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ORIGINAL RESEARCH

The Effects of Type 2 Diabetes on Postoperative Pneumonia in Patients with Video-Assisted Thoracoscopic Surgery: A Retrospective Cohort Study

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Purpose: The aim of the study was to investigate the relationship between type 2 diabetes (T2DM) and postoperative pneumonia (POP) after video-assisted thoracoscopic surgery, and explore the risk factors involved in the prediction of postoperative pneumonia in patients with T2DM.

Patients and Methods: A retrospective study was conducted on 476 inpatients with video-assisted thoracoscopic surgery (VATS) in The Second Hospital of Fujian Medical University between January 2019 and December 2023. Demographic information, clinical variables including surgical data and preoperative laboratory indices that potentially impact POP were included. Subgroup and logistic analysis were performed to demonstrate risk factors for POP in patients with T2DM.

Results: The incidences of POP were higher in patients with T2DM than patients without this condition (T2DM 23.08% vs non-diabetes 10.54%, $P<0.001$). Logistic analysis further demonstrated that T2DM [odds ratio (OR), 2.07, 95% confidence interval (CI), 1.13–3.83] is an independent risk of POP after adjusting for sex, age, hospital stay, American Society of Anesthesiologists (ASA) score, and tumor location. Thereafter, the subgroup analysis demonstrated that patients with T2DM in the setting of male gender, positive P53 and chemoradiotherapy displayed a higher incidence rate of POP. Subsequent logistic analysis indicated that sex and tumor location were independently associated with POP in patients with T2DM.

Conclusion: Patients with T2DM who underwent VATS display a higher incidence of POP than those without this disease. Additionally, male gender and tumor location were independent risk factor for POP in patients with T2DM. Thus, male patients with T2DM, perioperative management should be improved and optimized for patient safety.

Keywords: type 2 diabetes, postoperative pneumonia, video-assisted thoracoscopic surgery

Introduction

According to the Global Cancer Statistics 2020, lung cancer is the second most common cancer and has the highest mortality rate among cancers.[1] To date, surgical resection, particularly video-assisted thoracoscopic surgery, remains an effective and safe treatment for patients with lung cancer. However, postoperative pneumonia (POP), the most common pulmonary complication following lung cancer surgery, poses significant challenges to patient recovery.[2,3] The incidence of POP in lung cancer patients ranges from 2% to 25%.[4–7] Research has shown that POP can significantly extend hospital stays, increase healthcare costs, and even raise perioperative mortality rates.[4,8] Therefore, identifying the risk factors associated with POP among lung cancer patients is essential for predicting its occurrence in the early stages.

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Recent literature has reported that diabetes is associated with surgical complications, including POP. For instance, López-de-Andrés et al found that between 2001 and 2015, patients with type 2 diabetes (T2DM) exhibited a 21% higher incidence of POP compared to nondiabetic patients.[9] In 2019, Ma et al further demonstrated that the incidence of POP in patients with T2DM was 3.2%, while only 1.7% of patients without T2DM developed POP.[10] Additionally, two studies indicated that T2DM is an independent risk factor for POP in orthopedic surgery.[11,12] Although these studies highlight the significant impact of diabetes on POP, it remains uncertain whether T2DM increases the risk of POP in patients undergoing video-assisted thoracoscopic surgery (VATS).

Thus, this study was to investigate the association between T2DM and POP after VATS, and further explore the risk factors involved in POP in patients without T2DM.

Methods

Subjects

We performed this retrospective cohort study and obtained the ethic approval from Clinical Research Ethics Committee of the Second Hospital of Fujian Medical University (No. 2023496) on 28 July 2023. All patients undergoing VATS were from the Second Hospital of Fujian Medical University between January 2019 and December 2023. The inclusion criteria were listed as follows: 1) patients undergoing VATS due to the pathology diagnosis of lung cancer, 2) over 18 years old. The exclusion criteria: 1) patients diagnosed with pneumonia before surgery, 2) patients were diagnosed with other types of diabetes instead of T2DM, 3) pregnancy, 4) patients who underwent bilateral pulmonary resection, 5) patients who admitted to ICU after surgery and 6) patients with missing data.

Classification of Pneumonia and Diabetic Type

Pneumonia and diabetic types were determined via the codes of International Classification of Diseases-10 (ICD-10) classifications for hospital admissions. In order to distinguish POP from preoperative pneumonia, we recorded the diagnosis time of pneumonia. The preoperative pneumonia is that patients is diagnosed with pneumonia at the time of hospital admission or before surgery. In addition, the codes of T2DM were included in the study. The codes of other types of diabetes were excluded.

