Anesthesia for Esophageal Surgery

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Abstract

Esophageal surgery for cancer can be curative but is associated with significant morbidity and mortality. Scrutinizing the perioperative anesthetic management for the procedure seeks to understand its impact on outcomes and discover opportunities for improvement. Moreover, surgical approaches to esophagectomy continue to evolve with the advent of minimally invasive techniques and robotic surgery, and anesthetic methods and concerns must evolve in parallel.

Keywords

Esophageal cancer · Anesthesia · One-lung ventilation · Goal directed fluid therapy · Regional anesthesia · Thoracic epidural analgesia · Enhanced recovery after surgery

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Introduction

Esophageal surgery for cancer can be curative but is associated with significant morbidity and mortality. Scrutinizing the perioperative anesthetic management seeks to understand its impact on outcomes and discover opportunities for improvement. Moreover, surgical approaches to esophagectomy continue to evolve with the increased adoption of minimally invasive techniques and robotic surgery, and anesthetic methods and concerns must evolve in parallel.

The anesthesiologist plays a crucial role throughout the perioperative period, ensuring an appropriate preoperative evaluation and optimization of modifiable conditions, intraoperative management, and recovery. As esophagectomy care further develops through research and innovation, the role of the anesthesia provider during the perioperative period will likely become even more pronounced.

Preoperative Evaluation

Initial Assessment and Testing

Patients presenting for esophagectomy may have several comorbidities pertinent to their anesthetic management in addition to their esophageal pathology. Appropriate patient selection and evaluation is necessary to mitigate potential

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complications of what is already a highly morbid procedure.

Gastroesophageal reflux disease (GERD) and dysphagia are commonly associated with esophageal lesions and predispose to pulmonary aspiration. Severe GERD can cause pharyngolaryngitis, chronic cough, or asthma-like symptoms; chronic aspiration can lead to pulmonary fibrosis.

Smoking and alcohol use should be assessed with consideration for presence of chronic obstructive pulmonary disease (COPD) and hepatic dysfunction, respectively. Active smoking at the time of surgery, especially if combined with excessive alcohol use, is associated with an increase in postoperative complications after esophagectomy, such as decreased wound healing and increased cardiovascular and respiratory adverse events [1]. Tobacco smokers should quit at least 30 days prior to surgery. Electronic cigarette (e-cigarette) or vaping use has been associated with lung injury, which, if present, can place patients at increased morbidity risk. However, there are currently no evidence-based guidelines for perioperative management or cessation [2]. Perioperative medical or recreational cannabis use may have implications for airway reactivity, altered drug metabolism, unpredictable effects of anesthetics, and postoperative withdrawal symptoms—intoxication may prompt a delay in the procedure. *Cannabis withdrawal syndrome* has been described 24–72 h post cessation in heavy marijuana users (> 1.5 g/day inhales or > 20 mg/day PO) as irritability or anger, anxiety, insomnia, decreased appetite, restlessness, altered mood, and discomfort. Symptoms peak at one week and can last for two weeks [3]. *Heavy alcohol* users (more than 24 gm/day in women, 35 gm/day in men) are at increased risk for general morbidity, infections, pulmonary complications, increased hospital length of stay, intensive care unit admission and 30-day mortality. *Acute alcohol withdrawal* can occur within 6–8 h of abstinence, manifesting as hallucinations, seizures, and status epilepticus. *Delirium tremens* is observed after 48–96 h and can last up to two weeks. Cognitive dysfunction is common in this phase [4]. Risks from smoking and alcohol use may be reversible, depending on the duration of smoking and the interval of abstinence [5].

Poor nutritional status, resulting from the disease state, poor oral intake, or chemoradiation toxicity, decreases physiologic tolerance to the procedure and impairs healing and recovery [6]. Electrolyte impairment and coagulopathy can develop, as well as hypoalbuminemia with an effect on drug binding. A poor preoperative nutritional status has been associated with a worse postoperative outcome. Parameters used to assess nutrition include albumin, cholesterol, and total lymphocyte count [7].

