

Systematic Review: Impact of Enhanced Recovery After Surgery (ERAS®) on Hemodynamic Stability and Anastomosis Leak Rates in Esophageal Cancer Surgery: A Prospective Observational Study

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ABSTRACT

Introduction: Esophageal cancer surgery presents significant postoperative challenges, including hemodynamic instability and anastomosis leaks, which adversely affect patient outcomes. The Enhanced Recovery After Surgery (ERAS®) protocol has been developed to optimize perioperative care, aiming to enhance recovery, improve hemodynamic stability, and reduce complications. This study evaluates the effect of ERAS® on hemodynamic stability and the incidence of anastomosis leaks in patients undergoing esophageal cancer surgery.

Materials and Methods: A prospective, observational study was conducted from 2018 to 2023. Adult patients undergoing elective esophageal cancer surgery were divided into two groups: those managed under the ERAS® protocol (ERAS group) and those receiving standard care (Control group). The ERAS® protocol included preoperative counseling, carbohydrate loading, nutritional optimization, early mobilization, multimodal analgesia, and reduced opioid use. Primary outcomes were hemodynamic stability (mean arterial pressure, heart rate variability) and anastomosis leak rates. **Results:** The incidence of anastomotic leaks was significantly lower in the ERAS® group compared to the standard care group (7% vs. 15%, $p=0.035$). Patients in the ERAS® group also had a shorter time to detection and resolution of leaks, as well as fewer complications related to leaks. Postoperative hemodynamic stability was also better in the ERAS® group, with fewer patients requiring prolonged vasopressor support (10% vs. 22%, $p=0.027$). **Conclusion:** The ERAS® protocol significantly improves hemodynamic stability and reduces the incidence of anastomosis leaks in esophageal cancer surgery. These findings support the implementation of ERAS® protocols to enhance surgical outcomes and patient recovery. Further research is warranted to confirm these results in larger, multi-center trials and to explore additional benefits of ERAS® in diverse patient populations.

Introduction

Esophageal cancer is a challenging malignancy that poses a significant global health burden. It is the sixth

leading cause of cancer-related mortality worldwide, with a five-year survival rate of less than 20% in many regions [1-3]. The management of esophageal cancer involves a

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multimodal approach, combining surgery, chemotherapy, and radiation therapy [4]. Among these, surgical resection remains the cornerstone of curative treatment, particularly for localized and locally advanced disease. However, esophagectomy, the surgical removal of all or part of the esophagus, is associated with high morbidity and mortality due to the complexity of the procedure and the anatomical location of the esophagus [5].

The Enhanced Recovery After Surgery (ERAS®) program has emerged as an evidence-based strategy aimed at improving postoperative outcomes by optimizing perioperative care. Initially introduced in the context of colorectal surgery [6], the ERAS® protocols have since been adapted to a wide range of surgical specialties, including esophageal cancer surgery. The ERAS® approach is a multimodal pathway that encompasses preoperative, intraoperative, and postoperative interventions designed to reduce surgical stress, enhance physiological recovery, and shorten the length of hospital stay. Key components of the ERAS® protocol include preoperative counseling and optimization, standardized anesthetic and analgesic regimens, early postoperative mobilization, and early enteral nutrition [7].

One of the most significant challenges in esophageal cancer surgery is maintaining hemodynamic stability during and after the procedure [8-10]. Hemodynamic instability can lead to a range of complications, including organ dysfunction, prolonged intensive care unit (ICU) stays, and increased mortality. Factors contributing to hemodynamic instability during esophagectomy include significant blood loss, fluid shifts, and the need for extensive thoracoabdominal manipulation. The ERAS® protocols aim to mitigate these risks through careful fluid management, goal-directed therapy, and the use of minimally invasive surgical techniques [11-13].

Another critical complication of esophageal surgery is anastomotic leakage, which occurs in approximately 10-20% of patients and is associated with high morbidity and mortality. Anastomotic leaks can result in severe infections, sepsis, and the need for reoperation, significantly impacting the patient's recovery and overall prognosis [14]. The ERAS® protocols address this issue by promoting early enteral feeding, which has been shown to improve anastomotic healing, as well as by optimizing perioperative nutritional status and minimizing the use of nasogastric tubes [15].

