 patients, Pulmonary Hospital, Zakopane, Poland (33)].

### **Combined approaches**

Transcervical-subxiphoid-VATS maximal thymectomy is probably the MIS equivalent to maximal thymectomy avoiding sternotomy in patients with myasthenia gravis. The operation involves several incisions: cervical, subxiphoid and two for VATS. The cervical part of the procedure is performed with an open technique, the intrathoracic part of the procedure is performed with the videothoracoscopy assisted (VATS) technique [Pulmonary Hospital, Zakopane, Poland (34)].

A minimally invasive subxiphoid-right, videothoracoscopic technique was not only described for thymectomy of thymoma but also for rethymectomy [Pulmonary Hospital, Zakopane, Poland (35)].

We want to report our first experiences with two cases of VATS left-subxiphoid extended thymectomy for the resection of thymomas >5 cm in diameter in Masaoka-Koga stage II. This approach provides excellent control of the left phrenic nerve and innominate vein at the time of left-sided VATS dissection while the right cardiophrenic fatty tissue and right phrenic nerve can be easily controlled through the subxiphoid incision. The operative specimen containing large thymomas can be retrieved from the subxiphoid incision. There was no necessity for sterna lifting (submitted for publication).

### **Conclusions**

As one would expect there is no single European approach to thymic MIS. First reports of thymic surgery for thymic diseases date back to the German surgeon Sauerbruch. Surgeons from the European continent have helped shape thymic surgery together with valuable contributions from all over the globe to its current form. There is no reason to believe that the near future will not bring even more achievements in surgical techniques and technical innovations to thymic surgery and that a unified surgical approach to the thymus may not become a reality. The large repertoire of MIS techniques in the hands of experts harbors one perfect approach for every patient qualifying for thymic MIS.

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### **Footnote**

*Conflicts of Interest:* The authors have no conflicts of interest to declare.

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