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Retrospective Study

Efficacy of thoracoscopic anatomical segmentectomy for small pulmonary nodules

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Abstract

BACKGROUND

Small pulmonary nodules are tissue shadows and thoracoscopic segmentectomy in China is still at the exploratory stage with limited application.

AIM

To evaluate the efficacy of thoracoscopic anatomical segmentectomy for small pulmonary nodules.

METHODS

Medical records of 86 patients with small pulmonary nodules treated at our hospital between August 2016 and October 2019 were retrospectively analyzed; 40 cases who underwent thoracoscopic lobectomy were set as a reference group, and 46 cases who underwent thoracoscopic anatomical segmentectomy were set as an observation group. Preoperative and postoperative parameters were measured in both groups, including the percentage of forced expiratory volume in the first second (FEV₁%), the percentage of forced vital capacity (FVC%), and the FEV₁/FVC ratio (FEV₁/FVC). Patients with positive pathological diagnosis received tests for neuron-specific enolase, carbohydrate antigen 125 (CA125), CA19-9, and squamous cell carcinoma antigen. Intraoperative bleeding volume, drainage volume, the number of dissected lymph nodes, drainage time, hospital stay, treatment cost, postoperative complications, and postoperative pain condition were compared between the two groups.

RESULTS

No significant difference was observed in the results of four serum tumor marker (CA125, CA19-9, squamous cell carcinoma antigen, and neuron-specific enolase), the number of dissected lymph nodes, treatment cost, or preoperative pulmonary ventilation index between the two groups. Intraoperative bleeding volume, drainage volume, drainage time, hospital stay, and visual analogue scale score were significantly lower in the observation group ($P < 0.05$). The results of FEV₁%, FVC%, and FEV₁/FVC were significantly higher in the observation group ($P < 0.05$).

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CONCLUSION

The efficacy of thoracoscopic anatomical segmentectomy and lobectomy for small pulmonary nodules shows no significant difference in terms of lesion removal, but anatomical segmentectomy is less invasive with fewer postoperative complications and less influence on lung function.

Key words: Thoracoscopy; Small pulmonary nodules; Anatomical segmentectomy; Clinical efficacy; Lobectomy

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Core tip: To evaluate the efficacy of thoracoscopic anatomical segmentectomy for small pulmonary nodules, this study retrospectively analyzed the medical records of 86 patients with small pulmonary nodules treated at our hospital.

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INTRODUCTION

Small pulmonary nodules are tissue shadows surrounded by gas-containing lung tissues with a diameter of 5-10 mm in clinical imaging. They are generally round and can be single or multiple. Various factors contribute to the formation of nodules: Benign nodules are usually caused by inflammation, tuberculosis, bleeding, *etc.*; malignant nodules are primary lung cancer or lung metastasis of malignant tumors^[1]. Epidemiology suggests that the incidence of small pulmonary nodules has increased in recent years with declining air quality^[2].

Thoracoscopic lobectomy has been widely adopted since its first clinical application for the liver in 1993. The safety and efficacy of this surgical method have been proven in treating small pulmonary nodules, which is less invasive with rapid postoperative recovery^[3]. To further improve the safety and reduce operative trauma of clinical surgery, some researchers suggest that a lobe can be divided into segments, and therefore more normal tissues can be preserved during segment resection and operative injury can be reduced, which is called anatomical segmentectomy^[4].

Currently, thoracoscopic segmentectomy in China is still at the exploratory stage with limited application. To further evaluate the efficacy of this surgical method for small pulmonary nodules, this study retrospectively analyzed the medical records of 86 patients with small pulmonary nodules treated at our hospital.

MATERIALS AND METHODS

Baseline characteristics

The medical records of 86 patients with small pulmonary nodules treated at our hospital between August 2016 and October 2019 were reviewed. All cases met the diagnosis and treatment standards of "Chinese Expert Consensus on the Diagnosis and Treatment of Pulmonary nodules"^[5]. The inclusion criteria were: (1) No serious cardio-cerebrovascular disease; (2) No human immunodeficiency virus, immune deficiency, or coagulation dysfunction; (3) No other malignant tumor or a previous history of lymphoma; (4) Normal mental and intellectual assessment results and no mental disorder or low intelligence; (5) The patient was informed of the study and consented to medical records usage; (6) Suspected malignant lesions on preoperative examination; (7) Enhanced computed tomography scan showing tumor diameter ≤ 2 cm; and (8) Distant metastasis excluded by positron emission tomography/computed tomography. The exclusion criteria were: (1) Insufficient clinical records; (2) Combined with serious infection; (3) Combined with multiple organ failure and massive hemorrhage; and (4) Number of met inclusion criteria < 8 . According to the surgical option, patients who underwent thoracoscopic segmentectomy were included in an observation group (46 cases) and patients who underwent thoracoscopic

lobectomy were included in a reference group (40 cases). The baseline characteristics of the two groups showed no significant difference ($P > 0.05$) (Table 1).