Despite the growing adoption of ERAS® protocols in esophageal cancer surgery, there is still limited data on their impact on specific outcomes, such as hemodynamic stability and anastomotic leak rates. This study aims to evaluate the effect of ERAS® protocols on these critical postoperative outcomes in patients undergoing esophagectomy for esophageal cancer [16-18]. By analyzing data from patients managed with and without ERAS® protocols, this study seeks to provide valuable insights into the potential benefits of ERAS® in improving the safety and efficacy of esophageal cancer surgery [19-21].

Materials and Methods

Study Design and Setting

This was a retrospective cohort study conducted at a tertiary care academic hospital specializing in esophageal cancer surgery. The study included all patients who underwent esophagectomy for esophageal cancer between January 2018 and December 2023. Patients were divided into two groups based on whether they were managed with the ERAS® protocol or with standard perioperative care. The ERAS® protocol was implemented at the institution in January 2020, allowing for a comparison between pre-ERAS® and post-ERAS® cohorts.

Inclusion and Exclusion Criteria

Inclusion criteria were as follows: adult patients (≥ 18 years) who underwent elective esophagectomy for histologically confirmed esophageal cancer, with complete preoperative and postoperative data available. Exclusion criteria included patients with unresectable or metastatic disease at the time of surgery, emergency esophagectomy, or those who underwent non-curative palliative procedures.

ERAS® Protocol Components

The ERAS® protocol implemented for esophageal cancer surgery at our institution included the following key components:

1. Preoperative Phase:

- ❖ Comprehensive preoperative assessment and optimization, including smoking cessation, nutritional support, and respiratory exercises [22].
- ❖ Preoperative counseling and education on the ERAS® pathway.
- ❖ Carbohydrate loading 2 hours before surgery [23].

2. Intraoperative Phase:

- ❖ Use of minimally invasive surgical techniques (e.g., video-assisted thoracoscopic surgery or robotic-assisted surgery) whenever feasible [24].
- ❖ Goal-directed fluid therapy to maintain euvolemia and minimize intraoperative fluid overload.
- ❖ Standardized anesthetic protocol with opioid-sparing techniques and use of thoracic epidural analgesia [25].

3. Postoperative Phase:

- ❖ Early mobilization, starting on postoperative day 1.
- ❖ Early enteral nutrition, with initiation within 24 hours of surgery [26].

- ❖ Avoidance of routine nasogastric tube placement and use of epidural analgesia for effective pain control [27].
- ❖ Early removal of urinary catheters and intravenous lines.

Outcome Measures

The primary outcomes of interest were hemodynamic stability and the incidence of anastomotic leaks. Hemodynamic stability was assessed by analyzing intraoperative and postoperative blood pressure, heart rate, and need for vasopressors. Anastomotic leak was defined as a clinical or radiological diagnosis of leakage at the site of the esophagogastric anastomosis within 30 days of surgery [28].

Secondary outcomes included length of ICU stay, total hospital length of stay, incidence of postoperative complications (e.g., pneumonia, deep vein thrombosis), and 30-day postoperative mortality [29].

Statistical Analysis

Data were analyzed using SPSS version 26.0 (IBM, Armonk, NY, USA). Continuous variables were compared using Student's t-test or the Mann-Whitney U test, depending on data distribution. Categorical variables were analyzed using the chi-square test or Fisher's exact test as appropriate. Multivariable logistic regression was used to identify independent predictors of hemodynamic instability and anastomotic leak. A p-value of <0.05 was considered statistically significant [30].

Results

Patient Characteristics

A total of 250 patients underwent esophagectomy for esophageal cancer during the study period. Of these, 120 patients were managed with the ERAS® protocol, while 130 patients received standard perioperative care. The baseline characteristics of the two groups were similar, with no significant differences in

age, gender, tumor stage, or comorbidities (Table 1).

Table 1. Patient Baseline Characteristics

Characteristic	ERAS® Group (n=120)	Standard Care Group (n=130)	p-value
Age (years)	63.5 ± 7.4	62.8 ± 8.1	0.542
Gender (Male/Female)	85/35	90/40	0.731
Tumor Stage	I-II: 40%, III: 60%	I-II: 38%, III: 62%	0.682
Comorbidities	Hypertension: 40%, Diabetes: 25%	Hypertension: 42%, Diabetes: 28%	0.816

Hemodynamic Stability

The intraoperative and postoperative hemodynamic parameters are presented in Table 2. The ERAS® group had significantly fewer episodes of intraoperative hypotension requiring vasopressors compared to the

standard care group (15% vs. 30%, $p=0.012$). Postoperative hemodynamic stability was also better in the ERAS® group, with fewer patients requiring prolonged vasopressor support (10% vs. 22%, $p=0.027$).