Data Collection

All data were extracted and obtained from our Hospital Information System. The following sociodemographic variables were collected: age, sex, height, weight, hospital length of stay (LOS), ASA and hospital cost. Collected clinical data included: preoperative blood glucose level of patients with T2DM, comorbidity, tumor characteristics, chemoradiotherapy, and perioperative transfusion.

Statistical Analyses

All analyses were performed using the R software version 4.3.1. Numerical variables were expressed as mean ± standard deviation (SD). Comparisons were performed between groups using Student'*t* test and Analysis of Variance (ANOVA). Categorical data were compared via chi-square test. The multivariate logistic regression analysis was performed to analyze characteristic variables to obtain the independent risk factors involved in POP. $P<0.05$ was considered statistically significant.

Results

We initially screened 518 patients who underwent VATS from January 2019 and December 2023. After data collection, 42 patients were removed from the final analysis: 25 patients were diagnosed with preoperative pneumonia via CT; 11 patients required bilateral pulmonary resection; 4 patients admitted to ICU after surgery; 2 patients had missing data. Finally, a total of 476 patients were included into the current study. Among these patients, 73 patients (15.3%) had POP (Table 1). We next explored the risk factors of POP via logistic analysis. In the unadjusted logistic analysis, sex (crude odds ratio [OR] = 0.27, 95% confidence interval [CI] = 0.15–0.46, P<0.001), age (crude odds ratio [OR] = 1.03, 95% confidence interval [CI] = 1–1.05, P=0.04), hospital

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Table 1 Clinical Characteristics of Included 476 Patients

Characteristic	Diabetes		p value
	No (n=294)	Yes (n=182)	
Age	55.43±12.31	64.61±7.54	<0.001
Sex			<0.001
Male	123 (41.84%)	105 (57.69%)	
Female	171 (58.16%)	77 (42.31%)	
BMI	23.54±3.24	24.21±3.09	0.026
Hospital stays	8.78±4.60	13.93±7.84	<0.001
Blood loss	49.65±151.90	54.81±56.39	0.660
Tumor size	1.65±1.09	2.19±1.57	<0.001
Hypertension			<0.001
No	267 (90.82%)	129 (70.88%)	
Yes	27 (9.18%)	53 (29.12%)	
Anemia			0.164
No	278 (94.56%)	177 (97.25%)	
Yes	16 (5.44%)	5 (2.75%)	
Cardiovascular disease			<0.001
No	277 (94.22%)	155 (85.16%)	
Yes	17 (5.78%)	27 (14.84%)	
Transfusion			0.393
No	272 (92.52%)	170 (93.41%)	
RBC	3 (1.02%)	0 (0.00%)	
Autoblood	19 (6.46%)	12 (6.59%)	
Postoperative pneumonia			<0.001
No	263 (89.46%)	140 (76.92%)	
Yes	31 (10.54%)	42 (23.08%)	
ASA			<0.001
I	0 (0.00%)	2 (1.10%)	
II	293 (99.66%)	153 (84.07%)	
III	1 (0.34%)	27 (14.84%)	
TNM			<0.001
Stage I	283 (96.26%)	145 (79.67%)	
Stage II	1 (0.34%)	20 (10.99%)	
Stage III	9 (3.06%)	14 (7.69%)	
Stage IV	1 (0.34%)	3 (1.65%)	

(*Continued*)

Table 1 (Continued).

Characteristic	Diabetes		p value
	No (n=294)	Yes (n=182)	
Pulmonary function			0.311
Normal	126 (42.86%)	81 (44.51%)	
Mild	146 (49.66%)	79 (43.41%)	
Moderate	21 (7.14%)	21 (11.54%)	
Severe	1 (0.34%)	1 (0.55%)	
Location			0.664
Lobi medius pulmonis	25 (8.50%)	18 (9.89%)	
Right lobi superior	94 (31.97%)	58 (31.87%)	
Right lobus inferior pulmonis	50 (17.01%)	33 (18.13%)	
Left lobi superior	67 (22.79%)	42 (23.08%)	
Left lobus inferior pulmonis	31 (10.54%)	22 (12.09%)	
Other	27 (9.18%)	9 (4.95%)	
Histological classification			<0.001
Squamous carcinoma	15 (5.10%)	28 (15.38%)	
Adenocarcinoma	273 (92.86%)	148 (81.32%)	
Other	6 (2.04%)	6 (3.30%)	
CK5_6			0.006
Negative	273 (92.86%)	152 (83.52%)	
+	17 (5.78%)	23 (12.64%)	
++	1 (0.34%)	0 (0.00%)	
+++	3 (1.02%)	7 (3.85%)	
P40			0.003
Negative	273 (92.86%)	151 (82.97%)	
+	17 (5.78%)	26 (14.29%)	
+++	4 (1.36%)	5 (2.75%)	
Lymphatic_invasion			0.156
Negative	278 (94.56%)	166 (91.21%)	
Positive	16 (5.44%)	16 (8.79%)	
Chemoradiotherapy			0.027
No	223 (75.85%)	121 (66.48%)	
Yes	71 (24.15%)	61 (33.52%)	

