Submitted: 31 July, 2024 Accepted: 21 October, 2024 Published: 30 December, 2024 DOI:10.22514/jomh.2024.209

ORIGINAL RESEARCH

JOMH Journal of Men's Health

A clinical efficacy analysis of single-port thoracoscopic lung resection in the treatment of male patients with non-small cell lung cancer using surface localization and CT-guided sclerosant

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Abstract

Background: This study was done to explore the effectiveness of single-port thoracoscopic anatomical lung wedge resection in conjunction with Computed Tomography (CT)-guided sclerosants and surface localization for treating male patients diagnosed with non-small cell lung cancer (NSCLC). **Methods**: A retrospective analysis was conducted on the clinical data of 122 male NSCLC patients treated at our hospital from January 2020 to January 2022. Patients were divided into a study group (61 cases receiving single-port thoracoscopic anatomical wedge resection + CT-guided sclerosant and surface localization) and a control group (61 cases receiving single-port thoracoscopic anatomical wedge resection). The perioperative indicators, serum tumor markers, pulmonary function indicators and stress response indicators were compared between the two groups. **Results**: Postoperatively, the study group had shorter operation time (124.15 $\pm$ 12.52 minutes), hospital stay (7.38 $\pm$ 0.73 days), drainage tube removal time (5.75 $\pm$ 0.57 days), and lower levels of Cytokeratin 19 fragment (CYFRA21-1) (3.03 $\pm$ 0.51 ng/mL), Carcino-Embryonic Antigen (CEA) (9.77 $\pm$ 0.96 ng/mL), Cancer Antigen 19-9 (CA199) (45.57 $\pm$ 4.86 U/mL), Squamous Cell Carcinoma Antigen (SCC) (21.29 $\pm$ 2.38 g/L), Epinephrine (E) (60.87 $\pm$ 6.41 pg/mL), Norepinephrine (NE) (185.32 $\pm$ 18.53 pg/mL), and Cortisol (Cor) (97.63 $\pm$ 9.76 ng/mL) compared to the control group (operation time: 136.85 $\pm$ 13.77 minutes; hospital stay: 9.67 $\pm$ 0.91 days; drainage tube removal time: 7.23 $\pm$ 0.69 days; CYFRA21-1: 4.87 $\pm$ 0.55 ng/mL; CEA: 12.68 $\pm$ 1.32 ng/mL; CA199: 16.38 $\pm$ 1.59 U/mL; SCC: 10.58 $\pm$ 1.12 g/L; E: 77.86 $\pm$ 7.86 pg/mL; NE: 226.76 $\pm$ 22.66 pg/mL; Cor: 119.87 $\pm$ 11.89 ng/mL). **Conclusions**: In summary, the integration of thoracoscopic anatomical lung wedge resection through a single port with CT-guided sclerosant and surface localization has been shown to bring about notable improvements in perioperative parameters, preserve lung function and alleviate stress reactions in male patients diagnosed with NSCLC.

Keywords

Single-port thoracoscopic lung resection; CT-guided sclerosant; Surface localization; Non-small cell lung cancer; Clinical efficacy

1. Introduction

Non-small cell lung cancer (NSCLC) is the predominant form of lung cancer, constituting around 80% to 85% of total cases. It encompasses different subtypes like adenocarcinoma, squamous cell carcinoma, and large cell carcinoma [1]. The origin of NSCLC is multifaceted and varied, frequently linked to a smoking background in male individuals, who are susceptible to smoking-related health issues [2]. Consequently, early symptoms are usually subtle, and most patients are diagnosed at an advanced stage. Thanks to the progress in medical technology and diagnostic techniques, the rate of early detection for NSCLC is on the rise [3]. Effective surgical interventions and postoperative care can achieve favorable treatment outcomes and long-term survival goals.

Single-port thoracoscopic lung resection has shown notable benefits in the management of NSCLC [4]. According to relevant reports, reducing the number of surgical incisions directly decreases the damage to the chest wall muscles, nerves, and other tissues. This allows for a 30%–50% reduction in postoperative analgesic medication dosage, and results in less noticeable scarring after healing, providing good cosmetic outcomes. Simultaneously, this surgical procedure offers a well-defined operating field, minimizes the physical impact on

