

# International Journal of Gerontology



journal homepage: http://www.sgecm.org.tw/ijge/

# **Original Article**

# Constructing a Risk Prediction Model for Postoperative Pulmonary Infection in Elderly Patients with Lung Cancer

# Yu Zhong<sup>#</sup>, Guo He<sup>#</sup>, Qianwen Liu<sup>†</sup>, Ruiyun Zhu<sup>†</sup>, Zhongwen Sun<sup>\*</sup>

Sun Yat-sen University Cancer Center, State Key Laboratory of Oncology in South China, Collaborative Innovation Center for Cancer Medicine, Guangzhou, 510060, China

ARTICLEINFO	S U M M A R Y
Accepted 8 February 2021	Background: To construct the risk prediction model for postoperative pulmonary infection in elderly
Keywords:	<i>Methods</i> : A retrospective study of 240 elderly patients who underwent lung cancer resection from
elderly patients,	January to December 2018 at the Sun Yat-sen University Cancer Center in Guangzhou was conducted
lung cancer,	using a self-designed questionnaire. Basis information was collected. The risk factors were identified
postoperative pulmonary infection	by univariate analysis and logistic regression analysis. Prediction model was also constructed using logistic regression analysis. ROC curve was plotted to evaluate the predictive performance of the model.
	<i>Results:</i> The incidence of postoperative pulmonary infection in elderly patients with lung cancer was 10.0%. Four independent risk factors including heart disease, need for sputum suctioning, BMI and postoperative WBC count, were entered into the regression equation. The risk prediction equation was
	Z = 2.562 × heart disease + 2.322 × need for sputum suctioning + 2.963 × emaciation + 1.472 × over- weight/obesity + 0.148 × postoperative WBC count-3.747. The area under the ROC curve was 0.827, the Youden index was 0.532, the sensitivity was 70.8%, and the specificity was 82.4%.
	<i>Conclusion:</i> Heart disease, need for sputum suctioning, emaciation, overweight/obesity, and increased postoperative WBC count were the risk factors for postoperative pulmonary infection in elderly patients with lung cancer. The risk prediction model constructed in this study had an excellent predictive effect, which was of certain significance for guiding clinical observation and early screening.
	Copyright $\ensuremath{\mathbb{C}}$ 2021, Taiwan Society of Geriatric Emergency & Critical Care Medicine.

# 1. Introduction

Lung cancer, which originates from trachea, bronchi mucosa or gland, is the most common primary pulmonary malignancy associated with aging. According to the latest Cancer Statistics in China published by the National Cancer Institute, lung cancer ranks the first among malignant tumors in terms of incidence and mortality. Patients with lung cancer account for 20.03% of all malignancy patients, and the deaths incurred by lung cancer account for 26.99% of all tumor-related deaths.<sup>1,2</sup>

The average age at diagnosis of lung cancer is 70 years old, and two-thirds of the patients age over 65 years old. At present, the first and foremost treatment for lung cancer is surgery. However, elderly patients with lung cancer are at a higher risk of postoperative infection due to the decline of somatic and immune functions. Studies have shown that the incidence of postoperative nosocomial infection in elderly patients with lung cancer is 15.3%, and the most common infection is respiratory infection.<sup>3</sup> Besides, pneumonia in

\* Corresponding author. Sun Yat-sen University Cancer Center, State Key Laboratory of Oncology in South China, Collaborative Innovation Center for Cancer Medicine, No. 651, Dongfeng Road East, Guangzhou, Guangdong, 510060, China.

" E-mail address: sunzhw@sysucc.org.cn (Z.w. Sun)

elderly patients is usually occult, and the coexistence of multiple diseases may lead to a decrease of reactivity to pathogenic bacteria and drugs. Meanwhile, hidden clinical symptoms or (and) occult lesions may increase the difficulty of making a definitive diagnosis at the first visit, resulting in the missing optimal treatment window and deaths of elderly patients.<sup>4–6</sup>

Therefore, in this study, we established an effective risk prediction model for postoperative pulmonary infection in elderly patients with lung cancer (PPILC) through a comprehensive analysis and assessment of the physical conditions of elderly patients. The predictive effect of this model was evaluated.

### 2. Materials and methods

## 2.1. Patients

In this study, a total of 240 elderly patients who underwent lung cancer resection from January to December 2018 at the Sun Yat-sen University Cancer Center were included. This study was approved by the Ethics Committee of Sun Yat-sen University Cancer Center. All patients gave informed written consent to participate in the study. The inclusion criteria were as follows: (1)  $\geq$  60 years old; (2) pathologically diagnosed with lung cancer; (3) having received thoracoscopy or thoracotomy. The exclusive criteria were as follows: (1) hav-

<sup>&</sup>lt;sup>#</sup> The first author.

The second author.

ing been infected or been in the latency of infection before surgery; (2) metastases of other malignancies to the lungs.

#### 2.2. Data collection

A retrospective design was adopted, where the patient data were collected by checking the electronic medical records. A selfdesigned questionnaire was used, which covered the general information of patients (gender, age, BMI, smoking history), diseaserelated data (history of underlying diseases, including lung disease, heart disease, hypertension, nephrosis, history of anti-tumor therapy, pathological pattern and stage), laboratory test results in perioperative period (12 h preoperative and 2 h postoperative blood-gas (PH), PaO<sub>2</sub>, PaCO<sub>2</sub>, oxygenation index, lactic acid, preoperative and postoperative hemoglobin levels (HGB), serum albumin, postoperative WBC count, C-reactive protein (CRP)), pulmonary function tests (FVC (% pred), FEV1 (% pred), FEV1/FVC, PEF (% pred), MMEF (% pred), MVV, DLCOc (% pred), KCOc (% pred), operation-related information (surgical method, excision extension, surgical duration, intraoperative blood loss, need for secondary surgery), and information about postoperative medication, nursing and treatment (transfusion of blood products, obtundation, use of vasoactive drugs, drainage on the same day of surgery, whether pulmonary function training was undertaken, sputum suctioning, fever). The history of anti-tumor therapy surveyed included the history of chemotherapy, history of radiotherapy, history of targeted therapy, history of immunotherapy, and history of comprehensive therapy.

#### 2.3. Diagnostic criteria

Diagnostic criteria for pulmonary infection: The Healthcare Industry Standard of the People's Republic of China (WS 382-2012): The Diagnosis Criteria for Pneumonia, implemented since February 1, 2013, was adopted as the basis for the diagnosis of postoperative pulmonary infection. The diagnosis of hospital-acquired pneumonia should meet the following three criteria: (1) having received chest X-ray examination at least twice (only one chest X-ray was required for patients without underlying cardiac and pulmonary diseases such as respiratory distress syndrome, bronchopulmonary dysplasia, pulmonary edema, chronic obstructive pulmonary disease or congestive heart-failure), with the results conforming to at least one of the following criteria: a) newly appeared or progressive and persistent pulmonary infiltrates, b) consolidation, c) cavitation; (2) conforming to at least one of the following criteria: a) fever (body temperature > 38 °C) of unknown cause, b) peripheral WBC count >  $12 \times$  $10^{9}$ /L or < 4 ×  $10^{9}$ /L, c) mind change of unknown cause in patients aged  $\geq$  70 years; (3) conforming to at least two of the following criteria: a) expectoration or change in the characteristics of sputum, or increased respiratory secretions, or increased frequency of sputum suctions; b) cough, breathing difficulty or increased respiratory rate, or aggravation of existing cough, breathing difficulty or polypnea; c) rales or bronchial breath sounds; d) deterioration of gas exchange, increasing oxygen demand or demand for mechanical ventilation.

#### 2.4. Statistical analysis

SPSS 21.0 software was used for statistical analyses. For continuous variables with a percentage of missing value < 10, the mean value was used to fill the missing value, and the other missing values were not processed. The measurement data were expressed as mean  $\pm$  standard deviation, and enumeration data were expressed in frequency and percentage. In univariate analysis, the measurement data conforming to normal distribution were analyzed through the t-test, and not-normal distribution were analyzed through the rank-sum test. The enumeration data were analyzed through chisquare test. Then, the variables with statistical significance were entered into the multivariate analysis. Logistic binary regression was performed for multivariate analysis and construction of the risk prediction model for postoperative pulmonary infection. The ROC curve was plotted to evaluate the predictive performance of the model. p < 0.05 was considered as statistically significant difference. All data in this study have been recorded at Sun Yat-sen University Cancer Center for further reference (number RDDA2020001587).

#### 3. Results

#### 3.1. Basic characteristics

A total of 240 elderly patients with lung cancer were included in this study. The general information of the patients is shown in Table 1. There were 77 females and 163 males.

Among them, 24 patients were diagnosed with PPILC, the incidence was 10.0%. 198 patients aged between 60 and 69 years old, which accounted for 82.5% of total patients.

#### 3.2. Univariate analysis for PPILC

There were significant differences of fever, heart disease, need for sputum suctioning, BMI, postoperative  $PaO_2$ , postoperative oxygenation index, postoperative WBC count, and postoperative CRP between the PPILC and non-PPILC patents (p < 0.05). The patients with PPILC were more likely to have fever, heart disease, need for sputum suctioning, lower BMI, lower postoperative  $PaO_2$  and postoperative oxygenation index, higher postoperative WBC count and postoperative CRP (Table 2).

