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Analyzing robotic surgery impact on recovery quality & emotions

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ABSTRACT

Background: The objective of this study is to investigate the postoperative recovery quality and emotional status of patients with non-small cell lung cancer (NSCLC) who underwent robot-assisted and video-assisted thoracoscopic surgery using the 15-item Quality of Recovery (QoR-15) scale and to analyze the correlation.
Methods: We collected clinical data from 320 patients with NSCLC who underwent lobectomy using either robot-assisted thoracoscopic surgery (RATS) or video-assisted thoracoscopic surgery (VATS) at our center from January 2021 to December 2022. We compared perioperative parameters and followed up after the operation using the QoR-15 scale to objectively assess the quality of postoperative recovery and physical and emotional status.
Results: Apart from a notable distinction in anesthesia time, no significant differences were observed in other general data. Notably, the overall recovery rate for patients in the RATS group surpassed that of the VATS group ($P < 0.05$). Specifically, the recovery rates in the RATS group were significantly superior to those in the VATS group across nociceptive factors, emotional factors, activities of daily living, physiological factors, and cognitive ability ($P < 0.05$). Spearman correlation analysis between surgical methods and various indicators of the QoR-15 scale showed significant correlations between surgical methods ($P < 0.05$).
Conclusion: The QoR-15 scale is a valuable tool for assessing the postoperative recovery quality in lung cancer patients. The RATS plays a significant role in promoting the swift postoperative recovery of patients and demonstrates excellent efficacy, safety, and reliability.

1. Introduction

Surgery remains the "gold standard" for lung cancer treatment. However, postoperative comprehensive treatment, including chemotherapy, radiotherapy, and individualized targeted therapy, has become increasingly important. In recent years, advancements in Computed Tomography (CT) scanning have led to a higher detection rate of Ground Glass Opacity (GGO), resulting in iterative updates to lung cancer diagnosis and treatment technology. Consequently, the postoperative survival rate of lung cancer patients has gradually improved, along with enhancements in postoperative survival treatment. Good postoperative recovery is of paramount importance and serves as both the patients' expectation and our responsibility as surgeons. Surgical procedures can sometimes lead to postoperative complications and weakness due to surgical trauma, causing patients to worry about their prognosis. This can also lead to depression and anxiety, ultimately affecting the quality of postoperative rehabilitation. Numerous studies [1–5] have demonstrated that RATS offers significant advantages over VATS in terms of surgical treatment and long-term survival [6]. However, as the medical model undergoes transformation, patient expectations for disease management extend beyond the relief of postoperative pain and the

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restoration of physiological function. Patients now seek a higher quality of life and improved postoperative survival. Health-related quality of life encompasses various facets, including patients' subjective experiences and objective assessments by healthcare providers. These facets include physiological function, social and emotional well-being, mood, psychological health, and self-worth [7]. While foreign countries have developed numerous assessment tools for evaluating postoperative recovery quality, such tools are still in the research phase in China. Myles et al. [8] originally developed and validated the Quality of Recovery (QoR) scale, which was self-evaluated by patients. Subsequently, they created the 40-item Quality of Recovery (QoR-40) scale after clinical validation. This comprehensive scale encompasses five aspects: physical comfort, physical independence, psychological support, emotion, and pain management [9–11]. Due to the complexity of the QoR-40 scale, Stark et al. [9] developed the 15-item Quality of Recovery (QoR-15) in 2013, based on QoR-40 and the clinical significance of each item. The aim was to make it more feasible and patient-friendly while retaining its ability to measure psychological aspects. This study seeks to analyze the impact of RATS and VATS on the quality of postoperative recovery and the physiological and emotional well-being of patients, utilizing the version of the QoR-15.

2. Methods

2.1. Study design and patients

A total of 320 consecutive patients with NSCLC were enrolled in this study. These patients were admitted to the Department of Thoracic Surgery, General Hospital of Northern Theater Command, Shenyang, China from January 2021 to December 2022. To facilitate analysis, we categorized the patients into two groups: the RATS group, comprising 152 cases, and the VATS group, comprising 168 cases, based on the surgical methods used. All surgical procedures were performed by one surgeon (Dr. Shumin Wang) and his surgical team.

