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***Retrospective Study***

**Enhanced recovery after surgery in elderly patients with non-small cell lung cancer who underwent video-assisted thoracic surgery**

Sun MH *et al*. Enhanced recovery in NSCLC patients

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**Author contributions:** Yan J and Li XQ conceived and designed the study; Qiu YY screened patients to obtain clinical data and data analysis; Wu LS and Sun MH wrote the paper; All authors have read and approved the final draft. Wu LS proposed, designed, and analyzed the data and wrote the first draft of the paper. Sun MH was responsible for patient screening, enrollment, and the collection of clinical data. Both authors have made vital and indispensable contributions to the completion of the project and are therefore qualified to be co-first authors of the paper. As co-corresponding authors, Yan J and Li XQ played an important and indispensable role in project design, data interpretation, and manuscript preparation. Yan J and Li XQ applied for and were successful in obtaining funding for this project. Yan J conceived, designed, and supervised the entire project process. Li XQ assisted and was responsible for data reanalysis and reinterpretation, graphing, comprehensive literature search, preparation, and submission of the current version of the manuscript. The cooperation of Yan J and Li XQ was critical to the publication of this manuscript.

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**Abstract**

BACKGROUND

This study was designed to investigate the clinical outcomes of enhanced recovery after surgery (ERAS) in the perioperative period in elderly patients with non-small cell lung cancer (NSCLC).

AIM

To investigate the potential enhancement of video-assisted thoracic surgery (VATS) in postoperative recovery in elderly patients with NSCLC.

METHODS

We retrospectively analysed the clinical data of 85 elderly NSCLC patients who underwent ERAS (the ERAS group) and 327 elderly NSCLC patients who received routine care (the control group) after VATS at the Department of Thoracic Surgery of Peking University Shenzhen Hospital between May 2015 and April 2017. After propensity score matching of baseline data, we analysed the postoperative stay, total hospital expenses, postoperative 48-h pain score, and postoperative complication rate for the 2 groups of patients who underwent lobectomy or sublobar resection.

RESULTS

After propensity score matching, ERAS significantly reduced the postoperative hospital stay (6.96 ± 4.16 *vs* 8.48 ± 4.18 d, *P* = 0.001) and total hospital expenses (48875.27 ± 18437.5 *vs* 55497.64 ± 21168.63 CNY, *P* = 0.014) and improved the satisfaction score (79.8 ± 7.55 *vs* 77.35 ± 7.72, *P* = 0.029) relative to those for routine care. No significant between-group difference was observed in postoperative 48-h pain score (4.68 ± 1.69 *vs* 5.28 ± 2.1, *P* = 0.090) or postoperative complication rate (21.2% *vs* 27.1%, *P* = 0.371). Subgroup analysis showed that ERAS significantly reduced the postoperative hospital stay and total hospital expenses and increased the satisfaction score of patients who underwent lobectomy but not of patients who underwent sublobar resection.

CONCLUSION

ERAS effectively reduced the postoperative hospital stay and total hospital expenses and improved the satisfaction score in the perioperative period for elderly NSCLC patients who underwent lobectomy but not for patients who underwent sublobar resection.

**Key Words:** Enhanced recovery after surgery; Non-small cell lung cancer; Perioperative care; Propensity score; Video-assisted thoracic surgery

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**Core Tip:** This study was designed to investigate the clinical outcomes of enhanced recovery after surgery (ERAS) in the perioperative period in elderly patients with non-small cell lung cancer (NSCLC). ERAS significantly reduced the postoperative hospital stay (6.96 ± 4.16 *vs* 8.48 ± 4.18 d, *P* = 0.001) and total hospital expenses (48875.27 ± 18437.5 *vs* 55497.64 ± 21168.63 CNY, *P* = 0.014) and improved the satisfaction score (79.8 ± 7.55 *vs* 77.35 ± 7.72, *P* = 0.029) relative to those for routine care. ERAS effectively reduced the postoperative hospital stay and total hospital expenses and improved the satisfaction score in the perioperative period for elderly NSCLC patients who underwent lobectomy but not for patients who underwent sublobar resection.

