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Enhanced Recovery after Surgery (ERAS) in Postoperative Lung Cancer Patients: A Novel Perioperative Strategy for Preventing Venous Thromboembolism and Improving Quality of Life

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This study aimed to assess the impact of enhanced recovery after surgery (ERAS) intervention in preventing venous thromboembolism (VTE) among postoperative lung cancer patients. Conducted from January 2022 to January 2023, the research involved 125 lung cancer patients randomly assigned to either a control group (n = 60) receiving routine care, or an ERAS group (n = 65) which received both routine care and ERAS interventions. The ERAS program comprised a comprehensive series of interventions meticulously implemented throughout the preoperative, intraoperative, and postoperative phases. Thrombotic risk assessment using the Caprini Risk Assessment Model (RAM) was conducted preoperatively and on postoperative day 5 (POD 5), with plasma D-dimer levels measured preoperatively, on POD 1, POD 3, and POD 5. Quality of life and patient satisfaction were assessed at discharge using the European Organization for Research and Treatment of Cancer (EORTC) Quality of Life Questionnaire-Lung Cancer Module 13 (QLQ-LC13) and The Newcastle Satisfaction with Nursing Scale (NSNS), respectively. The ERAS group demonstrated significantly lower Caprini RAM scores on POD 5 compared to the control group, with lower D-dimer levels on POD 3 and POD 5. The incidence of VTE was lower in the ERAS group (1.54%) compared to the control group (11.67%) during hospitalization. At discharge, the ERAS group showed improved quality of life, with higher satisfaction scores for nursing care and their hospital stay. ERAS nursing interventions effectively mitigate thrombotic risk, improve D-dimer levels, enhance postoperative quality of life, and elevate patient satisfaction among individuals undergoing lung cancer surgery.

Keywords: enhanced recovery after surgery; lung cancer; nursing intervention; patient satisfaction; venous thromboembolism prevention
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Introduction

Venous thromboembolism (VTE), the most preventable cause of death in hospitalized patients, leads to considerable morbidity, healthcare costs, and complications, encompassing post-thrombotic syndrome after deep vein thrombosis (DVT) (20%-50% incidence) and chronic thromboembolic pulmonary hypertension after pulmonary embolism (PE) (0.1%-3.8% incidence) (Cronin et al. 2019). Surgery in cancer patients carries a 2- to 3-fold elevated risk of post-operative DVT and PE compared to non-cancer patients undergoing similar procedures (Agnelli et al. 2006). Lung cancer, known as primary bronchogenic carcinoma, arises from malignant changes in the bronchi's epithelial lining (Park et al. 2022), predominantly impacting elderly males, with non-small cell lung cancer (NSCLC) constituting around 80%-85% of cases (Abdel-Razeq et al. 2023). Notably, data from 2018 global cancer statistics highlighted the prevalence of lung cancer, constituting 11.6% of the 18.1 million newly diagnosed cancer cases (Bray et al. 2018). A previous study reported that 19.3% of lung cancer patients diagnosed with the condition underwent surgery, resulting in VTE incidences of 1.3% and 2.7% at 90 days and 1 year postoperatively, respectively

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(Akhtar-Danesh et al. 2022). The increased VTE incidence in lung cancer patients results from a complex interplay between cancer-related factors and surgery-related conditions. Lung cancer induces a hypercoagulable state due to tumor-related procoagulant substances, endothelial disruption, and inflammation (Pan et al. 2022). Surgery exacerbates VTE risk by causing tissue injury, releasing procoagulant factors, and promoting postoperative immobility, collectively elevating thrombotic susceptibility, especially in the postoperative phase (Ruppert et al. 2010).

Enhanced recovery after surgery (ERAS, also known as fast-track surgery) is a multimodal and perioperative management pathway to reduce the response to surgical stress and has been shown to decrease postoperative complications and length of stay after several types of surgery (Joliat et al. 2023). In 1999, Kehlet et al. discovered that effective pain management after open sigmoid colectomy could accelerate patient recovery, and in 2001, they were the first to propose the concept of ERAS (Kehlet and Wilmore 2008). The key elements of ERAS program include patient and family education and counseling, patient optimization prior to admission, minimal fasting (light meal up to six hours before surgery, carbohydrate beverage two hours before anesthesia), multimodal analgesia with appropriate use of opioids, nausea and vomiting prophylaxis, early nutrition and mobilization (Robella et al. 2023). Hospital stays and immobilization, as risk factors for VTE, are reduced by ERAS (Cho et al. 2022).

