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Original Article

The efficacy of enhanced recovery after surgery for the perioperative care of lung cancer patients with thoracoscopy

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Abstract: Objective: To observe the efficiency of the enhanced recovery after surgery (ERAS) program for lung cancer patients who received thoracoscopy in the perioperative period. Methods: A total of 144 patients with lung cancer admitted to the Department of Thoracoscopic Surgery in the Qingdao Haici Medical Group to receive thoracoscopy were enrolled in this study, and they were allocated to the observation group (ERAS, n=72) or the control group (conventional care, n=72) based on the care methods used. The hospital stays, postoperative exhaust time, time to ambulation, time to chest drainage tube removal, fluid volume drained from the thoracic cavity, postoperative pain, postoperative pulmonary function, and complications were observed and compared between the two groups. Results: Compared with the control group, the length of the hospital stay, the postoperative exhaust time, time to ambulation, and time to chest drainage tube removal of the observation group were shorter; furthermore, the costs of hospitalization were lower; the pain scores were lower at 24 hours, 3 days, and 5 days after surgery; the forced expiratory volume in one second (FEV1), FEV1%, maximal voluntary ventilation (MVV), MVV%, forced vital capacity (FVC) and FVC% at 3 days after surgery were higher, and the incidence of complications was lower (all $P<0.05$). Conclusion: The application of the ERAS accelerated the recovery of the bodies of lung cancer patients undergoing thoracoscopy in the perioperative setting, promoted the recovery of postoperative pulmonary function, and reduced postoperative pain and complications.

Keywords: Enhanced recovery after surgery, lung cancer, thoracoscopy, perioperative period, efficacy

Introduction

Lung cancer is a disease harmful to human health that has a high morbidity [1]. It is also the malignant tumor with the highest morbidity and mortality among all tumors in China [2]. Among the subtypes of lung cancers, non-small cell lung cancer is most common, followed by squamous cell cancer [3]. Advanced lung cancer is frequently accompanied by metastasis [4, 5]. Therefore, the early detection and treatment of lung cancer are positive and important aspects of the prognosis of patients with lung cancer. Surgical treatment is still the primary method of treatment of patients with early- and intermediate-stage lung cancer. With the development of science and technology, as well as the progress of minimally invasive technology, the preferred surgical method has gradually evolved from thoracotomy to thoracoscopy [6, 7]. Previous studies indicate that thoracoscopy has the advantages of less trauma and a faster recovery [8]. Although thoracoscopy is becoming increasingly advanced in clinical practice, postoperative complications are still inevitable, including post-operative pain, infection, and so on [9]. Therefore, optimizing the modes of perioperative care is helpful in treating the diseases and the quality of the patients' recovery.

Enhanced recovery after surgery (ERAS) is an optimized program of treatment and care for patients in the perioperative period. Specifically, it refers to a program to optimize the relevant measures for perioperative care employing evidence-based medical practices, and then implementing them in specific steps, to alleviate the psychological and physiological trauma,

reduce the stress response following surgery, enhance the recovery of gastrointestinal function, and reduce the postoperative complications [10, 11]. The ERAS program goes through the whole process before, during, and after surgery. It integrates the procedures of disease diagnosis, surgery, health care, and rehabilitation, leading to the early recovery of patients [12-15]. Currently, ERAS programs have been applied in many fields around the world and have achieved good effects [16, 17]. However, few studies have examined the use of ERAS in lung cancer patients undergoing thoracoscopy in China. Given this, in this study, the combination of the ERAS program with thoracoscopy for lung cancer was applied in order to observe their clinical efficacy in patients, with the aim of clarifying the clinical value of ERAS in lung cancer patients undergoing thoracoscopy.

Materials and methods

Clinical data

This study was approved by the Ethics Committee of Qingdao Haici Medical Group. A total of 144 patients with lung cancer who admitted to the Thoracoscopic Surgery Department in the Qingdao Haici Medical Group from October 2016 to October 2018 and who received thoracoscopy were enrolled in this retrospective study. According to the type of care, 72 patients with ERAS were placed in the observation group, and 72 patients with conventional care were placed in the control group. The patients varied in age from 30 to 68 years old, with a mean age of 63.29±8.28 years. All patients enrolled in this study signed and provided a written informed consent.

