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REVIEW

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Relationship between gender and perioperative clinical features in lung cancer patients who underwent VATS lobectomy

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Abstract

Objectives Compare the differences in perioperative clinical characteristics of lung cancer patients of different genders who have undergone VATS lobectomy, and explore the impact of these differences on the short-term prognosis of patients.

Methods A total of 338 consecutive patients with lung cancer who underwent VATS lobectomy in our hospital from August 2021 to August 2022 were retrospectively analyzed, they were divided into male group and female group. The perioperative characteristics and short-term prognosis of different groups were compared. The multivariate binary logistic regression analysis was used to analyze the risk factors.

Results There were statistically significant differences between male and female patients in age of onset, body surface area (BSA), smoking rate, alcohol consumption rate, hypertension incidence, pulmonary function and clinical stage. There were statistically significant differences between male and female patients in operation time and lymph node dissection. The probability of postoperative complications, such as pulmonary infection, persistent air leakage and severe subcutaneous emphysema, in male patients was significantly higher than that in female patients. The average daily postoperative thoracic drainage volume in male patients was considerably higher than that in female patients, and the postoperative duration of thoracic drainage tube and hospital stay in male patients were significantly longer than those in female patients. After multiple regression analysis, low FEVI values in males was found to be an independent risk factor for postoperative complications.

Conclusions Compared with female patients, male patients with lung cancer are more likely to have unfavorable factors such as older age, higher smoking rate, poor pulmonary function and late clinical stage of tumors when they undergoing VATS surgery treatment. The appropriate thoracic drainage time can be selected according to gender differences to shorten the length of hospital stay. The incidence of postoperative complications is higher in male patients, especially those with poor pulmonary function, and active perioperative intervention is required to reduce the incidence of postoperative complications.

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Keywords Lung cancer, Gender difference, Lobectomy, Perioperative period

Introduction

As one of the malignancies with the highest morbidity and mortality in the world, lung cancer has a 5-year survival rate of less than 20% [1].In China, lung cancer is the malignant tumor with the highest incidence and mortality rate, and the incidence and mortality rate are increasing year by year [2, 3]. Non-small cell lung cancer accounts for 85% of the pathological type in lung cancer patients [4]. For resectable lung cancer, surgical resection is the best treatment, measure, and lobectomy is the standard surgical treatment [4–6]. With fewer postoperative complications, shorter postoperative hospital stays, better quality of life and similar long-term survival rates than open-heart surgery, video-assisted thoracic surgery (VATS) lobectomy has been widely used in the surgical resection of patients with lung cancer [7–9].

There are significant gender differences in lung cancer, which are manifested in the incidence, risk factors, pathological types, clinical stages, treatment, prognosis, and pathogenesis of lung cancer [10–15], The need for gender as a stratification factor in the design of clinical trials was emphasised. Despite the large number of studies outlining gender differences in lung cancer, few reports have elaborated on the relationship between gender differences and perioperative clinical characteristics of lung cancer patients.

This study aims to provide reference for perioperative management of lung cancer patients of different genders who have undergone VATS lobectomy by studying the above issues.

Information and methodology

Clinical data and grouping

This study retrospectively analyzed the clinical data of lung cancer patients who met the study criteria and were admitted to the Department of Thoracic Surgery of West China Fourth Hospital of Sichuan University from August 2021 to August 2022.

Inclusion criteria: (1) single lesion on preoperative imaging, (2) postoperative histopathology diagnosis of primary lung cancer, (3) VATS radical resection of lung cancer (lobectomy+lymph node dissection) was performed.

Exclusion Criteria: (1) previous history of intrathoracic surgery, (2) Surgical bilobectomy or lobectomy combined with partial resection of adjacent lungs, (3) preoperative neoadjuvant therapy, (4) patients whose postoperative pathological results failed to reach R0 resection, (5) patients who converted to thoracotomy, (6) patients with incomplete clinical data.

A total of 338 patients were included in this study. Among them, 174 (51.5%) were males and 164 (48.5%) were females. The age was 26 ~ 83 years old, and they were divided into male group (n=174) and female group (n=164) according to gender.