**INTRODUCTION**

Lung cancer ranks first in all malignant tumours with respect to morbidity and mortality[1]. Surgery is the main treatment for early lung cancer[2], but the complication rate is approximately 30%-50%, resulting in delayed recovery, poor long-term outcomes, and high medical costs[3-5]. Elderly patients with lung cancer often experience a slow recovery and high complication rates after thoracic surgery and thus are a high-risk group for surgical treatment[6-8]. To reduce the postoperative complication rate and accelerate postoperative recovery, many treatment strategies and perioperative management approaches have been incorporated into the surgical field, including infection control, nutritional support, improved fluid management, and comprehensive preoperative assessment. In 2001, Henrik Kehlet, a Danish gastrointestinal surgeon, first proposed the concept of enhanced recovery after surgery (ERAS)[9]. Empirical evidence has demonstrated that effective perioperative management that incorporates ERAS reduces the stress response to surgical trauma and complications and improves surgical safety and patient satisfaction. ERAS has been proven to effectively reduce common complications and general pain in patients. In recent years, the application of ERAS after thoracic surgery has reduced the perioperative complication rate, length of hospital stay, and hospital expenses[10]. However, evidence of the effectiveness of ERAS following video-assisted thoracic surgery (VATS) is still remains uncertain. In particular, no clinical studies have been conducted to investigate ERAS in elderly patients with lung cancer who underwent VATS.

This study was designed to retrospectively analyse the clinical outcomes of ERAS in elderly patients with lung cancer who underwent VATS at Peking University Shenzhen Hospital over a 5-year period and to investigate the role of ERAS (after propensity score matching) in improving postoperative recovery.

**MATERIALS AND METHODS**

***Clinical data***

We retrospectively analysed the clinical data of 412 elderly patients with lung cancer who underwent VATS at the Department of Thoracic Surgery of Peking University Shenzhen Hospital between May 2015 and April 2017. Of these patients, 271 were men, and 141 were women; their mean age was 72.41 ± 4.7 years; and 85 patients underwent ERAS (the ERAS group), and 327 patients received routine care (the control group). Moreover, 187 patients underwent sublobar resection, and 225 patients underwent lobectomy; 330 patients were diagnosed with adenocarcinoma, and 82 patients were diagnosed with squamous cell carcinoma; and 235 patients were in tumor-node-metastasis (TNM) stage I, and 92 patients were in TNM stage II.

The inclusion criteria were as follows: (1) patients who underwent VATS and were pathologically confirmed to have non-small cell lung cancer (NSCLC) after surgery; (2) patients aged 65-80 years old; (3) patients with NSCLC in TNM stage I to II confirmed by postoperative pathology; and (4) patients with complete clinical data. The exclusion criteria were as follows: (1) patients with pneumonectomy; or (2) patients with pathologically confirmed small cell lung cancer.

***Methods***

**Perioperative management:** The patients were divided into the control group and the ERAS group. The control group received routine care, and the ERAS group underwent ERAS (Table 1).

Preoperative management: All patients underwent a one-stop preoperative assessment by surgeons, anaesthesiologists, and nurses to facilitate optimal preoperative preparation and were closely monitored during and after the operation for any complications. The ERAS group was given a copy of an ERAS education brochure with detailed descriptions about daily goals and was asked to complete a diary. Intraoperative management: All patients were given prophylactic antibiotics during the induction period. General anaesthesia was administered with double-lumen tracheal intubation and single-lung breathing. Intraoperative rehydration was achieved with intravenous infusion of balanced fluid, and hypertensive or antihypertensive drugs were given based on blood pressure monitoring during the operation. The indications and the feasibility for surgery were determined in accordance with the China Guidelines for the Diagnosis and Treatment of Primary Lung Cancer (2015). The scope of surgical resection was determined by the treating physician based on patient conditions. Effort was taken to make a small incision, and absorbable sutures were used to close the incision. At the end of surgery, a closed thoracic drainage tube was placed according to routine procedures. Postoperative management: Intravenous infusion was minimized, with adequate analgesia. Non-steroidal anti-inflammatory drugs and acetaminophen were used for pain management. Opioids were avoided whenever possible to prevent postoperative nausea and vomiting and other opioid-related adverse reactions. Patients were encouraged to get out of bed as soon as possible. The catheter was removed at 12 h after operation (Table 2).

**Criteria for discharge and follow-up:** Discharge criteria were as follows: (1) removal of the closed thoracic drainage tube; physical mobility; (2) no difficulty breathing (no shortness of breath, wheezing or stridor; oxygen saturation > 94%); and (3) no serious complications; complications (if any) were under control.