#### 3.3. PPILC multiple factors analysis

With the occurrence of PPILC as the dependent variable, the variables with statistical significance in the univariate analysis were

Table 1				
Basic characteristics.				
Characteristics	Ν	Percentage (%)		
Gender				
Female	77	32.1		
Male	163	67.9		
Age (years)				
60–69	198	82.5		
70–79	39	16.2		
80–92	3	1.3		
Pathological type				
Adenocarcinoma	164	68.3		
Squamous cell carcinoma	62	25.9		
Other <sup>ª</sup>	14	5.8		
Pathological stage				
Carcinoma in situ	1	0.4		
I	110	45.8		
II	98	40.8		
III	21	8.8		
IV	10	4.2		
Choice of operation				
Endoscopy	120	50.0		
Open surgery	120	50.0		
<sup>a</sup> Others include adenosquamo	us carcinoma,	lymphoepithelioma	like	

<sup>°</sup> Others include adenosquamous carcinoma, lymphoepithelioma like carcinoma, sarcomatoid carcinoma and neuroendocrine carcinoma.

## Table 2

Univariate analysis of PPILC in patients with different characteristics.

Under densities         With (n = 2)         V/V         p           Norming [nN]         2.79         0.249           Norming [nN]         110 (50.9)         8.(33.3)         2.79         0.249           Norming [nN]         110 (50.9)         8.(33.3)         2.779         0.249           Stop         37 (17.1)         5.(20.8)         1.01         1.01         1.01         1.01         1.01         1.01         1.01         1.01         1.01         1.01         1.01         1.00<	Champer and a single second	Pneun	·· <sup>2</sup> /· /7	_	
Socking (rs(s))         10         10         1445.8           Yes         69 (91.9)         11 (45.8)         5.307         0.021*           No         177 (75.2)         14 (45.8.3)         5.307         0.021*           No         177 (75.2)         14 (45.8.3)         5.307         0.021*           No         177 (75.2)         14 (45.8.3)         0.000         1.000           Ne         200 (02.6)         22 (0.7.7)         0.000         1.000           No         158 (73.1)         16 (66.7)         0.455         0.500           No         192 (88.9)         21 (87.5)         0.000         1.000           No         192 (88.9)         21 (87.5)         0.000         1.000           Yes         24 (11.1)         3 (12.5)         0.000         1.000           No         120 (97.7)         24 (10.0)         0.0		Without (n = 216)	With (n = 24)	h (n = 24) $\chi / t/2$	
No. Bin Jong         10 (66.9)         8 (33.3)         L.P.F.         Calls           Sing P         37 (72.1)         5 (20.8)	Smoking [n(%)]			2 779	0.249
'vs.		110 (50.9)	8 (33 3)	2.775	0.249
Sop         37 [17.1]         5 (20.2)           No         17 (79.2)         14 (53.3)         0.021*           No         17 (79.2)         14 (53.3)         0.021*           Respiratory disease [n (%)]         0.000 (1.000         1.000           No         200 (92.6)         22 (91.7)         1.000           Yes         16 (7.4)         2.8.3)         1.000           No         158 (73.1)         16 (6.7)         0.000         1.000           No         158 (73.1)         12 (8.7)         0.000         1.000           No         152 (69.3)         21 (87.5)         0.000         1.000           Yes         24 (1.1)         3 (12.5)         1.000         1.000           No         2.10 (97.2)         2.4 (10.1)         1.000         1.000           No         2.10 (97.2)         2.4 (10.1)         1.000         1.000           No         2.10 (97.2)         2.4 (10.1)         1.000         1.000           No         2.10 (97.2)         2.6 (3.1)         1.000         1.000           No         2.10 (97.2)         2.6 (3.1)         1.000         1.000         1.000         1.000         1.000         1.000         1.000	Voc	69 (31 9)	11 (45.8)		
funk         D (L.M.)         D (L.M.) <thd (l.m.)<="" th="">         D (L.M.)         <thd< td=""><td>Ston</td><td>27 (17 1)</td><td>5 (20.8)</td><td></td><td></td></thd<></thd>	Ston	27 (17 1)	5 (20.8)		
lew of (No)         T/T (75.2)         14 (58.3)         L.OC.1           key intrody diseases (n (k)]         0.000         1.000           No         200 (92.6)         22 (91.7)           Ves         16 (7.4)         28.3)           No         55 (7.5.1)         16 (66.7)           No         155 (7.5.1)         16 (66.7)           No         152 (85.8)         21 (87.5)           Heard disease (n (k))         0.000         1.000           No         212 (95.1)         21 (87.5)           Heard disease (n (k))         0.000         1.000           No         212 (97.2)         24 (100)         1.000           No         212 (97.2)         24 (100)         1.000           No         210 (97.2)         24 (100)         2.007           Statisty of cancer treastment [n (%)]         3.02 (17.1)         2.007           No         210 (97.2)         7.0281         3.01 (41.2)           Statisty of cancer treastment [n (%)]         3.02 (12.5)	Stop Envor $[n (\%)]$	57 (17.1)	5 (20.8)	5 207	0.021*
Train (1.2)         14 (2.6.3)         14 (2.6.3)           Beginstary diseases (n (%))         20 (2.2.)         2.3 (3.7.)         0.000         1.000           Ves         16 (7.4)         2 (8.3.)         0.455         0.530           No         158 (7.3.)         16 (6 G.7)         0.000         1.000           No         58 (7.6.9)         8 (3.3.)         0.000         1.000           No         159 (8.8.9)         21 (8 (7.5)         0.000         1.000           No         212 (98.1)         21 (8 (7.5)         0.000         1.000           Ves         4 (1.9)         3 (12.5)         0.000         1.000           Ves         6 (2.8)         0 (0)         0.000         1.000           No         210 (97.2)         24 (10.0)         1.000         1.000           Ves         6 (2.8)         0 (0)         1.000         1.000         1.000           No         21 (9.7)         2 (8.3)         1.000         1.000         1.000         1.000         1.000         1.000         1.000         1.000         1.000         1.000         1.000         1.000         1.000         1.000         1.000         1.000         1.000         1.000 <t< td=""><td></td><td>171 (70.2)</td><td>14 (59 2)</td><td>5.507</td><td>0.021</td></t<>		171 (70.2)	14 (59 2)	5.507	0.021
Perminany disesses (n (%))         D (2.0.3)         D (2.1.7)         0.000         1.000           No         0 (92.6)         2 (9.7,7)         0.455         0.500           No         158 (7.3.1)         16 (66.7)         0.455         0.500           No         158 (7.3.1)         16 (66.7)         0.000         1.000           No         192 (8.9)         21 (87.5)         0.000         1.000           Vers         24 (1.1.1)         31 (2.5)         0.000         0.000           No         212 (85.1)         21 (87.5)         0.000         0.000           Vers         24 (1.9)         31 (2.5)         0.000         1.000           Vers         21 (97.2)         24 (100)         0.000         1.000           Vers         21 (97.2)         2 (91.7)         0.000         1.000           Staunous cell cariconona is 10 (95 (95.3)	Vos	1/1 (75.2)	14(38.3) 10(417)		
negation (noise) (noise)         200 (92.6)         22 (91.7)         0           We         16 (7.A)         2 (8.3)	Pospiratory diseases [n (%)]	43 (20.8)	10 (41.7)	0.000	1 000
100         2.00 (9.00)         2.1 (9.1)           Prismation (n (%))         158 (73.1)         6 (6.7)         0.455           Prismation (n (%))         158 (73.1)         6 (6.7)         0.000         1.000           Ne         58 (26.9)         8 (33.3)         0.000         1.000           Ne         23 (41.1)         3 (12.5)         3         0.002         1.000           Ne         21 (98.1)         2.1 (87.5)         3         0.002         1.000           Ne         210 (97.2)         2.4 (100)         3         0.002         1.000           Ne         159 (90.3)         2.2 (91.7)         3         0.000         1.000           No         159 (90.3)         2.2 (91.7)         3         0.281         3           Ves         50 (60.4)         14 (8.8.3)         3         3         3         3           Squamus cell carcinoma         50 (55.5)         7 (29.2)         3         3         3         3         3           Ves         63 (38.3)         10 (41.7)         3         3         3         3         3         3         3         3         3         3         3         3         3         3	No	200 (02 6)	22 (01 7)	0.000	1.000
Ib         Ib <thib< th="">         Ib         Ib         Ib<!--</td--><td>No</td><td>200 (92.8)</td><td>22 (91.7)</td><td></td><td></td></thib<>	No	200 (92.8)	22 (91.7)		
mplet instant (n (%))158 (73.1)16 (66.7)3Bob35 (73.1)8 (33.3)1.000Diable mellitus (n (%))12 (88.9)2 (87.9)0.000Yes24 (11.1)3 (12.5)30.002 (10.00)Nend Gasse (n (%))12 (97.3)3 (12.5)1.0001.000Nend Gasse (n (%))12 (97.7)24 (10.0)1.0001.000Nend Gasse (n (%))10 (97.2)24 (10.0)1.0001.000No12 (97.7)24 (10.0)1.0001.000No12 (97.7)24 (10.0)1.0001.000No12 (97.7)24 (10.0)1.0001.000No15 (90.3)22 (91.7)1.0001.000No15 (90.3)12 (2.1)1.0001.000No15 (90.3)12 (2.5)7 (23.2)1.000Squarmous cell carcinoma55 (25.5)7 (23.2)1.000Squarmous cell carcinoma10 (65.3)10 (41.7)1.00010100 (46.3)10 (41.7)1.0001.0001130 (93.3)1 (4.2)1.0001.00011100 (46.3)10 (41.7)1.0001.00011100 (46.3)10 (41.7)1.0001.00011100 (46.3)10 (41.7)1.0001.00011100 (46.3)10 (41.7)1.0001.0001110 (10 (10.7)1.0001.0001.0001110 (10 (10.7)1.0001.0001.000 <trr>1110 (10 (10.7)</trr>	tes	16 (7.4)	2 (8.3)	0.455	0 500