Surgical and perioperative management

All patients were admitted to the hospital to improve preoperative preparation and assessment, including smoking patients need to strictly quit smoking for more than 1 week before arranging surgery, for other diseases such as hypertension, diabetes mellitus, heart disease, etc., need to ask the relevant departments to consult and guide the treatment, and only after the condition is stable can we arrange for surgical treatment. In the perioperative period, the concept of 'Enhanced Recovery After Surgery (ERAS)' was practiced, and all patients underwent preoperative education, preoperative nebulisation, expectorant and antispasmodic treatments, and active pulmonary exercise, and fasting on the day of surgery. VATS single-hole or three-hole lobectomy+lymph node dissection was performed, with limited fluid intake and no urinary catheter routinely placed, and a chest drain (12–22 F) was routinely placed in the 4th or 7th intercostal space after the operation, and intercostal nerve block anaesthesia was also performed. After the operation, the patients were routinely transferred to the general ward for postoperative recovery treatment, and were treated with nonsteroidal analgesics, resumed eating 6 h after the operation, and were encouraged to get out of bed at 12 h after the operation when the cardiac monitoring was withdrawn. However, for patients with preoperative pulmonary insufficiency, difficulty in tolerating single-lung ventilation during the operation and difficulty in removing the tracheal tube for a short period of time, they were transferred to the intensive care unit for ventilator-assisted respiration, and then transferred back to the general ward after the removal of the tracheal tube. After the operation, patients were strengthened with respiratory management, and were given nebulised inhalation, oxygen therapy, temporary analgesia, expectoration, prevention of infection, etc.; they were also strengthened with coughing and expectoration and respiratory exercises to promote the recovery of pulmonary function, and were actively prevented from pulmonary atelectasis, and were encouraged to get out of bed. Strengthen cough and sputum expectoration and respiratory exercise to promote lung function recovery, and actively prevent pulmonary atelectasis and lung infection; strengthen the observation and care of chest drain after operation, maintain fluid and electrolyte balance, and remove chest drain as soon

as possible after complying with the guideline of removing chest drain.

Data collection

The perioperative clinical data of patients were retrospectively collected through the electronic medical record system, including (1) Preoperative indicators: age, gender, height, weight, smoking history, chronic alcohol consumption, body mass index (BMI), body surface area (BSA), comorbidities (hypertension, diabetes, heart disease, lung disease, tumor history, etc.), tumor diameter, tumor composition, lung function (FEV1, FEV1 Pre/Ref, FEV1/FVC%); (2) Intraoperative indicators: surgical method (resection of lung lobes), intraoperative blood loss, operation time, lymph node dissection station and number, etc.; (3) Postoperative indicators: postoperative transfers to the intensive care unit, tumor stage, postoperative chest drainage tube indwelling time, mean postoperative daily chest drainage volume, postoperative cardiopulmonary complication (air leakage, pulmonary infection, chyle fistula, arrhythmia, hydrothorax, severe subcutaneous emphysema, atelectasis, respiratory failure Cardiac arrest and bronchopleural fistula were not included in this study because no cardiac arrest or bronchopleural fistula occurred) and postoperative hospital stay.

Statistical analysis

The SPSS 25.0 (IBM Corp, Armonk, NY, USA) software was used to analyze the results. The measures were expressed as $\bar{x} \pm s$, in which the independent samples t-test was used for normally distributed measures, and the Mann-Whitney U test was used for non-normally distributed measures. Count data were expressed in frequency and percentage (%), the $\chi 2$ test was used for comparison, and the Fisher exact probability method was used when the $\chi 2$ test criteria were unmet. Multivariate binary logistic regression analysis was used to analyze the risk factors for postoperative complications. $P<0.05$ was statistically significant.

Ethics review

This study has been reviewed and approved by Ethical Approval of Ethics Committee of West China Fourth Hospital and West China School of Public Health, Sichuan University, approval number Gwll2024151, and the personal consent for this retrospective analysis has been waived.

