Chapter 3

Prevention and Management of Complications from Esophagectomy

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Abstract

While surgery plays a major role in the treatment and potential cure of esophageal cancer, esophagectomy continues to have a significant amount of morbidity compared to other surgical oncology procedures. Efforts to improve morbidity and mortality from esophagectomy include the Consensus Guidelines for Complications from Esophagectomies, Enhanced Recovery after Surgery protocols as well as others. Although we strive to improve morbidity and mortality after these surgeries, adverse events still occur. They affect not only patient quality of life and increase cost of care for esophageal cancer but also have a negative impact on overall cancer survival. This chapter reviews the prevention of adverse outcomes from esophagectomies as well as discusses the management of many complications that may occur more common to the operation.

Keywords: esophagectomy complications, prevention of esophagectomy complications, management of esophagectomy complications

1. Introduction

Adverse events from esophagectomies directly impact patient quality of life, cancer recurrence/survival, hospital costs and resources, as well as require a great deal of energy from those managing them [1, 2]. Prevention of surgical complications is of utmost importance; however, adverse events from this major surgical procedure still occur, even in high-volume centers or experienced hands. Mortality can range from 7 to 9% while morbidity ranges from 17 to 74% [3]. Prevention, early recognition, and adequate management of complications can decrease mortality [4]. While many studies evaluate postoperative morbidity using even randomized methods, randomized studies on the management of postsurgical complications are by nature extremely limited.

2. Selection of the appropriate patient and surgeon

2.1. The optimal patient

Patient optimization and use of appropriate selection criteria are key to minimizing postoperative morbidity. Unfortunately, those risk factors for the development of esophageal cancer may also put patients at an increased risk for postoperative complications. Risk factors include age, elevated BMI, ECOG score/functional status, dyspnea, diabetes, chronic obstructive pulmonary disease, smoking, alkaline phosphatase level elevations, low serum albumin, and increased complexity score [5–11]. However, age and performance status continue to be the most commonly reported. Neoadjuvant treatments have not been consistently proven to be a risk factor. While fibrosis often occurs after chemoradiation, potentially making surgical resection more difficult, data showing optimal timing to surgery after neoadjuvant chemoradiation and its affect on postoperative morbidity are mixed [12].

2.2. How to optimize the patient

Malnutrition has been reported in 57–80% of patients with esophageal cancer [13, 14]. Many factors can be attributed to malnutrition prior to surgery and include patient factors, chemotherapy, radiation therapy, and tumor-related causes [15]. It is important to recognize that even obese patients can suffer from malnutrition. While laboratory values and anthropometric measurements can be useful, their values can vary and therefore may not be clinically relevant. Therefore, a weight loss of greater than 10% for 6 months or 5% for 1 month is considered malnourished [16].

For the malnourished patient, preoperative optimization of nutrition through the advice of a dietician is key, but other measures should be considered as well if a patient is unable to tolerate at least 50–75% of their caloric needs [15]. The preferred intervention should be handled in a multidisciplinary setting and be initiated as early as possible. This decreases the amount of weight loss, increases chances of completion of neoadjuvant therapies, and decreases hospital admissions [17].

Recommendations to maximize oral nutrition intake include dividing daily oral intake into five to six small meals where the patient is given enough time to eat, eating only foods with a high nutritional content, paying attention to presentation and preparation of meals to make food as desirable as possible, enriching meals and drinks and taking advantage of those days where the patient feels like eating, modifying the consistency of foods to ease swallowing, preventing fatigue, decreasing the risk of aspiration, eating non-irritating soft and smooth foods at room temperature and maintaining oral hygiene for those with mucositis [15]. Patients should also be advised to supplement meals with dietary supplements. The preoperative intake of combined “immunonutrition” products consisting of arginine, glutamine, polyunsaturated omega-3 fatty acids, nucleotides, and antioxidant micronutrients has been shown to decrease postoperative infectious complications and length of hospital stay [15, 18, 19].

For those unable to tolerate adequate nutrition, even with optimization and supplementation, other interventions are needed. These include either stent placement or percutaneous, endoscopic, or surgical placement of feeding gastrostomy or jejunostomy tubes. Esophageal stent placement has the benefit of being placed during endoscopic ultrasound, a common staging procedure. While it may improve dysphagia in the neoadjuvant setting, chest pain can occur and stent migration can be seen in up to 46% of patients [20]. although stent migration can be problematic, it is often a sign of tumor response to neoadjuvant therapy, and therefore the stent may not always need to be replaced. Other reported complications of stent placement in the neoadjuvant setting include perforation, mediastinitis, bowel perforation from migration, tracheo-esophageal fistula, and bleeding [21].

