Morbid-Mortality and Treatment of Complications

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18.1 Introduction

Despite the growing importance of chemotherapy and radiotherapy, surgery is still the preferred curative treatment for esophageal adenocarcinoma (EAC). Depending on the esophageal and gastric involvement of this tumor, a gastrectomy (with an exclusive abdominal approach) or an esophagectomy is required. The latter needs an abdomino-thoracic approach or a gastric pull-up, resulting in an increased morbidity and mortality.

Even if EAC is classified as an esophageal cancer together with squamous cell carcinoma (SCC), patients that suffer from these two cancers are very different. SCC patients are often smokers, heavy drinkers, and malnourished, resulting in significantly impaired pulmonary and hepatic functions. Conversely EAC patients often present a better general status, with half of patients suffering from obesity. This good preoperative performance status of EAC patients compared to the SCC leads to a smaller percentage of postoperative complications.

In studies with large cohort of patients receiving esophagectomy, mortality ranged between 2.7 % and 9.8 % with a morbidity of 17.9–57 %. This high variability was due to two main factors: (1) these large studies are mainly conducted on patient data collected from national databases, where both high and low volume centers are included without any weighting in the analysis for volume or type of operations; (2) there is a large variability in the definition of the postoperative complications making impossible to compare the different clinical trials.

Morbidity can be mainly divided in medical and surgical, with respiratory complications being the most frequent medical complications, occurring in 21–27 % of patients, and anastomotic leaks representing the main surgical complication, with percentages that stand between 3.7 % and 14 %. Other notable complications are atrial arrhythmias, chylothorax, and necrosis of the gastric conduit.

Complications seem to have an impact also in long-term patient prognosis, with a significantly higher risk of cancer recurrence in patients with complications after esophagectomy than in those where the operation was uneventful [1, 2]. The explanation for this phenomenon remains uncertain, but it seems to be correlated to the systemic inflammatory response with release of chemokines that guide the spreading of microscopic residual cancer using the same pathways as leukocytes during inflammation [3].

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In recent years many studies have demonstrated a reduction up to four times in postoperative mortality in high volume centers, as discussed at length in Chap. 12. However, morbidity remains significant even in these centers, with percentages that range between 40 and 60 %[4, 5]. These results highlight how complications are bound to occur due to the technical complexity of this operation. Therefore, better "know-how" in managing postoperative complications can lead to a higher percentage of resolutions, significantly reducing postoperative mortality.

Until now there is no widely accepted classification system for postoperative morbidity in esophageal surgery. As a consequence, it is difficult to compare morbidity-related outcomes between different studies. The heterogeneity of classifications relates to both the definition and the severity ranking of complications. Blencowe published in 2012 a systematic review on this topic, evidencing how most of the published papers lack in definitions and descriptions of complications and how many different definitions of the complications have been proposed [6]. This is apparent even for the main complications in esophageal surgery: anastomotic leak and pneumonia. As a consequence, the reported incidence in literature for anastomotic leak ranges between 0 % and 35 % and for pneumonia ranges between 1.5 % and 38.9 %.

Clavien-Dindo and Accordion classifications are used worldwide to classify complications on the basis of resource utilization [7, 8]. They have been validated in esophageal surgery, but they are nonspecific with regard to the different types of complication.

Recently Low established the esophagectomy complications consensus group (ECCG) among 21 high volume centers worldwide. The group is studying a system for defining and recording perioperative complications after esophagectomy. This could result in a standardization of international data collection on morbidity, to facilitate the interpretation and the comparison of data in the literature [9].

18.2   Patient Selection

EAC surgery is a major operation, highly demanding for the patient that is often already strained by the disease and by neoadjuvant treatments. Consequently the clinical status has to be analyzed when electing a patient for surgical resection, trying to identify patients at high risk before surgery in order to perform targeted perioperative treatments or to redirect them to other nonsurgical treatments.

Large cohort studies have been conducted to analyze the factors associated with morbidity and mortality after esophagectomy; in Table 18.1 data from seven large population studies are reported highlighting only the factors significant in multivariable analysis [10–16].

