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# Comparison of Clinical Outcomes and Postoperative Nutritional Status Between Early and Late Oral Feeding After Esophagectomy

## *An Open Labeled Randomized Controlled Trial*

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**Objective:** To compare nutritional and postoperative outcomes between early oral feeding and late oral feeding with jejunostomy feeding support after esophagectomy.

**Background:** Esophagectomy is associated with substantial body weight loss and malnutrition, impacting the prognosis of esophageal cancer patients. Despite many studies on postesophagectomy nutritional support, optimal strategies remain elusive. This study investigates the impact of jejunostomy feeding with late oral feeding compared to conventional oral feeding on nutritional and postoperative outcomes.

**Methods:** We performed a single-center prospective open-labelled randomized controlled trial between 2020 and 2022. Patients aged 18 to 75 years with resectable esophageal cancer were randomly assigned to undergo either early oral feeding (early group) or late oral feeding with jejunostomy feeding support (late group) after esophagectomy. The primary endpoint was body weight loss from preoperative body weight at postoperative 4 to 5 weeks and 4 months. Other perioperative and nutritional outcomes were also evaluated.

**Results:** We randomly assigned 29 patients to the early group and 29 patients to the late group. The late group exhibited significantly less body weight loss at both postoperative 4 to 5 weeks (8.3% vs. 5.6%; $P = 0.002$) and 4 months (15.0% vs. 10.5%; $P = 0.003$). The total calorie intake and protein intake were higher in the late group for both postoperative 4 to 5 weeks (1800 kcal/day vs. 1100 kcal/day; $P < 0.001$) and 4 months (1565 kcal/day vs. 1200 kcal/day; $P = 0.010$). Sixty percentage of the early group changed to malnutrition state, while 40% of the late group changed to malnutrition. The complication rate and length of hospital stays were similar.

**Conclusions:** The late group demonstrated prevention of significant body weight loss, enhanced nutritional intake, and reduced malnutrition without compromising short-term surgical outcomes.

**Keywords:** esophagectomy, body weight change, nutritional status, jejunostomy, enteral feeding

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Esophageal cancer, ranking eighth among the most prevalent cancers worldwide, is characterized by a challenging prognosis attributed to its aggressive nature.[1,2] Surgery stands as a primary intervention for both early and locally advanced esophageal cancer; however, esophagectomy, involving the thoracic, abdominal, and/or cervical regions, is associated with a substantial incidence of morbidity and surgical mortality due to its intricate procedures.[3,4] Nutritional challenges, such as perioperative body weight loss, are commonplace in esophageal cancer patients and constitute a significant prognostic factor for gastrointestinal tract cancer patients.[5–8] The obstructive mass often seen in esophageal cancer leads to progressive dysphagia and odynophagia, resulting in substantial body weight loss before diagnosis. The permanent anatomic and functional changes to the stomach after esophagectomy lead to inevitable postoperative body weight loss and malnutrition, with altered anatomy causing physiological dysfunction, including gastric dumping syndrome, eating difficulties, and pancreatic insufficiency.[9] Patients undergoing surgical treatment for esophageal cancer are predisposed to considerable perioperative body weight loss due to malnutrition, anorexia, and digestive dysfunction.[10] Given the association between perioperative body weight loss and poor postoperative recovery, early and long-term outcomes, and reduced quality of life.[11,12] It becomes crucial to identify patients at risk of malnutrition and implement appropriate perioperative nutritional support protocols.

Early enteral feeding following gastrointestinal surgery is a preferred method, preventing postoperative malnutrition, alleviating surgical stress, and reducing complications such as anastomosis leakage and length of stays.[13–15]

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Enhanced recovery after surgery protocols strongly recommend initiating early enteral feeding postesophagectomy.[16] Although enteral nutrition through a jejunostomy tube is common for esophagectomy patients, controversies surround its placement in esophageal cancer surgery. Advocates emphasize the necessity of jejunostomy tubes for sustainable and stable nutritional support during the perioperative period, especially in the immediate postoperative phase and for patients unable to pursue long-term oral feeding due to postoperative complications.[17] Conversely, skeptics question routine use due to potential complications and assert it may be unnecessary for patients capable of early oral feeding.[18,19] However, given the inevitable postoperative weight loss after esophagectomy and its association with poor prognosis, early prevention of nutritional imbalance is imperative. A recent retrospective study by Davis et al[17] suggested that early postoperative initiation of enteral feeding via jejunostomy may mitigate rapid postoperative weight loss. However, no randomized controlled trial has explored the impact of early postoperative enteral feeding supplementation through jejunostomy on nutritional and postoperative outcomes.

