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The clinical effect of thoracoscopic segmentectomy in the treatment of lung malignancies less than 2CM in diameter

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Abstract

Objective To investigate the clinical effect of thoracoscopic segmentectomy in the treatment of lung malignancies less than 2CM in diameter.

Methods In this retrospective study, a total of 103 patients with lung cancer who received outpatient or inpatient treatment from December 2020 to May 2022 were selected and divided into the lobectomy group ($n=48$) and the segmentectomy group ($n=55$) according to different surgical methods. The lobectomy group was treated with thoracoscopic lobectomy, while the segmentectomy group was treated with thoracoscopic segmentectomy. The prognostic effect, complications, blood gas level and respiratory function indexes of the two groups were observed and compared.

Results The general data of the two groups of patients, such as gender, age, course of disease, body mass index, lesion diameter, lesion site and pathological type, were analyzed by statistical software. There was no statistical significance in the operation time and the number of lymph node dissection between the two groups ($P>0.05$), while the drainage volume and intraoperative blood loss in the segmentectomy group were lower than those in the lobectomy group, and the drainage time and hospital stay were shorter than those in the lobectomy group, with statistical significance ($P<0.05$). Before treatment, there were no statistically significant differences in various lung function indexes between the two groups ($P>0.05$). After treatment, the values of FVC, FEV1 and FEV1/FVC in each group had different amplitude changes, and the values of FVC, FEV1 and FEV1/FVC in the segmentectomy group were significantly higher than those in the lobectomy group, with statistical significance ($P<0.05$). Thoracoscopic segmentectomy showed a lower incidence of respiratory complications ($P=0.042$) and higher pulmonary air leak ($P=0.023$) than thoracoscopic lobectomy. After propensity score-matched analysis, respiratory complications remained significantly higher in thoracoscopic segmentectomy ($P=0.017$). However, the difference in the total complication rate between the two groups was not statistically significant ($P>0.05$). There were no differences during the 2-year follow-up (median follow-up in months: 18.4; interquartile range, 14.8–21.3) in terms of overall survival ($P=0.49$) and disease-free survival ($P=0.34$) between groups ($P>0.05$).

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Conclusions For patients with lung cancer less than 2 cm in diameter, thoracoscopic segmentectomy can achieve good short-term efficacy, with rapid postoperative recovery and little impact on lung function, which may be helpful to improve patients' postoperative quality of life.

Keywords Lung cancer, Segmentectomy of lung, Thoracoscopic, Pulmonary nodules

Introduction

Lung cancer is one of the malignant tumors with high clinical harm, which seriously affects the quality of life of patients. At present, it is an urgent problem to improve the lung function and prognosis of lung cancer patients [1]. In the past, the detection rate of early lung cancer was low. With the development of imaging technology, the detection rate of more early lung cancer with a diameter less than 2 cm (solitary pulmonary nodules) gradually increased in physical examination [2, 3]. Therefore, early diagnosis and treatment of lung cancer is possible. At present, radical resection is often taken for patients with early lung cancer to prevent the spread of lesions, which can provide patients with a good prognosis and short-term survival rate [4]. It is pointed out that most patients with lung malignant tumor mainly choose thoracoscopic lobectomy [5], but early lung cancer patients with small tumors and too close to the center of the lung are especially suitable for thoracoscopic segmentectomy [6]. Thoracoscopic segmentectomy is to remove some lung tissue units smaller than the lung lobes, which theoretically protects the lung function of patients better, but its safety and efficacy still need to be further confirmed [7]. In view of this, our hospital takes some patients as the research object, and analyzes the surgical effect of thoracoscopic pneumonectomy in order to provide reference for the clinical treatment of early lung cancer patients. Now the research details are summarized and reported as follows.

