Risk Management and Healthcare Policy

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ORIGINAL RESEARCH

Bronchial Blockers versus Double-Lumen Endotracheal Tubes: Impact on Postoperative Pneumonia in Lung Cancer Patients Undergoing Video-Assisted Thoracoscopic Surgery – A Propensity Score-Matched Study

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Purpose: To compare the differential effects of bronchial blockers (BBs) versus double-lumen endotracheal tubes (DLETs) on postoperative pulmonary complications (PPCs) in patients undergoing video-assisted thoracoscopic surgery (VATS) for lung cancer.

Patients and Methods: This retrospective cohort study analyzed patients undergoing VATS requiring one-lung ventilation under general anesthesia from April 2023 to August 2024. Lung isolation was achieved using either BBs with single-lumen endotracheal tubes or DLETs. Propensity score matching was implemented to mitigate differences in patients' baseline characteristics. The primary outcome was the incidence of PPCs during hospitalization.

Results: Propensity score matching resulted in 152 matched pairs of patients in the BB and DLET groups. The incidence rates of PPCs (6.6% vs 16.4%; $P = 0.007$) and pneumonia (3.9% vs 11.8%; $P = 0.011$) during hospitalization were significantly lower in the BB group than in the DLET group. Average oxygen saturation ($P = 0.024$), end-tidal carbon dioxide ($P = 0.009$), fraction of inspired oxygen ($P = 0.010$), and respiratory rate ($P < 0.001$) were significantly higher in the BB group. Mechanical ventilation parameters, including average peak airway pressure ($P < 0.001$), mean airway pressure ($P < 0.001$), and tidal volume ($P = 0.003$), were significantly lower in the BB group.

Conclusion: Compared with patients intubated using a DLET, patients with lung cancer undergoing VATS and intubated using a BB experienced a lower incidence of PPCs.

Keywords: bronchial blocker, double-lumen endotracheal tube, lung cancer, video-assisted thoracoscopic surgery, postoperative pulmonary complication

Introduction

Lung cancer was the most frequently diagnosed malignancy worldwide in 2022, representing 12.4% of all new malignancies annually. As the leading contributor to global cancer mortality, lung cancer accounts for 1.8 million deaths per year, imposing a substantial socioeconomic burden on healthcare systems.[1] Surgical resection, usually via lobectomy, remains the primary curative treatment for early-stage non-small cell lung cancer.[2] Postoperative pulmonary complications (PPCs), driven by surgery-related impairment of respiratory function, ischemia–reperfusion injury, and the use of one-lung ventilation (OLV), continue to dominate surgical morbidity and mortality profiles.[3] These complications are clinically consequential, correlating with prolonged hospital stay, elevated healthcare expenditure, and increased

Received: 20 February 2025
Accepted: 23 June 2025
Published: 28 June 2025

mortality.[4–6] While the advent of video-assisted thoracoscopic surgery (VATS) has reduced the incidence of complications, PPCs remain a critical determinant of postoperative outcomes in patients with lung cancer.[7–9]

OLV is typically established using a double-lumen endotracheal tube (DLET) or by blocking a mainstem bronchus to allow lung collapse distal to the occlusion.[10,11] While DLET remains the conventional approach, bronchial blockers (BBs) are clinically preferred for patients with an anticipated difficult airway.[12] Emerging evidence suggests that BBs may confer advantages over DLETs, including a reduced incidence of airway injury and decreased sore throat and hoarseness after surgery.[13–15] Notably, in patients requiring sustained mechanical ventilation after surgery, the combined use of a single-lumen endotracheal tube (SLET) with a BB avoids emergent tube exchange procedures, substantially mitigating the risk of iatrogenic airway trauma and potential loss of airway patency. Existing comparative studies between DLET and BB have predominantly addressed technical considerations, including device placement and quality of lung isolation.[16,17] Limited studies have explored the PPCs associated with these intubation strategies, and those that have evaluated this topic have demonstrated conflicting results.[18–21] Critically, only one study has specifically evaluated the VATS population. This unresolved clinical issue regarding the impact of intubation device selection on the incidence of PPCs following VATS represents a critical knowledge gap. This study aims to evaluate this understudied relationship in a cohort of surgically managed patients with lung cancer.

