



# The role of minimally invasive surgery in the management of giant mediastinal tumors: a narrative review

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**Background and Objective:** Beyond diagnosis, minimally invasive surgery has traditionally not been considered suitable for large tumors, those invading vital structures or high-risk patients. However, with the improvement of multimodality treatments able to reduce tumor size preoperatively, patient evaluation and selection, perioperative care (including both surgical and anesthesiological techniques) and postoperative management, the indications of minimally invasive surgery, even in giant mediastinal tumors, have increased and will continue to broaden in future years. This review aims to summarize the existing literature regarding the role of minimally invasive surgery in the management of giant mediastinal tumors. We have focused in the role minimally invasive surgery has in diagnosis and treatment of these tumors and we have tried to provide an updated perspective to identify future applications and work-directions.

**Methods:** Data regarding minimally invasive surgery in giant mediastinal tumors are limited, including a proper definition of them. We performed a PubMed search of English and Spanish written studies until August 2021.

**Key Content and Findings:** There is limited data related to minimally invasive surgery in giant mediastinal tumors and much of the literature review we have performed has yielded isolated case reports, case series with a low number of cases or editorials. Although the role of minimally invasive surgery is well consolidated as a diagnostic approach, adequate patient selection, hospital volume and experience, multidisciplinary discussion of candidates, patient safety and adequate oncological resection remain the most important aspects to be taken into account when considering a minimally invasive approach for a giant mediastinal tumor.

**Conclusions:** With careful and multidisciplinary perioperative planning, minimally invasive surgery has shown to be safe and to provide at least similar outcomes when compared to open approaches in well selected cases. Although data is still limited, improved surgical techniques and available technology will pave the way to increased indications of minimally invasive surgery in giant mediastinal tumors.

**Keywords:** Mediastinum; surgery; minimally invasive; patient selection; care

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## Introduction

Mediastinal tumors are rare, as they account for around 3% of thoracic neoplasms (1,2). They include a wide range of diagnosis (1,3) that can present as asymptomatic findings or with different symptoms normally related to their size and their relationship with other mediastinal structures (3).

Surgical resection alone or as part of a multimodality treatment plan remains the treatment of choice in operable patients when an adequate oncological resection is achievable (4).

However, due to mediastinum anatomy, where multiple vital structures are located in a limited, non-expandable space, surgical resection may become challenging not only because of the relationship of the tumor with the surrounding structures, but also because of the mediastinal mass syndrome, with hemodynamic and respiratory considerations that should be taken into account in the operative plan (4,5).

Traditionally, median sternotomy, posterolateral thoracotomy, hemi-clamshell and clamshell incisions have been considered the preferred approaches for large mediastinal masses (6) or tumors affecting vascular structures. However, with increasing experience in video-assisted thoracoscopic surgery (VATS) and, specially, with robotic-assisted thoracoscopic surgery (RATS) (7,8) the indications for minimally invasive surgery in these cases have considerably increased (2,4,9-12).

In addition, minimally invasive approaches have shown improved outcomes when compared to open approaches, including less surgical trauma, fewer postoperative complications, shorter length of stay, shorter intensive care unit admissions and less blood loss (13-16), with not-inferior oncological results (13,14), in appropriately selected cases.

This review aims to summarize the existing literature regarding the role of minimally invasive surgery in the management of giant mediastinal tumors. We have focused in the role minimally invasive surgery has in diagnosis and treatment of these tumors and we have tried to provide an updated perspective to identify future applications and work-directions. We present the following article in accordance with the Narrative Review reporting checklist (available at <https://med.amegroups.com/article/view/10.21037/med-21-38/rc>).

## Methods

The search strategy is described in *Table 1*. To summarize,

we searched PubMed for articles written between January 1970 and August 2021.

Manuscripts in English and Spanish were taken into account. The search strategy included the words 'giant' or 'large', 'mediastinal', 'tumor' or 'mass', 'minimally invasive surgery' 'VATS' and 'robotic' combined or individually. Article types included retrospective case series, case-report studies, previous reviews and editorials. No prospective studies were identified on the topic. Articles without full text available or incomplete or irrelevant data were excluded of the review.

One of the main methodological limitations we found when performing the literature search and in the preparation of this manuscript is the lack of a standardized definition of 'giant mediastinal tumors'.

Furthermore, assessing the risk of bias of the selected studies using standardized tools (17,18) became challenging as they consisted mainly in single case reports.

