

The Relationship between the Duration of Surgery for Thoracoscopic Lobectomy and Postoperative Complications in Patients with Stage I Non-small Cell Lung Cancer

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Objective: To investigate the relationship between the duration of surgery for thoracoscopic lobectomy and postoperative complications in patients with stage I non-small cell lung cancer (NSCLC).

Methods: The clinical data of patients who underwent thoracoscopic lobectomy in the Department of Cardiothoracic Surgery, Shaoxing Central Hospital from September 2018 to September 2023 were retrospectively analyzed.

Results: A total of 263 patients with thoracoscopic lobectomy were enrolled in this study. The duration of surgery was longer for patients with postoperative hospital stay >7 days, atrial fibrillation, postoperative pulmonary air leakage (>5 days), pleural effusion, or pneumonia compared to patients without corresponding complications, and the differences were statistically significant. Further regression analysis showed that prolonged duration of surgery was a risk factor for pneumonia, pleural effusion, atrial fibrillation, and postoperative hospital stay >7 days, and the predictive value of prolonged duration of surgery for the above complications was moderate. The results of chi-square tests showed that pneumonia, atelectasis, urinary tract infection, liver dysfunction, postoperative pulmonary air leakage (>5 days), pleural effusion, and atrial fibrillation were associated with postoperative hospital stay >7 days.

Conclusion: Prolonged duration of surgery is a risk factor for complications such as pneumonia, pleural effusion, atrial fibrillation, and postoperative hospital stay >7 days.

Keywords: lung cancer; thoracoscopic complications; duration of surgery

Introduction

Prolonged duration of surgery increases perioperative complications, including length of hospital stays and readmission rate, and this relationship has been confirmed in neurosurgery, colonic surgery, urology, bariatric surgery, pediatric spinal surgery and other medical specialties [1–5]. However, there are few studies that focus on the relationship between the duration of surgery and postoperative complications in patients undergoing thoracoscopic lobectomy; moreover, the patients included in those studies were heterogeneous. Although more and more patients with early lung cancer undergo segmentectomy or wedge resection, lobectomy is still the standard surgical treatment for early lung cancer, and it is also one of the most common thoracoscopic surgeries in thoracic surgery department [6–8]. Lobectomy has greater requirements for one-lung ventilation and respiratory control, which also adds difficulty to the work of anesthesiologists [9,10]. It has been found in clinical work that patients with prolonged duration of

surgery are more likely to have perioperative complications. One-lung ventilation is required by thoracoscopic lobectomy, and this type of ventilation may cause intrapulmonary shunt, hypoxemia, hypoxic pulmonary vasoconstriction, cytokine release, severe oxidative stress, and free radical damage; it also impacts on stroke volume, cardiac output, heart rate, arterial pressure and other cardiopulmonary functions. In addition, there are anesthetic drugs, indwelling catheters, hypothermia, etc., which are likely to lead to postoperative complications [11, 12]. Therefore, we hypothesized that due to the special state of patients during thoracoscopic lobectomy, the duration of the operation would increase the occurrence of complications. From this perspective, the aim of this study was to collect relevant data for stage I non-small cell lung cancer (NSCLC) patients who underwent thoracoscopic lobectomy, in order to clarify the relationship between the duration of surgery and perioperative complications of thoracoscopic lobectomy.

Materials and Methods

The clinical data of NSCLC patients who underwent thoracoscopic lobectomy in the Department of Cardiothoracic Surgery of our hospital from September 2018 to September 2023 were collected and screened according to the following criteria. Inclusion criteria: (1) primary lung cancer, (2) stage I or stage \leq T2aN0M0 (UICC 8th edition TNM stag-

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ing), (3) undergoing thoracoscopic lobectomy. Exclusion criteria were as follows: (1) ≤ 18 years old; (2) secondary lung cancer; (3) sublobar resection or resection of more than one lung lobe; (4) previous lung or thoracic surgery history; (5) preoperative neoadjuvant therapy. A total of 263 patients were included in the study.