stays (crude odds ratio [OR] = 1.04, 95% confidence interval [CI] = 1–1.07, P=0.04), diabetes (crude odds ratio [OR] = 2.55, 95% confidence interval [CI] = 1.54–4.26, P<0.001), ASA (crude odds ratio [OR] = 2.41, 95% confidence interval [CI] = 1.00–5.46, P=0.041), and location (crude odds ratio [OR] = 0.75, 95% confidence interval [CI] = 0.61–0.9, P=0.003) were associated with the risk of POP during VATS (Table 2). In the multiple logistic analysis, diabetes was independently associated with the risk of POP (adjusted OR = 2.07, 95% CI = 1.13–3.86, P=0.019), after adjusting for sex, age, hospital stay, ASA, and tumor location (Figure 1). In addition, correlation analysis was conducted between diabetes and the risk of POP. The results demonstrated a positive correlation between them, implying that diabetes may play a role in promoting the occurrence of POP during VATS (cor=0.17, P<0.001; Figure 2).

Table 2 Univariate Analysis Results Related to Postoperative Pneumonia

Variables	Odds Ratio	95% CI	P value
Sex	0.27	0.15–0.46	**<0.001**
Age	1.03	1–1.05	**0.04**
Hospital stays	1.04	1–1.07	**0.04**
Diabetes	2.55	1.54–4.26	**<0.001**
Hypertension	1.49	0.78–2.7	0.207
Anemia	0.92	0.21–2.8	0.891
Cardiovascular disease	1.72	0.77–3.55	0.157
Transfusion	1.13	0.68–1.75	0.605
ASA	2.41	0.99–5.46	**0.041**
TNM	1.11	0.68–1.67	0.654
BMI	1.07	0.99–1.16	0.078
Pulmonary function	0.88	0.59–1.29	0.519
Location	0.75	0.61–0.9	**0.003**
Size	1.02	0.84–1.22	0.842
Histological classification	0.73	0.36–1.53	0.392
Ckpan	0.92	0.45–1.74	0.807
TTF1	1.07	0.76–1.47	0.695
CK7	1.07	0.77–1.47	0.669
NapsinA	1.03	0.73–1.43	0.845
CK5_6	1	0.57–1.56	0.992
P40	1.15	0.68–1.77	0.557
CD56	1.6	0.58–3.82	0.301
Ki67	1.33	0.8–2.22	0.274
syn	0.54	0.09–1.54	0.373
P63	2.28	0.61–7.02	0.174
Lymphatic invasion	1.3	0.47–3.08	0.58
Chemoradiotherapy	0.98	0.55–1.69	0.945

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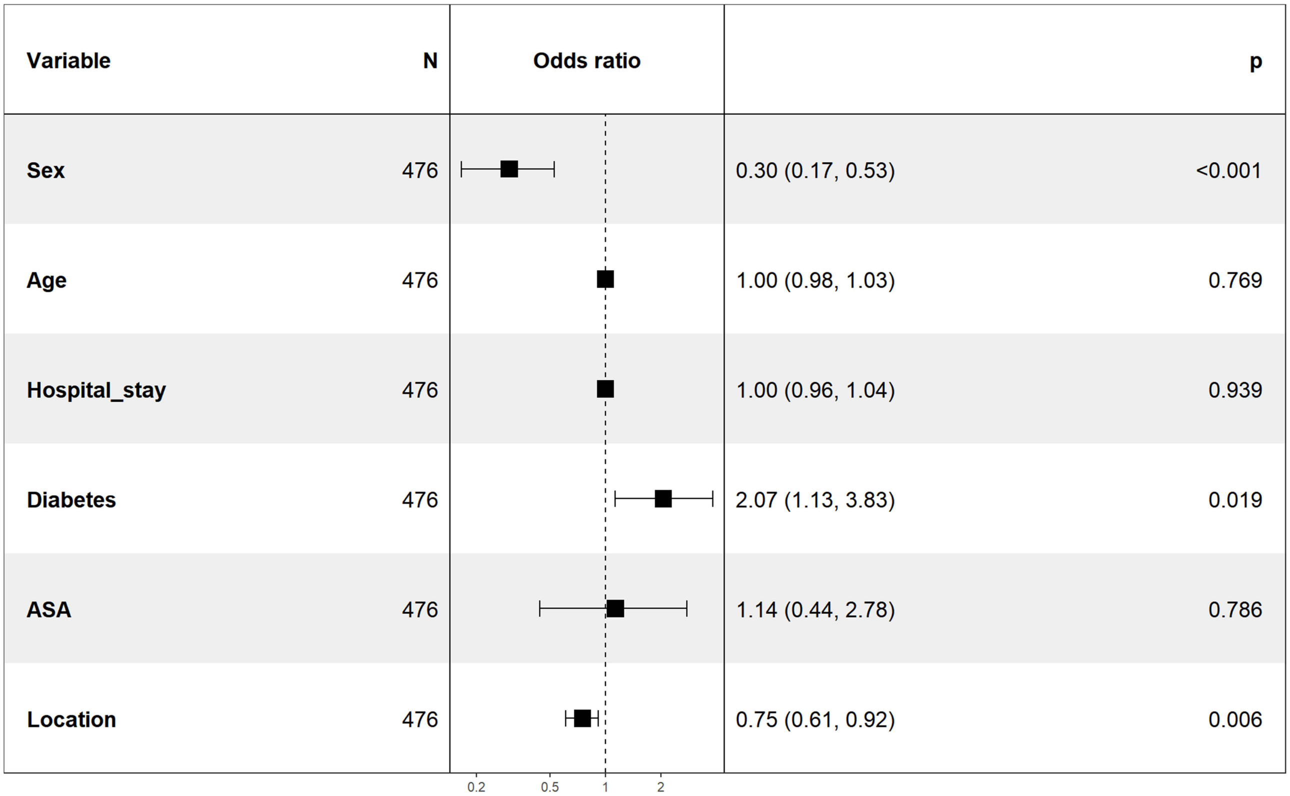