the patient, attains a high success rate in removing the affected tissue, and promotes swift recovery, ultimately optimizing lung function preservation. However, due to the complex anatomical structure of the lung lobes in male patients and the obscured lesion locations caused by smoking, accurate identification and localization can be challenging, especially since the physician's palpation is limited. Additionally, the surgical operating space and field of view are restricted, requiring more precise surgical skills when dealing with complex vascular and bronchial structures, which undoubtedly increases the difficulty of the procedure. Hence, the use of CT-guided sclerosant and surface localization can be employed to facilitate this procedure [5]. Its working principle involves injecting sclerosants under real-time CT guidance, which induces a localized inflammatory response and fibrosis. After delineating a distinct marker at the site of the lesion, the surface coordinates of the lesion are identified, facilitating accurate surgical removal [6]. In order to improve the precision of surgery and the overall effectiveness of treatment, this research project aims to integrate the use of CT-guided sclerosants and surface localization in a single-port thoracoscopic anatomical lung wedge resection procedure for male NSCLC patients. An evaluation system, disease management model, and rehabilitation plan tailored for male patients will be established, filling the gap in the application of single-port thoracoscopic techniques combined with multiple technologies.

2. Materials and methods

2.1 General information

A retrospective analysis was conducted on the clinical data of 122 male patients with NSCLC treated at our hospital from January 2020 to January 2022. Patients were divided into a study group (n = 61) and a control group (n = 61) based on treatment methods. In the study group, the age ranged from 41 to 64 years, with a mean age of (52.84 $\pm$ 5.71) years and a mean Body Mass Index (BMI) of (21.38 $\pm$ 2.37) kg/m^2. In the control group, the age ranged from 36 to 65 years, with a mean age of (53.08 $\pm$ 5.57) years and a mean BMI of (21.74 $\pm$ 2.59) kg/m^2. There were no significant differences in the general characteristics between the two groups ($p > 0.05$), ensuring comparability.

2.2 Inclusion and exclusion criteria

2.2.1 Inclusion criteria

(1) Pathologically confirmed NSCLC according to the diagnostic criteria of "Clinical Oncology" [7].

(2) Tumor diameter $\leq$2 cm.

(3) Has adequate cardiopulmonary function to tolerate surgery.

(4) First-time treatment.

(5) Number of lesions detected in the lungs $>$1.

(6) Complete clinical data.

2.2.2 Exclusion criteria

(1) Patients with psychiatric disorders.

(2) Concurrent liver or kidney dysfunction.

(3) Patients with other malignant tumors.

(4) Poor compliance and inability to tolerate surgery.

2.3 Methods

The control group patients underwent single-port thoracoscopic anatomical wedge resection.

(1) Patient Positioning and Anesthesia: Patients were positioned in a lateral position on the healthy side, ensuring that the head, neck and spine were aligned to avoid twisting. The anesthesiologist induced anesthesia using propofol (Xi'an Libang Pharmaceutical Co., Ltd., Xi'an, Shaanxi, China, National Drug Approval No.: H20010368). Once the patient was unconscious, double-lumen endotracheal intubation was performed, using a fiberoptic bronchoscope to confirm correct placement for unilateral lung ventilation.

(2) Incision Selection: A cut was performed along the midaxillary line, specifically at the fourth or fifth rib, measuring around 3 to 4 cm in size.

(3) Exploration of the Thoracic Cavity: Through the incision, a thoracoscope was inserted and positioned to thoroughly examine the thoracic cavity, with the main focus on identifying the lesion. Utilizing a cutting stapler, the lung lobe was methodically liberated along the fissure, leading to the exposure and excision of the corresponding section of lung tissue.

(4) Vessel and Bronchial Management: Small vessels and bronchi encountered during resection were managed with appropriate hemostatic measures.

(5) Drain Placement: Following the removal of the tissue, the surgical site was inspected for any signs of bleeding or air leakage. Subsequently, a drainage tube was inserted into the thoracic cavity to remove any postoperative fluid and gas, after which the incision was closed in layers.

The study group implemented single-port thoracoscopic wedge resection plus CT-guided sclerosants and surface localization.

(1) Localization: The patient was directed to lie flat on the CT scanning table, following the removal of any metal objects. After adjusting their position for comfort, an initial CT scan was conducted at a slice thickness ranging from 1 to 3 mm to locate and outline the estimated position of the lesion.

(2) Puncture: A second CT scan was performed to determine the puncture path and entry point. Upon reaching the lesion, a sufficient amount of sclerosants (Plecanatide, Jilin Aodong Pharmaceutical Group, Dunhua, Jilin, China, National Drug Approval No.: H20123357) was injected via the puncture needle, with the corresponding tumor position marked on the surface.

(3) Postoperative Care: Following the removal of the puncture needle, the puncture site was compressed to promote hemostasis and subsequently wrapped with a bandage. A final CT scan was performed to assess for any signs of bleeding or pneumothorax. If no irregularities were detected, the patient was deemed eligible for discharge.