As evidenced from the table, age is a significant factor in all the studies considered, with a cutoff mostly set at 75 years old. A review conducted by Markar and colleagues confirmed a higher risk of morbid-mortality in elderly people [17]. However,

Table 18.1 Factors associated with morbidity and mortality at multivariable analysis in large cohort studies

Author	Associated with morbidity	Associated with mortality
Dhungel B et al. [13]	Age DM Smoking/alcohol status Transfusion	Wound infection DM Dyspnea
Bailey SH et al. [12]	Age Dyspnea DM Smoking CRT	Age DM Dyspnea Liver function CRT
Atkins et al. [16]	Age Pneumonia	Age Pneumonia
Ott K et al. [11]	n.r.	Age
Sauvanet A [10]	ASA Age Male gender	ASA
Wright CD et al. [15]	Age Cardiopathy DM Smoking	Age Cardiopathy DM Smoking
Zingg U et al. [14]	n.r.	Smoking Comorbidities

DM diabetes mellitus, *CRT* neoadjuvant chemoradiotherapy, *n.r.* not reported

two recent studies in high volume centers on octogenarians demonstrated that with a careful selection (even with a higher incidence of overall complications) mortality is not increased [18, 19]. It is probably not the age that defines an increase in the complications rate, rather the fact that elderly patients present more comorbidities that in turn determine a higher fragility. Surgery should therefore not be denied to the elderly on the basis of their age alone; they should instead be redirected to a high volume center for assessment.

When an esophagectomy has to be performed, pulmonary morbidities are the main complications occurring in up to 30 % of the patients. Preoperative impaired pulmonary function is associated with higher morbidity. A careful functional study of the lung has to be done to properly decide if it is possible to perform a thoracotomy or if it is necessary to perform a transhiatal (THE) or thoracoscopic (MIE) approach. Bartels identified an increased mortality risk for patients with a vital capacity <90 % and a preoperative PaO2 < 70 mmHg [20]. Perioperative cares to optimize pulmonary function are described in the "pulmonary complication" section of this chapter.

Neoadjuvant treatments seem not to increase postoperative morbidity. Only a few studies evidenced a significant relation of these treatments with morbidity and mortality. Neither in the CROSS trial nor in a recent paper from the FREGAT group was there evidence of differences in postoperative complications between no-CRT and CRT group [21, 22]. Probably, even if neoadjuvant treatment is heavily demanding for the patient due to its side effects, it shrinks the cancer, thus improving patient's ability to eat and therefore their nutritional and general status.

Some studies have tried to develop a reliable scoring system to rank patients for morbid-mortality risk. The most notable work came from the Siewert group and was subsequently validated by Schröder et al. in 2006 [20, 23]. They identified four factors associated with mortality (Karnofsky index, aminopyrine breath test, pulmonary vital capacity, and PaO2) and produced a composite risk score, based on these factors, to predict postoperative mortality. Nevertheless the results of this study are limited and widely accepted scoring system has not yet been made.

Admittedly, scoring systems could be useful tools to identify patients that are most likely to develop postoperative complications; however strict adherence to these rankings for decision-making should be avoided, and every case should be evaluated on its own merit.

18.3   Medical Complications

The main medical complications are pulmonary and cardiac. These are more frequent in esophagectomy than gastrectomy due to the stress on the lungs and heart caused by the direct violation of the thorax and the mediastinum during a transthoracic or transhiatal approach.

18.3.1   Cardiac Complications

During the mediastinal dissection of the esophagus, the heart is directly manipulated and pressed by the retractors, while vagal dissection above the azygos is associated with the disruption of the vagal cardiac nerves, both resulting in possible rhythm alterations. Cardiac complications post-esophagectomy have been classified by Low et al. as follows [9]:

- Cardiac arrest
- Myocardial infarction
- Dysrhythmia atrial requiring treatment
- Dysrhythmia ventricular requiring treatment
- Congestive heart failure requiring treatment
- Pericarditis requiring treatment

The most frequent cardiac complication is atrial fibrillation (AF), which is described in 15–25 % of patients and occurs mostly during the second and third postoperative day [24]. Two studies found an association between AF and an increased postoperative mortality of up to four times [25, 26]. Mortality was not directly related to AF; instead there were often more severe underlying complications which triggered a series of other complications including AF.