Jejunostomy and gastrostomy tube placement have been proven safe and effective for perioperative nutrition. These can be placed in the laparoscopic, open, endoscopic, or even percutaneous settings. Endoscopic placement may be difficult if a patient has a severe malignant stricture/obstruction, which is often the case when a patient is suffering from severe malnutrition and unable to pass food or liquids through the site of tumor. Gastrostomy tubes have the advantage of bolus feeding, which may improve quality of life. While gastrostomy tube placement has been proven to be safe without increasing the risk of postoperative morbidity, jejunostomy tube placement is often preferred given the stomach is the preferred organ for a neo-esophagus. Jejunostomy tubes are often placed at the time of esophagectomy as well for supportive care. However, some data support that the placement of jejunostomy tubes during esophagectomy is not always necessary [22–24]. Unfortunately, tube feeds cannot be given in boluses with jejunostomy tubes, which, if occurs, can lead to diarrhea and further dehydration. Patients therefore require an ongoing pump connection for feedings.

Smoking cessation is crucial to improving morbidity from esophagectomy. This may be most beneficial if performed greater than 90 days before surgery [25]. Active smoking has also been shown to increase recurrence rates of cancer after esophagectomy [26]. Therefore, smoking cessation counseling and supportive programs are necessary when patients are being assessed for esophagectomy.

2.3. The optimal surgeon/hospital

When deciding the optimal surgeon, it is important to understand that outcomes depend on two major factors: experience and resources. It is well known that with increasing numbers of esophagectomies performed, postoperative morbidity and mortality are improved. In addition, long-term survival can also improve [27]. While data show improved outcomes at higher volume centers, this is inconsistent and may depend further on individual surgeon volumes and hospital resources [28]. Begg et al. described low-volume hospitals as 1–5 esophagectomies/year, medium volume 6–11 esophagectomies/year, and high-volume centers as those performing >11 esophagectomies/year, with an improved mortality with increasing hospital volumes [29]. Later, Birkmeyer et al. divided hospital volumes to <2 esophagectomies/year as low-volume and high-volume centers as >19 esophagectomies/year [30]. The 2003 Leapfrog Group recommended 13 esophagectomies/year as a minimum volume standard [31]. However, esophagectomies at mid-volume centers can also be safely performed, especially with a two-surgeon approach [32]. Hospital type may also be important where improved reoperation rates and mortality are seen when surgery is performed at University centers or institutions centralizing esophageal cancer care [33–35].

Early recognition and treatment of complications appears to be just as important as prevention to improve mortality [36]. The recognition of postoperative problems improves with experience, making hospital volumes as well as surgeon volumes important. With morbidity rates being high, early intervention is of utmost importance to prevent further adverse outcomes or even death. In fact, even in low-volume hospitals, mortality may remain low if adequate resources are available [28, 37]. Therefore, these surgeries should only be performed at institutions well equipped to handle the possible complications [38–40]. Ancillary departments that should be available in the postoperative care may include gastroenterology, interventional radiology, cardiology, an astute critical care team, and others. Resources readily available and proven to improve complications also include nurse-to-patient ratios, where the incidence of pulmonary and infectious complications was shown to be increased when nurses had more than two patients [41].

2.4. Optimal surgical approach

Tumor location as well as surgeon experience often dictates the type of surgery performed. Multiple accepted operative approaches to esophageal carcinoma include Ivor Lewis esophagogastrectomy, McKeown esophagogastrectomy, transhiatal esophagogastrectomy, and left transthoracic or thoracoabdominal approaches. Minimally invasive techniques include laparoscopic and robotic esophagectomies. While minimally invasive esophagectomies have been shown to be safe and effective with equivalent oncologic outcomes, robotic, rather than laparoscopic approaches are becoming common [42–44]. However, one should be aware that there is a learning curve when a surgeon is transitioning to minimally invasive esophagectomies [45]. Transthoracic esophagectomies include the Ivor Lewis esophagogastrectomy and the McKeown esophagogastrectomy. Morbidity varies on the location of the anastomosis and if the transthoracic approach was used. While the transthoracic approach may have an increased morbidity, it does allow for extended lymphadenectomies to be performed, possibly increasing long-term survival [10, 46] .