In this randomized controlled trial, our hypothesis is that late oral feeding prolonged enteral feeding supplementation through jejunostomy will mitigate body weight loss and lead to higher nutritional intake compared to early oral feeding alone during the immediate postoperative period without compromising surgical outcomes.

## METHODS

### Study Design

This investigator-initiated and investigator-driven study was a single-center prospective open-labeled randomized controlled phase 3 trial. We compared two groups: the conventional early oral feeding group (early group) and the jejunostomy feeding maintenance with late oral feeding (late group), following esophagectomy in patients with resectable esophageal cancer. The trial adhered to the Consolidated Standards of Reporting of Trials guidelines and followed the principles of the Declaration of Helsinki and the guidelines for Good Clinical Practices.[20] Ethical approval was obtained from the institutional review board of Seoul National University Hospital on August 10th, 2020 (H-2006-106-1134), and written informed consent was obtained from all participating patients.

### Participants

Patients eligible for surgical resection with biopsy-proven esophageal squamous cell carcinoma or adenocarcinoma of the middle or lower third of the esophagus were included in the trial. Inclusion criteria encompassed esophageal cancer of any clinical T, N, M stage, eligibility for curative intent esophageal resection and reconstruction by a multidisciplinary team, receipt or nonreceipt of neoadjuvant radiotherapy, chemotherapy, or both, age between 19 and 75 years, and the ability to provide written informed consent. Exclusion criteria included a body mass index below 18 kg/m$^2$ or exceeding 27 kg/m$^2$, the need for enteral feeding before esophagectomy, liver cirrhosis, renal failure requiring renal replacement therapy, poorly controlled diabetes mellitus or thyroid function abnormality, and patients requiring esophageal reconstruction using the colon or jejunum instead of the stomach.

### Randomization

Patients were screened and informed for inclusion during admission for surgery. After obtaining written informed consent, patients were randomized using web-based randomization at the Medical Research Collaborating Center of Seoul National University Hospital. They were assigned to either the early group or the late group in a 1:1 ratio without stratification. Blinding was not implemented in this study, and information regarding allocation and treatment was open to all involved parties. All surgical procedures were performed by experienced surgeons at Seoul National University Hospital (C.H.K. and K.J.N.). Outcomes were recorded daily and prospectively by a designated research nurse (E.S.).

### Surgical Procedures

Patients considered for curative surgery underwent a comprehensive preoperative workup, including clinical tumor staging with the tumor–node–metastasis (cTNM) system based on data from computed tomography, endoscopic ultrasonography, and positron-emission tomography. The use of neoadjuvant therapy was determined locally by the multidisciplinary tumor board following national and international guidelines.[21,22] At our center, we recommended neoadjuvant treatment to patients with more than clinical T3 and/or positive lymph node metastasis. All patients were scheduled for transthoracic en-bloc esophagectomy with a gastric conduit, and the choice of the surgical procedure was made by the patients. The level of esophagogastric anastomosis (cervical or thoracic) and the extent of lymph node dissection (2-field or 3-field) were determined based on tumor location and cancer stage. Pyloric drainage procedures were routinely performed if there were no contraindications. The anastomosis was either sutured or stapled at the discretion of the operating surgeon.

Routine postoperative procedures included the placement of a nasogastric tube, right chest tube, and Jackson-Parrett drain. Postoperative vocal fold examination was conducted on day 3 to evaluate vocal fold paralysis, and postoperative esophagography was routinely performed on days 5 to 7 to assess anastomosis leakage.

### Nutritional Support Protocol

The detailed nutritional support protocol for both the early and late groups is outlined in Supplementary Table 1, Supplemental Digital Content 1, http://links.lww.com/SLA/F193. Patients in both groups maintained nil per os until the postoperative day and commenced enteral feeding through a jejunostomy tube from the first postoperative day. If no evidence of anastomosis leakage was found on postoperative esophagography, and there were no signs of aspiration due to vocal fold paralysis, both groups began sips of water the day after esophagography.