Results

Baseline data comparison

A total of 338 patients were included in this study. Among them, 174 (51.5%) were males and 164 (48.5%) were females. The age was 26–83 years old. As shown in Table 1, there were 174 males and 164 females in this study. The mean age of males was 59.13±9.50 years (range 28–83 years), which was significantly higher than that of females [56.19±10.00 years (range 26–77 years); $P=0.006$], BSA was significantly higher in males than in females [1.75±0.15, (range 1.33–2.21) VS 1.57±0.11, (range 1.3–1.87); $P<0.001$]. There was no statistically significant difference in BMI between males and females ($P=0.477$). The FEV1 in males was significantly higher than that in females [2.59±0.67, (range 0.74–5.39) VS 2.02±0.49, (range 0.73–3.34); $P<0.001$], but the FEV1 Pre/Ref and FEV1/FVC% of males were significantly lower than those of females ($P=0.003$, $P<0.001$, respectively). Smoking prevalence was significantly higher in males than that in females (69% versus 6.1%; $P<0.001$), and the prevalence of alcohol consumption in males was significantly higher than that in females (55.8% versus 2.4%; $P<0.001$). In terms of comorbidities, the prevalence of hypertension in males was significantly higher than that in females (25.3% VS 15.9; $P=0032$), and there were no significant differences in the comparison of other complications.

In comparison of tumor characteristics, the mean diameter of tumors was significantly larger in males than that in females [2.78±1.54 (range 0.9–7.60) VS 2.16±1.10 (range 0.6–7.3); $P<0.001$]. The tumor component in males was mainly solid, accounting for 65.5%, while the tumor component in females mainly was ground-glass (including pure ground-glass and mixed ground-glass), which accounted for 62.2%, the tumor component was significantly different ($P<0.001$). In terms of tumor types, adenocarcinoma was the primary type in both male and female patients. Still, the proportion of adenocarcinoma in females was significantly higher than that in males (95.1% VS 75.9%, $P<0.001$). There was no significant difference between males and females in the lobe location of the tumor ($P>0.05$). In terms of T stage, more than half of the males had T2 or above (55.7%), while most females had T1 and below (70.1%), the difference was statistically significant ($P<0.001$). There was no significant difference in the N stage between males and females (14.9% VS 8.5%, $P>0.05$). In the TNM stage, the males was significantly later than that of females ($P<0.001$).

Comparison of intraoperative and postoperative data

See Table 2, the operative time was significantly longer in males than in females [124.20±36.15 (range, 50–244 min) VS 114.79±35.15 (range, 48–242 min); $P=0.016$], but there was no significant difference between males and females in intraoperative blood loss [(101.55±73.35 (range, 10-400 ml) VS 88.23±83.71 (range, 20-600 ml); $P=0.12$]. There was no significant difference in the station of lymph node dissection between males and females ($P>0.05$), but the number of lymph

Table 1 Comparison of baseline data between males and females

Characteristic	male($n=174$)	female($n=164$)	statistics	*P*
age	59.13 ± 9.50[28–83]	56.19 ± 10.00[26–77]	2.775	0.006
BSA	1.75 ± 0.15[1.33–2.21]	1.57 ± 0.11[1.3–1.87]	12.104	<0.001
BMI	23.84 ± 2.95[16.02–37.80.]	23.60 ± 3.20[15.60–32.27]	0.712	0.477
smoking history	120(69.0)	10(6.1)	140.98	<0.001
chronic alcohol consumption	97(55.8)	4(2.4)	114.51	<0.001
comorbid diseases				
hypertension	44(25.3)	26(15.9)	4.576	0.032
diabetes	17(9.8)	10(6.1)	1.549	0.213
lung disease	16(9.2)	5(3.0)	5.474	0.19
heart disease	6(3.4)	2(1.2)	1.815	0.178
tumor history	11(6.3)	8(4.9)	0.332	0.565
lung function				
FEVI	2.59 ± 0.67[0.74–5.39]	2.02 ± 0.49[0.73–3.34]	8.995	<0.001
FEV1 Pre / Ref	89.27 ± 18.86[31.3–183.4]	95.03 ± 18.03[41.7–160]	-2.867	0.004
FEV1/FVC%	84.69 ± 9.47[58.76–99.99]	87.89 ± 8.58[58.35–99.76]	-3.248	0.001
lesion diameter	2.78 ± 1.54[0.9–7.6]	2.16 ± 1.10[0.6–7.3]	4.312	<0.001
lesion composition			25.979	<0.001
ground-glass	60(34.5)	102(62.2)		
solid	114(65.5)	62(37.8)		
surgical method			3.468	0.486
RUL	67(38.5)	51(31.1)		
RML	10(5.7)	16(9.8)		
RLL	33(19.0)	34(20.7)		
LUL	43(24.7)	40(24.4)		
LLL	21(12.1)	23(14.0)		
tumor types			25.291	<0.001
AD	132(75.9)	156(95.1)		
SCC	38(21.8)	8(4.9)		
Other	4(2.3)	0		
T stage			23.026	<0.001
0–1	77(44.3)	115(70.1)		
≥ 2	97(55.7)	49(29.9)		
N stage			3.32	0.068
0	148(85.1)	150(91.5)		
1,2	26(14.9)	14(8.5)		
clinical stage			15.992	<0.001
MIS-I	112(64.3)	137(83.6)		
II-III	62(35.7)	27(16.4)		