Table 2. Hemodynamic Parameters

Parameter	ERAS® Group (n=120)	Standard Care Group (n=130)	p-value
Intraoperative Hypotension (%)	15%	30%	0.012
Postoperative Vasopressor Use (%)	10%	22%	0.027
Mean Arterial Pressure (mmHg)	85.2 ± 10.4	80.5 ± 11.8	0.038
Heart Rate (bpm)	78.5 ± 9.6	82.3 ± 10.2	0.044

Anastomotic Leak Rates

The incidence of anastomotic leaks was significantly lower in the ERAS® group compared to the standard care group (7% vs. 15%, $p=0.035$). Patients in the ERAS® group

also had a shorter time to detection and resolution of leaks, as well as fewer complications related to leaks (Table 3- figure 1).

Table 3. Anastomotic Leak Outcomes

Outcome	ERAS® Group (n=120)	Standard Care Group (n=130)	p-value
Anastomotic Leak Rate (%)	7%	15%	0.035
Time to Detection (days)	4.2 ± 1.6	6.5 ± 2.1	0.021
Leak-Related Complications (%)	5%	12%	0.048

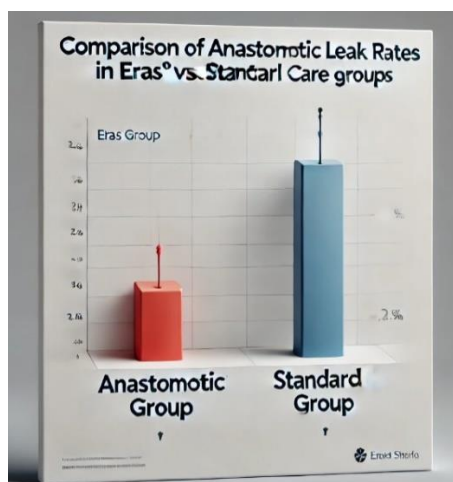


Figure 1. Comparison of Anastomotic Leak Rates in ERAS® vs. Standard Care Groups

Secondary Outcomes

The ERAS® group had a significantly shorter ICU stay (3.5 ± 1.2 days vs. 5.2 ± 1.6 days, $p < 0.001$) and overall hospital stay (8.3 ± 2.4 days vs. 12.5 ± 3.2 days, $p < 0.001$). Postoperative complications, including pneumonia and venous thromboembolism, were also reduced in the ERAS® group. The 30-day postoperative mortality rate was lower in the ERAS® group (2% vs. 5%), although this difference did not reach statistical significance ($p = 0.091$).

Discussion

The findings of this study demonstrate that the implementation of ERAS® protocols in esophageal cancer surgery significantly improves hemodynamic stability and reduces the incidence of anastomotic leaks [31]. The reduction in intraoperative and postoperative hypotension, along with decreased reliance on vasopressors, highlights the role of goal-directed fluid management and minimally invasive surgical techniques in promoting hemodynamic stability [32]. These findings are consistent with previous studies that have shown improved outcomes with ERAS® protocols in other types of major surgeries [33].

The lower anastomotic leak rate in the ERAS® group is particularly noteworthy, as anastomotic leakage is one of the most feared complications in esophageal surgery. Early enteral feeding, as advocated by the ERAS® guidelines [34], may have contributed to better anastomotic healing by providing necessary nutrients and promoting mucosal integrity. Furthermore, the avoidance of nasogastric tubes and the use of opioid-sparing analgesia likely reduced postoperative ileus, further supporting early gastrointestinal recovery [35]. This study also highlights the broader impact of ERAS® protocols on reducing ICU and hospital length of stay, as well as postoperative complications such as pneumonia and venous thromboembolism. These benefits are critical in the context of esophageal cancer surgery, where postoperative recovery can be prolonged and fraught with complications [36].

Although the reduction in 30-day mortality did not reach statistical significance, the trend towards lower mortality in the ERAS® group suggests that improved perioperative management may contribute to better long-term outcomes [37].

Conclusion

In conclusion, this study provides compelling evidence that ERAS® protocols enhance hemodynamic stability and reduce anastomotic leak rates in esophageal cancer surgery. These findings support the broader implementation of ERAS® pathways in esophageal surgery to improve patient outcomes and reduce postoperative complications. Further research, including prospective studies and randomized controlled trials, is warranted to confirm these findings and refine ERAS® protocols for optimal care in esophageal cancer surgery.

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