A recent study by Cormack et al. on 473 SCC and EAC found that new onset AF occurred in 20 % of the patients and was associated with older age, preoperative cardiovascular disease, DM, and, interestingly, neoadjuvant treatment. AF was associated with other complications in more than 80 % of these patients, mainly pulmonary complications. Interestingly mortality of FA patients was not increased. The author explained the low mortality in FA patients by a close observation and early treatment of the underlying complication [26].

Strategies to prevent AF are still limited and come from studies conducted in cardiothoracic surgery. Proposed strategies include intraoperative fluid restriction, balancing of electrolytes, and cardiac nerves sparing. Many drugs have been studied including amiodarone, digoxin, b-blockers, calcium antagonist, and magnesium sulfate, with limited results and no indications for prophylactic use at present [24, 27, 28].

Concluding, care must be exercised when a patient has postoperative AF. Although the complication is not difficult to treat properly (even at ward level), it may be an indirect sign of other underlying complications that have to be promptly diagnosed and treated in order to not increase the postoperative mortality.

18.3.2 Pulmonary Complications

Esophagectomy is a stressful operation for the lungs because of supra-mesocolic surgery, thoracotomy, and lung manipulation, which require an increase of the perioperative ventilatory demand. When the request exceeds the patient's ventilatory capacity, there can be a ventilatory pump failure, resulting in an alveolar hypoventilation that can lead to pneumonia and respiratory failure.

Pulmonary complications are the most frequent cause of morbidity after esophagectomy, ranging from 2.5 to 27 % in the different studies [10–16]. High variability of the results is due to a wide range of definitions for documenting or stratifying these complications, making it difficult to compare results from different papers.

A physiopathology of pulmonary complications has been recently published by Boshier et al., a group from London. The paper describes different stress mechanisms that act during and after esophagectomy, briefly consisting of ischemia-reperfusion lung injury, high fraction of inspired oxygen of the ventilating lung, ventilator-induced lung injury, and pulmonary capillary stress failure of the ventilating lung [29].

Reported pulmonary complications are many, ranging from pleural effusion with atelectasis to pneumonia, to ALI and ARDS with possible respiratory failure requiring prolonged mechanical ventilation [30]. Low et al. classified pulmonary complications as follows [9]:

- Pneumonia (definition of the American Thoracic Society and Infectious Diseases Society of America [31, 32])
- Pleural effusion requiring drainage
- Pneumothorax requiring treatment
- Atelectasis mucous plugging requiring bronchoscopy
- Respiratory failure requiring intubation
- Acute respiratory distress syndrome (ARDS)
- Acute aspiration
- Tracheobronchial injury
- Chest tube maintenance for air leak for > 10 days postoperatively

Of these complications pneumonia is the most frequent, and it has a significant impact on patient's prognosis raising the mortality rate from 3 % up to 20 % [33]. Less frequent than pneumonia but more severe is ARDS that has an incidence of up to 10–15 % and a mortality rate of about 50 %.

This data highlights the importance for pulmonary complications of correct preoperative prevention and intraoperative and postoperative care.

Objectives of preoperative prevention include optimization of nutritional status and smoking cessation. The correction of malnutrition and cachexia leads to an optimization of respiratory muscle function and efficacy of immune system. To stop smoking is of primary importance, and the patient has to be informed of the increased

morbidity risk due to an active perioperative tobacco consuming. It is still debated on how long before the operation consumption has to be stopped in order to have the best results, but a period of four weeks seems to guarantee significantly better outcomes [34]. In a recent study on gastrectomy, the authors evidenced statistically significant improvements even for a quitting period of two weeks or more [35]. Shorter periods, even if not harmful, do not seem to influence postoperative morbidity [36].

Patients should be assessed and treated by a physiatrist in order to optimize the preoperative lung function. In the literature there are limited studies describing the use of intensive respiratory training in small cohort esophagectomy patients. Positive results have been obtained with the use of IMT (inspiratory muscle training) in two recent studies, which found a significative reduction in pulmonary complications in the IMT group [37, 38]. An ongoing multicenter RCT from the Netherlands is studying the incidence of pneumonia after esophagectomy in patients treated with IMT is expected to provide further evidence on this argument in the coming years [39].