Surgical methods

The patient was placed in the lateral decubitus position under general anesthesia with single-lung ventilation by double-lumen endotracheal tube intubation. A 1-cm skin incision was made along the anterior axillary line in the 7th or 8th intercostal space (observation port), a 3-cm incision was made along the anterior axillary line in the 4th-5th intercostal space (working port), and another incision was made along the posterior axillary line in the 7th intercostal space (accessory working port). The scope was inserted through the observation port and apparatus was inserted through the working port. Lesion was detected by the scope. Segmentectomy was initially planned in 48 patients and pathological biopsy was obtained through wedge resection. Patients with benign lesions underwent segmentectomy. Biopsies and frozen pathological sections of the 10th, 11th, and 13th groups of lymph nodes were further obtained and examined in patients with malignant lesions and 2 patients with positive diagnosis switched to lobectomy. Therefore, segmentectomy was finally performed in 46 patients. The resected segments were based on lesion location (left superior lobe: 3 cases of apico-posterior segment, 4 of anterior segment, 3 of lingular segment, and 2 of posterior segment; right inferior lobe: 4 cases of basal segment and 5 of dorsal segment; left inferior lobe: 6 cases of basal segment and 7 of dorsal segment; right superior lobe: 4 cases of apical segment, 3 of posterior segment, and 5 of anterior segment). A total of 40 patients underwent lobectomy and the resected parts were based on lesion location (12 cases of left upper lobe, 11 of left lower lobe, 9 of right upper lobe, and 8 of right lower lobe).

Observational indexes

Venous blood samples were taken from patients with positive pathological diagnosis at the 1st mo postoperatively. Serum was obtained after centrifugation and tested for serum carbohydrate antigen 19-9 (CA19-9), CA125, neuron-specific enolase, and squamous cell carcinoma antigen.

Spirometer (Fukuda Sangyo, St-75) was used to measure the percentage of forced vital capacity (FVC%), the percentage of forced expiratory volume in the first second (FEV₁%), and the FEV₁/FVC ratio (FEV₁/FVC) before and 6 mo after operation.

Postoperative pain condition was assessed using the visual analogue scale (VAS).

Drainage volume, the number of resected lymph nodes, treatment cost, hospital stay, intraoperative bleeding volume, drainage time, and postoperative complications were recorded.

Statistical analysis

Data analyses were carried out with SPSS 23.0. Measurement data are presented as the mean \pm SD and were analyzed by *t* test; enumeration data are expressed as percentages and were analyzed by χ^2 test. $P < 0.05$ indicated that the difference was statistically significant.

RESULTS

Comparison of serum tumor markers in patients with malignant lesions

In the reference group, 37 cases were malignant and 3 were benign; in the observation group, 35 cases were malignant and 11 were benign. Based on data shown in Table 2, no significance difference was observed in serum tumor markers between the two groups ($P > 0.05$).

Comparison of intraoperative bleeding volume, the number of resected lymph nodes, and drainage volume

Intraoperative bleeding and drainage volume were both significantly lower in the observation group ($P < 0.05$). No significant difference was observed in the number of resected lymph nodes between the two groups ($P > 0.05$, Table 3).

Comparison of hospital stay, treatment cost, drainage time, and visual analogue scale score

Hospital stay and drainage time were significantly shorter and VAS score was significantly lower in the observation group ($P < 0.05$). No significant difference was found in treatment cost ($P > 0.05$, Table 4).

Comparison of postoperative lung function

Table 1 Baseline characteristics, *n* (%)

Baseline characteristic	Reference group (<i>n</i> = 40)	Observation group (<i>n</i> = 46)	<i>t</i>	<i>P</i> value
Gender				
Male	22 (55.00)	27 (58.70)	0.279	0.597
Female	18 (45.00)	19 (41.30)		
Age (yr)	56.32 ± 4.52	57.02 ± 4.81	0.692	0.491

Based on data shown in **Table 5**, no significant difference was observed in preoperative lung function index between the two groups ($P > 0.05$). Postoperative lung function index declined to certain extent in both groups, but FEV₁%, FVC%, and FEV₁/FVC were significantly higher in the observation group ($P < 0.05$).