Protocol

Two groups of surgeries were included in this retrospective study: the lobectomy group underwent thoracoscopic lobectomy, and the segmentectomy group underwent thoracoscopic segmentectomy. Indications for Lobectomy: British Thoracic Society (BTS) 2001 guidelines suggest absolute preoperative FEV1 of 1.5 L for lobectomy. Indications for Segmentectomy: The 2020 National Comprehensive Cancer Network Guidelines suggest patients aged ≥ 75 years or poor pulmonary function or other severe comorbidities who cannot tolerate lobectomy for segmentectomy. The following is a description of the specific procedures and data collection methods for these two groups of surgeries:

Procedures for the lobectomy group (video-assisted thoracoscopic lobectomy)

Patient anesthesia

Before the operation begins, the patient is sent to the operating room, and the anesthesiologist gradually injects general anesthetic drugs into the patient to bring him into a pain-free state of consciousness. Anesthesia monitoring equipment is used to monitor vital signs such as heart rate, blood pressure, and respiration of patients.

Preparation for surgery

The surgeon will make a small incision in the patient's chest, usually right in front of the chest. The size of this incision is usually around 2–4 cm, which is large enough to accommodate the thoracoscope. At the incision, the surgeon inserts a balloon that expands the visible area of the chest to allow for surgery.

Locating the lesion

Once the thoracoscope is inserted, the surgeon uses a mirror to examine the conditions within the chest cavity to locate malignant tumors or other abnormal tissue within the lungs. This step involves viewing through a thoracoscope while manipulating it with specific surgical instruments.

Removal of a lobe

Once the tumor or abnormal tissue is accurately located, the surgeon proceeds to remove the entire affected lobe. Resection usually includes the lobe of the lung where the tumor is located and the tissue adjacent to it. This procedure may require the use of various surgical tools, such as electrosurgery or lasers, to ensure complete removal of the lesion.

Lymph node dissection

If lymph node involvement is suspected in or around the lesion, the surgeon will perform lymph node dissection. This involves carefully removing lymph nodes to determine if any cancer cells have spread to those lymph nodes. The removed lymph nodes are usually sent to a laboratory for pathological examination.

Drainage

After surgery, the surgeon will place a drainage tube to drain fluids, such as blood or lymph, that may have accumulated during or after surgery. A drainage tube is inserted into the chest through another small incision

to direct the fluid to an external container to ensure the patient does not develop fluid accumulation and reduce the risk of infection.

Procedures for the segmentectomy group (video-assisted thoracoscopic segmentectomy)

Patient anesthesia

The operation of the segmentectomy group is similar to that of the lobectomy group. General anesthesia is also required to ensure that the patient is painless during the operation.

Surgical preparation

Similarly, the surgeon makes a small incision in the patient's chest and inserts the thoracoscope through this incision. The incision is usually relatively small to accommodate the thoracoscope and other necessary tools.

Locating lesions

Use thoracoscopy to locate malignant tumors or other abnormal tissues in the lungs.

Resection of lung segments

This is the key difference in the operation of the segmentectomy group. Unlike the lobectomy group, the surgeons removed only the segment of the lung containing the disease rather than the entire lobe. This step requires the surgeon to precisely remove the affected lung segment and ensure the integrity of surrounding healthy tissue.

Lymph node dissection

If lymph node involvement is suspected in or around the lesion, the surgeon will perform lymph node dissection. This involves carefully removing lymph nodes to determine if any cancer cells have spread to those lymph nodes. The removed lymph nodes are usually sent to a laboratory for pathological examination.

Drainage

After surgery, the surgeon will place a drainage tube to drain potential pleural effusion.

Data collection method

Data collection is a key part of this study to compare the surgical effects and postoperative conditions between the two groups.

General information

including gender, age, disease duration, body mass index, lesion diameter, lesion location, pathological type and other general information. This information was obtained through case records and patient questionnaires and analyzed using statistical software to ensure that the two groups were comparable.

Operation time and number of lymph node dissections

These data are recorded by the operating room recorder or surgeon. The operation time is the time from the beginning to the end of the operation, and the number of lymph node dissections records the number of dissections.

Drainage volume and intraoperative blood loss

These data are usually recorded by the operating room nurse. The drainage volume is measured through the fluid in the drainage tube and surgical cloth. The intraoperative blood loss is estimated by the surgeon during the operation.

