RESEARCH ARTICLE

Quality of Recovery Following Lobectomy for Lung Cancer under the Enhanced Recovery After Surgery (ERAS) Program: A Single-Center, Cross-Sectional Study in Vietnam

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Abstract

Background: The Enhanced Recovery After Surgery (ERAS) protocol aims to achieve early recovery. However, its effects on the quality of recovery (QoR), as measured by patient-reported outcomes, still require further evaluation. This study aims to assess the QoR in patients undergoing lobectomy under ERAS protocol and identify the factors influencing QoR. **Methods:** A cross-sectional study was conducted using the QoR-15 score to measure QoR. The implementation of its twenty-seven components measured ERAS protocol adherence. Descriptive statistics were applied to describe the characteristics of QoR. Correlation and multivariable regression analyses assessed associations between ERAS adherence and QoR-15. Structural equation modeling (SEM) was used to evaluate whether potential factors mediated the ERAS adherence and QoR relationship via the average causal mediation effect (ACME). **Results:** This study included 98 patients. Their median QoR-15 score was 133, with an interquartile range of 130 to 134. QoR was excellent in 9.2%, good in 85.7%, and moderate in 5.1% of patients. The QoR-15 score moderately correlated with pain severity within the first 24 hours postoperatively (at POD0; $\rho=-0.43$, p<0.001) and ERAS adherence levels ($\rho=0.31$, p=0.002). Multivariable linear regression showed that pain at POD0 independently affected QoR-15 scores ($\beta=-0.296$, 95% confidence interval [CI] -0.407 to -0.184, p<0.001), while overall ERAS adherence did not ($\beta=0.288$, 95% CI -0.293 to 0.868, p=0.327). SEM analysis confirmed that higher ERAS adherence significantly reduced pain severity at POD0 ($\beta = -0.47$ per additional factor adhered to, p < 0.001), which in turn improved QoR-15 scores via a significant indirect effect (ACME = 0.381, p = 0.016). **Conclusions:** Patients undergoing lobectomy under the ERAS protocol generally report positive QoR experiences. Adherence to the ERAS protocol may indirectly enhance QoR by reducing early postoperative pain. The study shows favorable QoR outcomes with ERAS implementation and highlights the importance of protocol adherence.

Keywords: Enhanced recovery after surgery (ERAS)- non-small cell lung cancer- lobectomy- quality of recovery

Introduction

Lung cancer is the primary cause of cancer deaths worldwide, with non-small cell lung cancer (NSCLC) accounting for approximately 80 to 85% of cases [1]. For those diagnosed early, lobectomy is the standard surgical treatment. The Enhanced Recovery After Surgery (ERAS) program aims to facilitate early recovery through a comprehensive perioperative care approach [2]. Studies indicate that strict adherence to ERAS protocols significantly improves outcomes, reducing complications and hospital stays after lung surgery [3, 4].

Current research primarily focuses on the length of hospital stay, which assesses recovery rate rather than quality of recovery (QoR). Studies on postoperative complications and morbidities were typically evaluated using clinician-reported outcome measures (CROMs); however, they often do not incorporate patient-reported outcome measures (PROMs) [5, 6]. The enthusiasm of surgeons and anesthesiologists for fast-track and ERAS

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protocols may not fully align with patient-centered care. Therefore, the postoperative QoR in patients under the ERAS protocol remains inadequately evaluated.

At our institution, the ERAS program for lung surgery has been gradually introduced and implemented since 2021 as part of a multidisciplinary perioperative care initiative. The program is applied collaboratively by thoracic surgeons, anesthesiologists, perioperative nurses, physiotherapists, and clinical nutrition staff following ERAS Society recommendations [2]. As the ERAS protocol continues to be standardized and optimized at our center, evaluating patient-reported quality of recovery is essential to understand how well these efforts align with patient-centered outcomes in real-world practice.

Thus far, limited studies have examined postoperative QoR based on the patient's perspective following the ERAS protocol [7]. Additionally, the multifactorial and multidisciplinary nature of the ERAS program presents challenges in protocol adherence and raises concerns about its impact on QoR [8]. This study primarily aims to evaluate the QoR in patients undergoing lobectomy under the ERAS protocol. It further investigates how adherence to ERAS protocol contributes to QoR, hypothesizing that higher adherence levels result in better QoR scores.

Materials and Methods

Study settings and patients

This cross-sectional study was conducted at the University Medical Center Ho Chi Minh City (UMC HCMC) and involved patients scheduled for lobectomy for NSCLC from February 2022 to December 2023. Patients without pathologic confirmation of lung tumors were scheduled for surgery and received an intraoperative frozen section biopsy. These patients were initially included in the ERAS program; however, if the biopsy results ruled out NSCLC, they were excluded from the study. This study was conducted following the STROBE guidelines. The sample size comprised all eligible patients who met the inclusion criteria within the project timeframe. This research was incorporated into a broad project that assesses multiple facets of surgical outcomes for lung cancer patients under the ERAS framework. Earlier studies from this project have investigated various outcomes utilizing the same data, contributing to a comprehensive evaluation of the ERAS program's effectiveness at the University Medical Center Ho Chi Minh City. This article specifically focuses on the quality of recovery, adding a critical dimension to the overall assessment of ERAS implementation for lung cancer surgery.

