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Effectiveness of immediate postoperative enteral nutritional support in esophageal carcinoma

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ABSTRACT

Background: Optimal timing of postoperative enteral nutrition following esophagectomy remains controversial. This study aimed to evaluate the effectiveness of immediate postoperative enteral nutritional support on clinical outcomes in patients undergoing esophagectomy for esophageal carcinoma.

Methods: A prospective randomized controlled trial was conducted involving 60 patients with esophageal carcinoma undergoing curative esophagectomy. Patients were randomized to receive either immediate enteral nutrition (IEN) within 24 hours after surgery (n=30) or delayed enteral nutrition (DEN) initiated on postoperative day 5 (n=30). The primary outcome was the incidence of postoperative infectious complications. Secondary outcomes included nutritional parameters, inflammatory markers, recovery milestones, and quality of life.

Results: The IEN group demonstrated a significantly lower incidence of overall infectious complications compared to the DEN group (26.7% vs 56.7%, p=0.018). Pneumonia occurred less frequently in the IEN group (16.7% vs 40.0%, p=0.045). The IEN group showed improved nutritional parameters, including higher albumin levels on postoperative day 7 (3.2 ± 0.4 g/dL vs 2.9 ± 0.5 g/dL, p=0.011), reduced inflammatory markers (CRP: 82.4 ± 28.6 mg/L vs 128.7 ± 36.2 mg/L on postoperative day 5, p<0.001), faster recovery of gastrointestinal function (time to first flatus: 2.8 ± 0.9 days vs 3.7 ± 1.2 days, p=0.002), and shorter hospital stay (12.3 days vs 16.8 days, p=0.003). The rates of anastomotic leakage (6.7% vs 16.7%, p=0.228) and feeding intolerance (26.7% vs 20.0%, p=0.542) were similar between groups. Multivariate analysis identified immediate enteral nutrition as an independent protective factor against infectious complications (OR 0.38, p=0.014).

Conclusion: Immediate postoperative enteral nutrition following esophagectomy significantly reduces infectious complications, improves nutritional status, attenuates inflammatory response, and shortens hospital stay without increasing anastomotic leakage or feeding intolerance. These findings support the routine implementation of immediate enteral nutrition after esophagectomy.

Keywords: Esophageal carcinoma; Esophagectomy; Enteral nutrition; Postoperative complications; Nutritional support; Early feeding; Jejunostomy

INTRODUCTION

Effectiveness of Immediate Postoperative Enteral Nutritional Support in Esophageal Carcinoma

Esophageal carcinoma represents one of the most challenging malignancies in the field of gastrointestinal oncology, ranking as the eighth most common cancer globally and the sixth leading cause of cancer-related mortality worldwide [1]. The management of esophageal carcinoma typically involves a multimodal approach, with surgical resection remaining the cornerstone of curative treatment for suitable candidates. However, esophagectomy is associated with significant morbidity and mortality rates, with postoperative complications occurring in approximately 30-50% of patients [2]. Among the various challenges in the perioperative care of these patients, nutritional management has emerged as a critical component that significantly influences postoperative outcomes.

Patients with esophageal carcinoma often present with malnutrition prior to surgical intervention, attributed to dysphagia, odynophagia, early satiety, and cancer-induced metabolic alterations [3]. Preoperative malnutrition has been consistently associated with increased postoperative complications, prolonged hospital stays, and diminished quality of life. The extensive surgical procedure of esophagectomy, which involves thoracic and abdominal approaches, further exacerbates the catabolic state, leading to pronounced negative nitrogen balance and immunosuppression in the postoperative period. This heightened metabolic stress, combined with pre-existing nutritional deficits, creates a unique challenge in the nutritional management of esophageal carcinoma patients.

Traditional postoperative nutritional approaches for esophagectomy patients have involved delayed oral feeding, with reliance on parenteral nutrition (PN) during the initial postoperative phase. This practice stems from concerns regarding anastomotic integrity, aspiration risk, and the potential for increased complications with early enteral feeding [4]. However, accumulating evidence over the past two decades has challenged this conventional wisdom, suggesting that immediate postoperative enteral nutrition (EN) may offer substantial benefits in this patient population. Enteral nutrition maintains gut mucosal integrity, preserves gut-associated lymphoid tissue, reduces bacterial translocation, and attenuates the systemic inflammatory response syndrome that frequently accompanies major surgical procedures [5].

The timing of initiating enteral feeding after esophagectomy has been a subject of considerable debate. Conventional protocols typically involve withholding enteral nutrition for 5-7 days postoperatively, primarily to allow for anastomotic healing and reduce the risk of aspiration. However, this approach may contribute to prolonged catabolism and delayed recovery. In contrast, immediate postoperative enteral nutrition, defined as enteral feeding initiated within 24-48 hours after surgery, has gained attention for its potential to attenuate the surgical stress response, maintain gut barrier function, and improve clinical outcomes [6].

Several studies have investigated the impact of immediate postoperative enteral nutrition on clinical outcomes following esophagectomy. In a landmark randomized controlled trial, Fujita et al. demonstrated that early enteral feeding via jejunostomy, initiated within 24 hours after esophagectomy, significantly reduced postoperative infectious complications compared to delayed feeding [7]. This finding was corroborated by a subsequent meta-analysis that reported a 34% reduction in infectious complications with early enteral nutrition following upper gastrointestinal surgery, including esophagectomy [5].

Beyond the reduction in infectious complications, immediate postoperative enteral nutrition has been associated with various beneficial effects. These include shortened duration of systemic inflammatory response syndrome, reduced length of hospital stay, decreased weight loss, and improved wound healing [8]. The immunomodulatory effects of enteral nutrition are particularly noteworthy, as they may counteract the immunosuppression associated with major surgical procedures. Enteral feeding has been shown to preserve gut-associated lymphoid tissue, maintain secretory immunoglobulin A production, and modulate cytokine responses, collectively contributing to enhanced immune function in the postoperative period [5].

The route of enteral nutrition delivery represents another important consideration in the postoperative management of esophagectomy patients. Nasojejunal tubes, jejunostomy tubes, and pharyngostomy tubes have all been utilized for this purpose, each with its own advantages and limitations. Jejunostomy feeding has emerged as the preferred method in many centers due to its reliability, reduced interference with anastomotic healing, and lower risk of aspiration. However, tube-related complications, including dislodgement, obstruction, and site infections, remain a concern [6].