3. Prevention and management of complications

The Esophagectomy Complications Consensus Group (ECCG) is a group of 21 high-volume surgeons from 14 countries that compiled a complete list of complications from esophagectomies [3]. These adverse events are separated into pulmonary, cardiac, gastrointestinal, urologic, thromboembolic, neurologic/psychiatric, infectious, wound/diaphragm, and others. They also aimed to standardize the definitions and reporting of complications since reported literature varied depending on adverse reactions and even mortality definitions. These definitions were defined for anastomotic leak, conduit necrosis, chyle leak and vocal cord injury/palsy. Given the large number of possible complications, this chapter reviews those more common or even specific to esophagectomy.

3.1. Atrial fibrillation

Atrial fibrillation can occur in over 20% of patients undergoing esophagectomy, particularly when the transthoracic approach is used [47, 48]. Its occurrence unfortunately can result in hemodynamic instability as well as put patients at an increased risk for stroke. Atrial Fibrillation may also be an early warning sign for morbidity, especially anastomotic leak [49]. The mechanism and pathophysiology of postoperative atrial fibrillation is incompletely understood, although we know predisposing factors include advanced age, coronary artery disease, heart failure, hypertension, mitral valve disease, and previous history of atrial fibrillation [50]. One randomized, controlled trial showed that the preoperative use of amiodarone via IV infusion significantly reduced the incidence of atrial fibrillation; however, no differences were seen in median hospital stay, ICU stay, or adverse events [51]. In a study evaluating amiodarone administration through the jejunostomy tube postoperatively, there was only a trend towards lower occurrence and a shorter length of stay [52]. Beta-blockers should be continued for the prevention of atrial fibrillation as well if a patient is already taking them, but may require a reduced dose for the prevention of hypotension, especially with epidural anesthesia. Calcium channel blockers, particularly diltiazem, can also be used for the prevention of atrial fibrillation and may have less effect on blood pressure than other calcium channel blockers or beta-blockers [53]. If atrial fibrillation occurs, amiodarone, calcium channel blockers, and beta-blockers are all treatments to be considered, depending on the patient's hemodynamics.

3.2. Respiratory failure/pneumonia/prolonged ventilation

Respiratory complications in patients undergoing esophagectomy can be problematic and are often causes of mortality. When patients need to be reintubated, many require bag ventilation or positive pressure prior to intubation, which may cause insufflation of the esophagus and stomach, placing pressure on the anastomosis or staple lines. For that reason, CPAP is often avoided as well. Direct airway visualization during reintubation is also important to prevent mechanical injury in case the esophagus is intubated rather than the trachea, especially if a cervical anastomosis is performed.

Pneumonia has been shown to significantly increase mortality compared to other complications, even anastomotic leak [6, 8]. Unfortunately, it can also be the most common postoperative complication and cause for respiratory failure and prolonged ventilation [7]. The American Thoracic Society and American Infections Diseases Society define pneumonia into hospital-acquired pneumonia (HAP), ventilator-associated pneumonia (VAP), and health-care-associated pneumonia (HCAP) [54]. The revised Uniform Pneumonia Score aims to define pneumonia occurring after esophagectomies and includes temperature, leukocyte count, and pulmonary radiographic findings [55]. Prevention, early recognition, and treatment as well as correction of causes are key.

Aspiration is a major cause of pneumonia. This occurs more often with a cervical anastomosis, especially with recurrent laryngeal nerve injury. Recurrent laryngeal nerve palsy can occur secondary to stretching, thermal injury, or even compression. If occurs, patients may suffer from hoarseness as well as pulmonary complications such as dyspnea and aspiration, which puts them at an increased risk for pneumonia and reintubation/prolonged ventilation. However, recurrent laryngeal nerve injury may not always present as obvious hoarseness, as we know from thyroid surgery data, and therefore its occurrence may be underreported. The ECCG defines vocal cord injury/palsy as a vocal cord dysfunction postresection where confirmation and assessment are achieved by direct examination [3]. There are three types of injuries/palsies that are each further separated into unilateral (A) and bilateral (B): Type 1 includes a transient injury requiring no therapy, where only dietary modifications are needed; Type 2 is an injury requiring elective surgical procedures such as thyroplasty or medialization procedures; Type 3 is an injury requiring acute surgical intervention due to aspiration or other respiratory issues that include thyroplasty or medialization procedures. Injury to the left recurrent laryngeal nerve is most common and is mainly associated with esophagectomies that include cervical anastomoses or dissections, McKeown-type operations. Therefore, prevention may include performing thoracic anastomoses or careful dissection and prevention of injury from the above causes. The early recognition of injury and treatment (which may include medialization of the vocal fold) may prevent aspiration and pneumonia and therefore may be of benefit early in the postoperative course [56, 57].