The primary aim of this study is to assess the effectiveness of ERAS nursing interventions in reducing postoperative VTE occurrences and enhancing the overall quality of life among lung cancer patients undergoing resection. Anticipated outcomes encompass the potential impact of ERAS interventions on significantly lowering postoperative VTE incidence and improving patient quality of life. Through a comprehensive evaluation covering thrombotic risk, plasma D-dimer levels, quality of life metrics, and patient satisfaction, this study seeks to illuminate the potential advantages of implementing ERAS protocols within the realm of lung cancer surgery. These findings hold promise in shaping tailored perioperative strategies that address both clinical endpoints and the holistic patient experiences during the recovery phase.

Methods

Participants

The study was conducted between January 2022 and January 2023. A total of 125 patients aged 18 years or older and diagnosed with lung cancer were enrolled in the study who underwent lung cancer resection (lobectomy, pneumonectomy) with or without lymph node dissection. Participants were randomly assigned to two groups using computer-generated randomization codes: a control group (n = 60) receiving routine care, and an ERAS group (n = 65) receiving both ERAS interventions and routine care. The study adhered to the ethical principles set forth in the Declaration of Helsinki and received ethical approval from the Ethics Committee of the West China Hospital, Sichuan University to its commencement.

Inclusion and exclusion criteria

The inclusion criteria were as follows: 1) Patients with stage I to III lung cancer, in accordance with the NCCN Clinical Practice Guidelines in Oncology (NCCN Guidelines, Version 2.2021) for NSCLC (Ettinger et al. 2021), rendering them suitable candidates for surgical resection; 2) Patients who had not previously undergone radiotherapy or chemotherapy; 3) Preoperative computed tomography (CT) scans indicated the absence of mediastinal or hilar lymph node metastasis, with no concurrent malignant tumors; 4) Patients exhibited no significant concurrent organ functional disorders and had no history of liver or kidney system diseases. Patients who met any of the exclusion criteria, such as the use of oral anticoagulants prior to surgery and with continued prophylaxis afterwards, severe liver disease or kidney disease, skin allergies or infections, preoperative lung infections, benign lung lesions, autoimmune diseases, or respiratory failure, were excluded from the study. Patients with cognitive impairments that hindered their cooperation with nursing interventions and observations were also excluded.

Interventions

The control group received standard preoperative information without specific counseling, lacked specialized nutritional assessment or oral supplements, advised smoking and alcohol restrictions without emphasis on timing before surgery, and lacked tailored preoperative rehabilitation. Upon admission, they followed conventional fasting guidelines and received sedatives as needed. During the perioperative phase, they had venous thromboembolism prophylaxis based on necessity, lacked standardized antibiotic timing, used standard warming measures, conventional anesthesia, and approaches to prevent postoperative nausea and vomiting (PONV). Pain relief was administered as needed, employing local anesthesia without a specific pain management plan. They received conventional intravenous fluid administration, and routine chest drain and urinary drainage management postoperatively. The ERAS program was an extensive collection of interventions that were meticulously devised and strategically implemented throughout the preoperative, intraoperative, and postoperative phases, adhering to the guidelines outlined in "Guidelines for Enhanced Recovery After Lung Surgery: Recommendations of the ERAS Society and the European Society of Thoracic Surgeons" (Batchelor et al. 2019). The ERAS group, in addition to routine care, received specific preoperative counseling, nutritional assessments, and oral supplements for malnourished patients, emphasized smoking cessation and alcohol abstinence at least 4 weeks before surgery, and considered prehabilitation for borderline lung function patients. Upon admission, they followed modified

fasting guidelines, received no routine preanesthetic sedatives, and had standardized measures for venous thromboembolism prophylaxis. They received antibiotics within a specified time, utilized active warming devices, lung-protective anesthesia techniques, and a multimodal approach for PONV. Pain relief included regional anesthesia, reduced opioid use, and specific analgesic combinations. They received balanced fluid administration, discontinued IV fluids for oral intake, and had modified chest drain and urinary drainage management. Additionally, they emphasized early mobilization within 24 hours post-surgery and tailored physiotherapy adjuncts for rehabilitation. The detailed information has been indicated in Table 1. Throughout the observation period, there were no occurrences of patients dropping out of the study for reasons unrelated to the research objectives, nor were there any instances of missing data due to unforeseen circumstances.