up         18 (15.1)         18 (15.1)         18 (15.1)           Dabers         (13.3)	No	158 (72.1)	16 (66 7)	0.455	0.500
number of the set of	NO	158 (75.1)	10 (00.7)		
Data and Balance (In (%))         1.000         1.000           No         122 (8.2.)         21 (87.5.)	ies Diskatas mollitus (n (%))	58 (20.9)	8 (33.3)	0.000	1 000
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Diabetes menitus [n (%)]	102 (88.0)		0.000	1.000
Test         Test <thtest< th="">         Test         Test         <tht< td=""><td>NO X</td><td>192 (88.9)</td><td>21 (87.5)</td><td></td><td></td></tht<></thtest<>	NO X	192 (88.9)	21 (87.5)		
near tossing (n (%))         a         0.024 <sup>-1</sup> Yes         212 (98.1)         21 (87.5)         -           Yes         210 (97.2)         24 (100)         -           No         210 (97.2)         24 (100)         -           No         6 (2.8)         0 (0)         -           History of cancer treatment [n (%)]         -         0.000         1.000           No         195 (90.3)         22 (91.7)         0.000         1.000           Yes         21 (9.7)         24 (100)         - <td>tes</td> <td>24 (11.1)</td> <td>3 (12.5)</td> <td>_</td> <td>0.024*</td>	tes	24 (11.1)	3 (12.5)	_	0.024*
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Heart disease [n (%)]	212 (00.1)		a	0.024*
Test         1 (1.5)         3 (1.5)           No         20 (97.2)         24 (100)	NO X	212 (98.1)	21 (87.5)		
Net property (rs, x)]         a         Lood           No         210 (97, 2)         24 (100)	Yes	4 (1.9)	3 (12.5)	_	1 000
No         2.10 (97.2)         2.4 (100)           Yes         6 (2.8)         0 (0)         1.000           No         95 (90.3)         22 (91.7)         2 (8.3)	Nephropatny [n (%)]	210 (07.2)	24 (100)	a	1.000
res       b (2.3)       U (0)         No       195 (90.3)       22 (91.7)       Ves         Pathological type [n (%)]       2 (8.3)       2         Pathological type [n (%)]       2.537       0.281         Adenocaricoma       55 (25.5)       7 (29.2)       0         Others       11 (5.1)       3 (12.5)       0.804         Squamous cell carcinoma       55 (25.5)       7 (29.2)       0.804         Others       1.937       0.804       0.60         Carcinoma in situ       10 (0.6(3)       10 (41.7)       1         I       100 (46.3)       10 (41.7)       1         II       20 (9.3)       1 (4.2)       1         V       9 (4.2)       1       2 (8.3)       1         V       9 (4.2)       1 (4.2)       1       1         V       9 (3.1)       2 (8.3)       1       1         No       13 (14.9       2 (8.3)       1       1         Poper surgery       109 (16.5)       1       1       1       1         Ves       39 (18.1)       6 (25)       1       1       1       1       1       1       1       1       1       1 <td< td=""><td>No</td><td>210 (97.2)</td><td>24 (100)</td><td></td><td></td></td<>	No	210 (97.2)	24 (100)		
history of cancer treatment [n (%])	Yes	6 (2.8)	0 (0)	0.000	4 000
No195 (90.3)22 (91.7)Yes21 (9.7)28.3)Pathological type [n (%)]	History of cancer treatment [n (%)]			0.000	1.000
Ves         2 [8,7]         2 (8,3)           Adencoarcinoma         150 (69.4)         14 (58.3)           Adencoarcinoma         55 (25.5)         7 (29.2)           Others         11 (5.1)         3 (12.5)           Others         11 (5.1)         3 (12.5)           Carcinoma in situ         1 (0.5)         0 (0)         1           I         100 (46.3)         10 (41.7)         I           II         8 (39.8)         12 (50)         III           III         8 (39.8)         14 (4.2)         III           V         9 (4.2)         1 (4.2)         III           No         1 (1.4)         2 (8.3)         III           No         9 (31.4)         2 (8.3)         III           Choice of operation [n (%)]         III         10.85         0.667           Endoscopy         107 (49.5)         13 (54.2)         IIII         0.804         0.851           Open surgery         109 (50.5)         11 (45.8)         IIIII         0.073         IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	No	195 (90.3)	22 (91.7)		
Pathological type [n [%])         2.5.37         2.5.37         0.281           Squamous cell carcinoma         55 (25.5)         7 (29.2)         7 (29.2)           Others         11 (5.1)         3 (12.5)         3 (12.5)           Stage [n (%)]         10 (0.63)         0 (0)         1           I         100 (46.3)         10 (41.7)         1           II         100 (46.3)         12 (50)         1           III         20 (9.3)         1 (4.2)         7           Vo         9 (4.2)         1 (4.2)         7           Vo         9 (4.2)         1 (4.2)         7           Ves         3 (1.4)         2 (8.3)         0.667           Endoscopy         107 (49.5)         13 (54.2)         7           Open surgery         109 (50.5)         11 (45.8)         7           No         17 (81.9)         18 (75)         7           Ves         39 (18.1)         6 (25)         7           No         46 (21.3)         9 (37.5)         7           Ves         17 (78.7)         17 (70.8)         7           Ves         49 (22.7)         7 (23.2)         7           No         167 (77.3)         17	Yes	21 (9.7)	2 (8.3)		
Adenocarinoma         150 (69.4)         14 (58.3)           Squamous cell carcinoma         15 (52.5)         7 (29.2)           Others         11 (5.1)         3 (12.5)           Carcinoma in situ         1 (0.5)         0 (0)         1.937         0.804           Carcinoma in situ         1 (0.5)         0 (0)         1.937         0.804           II         86 (39.8)         12 (50)         1.14.2)         1.42.1           III         20 (9.3)         1 (4.2)         1.42.1           Reoperation [n (%)]         2 (39.6)         2 (9.17)         2 (8.3)           No         0.015         1.13 (54.2)         0.667           Endoscopy         109 (50.5)         11 (45.8)         0.667           Endoscopy         109 (50.5)         11 (45.8)         0.667           Stocopy         109 (50.5)         11 (45.8)         0.053           Bood transfusion products [n (%)]         6 (25.1)         0.002         0.073           No         177 (81.9)         13 (52.5)         12         0.073           No         167 (77.3)         17 (70.8)         20.09         1.42           No         167 (77.3)         17 (70.8)         20.02         0.057	Pathological type [n (%)]			2.537	0.281
Squamous cell carcinoma         55 (25.5)         7 (29.2)           Others         11 (5.1)         3 (12.5)           Stage (n %0)         1.937         0.804           Carcinoma in situ         10 (0)         1           II         00 (0)         1           III         00 (9.3)         11 (4.2)           V         9 (4.2)         14 (4.2)           V         9 (4.2)         14 (4.2)           V         9 (4.2)         14 (4.2)           V         9 (4.2)         13 (5.2)           No         9 (4.2)         13 (5.4)           Open surgery         0.185         0.667           Endoscopy         107 (49.5)         13 (54.2)           Open surgery         109 (55.5)         11 (45.8)           Blood transfusion products [n (%)]         6 (25.3)         0.073           Yes         39 (18.1)         6 (25.5)         12           Use of painkillers [n (%)]         5 (25.5)         12         0.073           No         167 (77.3)         17 (70.8)         2         0.073           Yes         19 (27.7)         15 (62.5)         12         12           No         17 (58.8)         14 (58.3)	Adenocarcinoma	150 (69.4)	14 (58.3)		
Others11 (5.1)3 (12.5)Carcinoma in situ1 (0.5)0 (0)I100 (46.3)10 (41.7)II36 (39.8)12 (50)III20 (9.3)1 (4.2)IV9 (4.2)1 (4.2)Reoperation [n (%)]a0.080No213 (98.6)22 (91.7)Yes3 (1.4)2 (8.3)Choice of operation [n (%)]0.1850.667Endoscopy107 (49.5)11 (45.8)Open surgery109 (50.5)11 (45.8)Blood transfusion products [n (%)]0.3040.581No177 (81.9)18 (75)Yes30 (18.1)6 (25)Use of painkillers [n (%)]3.2100.073No46 (21.3)9 (37.5)Yes49 (22.7)7 (29.2)Ves39 (41.2)17 (70.8)Yes99 (42.2)10 (41.7)No127 (58.8)14 (58.3)Yes89 (41.2)10 (41.7)Yes99 (41.2)10 (41.7)Yes99 (41.2)6 (25)No127 (58.8)14 (57.3)Nomber of hemostatic drugs [n (%)]18 (75)Yes4 (1.9)6 (25)Number of hemostatic drugs [n (%)]2.353Number of hemostatic drugs [n (%)]2.353Number of hemostatic drugs [n (%)]31 (5.3)Yes2 (0.9)1 (4.2)Number of hemostatic drugs [n (%)]2.353Number of hemostatic drugs [n (%)]2.353No2 (23.3)0 (0) <td>Squamous cell carcinoma</td> <td>55 (25.5)</td> <td>7 (29.2)</td> <td></td> <td></td>	Squamous cell carcinoma	55 (25.5)	7 (29.2)		