Other causes of respiratory failure or shortness of breath can include ARDS, cardiac causes, pleural effusions, pneumothorax, phrenic nerve injury, or fistula. Other infections can put patients at risk for ARDS (acute respiratory distress syndrome), and cardiac causes may also result in respiratory failure and need for reintubation. If ARDS occurs, the cause should be evaluated, including examining for other infections (urine, leak, etc.). If cardiac in nature, most commonly secondary to atrial fibrillation, heart rate control is usually necessary to alleviate symptoms. Pleural effusions and pneumothorax are common and can be managed with chest tube placement or percutaneous radiologic drainage, depending on the size of the effusion or pneumothorax. If effusions occur simultaneously with anastomotic leak, adequate drainage should be performed to prevent empyema and life-threatening mediastinitis. While phrenic nerve injury is rare, immediate surgical intervention is not always needed. However, patients may require tracheostomy placement for pulmonary conditioning. It is also important to remember that patients are at an increased risk for deep vein thrombosis and even pulmonary embolism. This may occur prior to or even after esophagectomy. Perioperative prophylactic anticoagulation should be administered in the perioperative setting to prevent deep vein thrombosis/pulmonary embolism. Tracheoesophageal fistula should also be considered, especially later in the recovery period or in a complicated postoperative recovery setting.

Impaired lung function is a significant risk factor for pulmonary complications [8]. With preoperative chemoradiation, pneumonitis can occur, making patients at an increased risk for postoperative respiratory failure and pneumonia [8]. While some degree of inflammation is often seen in preoperative imaging, assuring patient lung function has not decompensated is prudent. This can often cause delays in surgery; however, allowing the recovery of lung function may improve postoperative pulmonary failure.

Consistent with the recommendations of the Enhanced Recovery After Surgery pathways, intravenous fluid administration should be minimized to improve time to return of bowel function and decrease the length of hospital stay. Excessive fluid administration/fluid overload should also be considered in all patients with acute respiratory failure since the administration of diuretics may quickly improve symptoms.

3.3. ***Anastomotic leak/conduit necrosis***

Anastomotic leak after esophagectomy can be difficult to manage and has a major impact on patient quality of life as well as may affect long-term survival [58, 59]. Incidence varies from 5.7 to 14.3% with a higher incidence in cervical anastomoses versus thoracic [60]. The International Study Group for Rectal Cancer proposed the verbiage of anastomotic leak as, "A defect of the integrity in a surgical joint between two hollow viscera with communication between the intraluminal and extraluminal compartments," which was later validated and expanded to the entire gastrointestinal tract [61]. Lerut et al. with the Surgery Infection Study Group defined anastomotic leak severity as Type 1, a radiological leak without any clinical findings; Type 2 with minor clinical findings of local inflammation (cervical wound) or X-ray showed suppressed leak (thoracic anastomosis); Type 3, a major clinical leak with severe disruption and sepsis; Type 4, conduit necrosis seen by endoscopic confirmation [62]. The Early Complications Consensus Group (ECCG) defined anastomotic leak as a full-thickness GI defect involving esophagus, anastomosis, staple line, or conduit, irrespective of the presentation of the method of identification [3]. Type 1 includes a local defect requiring no change in therapy or treated medically or with dietary modification. Type 2 is a localized defect requiring interventional but not surgical therapy (interventional radiology drainage, stent or bedside opening and packing of incision). Type 3 is a localized defect requiring surgical therapy.

Many patient factors as well as peri- and intraoperative factors can contribute to anastomotic leak. Patients at an increased risk for anastomotic leak include those with increased comorbidities, advanced pathologic stage, prior esophagogastric surgeries, and active smoking [63]. Patient factors can include preoperative malnutrition, diabetes, prolonged hospitalization, hypotension, hypoxemia, preoperative chemotherapy, preoperative chemoradiation, and age. Technical factors also impacting the rate of anastomotic leak include the location of the anastomosis, surgery type, tension on the anastomosis, the type of anastomosis (hand sewn vs. stapled), arterial and venous insufficiency, excessive bleeding, and surgeon experience. While leak incidence may be higher in a single-layer anastomosis, the incidence of stricture may be higher in a double-layer anastomosis [64–66]. While data are mixed, the incidence of leak and stricture may also be lower with a stapled anastomosis [67, 68]. Postoperative factors may include gastric distention, external compression, infection, re-exploration for bleeding, prolonged mechanical ventilation, and continued hypoxemia and hypotension [69]. Technical considerations to decrease the rate of anastomotic leak may include anastomotic support with omentum, pleura, pericardium, and fat tissue. Prospective randomized studies have shown that omental wrapping of the anastomosis may decrease the rate of leak or even stricture [70, 71].