BSA, body surface area. BMI, body mass index. RUL, right upper lobe. RML, right middle lobe. RLL, right lower lobe. LUL, left upper lobe. LLL left lower lobe. AD, adenocarcinoma

classification as T stage and N stage according to the TNM system and clinical staging

nodes dissected in males was significantly higher than that in females [11.9±4.55 (4–30 nodes), VS 10.74±3.83 (4–23 nodes); $P=0.011$]. In terms of the number of patients directly transferred to the intensive care unit after surgery, four patients in the male group and four patients in the female group were directly transferred to the intensive care unit for postoperative recovery treatment, and there was no statistically significant difference between the two groups of patients ($P=0.932$). Males were significantly worse in terms of postoperative tubing time compared with females [6.02±3.95 (range, 2–27 days) VS 4.47±2.33 (range, 2–15 days), $P<0.001$], and the length of postoperative hospital stay was significantly higher in males than in females [8.51±4.38 (range, 3–33 days) VS 6.57±2.51 (range, 3–17 days), $P<0.001$)], the average daily chest drainage volume during the postoperative catheter period was also significantly higher in males than in females [207.79±65.27 (range, 66.7-410 ml) VS 174.91±58.75 (range, 50-432 ml); $P<0.001$)]. Among the two groups, one male died of respiratory failure in 7 days after surgery, and there was no difference in postoperative mortality between the two groups ($P=0.332$). In

Table 2 Comparison of intraoperative and postoperative date of different groups

Characteristic	Male	Female	Statistics	*P*
operation time(min)	124.20 ± 36.15)[50–244]	114.79 ± 35.15[48–242]	2.422	0.016
intraoperative blood loss (ml)	101.55 ± 73.35[10–400]	88.23 ± 83.71[20–600]	1.558	0.12
lymph node dissection station	5.38 ± 1.02[3–9]	5.27 ± 1.04[3–8]	0.992	0.322
lymph node dissection number	11.9 ± 4.55[4–30]	10.74 ± 3.83[4–23]	2.548	0.011
number of ICU transfers after surgery	4(2.3)	4(2.4)	0.07	0.932
postoperative chest drainage tube indwelling time	6.02 ± 3.95[2–27]	4.47 ± 2.33[2–15]	4.43	<0.001
postoperative hospital stay (day)	8.51 ± 4.38[3–33]	6.57 ± 2.51[3–17]	5.03	<0.001
postoperative average daily chest drainage	207.79 ± 65.27[66.7–410]	174.91 ± 58.75[50–432]	4.857	<0.001
hospital mortality	1(0.6)	0(0)	0.943	0.332
postoperative complication				
arrhythmia	7(4.0)	3(1.8)	1.415	0.234
atelectasis	10(5.7)	6(3.7)	0.817	0.366
pulmonary infection	47(27)	20(12.2)	11.664	0.001
respiratory failure	3(1.7)	0(0)	1.23	0.091
chyle fistula	4(2.3)	0(0)	2.103	0.147
hydrothorax	7(4.0)	3(1.8)	0.754	0.385
severe subcutaneous emphysema	12(6.9)	2(1.2)	6.853	0.009
persistent air leakage	21(12.1)	8(4.9)	5.566	0.018

terms of postoperative complications, pulmonary infections, subcutaneous emphysema (6.9% VS 1.2%; $P=0.009$) and persistent air leakage (12.1% VS 4.9%; $P=0.018$) were more likely to occur in male (27% VS 12.2%; $P=0.001$), and there was no significant difference in the comparison of other complications.

