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CASE REPORT

Preoperative physiotherapy for improving the reserve capacity in a patient with esophageal cancer and frailty: A case report

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Abstract

Introduction: Frailty is significantly correlated with a higher incidence of medical complications during hospitalization after esophagectomy. As frailty is thought to be a reversible condition, improving the reserve capacity through preoperative physical therapy is expected to reduce the risk of postoperative pulmonary complications (PPCs). Herein, we report our experience with preoperative physical therapy in a patient with esophageal cancer who was considered to have inadequate fitness for surgery owing to poor physical performance.

Case Presentation: A 72-year-old man (height: 169.5 cm, weight: 54.7 kg, body mass index: 18.9 kg/m^2) with esophagogastric junction tumors (cStage IIIA) was hospitalized and scheduled to undergo surgery based on preoperative screening. He was categorized as frail according to the revised Japanese version of the Cardiovascular Health Study criteria and the Mini Nutritional Assessment Short-Form indicated severe malnutrition. We focused on physical therapy to improve exercise tolerance and prevent PPCs and devised a short-term intensive physical therapy program comprising minimal exercises that the patient could perform efficiently. The program consisted of only inspiratory muscle training and aerobic exercises. His maximal inspiratory pressure (MIP) and 6-min walking distance improved by 30 cm H_2O and 145 m, respectively, on the day before surgery compared with those on day 8. The percentage predicted value of the MIP improved from 56.6% at the start of physical therapy to 102.9% on the day before surgery. On day 43, the patient underwent subtotal esophagectomy and was able to ambulate on postoperative day 5 without respiratory complications.

Conclusion: We conducted a short-term, intensive, and minimal preoperative physical therapy program for a patient with esophageal cancer who had physical frailty. Preoperative physical therapy to increase the reserve capacity may result in a favorable postoperative course even in patients with physical frailty.

KEYWORDS
esophageal cancer, frailty, preoperative physiotherapy, reserve capacity

1 | INTRODUCTION

Surgical resection of esophageal cancer is among the most invasive gastrointestinal cancer surgeries and the incidence of postoperative complications is high (Low et al., 2019). Postoperative pulmonary complications (PPCs) are associated with prolonged hospitalization and postoperative mortality. Age, neoadjuvant chemoradiotherapy, frailty, smoking, exercise tolerance, and respiratory muscle strength are reportedly related to PPCs in patients with esophageal cancer (Ferguson & Durkin, 2002; Inoue et al., 2020; Okura et al., 2023; Shahrestani et al., 2023; Yoshida et al., 2014). Of these, preoperative physical therapy can improve frailty, exercise tolerance, and respiratory muscle strength, consequently aiding in preventing PPCs.

Frailty is a common problem in elderly patients. Frailty is defined as "vulnerability to poor resolution of homeostasis following stress and is a consequence of the cumulative decline in multiple physiological systems over the lifespan" (Clegg et al., 2013). Frailty is significantly correlated with a higher incidence of medical complications in patients hospitalized after esophagectomy (Shahrestani et al., 2023). Patients with frailty have higher mortality, duration and cost of hospitalization, and non-home discharge rates than those without frailty (Lee et al., 2022). Frailty is present when more than 3 of the 5 items (shrinking, weakness, exhaustion, slowness, and low activity) in the revised Japanese version of the Cardiovascular Health Study (revised J-CHS) criteria are fulfilled (Satake & Arai, 2020). As frailty is thought to be reversible, improving the reserve capacity through preoperative physical therapy is expected to reduce the risk of PPCs.

Herein, we report our experience with preoperative physical therapy in a patient with esophageal cancer who was deemed to have inadequate capacity to tolerate surgery because of low physical performance.