In the early group, patients started with a liquid diet at post-esophagography day 2 (postoperative 7 to 9 days), transitioned to a soft blended diet at post-esophagography day 3 (postoperative 8 to 10 days), and gradually reduced enteral feeding through the jejunostomy tube and stopped enteral feeding at discharge. Upon discharge, they continued a soft blended diet, advancing to a regular diet at the first postoperative outpatient clinic visit (postoperative 4 to 5 weeks). The jejunostomy tube was removed at this visit.

In the late group, patients received enteral nutrition through a jejunostomy tube, meeting almost their nutritional requirements, and were also provided with a small

amount of oral liquid diet from post-esophagography day 2 (postoperative 7 to 9 days). This regimen was maintained at discharge, and a soft blended diet was introduced at the first postoperative follow-up clinical visit (4 to 5 weeks after surgery). By 6 weeks postoperatively, patients transitioned to a regular diet, and the jejunostomy tube was removed.

## End Points

The primary endpoint was the percentage of weight loss preoperative weight at 4 to 5 weeks and 4 months postoperatively. Secondary end points included postoperative complication rates, in-hospital mortality, length of stays, jejunostomy-related complications, and nutritional assessment parameters. Nutritional assessments comprised measurements of preoperative body weight, handgrip strength, serum albumin (g/dL), and prealbumin level (g/dL). The Global Leadership Initiative on Malnutrition (GLIM) criteria for malnutrition were also evaluated. Postoperatively, assessments were conducted at 4 to 5 weeks and 4 months, measuring body weight, handgrip strength, serum albumin (g/dL), prealbumin level (g/dL), GLIM criteria for malnutrition, total calorie intake (kcal/day), and protein intake (g/day) using the 24-hour recall method. The assessments were carried out by an experienced registered dietitian nutritionist. (Y.R.K., M.J.K, E.H.S., and E.J.J.)

Quality of life data were collected through the European Organization for Research and Treatment (EORTC) of Cancer-Quality of Life Question-Core (QLQ-C30) and Oesophageal Cancer Module (QLQ-OES-18) questionnaires. The Korean version of the scale, with proven validity and reliability, was utilized. All questionnaires were collected and managed by a dedicated research nurse (E. S.) after obtaining informed consent from the patients before the operation and at follow-ups (postoperative 4 to 5 weeks and 4 months) at the outpatient clinic.

## Sample Size and Statistical Analysis

We explored our own retrospective data from April 2013 to August 2017; there were 191 esophagectomy patients, and 61 and 128 patients received conventional early oral feeding and jejunostomy feeding with late oral feeding, respectively. The average percentage of body weight loss at postoperative 4 weeks was $8.0 \pm 3.7\%$ and $5.1 \pm 3.5\%$ for the early and late oral feeding groups, respectively. Based on this data, 52 patients (26 in each group) with resectable esophageal cancer were calculated to be needed to detect body weight changes postoperatively. With an estimated 10% compensation for dropouts, the total number of patients required was 58 (29 in each group).

All analyses adhered to the intention-to-treat principle. Categorical variables were presented using subject numbers and proportions, while continuous variables were presented using median values and ranges. Differences between groups were evaluated using the $\chi^2$ test or Fisher exact for categorical variables and the Student *T*-test and nonparametric Mann-Whitney *U* test for continuous variables. All reported P values were 2-sided, with a significance level set at 0.05. Statistical analyses were performed using R software version 4.2.2.

# RESULTS

## Patients

The patient flow throughout the trial is illustrated in Figure 1. Between December 2020 and July 2022, 109 patients were screened for eligibility. Of these, 51 patients were excluded: 20 for not meeting the body mass index criteria, 12 due to patient refusal, 6 because of age exceeding 75 years, 5 deemed inappropriate participants by investigator decision, 3 with poorly controlled diabetes mellitus, 3 due to the cancellation of the operation, 1 enrolled in another trial, and 1 with cooperation issues related to other intestinal problems. Subsequently, 58 patients underwent randomization, with 29 patients assigned to both early and late groups. One patient in the early group was excluded due to acute respiratory distress syndrome on postoperative day 1. In the late group, 3 patients were excluded: 1 with severely uncontrolled diabetes mellitus, 1 with jejunostomy tube clogging preventing enteral feeding immediately postoperatively, and 1 who died shortly after discharge. These patients were excluded from the analysis, resulting in 28 patients in the early group and 26 patients in the late group for the final analysis. Baseline demographic and clinical characteristics did not significantly differ between the 2 groups (Table 1).