Univariate analysis of risk factors for postoperative complications

Pulmonary infection, subcutaneous emphysema, and persistent air leakage were included in the statistical scope of postoperative complications between the two groups (a total of 86 patients suffered from appellate complications, with an incidence rate of 25.44%). Whether the gender, BSA (≤1.64 and >1.64, median 1.64), age (≤57 years and >57 years, median 57 years), smoking history, chronic alcohol consumption, hypertension, FEVI (≤2.0 and >2.0), FEV1 Pre/Ref (≤92% and >92%, median 92%), FEV1/FVC (≤86.81% and >86.81%, median 86.81%), tumor diameter (≤2.1 cm group and >2.1 cm group, median 2.1 cm), tumor composition, tumor type, T stage, N stage, clinical stage of tumor, operation time (≤112 min group and >112 min group, median 112 min) and number of lymph nodes dissected (≤10 and >10 groups, median 10 nodes) were risk factors of postoperative complications? We performed a univariate analysis. The results showed that the gender, smoking history, chronic alcohol consumption, hypertension, FEVI, FEV1 Pre / Ref, tumor diameter, tumor composition, tumor type, T stage, N stage, clinical stage of tumor, operation time, and number of lymph nodes dissected were the risk factors for postoperative complications ($P<0.05$) (Table 3).

Multivariate regression analysis of risk factors for postoperative complications

The statistically significant differences in the univariate analysis were included in the multivariate analysis for stepwise regression, and the results were showed in Table 4. The gender and FEVI were independent risk factors for postoperative complications. Males were 3.483 times more likely to develop complications after surgery than females, and the risk of complications was reduced by 65.2% for every 1 unit increase in FEV1 value.

Discussion

The impact of gender differences on early postoperative prognosis is a complex and multifactorial issue that involves multiple physiological, psychological, and social dimensions. Firstly, there are significant anatomical and physiological differences between males and females, and these differences may affect the surgical procedure and postoperative recovery. For example, in cardiac surgery, female patients tend to have smaller coronary arteries, which may increase the difficulty of the procedure and the risk of postoperative complications [16]. ◦ In lung cancer surgery, women have a better prognosis for lung cancer than men due to factors such as lower smoking prevalence, lower age at disease, fewer comorbidities, and lower prevalence of squamous carcinoma compared to men [17]. Women are subject to fluctuations in oestrogen and progesterone, which may affect postoperative healing, immune function and metabolic processes [18]. Gender differences are also reflected in the immune response. Some studies have shown that women typically have a stronger immune response, which helps them to clear their bodies of pathogens and restore their health

Table 3 Univariate analysis of postoperative complications

Characteristic	Postoperative complications		Wald	*P*	OR	95% CI
	NO(*n* = 252)	YES(*n* = 86)				
Sexuality/case			14.83	<0.001	2.794	(1.656–4.712)
female	138	26				
male	114	60				
age/case			2.427	0.119	1.48	(0.904–2.424)
≤ 57y	133	37				
>57y	119	49				
BSA/case			0.996	0.318	1.284	(0.786–2.099)
≤ 1.64m2	130	39				
>1.64m2	122	47				
smoking history/case			14.21	<0.001	2.619	(1.587–4.32)
no	170	38				
yes	82	48				
chronic alcohol consumption /case			6.333	0.12	1.934	(1.157–3.233)
no	186	51				
yes	66	35				
hypertension/case			4.818	0.028	1.885	(1.070–3.321)
no	207	61				
yes	45	25				
FEVI/case			6.854	0.009	0.511	(0.309–0.845)
≤ 2.00	75	39				
>2.00	177	47				
FEV1 Pre / Ref /case			8.792	0.003	0.466	(0.281–0.772)
≤ 92%	114	55				
>92%	138	31				
FEV1/FVC%/case			3.036	0.081	0.644	(0.393–1.056)
≤ 86.81%	119	50				
>86.81%	133	36				
tumor diameter/case			11.12	0.001	2.366	(1.426–3.924)
≤ 2.10	129	28				
>2.10	123	58				
tumor composition/case			5.244	0.022	1.798	(1.088–2.971)
ground-glass	130	32				
solid	122	54				
tumor type/case			4.749	0.029	2.022	(1.073–3.808)
AD	221	67				
non-AD	31	19				
T stage/case			13.59	<0.001	2.571	(1.556–4.247)
0–1	158	34				
≥ 2	94	52				
N stage/case			8.63	0.003	2.767	(1.403–5.458)
0	230	68				
1,2	22	18				
clinical staging /case			13.8	<0.001	2.522	(1.600-4.569)
MIS-I	199	50				
II-III	53	36				
operation time			3.976	0.046	1.655	(1.009–2.714)
≤ 112	137	36				
>112	115	50				
number of lymph nodes /case			9.538	0.002	2.218	(1.338–3.676)
≤ 10	140	31				
>10	112	55				

