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RESEARCH ARTICLE

The Effect of "Prehabilitation" on Patients Who Underwent Thoracic Eras in Our Clinic

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ABSTRACT

Objectives: Enhanced Recovery After Surgery (ERAS) protocols have been developed to reduce postoperative complications and shorten hospital stays. In this study, we aimed to investigate the effects of prehabilitation and the ERAS protocol in patients who underwent thoracic surgery.

Methods: Between May 15, 2022, and February 15, 2023, 80 individuals scheduled for surgery were included in the study. A prehabilitation program was designed for these patients, which consisted of incentive spirometry, endurance exercises, and breathing exercises within the ERAS protocol. After the prehabilitation program, respiratory function tests were repeated, and pre- and post-program values were compared.

Results: The discharge times of patients in the ERAS group were found to be significantly shorter ($p<0.001$). A statistically significant difference ($p<0.001$) was also observed in terms of chest drain removal times. Moreover, when the results of respiratory function tests and the 6-minute walking test before and after prehabilitation were compared, a statistically significant improvement was found in all evaluated parameters following prehabilitation ($p<0.001$).

Conclusion: Prehabilitation is the first step of the ERAS protocol and the least emphasized component in previous studies. Our study highlighted the effect and importance of prehabilitation in thoracic surgery patients undergoing the ERAS protocol.

Keywords: ERAS protocol, prehabilitation, thoracic surgery

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Introduction

Lung cancer is the leading cause of cancer-related deaths worldwide.[1] The reported postoperative complication rates in lung resections performed due to non-small cell lung cancer range from 9% to 37%.[1–3] In thoracic surgery patients, tests that measure respiratory capacity such as blood gas, RFT (Respiratory Function Test), DLCO, VO2max, and the 6-minute walking test are of great importance in determining preoperative risk and guiding the surgery to be performed if lung resection is planned.[4]

In addition to lung capacity tests, preoperative tests examining the patient's motor functions and muscle strength have begun to be used to determine preoperative risk factors. It is known that the frequency of postoperative side effects increases in the surgical treatment of elderly patients due to limited physiological reserves and the increase in sarcopenia index with age.[5] Additionally, more than half of advanced-stage cancer patients have sarcopenia.[6] Current studies have shown that the presence of preoperative sarcopenia increases the risk of postoperative complications and that survival is worse in sarcopenic patients.

The ERAS (Enhanced Recovery After Surgery) guideline, based on evidence-based practices, was published by the European Society of Thoracic Surgeons (ESTS) with the aim of improving the quality of life of patients after lung cancer surgery and reducing complications and mortality.

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Enhanced Recovery After Surgery (ERAS) protocols are derived from the need to minimize hospital stay duration and reduce hospital costs. In the ERAS protocol and current studies, weak preoperative exercise capacity is associated with early and late postoperative complications and survival in curative lung cancer surgery.[7–9] Therefore, we aimed to improve the preoperative respiratory functions of patients undergoing thoracic surgery through "prehabilitation" (preoperative rehabilitation), and consequently to shorten postoperative thoracic drain removal time and the length of stay in hospital and intensive care.

Methods

For our study, 80 patients who applied to the Mersin University Hospital Chest Surgery outpatient clinic between May 2022 and December 2022, who met the inclusion and exclusion criteria, and who were scheduled for elective thoracic surgery were evaluated as the study group. The data of the control group patients were obtained retrospectively from hospital records. Ethics committee approval was obtained for the study by the Mersin University Clinical Research Ethics Committee with the decision numbered 2022/314 dated 11.05.2022. This study was conducted in accordance with the Declaration of Helsinki.

The study was designed as a retrospective–prospective cohort design. After the decision for elective surgery was made for the individuals included in the study, a prehabilitation program was created within the scope of the ERAS protocol routinely applied in our clinic, and the patients were asked to continue breathing and endurance exercises until the date of surgery.

As part of the prehabilitation program, a daily walking schedule was prepared for the patients until their surgery dates, in accordance with their physical capacities. If the patients could walk for 0–5 minutes, they were asked to walk at least twice a day (optimally 3 times). If they could walk for 5–10 minutes, they were asked to walk twice a day. If they could walk for 10–15 minutes, they were asked to walk at least once. If they could walk for 15–20 minutes, they were asked to walk once a day. The patients were also given a program that included shoulder, arm, and leg exercises.