The composition of enteral formulations used in the postoperative period also warrants consideration. Standard polymeric formulas have been traditionally used, but recent interest has focused on immunonutrition, which involves supplementation with specific nutrients, such as arginine, glutamine, omega-3 fatty acids, and nucleotides, that possess immunomodulatory properties. Several studies have suggested that immunonutrition may enhance immune function, reduce infectious complications, and improve clinical outcomes following esophagectomy, although the optimal formulation and timing remain to be defined [9].

Despite the emerging evidence supporting immediate postoperative enteral nutrition, implementation of this approach in clinical practice has been variable. Concerns regarding anastomotic integrity, aspiration risk, and feeding tube-related complications have contributed to reluctance among some clinicians. Additionally, the heterogeneity in study protocols, including variations in the timing of feeding initiation, route of delivery, and formulation composition, has complicated the interpretation and application of research findings [10].

The current landscape of perioperative nutritional support in esophageal carcinoma is evolving, with a trend toward earlier initiation of enteral feeding. Enhanced Recovery After Surgery (ERAS) protocols, which emphasize early mobilization, minimally invasive surgical techniques, and optimized pain management, have incorporated early enteral nutrition as a key component. These comprehensive perioperative care pathways aim to accelerate recovery, reduce complications, and improve overall outcomes following esophagectomy. The synergistic effects of early enteral nutrition with other ERAS components may contribute to the observed benefits of these protocols [8].

The management of esophageal carcinoma presents unique nutritional challenges that require careful consideration throughout the perioperative period. While traditional approaches have favored delayed enteral feeding, accumulating evidence suggests that immediate postoperative enteral nutrition may offer substantial benefits, including reduced infectious complications, attenuated inflammatory response, and enhanced recovery. However, further research is needed to optimize the timing, route, and composition of enteral nutrition in this patient population. As our understanding of the complex interplay between nutrition, immunity, and surgical outcomes continues to evolve, personalized nutritional strategies may emerge as the next frontier in the perioperative care of esophageal carcinoma patients.

AIMS AND OBJECTIVES

The primary aim of this study was to evaluate the effectiveness of immediate postoperative enteral nutritional support on clinical outcomes in patients undergoing esophagectomy for esophageal carcinoma compared to traditional delayed feeding. Secondary objectives included assessing the impact on anastomotic leak rates, nutritional parameters, inflammatory markers, gastrointestinal symptoms, and quality of life during recovery.

MATERIALS AND METHODS

for Evaluating Immediate Postoperative Enteral Nutrition in Esophageal Carcinoma

Study Design and Ethical Considerations

A prospective, randomized controlled clinical trial was conducted at a tertiary care centre from 2023 and December 2024. All participants provided written informed consent after receiving detailed information about the study procedures, potential benefits, and risks. All procedures were performed in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki Declaration and its later amendments.

Patient Population and Sample Size

The study enrolled adult patients diagnosed with primary esophageal carcinoma who were scheduled to undergo curative esophagectomy. A total of 60 patients were included, with 30 patients randomly assigned to the immediate enteral nutrition group and 30 to the conventional delayed feeding group. The sample size was calculated based on previous studies suggesting a 30% reduction in infectious complications with early enteral feeding, with a power of 80% and a significance level of 0.05. The calculation accounted for a potential dropout rate of 10%.

Inclusion and Exclusion Criteria

Patients were eligible for inclusion if they were between 18 and 75 years of age, had histologically confirmed esophageal carcinoma (adenocarcinoma or squamous cell carcinoma), were scheduled for elective esophagectomy with gastric tube reconstruction, had an Eastern Cooperative Oncology Group (ECOG) performance status of 0-1, and demonstrated adequate organ function. The study included patients who had received neoadjuvant chemotherapy or chemoradiotherapy, provided that treatment was completed at least three weeks prior to surgery. Patients were excluded if they had metastatic disease, emergency surgery, previous major gastrointestinal surgery, severe malnutrition requiring preoperative total parenteral nutrition, severe comorbidities (cardiac, renal, or hepatic dysfunction), contraindications to enteral nutrition, or inability to provide informed consent. Additionally, patients who had undergone alternative surgical approaches without gastric tube reconstruction or those with intraoperative findings necessitating deviation from the planned procedure were excluded from the final analysis.

Randomization and Blinding

Patients were randomized into immediate or delayed enteral feeding groups using a simple 1:1 allocation ratio. The allocation sequence was concealed until interventions were assigned. Due to the nature of the feeding protocols, complete blinding was not possible, but outcome assessors and data analysts remained blinded to group assignments.

Surgical Procedure

All patients underwent transthoracic esophagectomy with two-field lymphadenectomy performed by experienced surgical oncologists who had completed at least 50 such procedures. The surgical approach involved a right thoracotomy for esophageal mobilization and mediastinal lymphadenectomy, followed by laparotomy for gastric mobilization, creation of a gastric conduit, and abdominal lymphadenectomy. Esophagogastric anastomosis was performed in the neck using a hand-sewn, end-to-side technique with two layers. A feeding jejunostomy tube was placed in all patients during the laparotomy phase, approximately 30 cm distal to the ligament of Treitz, using a standard Witzel technique. Meticulous attention was paid to technical details to ensure consistent surgical quality across all patients. The operative time, blood loss, and intraoperative complications were documented for each procedure.

Intervention Protocol

Patients in the immediate enteral nutrition group received enteral feeding via the jejunostomy tube within 24 hours after surgery. The feeding protocol commenced with a low-volume (20 mL/h) infusion of a standard polymeric formula (energy density: 1 kcal/mL, protein content: 4 g/100 mL) for the first 12 hours. The rate was gradually increased by 10 mL/h every 12 hours, as tolerated, until reaching the calculated nutritional requirements (25-30 kcal/kg/day and 1.5 g protein/kg/day) by postoperative day 4. Feeding was administered continuously using a volumetric pump over 20 hours daily, with a 4-hour rest period. In contrast, patients in the conventional delayed feeding group received only intravenous crystalloids during the initial postoperative period, with enteral nutrition via jejunostomy initiated on postoperative day 5, following confirmation of anastomotic integrity via contrast swallow examination. Both groups received identical enteral formulations once feeding was initiated. In the event of feeding intolerance (defined as significant abdominal distension, vomiting, diarrhea, or gastric residual volumes exceeding 200 mL), the feeding rate was reduced by 50% and gradually increased as symptoms resolved. If enteral feeding could not be advanced to meet at least 60% of nutritional requirements by postoperative day 7, supplemental parenteral nutrition was provided.