Neoadjuvant chemoradiation is often used in the preoperative period to decrease tumor size, increase the curative success of surgery, and decrease distant micrometastases [8, 9]. *Chemotherapeutic agents* can cause bone marrow suppression with anemia and thrombocytopenia. Anemia increases the chances of red blood cell transfusion with its associated complications. Thrombocytopenia may exacerbate intraoperative bleeding or preclude neuraxial blockade. Platinum derivatives can cause renal dysfunction or impaired hearing [10], while fluorouracil is associated in rare cases with cardiomyopathy, hyperammonemia and encephalopathy [11]. *Immunotherapy*, a successful treatment for melanoma and lung cancer, is being investigated in patients with esophageal tumors, showing some promising results [12]. These drugs specifically target T-cells and their receptors, re-activating the immune system against cancer cells. Their potency seems to be increased after exposure to radiation treatment and because of their mechanism of action, they can activate several immune-related side effects within 3–6 months of exposure. The severity is variable and, in most cases, transient. Skin rashes and diarrhea are the most common side effects. Hypophysitis, hypothyroidism, diabetes mellitus, and adrenal insufficiency with secondary hyponatremia have been reported. Hypoparathyroidism with hypocalcemia has also been observed but is extremely rare. Mild cases are usually monitored and managed conservatively, while for severe cases, steroid treatment with thyroid replacement is recommended [13, 14]. Immunotherapy is usually continued unless severe symptoms are present.

After completing a thorough history and physical exam, appropriate *laboratory studies* should include a comprehensive metabolic panel to analyze electrolytes, renal function, and hepatic function, and a complete blood count to quantify anemia and thrombocytopenia, if present. *Coagulation studies* are relevant for patients with a bleeding diathesis or who are taking anticoagulants but also serve to evaluate hepatic function and safety of neuraxial blockade. Severe malnutrition may be associated with abnormal coagulation studies.

Comorbid *cardiovascular disease* can significantly increase patient mortality risk and should be evaluated in accordance with American College of Cardiology/American Heart Association guidelines (ACC/AHA) [15]. *Twelve-lead electrocardiogram* is performed as indicated for patients with known coronary heart disease, significant arrhythmia, peripheral arterial disease, cerebrovascular disease, or other significant structural heart disease, or may be performed as screening for myocardial ischemia or arrhythmia. More invasive cardiac testing (e.g., *stress test, angiogram*) is indicated in patients at high risk, such as those with unstable angina, decompensated chronic heart failure, arrhythmias, and severe valvular disease [15]. *Preoperative angina* in patients with previous myocardial infarction (MI) is associated with a higher incidence of postoperative adverse cardiac events, such as MI and/or cardiac arrest [16]. If patients require revascularization, elective surgery needs to be postponed. The dilemma of how long to wait needs to be discussed with the surgeon and oncologist due to the concern for potential disease progression [17]. *Cardiac stents*, especially drug-eluting ones, represent a significant problem due to the prolonged need for anticoagulation. Stopping dual antiplatelet therapy (DAPT) (aspirin plus a $P2Y_{12}$ inhibitor) is associated with increased risk of stent thrombosis, while continuing DAPT leads to increased risk of intra- and postoperative bleeding and precludes neuraxial anesthetic techniques [18]. The duration of DAPT prior to undergoing elective noncardiac surgery is based upon the type of stent: bare metal stents require 30 days after implantation, while drug-eluting stents require 6 months for purely elective procedures and 3 months for cases in which the risk of further delay in surgery is greater than the expected risks of stent thrombosis. If the $P2Y_{12}$ inhibitor therapy is stopped prior to surgery, it is recommended that aspirin be continued if possible and the $P2Y_{12}$ platelet receptor inhibitor (clopidogrel, prasugrel, or ticagrelor) be restarted as soon as possible after surgery [19].

