Robotic Applications to the Mediastinum

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Abstract

The mediastinum can present a surgical challenge for patients and their surgeons. In some situations, to obtain sufficient diagnostic tissue or to completely resect relatively small lesions requires sizeable incisions that can result in unnecessary pain and debility. Minimally invasive techniques have not consistently provided the needed angles of approach, dexterity within the confined space of the mediastinum, and the surgeon-directed visibility necessary to perform a thorough and safe procedure. The robotic surgery platform meets those demands. The special considerations for an efficient procedure are reviewed.

Keywords

Mediastinum • Robotic surgery • Minimally invasive • Thymectomy • Thymoma • Parathyroid adenoma • Thymic cyst • Anterior mediastinal tumor • Germ cell tumor • Robotic assisted • Thoracoscopic surgery • Thymus hyperplasia • Extended thymectomy • Surgical technique

The mediastinum is the site of a wide spectrum of diseases. The diagnosis and treatment of benign and malignant diseases of the mediastinum remains a challenge to thoracic surgeons. A reasonable differential diagnosis can often be made on the basis of clinical history, physical examination, and radiologic workup; however, in the majority of cases a precise diagnosis can not be made without histologic examination of the tissue. Traditional surgical applications to the mediastinum involve both diagnostic and therapeutic procedures. Diagnostic procedures have been used principally for the evaluation of unknown masses and conformation of suspected hematopoietic malignancies, such as lymphoma and Hodgkin's disease. Therapeutic resections have been primarily applied to patients with thymoma, myasthenia gravis, neurogenic tumors, and cysts [1–5].

Diagnostic surgery of the mediastinum includes thoracoscopy and mediastinoscopy (anterior and cervical). The prevailing gold standard for resectional therapy of thymoma, with or without myasthenia gravis, has generally been median sternotomy, with thoracoscopy advocated as an alternative for the treatment of known benign cystic diseases [3–5]. The introduction of robotic-assisted technologies provided an improvement in visualization and surgical dexterity over thoracoscopy. The authors believe that the robotic-assisted technology is optimally suited for resectional therapy of most mediastinal disease [1, 2].

The mediastinum is among the most complex anatomical regions of the human body. A thorough understanding of its anatomic components and their three-dimensional relationships is a precursor to the effective application of robotic-assisted surgery. From a surgical perspective the mediastinum is divided into three separate compartments: anterior, middle (visceral), and posterior (para-vertebral). The anterior compartment extends from the thoracic inlet to the diaphragm and is bounded by the posterior aspect of the sternum anteriorly, the pericardium posteriorly, and by the pleura laterally. From a practical surgical standpoint the most important anatomic boundary of the anterior mediastinum is the posterior lateral extent which is bounded on either side by the right

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and left phrenic nerves. The middle compartment is bounded by the pleura laterally, the diaphragm and thoracic inlet proximally and distally, the vertebral bodies posteriorly, and the phrenic nerve anteriorly. The middle compartment contains the heart, great vessels, lymphatics, pulmonary hilum, and esophagus. The posterior compartment extends from the anterior surface of the vertebral bodies to the para-vertebral sulci, and primarily contains neural structures and the sympathetic chain.

The therapeutic decisions on how to manage a mediastinal mass depend on location, the expected histopathologic diagnosis, clinical presentation, patient age and co-morbidities. Generally patients with cystic lesions or well encapsulated solid masses without signs of invasiveness, complete resection of the lesion is advisable, being diagnostic as well as therapeutic. This is the case for most lesions in the posterior mediastinum, and for cystic lesions of the middle mediastinum. This also applies to cystic lesions of the anterior mediastinum as well as encapsulated thymomas and teratomas. Resection of most masses in the mediastinum which fit these characteristics can be safely and effectively carried out with the aide of robotic-assisted technologies, and it is the authors' preference to use robotic-assisted technologies for all resectional mediastinal masses which meet the above criteria. Large lesions (>7 cm), and especially extra-capsular thymomas (where the risk of tumor speeding is high) remain an indication for an open procedure.