Drainage volume time and hospital stay

These data are recorded by ward nurses and doctors. The retention time of the drainage tube is usually measured from the end of the operation, and the hospital stay is the time from admission to discharge after the operation.

Pulmonary function indicators and blood gas analysis

Lung function indicators include FVC (forced vital capacity), FEV1 (forced expiratory volume in one second) and FEV1/FVC value, which are used to evaluate lung function. It was performed before treatment and 6 months later treatment. These are measured before and after treatment with respiratory function tests (such as a spirometer) to determine the impact of surgery on lung function. Measurements are usually recorded in the patient's medical record. Blood gas analysis was performed before and 24 h after treatment, Partial Pressure of Carbon Dioxide in Arterial Blood (PaCO2), Partial Pressure of Oxygen in Arterial Blood (PaO2), and Oxygenation Index (OI) were measured in mmHg.

Follow-up

The patients were followed up for 2 years in terms of overall survival (OS) and disease-free survival (DFS) via telephone.

Data analysis

Data analysis software SPSS 22.0 was used. Descriptive statistics for continuous data are presented as ($\overline{x} \pm s$,%), and t-test analysis was conducted. Descriptive statistics for categorical data are presented as n (%), and chi-square test analysis was performed. Log-rank analysis was performed for OS and DFS survival analysis. Propensity score-matched analysis was conducted to mitigate bias and improve the reliability of the data. A P value less than 0.05 indicates statistical significance.

Representative results

In order to ensure that the baseline data between the two groups will not affect the fairness of the data obtained in the follow-up study, the general data such as gender, age, course of disease, body mass index, lesion diameter, lesion site and pathological type of the two groups were analyzed by statistical software, and the data obtained from the test showed that $P>0.05$, indicating comparability, as shown in Table 1; Fig. 1.

There was no significant difference in operation time and number of lymph node dissection between the two groups ($P>0.05$). However, the drainage volume and intraoperative bleeding volume of patients in the segmentectomy group were lower than those of the lobectomy group, and the drainage time and hospital stay were shorter than those of the lobectomy group. The differences were statistically significant ($P<0.05$), as shown in Table 2.

Before treatment, there was no significant difference in blood gas levels between the two groups ($P>0.05$). After treatment, PaCO2 in segmentectomy group was lower than that in lobectomy group, PaO2 and OI were higher than those in lobectomy group, and the differences had statistical significance ($P<0.05$), as shown in Table 3.

Before treatment, there was no significant difference in various pulmonary function indexes between the two groups ($P>0.05$). After treatment, the FVC, FEV1 and FEV1/FVC values in each group showed different amplitude changes, while the FVC, FEV1 and FEV1/FVC values in the segmentectomy group were significantly higher than those in the lobectomy group with a statistically significant difference ($P<0.05$), as shown in Table 4.

Thoracoscopic segmentectomy showed a lower incidence of respiratory complications ($P=0.042$) and higher pulmonary air leak ($P=0.023$) than thoracoscopic lobectomy. After propensity score-matched analysis, respiratory complications remained significantly higher in thoracoscopic segmentectomy ($P=0.017$). However, the difference in the total complication rate between the two groups was not statistically significant ($P>0.05$), as shown in Table 5.

There were no differences during the 2-year follow-up (median follow-up in months: 18.4; interquartile range, 14.8–21.3) in terms of overall survival ($P=0.49$) and disease-free survival ($P=0.34$) between groups, as shown in Figs. 2 and 3.

Discussion

At present, surgical treatment is the first choice for patients with early and middle stage lung cancer. The traditional posterolateral thoracotomy requires the help of distractors, which easily leads to excessive traction causing chest wall injury, affecting thoracic movement and limiting diaphragmatic activity. In addition, lung cancer patients generally have physical dysfunction and poor tolerance. If the injury is severe, it can cause restrictive respiratory disorder [8–10], further affecting the therapeutic effect. Therefore, it is important to improve the surgical methods of early lung cancer to improve the efficacy and prognosis of patients.