General data such as age, gender, duration of surgery, preoperative American Society of Anesthesiologists (ASA) classification, and smoking history were collected after inclusion in the study. When duration of surgery was collected, we rounded up the number of minutes, so the value of the single-digit position was 0 or 5. At the same time, whether the patients were transfused red blood cells during the operation, and whether there were postoperative complications such as pneumonia, atelectasis, urinary tract infection, abnormal liver function, pleural effusion, atrial fibrillation, postoperative lung air leakage time > 5 days, and postoperative hospital stay > 7 days were also recorded. It should be noted that the typical length of stay after lung surgery is 5–7 days in our hospital, and studies related to lung surgery in China generally consider that the length of a hospital stay up to 7 days is normal; therefore we identified “hospitalization > 7 days” as a complication [13, 14]. IBM SPSS 26.0 software (IBM Corp., Armonk, NY, USA) was used for statistical analysis. Exploratory analysis revealed that age and duration of surgery were not normally distributed and did not conform to homogeneity of variance; therefore, these variables were represented by the median and interquartile range (P25, P75). Due to non-normal distributions, one of nonparametric test, the Mann–Whitney U test, was used for comparisons between two groups. Qualitative data were expressed as a percentage (%). Binary logistic regression was used to analyze the risk of complications. The receiver operating characteristic (ROC) curve was estimated, and the area under the ROC curve (AUC) was calculated to compare the predictive value of duration of surgery for complications. The chi-square test was used to identify correlations between complications and postoperative hospital stay > 7 days. p -values < 0.05 were considered statistically significant.

Results

General Information

Among the 263 patients, 100 (38.02%) were male and 163 (61.98%) were female. The average age was 62.29 ± 12.00 years. There were 190 cases (72.24%) of ASA grade 2 or above. 91 patients (34.60%) had a history of smoking. The mean operation duration was 120.00 (110.00, 120.00) minutes.

Relationships between Surgical Complications and Duration of Surgery

The most common complication was postoperative hospital stay > 7 days (26.99%), followed by atrial fibrillation, postoperative pulmonary air leakage (> 5 days), liver dysfunction, atelectasis, pleural effusion, pneumonia, urinary

tract infection, and intraoperative red blood cell transfusion. We tested the data using the nonparametric Mann–Whitney U test. Patients with postoperative hospital stay > 7 days, atrial fibrillation, postoperative pulmonary air leakage (> 5 days), pleural effusion, or pneumonia had longer duration of surgery than those without corresponding complications, and the differences were statistically significant ($p < 0.05$; Table 1).

Effect of Operation Duration on Surgical Complications

Since all of the above-mentioned complications were dichotomous variables, we also performed binary logistic regression analyses. The variables in Table 1 with $p \leq 0.05$ were included as dependent variables, and the duration of surgery was included as a covariate. Binary logistic regression analysis showed that prolonged duration of surgery was associated with the occurrence of pneumonia, pleural effusion, atrial fibrillation, and postoperative hospital stay > 7 days, and these associations were statistically significant ($p < 0.05$) (Table 2).

The Duration of Surgery Predicts Postoperative Complications

The duration of surgery was used as the test variable, and pneumonia, pleural effusion, atrial fibrillation, and postoperative hospital stay > 7 days were used as the state variables to estimate the ROC curve. The results showed that the area under the curves (AUCs) for pneumonia and atrial fibrillation were higher than that of other indicators, and their diagnostic value was the highest. The AUCs of the four state variables ranged from 0.75 to 0.8, with no significant differences among them, and their diagnostic value was moderate (Table 3, Fig. 1).

Relation between Surgical Complications and Postoperative Hospital Stay > 7 Days

Because the occurrence of complications may lead to a longer hospital stay, we grouped patients according to whether they were hospitalized for > 7 days, and used the chi-square tests to compare the differences in the incidence of various complications between the two groups. The results showed that there were statistically significant differences in the incidence of pneumonia, atelectasis, urinary tract infection, liver dysfunction, postoperative pulmonary air leakage (> 5 days), pleural effusion, and atrial fibrillation between the two groups (Table 4). These complications contributed to the length of hospital stay > 7 days.