## Current literature review and discussion

Throughout our search, we identified 44 manuscripts meeting full inclusion criteria. Most of them were case reports of isolated successful resections of giant mediastinal tumors of different origins (19,20), others were retrospective case series (7,21) and there were a few of previous reviews and editorials (4,22). Resected tumors were located in all three mediastinal compartments (19,23,24) and, although these manuscripts show the feasibility of minimally invasive techniques in selected patients, they don't allow for data extrapolation or further robust conclusions.

Furthermore, the number of case series of minimally invasive resection of large mediastinal tumors is limited. In 1998, Demmy *et al.* (7) reported a 48-patient multicentric series of VATS surgery for mediastinal tumors, with 6 open conversions for bleeding and different operative times depending on the tumor location: shorter for posterior mediastinal tumors (93±41 min) than for middle mediastinum tumors (170±78 min) and for anterior mediastinal tumors (190±46 min). The larger size of the tumors operated on was 5.2 cm. In 2004, Bodner *et al.* (8) presented their initial experience with robotic surgery in mediastinal masses and they reported no mortality or major morbidity with a median operation time of 166 min for the total procedure. However, they concluded robotic surgery was not feasible for tumors measuring 10 cm or more.

Cerfolio *et al.* (21) published their experience in inferior or posterior mediastinal masses in 75 patients. The mean

**Table 1** Search strategy summary

Items	Specification
Date of search	15 <sup>th</sup> August–31 <sup>st</sup> August 2021
Databases and other sources searched	PubMed
Search terms used (including MeSH and free text search terms and filters)	Search terms: 'giant' and/or 'large', 'mediastinal', 'tumor' and/or 'mass', 'minimally invasive surgery' and/or 'VATS' and/or 'robotic'
Timeframe	Between January 1970 and August 2021
Inclusion and exclusion criteria	Inclusion criteria: (I) English and Spanish language articles (II) Article types: Retrospective case series Case-report studies Reviews Editorials Exclusion criteria: (I) Articles without full text available (II) Articles with incomplete or irrelevant data
Selection process	There were two independent reviewers M Rodriguez and L Milla who reached a consensus about the manuscripts to be included in the review

tumor size was 4.4 cm (range, 1–15.2 cm), 1 patient needed conversion to open approach, no operative mortality was observed and only one patient experienced major postoperative morbidity.

More recently, Chen *et al.* (9) evaluated the feasibility and safety of robotic surgery in a retrospective review of their experience with 84 patients diagnosed with mediastinal masses located in different locations. They reported a mean tumor size of 5.03±2.46 cm with only one intraoperative conversion due to mediastinal structure invasion.

Other reviews (22,25,26) highlight the feasibility and good outcomes of minimally invasive approaches in mediastinal masses but none of them includes a direct comparison between minimally invasive and open approaches. In addition, most of the outcomes of minimally invasive approaches compared with open approaches have been extrapolated from retrospective case series (27,28) or analyzed taking into account the already published reports (27,29).

Several authors (10,12), in light of recent technological advances, suggested more and more technically complex surgeries, including those of giant mediastinal tumors or tumors invading vital structures could be done minimally

invasive. To assure the success of these approaches, there are some key elements, regarding indications, patient selection, perioperative planning and safety we will discuss in depth.

### ***Indications of minimally invasive surgery in giant mediastinal tumors***

Although minimally invasive approaches have been proven to be feasible and safe in mediastinal surgery beyond diagnosis strategies, careful consideration of different aspects related to the tumor's and patient's characteristics, as well as to the medical team experience, is important prior to minimally invasive approach choice:

### **Multidisciplinary team discussion, including patient's operative risk**

Careful preoperative evaluation becomes mandatory in patients diagnosed with giant mediastinal tumors. This must include a multidisciplinary team meeting between surgeons, pulmonologists, medical and radiation oncologists, radiologists, pathologists and anesthesiologists (4). In these meetings, not only diagnosis strategies and neo-adjuvant treatments should be discussed, but also patients' operative

risk, goals and expectations.

The routine preoperative work up must include anatomical and vascular assessment with high resolution computed tomography (CT) and magnetic resonance imaging (MRI) when considered appropriate (4) and pulmonary function tests to evaluate the risk of pulmonary postoperative complications, especially if a lung resection may be necessary (30). Combined positron emission tomography/CT (PET-CT) may help to determine if intra or extra-thoracic metastasis are present.

Furthermore, careful cardiac evaluation with electrocardiogram (ECG), echocardiogram and coronary angiography, when needed, should be considered.