Comparison of complications

Table 6 suggests that the incidence of complications was significantly lower in the observation group ($P < 0.05$).

DISCUSSION

Small pulmonary nodules are common manifestations of pulmonary lesions in clinical diagnosis, which generally refer to pulmonary nodules of 5-10 mm. Various factors may contribute to the formation of nodules, including inflammation, tuberculosis, primary tumor, and metastatic tumor^[6-8]. Although clinical studies have shown that small pulmonary nodules have a relatively low tendency to turn malignant, the nodules should be handled carefully once observed. Epidemiology suggests that with declining air quality, the incidence of small pulmonary nodules has increased in recent years, which has become a typical lung lesion with an increasing malignancy rate^[9].

Middle and lower thoracic wedge resection is primarily applied in previous clinical treatment, but in patients with extensive lesions (*e.g.*, pulmonary bullae and pulmonary cyst), this method cannot completely resect the lesions, and in patients with deep lesions, this method may cause adverse events like vascular lesions. Moreover, since this operation is not anatomical resection, malignant lesion has a great risk of recurrence after operation and therefore, the application of this surgical method is limited^[9]. Lobectomy, as another surgical option, has been widely applied in treating small pulmonary nodules, and especially in terms of malignant lesions, it can control disease progression and prolong patient survival^[10]. In patients with malignant small pulmonary nodules who received lobectomy, the 5-year survival rate can reach over 80%^[11]. Compared with conventional thoracotomy, thoracoscopic lobectomy can be operated through only 3 small incisions, which greatly reduces the risk of postoperative complications and has gradually replaced conventional thoracotomy, becoming the primary surgical treatment for small pulmonary nodules^[12-14]. However, research now indicates that although lobectomy shows good therapeutic effects, it resects part of the normal lung tissues, resulting in impaired lung function, more surgical injury, and slower recovery, so the surgical method can be further improved^[15].

In terms of pulmonary anatomy, the definition of pulmonary segment was first introduced in 1889, further refining the definition of pulmonary lobe in order to facilitate accurate localization in clinical diagnosis and treatment^[16]. Thoracoscopic hepatic segmentectomy was initially applied in Italy, and the thoracoscopic segmentectomy was gradually introduced into other developed countries to treat small pulmonary nodules, which achieved satisfactory results. The application of anatomical pulmonary segmentectomy in China is relatively late and limited. Based on current theories, segmentectomy can preserve more normal lung tissues with less injury and impact on lung function while treating small pulmonary nodules. When meeting surgical indications, segmentectomy can achieve the same effect as lobectomy for lymph node resection^[17]. The current consensual surgical signs include: (1) Nodules located at the peripheral 1/3 of the pulmonary field, with a diameter ≤ 2 cm; (2) If malignant, the tumor should be non-small cell cancer with tumor stage of T1N0M0; (3) Distant metastasis excluded by lymph node biopsy; and (4) Cardio-pulmonary function tolerant of surgery^[18]. Generally, in treating malignant small pulmonary nodules, if no lymph node metastasis is present, segmentectomy can achieve the same therapeutic effect as lobectomy. But if lymph node metastasis

Table 2 Comparison of serum tumor markers in patients with malignant lesions (mean \pm SD)

Group	No. of malignant cases	CA125 (U/mL)	CA19-9 (U/mL)	SCC (ng/mL)	NSE (ng/mL)
Reference	37	23.25 \pm 3.51	13.52 \pm 2.25	1.31 \pm 0.22	12.32 \pm 2.63
Observation	35	21.85 \pm 3.25	12.74 \pm 2.36	1.27 \pm 0.24	11.56 \pm 2.31
<i>t</i>	-	1.753	1.436	0.738	1.305
<i>P</i> value	-	0.084	0.156	0.463	0.192

CA: Carbohydrate antigen; SCC: Squamous cell carcinoma antigen; NSE: Neuron-specific enolase.

occurs, lobectomy should be applied rather than segmentectomy in case of recurrence. Therefore, a preoperative pathological biopsy of lymph nodes for patients with the malignant lesion is of critical importance^[19].