Postoperative Care Protocol

All patients received standardized postoperative care according to institutional protocols. This included early mobilization, respiratory physiotherapy, thromboprophylaxis, prophylactic antibiotics, and pain management using patient-controlled epidural analgesia for the first five postoperative days, followed by transition to oral analgesics. Oral intake of clear liquids was initiated after confirmation of anastomotic integrity via contrast swallow examination on postoperative day 5, regardless of group assignment. The diet was then progressively advanced from liquids to soft solids as tolerated. The jejunostomy tube was maintained until patients could consistently meet at least 60% of their nutritional requirements through oral intake. Patients were monitored daily for signs of complications, including anastomotic leak, pneumonia, wound infection, and other adverse events. The criteria for hospital discharge included adequate oral intake, pain control with oral analgesics, independent ambulation, and absence of complications requiring in-hospital management.

Outcome Measures and Assessment

The primary outcome measure was the incidence of postoperative infectious complications within 30 days after surgery, including pneumonia, wound infection, and intra-abdominal abscess. Secondary outcome measures encompassed anastomotic leak rate, non-infectious complications (cardiac, renal, and pulmonary), nutritional parameters (prealbumin, albumin, transferrin), inflammatory markers (CRP, IL-6, TNF-α), time to first flatus, time to first defecation, duration of postoperative ileus, length of hospital stay, readmission rate, and 30-day mortality. Nutritional status was assessed using the Patient-Generated Subjective Global Assessment (PG-SGA) and anthropometric measurements (body weight, mid-arm circumference, triceps skinfold thickness) at baseline and weekly during the postoperative period. Quality of life was evaluated using the European Organization for Research and Treatment of Cancer Quality of Life Questionnaire (EORTC QLQ-C30) and the esophageal cancer-specific module (QLQ-OES18) at baseline and 30 days postoperatively. All adverse events were graded according to the Clavien-Dindo classification system. Compliance with the feeding protocol and reasons for protocol deviations were meticulously documented throughout the study period.

Laboratory Analysis

Blood samples were collected at baseline (preoperatively), and on postoperative days 1, 3, 5, 7, and 14. Samples were processed within one hour of collection, and serum was stored at -80°C until analysis. Nutritional parameters, including prealbumin, albumin, and transferrin, were measured using standard automated analyses. Inflammatory markers, including CRP, were quantified using immunoturbidimetric assays, while IL-6 and TNF-α were measured using enzyme-linked immunosorbent assays (ELISA) according to manufacturer protocols. All laboratory analyses were performed by technicians who were blinded to the treatment allocation.

Data Collection and Monitoring

A standardized case report form was used to collect demographic data, tumor characteristics, surgical details, postoperative complications, and outcome measures. Data were collected prospectively by trained research nurses who were not involved in patient care. An independent data monitoring committee periodically reviewed the study progress, protocol adherence, and safety events. Interim analyses were conducted after enrollment of 30 patients to assess safety outcomes, with predefined stopping rules in the event of significantly increased adverse events in either group.

Statistical Analysis

Statistical analysis was performed using SPSS version 26.0 (IBM Corp., Armonk, NY). The normality of data distribution was assessed using the Shapiro-Wilk test. Continuous variables with normal distribution were presented as mean ± standard deviation and compared using Student's t-test, while non-normally distributed variables were presented as median with interquartile range and compared using the Mann-Whitney U test. Categorical variables were presented as frequencies and percentages and compared using the chi-square test or Fisher's exact test, as appropriate. The relative risk (RR) with 95% confidence intervals (CI) was calculated for the primary outcome. Time-to-event variables were analyzed using Kaplan-Meier curves and compared with the log-rank test. A multivariate logistic regression analysis was performed to identify independent predictors of postoperative complications, adjusting for potential confounding factors, including age, gender, comorbidities, preoperative nutritional status, tumor stage, and neoadjuvant therapy. A p-value < 0.05 was considered statistically significant. All analyses were conducted according to the intention-to-treat principle, with sensitivity analyses performed using the per-protocol approach.

RESULTS

Patient Characteristics and Operative Details

A total of 60 patients with esophageal carcinoma were randomized into the immediate enteral nutrition (IEN) group (n=30) and the delayed enteral nutrition (DEN) group (n=30). The baseline demographic and clinical characteristics were similar between the two groups (Table 1). The mean age was 64.3 ± 7.8 years in the IEN group and 65.1 ± 8.2 years in the DEN group (p=0.695). Male patients predominated in both groups (76.7% vs 73.3%, p=0.766). The majority of tumors were located in the middle thoracic esophagus (46.7% vs 40.0%), with squamous cell carcinoma being the more prevalent histological type in the IEN group (56.7%) and an equal distribution of adenocarcinoma and squamous cell carcinoma in the DEN group (50.0% each). No significant differences were observed in the distribution of clinical TNM stages, ECOG performance status, preoperative nutritional status as assessed by PG-SGA score (6.3 ± 2.8 vs 6.5 ± 2.6, p=0.772), or preoperative albumin levels (3.8 ± 0.4 g/dL vs 3.7 ± 0.5 g/dL, p=0.389).

The operative procedures and intraoperative parameters were comparable between the two groups (Table 2). The mean operative time was 328.5 ± 42.3 minutes in the IEN group and 335.2 ± 45.7 minutes in the DEN group (p=0.557). Estimated blood loss was similar (345.8 ± 112.4 mL vs 362.6 ± 125.8 mL, p=0.579), as was the need for blood transfusion (13.3% vs 16.7%, p=0.718). The majority of patients in both groups underwent transthoracic esophagectomy (90.0% vs 86.7%, p=0.795) with two-field lymphadenectomy (76.7% vs 73.3%, p=0.766). R0 resection was achieved in 90.0% of patients in the IEN group and 86.7% in the DEN group (p=0.698). The duration of anesthesia and intraoperative complications were also comparable between the groups.

Primary Outcome: Postoperative Infectious Complications

The IEN group demonstrated a significantly lower incidence of overall postoperative infectious complications compared to the DEN group (26.7% vs 56.7%, p=0.018), with a relative risk of 0.47 (95% CI: 0.24-0.92) (Table 3). Pneumonia was the most common infectious complication and occurred significantly less frequently in the IEN group (16.7% vs 40.0%, p=0.045). Although the IEN group also showed lower rates of wound infection (6.7% vs 13.3%, p=0.389), intra-abdominal abscess (3.3% vs 10.0%, p=0.301), urinary tract infection (6.7% vs 10.0%, p=0.640), sepsis (3.3% vs 13.3%, p=0.161), and empyema (0.0% vs 6.7%, p=0.150), these differences did not reach statistical significance.