Patients with a history of COPD, prior lung resection, chronic lung disease or morbid obesity should undergo *pulmonary function testing (PFTs)* in anticipation of one-lung ventilation (OLV). A computed tomography (CT) scan or positron emission tomography (PET) scan of the chest done for cancer staging or to assess chemotherapeutic treatment response may also be used by the anesthesiologist to evaluate airway abnormalities or lung disease. Poor PFTs are associated with an increased incidence of respiratory complications, with potential benefits from preoperative pulmonary rehabilitation or training (i.e., incentive spirometry, deep diaphragmatic breathing, coughing). Respiratory rehabilitation has been proposed as part of a multidisciplinary approach to improve respiratory mechanics and decrease complications [20].

Preoperative staging involves cross-sectional imaging and *endoscopic ultrasound (EUS) evaluation*, the latter of which is done as an outpatient procedure and requires an anesthetic [21]. The decision between sedation versus general anesthesia is based on the severity of symptoms and the experience of the provider.

Patient Selection

Predicting which patients are going to have a complicated recovery or increased mortality following esophagectomy is valuable information for all involved. In general, poor overall health and preexisting organ system dysfunction negatively impact esophagectomy outcomes [22].

The use of *scoring algorithms* can add objectivity to the selection criteria.

- The *Glasgow Prognostic Score* (GPS) and modified GPS (mGPS) combine elevated C-Reactive protein and hypoalbuminemia as markers of systemic inflammation. Seven studies of the GPS and mGPS in esophageal cancer have shown prognostic value independent of tumor stage and pathological features [23]. While GPS for squamous cell carcinoma correlates strongly with mortality after esophagectomy [24], mGPS for adenocarcinoma correlates with disease severity but not mortality [25].
- The Physiological and Operative Severity Score for the enumeration of Mortality and Morbidity (*POSSUM*), Portsmouth *(P) POSSUM* and upper gastrointestinal *(O) POSSUM* models were developed for calculating risk-adjusted mortality using a two-part scoring system: a 12-factor physiological score and a six-factor operative severity score. A comparison of the three models showed that P-POSSUM provided the most accurate prediction of in-hospital mortality after esophagectomy [26]. A comparison of POSSUM models with mGPS showed that the POSSUM physiology score was useful in predicting postoperative morbidity, while mGPS was the best predictor of cancer-specific survival [27].

Cardiopulmonary exercise testing (CPET) is a method for determining a patient's physiological capacity to tolerate the stress of surgery. The test involves exercising against increasing levels of known resistance in the form of a cycle ergometer, treadmill, or a hand crank for approximately ten minutes while recording ventilatory parameters, inspiratory and expiratory gases, blood pressure, and electrocardiogram. From this data, the body's maximum oxygen uptake and the anaerobic threshold (the point at which anaerobic metabolism exceeds aerobic metabolism) are determined [28]. In elderly patients undergoing major abdominal or thoracic surgery, results of CPET have shown that an anaerobic threshold (AT) of < 11 ml/kg/min predicted postoperative cardiopulmonary deaths [28]. The utility of CPET for assessment of preoperative exercise capacity and as a tool for risk stratification for esophagectomy patients was previously studied and shown to correlate well with postoperative cardiopulmonary morbidity; however, CPET did not previously demonstrate adequate discriminatory ability [29, 30]. The topic was revisited by Patel et al. in 2019, who found that patients with $\dot{V}O_{2peak} < 17$ mL/kg/min ($\dot{V}O_{2peak}$ is the highest volume of oxygen use achieved during the final 30 s of the test) and AT < 10.5 ml/kg/min were over twice as likely to develop major morbidity after esophagectomy [32]. The results have renewed interest in CPET, though in the setting of cost and resource limitations, simpler ergometric testing (e.g., shuttle walk test or stair climb test) or assessment of functional status by metabolic equivalents may be favored.

In sum, patient assessment for surgery based on scoring systems and assessment of functional status can help with patient selection and risk stratification, but should not be used in isolation for clinical decision-making. Experienced judgment of the surgeon and anesthesiologist, who consider multiple factors, still takes precedent.

Optimization

Reduction of modifiable risk factors is the main focus in preparation for surgery, with an emphasis on smoking cessation, correction of anemia, and improved nutritional state.