Outcome measurement

All assessments and measurements in this study were performed by the same researcher. Thrombotic risk assessment utilized the Caprini Risk Assessment Model (RAM), incorporating over 30 distinct risk factors (Sterbling et al. 2018). This assessment was conducted both prior to surgery and on postoperative day 5 (POD 5). Parameters for classification encompassed clinical factors such as age, abnormal pulmonary function, body mass index (BMI), bed confinement, major open surgery, and chemotherapy, each assigned a weighted score ranging from 1 to 5 points. Instances of DVT and PE within the perioperative period

Table 1. Comparison of interventional aspects between control group and enhanced recovery after surgery (ERAS) group in preoperative, perioperative, and postoperative phases.

	Control group	ERAS group
Preoperative phase		
1. Preadmission information, education, and counseling	Basic preoperative info provided; no dedicated counseling	Dedicated preoperative counseling routinely
2. Perioperative nutrition	Lack of specialized nutritional assessment or supplements	Nutritional status assessment; Oral supplements for malnourished
3. Smoking cessation	Advised without emphasis on 4 weeks prior	Emphasizes quitting ≥ 4 weeks pre-surgery
4. Alcohol dependency management	Limits intake pre-surgery; lacks 4-week guideline	Avoidance ≥ 4 weeks pre-surgery
5. Pulmonary rehabilitation	No tailored plan or training	Considered for borderline lung function
Admission		
1. Preoperative fasting and carbohydrate treatment	Conventional fasting	Clear fluids until 2h pre-anesthesia; Carbohydrate loading routine
2. Preanesthetic medication	Sedatives provided as needed	Avoid routine anxiety sedatives
Perioperative phase		
1. Venous thromboembolism prophylaxis	Based on need, lacks standardized protocol	Pharmacological & mechanical prophylaxis for major lung resection
2. Antibiotic prophylaxis	Administered as needed; timing not specified	Routine intravenous (IV) antibiotics ≤ 60 min before incision
3. Preventing intraoperative hypothermia	Usual warming methods	Maintain normothermia; Continuous core temp monitoring
4. Standard anesthetic protocol	Conventional techniques	Regional & general anesthesia combos; Short-acting options
5. PONV control	Conventional measures	Non-pharmacological & multimodal pharmacological
6. Regional anesthesia and pain relief	Local anesthesia provided as needed	Emphasis on regional anesthesia; Multimodal pain management
7. Perioperative fluid management	Conventional IV fluids	Avoid extreme regimes; Balanced crystalloids; Oral intake after IV fluids
Postoperative phase		
1. Chest drains management	Standard drainage methods	Avoid routine external suction; Digital drainage systems; Tube removal after high-volume effusion
2. Urinary drainage	Provided as needed	Avoid routine catheter in normal renal function; Reasonable for epidural anesthesia
3. Early mobilization and adjuncts to physiotherapy	General rehabilitation	Mobilization within 24 hours post-surgery

PONV, postoperative nausea and vomiting.

were diligently recorded. DVT manifestations included redness, tenderness, swelling, pitting edema, and the emergence of superficial collateral veins in the legs. PE was characterized by symptoms such as dyspnea, chest pain, cough, tachycardia, cyanosis, dizziness, fainting, and excessive sweating (Falanga et al. 2023). Verification of VTE was accomplished through Doppler ultrasonography and computer tomography pulmonary angiography (CTPA). Blood samples were collected from participants in the morning before surgery and on POD 1, POD 3 and POD 5 to assess plasma D-dimer levels. The quality of life experienced by participants was meticulously evaluated through the administration of the European Organisation for Research and Treatment of Cancer (EORTC) Quality of Life Questionnaire-Lung Cancer Module 13 (QLQ-LC13), including dyspnea (rest, walking and stair activity), coughing, hemoptysis, sore mouth, dysphagia, neuropathy, alopecia, pain in chest, pain in arm or shoulder and pain in other parts (Wang et al. 2022). The Newcastle Satisfaction with Nursing Scale (NSNS) (Supplementary Table S1) assessed patients' satisfaction and experiences with nursing care (Garczyk et al. 2013). Comprising three sections, the self-completion questionnaire includes the Experiences of Nursing Care Subscale (ENCS) with 26 statements rated on a 7-point Likert scale. The Satisfaction with Nursing Care Subscale (SNCS) includes 19 items scored on a 5-point Likert scale. These subscales yield scores ranging from 0 to 100. The questionnaire also includes a demographic section and two seven-point response scales to evaluate nursing care and hospital stay experiences.