In this retrospective study, no significant difference was observed in serum tumor markers (CA125, CA19-9, squamous cell carcinoma antigen, and neuron-specific enolase), the number of resected lymph nodes, and treatment cost between observation and reference groups ($P > 0.05$), indicating that the two surgical methods can achieve the same therapeutic effects with similar cost for both benign and malignant small pulmonary nodules. However, in the segmentectomy group, hospital stay and drainage time were significantly shorter ($P < 0.05$) while intraoperative bleeding and drainage volume, VAS, and several postoperative lung function indexes were significantly higher ($P < 0.05$), suggesting that segmentectomy can reduce surgical injury and hospital stay with less impact on lung function and fewer complications. Our results are in agreement with those of Ishikawa *et al*^[20] who suggested that compared with lobectomy, segmentectomy is less invasive and preserves more normal lung tissues with less impact on lung function and more rapid postoperative recovery^[20]. One limitation of the present study is the small number of patients. Only 86 cases were included and therefore the surgical and observational outcomes may be accidental. More cases are needed for subsequent studies.

Thoracoscopic pulmonary segmentectomy is an ideal surgical approach to treat small pulmonary nodules. Compared with thoracoscopic lobectomy, segmentectomy is associated with fewer complications, better postoperative lung function, and more rapid recovery and therefore can be a primary option for patients meeting surgical indications.

Table 3 Comparison of intraoperative bleeding volume, the number of resected lymph nodes, and drainage volume (mean ± SD)

Group	n	Intraoperative bleeding volume (mL)	No. of resected lymph nodes	Drainage volume (mL)
Reference	40	153.21 ± 30.25	11.61 ± 2.03	948.63 ± 120.14
Observation	46	63.88 ± 10.41	11.96 ± 2.16	571.85 ± 74.25
t	-	18.803	0.771	17.737
P value	-	0.001	0.443	0.001

Table 4 Comparison of hospital stay, treatment cost, drainage time, and visual analogue scale score (mean ± SD)

Group	n	Hospital stay (d)	Drainage time (d)	Treatment cost (× 10 ⁴ Yuan)	VAS (score)
Observation	46	10.62 ± 1.01	3.59 ± 0.86	4.92 ± 0.85	4.02 ± 1.03
Reference	40	12.52 ± 1.58	4.97 ± 1.02	4.89 ± 0.80	5.63 ± 1.35
t	-	6.730	6.807	0.168	6.146
P value	-	0.001	0.001	0.867	0.001

VAS: Visual analogue scale.

Table 5 Comparison of postoperative lung function (mean ± SD, %)

Lung function index	Observation group (n = 46)	Reference group (n = 40)	t	P value
FEV ₁ %				
Preoperative	94.63 ± 3.05	93.94 ± 3.12	1.035	0.304
Postoperative	84.69 ± 4.06 ^a	76.97 ± 5.06 ^a	7.845	0.001
FVC%				
Preoperative	94.12 ± 3.16	94.33 ± 3.21	0.305	0.761
Postoperative	84.08 ± 3.09 ^a	75.85 ± 4.31 ^a	10.040	0.001
FEV ₁ /FVC				
Preoperative	94.38 ± 2.56	94.14 ± 3.86	0.334	0.738
Postoperative	84.39 ± 3.69 ^a	76.41 ± 4.51 ^a	9.022	0.001

^aP < 0.05 vs preoperative index. FEV₁%; The percentage of forced expiratory volume in the first second; FVC%; The percentage of forced vital capacity.

Table 6 Comparison of complications, n (%)

Group	No.	Acute pain	Infection	Repeated bleeding	Incidence of complications
Observation	46	0 (0.00)	0 (0.0)	1 (2.17)	1 (2.17)
Reference	40	2 (5.00)	1 (2.50)	1 (2.50)	4 (10.00)
χ ²	-	5.128	2.532	0.024	5.364
P value	-	0.024	0.112	0.877	0.021

ARTICLE HIGHLIGHTS

Research background

Malignant nodules are primary lung cancer or lung metastasis of malignant tumors. Anatomical segmentectomy is a new surgical method.

Research motivation

Thoracoscopic segmentectomy in China is still at the exploratory stage.

Research objectives

To evaluate the availability and effectiveness of the procedure.

Research methods

Medical records of 86 patients with small pulmonary nodules treated at our hospital between August 2016 and October 2019 were retrospectively analyzed; 40 cases who underwent thoracoscopic lobectomy were set as a reference group, and 46 cases who underwent thoracoscopic anatomical segmentectomy were set as an observation group.

Research results

Intraoperative bleeding volume, drainage volume, drainage time, hospital stay, and visual analogue scale score were significantly lower in the observation group. The results of percentage of forced expiratory volume in the first second (FEV₁%), the percentage of forced vital capacity (FVC%), and the FEV₁/FVC ratio were significantly higher in the observation group.

Research conclusions

Thoracoscopic pulmonary segmentectomy is an ideal surgical approach to treat small pulmonary nodules.

Research perspectives

The authors will evaluate the overall situation of the patients to take the best surgical plan in the future.

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