At present, patients with lung cancer are mainly treated with lobectomy combined with lymph node dissection [11], but some patients with such patterns cannot tolerate it. On this basis, segmentectomy has emerged, and the main purpose of its treatment is to dissect and remove lymph nodes and lesion sites as much as possible [12]. At present, the method of thoracoscopic segmentectomy has been gradually recognized by more people, and in terms of small pulmonary nodules, the surgeon can not only confirm the pathological diagnosis, but also free the segmental vessels and bronchi that need to be removed and perform radical resection of the lesion in a timely manner without prolonging the surgical incision [13, 14]. In this study, patients with lung cancer less than 2 cm in diameter in our hospital were selected as the study subjects and underwent segmentectomy and lobectomy, respectively, but three-hole thoracoscopic segmentectomy was used because it had less angle limitation in operation, and could more clearly identify the exposure

Table 1 Comparison of the general material between two group($\overline{x} \pm s$,%)

Group			Lobectomy group ($n=48$)	Segmentectomy group ($n=55$)	t value	*P* value
Gender		Male	30	29	0.759	0.433
		Female	18	26		
Age(years)			63.54 ± 6.22	64.12 ± 6.63	0.647	0.511
BMI(kg/m^2)			22.84 ± 1.92	22.37 ± 1.89	0.476	0.632
Lesion diameter(cm)			1.85 ± 0.27	1.83 ± 0.29	0.083	1.919
Lesion site	Left lung		16	18	0.359	0.671
	Right lung		32	37		
Pathological type	Adenocarcinoma		21	26	0.282	0.770
	Squamous carcinoma		15	19		
	Adenosquamous carcinoma		12	10		

