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ORIGINAL ARTICLE

Comparison of efficacy between thoracoscopic anatomic segmentectomy and thoracoscopic lobectomy in treating early-stage non-small cell lung cancer

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Summary

Purpose: *To compare the efficacy and safety between thoracoscopic anatomic segmentectomy and thoracoscopic lobectomy in the treatment of early-stage non-small cell lung cancer (NSCLC).*

Methods: *The clinical information of patients with early-stage NSCLC were retrospectively analyzed. Sixty-eight patients were treated via thoracoscopic anatomic segmentectomy and 76 underwent thoracoscopic lobectomy. The two groups were compared according to surgical duration, intraoperative blood loss, number of lymph nodes dissected, indwelling time of postoperative thoracic drainage tube, thoracic drainage volume, length of postoperative hospital stay, perioperative complications, pulmonary function before operation and at 1 year after operation and postoperative changes. The patient survival time was recorded.*

Results: *The general clinical features of the patients in both groups were comparable without perioperative deaths. Segmentectomy group showed significantly longer surgical duration than lobectomy group (p=0.009), and the intraoperative blood loss was significantly less than that in lobectomy group (p=0.195). The differences in the number of lymph nodes dissected in the two groups and the indwelling time of postoperative thoracic drainage tube were not statistically significant (p=0.055). Segmentectomy group showed substantially lower thoracic drainage volume and prominently shorter postoperative hospital stay than lobectomy group (p=0.001). The incidence rate of postoperative complications in the two groups of patients was 10.3% vs. 11.8% (p=0.797). Compared with that before operation, the lung function of both groups of patients was obviously weakened (p<0.05), and at 1 year after operation, all the lung function indicators in segmentectomy group were notably higher than those in lobectomy group (p=0.020, p=0.001 and p=0.001). During the follow-up, there was no death in the two groups, and the disease-free survival in both groups was 89.7% (6/1/68) vs. 93.4% (71/76) (p=0.622).*

Conclusions: *Thoracoscopic anatomic segmentectomy is as clinically effective as lobectomy, but with higher safety, and since it has such advantages like smaller postoperative thoracic drainage volume, shorter hospital stay and more favorable postoperative lung function recovery, it deserves clinical promotion.*

Key words: *non-small cell lung cancer, thoracoscope, segmentectomy, lobectomy*

Introduction

Lung cancer is one of malignancies with the highest incidence and mortality rates in China now, and as surgical techniques and examination methods continue to progress, early detection and minimally invasive treatments enable the majority of lung cancer patients to receive timely and effective therapies [1,2]. In recent years, with the advantages of small trauma and quick recovery, thoracoscopic surgery has been gradually accepted by the patients with non-small cell lung cancer

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(NSCLC), and has become a standard procedure for the surgical treatment of early-stage NSCLC for its merits including safety and minimal invasiveness [3,4]. Video-assisted thoracoscopic surgery (VATS) is recommended as an operation procedure for early-stage lung cancer in the 2006 National Comprehensive Cancer Network (NCCN) Practice Guidelines [5], while thoracoscopic lobectomy combined with lymph node dissection is regarded as a radical treatment for early-stage NSCLC in the 2015 NCCN Guidelines [6]. As medical technologies progress and the notion of ''precise surgery'' has been interiorized, surgeons are doing their best to effectively retain patients' healthy lung tissues under the foundation that the tumor lesions are radically removed, thereby reducing the surgical traumas in patients. In NCCN Clinical Practice Guidelines for NSCLC released in 2010, it is clearly specified that partial lobectomy is allowed to be selectively performed in the patients with early-stage NSCLC [7].

In the present study, a retrospective analysis was carried out in 68 cases of anatomic segmentectomy and 76 cases of lobectomy, both conducted under thoracoscope in our department from January 2014 to January 2016, and indicators such as surgical duration, intraoperative blood loss, number of lymph nodes dissected, thoracic drainage volume, length of postoperative hospital stay, complications and survival were recorded in the two groups of patients to compare the clinical efficacy and safety of these two surgical procedures.

Methods

General information

This study was approved by the Ethics Committee of Affiliated Jiangyin Hospital of Southeast University Medical College. Signed informed consents were obtained from all participants before the study entry. A retrospective analysis was performed for the information of 144 patients with early-stage NSCLC who underwent thoracoscopic surgery in the hospital from January 2014 to January 2016, and among the above patients, there were 68 cases of thoracoscopic anatomic segmentectomy and 76 cases of thoracoscopic lobectomy. The segmentectomy group consisted of 37 males and 31 females, aged 37-73 years (mean 56.86±9.73) and with 7 cases of hypertension, 11 cases of diabetes and 6 cases of coronary heart disease, while in the lobectomy group, there were 43 males and 33 females aged 36-74 years (mean 55.91±8.85) and 10 cases of hypertension, 13 cases of diabetes and 7 cases of coronary disease. General information such as sex, age and complications were compared between the two groups of patients, without statistically significant differences ($p>0.05$).