**Calculation of medical expenses**: The hospital medical records were used to record and calculate the total medical expenses, including laboratory tests, physical examinations, medications, nursing, surgery, supplies, and postoperative rehabilitation.

**Satisfaction:** A homemade satisfaction questionnaire was used during the week after discharge to evaluate patient satisfaction. The contents included staff attitude, operating techniques, timeliness of nursing, overall hospital experience, and pain score. Quality of life was analysed, including physical performance, physical pain, mental state, and general health.

**Statistical analysis**: R language 3.5.3 was used for propensity score matching of pathological classification, TNM stage, and surgical approach at 1:1 between the ERAS group and the control group.

SPSS v25.0 was used for statistical analysis. Measurement data are expressed as the mean value ± SD and analysed with the independent sample *t*-test or Mann-Whitney U test; count data are expressed as the frequency and were analysed with the chi-square test or Fisher’s exact test. All tests were two-sided, and *P* < 0.05 was considered statistically significant.

**RESULTS**

***Baseline data***

Among the 412 elderly patients with lung cancer who underwent VATS, 327 patients were in the control group and 85 patients were in the ERAS group. No significant between-group differences were observed regarding age (*P* = 0.220), sex (*P* = 0.982), body mass index (*P* = 0.540), or forced expiratory volume in the first second (*P* = 0.615) (Figure 1). Moreover, 330 patients had adenocarcinoma, and 82 patients had squamous cell carcinoma; 290 patients were in TNM stage I, and 122 patients were in stage II; 187 patients underwent sublobar resection, and 225 patients underwent lobectomy (Table 3). After matching, the control group and the ERAS group each included 85 patients.

No patient died during the perioperative period or required blood transfusion. At the end of surgery, the tracheal intubation was removed in the operating room, and the patients were able to breathe spontaneously with normal blood gas analysis results. All patients were sent back to the general ward, and no patient required mechanical ventilation in the intensive care unit. Before discharge, any postoperative complications were alleviated and resolved with treatment.

***Clinical outcome measures***

ERAS significantly improved postoperative hospital stay (6.98 ± 4.3 *vs* 8.92 ± 4.42 d, *P* = 0.002), total hospital expenses (52041.86 ± 19062.33 *vs* 60760.79 ± 20511.58, *P* = 0.016), and overall satisfaction (79.66 ± 7.5 *vs* 76.26 ± 7.42, *P* = 0.013) in the lobectomy subgroup (Table 4). Postoperative hospital stay also improved in the sublobar resection subgroup (6.94 ± 4.03 *vs* 7.86 ± 3.78 d, *P* = 0.09), but the differences of total hospital expenses (*P* = 0.247) and overall satisfaction (*P* = 0.621) did not reach statistical significance. In the ERAS group (*n* = 85), 3 patients had atelectasis, 9 had pulmonary infection, 4 had atrial fibrillation, and 2 had arrhythmia; the postoperative complication rate was 21.2%. In the control group (*n* = 85), 4 patients had atelectasis, 12 had pulmonary infection, 4 had atrial fibrillation, and 3 had arrhythmia; the postoperative complication rate was 27.1%. The difference did not reach statistical significance (Table 5).