Materials and Methods

This retrospective study was conducted at Peking University Cancer Hospital and is registered in the Chinese Clinical Trial Registry (Registration number: ChiCTR2400089091). Ethical approval (2024YJZ90) was granted by the institutional review board prior to study commencement, and the requirement for written informed consent was waived by the ethics committee due to the retrospective study design. The study was conducted in compliance with the Declaration of Helsinki, and all data were anonymized and handled in strict confidence in accordance with the ethical principles of the Declaration of Helsinki. Consecutive patients with a potential diagnosis of lung cancer who underwent selective VATS requiring OLV under general anesthesia between April 2023 and August 2024 were eligible for inclusion. The exclusion criteria were 1) patients undergoing total pneumonectomy, sleeve resection, or simultaneous multi-lobar resection (>2 lobes); 2) those undergoing secondary thoracic surgery or who required conversion to open thoracotomy; 3) histological confirmation of benign pathology or small cell lung cancer; and 4) patients lacking postoperative arterial blood gas analysis results or with incomplete clinical records.

Anesthesia and Surgery

All anesthesia procedures were performed by a group of anesthesiologists specializing in thoracic surgery, each possessing a minimum of 5 years of clinical experience in advanced airway management during thoracic interventions. All patients underwent standard intraoperative monitoring, including electrocardiography, pulse oxygen saturation (SpO_2), invasive arterial pressure, and bispectral index. Following preoxygenation, induction of anesthesia was achieved using intravenous sufentanil or oxycodone with propofol and/or etomidate, combined with neuromuscular blocking agents (rocuronium or cisatracurium). Airway management was performed using a video laryngoscope with either a SLET (7.5/8.0 mm ID) and a 9-Fr BB (Tappa, Hangzhou, China) or a video DLET (32/35/37 Fr, Wellead Medical Co., Guangzhou, China). Device selection was at the clinician's discretion, and all participating anesthesiologists demonstrated dual proficiency in operating both devices according to standardized protocols. Bronchoscopic confirmation was mandatory for BB placement and was selectively performed for DLET positioning. Protective ventilation parameters were strictly protocolized. Volume-controlled mode was used with a tidal volume of 6–8 mL/kg (predicted body weight) during two-lung ventilation, which was reduced to 4–6 mL/kg during OLV. Positive end-expiratory pressure was set at 0–10 cmH_2O. The respiratory rate was set at 12–20 breaths/min to maintain a target end-tidal carbon dioxide ($EtCO_2$) of 30–40 mmHg. Maintenance of anesthesia was achieved using sevoflurane, remifentanil infusion, and intermittent administration of a neuromuscular blocking agent, with optional propofol supplementation. Intercostal nerve blockade was determined by the surgical/anesthesia teams. Thoracic procedures included lobectomy, segmentectomy, wedge resection, or some combination of the three, which were performed by designated thoracic surgeons from the same general thoracic ward. Postoperatively, BBs were removed prior to post-anesthesia care unit (PACU) transfer.

Neuromuscular reversal with neostigmine and extubation followed complete recovery. Postoperative arterial blood gas analysis was routinely obtained in the PACU after extubation, and patient-controlled opioid analgesia was implemented. The patients were discharged to thoracic wards unless they required intensive care unit admission. Standard postoperative care was provided by physicians and nurses from the same ward.

Measurements

Patient demographics, preoperative assessments, surgical documentation, postoperative laboratory analyses, and chest radiographic findings were retrieved from the electronic medical records system. Intraoperative vital signs and mechanical ventilation parameters, along with post-extubation arterial blood gas measurements obtained in the PACU, were collected from the anesthesia records system. PPC data were identified through chart review within the electronic medical records. PPCs were defined as a composite of major respiratory events, including pneumonia, bronchospasm, respiratory failure, acute respiratory distress syndrome, bronchoscopy-required pulmonary atelectasis or secretion retention, thoracentesis-necessitated pleural effusion or pneumothorax, and delayed chest tube removal (>7 days postoperatively). Pneumonia diagnosis required radiographic evidence of new or progressive infiltrates accompanied by at least one clinical criterion of fever (>38°C), leukocyte count abnormality (leukocytosis or leukopenia), or purulent airway secretions. Respiratory failure was defined as postoperative hypoxemia (partial pressure of oxygen [PaO_2] <60 mmHg or SpO_2 <90%) that persisted despite oxygen supplementation, or the requirement for non-invasive/invasive mechanical ventilation support. Acute respiratory distress syndrome was diagnosed according to the Berlin criteria.[22]

In accordance with the pathophysiological rationale that ventilation-associated PPCs primarily manifest during the immediate postoperative period, the primary endpoint was defined as the incidence of PPCs during hospitalization. The secondary outcomes comprised radiographic alterations in pulmonary infiltration, atelectasis, pleural effusion, or pneumothorax observed on postoperative chest imaging (with pleural effusion and pneumothorax classified as PPCs when detected in the dependent lung, accounting for surgical influences); intraoperative mechanical ventilation parameters, such as peak airway pressure; occurrence of intraoperative hypoxemia (defined as PaO_2 <60 mmHg or SpO_2 <92%); postoperative PaO_2; and duration of hospitalization.

