Review Article

Surgical approaches to mediastinal cysts: clinical practice review

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Abstract: The traditional approach to mediastinal cyst and mass resection has been open via median sternotomy or thoracotomy. With the advent of minimally invasive techniques, there have been successful cases completed via video-assisted thoracoscopic (VATS) and robot-assisted thoracoscopic surgery (RATS). Although mediastinal cysts are uncommon, they are a significant and relevant topic in the practice of thoracic surgery. Thus, this clinical practice review aims to summarize and highlight some of the key case series and retrospective studies in order to provide insight on each of the approaches. In addition, there is a brief review of other approaches, such as subxiphoid, and the utility of endobronchial ultrasound in the management of mediastinal cysts. In this review, the identified benefits of VATS and RATS lie largely in quality improvement of the patient experience—decreased length of stay (LOS) and pain—without compromising patient outcomes. However, the open approach remains a viable option, particularly for the management of large cysts or as a bail-out option. When surgeons approach with VATS or RATS and encounter bleeding or difficult dissection planes, it is consistent in the literature that conversion to thoracotomy is the safe next step. Our clinical practice is to attempt VATS or RATS approach for mediastinal cysts when possible. The data used for this review relies heavily on case reports and case series, and thus is the main limitation of this clinical practice review.

Keywords: Mediastinal cyst; open approach; minimally invasive approach

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Introduction

Mediastinal cysts are an uncommon but relevant topic in the thoracic surgery literature. With the advent of minimally invasive technique, it is important to explore how these techniques impact the surgical approach and management of mediastinal cysts and compare their outcomes to the traditional open approach. From our review of the literature, there has not been comprehensive studies comparing thoracoscopic, robotic, and open approaches for management of mediastinal cysts. Thus, the aim of this clinical practice review is to review the benefits and risks of these approaches and potential clinical scenarios when one technique is more appropriate than the others.

Mediastinal cysts are grouped by location—anterior, middle, and posterior. Mediastinal cysts are predominantly found in the middle mediastinum and make up 12–20% of mediastinal masses (1-3). The most common mediastinal cysts include bronchogenic, esophageal, thymic, and pericardial cysts. Of these, foregut cysts (bronchogenic and esophageal) are the most common and account for 50% of all mediastinal cysts (1,3,4). The majority of these cysts are created during embryonic development and are identified incidentally or due to the presence of symptoms,

such as cough, dyspnea, and chest pain. Although malignant transformations of foregut cysts are rare, surgical resection is recommended and is the standard treatment due to incidence of complications with observation, such as infection, development of clinical symptoms, and increase in cyst size (3,5,6).

Anterior cysts can include thymic cysts and lymphangioma (1). Thymic cysts account for 3% of all mediastinal masses and can be unilocular or multilocular (6,7). Although both can cause compressive symptoms, unilocular cysts are more likely congenital whereas multilocular cysts are more frequently a result of inflammation from surgery or infection. Surgical resection is usually required because these lesions can continue to increase in size and cause compressive symptoms (3). Complicated thymic cysts can appear similar to cystic thymoma and thus the identification of solid portions of a cystic mass is important (8). Rarely, thymoma can be identified in thymic cysts, typically arising from the cyst wall (9,10).

Middle mediastinal cysts are typically pericardial or bronchogenic in nature (1). Pericardial cysts are usually due to persistent parietal recess during embryogenesis but in rare cases can be acquired secondary to iatrogenic means or pericarditis. Seventy percent of pericardial cysts are located at the right cardiophrenic angle. Treatment depends on size and presence of symptoms. Thus, if they are asymptomatic, watchful waiting with serial imaging can be performed (1,4). However, risks of observation include eventual infection, rupture, tamponade or compression of mediastinal structures (4,6). Bronchogenic cysts can be found in the middle and posterior mediastinum and are due to anomalous budding of the laryngotracheal groove. Their eventual location depends on timing of development during embryogenesis and can be intraparenchymal, paratracheal, subcarinal, hilar, and even arising from the diaphragm. Imaging features can be nonspecific and include a broad differential diagnosis, and thus the recommendation is to pursue surgical resection for definitive diagnosis (1,5).

Posterior cysts include neurogenic, bronchogenic, and enteric cysts (1). Enteric or enterogenous cysts originate from the dorsal foregut and these can contain gastric or pancreatic tissue, which can secrete enzymes and fluid and increase risk for rupture and hemorrhage. Esophageal duplication cysts are attached to or part of the esophageal wall and are associated with other gastrointestinal tract malformations, such as tracheoesophageal fistulas and esophageal atresia (1,11). Neurogenic cysts can comprise both enteric and neural tissue and are mostly found in the posterior mediastinum. Of mediastinal cysts, these are most frequently associated with other developmental anomalies such as spina bifida, vertebral fusion, and scoliosis. Most are symptomatic in early childhood due to local compression, and thus surgical excision is recommended (1).