1. In a retrospective analysis, the incidence of pneumonia decreased with a longer duration of *smoking cessation* prior to esophagectomy. It is unclear how long is needed to decrease postoperative complications, with some providers suggesting at least 4–8 weeks [33]. Another study showed smoking cessation ≤ 30 days was an independent risk factor for pneumonia and smoking cessation ≤ 90 days was an independent risk factor for other severe morbidities [34]. It is strongly recommended that the perioperative

provider counsel patients at the preoperative visit and may suggest behavioral and pharmacological interventions [5]. Respiratory physiotherapy has been studied (i.e., inspiratory muscle training) and shown to improve respiratory function but not incidence of postoperative pneumonia after esophagectomy [35].

2. *Anemia* is commonly found with esophageal cancer and increases the likelihood of red blood cell transfusion, which is significantly associated with higher overall complications and increased risk of surgical site infections [36]. Iron deficiency anemia may be corrected preoperatively with oral or intravenous iron supplementation; oral iron takes two weeks to increase the serum hemoglobin level and two months to normalize it [37]. Intravenous iron infusions can correct anemia faster—a dose of 1000–1500 mg has 50% effect in five days and full effect in three weeks. It is unclear if the use of iron supplements with or without erythropoietin decrease the need for transfusion [38] or have beneficial effect with respect to outcomes after major upper gastrointestinal surgery [39].
3. *Malnutrition* is likely to predispose to postoperative complications and is exacerbated by surgical stress and metabolic demands of recovery. While nutrition is not easily improved in patients with dysphagia, a nutritional assessment should be performed and attempts to improve nutrient intake should be made. *Carbohydrate loading* prior to appropriate preoperative fasting may attenuate the surgical stress response, insulin resistance and subsequent hyperglycemia, as well as muscle breakdown of the patient [40, 41]. In severe cases of malnutrition, feeding tubes can be placed prior to surgery. However, elective enteral nutrition has not been shown to improve outcome prior to neoadjuvant treatment and therefore should not be recommended unless deemed necessary [42].

Prehabilitation has been suggested to improve outcome. Supervised exercise programs, in addition to smoke cessation programs and dietary assessment especially in malnourished patients, have the theoretical advantage to improve fitness and provide a faster return to baseline preoperative functional status [43]. The literature has yet to demonstrate a convincing relationship between prehabilitation and oncological outcomes [44]. In addition, many programs require 2–4 weeks for success, potentially delaying a curative operation.

Intraoperative Management

Surgical Approach

The anesthetic preparation must consider the planned surgical approach, as each has its own considerations. Independent of the technique (open versus minimally invasive) and the type of operation (Ivor Lewis, McKeown, transhiatal, etc.), patients undergoing esophagectomy are at risk of aspiration on induction and emergence and require optimal analgesia. Invasive m onitoring is commonly used independently of the technique, due to the potential arrhythmias during the thoracic dissection or in the postoperative period. Proper positioning to avoid neuropathy is essential for cases of long duration [45]. *Extubation* at the end of the case is recommended to avoid ventilation associated respiratory injury and hemodynamic instability as a consequence of the sedation required to tolerate the ventilator.

Open approaches involve large incisions and violate both the peritoneal and pleural cavities, making it a painful procedure for the patient. Inadequate pain control can complicate extubation and impair effective pulmonary toilet and ambulation during recovery without a multimodal analgesic plan in place. Proper analgesia is important, usually in the form of epidural or paravertebral catheters, removed within 2–3 days if the patient is enrolled in an enhanced recovery after surgery (ERAS) pathway.