2.2. Inclusion criteria

(i)Preoperative imaging data should not reveal any contraindication to surgery, including chest CT, cardiac function assessment, hepatobiliary and splenic ultrasound, head CT, and whole-body bone scan; (ii)Normal preoperative test results, including blood routine analysis, liver and kidney function, coagulation function and blood electrolytes tests; (iii) Patients who have not received any form of adjuvant therapy before surgery and have self-detected pulmonary nodules during the follow-up stage; (iv) Patients and their

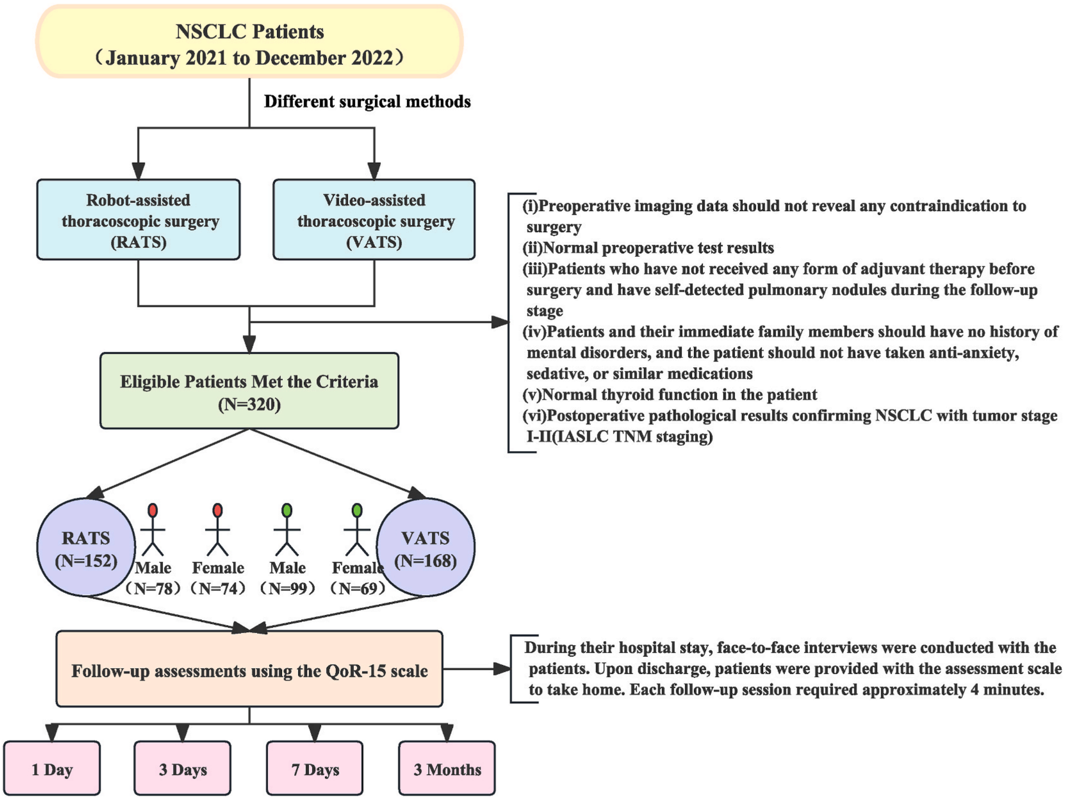

Fig. 1. Study profile. Abbreviations: RATS, Robot-assisted thoracoscopic surgery; VATS, Video-assisted thoracoscopic surgery; QoR-15, 15-item Quality of Recovery scale; N, number; NSCLC, non-small cell lung cancer; IASLC, International Association for the Study of Lung Cancer.

immediate family members should have no history of mental disorders, and the patient should not have taken anti-anxiety, sedative, or similar medications; (v) Normal thyroid function in the patient; (vi) Postoperative pathological results confirming NSCLC with tumor stage I-II according to the latest edition of the International Association for the Study of Lung Cancer (IASLC) TNM staging. (refer to Fig. 1).

2.3. Surgery

RATS group was performed by a same surgeon using the da Vinci S system (Surgical Intuitive, Mountain View, CA, USA) with three robotic arms and VATS group utilized a high-resolution SONY Corporation monitor in conjunction with the STRYKER 988i thoracoscope (MI, USA). Both RATS and VATS groups had procedures performed by the same surgical team. In RATS group, the surgeon operated on a robotic table with an assistant's support following a specific incision design. General anesthesia was administered to both groups, and patients were positioned in a healthy lateral decubitus jacket position. For RATS, a 2–3 cm incision was made at the 7th intercostal space of the midaxillary line for the auxiliary port. Robotic arm holes were created strategically in the 7th or 8th intercostal space of the scapular line and the 5th intercostal space of the anterior axillary line based on lesion location. In VATS group, a 1 cm access port was placed in the 7th intercostal space of the midaxillary line, and an operating port of 3–5 cm was made in the 4th or 5th intercostal space of the anterior axillary line. Both groups directly approached lymph node dissection if preoperative or intraoperative pathology indicated malignancy, performing lobectomy and systematic lymph node dissection. Criteria for systematic lymph node dissection included 3–7 and 9–12 lymph nodes on the left side and 2–4 and 7–12 lymph nodes on the right side.