Sample Size

A previous study reported a pulmonary infection incidence of 3% in the BB group versus 15% in the DLET group.[23] On the basis of this information, we performed a power analysis using Power Analysis and Sample Size software, version 11.0 (NCSS, Kaysville, UT, US). The two-tailed Z-test with unpooled variance indicated that a sample size of 118 patients per group would yield 90% statistical power at a significance level of 5%.

Statistical Analysis

Statistical analyses were conducted using SPSS software, version 27.0 (IBM Corp., Armonk, NY, US). Continuous data were presented as the mean with standard deviation or median with interquartile range following distribution normality assessment. Intergroup comparisons were performed using the Student's *t*-test for parametric data and the Mann–Whitney *U*-test for non-parametric data. Categorical variables were summarized as frequency (%) and were analyzed using Pearson's chi-square test or Fisher's exact test, as appropriate. Propensity score matching (PSM; 1:1 nearest-neighbor) was implemented to mitigate confounding between the BB and DLET groups. Variables demonstrating $P < 0.1$ in the univariate analysis, as well as established PPC predictors, including age, sex, American Society of Anesthesiologists classification, body mass index, pulmonary comorbidities, diabetes mellitus, smoking status, intraoperative fluid balance, surgical duration, and operative blood loss, were included for propensity score calculation.[24–28] Matching was performed using a logistic regression model. A logistic regression model generated a caliper width constrained to 0.2 of the logit score. Post-matching balance was verified by standardized mean differences of <0.1 across all covariates. All statistical analyses were two-tailed, with statistical significance defined as $P < 0.05$.

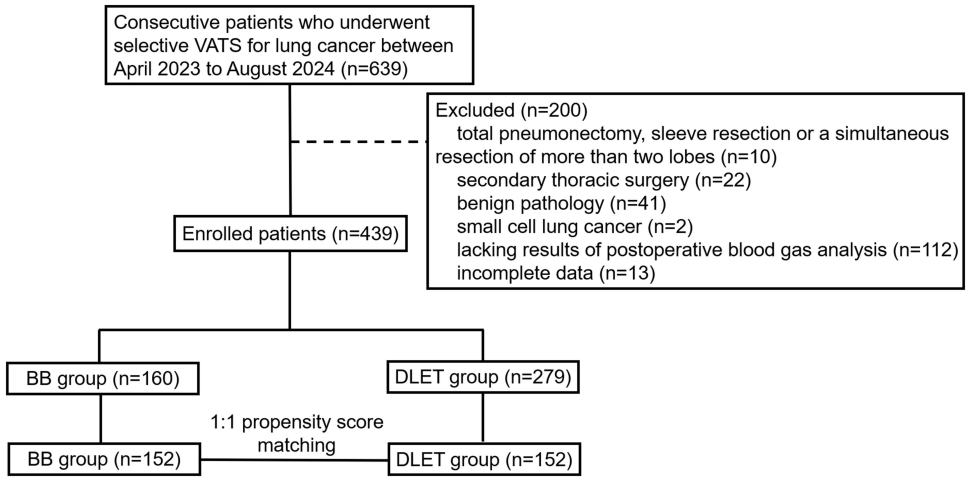

Figure 1 STROBE flow chart.
Abbreviations: VATS, video-assisted thoracoscopic surgery; BB, bronchial blocker; DLET, double-lumen endotracheal tube.

Results

During the study period, 639 patients underwent eligibility screening, with 439 meeting the inclusion criteria (Figure 1). The cohort comprised 160 patients who underwent SLET intubation with a BB and 279 who received DLET intubation. Notably, three patients failed DLET intubation and required conversion to BB intubation; these patients were subsequently allocated to the BB group. PSM yielded 152 pairs for the comparative analysis. As detailed in Table 1, the

Table 1 Patients' Demographic and Clinical Characteristics Before and After Propensity Score Matching