Minimally invasive esophagectomy (MIE) has become more popular since the early 2000s, particularly at high-volume academic centers, with the goal of decreasing risk and improving outcomes by decreasing surgical stress, inducing less postoperative pain, and easing recovery overall. All forms of dissections can be performed minimally invasively [45], with similar morbidity and mortality to the open approach [46–48]. The main concerns for these cases are related to the positioning, the creation of pneumoperitoneum and pneumothorax, and arrhythmias during the thoracic phase. In most cases, patients are first in reverse Trendelenburg followed by the lateral decubitus. However, the prone position is used in some centers for the thoracoscopic dissection [49]. Steep reverse Trendelenburg requires a secured patient to prevent falls and padding of the feet to avoid pressure sores. Hypotension can occur soon after positioning, it is exacerbated by decreased venous return from abdominal insufflation, and may require intravascular volume loading, vasopressors, or inotropes. At the time of the crural dissection, a left pneumothorax may develop and require desufflation of the peritoneal cavity, fluid and vasopressor/inotrope administration, leveling of the operating room table, and decompression of the pleural cavity with chest tube placement in severe cases [50].

Intraoperative Monitoring

The duration and complexity of esophagectomy require the ability to monitor patient hemodynamics and metabolic state comprehensively and expeditiously. Standard monitoring should include pulse oximetry, noninvasive blood pressure monitoring, electrocardiography, and temperature monitoring. Placement of an arterial line for continuous blood pressure monitoring is commonly used to guide hemodynamic support and ventilator settings, especially for OLV. Furthermore, surgical dissection in the thorax and manipulation of the mediastinum has the potential for large vessel compression or injury and stimulation of cardiac dysrhythmias that need to be detected and intervened upon quickly. Arterial blood samples from the arterial line may be used for point-of-care analysis of hemoglobin level, electrolyte balance, acid–base status, arterial oxygenation and lactic acid concentration. Central venous access is usually unnecessary except in cases of difficult intravenous access or if desired for vasopressor infusion. If a cervical surgical incision is being employed, left internal or external jugular venous cannulation should be avoided and implanted ports in the left chest wall should not be used. A temperature probe can be placed in the oropharynx, nasopharynx, external auditory canal, bladder, or rectum. However, care should be taken to avoid placement of temperature probes or other devices in the esophagus except in conjunction with the surgical team.

Induction and Airway Management

Induction of anesthesia for esophagectomy should be done with comorbid conditions in mind—particularly that of aspiration risk. While some patients may be able to swallow normally with minimal or no GERD, or have complete resolution of dysphagia after neoadjuvant chemotherapy, anesthesiologists must be vigilant for this risk and take precautions when appropriate. The head-of-bed should be kept elevated at 30 degrees until the airway is secured. A rapid sequence induction is advocated using an intravenous induction agent, such as propofol, and succinylcholine or rocuronium for rapid-onset neuromuscular blockade. A double lumen tube (DLT) or single lumen tube (SLT) with bronchial blocker may be used to provide OLV during transthoracic procedures, especially for minimally invasive techniques [51]. Fiberoptic bronchoscopy confirms the correct placement of either device after intubation and after the change in patient position. If the surgical team is planning an initial flexible bronchoscopy for evaluation of airway involvement or if the patient has disadvantageous anatomy, a SLT may be placed and subsequently exchanged for a DLT or kept in place for use with a bronchial blocker. Attempting a rapid sequence induction for placement of a DLT can be challenging even for experienced providers and should be approached thoughtfully and with a plan in case of difficult intubation. Videolaryngoscopy or fiberoptic bronchoscopy can greatly improve glottic view for easier DLT placement and can be part of the primary or backup plan [52]. A supraglottic airway device may be placed for rescue of failed intubation, though it is not ideal for patients at risk for aspiration. Once in place, it may be exchanged for an endotracheal tube. Finally, awake intubation may be necessary for patients who have an anticipated difficult airway.

