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Thymectomy

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Continuing Education Activity

Thymectomy is the resection of the thymus gland and is most commonly performed for patients with myasthenia gravis and thymoma. It is currently performed utilizing a minimally invasive approach with the use of video-assisted thoracoscopic or robotic-assisted surgery. Historically a median sternotomy was performed. This activity reviews thymectomy and the interprofessional team's role in evaluating and treating patients who undergo this procedure.

Objectives:

- Identify the indications for performing a thymectomy.
- Outline the equipment, personnel, preparation, and technique in regards to thymectomy.
- Describe the appropriate evaluation of the potential complications and clinical significance of thymectomy.
- Review interprofessional team strategies for improving care coordination and communication to advance thymectomy and improve outcomes.

Earn continuing education credits (CME/CE) on this topic.

Introduction

Thymectomy is the resection of the thymus gland. This anterior mediastinal organ can enlarge as in myasthenia gravis and thymoma and harbor malignant cells such as in thymic carcinoma or neuroendocrine tumors. The first thymectomies were performed incidentally in conjunction with thyroidectomies for Grave disease by Garre and Sauerbruch, but it was not until Blalock and colleagues that multiple series were performed with adequate results.[1]

This also included patients with myasthenia gravis but without thymomas. The gold standard approach for thymectomy is a median sternotomy or transsternal approach, but this has evolved to less invasive techniques such as upper partial sternotomy, transcervical, video-assisted thoracoscopic thymectomy, and robot-assisted approaches. Preoperative evaluation should include the functional status and pulmonary function tests, especially with single-lung ventilation in thoracoscopic approaches. Video-assisted and robot-assisted thoracoscopic thymectomies have shown to be superior to the traditional open approaches (transsternal or transcervical) in promoting shorter hospital length of stay and decreased morbidity and mortality.

Anatomy and Physiology

The thymus is located in the superior and anterior mediastinum. Depending on the classification scheme, there can be three or four compartments of the mediastinum. Within the three-compartment scheme, the superior segment is contained within the anterior segment. The rest of the mediastinum includes the middle and posterior segments. The anterior mediastinum is bordered by the sternum anteriorly, the pericardium posteriorly, the diaphragm inferiorly, and

a line connecting the angle of Louie to the fourth thoracic vertebra or most superior to the thoracic outlet. Other structures within the anterior mediastinum include mediastinal fat and lymph nodes. The thymus arises from the third pharyngeal pouch. It continues to grow until puberty and then begins to involute, approximately 1 to 3% weight per year, with thymic tissue being replaced by fat. The thymus is made of two lobes and can extend superiorly to the thyroid gland. Ectopic thymic tissue can also occur, most commonly within the anterior mediastinal fat.

The thymus derives its blood supply from the inferior thyroid artery and branches of the internal mammary arteries (also known as internal thoracic arteries) and a small supply from pericardiophrenic and intercostal arteries. Venous drainage is via corresponding veins and a large posterior vein that drains in the left innominate vein. Lymphatic drains follow the parasternal, tracheobronchial, and brachiocephalic nodes. The left brachiocephalic vein and superior vena cava are positioned posteriorly to the thymus. The thymus is covered with a fibrous capsule. The thymus' parenchyma is divided into lobules by extensions of the capsule (septa), composed of a cortex and a medulla. The cortex houses thymic lymphocytes, also known as thymocytes.[2][3]

The thymus has an immunologic function, participating in cellular immunity. Lymphocytes from bone marrow travel to the thymus to mature into inducer and cytotoxic cells, capable of recognizing non-self antigens and initiating a cell-mediated response. The thymus's most common autoimmune disease is myasthenia gravis, resulting in the most common tumor of the anterior mediastinum, a thymoma. Myasthenia gravis is characterized by autoantibodies to acetylcholine receptors. This results in muscle fatigue (with continued contractions), affecting ocular, facial, oropharyngeal, and limb muscles.[3]

Indications

The most common indications for thymectomy are thymoma and myasthenia gravis. Less common indications for thymectomy include malignant tumors such as thymic carcinoma, neuroendocrine tumors, and benign tumors like thymic cysts. Ectopic parathyroid glands may also be present in the thymus and require resection. Indications for minimally invasive techniques such as video-assisted thoracoscopic surgery and robotic-assisted are similar to the open procedure.[4] Additional indications include nonthymomatous (juvenile/ocular) myasthenia gravis—partial thymectomy reserved for diagnostic biopsy of lymphoma.