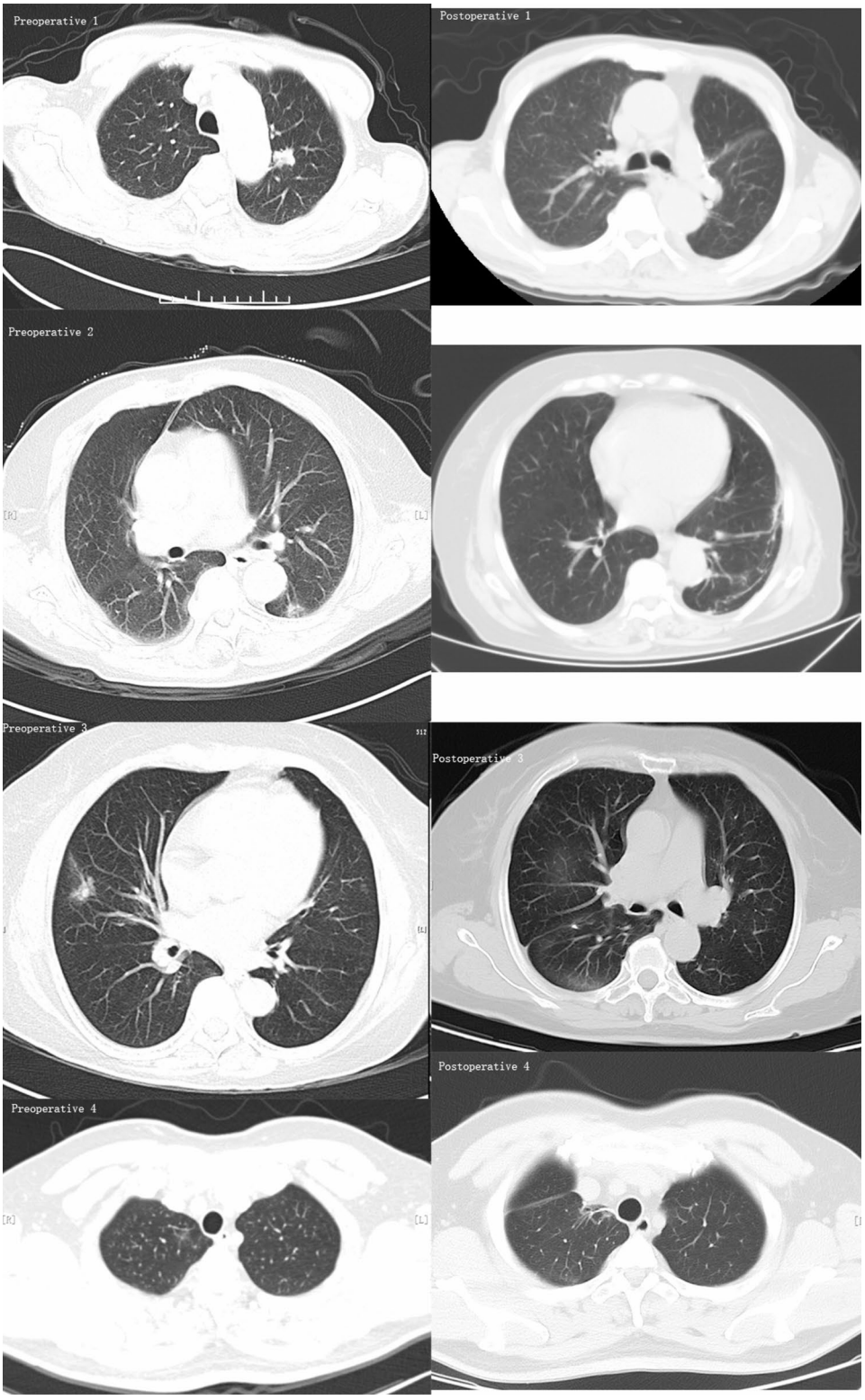

Fig. 1 Comparison of perioperative indexes between two groups of patients

Table 2 Comparison of perioperative indexes between two groups of patients($\overline{x} \pm s$)

Group	Lobectomy group($n=48$)	Segmentectomy group ($n=55$)	t value	*P* value
Operation time (min)	145.63 ± 13.87	141.37 ± 10.65	1.636	0.192
Hospital stay (d)	14.14 ± 2.47	11.81 ± 2.15	10.043	0.014
Drainage time (d)	4.54 ± 1.44	2.02 ± 1.78	9.491	0.002
Drainage volume (ml)	469.12 ± 17.08	273.10 ± 11.07	11.326	0.007
Intraoperative bleeding volume (ml)	86.20 ± 18.29	65.49 ± 13.16	10.955	0.006
Number of lymph node dissection(cases)	16.86 ± 2.16	16.83 ± 3.21	0.793	0.065

Table 3 Comparison of blood gas levels between the two groups($\overline{x} \pm s$)

Group		Lobectomy group ($n=48$)	Segmentectomy group ($n=55$)	t value	*P* value
Pa CO_2(mmHg)	Before treatment	56.82 ± 8.16	57.10 ± 8.13	0.183	0.837
	After treatment	49.56 ± 7.05[a]	41.19 ± 6.20[a]	7.015	0.003
Pa O_2(mmHg)	Before treatment	58.84 ± 8.80	58.87 ± 9.73	1.324	0.195
	After treatment	89.57 ± 10.17[a]	94.54 ± 12.34[a]	6.409	0.002
OI(mmHg)	Before treatment	187.52 ± 30.23	188.06 ± 30.59	1.518	0.138
	After treatment	265.96 ± 33.48[a]	348.42 ± 36.19[a]	10.132	0.001

Note compared with the same group before treatment,[a]$P<0.05$

Table 4 Comparison of pulmonary function indexes between the two groups($\overline{x} \pm s$)