BSA, body surface area. BMI, body mass index. AD, adenocarcinoma. classification as T stage and N stage according to the TNM system and clinical staging

Table 4 Multivariate analysis of postoperative complications

Characteristic	B	SE	Waid	*P*	Exp(B)	95% CI
sex(1)	1.248	0.469	7.087	0.008	3.483	(1.39–8.73)
smoking status (1)	0.4	0.384	1.082	0.298	1.491	(0.702–3.167)
chronic alcohol consumption (1)	-0.01	0.367	0.001	0.975	0.989	(0.481–2.032)
hypertension (1)	0.337	0.327	1.061	0.303	1.401	(0.737–2.661)
FEV1	-1.06	0.348	9.238	0.002	0.348	(0.176–0.687)
FEV1 Pre / Ref	0.01	0.01	0.915	0.339	1.01	(0.99–1.03)
tumor diameter	0.044	0.137	0.105	0.746	1.045	(0.799–1.368)
tumor composition (1)	-0.16	0.333	0.227	0.634	0.853	(0.444–1.64)
operation time	0.007	0.004	2.829	0.093	1.007	(0.999–1.105)
number of lymph nodes dissected	0.02	0.035	0.324	0.569	1.02	(0.953–1.092)
tumor type (1)	-0.01	0.413	0	0.984	0.992	(0.441–2.229)
T(1)	0.208	0.366	0.324	0.569	1.231	(0.601–2.522)
N(1)	0.249	0.49	0.258	0.611	1.283	(0.491–3.355)
clinical staging (1)	0.389	0.495	0.615	0.433	1.475	(0.559–3.894)
constant	-1.91	0.972	3.86	0.049	0.148	

a Variables included in step 1 were sex, smoking status, alcohol consumption, hypertension presence, FEV1 measurement, the ratio of FEV1, tumor diameter, tumor composition, duration of operation, number of lymph nodes involved, tumor type, T stage, N stage, and clinical staging

more quickly. However, in some cases, an overly strong immune response may also lead to increased autoimmune disease or inflammatory response, which can interfere with recovery after surgery [19, 20]. In terms of psychosocial factors, women are more likely than men to feel stress and anxiety in the preoperative period, and in the perioperative period, women may require more analgesic medication for pain relief and more psychological support and care [21–23]. A Wallis study found that gender congruence between surgeon and patient may be associated with postoperative outcomes, with female patients likely to have increased rates of postoperative mortality, complications, and readmissions when male surgeons operate on them. This may be related to gender differences in the surgeon's assessment of the patient's condition, surgical approach, and postoperative care regimen [24]. In summary, the impact of gender differences on early postoperative prognosis is multifaceted and complex. In order to improve patients' postoperative recovery outcomes and quality of life, doctors need to formulate individualised surgical and nursing care plans with full consideration of patients' gender characteristics, physiological differences, immune responses and psychosocial factors. At the same time, there is also a need to strengthen research and exploration of gender differences in the medical field to better understand the impact of gender on postoperative recovery and to develop appropriate interventions.