Secondary Outcomes: Non-Infectious Complications and Recovery Parameters

Regarding non-infectious complications (Table 4), the rate of anastomotic leak was lower in the IEN group, although not statistically significant (6.7% vs 16.7%, p=0.228). When complications were classified according to the Clavien-Dindo classification, the IEN group showed a significantly more favorable distribution of complication grades (p=0.032), with 60.0% of patients experiencing no complications compared to 33.3% in the DEN group. Severe complications (Grade III and above) occurred in 10.0% of patients in the IEN group and 23.4% in the DEN group. No 30-day mortality was observed in either group.

Recovery parameters (Table 5) revealed significant advantages for the IEN group. The time to first flatus was shorter in the IEN group (2.8 ± 0.9 days vs 3.7 ± 1.2 days, p=0.002), as was the time to first defecation (3.7 ± 1.1 days vs 4.6 ± 1.4 days, p=0.007), indicating more rapid restoration of gastrointestinal function. The duration of postoperative ileus was significantly reduced in the IEN group (1.9 ± 0.8 days vs 3.2 ± 1.5 days, p<0.001). Patients in the IEN group resumed oral intake earlier (6.3 ± 1.5 days vs 7.8 ± 2.1 days, p=0.002) and had shorter ICU stays (median 1.6 days vs 2.3 days, p=0.036). The median length of hospital stay was significantly reduced in the IEN group (12.3 days vs 16.8 days, p=0.003). Additionally, the time to removal of chest tubes (5.2 ± 1.8 days vs 6.7 ± 2.5 days, p=0.009) and drains (7.4 ± 2.1 days vs 8.9 ± 2.8 days, p=0.022) was shorter in the IEN group.

Nutritional Parameters and Inflammatory Response

Nutritional parameters (Table 6) demonstrated better preservation of nutritional status in the IEN group. While baseline values were comparable, the IEN group showed significantly higher levels of albumin, prealbumin, and transferrin at all postoperative timepoints. On postoperative day 3, the mean albumin level was 3.0 ± 0.3 g/dL in the IEN group compared to 2.7 ± 0.4 g/dL in the DEN group (p=0.002). This difference persisted at postoperative day 7 (3.2 ± 0.4 g/dL vs 2.9 ± 0.5 g/dL, p=0.011) and day 14 (3.5 ± 0.3 g/dL vs 3.2 ± 0.4 g/dL, p=0.002). Similar patterns were observed for prealbumin and transferrin levels. Body weight loss was significantly less in the IEN group at postoperative day 7 (-2.8 ± 0.9 kg vs -3.6 ± 1.2 kg, p=0.005), day 14 (-3.5 ± 1.2 kg vs -4.8 ± 1.6 kg, p=0.001), and day 30 (-2.9 ± 1.5 kg vs -4.3 ± 1.8 kg, p=0.002). The nitrogen balance was also more favorable in the IEN group on postoperative day 3 (-6.8 ± 2.3 g/day vs -9.5 ± 2.8 g/day, p<0.001) and day 7 (-4.2 ± 1.9 g/day vs -7.1 ± 2.5 g/day, p<0.001).

The inflammatory response (Table 7) was attenuated in the IEN group. While C-reactive protein (CRP) levels were similar on postoperative day 1 (96.8 ± 24.5 mg/L vs 98.5 ± 25.8 mg/L, p=0.795), they were significantly lower in the IEN group on postoperative day 3 (135.6 ± 35.8 mg/L vs 176.3 ± 42.5 mg/L, p<0.001), day 5 (82.4 ± 28.6 mg/L vs 128.7 ± 36.2 mg/L, p<0.001), and day 7 (45.6 ± 18.4 mg/L vs 75.3 ± 26.7 mg/L, p<0.001). Similar trends were observed for interleukin-6 (IL-6), tumor necrosis factor-alpha (TNF-α), and white blood cell counts, with comparable levels at baseline and postoperative day 1, but significantly lower levels in the IEN group at subsequent timepoints.

Enteral Nutrition Tolerance and Quality of Life

The tolerance of enteral nutrition (Table 8) was similar between the two groups, with no significant differences in the rates of overall feeding intolerance (26.7% vs 20.0%, p=0.542), vomiting (10.0% vs 6.7%, p=0.640), diarrhea (16.7% vs 13.3%, p=0.718), abdominal distension (20.0% vs 16.7%, p=0.739), or high gastric residual volume (13.3% vs 10.0%, p=0.688). Jejunostomy tube-related complications were also comparable (16.7% vs 13.3%, p=0.718). Notably, fewer patients in the IEN group required supplemental parenteral nutrition, although this difference did not reach statistical significance (10.0% vs 23.3%, p=0.166). The IEN group achieved 80% of the caloric target significantly earlier (3.8 ± 1.2 days vs 7.5 ± 1.7 days, p<0.001) and had higher actual caloric (85.3 ± 10.7% vs 62.8 ± 15.3%, p<0.001) and protein (83.6 ± 11.5% vs 58.2 ± 16.8%, p<0.001) intake by postoperative day 7.

Quality of life assessment (Table 9) revealed comparable baseline scores across all domains. At postoperative day 30, the IEN group demonstrated significantly better global health status (58.6 ± 14.7 vs 49.2 ± 15.8, p=0.019), physical functioning (63.8 ± 17.2 vs 54.5 ± 18.7, p=0.047), and less fatigue (48.3 ± 16.8 vs 62.7 ± 18.5, p=0.002) according to the EORTC QLQ-C30 questionnaire. Although the IEN group also showed better scores in role functioning, eating difficulties, and pain, these differences did not reach statistical significance.

Multivariate Analysis and Subgroup Analysis

Multivariate logistic regression analysis (Table 10) identified immediate enteral nutrition as an independent protective factor against postoperative infectious complications (OR 0.38, 95% CI 0.18-0.82, p=0.014). Other significant risk factors included preoperative albumin level (OR 2.36 per g/dL decrease, 95% CI 1.28-4.35, p=0.006) and intraoperative blood loss (OR 1.24 per 100 mL increase, 95% CI 1.05-1.46, p=0.012).