9.1 Operative Technique

All cases are performed with selective single-lung ventilation with a radial artery and central venous catheters. For anterior and middle mediastinal lesions the patient is placed supine with either the right or left chest elevated 30°, with the ipsilateral shoulder retracted and depressed, the arm internally rotated and elbow flexed and at the patients side (Fig. 9.1). This position allows accesses to anterior and midaxillary lines without brachial plexus traction and free motion of the robotic instrumentation. Laterality is determined by the anatomic predominance of the mediastinal mass. However, it is the authors' preference to approach all anterior mediastinal masses from a right-sided approach. The left-sided approach is difficult owing to diminished mediastinal working space secondary to the cardiac mass. The heart impairs the reach of the lowest robotic arm into the superior-most anterior mediastinum, and visualization of the right phrenic nerve across the midline. If predominance of an anterior mediastinal masses is left of the left phrenic nerve, then the lesion is generally approached in either an open fashion, or if it is a small lesion (<5 cm) it is treated as a left-sided middle mediastinal lesion (described below).

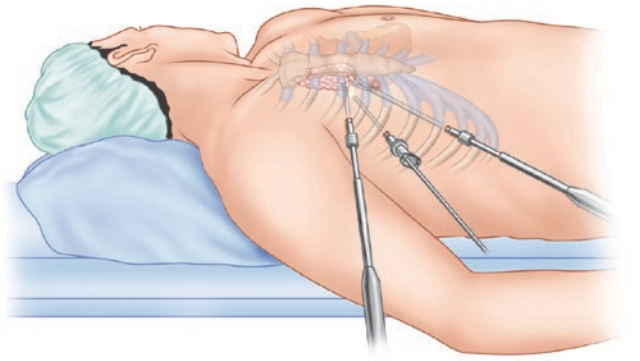

Fig. 9.1 Right-side approach for anterior mediastinal masses. A 10–12-mm port is placed in the fifth intercostal space in the midaxillary line (Port Site A) and the other ports placed according to the visual findings with a 30-degree 5-mm thoracoscope. Typically, the other ports are placed in the anterior axillary line in the third (Port B) and seventh (Port C), respectively. The robot or bedside cart is brought from the opposite side of the operating room table

All port sites are infiltrated with a local anesthetic agent (0.25% bupivacaine). A 30-degree 5 mm telescope is placed through a 10-mm port placed in the fifth intercostal space in the midaxillary line. For the left-sided approaches all port sites in general should be placed 1–2 cm more posterior than their respective right-sided locations. The mediastinum is evaluated and the feasibility of resection and location of additional port sites is determined. For an anterior mediastinal lesion if an anterior mediastinal mass is noted to be extra capsular, a biopsy is taken. Frozen section results are then used to determine feasibility and type of resection. The robotic surgical system is brought up to the table from the patients left side (right side for left sided approaches) for right sided port placement. A 30-degree telescope is used and the additional robotic instruments are introduced through generally the third and seventh intercostals spaces, in the anterior axillary line. These port placements can be adjusted based on their optimal position as determined during the initial thoroscopic evaluation of the lesion to be resected and its respective location to anatomic structures. In young female patients the camera port is generally placed strategically in the sub-mammary fold for improved cosmetics.

In general exposure is facilitated by right lung (or left in a left sided approach) deflation and CO_2 insufflation to a pressure of 10–15 mmHg. The radial arterial and central venous pressures are monitored to ensure adequate hemodynamics during CO_2 insufflation. Maximizing the pressure of insufflation helps create space and facilitates visualization especially for anterior mediastinal resections.

Resections of lesion in the middle mediastinum are generally straight forward and are facilitated by gentle counter traction usually through the most superior port and a gentle blunt dissection technique sweeping the mass or cyst away

from the corresponding phrenic nerve and adjacent structures in the pulmonary hilum, generally the pulmonary vein and or artery. The base of the mass or cyst is generally clipped and then the entire specimen is removed with an endoscopic bag thru the most inferior port.