Inclusion criteria: Patients without obvious surgical contraindications and severe heart, liver, kidney and lung dysfunctions according to the routine preoperative examinations, those with no history of malignant tumors, whose computed tomography (CT), bone scan and B-ultrasound examinations revealed no distant metastasis, and those who were definitely diagnosed with T1b or earlier-stage NSCLC via histopathology or cytopathology.

Exclusion criteria: Patients who received no radiotherapy or chemotherapy, those whose postoperative pathology indicated benign lesions or small-cell lung cancer, or those who were not able to undergo thoracoscopic surgery due to extensive pleural adhesions, whose lymph node biopsy revealed metastases, or who had poor cardiopulmonary compensatory ability or suffered from NSCLC complicated by severe cardiac or renal dysfunction. The present study was approved by the Ethics Committee of our hospital. All the subjects abided by the Helsinki Declaration, and signed the informed consent after been informed by the researchers about the strategies of the study.

Surgical procedures

Before operation, all the patients were subjected to thin-section CT scan of the chest to confirm the position of lesions, and then pulmonary function tests and arterial blood gas analysis were performed to verify whether the patients were able to tolerate the operations. Under double-lumen endotracheal intubation and one-lung ventilation, the patients underwent surgery in the healthy lateral position, with the chest properly raised. Intraoperatively, the position of patients was timely adjusted to help expose the surgical field. A thoracoscopic observation incision was made in the midaxillary line in the 7^{th} or 8^{th} intercostal space, and an about 4 cm-long main operation incision in the anterior axillary line in the 4^{th} or 5^{th} intercostal space without retracting the ribs.

Segmentectomy: Firstly, the pleural cavity and lung surface were explored to ascertain whether there were metastases and deposits, and superficial nodules were removed via wedge resection and sent for frozen section biopsy. The operation started from the lung hilum and advanced into the pulmonary parenchyma, and the pulmonary arteries, veins and bronchi were dissociated to excise the branch of the lung segment. Arteries and veins of the lung segment were treated with a Hem-o-lok clip or ligated using silk threads, and the vessels with a relatively large diameter and segmental bronchi were sewed using linear cutting staplers. During the operation, intrasegmental and intersegmental lymph node biopsies were carried out and the lumps and lymph nodes were sent for examination. Finally, lung segment, lung hilum and mediastinal lymph nodes were dissected using a conventional system.

Lobectomy: After the lesions were probed, the lobar veins were dissociated and cut off using a thoracoscopic cutting stapler, and at the deep place, the lobar bronchi were subjected to the same operations as above. Subsequently, each branch of lobar arteries was dissociated, and the proximal branches were double-ligated and cut off using an ultrasound knife. The lung fissures were treated with thoracoscopic cutting stapler. Finally, the lung hilum and mediastinal lymph nodes were routinely removed.

Observation indicators

The patients were reviewed every 3-6 months for the next 2 years, while the review was every 6 months for the next 2-5 years. The follow-up ended in January 2019 or when the patient died. The specific examinations included medical history, physical examinations, hematological examinations (full blood counts and serum biochemistry), tumor marker tests, imaging examinations, including chest CT, brain CT, full-abdominal B ultrasound and whole-body bone scan or PET-CT and pulmonary function test.

The duration of operation, intraoperative blood loss, number of lymph nodes dissected, indwelling time of thoracic drainage tube (extubation indication: the thoracic drainage volume at 24 h after operation is less than 100 mL, and after patients cough, no bubble overflow is detected and in the review, the anteroposterior and lateral chest films reveal favorable lung recruitment), thoracic drainage volume and postoperative hospital stay were recorded in the two groups of patients. Additionally, their perioperative complications including pulmonary infection, chylothorax, pulmonary air leak, pulmonary atelectasis, arrhythmia and incision infection were recorded. Pulmonary function test: The forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1)/FVC ratio (%) and maximal voluntary ventilation (MVV) of the patients were measured by the same medical staff using the pulmonary function tester HypAir before operation and at 6 months after operation, respectively. The patients were followed up, and their 3-year recurrence and survival rates were assessed. Tumor recurrence is referred to as local recurrence or that in the corresponding drainage areas, including lateral hilar and mediastinal lymph node recurrences, bronchial stump recurrence and distant metastasis in other regions. The progression-free survival is defined as the time interval from the end of surgery to the progression of disease, including local recurrence or distant metastasis.