Diagnosis can be made by clinical suspicion if a patient presents with fevers, leukocytosis, empyema, pleural effusion, pneumomediastinum, increased drainage from the chest tube (bile or other gastric contents), the presence of enteric bacteria or bacterial culture or tachycardia. The early detection of anastomotic leaks may also include CRP/ESR elevation, an increase in procalcitonin level, and leukocytosis extending past the second and fifth postoperative days, respectively [72, 73]. While contrast esophagogram can be performed to determine subclinical leaks, caution is advised given the risks of aspiration [4, 74]. A barium swallow can be performed to detect an anastomotic leak; however, its sensitivity can be relatively low and may often be performed too early to detect [75, 76]. The oral intake of methylene blue may be used given it is otherwise nontoxic. CT scan with oral contrast may also be helpful and show contrast extravasation as well as concerning areas for infection.

The etiology of the leak is vital to ascertain where patients with conduit tip necrosis or complete conduit ischemia may require different interventions. This often requires direct visualization with EGD for conduit evaluation as well as evaluation of the defect size. The ECCG defines conduit necrosis into three types, with recommendations for specific treatments: Type 1 includes a focal conduit necrosis that is identified endoscopically, requiring only additional monitoring or nonsurgical therapy; Type 2 includes focal conduit necrosis that is identified endoscopically and is not associated with free anastomotic or conduit leak. Surgical therapy not involving esophageal diversion is performed; Type 3 includes extensive conduit necrosis that is treated with conduit resection and diversion [3].

If a leak occurs, source control with drain placement with or without operative intervention remains key to preventing mortality. For this reason, intraoperative drain placement for detection and source control is common. Management often is determined by anastomotic location; however, mediastinitis can occur with both intrathoracic and cervical anastomoses, a possibly fatal diagnosis for which requires close monitoring and rapid evaluation and treatment. Turkyilmaz et al. created algorithms to help guide treatment for anastomotic leak. For cervical anastomoses, a limited leak that is clinically occult may be managed with antibiotics, dressing changes, and cleansing with oral isotonic fluid. If there is a clinically prominent cervical leak, antibiotics, opening of the cervical wound, drain placement, nasogastric decompression, nutritional support, and cleaning are typically needed. For cervical anastomotic leaks that have intrathoracic complications and clinical sepsis failing to improve, drain placement, stent placement, decortication, resection/diversion or resection/colonic interposition may be needed. For thoracic anastomoses, if a contained leak with less than 30% disruption, injection with fibrin glue, endoclips, or stents can be used for management. However, if the defect is larger, drainage and esophageal stent placement can be performed followed by surgery if stent placement and drainage are unsuccessful (can include primary or supporting tissue repair). However, if the anastomosis has a greater than 70% disruption, surgery including drainage and primary repair should be performed first with esophageal diversion with possible colonic interposition if unable to be performed [69].

With the use of self-expanding metal stents, endoscopic management alone has become possible for anastomotic leaks/disruptions. Covered stents can be placed to control the leak, preventing further seeding into the mediastinum for both cervical and thoracic anastomoses. If well controlled, oral intake may also be safe. However, stent migration can occur, requiring retrieval and replacement [77]. Stent use may be limited in large defects (which may occur from conduit necrosis or staple line disruption). It is also important to understand that lumen caliber differences between the esophagus and gastric conduit can result in the reflux of gastric contents around the distal aspect of a stent. This unfortunately may not be seen with an esophagogram, but rather be noticed with other imaging such as CT after the reflux of contrast and gastric contents occur and may be delayed. Therefore, other options for control have emerged including endoscopic vacuum-assisted closure devices and may even be more effective than stent placement [78–81].