2 | CASE PRESENTATION

A 72-year-old man (height: 169.5 cm, weight: 54.7 kg, body mass index: 18.9 kg/m^2) with esophagogastric junction tumors (cStage IIIA) was hospitalized for detailed examination and treatment (day 1). He had a history of smoking 25 cigarettes per day for 50 years and daily alcohol consumption. The patient had several comorbidities, including chronic obstructive pulmonary disease, diabetes mellitus, chronic kidney disease, and hypertension, with an Eastern Cooperative Oncology Group Performance Status (PS) of 3. Owing to his low exercise tolerance, he needed wheelchair assistance to walk far in the hospital. His food intake was approximately 10%–40% because he experienced sensations of food sticking in the throat and food form. Esophagography revealed adenocarcinoma of the esophagogastric junction, gastric cancer, and atrophic gastritis. The duodenum was clear. His blood pressure, pulse rate, and oxygen saturation were 110/69 mmHg, 89 beats/min, and 96%, respectively. Hematological testing revealed the following: hemoglobin, 9.1 g/dL; albumin, 2.8 g/dL; blood urea nitrogen, 51.7 mg/dL; creatinine, 2.97 mL/min/1.73 m^2; estimated glomerular filtration rate, 17.3 mL/min/1.73 m^2; HbA1c, 5.7%; and C-reactive protein (CRP), 17.3 mg/dL. Spirometry showed a vital capacity (%predicted) of 3.76 L (113.3%) and forced expiratory volume in 1 s of 2.84 L (115.9%). An oral screening examination revealed severe periodontitis, and three teeth were extracted on day 7. He was taking azilsartan (20 mg), cilnidipine (10 mg), sitagliptin (25 mg), febuxostat (20 mg), montelukast (10 mg), ethyl icosapentate (600 mg), doxazosin (2 mg), olopatadine hydrochloride (5 mg), and sennoside (12 mg).

The patient was scheduled for surgery on day 22 (approximately 2 weeks later) according to preoperative screening testing. However, he was considered to have inadequate exercise tolerance because of his general condition. Therefore, he was referred to the rehabilitation department on day 7 to improve exercise tolerance. He was exhausted by the examination, and physical therapy was initiated on day 8. The assessments included hand grip strength, 10-m walking test, short physical performance battery, maximal inspiratory pressure (MIP), and 6-min walking test during pre- and postoperative physical therapy (Table 1). The handgrip strength was measured as the maximum of two values on each side using a digital dynamometer (Grip-D; Takei Scientific Instruments, Niigata, Japan). The MIP was measured using a digital inspiratory muscle training (IMT) device (POWERbreathe KH2; POWERbreathe International, Ltd).

During the initial evaluation (day 8), the patient was reluctant to exercise and appeared depressed. The Vitality index sum score (Toba et al., 2002), excluding one item of feeding, was 6 points (wake up 2 points, communication 1 point, on and off toilet 2 points, and rehabilitation 1 point). He met 4 of 5 items (shrinking, weakness, exhaustion, and low activity) of the revised J-CHS criteria and was categorized as frail (Satake & Arai, 2020). The Mini Nutritional Assessment Short-Form score was 4, indicating severe malnutrition. The following three problems were considered before introducing preoperative physical therapy: (1) inability to perform multiple exercises because of severe deconditioning, (2) short time to operation, and (3) poor acceptance of exercise. Therefore, we focused on physical therapy to improve exercise tolerance and prevent PPCs and devised an intensive short-term physical therapy program comprising minimal exercises that could be performed easily. The program consisted of IMT and aerobic exercises. IMT was performed twice daily with 30 breaths, and the training load was set at 40% of the MIP using a digital IMT device (POWERbreathe KH2; POWERbreathe International. Ltd.). Aerobic exercise was performed using a bicycle ergometer at an intensity of 13 on the Borg Scale for 10 min per set.

TABLE 1 Progress in physical function.

	Unit	Day 8	Day 29	Day 42	PO 16	PO 28	PO 35
Right HGS	kg	27.1	24.1	26.2	21.9	25.6	27
Left HGS	kg	20.5	22.9	20.4	22.5	22	24
Usual gait speed[a]	m/s	1.0	1.2	1.4	0.9	1.0	1.1
SPPB	Point	9	10	9	8	11	10
5STS	s	14.8	14.36	17.9	12.54	8.34	12.54
MIP	cm H_2O	42	48	72	52	77	72
6MWD	m	239.7	-	384.9	-	-	-

Note: Day 1 refers to the day of admission. Preoperative physical therapy was conducted from day 8 to day 42. He was discharged on postoperative day (PO) 35.

Abbreviations: 5STS, five-time sit-to-stand test; 6 MWD, six-minute walking distance; HGS, hand grip strength; MIP, maximal inspiratory pressure; SPPB, short physical performance battery.

[a]Usual gait speed was calculated using the 10-m walking test.

Each exercise was conducted 5 days a week. The MIP and Borg scales were measured and the intensity of IMT and aerobic exercise was set for every session.