Figure 1 Multiple logistic regression models based on 476 patients underwent video-assisted thoracoscopic surgery.

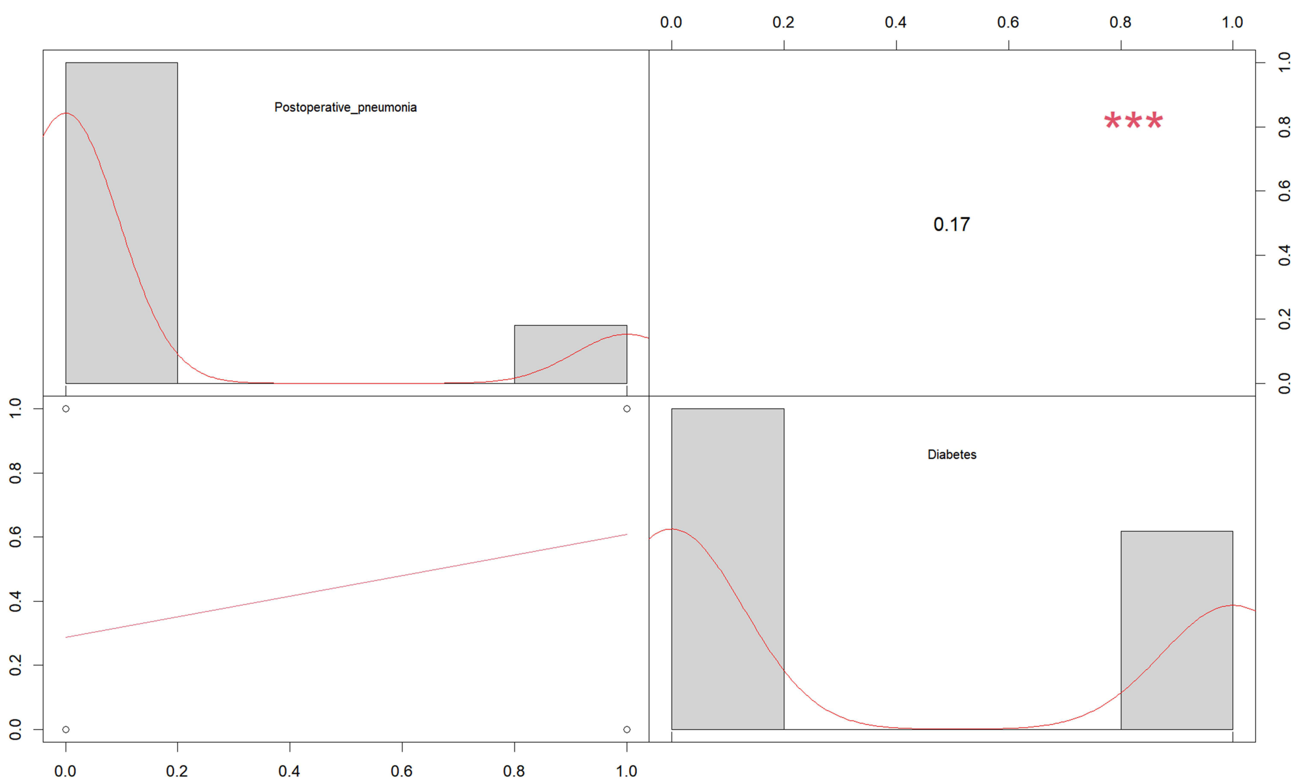

Figure 2 Correlation between diabetes and postoperative pneumonia. ***P<0.001.