The patients were scheduled to do a daily "Diaphragmatic Breathing Exercise". As part of the exercise, patients were asked to lie down at 45 degrees, hold their breath as long as they could, take a deep breath, and slowly release it while pressing their hands on their abdomen. They were told to repeat this exercise 10 times every hour. In addition, patients were provided with a "Triflow" breathing exercise device and given training on its use. Patients were asked to practice this exercise for 30 minutes a day.

Minimally invasive surgery is the most important perioperative element of the ERAS protocol. In the study group patients to whom we applied the ERAS protocol, a hybrid method was used instead of traditional posterolateral thoracotomy in the lung resection and thoracotomy patient group. In this hybrid approach, a muscle-sparing mini thoracotomy incision with a length ranging from 5 to 8 cm was combined with a videothoracoscopic camera port placed at the level of the 7th intercostal space anterior axillary line.

PET-CT images taken in the preoperative period in 80 patients included in the study were evaluated via PACS (picture archiving and communication systems) CT slices. Right and left psoas muscle densities and areas were calculated at the level of the 3rd lumbar vertebra for the purpose of evaluating sarcopenia. Individuals with a psoas muscle mass below 1436 mm^2 for male patients and below 918 mm^2 for female patients were radiologically evaluated as sarcopenic (Fig. 1).

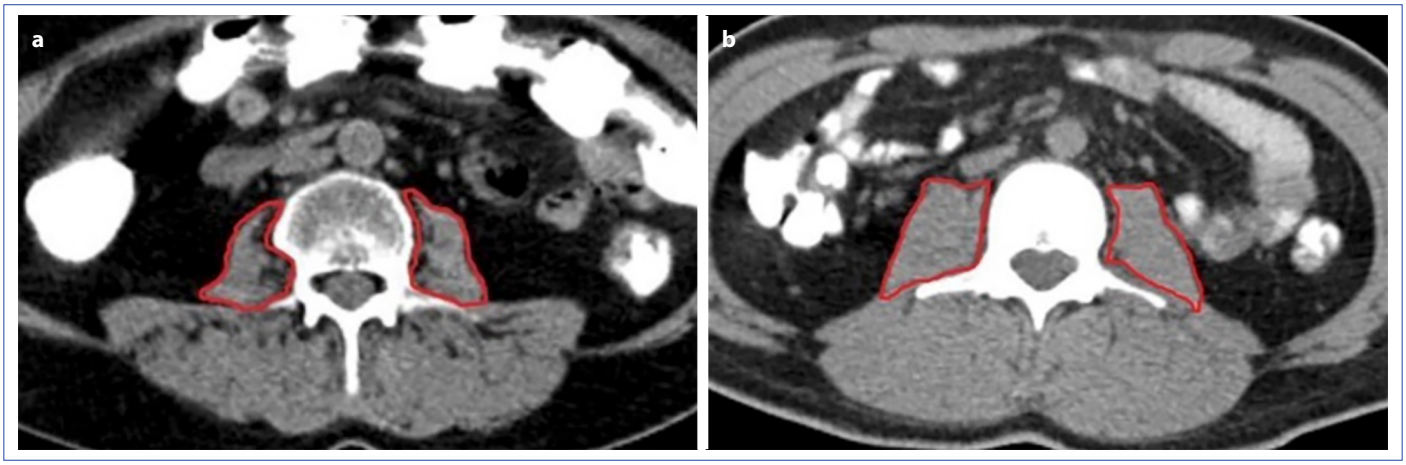

Figure 1. (a) On the left, a CT section taken from the L3 vertebra level of a 56-year-old female patient (Total psoas area: 736 mm^2), and **(b)** a CT section taken from the L3 vertebra level of a 24-year-old male patient (Total psoas area: 2403 mm^2).

CT: Confidence interval.

Table 1. Postoperative hospitalization and drain removal durations of the study group patients

Operation	Average postoperative stay duration (days)	Average intensive care unit length of stay (hours)	Average drain termination time (days)	Case number
Bronchoscopy	1	X	x	7
Mediastinoscopy	1	X	x	6
Tumor excision	10	X	x	3
Thoracotomy	4.81	25.44	3.75	16
Thoracotomy/resection	5.38	33.12	4.04	21
VATS	3.25	25.68	2.70	27
Grand total	4.01	27.84	3.40	80

VATS: Video-assisted thoracoscopic surgery.