2.4 Observational indicators

(1) Perioperative Indicators: length of hospital stays, amount of intraoperative bleeding, time spent removing drainage tubes, and total amount of postoperative drainage volume.

(2) Serum Tumor Marker Indicators: changes in CYFRA21-1, CEA, CA199 and SCC levels.

(3) Pulmonary Function Indicators: changes in Forced Vital Capacity (FVC), Forced Expiratory Volume in One Second (FEV_1) and Tiffeneau-Pinelli (FEV_1/FVC) index levels.

(4) Stress Response Indicators: changes in E, NE and Cor levels.

2.5 Statistical analysis

All data were statistically analyzed using SPSS 23 software (International Business Machines Corporation, Armonk, NY, USA). Categorical data were analyzed with the chi-square test; continuous data were expressed as mean ± standard deviation. Paired *t*-tests were used for comparisons before and after treatment within groups, while independent samples *t*-tests were used for comparisons between groups. Rank sum tests were employed for ordinal data, and correlation analyses were conducted among various indicators. A *p*-value of less than 0.05 was considered statistically significant.

3. Results

3.1 Comparison of perioperative indicators between the two groups

After the surgery, the patients in the study group experienced significantly reduced lengths of hospital stays, surgical durations, time for drainage tube removal, intraoperative blood loss and total postoperative drainage volume ($p < 0.05$). See Table 1 for details.

3.2 Comparison of serum tumor marker indicators between the two groups

There was no significant difference ($p > 0.05$) in the levels of CYFRA21-1, CEA, CA199 and SCC between the two groups of patients before surgery. Following the surgical procedure, it was observed that individuals in the experimental group exhibited notably reduced levels of CYFRA21-1, CEA, CA199 and SCC in comparison to those in the control group ($p < 0.05$). See Table 2 for details.

3.3 Comparison of pulmonary function indicators between the two groups

There was no significant difference ($p > 0.05$) in the levels of FVC, FEV_1 and FEV_1/FVC between the two groups of patients before surgery. Following the surgical procedure, individuals in the experimental group exhibited notably elevated levels of FVC, FEV_1 and FEV_1/FVC in comparison to those in the control group ($p < 0.05$). See Table 3 for details.

3.4 Comparison of stress response indicators between the two groups

There was no significant difference ($p > 0.05$) in levels of E, NE and Cor between the two groups of patients before surgery. Following the surgical procedure, individuals in the experimental group exhibited notably decreased levels of Epinephrine, Norepinephrine, and Cortisol in comparison to those in the control group ($p < 0.05$). See Table 4 for details.

4. Discussion

Single-port thoracoscopic procedures are increasingly being used in the treatment of non-small cell lung cancer. Nevertheless, the challenges posed by intricate pulmonary lobe structures in male patients, combined with the limited visibility during thoracoscopic surgeries, contribute to the intricacy of surgical procedures [8], and unclear lesion boundaries caused by smoking-induced changes, some male patients may require conversion to open surgery midway through the procedure. Hence, precise preoperative localization of lesions is crucial for reducing patient trauma and improving clinical results [9]. In clinical practice, proactive strategies like the use of CT-guided sclerosing agents and surface localization are implemented to improve surgical visualization. By offering accurate details about lesions, these methods contribute to better perioperative results for patients [10].

In our study, patients in the research group showed significantly shorter hospital stays, surgical times, times for drainage tubes to be removed, intraoperative blood losses, and total postoperative drainage volumes, all with $p < 0.05$. These findings suggest that combined procedures effectively improve perioperative outcomes for NSCLC patients [11]. Perhaps the explanation lies in the fact that with the guidance of CT imaging, the administration of sclerosant directly to the surface enables a more accurate identification of the tumor's position and the site for surgical resection. As a result, there is a potential reduction in the duration of the surgical procedure [12]. Precise localization enables the attending physicians to strategize the most optimal surgical approach and operative pathway, leading to reduced harm to nearby healthy tissues

TABLE 1. Comparison of perioperative conditions between the two groups ($\bar{x} \pm s$).

Grouping	Number of cases	Time of Operation (min)	Length of Hospital Stay (d)	Drainage Tube Removal (d)	Intraoperative blood loss (mL)	Total postoperative drainage (mL)
Study group	61	124.15 ± 12.52	7.38 ± 0.73	5.75 ± 0.57	121.29 ± 12.31	748.13 ± 74.93
Control group	61	136.85 ± 13.77	9.67 ± 0.91	7.23 ± 0.69	158.86 ± 16.12	847.39 ± 85.69
t value	——	−5.331	−15.355	−12.870	−14.476	−6.811
p value	——	<0.001	<0.001	<0.001	<0.001	<0.001

TABLE 2. Comparison of serum tumor marker indicators between the two groups ($\bar{x} \pm s$).