Statistics

In the present study, the SPSS 22.0 software (IBM, Armonk, NY, USA) was used for statistical analyses. Measurement data were expressed as mean ± standard deviation and compared between the two groups using t-test. Enumeration data were expressed as ratio (%) and x^2 test was performed for intergroup comparisons. Survival analysis was carried out via the Kaplan-Meier method and log-rank test. $P<0.05$ suggested that the difference was statistically significant.

Results

Postoperative general information

Operations were conducted successfully in the two groups, without perioperative deaths and cas-

Table 1. Baseline demographic and clinical characteristics of the studied patients

Characteristics	*Segmentectomy group, n=68* *n (%)*	*Lobectomy group, n=76* *n (%)*	*p value*
Age, years (mean±SD)	56.86±9.73	55.91±8.85	0.385
Gender			0.867
Male	37 (54.4)	43 (56.6)	
Female	31 (45.6)	33 (43.4)	
Tumor diameter (cm) (mean±SD)	1.46±0.31	1.55±0.29	0.074
Tumor location			0.962
Left upper lobe	18 (26.5)	16 (21.1)	
Left lower lobe	13 (19.1)	15 (19.7)	
Right upper lobe	17 (25.0)	21 (27.6)	
Right middle lobe	9 (13.2)	11 (14.5)	
Right lower lobe	11 (16.2)	13 (17.1)	
Pathological type			0.759
Squamous cell carcinoma	19 (27.9)	23 (30.3)	
Adenocarcinoma	49 (72.1)	53 (69.7)	
TNM stage			0.088
0	6 (8.8)	2 (2.6)	
IA	59 (86.8)	65 (85.5)	
IB	3 (4.4)	9 (11.9)	
Systemic disease			0.948
Hypertension	7 (10.3)	10 (13.2)	
Diabetes Mellitus	11 (16.2)	13 (17.1)	
Coronary heart disease	6 (8.8)	7 (9.2)	

TNM: tumor, lymph node, metastasis

es of thoracotomy. According to the postoperative pathological examinations, in the segmentectomy group there were 49 cases of adenocarcinoma and 19 cases of squamous cell carcinoma, while the lobectomy group comprised 53 cases of adenocarcinoma and 23 cases of squamous cell carcinoma. The tumor mean diameter in the two groups was 1.46±0.31 cm (segmentectomy group) *vs.* 1.55±0.29 cm (lobectomy group), and the number of cases of the left upper lobe tumor was 18 (26.5%) *vs.* 16 (21.1%), that of the left lower lobe tumor was 13 (19.1%) *vs.* 15 (19.7%), that of the right upper lobe tumor was 17 (25.0%) *vs.* 21 (27.6%), that of the right middle lobe tumor was 9 (13.2%) *vs.* 11 (14.5%) and that of the right lower lobe tumor was 11 (16.2%) *vs.* 13 (17.1%). In terms of TNM stage, the segmentectomy group consisted of 6 (8.8%) cases in stage 0, 59 (86.8%) cases in stage IA, and 3 (4.4%) cases in stage IB, while the lobectomy group comprised 2 (2.6%) cases in stage 0, 65 (85.5%) cases in stage IA, and 9 (11.9%) cases in stage IB. There were no statistical differences in tumor-related conditions between the two groups of patients (p>0.05) (Table 1).

Comparisons of perioperative indicators

The segmentectomy group showed longer surgical duration than the lobectomy group (161.57±26.30 min *vs.* 149.22±29.47 min) (p=0.009), and the the intraoperative blood loss was less than that in the lobectomy group (137.51±74.46 mL *vs.* 155.45±89.16 mL) (p=0.195). The number of lymph nodes dissected in the two groups was 12.4±3.1 *vs.* 12.9±2.8; p=0.311, and the indwelling time of postoperative thoracic drainage tubes was 4.2±1.7 d *vs.* 4.7±1.4 days (p=0.055), displaying no statistically significant difference. The segmentectomy group showed substantially lower thoracic drainage volume and prominently shorter postoperative hospital stay than the lobectomy group (670.63±272.64 mL *vs.* 785.45±311.36 mL; p=0.021) and 6.7±1.1 days *vs.* 8.3±1.3 days (p=0.001). The incidence rate of postoperative complications in the two groups of patients was 10.3% *vs.* 11.8% with no statisti-