Stage [n [%]]1.9370.804Carcinoma in situ1 (0.5)0 (0)I100 (46.3)10 (41.7)II86 (39.8)12 (50)III20 (9.3)1 (4.2)IV9 (4.2)1 (4.2)IV9 (4.2)1 (4.2)IV9 (4.2)1 (4.2)IV9 (4.2)1 (4.2)IV9 (4.2)1 (4.2)No213 (98.6)22 (91.7)Yes3 (1.4)2 (8.3)Choice of operation [n (%)]0.1850.667Endoscopy107 (49.5)11 (45.8)Open surgery109 (50.5)11 (45.8)Blood transfusion products [n (%)]0.3040.581No177 (81.9)18 (75)Yes39 (18.1)6 (25)Use of painkillers [n (%)]0.5070.476No167 (77.3)17 (70.8)Yes100 (27.7)5 (62.5)Ves121 (98.4)10 (41.7)Ves9 (32.7)0.002No167 (77.3)17 (70.8)No167 (77.3)17 (70.8)No167 (77.3)17 (70.8)No167 (77.3)16 (53.3)No158 (73.1)18 (75)Yes212 (98.1)18 (75)No158 (73.1)18 (75)No158 (73.1)18 (75)No158 (73.1)18 (75)No158 (73.1)18 (75)No162 (23)0.00Above 32 (0.9)1 (4.2)Above 4	Others	11 (5.1)	3 (12.5)		
Carcinoma in situ         1 (0.5)         0 (0)           I         100 (46.3)         10 (41.7)           II         86 (39.8)         12 (50)           III         20 (9.3)         1 (4.2)           V         9 (4.2)         14.2)           Reoperation [n (%)]         a         0.80           No         23 (98.6)         22 (91.7)           Yes         3 (1.4)         2 (8.3)           Choice of operation [n (%)]         0.185         0.667           Endoscopy         107 (49.5)         13 (54.2)         0.667           Open surgery         109 (50.5)         11 (45.8)         0.67           Blood transfusion products [n (%)]         625         -         0.073           Ne         177 (81.9)         18 (75)         -         0.073           Ves of vasoactive drugs [n (%)]         -         -         -         -           No         167 (77.3)         17 (70.8)         -         -         -           Ves         49 (22.7)         7 (22.2)         -         -         -         -           No         167 (77.3)         17 (70.8)         -         -         -         -           Yes	Stage [n (%)]		- /->	1.937	0.804
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Carcinoma in situ	1 (0.5)	0 (0)		
II         86 (39.8)         12 (50)           III         20 (9.3)         1 (4.2)           V         9 (4.2)         1 (4.2)           Reoperation [n (%)]         a         0.080           No         213 (98.6)         22 (91.7)         a         0.080           Choice of operation [n (%)]         a         0.185         0.667           Endoscopy         107 (49.5)         13 (54.2)             Open surgery         109 (50.5)         11 (45.8)             No         177 (81.9)         18 (75)              Ne         46 (21.3)         9 (37.5)                No         46 (21.3)         9 (37.5)                No         46 (21.3)         9 (37.5)                No         127 (75.8)         13 (45.2)                Ves         107 (77.3)         17 (70.8)	1	100 (46.3)	10 (41.7)		
III20 (9.3)1 (4.2)IV9 (4.2)1 (4.2)Reoperation [n (%)]a0.080No213 (98.6)22 (9.7)Yes3 (1.4)2 (8.3)Endoscopy107 (49.5)13 (54.2)Open surgery109 (50.5)11 (45.8)Blood transfusion products [n (%)]0.3040.581No46 (21.3)9 (37.5)Yes39 (18.1)6 (25)Use of painkillers [n (%)]3.2100.073No46 (21.3)9 (37.5)Yes170 (78.7)15 (62.5)Use of vasoactive drugs [n (%)]0.0570.476No167 (77.3)17 (70.8)Yes49 (22.7)7 (29.2)No127 (58.8)14 (58.3)Yes30 (41.7)23.457No212 (98.1)18 (75)Yes41 (19.23.457No212 (98.1)18 (75)Yes3 (12.3)0 (0)25 (23.3)0 (0)25 (23.6)5 (20.8)Above 3(20.9)14 (2.2)Wedge excision33 (15.3)4 (16.7)Ubetorny182 (84.3)19 (79.2)Pneumonectomy10.51 (4.2)Pneumonectomy10.51 (4.2)Age (years, $\bar{x} \pm s$ )65 67 ± 49164 81 34.000.03000.764	II 	86 (39.8)	12 (50)		
IV       9 (4.2)       1 (4.2)         Reoperation [n (%)]       a       0.080         No       213 (98.6)       22 (91.7)         Yes       3 (1.4)       28.3         Choice of operation [n (%)]       0.185       0.667         Endoscopy       107 (49.5)       13 (54.2)       0.85       0.667         Open surgery       1007 (49.5)       13 (54.2)       0.85       0.667         Bood transfusion products [n (%)]       0.304       0.581       0.581         No       177 (81.9)       18 (75)       2       0.073         Yes       0.318.1)       6 (25)       0.073         No       167 (77.3)       9 (37.5)       0.073       0.073         Ves       167 (77.3)       17 (70.8)       0.507       0.476         Ves       0.002       0.965       0.002       0.965         No       127 (58.8)       14 (58.3)       2       0.002       0.965         No       127 (58.8)       14 (57.3)       2       0.002       0.965         No       127 (58.8)       14 (57.3)       2       0.002       0.965         No       127 (58.3)       16 (87.3)       8 (75.3)       0.406		20 (9.3)	1 (4.2)		
Reoperation [n (%)]a0.080No213 (98.6)22 (91.7)Yes3 (1.4)2 (8.3)Choice of operation [n (%)]	IV	9 (4.2)	1 (4.2)		
No         213 (98.6)         22 (91.7)           Yes         3 (1.4)         2 (8.3)           Choice of operation [n (%)]         0.185         0.667           Endoscopy         107 (49.5)         13 (54.2)           Open surgery         109 (50.5)         11 (45.8)           Blood transfusion products [n (%)]         0.304         0.581           No         177 (81.9)         18 (75)         -           Yes         39 (18.1)         6 (25)         -           Use of painkillers [n (%)]         3 (56.2)         -         -           No         46 (21.3)         9 (37.5)         -         -           Ves         30 (18.7)         15 (62.5)         -         -           Use of vasoactive drugs [n (%)]         7 (78.7)         15 (62.5)         -         -           No         167 (77.3)         17 (70.8)         -         -           No         127 (58.8)         14 (48.3)         -         -           No         127 (58.8)         14 (87.5)         -         -           No         212 (98.1)         18 (75)         -         -           Number of hemostatic drugs [n (%)]         6 (25)         -         -         <	Reoperation [n (%)]			а	0.080
Yes         3 (1.4)         2 (8.3)           Choice of operation [n (%)]         0.185         0.667           Endoscopy         107 (49.5)         13 (54.2)         0           Open surgery         109 (50.5)         11 (45.8)	No	213 (98.6)	22 (91.7)		
Choice of operation [n (%)]       0.185       0.667         Endoscopy       107 (49.5)       13 (54.2)       0         Open surgery       109 (50.5)       11 (45.8)       0.304       0.581         Blood transfusion products [n (%)]       6 (25)       1       0.007       0.073         No       167 (77.3)       9 (37.5)       0.073       0.073         No       46 (21.3)       9 (37.5)       0.073       0.476         No       167 (77.7)       15 (62.5)       0.071       0.476         No       167 (77.3)       17 (70.8)       0.072       0.476         Yes       199 (22.7)       7 (29.2)       0.002       0.965         No       127 (58.8)       14 (58.3)       0.002       0.965         Yes       89 (41.2)       10 (41.7)       5       0.002       0.965         No       127 (58.8)       14 (58.3)       2.457       <0.001**	Yes	3 (1.4)	2 (8.3)		
Endoscopy107 (49.5)13 (54.2)Open surgery109 (50.5)11 (45.8)Blood transfusion products [n (%)]0.3040.581No177 (81.9)18 (75)Yes39 (18.1)6 (25)Use of painkillers [n (%)]3.2100.073No46 (21.3)9 (37.5)Yes170 (78.7)15 (62.5)Use of vasoactive drugs [n (%)]0.5770.476No167 (77.3)17 (70.8)Yes49 (22.7)7 (29.2)Pulmonary respiratory exercise [n (%)]0.0020.965No127 (58.8)14 (58.3)Yes89 (41.2)10 (41.7)Sputum suctioning [n (%)]23.457<0.001**	Choice of operation [n (%)]			0.185	0.667
Open surgery10 (50.5)11 (45.8)Blood transfusion products [n (%)]0.3040.581No177 (81.9)18 (75)0.073Yes39 (18.1)6 (25)0.073Use of painkillers [n (%)]3.2100.073No46 (21.3)9 (37.5)9 (37.5)Yes170 (78.7)15 (62.5)0.607Use of vasoactive drugs [n (%)]0.5070.476No167 (77.3)17 (70.8)7 (29.2)Yes49 (22.7)7 (29.2)7Pulmonary respiratory exercise [n (%)]0.0020.965No127 (58.8)14 (58.3)7Yes89 (41.2)10 (41.7)1Sputum suctioning [n (%)]2.3457<0.001**	Endoscopy	107 (49.5)	13 (54.2)		
Blood transfusion products [n (%)] $0.304$ $0.581$ No177 (81.9)18 (75)Yes39 (18.1)6 (25)Use of painkillers [n (%)] $3.210$ $0.073$ No46 (21.3)9 (37.5)Yes170 (78.7)15 (62.5)Use of vasoactive drugs [n (%)] $0.507$ $0.476$ No167 (77.3)17 (70.8)Yes49 (22.7)7 (29.2)Pulmonary respiratory exercise [n (%)] $0.002$ $0.965$ No127 (58.8)14 (58.3)Yes89 (41.2)10 (41.7)Sputtum suctioning [n (%)] $2.3457$ $< 0.001^{**}$ No121 (98.1)18 (75)No212 (98.1)18 (75)No158 (73.1)18 (75)Number of hemostatic drugs [n (%)] $2 (0.9)$ $1 (4.2)$ Above 32 (0.9)1 (4.2)Method of operation [n (%)] $3 (15.3)$ 4 (16.7)wedge excision133 (15.3)4 (16.7)Lobectomy182 (84.3)19 (79.2)Pneumonectomy1 (0.5)1 (4.2)Age (vears, $\overline{x} \pm s$ )65.67 ± 4.9164.88 ± 3.40 $0.300$ Age (vears, $\overline{x} \pm s$ )23.94 2.9423.94 3.961.1528Dull Xe st23.94 2.9423.94 3.961.1528D.128	Open surgery	109 (50.5)	11 (45.8)		
No177 (81.9)18 (75)Yes39 (18.1)6 (25)Use of painkillers [n (%)]	Blood transfusion products [n (%)]	/		0.304	0.581