The study group that underwent the ERAS protocol was compared with the control patient group treated in our clinic before the ERAS protocol in terms of postoperative hospital stay, need for intensive care, and tube thoracostomy termination time. In our study, the respiratory function tests and 6-minute walking tests of patients who underwent "Prehabilitation" were compared before and after "Prehabilitation".

Data Analysis

The distribution of the data was checked with the Shapiro-Wilk test. Numerical variables that did not provide the normal distribution assumption were summarized as median (25P–75P), and variables that did were summarized as mean±standard deviation. Categorical variables were summarized as numbers and percentages.

In the comparison of two independent groups, the Independent Sample t test was used when the distribution assumption was met, and the Mann-Whitney U test was used when it was not met. For more than two groups, ANOVA (post hoc test: Bonferroni) or Kruskal-Wallis test (post hoc: Dunn) was performed according to the distribution assumption, and Bonferroni correction was applied to p values.

Spearman correlation coefficient was calculated to investigate the relationship between continuous variables. Chi-square test was used to determine the relationship between categorical variables. $p<0.05$ was accepted as the statistical significance level.

The analyses were performed with Statistica v.13.3.1.

Results

In the study group, 21 patients underwent lung resection, 16 patients underwent thoracotomy, 27 patients underwent VATS, 7 patients underwent bronchoscopy, 6 patients underwent mediastinoscopy, and 3 patients underwent soft tissue tumor excision. The control group, which was not subjected to the ERAS protocol and was examined retrospectively, was randomly determined to match the number of the study group according to the type of surgery.

The average length of stay in the study group patients who underwent the ERAS protocol according to the type of operation was found to be 5.38 days for patients who underwent lung resection, 4.81 days for patients who underwent thoracotomy, and 3.25 days for patients who underwent VATS (Video-Assisted Thoracic Surgery). The average length of stay in the control group patients, who did not undergo the ERAS protocol and were operated on by the same surgeon in our clinic in 2019 and 2020, was found to be 9.33 days for patients who underwent lung resection, 7.68 days for patients who underwent thoracotomy, and 6.18 days for patients who underwent VATS. When the discharge times of patients who underwent lung resection, thoracotomy, and VATS were compared, it was found that the patients in the study group were discharged from the hospital in a statistically significant shorter time ($p<0.001$) (Table 1–3).

The mean drain removal times according to the type of operation in the study group patients were found to be 4.04 days postoperatively for lung resection, 3.75 days postoperatively for thoracotomy, and 2.7 days postoperatively for VATS. When the control group patients were evaluated, it was found to be 6.61 days postoperatively for lung resection, 6.31 days postoperatively for thoracotomy, and 4.59 days postoperatively for VATS. A statistically significant difference was found for the thoracic drain termination times for all three types of operations ($p<0.001$) (Table 1, 2, 4).

When the preoperative pre- and post-rehabilitation spirometry and six-minute walk test results of 80 patients who underwent the ERAS protocol were evaluated, after preoperative rehabilitation:

Table 2. Postoperative hospitalization and drain removal durations of the control group patients

Operation	Average postoperative stay duration (days)	Average intensive care unit length of stay (hours)	Average drain termination time (days)	Case number
Bronchoscopy	1.5	x	x	7
Mediastinoscopy	1.2	x	x	6
Tumor excision	10	X	x	3
Thoracotomy	7.68	28.32	6.31	16
Thoracotomy/resection	9.33	42.24	6.61	21
VATS	6.18	27.36	4.59	27
Grand total	6.67	32.4	5.68	80

VATS: Video-assisted thoracoscopic surgery.

Table 3. Comparison of hospitalization durations between the ERAS group and the control group

Operation	ERAS group postoperative hospitalization duration (days)	Control group postoperative hospitalization duration (days)	Difference between the two groups (days)
Lung resection	5.38	9.33	3.95
Thoracotomy	4.81	7.68	2.87
VATS	3.25	6.18	2.93

ERAS: Enhanced recovery after surgery.

Table 4. Comparison of chest tube removal times between the ERAS group and the control group

Operation	ERAS group chest tube termination time (days)	Control group chest tube termination time (Days)	Difference between the two groups (days)
Lung resection	4.04	6.61	2.86
Thoracotomy	3.75	6.31	2.27
VATS	2.7	4.59	1.89

For spirometry values: It was determined that there was a 0.07 L (2.9%) increase in FEV_1 value, a 0.06 L (1.8%) increase in FVC value, and a 1.1 unit (1.38%) increase in the FEV_1/FVC ratio.

