**Video Assisted Thoracoscopic Resection of a Large Anterior Mediastinal Mass**

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**Abstract**

Mediastinal masses comprise the majority of thoracic masses in children and are most commonly found in the anterior mediastinum. Minimally invasive surgery offers a technically safe and oncologically sound resection, though most anterior mediastinal masses are benign. The minimally invasive approach also provides the potential benefit of reduced hospital stay, smaller incisions, decreased surgical site infections, quicker return to chemotherapy when appropriate, and less post-operative pain which minimizes opioid use. With growing interest in employing minimally invasive surgery for resection of chest masses, this operative technique feature provides the technical and anatomical details of the resection of a large anterior mediastinal mass with a corresponding video highlighting key steps of the operation.

**Key words:** minimally invasive surgery, pediatric surgery, mediastinal tumor, video assisted thoracoscopic surgery, operative technique

**Notification of video:** Please see corresponding video entitled, “Video Assisted Thoracoscopic Resection of a Large Mediastinal Tumor,” which highlights key steps of the operation.

**1.0 Introduction**

Pediatric mediastinal masses pose a challenging case for the pediatric surgeon due to narrow working space and a concentration of vital structures in the area. Mediastinal masses are typically diagnosed on chest radiograph in a child presenting with dyspnea, cough, fever, and/or general malaise, though a large proportion of mediastinal masses are diagnosed as incidental findings on chest radiographs obtained for other reasons. After initial diagnosis, the mass can be further characterized via ultrasound, CT scan, or MRI. The differential diagnosis for mediastinal masses in children is broad and includes neoplastic and non-neoplastic processes. The location of the mass (anterior, middle, or posterior mediastinum) helps to narrow the differential diagnosis. The most common neoplasm of the mediastinum is lymphoma found in all compartments of the mediastinum, followed by neurogenic tumors (ganglioneuroma, ganglioneuroblastoma, neuroblastoma), found primarily in the posterior mediastinum. Thymomas and germ cell tumors (i.e., seminomas and teratomas) are most commonly found in the anterior mediastinum [1]. With the exclusion of lymphomas, which respond to chemotherapy and/or radiotherapy, all mediastinal masses in children should be resected when feasible [2].

When resection is indicated, current surgical management of pediatric mediastinal masses relies primarily on open resection via median sternotomy or posterolateral thoracotomy depending on the anatomical extent of the mass [2]. However, based on a growing body of literature suggesting that a minimally invasive approach is both feasible and safe in appropriately selected adult patients, some pediatric surgeons have adopted video-assisted thoracoscopic surgery (VATS) for resection of mediastinal tumors in children [3, 4]. There is still significant hesitation among pediatric surgeons to employ VATS for resection of mediastinal tumors due to lack of familiarity with the technique and close proximity to vital structures. The present article aims to provide a basic framework for VATS resection of anterior mediastinal tumors.

**2.0 Description of Operative Technique**

*2.1 Patient selection*

Patient selection is of utmost importance when considering a VATS approach to resect an anterior mediastinal mass. Patients most amenable to a minimally invasive resection are those with manageable tumor volumes, which are typically those discovered at earlier stage. The VATS approach should be avoided in patients with excessively large tumors encasing great vessels or those with concomitant cardiorespiratory compromise that would render them unable to tolerate intrathoracic carbon dioxide insufflation [4, 5]. Another consideration would be the potential need for cardiopulmonary bypass.

*2.2 Preoperative planning*

Successful execution of a VATS resection of a pediatric anterior mediastinal tumor requires careful preoperative planning including advanced communication with anesthesia providers. After administration of general anesthesia, the trachea is intubated with a dual-lumen endotracheal tube to allow for single-lung ventilation. Appropriate positioning of the endotracheal tube is confirmed with intraoperative bronchoscopy. The patient is then positioned supine with a bump to elevate the operative side of the body. The ipsilateral arm is elevated above the head and placed on a lateral arm rest with padding to avoid nerve injury or palsy (Figure 1). The neck, chest, and abdomen are prepped in the usual sterile fashion in case conversion to open sternotomy is required.

*2.3 Port placement*

After initiating single-lung ventilation of the contralateral lung, the first 5 mm port is placed in the anterior chest in the sixth intercostal space just inferior to the nipple. The chest is entered using a Kelly clamp, and a Veress needle is placed in order to insufflate the chest to 4 mm Hg. A 5 mm, 30-degree scope is placed through the 5 mm port and the hemithorax is surveyed for signs of injury and to ensure the lung is well-isolated and deflated. Two additional 5 mm ports are placed under direct visualization in the mid-axillary line (Figure 1B).