Yes39 (18.1)6 (25)Use of painkillers [n (%)] $3.210$ 0.073No46 (21.3)9 (37.5) $3.210$ Yes170 (78.7)15 (62.5) $3.210$ Use of vasoactive drugs [n (%)] $0.507$ 0.476No167 (77.3)17 (70.8) $7$ (29.2)Pulmonary respiratory exercise [n (%)] $0.002$ 0.965No127 (58.8)14 (58.3) $9$ (27.7)Yes89 (41.2)10 (41.7) $23.457$ Sputum suctioning [n (%)] $212$ (98.1)18 (75)Yes4 (1.9)6 (25) $2.353$ Number of hemostatic drugs [n (%)] $2.353$ 0.4600158 (73.1)18 (75) $2.353$ 15 (2.3)0 (0) $2.2$ 251 (23.6)5 (20.8) $4.64$ Above 32 (0.9)1 (4.2) $3.464$ 0.205wedge excision33 (15.3)4 (16.7) $4.67$ Lobectomy182 (84.3)19 (79.2) $7.92$ Pneumonectomy1 (0.5)1 (4.2)Age (years, $\overline{x} \pm s$ )65.67 \pm 4.9164.88 \pm 3.40-0.3000.764Age (years, $\overline{x} \pm s$ )23.93 \pm 3.961.5280.128	No	177 (81.9)	18 (75)		
3.2100.073No46 (21.3)9 (37.5)Yes170 (78.7)15 (62.5)Use of vasoactive drugs [n (%)]0.5070.476No167 (77.3)17 (70.8)9Yes49 (22.7)7 (29.2)7Pulmonary respiratory exercise [n (%)]0.0020.965No127 (58.8)14 (58.3)9Yes89 (41.2)10 (41.7)7Sputum suctioning [n (%)]23.457< 0.001**No212 (98.1)18 (75)7Yes4 (1.9)6 (25)7Number of hemostatic drugs [n (%)]2.3530.4600158 (73.1)18 (75)715 (2.3)0 (0)2251 (23.6)5 (20.8)3.464Above 32 (0.9)1 (4.2)3.464Wedge excision33 (15.3)4 (16.7)Lobectomy120 (84.3)19 (79.2)Pneumonectomy1 (0.5)1 (4.2)Age (years, $\overline{x} \pm s$ )65.67 ± 4.9164.88 ± 3.40-0.300Age (years, $\overline{x} \pm s$ )65.67 ± 4.9164.88 ± 3.40-0.3000.764	Yes	39 (18.1)	6 (25)		
No46 (21.3)9 (37.5)Yes170 (78.7)15 (62.5)Use of vasoactive drugs [n (%)]0.5070.476No167 (77.3)17 (70.8)Yes49 (22.7)7 (29.2)Pulmonary respiratory exercise [n (%)]0.0020.965No127 (58.8)14 (58.3)Yes89 (41.2)10 (41.7)Sputum suctioning [n (%)]212 (98.1)18 (75)Yes4 (1.9)6 (25)No212 (98.1)18 (75)Yes4 (1.9)6 (25)Number of hemostatic drugs [n (%)]2.3530.4600158 (73.1)18 (75)15 (2.3)0 (0)251 (23.6)5 (20.8)Above 32 (0.9)1 (4.2)Method of operation [n (%)]33 (15.3)4 (16.7)Lobectomy182 (84.3)19 (79.2)Pneumonectomy1 (0.5)1 (4.2)Age (years, $\bar{x} \pm s$ )65.67 ± 4.9164.88 ± 3.400-0.3000.764Age (years, $\bar{x} \pm s$ )65.67 ± 4.9163.83 ± 3.96-0.1280.128	Use of painkillers [n (%)]		- /1	3.210	0.073
Yes1/0 (78.7)15 (62.5)Use of vasoactive drugs [n (%)]	No	46 (21.3)	9 (37.5)		
Use of vasoactive drugs [n (%)] $0.476$ No167 (77.3)17 (70.8)Yes49 (22.7)7 (29.2)Pulmonary respiratory exercise [n (%)] $0.002$ $0.965$ No127 (58.8)14 (58.3)Yes89 (41.2)10 (41.7)Sputum suctioning [n (%)] $212 (98.1)$ 18 (75)No212 (98.1)18 (75)Yes4 (1.9)6 (25)Number of hemostatic drugs [n (%)] $2.353$ $0.460$ 0158 (73.1)18 (75)15 (2.3)0 (0)251 (23.6)5 (20.8)Above 32 (0.9)1 (4.2)Method of operation [n (%)] $33 (15.3)$ 4 (16.7)Lobectomy182 (84.3)19 (79.2)Pneumonectomy1 (0.5)1 (4.2)Age (years, $\overline{x} \pm s$ )65.67 ± 4.9164.88 ± 3.40-0.300Mol ( $\overline{x} \pm s$ )27.9423.93 ± 3.96-1.5280.128	Yes	170 (78.7)	15 (62.5)		
No167 (77.3)17 (70.8)Yes49 (22.7)7 (29.2)Pulmonary respiratory exercise [n (%)]0.0020.965No127 (58.8)14 (58.3)Yes89 (41.2)10 (41.7)Sputum suctioning [n (%)]212 (98.1)18 (75)Yes4 (1.9)6 (25)Number of hemostatic drugs [n (%)]2.3530.4600158 (73.1)18 (75)15 (2.3)0 (0)251 (23.6)5 (20.8)Above 32 (0.9)1 (4.2)Method of operation [n (%)]3.4640.205wedge excision33 (15.3)4 (16.7)Lobectomy182 (84.3)19 (79.2)Pneumonectomy1 (0.5)1 (4.2)Age (years, $\overline{x} \pm s$ )65.67 ± 4.9164.88 ± 3.40-0.300O0.76421.93431.94.316MUI ( $\overline{x} \pm s$ )22.93423.94 ± 3.96-1.5280.128	Use of vasoactive drugs [n (%)]	/		0.507	0.476
Yes49 (22.7)7 (29.2)Pulmonary respiratory exercise [n (%)]0.0020.965No127 (58.8)14 (58.3)Yes89 (41.2)10 (41.7)Sputum suctioning [n (%)]212 (98.1)18 (75)No212 (98.1)18 (75)Yes4 (1.9)6 (25)Number of hemostatic drugs [n (%)]2.3530.4600158 (73.1)18 (75)15 (2.3)0 (0)251 (23.6)5 (20.8)Above 32 (0.9)1 (4.2)Method of operation [n (%)]33 (15.3)4 (16.7)Lobectomy182 (84.3)19 (79.2)Pneumonectomy1 (0.5)1 (4.2)Age (years, $\overline{x} \pm s$ )65.67 ± 4.9164.88 ± 3.400-0.300PMI ( $\overline{x} \pm s$ )22 9423 93 ± 3 96-1 5280 128	No	167 (77.3)	17 (70.8)		
Pulmonary respiratory exercise [n (%)]0.0020.965No127 (58.8)14 (58.3)Yes89 (41.2)10 (41.7)Sputum suctioning [n (%)]212 (98.1)18 (75)No212 (98.1)18 (75)Yes4 (1.9)6 (25)Number of hemostatic drugs [n (%)]2.3530.4600158 (73.1)18 (75)15 (2.3)0 (0)251 (23.6)5 (20.8)Above 32 (0.9)1 (4.2)Method of operation [n (%)]33 (15.3)4 (16.7)Lobectomy182 (84.3)19 (79.2)Pneumonectomy1 (0.5)1 (4.2)Age (years, $\overline{x} \pm s$ )65.67 ± 4.9164.88 ± 3.40-0.300RMI ( $\overline{x} \pm s$ )27.93 ± 2.9423.93 ± 3.96-1.5280.128	Yes	49 (22.7)	7 (29.2)		
No127 (58.8)14 (58.3)Yes89 (41.2)10 (41.7)Sputum suctioning [n (%)] $23.457$ < 0.001**	Pulmonary respiratory exercise [n (%)]			0.002	0.965
Yes $89 (41.2)$ $10 (41.7)$ Sputum suctioning [n (%)] $23.457$ $< 0.001**$ No $212 (98.1)$ $18 (75)$ Yes $4 (1.9)$ $6 (25)$ Number of hemostatic drugs [n (%)] $2.353$ $0.460$ 0 $158 (73.1)$ $18 (75)$ 1 $5 (2.3)$ $0 (0)$ 2 $51 (23.6)$ $5 (20.8)$ Above 3 $2 (0.9)$ $1 (4.2)$ Method of operation [n (%)] $3.464$ $0.205$ wedge excision $33 (15.3)$ $4 (16.7)$ Lobectomy $182 (84.3)$ $19 (79.2)$ Pneumonectomy $1 (0.5)$ $1 (4.2)$ Age (years, $\overline{x} \pm s)$ $65.67 \pm 4.91$ $64.88 \pm 3.40$ $-0.300$ $0.764$ RMI ( $\overline{x} \pm s$ ) $22 93 \pm 2.94$ $23 93 \pm 3.96$ $-1 528$ $0.128$	No	127 (58.8)	14 (58.3)		
Sputum suctioning [n (%)]23.457< 0.001**No212 (98.1)18 (75)Yes4 (1.9)6 (25)Number of hemostatic drugs [n (%)]2.3530.4600158 (73.1)18 (75)15 (2.3)0 (0)251 (23.6)5 (20.8)Above 32 (0.9)1 (4.2)Method of operation [n (%)]3.4640.205wedge excision33 (15.3)4 (16.7)Lobectomy182 (84.3)19 (79.2)Pneumonectomy1 (0.5)1 (4.2)Age (years, $\overline{x} \pm s$ )65.67 $\pm 4.91$ 64.88 $\pm 3.40$ -0.300Above 322 93 $\pm 2.94$ 23 93 $\pm 3.96$ -1 5280 128	Yes	89 (41.2)	10 (41.7)		
No $212 (98.1)$ $18 (75)$ Yes $4 (1.9)$ $6 (25)$ Number of hemostatic drugs [n (%)] $2.353$ $0.460$ 0 $158 (73.1)$ $18 (75)$ 1 $5 (2.3)$ $0 (0)$ 2 $51 (23.6)$ $5 (20.8)$ Above 3 $2 (0.9)$ $1 (4.2)$ Method of operation [n (%)] $33 (15.3)$ $4 (16.7)$ Lobectomy $182 (84.3)$ $19 (79.2)$ Pneumonectomy $1 (0.5)$ $1 (4.2)$ Age (years, $\overline{x} \pm s)$ $65.67 \pm 4.91$ $64.88 \pm 3.40$ $-0.300$ RMI ( $\overline{x} \pm s$ ) $22 93 \pm 2.94$ $23 93 \pm 3.96$ $-1 528$ $0.128$	Sputum suctioning [n (%)]			23.457	< 0.001**
Yes4 (1.9)6 (25)Number of hemostatic drugs [n (%)]2.3530.4600158 (73.1)18 (75)15 (2.3)0 (0)251 (23.6)5 (20.8)Above 32 (0.9)1 (4.2)Method of operation [n (%)] $3.464$ 0.205wedge excision33 (15.3)4 (16.7)Lobectomy182 (84.3)19 (79.2)Pneumonectomy1 (0.5)1 (4.2)Age (years, $\overline{x} \pm s$ )65.67 ± 4.9164.88 ± 3.40-0.300RMI ( $\overline{x} + s$ )22 93 ± 2 9423 93 ± 3 96±1 5280 128	No	212 (98.1)	18 (75)		
Number of hemostatic drugs [n (%)]2.3530.4600158 (73.1)18 (75)15 (2.3)0 (0)251 (23.6)5 (20.8)Above 32 (0.9)1 (4.2)Method of operation [n (%)] $3.464$ 0.205wedge excision33 (15.3)4 (16.7)Lobectomy182 (84.3)19 (79.2)Pneumonectomy1 (0.5)1 (4.2)Age (years, $\overline{x} \pm s$ )65.67 ± 4.9164.88 ± 3.40-0.3000.764RMI ( $\overline{x} + s$ )22 93 ± 2 9423 93 ± 3 96±1 5280 128	Yes	4 (1.9)	6 (25)		
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Number of hemostatic drugs [n (%)]			2.353	0.460
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	0	158 (73.1)	18 (75)		
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	1	5 (2.3)	0 (0)		
Above 32 (0.9)1 (4.2)Method of operation [n (%)] $3.464$ 0.205wedge excision $33 (15.3)$ 4 (16.7)Lobectomy182 (84.3)19 (79.2)Pneumonectomy1 (0.5)1 (4.2)Age (years, $\overline{x} \pm s$ ) $65.67 \pm 4.91$ $64.88 \pm 3.40$ $-0.300$ RMI ( $\overline{x} \pm s$ ) $22 93 \pm 2 94$ $23 93 \pm 3 96$ $\pm 1 528$ 0 128	2	51 (23.6)	5 (20.8)		
Method of operation [n (%)] $3.464$ $0.205$ wedge excision $33 (15.3)$ $4 (16.7)$ $162 (84.3)$ $19 (79.2)$ Dectomy $182 (84.3)$ $19 (79.2)$ $1 (4.2)$ Age (years, $\overline{x} \pm s$ ) $65.67 \pm 4.91$ $64.88 \pm 3.40$ $-0.300$ $0.764$ BMI ( $\overline{x} \pm s$ ) $22 93 \pm 2.94$ $23 93 \pm 3.96$ $\pm 1.528$ $0.128$	Above 3	2 (0.9)	1 (4.2)		
wedge excision $33 (15.3)$ $4 (16.7)$ Lobectomy $182 (84.3)$ $19 (79.2)$ Pneumonectomy $1 (0.5)$ $1 (4.2)$ Age (years, $\overline{x} \pm s)$ $65.67 \pm 4.91$ $64.88 \pm 3.40$ $-0.300$ $0.764$ BMI ( $\overline{x} \pm s$ ) $22 93 \pm 2.94$ $23 93 \pm 3.96$ $= 1.528$ $0.128$	Method of operation [n (%)]			3.464	0.205
Lobectomy182 (84.3)19 (79.2)Pneumonectomy1 (0.5)1 (4.2)Age (years, $\bar{x} \pm s$ )65.67 $\pm 4.91$ 64.88 $\pm 3.40$ -0.3000.764RMI ( $\bar{x} \pm s$ )22 93 $\pm 2.94$ 23 93 $\pm 3.96$ $\pm 1.528$ 0.128	wedge excision	33 (15.3)	4 (16.7)		
Pneumonectomy1 (0.5)1 (4.2)Age (years, $\overline{x} \pm s$ ) $65.67 \pm 4.91$ $64.88 \pm 3.40$ $-0.300$ $0.764$ BMI ( $\overline{x} \pm s$ ) $22.93 \pm 2.94$ $23.93 \pm 3.96$ $-1.528$ $0.128$	Lobectomy	182 (84.3)	19 (79.2)		
Age (years, $\overline{x} \pm s$ )65.67 $\pm 4.91$ 64.88 $\pm 3.40$ -0.3000.764BMI ( $\overline{x} \pm s$ )22.93 $\pm 2.94$ 23.93 $\pm 3.96$ $\pm 1.528$ 0.128	Pneumonectomy	1 (0.5)	1 (4.2)		
RMI $(\overline{x} + s)$ 22 93 + 2 94 23 93 + 3 96 -1 528 0.128	Age (years, $\overline{x} \pm s$ )	$65.67 \pm 4.91$	$64.88 \pm 3.40$	-0.300	0.764
Dim (x ± 3)         22:33 ± 2:34         23:33 ± 3:30         1:320         0:120	BMI ( $\overline{x} \pm s$ )	$\textbf{22.93} \pm \textbf{2.94}$	$\textbf{23.93} \pm \textbf{3.96}$	-1.528	0.128