We further investigated the risk factors associated with POP in patients with T2DM. In this study, 182 patients were diagnosed with T2DM. The incidence of POP was demonstrated more higher among male patients than female in T2DM populations (76.19% and 23.81%, p=0.006) (Table 3). The positive rate of P63 in patients with T2DM with POP was

Table 3 Clinical Characteristics of Included 182 Diabetes Patients

Characteristic	Postoperative Pneumonia		p value
N	No (n=140)	Yes (n=42)	
Age	64.46±7.84	65.12±6.50	0.619
Sex			**0.006**
Male	73 (52.14%)	32 (76.19%)	
Female	67 (47.86%)	10 (23.81%)	
BMI	24.25±3.17	24.06±2.85	0.730
Hospital stays	14.20±8.30	13.05±6.06	0.405
Tumor size			0.284
Hypertension	102 (72.86%)	27 (64.29%)	
No	38 (27.14%)	15 (35.71%)	
Yes			0.362
Anemia	137 (97.86%)	40 (95.24%)	
No	3 (2.14%)	2 (4.76%)	
Yes			0.339
Cardiovascular disease	137 (97.86%)	42 (100.00%)	
No	3 (2.14%)	0 (0.00%)	
Yes	15 (10.71%)	4 (9.52%)	
Transfusion			0.170
No	122 (87.14%)	33 (78.57%)	
RBC	18 (12.86%)	9 (21.43%)	
Autoblood			0.586
ASA			0.244
I	1 (0.71%)	1 (2.38%)	
II	121 (86.43%)	32 (76.19%)	
III	18 (12.86%)	9 (21.43%)	
TNM			0.740
Stage I	111 (79.29%)	34 (80.95%)	
Stage II	16 (11.43%)	4 (9.52%)	
Stage III	10 (7.14%)	4 (9.52%)	
Stage IV	3 (2.14%)	0 (0.00%)	

(*Continued*)

Table 3 (Continued).

Characteristic	Postoperative Pneumonia		p value
Pulmonary function			0.421
Normal	61 (43.57%)	20 (47.62%)	
Mild	59 (42.14%)	20 (47.62%)	
Moderate	19 (13.57%)	2 (4.76%)	
Severe	1 (0.71%)	0 (0.00%)	
Location			0.161
Lobi medius pulmonis	10 (7.14%)	8 (19.05%)	
Right lobi superior	44 (31.43%)	14 (33.33%)	
Right lobus inferior pulmonis	25 (17.86%)	8 (19.05%)	
Left lobi superior	33 (23.57%)	9 (21.43%)	
Left lobus inferior pulmonis	20 (14.29%)	2 (4.76%)	
other	8 (5.71%)	1 (2.38%)	
Histological_classification			0.390
Squamous carcinoma	21 (15.00%)	7 (16.67%)	
adenocarcinoma	113 (80.71%)	35 (83.33%)	
other	6 (4.29%)	0 (0.00%)	
P63			**0.029**
Negative	137 (97.86%)	38 (90.48%)	
Positive	3 (2.14%)	4 (9.52%)	
Lymphatic_invasion			0.156
Negative	278 (94.56%)	166 (91.21%)	
Positive	16 (5.44%)	16 (8.79%)	
Chemoradiotherapy			**0.027**
No	92 (65.71%)	29 (69.05%)	
Yes	48 (34.29%)	13 (30.95%)	

9.52%, which was higher than that of patients with T2DM without POP (P<0.001) (Table 3). Additionally, 34.29% of patients with T2DM without POP received chemoradiotherapy, surpass the patients with T2DM with POP (30.95%, P=0.027) (Table 3). Importantly, we evaluated the effect of preoperative blood glucose control on the occurrence of POP in patients with T2DM. We divided patients with T2DM into low-glucose group and high-glucose group according to the median preoperative blood glucose level. We found that POP was demonstrated more frequently among patients in high-glucose group than patients in low-glucose group (25.3% and 13.2%, p=0.039). Subsequently, we screened the independent risk indicators for predicating the probability of POP in patients with T2DM by using logistic analysis. The results demonstrated that sex, P63 and tumor location were involved in the occurrence of POP for patients with T2DM (Table 4). Importantly, sex and tumor location were independent predicators, after adjusting confounding variables (Figure 3).

