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Original Article

High FEV1 and BMI as protective factors in reducing the infection incidence of lung cancer in patients who underwent thoracoscopic surgery

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Abstract: Objective: Thoracoscopic surgery has become an important treatment approach for lung cancer in China. However, postoperative complications seriously affect surgical outcomes and prognoses. This study explored the risk factors involved in perioperative concurrent infections. Methods: A total of 253 patients with lung cancer undergoing video-assisted thoracoscopic surgeries were classified into infected (47) and non-infected (206) groups. Univariate analysis and logistic regression were used to analyze factors associated with concurrent infection. Results: Single factor analysis on preoperative factors showed that age, smoking index, diabetes mellitus, forced expiratory volume in the first second (FEV1), ejection fraction (EF) value, body mass index (BMI), and albumin levels influenced the incidence of infections after the thoracoscopic surgery in patients with lung cancer. Single factor analysis on intraoperative factors showed that operation time and intraoperative blood loss may influence the incidence of infection following thoracoscopic surgery. Single factor analysis on postoperative factors showed that postoperative drainage time also influenced the incidence of postoperative infections in patients with lung cancer. On multivariate analysis, age, operative time, postoperative drainage time, and diabetes mellitus were risk factors for higher incidence of postoperative infections in patients with lung cancer ($P<0.05$), whereas high FEV1 and BMI were protective factors in reducing postoperative infection ($P<0.05$). Conclusion: Age, operative time, postoperative drainage time, and diabetes mellitus are risk factors for infections following a thoracic surgery in patients with lung cancer. High FEV1 and BMI are protective factors in reducing the incidence of postoperative infections.

Keywords: Thoracoscopic surgery, perioperative infections, lung cancer, preoperative interventions

Introduction

Lung cancer is the first leading cause of cancer deaths worldwide. Approximately 1.1 million people have been reported to die from lung cancer, and approximately 1.2 million new cases were diagnosed each year worldwide. In China, lung cancer is also the most common malignant tumor. Currently, surgical treatment remains one of the primary treatment methods. In recent years, with the development of minimally invasive techniques with the aim to improve patients' quality of life, thoracoscopic surgery has become an important treatment alternative, especially in patients with early-stage lung cancer. However, due to factors such as underlying diseases, surgical factors, comorbidities, and compromised immunity, patients may experience postoperative complications [1, 2], such as infections, atelectasis, arrhythmias, respiratory failure, heart failure, and pulmonary embolism, among others. The occurrence of postoperative complications can seriously affect the surgical outcomes and patient prognosis [3, 4] and may also seriously endanger patients' lives. Among these complications, postoperative infection is one of the most common, with an incidence of about 20% [5]. Once a patient acquires an infection, it often leads to exacerbations and is not conducive to a favorable prognosis.

Although thoracoscopic surgery is superior to open surgery in terms of surgical trauma and postoperative recovery, postoperative infection remains its major complication [6]. Therefore, analysis on risk factors for postoperative infection after a thoracoscopic surgery can provide the theoretical basis for the prevention and treatment of concurrent infections in patients undergoing thoracoscopic procedures. Previous screening on risk factors has focused on postoperative-related factors. However, the underlying health status of preoperative patients also carries the potential risk of coinfection.

Therefore, this study evaluated the risk factors of perioperative concurrent infections by analyzing the patient's basic preoperative status and related factors postoperatively, with the aim of providing a basis for early intervention and treatment of postoperative infections.

Materials and methods

Patient eligibility

We retrospectively analyzed the data of 253 patients with lung cancer who underwent thoracoscopic surgery at Shulan (Hangzhou) Hospital. All patients were diagnosed with lung cancer by pathological examination and had no prior thoracoscopic surgery. Exclusion criteria included the following: (1) patients with acute and chronic infection preoperatively; (2) allergies to antibiotics; (3) secondary surgery for lung cancer recurrence; (4) previous history of other malignant tumors; and (5) incomplete data.

Treatment method

All patients underwent lung surgery after completing preoperative examinations, adequate smoking cessation, lung function training, and airway preparation. All surgeries were performed under thoracoscopic non-contrast vision. The decision to perform lung lobe, lung segment, wedge resection, or pneumonectomy depends on the patient's condition. Lobectomy was performed using Wang's method. The sub-lobectomy margin was required to be not smaller than the tumor diameter or ≥2 cm. Mediastinal lymph node sampling was performed on some wedge resections, while systemic lymph node dissection was performed for the remainder.