Table 2 Continued.

	Pneun	2 / . / ¬		
Characteristics –	Without (n = 216)	With (n = 24)	- χ /t/2	p
BMI n(%)			13.692	0.001**
< 18.5 (Emaciation)	14 (6.5)	4 (16.7)		
18.5–24 (Normal)	129 (59.7)	5 (20.8)		
> 24 (Overweight/obesity)	73 (33.8)	15 (62.5)		
Length of operation (min, $\overline{x} \pm s$ )	$171.04 \pm 82.03$	$189.17 \pm 93.35$	-0.910 <sup>b</sup>	0.363
Postoperative drainage (ml, $\overline{x} \pm s$ )	$432.37 \pm 246.58$	$402.50 \pm 286.57$	-1.015 <sup>b</sup>	0.310
Intraoperative blood loss (ml, $\overline{x} \pm s$ )	$102.32 \pm 78.38$	$116.67 \pm 150.09$	-0.007 <sup>b</sup>	0.995
FVC (pred%) ( $\overline{x} \pm s$ )	$102.12 \pm 15.86$	$98.29 \pm 18.13$	1.106 <sup>c</sup>	0.270
FEV1 (pred%) ( $\overline{x} \pm s$ )	$95.85\pm16.87$	$90.64 \pm 16.34$	1.440 <sup>c</sup>	0.151
FEV1/FVC ( $\overline{x} \pm s$ )	$89.26 \pm 10.22$	$87.20 \pm 10.77$	-0.893 <sup>b</sup>	0.372
PEF (pred%) ( $\overline{x} \pm s$ )	$87.57 \pm 18.20$	$83.15 \pm 23.02$	1.098 <sup>c</sup>	0.273
MMEF (pred%) ( $\overline{x} \pm s$ )	$\textbf{62.00} \pm \textbf{25.43}$	$58.45 \pm 24.00$	-0.452 <sup>b</sup>	0.651
MVV ( $\overline{x} \pm s$ )	$92.17\pm53.07$	$82.11 \pm 19.07$	-1.746 <sup>b</sup>	0.081
DLCOc ( $\overline{x} \pm s$ )	$95.30\pm16.52$	$98.16 \pm 20.13$	-0.333 <sup>b</sup>	0.739
KCOc ( $\overline{x} \pm s$ )	$107.82 \pm 15.92$	$109.84 \pm 24.22$	-0.243 <sup>b</sup>	0.808
Preoperative PH ( $\overline{x} \pm s$ )	$\textbf{7.42}\pm\textbf{0.05}$	$\textbf{7.43} \pm \textbf{0.02}$	-1.939 <sup>b</sup>	0.053
Preoperative PaO2 ( $\overline{x} \pm s$ )	$\textbf{86.96} \pm \textbf{12.53}$	$\textbf{85.69} \pm \textbf{7.11}$	-0.282 <sup>b</sup>	0.778
Preoperative PaCO2 ( $\overline{x} \pm s$ )	$\textbf{38.35} \pm \textbf{2.84}$	37.72 ± 2.42	-0.815 <sup>b</sup>	0.415
Preoperative HGB ( $\overline{x} \pm s$ )	$138.15\pm14.48$	$134.62 \pm 17.14$	1.111 <sup>c</sup>	0.268
Preoperative lactic acid ( $\overline{x} \pm s$ )	$\textbf{1.84}\pm\textbf{0.97}$	$\textbf{2.04} \pm \textbf{1.13}$	-0.360 <sup>b</sup>	0.719
Preoperative oxygenation index ( $\overline{x} \pm s$ )	$\textbf{413.23} \pm \textbf{43.91}$	$409.21 \pm 33.99$	-0.347 <sup>b</sup>	0.728
Preoperative ALB ( $\overline{x} \pm s$ )	$\textbf{43.20} \pm \textbf{3.52}$	$\textbf{42.41} \pm \textbf{4.01}$	-0.832 <sup>b</sup>	0.405
Postoperative PH ( $\overline{x} \pm s$ )	$\textbf{7.35}\pm\textbf{0.04}$	$\textbf{7.39} \pm \textbf{0.13}$	-1.411 <sup>b</sup>	0.158
Postoperative PaO2 ( $\overline{x} \pm s$ )	$110.14\pm30.53$	$91.90 \pm 26.53$	-2.785 <sup>b</sup>	0.005**
Postoperative PaCO2 ( $\overline{x} \pm s$ )	$\textbf{43.82} \pm \textbf{5.18}$	$\textbf{42.43} \pm \textbf{6.81}$	-1.045 <sup>b</sup>	0.296
Postoperative lactic acid ( $\overline{x} \pm s$ )	$\textbf{2.03} \pm \textbf{1.03}$	$\textbf{1.97} \pm \textbf{0.80}$	-0.091 <sup>b</sup>	0.927
Postoperative HGB ( $\overline{x} \pm s$ )	$121.78 \pm 14.97$	$122.87 \pm 14.70$	-0.341 <sup>c</sup>	0.733
Postoperative oxygenation index ( $\overline{x} \pm s$ )	$335.79 \pm 98.53$	$268.75 \pm 98.13$	-2.619 <sup>b</sup>	0.009**
Postoperative WBC ( $\overline{x} \pm s$ )	$12.52\pm3.54$	$\textbf{15.63} \pm \textbf{4.57}$	-3.318 <sup>b</sup>	0.001**
Postoperative ALB ( $\overline{x} \pm s$ )	$\textbf{34.11} \pm \textbf{3.44}$	$\textbf{33.69} \pm \textbf{3.83}$	0.550 <sup>c</sup>	0.583
Postoperative CRP ( $\overline{x} \pm s$ )	$\textbf{103.41} \pm \textbf{64.94}$	$141.11 \pm 81.62$	-2.351 <sup>b</sup>	0.019*