Contraindications

Contraindications for thymectomy include those associated with any surgery, such as inability to tolerate general anesthesia, hemodynamic instability, coagulopathy, etc. Specifically, to thymectomy and a minimally invasive approach, invasion of the great vessels would necessitate an open procedure. Also, if the patient is deemed unable to tolerate single-lung ventilation, resection via a sternotomy or transcervical approach is indicated.[4]

Equipment

Equipment required in the open approach (median sternotomy, transcervical approach) include:

- Sternal saw
- Sternal retractor
- Energy devices (electrocautery, bipolar, ultrasonic)
- Staplers
- Sternal wires for closure

Equipment used in video-assisted thoracoscopic thymectomy include:

- Surgical hooks to elevate the sternum
- 30-degree camera

- Electrocautery or ultrasonic energy devices
- Standard endoscopic instruments
- Endoscopic staplers
- An endo catch bag

Robotic-assisted thoracoscopic thymectomy needs the following equipment:

- The Da Vinci surgical system which consists of four robotic arms that are controlled by a surgical console that the surgeon sits at and directs
- A high-definition stereoscopic camera
- Endoscopic graspers
- Needle drivers
- Staplers
- Endocatch bag
- Electrocautery devices [4]
- This surgical system also requires a surgical assistant to help with transferring of instruments at the bedside

Personnel

Personnel required in the open approach (median sternotomy, transcervical approach) include:

- Primary surgeon
- Anesthesiologist
- Nurse anesthetist
- Surgical technologist

Personnel needed in video-assisted thoracoscopic thymectomy include:

- Primary surgeon
- Anesthesiologist
- Nurse anesthetist
- Surgical technologist

Robotic-assisted thoracoscopic thymectomy needs the following personnel:

- Primary surgeon
- Anesthesiologist
- Nurse anesthetist
- Surgical technologist (trained in robotic surgery)

Preparation

Before thymectomy, the preoperative evaluation contains many of the same characteristics common to all surgeries, including a comprehensive history and physical exam. The type of work-up also depends on the disease process necessitating a thymectomy. If thymectomy is performed for underlying myasthenia gravis, adequate preoperative stabilization is necessary to avoid myasthenia crisis. This includes anticholinesterase inhibitors, intravenous immunoglobulin, and/or plasmapheresis. Preoperative imaging includes a CT scan with IV contrast to evaluate nearby structures' involvement, including blood vessels (innominate vein).[4]

MRI and PET-CT scans may also benefit from differentiating between thymic hyperplasia and thymoma and identifying nodal or distant metastases 30928002. Preoperative evaluation should also include pulmonary and cardiac function tests. Even if pulmonary resection is not indicated, there is a large respiratory burden following median sternotomy or at baseline from myasthenia gravis. Therefore, pulmonary function tests, electrocardiogram, and a cardiac stress test may all be indicated depending on the patient's co-morbidities.[5]

Technique

There are different approaches for thymectomy; these are summarized below. Step by step technique of thymectomy is described as follows.

- Intubation: Left-sided double-lumen endotracheal tube, confirmed with bronchoscopy.
- Recommended:
- - Foley catheter for urinary output.
  - Possible- thoracic epidural for pain control.
  - An arterial line for blood pressure monitoring.
- Median Sternotomy Approach:
- - Positioning: supine
  - The bilateral chest including the sternum is prepped and draped.
  - The surgery begins with a vertical median sternotomy, which can be either a partial or a complete incision depending on the resection extent. The mediastinal pleura is then incised to access the anterior mediastinum. Borders of dissection extend superiorly to the thoracic inlet, specifically the innominate vein, inferiorly to the diaphragm, and laterally to the phrenic nerves. All thymic tissue is resected, including its associated mediastinal fat surrounding tissue or organs may also need to be removed if involved in the disease process. Next, mediastinal drains are placed, including chest tubes, into the pleural space. The sternum is then closed with sternal wires and primary closure.[6]
- Video-Assisted Thoracoscopic Surgery (VATS) Approach:
- - Positioning: supine
  - The bilateral chest, including the sternum, is prepped and draped.
  - The VATS procedure is usually approached via a right or left thoracoscopic method (right-sided approach may provide better exposure). The patient is placed in the right lateral 30-degree decubitus position. Selective lung ventilation may aid in exposure to the apex of the thoracic cavity (valve trocars can be utilized instead to allow low-pressure CO2 insufflation into the hemithorax instead). The mediastinum is accessed through the right chest; all 3 trocars are placed along the submammary fold. Ports should be triangulated to improve working conditions. The two working ports are placed anteriorly or posteriorly to the scope port. A combination of hook cautery, scissors are utilized to incise the pleura anterior to the phrenic nerve. The lateral border of the left lobe of the thymus is where the phrenic nerve is. Dissection of the thymus begins from the diaphragm inferiorly to the inferior portion of the thyroid superiorly and is

extended laterally to the border of the phrenic nerves. Dissection is continued on the left side up to the right phrenic nerve. Once this is complete, a chest tube is placed on the right side and the attention is turned towards the contralateral side. If visualization is difficult, ports can be placed in the contralateral chest as well- ports are positioned similarly, and dissection continues until the thymus is free. The thymic tissue is placed in an Endocatch bag, and another chest tube is placed on the right side. Each lung is allowed to re-expand under direct vision and the procedure is completed.[7]