Ventilator Management

Protective lung strategies have been advocated intraoperatively due to the potential for lung injury that can be more pronounced after OLV. Postoperative pulmonary complications remain the most common type of complication after esophagectomy, with a prevalence of 20–40% according to National Surgical Quality Improvement Program (NSQIP) data [53]. Perioperative acute lung injury is multifactorial, resulting from surgical trauma, alveolar inflammation, and ventilator-induced lung injury (VILI). Protective strategies include maintaining low tidal volumes based on predicted body weight, optimizing end expiratory positive pressure (PEEP), performing routine recruitment maneuvers, reducing inspired oxygen concentration, avoiding high peak inspiratory and plateau airway pressures, and limiting the duration of OLV [54, 55]. Precise guidelines for ventilation parameters are yet to be elucidated. For patients with difficulty oxygenating during OLV, continuous positive airway pressure (CPAP) can be a useful technique to apply to the lung on the operative side of transthoracic surgery when performed in agreement with the surgical team. However, due to the potential of lung expansion, CPAP is usually only adopted after changes in the ventilator parameters and confirmation that the lung isolation device is still in good position.

Analgesia

Effective pain control for esophagectomy can have widespread benefits for the patient, and it is an important component of many enhanced recovery pathways. *Thoracic epidural analgesia* (TEA) remains the gold standard for open esophagectomy, reducing the systemic inflammatory response and providing better pain relief than parenteral opioids [56, 57]. Epidural catheters are usually placed preoperatively at a thoracic level that allow coverage from T4 to L1. Commonly used medications include a diluted local anesthetic with or without opioid—typically bupivacaine or ropivacaine with fentanyl or hydromorphone. There is some evidence that preemptive analgesia with TEA reduces acute postoperative pain for thoracotomy when compared to TEA initiated at completion of surgery [58], but there are no studies dedicated to esophagectomy. In addition to effective pain control, demonstrated benefits of TEA include facilitation of early extubation, better analgesia for postoperative mobility, and reduced incidence of pneumonia and anastomotic leak [57, 59]. TEA can have complications, such as urinary retention, hypotension, and failed or incomplete block [59].

Paravertebral block (PVB) or catheters are an alternative to TEA, providing equivalent analgesia with fewer pulmonary complications and more favorable overall side effect profile when used for thoracotomy [60]. PVB is a more challenging procedure than epidural placement, as it requires injection or catheter placement in a deep space. With the advent of ultrasound guidance the success rate has improved. Paravertebral catheters can be placed intraoperatively under direct vision by the surgeon before chest closure. The main advantage for PVB is its unilaterality; the main disadvantage is the lack of coverage for the abdominal incision. To date, there are no prospective studies that have compared PVB versus TEA for thoracolaparotomy or esophagectomy, though a Cochrane review of PVB versus TEA for thoracotomy supported PVB use to reduce the risks of developing minor complications and supported its efficacy as noninferior to TEA in controlling acute pain [61].

Peripheral nerve blocks may be used when neuraxial techniques are contraindicated. Intercostal nerve blocks and transversus abdominis plane blocks are viable opioid-sparing regional techniques. Early reports show the serratus plane block and erector spinae plane block may also be effective for thoracotomy pain with low-risk profiles [62, 63]. Even so, peripheral nerve blocks provide suboptimal analgesia alone; opioids and adjuvants are still needed. Various intravenous and oral medications may be added to the analgesic regimen, such as acetaminophen, nonsteroidal anti-inflammatory drugs (NSAIDs), alpha-2 agonists (e.g., dexmedetomidine), NMDA antagonists (e.g., ketamine), and gabapentinoids (e.g., gabapentin and pregabalin). Studies specific to the efficacy of these analgesic adjuvants for esophagectomy are lacking. Of note, concern has risen with the use of NSAIDs for colorectal surgery because of an association with impaired anastomotic healing and increased rate of leakage, and their use in esophagectomy patients may be unfavorable [64, 65]. Gabapentin has been associated with sedation and respiratory depression after laparoscopic surgery especially in the elderly patients and when combined with long-acting opioids and benzodiazepines [66]. Gabapentinoids as a class have fallen out of favor for widespread analgesic use in the perioperative setting [67].

Currently, there is no gold standard analgesic for MIE. Unlike for open esophagectomy, use of TEA for minimally invasive procedures is variable and mostly dependent on patient respiratory comorbidities. Multiple port sites and fields of operation still cause enough pain that multimodal analgesia is required for patient comfort and recovery. If not contraindicated for the patient, a thoracic epidural should be placed preoperatively for MIE if there is a high likelihood of conversion to an open procedure. Patients with chronic opioid use and tolerance, history of side effects or allergy to opioids, poor respiratory function, propensity for delirium, or other conditions that make opioid use less effective or desirable will also likely benefit from TEA for MIE. Truncal fascial plane blocks with or without catheter techniques may be implemented as part of a multimodal, opioid-sparing analgesic approach.