**DISCUSSION**

ERAS is a multimodal perioperative protocol based on best medical evidence. In the 1990s, Kehlet *et al*[11] first used it for patients undergoing colectomy to enhance postoperative recovery[11]. It includes preoperative optimization, intraoperative stress management, and enhanced postoperative recovery, with the goal of accelerating the recovery and resumption of normal activities. It reduces the length of the hospital stay and hospital expenses without increasing the readmission rate. With the gratifying results and low surgical wound, VATS approach is recommended as the standard scheme by several international academic organizations, including the European Society of Thoracic Surgeon, the American College of Chest Physicians and Minimally Invasive Cardiothoracic Surgery[12]. In thoracic surgeries, VATS is a main part of ERAS protocols in the relevant guidelines[13]. At present, class I evidence of the effectiveness of ERAS after thoracic surgery is scarce, especially in elderly patients with lung cancer. This study showed that ERAS improved the clinical efficacy of VATS in elderly patients with lung cancer. At present, data on ERAS in patients undergoing thoracic surgery are limited. Cerfolio *et al*[14] applied ERAS in patients undergoing open pneumonectomy, with a special focus on preoperative patient education, the use of epidural anaesthesia, active standardized removal of the catheter and drainage tube after surgery, early physical movement, and a daily plan for discharge within 4 days after surgery[14]. The intervention accelerated recovery without increasing the complication or mortality rate. A small randomized controlled study also showed that preoperative food intake (no fasting), conduction anaesthesia, early postoperative food intake, and early physical movement significantly reduced the incidence of postoperative pulmonary complications[15]. Salati *et al*[16] performed propensity score matching and demonstrated that ERAS effectively reduced the length of the hospital stay. The study focused on preoperative patient education, standardized postoperative care, and active drainage tube management[16]. In recent years, thoracic surgery-specific ERAS has gradually improved. Madani *et al*[17] described their ERAS procedures for open lobectomy, including standardized care, as well as preoperative, intraoperative, and postoperative management. The study showed that ERAS significantly reduced the length of the hospital stay and complications without increasing the readmission rate. However, their procedures were relatively conservative. Recent studies have shown that paraspinal block (instead of epidural analgesia) and a more aggressive closed thoracic drainage regimen may provide greater benefits to patients[18-20]. This study showed that ERAS significantly reduced postoperative hospital stay, total hospital expenses, and postoperative complications and improved satisfaction. Subgroup analysis per surgical approach (lobectomy *vs* sublobar resection) showed that ERAS did not significantly reduce postoperative hospital stay, total hospital expenses, and postoperative complications nor significantly improve satisfaction in the sublobar resection subgroup. The scope of sublobar resection was relatively small, with less impact on postoperative recovery, which may explain the lack of a significant difference between patients with sublobar resection in the ERAS group and the control group. On the other hand, lobectomy involves a greater scope of resection and surgical trauma, and thus, ERAS was superior to routine care in postoperative recovery. These data provide a reference for the selection of an appropriate rehabilitation regime. For ERAS, clinicians must pay attention to the readmission rate. Some studies have shown that for patients with lung cancer, readmission is related to shorter survival19. However, it is not clear whether ERAS will increase the readmission rate of lung cancer patients[17]. In this study, the 30-d readmission rate was 1.2% (only 1 patient in the ERAS group; *P* > 0.05), which was lower than those reported by other studies.

In recent years, a large body of evidence has demonstrated that VATS reduces complications and improves the prognosis of patients with lung cancer[5,21]. At present, however, evidence of the effectiveness of ERAS following VATS is inadequate, especially evidence on the role of ERAS following VATS in elderly patients with lung cancer. This was the first study to investigate the role of ERAS in the perioperative period in elderly patients with lung cancer. We performed propensity score matching to optimize the control group and comprehensively analysed perioperative outcome measures, including postoperative hospital stay, total hospital expenses, postoperative 48-hour pain score, and satisfaction score. This study showed that for elderly patients with lung cancer, ERAS effectively improved postoperative recovery (including hospital stay and hospital expenses) and patient satisfaction and reduced the postoperative complication rates.

**CONCLUSION**

This is the first study to perform propensity score matching to demonstrate the effectiveness of ERAS for elderly patients with lung cancer. Further subgroup analysis showed that ERAS had significant effects in the lobectomy subgroup. In summary, ERAS may be used as an effective treatment for elderly patients with lung cancer, especially patients undergoing lobectomy.

**ARTICLE HIGHLIGHTS**

***Research background***

Lung cancer is the leading cause of death worldwide, and non-small cell lung cancer (NSCLC) in the elderly accounts for a significant proportion. With the significant growth of the aging population, the need for surgical treatment of elderly patients has gradually become more prominent. Video-assisted thoracic surgery (VATS) has become an important choice for the treatment of senile NSCLC due to its characteristics of less trauma and rapid recovery. However, current systematic studies on VATS in postoperative recovery in elderly patients are relatively limited. Therefore, an in-depth understanding of the influence of VATS on elderly patients and revealing its potential role in postoperative rehabilitation are of great significance for guiding the individualized treatment of elderly patients with NSCLC and improving surgical results.

***Research motivation***

The aim of this study was to investigate the potential enhancement of VATS in postoperative recovery in elderly patients with NSCLC.

***Research objectives***

This study was designed to investigate the clinical outcomes of enhanced recovery after surgery (ERAS) in the perioperative period in elderly patients with NSCLC.