Indicators	Study group (n = 61)	Control group (n = 61)	*t* value	*p* value
CYFRA21-1 (ng/mL)				
Before surgery	8.03 ± 0.87	8.21 ± 0.75	−1.164	0.247
After surgery	3.03 ± 0.51	4.87 ± 0.55	−19.331	<0.001
t value	39.076	29.373		
p value	<0.001	<0.001		
CEA (ng/mL)				
Before surgery	34.28 ± 3.69	34.49 ± 3.53	−0.336	0.737
After surgery	9.77 ± 0.96	12.68 ± 1.32	−13.867	<0.001
t value	47.278	43.410		
p value	<0.001	<0.001		
CA199 (U/mL)				
Before surgery	45.57 ± 4.86	45.81 ± 4.72	−0.277	0.783
After surgery	9.48 ± 0.95	16.38 ± 1.59	−29.024	<0.001
t value	56.983	45.905		
p value	<0.001	<0.001		
SCC (g/L)				
Before surgery	21.29 ± 2.38	21.48 ± 2.26	−0.452	0.652
After surgery	6.87 ± 0.69	10.58 ± 1.12	−22.140	<0.001
t value	47.840	31.856		
p value	<0.001	<0.001		

CYFRA21-1: Cytokeratin 19 fragment; CEA: Carcino-Embryonic Antigen; CA: Cancer Antigen; SCC: Squamous Cell Carcinoma Antigen.

TABLE 3. Comparison of pulmonary function indicators between the two groups ($\bar{x} \pm s$).

Indicators	Study group (n = 61)	Control group (n = 61)	*t* value	*p* value
FVC (L)				
Before surgery	1.72 ± 0.51	1.78 ± 0.53	−0.636	0.526
After surgery	2.53 ± 0.52	2.34 ± 0.51	2.156	0.033
t value	−8.367	−6.402		
p value	<0.001	<0.001		
FEV_1 (L)				
Before surgery	1.69 ± 0.54	1.73 ± 0.51	−0.317	0.752
After surgery	2.18 ± 0.50	1.90 ± 0.52	2.925	0.004
t value	−4.735	−1.922		
p value	<0.001	<0.001		
FEV_1/FVC (%)				
Before surgery	31.67 ± 3.21	31.83 ± 3.08	−0.281	0.779
After surgery	54.39 ± 5.43	42.28 ± 4.23	13.766	<0.001
t value	−29.030	−15.532		
p value	<0.001	<0.001		

FVC: Forced Vital Capacity; FEV_1: Forced Expiratory Volume in One Second.

TABLE 4. Comparison of stress response indicators between the two groups ($\bar{x} \pm s$).

Indicators	Study group (n = 61)	Control group (n = 61)	*t* value	*p* value
E (pg/mL)				
Before surgery	47.35 ± 4.83	47.62 ± 4.69	−0.313	0.755
After surgery	60.87 ± 6.41	77.86 ± 7.86	−13.084	<0.001
t value	−12.705	−24.897		
p value	<0.001	<0.001		
NE (pg/mL)				
Before surgery	121.45 ± 12.68	121.63 ± 12.13	−0.080	0.936
After surgery	185.32 ± 18.53	226.76 ± 22.66	−11.054	<0.001
t value	−22.032	−30.620		
p value	<0.001	<0.001		
Cor (ng/mL)				
Before surgery	67.22 ± 6.87	67.64 ± 6.51	−0.355	0.723
After surgery	97.63 ± 9.76	119.87 ± 11.89	−11.287	<0.001
t value	−18.698	−26.774		
p value	<0.001	<0.001		

E: Epinephrine; NE: Norepinephrine; Cor: Cortisol.

and blood vessels. As a result, intraoperative bleeding is minimized, and tissue trauma reactions are significantly decreased [13]. Moreover, decreased pulmonary exudation in individuals results in a reduction in the overall drainage volume. Milder injuries facilitate the recovery of patients' physiological functions, expedite the healing process and shorten the duration required for the removal of drainage tubes [14].