Characteristics	Before Matching (n=439)			After Matching (n=304)		
	BB Group (n=160)	DLET Group (n=279)	*P* value	BB Group (n=152)	DLET Group (n=152)	*P* value
Age, y	62.0 (57.0–69.0)	62.0 (55.0–67.0)	0.327	62.0 (57.0–69.0)	64.0 (56.0–69.0)	0.799
Sex			0.069			0.812
Male	58 (36.3%)	126 (45.2%)		55 (36.2%)	57 (37.5%)	
Female	102 (63.7%)	153 (54.8%)		95 (61.7%)	96 (62.3%)	
Height, cm	160.0 (155.0–167.0)	162.0 (156.0–167.0)	0.288	160.0 (155.3–167.0)	161.0 (155.0–167.0)	0.997
Weight, kg	64.5 (56.0–71.0)	64.0 (58.0–71.0)	0.493	64.0 (56.0–71.0)	64.0 (58.0–70.0)	0.814
BMI, kg/m^2	24.4 (22.5–27.2)	24.7 (22.6–27.0)	0.826	24.3 (22.5–27.0)	24.6 (22.7–26.7)	0.909
Pulmonary comorbidities	11 (6.9%)	28 (10.0%)	0.263	11 (7.2%)	7 (4.6%)	0.331
COPD	8 (5.0%)	13 (4.7%)	0.872	8 (5.3%)	2 (1.3%)	0.054
Diabetes mellitus	26 (16.3%)	47 (16.8%)	0.872	26 (17.1%)	24 (15.8%)	0.757
Anemia	3 (1.9%)	17 (6.1%)	0.041	3 (2.0%)	3 (2.0%)	0.658
Smoking history						
Past smoker	49 (30.6%)	96 (34.4%)	0.417	47 (30.9%)	47 (30.9%)	1.000
Current smoker	2 (1.3%)	9 (3.2%)	0.338	2 (1.3%)	3 (2.0%)	0.500
Alcohol abuse	19 (11.9%)	42 (15.1%)	0.354	17 (11.2%)	17 (11.2%)	1.000
Albumin, g/L	45.6 (44.0–47.0)	45.6 (43.8–47.3)	0.643	45.6 (43.9–47.2)	45.8 (44.0–47.3)	0.821
ASA classification			0.369			0.840
I/II	144 (90.0%)	258 (92.5%)		139 (91.4%)	138 (90.8%)	
III/IV	16 (10.0%)	21 (7.5%)		13 (8.6%)	14 (9.2%)	
Neoadjuvant therapy						
Chemotherapy	7 (4.4%)	42 (15.1%)	<0.001	7 (4.6%)	9 (5.9%)	0.607
Immunotherapy	5 (3.1%)	24 (8.6%)	0.026	5 (3.3%)	5 (3.3%)	1.000

(*Continued*)

Table 1 (Continued).

Characteristics	Before Matching (n=439)			After Matching (n=304)		
	BB Group (n=160)	DLET Group (n=279)	*P* value	BB Group (n=152)	DLET Group (n=152)	*P* value
Combined nerve block	17 (10.6%)	65 (23.3%)	0.001	17 (11.2%)	16 (10.5%)	0.854
Intraoperative fluid intake, mL	1400.0 (1200.0–1500.0)	1350.0 (1200.0–1500.0)	0.656	1400.0 (1200.0–1400.0)	1400.0 (1200.0–1587.5)	0.465
Blood loss, mL	30.0 (30.0–50.0)	30.0 (30.0–50.0)	0.778	30.0 (30.0–50.0)	30.0 (30.0–50.0)	0.681
Length of surgery, min	105.0 (74.0–133.0)	110.0 (74.0–145.0)	0.075	105.0 (74.0–130.0)	103.5 (72.5–140.0)	0.516
Length of anesthesia, min	155.0 (125.0–189.3)	160.0 (129.0–195.0)	0.092	155.0 (125.0–186.5)	155.0 (125.5–193.8)	0.446
Type of surgery			0.278			0.097
Lobectomy	75 (46.9%)	137 (49.1%)		70 (46.1%)	65 (42.8%)	
Segmentectomy	49 (30.6%)	67 (24.0%)		48 (31.6%)	37 (24.3%)	
Wedge resection	36 (22.5%)	75 (26.9%)		34 (22.4%)	50 (32.9%)	
Pathology			0.868			0.603
Adenocarcinoma	144 (90.0%)	253 (90.7%)		136 (89.5%)	139 (91.4%)	
SCC	11 (6.9%)	16 (5.7%)		11 (7.2%)	7 (4.6%)	
Other malignancy	5 (3.1%)	10 (3.6%)		5 (3.3%)	6 (3.9%)	

Note: Data are shown as the median (interquartile range) or frequency (%).
Abbreviations: BB, bronchial blocker; DLET, double-lumen endotracheal tube; BMI, body mass index; COPD, chronic obstructive pulmonary disease; ASA, American Society of Anesthesiologists; SCC, squamous cell carcinoma.

baseline characteristics of the groups demonstrated significant differences pre-matching, including preoperative anemia, neoadjuvant therapy (chemotherapy/immunotherapy), and combined nerve block. These intergroup disparities were effectively balanced post-PSM.