2.4. Postoperative management

After surgery, the patient was transferred to the thoracoscopic surgery intensive care unit for continuous 24-h monitoring. Standard protocols for support, infection prevention, nebulization, and expectorant treatments were administered. Within the first 24 h post-surgery, an analgesic pump (dexmedetomidine 200μg, oxycodone hydrochloride 60mg, and ondansetron hydrochloride 24mg) was employed, and ketorolac tromethamine was prescribed for pain management until discharge. Patients, based on their vital signs, were transitioned to the general thoracoscopic surgery ward if they met specific criteria. They were encouraged to mobilize as soon as possible while ensuring their safety. Those who fulfilled the conditions for chest drainage tube removal (indicated by a change in drainage fluid from bloody to lightly bloody or orange-clear and drainage volume less than 200mL/24h) could be discharged without any postoperative complications after the removal of the chest drainage tube.

2.5. Evaluation methods and follow-up

All eligible patients underwent follow-up assessments using the QoR-15 scale at four time points: 1 day (d), 3 days (d), 7 days (d), and 3 months post-surgery. During their hospital stay, face-to-face interviews were conducted with the patients. Upon discharge, patients were provided with the assessment scale to take home. Each follow-up session required approximately 4 min.

Table 1
Summary of baseline patient characteristics.

Parameter	RATS group	VATS group	t/x^2 value	P value
Gender			1.871	0.171
Male	78(51.3 %)	99(58.9 %)		
Female	74(48.7 %)	69(41.1 %)		
Age(yr)	(61.87 ± 9.30)	(60.93 ± 8.27)	0.951	0.342
BMI(kg/m^2)	(25.23 ± 3.22)	(25.30 ± 3.84)	−0.181	0.857
Smoking Index			0.008	0.928
Ever	65(42.8 %)	71(42.3 %)		
Never	87(57.2 %)	97(57.7 %)		
Education level			1.926	0.382
Middle school	74(48.7 %)	71(42.3 %)		
High school	34(22.4 %)	48(28.6 %)		
Bachelor's or Higher	44(28.9 %)	49(29.2 %)		
Tumor Type			2.676	0.262
Adenocarcinoma	116(76.3 %)	115(68.5 %)		
Squamous Cell Carcinoma	22(14.5 %)	35(20.8 %)		
Other	14(9.2 %)	18(10.7 %)		
TNM Stage			2.277	0.320
IA	118(77.6 %)	118(70.2 %)		
IB	23(15.1 %)	33(19.6 %)		
II	11(7.2 %)	17(10.1 %)		
Anesthesia time	(127.02 ± 29.41)	(166.89 ± 56.83)	−7.988	<0.001

Data are number (percentage) or (Mean ± Standard Deviation).
BMI, body mass index.
Robot-assisted thoracoscopic surgery (RATS); Video-assisted thoracoscopic surgery (VATS).

2.6. Statistical analysis

Categorical variables were assessed using the chi-squared (χ^2) test and expressed as percentages, rounded to one decimal place. Continuous variables were presented as ($\bar{x} \pm s$). For correlation analysis, Spearman correlation analysis was employed, with the coefficients expressed as ρ. Statistical analyses were performed using SPSS software version 26.0 (IBM, Armonk, NY, USA) and GraphPad Prism version 9.0 (GraphPad Software, San Diego, CA, USA).

3. Results

3.1. Patient characteristics

A total of 320 patients were included in the study, with 152 in the RATS group and 168 in the VATS group. The average age of the patients was (61.38 ± 8.77) years, and the average BMI was (25.27 ± 3.55) Kg/m^2. Notably, there was a significant difference in anesthesia time between the RATS and VATS groups [(127.02 ± 29.41) min vs. (166.89 ± 56.83) min, $P < 0.001$], while no significant differences were observed in other baseline characteristics (refer to Table 1).

Table 2
Comparison of different time nodes Recovery Quality.