ERAS protocols

The ERAS program at the UMC HCMC followed guidelines from the ERAS Society [2] and recommendations by the French Society of Anaesthesia and Intensive Care Medicine for lobectomy [10]. The protocol included a detailed evaluation of twelve preoperative, nine intraoperative, and six postoperative factors, covering aspects of patient care, facility conditions, and medical staff practices under the guidance of the hospital's Scientific Council. Adherence to the

ERAS program was measured by the total number of factors fulfilled throughout the perioperative period, with a maximum possible score of 27 factors. Details of the ERAS program are provided in Supplement 1.

Quality of recovery

The Quality of Recovery-15 (QoR-15) scale was developed based on PROMs [11]. It can provide valuable insights into perioperative clinical outcomes, recommended by the European Society of Anaesthesiology and the American Society for Enhanced Recovery and Perioperative Quality Initiative [12, 13]. The QoR-15 scale includes 15 items, each rated from 0 to 10 points, detailed in Supplement 2. Overall scores ranged from 0 to 150 and were classified into four categories: excellent (135–150), good (122–134), moderate (90–121), and poor (0–89) [14].

Data collection

Data were extracted from electronic medical record databases. Preoperative variables included age, gender, body mass index (BMI), pulmonary function, smoking status, comorbidities, American Society of Anesthesiologists (ASA) physical status, clinical symptoms, and pathological features. Intraoperative variables included operative method, operation time, and blood loss. Patients who underwent VATS converted to thoracotomy were also categorized as thoracotomy procedures. Postoperative variables included the duration in the post-anesthesia care unit, postoperative fasting time, urinary catheter retention time, duration of thoracic drainage, and total treatment costs. Postoperative pain severity was assessed daily using the visual analog scale (VAS) while resting. The highest score was selected if multiple pain scores were recorded in a single interval. We assessed the quality of recovery (QoR) for each patient on postoperative day (POD) 2, representing the early recovery phase and corresponding to the peak of acute postoperative pain, through a direct interview.

Sample Size and Bias

We employed a convenience sampling method that included all eligible patients undergoing lobectomy for NSCLC at our center during the study period. A post-hoc power analysis for the mediation pathway to QoR demonstrated adequate statistical power, exceeding the commonly accepted threshold of 0.80 for mediation models. To reduce the risk of overfitting and improve parameter stability in our structural equation modeling (SEM), we simplified the model by including only essential covariates (age, sex, and surgical approach). Model robustness was further supported through nonparametric bootstrapping with 2,000 resamples. Selection bias was minimized by enrolling all consecutive eligible cases, while information bias was mitigated through standardized EMR-based data collection and consistent administration of the QoR-15 questionnaire by trained research personnel.

Statistical analysis

Statistical analysis was conducted using R software (version 4.3.2). Descriptive statistics are presented as (1) frequencies and percentages for categorical variables, (2)

means and standard deviations for normally distributed numeric variables, and (3) medians and interquartile ranges for non-normally distributed numeric variables. However, QoR-15 scale items were presented using means and standard deviations.

Differences in QoR scores between groups were evaluated using (1) Chi-square or Fisher's exact test for categorical variables, (2) Independent t-tests or analysis of variance (ANOVA) for numeric variables with normal distributions, and (3) Wilcoxon rank-sum test or Kruskal-Wallis test for numeric variables with non-normal distributions. Correlations were analyzed using Pearson correlation coefficient (r) for normal distributions and Spearman rho (ρ) for non-normal distributions. Multivariable linear regression was utilized to identify independent associations between variables and outcomes, including QoR and pain severity. Variables included in the multivariable models were age, gender, and statistically or clinically significant factors from univariate analyses. Variance inflation factor (VIF) scores were calculated to examine multicollinearity [15].

The SEM was employed to examine the relationships among potential factors influencing postoperative QoR. Age, sex, and surgical approach were included as covariates to adjust for baseline differences. Standardized path coefficients (β) and p-values were reported for each pathway. Indirect (average causal mediation effect, ACME), direct (average direct effect, ADE), and total effects (TE) were estimated using nonparametric bootstrapping with 2,000 resamples and bias-corrected 95% confidence intervals. The proportion mediated was calculated as the ratio of the indirect to total effect. Post-hoc statistical power for each path was evaluated using the Wald/Sobel approximation to assess the stability of the mediation model, given the limited sample size. Statistical significance was defined as a two-tailed $p < 0.05$.

Ethical consideration

The study followed the Declaration of Helsinki (as revised in 2013). The study was approved by the Ethics Committee in Biomedical Research of the University of Medicine and Pharmacy at Ho Chi Minh City on February 21, 2022 (No. 2294/ĐHYD-HĐ), and informed consent was obtained from all individual patients.