Discussion

The duration of surgery is not only affected by the type of operation itself, but also by various other factors, such as the patient's age, physiological state, underlying diseases, anesthetic drugs, etc. Even if the same surgical team does the same type of operation in the operating room of the same medical center, the duration of each surgery is different, because there are no two patients with identical con-

Table 1. Univariate relationships between surgical complications and duration of surgery.

Complications	n(%)	Mean duration of surgery (min) with/without complication	Z	p
Pneumonia	14(5.32%)	140.00(121.25, 152.50)/ 120.00(110.00, 120.00)	-3.351	<0.001
Atelectasis	18(6.84%)	127.50(110.00, 150.00)/ 120.00(110.00, 120.00)	-1.868	0.062
Urinary tract infection	11(4.18%)	120.00(110.00, 140.00)/ 120.00(110.00, 120.00)	-1.062	0.287
Intraoperative RBC transfusion	8(3.04%)	132.50(112.50, 148.75)/ 120.00(110.00, 120.00)	-2.099	0.056
Liver dysfunction	21(7.98%)	120.00(107.50, 132.50)/ 120.00(110.00, 120.00)	-1.271	0.204
Postoperative pulmonary air leakage (>5 days)	24(9.12%)	125.00(121.25, 128.75)/ 120.00(110.00, 120.00)	-3.845	<0.001
Pleural effusion	17(6.46%)	125.00(120.00, 142.50)/ 120.00(110.00, 120.00)	-3.518	<0.001
Atrial fibrillation	32(12.17%)	132.50(120.00, 145.00)/ 120.00(110.00, 120.00)	-5.157	<0.001
Postoperative hospital stay >7 days	71(26.99%)	125.00(120.00, 140.00)/ 120.00(110.00, 120.00)	-6.673	<0.001

Table 2. Logistic regression analysis of the effect of operation duration on surgical complications.

Complications	β	S.E.	Wald	OR	p
Pneumonia	0.068	0.016	17.454	1.071	<0.001
Postoperative pulmonary air leakage (>5 days)	0.024	0.013	3.611	1.025	0.057
Pleural effusion	0.056	0.015	14.397	1.057	<0.001
Atrial fibrillation	0.067	0.014	22.314	1.070	<0.001
Postoperative hospital stay >7 days	0.081	0.015	31.173	1.085	<0.001

ditions. Prolonged duration of surgery increases the incidence of postoperative complications, the length of hospital stays, and the rate of readmission, and these associations have been confirmed in retrospective analyses in many medical specialties [1–5, 15–17]. Although some studies have included patients who underwent thoracic surgery, the literature on the relationship between the duration of thoracic surgery and complications is very limited, and the patients included were heterogeneous with respect to the type of thoracic surgery [18]. For example, among stage I NSCLC patients that were treated by surgery, wedge resection had fewer complications, and multiple lobectomy and pneumonectomy had a higher incidence of complications, compared to lobectomy-only patients. Therefore, based on this information, the present study included data for stage I NSCLC patients who underwent thoracoscopic lobectomy in our hospital. The analysis found that the duration of surgery was a risk factor for postoperative pneumonia, postoperative pulmonary air leakage (>5 days), pleural effusion, atrial fibrillation, and postoperative hospital stay >7 days.