It has to be noted that many EAC patients are overweight. Even if obesity is not an absolute contraindication for esophageal surgery, a BMI >30 mg kg-2 seems to be associated with a higher risk of pulmonary complications [40, 41]. In these patients an effort should be made to optimize the preoperatory respiratory function and to reduce the pulmonary injury during the operation (MIE, THE) [42].

Intra- and postoperatory management require fluid restriction, protective ventilation with reduced tidal volume and the introduction of positive end-expiratory pressure (PEEP) during one lung ventilation, early extubation and mobilization, an aggressive management of secretions with intense physiotherapy and toilet bronchoscopies, and an adequate analgesia [43]. All these strategies are part of ERAS (enhanced recovery after surgery) protocols that are fully described in Chap. 21.

The use of a transhiatal approach, without a direct access in the thoracic cavity, has been pro-posed to reduce respiratory complications, at the cost of an incomplete mediastinal lymph node dissection. Results of two recent meta-analyses seem to confirm this benefit; both Boshier and Wei evidenced a statistically significant reduction of pulmonary complications in the pooled analysis [44, 45]. THE has to be reserved to high risk pulmonary patients, where even a thoracoscopy should be avoided, because in THE the impossibility of performing a correct mediastinal lymph nodal harvesting and a higher percentage of positive circumferential margin may affect the oncological outcome of the operation.

18.4   Surgical Complications

Esophagectomy and total gastrectomy are challenging operations that require a great amount of surgical experience in the operating room and expertise in the postoperative treatment in order to reduce intraoperative and postoperative morbidity.

Anastomotic leak is the most frequent surgical complication for both esophagectomy and gastrectomy, while necrosis of the gastric conduit, chylothorax, and tracheobronchial fistulization belong exclusively to the esophagectomy.

18.4.1 Anastomotic Leak

There is still no consensus on the definition of anastomotic leak, and consequently the incidence of this complication in the literature is variable (from 0 % to 35 %). Leak definitions range from a radiological contrast swallow finding in the absence of symptoms up to discharge of gastrointestinal content through a drain. Many groups have proposed different leak classifications. Urschel et al. published a classification based on location and symptoms, while Schuchert et al. used a classification based on direct endoscopic vision of the defect and the degree of intervention required [46, 47]. However, these classifications are not widely accepted, and, at present, Low et al. are working on an international consensus on standardization of complication definitions for

esophagectomy [9]. Low et al.'s definition of anastomotic leak is a full thickness gastrointestinal defect involving esophagus, anastomosis, or staple line irrespective of presentation or method of identification.

Different factors contribute to the high incidence of anastomotic leakage, at both systemic and local level. Systemic factors include severe malnutrition, impaired cardiovascular and pulmonary function, and advanced tumor stage. Local factors are the absence of an outer serosa layer and longitudinal orientation of esophageal muscle fibers that seem to make esophageal anastomosis disadvantaged compared to other visceral anastomosis; impaired vascularization of the graft end due to an insufficient arterial supply or venous drainage; and an excessive mechanical tension on the anastomosis. It is still under investigation if the positioning of the esophago-gastro anastomosis in the neck (TTE) is associated with a higher incidence of anastomotic leak due to the necessity of performing a longer conduit, with consequently a microvascular insufficiency of the apex and a higher mechanical tension on the anastomosis. In a recent meta-analysis conducted by Markar and Al on RCT and retrospective studies, neck and thoracic anastomosis resulted in the same leakage rate (neck 8.8 % vs thoracic 7.8 %). However, if only RCT were considered, there was a statistically significant higher percentage of leak in neck anastomosis compared to thoracic anastomosis (13,64 % vs 2,96 %) [48]. Thoracic anastomosis should therefore be preferred in all patients fit for a thoracotomy, reserving cervical anastomosis to the patients with low pulmonary function in order to perform a THE or a thoracoscopic approach.

Cervical anastomosis can be performed either hand sewn or mechanically, depending on the surgeon's preference, as the incidence of anastomotic leak has been found comparable in our experience and in two recent meta-analyses [48–50].