Note: a: Fisher's exact test statistic value. b: Z value. c: t value. Respiratory diseases included acute respiratory distress syndrome, pulmonary hypertension, pulmonary tuberculosis and silicosis.

\* *p* < 0.05, \*\* *p* < 0.01.

entered into the binary logistic regression analysis as independent variables. It was found that heart disease, need for sputum suctioning, BMI and postoperative WBC count were independent influence factors of PPILC (Table 3). The risk prediction equation was Z = 2.562 × heart disease + 2.322 × need for sputum suctioning + 2.963 × emaciation + 1.472 × overweight/obesity + 0.148 × postoperative WBC counts-3.747 (Table 4).

# 3.4. Evaluation of risk prediction model

The ROC curve was plotted to analyze the predictive performance of the PPILC risk model. The area under the ROC curve was 0.827 (95% CI: 0.734–0.919, p < 0.001), suggesting that the predictive performance of the prediction model was good (Figure 1). The maximum Youden index (0.532) was used to determine the optimal cutoff value of the prediction model, which was -0.107, while the sensitivity was 70.8% and the specificity was 82.4%.

#### 4. Discussion

In our study, it was found that showed that heart disease, need for sputum suctioning, emaciation or overweight/obesity, and increased postoperative WBC count were independent influence factors of PPILC. The AUC of the risk prediction model was 0.827, which indicated that the model was able to screen elderly patients with lung cancer who would suffer from a postoperative pulmonary infection.

We found that the concomitant heart disease in elderly patients

with lung cancer was the independent risk factor for PPILC (OR = 12.956, p = 0.004), which was consistent with results from the previous studies.<sup>7,8</sup> Cardiovascular disease is one of the common underlying diseases in elderly patients, and operative treatment is likely to induce or aggravate cardiac insufficiency and secondary pulmonary infection. The incidence of vascular disease increases with aging, leading to higher mortality of postoperative cardiopulmonary complications. According to the ACC/AHA Guideline on Perioperative Cardiovascular Evaluation and Management of Patients Undergoing Non-cardiac Surgery, the heart risk of intrathoracic surgery ranges from 1 to 5%. For patients aged over 70 years, further examinations shall be administered before moderate- or high-risk surgeries to evaluate their surgical tolerance.<sup>9</sup>

The need for sputum suctioning was a risk factor for PPILC in elderly patients (OR = 10.195, p = 0.0009). Infirmity, weakened cough reflex, and postoperative pain of elderly patients were indications of the need for sputum suctioning. Degenerative changes occur in each organ due to aging, and the clearing function of airway cilia, cough ability and sputum excretion ability decline. Therefore, the airway secretions will deposit, which may lead to PPILC. The need for sputum suctioning indicated that the poor postoperative cough ability and sputum excretion ability, thus increasing the risk for PPILC. It was suggested that the inhibition of cough reflex became more obvious with aging.<sup>10</sup> It has shown that training in active circular breathing technique was helpful to remove the respiratory secretions in elderly patients.<sup>11</sup> Therefore, nurses should guide elderly patients to take up active breathing training before surgeries, closely observe them after surgeries, and encourage and help them Table 3

Assignment of variables into regression model.