Based on whether infection occurred postoperatively, patients were divided into infected (n=47) and non-infected (n=206) groups. Infections included lung infections and incision infections.

Data collection

Preoperative factors: For all patients, basic data were routinely collected upon admission and after preoperative examinations, which included pulmonary function, echocardiography, natriuretic peptide (BNP) levels, liver and renal function tests, and hematuria examination. The following indicators were included in the statistical analysis: (1) general information: age, sex, and smoking index (>400, ≤400); (2) concomitant diseases: chronic diseases such as diabetes mellitus, coronary heart disease, hypertension, and stroke; (3) pulmonary function: FEV1% (the actual ratio of the forced expiratory volume in the 1st s ratio >60%, ≤60%); (4) heart function: EF (>55%, ≤55%) measured by cardiac ultrasound and blood BNP levels (>500 pg/mL, ≤500 ng/mL); and (5) nutritional indicators: body mass index [BMI] (>24 kg/m^2, ≤24 kg/m^2) and serum albumin level (>35 g/L, ≤35 g/L).There were 12 factors in total. The smoking index was calculated as follows: number of cigarettes smoked per day × years of smoking. BMI was defined as weight/height^2.

Intraoperative factors: A total of three intraoperative factors were included: the type of surgery (pulmonary resection, sub-lobectomy, lobectomy), operative time (>3 h, ≤3 h), and intraoperative blood loss (>300 mL, ≤300 mL).

Postoperative factors: A total of four postoperative factors were included: pathological type (squamous cell carcinoma, adenocarcinoma, small cell carcinoma, large cell carcinoma, others), pathological stage (I, II, III, IV), pathological differentiation (low differentiation, moderately well-differentiated), and drainage time (>60 h, ≤60 h).

Statistical analysis

The data obtained in this study were analyzed using SPSS 19.0 statistical software. Measured data were expressed as mean ± standard deviation ($\overline{x}$ ± s). Independent sample t-tests were used to compare the mean values between the two groups. Count data were represented as n. Categorical data were compared with the x^2

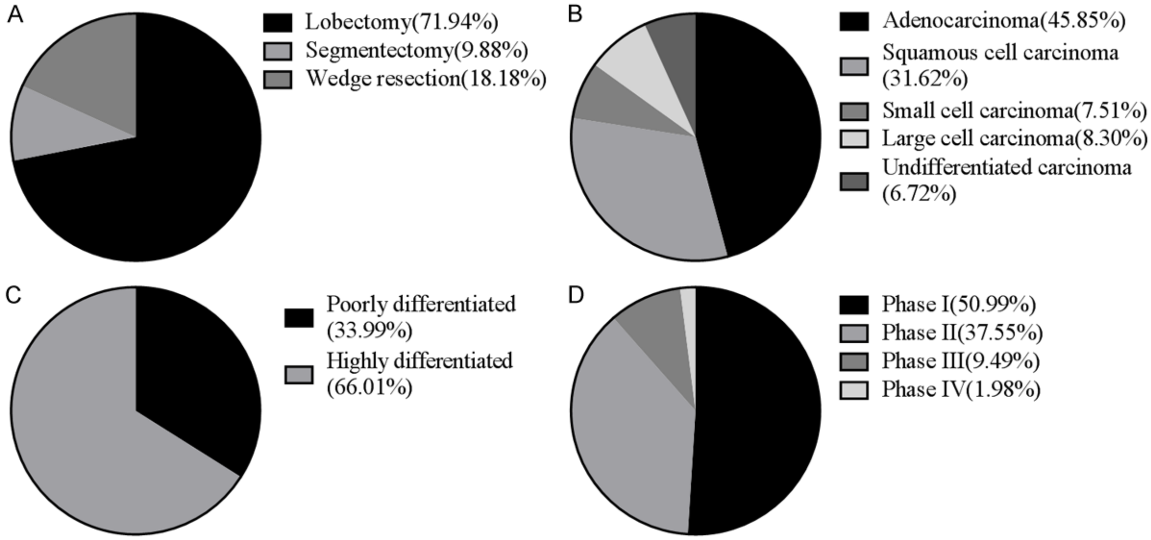

Figure 1. Basic statistics of 253 cases of lung cancer patients undergoing thoracoscopic surgery. A: Surgical type; B: Pathological type; C: Degree of differentiation; D: Pathological stage.

test, and rank data were computed with the sum test. In multivariate logistic regression analysis, a P<0.05 indicated statistical significance.