With reference to intrathoracic anastomosis, nowadays it is performed almost always mechanically. This raises questions on the possibility of performing safely an intrathoracic anastomosis with a minimally invasive technique.

18.4.2 Diagnosis and Treatment

An anastomotic leak has different clinical presentations according to the anastomosis location (neck or mediastinum) and to the entity of the defect. Based on this, anastomotic leak can range from an asymptomatic radiologic finding to a necrotizing infection accompanied by sepsis.

Timing in diagnosis and severity assessment with early proper treatment is crucial to obtain healing using the least invasive efforts in a frail patient.

There is no agreement at present on the necessity of performing a postoperative upper GI study to assess anastomotic integrity. Many centers still perform a routine contrast swallow within ten days of the esophagectomy, before allowing the patient any oral intake, but the sensibility of this test is low (and with high variability, probably depending on operator experience) ranging between 20 % and 87 %, thus accounting for a large number of false-negative patients [51–53]. On the other hand, contrast swallow has a high specificity (94–100 %), so that a positive test represents almost always a leak. In our opinion routine use of contrast esophagogram is not recommended and has to be reserved to clinically suspicious patients due to its high specificity [54].

Recent studies demonstrated the safety of early postoperative endoscopy, pointing the attention to its high sensibility and specificity (close to 100 %) for anastomotic leak, and the fact that the exam also gives information about the condition of the gastric conduit [51, 55]. This tool is of great clinical interest, but it is still an invasive procedure and should be performed mainly on the basis of a clinical suspect.

At present no guidelines exist on this argument, the evidences are low, and literature is still at an "expert opinion" level. Below are described our recommendations on the diagnosis and treatment of the anastomotic leaks based on anastomotic site and patient symptoms (as proposed by Urschel et al.[46]):

1. Clinically silent cervical and thoracic leaks: They are detected using a contrast swallow imaging or endoscopy in asymptomatic

patients with no laboratory signs of infection. These leaks are usually small and are limited by surrounding tissues. In this case conservative management with avoidance of oral intake, nasogastric tube decompression, nutritional parenteral or, preferably, enteral support (via a feeding jejunostomy placed during the operation or a fine-bore nasojejunal tube), broad spectrum antibiotics, and antifungal therapy provide a high success rate. Patient must be carefully monitored for signs of sepsis or leak progression in order to perform a more aggressive treatment (percutaneous drainage, endoscopic procedure) where necessary. In our clinical practice, we do not perform a routine contrast swallow anymore, and consequently we cannot discover clinically silent leaks before resuming oral intake. Despite this change, we did not experience an increase of clinical leaks. Hence, we have come to conclude that clinically silent leaks heal without any specific treatment in the majority of cases.

2. Clinically evident leaks:

   (a) Clinical cervical leaks are usually clinically detectable within ten days from the operation by neck erythema, with a palpable cavity with fluid and subcutaneous crepitus. Fever and laboratory sepsis exams reveal an ongoing infection. The main treatment consists in opening the wound to drain the leak. When the cavity is cleaned, the positioning of a compressive medication can help the healing process, together with fasting, nasogastric tube decompression, nutritional support, and antibiotic therapy. In some cases low esophago-gastro cervical anastomosis can drop down in the upper thorax; in these cases the anastomotic leak has to be managed as a thoracic leak.

   (b) Clinical thoracic leaks usually appear at the 7th–10th postoperative day with fever, leucocytosis, high CRP levels, and a quick deterioration of the patient conditions toward a mediastinitis. If mediastinal drainage is in place, an increased drain volume, odor, and turbidity appear. A water-soluble contrast swallow can confirm the diagnosis, but a CT scan is mandatory to assess the entity of the thoraco-mediastinal fluid collections. Endoscopy allows to have a direct visualization of the dehiscence and to perform endoluminal treatments, but it has to be done by an expert GI endoscopist to avoid further damage to the anastomosis.

In stable patients a conservative treatment can be attempted through an adequate drainage of the infected fluid collections (under CT scan or ultrasonographic guidance). Systemic measures are the same described in the cervical leak paragraph.