Parameter	1 Day	3 Days	7 Days	3 Months
Smoother breathing				
RATS	(5.11 ± 1.70)[b]	(7.37 ± 2.63)	(9.54 ± 0.50)[b]	(9.68 ± 0.47)[b]
VATS	(3.55 ± 1.73)	(7.18 ± 2.55)	(9.01 ± 0.93)	(9.48 ± 0.80)
Improved appetite				
RATS	(8.90 ± 0.88)	(8.01 ± 0.92)	(8.54 ± 0.66)	(8.72 ± 1.28)
VATS	(8.77 ± 0.98)	(7.97 ± 0.99)	(8.48 ± 0.80)	(8.48 ± 1.14)
Increased feelings of relaxation				
RATS	(9.20 ± 0.79)[b]	(8.79 ± 1.06)	(9.10 ± 0.92)	(9.10 ± 0.92)[b]
VATS	(8.93 ± 0.88)	(8.91 ± 0.99)	(9.04 ± 0.93)	(8.82 ± 1.02)
Have had a good sleep				
RATS	(9.03 ± 0.95)	(9.08 ± 0.92)[b]	(8.42 ± 1.51)[b]	(8.84 ± 1.02)
VATS	(8.96 ± 0.92)	(8.83 ± 0.96)	(8.92 ± 0.94)	(8.89 ± 1.02)
Enhanced self-care ability				
RATS	(7.89 ± 1.53)[b]	(9.26 ± 0.83)[b]	(8.74 ± 1.00)	(8.97 ± 1.00)
VATS	(7.48 ± 1.71)	(8.83 ± 1.06)	(8.81 ± 0.99)	(9.05 ± 1.16)
Able to communicate with family or friends				
RATS	(8.96 ± 0.86)	(8.94 ± 1.04)	(9.12 ± 0.91)	(9.27 ± 0.74)
VATS	(9.12 ± 0.84)	(8.84 ± 1.06)	(9.10 ± 0.90)	(9.25 ± 0.75)
Getting support from others				
RATS	(8.66 ± 1.03)	(8.72 ± 1.01)	(9.01 ± 0.92)	(9.13 ± 0.88)
VATS	(8.74 ± 1.01)	(8.74 ± 1.01)	(9.07 ± 0.82)	(8.94 ± 1.00)
Greater freedom of movement				
RATS	(5.18 ± 1.60)	(8.67 ± 1.14)[b]	(8.88 ± 1.15)[b]	(8.63 ± 1.44)[b]
VATS	(5.27 ± 1.58)	(8.36 ± 1.62)	(8.55 ± 1.40)	(8.31 ± 1.37)
Improved self-control				
RATS	(7.43 ± 1.83)	(8.79 ± 1.01)	(8.70 ± 1.02)	(9.01 ± 0.92)
VATS	(6.71 ± 1.96)	(8.92 ± 1.01)	(8.58 ± 1.28)	(8.97 ± 0.99)
Better general health perception				
RATS	(7.12 ± 1.53)	(8.11 ± 1.71)	(8.76 ± 1.04)[b]	(8.63 ± 1.09)[b]
VATS	(7.08 ± 1.69)	(7.95 ± 1.70)	(8.38 ± 1.15)	(8.26 ± 1.46)
Moderate pain[a]				
RATS	(4.88 ± 2.40)	(4.21 ± 2.10)[b]	(3.89 ± 1.02)[b]	(3.41 ± 1.41)
VATS	(4.70 ± 2.22)	(4.72 ± 2.03)	(4.23 ± 1.01)	(3.69 ± 1.41)
Severe pain[a]				
RATS	(5.86 ± 1.75)[b]	(6.89 ± 1.02)[b]	(3.72 ± 1.44)	(2.80 ± 1.61)
VATS	(6.55 ± 1.78)	(7.15 ± 0.92)	(3.41 ± 1.38)	(3.01 ± 1.55)
Nausea or vomiting[a]				
RATS	(5.72 ± 0.99)[b]	(4.84 ± 1.02)	(6.66 ± 1.03)	(3.98 ± 1.01)
VATS	(5.93 ± 0.88)	(4.89 ± 1.02)	(6.74 ± 1.01)	(4.00 ± 0.91)
Feeling worried or anxious[a]				
RATS	(4.89 ± 1.02)[b]	(3.64 ± 1.69)	(2.89 ± 1.02)[b]	(3.21 ± 2.10)[b]
VATS	(5.15 ± 0.92)	(3.93 ± 1.69)	(3.26 ± 0.99)	(3.72 ± 2.03)
Feeling sad or depressed[a]				
RATS	(3.20 ± 0.90)[b]	(3.14 ± 0.83)[b]	(4.01 ± 0.92)	(3.13 ± 1.73)[b]
VATS	(3.92 ± 1.01)	(2.95 ± 0.86)	(3.97 ± 0.99)	(3.56 ± 1.93)

Data are number (percentage) or (Mean ± Standard Deviation).
Robot-assisted thoracoscopic surgery (RATS); Video-assisted thoracoscopic surgery (VATS).
[a] Indicates reverse score.
[b] indicates item $P < 0.05$.