For the six-minute walk test: There was a 0.7 unit (0.7%) increase in input saturation, a 2 unit (2.2%) increase in output saturation, a 1.6 unit (27.5%) decrease in the amount of desaturation, and a 15 m (3.4%) increase in walking distance.

When the values before and after the preoperative rehabilitation applied to the study group patients were compared, it was determined that there was a statistically significant improvement in all the parameters evaluated after the rehabilitation ($p<0.001$) (Table 5).

The correlation between total psoas area, spirometry, six-minute walk test, and hand dynamometry results in the study group patients was studied. Data analysis was evaluated with Spearman's rank correlation coefficient.

There was a statistically significant, positive, and good correlation between the handgrip dynamometry test and FEV_1 ($r=0.686$, $p<0.001$), FVC ($r=0.732$, $p<0.001$), total psoas area ($r=0.694$, $p<0.001$), and walking distance ($r=0.476$, $p<0.001$).

There was a statistically significant, positive, and moderate correlation between total psoas area and FEV_1 ($r=0.535$, $p<0.001$), FVC ($r=0.574$, $p<0.001$), and walking distance ($r=0.403$, $p<0.001$).

When the data were examined, it was seen that the total psoas muscle area measurement used in the evaluation of sarcopenia and the six-minute walk test and spirometry tests used to evaluate respiratory functions were statistically significantly correlated.

Table 5. Changes in respiratory parameters before and after prehabilitation

	Average value before prehabilitation	Average value after prehabilitation	Change amount	Percentage of change
FEV_1	2.35 lt	2.42 lt	0.07 lt	2.9%
FVC	3.23 lt	3.29 lt	0.06 lt	1.8%
FEV_1/FVC	72%	73%	%1	1.38%
Walking distance	432 m	447 m	15 m	3.4%
Desaturation rate	5.8%	4.2%	1.6%	27.5%
Input saturation	95.5	96.2	0.7	0.7%
Output saturation	90.2	92.2	2	2.2%

FEV_1: Forced expiratory volume in one second; FVC: Forced vital capacity

There was a statistically significant, positive, and moderate relationship between walking distance and total psoas area (r=0.403, p<0.001), FEV_1 (r=0.572, p<0.001), and FVC (r=0.544, p<0.001); while there was a statistically significant, inverse, and moderate relationship with age (r=-0.416, p<0.001).

Discussion

Lung cancer is one of the leading malignancies causing death worldwide. The only curative treatment option for small cell lung cancer is anatomical lung resection. The patient's cardiopulmonary capacity must be above a certain level for them to tolerate lung resection.[10] Approximately 37% of patients suitable for anatomical lung resection due to lung cancer cannot undergo surgery because of limitations in respiratory functions.[11]

The ERAS protocol has been adapted for other surgical disciplines based on evidence that it accelerates postoperative recovery, reduces hospital stay, and decreases morbidity.[12] The Thoracic ERAS program includes three main sections: preoperative, intraoperative, and postoperative. The intraoperative phase includes minimally invasive surgery and optimal analgesia. The postoperative phase includes pain control, early mobilization, early oral intake, and the prevention of nausea and vomiting. The preoperative period involves nutritional support, counseling, correction of anemia, and prehabilitation.[13]

Prehabilitation is a comprehensive set of rehabilitation programs aimed at increasing patients' respiratory and physiological capacities during the preoperative period. It starts with the clinic examination where the surgical decision is made and continues until the day of the operation.[14] In this study, we aimed to emphasize the preoperative rehabilitation phase, which is perhaps the least highlighted but one of the most important phases of the ERAS protocol in the literature.

In our study, patients in the ERAS group underwent a prehabilitation program lasting an average of 10 days. Evaluation of the preoperative and post-rehabilitation spirometry and six-minute walk test results of 80 patients who underwent the ERAS protocol revealed statistically significant increases in FEV_1, FVC, and FEV_1/FVC after preoperative rehabilitation (prehabilitation). The six-minute walk test results also showed an average increase in walking distance of 15 m, which was statistically significant. As seen in our study, sarcopenia has been observed to coexist, particularly in older patients. Initiating breathing and muscle exercises in patients is believed to be beneficial by increasing muscle activation and respiratory capacity, especially in sarcopenic patients.