Endoscopic techniques for anastomotic leak treatment include clip placement, stent placement, and vacuum therapy. We consider clip placement to close leaks smaller than 30 %. During a preliminary endoscopy, an accurate analysis of the defect has to be performed: the absence of ischemia and vital wound margins are necessary to try the clip placement. Normal clips (through-the-scope clips) can be used for small anastomotic defects, while the newly developed over-the-scope clip (OVESCO™) has been proposed to close larger dehiscence with a reported success rate of 70 %[56, 57].

Stent placement is proposed for a >30 % degree dehiscence of the anastomosis [58]. An extractible stent is placed along the anastomosis in order to cover the defect and isolate the mediastinal space, promoting the healing of the leak and allowing the patient to resume oral intake earlier. Success rate is 70–80 % with 30–70 % of stent-related complications, including migration, bleeding, perforation, and ingrowth [59–61]. Stent migration is the commonest complication occurring in up to 30 % of cases. It is probably caused by the absence of a stenosis that can help the stent to hold the position and by the different diameters of the esophageal remnant and the conduit. This hypothesis of lumen discrepancy is supported by recent data that evidenced a lower incidence of stent migration in esophago-jejunal anastomosis with respect to esophago-gastro anastomosis, probably due to the closer diameter

of the two conduits [61]. Partially covered self-expanding metal stent seems to have the better results than the other types of stent with a migration of 12 %[62].

Vacuum therapy has the advantage of keeping clean the perianastomotic cavity, continuing to remove the wound secretion and to improve the tissue microcirculation, thus facilitating anastomotic healing. Limited studies have been published on the topic, with a high closure rate (which is 83–100 %) and no significant complications [59, 63]. These data have to be carefully generalized because they come from studies that used small populations. At the moment, endoscopic treatments should only be considered in experienced centers, as an option in patients with limited mediastinal or pleural contamination.

Surgery is indicated in case of unstable septic patient or after failure of conservative treatments. For complete anastomotic disruption or leak with an associated conduit necrosis, a takedown of the gastric conduit has to be done. Main steps are a thoracotomy with a toilet of the pleural and mediastinal cavity with the placement of a drainage, the takedown of the gastric conduit, a laparotomy with jejunostomy, and a cervicotomy with proximal esophageal diversion.

Direct repair of the defect is possible only for early leaks (within 48 h after the operation). As discussed later, early leaks are caused by a technical problem during the primary operation and have to be operated as soon as they are discovered in order to fix the defect or redo the anastomosis.

In case of late leaks (>48 h) a direct repair is no more effective. If the leak is limited and there are no signs of ischemia, a combined endoscopic and surgical approach can be attempted. During the reoperation, after the toilet of the thorax, the endoscopist places a stent to cover the defect, while the surgeon fixes the stent on the esophageal wall with slow-reabsorbable stitches in order to reduce the possibility of stent migration. With this treatment the anastomosis is covered and will heal by secondary intention. We performed this treatment on three patients with septic shock due to a thoracic leak with a defect of 80 %. In all cases the leak healed, and the stent was removed easily by the endoscopist, cutting the stitches before taking out the stent.

3. Early clinical anastomotic leaks (within 48 h): They are considered a technical error, usually treated with a reoperation and, if technically feasible, a redo of the anastomosis. If a diffuse conduit necrosis is also associated, a takedown of the conduit has to be performed with a proximal and a distal diversion.

Figure 18.1 illustrates a flowchart for the treatment of anastomotic leak after transthoracic esophagectomy.

18.4.3 Conduit Necrosis

Conduit necrosis is a vascular suffering of the gastric/jejunal substitute due to an insufficient arterial blood supply or an inadequate venous outflow. It can be caused by systemic or local problems such as hypotension, the use of vasopressor agents, conduit distension, vascular pedicle torsion, or strangulation. Its incidence ranges between 0 and 3 % in the different studies on the subject [64]. Historically, conduit necrosis was diagnosed only in case of extensive and symptomatic necrosis. Today, with the increasing use of postoperative endoscopy, now considered safe even in the early postoperatory phase [55], a more detailed description of the conduit vascular suffering has been achieved. It has been hypothesized that an early identification of a limited conduit ischemia can predict the occurrence of an anastomotic leakage; therefore it makes possible to perform preventive measures to stop the leakage development. However, it has to be specified that early postoperative endoscopy is still used only in controlled studies because its clinical utility is under investigation. CT scan has been proposed for the diagnosis of the conduit necrosis because it is less invasive than endoscopy, but it has demonstrated low accuracy [65].