Inclusion criteria

Patients were eligible for enrollment if they had lung cancer confirmed by preoperative fiberoptic bronchoscopy and postoperative pathological evidence and underwent thoracoscopy [3]; tumor size ≤6 cm; no mediastinal lymph node enlargement, but the tumors had not invaded the chest wall; the tumor, node, metastasis (TNM) classification of stages I a-III a; normal blood coagulation and bone marrow function; and complete clinical data.

Exclusion criteria

Patients were illegible for enrollment if they had cardiac insufficiency; other primary malignant tumors; abnormal blood coagulation or bone marrow functions; hepatorenal insufficiency; were unable to cooperate in the study; changed to receive thoracotomy due to a massive hemorrhage during thoracoscopy; or lacked clinical data.

Methods

The control group received conventional care during the perioperative period, which included (1). Admission education: inquiry of the patients' medical history, introduction to the ward environment, education on safety knowledge (such as how to prevent falls or falling off the bed), introduction to the physicians and nurses in charge, introduction to the ward visit timing and the visit system, education on diet-related knowledge, and surgery-related introduction. (2). Exercise on postoperative pulmonary function: the nurse in charge demonstrated and instructed the patients to do respiratory function training, mainly by means of pursed lips and ventral breathing and the balloon-blowing mode. (3). No administration of analgesics at regular intervals, 50-100 mg of flurbiprofen, an analgesic drug (Beijing Tide Pharmaceutical Co., LTD, China), was injected intravenously when the patient had a visual analog scale (VAS) score higher than 4. (4). No abnormal results of blood routine examination or abnormal body temperature, with pleural fluid drainage of less than 100 mL/d, no leakage of the thoracic duct, cough fluctuation less than 2 cm, and no purulent, chylous, or bloody drainage. The thoracic duct was removed when the chest X-ray showed lung recruitment in good condition.

The observation group adopted the ERAS program for perioperative care. The program was performed based on the consensus of experts on perioperative management by the ERAS in China in 2016 [18]. The detailed program consists of the following steps:

Step 1, health education including: a) admission health education: at clinical visits, the outpatient physicians handed out leaflets related to the perioperative period to the patients, so that the patients could get a preliminary understanding of the perioperative period. After admission, the nurses in charge of the beds explained to the patients the relevant knowledge on ERAS and its application methods, and informed them of the causes, mechanisms of

onset and development, treatment methods at different stages, and the prognosis of lung cancer, and they emphasized the harm of smoking to humans and advocated the necessity of quitting smoking and active cooperation of the patients and their families in implementing ERAS in the perioperative period; b) education timing: presentations were made to the patients and their families by the head nurse twice a week before surgery; c) education contents: the procedures and importance of ERAS were introduced to enable the patients to get an understanding of the surgery and the present status of the departments of the hospital, so as to eliminate their doubts and build their confidence in treatment; an introduction to the key points (including preoperative preparation and respiratory function exercises) that should be done by the patients in cooperation before and after surgery, as were the focuses of postoperative diets and ambulatory activities; communicating with the patients and solving the difficulties encountered by patients in a timely manner could make them feel relaxed and comforted before and after surgery.

Step 2, early respiratory function training and ambulatory activities: on day 1 after their surgeries, the patients were encouraged to participate in respiratory function trainings (including inspiration and exhalation) 4-6 times a day, within the limit of physical tolerance; they were encouraged to get out of bed to stand, and do ambulatory activities as early as possible if they had no discomfort or intolerable pain.

Step 3, analgesic management: prophylactic analgesia was performed within 3 days after the surgery, i.e. a daily intravenous injection of flurbiprofen (50-100 mg) was administered every 12 h.

Step 4, drainage tube removal: the drainage tube was removed when the patient reached a normal body temperature, had no infection according to a blood routine examination, the daily drained volume <300 mL/d, fluid-level fluctuation <2 cm in the case of cough, and lung compression <20% on the chest X-ray.

Outcome measures

Primary outcome measures: Postoperative length of hospital stays: this was defined as the days from the initial hospitalization in the ward after the completion of surgery to discharge from the hospital.

Postoperative exhaust time: this was defined as the time to the patient's first anal exhaust after the surgery.

Time to ambulation after surgery: this was defined as the time to ambulation in the ward without discomfort after surgery (generally more than 30 minutes after completion of the surgery), and the time was recorded by the hour.

Time to chest drainage tube removal and drained volume: the time to chest drainage tube removal was defined as the time from the completion of the surgery to the time of the chest drainage tube removal; and the drained volume upon tube removal was also recorded.