3.2. Comparison of different time nodes recovery quality

The quality of recovery was assessed at various time points following surgery in both the RATS and VATS groups. On the first day post-surgery, the RATS group exhibited better outcomes compared to the VATS group in terms of smoother breathing, increased feelings of relaxation, and enhanced self-care ability. Additionally, the RATS group experienced less severe pain, nausea or vomiting, anxiety, sadness and depression, all of which showed statistically significant differences ($P < 0.05$).By the third day after surgery, statistically significant differences emerged between the two groups in sleep quality, self-care ability, mobility, moderate pain, severe pain, and feelings of sadness and depression ($P < 0.05$).On the seventh day post-operation, significant differences were observed between the RATS and VATS groups in smoother breathing, sleep quality, mobility, general health, mild pain, and anxiety ($P < 0.05$). At the three-months mark after surgery, the RATS group continued to exhibit superior outcomes. They experienced smoother breathing, greater relaxation, improved activity levels, and a heightened perception of overall health compared to the VATS group. Patients in the VATS group were more likely to report stress, anxiety, and feelings of sadness and depression ($P < 0.05$) (refer to Table 2).

3.3. Comparison of overall recovery quality

When comparing the overall recovery quality between the two groups, it was evident that RATS patients exhibited superior outcomes compared to VATS patients. Specifically, RATS patients in the RATS group demonstrated:(i) Smoother breathing [(31.69 ± 3.10) vs. (29.22 ± 3.38), $P < 0.001$]; (ii) Improved appetite [(34.18 ± 1.82) vs. (33.70 ± 2.16), $P < 0.001$]; (iii) Increased feelings of relaxation [(36.18 ± 1.82) vs. (35.70 ± 1.92), $P = 0.022$]; (iv) Enhanced self-care ability [(34.86 ± 2.23) vs. (34.17 ± 2.46), $P = 0.009$]; (v) Greater freedom of movement [(31.36 ± 2.84) vs. (30.48 ± 3.00), $P = 0.008$]; (vi) Improved self-control [(33.93 ± 2.60) vs. (33.18 ± 2.84), $P = 0.015$]; (vii) Better general health perception [(32.61 ± 2.82) vs. (31.67 ± 3.04), $P = 0.005$]. Additionally, RATS patients reported lower levels of mild pain [(16.38 ± 4.53) vs. (17.34 ± 3.09), $P = 0.030$] and severe pain [(19.26 ± 2.89) vs. (20.12 ± 2.74), $P = 0.007$] compared to the VATS group. RATS patients also experienced less anxiety [(14.63 ± 3.71) vs. (16.07 ± 3.06), $P < 0.001$] and lower levels of sadness and depression [(13.48 ± 2.32) vs. (14.40 ± 2.41), $P = 0.001$], showcasing significant advantages over the VATS group (refer to Table 3).

3.4. Analysis of surgical methods and postoperative recovery quality

We conducted an analysis to investigate the correlation between different surgical methods and the quality of postoperative recovery. The results revealed significant correlations between surgical methods and various recovery aspects: Smoother breathing; Increased feeling of relaxation; Enhanced self-care ability; Greater freedom of movement; Improved self-control; Better general health conception; Moderate pain; Severe pain; Feeling worried or anxious; Feeling sad or depressed. All these correlations were statistically significant ($P < 0.05$). For a visual representation, please refer to Fig. 2.

4. Discussion

The reasonable assessment and improvement of postoperative recovery quality are vital for ensuring the rapid recuperation of patients. Postoperative recovery quality is influenced by a range of subjective and objective factors, encompassing psychosocial well-being, emotional state, postoperative pain, and complications. In clinical practice, we often emphasize whether various postoperative

Table 3
Comparison of overall recovery quality.