Figure 1 shows the patient's clinical course. Owing to tooth extraction, the patient could not eat enough during the initial phase of preoperative physical therapy. The diet was changed to gruel in three degrees, and a nutritional supplement was added on day 12, resulting in an energy-sufficient diet. Thereafter, the patient's body weight (BW) and MIP increased. The surgery, scheduled on day 22, was rescheduled because he had taken ethyl icosapentate the night before. Unfortunately, the surgery was postponed again because the patient experienced diverticular bleeding, anemia, active interstitial pneumonia, and a persistent decline in renal function from day 23 to day 28. Therefore, he was ordered to fast and receive intravenous nutrition only (Table 2 shows the laboratory data during this period). Physical therapy was suspended during this period for the same reason. Preoperative physical therapy was resumed on day 29. At this juncture, his physical function was preserved, and we continued to implement the program before suspending it (Table 1). The day before surgery, his MIP and 6-m walking distance (6MWD) improved by 30 cm H_2O and 145 m, respectively, compared to day 8. The percentage predicted value of the MIP improved from 56.6% at the start of physical therapy to 102.9% on the day before surgery.

On day 43, the patient underwent total gastrectomy, D2 dissection, Roux-en-Y reconstruction, and cholecystectomy (operative time, 7 h 18 min; anesthesia time, 8 h 58 min; blood loss, 332 mL; urine volume, 253 mL, infusion, 3350 mL = 9.4 mL/kg/h). The patient could walk on postoperative day 5 without respiratory complications and was discharged on postoperative day 36.

Table 2 presents the mean ± standard deviation values of MIP, BW, geriatric nutritional risk index (GNRI), hemoglobin, and CRP every 7 days. The Vitality index was 8 (full score except for Feeding) and the patient had a positive attitude toward physical therapy. Table 3 presents the Mean ± standard deviation values of each parameter measured on days 8–14, days 15–21, days 29–35, and days 36–42.

3 | DISCUSSION

Several factors, including physical frailty, malnutrition, and respiratory muscle weakness, predicted a poor postoperative course for this patient. His physical performance was extremely low and determined to be inadequate for surgery. His exercise tolerance and inspiratory muscle strength improved after 4 weeks of preoperative physical therapy. The patient's postoperative course was better than anticipated, with no postoperative complications or delayed early mobilization.

The factors affecting the postoperative course of esophageal cancer present in this patient were age, PS, smoking history (Brinkmann index ≥800), physical frailty, poor exercise tolerance (≤454 m), and inspiratory muscle weakness (Ferguson & Durkin, 2022; Inoue et al., 2020; Okura et al., 2023; Shahrestani et al., 2023; Yoshida et al., 2014). Additionally, comorbid interstitial pneumonia, malnutrition, poor oral function (due to tooth extraction), and decreased tongue pressure influence the development and prognosis of PPCs in patients undergoing thoracic surgery (Enogren et al., 1999; Kojima et al., 2023; Miura et al., 2020; Pompili et al., 2010; Yamana et al., 2015). Physical frailty, low exercise endurance, and inspiratory muscle weakness are expected to improve with physical therapy.

Sarcopenia is among the etiological factors for physical frailty. In this case, the skeletal muscle mass was not measured, and a diagnosis of sarcopenia was not made. However, sarcopenia was suspected mainly due to generalized muscle weakness and malnutrition. Sarcopenia is a predictor of comorbidity and occurs as a postoperative complication and poor prognostic factor in patients with esophageal cancer (Park et al., 2023). Sarcpopenia leads to deterioration in the long-term postoperative health-related quality of life and malnutrition (Sugawara et al., 2022). The factors associated with sarcopenia include aging, inactivity, malnutrition, and cachexia. The GNRI score was below 80 during preoperative physical therapy, and the patient had severe malnutrition (Bouillanne et al., 2005). However, the energy level was satisfactory during hospitalization. Exercise tolerance and respiratory muscle strength were highly responsive to exercise despite