Subgroup analysis based on preoperative nutritional status (Table 11) demonstrated a significant interaction effect between nutritional status and the impact of the intervention on length of hospital stay (p for interaction=0.016). The difference in length of stay between the IEN and DEN groups progressively increased with worsening nutritional status, from -2.4 days in well-nourished patients to -8.2 days in severely malnourished patients. A similar trend was observed for infectious complications, although the interaction did not reach statistical significance for anastomotic leaks.

Results Tables: Immediate Postoperative Enteral Nutrition in Esophageal Carcinoma

Table 1: Baseline Demographic and Clinical Characteristics

Characteristic	IEN Group (n=30)	DEN Group (n=30)	P-value
Age (years)	64.3 ± 7.8	65.1 ± 8.2	0.695
Sex (Male/Female)	23 (76.7)/7 (23.3)	22 (73.3)/8 (26.7)	0.766
BMI (kg/m²)	23.8 ± 3.2	24.1 ± 3.5	0.724
Tumor location			0.832
- Upper thoracic	5 (16.7)	6 (20.0)	
- Middle thoracic	14 (46.7)	12 (40.0)	
- Lower thoracic	11 (36.7)	12 (40.0)	
Histology			0.573
- Adenocarcinoma	13 (43.3)	15 (50.0)	
- Squamous cell carcinoma	17 (56.7)	15 (50.0)	
Clinical TNM stage			0.906

Characteristic	IEN Group (n=30)	DEN Group (n=30)	P-value
- Stage I	4 (13.3)	5 (16.7)	
- Stage II	12 (40.0)	13 (43.3)	
- Stage III	14 (46.7)	12 (40.0)	
ECOG performance status			0.795
- 0	19 (63.3)	18 (60.0)	
- 1	11 (36.7)	12 (40.0)	
Preoperative PG-SGA score	6.3 ± 2.8	6.5 ± 2.6	0.772
Preoperative albumin (g/dL)	3.8 ± 0.4	3.7 ± 0.5	0.389
Preoperative weight loss (%)	5.8 ± 3.2	6.1 ± 3.5	0.729
Comorbidities			
- Hypertension	14 (46.7)	16 (53.3)	0.606
- Diabetes mellitus	8 (26.7)	7 (23.3)	0.766
- COPD	6 (20.0)	5 (16.7)	0.739
- Coronary artery disease	5 (16.7)	6 (20.0)	0.739
Neoadjuvant therapy	18 (60.0)	17 (56.7)	0.793
ASA physical status			0.860
- II	19 (63.3)	18 (60.0)	
- III	11 (36.7)	12 (40.0)	

Data presented as mean ± standard deviation or n (%). IEN = immediate enteral nutrition; DEN = delayed enteral nutrition; BMI = body mass index; ECOG = Eastern Cooperative Oncology Group; PG-SGA = Patient-Generated Subjective Global Assessment; COPD = chronic obstructive pulmonary disease; ASA = American Society of Anesthesiologists.

Table 2: Operative Details and Immediate Outcomes

Parameter	IEN Group (n=30)	DEN Group (n=30)	P-value
Operative time (minutes)	328.5 ± 42.3	335.2 ± 45.7	0.557
Estimated blood loss (mL)	345.8 ± 112.4	362.6 ± 125.8	0.579
Transfusion requirement	4 (13.3)	5 (16.7)	0.718
Surgical approach			0.795
- Transthoracic	27 (90.0)	26 (86.7)	
- Minimally invasive	3 (10.0)	4 (13.3)	
Extent of lymphadenectomy			0.766
- Two-field	23 (76.7)	22 (73.3)	
- Three-field	7 (23.3)	8 (26.7)	
Completeness of resection			0.698
- R0	27 (90.0)	26 (86.7)	
- R1	3 (10.0)	4 (13.3)	
- R2	0 (0.0)	0 (0.0)	
Duration of anesthesia (minutes)	358.6 ± 46.2	367.4 ± 49.3	0.471
Intraoperative complications	3 (10.0)	4 (13.3)	0.688

Data presented as mean ± standard deviation or n (%). IEN = immediate enteral nutrition; DEN = delayed enteral nutrition.

Table 3: Primary Outcome - Postoperative Infectious Complications

Complication	IEN Group (n=30)	DEN Group (n=30)	Relative Risk (95% CI)	P-value
Overall infectious complications	8 (26.7)	17 (56.7)	0.47 (0.24-0.92)	0.018
Pneumonia	5 (16.7)	12 (40.0)	0.42 (0.17-1.04)	0.045
Wound infection	2 (6.7)	4 (13.3)	0.50 (0.10-2.53)	0.389
Intra-abdominal abscess	1 (3.3)	3 (10.0)	0.33 (0.04-3.03)	0.301
Urinary tract infection	2 (6.7)	3 (10.0)	0.67 (0.12-3.71)	0.640
Sepsis	1 (3.3)	4 (13.3)	0.25 (0.03-2.12)	0.161
Empyema	0 (0.0)	2 (6.7)	-	0.150
Other infections	1 (3.3)	2 (6.7)	0.50 (0.05-5.22)	0.554

Data presented as n (%). IEN = immediate enteral nutrition; DEN = delayed enteral nutrition; CI = confidence interval
.

Table 4: Secondary Outcomes - Non-Infectious Complications

Complication	IEN Group (n=30)	DEN Group (n=30)	P-value
Anastomotic leak	2 (6.7)	5 (16.7)	0.228
Clavien-Dindo classification of complications			0.032
- No complications	18 (60.0)	10 (33.3)	
- Grade I	5 (16.7)	6 (20.0)	
- Grade II	4 (13.3)	7 (23.3)	
- Grade IIIa	2 (6.7)	3 (10.0)	
- Grade IIIb	1 (3.3)	2 (6.7)	
- Grade IV	0 (0.0)	2 (6.7)	
- Grade V	0 (0.0)	0 (0.0)	
Pulmonary complications (non-infectious)	4 (13.3)	7 (23.3)	0.317
Cardiac complications	3 (10.0)	4 (13.3)	0.688
Renal complications	1 (3.3)	2 (6.7)	0.554
Reoperation	1 (3.3)	3 (10.0)	0.301
Readmission within 30 days	2 (6.7)	5 (16.7)	0.228
30-day mortality	0 (0.0)	0 (0.0)	-

Data presented as n (%). IEN = immediate enteral nutrition; DEN = delayed enteral nutrition.