Results

This study included 98 patients. Table 1 shows that patients aged sixty and older accounted for 59.2%. Gender distribution was nearly equal (56.1% female, 43.9% male). Most patients (61.2%) had normal-range BMI. Most patients were classified as ASA-II (50%), followed by ASA-III (43.9%). The most common comorbidities were hypertension (52.0%) and diabetes mellitus (13.3%). The percentage of patients who underwent VATS was 72.4%. There were differences in the mean of QoR-15 scores between males and females (130.4 and 132.8, p=0.009), as well as between thoracotomy and VATS (129.1 and 132.8, p<0.001).

Quality of recovery

Table 1. Characteristics of Study Patients Undergoing Lobectomy under the ERAS Protocol

Characteristics	Number (%)	QoR-15 score	P-value
Age group			
<60 years old	40 (40.8)	132.6 ± 3.2	0.118
≥60 years old	58 (59.2)	131.2 ± 5.1	
Gender			
Female	55 (56.1)	132.8 ± 3.6	0.009
Male	43 (43.9)	130.4 ± 5.1	
BMI status			
Underweight	3 (3.1)	132.5 ± 2.1	0.086
Normal weight	60 (61.2)	133 ± 2.6	
Overweight or obese	35 (35.7)	132.1 ± 3.2	
Physical status			
ASA-I	6 (6.1)	133.3 ± 2.6	0.545
ASA-II	49 (50.0)	131.7 ± 4.2	
ASA-III	43 (43.9)	131.7 ± 5.0	
Smoking status			
Non-smoker	70 (71.4)	132.5 ± 4.0	0.076
Current smoker	10 (10.2)	128.9 ± 5.7	
Former smoker	18 (18.4)	130.6 ± 4.8	
Hypertension			
Presence	51 (52.0)	132.5 ± 3.8	0.085
Absence	47 (48.0)	131.0 ± 5.0	
Asthma or COPD			
Presence	4 (4.1)	132.3 ± 2.2	0.825
Absence	94 (96.0)	131.7 ± 4.5	
Diabetes			
Presence	13 (13.3)	132.1 ± 3.3	0.788
Absence	85 (86.7)	131.7 ± 4.6	
Coronary artery disease			
Presence	11 (11.2)	131.4 ± 4.5	0.753
Absence	87 (88.8)	131.8 ± 4.5	
Sequelae of stroke			
Presence	2 (2.0)	133.5 ± 0.7	0.581
Absence	96 (98.0)	131.7 ± 4.5	
Thyroid dysfunction			
Presence	6 (6.1)	133 ± 3.0	0.486
Absence	92 (94.0)	131.7 ± 4.5	
Extrapulmonary cancers			
Presence	2 (2.0)	133.5 ± 2.1	0.581
Absence	96 (98.0)	131.7 ± 4.5	
Disease detection scenario			
Symptomatic	51 (52.0)	131.5 ± 4.8	0.557
Asymptomatic	47 (48.0)	132.0 ± 4.0	
Specific symptoms			
Persistent cough	23 (45.1)	131.2 ± 5.6	0.115
Chest pain	12 (23.5)	132.7 ± 2.8	

Continuous variables are expressed as mean ± standard deviation. Categorical variables are shown as numbers (percentages). †Patients who underwent open surgery or VATS converted to open surgery were categorized under thoracotomy procedures. Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index; COPD, chronic obstructive pulmonary disease; ERAS, Enhanced Recovery After Surgery; TNM, tumor – node – metastasis; VATS, video-assisted thoracoscopic surgery.

Table 1. Continued

Characteristics	Number (%)	QoR-15 score	P-value
Specific symptoms			
Weight loss	2 (3.9)	125.5 ± 10.6	
Anorexia and fatigue	12 (23.5)	132.3 ± 4.0	
Hemoptysis	2 (4.0)	129.5 ± 3.5	
Duration of illness			
<1 month	18 (35.3)	131.2 ± 3.7	0.135
1−3 months	11 (21.6)	132.2 ± 4.1	
3-6 months	12 (23.5)	131.5 ± 5.6	
≥ 6 months	10 (19.6)	131.4 ± 6.9	
Tumor location			
Left upper lobe	21 (21.4)	130.5 ± 5.2	0.066
Left lower lobe	21 (21.4)	131.9 ± 5.1	
Right upper lobe	21 (21.4)	131.8 ± 3.8	
Right lower lobe	22 (22.5)	132.4 ± 4.7	
Right middle lobe	13 (13.3)	132.5 ± 2.4	
TNM staging			
Stage I	35 (35.7)	132.2 ± 2.6	0.135
Stage II	44 (44.9)	131.3 ± 5.2	
Stage III	19 (19.4)	130.7 ± 4.9	
Histological features			
Adenocarcinoma	81 (82.7)	131.7 ± 4.7	0.860
Squamous cell carcinoma	17 (17.3)	131.8 ± 2.5	
Large cell carcinoma	0 (0.0)		
Cell differentiation		131.6 ± 3.3	0.325
Well-differentiated	10 (10.2)	131.7 ± 4.5	
Moderately differentiated	77 (78.6)	132.4 ± 5.5	
Poorly differentiated	11 (11.2)	131.5 ± 4.8	0.557
Operation method			
VATS	71 (72.4)	132.8 ± 3.8	<0.001
Thoracotomy†	27 (27.6)	129.1 ± 5.1	

Continuous variables are expressed as mean ± standard. Categorical variables are shown as numbers (percentages). †Patients who underwent open surgery or VATS converted to open surgery were categorized under thoracotomy procedures. Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index; COPD, chronic obstructive pulmonary disease; ERAS, Enhanced Recovery After Surgery; TNM, tumor – node – metastasis; VATS, video-assisted thoracoscopic surgery.