The overall incidence of PPCs during hospitalization was 11.5%. After PSM, the incidence of PPCs was 6.6% in the BB group and 16.4% in the DLET group ($P = 0.007$; Table 2 and Figure 2). The BB group exhibited a significantly lower incidence of pneumonia (3.9% vs 11.8%; $P = 0.011$) and lower rates of radiographic infiltration postoperatively (12.5% vs 21.1%; $P = 0.046$) than the DLET group. The intraoperative and post-anesthesia data are shown in Table 3. On average, the BB group had significantly higher SpO_2, $EtCO_2$, fraction of inspired oxygen (FiO_2), and respiratory rate than the DLET group. The BB group also demonstrated lower peak airway pressure, mean airway pressure, and tidal volume

Table 2 Comparative Assessment of Postoperative Pulmonary Complications and Radiographic Alterations

Variables	BB Group (n=152)	DLET Group (n=152)	*P* value
PPCs	10 (6.6%)	25 (16.4%)	0.007
Pneumonia	6 (3.9%)	18 (11.8%)	0.011
Bronchospasm	0 (0.0%)	1 (0.7%)	0.500
Requirement of thoracentesis	0 (0.0%)	2 (1.3%)	0.249
Requirement of bronchoscopic treatment	2 (1.3%)	7 (4.6%)	0.087
Delayed drainage removal (>7 days)	2 (1.3%)	6 (3.9%)	0.141
Changes on chest radiographs			
Infiltration	19 (12.5%)	32 (21.1%)	0.046
Atelectasis	53 (34.9%)	49 (32.2%)	0.627
Pleural effusion	19 (12.5%)	25 (16.4%)	0.328
Pneumothorax	1 (0.7%)	0 (0.0%)	0.500

Note: Data are shown as frequency (%).
Abbreviations: BB, bronchial blocker; DLET, double-lumen endotracheal tube; PPC, postoperative pulmonary complication.

https://doi.org/10.2147/RMHP.S521884

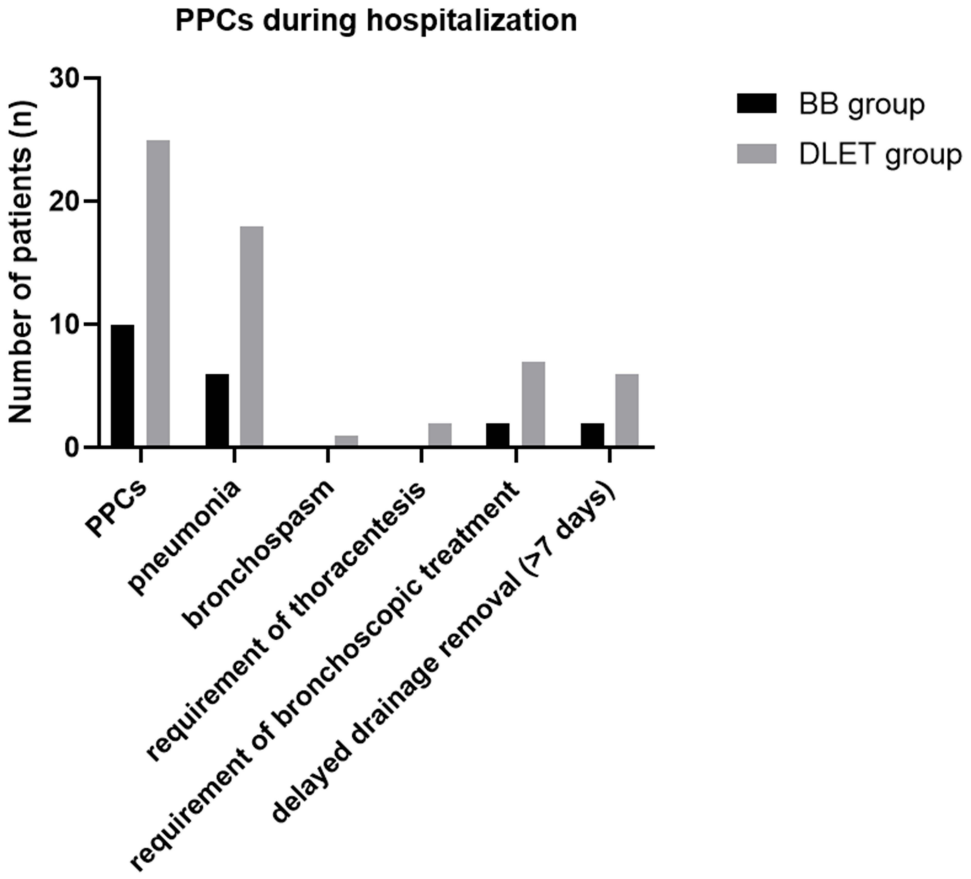

Figure 2 Major PPCs during hospitalization in the BB versus DLET groups.
Abbreviations: BB, bronchial blocker; DLET, double-lumen endotracheal tube; PPC, postoperative pulmonary complication.