Postoperative pain: the patient's subjective pain was quantified using a linear visual analogue scale (VAS). On the 10 cm scale, there were two finite boundaries at 0 and 10 cm (the end of the scale), where 0 represented no pain and 10 represented the most severe pain experienced by the patient. The patient selected a certain point between 0 and 10 on the scale according to the degree of pain and measured the selected point. The numerical value at the point was the patient's VAS score. The degree of pain was measured for each patient at 6 hours, 24 hours, 3 days, and 5 days after the surgery, respectively [19].

Pulmonary function tests: the forced expiratory volume in one second (FEV1), the maximal voluntary ventilation (MVV), and the forced vital capacity (FVC) were measured before surgery, and at 3 and 7 days after surgery, as were FEV1, MVV and FVC as a percentage of the predicted values.

Secondary outcome measures: Postoperative complications: the postoperative complications included pulmonary infections, arrhythmia, atelectasis, pleural effusion, surgical-site infection, thrombosis, etc. The number of complications in the patients was recorded. Incidence of complications = Number of complications/Total number of patients *100%.

Statistical analysis

Statistical analyses were performed using SPSS statistical software, version 17.0. The continuous data were expressed as the mean ± standard deviation) ($\bar{x}$ ± sd). The continuous

Table 1. General information

Variables	Control group (n=72)	Study group (n=72)	t/X^2	P
Sex (male:female)	42:30	40:32	0.113	0.736
Age (year)	63.1±8.3	63.5±8.3	0.261	0.795
Types of cancer				
Adenocarcinoma	46	48	0.123	0.726
Squamous carcinoma	26	24		
Stages of TNM differentiation				
Stage of I-II	61	60	0.052	0.820
Stage of III	11	12		
Degree of tumor				
High differentiation	42	41	0.123	0.940
Moderately differentiated	26	26		
VAS pain score			F	P
Poorly differentiated	4	5		
Tumor size (cm)	0.57±0.35	0.61±0.33	0.624	0.534

Note: VAS, visual analog scale.

data with a normal distribution and a homogeneity of variance were measured using a *t*-test, and a one-way analysis of variance (ANOVA) was used for the comparisons at different time points within a group, followed by the post hoc, least significant difference (LSD) test. The comparisons between two groups at multiple time points were made with the use of a repeated measure ANOVA combined with the post hoc, LSD test. The continuous data without a normal distribution and homogeneity of variance were detected using a rank sum test. The count data were expressed as % and analyzed using a Pearson chi-squared test. The differences were statistically significant at $P<0.05$.

Results

General information

There were no significant differences in terms of sex, age, types of cancer, stages of TNM and degree of tumor differentiation between the two groups (all $P>0.05$; **Table 1**).

Comparison of the postoperative indicators

The observation group had shorter hospital stays, postoperative exhaust times, time to ambulation, time to chest drainage tube removal, and lower hospitalization costs than the control group (all P<0.05; **Table 2**).

Comparison of postoperative pain scores

The pain scores were lower at 24 hours, 3 days, and 5 days after surgery in the observation group than they were the control group (all P<0.05; **Table 3**).

Comparison of pulmonary function before and after surgery

The FEV1, FEV1%, MVV, MVV%, FVC, and FVC% values were insignificantly different between the two groups before and 7 days after surgery (all $P>0.05$); however, the corresponding values in the observation group were higher than those in the control group 3 days after surgery (all $P<0.05$; **Table 4** and **Figure 1**).

Comparison of postoperative complications

The comparisons of the postoperative complications between the two groups showed that the overall rate of complications (pulmonary infection, systemic inflammatory response, atelectasis, pleural effusion, surgical-site infection, and thrombosis) in the observation group was lower than it was in the control group, and the differences were statistically significant ($P<0.05$), as shown in **Table 5**.

Discussion

Among the studies on the post-operative recovery of patients, a previous meta-analysis included seven randomized controlled studies involving 486 patients. The results of the analysis demonstrate that the ERAS protocol shortens the length of hospital stay, reduces hospitalization costs and postoperative complications, and enhances the post-operative recovery of patients [20]. In another study, ERAS was employed in combination with single-port thoracoscopy in the management of patients with lung cancer. After the use of the ERAS and single-port thoracoscopy, the patients showed significantly reduced pain scores, a shorter time to chest drainage tube removal, and shorter hospital stays [21]. In our present study, we found that the patients in the observation group had shorter hospital stays, postoperative exhaust times, times to ambulation, and times to chest drainage tube removal, and lower hospitalization costs than the control group, a finding con-