When a patient is deemed high risk to develop mediastinal mass syndrome, an awake bronchoscopy to evaluate the collapse of the airway in supine position can help make the appropriate anesthetic and surgical choices (4,5,31).

If after multidisciplinary evaluation, including anesthesiologist's assessment, the patient is considered 'safe' or 'low risk' for mediastinal mass syndrome, a minimally invasive approach can be taken into account (4,5). For patient's considered 'unsafe' or 'high risk' or 'uncertain' for mediastinal mass syndrome, a minimally invasive approach may not be recommended in our practice, specially taking into account a cardiorespiratory collapse would require a fast resection of the mass and the CO<sub>2</sub> insufflation required for minimally invasive approaches could worsen this collapse (4,5).

### **Tumor size**

Whether or not a large mediastinal tumor is suitable for a minimally invasive approach is still a matter of debate, with some authors restricting it to tumors less than 5 cm without vascular invasion and other advocating for tumors smaller than 8 cm (32) or 10 cm (2,4,8) or even no size limitation in benign histologies (12).

### **Tumor relationship with other mediastinal structures**

Tumor relationship with vital mediastinal structures as the airway, the great vessels or the heart is directly related with the risk of mediastinal mass syndrome (5) and the risk of bleeding and complications.

Currently, tumors invading the pericardium, phrenic nerve, lung and innominate vein are increasingly considered for minimally invasive resection (10,12). On the other hand, invasion of the chest wall and major vessels (superior vena cava, aorta or main pulmonary artery) are considered contraindications for minimally invasive

approaches (12).

### **Risk of bleeding**

The risk of bleeding, not only related to the invasion of large vessels but also to the tumor vasculature (that has been proven to be very inconsistent in large mediastinal masses) should also be considered (4,33-35) when making the decision to proceed with a minimally invasive approach. The need for vascular resection and reconstruction should be taken into account when indicating a minimally invasive approach.

### ***Preoperative planning and technical considerations***

Ideally, patients diagnosed with giant mediastinal tumors should be referred to high volume centers experienced in treating them (36). A multidisciplinary team with fully dedicated cardiothoracic surgeons and anesthesiologists is crucial to avoid life threatening complications during the perioperative period.

Once minimally invasive tumor resection has been considered feasible, taking into account patient's and tumor's characteristics, thorough planning to mitigate sources of possible intraoperative complications should be started.

This planning includes enough operating room staff to help both the anesthesiologists and the surgeons if complications occur (5). Also, it must carefully consider the need not only for conversion in case of cardiovascular or respiratory collapse (4), but also the need to change beforehand the operative plan (4).

In this setting, extracorporeal circulation support may be available in the room in case it is needed (4), as it has been shown that planned extracorporeal circulation improves survival when compared to non-planned or emergency indication (4).

Depending on the tumor location and characteristics, preoperative strategies to mitigate the risk of bleeding, especially from the tumor vasculature, as embolization, should be taken into account and planned accordingly (4,33-35). Embolization of aberrant tumor feeding vessels, present in up to 35% of large mediastinal masses (33) and arising from variable sites such as bronchial arteries, internal mammary arteries, thyrocervical trunks (34) or even coronary arteries (35) can significantly facilitate the resection.

The operative approach that would determine patient positioning (important in case on conversion) and accesses (fundamental in case of cardiovascular or respiratory

collapse) should be defined in advance, taking into account tumor's characteristics and the type of resection needed (12,13,37):

- (I) Lateral thoracic approach: from the right or the left sides, or even bilaterally, depending on tumor's location and team preferences', has been traditionally used for resection of anterior and posterior mediastinal masses (10,12,13,37). It requires three ports or robotic arms, and has been shown to allow resection of the pericardium, the phrenic nerves, the innominate vein and the lung (32).
- (II) Subxiphoid approach: this approach allows for a wide view of the mediastinum, very similar to the field of the sternotomy, especially of the upper thymic poles, the innominate vein and bilateral phrenic nerves. It has been shown to be feasible (11) and to have good early clinical outcomes (38). Depending on the extension of the lesion and the technical difficulty of the resection, it could be performed with three or four robotic arms.
- (III) Modified subxiphoid approach: it combines both, the traditional lateral thoracic approach and the subxiphoid approach. A four-arm-based approach allows for a better hilar dissection in case a combined pulmonary lobectomy is needed (12). Here, some ports are located in the anterior intercostal spaces and at least one is subxiphoid.