## Operative Detail

Operative details are provided in Table 2. Most patients in both groups underwent minimally invasive esophagectomy, and the difference was not significant. Anastomosis level, anastomosis method, extent of lymph node dissection, and operation time did not significantly differ between the 2 groups.

## Postoperative Outcome

Postoperative esophagography was conducted at a median of 6 days postoperatively (range 5 to 11 days). Two patients in the late group could not undergo postoperative esophagography due to aspiration tendency related to postoperative vocal fold palsy. These patients underwent repetitive videofluoroscopic swallowing studies and swallowing rehabilitation and commenced oral feeding at postoperative 49 and 83 days. In the early group, 3 patients received enteral feeding through a jejunostomy tube after discharge due to very poor oral intake.

The rate of all complications for the early group was 67.9% versus 67.9% for the late group ($P = 0.770$). Pneumonia developed in 2 patients (7.1%) for the early group versus 4 patients (15.3%) for the late group ($P = 0.413$). Anastomosis leakage occurred in 1 patient (3.6%) for the early group versus 1 patient (3.8%) for the late group ($P = 1.000$). (Table 3) The rate of other complications was also similar between the 2 groups. In-hospital mortality was not observed in both groups. Length of hospital stays was a median of 15 days (range 11 to 37 days) for the early group versus a median of 15 days (range 9 to 30 days) for the late group ($P = 0.972$). Notably, 2 patients in the late group experienced jejunostomy-related complications during the whole study period. One patient developed cellulitis of the abdominal wall around the jejunostomy tube (Clavien-Dindo classification 1), and the other patient developed obstruction of the jejunostomy tube (Clavien-Dindo classification 1).

## Nutritional Outcomes

All nutritional outcomes are described in Table 3. The difference in body weight loss from preoperative levels at 4 to 5 weeks postoperatively was significantly larger in the early group (median 8.3%, range -3.1 to 13.0) compared to the late group (median 5.6%, range 0.7 to 10.0) ($P = 0.002$).