In Figure 1, the median QoR-15 score exhibited a narrow distribution, with a median of 133 and an interquartile range of 130 to 134. QoR outcomes were classified as excellent in 9.2%, as good in 85.7%, and as moderate in 5.1% of patients. No patients experienced poor QoR levels.

Figure 2 illustrates the average scores on a scale of 10 for various factors that limit the QoR. The factors identified include personal hygiene autonomy (7.9 ± 0.4), resumption of work or home activities (8.0 ± 0.5), sadness or depression level (8.1 ± 0.7), and general well-being (8.2 ± 0.7).

Correlated factors of the quality of recovery

Figure 3 shows a moderate positive correlation between overall ERAS adherence and the QoR-15 score (ρ = 0.31, p = 0.002). Conversely, Figure 4 shows that pain severity at POD0 and POD1 had moderate negative correlations (ρ=−0.43 and ρ=−0.34, p<0.001), while at POD2, there was a weak negative correlation with the QoR-15 score (ρ=−0.24, p<0.05). Additionally, pain severities from POD0 to POD4 and the overall ERAS adherence levels demonstrated a strong negative correlation (ρ<−0.6, p<0.001).

Structural relationship of quality of recovery

In Figure 5A, when using the univariable regression model, factors significantly associated with the QoR-15 score included gender, operative method, pain severity from POD0 to POD2, and ERAS adherence level. However, the multivariable analysis revealed that only pain severity at POD0 independently influenced the QoR-15 score (β=−1.953, 95% confidence interval [CI] −3.088 to −0.817, p<0.001). This model showed signs of multicollinearity, as indicated by elevated VIF (more than 5).

In Figure 5B, the independent determinants of pain severity at POD0 included the operative method and adherence to ERAS protocols. Specifically, compared to VATS, thoracotomy was associated with an increased pain severity (β=0.973, 95% CI 0.471 to 1.475, p<0.001). Greater adherence to ERAS components significantly lowers pain severity (β=−0.296, 95% CI −0.407 to −0.184, p<0.001).

In the SEM analysis (Figure 6), higher ERAS adherence was significantly associated with lower pain severity at POD0 (β = −0.47, p < 0.001), which in turn predicted better QoR (β = −0.34, p = 0.015). The direct effect was nonsignificant (β = 0.003, p = 0.831), indicating a full mediation effect through pain at POD0. Bootstrapped analysis confirmed a significant indirect effect (ACME = 0.381, p = 0.016), with 85% of the total effect mediated. Post-hoc power analysis demonstrated strong power for the indirect mediation pathways (a = 0.999; b = 0.678), with overall power exceeding 0.85 for the indirect effect, supporting model robustness.

Discussion

This study assesses QoR in lobectomy patients following the ERAS program and its contributing factors. Our findings indicate that patients under the ERAS program generally experience favorable QoR. Specifically, the median QoR-15 score exhibited a narrow distribution, with a median of 133 and an interquartile range of 130 to 134. QoR outcomes were classified as excellent in 9.2%, good in 85.7%, and moderate in 5.1% of patients. Furthermore, the study indicates that better adherence to ERAS protocol results in reduced early pain severity, which, in turn, indirectly enhances QoR.

In our study, the QoR-15 scores remain favorable among patients following the ERAS protocol. Currently, limited studies compare QoR scores before and after implementing the ERAS protocol in lobectomy patients. However, research in patients with gastric cancer has
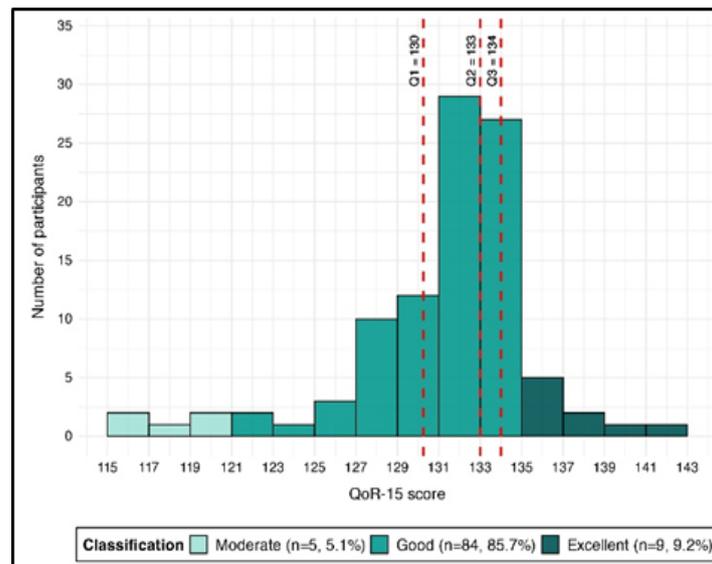
Figure 1. Histogram Representing the Spectrum of QoR among Study Patients. The QoR-15 scores were classified into four categories: excellent (135–150), good (122–134), moderate (90–121), and poor (0–89). Abbreviations: QoR: quality of recovery, Q1 - 25th percentile, Q2 - 50th percentile (median), Q3: 75th percentile