All masses to be resected in the anterior mediastinum are resected by complete thymectomy, and all are approached by the author from the right side. The thymic dissection is begun at the right pericardiophrenic angle and continued up along the right phrenic nerve to the superior vena caval innominate junction the corresponding phrenic nerve is the most important anatomic structure to identify in all anterior and middle resections of the mediastinum. The thymus is then resected free from the retro sternal area to beyond the left internal mammary artery, extending superiorly until the innominate vein is exposed. The thymus is then retracted rightward, and with rotation of the scope caudally and towards the left chest. The left phrenic nerve can generally be identified. The leftward thymic extent can be dissected in a cephalad manner. If the left phrenic nerve cannot be identified, the left pleural space is entered and the scope passed across the midline into the left chest. The scope can then be used to look down and back while ventilation is temporarily interrupted so that the exact position of the left phrenic nerve may be verified.

Exposure of the thymic cords is facilitated by the CO_2 insufflation, and each pole is grasped and dissected bluntly in its entirety. The thymic venous tributaries that drain the innominate vein are identified, clipped, and divided. The thymus is then placed in an endoscopic bag and removed through the lower port. If the contra-lateral space was entered a small chest tube is placed across the midline, aspirated, and removed. The robotic instruments are removed, and rib bocks of 0.25% bupivicaine are placed, and a small chest tube is left postoperatively. The lung is re-inflated under direct vision, and the incisions are closed in multiple layers.

Posterior mediastinal lesions are approached the same as middle mediastinal masses except that the patient is placed in a full lateral position, exactly as the patient would be positioned for a posterior lateral thoracotomy. Laterality is determined by the anatomic predominance of the mediastinal mass. The robot is positioned anterior to the patient (from the left-side of the table for a right sided lesion). The initial 10-mm camera port is placed in the fifth intercostal space at the mid-axillary line, and the determination of the additional robotic ports is determined by inspecting the exact location of the mass relative to the two operative robotic instruments. Theses ports are generally placed in the third and seventh interspace in the posterior axillary line. Port placement is the most important technical aspect of resecting a position mediastinal mass, and therefore it is facilitated by placing the ports in a position that allows each arm to reach the mass, without creating internal collisions. While the author generally prefers to use a 30-degree scope looking backwards towards the area of interested, in many cases a 0-degree scope can facilitate visualization of the posterior mediastinum. A traction stitch is then passed thru the posterior mediastinal mass and gentle traction thru the most inferior port helps facilitate gentle sharp and blunt dissection of the base of the masses. Once the stalk is encountered it is doubly clipped, and the stalk is divided and the mass is removed with an endoscopic bag.

9.2 Tips and Pitfalls

The most important technical aspect of orbit-assisted mediastinal resection is port placement. We have attempted to provide the reader with a basic port placement strategy, however it should be noted that with experience all ports other than the initial camera port are positioned under direct vision. The ports should be placed in such a way to facilitate the operation and to avoid collisions with the robotic instruments and camera.

It is the authors' opinion that robotic technologies are best suited to resection of anterior mediastinal masses, and new users should focus on this area first. With experience each surgeon will develop their own unique methodology to assure optimal port placement, which is of utmost importance when tackling lesions in the posterior mediastinum.

The authors also feel that each and every lesion should be assessed thorascopicly to determine the feasibility of resection. This is particularly important with thymomas. The authors feel that thymomas with their propensity to seed the mediastinum and pleural space should only be resected with robotic-assisted techniques if the masse is not extra capsular, and all efforts should be made to avoid grasping the thymoma directly. If an extra capsular lesion is seen then the procedure should be converted to an open (median sternotomy is the author's preference) procedure.

9.3 Outcomes

Robotic-assisted techniques allow optimal exposure of the entire mediastinum and allow for precise and meticulous dissection. Robotic-assisted surgery has generally been applied to thymectomies, with excellent results [4, 5], but there have been sporadic reports on it's usage in the middle and posterior mediastinum. The robotic-technique clearly is a safe and effective means of resectional therapy to mediastianl masses. For thymectomies it allows for the ability to perform extensive and complete thymectomies from a single-sided approach, and hence has become the authors preferred approach to all respectable masses in the anterior mediastinum.

The robotic-assisted technique provides access to all parts of the mediastinum, with excellent exposure, provides a diagnosis if necessary, an excellent cosmetic result, and allows for complete resection and staging of mediastinal lesions. The ability to both diagnosis and treat from the same port sites makes robotic-assisted surgery a vital and perhaps ideal tool in the treatment of complex mediastinal lesions.

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