Table 4 Univariate Analysis Results Related to Postoperative Pneumonia in 182 Diabetes Patients

Variables	Odds Ratio	95% CI	P value
Sex	0.34	0.15–0.72	**0.007**
Age	1.01	0.97–1.06	0.617
Hospital stays	0.98	0.93–1.03	0.404
Hypertension	1.49	0.71–3.08	0.285
Anemia	2.28	0.29–14.24	0.375
Cardiovascular disease	1.85	0.73–4.41	0.175
Transfusion	0.81	0.31–1.61	0.588
ASA	1.59	0.64–3.74	0.297
TNM	0.92	0.52–1.51	0.767
BMI	0.98	0.87–1.1	0.728
Pulmonary function	0.73	0.43–1.22	0.244
Location	0.72	0.54–0.94	**0.02**
Size	0.98	0.77–1.21	0.869
Histological classification	0.71	0.32–1.63	0.416
ckpan	0.92	0.34–2.21	0.859
TTF1	1.25	0.81–1.91	0.303
CK7	1.2	0.77–1.82	0.407
NapsinA	1.16	0.74–1.78	0.495
CK5_6	0.84	0.41–1.43	0.558
P40	1.05	0.55–1.81	0.871
CD56	2.28	0.29–14.24	0.375
Ki67	1.12	0.54–2.29	0.757
syn	0.81	0.06–2.93	0.793
P63	4.81	1.02–25.29	**0.046**
Lymphatic invasion	1.12	0.3–3.44	0.848
Chemoradiotherapy	0.86	0.4–1.78	0.688

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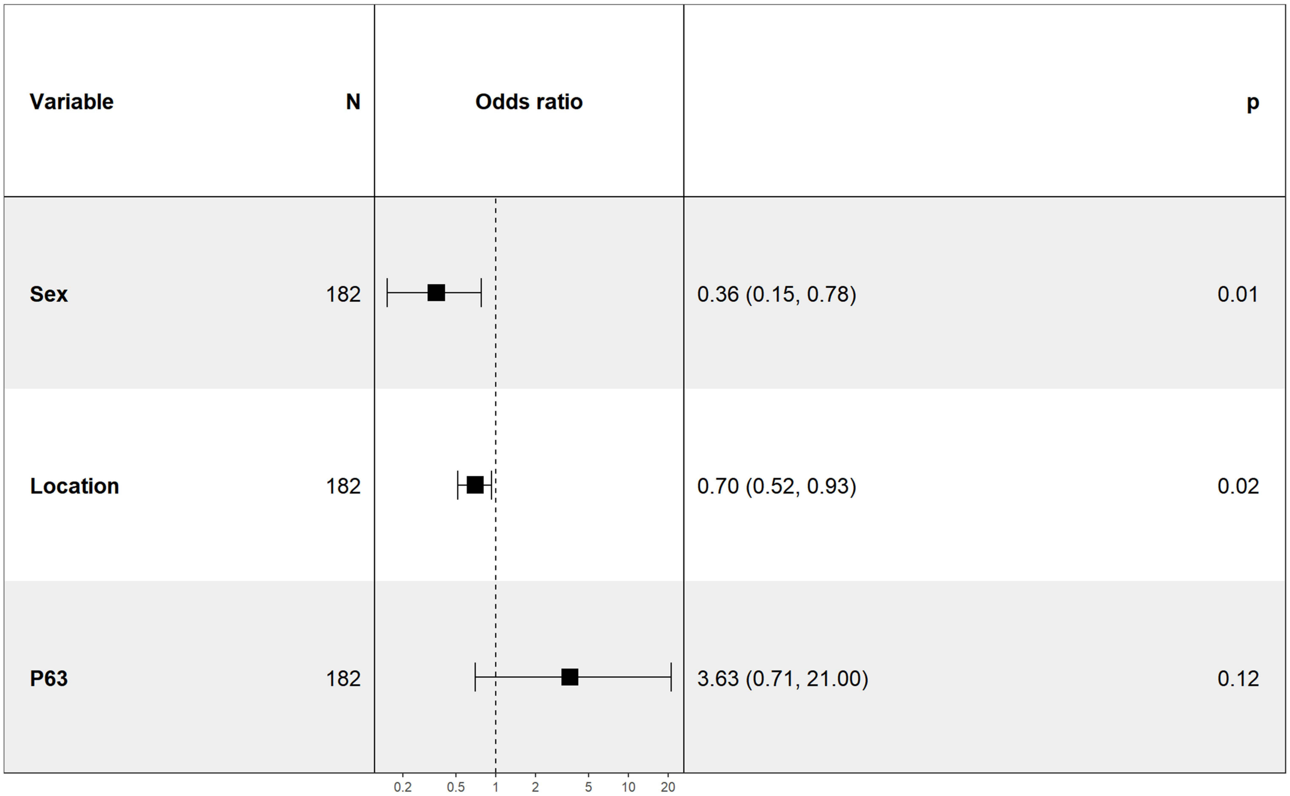

Figure 3 Multiple logistic regression models based on 182 type 2 diabetes patients underwent video-assisted thoracoscopic surgery.