demonstrated that the postoperative QoR-40 scores in the ERAS group were significantly higher than those in the control group [16]. Another study in patients with total hip arthroplasty has also demonstrated that the implementation of ERAS protocols significantly improves CROMs without adversely affecting or compromising PROMs [17]. This suggests that implementing the ERAS protocol can improve CROMs, such as length of stay, complications, and morbidities, without inadvertently affecting PROMs like QoR. Therefore, the ERAS program represents a comprehensive approach to patient care, positively affecting both CROMs and PROMs.
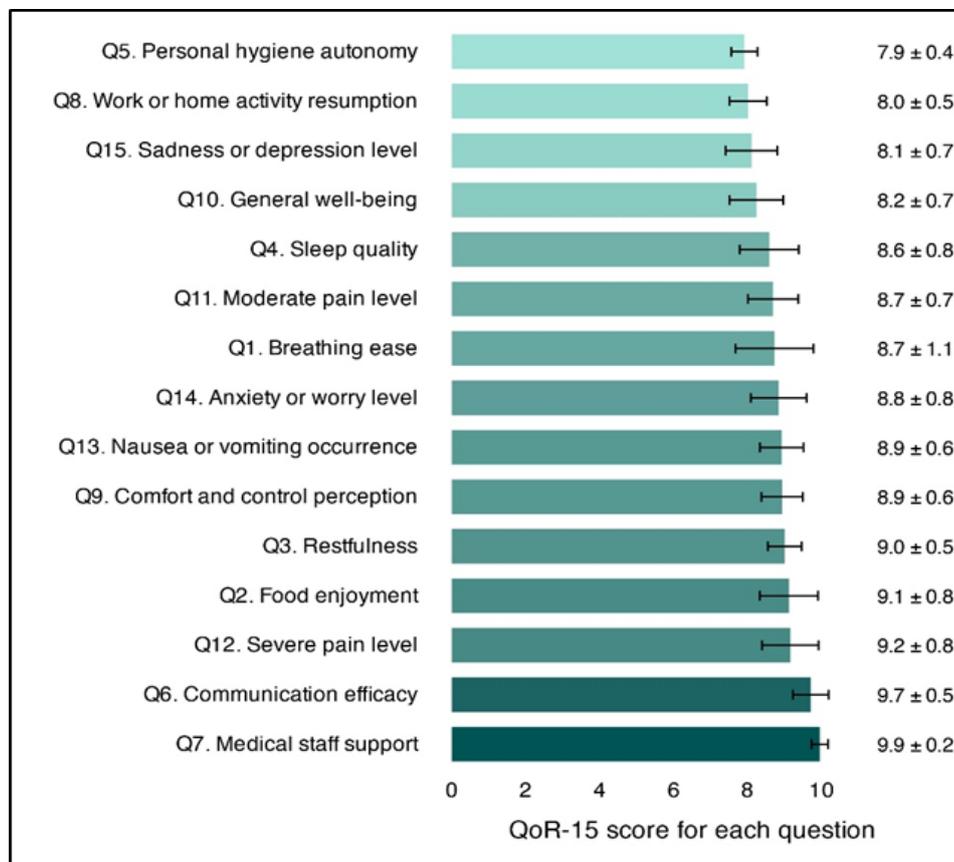
Figure 2. Distribution of QoR Scores Across Domains in Patients Undergoing Lobectomy under ERAS Protocol. Questions are arranged in ascending order based on their average scores. Abbreviations: QoR: quality of recovery, Qx: the question number x in QoR-15 scale
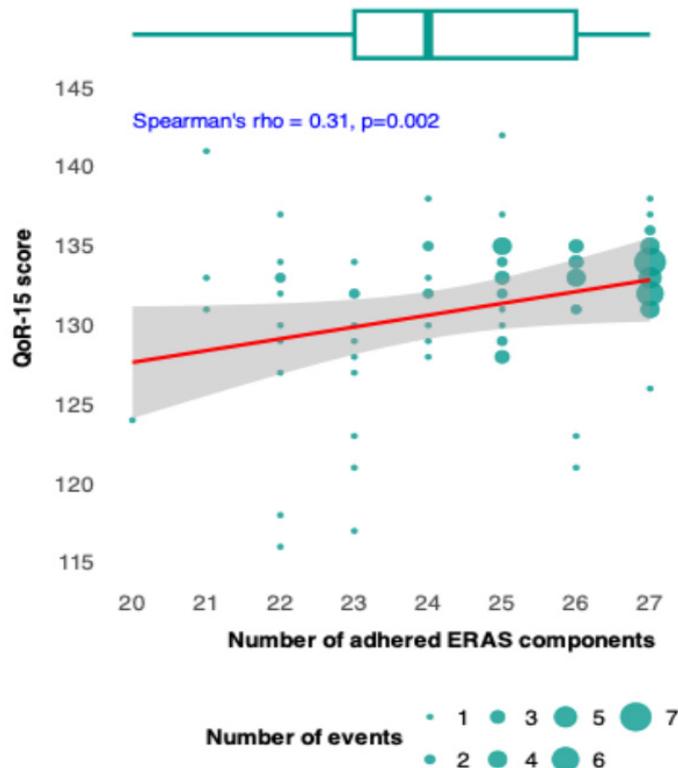
Figure 3. Scatter Plot Showing the Correlation between QoR-15 Scores and ERAS Adherence Levels with the Spearman Coefficient. Abbreviations: ERAS, enhanced recovery after surgery; QoR, quality of recovery
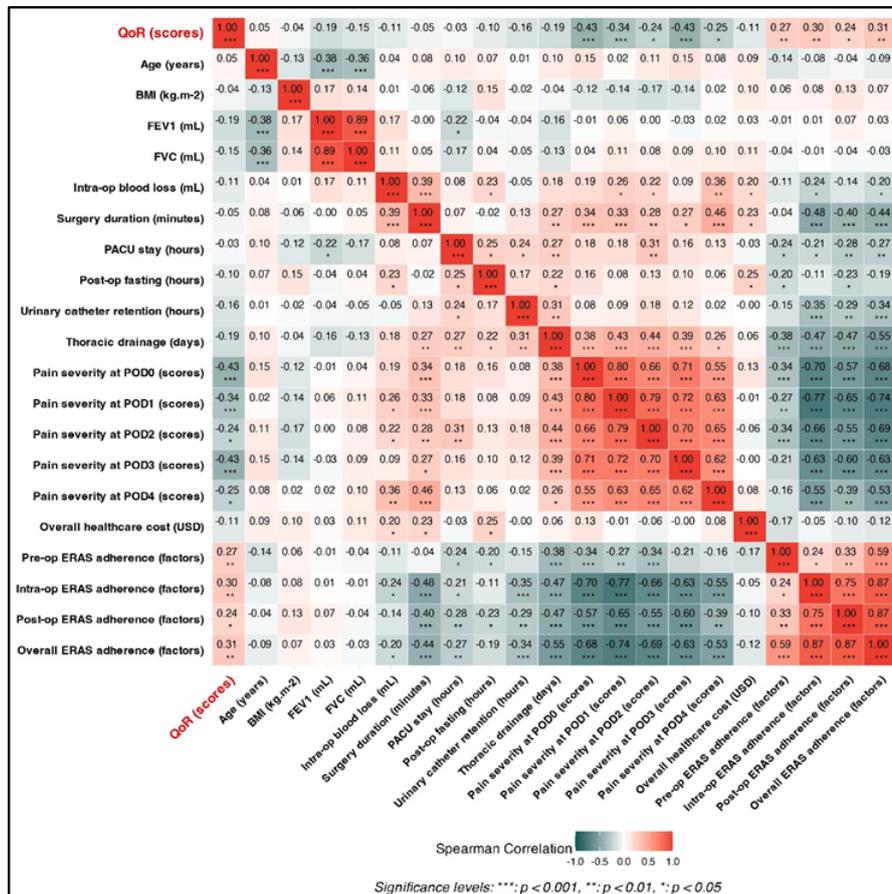