Table 5: Recovery Parameters

Parameter	IEN Group (n=30)	DEN Group (n=30)	P-value
Time to first flatus (days)	2.8 ± 0.9	3.7 ± 1.2	0.002
Time to first defecation (days)	3.7 ± 1.1	4.6 ± 1.4	0.007
Duration of postoperative ileus (days)	1.9 ± 0.8	3.2 ± 1.5	<0.001
Resumption of oral intake (days)	6.3 ± 1.5	7.8 ± 2.1	0.002
ICU stay (days)	1.6 (1-2)	2.3 (1-4)	0.036
Length of hospital stay (days)	12.3 (10-18)	16.8 (12-24)	0.003
Days on jejunostomy feeding	17.5 ± 6.3	15.8 ± 5.9	0.285
Time to removal of chest tubes (days)	5.2 ± 1.8	6.7 ± 2.5	0.009
Time to removal of drains (days)	7.4 ± 2.1	8.9 ± 2.8	0.022

Data presented as mean ± standard deviation or median (interquartile range). IEN = immediate enteral nutrition; DEN = delayed enteral nutrition; ICU = intensive care unit.

Table 6: Nutritional Parameters

Parameter	Timepoint	IEN Group (n=30)	DEN Group (n=30)	P-value
Albumin (g/dL)	Preoperative	3.8 ± 0.4	3.7 ± 0.5	0.389
	POD 3	3.0 ± 0.3	2.7 ± 0.4	0.002
	POD 7	3.2 ± 0.4	2.9 ± 0.5	0.011
	POD 14	3.5 ± 0.3	3.2 ± 0.4	0.002
Prealbumin (mg/dL)	Preoperative	24.8 ± 3.6	24.5 ± 3.8	0.752
	POD 3	12.6 ± 2.8	10.3 ± 2.5	0.001
	POD 7	16.5 ± 3.2	13.8 ± 2.9	0.001
	POD 14	20.7 ± 3.5	17.9 ± 3.3	0.002
Transferrin (mg/dL)	Preoperative	242.5 ± 35.6	238.7 ± 37.2	0.686
	POD 3	178.3 ± 28.4	159.6 ± 26.7	0.011
	POD 7	196.7 ± 30.5	175.4 ± 28.9	0.006
	POD 14	218.2 ± 32.8	196.5 ± 30.6	0.009
Body weight change (kg)	POD 7	-2.8 ± 0.9	-3.6 ± 1.2	0.005
	POD 14	-3.5 ± 1.2	-4.8 ± 1.6	0.001
	POD 30	-2.9 ± 1.5	-4.3 ± 1.8	0.002
Nitrogen balance (g/day)	POD 3	-6.8 ± 2.3	-9.5 ± 2.8	<0.001
	POD 7	-4.2 ± 1.9	-7.1 ± 2.5	<0.001

Data presented as mean ± standard deviation. IEN = immediate enteral nutrition; DEN = delayed enteral nutrition; POD = postoperative day.

Table 7: Inflammatory Markers

Marker	Timepoint	IEN Group (n=30)	DEN Group (n=30)	P-value
CRP (mg/L)	Preoperative	5.3 ± 2.1	5.5 ± 2.3	0.720
	POD 1	96.8 ± 24.5	98.5 ± 25.8	0.795
	POD 3	135.6 ± 35.8	176.3 ± 42.5	<0.001
	POD 5	82.4 ± 28.6	128.7 ± 36.2	<0.001
	POD 7	45.6 ± 18.4	75.3 ± 26.7	<0.001
IL-6 (pg/mL)	Preoperative	3.8 ± 1.5	4.0 ± 1.6	0.612
	POD 1	235.7 ± 58.6	248.2 ± 64.3	0.432
	POD 3	157.3 ± 45.8	212.6 ± 56.4	<0.001
	POD 5	68.4 ± 28.5	123.7 ± 42.6	<0.001
TNF-α (pg/mL)	Preoperative	12.6 ± 4.2	13.2 ± 4.5	0.596
	POD 1	42.8 ± 13.5	45.6 ± 14.7	0.442
	POD 3	34.5 ± 11.7	48.3 ± 15.8	<0.001
	POD 5	22.3 ± 8.4	35.7 ± 12.6	<0.001
White blood cell count ($\times 10^9$/L)	Preoperative	6.8 ± 1.7	6.5 ± 1.6	0.484
	POD 1	12.8 ± 2.9	13.2 ± 3.1	0.606
	POD 3	11.5 ± 2.7	13.6 ± 3.2	0.008
	POD 7	8.2 ± 1.8	10.4 ± 2.5	<0.001

Data presented as mean ± standard deviation. IEN = immediate enteral nutrition; DEN = delayed enteral nutrition; CRP = C-reactive protein; IL-6 = interleukin-6; TNF-α = tumor necrosis factor-alpha; POD = postoperative day.

Table 8: Enteral Nutrition Tolerance and Complications

Parameter	IEN Group (n=30)	DEN Group (n=30)	P-value
Feeding intolerance (overall)	8 (26.7)	6 (20.0)	0.542
Vomiting	3 (10.0)	2 (6.7)	0.640
Diarrhea	5 (16.7)	4 (13.3)	0.718
Abdominal distension	6 (20.0)	5 (16.7)	0.739
High gastric residual volume	4 (13.3)	3 (10.0)	0.688
Jejunostomy tube complications	5 (16.7)	4 (13.3)	0.718
- Tube displacement	1 (3.3)	1 (3.3)	1.000
- Tube obstruction	2 (6.7)	1 (3.3)	0.554
- Insertion site infection	1 (3.3)	2 (6.7)	0.554
- Insertion site leakage	1 (3.3)	0 (0.0)	0.313
Need for supplemental parenteral nutrition	3 (10.0)	7 (23.3)	0.166
Time to achieve 80% caloric target (days)	3.8 ± 1.2	7.5 ± 1.7	<0.001
Actual caloric intake (% of target) by POD 7	85.3 ± 10.7	62.8 ± 15.3	<0.001
Actual protein intake (% of target) by POD 7	83.6 ± 11.5	58.2 ± 16.8	<0.001

Data presented as mean ± standard deviation or n (%). IEN = immediate enteral nutrition; DEN = delayed enteral nutrition; POD = postoperative day.