Open approach

The traditional approach to mediastinal cyst excision is an open approach via sternotomy or thoracotomy. The benefits of an open approach include visibility and accessibility in the event of injuries to nearby structures. However, the main disadvantages to the open approach are postoperative pain and longer length of hospital stay (12-16).

For larger cysts, an open approach has been successful due to not requiring space for maneuvering minimally invasive instruments in the thoracic cavity. In a case report of an 8 cm x 8 cm pericardial cyst, the authors were able to completely excise the cyst via a sternotomy incision and the patient was able to be discharged on postoperative day 2 with complete resolution of their preoperative dyspnea and chest pain (4). In a rare 11 cm × 5 cm × 4 cm thoracic duct cyst that extended from the right inferior pulmonary vein to the first lumbar vertebra, the surgeons were also able to completely remove the cyst via a thoracotomy incision (2). An infant with an 11 cm esophageal duplication cyst that was associated with hemivertebrae underwent excision via a thoracoscopic approach and required conversion to open thoracotomy in order to achieve complete excision. Preoperative work up was unable to clearly demonstrate the exact location and extent of the cyst in relation to neighboring structures and was difficult to be seen via thoracoscopy (11).

Michel *et al.* wrote that the subcarinal position or cysts with a common wall with the bronchus or esophagus may benefit from a thoracotomy approach since the dissection can be dangerous and speed and accessibility to obtain control of bleeding and leak are imperative. In addition, they suggest that tactile feedback via an open approach may be particularly necessary in esophageal wall cysts in order to prevent esophageal injury (17).

Video-assisted thoracoscopic surgery (VATS)

Although thoracotomy was the standard of care for middle and posterior mediastinal cysts, the 3-port and uniport VATS approach has been proven to be safe and effective for

cysts in all 3 compartments of the mediastinum. Advantages over thoracotomy include decreased pain, length of stay (LOS), and morbidity (12-18).

Michel *et al.* concluded that thoracoscopy is better than open not only because of less postoperative pain and lower costs due to shorter overall LOS, but also because the smaller incisions disrupt less muscle and decrease pulmonary reserve to a lesser extent. Of their 22-patient case series, 4 patients did not achieve complete excision via VATS approach. This was more common if the cyst walls were adhered to the trachea and/or esophagus. In these instances, they fulgurated the cystic walls to decrease the chance of recurrence. However, they found that visibility was not an issue and that "almost the entire anterior and posterior mediastinum is visible by thoracoscopy". They suggest using carbon dioxide insufflation to help maintain good exposure if needed. Despite having incomplete excisions, they had no recurrences within the 6 years of surveillance performed (17). Although Michel *et al.* suggested that tactile feedback for esophageal cysts may be a benefit for open procedure in those instances, there is a 6-patient Japanese case series demonstrating successful esophageal duplication cyst removal via thoracoscopy. This group converted to open once when there was an identified esophageal perforation (13-17).

For extremely large cysts, multiple authors suggested the benefit of needle decompression and aspiration intraoperatively prior to proceeding with excision via thoracoscopy (15,17,18). A 69-year-old woman with a 10.5 cm × 7.5 cm posterior cystic lymphangioma underwent successful VATS excision after decompression of 500 mL of milky fluid intraoperatively. There was no recurrence within 2 years of follow up (18).

Positioning of the patient varied in different successful VATS reports. A group that has had success with prone positioning for thoracoscopic esophagectomies performed a complete excision of a 3-cm bronchogenic cyst arising from the diaphragm in the same position. The authors cited the downward position of the lungs to be helpful for exposure of the posterior space but state that transition to thoracotomy is more challenging. They do not recommend the prone position for anterior lesions. The benefits for prone positions include less wrist fatigue and faster learning curve (5). Another group published a successful excision of a 3 cm × 3 cm × 4 cm paravertebral esophageal duplication cyst in the left lateral decubitus with a slight prone position in a 19-month-old male. The cyst was adhered to the lung, hilum, and aorta but was able to be successfully removed in its entirety in this position (12).

In a Chinese case series of 99 bronchogenic cysts undergoing VATS vs thoracotomy, the VATS group had shorter operating room (OR) time by 40 min (P<0.001), lower estimated blood loss of 20 *vs.* 100 mL (P<0.001) and shorter LOS of 5 *vs.* 8 days (P<0.001). They concluded that posterolateral thoracotomy and VATS are both reliable but VATS is superior because of shorter OR time, patients spend less time with a thoracostomy tube, and shorter LOS. They had one complication of postoperative bleeding in the VATS group and two chylothoraces in the thoracotomy group, but otherwise no significant differences in postoperative complications. In both groups, there were incompletely removed cysts due to severe adhesions to nearby vital structures. No recurrences were identified in either group during the 2-year follow up period (15). A French group of pediatric cases comparing VATS to thoracotomy found similar findings of shorter LOS and less time with a thoracostomy tube in their VATS group. Their mean OR time was 70 minutes for thoracotomy and 78 minutes for VATS. These authors concluded that VATS should be the first-line approach to bronchogenic cysts (16).