3.4. Fistula

In addition to source control, the awareness and prevention of esophago/gastrotracheal fistula is also necessary. This can occur from infection itself or even the erosion of foreign material (stent, staples, etc.) into the trachea. One should be suspicious in patients with frequent uncontrolled coughing, especially after swallowing, or "Ono's sign" [82]. Workup and diagnosis can include an upper gastrointestinal X-ray with oral contrast or even direct visualization with esophagoscopy or bronchoscopy. Prevention may include a pleural wrap around the anastomosis at the time of original operation or even at the time of reoperation if a leak occurs and anastomotic repair is possible. If reoperation is not performed, stent placement may help control symptoms and healing [83]. However, distal feeding tube placement and resection may be needed. Treatment is necessary to prevent recurring pneumonia.

3.5. Delayed gastric emptying

Delayed or inappropriate gastric emptying can occur secondary to the disruption of vagal nerve complexes to the stomach. This can result in delayed emptying of the stomach, which affects not only patient quality of life and inability to obtain oral nutrition but also can put patients at an increased risk for reflux of gastric contents and even aspiration. The most common options for the management of the pylorus include pyloromyotomy, pyloroplasty, intra-pyloric botulinum toxin injection as well as no intervention. While one multicenter study showed no significant difference between pyloroplasty, botulinum toxin-injection, and no pyloric treatment, one study did show that intra-pyloric botulinum toxin can increase the risk of postoperative reflux and increase the use of promotility agents and endoscopic interventions [84, 85]. While delayed gastric emptying can occur anywhere from 10 to 50%, it also can be successfully managed with prokinetic agents (75%) and endoscopic dilation [86].

3.6. Chyle leak/chylothorax

With the thoracic duct being the largest lymphatic vessel in the body as well as being located in the chest, posterior to the esophagus, injury can occur. Its location, however, often varies. The incidence of chyle leak is rather low (1–4%); however, when it occurs, it can be very problematic [87]. Chyle contains triglycerides in the form of chylomicrons as well as lymphocytes. Chyle leaks can result in malnutrition (with continued protein loss), immune compromise, hypovolemia, electrolyte abnormalities, hypoalbuminemia, lymphopenia, and infection [88]. The ECCG defines a chyle leak into three different types, where output <1 L/day is further classified as "A," and "B" is further classified as >1 L/day [3]. Type 1 leaks can be managed with enteric dietary modifications alone. Type 2 can be managed with total parenteral nutrition. Type 3 requires management with interventional or surgical therapy.

Following esophagectomy, drainage from a chest tube of >500 mL/day is suggestive of a chyle leak; however, the measurement of chylomicrons or triglycerides is most commonly utilized [89]. A measurement of >4% chylomicrons or fluid containing >100–110 mg/dL of triglycerides is typically considered indicative of a chyle leak. Since a chyle leak may present with increased serous or even serosanguinous drainage while fasting, a clinical diagnosis can be made by the oral intake of cream followed by milky drainage from the chest tube/drains.

Prevention unfortunately is difficult. Selective en masse ligation has been shown to reduce the rate of chylothorax [90]. Also, the preoperative oral administration of cream may help identify the thoracic duct to aid in the prevention of its injury or to identify the thoracic duct for prophylactic ligation [91]. The initial management of a chyle leak usually includes drainage as well as TPN and bowel rest. Decreasing oral or enteral fat intake decreases the flow of chyle through the leak, possibly allowing spontaneous closure [92]. Long chain fatty acids should be avoided with diets supported by high percentages of medium-chain triglycerides since they are typically absorbed directly into intestinal cells, bypassing the thoracic duct [87]. If conservative management is not successful, surgical intervention may be necessary, especially if the fistula is of high output. Aggressive surgical intervention should be performed if chyle output is >1.5 L/day for >5–7 days [93]. Surgical intervention includes thoracotomy or thoracoscopic thoracic duct ligation on the side of the chylothorax. This is usually assisted by the preoperative administration of cream or lipophilic dye to help identify the thoracic duct. If the leak can be localized, this may be controlled with clips or suture; however, if the leak is unclear, ligation of the thoracic duct just cephalad to the aortic hiatus is recommended [94–96]. Pleurodesis can also be performed at the time of ligation as well.

Radiologic-guided/percutaneous embolization is becoming more popular, especially for patients who are poor operative candidates. This includes lymphangiography followed by transabdominal percutaneous needle cannulation, although a retrograde subclavian vein approach can be used [97, 98]. Once the cisterna chyli is canalized, a catheter is advanced into the thoracic duct and contrast used to identify the leak. Embolization can then be performed. Since surgical intervention to ligate the thoracic duct using thoracoscopy or a thoracotomy can result in increased morbidity and mortality, thoracic duct embolization has become increasingly more popular when conservative management fails.

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