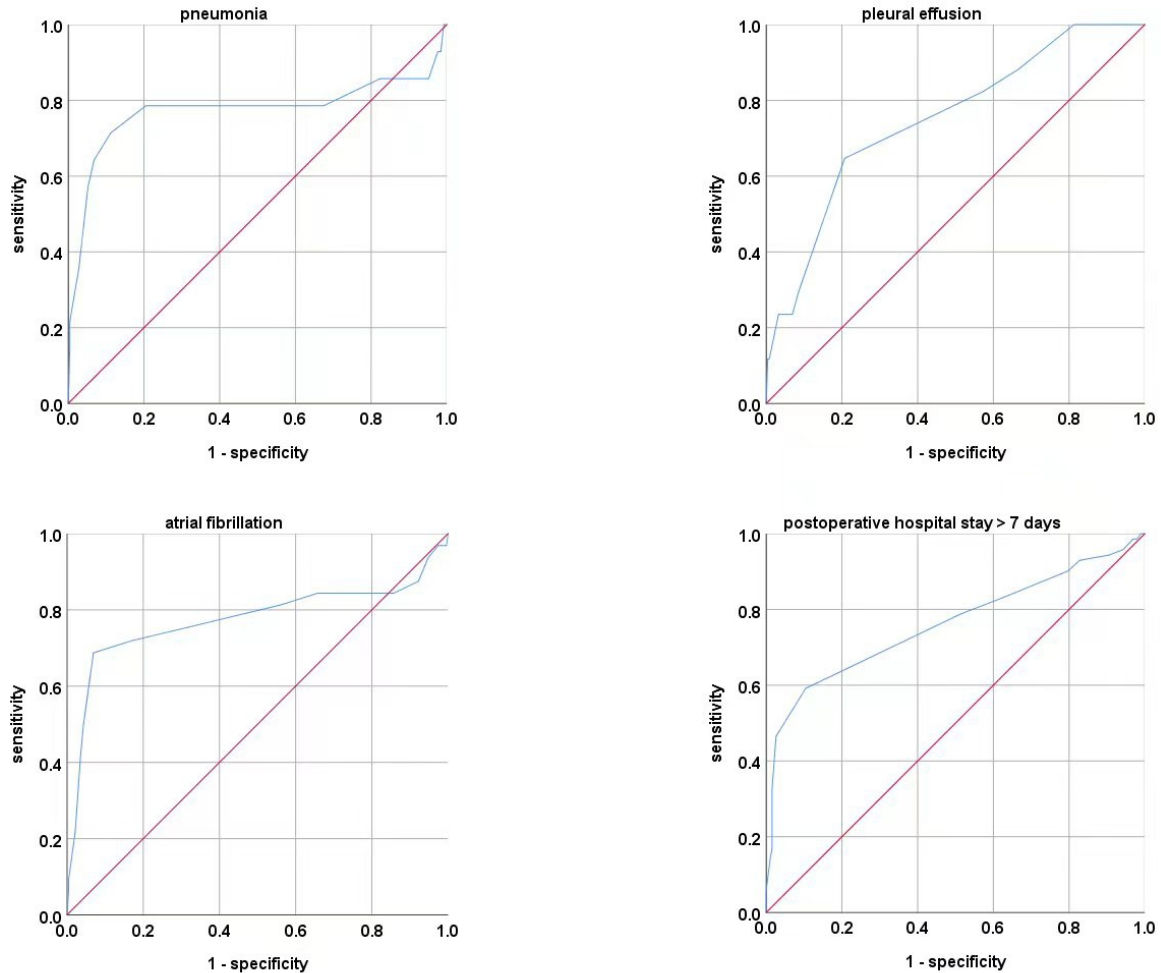
This study showed that prolonged duration of surgery was a risk factor for postoperative pneumonia. Comprehensive analyses have shown that various factors during the operation can cause direct or indirect damage to the lung. From the perspective of surgical operation, intraoperative manipulations, such as the use of oval forceps to repeatedly clamp and flip the lung tissue, will increase the risk of pneumonia. The occurrence of pulmonary infection may also be related to patients having unsatisfactory postoperative analgesia and inadequate cough and thorough discharge of sputum. Mechanical ventilation during anesthesia, especially one-lung ventilation, inevitably leads to injury of the patient's lung, but the mechanism is complex and still not completely clear. The duration of mechanical ventilation is an important factor for the severity of the lung injury [19, 20]. The duration of lobectomy represents prolonged anesthesia and more serious lung injury. During surgery, anesthesiologists may need to inflate the lung many times. Although some protective measures have been proposed [21], this will still cause a certain degree of damage to the lung.