Figure 4. Heatmap of Spearman Correlation Coefficients between Clinical Parameters and QoR of Study Patients Undergoing Lobectomy under the ERAS Protocol. Abbreviations: BMI, body mass index; ERAS, enhanced recovery after surgery; FEV1, forced expiratory volume in the first second; FVC, forced vital capacity; intra-op, intraoperative; PACU, post-anesthesia care unit; POD, postoperative day; QoR, quality of recovery
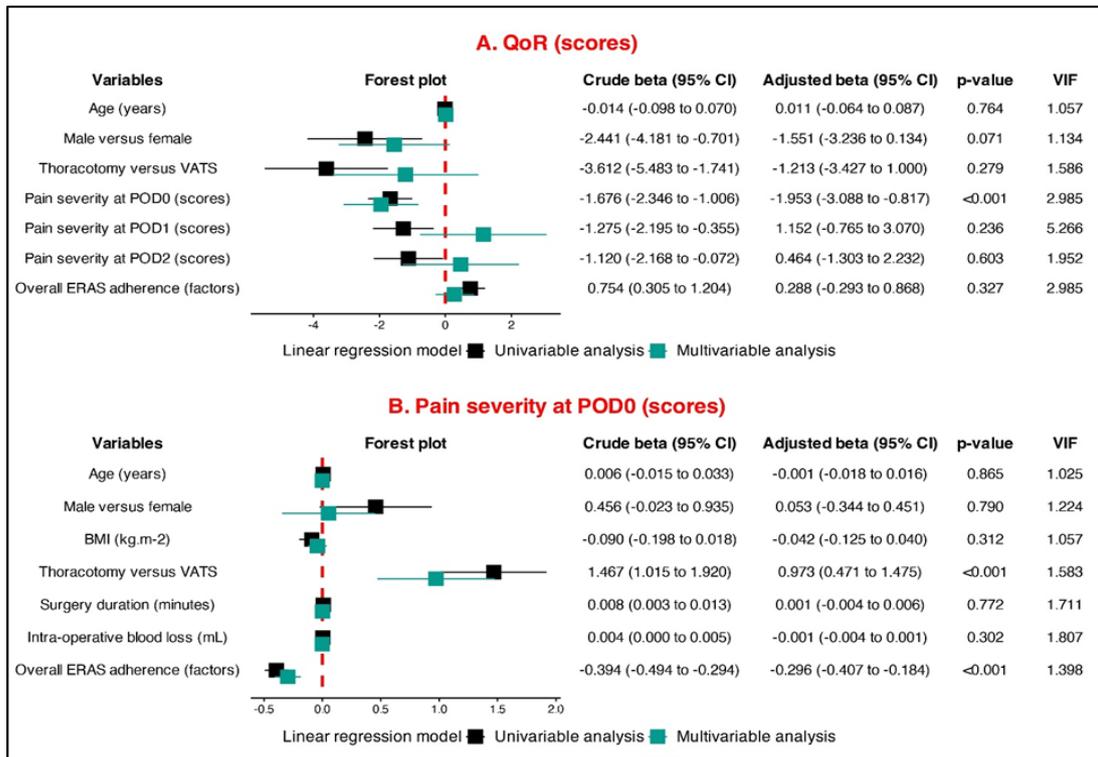
Figure 5. Forest Plots for Linear Regression Analysis of Factors Related to Continuous Outcomes. Panel A explores independent factors affecting the QoR-15 score, while panel B investigates independent factors affecting pain severity at POD0. Abbreviations: BMI, body mass index; CI, confidence interval; ERAS, enhanced recovery after surgery; VATS, video-assisted thoracoscopic surgery; VIF, variance inflation factor; POD, postoperative day; QoR, quality of recovery.
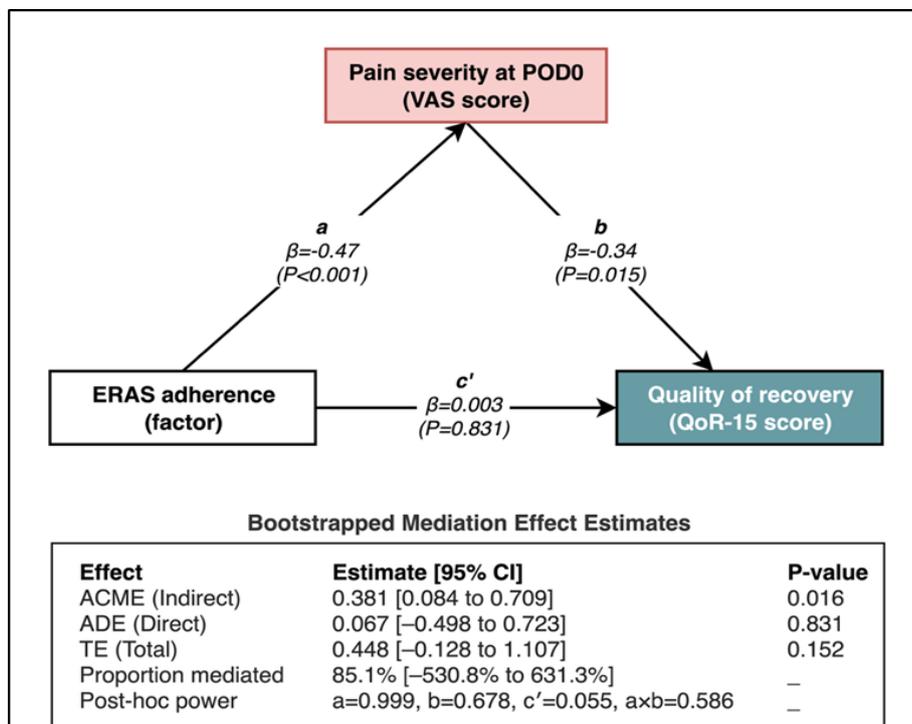