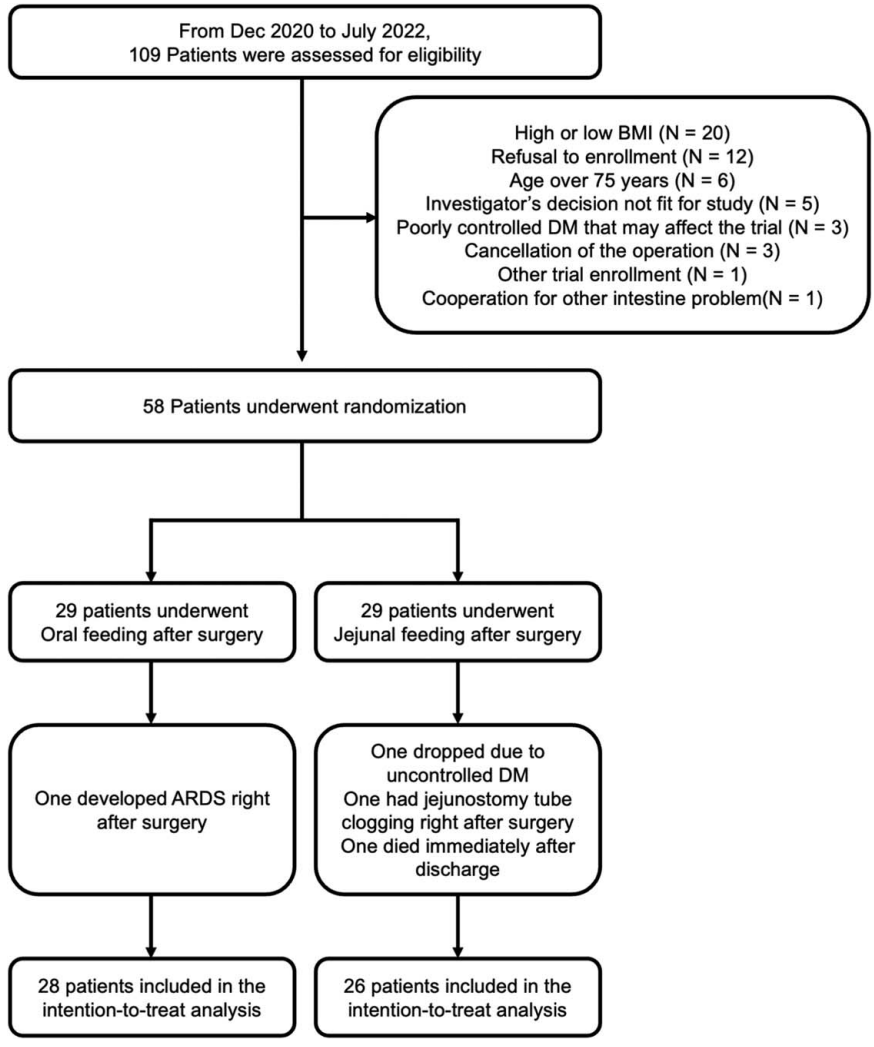


**FIGURE 1.** Overall study flow. ARDS indicates acute respiratory distress syndrome; BMI, body mass index; DM, diabetes mellitus.

This significant difference was maintained at 4 months postoperatively; the early group exhibited a significantly larger difference from preoperative body weight (median 15.0%, range 3.7 to 24.7) compared with the late group (median 10.5%, range 1.1 to 18.0) ($P = 0.003$).

Baseline nutrition status, as measured by the GLIM criteria, did not significantly differ between the 2 groups ($P = 0.828$). The majority of patients did not have malnutrition at baseline (89.3% in the early group versus 84.6% in the late group). At 4-5 weeks postoperatively, patients in the early group had rates of no malnutrition, moderate malnutrition, and severe malnutrition at 26.9%, 32.1%, and 41.0%, respectively. In contrast, 8.0% and 4.0% of patients in the late group had moderate malnutrition and severe malnutrition, while 88.0% had no malnutrition. Patients with malnutrition status were significantly worse in the early group at this time point ($P < 0.001$). This trend persisted at 4 months postoperatively, with patients in the early group having rates of no malnutrition, moderate malnutrition, and severe malnutrition at 26.9%, 15.4%, and 57.7%, respectively. In contrast, 45.5% and 9.0% of patients in the late group had moderate malnutrition and severe malnutrition, while 45.5% had no malnutrition ($P < 0.001$). Notably, patients with malnutrition status were significantly worse in the early group at this time point as well ($P < 0.001$).

Total calorie intake at postoperative 4 to 5 weeks was significantly higher in the late group (median 1800 kcal/day, range 700 to 2600) than in the early group (median 1100 kcal/day, range 450 to 2000) ($P < 0.001$). Consistently, the late group had significantly higher calorie intake (median 1565 kcal/day, range 800 to 2000) than the early group (median 1200 kcal/day, range 600 to 1900) ($P = 0.010$) at postoperative 4 months. Moreover, daily protein intake was significantly higher in the late group than the early group at both postoperative 4 to 5 weeks (90 g/day in the late group versus 43 g/day in the early group; $P < 0.001$) and postoperative 4 months (median 61 g/day in the late group versus 45 g/day in the early group; $P < 0.001$).

Regarding handgrip strength, there was no difference between the 2 groups at baseline ($P = 0.436$), postoperative 4 to 5 weeks ($P = 0.888$), and postoperative 4 months ($P = 0.465$). Serum levels of prealbumin and albumin were also similar between the 2 groups at baseline ($P = 0.241$ for prealbumin; $P = 0.997$ for albumin), 4 to 5 weeks postoperatively ($P = 0.519$ for prealbumin; $P = 0.113$ for

 