Results

Analysis of surgical management

A total of 253 patients underwent a surgery; among them 182 (71.94%) underwent thoracoscopic lobectomy and 71 underwent sub-lobar resection. Out of the 71 patients who had sub-lobar resection, 25 (9.88%) underwent segmental resection and 46 (18.18%) wedge resection. The postoperative infection rate was 18.58% (47/253). None of the patients died during the perioperative period. Postoperative histological types included 116 cases (45.85%) of adenocarcinoma, 80 cases of squamous cell carcinoma (31.62%), 19 cases of small cell carcinoma (7.51%), 21 cases of large cell carcinoma (8.30%), and 17 cases of undifferentiated carcinoma. Pathological differentiation was determined as poor in 86 cases (33.99%) and moderate in 167 cases (66.01%). The postoperative pathological stages included 129 cases (50.99%) in stage I, 95 cases (37.55%) in stage II, 24 cases (9.49%) in stage III, and 5 cases (1.98%) in stage IV. Among the 47 infected patients, one case had incision infection and one had incision infection combined with lung infection (**Figure 1**).

Single factor analysis

Single factor analysis of the preoperative factors in the two groups showed that was the difference in the incidence of infections with regard to sex; presence of hypertension, coronary heart disease, stroke; or BNP levels was not significant between the infected and non-infected groups (P>0.05). However, a statistically significant difference was observed with regard to age, smoking index, diabetes mellitus, FEV1%, EF, BMI, and albumin levels (P<0.05), which suggested that these factors may influence the incidence of infections in patients with lung cancer after a thoracoscopic surgery (**Table 1**).

The proportion of patients with operative time of >3 h and blood loss of >300 mL in the infected group was significantly higher than that in the non-infected group (**Table 2**). The drainage time of the infected group was significantly higher than that of the non-infected group (**Table 3**), which suggested that operative time, intraoperative blood loss, and postoperative drainage time may be the influencing factors for infections in patients with lung cancer after a thoracoscopic surgery.

Multivariate analysis

Multivariate analysis showed that BMI is a protective factor to reduce postoperative infection.

Table 1. Analysis of preoperative factors in patients with lung cancer with and without infection after undergoing thoracoscopic surgery

Terms	Infection group *n*=47	Non-infection group *n*=206	Statistics	*P*
Gender				
Male	26 (55.32%)	117 (56.80%)		
Female	21 (44.68%)	89 (43.20%)	0.034▲	0.854
Age (years, n)				
<60	11 (23.40%)	83 (40.29%)		
≥60	36 (76.60%)	123 (59.71%)	2.158△	0.031
Smoking index (n)				
<400	13 (27.66%)	116 (56.31%)		
≥400	34 (72.34%)	90 (43.69%)	3.538△	0.000
Combined diseases (n)				
Diabetes (with/without)	31/16	65/141	19.237▲	0.000
Hypertension (with/without)	28/19	126/80	0.041▲	0.840
Coronary heart disease (with/without)	26/21	87/119	2.652▲	0.103
Stroke (with/without)	6/41	16/190	1.205▲	0.272
FEV1% (n)				
>60%	17 (36.17%)	152 (73.39%)		
≤60%	30 (63.83%)	54 (26.21%)	4.931△	0.000
EF value (%)	54.23±6.05	56.14±5.39	2.142#	0.033
BNP level (pg/mL)	357.28±112.53	316.57±153.91	1.711#	0.088
BMI (kg/m^2)	17.93±5.28	20.39±4.32	3.373#	0.001
Albumin (g/L)	30.56±6.19	37.83±5.31	8.204#	0.000

Note: ▲The statistical value is χ^2value; △The statistical value is Z value; #Statistical value is t value.

Therefore, preoperative assessment of a patient's nutritional status by measuring BMI can have a certain predictive value for the occurrence of postoperative infection (**Table 4**).