Figure 6. Structural Equation Model (SEM) Illustrating the Mediating Role of Pain Severity at Postoperative Day 0 (POD0, VAS score) in the Relationship between ERAS Adherence (Factor) and Quality of Recovery (QoR-15 score). Models were adjusted for age, sex, and surgical approach and displays standardized path coefficients (β) and p-values for direct (c'), indirect (a×b), and total effects. Indirect (ACME), direct (ADE), and total (TE) effects were estimated using nonparametric bootstrapping with 2,000 resamples and bias-corrected 95% confidence intervals. Post-hoc statistical power for each path (a, b, c', and a×b) was assessed using the Wald/Sobel approximation, as the model was just-identified (df = 0). Abbreviations: ERAS, enhanced recovery after surgery; QoR, quality of recovery; POD, postoperative day; VAS, visual analogue scale; ACME, average causal mediation effect (indirect effect); ADE, average direct effect; TE, total effect.

Our study found that pain severity at POD0 and POD1 had moderate negative correlations (($\rho=-0.43$ and $\rho=-0.34$, $p<0.001$). These results are closely aligned with those of Yoon et al. ($\rho=-0.45$, $p<0.001$) [18]. Additionally, our multivariable analysis showed that pain severity at POD0 independently influenced the QoR-15 score ($\beta=-0.296$, 95% CI -0.407 to -0.184, $p<0.001$). In our findings, the lowest average scores were noted in personal hygiene autonomy (7.9/10), resumption of work/home activities (8.0/10), sadness and depression (8.1/10), and general well-being (8.2/10), indicating that physical independence and emotional state remain limited under the ERAS protocol. Yoon et al. further support this by demonstrating a significant correlation between pain intensity and physical comfort, emotional state, and physical independence [18]. Thus, our findings suggest that pain severity influences QoR similarly across physical and emotional aspects, reinforcing the results of the referenced study.

In our study, we found that improved adherence to the ERAS protocol is associated with a decrease in pain severity. Specifically, an increase in adherence to each factor of the ERAS protocol leads to a reduction in pain severity at POD0, with $\beta=-0.296$, 95% CI -0.407 to -0.184, $p<0.001$. Rice et al. demonstrated that the implementation of an ERAS pathway was associated with effective postoperative analgesia, significant reductions in opioid consumption, and pain severity compared to conventional care [9]. Our protocol items 14th, 17th, and 25th of the ERAS protocol emphasize the role of minimally invasive surgery and multimodal analgesia, particularly involving effective analgesic techniques like TEA, TPVB, and ESPB. Theoretically, the perioperative components of the ERAS protocol also focus on optimizing pain reduction and opioid sparing. Our study demonstrates that better ERAS adherence reduces early pain severity, indirectly enhancing the QoR. Thus, this study suggests that ERAS adherence levels and early postoperative pain management are essential for improving postoperative QoR.

Despite its single-center nature, this study offers several clinically actionable insights. Our findings suggest that improved adherence to ERAS protocols contributes to better early postoperative recovery, primarily through effective pain control. This highlights the central role of pain management as a mechanistic pathway connecting perioperative practices and PROMs. Clinicians can apply these insights by prioritizing consistent implementation of ERAS elements such as minimally invasive surgery, early mobilization, and multimodal analgesia, interventions that are feasible and impactful across various clinical settings. Moreover, incorporating PROMs like the QoR-15 in routine practice provides a structured, patient-centered lens to assess recovery beyond traditional clinical endpoints. While the single-institution setting may limit generalizability, the standardized ERAS implementation and methodological transparency enhance the relevance of our findings to other thoracic surgical centers seeking to optimize postoperative care.

This study evaluates QoR based on PROMs at the forefront of current healthcare reform. It also explains how ERAS adherence influences QoR. However, this study faces several limitations. First, the relatively small sample size may increase the risk of overfitting and reduce parameter stability in SEM; to address this, we employed a simplified model with only essential covariates and confirmed its adequacy through post-hoc power analysis and bootstrap validation. Second, the absence of preoperative QoR-15 assessments precluded adjustment for baseline recovery potential, and the evaluation at a single early time point limits generalizability across the entire recovery trajectory. Third, as a single-center study without a pre-ERAS control group, the effect size attributable to ERAS implementation could not be directly quantified. Finally, our pain assessment was restricted to resting pain, potentially underestimating the impact of dynamic pain on functional recovery. These limitations emphasize the need for future multicenter studies incorporating both pre- and postoperative PROMs assessed at multiple time points to capture recovery trajectories more accurately and to evaluate the specific impact of individual ERAS components on QoR domains.

In conclusion, patients undergoing lobectomy following the ERAS protocol typically have good QoR experiences. ERAS protocol adherence may indirectly enhance recovery outcomes by mitigating early postoperative pain. Therefore, this study suggests that ERAS adherence levels and early postoperative pain management are essential for optimal QoR outcomes.

Author Contribution Statement

The conception and design of the study were carried out by LTC, HTB and NVT. Administrative support was provided by LQAT and PTNV. HTB, TTV, and PTNV were responsible for providing study materials or patient data. Data collection and assembly were performed by HTB, TTV, and LTC, while HQH and LTC conducted data analysis and interpretation. All authors contributed to the manuscript writing and approved the final version of the manuscript.

Acknowledgements

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