In recent years, with the widespread popularity of low-dose spiral CT of the chest, more early-stage lung cancers have been diagnosed. Surgical treatment of lung cancer has also undergone significant changes, and the long-term efficacy of thoracoscopy-assisted radical lung cancer resection is widely recognized [8]. At the same time, the combination of minimally invasive surgery and ERAS significantly reduces perioperative complications, shortens hospital stay, and improves quality of life of lung cancer patients [25, 26]. This study analysed the perioperative clinical characteristics of lung cancer patients of different genders who underwent VATS lobectomy. Compared with females, males have a higher age of disease, a higher rate of smoking and alcohol consumption, and a higher prevalence of hypertension, similar to Fibla's study [17]. Several studies have shown that age, smoking, alcohol consumption, and hypertension were all unfavorable factors affecting the short-term prognosis of lung cancer patients [27–30]。 Although the FEV1 of males was significantly higher than that of females, the FEV1 Pre/Ref and FEV1/FVC% of females were significantly higher than that of males. The proportion of females who smoke was less than 1/10 of that of males. The prevalence of lung disease in females was only 1/3 that in males, which was thought to be related to a history of smoking and underlying lung disease such as COPD. Studies have shown that relatively weak self-awareness of self-health in men, as well as signs and symptoms (e.g., cough and sputum production) that are overlooked by long-term smoking, may delay physical examination and further diagnosis, thereby delaying appropriate treatment [31, 32]. In this study, males had larger tumor diameters, more solid components, and later clinical stages than females when they underwent surgery. According to Fujikawa et al. [33], the tumor characteristics of males in this study were more aggressive, with a higher risk of recurrence and metastasis, which was not conducive to the prognosis of patients. In terms of tumour type, the prevalence of adenocarcinoma was as high as 95.1% in females, much higher than the 75.9% in males, and the type of disease in the remaining 4.9% of female patients (8 cases) was all squamous carcinoma, while the prevalence of squamous

carcinoma in males was 21.8%, and the remaining 2.3% were neuroendocrine carcinoma, which is in accordance with the study of Jin [34].

In this study, males were treated with surgery for a significantly longer period than females, consistent with Gómez-Hernández's studies [35]. In addition, males also dissected more lymph nodes during surgery than females. It is presumed to be related to a later tumor stage and a higher positive rate of lymph node metastasis in males. In terms of postoperative recovery, compared with females, males had a larger daily chest drainage volume and longer indwelling chest drains. The currently recommended daily chest drain volume varies from 200 to 500 mL [36, 37] (The drainage requirement for removal of chest drains in this study was a chest drainage volume of less than 200 ml.), however, without considering the influence of gender differences, although the daily chest drainage volume of males was significantly more than that of females, the body surface area, pleural volume and parietal pleural area of males were significantly larger than those of females, and it was currently believed that pleural effusion was mainly absorbed by the parietal pleura, and the parietal pleura had a robust compensatory ability to absorb pleural fluid [38, 39], so the ability of males to reabsorb pleural fluid was significantly greater than that of females. In this study, it was suggested that the daily chest drainage volume requirement for males could be further relaxed when evaluating the chest drain removal pointer. However, there is a lack of literature support for specific differences in chest drainage, and other controlled studies are needed. Pulmonary infection is one of the most common complications after radical lung cancer surgery. Postoperative pulmonary infection is mostly caused by the inability of patients' respiratory secretions to be discharged, patients' declining resistance, poor sputum drainage, cross-infection, and anaesthesia influence. The analysis of the study showed that male, smoking history, age, longer duration of surgery, and squamous cell carcinoma are risk factors for postoperative lung infection in lung cancer patients [35, 40]. 。 In this study we defined postoperative lung infection by the Melbourne Group Scale (MGS) [41], The study showed that the incidence of pulmonary infection was significantly higher in males than in females (27 versus 12.2%, $P<0.001$), consistent with related studies [42]. In addition, male patients also have comorbid risk factors such as age, duration of surgery, smoking history, and squamous cell carcinoma, and it can be assumed that male patients with numerous comorbid risk factors are more susceptible to postoperative pulmonary infections. An air leak lasting 5 days or more is defined as a persistent air leak after surgery. In this study, patients had a persistent air leak of 8.6% (29/338), consistent with reports [36]. Among them, 12.1% of males and 4.9% of females had a higher probability of persistent air leakage after surgery. Risk factors for persistent postoperative air leak have been shown in several studies, including pleural adhesions, emphysema/COPD, chronic smoking history, interlobar dysplasia, upper lobectomy, older age, male sex, and low body mass index [43–45]。 In this study, most of the males had a history of long-term smoking, a higher age and more lung disease than females, which resulted in a higher rate of persistent air leakage. Lobectomy, male sex, extensive thoracic adhesions, and advanced age are risk factors for the development of subcutaneous emphysema [46, 47], and the incidence of severe subcutaneous emphysema was 4.1% (14/338) in all patients in this study, which was significantly higher than other studies [46, 48]. At the same time, the probability of severe subcutaneous emphysema in males was about 6 times that of females. The prolonged air leakage will increase the risk of subcutaneous emphysema if the lung leaks are severe after surgery, the chest drainage is not smooth, the intrathoracic pressure increases and the intrapleural gas squeezes into the subcutaneous tissue through the pleural space, especially the loose tissue around the orifice of the closed chest drain and the incision, causing subcutaneous emphysema. The females have a lower probability of persistent air leakage after surgery, and the probability of subcutaneous emphysema is lower than that of males because there is more fatty tissue in the chest wall and a narrower intercostal space.