Parameter	RATS group	VATS group	*t* value	*P* value
Smoother breathing	(31.69 ± 3.10)	(29.22 ± 3.38)	6.796	<0.001
Improved appetite	(34.18 ± 1.82)	(33.70 ± 2.16)	2.165	0.031
Increased feelings of relaxation	(36.18 ± 1.82)	(35.70 ± 1.92)	2.302	0.022
Have had a good sleep	(35.38 ± 2.22)	(35.60 ± 1.94)	−0.972	0.332
Enhanced self-care ability	(34.86 ± 2.23)	(34.17 ± 2.46)	2.618	0.009
Able to communicate with family or friends	(36.29 ± 1.82)	(36.30 ± 1.62)	−0.073	0.941
Getting support from others	(35.51 ± 1.81)	(35.50 ± 1.90)	0.063	0.950
Greater freedom of movement	(31.36 ± 2.84)	(30.48 ± 3.00)	2.684	0.008
Improved self-control	(33.93 ± 2.60)	(33.18 ± 2.84)	2.458	0.015
Better general health perception	(32.61 ± 2.82)	(31.67 ± 3.04)	2.858	0.005
Moderate pain[a]	(16.38 ± 4.53)	(17.34 ± 3.09)	−2.188	0.030
Severe pain[a]	(19.26 ± 2.89)	(20.12 ± 2.74)	−2.738	0.007
Nausea or vomiting[a]	(21.20 ± 1.99)	(21.57 ± 1.84)	−1.747	0.082
Feeling worried or anxious[a]	(14.63 ± 3.71)	(16.07 ± 3.06)	−3.748	<0.001
Feeling sad or depressed[a]	(13.48 ± 2.32)	(14.40 ± 2.41)	−3.464	0.001

Data are number (percentage) or (Mean ± Standard Deviation).
Robot-assisted thoracoscopic surgery (RATS); Video-assisted thoracoscopic surgery (VATS).
[a] Indicates reverse score.

indicators meet discharge criteria and department bed turnover rates. However, there's a tendency to overlook the importance of evaluating patients' subjective experiences. Currently, the postoperative recovery quality evaluation systems for patients are inconsistent. The complexity of these systems not only burdens healthcare professionals but also affects their effectiveness due to their limited coverage [12]. In comparison to the QoR-40 scale, the QoR-15 scale reduces the incidence of low postoperative complications while retaining similar content items. Stark et al. [9,10,13] utilized the QoR-15 scale to assess the recovery quality of 127 patients after general anesthesia on the first day post-surgery, confirming the efficacy, reliability, and clinical acceptance of QoR-15. Their study showed that QoR-15 had improved clinical acceptance compared to the more complex QoR-40 scale. Patients found QoR-15 more accessible, with most completing it within 3 min. Lin [14] was the first to translate QoR-15 into Chinese and assess postoperative recovery quality in hepatectomy patients, confirming the scale's reliability, validity, and clinical feasibility in domestic applications (refer to Fig. 3). Patients undergoing lung cancer surgery are particularly vulnerable to negative emotions such as postoperative pain, dyspnea, nervousness, anxiety, pessimism, and depression. Moreover, the retention of thoracic drainage tubes and urinary catheters after surgery intensifies patients' anxiety and fear, causing psychological and physiological stress trauma [15,16]. Most lung cancer patients are elderly and may have anesthesia and metabolism issues, making them prone to postoperative cognitive dysfunction such as delirium, restlessness, nausea, and vomiting. Surgical trauma and postoperative complications contribute to various psychological issues, including anxiety and tension, directly impacting early postoperative recovery quality.

Disease occurrence, development, and recovery are not solely rooted in patients' physical pathology but are closely intertwined with their social and psychological factors. Modern medical treatment has transitioned into a bio-psycho-social medical model. Advancements in medical equipment and technology offer new hope for patients. As early as the early 21st century, Melfi et al. [17] successfully applied RATS technology to pulmonary resection in thoracoscopic surgery. Due to safety concerns, RATS was initially primarily used for treating stage I and II lung cancer [18]. RATS overcomes many limitations of VATS. RATS employs wrist instruments inserted into the chest through an 8-mm port, mimicking human hand movements. Additionally, the undistorted magnification and three-dimensional imaging system provide surgeons with high-definition lung images, an advantage unique to this surgical modality.