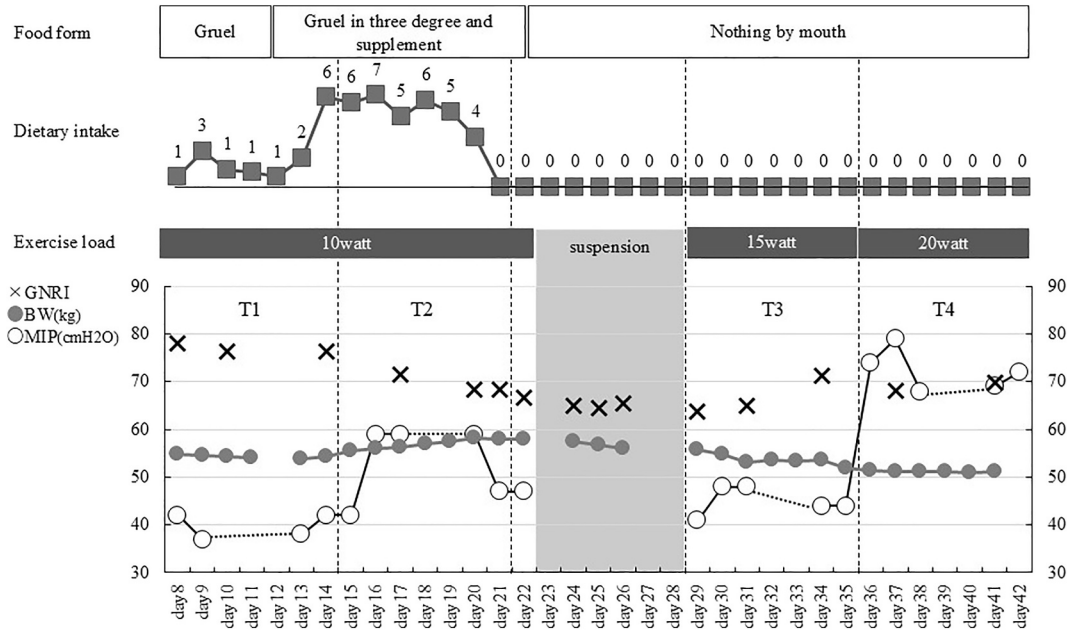

FIGURE 1 Preoperative clinical course. The preoperative physical therapy program comprised inspiratory muscle training (IMT) and aerobic exercise on a bicycle ergometer (10 min). The surgery scheduled on day 22 was rescheduled because the patient had taken ethyl icosapentate the night before. Unfortunately, the surgery was postponed again because of diverticular bleeding, anemia, active interstitial pneumonia, and persistent renal function decline during days 23–28. Physical therapy was suspended during this period for the same reason. White circle, maximal inspiratory pressure (MIP); gray circle, body weight (BW); black cross, geriatric nutritional risk index (GNRI); gray square, dietary intake.

TABLE 2 Laboratory data during the interruption in preoperative physical therapy.

	Unit	Day 21	Day 22	Day 23	Day 24	Day 25	Day 26	Day 27	Day 28	Day 29
Hb	g/dL	10	7.5	10.4	10	9.8	10.4	9.9	-	10.3
Alb	g/dL	2	1.9	1.8	1.8	1.8	1.9	1.7	-	1.8
BUN	mg/dL	41.2	60.5	51.3	36.3	29.9	22.1	18.9	-	14.3
Cre	mL/min/1.73 m^2	2.34	2.5	2.57	2.39	2.34	2.17	2.17	-	2.09
eGFR	mL/min/1.73 m^2	22.4	20.9	20.2	21.9	22.4	24.4	24.4	-	25.4
CRP	mg/dL	12.39	10.55	11.17	14.32	14.98	16.15	12.06	-	9.97

Abbreviations: Alb, albumin; BUN, blood urea nitrogen; Cre, creatinine; CRP, C-reactive protein; eGFR, estimated glomerular filtration rate; Hb, hemoglobin.

TABLE 3 Mean ± standard deviation values of each parameter measured on days 8–14 (T1), days 15–21 (T2), days 29–35 (T3), and days 36–42 (T4).

	Unit	T1	T2	T3	T4
MIP	cm H_2O	39.8 ± 2.6	53.2 ± 8.1	45.0 ± 3.0	72.4 ± 4.4
BW	kg	54.3 ± 0.3	56.9 ± 1.0	53.4 ± 1.0	51.2 ± 0.1
GNRI		76.8 ± 1.0	69.4 ± 1.9	66.7 ± 4.0	69.0 ± 1.1
Hb	g/dL	7.9 ± 1.3	9.4 ± 2.7	10.2 ± 0.2	9.7 ± 0.7
CRP	mg/dL	6.5 ± 1.3	9.6 ± 3.6	5.5 ± 4.2	1.1 ± 0.3

Note: Preoperative physical therapy was suspended between days 22 and 28.