Statistical analysis

The data underwent comprehensive statistical analysis utilizing GraphPad Prism 8.0 software (San Diego, CA, USA). Continuous variables were portrayed as means ± standard deviations (SD) or medians along with interquartile ranges (IQR), contingent upon the distribution characteristics following the Shapiro-Wilk test. Categorical variables were represented as frequencies. For continuous variables with a normal distribution, t-test or analysis of variance (ANOVA) was employed to assess group differences. In scenarios where data deviate from normality, Mann-Whitney U tests were utilized for between-group comparisons. Additionally, paired tests will be applied to examine changes within groups over time.

Results

Baseline characteristics of lung cancer patients

Table 2 summarized the characteristics of participants in both the ERAS and control groups. Both groups exhibited similar distributions in terms of age (median age 56.0 in ERAS vs. 54.5 in control, $P = 0.776$), sex ($P = 0.850$), education level ($P = 0.475$), smoking history ($P = 0.571$), alcohol history ($P = 0.828$), presence of chronic obstructive pulmonary disease ($P = 0.703$), hypertension ($P = 0.626$), diabetes ($P = 0.519$), tumor type ($P = 0.104$), and stage of cancer disease ($P = 0.520$). These similarities in baseline characteristics suggest a comparable distribution of demographic and clinical features between the ERAS and control groups.

Comparing Caprini RAM scores and VTE incidence between ERAS and control groups

The normality of distribution for Caprini RAM scores was assessed through the Shapiro-Wilk test, revealing non-normal distribution in both preoperative and postoperative patient groups (both $P < 0.05$). Prior to surgery, the Mann-Whitney U test revealed no significant divergence in Caprini RAM scores between the groups ($P = 0.991$). However, on postoperative day 5, the ERAS group exhibited significantly lower Caprini RAM scores compared to the control group ($P = 0.005$), as depicted in Fig. 1A. Employing the Wilcoxon matched-pairs signed rank test, both cohorts demonstrated escalated Caprini RAM scores post-surgery (both $P < 0.05$). Across the study cohort of 125 lung cancer patients, a total of 8 cases of VTE emerged during hospitalization, contributing to an overall incidence rate of 6.4%. Within the ERAS group (n = 65), 1 VTE case arose, contrasting with the control group (n = 60), which recorded 7 VTE cases (including 5 cases of DVT and 3 cases of PE occurrences). The statistical evaluation denoted a discernable dichotomy between the two groups ($P = 0.028$, Fig. 1B).

Comparison of D-dimer concentrations between ERAS and control groups

As illustrated in Fig. 2, both groups experienced a significant increase in D-dimer levels following surgery. However, this elevation was not uniform, as a slight decrease was observed on POD 3, even though the levels remained higher than the preoperative baseline. The zenith of D-dimer concentration was reached on POD 5. While no significant differences were evident in D-dimer concentrations between the two groups before surgery [ERAS group: 485 (232-628) μg/L; control group: 398.5 (280.8-602.5) μg/L] and on POD 1 [ERAS group: 1,453 (970.5-1,931) μg/L; control group: 1,368 (878-1,815) μg/L], notable distinctions were observed on POD 3 [ERAS group: 825 (499.5-1,125) μg/L; control group: 1,227 (723.5-1,565) μg/L] and POD 5 [ERAS group: 2,088 (1,168-2,932) μg/L; control group: 2,985 (1,928-4,439) μg/L]. Specifically, the D-dimer levels were significantly lower in the ERAS group compared to the control group (both $P < 0.001$).