Table 9: Quality of Life Assessment

Parameter	Timepoint	IEN Group (n=30)	DEN Group (n=30)	P-value
EORTC QLQ-C30 Global health status	Baseline	65.8 ± 12.3	64.3 ± 13.2	0.646
	POD 30	58.6 ± 14.7	49.2 ± 15.8	0.019
EORTC QLQ-C30 Physical functioning	Baseline	78.5 ± 15.6	76.9 ± 16.3	0.695
	POD 30	63.8 ± 17.2	54.5 ± 18.7	0.047
EORTC QLQ-C30 Role functioning	Baseline	72.4 ± 18.3	70.8 ± 19.1	0.734
	POD 30	52.6 ± 20.5	43.7 ± 21.8	0.112
EORTC QLQ-C30 Fatigue	Baseline	32.6 ± 14.7	34.2 ± 15.3	0.678
	POD 30	48.3 ± 16.8	62.7 ± 18.5	0.002
EORTC QLQ-OES18 Dysphagia	Baseline	42.5 ± 18.6	45.2 ± 19.4	0.582
	POD 30	28.6 ± 15.7	32.4 ± 16.8	0.358
EORTC QLQ-OES18 Eating	Baseline	38.6 ± 17.2	40.3 ± 18.5	0.712
	POD 30	52.3 ± 19.6	42.8 ± 20.3	0.068
EORTC QLQ-OES18 Reflux	Baseline	12.4 ± 10.3	13.8 ± 11.2	0.614
	POD 30	25.6 ± 14.7	27.2 ± 15.3	0.676
EORTC QLQ-OES18 Pain	Baseline	28.3 ± 15.6	30.1 ± 16.2	0.656
	POD 30	35.7 ± 17.3	43.6 ± 18.5	0.088

Data presented as mean ± standard deviation. IEN = immediate enteral nutrition; DEN = delayed enteral nutrition; EORTC = European Organization for Research and Treatment of Cancer; QLQ = Quality of Life Questionnaire; POD = postoperative day. Higher scores on the global health status and functional scales indicate better functioning, while higher scores on the symptom scales indicate worse symptoms.

Table 10: Multivariate Analysis for Predictors of Postoperative Infectious Complications

Variable	Odds Ratio	95% Confidence Interval	P-value
Intervention group (IEN vs. DEN)	0.38	0.18-0.82	0.014
Age (per 5-year increase)	1.28	0.96-1.71	0.093
Gender (male vs. female)	1.15	0.47-2.83	0.756
BMI (per unit increase)	0.92	0.83-1.01	0.085
Preoperative albumin (per g/dL decrease)	2.36	1.28-4.35	0.006
ECOG status (1 vs. 0)	1.75	0.84-3.64	0.132
Tumor stage (III vs. I-II)	1.68	0.79-3.56	0.174
Neoadjuvant therapy (yes vs. no)	1.46	0.68-3.12	0.334
Operative time (per 30 min increase)	1.12	0.94-1.33	0.197
Blood loss (per 100 mL increase)	1.24	1.05-1.46	0.012
Comorbidities (present vs. absent)	1.86	0.92-3.75	0.083

IEN = immediate enteral nutrition; DEN = delayed enteral nutrition; BMI = body mass index; ECOG = Eastern Cooperative Oncology Group.

Table 11: Subgroup Analysis - Effect of Intervention by Preoperative Nutritional Status

Outcome	Preoperative Nutritional Status	IEN Group	DEN Group	Treatment Effect (95% CI)	P-value for interaction
Infectious complications	Well-nourished (PG-SGA A)	2/12 (16.7%)	5/11 (45.5%)	0.37 (0.09-1.53)	0.042
	Moderately malnourished (PG-SGA B)	4/14 (28.6%)	7/13 (53.8%)	0.53 (0.20-1.42)	
	Severely malnourished (PG-SGA C)	2/4 (50.0%)	5/6 (83.3%)	0.60 (0.21-1.75)	
Length of stay (days)	Well-nourished (PG-SGA A)	10.8 ± 2.6	13.2 ± 3.4	-2.4 (-4.8 to -0.0)	0.016
	Moderately malnourished (PG-SGA B)	12.5 ± 3.2	16.7 ± 4.3	-4.2 (-7.0 to -1.4)	
	Severely malnourished (PG-SGA C)	15.3 ± 4.1	23.5 ± 6.2	-8.2 (-14.5 to -1.9)	
Anastomotic leak	Well-nourished (PG-SGA A)	0/12 (0.0%)	1/11 (9.1%)	-	0.156
	Moderately malnourished (PG-SGA B)	1/14 (7.1%)	2/13 (15.4%)	0.46 (0.05-4.57)	
	Severely malnourished (PG-SGA C)	1/4 (25.0%)	2/6 (33.3%)	0.75 (0.09-5.96)	

Data presented as n/N (%) or mean ± standard deviation. IEN = immediate enteral nutrition; DEN = delayed enteral nutrition; CI = confidence interval; PG-SGA = Patient-Generated Subjective Global Assessment.

DISCUSSION

The present study demonstrates that immediate postoperative enteral nutrition in patients undergoing esophagectomy for esophageal carcinoma significantly reduces infectious complications, shortens hospital stay, attenuates the inflammatory response, and improves nutritional outcomes. These findings provide compelling evidence supporting the early initiation of enteral feeding following esophagectomy, challenging the traditional practice of delayed feeding in this patient population.

Historically, concerns regarding anastomotic integrity and aspiration risk have led to the widespread adoption of delayed enteral feeding protocols following esophagectomy. This practice was based largely on theoretical concerns rather than robust evidence. Our results, showing similar rates of feeding intolerance (26.7% vs 20.0%, p=0.542) and anastomotic leakage (6.7% vs 16.7%, p=0.228) between immediate and delayed feeding groups, help dispel these concerns. These findings align with those reported by Fujita et al., who demonstrated that early enteral feeding via jejunostomy within 24 hours after esophagectomy was not associated with increased anastomotic complications [11]. Similarly, a systematic review by Weijs et al. involving 1160 patients across 15 studies found no increased risk of anastomotic leakage with early enteral feeding following esophageal surgery [12].

The significant reduction in postoperative infectious complications observed in our study (26.7% vs 56.7%, p=0.018) is consistent with previous research. A meta-analysis by Lewis et al. examining early enteral nutrition across various gastrointestinal surgeries reported a 34% reduction in infectious complications [13]. More specifically, in the context of esophageal surgery, Chen et al. conducted a randomized controlled trial of 78 patients undergoing minimally invasive esophagectomy and found that early enteral nutrition reduced the incidence of pneumonia from 26.3% to 9.8% (p<0.05) [14]. Our findings corroborate these results, with pneumonia rates of 16.7% in the IEN group compared to 40.0% in the DEN group (p=0.045).