Table 2. Comparison of perioperative parameters

Parameters	*Segmentectomy group, n=68*	*Lobectomy group, n=76*	*p value*
Operation time (min)	161.57±26.30	149.22±29.47	0.009
Blood loss (mL)	137.51±74.46	155.45±89.16	0.195
Lymph node dissection number	12.4±3.1	12.9±2.8	0.311
Postoperative catheter drainage time (days)	4.2±1.7	4.7±1.4	0.055
Chest drainage volume (mL)	670.63±272.64	785.45±311.36	0.021
In-hospital time (days)	6.7±1.1	8.3±1.3	0.001
Complications, n (%)	7 (10.3)	9 (11.8)	0.797
Incision infection	1 (1.5)	1 (1.3)	
Pulmonary infection	2 (2.9)	3 (3.9)	
Atelectasis	0 (0)	0 (0)	
Pulmonary air leakage	2 (2.9)	1 (1.3)	
Chylothorax	0 (0)	1 (1.3)	
Arrhythmia	2 (2.9)	3 (3.9)	

Table 3. Comparison of preoperative and postoperative pulmonary function indexes of patients in the two groups

Parameters	*Segmentectomy group, n=68*	*Lobectomy group, n=76*	*p value*
FVC (mL)			
Preoperative	104.2±10.7	101.6±12.9	0.193
Postoperative	93.7±15.2	87.9±14.3	0.020
FEV_1			
Preoperative	85.4±12.8	84.1±11.9	0.529
Postoperative	76.2±10.4	67.9±13.8	0.001
MVV (mL)			
Preoperative	98.7±17.2	97.7±16.6	0.723
Postoperative	88.9±17.3	73.4±18.2	0.001

FVC: forced vital capacity, FEV: forced expiratory volume, MVV: maximum ventilatory volume

cally significant difference (p=0.797). Specifically, incision infection occurred in 1 case each in the two groups, pulmonary infection in 2 cases and 3 cases, respectively, pulmonary air leak in 2 cases and 1 case, respectively, arrhythmia in 2 cases and 3 cases, respectively, chylothorax in 1 case in the lobectomy group and no pulmonary atelectasis in the two groups. After symptomatic treatments, all the complications were improved and the patients were discharged (Table 2).

Comparisons of pulmonary function indicators

The differences in the preoperative pulmonary function indicators FVC, FEV1/FVC ratio (%) and MVV were not statistically significant between the two groups of patients (p=0.193, p=0.529 and p=0.723). Compared with that before operation, the lung function of both groups of patients was obviously weakened (p<0.05), and at 1 year after operation all the lung function indicators in the segmentectomy group were notably higher than those in the lobectomy group (p=0.020, p=0.001 and p=0.001) (Table 3).

Survival

All the 144 patients were followed up after operation until January 2019, and the follow-up time in the segmentectomy and lobectomy group was 36-54 months (mean 46.6±7.8 *vs.* 36-57 months) (mean 47.3±9.5). During follow-up, no patients died in both groups. In the segmentectomy group, there were 7 cases of recurrence occurring at 21, 36, 42, 48, 48, 54 and 54 months after operation, respectively, while in the lobectomy group, 5 patients suffered from recurrence at 27, 39, 45, 51 and 57 months after operation, respectively. At the end of follow-up, the disease-free survival rate in the two groups of patients was 89.7% (61/68) *vs.* 93.4% (71/76). The log-rank test revealed that the difference in the disease-free survival was not statistically significant between the two groups of NSCLC patients (p=0.622), and the survival curve is shown in Figure 1.

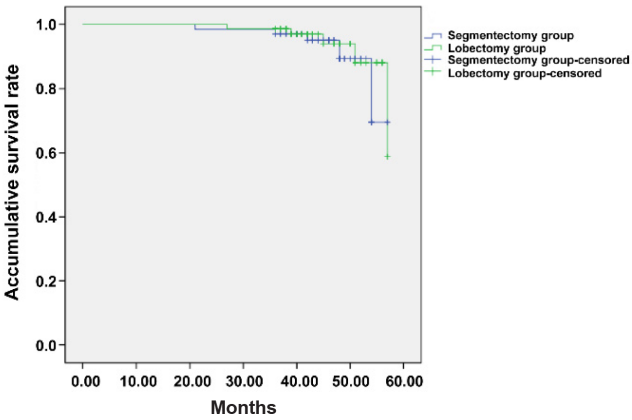

Figure 1. Kaplan-Meier survival curve of patients in the segmentectomy group and lobectomy group. The disease-free survival rate of patients in the segmentectomy group had no significant difference compared with that of the lobectomy group (p=0.622).