Discussion

In this study, we found a higher prevalence of hospitalization due to POP in patients with T2DM undergoing VATS compared to patients without this comorbidity. Additionally, we demonstrated that a higher incidence rate of POP in patients with T2DM was observed among male patients, those with positive P53, and those who had not received chemoradiotherapy. Importantly, effective preoperative blood glucose control can significantly reduce the incidence rate of POP in patients with T2DM.

Numerous studies have reported an association between T2DM and the risk of POP. In an observational analysis involving patients who underwent total joint arthroplasty (including total hip arthroplasty and total knee arthroplasty), diabetes mellitus was identified as an independent risk factor for POP.[13] Additionally, a previous study using data from the American College of Surgeons National Surgical Quality Improvement Program found a greater risk of POP in patients with diabetes undergoing lumbar fusion surgeries compared to those without this condition.[12] One underlying explanation is that diabetes-induced immunosuppression may increase susceptibility to POP.[14] Following coronary artery bypass grafting, diabetes is associated with a 1.26-fold increased risk of POP.[15] In a retrospective study of 555 patients who underwent elective hepatectomy, Pessaux et al identified several independent risk factors for POP, including diabetes.[16] Importantly, they also provided potential explanations for the mechanisms that may promote the occurrence of POP, primarily due to significant changes in immune cell function, vascular permeability, and bacterial proliferation. In 2019, a study utilized the Spanish National Hospital Discharge Database to analyze the temporal trends, demographic and clinical characteristics, and hospital mortality rates of POP among patients with T2DM in Spain from 2001 to 2015. The study found that T2DM is significantly associated with an increased risk of POP, but it did not influence in-hospital mortality.[9] Subsequently, the researchers proposed several possible explanations for this association between T2DM and POP, including the rising complexity and rates of surgeries, as well as increases in mean age and the prevalence of concomitant conditions. In contrast, a Chinese retrospective study involving 43,174 inpatients who underwent surgery found that patients with T2DM are more susceptible to POP, and that the mortality rate significantly increases when patients with T2DM are concurrently diagnosed with POP.[10]

In our study, we observed a significant increase in the incidence of POP in patients with T2DM undergoing VATS after adjusting for potential confounding factors. Subsequently, we explored the underlying risk factors for POP in T2DM patients using logistic analysis and identified two independent risk factors: sex and tumor location. In a retrospective cohort study involving 1208 patients aged ≥ 65 years who underwent hip fracture surgery from 2005 to 2021, male sex (OR, 3.01; P = 0.017) was identified as a significant risk factor for postoperative aspiration pneumonia.[17] A previous study analyzing 1495 geriatric patients (>65 years) who underwent intertrochanteric fracture surgery from a prospective hip fracture database found that male sex (OR = 2.13; P = 0.017) was an independent risk factor for the incidence of POP.[18] Similarly, we observed a higher incidence of POP in male patients with T2DM compared to female patients (76.19% vs 23.81%). This phenomenon may be attributed to the fact that, when compared to women, a greater proportion of men are smokers, which adversely affects their respiratory health. Additionally, tumor location was also found to be correlated with POP, a relationship that has not been previously reported.

Our study has several limitations. First, it was a single-center, retrospective analysis. Multicenter studies should be conducted to further investigate the incidence of and risk factors for POP within 30 days or even 1 year following VATS to validate our findings. Second, some factors or diseases, such as Parkinson's disease and dementia, which could contribute to an increased incidence of POP, were not included in our study. Third, the severity scores of pneumonia were not assessed in our analysis.

In summary, patients with T2DM who underwent VATS exhibit a higher incidence of POP compared to those without this condition. Additionally, male gender and tumor location are independent risk factors for POP in patients with T2DM. Therefore, perioperative management should be improved and optimized for male patients with T2DM to enhance patient safety.

Data Confidentiality Statement

All of data involve in patients' privacy and thus the authors do not have permission to share data.

Ethical Approval

This study complied with the Declaration of Helsinki and was approved by Ethics Committee of the Second Affiliated Hospital of Fujian Medical University (approval number: 2023496). Informed consent was waived by the ethics committee of the Second Affiliated Hospital of Fujian Medical University.

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Disclosure

No potential conflict of interest was reported by the author(s).