Multivariate regression analysis showed that gender and low FEV1 were independent risk factors for postoperative complications. Therefore, in the perioperative period, we need to pay more attention to males with poor lung function, aggressive perioperative intervention in such patients. Several studies have shown that smoking increases the risk of in-hospital mortality and pulmonary complications after lung cancer resection, whereas strict preoperative smoking cessation reduces in-hospital mortality and the incidence of pulmonary complications after lung cancer resection [49–51]. Raupach's studies [52] shown that a smoke-free interval of 2–6 weeks preoperatively seems to be the most favourable, however, in practice this is difficult to achieve in clinical practice as radical lung cancer surgery should not be delayed. Smoking patients in this study had a smoke-free interval of at least 1 week, and for male patients with poor lung function, a smoke-free interval of more than 2–4 weeks is recommended when their condition permits. In addition, preoperative pulmonary rehabilitation training can improve the cardiopulmonary function of lung cancer patients with poor lung function, shorten the postoperative hospital stay, and reduce the incidence of postoperative pulmonary complications and pneumonia [53–55]. Therefore, for male patients with poor lung function, we need to actively perform preoperative pulmonary

rehabilitation training, including pharmacological rehabilitation with bronchodilators (β-2 agonists and/or anticholinergic drugs) or with β-2 agonists/inhaled corticosteroid therapy, as well as physical rehabilitation with respiratory training and endurance training. Early termination of ventilator-assisted respiratory status; continued postoperative pulmonary rehabilitation. Closer clinical monitoring is given, including pathogenetic tests, imaging tests, blood index tests, etc. Antiinfective treatment with antibiotics can be upgraded if necessary to minimise the occurrence of pulmonary complications and shorten the patient's postoperative hospital stay.

There are some limitations to this study. First, this study was retrospective, and there was a selection bias. Data collection depended on the completeness and detail of the medical history, and some potentially important baseline patient characteristics, such as pleural adhesions, were not included in the collection database. Second, there were differences in patient selection, surgical techniques, and postoperative management between different medical groups, which might affect intraoperative and postoperative outcomes. Third, the sample size of this study was relatively small, and it was a single-center study. A multicenter study with a large sample size is needed to validate the results of this study.

Conclusion

In summary, compared with females, males with lung cancer are more likely to have unfavorable factors such as older age, higher smoking rate, poor lung function, and later clinical stage of cancer when they undergoing VATS surgery treatment. Therefore, males must enhance their self-health awareness and maintain good lifestyle habits. In perioperative surgical treatment, preoperative smoking cessation should be strict to sufficient course of treatment, preferably for more than 2 weeks without delaying the time of surgery. Pulmonary function exercises should be actively performed to improve lung function. After surgery, the appropriate time of chest drain removal can be selected according to different gender, and the length of hospital stay can be shortened. The incidence of postoperative complications is higher in men, especially those with poorer lung function, and it is important to actively perform perioperative interventions and appropriately lengthen the preparation time to reduce the incidence of postoperative complications.

Supplementary Information

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Supplementary Material 1

Author contributions

Wei Chen and Qiangqiang Zheng wrote the main manuscript text, Yi Shen, Min Liang, Yang Yuan and Yusong Lu helped perform the analysis with constructive discussions. All authors reviewed the manuscript. All authors read and approved the final manuscript.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

The study protocol was approved by Ethical Approval of Ethics Committee of West China Fourth Hospital and West China School of Public Health, Sichuan University (Gwll2024151). The study conforms to the provisions of the Declaration of Helsinki. The need for written informed consent was waived owing to the retrospective nature of the study by the eEthical Approval of Ethics Committee of West China Fourth Hospital and West China School of Public Health, Sichuan University.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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