Discussion

Lung infection in patients undergoing thoracoscopic surgery is a common postoperative complication and affects postoperative recovery [7, 8]. A large number of studies [9, 10] have shown that pulmonary complications will affect long-term outcomes in patients undergoing lung surgery. Due to various factors, concurrent infection in patients undergoing thoracoscopic surgery for lung cancer remains a complication with high postoperative incidence. Therefore, clinical prevention is of utmost significance to identify factors that may influence the incidence of concurrent infections in patients with lung cancer who underwent thoracoscopic surgery. This study found that age, operative time, postoperative drainage time, and diabetes mellitus were risk factors for postoperative infection after a thoracic surgery in patients with lung cancer, while high levels of FEV1% and BMI may be protective factors in preventing postoperative infection.

Preoperative evaluation is closely related to the risk of surgical treatment. A comprehensive preoperative evaluation [11] includes tumor staging, cardiopulmonary function assessment, and nutritional status assessment, among others. The statistical analysis of preoperative indicators in this study included assessment of FEV1%, EF values, BNP levels, BMI, and albumin levels. The cardiopulmonary function of patients was comprehensively evaluated to investigate the correlation between heart and lung functions and postoperative infection. Univariate analysis showed that age, smoking index, diabetes, FEV1%, EF values, BMI, and albumin levels may be influencing factors of infections in patients with lung cancer after a thoracoscopic surgery. Single factor analysis on intraoperative and postoperative indexes showed that differences in operation time,

Table 2. Analysis of intraoperative conditions in lung cancer patients with and without infection after undergoing thoracoscopic surgery

Terms	Infected group *n*=47	Non-infected group *n*=206	Statistics	*P*
Surgery type (n)				
Sub-lobar resection	17 (36.17%)	54 (26.21%)		
Lobectomy	30 (63.83%)	152 (73.79%)	1.879▲	0.170
Operation time (n)				
≤3 h	21 (44.68%)	154 (74.76%)		
>3 h	26 (55.32%)	52 (25.24%)	4.021△	0.000
Intraoperative blood loss (n)				
≤300 mL	28 (59.57%)	185 (89.81%)		
>300 mL	19 (40.43%)	21 (10.19%)	5.116△	0.000

Note: ▲The statistical value is χ^2 value; △The statistical value is Z value.

Table 3. Analysis of postoperative factors in lung cancer patients with and without infection after undergoing thoracoscopic surgery

Terms	Infected group *n*=47	Non-infected group *n*=206	χ^2	*P*
Pathological type				
Squamous cell carcinoma	13 (27.66%)	67 (32.52%)		
Adenocarcinoma	21 (44.68%)	95 (46.12%)		
Small cell carcinoma	4 (8.51%)	15 (7.28%)		
Large cell carcinoma	5 (10.64%)	16 (7.77%)		
Other	4 (8.51%)	13 (6.31%)	1.036▲	0.904
Pathological stage				
Phase I	27 (57.45%)	102 (49.51%)		
Phase II	15 (31.91%)	80 (38.83)		
Phase III	3 (6.38%)	21 (10.19)		
Phase IV	2 (4.26%)	3 (1.46%)	0.851△	0.395
Pathological differentiation				
Poor differentiation	12 (25.53%)	74 (35.92%)		
Highly differentiated	35 (74.47%)	132 (64.08%)	1.354△	0.176
Drainage time (h)	78.61±12.58	61.27±11.39	9.234#	0.000

Note: ▲The statistical value is χ^2 value; △The statistical value is Z value; #The statistical value is t value.

intraoperative blood loss, and postoperative drainage time between the two groups were statistically significant (P<0.05).