Table 2. Comparison of the postoperative indicators

Variables	Control group (n=72)	Study group (n=72)	t	P
Hospital stay (d)	8.94±2.38	12.01±3.97	5.628	<0.001
Postoperative exhaust time (h)	21.14±2.72	26.43±3.15	10.785	<0.001
Pleural drainage (ml)	132.13±3.68	299.87±5.17	18.265	<0.001
Time to ambulation (h)	24.63±2.20	29.54±3.07	11.023	<0.001
Time to chest drainage tube removal (d)	2.91±0.33	5.50±0.63	6.039	<0.001

Table 3. Comparison of the postoperative pain scores

VAS pain score	Control group (n=72)	Study group (n=72)	F	P
3 days after surgery	2.65±0.52[a]	4.85±0.65	344.893	<0.001
4 days after surgery	1.04±0.27[a,*]	2.07±0.27[*]		
5 days after surgery	0.37±0.36[a,*,#]	1.25±0.38[*,#]		
F	1087.347	321.895		
P	<0.001	<0.001		

Note: VAS, visual analogue scale. [*]Compared 1 day after surgery, [#]compared 3 days after surgery, [a]compared with the control group, *P*<0.05.

Table 4. Comparison of pulmonary function before and after surgery

Variables	Control group (n=72)	Study group (n=72)	F	P
Forced expiratory volume in the one second (FEV1)/L				
Before surgery	2.64±0.79	2.63±0.83	365.938	<0.001
3 days after surgery	1.59±0.41[a]	1.23±0.28		
7 days after surgery	1.93±0.39	1.95±0.36		
FEV1%				
Before surgery	98.25±11.89	97.89±11.44	387.882	<0.001
3 days after surgery	57.51±10.85[a]	43.69±7.56		
7 days after surgery	74.63±9.58	73.62±8.72		
Maximal voluntary ventilation (MVV)/L				
Before surgery	92.58±23.78	91.45±22.89	3710.094	<0.001
3 days after surgery	58.51±20.53[a]	44.89±16.59		
7 days after surgery	67.82±18.23	66.68±18.9		
MVV%				
Before surgery	99.58±23.98	98.45±22.78	3567.902	<0.001
3 days after surgery	50.74±8.51[a]	42.65±7.26		
7 days after surgery	61.74±18.74	66.48±18.89		
Forced vital capacity (FVC)/L				
Before surgery	2.92±1.18	2.95±1.23	810.832	<0.001
3 days after surgery	1.79±0.56[a]	1.46±0.62		
7 days after surgery	1.92±0.75	1.91±0.80		
FVC%				
Before surgery	98.56±11.78	98.98±11.26	772.341	<0.001
3 days after surgery	54.62[a]±8.26	42.98±7.56		
7 days after surgery	72.36±8.69	71.63±8.67		

Note: [a]compared with the control group, P<0.05. FEV1, the forced expiratory volume in one second; MVV, maximal voluntary ventilation; FVC, forced vital capacity.