This study showed that prolonged duration of surgery was a risk factor for postoperative pleural effusion. For lung

Table 3. Effect of operation duration on the prediction of surgical complications.

Complications	AUC (95% CI)	S.E.	p
Pneumonia	0.774 (0.585–0.962)	0.096	0.001
Pleural effusion	0.749 (0.627–0.870)	0.062	0.001
Atrial fibrillation	0.774 (0.655–0.893)	0.061	<0.001
Postoperative hospital stay >7 days	0.761 (0.686–0.873)	0.039	<0.001

AUC, area under the curve.

**Fig. 1. The receiver operating characteristic (ROC) curve of the test variable.**

surgery, prolonged duration of surgery leads to poor fluid management, which may lead to increased cardiac load and increased postoperative microcirculatory venous pressure [22, 23]. Prolonged duration of surgery and aggravated pleurisy reaction will lead to increased microcirculation permeability. All of these factors disrupt the balance between production and reabsorption of fluid in the pleural space.

This study showed that prolonged duration of surgery was a risk factor for postoperative atrial fibrillation, which may be caused by multiple intraoperative factors that cause hemodynamic instability and aggravation of cardiopulmonary burden. Surgical resection of part of lung tissue and intra-

operative one-lung ventilation will lead to increased pulmonary artery pressure and hemodynamic instability of the right side of the heart, which will greatly increase the incidence of atrial fibrillation [24–26]. In addition, prolonged duration of surgery, poor intraoperative fluid management, and greater fluid supplementation, especially crystalloid, will also increase the workload of the heart and lungs [22, 23]. From the perspective of anesthesia, the choice of anesthetic drugs, and the combination of different anesthetic drugs, will impact the hemodynamics of patients undergoing lobectomy, leading to postoperative complications such as arrhythmia [27–29].

Table 4. Relationships between surgical complications and postoperative hospital stay >7 days.

Complications	χ^2	<i>p</i>
Pneumonia	19.958	<0.001
Atelectasis	11.410	0.001
Urinary tract infection	4.421	0.035
Intraoperative RBC transfusion	2.215	0.137
Liver dysfunction	28.025	<0.001
Postoperative pulmonary air leakage (>5 days)	4.755	0.029
Pleural effusion	9.342	0.002
Atrial fibrillation	32.228	<0.001

This study showed that prolonged duration of surgery was a risk factor for postoperative hospital stay >7 days, and further analysis found that the incidence of pneumonia, atelectasis, urinary tract infection, liver dysfunction, postoperative pulmonary air leakage (>5 days), pleural effusion, and atrial fibrillation was higher in patients with postoperative hospital stay >7 days. Due to the occurrence of these complications, patients obviously need to be hospitalized for a longer period of time. In addition, for patients with long operation time and related complications, clinicians will also subjectively delay the discharge of patients from the perspective of safety.

Conclusion

In conclusion, the duration of thoracoscopic lobectomy for stage I NSCLC is a risk factor for pneumonia, pleural effusion, atrial fibrillation, and postoperative hospital stay >7 days. However, the sample size of this study is small and it is a single-center study, which inevitably has bias. The conclusions need to be further verified by large-scale, multi-center studies.

Availability of Data and Materials

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions

Conceptualization: XBL; data collection: BL; data sorting: HJ; statistical analysis: HJ, GWW; writing—original draft preparation: HJ; writing—review and editing: XBL; project administration: XBL; All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

This study has been approved by the Committee of Shaoxing Central Hospital, approval no.: 2023034. Informed patient consent was obtained for this study in accordance with the Declaration of Helsinki.

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Conflict of Interest

The authors declare no conflict of interest.

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