Comparison of quality of life between ERAS and control groups

Quality of life assessments, including evaluations of dyspnea (at rest, during walking, and during stair activity), coughing, hemoptysis, sore mouth, dysphagia, neuropathy, alopecia, pain in the chest, pain in the arm or shoulder, and pain in other body parts, were conducted for both the ERAS group and the control group (Table 3). No statistically sig-

nificant differences were observed between the ERAS and control groups in terms of individual symptom scales and the symptom summary score before surgery (all $P > 0.05$). Both groups exhibited notable improvements in dyspnea, coughing, sore mouth, dysphagia, neuropathy, alopecia, pain in the chest, pain in the arm or shoulder, and pain in other body parts (all $P < 0.05$). Upon hospital discharge, in comparison to the control group, the ERAS group demonstrated lower scores in dyspnea at rest [4 (2-5) vs. 5 (4-6.75), $P < 0.001$], dyspnea during walking [17 (15-18) vs. 18.5 (17-21), $P < 0.001$], dyspnea during stair activity [21 (19-23) vs. 22 (21-25), $P = 0.001$], coughing [30 (27-31) vs. 32 (30-34), $P < 0.001$], sore mouth [5 (4-6) vs. 4 (3-6), $P = 0.029$], alopecia [7 (6-9) vs. 9.5 (6-11), $P = 0.019$], pain in the chest [6 (5-8) vs. 8 (6-10), $P = 0.001$], pain in the arm or shoulder [9 (8-11) vs. 11 (9-12), $P = 0.005$], and pain in other body parts [18 (16-20) vs. 20.5 (18-23.75), $P < 0.001$]. The symptom summary score also displayed significant disparity between the two groups [ERAS group: 11 (10.54-11.5), control group: 12.33 (11.83-12.92), $P < 0.001$].

Comparison of patient satisfaction at discharge between ERAS and control groups

Using the NSNS, we assessed patient satisfaction in both the ERAS and control groups (Table 4). The ERAS group showed higher scores in the ENCS [81 (IQR: 75.5-92) vs. 69.5 (IQR: 58.25-85), $P < 0.001$], SNCS [79 (IQR: 71-87) vs. 71 (IQR: 49.25-83.75), $P = 0.002$], patients' overall evaluation of nursing care [6 (IQR: 5-6) vs. 5 (IQR: 4-6), $P = 0.002$], and evaluation of the hospital stay [5 (IQR: 4-7) vs. 5 (IQR: 4-6.75), $P = 0.034$]. This indicates higher satisfaction levels in the ERAS group during discharge, regarding nursing care and the hospital stay.

Discussion

A major discovery in this study is the substantial decrease in VTE occurrence among the ERAS group in comparison to the control group while hospitalized. The

Table 2. Sociodemographic characteristics of the study participants in the enhanced recovery after surgery (ERAS) group and control group.

Characteristic	ERAS Group (n = 65)	Control group (n = 60)	*P*
Age (years)	56.0 (IQR: 46.0~69.0)	54.5 (IQR: 50.0~63.0)	0.776
Sex			0.850
Male	44	39	
Female	21	21	
Education			0.475
≤ 12 years	31	33	
> 13 years	34	27	
Smoking history			0.571
Yes	42	42	
No	23	18	
Alcohol history			0.828
Yes	15	12	
No	50	48	
Chronic obstructive pulmonary disease			0.703
Yes	22	18	
No	43	42	
Hypertension			0.626
Yes	11	8	
No	54	52	
Diabetes			0.519
Yes	4	6	
No	61	54	
Tumor type			0.104
Adenocarcinoma	35	41	
Squamous cell	30	19	
Stage of cancer disease			0.520
I	21	18	
II	33	34	
III	11	8	

IQR, interquartile ranges.