than the DLET group. The incidence of intraoperative hypoxia did not differ significantly between the BB and DLET groups (6.6% vs 9.2%, respectively; $P = 0.395$). The incidence of non-pulmonary complications did not differ significantly between the two groups (0.7% vs 3.9%, respectively; $P = 0.060$). Both groups shared equivalent median hospital stays (5.0 [4.3–6.0] days in the BB group vs 5.0 [5.0–6.8] days in the DLET group; $P = 0.265$).

Table 3 Intraoperative Data Including Mechanical Ventilation Parameters and Post-Anesthesia Blood Gas Analysis

Variables	BB Group (n=152)	DLET Group (n=152)	*Z*	*P* value
Average SpO_2	99.5 (98.5–100.0)	99.0 (98.0–99.8)	−2.258	0.024
Average $EtCO_2$	33.5 (31.3–36.0)	32.5 (30.7–35.0)	−2.614	0.009
Average FiO_2	93.0 (92.0–95.3)	92.3 (82.7–95.0)	−2.579	0.010
Average respiratory rate	17.4 (15.0–18.0)	14.5 (13.0–16.7)	−7.010	<0.001
Average peak airway pressure	19.0 (17.0–21.5)	21.3 (19.5–24.2)	−6.256	<0.001
Average mean airway pressure	8.5 (7.7–9.5)	9.5 (8.7–10.3)	−5.306	<0.001
Average tidal volume	348.6 (329.3–376.9)	365.0 (336.4–405.0)	−2.931	0.003
Post-anesthesia PaO_2	163.0 (124.3–202.8)	156.0 (106.0–201.5)	−1.389	0.165
Post-anesthesia $PaCO_2$	48.5 (44.0–52.0)	49.0 (45.0–53.0)	−1.434	0.152

Notes: Data are shown as the median (interquartile range). SpO_2, $EtCO_2$, FiO_2, and mechanical ventilation parameters were collected at standardized intervals: 10 minutes post-incision, hourly assessments, and 20 minutes pre-closure.
Abbreviations: BB, bronchial blocker; DLET, double-lumen endotracheal tube; SpO_2, pulse oxygen saturation; $EtCO_2$, end-tidal carbon dioxide; FiO_2, fraction of inspired oxygen; PaO_2, partial pressure of oxygen; $PaCO_2$, partial pressure of carbon dioxide.

Discussion

In the present study, the overall incidence of PPCs following VATS was 11.5%, with rates of 6.6% in the BB group and 16.4% in the DLET group. Previous studies have reported PPC incidences ranging from 7.4% to 30% after VATS.[7–9,24] This variation in the PPC rates may be attributed to divergent surgical techniques and variable PPC diagnostic criteria. Our analysis focused exclusively on patients undergoing VATS lobectomy, segmentectomy, or wedge resection, excluding patients requiring intraoperative conversion to open thoracotomy. Owing to the retrospective study design, PPCs were evaluated during hospitalization, with radiographic findings only incorporated if accompanied by clinically significant manifestations necessitating intervention. Furthermore, the study utilized a contemporary cohort spanning 2 years, potentially enhancing the relevance of our findings to current clinical practice. These methodological considerations may collectively explain the comparatively lower incidence of PPCs in the present study.