***Research methods***

We retrospectively analysed the clinical data of 85 elderly NSCLC patients who underwent ERAS (the ERAS group) and 327 elderly NSCLC patients who received routine care (the control group) after VATS at the Department of Thoracic Surgery of Peking University Shenzhen Hospital between May 2015 and April 2017. After propensity score matching of baseline data, we analysed the postoperative stay, total hospital expenses, postoperative 48-hour pain score, and postoperative complication rate for the 2 groups of patients who underwent lobectomy or sublobar resection.

***Research results***

After propensity score matching, ERAS significantly reduced the postoperative hospital stay (6.96 ± 4.16 *vs* 8.48 ± 4.18 d, *P* = 0.001) and total hospital expenses (48875.27 ± 18437.5 *vs* 55497.64 ± 21168.63 CNY, *P* = 0.014) and improved the satisfaction score (79.8 ± 7.55 *vs* 77.35 ± 7.72, *P* = 0.029) relative to those for routine care. No significant between-group difference was observed in postoperative 48-h pain score (4.68 ± 1.69 *vs* 5.28 ± 2.1, *P* = 0.090) or postoperative complication rate (21.2% *vs* 27.1%, *P* = 0.371). Subgroup analysis showed that ERAS significantly reduced the postoperative hospital stay and total hospital expenses and increased the satisfaction score of patients who underwent lobectomy but not of patients who underwent sublobar resection.

***Research conclusions***

ERAS effectively reduced the postoperative hospital stay and total hospital expenses and improved the satisfaction score in the perioperative period for elderly NSCLC patients who underwent lobectomy but not for patients who underwent sublobar resection.

***Research perspectives***

We look forward to more large-sample, multicenter studies to validate the recovery benefits of VATS in elderly patients with NSCLC and to further clarify the safety and effectiveness of the surgical technique. At the same time, combined with biological markers and imaging techniques, the specific mechanism of VATS on postoperative inflammatory response, immune function, and quality of life in elderly patients was further studied. With the help of advanced technical means, the individual differences of elderly patients were finely delineated to provide a more accurate basis for personalized surgical treatment. In addition, the long-term efficacy and survival rate of VATS in elderly patients were evaluated through long-term follow-up to comprehensively understand the long-term impact of surgery. These future research directions will provide an in-depth and comprehensive understanding for further promoting the development of surgical treatment for elderly NSCLC.

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**Footnotes**

**Institutional review board statement:** The study was approved by the Institutional Review Board of Peking University Shenzhen Hospital, and all patients provided their informed consent before starting the treatment.

**Informed consent statement:** As it was a retrospective clinical study, all the patients were contacted by telephone to obtain verbal informed consent and it was approved by the ethics committee.

**Conflict-of-interest statement:** All the authors report no relevant conflicts of interest for this article.

**Data sharing statement:** All data collected and analyzed in this study are included in this article, and technical appendix, statistical code, and dataset available from the corresponding author at dr.lixiaoqiang@gmail.com.

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**Figure Legends**

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**Figure 1 Include standard flow chart.** ERAS: Enhanced recovery after surgery.

**Table 1 Perioperative management**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Measures** | **Routine care** | **ERAS** |
| Preoperative | Education | Routine preoperative education | ERAS education |
| Diet | Fasting for 6 h | Drink 1000 mL of 10% glucose the night before surgery; drink 200 mL of 10% glucose 2 h before surgery |
| Sedatives (to improve sleep) | Yes | Yes |
| Intraoperative | Indwelling catheter after anaesthesia | Yes | Yes |
| Temperature maintenance | No | Yes |
| Postoperative | Analgesia | Patient-controlled epidural analgesia | Use of NSAIDs for 48 h |
| Infusion volume | Total intravenous infusion during the first 24 h after the operation < 1500 mL, infusion rate 20-30 mL/min; vasoconstrictors may be used in the case of hypotension or urine output < 20 mL/h | Rapid intravenous drip of 250 mL of saline within 1 h; the remaining parameters were the same as those in the routine care group |
| Diet during the first 6 hours after the operation | A small amount of water | 400 mL of liquid food |
| Promote bowel movements | No | Chewing gum |
| Catheter removal | 24 h after the operation | 12 h after the operation |
| Early exercise | Patient choice | Lower limb movements |

NSAIDs: Non-steroidal anti-inflammatory drugs.