The conversion strategies should also be carefully discussed among team members, especially in case of cardiorespiratory collapse or bleeding.

In the supine position with or without operative side elevation (12), the incision of choice for conversion would be a median sternotomy or a hemi-clamshell incision if lateral, hilar or pleural exposure are needed (32,39).

Careful evaluation of oncologic resection should be made prior to conversion or when irreversible surgical steps are going to be undertaken (4,10,12).

In case extracorporeal circulation support is needed, patient accesses should be planned beforehand, as central cannulation, given tumor characteristics and location, may not be feasible or may interfere with the operation (4,40). Furthermore, it should be taken into account that extracorporeal circulatory support may take up to 20 min to establish (41), with the risk of added neurological complications. For this reason, given the improved survival of planned extracorporeal circulation (4), femoral accesses should be prepared in advance in case they are emergently needed (4,41).

Finally, when the resection has been successfully completed through a minimally invasive approach, specimen removal can become one of the challenging parts of the intervention. Depending on tumor consistency, size and characteristics, different removal strategies have been described:

- (I) Controlled cutting of a rib anteriorly to allow the intercostal space to be widened with minimal force (42);
- (II) Resection of short rib segment (43);
- (III) Brief rib spreading with a retractor (43);
- (IV) Conversion to thoracotomy/sternotomy (43);
- (V) Subxiphoid extraction (44-46).

Regardless of the retrieval method chosen, oncologic principles such as avoiding capsule disruption and minimizing tumor manipulation should always be taken into account and the specimen removed in a bag (47).

#### *The day of surgery: patient safety and oncological resection as primary goals*

On the day of surgery, all the previously stated considerations should be put into practice. Even if anesthesia and surgery seem to be going as planned, the team should always be prepared for the unexpected, prioritizing patient safety and R0 resection to surgical approach (4).

Evaluation of oncologic resection should be continuously made, as we have stated previously, to avoid any irreversible maneuvers (4,12).

Regardless of the minimally invasive approach, conversion tray should be open on the table and ready to be used emergently if needed.

If cardiovascular and/or respiratory decompensation occur and they do not improve despite anesthesiologist's efforts, we should not forget that the most effective treatment in this situation is fast surgical decompression of mediastinal structures via tumor elevation (5) and a median sternotomy if this cannot be achieved by other means.

An important technical aspect in these interventions is to minimize tumor manipulation to prevent capsule disruption and possible pleural spread (especially in thymic epithelial tumors) (12). If this principle cannot be assured through a minimally invasive approach (sometimes because of the limited space to work allowed by the tumor), conversion should be considered (12).

We have previously mentioned CO<sub>2</sub> insufflation can worsen mediastinal mass syndrome and lead to cardiovascular decompensation. If this happens, even with



low CO<sub>2</sub> insufflation pressures (5 to 8 mmHg), we would recommend conversion to sternotomy to assure an adequate field for tumor resection (4,12).

All possible involved vessels should be controlled proximally and distally to evaluate resectability and their risk of bleeding. If this is not achievable by means of minimally invasive surgery, an open approach may be needed (12).

Furthermore, extracorporeal circulation should be ready to start as planned. Cardiac and Vascular surgeons should be on stand-by, or even in the field, if considered necessary due to tumor's heart and vascular relationships, and enough help and personnel support should be available in case massive bleeding occurs (4).

### Postoperative considerations

Postoperative care does not differ much from the standard principles and other recommendations included in previous chapters. Special attention should be paid to those patients that required vascular resection or reconstruction, concomitant lung resection and phrenic nerve resection (4).

### Conclusions

When considering a minimally invasive approach for the treatment of large mediastinal masses, special attention should be paid to tumor size and histology (including possible preoperative strategies to decrease its size), and to the tumor's relationship with other mediastinal structures. Careful multidisciplinary preoperative evaluation, including the risk of mediastinal mass syndrome and anesthesiology assessment, will help determine the best operative plan. This plan, regardless of the chosen approach, should never compromise patient safety and oncological outcomes and should include all the possible intraoperative and postoperative complications expected.

### Take home messages

- (I) Beyond diagnosis, minimally invasive surgery in the treatment of giant mediastinal masses should be considered in large volume experienced centers;
- (II) Minimally invasive approaches should only be taken into account for patients with low risk of mediastinal mass syndrome;
- (III) Multidisciplinary discussion of these patients, including diagnosis, neo-adjuvant treatment, surgical planning and postoperative management is mandatory;

- (IV) Patient safety and oncological resection should prevail over the type of approach.

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