Fluid Management

There is still a lack of evidence on the appropriate amount of intravenous fluid needed during esophagectomy. As for any other surgery, fluid management should target euvolemia, homeostasis and normal physiology. The volume and the type of fluid used should be customized to the patient and the type of surgery [68]. Fluid restriction to the point of hypovolemia could decrease cardiac output and tissue oxygen delivery, compromising renal function and perfusion of the esophagogastric anastomosis. Conversely, liberal fluid administration to the point of excess could cause shifts into the interstitial space, impairing anastomotic healing and bowel function and contributing to pulmonary complications [69]. Balanced crystalloids are recommended. Colloids may be added given a lack of evidence that they increase morbidity or mortality in various types of shock. Moreover, unfavorable outcome data from prolonged use of colloids may not be applicable to the surgical population, which is exposed for limited time intervals. Based on data extrapolated from existing studies on fluid administration and complication rates after thoracic surgery and esophagectomy, one review has suggested total intraoperative fluid volume should be between 3 ml/kg/hr and 10 ml/kg/hr [70]. However, emphasis should be made that individual fluid requirements vary widely, and there is no strong evidence for fixed fluid replacement recommendations by total volume or by rate on outcomes.

A more tailored approach to fluid replacement is based on *goal directed fluid therapy* (GDFT), which focuses on objective measures or estimates of volume status and responsiveness. The challenge for using GDFT in esophagectomy is that flow-related hemodynamic endpoints (e.g., stroke volume variation and pulse pressure variation) may be inaccurate with an open hemithorax or in the presence of pneumoperitoneum. They are also affected by the presence of arrhythmias, mechanical ventilation with low tidal volumes (< 8 cc/kg IBW), and decreased chest wall compliance. Unfortunately, neither esophageal Doppler nor transesophageal echocardiography can be used for GDFT during surgery on the esophagus. Some advanced hemodynamic parameters (and trends in more conventional hemodynamic parameters) provide valid information related to preload, afterload, and contractility during the procedure and can help dynamically guide fluid and vasopressor administration. A decrease in the incidence of pneumonia has been observed in the GDFT arm of an observational quality improvement project where GDFT with a noninvasive cardiac output monitor was compared to standard treatment in patients undergoing either MIE or open esophagectomy [71].

NPO status guidelines have changed, especially with the advent of ERAS pathways, allowing patients to have clears until 2 h preoperatively. Thus, preoperative intravascular volume depletion is minimal (200–400 cc) with no need for replacement. Bowel preparation is also not used routinely, contributing to less preoperative volume deficit [68]. Intraoperative blood loss for open and minimally invasive procedures is also usually minimal; insensible losses during open esophagectomy may be consequential but are negligible during MIE.

Perfusion of the Esophagogastric Anastomosis

Anastomotic leak due to ischemia of the esophagogastric anastomosis is a devastating complication after esophagectomy. Preservation of perfusion of the gastric conduit for adequate tissue oxygenation of the anastomotic site is key. Blood supply to the gastric fundus, which is used to construct the conduit, is reduced in the process of ligating arteries for gastric mobilization. Thus, blood flow to the anastomosis is heavily reliant on the local microvascular network within the fundus ventriculi. For the anesthesiologist, avoidance of hypotension is important for perfusion, though supranormal mean arterial pressures do not improve gastric conduit perfusion in experimental models [72]. Hypotension due to anesthesia or TEA can be readily corrected with vasopressor or inotrope administration [73]. The belief that vasopressors should be completely avoided during esophagectomy is not supported by the literature. A study using laser speckle contrast imaging to intraoperatively assess microcirculation 1 mm below the tissue surface showed that changes in perfusion were related more to the operative procedure than to TEA-use or phenylephrine support [74]. Moreover, a 2021 retrospective study of vasopressor use in open and minimally invasive esophagectomies did not find an association between vasopressor administration and anastomotic leak rates [75]. New modalities are needed to ensure healing of the esophagogastric anastomosis, and some promise has been shown with intraoperative use of indocyanine green fluorescein imaging to forewarn of areas of poor perfusion [76].