**Table 2 Patient education**

|  |
| --- |
| **Patient preoperative education** |
| Pre-operative | Be familiar with the environment and hospitalization process |
|  | Preoperative nutritional risk screening |
|  | Eat a healthy diet & stay active (1-2 wk before surgery) |
|  | Normal diet the day before surgery |
|  | Drink moderate glucose 2 h before surgery |
|  | Preventive use of antibiotics |
| Postoperative | Eating liquid food moderately within six hours after surgery & infusion |
|  | Receive any necessary medications |
|  | Removed catheter at 12 h after operation |
| Day after surgery | Normal diet |
|  | Use mixture of non-narcotic pain medication to keep comfortable |
|  | Get out of bed as soon as possible |
|  | Try to cough and expectorate |

**Table 3 Baseline data**

|  |  |  |
| --- | --- | --- |
| **Baseline data** | **Before the match (*n* = 412)** | **After match (*n* = 170)** |
| **Routine care (*n* = 327)** | **ERAS (*n* = 85)** | ***P* value** | **Routine care (*n* = 85)** | **ERAS (*n* = 85)** | ***P* value** |
| Age | 72.18 ± 4.53 | 72.91 ± 4.94 | 0.22 | 72.55 ± 5 | 72.91 ± 4.94 | 0.643 |
| Sex | Male | 215 | 56 | 0.982 | 59 | 56 | 0.624 |
| Female | 112 | 29 |  | 26 | 29 |  |
| BMI (kg/m2) | 22.54 ± 2.69 | 22.73 ± 2.62 | 0.54 | 22.51 ± 2.4 | 22.73 ± 2.62 | 0.565 |
| FEV1 (L) | 3.21 ± 0.45 | 3.24 ± 0.41 | 0.615 | 3.24 ± 0.41 | 3.24 ± 0.41 | 0.983 |
| Pathological classification | Adenocarcinoma | 261 | 69 | 0.78 | 69 | 69 | 1 |
| Squamous cell carcinoma | 66 | 16 |  | 16 | 16 |  |
| TNM stage | I | 235 | 55 | 0.198 | 55 | 55 | 1 |
| II | 92 | 30 |  | 30 | 30 |  |
| Surgical approach | Uniportal VATS | 282 | 69 | 0.242 | 75 | 69 | 0.201 |
| Three ports VATS | 45 | 16 |  | 10 | 16 |  |
| Scope of resection | Pulmonary wedge | 66 | 14 | 0.64 | 14 | 14 | 1 |
| Lung segment | 86 | 21 |  | 21 | 21 |  |
| Lobectomy | 175 | 50 |  | 50 | 50 |  |

ERAS: Enhanced recovery after surgery; BMI: Body mass index; FEV1: Forced expiratory volume in the first second; TNM: Tumor-node-metastasis; VATS: Video-assisted thoracic surgery.