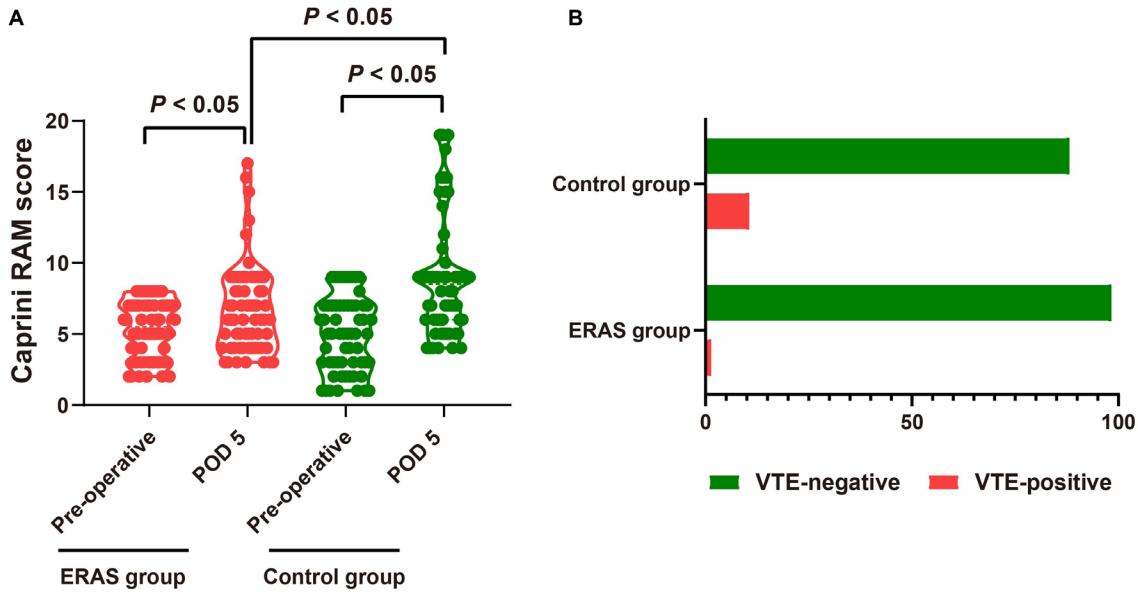

Fig. 1. Comparing Caprini Risk Assessment Model (RAM) scores and venous thromboembolism (VTE) incidence between enhanced recovery after surgery (ERAS) and control groups.
A. Preoperative and postoperative Caprini RAM scores in ERAS and control groups. B. ERAS group had 1 VTE case (1.5%), while control group recorded 7 VTE cases (11.7%). Statistical analysis revealed significant difference between the groups.

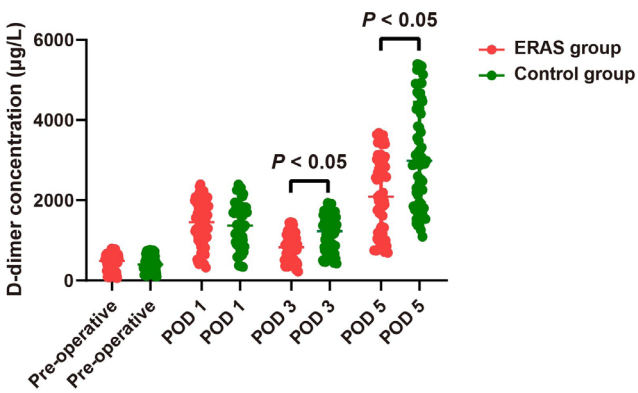

Fig. 2. Comparison of D-dimer concentrations between enhanced recovery after surgery (ERAS) and control groups.
Notable distinctions were observed on postoperative day 3 (POD 3) and postoperative day 5 (POD 5).

ERAS group exhibited a notably lower VTE incidence (1.54%) compared to the control group (11.67%). This significant reduction suggests that ERAS interventions may be pivotal in minimizing the risk of postoperative thrombotic events. This aligns with other studies demonstrating decreased VTE risk after colon cancer resection with ERAS (Vendler et al. 2017) and with ERAS implementation in various surgeries, including major abdominal and pelvic procedures (Rasmussen et al. 2009). Moreover, the rate of VTE events remained low (≤ 1%) among patients on the ERAS pathway for laparotomy and minimally invasive gynecologic surgery (Taylor et al. 2023), and a similar reduction was observed after radical cystectomy with a perioperative VTE prophylaxis program within an ERAS protocol (Chiang et al. 2020). With implementation of an ERAS protocol, only 1 in 46 patients for ovarian cancer patients during first-line therapy experienced a VTE within 30 days after surgery (Li et al. 2021). ERAS interventions significantly contribute to reducing VTE incidence through a multifaceted approach. Patient education emphasizes early mobilization, reducing immobility-related risks. Optimized fluid management minimizes volume overload, aiding circulation. Pharmacological and mechanical prophylaxis targets coagulation and improves blood flow. Enhanced pain control promotes early mobility, mitigating stasis-related VTE risks. Overall, ERAS strategies collectively optimize perioperative factors, addressing stasis, coagulation, and mobility, effectively reducing VTE occurrence.