Our analysis revealed a significantly lower incidence of PPCs in the BB group than in the DLET group following VATS, with pneumonia emerging as the most frequent PPC. Radiographic infiltration also demonstrated a lower frequency in the BB group. While limited comparative data exist regarding OLV device selection and PPCs, our findings support those of a retrospective study showing a reduced rate of composite PPCs and respiratory infections with BB use in patients undergoing lung cancer surgery, encompassing both open thoracotomy and VATS approaches.[20] Another randomized controlled trial (RCT) involving patients with thoracic tuberculosis reported fewer cases of pulmonary infection in the BB group (3% vs 15%).[23] Contrastingly, a retrospective study using a population-based nationwide insurance database in Taiwan associated BBs with higher pulmonary complication-related readmission rates in the first postoperative year compared with DLETs.[21] However, this study encompassed heterogeneous cardiac/thoracic procedures, and the patients had undergone surgery a decade prior. Despite this, their analysis lacked adjustments for PPC-specific confounders. Similarly, a PSM cohort study observed greater radiographic infiltration in the BB group. However, analyses of pneumonia/PPCs and their clinically significant predictors, including intraoperative mechanical ventilation parameters such as airway pressure and tidal volume, were not incorporated in the study owing to data recording constraints.[19] The investigated cohort included patients undergoing open, thoracoscopic, and robotic surgical approaches. The tidal volume implemented in their protocol exceeded the lower tidal volume (4–6 mL/kg predicted body weight during OLV) used in the protective lung ventilation protocols that are currently standard at our institution. Furthermore, while the authors utilized PSM analysis to balance baseline characteristics between the groups, their model did not account for established predictors of PPCs. Notably, 90% of the patients underwent DLET intubation, introducing substantial operator bias, while undocumented intraoperative technique/surgical conversions further limited the study's validity. These methodological variations may explain the divergent findings regarding radiographic pulmonary infiltrates observed on postoperative chest radiographs compared with our institutional experience. Crucially, prior investigations have predominantly combined VATS and thoracotomy cohorts, unlike our VATS-exclusive design. The sole comparable VATS-focused study detected no difference in the rate of pneumonia between groups intubated with a laryngeal mask combined with a BB, a tracheal tube combined with a BB, and a DLET, yet its underpowered sample size (n=56 per group) and exclusion of other major PPCs diminished the generalizability of the results.[18] These discrepancies highlight the need for multicenter trials controlling for the surgical approach and intraoperative variables to resolve conflicting evidence. Our study advances this discourse through contemporary VATS-specific data and comprehensive PPC assessment, though large-scale validation remains imperative.

We propose several potential explanations for the observed findings. First, the distinct physical characteristics between BBs and DLETs result in different bronchial stimulation patterns. Notably, BBs allow for timely removal from the SLET upon cessation of the requirement for OLV, whereas DLETs maintain bronchial contact even after cuff deflation. Our intraoperative analysis revealed significantly lower airway pressure in the BB group than in the DLET group, consistent with the findings of an RCT involving patients undergoing thoracic surgery for tuberculosis.[23] This pressure differential may be attributed to the larger inner diameter of SLETs used with BBs, which reduces airway resistance and pressure compared with narrower DLET lumens.[29] The prevalent use of 35-Fr video DLETs in our study reflects both the anatomical considerations that airway dimensions are narrower in Chinese patients[30] and the inherent characteristic of a larger outer diameter of video-assisted DLETs. These observations align with established evidence

linking elevated airway pressures during mechanical ventilation to ventilator-induced lung damage and PPCs.[31] Furthermore, the BB group demonstrated reduced tidal volume, a parameter strongly associated with pulmonary protection. Evidence suggests that tidal volume reduction during OLV attenuates epithelial damage and proinflammatory responses, potentially reducing the risk of acute lung injury.[32,33] Recent data from major lung resection cases further support the correlation between low tidal volume and the decreased incidence of acute respiratory distress syndrome,[34] reinforcing its role in protective ventilation strategies.[35,36] The concordance between these ventilator parameters and reduced postoperative radiographic infiltrations in the BB group strengthens our mechanistic interpretation. While these findings suggest physiological advantages of BBs in terms of reducing PPCs, the exact mechanisms warrant further elucidation. Notably, despite demonstrating lower rates of PPCs, the BB group showed a comparable hospitalization duration to the DLET group, which is consistent with several previous investigations.[18,19] The potential impact of BB utilization on short- and long-term outcomes in patients undergoing VATS for lung cancer remains an important area for prospective investigation.

A large-scale observational study involving 2127 patients undergoing OLV for thoracic procedures revealed a 20% incidence of desaturation in the DLET group.[37] The authors proposed that BB utilization potentially reduced desaturation episodes. In addition, they stated that the use of BBs may allow more rapid recognition of dislocation and subsequent corrective adjustments that may prevent ventilation inadequacy and mitigate hypoxic events. These observations are consistent with a recent meta-analysis demonstrating a significantly elevated risk of hypoxemia associated with DLETs compared with BBs.[38] Contrary to previous findings, our results demonstrated comparable intraoperative hypoxia episodes between the BB and DLET groups (6.6% vs 9.2%, respectively). While a statistically significant difference emerged in intraoperative oxygen saturation (BB: 99.5% vs DLET: 99.0%), this 0.5% SpO_2 discrepancy lacks clinical relevance. Notably, we identified elevated FiO_2 in the BB group, potentially attributable to anesthesiologists' proactive oxygenation strategies during the critical apneic phase of lung isolation initiation—a precautionary measure against rapid desaturation in BB-mediated lung collapse scenarios. Analysis of oxygenation parameters (SpO_2, FiO_2) and ventilation indicators ($EtCO_2$) suggests that the intergroup differences, though statistically present, do not translate to clinically meaningful disparities in respiratory management outcomes because they all maintained physiological acceptable thresholds in both groups.