A Turkish case series of 60 patients with mediastinal cysts in the anterior, middle, and posterior mediastinum drew similar conclusions as above and had an average shorter OR time by 40 minutes and LOS by 4 days in the VATS group. They conclude that VATS cystectomy is effective and safe in treatment of all mediastinal cysts, regardless of location (14).

In addition to the 3-port technique, there have been successes with uniportal VATS in mediastinal tumor (cyst and mass) excisions (19-21). One study of 40 patients had an average incision length of 3.2 cm with a mean operative time of 97 minutes and concluded preliminarily that uniportal VATS is an acceptable approach as well (22). Another study comparing uniportal to tri-portal VATS and RATS technique for mediastinal lesions found that the LOS and length of time with a chest tube was shortest in those who underwent uniportal VATS. These authors used a 3–4 cm incision in the anterior to mid-axillary line at the 3rd, 4th, or 5th intercostal space (23).

Robot-assisted thoracoscopic surgery (RATS)

Since its approval for cardiac surgery in 2002, RATS has gained traction (24). There are a number of successful case series of mediastinal cyst and mass excisions using this technique and authors frequently cite the degrees of freedom with the robot arms, removal of the "surgeon's

tremor", and improved visibility as benefits of this approach (25-29). The described reports below used a 4-port approach unless otherwise specified.

A 2-cm posterior Mullerian cyst along the right anterolateral aspect of T5 vertebral body was able to be successfully excised in the left lateral decubitus position via the RATS approach and was able to be discharged on POD2. The surgeons chose the robot-assisted approach because of the "precise manipulation of the machine arms" and magnification that allowed them to separate the cyst from the spine without damage to neighboring veins (25).

A Korean group comparing RATS to open approach in 68 patients with anterior mediastinal masses found that the RATS group had a significantly lower number of drains, days with a drain, chest tube output volume, drop in hemoglobin, and LOS. They had one conversion to open procedure due to significant adhesions. However, unlike the VATS studies, there was no difference in OR time between RATS and open. They positioned their patients in the supine position with a bump on the operative side and were able to approach the anterior mediastinum from the right, left, and/or bilateral if needed. They cite the removal of "surgeons' tremor" as an improvement in safety and better visualization to allow for meticulous dissection as additional benefit to RATS approach (26). Other similar case series conclude RATS as equivalent to open sternotomy for anterior mediastinal masses (27,28,30,31). Rea *et al.* concluded that even posterior lesions could benefit from RATS because of the magnification, precision, and articulation of the robot. Potential downfalls of RATS include "high initial costs and the long operating time compared with conventional procedures, mainly during the learning curve (28)."

In a case series of 84 patients who underwent RATS resection of mediastinal masses, Chen *et al.* wrote that disadvantages to VATS include suboptimal visualization and inflexible instruments whereas RATS incorporates three-dimensional imaging, removes hand tremors, and has a wider range of surgical instrument motion. They were able to perform RATS in lateral decubitus, semi-lateral decubitus, and reverse Trendelenburg positions. Of their 84 patients, they required one conversion from RATS to open. Their mean tumor size was 5 cm and mean OR time was 92 minutes with a mean LOS of 3.6 days (29).

Additional approaches

In addition to the advent of minimally invasive surgical technique, the use of endoscopy and endobronchial ultrasound (EBUS) has also been introduced in the management of mediastinal cysts. A 4-cm bronchogenic cyst that was incompletely excised due to adhesions recurred within 8 months and underwent EBUS-guided transbronchial needle aspiration (EBUS-TBNA). At follow up 18 months later, the cyst had not regrown (32). These authors and others cite that endobronchial drainage should be considered for patients who are asymptomatic or prefer a non-surgical approach. They hypothesize that complete aspiration of simple or loculated mediastinal cysts with EBUS can cause apposition of the mucosal lining and thus help prevent recurrence (32,33). The most common complications after EBUS include bleeding, pneumothorax, pneumomediastinum, and mediastinitis. Infection can result due to bacterial seeding of the space previously occupied by the cyst. Poor perfusion and significant potential space increase the risk of mediastinal infections (34). In one review of 19 patients with mediastinal cysts managed with EBUS-TBNA, complete resolution of imaging and symptoms occurred only in 5.5% of patients. These authors concluded and support EBUS-TBNA as a diagnostic tool but that its role as a therapeutic modality for mediastinal cysts is not yet well-defined (35). In a systematic case review of mediastinal cysts treated with EBUS-TBNA, there was an overall complication rate of 16%, similar to complication rates for those undergoing surgical resection. Prophylactic antibiotics were given to 5 patients and 1 patient developed mediastinitis. The review cited the importance of different prophylactic antibiotics depending on endobronchial or transesophageal approach. These authors also support EBUS as a diagnostic tool and conclude that TBNA as a primary treatment modality is yet to be determined (36).