The study also revealed lower Caprini RAM scores in the ERAS group on POD 5, indicating a reduced overall thrombotic risk. Although both groups demonstrated increased Caprini RAM scores post-surgery, the ERAS group exhibited a more favorable trend, underscoring the potential of ERAS interventions in managing thrombotic risk. D-dimer, a robust VTE indicator that also predicts prognosis and long-term survival post-antitumor therapy (Ke et al. 2020), showed a significant increase in both groups post-surgery. However, a slight decrease was noted on POD 3, even though levels remained elevated compared to the preoperative baseline. The peak D-dimer concentration was observed on POD 5, consistent with previous studies (Kodama et al. 2010). Notably, studies on different surgeries such as primary total hip arthroplasty, hepatocellular

Table 3. Comparison of quality of life between enhanced recovery after surgery (ERAS) and control groups.

QLQ-LC13	Pre-operative		*P*	Hospital discharge		*P*
	ERAS group	Control group		ERAS group	Control group	
Symptom scale						
Dyspnea						
Dyspnea, rest	5.0 (5.0-6.0)	6.0 (5.0-7.0)	0.140	4.0 (2.0-5.0)*	5.0 (4.0-6.8)*	< 0.001
Dyspnea, walking	20.0 (18.0-21.0)	20.0 (18.0-21.0)	0.920	17.0 (15.0-18.0)*	18.5 (17.0-21.0)*	< 0.001
Dyspnea, stair activity	24.0 (22.0-26.0)	25.0 (22.3-26.8)	0.136	21.0 (19.0-23.0)*	22.0 (21.0-25.0)*	0.001
Coughing	34.0 (32.0-36.0)	34.0 (32.0-35.8)	0.867	30.0 (27.0-31.0)*	32.0 (30.0-34.0)*	< 0.001
Hemoptysis	2.0 (1.0-3.0)	2.0 (2.0-3.0)	0.989	2.0 (1.0-3.0)	2.0 (0.3-3.0)	0.597
Sore mouth	5.0 (4.5-7.0)	6.0 (4.0-7.0)	0.888	5.0 (4.0-6.0)*	4.0 (3.0-6.0)*	0.029
Dysphagia	3.0 (2.0-4.0)	3.0 (3.0-3.8)	0.908	3.0 (2.0-3.0)*	3.0 (2.0-4.0)	0.168
Neuropathy	14.0 (12.0-15.0)	13.5 (12.0-15.0)	0.847	12.0 (10.0-13.0)*	12.0 (11.0-14.0)*	0.113
Alopecia	10.0 (8.0-11.0)	9.0 (7.0-11.8)	0.889	7.0 (6.0-9.0)*	9.5 (6.0-11.0)*	0.019
Pain in chest	8.0 (7.0-10.0)	9.0 (7.0-10.0)	0.554	6.0 (5.0-8.0)*	8.0 (6.0-10.0)*	0.001
Pain in arm or shoulder	11.0 (9.5-12.5)	11.0 (10.0-12.8)	0.927	9.0 (8.0-11.0)*	11.0 (9.0-12.0)*	0.005
Pain in other parts	21.0 (19.0-23.0)	22.0 (20.0-24.8)	0.131	18.0 (16.0-20.0)*	20.5 (18.0-23.8)*	< 0.001
Symptom summary score	13.1 (12.8-13.4)	13.3 (12.9-13.7)	0.187	11.0 (10.5-11.5)*	12.3 (11.8-12.9)*	< 0.001

Data are shown as medians (interquartile ranges, IQR). Compared to pre-operative data, *$P < 0.05$.
QLQ-LC13, Quality of Life Questionnaire-Lung Cancer Module 13.

Table 4. Comparison of patient satisfaction at discharge between enhanced recovery after surgery (ERAS) and control groups.