Discussion

In recent years, as spiral CT is widely applied in the screening of healthy people in the frame of check-up and people at a high risk for lung cancer, and ever increasing number of lung cancers have been diagnosed at an early stage [8]. VATS lobectomy combined with systemic mediastinal lymph node dissection is a radical surgery for NSCLC patients in clinical stages I, II and IIIA [5]. However, a study suggested that sub-lobectomy including segmentectomy and pulmonary wedge resection has a favorable therapeutic effect in the elderly with lung cancer who exhibit poor cardiopulmonary function and low tolerance to lobectomy [9]. In the treatment of early-stage NSCLC with a diameter less than 2 cm, sub-lobectomy has the same efficacy as lobectomy and higher safety [10]. There are no statistically significant differences in the incidence rate of postoperative complications, local recurrence rate, postoperative survival rate and mortality rate between sub-lobectomy, especially anatomic segmentectomy, and lobectomy [11]. Thoracoscopic anatomic segmentectomy requires surgeons proficient in mirror operation techniques and cardiothoracic surgery anatomy to lower the degree of the surgical trauma of the body as much as possible, thus reducing intraoperative blood loss, surgical trauma and surgical time. Moreover, this operation has the advantages of including small surgical incision, low drainage volume, mild postoperative pain, low incidence rate of postoperative complications, mild cardiopulmonary damage and fast postoperative recovery [12]. Therefore, it gradually becomes an effective surgical treatment for early-stage NSCLC.

In the present study, the efficacy and safety were compared between thoracoscopic anatomic segmentectomy and thoracoscopic lobectomy in treating early-stage NSCLC. According to the results, the surgical duration in the segmentectomy group was longer than that in the lobectomy group (p=0.09), and the segmentectomy group exhibited substantially lower drainage volume of thoracic tube (p=0.021) and shorter postoperative hospital stay (p=0.001) than the lobectomy group. The above findings are consistent with those of previous studies. This study found that at 1 year after operation, the segmentectomy group had notably higher pulmonary function indicators [FVC, FEV1/FVC ratio

(%) and MVV] than the lobectomy group (p=0.020, p=0.001 and p=0.001), and no statistically significant difference was found in the occurrence of complications between these two surgical procedures. Segmentectomy has the biggest merit that a small part of the lung is removed with more pulmonary tissues saved, ensuring better pulmonary function and patient quality of life after operation. However, since vascular and bronchial structures of the lung hilum need to be more elaborately anatomized in segmentectomy, it is normally more difficult than common lobectomy and the time spent on the anatomy is longer than that in the latter as well. Zooming in on the high-resolution view under a thoracoscope is more beneficial to the anatomy and resection of the lung segments.

The postoperative recurrence rate and survival time of patients serve as important indicators for evaluating surgical efficacy. Shapiro et al did a research in 2009 and found that there are no significant differences in the local recurrence rate (3.5 *vs.* 3.6%) and long-term survival rate between segmentectomy and lobectomy [14]. A study of Sugi et al [15] on the peripheral lung cancer at T1N0M0 stage revealed that there are no statistical differences in the 5-year disease-free survival rate (93.4 *vs.* 93.3%) and the overall survival rate (87.9 *vs.* 87.3%) in patients between thoracoscopic segmentectomy and thoracoscopic lobectomy. According to a meta-analysis by Cao et al in 2015 that involved 54 studies and 28,959 patients, the overall survival rate was not significantly different between patients undergoing sub-lobectomy and those undergoing lobectomy [16]. Bedetti et al [17] conducted a meta-analysis in 2017 that included 27 studies and 24,542 patients, and pointed out that thoracoscopic segmentectomy and lobectomy are not significantly different from each other in the postoperative survival rate in the patients with early-stage NSCLC. In the present study, it was found that during the follow-up, there was no death in the two groups, and the disease-free survival rate in both groups of patients was 89.7% (6/1/68) *vs.* 93.4% (71/76), showing no statistically significant difference (p=0.622).

There are certain limitations in this study which was a single-center retrospective trial. The size of the sample was not large enough, and the influence of the specific tumor location, peripheral or central type, on the efficacy of the two kinds of operation was not explored. Thus, prospective multi-center randomized controlled trials still need to be further conducted to corroborate the results of this study in the future.

Conclusions

In the treatment of early-stage NSCLC, thoracoscopic anatomic segmentectomy has clinical efficacy comparable with lobectomy, but higher safety, and since it has the advantages of smaller postoperative thoracic drainage volume, shorter hospital stay and more favorable postoperative lung function recovery, it is worth of clinical promotion.

Conflict of interests

The authors declare no conflict of interests.

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