The primary limitation of this study originates from its single-center, retrospective design. The retrospective design precluded documentation of intraoperative variables, such as lung isolation quality, OLV duration, and intraoperative airway management strategies. Potential selection bias may exist because the choice between BBs or DLETs was determined by the anesthesiologists' clinical judgment and surgical team preferences. While operator proficiency with these two devices naturally varies among practitioners, it should be noted that all participating anesthesiologists possessed substantial thoracic anesthesia experience and were proficient in both BB and DLET application. To address potential confounding factors, we implemented PSM analysis to account for measurable differences in baseline demographics, intraoperative parameters, and PPC-related variables, while unmeasured factors, such as the anesthesiologists' subjective device preferences, could persist. A second limitation arises from the temporal scope of PPC surveillance, which was confined to the in-hospital period spanning from anesthesia induction to fulfillment of the discharge criteria. This truncated observation window may have led to an underestimation of the postoperative complication rates, particularly for late-onset conditions post-discharge, such as pneumonia or pleural effusion. The potential for early discharge in enhanced recovery after surgery pathways further exacerbates this detection bias. To address this evidence gap, future prospective cohort studies incorporating 30-day post-discharge surveillance through structured telemedicine follow-ups or standardized readmission assessments are strongly recommended. Third, our analysis lacked critical mechanical ventilation parameters associated with PPC risk assessment, including positive end-expiratory pressure and driving pressure, because these parameters are not routinely captured by our electronic medical records system. Future studies incorporating rigorous adjustment for potential confounders (eg, physician experience and intraoperative parameters) are warranted, particularly multicenter prospective RCTs with sufficiently powered sample sizes to validate our findings and address the methodological limitations inherent to observational study designs. Extended postoperative surveillance periods are essential to improve the detection of late-onset complications. Finally, mechanistic studies

elucidating how different airway management devices influence the pathogenesis of PPCs would significantly advance our clinical understanding of this field.

Conclusion

Patients undergoing BB-assisted OLV during VATS for lung cancer demonstrated a lower incidence of PPCs, particularly pneumonia, than those managed with DLETs. These findings highlight the need for large-scale multicenter RCTs to validate these observations and elucidate the mechanisms underlying the differential effects of airway devices on respiratory outcomes. Future studies incorporating prolonged postoperative surveillance are warranted to enhance the detection of late-onset complications and optimize clinical risk stratification.

Abbreviations

PPC, postoperative pulmonary complication; OLV, one-lung ventilation; VATS, video-assisted thoracoscopic surgery; DLET, double-lumen endotracheal tube; BB, bronchial blocker; SLET, single-lumen endotracheal tube; SpO_2, pulse oxygen saturation; $EtCO_2$, end-tidal carbon dioxide; PACU, post-anesthesia care unit; PaO_2, partial pressure of oxygen; PSM, propensity score matching; FiO_2, fraction of inspired oxygen; RCT, randomized controlled trial.

Data Sharing Statement

The datasets used and analyzed in this study are available from the corresponding author upon reasonable request. De-identified research data containing primary outcome measures, the study protocol, and statistical analysis plans will be shared upon request with appropriate institutional review board approval as well as data use agreement. Data availability will be maintained for 24 months post-publication date as the data on the occurrence of postoperative complications may be updated over time. Formal data requests should be directed to maggitan@yeah.net. We may balance the potential benefits and risks for each request and then provide the data that could be shared.

Ethics Approval and Informed Consent

This study was approved by the Institutional Review Board at Peking University Cancer Hospital (approval number 2024YJZ90). The requirement for written informed consent was waived by the ethics committee because of the retrospective design of the research. The study was conducted in compliance with the Declaration of Helsinki. All research data collection and processing operations adhered to the principle of data minimization, with only essential dataset elements required for study endpoint evaluation being retained. Identifiable personal health information, including but not limited to names, medical record numbers, and contact details, were systematically replaced with de-identified numerical codes to ensure confidentiality.

Acknowledgment

We thank Emily Woodhouse, PhD, from Liwen Bianji (Edanz) (http://www.liwenbianji.cn) for editing the English text of a draft of this manuscript.

Funding

There is no funding to report.

Disclosure

The authors declare that they have no conflicts of interest in this work.

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