The duration of traditional pulmonary rehabilitation typically varies between 8–14 weeks.[10] However, since chest surgery operations are mostly performed due to malignancies, long rehabilitation programs are not suitable for many chest surgery patients. Many associations, including the British Thoracic Society, advocate that lung resection surgery for lung cancer should not be postponed for more than 4 weeks.[15]

In our study, we found that there was a statistically significant increase in the vital and exercise capacity of patients with prehabilitation, which is consistent with the literature. When compared with the current literature, it was observed that the improvement in vital capacity and exercise capacity was statistically significant in our study, but the improvement in respiratory functions was less compared to other studies. We think that this situation is related to our short preoperative rehabilitation period. In the studies in the literature, the prehabilitation period was determined as an average of 4 weeks.

In our clinic, 16 out of 80 patients in the study group who underwent surgery were found to be sarcopenic in their radiological imaging. Fourteen of these 16 sarcopenic patients were observed to have decreased muscle strength

in the hand dynamometry test. All patients with decreased muscle strength in the hand dynamometry test were also observed to be sarcopenic radiologically.

In our study, a positive, statistically significant, and moderate correlation was observed between total psoas area, FEV_1, FVC, and walking distance values. In line with the literature, it was observed that sarcopenia values and respiratory function values were correlated in our study. This suggests that sarcopenia and decreased muscle strength may be important indicators in terms of postoperative complication risks.

In our study, the patient group operated on by the same surgeon and treated with the ERAS protocol and the patient group not treated with the ERAS protocol were compared in terms of postoperative hospitalization time, intensive care unit stay, and chest tube termination time. There was no significant difference between the ERAS and non-ERAS groups in terms of age, gender, and type of operation. However, when the ERAS and non-ERAS groups were compared, it was determined that chest tube termination time and postoperative hospitalization time were statistically significantly shortened in the patient groups that underwent lung resection, thoracotomy, and VATS. No significant difference was found between the two groups in terms of intensive care unit stay.

It was observed that the postoperative hospital stay was shortened by an average of 4 days in the resection patients who applied the ERAS protocol, 2.8 days in the thoracotomy group, and 2.9 days in the VATS group. When all types of operations were included, the average hospital stay was reduced by 2.6 days, and the chest tube termination time was improved by an average of 2 days. The best improvement in postoperative hospital stay according to the type of operation was in the resection and thoracotomy patient groups.

In the study group patients to whom we applied the ERAS protocol, the hybrid method was used instead of traditional posterolateral thoracotomy in the lung resection and thoracotomy patient groups. In the study conducted by Yamamoto et al.,[16] no significant difference was found between the hybrid approach and the 3-port VATS approach in terms of bleeding, chest tube termination time, and postoperative hospital stay in patients who underwent anatomic lung resection.

In a study conducted by Senturk et al.,[17] they particularly emphasized the "awareness" aspect of Thoracic ERAS for clinicians and noted that even considering the implementation of the ERAS protocol contributes to the success of perioperative care.

With the ERAS protocol, the postoperative hospitalization period of our study patients was statistically significantly shortened in accordance with the current literature. With the ERAS protocol, prehabilitation was applied to the patients, and they entered the operation more prepared in terms of mental and exercise capacity. The thoracotomy incision was reduced, and a muscle-sparing hybrid incision was applied. The traditional approach in chest tube termination criteria was abandoned, and chest tubes were removed earlier in line with ERAS recommendations. After discharge, none of the study group patients required rehospitalization. Although our prehabilitation period can be considered short, significant improvements were obtained in patients' respiratory and exercise capacity in this short time. It was observed that prehabilitation provided meaningful benefits in hospitalization period and morbidity.

One of the limitations of our study is that all ERAS group patients were selected and planned from a recent period (2022), while the patients in the control group were selected and planned from the 2019–2020 period.

Conclusion

Prehabilitation, the first step of the ERAS protocol, is the stage where standardization has still not been equally achieved across centers. While its importance has not been sufficiently emphasized in studies conducted to date, it is a crucial step for accelerating recovery. Considering the results obtained in our study, prehabilitation becomes even more significant, especially in surgeries with high mortality and morbidity rates, such as thoracic surgery.

Disclosures

Ethics Committee Approval: The study was approved by the Mersin University Clinical Research Ethics Committee (no: 2022/314, date: 11/05/2022).

Informed Consent: Informed consent was obtained from all participants.

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