Further multivariate logistic regression analysis showed that age, operative time, postoperative drainage time, and diabetes mellitus were risk factors for infection after a thoracic surgery in patients with lung cancer (P<0.05), while elevated levels of FEV1% and BMI were protective factors in reducing the incidence of postoperative infection (P<0.05). Smoking is closely related to the occurrence of lung cancer [12] and can lead to chronic respiratory inflammatory reactions, including bronchial glandular hyperplasia, goblet cell proliferation, and destruction of the normal physiological structure of the lung tissues. Likewise, smoking can damage the endothelial cells of the lung, resulting in reduced alveolar compliance, postoperative lung insufflation, poor drainage, and postoperative complications such as infection. Studies [13] have shown that the incidence of postoperative complications in patients with a smoking index of ≥400 is 2.4 times higher than those with a smoking index of <400. Therefore, in patients with a smoking index of ≥400, preoperative respiratory tract preparation should be reinforced in order to reduce respiratory mucosal inflammatory responses and improve the repair of the mucosal epithelium. Furthermore, respi-

Table 4. Multivariate analysis of risk factors for concurrent infection in lung cancer patients undergoing thoracoscopic surgery

Factor	*β*	*S.E.*	*Wals* χ^2	*OR*	*95% CI*	*P*
Age	1.122	0.651	4.236	1.127	1.012~9.204	0.013
Operation time	1.585	0.835	6.594	1.216	2.933~35.267	0.002
Smoking index	0.759	0.124	7.525	2.763	1.125~11.938	0.000
BMI	-0.521	0.328	4.921	0.875	0.219~2.623	0.021
FEV1%	-0.093	0.167	3.617	0.729	0.348~1.269	0.023
Diabetes	1.036	0.598	3.872	1.172	1.018~3.216	0.025
Drainage time	1.235	0.716	4.383	3.528	1.293~13.117	0.000

ratory function training should be increased to facilitate postoperative lung lobe expansion and sputum discharge. Pulmonary function is an important indicator for the risk assessment during thoracic surgery [14]. Because elderly patients with lung cancer have decreased chest wall compliance and decreased respiratory muscle strength, their combined lung function reserve capacity is often reduced, and postoperative chest pain can further limit the compensation of lung function; therefore, airway resistance, lung tissue elasticity, and thoracic and respiratory muscle function should be fully assessed using preoperative lung function measurements. By strengthening preoperative exercises and postoperative care, patients' lung function can be improved to a certain extent, and the risk of postoperative infections can be reduced.

Diabetes mellitus is a risk factor for postoperative infections, which induced microcirculatory disturbances. The incidence of postoperative pulmonary infection in patients with diabetes and lung cancer has been reported to be significantly higher than that in patients without diabetes [14-17], and diabetes is associated with postoperative wound infections. Therefore, in patients with lung cancer with diabetes, preoperative blood pressure reduction is recommended, diet should be adjusted, postoperative glucose levels closely monitored, surgical incisions observed, dressings changed regularly, and strict aseptic conditions maintained [18, 19].

Surgical time is also a risk factor for postoperative infection. Because the entire procedure requires mechanical ventilation, the longer the operation time is, the higher the risk of lung infection. Therefore, the anatomical structure of the patient's lesion should be fully assessed preoperatively to predict risks and potential emergencies and minimize the operation time. Malnutrition is an important factor affecting postoperative recovery in elderly patients [20]. Because of blood loss during surgery, limited postoperative fluid consumption, nutritional intake, and other related factors, the overall loss of nutrients postoperatively reduces the body's immune response and increases the risk of infection [21]. The present study showed that BMI and albumin levels in the infected group were significantly lower than those in the non-infected group, indicating that nutritional status is an influencing factor for postoperative infection. Multivariate analysis showed that BMI is a protective factor to reduce postoperative infection. However, albumin levels in the multivariate analysis did not show any statistical significance. The reason may be related to higher BMI. However, [22] the decline in albumin levels has been reported to be associated with postoperative infection. Therefore, a patient's albumin levels should be monitored postoperatively, and if necessary, hypoproteinemia should be promptly corrected. In addition, patients should be encouraged to consume a high-protein diet and increase nutritional intake. In the univariate analysis, the EF value observed in this study was higher in the non-infected group than that in the infected group. However, no statistical significance was demonstrated in the multivariate analysis, which is likely due to the small sample size.

In conclusion, age, operative time, postoperative drainage time, and diabetes mellitus are risk factors for postoperative thoracic surgery in patients with lung cancer. Elevated levels of FEV1% and BMI are protective factors in reducing the incidence of postoperative infection. Patients with lung cancer with these associated risk factors should be managed with appropriate preoperative intervention and postoperative care, reduced operation time, stronger emphasis on the recognition of relevant risk factors, and effective measures to avoid and reduce the occurrence of concurrent infections.

Disclosure of conflict of interest

None.

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