For NSCLC patients, when cancer cells proliferate rapidly and undergo necrosis, large amounts of keratin fragments are released into the blood. As a result, there is a rise in the production and secretion of glycoproteins, along with the disruption and impairment of the patient's immune system, leading to functional impairments that elevate levels of carcinoembryonic antigen and squamous cell carcinoma antigen [15]. In this study, postoperative levels of CYFRA21-1, CEA, CA199 and SCC were significantly lower in the research group ($p < 0.05$). This suggests that combined surgery has a superior tumor clearance effect and can improve patient prognosis. This could be because using CT-guided sclerosant and surface localization during surgery can help avoid tumor compression [16], which prevents tumor cells from shedding into the lymphatic and blood circulation and lowers the risk of dispersion and metastasis.

It minimizes leftover tumor tissue and effectively defines the limits and extent of the tumor, allowing for a more thorough and complete excision. This method also helps to minimize the degree and seriousness of body trauma, leading to a reduction in stress and inflammation, as well as a decrease in the activation of tumor cell growth and metabolic activity [17]. Moreover, it helps the immune system to effectively surveil and eliminate any remaining tumor cells, consequently lowering the production of tumor markers [18].

The expansion and spread of lung tumors lead to the filling of patients' lung cavities, causing compression and blockage of the bronchi, bronchioles, and alveoli. The destruction of the alveolar structure and function by tumor cells results in a decline in lung function. In this study, patients in the research group showed significantly higher postoperative levels of FVC, FCV_1 and FCV_1/FVC ($p < 0.05$). Combined surgery suggests a higher preservation of lung function, contributing to improved quality of life for patients. Potential reasons for this could be the precise localization that enables the accurate elimination of the affected tissue, consequently enhancing the retention of normal lung tissue and functional units, while reducing harm to the healthy lung tissue [19]. Anatomical wedge resection under single-port thoracoscopy itself offers the advantage of minimal trauma, causing less damage to chest wall muscles, nerves and blood vessels, which helps maintain the integrity and function of alveoli and airway epithelial cells. Moreover, it promotes the early start of respiratory exercises and rehabilitation programs, which can help speed up lung expansion and functional recovery.

Tumor cells act as a stressor, triggering activation of the patient's sympathetic-adrenal medullary system [20], hypothalamic-pituitary-adrenal axis to release more stress hormones in response to psychological stress, pain perception, and increased energy demands. In this study, patients in the research group showed significantly lower postoperative levels of Epinephrine, Norepinephrine and Cortisol ($p < 0.05$).

Combining surgery under single-port thoracoscopy with CT-guided sclerosant and surface localization may reduce patient stress reactions and accelerate recovery. One possible explanation is that the integration of surgical procedures enables a higher level of precision in delineating and managing tumor boundaries, leading to smaller incisions, decreased nerve irritation, and suppression of overactive hypothalamic-pituitary-adrenal and sympathetic-adrenal medullary systems [21]. The use of CT-guided sclerosant along with surface localization techniques has the potential to minimize surgical uncertainties, boost patients' trust in the procedure, alleviate psychological distress and anxiety, and lower overall levels of psychological stress [22].

5. Conclusions

In summary, the utilization of single-port thoracoscopic anatomical lung resection in conjunction with CT-guided sclerosant administration and surface localization has shown promising results in enhancing perioperative outcomes, optimizing tumor clearance rates, preserving pulmonary function, and mitigating stress responses in male NSCLC patients. However, this study has certain limitations such as small sample size, incomplete ward information, and lack of transparency, which may lead to certain biases in the results. Further research will be conducted to address these issues.

AVAILABILITY OF DATA AND MATERIALS

The authors declare that all data supporting the findings of this study are available within the paper and any raw data can be obtained from the corresponding author upon request.

AUTHOR CONTRIBUTIONS

QHWa—designed the study and carried them out. QHWa, YJH, XWX and QHWu—supervised the data collection. QHWa, YJH and XWX—analyzed the data. QHWa and YJH—interpreted the data. QHWa and QHWu—prepared the manuscript for publication and reviewed the draft of the manuscript. All authors have read and approved the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This work was supported by Affiliated Hospital of JiangNan University, (Grant No. LS2024062). Written informed consent was obtained from a legally authorized representative for anonymized patient information to be published in this article.

ACKNOWLEDGMENT

Not applicable.

FUNDING

Top Talent Support Program for young and middle-aged people of Wuxi Health Committee (NO. BJ2020048) and the Project of Transforming Medicine Institution of Wuxi (NO. LCYJ202221).

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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How to cite this article: Qinghua Wang, Yujie He, Xiaowei Xie, Qinghua Wu. A clinical efficacy analysis of single-port thoracoscopic lung resection in the treatment of male patients with non-small cell lung cancer using surface localization and CT-guided sclerosant. Journal of Men's Health. 2024; 20(12): 138-144. doi: 10.22514/jomh.2024.209.