Variables	Assignment		
Fever	Yes = 1, No = 0		
Heart disease	Yes = 1, No = 0		
Sputum suctioning	Yes = 1, No = 0		
BMI	Taking BMI as a sub variable, X1 = emaciation (0,1), X2 = overweight/obesity (0,1)		
Postoperative PaO2, Postoperative oxygenation index, Postoperative WBC Postoperative CRP	Original value		

Table	4
-------	---

Multivariate analysis of PPILC.						
Independent variable	Regression coefficient	Standard error	Wals χ2	OR	р	95% CI
Heart disease	2.562	0.898	8.134	12.956	0.004	2.228-75.332
Sputum suctioning BMI	2.322	0.893	6.766	10.195	0.009	1.772–58.637
Emaciation	2.963	0.842	12.392	19.355	< 0.001	3.718-100.746
Overweight/obesity	1.472	0.607	5.885	4.359	0.015	1.327-14.318
Postoperative WBC	0.148	0.068	4.803	1.160	0.028	1.016-1.325
Constant	-3.747	1.532	5.982	0.024	0.014	



Figure 1. ROC curve of the PPILC risk model.

excrete airway secretions to reduce the incidence of PPILC.

In this study, the emaciated patients were more likely to suffer from PPILC than those with normal BMI (OR = 19.355, p < 0.001), which suggested that emaciation and malnutrition were independent risk factors for PPILC in elderly patients. The risk of PPILC in patients with BMI > 24 was 4.359 times of patients with normal BMI (p = 0.015), which suggested that overweight or obesity was one of the risk factors for PPILC. This result is consistent with previous study.<sup>12</sup> First, obesity may cause pharyngeal airway stenosis, an increase of upper airway collapse, and a higher risk of respiratory infection, which further lead to pulmonary dysfunction, thus impairing the prognosis of patients.<sup>13,14</sup> Second, excessive fat in overweight/ obese patients make the surgical manipulations more difficult, and the duration of surgery and anesthesia is prolonged, which can lead to an increase of the exposure time of surgical field and the number of repeated squeezing and kneading of lung tissues, resulting in a higher probability of contamination. After surgery, overweight/ obese patients may have difficulty in turning over in bed or have poor activity endurance, which may also lead to PPILC.<sup>15</sup> It has showed that patients with abdominal obesity usually have a lower pulmonary function and lower lung reserve capacity.<sup>15</sup>

Early postoperative inflammatory reactions can lead to a transient elevation of WBC count and other inflammatory factors, typically within 24 h after surgery. The WBC count and the levels of inflammatory factors fall back after peaking at 72 h after surgery.<sup>16,17</sup> In this study, the peak WBC count of patients at 4–10 days after surgery was evaluated. It indicated that the peak WBC count in the PPILC group was 15.63  $\pm$  4.57, which was higher than that of the non-PPILC group (12.52  $\pm$  3.54). Therefore, the continuous increase of WBC count was an independent risk factor for PPILC, suggesting postoperative inflammatory response. This result is consistent with two previous studies.<sup>18,19</sup> Therefore, it is necessary to dynamically monitor the levels of inflammatory factors, such as postoperative WBC count, to detect infection and intervene as early as possible, which may be helpful to improve the prognosis of PPILC.

A good differentiating ability is considered if the AUC is within the range of 0.8–0.9. In this study, the AUC of this risk prediction model was 0.827, which indicated that the model was able to screen for elderly patients with lung cancer who would suffer from a postoperative pulmonary infection. According to this risk prediction model, when Z-value in the equation  $\geq$  -0.107, elderly patients with lung cancer were at risk for postoperative pulmonary infection. This model might help clinician to identify elderly patients at risk of pulmonary infection, thus conducting early intervention and management to improve their prognosis. A previous study on the the risk factors associated with postoperative pneumonia after lung resection showed that patients with older age, smoking and extent of excision of more than one lobe have a higher risk for pneumonia after lung cancer surgery.<sup>20</sup> The main reason for the difference with our study was that we included the elderly patients  $\geq$  60 years old, while in that study, the included patients were obvious younger than that in our study.

There were also some limitations in this study. This study was a single-center, retrospective study with limited sample size, and the predictive performance of the model needs to be evaluated in a validation cohort. Multi-center prospective studies were still needed to be conducted with expanded sample size.

In conclusion, the risk prediction model for postoperative pulmonary infection in elderly patients with lung cancer was constructed in this study had a good predictive performance. Our findings might be helpful to the management, monitoring, early screening and intervention among elderly patients in the perioperative period.

#### Acknowledgements

None.

# **Conflict of interest**

The authors declare that they have no conflict of interest.

#### **Ethics statement**

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This study is approved by the Ethics Committee of Sun Yat-sen University Cancer Center. Written informed consent was obtained.

#### References

- Herbst RS, Morgensztern D, Boshoff C. The biology and management of non-small cell lung cancer. *Nature*. 2018;553:446–454.
- 2. Zheng RS, Sun KX, Zhang SW, et al. Report of cancer epidemiology in China, 2015. Zhonghua Zhong Liu Za Zhi. 2019;41:19–28.
- Wang Z, Cai XJ, Shi L, et al. Risk factors of postoperative nosocomial pneumonia in stage I-IIIa lung cancer patients. *Asian Pac J Cancer Prev.* 2014; 15:3071–3074.
- Hu Y, Liu C, Shen Z, et al. Prevalence, risk factors and molecular epidemiology of carbapenem-resistant Klebsiella pneumoniae in patients from Zhejiang, China, 2008-2018. *Emerg Microbes Infect*. 2020;9:1771– 1779.
- Cao B, Huang Y, She DY, et al. Diagnosis and treatment of communityacquired pneumonia in adults: 2016 clinical practice guidelines by the Chinese Thoracic Society, Chinese Medical Association. *Clin Respir J*. 2018;12:1320–1360.
- Mahmood I, Younis B, Ahmed K, et al. Occult pneumothorax in patients presenting with blunt chest trauma: An observational analysis. *Qatar Med J.* 2020;2020:10.
- Li W, Ding C, Yin S. Severe pneumonia in the elderly: a multivariate analysis of risk factors. Int J Clin Exp Med. 2015;8:12463–12475.

- Tong C, Li T, Huang C, et al. Risk factors and impact of conversion to thoracotomy from 20,565 cases of thoracoscopic lung surgery. *Ann Thorac Surg.* 2020;109:1522–1529.
- Gregoratos G, Cheitlin MD, Conill A, et al. ACC/AHA Guidelines for implantation of cardiac pacemakers and antiarrhythmia devices: Executive summary--a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on Pacemaker Implantation). *Circulation*. 1998;97:1325–1335.
- Henig O, Kaye KS. Bacterial pneumonia in older adults. Infect Dis Clin North Am. 2017;31:689–713.
- Yang M, Zhong JD, Zhang JE, et al. Effect of the self-efficacy-enhancing active cycle of breathing technique on lung cancer patients with lung resection: A quasi-experimental trial. *Eur J Oncol Nurs*. 2018;34:1–7.
- Rieber J, Deeg A, Ullrich E, et al. Outcome and prognostic factors of postoperative radiation therapy (PORT) after incomplete resection of nonsmall cell lung cancer (NSCLC). *Lung Cancer*. 2016;91:41–47.
- Wang JF, Zhang Q, Xie YP, et al. Analysis of the overweight and obesity effects on pulmonary function in OSA patients. *Lin Chung Er Bi Yan Hou Tou Jing Wai Ke Za Zhi*. 2019;33:611–614.
- Bostanci A, Bozkurt S, Turhan M. Impact of age on intermittent hypoxia in obstructive sleep apnea: a propensity-matched analysis. *Sleep Breath*. 2018;22:317–322.
- Yasuura Y, Maniwa T, Mori K, et al. Quantitative computed tomography for predicting cardiopulmonary complications after lobectomy for lung cancer in patients with chronic obstructive pulmonary disease. *Gen Thorac Cardiovasc Surg.* 2019;67:697–703.
- Roh S, Iannettoni MD, Keech J, et al. Timing of esophagectomy after neoadjuvant chemoradiation therapy affects the incidence of anastomotic leaks. *Korean J Thorac Cardiovasc Surg.* 2019;52:1–8.
- Shao CY, Liu KC, Li CL, et al. C-reactive protein to albumin ratio is a key indicator in a predictive model for anastomosis leakage after esophagectomy: Application of classification and regression tree analysis. *Thorac Cancer.* 2019;10:728–737.
- Noble F, Curtis N, Harris S, et al. Risk assessment using a novel score to predict anastomotic leak and major complications after oesophageal resection. J Gastrointest Surg. 2012;16:1083–1095.
- Edwards MR, Sultan P, del Arroyo AG, et al. Metabolic dysfunction in lymphocytes promotes postoperative morbidity. *Clin Sci (Lond)*. 2015;129: 423–437.
- Liu GW, Sui XZ, Wang SD, et al. Identifying patients at higher risk of pneumonia after lung resection. J Thorac Dis. 2017;9:1289–1294.