Abbreviations: BW, body weight; CRP, C-reactive protein; GNRI, geriatric nutritional risk index; Hb, hemoglobin; MIP, maximal inspiratory pressure.

malnutrition. Thus, it can be inferred that the low exercise tolerance and respiratory muscle weakness were due to inactivity. Implementing preoperative physical therapy based on an individualized plan prevented further muscle weakness and facilitated improvement in respiratory muscle weakness, although without improving physical function or malnutrition. These results suggest that preoperative physiotherapy may positively affect the postoperative course of patients with physical frailty by increasing their reserve capacity.

Several studies have investigated preoperative physical therapy for patients with esophageal cancer. Minnella et al. (2018) conducted a median 36-day (interquartile range [IQR] 17–73 days) exercise and nutritional adjustment pre-rehabilitation program. They reported a mean improvement of 36.9 m (standard deviation, SD: 51.4) in the 6MWD from a baseline of 452.1 m (SD: 83.4 m) (18). Dettling et al. (2013) performed IMT for a minimum of 2 weeks (median

25.4 days) and reported a significant increase in the median MIP from 73.5 (IQR: 47–90) cm H_2O at baseline to 90.5 (IQR: 66–110) cm H_2O on the day before surgery (19). In this study, the patient's 6 MWD and MIP values were lower than those reported in previous studies. He was unable to perform multiple programs in a single session. Furthermore, the time to surgery was only 2 weeks. Therefore, we designed and implemented a physical therapy program focused on building exercise tolerance and respiratory muscle strength, which are essential for the postoperative course. Accidental postponement of surgery provided an adequate period for preoperative physiotherapy. Although physical frailty did not improve sufficiently, inspiratory muscle strength and exercise tolerance improved after intensive training. The patient could move smoothly soon after surgery, suggesting that improved physical function through preoperative physical therapy contributed to a favorable postoperative course.

We measured the MIP during every session, which made it possible to track the changes in the MIP. The patient's MIP showed two levels of improvement on days 16 and 36. MIP is affected not only by IMT but also by the general condition, including nutritional status and oral function. The initial change can be interpreted as reflecting the general condition, with a contemporaneous improvement in the nutritional status. The 2-week period also supports this interpretation. Since the increase was more than 2 SD higher than the previous IMT and was maintained thereafter, the second change can be interpreted as a significant improvement that exceeds the measurement error. Until this change was observed, there had been no improvement in the patient's general condition, such as malnutrition or exacerbation of interstitial pneumonia. In addition, oral function was not expected to improve after tooth extraction. In other words, no confounding factors other than IMT that could increase MIP were considered. Previous studies have reported that IMT over 2 weeks improves MIP (Dettling et al., 2013; Valkenet et al., 2018). Although there was a pause in preoperative physical therapy in this case, it can be considered a reasonable amount of time before the effect of IMT became evident. Based on the above-mentioned findings, the improvement in MIP observed in this study can be interpreted as the effect of preoperative physiotherapy. The odds ratio for the occurrence of PPCs is 3.58 in patients with esophageal cancer with inspiratory muscle weakness (MIP <80% of the predicted value) (Okura et al., 2023). The predicted MIP value improved from 56.6% at the onset of preoperative physical therapy to 102.9% on the day before surgery, indicating that preoperative physical therapy overcame the weakening of the respiratory muscles. The MIP temporarily decreased postoperatively, suggesting that the preoperative improvement in the MIP resulted in a favorable postoperative course.

4 | IMPLICATIONS ON PHYSIOTHERAPY PRACTICE

We conducted a short-term, intensive, and minimalistic preoperative physical therapy program for a patient with esophageal cancer and physical frailty. Although the patient's physical performance did not significantly improve, significant improvements were observed in exercise tolerance and respiratory muscle strength. The patient was able to start walking soon after surgery and had a better outcome than expected. Preoperative physical therapy to increase the reserve capacity may result in a favorable postoperative course, even in patients with physical frailty.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data used in this report are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

Not applicable.

PATIENT CONSENT STATEMENT

Written informed consent was obtained from the patient for the publication of this report and accompanying images.

PERMISSION TO REPRODUCE MATERIAL FROM OTHER SOURCES STUDY REGISTRATION

Not applicable.

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