*2.4 Dissection technique*

 A long flat grasper is used to retract the lung tissue carefully and visualize the mass. Any visceral pleura and lung that is fixed to the mass can be dissected off using a combination of hook cautery and the LigaSure device (Medtronic, Minneapolis, MN). When possible, it is preferable to begin the dissection of the mass at its anterior surface, as one is least likely to encounter vital structures anterior to the mass. The anterior surface of the mass is dissected using a combination of blunt dissection with the Endoscopic Kittner as well as the LigaSure device. Dissection is continued to the contralateral pleural surface. Care is taken to ensure the contralateral pleural is not violated and that the contralateral phrenic nerve is preserved.

 Once the contralateral pleural space is reached, attention can be directed to the posterior dissection of the mass. The posterior aspect of the mass is dissected in a similar manner, taking care to avoid and protect the phrenic nerve posteriorly. Following the anterior and posterior dissection, the superior and inferior aspect of the mass can be dissected again using blunt dissection with the Endoscopic Kittner whenever possible. Areas that are unable to be dissected bluntly are taken with the hook electrocautery or the LigaSure device. Figure 2 outlines vital structures that might be encountered during the dissection. Once the mass is freed superiorly and inferiorly, it can be retracted posteriorly in order to free it from the contralateral lung. At this point, the mass should be freed from all attachments and can be mobilized out of the mediastinum. After the mass is mobilized, the surgeon assesses for hemostasis and confirms that vitals structures are intact including pericardium, great vesssels, and phrenic nerves. If the contralateral phrenic nerve cannot be visualized, an additional port should be placed on the contralateral side to confirm the contralateral phrenic nerve remains intact in its entirety.

 To remove the mass, the superior port site in the midaxillary line is enlarged and an Alexis wound protector is placed in the incision. A 15 mm Endo-Catch bag is used to collect and exteriorize the mass. The incision used to exteriorize the mass is closed in layers using an 0 vicryl as the pericostal stitch followed by 2-0, 3-0, and 4-0 vicryl for the muscles layers. 4-0 monocryl is used for the skin stitch. A 19-French Blake drain is placed through the inferior port site and secured to the skin using 3-0 vicryl. The drain is connected to a Pleur-Evac which is connected to -20 mmHg suction and dressed with an occlusive dressing. The remaining port sites are closed using 3-0 and 4-0 vicryl followed by 4-0 monocryl. All incisions are covered with dermabond.

*2.5 Post-operative care and follow-up*

Post-operative chest radiograph should be obtained in the post-anesthesia recovery unit (PACU). The pleural drain is maintained to -20 mm Hg suction for approximately 24 hours post-operatively. If there is no air leak on post-operative day 1, the Pleur-Evac can be transitioned to water seal. No objective data exists for clear endpoints to guide timing of pleural drain removal, but one group suggests that drain removal should be considered in patients with output less than 4 ml/kg/day without air leak. Daily chest radiographs should be obtained while the plueral drain is in place as well as repeat radiograph 4 hours after removal to assess for pneumothorax or pleural effusion. Alternatively, no chest tube can be placed if the surgeon is confident of hemostasis and no lung injury. Given the minimally invasive approach, the procedure is generally well-tolerated by the patient from a pain standpoint. Post-operative pain can be managed with hydromorphone or morphine patient-controlled analgesia (PCA) for the first 24 hours after operation, and the patient can be transitioned to oral pain medications when tolerating a diet.

As with any major surgery, early post-operative mobilization helps to enhance recovery. Depending on pain control, mobilization, and timing of pleural drain removal, patients are typically appropriate for discharge between 2 and 5 days post-operatively. Patients should follow up in clinic between 2 and 4 weeks post-operatively then as needed.

**3.0 Discussion**

When considering a minimally invasive resection of a pediatric mediastinal tumor, the first priority is to provide a technically safe operation. There are certain cases when VATS is simply not feasible such as with excessively large tumors or those encasing major vasculature. MIS instruments provide limited tactile feedback making good visualization of key structures absolutely paramount. An additional port can and should be placed if necessary. Furthermore, an oncologically sound operation must not be sacrificed for the minimally invasive approach. Guidelines for a complete oncologic resection vary based on tumor type, but in general may include gross total resection, avoidance of tumor spillage, and adequate lymph node sampling. Multiple studies have shown that MIS resections maintain oncologic fidelity without compromising relapse-free or overall survival [6-10]. If unable to complete a technically safe or oncologically complete resection with the minimally invasive approach, the operating surgeon must be willing and prepared to convert to an open operation.