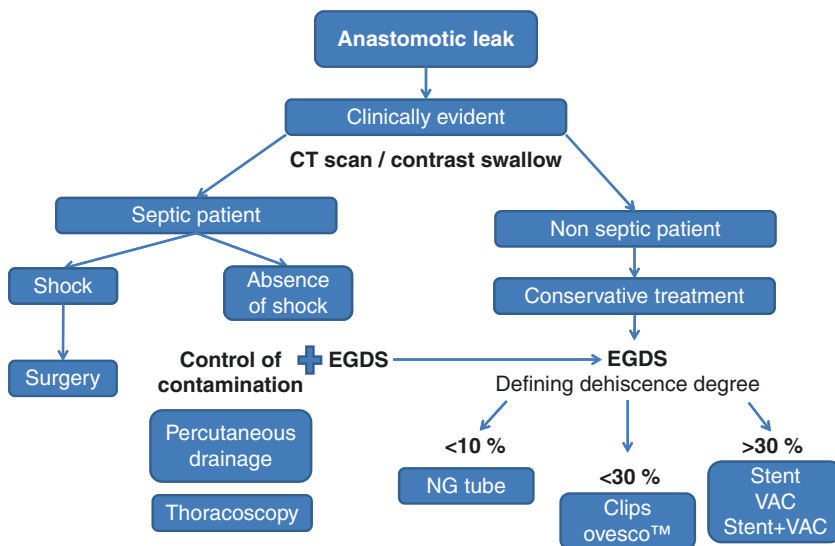Conduit necrosis is classified, on endoscopic and treatment basis, as follows:

Fig. 18.1 Proposed flowchart for the treatment of anastomotic leak in transthoracic esophagectomy. *CT scan* computed tomography scan, *EGDS* esophagogastroduodenoscopy, *NG tube* nasogastric tube, *VAC* vacuum-assisted closure

1. Asymptomatic focal necrosis identified endoscopically and requiring nonsurgical therapy
2. Focal necrosis not associated with an extensive anastomotic or conduit leak, requiring surgical therapy not involving esophageal diversion
3. Extensive conduit necrosis requiring resection with esophageal diversion [9]

Treatment of asymptomatic limited necrosis without involvement of the anastomosis is the cessation of oral intake with nasoenteric decompression and nutritional support. A careful monitoring of patient conditions and a short-term endoscopic reevaluation are needed to assess the viability of the conduit.

If a focal necrosis of the conduit close to the anastomosis is discovered, the treatment depends on the clinical conditions of the patient. These patients have to be treated according to the anastomotic leak section.

Extensive conduit necrosis generally presents within 48 h with sepsis and often purulent anastomotic drainage. On clinical suspicion an early endoscopic diagnosis and reoperation are mandatory. Re-exploration with resection of the necrotic conduit, cervicostomy, and jejunostomy are often necessary to secure the survival of the patient.

An increased incidence of conduit necrosis has been evidenced after minimally invasive esophagectomy, reaching 3–10 %; this has been related to technical factors [66, 67]. The main ones are the impossibility in intracorporeal gastric tubulization of stretching the organ during stapling, consequently making a shorter conduit, and an insufficient Kocher maneuver. To overcome this problem, alternative techniques have been proposed, such as ischemic conditioning and the extracorporeal preparation of the gastric conduit [68, 69]. Ischemic conditioning of the conduit is not widely used as it has not demonstrated significant advantage in reducing conduit necrosis and at present is not used. Extracorporeal preparation of the conduit requires a small laparotomy but has the theoretical advantage of performing an adequate stretching of the stomach during stapling obtaining therefore a longer conduit.