Group		Lobectomy group ($n=48$)	Segmentectomy group ($n=55$)	t value	*P* value
FVC(L)	Before treatment	2.16 ± 0.15	2.12 ± 0.13	1.509	0.137
	After treatment	1.32 ± 0.19[a]	1.59 ± 0.14[a]	7.226	0.003
FEV1(L)	Before treatment	2.01 ± 0.21	2.05 ± 0.32	0.094	0.854
	After treatment	1.55 ± 0.24[a]	1.83 ± 0.46[a]	10.346	0.009
FEV1/FVC(%)	Before treatment	58.31 ± 7.45	59.50 ± 7.19	0.652	0.433
	After treatment	61.74 ± 10.33[a]	69.02 ± 10.17[a]	10.824	0.006

Note compared with the same group before treatment,[a]$P<0.05$

of the surgical field and hilar structure, and then timely solve the intractable problems encountered during the operation [15], so as to avoid interference with perioperative indicators. The results of this study showed that the differences in the operation time and the number of dissected lymph nodes between the two groups had no statistical significance, while the drainage volume and intraoperative blood loss in the segmentectomy group were lower than those in the lobectomy group, and the drainage time and hospital stay were shorter than those in the lobectomy group, and the differences had statistical significance, suggesting that thoracoscopic segmentectomy was beneficial to postoperative recovery. Clinically, it is pointed out that the scar tissue formed by intercostal muscle flesh injury after lobectomy is irreversible and will cause permanent respiratory muscle injury [16], while the greatest advantage of thoracoscopic segmentectomy is that it has its own anatomical theoretical basis and according to the characteristics of dual supply of qi and blood in lung tissue, anatomical resection of one or two segments of the lung is performed independently, and lymph nodes that may metastasize between segments can be treated, and then effectively protect postoperative residual pulmonary function [17–19]. This study compared postoperative blood gas levels and pulmonary function-related indicators between the two groups. The results showed that after treatment, PaCO2 in segmentectomy group was lower than that in lobectomy group, PaO2 and OI were higher than those in lobectomy group, while FVC, FEV1 and FEV1/FVC in segmentectomy group had different amplitude changes, and the differences had statistical significance, suggesting that thoracoscopic segmentectomy had better therapeutic effect in protecting postoperative residual pulmonary function. The analysis suggests that thoracoscopic segmentectomy can well relieve the patient 's condition may be related to both the minimally invasive advantages of thoracoscopic surgery and the relatively less destruction of lung tissue by this surgery [20]. Thoracoscopic surgery is less invasive and does not cause greater damage to tissues such as ribs and nerves, while segmentectomy requires only attention to the safe distance from the tumor margin during the procedure [21, 22]. Therefore, thoracoscopic segmentectomy can preserve more normal lung tissue while ensuring systematic lymph node dissection, reduce the damage caused by surgery to lung volume, and then shorten the length of lung recruitment, which is helpful for postoperative rehabilitation. Studies have shown that compensatory expansion of the remaining lobe after lobectomy can gradually replace the original resected lobe space, and the expansion of this lobe is uncontrollable and easily squeezes the remaining healthy lobe, resulting in changes in lobar bronchial angle, airway torsion and increased airway resistance, which in

Table 5 Comparison of the complications between two groups(%)

Group		Lobectomy group($n=48$)	Segmentectomy group ($n=55$)	X^2	*P* value
Pulmonary air leak		2(4.17)	4(7.27)	2.791	0.023
Respiratory complications	Atelectasis	2(4.17)	1(1.81)	3.167	0.042
	Lung infection	2(4.17)	0(0.00)		
	Pleural effusion	2(4.17)	1(1.81)		
Total incidence of adverse reactions		8(16.67)	6(10.90)	1.348	0.066