Postoperative Recovery

Complications

Adverse outcomes can occur postoperatively in up to 60% of esophagectomy patients [77].

Pulmonary complications are the most common, and primarily include pneumonia, aspiration pneumonitis, acute lung injury (ALI), acute respiratory distress syndrome (ARDS), bronchopleural fistula, atelectasis, and pulmonary embolism. ARDS is the most critical pulmonary complication with mortality rates up to 50% [78]. There are a multitude of factors that contribute to these adverse pulmonary outcomes [79]. Intraoperative mechanical ventilation may be a significant component especially when combined with surgical manipulation and lung isolation. Poor analgesia or excessive sedation can lead to poor respiratory efforts, contributing to hypoventilation. Opioid-related sedation can also contribute to aspiration.

Cardiovascular complications also account for significant morbidity and mortality after esophagectomy, predominantly in the form of arrhythmias. Supraventricular tachyarrhythmias, mostly atrial fibrillation, occur in about 18% of cases [80] and lead to a higher rate of ICU admission, longer hospital stay and higher 30-day mortality rate [81]. Several protocols are in place for the treatment, mainly relying on pharmacological cardioversion (amiodarone, sotalol) or rate control with beta blockers, calcium channel blockers, or amiodarone. Age, gender, type of procedure and elevated brain natriuretic peptide (BNP > 30 pg/ml) have been associated with an increased postoperative risk of developing atrial fibrillation [82]. Amiodarone or calcium channel blockers are the drugs of choice for prophylaxis. Beta-blockers should be continued in patients already taking them. Magnesium, statins, and ACE inhibitors have also been proposed as weak prophylactic agents.

Esophageal anastomotic leakage adds to the morbidity of recovery and significantly increases the mortality in the postoperative period.

Other less common but notable complications include chylothorax, recurrent laryngeal nerve injury, ileus, abscess formation and wound infection. These are complications that may require surgical treatment and therefore the need of an anesthetic.

Enhanced Recovery Pathway

Formalizing results from well-conducted, peer-reviewed studies into a streamlined protocol of perioperative care known as an enhanced recovery after surgery (ERAS) pathway has been successful in minimizing complications and speeding recovery for a variety of surgical populations [38]. This approach is now being evaluated for its effectiveness in esophagectomy care, given that a comprehensive set of interventions is likely needed to see an overall improvement in outcomes. The general focus of an ERAS pathway is on five categories of care: (1) preoperative assessment, planning, and preparation before admission; (2) reducing the physiologic stress of the operation; (3) a structured approach to immediate postoperative and perioperative management, including pain relief; (4) early mobilization; and (5) early enteral feeding [83]. In 2019, ERAS guideline recommendations were published specific to esophagectomy [84].

Currently, there is minimal evidence for individual interventions for esophagectomy, with many recommendations derived from non-esophageal thoracoabdominal surgery. Yet, adapting existing ERAS protocols to esophagectomy is a logical approach and has promise to make surgical treatment of esophageal cancer safer for the patient thanks in part to better teamwork and education.

Conclusions

Anesthetic perspectives on esophagectomy care continue to evolve with increasing focus on multidisciplinary teams, multimodal monitoring and analgesia, and minimally invasive techniques. As enhanced recovery pathways further develop, the role of the anesthesiologist will become more active in the coordination of care from the time of prehabilitation through the continuum of surgery, recovery, and follow-up. Optimizing the functional status in the preoperative period, planning each aspect of the anesthetic, and preventing medical complications in the postoperative period are all goals for a successful patient experience. Achieving these goals will require continued efforts to research and implement best practices specific to esophageal cancer patients.

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