18.5 Chylothorax

Chylothorax is an important complication after esophagectomy with an incidence of 0.5–4 % according to different reports. Historically, mortality was at 50 %; nowadays, in high volume

centers with an early recognition and an aggressive treatment, it has been decreased to <10 %[70, 71]. Chylothorax is defined as the presence of chyle in the pleural cavity and is caused by a damage to the thoracic duct or to one of its tributaries that lay close to the esophagus, between the aorta and the azygos vein. The duct has a wide anatomical variability that can be partially responsible for the possible occurrence of this complication, despite the surgeon's experience. Chyle loss becomes generally clinically apparent after 2–7 days after surgery, when oral or enteral intake is resumed. It presents with a huge pleural fluid collection that compresses the lung and can cause a hemodynamic impairment, or, if a drainage is within the thorax, with an increased drainage output usually with a milky aspect. The diagnosis is confirmed by the presence of a high concentration of chylomicrons, triglyceride, and leukocyte in the fluid.

Consequences of chylothorax are respiratory, immunological, and nutritional. Pulmonary impairment is directly consequent to the pleural effusion that causes the development of atelectasis. A prolonged depletion of chyle causes a reduction in lymphocytes and immunoglobulins with consequent immunodepression. Moreover, the loss of chyle leads to electrolyte disturbance and, in the long term, depletion of fatty acids and proteins, causing a severe malnutrition state [72].

Optimal treatment for chylothorax is still controversial, and literature is limited to small studies in high volume centers. The two main options are conservative treatment and surgical ligation of the thoracic duct. It is generally accepted that a conservative attempt has to be done before considering surgery, but a precise indication on how to decide whether to continue or abandon this treatment still does not exist.

Conservative treatment consists of the elimination of oral or enteral nutrition in order to reduce the output of the fistula, with the setup of an adequate total parenteral nutrition to rebalance the chylous loss (electrolyte and fluid balance). Prophylactic antibiotic therapy is not indicated, but these patients have to be carefully monitored because they are at high risk of infection. Limited data exists on the use of octreotide, a somatosta-

tin analogues, in the reduction of the chyle output, but its use can be considered [72, 73]. An effective drainage of the pleural cavity has to be completed. If a thoracic drainage is not present, this has to be placed and aspiration has to be avoided in order not to sustain the fistula. A precise daily monitoring of the loss from the drainage is the main predictor of success in the conservative approach.

An output of less than 10 ml/kg/24 h after five days of conservative treatment is considered a predictor of success, and, on this basis, different flowcharts have been proposed [70–72, 74]. We consider it appropriate to try with a conservative approach for five days, with careful monitoring of the patient condition and reserve surgery if either the condition decays or if chyle output does not improve significantly or if after five days output is still >1000 ml/24 h.

Conservative management of chyle leaks has a success rate of 70–80 % within four weeks [5]. A prolonged treatment with persistent high chyle output can put the patient at high risk of severe infectious and metabolic complications. Therefore, we suggest to not prolong the treatment over a two-week period if the chyle output does not considerably reduce [75, 76].

The aim of surgical management is the closure of the thoracic duct. Even if some studies suggest the possibility of closing the thoracic duct with an abdominal approach, we suggest the thoracic approach because of the wide variability of the abdominal lymphatic tree. Surgery can be performed either via right thoracotomy or thoracoscopy [77, 78]. We treated three cases with a thoracoscopic approach successfully ligating the duct in patients with a three-field esophagectomy, after five days of conservative treatment, without encountering many adhesions, possibly because of the continued "washing" of the chyle in the thoracic cavity.

One hour before the operation, a high fat liquid (such as butter or cream) is administered enterally to the patient in order to stimulate chylous production and facilitate the visualization of the leak during the operation.

The thoracic duct should be visualized and ligated just above the diaphragm. If the duct is

not visible, some surgeons suggest a "mass liga-
tion" of the prevertebral tissues between the azy-
gos and the aorta, in which the duct and its
collateral should be located [72].

Lymphangiography with endovascular closure
of the thoracic duct has been proposed as an
alternative to surgery in different studies with
variable success rates, but this method is complex
and should be considered only as a second choice
and in experienced centers [4, 79].

Concluding, surgery for EAC has a high mor-
bidity and mortality because of patient general
status and technical difficulties. Therefore, it
requires experienced centers with dedicated staff
that can optimize the perioperative patient condi-
tions (nutritionist, physiatrist, physiotherapist,
and psychologist) and adequately diagnose and
treat the postoperative complications (anesthesi-
ologist, surgeon, and radiologist).

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