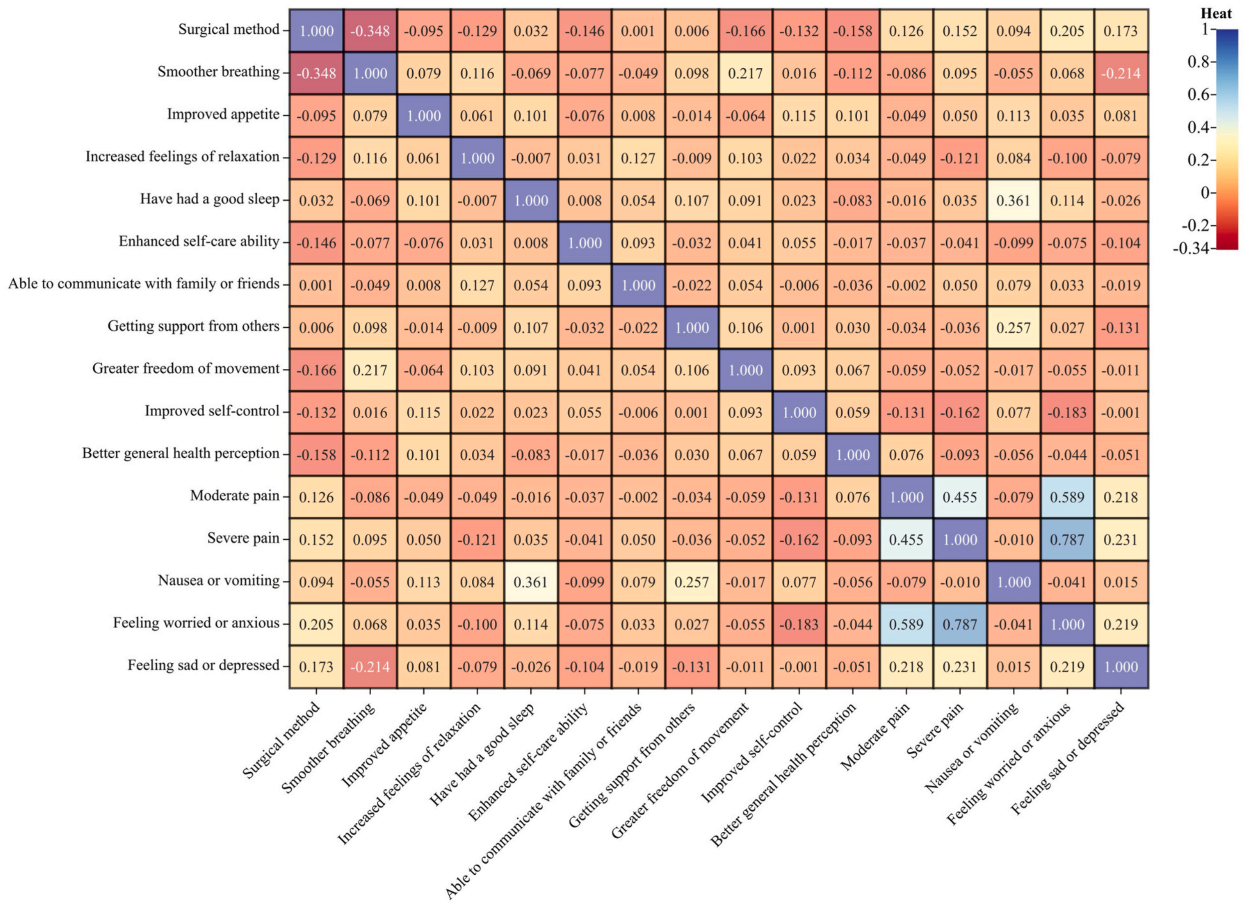

Fig. 2. Analysis of Surgical Methods and Postoperative Recovery Quality
Spearman correlation analysis was employed, with the coefficients expressed as ρ.
Darker colors represent more distinct correlations, and the difference is statistically significant($P < 0.05$). (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

15-item Quality of Recovery，QoR-15

Name Gender M☐ F☐

Age Date

Surgery

How have you been feeling in the last 24 hours?

(0 to 10, where:0=none of the time [poor]and 10=all of the time[excellent])

1. Smoother breathing	0	1	2	3	4	5	6	7	8	9	10
2. Improved appetite	0	1	2	3	4	5	6	7	8	9	10
3. Increased feelings of relaxation	0	1	2	3	4	5	6	7	8	9	10
4. Have had a good sleep	0	1	2	3	4	5	6	7	8	9	10
5. Enhanced self-care ability	0	1	2	3	4	5	6	7	8	9	10
6. Able to communicate with family or friends	0	1	2	3	4	5	6	7	8	9	10
7. Getting support from others	0	1	2	3	4	5	6	7	8	9	10
8. Greater freedom of movement	0	1	2	3	4	5	6	7	8	9	10
9. Improved self-control	0	1	2	3	4	5	6	7	8	9	10
10. Better general health perception	0	1	2	3	4	5	6	7	8	9	10

Have you had any of the following in the last 24 hours?