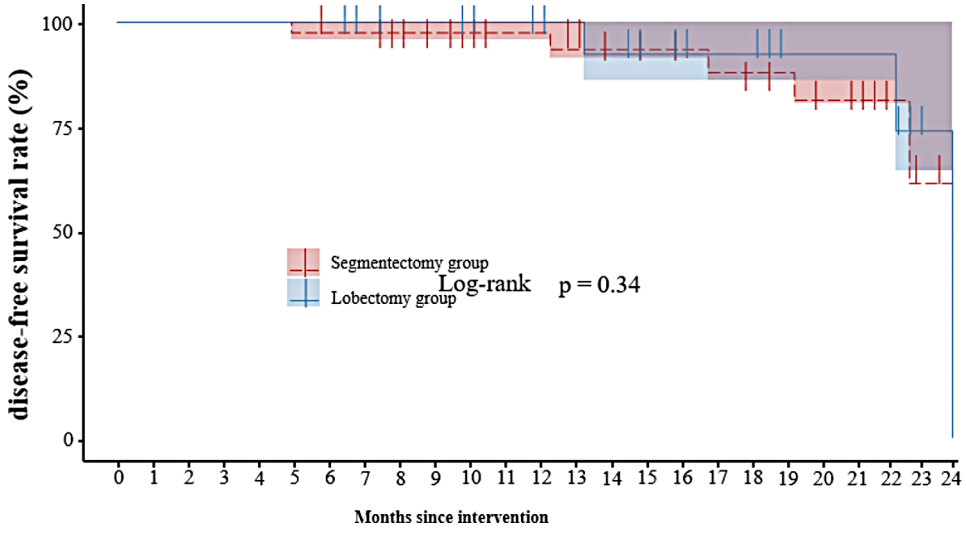

Fig. 2 Disease-free survival rate

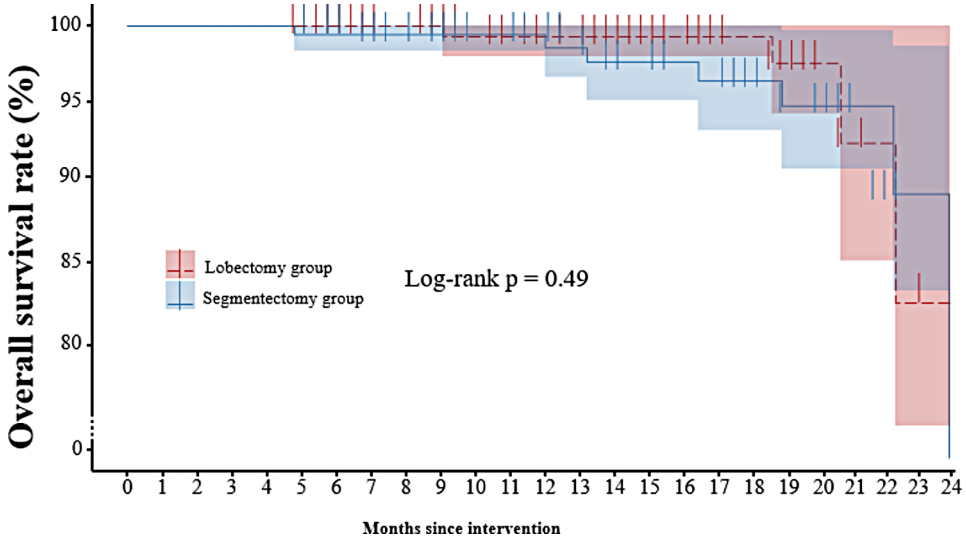

Fig. 3 Overall survival rate

turn affects pulmonary ventilation and ventilation function, while segmentectomy only removes part of the lung segment without causing growth expansion and avoiding bronchial angle and airway effects [23–25]. Segmentectomy requires the surgeon to have higher operating skills and anatomical knowledge, so this surgeon is more complex than thoracoscopic lobectomy [26]. However, the results of this study showed that there was no significant difference in the incidence rate of total complications between the two groups, and the clinical effective rate of the segmentectomy group was significantly higher than that of the lobectomy group, and the difference was statistically significant, suggesting that the safety of thoracoscopic segmentectomy in early lung cancer with the maximum diameter < 2 cm is equivalent to thoracoscopic lobectomy, which can avoid postoperative complications

caused by pulmonary interstitial and alveolar membrane edema caused by contusion, and can achieve better short-term efficacy. The analysis suggests that this may be related to the fact that patients undergoing thoracoscopic segmentectomy must have negative margins and intraoperative lymph node biopsy is clearly negative. It has been proposed that hilar and mediastinal lymph node metastasis rates are high in lung cancer < 2 cm in diameter, and timely dissection is required here to ensure staging accuracy [27]. In this study, the segmentectomy group underwent intersegmental, interlobar, hilar and mediastinal lymph node sampling sent for frozen pathological examination, and routine hilar and mediastinal lymph node dissection, so the surgical results were good.