**TABLE 1.** Preoperative Characteristics of the Study Population

| Variables | Early group, n (%) | Late group, n (%) | *P* |
|---|---|---|---|
| Age (y) | 65.0 (36-74) | 62 (50-74) | 0.152 |
| Gender (male) | 23 (82.1) | 21 (80.8) | 1.000 |
| BMI (kg/m$^2$) | 23.3 (20.4-26.1) | 24.3 (19.5-26.7) | 0.390 |
| Smoking (ever) | 21 (75.0) | 20 (76.9) | 1.000 |
| ECOG PS | | | 0.320 |
| 0 | 24 (85.7) | 19 (73.1) | |
| 1 | 4 (14.3) | 7 (26.9) | |
| CCI (age-adjusted) | | | 0.181 |
| 0 | 1 (3.6) | 0 | |
| 1 | 2 (7.1) | 6 (23.1) | |
| 2 | 8 (28.6) | 10 (38.5) | |
| 3 | 5 (17.9) | 5 (19.2) | |
| ≥4 | 12 (42.9) | 5 (19.2) | |
| Neoadjuvant treatment | 10 (35.7) | 10 (38.5) | 1.000 |
| Clinical T stage | | | 0.594 |
| 1 | 18 (64.3) | 14 (53.8) | |
| 2 | 3 (10.7) | 5 (19.2) | |
| 3 | 7 (25.0) | 7 (26.9) | |
| Clinical N stage | | | 0.923 |
| 0 | 18 (64.3) | 18 (69.2) | |
| positive | 10 (35.7) | 8 (30.8) | |

ECOG indicates Eastern Cooperative Oncology Group; $D_{LCO}$, diffusing capacity of carbon monoxide; FVC, forced vital capacity; $FEV_1$, forced expiratory volume in one second; PS, performance stratus.

albumin), and 4 months postoperatively ($P = 0.806$ for prealbumin; $P = 0.458$ for albumin).

## Quality of Life

Supplementary Table 2, Supplemental Digital Content 1, http://links.lww.com/SLA/F193 and 3, Supplemental Digital Content 1, http://links.lww.com/SLA/F193 present the EORTC QLQ-C30 and QLQ-OES18 quality of life scores for the 2 groups. The global health status and functional scales did not differ between the 2 groups at preoperative status, postoperative 4 to 5 weeks, and 4 months. Overall trends of symptoms were similar between the two groups, except the pain score at postoperative 4 to 5 weeks was higher in the early group ($P = 0.014$).

Regarding the esophagus-specific quality of life, most symptoms were similar between the 2 groups, except the dysphagia score was lower at postoperative 4 to 5 weeks in the late group ($P = 0.023$), and the pain score at postoperative 4 months was higher in the early group ($P = 0.019$). However, there was no overall trend of esophageal cancer-specific symptoms in both groups.

## DISCUSSION

This study sought to compare the nutritional and postoperative outcomes between conventional early oral feeding and jejunostomy feeding with late oral feeding after esophagectomy. The results indicate that the late group experienced significantly less body weight loss at both postoperative 4 to 5 weeks and 4 months. In addition, this group exhibited higher total calorie and protein intake, along with a lower prevalence of malnutrition at both time points. Despite these nutritional benefits, there were no significant differences in complication rates and length of hospital stays between the two groups.

Patients undergoing esophagectomy often face substantial body weight loss and malnutrition, particularly

**TABLE 2.** Operative Detail and Postoperative Outcomes

| Variables | Early group, n (%) | Late group, n (%) | *P* |
|---|---|---|---|
| Thorax operation | | | 0.481 |
| MIS* | 28 (100.0) | 25 (96.2) | |
| Open | 0 | 1 (3.8) | |
| Abdomen operation | | | 0.253 |
| MIS* | 22 (78.6) | 24 (92.3) | |
| Open | 6 (21.4) | 2 (7.7) | |
| Anastomosis level | | | 0.856 |
| Cervical | 7 (25.0) | 5 (19.2) | |
| Thorax | 21 (75.0) | 21 (80.8) | |
| Anastomosis method | | | 0.491 |
| Linear stapler | 26 (92.9) | 25 (96.2) | |
| Circular stapler | 0 | 0 | |
| Hand-sewing method | 2 (7.1) | 1 (3.8) | |
| Lymph node dissection | | | 0.345 |
| Standard two field | 2 (7.1) | 0 | |
| Total two field | 19 (67.9) | 16 (61.5) | |
| Three field | 7 (25.0) | 10 (38.5) | |
| Operation time (min) | 402.5 (305-670) | 420 (330-550) | 0.253 |
| Complications | 19 (67.9) | 19 (67.9) | 0.770 |
| Pneumonia | 2 (7.1) | 4 (15.3) | 0.413 |
| Anastomosis leakage | 1 (3.6) | 1 (3.8) | 1.000 |
| Atrial fibrillation | 1 (3.6) | 4 (15.4) | 0.699 |
| Vocal fold palsy | 12 (42.9) | 15 (57.7) | 0.414 |
| Chyle leakage | 5 (17.9) | 3 (11.5) | 0.706 |
| Ileus | 2 (7.1) | 0 | 0.491 |
| Diarrhea | 2 (7.1) | 3 (11.5) | 0.342 |
| Jejunostomy-related complications | 0 | 2 | 0.218 |
| In-hospital mortality | 0 | 0 | NA |
| Length of stay (d) | 15 (11-37) | 15 (9-30) | 0.972 |