References

1. Sung H, Ferlay J, Siegel RL, et al. Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin*. 2021;71(3):209–249. doi:10.3322/caac.21660
2. Choi JW, Jeong H, Ahn HJ, et al. The impact of pulmonary function tests on early postoperative complications in open lung resection surgery: an observational cohort study. *Sci Rep*. 2022;12(1):1277. doi:10.1038/s41598-022-05279-8

3. Chang S, Zhou K, Wang Y, Lai Y, Che G. Prognostic value of preoperative peak expiratory flow to predict postoperative pulmonary complications in surgical lung cancer patients. *Front Oncol*. 2021;11:782774. doi:10.3389/fonc.2021.782774
4. Song Y, Liu J, Lei M, et al. An external-validated algorithm to predict postoperative pneumonia among elderly patients with lung cancer after video-assisted thoracoscopic surgery. *Front Oncol*. 2021;11:777564. doi:10.3389/fonc.2021.777564
5. Motono N, Ishikawa M, Iwai S, Iijima Y, Usuda K, Uramoto H. Individualization of risk factors for postoperative complication after lung cancer surgery: a retrospective study. *BMC Surg*. 2021;21(1):311. doi:10.1186/s12893-021-01305-0
6. Yang R, Du C, Xu J, Yao L, Zhang S, Wu Y. Excessive intravenous crystalloid infusion after video-assisted thoracoscopic surgery lobectomy is associated with postoperative pneumonia. *J Cardiothorac Surg*. 2019;14(1):209. doi:10.1186/s13019-019-1024-6
7. Schussler O, Alifano M, Dermine H, et al. Postoperative pneumonia after major lung resection. *Am J Respir Crit Care Med*. 2006;173 (10):1161–1169. doi:10.1164/rccm.200510-1556OC
8. Fujishima S, Tsujimoto H, Nagata K, et al. Postoperative pneumonia causes the loss of skeletal muscle volume and poor prognosis in patients undergoing esophagectomy for esophageal cancer. *Gen Thorac Cardiovasc Surg*. 2021;69(1):84–90. doi:10.1007/s11748-020-01482-4
9. López-de-Andrés A, Perez-Farinos N, de Miguel-Díez J, et al. Type 2 diabetes and postoperative pneumonia: an observational, population-based study using the Spanish Hospital Discharge Database, 2001-2015. *PLoS One*. 2019;14(2):e0211230. doi:10.1371/journal.pone.0211230
10. Ma CM, Liu Q, Li ML, et al. The effects of type 2 diabetes and postoperative pneumonia on the mortality in inpatients with surgery. *Diabetes Metab Syndr Obes*. 2019;12:2507–2513. doi:10.2147/DMSO.S232039
11. Patterson DC, Shin JI, Andelman SM, Olujimi V, Parsons BO. Increased risk of 30-day postoperative complications for diabetic patients following open reduction-internal fixation of proximal humerus fractures: an analysis of 1391 patients from the American college of surgeons national surgical quality improvement program database. *JSES Open Access*. 2017;1(1):19–24. doi:10.1016/j.jses.2017.03.006
12. Bohl DD, Mayo BC, Massel DH, et al. Incidence and risk factors for pneumonia after posterior lumbar fusion procedures: an ACS-NSQIP study. *Spine*. 2016;41(12):1058–1063. doi:10.1097/BRS.0000000000001389
13. Bohl DD, Saltzman BM, Sershon RA, Darrith B, Okroj KT, Della Valle CJ. Incidence, risk factors, and clinical implications of pneumonia following total hip and knee arthroplasty. *J Arthrop*. 2017;32(6):1991–1995.e1991. doi:10.1016/j.arth.2017.01.004
14. Golinvaux NS, Varthi AG, Bohl DD, Basques BA, Grauer JN. Complication rates following elective lumbar fusion in patients with diabetes: insulin dependence makes the difference. *Spine*. 2014;39(21):1809–1816. doi:10.1097/BRS.0000000000000506
15. Strobel RJ, Liang Q, Zhang M, et al. A preoperative risk model for postoperative pneumonia after coronary artery bypass grafting. *Ann Thorac Surg*. 2016;102(4):1213–1219. doi:10.1016/j.athoracsur.2016.03.074
16. Pessaux P, van den Broek MA, Wu T, et al. Identification and validation of risk factors for postoperative infectious complications following hepatectomy. *J Gastrointest Surg*. 2013;17(11):1907–1916. doi:10.1007/s11605-013-2226-1
17. Ahn J, Chang JS, Kim JW. Postoperative pneumonia and aspiration pneumonia following elderly hip fractures. *J Nutr Health Aging*. 2022;26 (7):732–738. doi:10.1007/s12603-022-1821-9
18. Zhao K, Zhang J, Li J, et al. In-hospital postoperative pneumonia following geriatric intertrochanteric fracture surgery: incidence and risk factors. *Clin Interv Aging*. 2020;15:1599–1609. doi:10.2147/CIA.S268118