- Robotic Approach:
- - Positioning: Supine with right side elevated using folded blankets or gel pad.
  - The bilateral chest, including the sternum, is prepped and draped.
  - Port position: Fifth intercostal space anterior/midaxillary line (camera), third intercostal space midaxillary (left robotic arm), fifth intercostal space parasternal (right robotic arm), and an assistant port. [8]
  - Once ports are placed, the surgeon assumes control of the robot console. Any chest wall, pleura, or lung abnormalities are addressed and biopsied if necessary. Next, lysis of any adhesions from prior surgeries is performed. Once adequate visualization is achieved, dissection of the thymus begins starting at the inferior border. This continues anteriorly to the sternal edge and then superiorly and laterally. Once to the superior edge, the right superior thymus horn is dissected free. This is followed by dissection of the left superior horn until the entire thymus has been freed. The thymus is then placed in an Endocatch bag and removed from the thorax via the assistant port. Hemostasis is confirmed from the underlying and surrounding tissue as well as from the port sites. The right lung is re-insufflated under direct vision, and a chest tube is placed. Port sites are closed according to the surgeon's preference.[4] The bilateral approach has been found to reduce injury to the bilateral phrenic nerves compared to a unilateral VATS approach. [9]
- Specific Considerations-
- - Trocar placement is adjusted depending on the anatomy of the patient.
  - Single lung ventilation may assist in exposure to the thymus.
  - A right-sided approach may offer improved thoracic inlet access to the thymic veins as they drain into the innominate vein.

Complications

Complications that may arise during a thymectomy include:

- Bleeding and damage to surrounding structures. Bleeding can be from small thymic veins or larger vessels such as the innominate vein. Injury to Keynes's great vein, the largest thymic vein originating from the left brachiocephalic vein, can cause massive bleeding. This may require conversion from minimally-invasive to an open median sternotomy approach.
- Pneumothorax or persistent air leak may be appreciated during the postoperative period, requiring prolonged tube thoracostomy.
- Chylothorax is another complication that can arise due to damage to underlying lymphatic tissue, especially along the thymus' poles.
- Thymectomy may not completely resolve the patient’s symptoms, or a thymoma recurrence could occur if incomplete resection is performed.
- Pericardial injury, injury to the heart, or the phrenic nerve.

- The phrenic nerves are also closely invested with the thymus and can be injured during dissection. This could lead to dysfunction of the diaphragm postoperatively.
- Incomplete thymectomy for myasthenia gravis.

Clinical Significance

There are several techniques for resection of the thymus gland and its associated pathologies. The previous gold standard technique involved a median sternotomy; however, recent minimally invasive techniques have garnered more interest due to several key advantages. Robotic thymectomy was shown to have lower operative blood loss rates, fewer postoperative complications, and reduced hospital stay than the open approach. Advantages have also been seen in oncologic resection with high rates of negative margins.[10][7] These findings were consistent with the VATS approach, demonstrating no significant difference between VATS and robotic-assisted surgery.[11]

Enhancing Healthcare Team Outcomes

Thymectomy is a complex surgery that requires input from an interprofessional team of healthcare individuals in the preoperative, intraoperative, and postoperative phases. Because of the numerous etiologies requiring thymectomy, this procedure requires several specialties, from internal medicine to neurology, to cardiothoracic surgery. Strong communication between specialties can help to properly stage patients and provide preoperative evaluation and risk stratification for impending surgery. Intraoperatively, there must be effective communication between the anesthesiology staff and the surgeon to effectively manage patients with myasthenia gravis and monitor cardiovascular function during these large procedures. Postoperatively, these patients are managed on the thoracic surgery service and require coordination from the intensive care team, including intensivists, nurses, and respiratory, physical, and occupational therapists. By coordinating among these groups with strong communication, thymectomy can be a safe and effective procedure for treating a myriad of disease processes. [Level 1]

Continuing Education / Review Questions

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