*MIS includes both video-assisted thoracic surgery and robotic surgery. MIS indicates minimally invasive surgery; NA, not applicable.

given the surgical procedure's inherent morbidity and permanent anatomical alterations.[5–7,10,23] This study aligns with previous findings reporting insufficient oral intake to meet nutritional requirements postesophagectomy[24] and the challenge of regaining lost weight.[25,26] Given the notable prognostic impact of body weight loss and malnutrition in esophageal cancer patients, optimizing nutritional support after esophagectomy remains a subject of extensive investigation.[5–7,10,23]

Jejunal feeding is one of the most common methods considered for nutritional support after esophagectomy.[16,17,19] Our group routinely place jejunostomy tubes for postoperative nutritional support from the early 2010s. Though routine jejunostomy placement in esophagectomy has not been recommended in meta-analysis[27] and ERAS guideline,[16] there is some evidence that jejunal feeding is beneficial for nutritional outcomes. Two pilot randomized controlled studies showed similar results to our study regarding the effect of jejunal feeding on nutritional outcomes. Bowrey et al[28] conducted a study comparing 6-week jejunostomy feeding maintenance after surgery with routine oral feeding. They reported that body weight loss was significantly less in the intervention group, and this difference was maintained till postoperative 6 months. Another study conducted by Froghi et al[29] showed that jejunostomy feeding maintenance after upper gastrointestinal surgery greater overall energy intake though the oral intake was similar between intervention and control

**TABLE 3.** Nutritional Outcomes

| Variables | Early group | Late group | *P* |
|---|---|---|---|
| Percentage of body weight loss from preoperative status (%) | | | |
| Postoperative 4-5 wks | 8.3 (-3.1 to 13.0) | 5.6 (0.7 to 10.0) | 0.002 |
| Postoperative 4 mo | 15.0 (3.7 to 24.7) | 10.5 (1.1 to 18.0) | 0.003 |
| GLIM criteria for malnutrition, n (%) | | | |
| Preoperative status | | | |
| No malnutrition | 25 (89.3) | 22 (84.6) | 0.828 |
| Moderate malnutrition | 3 (10.7) | 3 (11.5) | |
| Severe malnutrition | 0 | 1 (3.8) | |
| Postoperative 4-5 wks, n (%) | | | |
| No malnutrition | 7 (26.9) | 22 (88.0) | < 0.001 |
| Moderate malnutrition | 9 (32.1) | 2 (8.0) | |
| Severe malnutrition | 12 (41.0) | 1 (4.0) | |
| Postoperative 4-5 wks, n (%) | | | |
| No malnutrition | 7 (26.9) | 10 (45.5) | 0.001 |
| Moderate malnutrition | 4 (15.4) | 10 (45.5) | |
| Severe malnutrition | 15 (57.7) | 2 (9.0) | |
| Handgrip strength (kg) | | | |
| Preoperative status | 31.1 (16.1 to 39.8) | 33.3 (15.7 to 39.1) | 0.436 |
| Postoperative 4-5 wks | 28.5 (14.5 to 41.6) | 29.9 (13.4 to 38.8) | 0.888 |
| Postoperative 4 mo | 25.4 (14.5 to 38.4) | 28.3 (13.7 to 38.1) | 0.465 |
| Serum prealbumin (mg/dL) | | | |
| Preoperative status | 27.0 (19.0 to 37.0) | 26.0 (20.0 to 34.0) | 0.241 |
| Postoperative 4-5 wks | 23.5 (10.0 to 30.0) | 24.0 (14.0 to 31.0) | 0.519 |
| Postoperative 4 mo | 25.0 (13.0 to 37.0) | 24.0 (14.0 to 31.0) | 0.806 |
| Serum albumin (g/dL) | | | |
| Preoperative status | 4.2 (3.6 to 4.9) | 4.2 (3.8 to 4.6) | 0.997 |
| Postoperative 4-5 wks | 4.0 (3.1 to 4.9) | 3.8 (3.4 to 4.4) | 0.113 |
| Postoperative 4 mo | 4.1 (3.5 to 4.5) | 4.1 (3.4 to 4.3) | 0.458 |
| Total calorie intake (kcal/day) | | | |
| Postoperative 4-5 wks | 1100 (450 to 2000) | 1800 (700 to 2600) | < 0.001 |
| Postoperative 4 mo | 1200 (600 to 1900) | 1565 (800 to 2000) | 0.010 |
| Protein intake (g/day) | | | |
| Postoperative 4-5 wks | 43 (16 to 86) | 90 (32 to 113) | < 0.001 |
| Postoperative 4 mo | 45 (20 to 73) | 61 (30 to 88) | < 0.001 |