Transcervical and subxiphoid approaches to mediastinal masses, particularly in the anterior mediastinum and thymic lesions, have also been described. A subxiphoid approach combined with thoracoscopy was used to remove a 11 cm thymic lesion. The patient was able to be discharged home on postoperative day 3. Authors cite the improved visibility of bilateral phrenic nerves with this approach, particularly with the flexibility in moving the camera (37,38). Transcervical approach to thymectomy is largely discussed in the otolaryngology literature and has been successful for thymectomies as well as excision of parathyroid adenomas. In a case series of over 120 patients, a 10-cm transcervical incision was successful in removing the thymoma or parathyroid adenoma in the majority of cases. 4 patients required conversion to partial or full median

sternotomy. These authors found that lesions less than 4 cm were more amenable to the transcervial approach. Overall complication rate was 13% with a mean operative time of 95 minutes (39). A prospective case series followed 100 consecutive patients who underwent transcervical-subxiphoid-videothoracoscopic thymectomy. This exposure and technique spared patients from undergoing a median sternotomy. Postoperative morbidity was 15.0% and these authors found that having 2 teams operating from both directions decreased operative time. The authors were unable to conclude on the rates of remission of myasthenia gravis compared to other techniques, given their follow up of 2 years (40).

In our clinical practice, our preferred approach to mediastinal cysts is either VATS or RATS unless we anticipate, based on preoperative imaging, not being able to insufflate or see beyond the cyst during a minimally invasive technique. We found that the use of double lumen endotracheal intubation and carbon dioxide insufflation in the lateral decubitus position allows for adequate exposure in cysts of the anterior, middle, and posterior mediastinum. We can safely and completely excise mediastinal cysts via these approaches and they give our patients the decreased postoperative pain and shorter LOS as cited in the literature. At our institution, the approach of RATS or VATS will be determined by the individual surgeon's experience with either technique. However, if the patient is morbidly obese (BMI >40), then we would prefer the RATS approach for improved surgeon's ergonomics and accessibility. If necessary, due to size of the cyst, inability to maneuver our thoracoscopic instruments for dissection, or lack of tactile feedback and invasion into neighboring structures, we may proceed with an open approach first. We do not typically perform needle decompression of these large cysts due to risk, though small, of contamination of the thoracic cavity.

Conclusions

Mediastinal cysts represent a heterogenous group of pathologies and locations. This review evaluated the existing literature, which is largely represented by successful case series and case reports with a lack of a good "control" group. We acknowledge that these are limitations of the nature of our review.

We found the paper by Guo *et al.* most compelling. Despite being a retrospective study, this was a direct comparison of patients who underwent posterolateral thoracotomy and 3-port VATS technique and their outcomes. The size of the mediastinal cysts in each technique was comparable and they had one case requiring conversion to open approach (15). In the robot-assisted literature, we found the studies comparing RATS to median sternotomy or VATS (Seong *et al.*, Rückert *et al.*, Cakar *et al.*, and Augustin *et al.*) more educational and of more clinical significance (26,27,30,31). The area of research that we would like to see more of is comparing RATS to thoracotomy, as the pain and morbidity of a thoracotomy are greater than for a median sternotomy.

We did not find that cyst size was a limiting factor for those who supported VATS or RATS because cyst aspiration was frequently cited as a method to continue via minimally invasive technique while ensuring adequate visibility and space for laparoscopic and robotic instruments. Our clinical practice does not utilize cyst aspiration. However, for the studies that did utilize aspiration, they had minimal or no rates of recurrence within their follow up period. Similarly, location (left or right, anterior, middle, or posterior) was also not a limiting factor for those who performed studies evaluating the success of VATS and RATS. There are suggestions of caution when operating in the subcarinal space, but this did not seem to be a limiting factor for any of the techniques detailed.

Although the traditional approach of open surgery for surgical resection of mediastinal cysts is no longer the first line for many surgeons, it continues to have its advantages of providing tactile feedback and allowing easy access in the event of complications. In addition, surgeons attempting minimally invasive approaches should have a low threshold to convert to open technique if complications occur or if visibility and dissection planes are unclear. The minimally invasive approaches (VATS and RATS) have moved to the forefront with improved patient outcomes, particularly in hospital LOS and time spent with a drain.

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