Keeping these potential downfalls in mind, the method outlined above for VATS resection of pediatric mediastinal tumors offers and appealing alternative to open resection in the appropriately selected patient as it carries all the benefits of a minimally invasive approach. Retrospective studies comparing minimally invasive to open resection to treat pediatric tumors in general have showed decreased length of hospital stay, decreased blood loss, and possibly decreased time to initiation of or return to chemotherapy in patients undergoing MIS resection [6, 8].

Clear and consistent communication between surgeon and anesthesiologist is critical to the success of the operation not only to achieve single-lung ventilation but also due to potential cardiopulmonary compromise secondary to mass compression on great vessels which can be exacerbated when undergoing general anesthesia [11]. In questionable cases, preoperative echocardiogram can assist in assessing degree of cardiopulmonary compromise and can assist in developing an anesthesia plan.

Here we outline the technique for VATS resection of mediastinal masses in pediatric patients with a focus on anterior mediastinal masses. In summary, a successful operation relies on appropriate patient selection, careful positioning on the operating table, excellent communication with anesthesia providers, meticulous dissection around critical structures, and thoughtful post-operative care. When carried out in the right patient, the technique offers a safe resection with high oncologic fidelity and provides all the benefits typically associated with a minimally invasive approach.

**References**

[1] Franco A, Mody NS, Meza MP. Imaging evaluation of pediatric mediastinal masses. Radiologic clinics of North America 2005;43(2):325-53.

[2] Tovar JA. chapter 25 - MEDIASTINAL TUMORS. In: Holcomb GW, Murphy JP, Ostlie DJ, editors. Ashcraft's Pediatric Surgery (Fifth Edition). Philadelphia: W.B. Saunders; 2010, p. 322-9.

[3] Marshall MB, DeMarchi L, Emerson DA, Holzner ML. Video-assisted thoracoscopic surgery for complex mediastinal mass resections. Ann Cardiothorac Surg 2015;4(6):509-18.

[4] Sato T, Kazama T, Fukuzawa T, Wada M, Sasaki H, Kudo H, et al. Mediastinal tumor resection via open or video-assisted surgery in 31 pediatric cases: Experiences at a single institution. Journal of pediatric surgery 2016;51(4):530-3.

[5] Phelps HM, Lovvorn HN, 3rd. Minimally invasive surgery to treat embryonal tumors of childhood. Cancer metastasis reviews 2019;38(4):695-708.

[6] Phelps HM, Ayers GD, Ndolo JM, Dietrich HL, Watson KD, Hilmes MA, et al. Maintaining oncologic integrity with minimally invasive resection of pediatric embryonal tumors. Surgery 2018;164(2):333-43.

[7] Metzelder ML, Kuebler JF, Shimotakahara A, Glueer S, Grigull L, Ure BM. Role of diagnostic and ablative minimally invasive surgery for pediatric malignancies. Cancer 2007;109(11):2343-8.

[8] Malek MM, Mollen KP, Kane TD, Shah SR, Irwin C. Thoracic neuroblastoma: a retrospective review of our institutional experience with comparison of the thoracoscopic and open approaches to resection. Journal of pediatric surgery 2010;45(8):1622-6.

[9] Fraga JC, Rothenberg S, Kiely E, Pierro A. Video-assisted thoracic surgery resection for pediatric mediastinal neurogenic tumors. Journal of pediatric surgery 2012;47(7):1349-53.

[10] Irtan S, Brisse HJ, Minard-Colin V, Schleiermacher G, Canale S, Sarnacki S. Minimally invasive surgery of neuroblastic tumors in children: Indications depend on anatomical location and image-defined risk factors. Pediatric blood & cancer 2015;62(2):257-61.

[11] Pearson JK, Tan GM. Pediatric Anterior Mediastinal Mass: A Review Article. Semin Cardiothorac Vasc Anesth 2015;19(3):248-54.

**Figure Captions**

**Figure 1.** Chest radiograph in a 17-year-old male complaining of cough and chest pain demonstrates a mediastinal mass (1A). Further workup with CT scan reveals anterior mediastinal mass. The patient is taken to the operating room and positioned supine with a right-sided bump in preparation for right VATS (1B).

**Figure 2.** Video assisted thoracoscopic view of the right chest in a 17-year-old male undergoing resection of a large anterior mediastinal mass. Camera is positioned in the inferior midaxillary port directed at the anterior mediastinal mass (1A) then directed more superiorly to provide a view of the visible critical structures (1B).