**Table 4 Clinical outcome measures (scope of resection subgroup analysis)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Outcome Measures** | **Total (*n* = 170)** | **Pulmonary wedge (*n* = 28)** | **Segmentectomy (*n* = 42)** | **Pulmonary lobe (*n* = 100)** |
| **ERAS (*n* = 85)** | **Routine care (*n* = 85)** | ***P* value** | **ERAS (*n* = 14)** | **Routine care (*n* = 14)** | ***P* value** | **ERAS (*n* = 21)** | **Routine care (*n* = 21)** | ***P* value** | **ERAS (*n* = 50)** | **Routine care (*n* = 50)** | ***P* value** |
| Postoperative hospital stay (d) | 6.06 ± 2.07 | 6.61 ± 1.68 | 0.024 | 5.43 ± 1.91 | 6.14 ± 1.99 | 0.352 | 5.9 ± 2.51 | 6.29 ± 1.65 | 0.325 | 6.3 ± 1.91 | 6.88 ± 1.59 | 0.040 |
| Total hospital expenses (CNY) | 42757.63 ± 14963.16 | 53748.72 ± 18356.11 | 0.000 | 37812.08 ± 13327.54 | 41836.7 ± 13282.69 | 0.454 | 39187.44 ± 18933.83 | 51245.25 ± 16865.5 | 0.007 | 45641.86 ± 13016.75 | 58135.55 ± 18757.68 | 0.001 |
| Postoperative 48-h pain score | 2.38 ± 0.91 | 2.59 ± 0.88 | 0.109 | 2.29 ± 0.83 | 2.43 ± 0.76 | 0.667 | 2.33 ± 1.11 | 2.48 ± 0.87 | 0.560 | 2.42 ± 0.86 | 2.68 ± 0.91 | 0.135 |
| Satisfaction score | 80.65 ± 7.74 | 76.67 ± 7.1 | 0.001 | 80 ± 7.99 | 77 ± 6.86 | 0.427 | 80.29 ± 7.12 | 76.9 ± 5.66 | 0.130 | 80.98 ± 8.04 | 76.48 ± 7.79 | 0.003 |
| Readmission within 30 d | 0 | 1 | 1.000 | 0 | 0 |  | 0 | 0 |  | 0 | 1 | 1.000 |
| Complications (*n*) | 14 | 26 | 0.030 | 2 | 2 | 1.000 | 5 | 12 | 0.028 | 7 | 12 | 0.065 |
| Air leakage | 7 | 13 | 0.153 | 1 | 1 | 1.000 | 3 | 7 | 0.277 | 3 | 5 | 0.712 |
| Atelectasis | 2 | 4 | 0.678 | 0 | 0 |  | 1 | 2 | 1.000 | 1 | 2 | 1.000 |
| Pulmonary infection | 3 | 6 | 0.493 | 1 | 1 | 1.000 | 1 | 1 | 1.000 | 1 | 4 | 0.359 |
| Atrial fibrillation | 1 | 2 | 1.000 | 0 | 0 |  | 0 | 1 | 1.000 | 1 | 1 | 1.000 |
| Arrhythmia | 1 | 1 | 1.000 | 0 | 0 |  | 0 | 1 | 1.000 | 1 | 0 | 1.000 |

ERAS: Enhanced recovery after surgery.

**Table 5 Clinical outcome measures (age subgroup analysis)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Outcome measures** | **Total (*n* = 170)** | **Age 60-73 (*n* = 28)** | **Age 74-80 (*n* = 42)** |
| **ERAS (*n* = 85)** | **Routine (*n* = 85)** | ***P* value** | **ERAS (*n* = 14)** | **Routine care (*n* = 14)** | ***P* value** | **ERAS (*n* = 21)** | **Routine care (*n* = 21)** | ***P* value** |
| Postoperative hospital stay (d) | 6.06 ± 2.07 | 6.61 ± 1.68 | 0.024 | 5.96 ± 2 | 6.57 ± 1.7 | 0.057 | 6.18 ± 2.17 | 6.67 ± 1.69 | 0.188 |
| Total hospital expenses (CNY) | 42757.63 ± 14963.16 | 53748.72 ± 18356.11 | 0.000 | 42122.76 ± 13923.83 | 52334 ± 18206.28 | 0.008 | 43471.85 ± 16202.51 | 55417.37 ± 18628.5 | 0.001 |
| Postoperative 48-h pain score | 2.38 ± 0.91 | 2.59 ± 0.88 | 0.109 | 2.33 ± 0.83 | 2.8 ± 0.83 | 0.006 | 2.43 ± 1.01 | 2.33 ± 0.87 | 0.687 |
| Satisfaction score | 80.65 ± 7.74 | 76.67 ± 7.1 | 0.001 | 81.16 ± 7.52 | 76.78 ± 6.31 | 0.004 | 80.08 ± 8.04 | 76.54 ± 8.01 | 0.055 |
| Readmission within 30 d | 0 | 1 | 1.000 | 0 | 0 |  | 0 | 1 | 1.000 |
| Complications (*n*) | 14 | 26 | 0.030 | 5 | 11 | 0.109 | 8 | 15 | 0.071 |
| Air leakage | 7 | 13 | 0.153 | 4 | 5 | 1.000 | 3 | 8 | 0.179 |
| Atelectasis | 2 | 4 | 0.678 | 1 | 2 | 1.000 | 1 | 2 | 0.982 |
| Pulmonary infection | 3 | 6 | 0.493 | 1 | 3 | 0.625 | 2 | 3 | 0.977 |
| Atrial fibrillation | 1 | 2 | 1.000 | 0 | 1 | 1.000 | 1 | 1 | 1.000 |
| Arrhythmia | 1 | 1 | 1.000 | 0 | 0 |  | 1 | 1 | 1.000 |

ERAS: Enhanced recovery after surgery.