groups. Though our study maintained full nutritional support in the late group, which is different from the aforementioned studies, we also demonstrated significantly less body weight loss in the late group, and this trend was well-maintained till postoperative 4 months after discontinuation of jejunostomy feeding. In terms of total calorie and protein intake, the results were similar to the previous study. It was notable that the calorie and protein intake was significantly higher after discontinuation of jejunostomy feeding in the late group. The jejunostomy feeding might work as a reservoir to build up the oral feeding during the immediate postoperative period.

Accompanying the less body weight loss, we also found that patients in a malnutrition state were significantly less in the late group. At postoperative 4 months, more than half of the early group had a severe malnutrition state, while below 10% of the late group had a severe malnutrition state. According to our findings, patients who maintain jejunostomy feeding were prevented from malnutrition during the early postoperative phase. Moreover, at postoperative 4 months, many patients were shifted to a severe malnutrition state in the early group, while most of the patients remained in a moderate malnutrition state in the late group. Of note, 50% of the late group had changed to a malnutrition state after discontinuation of jejunostomy feeding, so the trend should be monitored carefully for the long-term period.

Some studies demonstrated that nutritional management and jejunostomy tube placement might affect the postoperative outcome; our study showed that the complication rates were similar. Bolton et al[30] showed that delayed oral feeding is associated with less anastomosis leakage. However, our results showed both groups had similar leakage rate. As recommended in ERAS guideline[16] and results from the earlier studies,[13,15] early oral feeding may be tolerable after esophagectomy in terms of dealing with complications. There appears to be wide variation in the incidence of jejunostomy tube-related complications reported in different studies.[31] The overall rate of tube-related complications varied from 5 to 51%, and some reported surgical intervention for the problems. Our study showed a relatively low rate of tube-related complications (N = 2) compared to previous studies, and the complications were minor and did not require any intervention. Regarding quality of life after esophagectomy, most of the quality of life scores were similar between the 2 groups. Notably, the early group showed a significantly higher pain score postoperatively. This may be attributed to the high proportion of open abdominal surgery in the early group.

There are several limitations of this study. First, though it is a prospective, randomized controlled study, the trial was conducted by a single center. It is indeed impossible to reflect the differences which might originate across centers and ethnicities. The long-term effect of jejunal feeding should be followed up, as whether better weight maintenance in the early months translates into long-term benefit is unknown. The effect of jejunal feeding on long-

term oncologic outcomes, sarcopenia, malnutrition, and tube-related complications should be checked.

## CONCLUSIONS

In this prospective randomized controlled trial, our findings showed the superiority of jejunal feeding maintenance over conventional early oral feeding regarding less body weight loss, higher calorie and protein intake, and less malnutrition state in esophagectomy patients. In addition, the late group showed similar postoperative outcomes as the early group, with comparable postoperative complications and quality of life. The long-term clinical and nutritional outcomes should be warranted in future follow-ups.

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