(0 to 10, where:10=none of the time [excellent]and 0=all of the time[poor])

11. Moderate pain	0	1	2	3	4	5	6	7	8	9	10
12. Severe pain	0	1	2	3	4	5	6	7	8	9	10
13. Nausea or vomiting	0	1	2	3	4	5	6	7	8	9	10
14. Feeling worried or anxious	0	1	2	3	4	5	6	7	8	9	10
15. Feeling sad or depressed	0	1	2	3	4	5	6	7	8	9	10

Fig. 3. 15-Item quality of recovery, QoR-15.

RATS allows for more minimally invasive lung cancer resections, such as pneumonectomy or sleeve resection, with enhanced controllability, precision, and stability, especially in complex thoracoscopic surgery [1,19,20]. The multi-dimensional robotic arm and the innovative wrist rotation system enable surgical instruments under a microscope to synchronize with human hand movements, achieving true hand-eye coordination and man-machine integration. Simultaneously, the operating system filters out any inadvertent hand tremors, compensating for the shortcomings of VATS. Moreover, multi-articulated instruments within the thoracic cavity enable smooth and natural manipulation during surgical dissection, a significant advantage over conventional VATS techniques that require straight instruments.

Our study results demonstrated a significant difference in anesthesia duration between the RATS group and the VATS group. The flexibility of RATS surgery minimizes overall anesthesia time. Tracheal intubation, an invasive procedure, continuously stimulates sympathetic nerves around the trachea, increasing cardiovascular risks during prolonged periods. By ensuring effective surgery while reducing anesthesia time, the RATS technique minimizes anesthesia-related risks and complications [21–23]. Our study also revealed that the RATS group experienced less severe pain and mild pain than the VATS group on the first- and third-days post-surgery, respectively, with statistically significant differences ($P < 0.05$). Overall, the RATS group demonstrated superior recovery regarding mild pain and severe pain compared to the VATS group. Furthermore, our correlation analysis indicated significant associations between surgical methods and moderate pain ($\rho = 0.126$) and severe pain ($\rho = 0.152$). Moderate pain and severe pain correlated with anxiety ($\rho = 0.589$) and sadness and depression ($\rho = 0.218$). These findings emphasizing that different postoperative pain experiences can exacerbate patients' psychological burden, affecting their subjective well-being.

Modern medicine has further refined the implementation of Enhanced Recovery After Surgery (ERAS). ERAS is an innovative revolution in treatment models, challenging many traditional surgical concepts. It adopts a patient-centered approach, involving "physicians, nurses, and patients" throughout the hospital stay, employing multiple methods to reduce postoperative complications, accelerate recovery, and shorten hospitalization durations. The RATS technique not only ensures surgical efficacy but also reduces patients' psychological stress and postoperative pain, thus enhancing their sleep and post-surgery comfort, ultimately improving long-term patient quality of life. In summary, this systematic review of the effects of different surgical methods on postoperative mental health in NSCLC patients, using the QoR-15 scale, suggests that RATS surgery alleviates postoperative psychological pressure while maintaining safety and effectiveness. This leads to enhanced psychological well-being, improved treatment compliance, and expedited patient recovery. This study has identified certain limitations. Firstly, the number of cases remains relatively small. Additionally, we acknowledge the necessity of exploring the influence of age on both the physical and emotional aspects of patients. In the next phase, we plan to expand the sample size, conducting a large-scale multicenter survey study to address these limitations. Moreover, we recognize the importance of analyzing variable factors that could impact the quality of postoperative recovery. This analysis aims to establish a foundation for rehabilitation intervention. In the subsequent steps, we intend to employ the QoR-15 scale for evaluating the efficacy of rehabilitation interventions.

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None.

Reporting checklist

The authors have completed the STROBE reporting checklist.

Contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by [M Cheng], [R Ding] and [W Xu]. The first draft of the manuscript was written by [M Cheng] and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Ethical Statement

The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study was approved by the ethics board of General Hospital of Northern Theater Command (NO. Y2023-075) and individual consent for this retrospective analysis was waived.

Data availability statement

The data are available from the corresponding author on reasonable request.

CRediT authorship contribution statement

Ming Cheng: Data curation, Writing- Original draft preparation, Conceptualization, Methodology, Software. **Renquan Ding:** Visualization, Investigation. **Wei Xu:** Supervision, Validation. **Shumin Wang:** Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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