The study presented in this passage investigates the safety and efficacy of thoracoscopic segmentectomy as a surgical treatment for patients with pulmonary malignant tumors less than 2 cm in diameter, as compared to traditional thoracoscopic lobectomy. The study finds that thoracoscopic segmentectomy has several advantages, including reduced drainage volume and intraoperative blood loss, shorter drainage time and hospital stay, and better preservation of postoperative pulmonary function. The minimally invasive nature of thoracoscopic surgery, combined with the anatomical resection of specific lung segments, allows for the preservation of more normal lung tissue, thus contributing to faster postoperative recovery. Furthermore, the study suggests that thoracoscopic segmentectomy is as safe as thoracoscopic lobectomy in terms of postoperative complications and short-term efficacy.

However, there are limitations to this study. First, the sample size is relatively small, and the study population has a relatively high average age, which may limit the generalizability of the results to a broader range of patients, including younger individuals with different physiological profiles. Second, the study's short observation period may not provide a complete understanding of the long-term outcomes and potential complications associated with thoracoscopic segmentectomy. Additionally, the study lacks a comprehensive assessment of various postoperative outcomes and might benefit from a more extensive set of outcome measures to thoroughly evaluate the efficacy and safety of the procedure. In conclusion, this study provides valuable insights into the benefits of thoracoscopic segmentectomy for small pulmonary tumors but requires further research with larger and more diverse samples, longer follow-up periods, and a more comprehensive range of outcome measures to validate its findings and generalize the results to a broader patient population.

In summary, thoracoscopic segmentectomy is safe and feasible for patients with pulmonary malignant tumors less than 2 cm in diameter, has little effect on pulmonary function after operation, and can accelerate postoperative rehabilitation, which has important clinical application value. However, there are still shortcomings in this study. First, due to the limitation of disease source, the age of enrolled subjects is relatively high, the physiological function of younger patients is decreased, and the degree of statistical freedom is limited. The study results need to be further verified. Second, due to the limitation of follow-up hospital test items, more indicators failed to be included in the study before and after treatment changes, and the efficacy assessment was not comprehensive enough. In this study, the observation cycle was short and its long-term outcome could not be clarified. Future prospective disease studies with larger parallel sample sizes continue to be followed up to obtain more representative overall study data and thus more generalizable study results.

Summary

This study compared the outcomes of thoracoscopic segmentectomy and thoracoscopic lobectomy in the treatment of lung malignancies smaller than 2 cm. The research included 103 patients and found that segmentectomy led to lower blood loss, shorter hospital stays, and improved postoperative lung function. Respiratory complications remained significantly higher in thoracoscopic segmentectomy, while no differences were observed during the 2-year follow-up (median follow-up in months: 18.4; interquartile range, 14.8–21.3) in terms of overall survival ($P=0.49$) and disease-free survival ($P=0.34$) between groups. Thoracoscopic segmentectomy appears to be a favorable option for these patients.

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Author contributions

ZYF and SRZ conceptualized and designed the study, drafted the initial manuscript, and reviewed and revised the manuscript.ZYF, SRZ and ZKY designed the data collection instruments, collected data, carried out the initial analyses, and reviewed and revised the manuscript.ZKY coordinated and supervised data collection, and critically reviewed the manuscript for important intellectual content.All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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Data availability

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This study was conducted in accordance with the declaration of Helsinki.This study was conducted with approval from the Ethics Committee of Jinshan Branch of Shanghai Sixth People's Hospital.A written informed consent was obtained from all participants.

Consent for publication
Not applicable.

Conflict of interest
Ensure that all authors have disclosed any and all conflicts of interest.

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