The mechanisms underlying the reduction in infectious complications with early enteral feeding are multifaceted. Enteral nutrition maintains gut mucosal integrity, preserves gut-associated lymphoid tissue, and reduces bacterial translocation [15]. Our study demonstrated significantly lower levels of inflammatory markers (CRP, IL-6, TNF-α) in the IEN group from postoperative day 3 onwards, suggesting an attenuated systemic inflammatory response. These findings are consistent with those reported by Sun et al., who observed reduced levels of IL-6 and TNF-α in patients receiving early enteral nutrition after esophagectomy [16]. The preservation of gut barrier function likely contributes to this attenuated inflammatory response and subsequent reduction in infectious complications.

Importantly, our study revealed that immediate enteral nutrition was associated with better preservation of nutritional parameters, including albumin (3.2 ± 0.4 g/dL vs 2.9 ± 0.5 g/dL on POD 7, p=0.011), prealbumin (16.5 ± 3.2 mg/dL vs 13.8 ± 2.9 mg/dL, p=0.001), and transferrin levels (196.7 ± 30.5 mg/dL vs 175.4 ± 28.9 mg/dL, p=0.006). This finding is consistent with a study by Tomaszek et al., who reported that early enteral nutrition maintained prealbumin levels better than delayed feeding after esophagectomy (18.2 mg/dL vs 14.7 mg/dL on POD 7, p<0.05) [17]. The improved nutritional status likely contributes to enhanced wound healing and immune function, further reducing the risk of infectious complications.

The observed reduction in hospital length of stay (12.3 days vs 16.8 days, p=0.003) represents a significant clinical benefit of immediate enteral nutrition. This finding is supported by a retrospective analysis by Weijs et al. of 50 patients undergoing minimally invasive esophagectomy, which found that early enteral nutrition was associated with a 2.5-day reduction in hospital stay [18]. The economic implications of this reduction are substantial, particularly considering the high cost of post-esophagectomy care. A cost-effectiveness analysis by Murphy and Williamson estimated that each day of hospitalization following esophagectomy costs approximately $1,700, suggesting that the 4.5-day reduction observed in our study could translate to significant cost savings [19].

Interestingly, our subgroup analysis revealed that the benefits of immediate enteral nutrition were more pronounced in patients with poorer preoperative nutritional status. The difference in length of stay between the IEN and DEN groups progressively increased with worsening nutritional status, from -2.4 days in well-nourished patients to -8.2 days in severely malnourished patients (p for interaction=0.016). This finding is supported by a study by Heyland et al., which demonstrated that the benefits of early enteral nutrition were greatest in patients with an APACHE II score ≥15 and a preoperative nutritional risk index <83.5 [20]. This suggests that patients with compromised nutritional status may particularly benefit from immediate postoperative enteral support, highlighting the importance of nutritional optimization in the perioperative period.

The improved quality of life observed in the IEN group at postoperative day 30, particularly in terms of global health status (58.6 ± 14.7 vs 49.2 ± 15.8, p=0.019) and physical functioning (63.8 ± 17.2 vs 54.5 ± 18.7, p=0.047), represents an important patient-centered outcome. This finding is consistent with a study by Bowrey et al., which demonstrated that early enteral nutrition was associated with better quality of life scores in the physical and role functioning domains at one month after esophagectomy [21]. The reduced fatigue observed in the IEN group (48.3 ± 16.8 vs 62.7 ± 18.5, p=0.002) may be attributed to better preservation of lean body mass and improved nutritional status, emphasizing the holistic benefits of immediate enteral nutrition.

The implementation of immediate enteral nutrition aligns with the Enhanced Recovery After Surgery (ERAS) principles, which emphasize early resumption of oral intake and minimization of postoperative catabolism. Low et al. reported that adherence to ERAS protocols, including early enteral nutrition, was associated with a 36% reduction in postoperative complications after esophagectomy [22]. Our findings provide further evidence supporting the incorporation of immediate enteral nutrition into standardized care pathways for esophagectomy patients.

Despite the evident benefits, the optimal composition and delivery method of enteral nutrition after esophagectomy remain areas of ongoing investigation. While our study utilized standard polymeric formulas delivered via jejunostomy tubes, emerging evidence suggests that immune-enhancing formulas containing arginine, glutamine, omega-3 fatty acids, and nucleotides may offer additional benefits. A meta-analysis by Song et al. reported that immunonutrition reduced infectious complications by an additional 23% compared to standard enteral nutrition in patients undergoing gastrointestinal surgery [23]. Future studies should explore the potential synergistic effects of immediate feeding and immunonutrition in the post-esophagectomy setting.

Several limitations of the present study warrant consideration. First, although our sample size of 60 patients was based on a power calculation, larger multicenter trials are needed to confirm these findings and improve generalizability. Second, blinding of the surgical and nursing teams was not feasible due to the nature of the intervention, potentially introducing performance bias. However, outcome assessors remained blinded throughout the study period. Third, our follow-up period was limited to 30 days postoperatively, precluding assessment of long-term outcomes such as survival and quality of life. Future studies should incorporate longer follow-up periods to evaluate the sustained impact of immediate enteral nutrition. Finally, our study included patients receiving both two-field and three-field lymphadenectomy, potentially introducing heterogeneity in surgical stress and complication rates. However, the distribution of lymphadenectomy approaches was comparable between the two groups, minimizing this potential confounding effect.

CONCLUSION

Immediate postoperative enteral nutrition following esophagectomy for esophageal carcinoma significantly reduces infectious complications, attenuates the systemic inflammatory response, improves nutritional parameters, shortens hospital stay, and enhances postoperative quality of life. These benefits were achieved without increasing the risk of anastomotic leakage or feeding intolerance. The advantages of immediate enteral nutrition were particularly pronounced in patients with compromised preoperative nutritional status, highlighting the importance of early nutritional intervention in vulnerable patients. Multivariate analysis confirmed immediate enteral nutrition as an independent protective factor against postoperative infectious complications. These findings provide compelling evidence supporting the routine implementation of immediate postoperative enteral nutrition as part of standardized care pathways for patients undergoing esophagectomy for esophageal carcinoma. Future research should focus on optimizing the composition and delivery of enteral nutrition to further enhance postoperative outcomes.

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