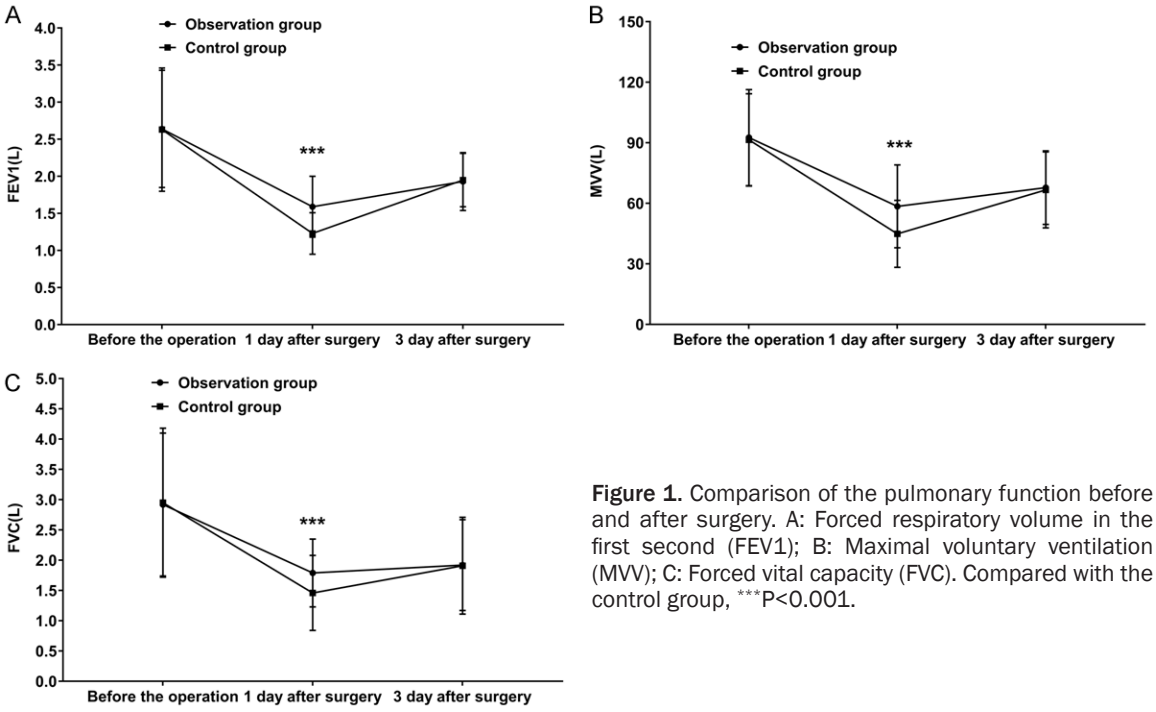

Figure 1. Comparison of the pulmonary function before and after surgery. A: Forced respiratory volume in the first second (FEV1); B: Maximal voluntary ventilation (MVV); C: Forced vital capacity (FVC). Compared with the control group, ***P<0.001.

Table 5. Comparison of postoperative complications

Postoperative complications	Control group (n=72)	Study group (n=72)	χ^2	P
Pulmonary infection	2 (2.78%)	4 (5.56%)		
Systemic inflammatory response	1 (1.39%)	3 (4.17%)		
Pulmonary atelectasis	1 (1.39%)	3 (4.17%)		
Pleural effusion	4 (5.56%)	4 (5.56%)		
Thrombosis	0 (0.00%)	2 (2.78%)		
Surgical-site infection	2 (2.78%)	4 (5.56%)		
The total proportion	10 (13.89%)	20 (27.78%)	4.211	0.040

sistent with the findings of the studies described above.

Previous studies on post-operative pain show that surgical trauma could lead to a significant increase in potassium ion secretion, and the increase in pain-inducing factors could result in pain in the sensory nerve endings [22]; thus, it is necessary to implement pain management in the ERAS program for perioperative care [23]. In addition, a study of the ERAS combined with single-port thoracoscopy revealed significantly decreased postoperative pain scores [21]. Another study found that the use of the ERAS protocol with prophylactic analgesia not only enabled the patients to remove the urinary catheter and ambulate earlier, but it also promoted the blood circulation of patients while they were being administered analgesia, and it enhanced the expansion and re-expansion of the lungs. As a result, the quality of recovery of patients was assured [24]. In our present study, we found that the pain scores of the observation group were lower than those of the control group at 24 hours, 3 days, and 5 days after surgery, consistent with the findings of the above studies.

About the effect of the ERAS on pulmonary function, a previous study mentioned above indicated that the ERAS protocol provided patients with early ambulation, which promoted blood circulation and an expansion of the lungs [24]. In addition, early ambulation also increased respiratory amplitude and improved the removal of pulmonary secretions, lung recruitment, and pulmonary function [25]. In the present study, we also found that the ERAS protocol led to a faster recovery of pulmonary function, which is similar to the finding of the studies described above. Among the studies examining post-operative complications, one study indicated the ERAS protocol reduced the incidence

of post-operative complications [20]. Another study demonstrated that the ERAS protocol resulted in earlier ambulation, greater respiratory amplitude, a better removal of pulmonary secretions, and lower rates of post-operative pulmonary infection, pleural effusion and atelectasis [25]. We also found in the present study that use of the ERAS protocol reduced the incidence of postoperative complications in lung cancer patients, consistent with the above-mentioned studies.

However, in this study, the sample size was small, so a larger sample size is required for further research. Moreover, the follow-up time was short, so longer follow-up times are needed for a systematic evaluation of the effects of the interventions using ERAS on the mid-term and long-term outcomes of lung cancer patients undergoing lobectomies.

In conclusion, use of the ERAS for the perioperative care of lung cancer patients undergoing thoracoscopy results in a faster recovery of the body, an improved recovery of pulmonary function, and less pain and fewer complications after surgery in such patients.

Disclosure of conflict of interest

None.

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