NSNS subscales	ERAS group	Control group	*P*
ENCS	81.0 (75.5-92.0)	69.5 (58.3-85.0)	< 0.001
SNCS	79.0 (71.0-87.0)	71.0 (49.3-83.8)	0.002
Patient's overall evaluation of nursing care	6.0 (5.0-6.0)	5.0 (4.0-6.0)	0.002
Evaluation of hospital stay	5.0 (4.0-7.0)	5.0 (4.0-6.8)	0.034

Data are shown as medians (interquartile range, IQR).
NSNS, Newcastle Satisfaction with Nursing Scale; ENCS, Experiences of Nursing Care Subscale; SNCS, Satisfaction with Nursing Care Subscale.

carcinoma hemihepatectomy, and hepatectomy for benign liver lesions also showed significantly lower D-dimer levels in patients receiving ERAS programs (Zhou et al. 2020, 2022; Wang et al. 2023). In the present study, the ERAS group exhibited improved D-dimer levels on POD 3 and POD 5, potentially explaining the observed decrease in VTE incidence. Reduced D-dimer levels suggest a dampened coagulation system activation and fibrinolysis (Thaler et al. 2022), reinforcing the efficacy of ERAS interventions in preventing thrombotic events.

ERAS has shown its ability to enhance the quality of life for patients during the early phases of recovery, spanning various domains such as bowel function, physical, social, and cognitive functioning, sleep, and pain control among those undergoing urologic oncology surgery (Brooks et al. 2022). Similarly, the utilization of ERAS protocols in colorectal surgery not only reduces surgery-related complications but also positively influences functional recovery, minimizing the adverse impact of surgery on patient quality of life (Leon Arellano et al. 2020). This study also uncovered improvements in the quality of life within the ERAS group, manifesting as enhanced well-being across diverse symptoms compared to the control group. Notably, the ERAS group displayed lower scores in symptoms like dyspnea, coughing, sore mouth, alopecia, chest and arm/shoulder pain, and other bodily discomfort. These findings emphasize that ERAS interventions go beyond physical recovery to positively affect patients' subjective experiences, aligning seamlessly with the overarching aims of patient-centered care. Reports from patients who underwent laparoscopy or laparotomy for suspected malignancy or malignancy reinforced the favorable sentiment towards the ERAS pathway (Thangavel et al. 2021). Notably, high levels of postoperative satisfaction were observed in cases of total hip and knee replacement surgery, where early discharge and swift return to independent daily activities were facilitated (Frassanito et al. 2020). Similarly, implementing the ERAS program in gynecological oncology surgery led to an increased outpatient rate, decreased complications in minimally invasive procedures, and positive patient satisfaction (Fernandez et al. 2023). Patient satisfaction scores were markedly elevated within the ERAS group, signifying

the constructive impact of ERAS interventions on nursing care and the overall hospital stay experience. This resonance with the patient-centric principles of ERAS, which emphasize tailored care plans, preoperative education, and postoperative support, underscores the significance of involving patients in their recovery journey. The higher levels of patient satisfaction observed in the ERAS group underscore the pivotal role of patient engagement and empowerment throughout the recovery process.

Despite promising outcomes, this study has limitations that merit acknowledgment. While the sample size sufficed for this investigation, larger multi-center studies are needed to validate findings across diverse patient profiles and settings. Additionally, the study's duration may not capture the long-term effects of ERAS interventions comprehensively, warranting extended follow-up periods. Further research should focus on elucidating the underlying mechanisms of ERAS interventions on VTE prevention and enhancing quality of life. Diversifying the study population and targeting specific subgroups would bolster generalizability. Lastly, the multifaceted nature of ERAS makes it challenging to isolate individual intervention impacts, potentially confounding observed effects.

In conclusion, this study highlights the promising role of ERAS nursing interventions in preventing VTE and enhancing the quality of life in postoperative lung cancer patients. The lower VTE incidence, improved thrombotic risk scores, better D-dimer profiles, and enhanced patient satisfaction observed in the ERAS group collectively suggest that ERAS protocols contribute to more favorable clinical outcomes and patient experiences. These findings emphasize the importance of adopting comprehensive perioperative strategies that prioritize patient well-being and contribute to improved surgical outcomes in lung cancer patients.

Author Contributions

The sole author (H.Y.) was responsible for the entire research project, including the study design, experimental execution, data analysis, and interpretation of results. H.Y. also undertook the writing and revision of all sections of this paper.

Conflict of Interest

The author declares no conflict of interest.

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Supplementary Files

Please find supplementary file(s);
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