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INTRAOPERATIVE PROTECTIVE LUNG VENTILATION STRATEGIES AND POSTOPERATIVE PULMONARY COMPLICATIONS IN PATIENTS WITH COPD: A SYSTEMATIC REVIEW

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Abstract

Background: Patients with chronic obstructive pulmonary disease (COPD) undergoing elective surgery under general anesthesia carry an elevated risk of postoperative pulmonary complications (PPCs). Evidence on optimal intraoperative ventilation strategies in COPD-specific populations remains limited. Methods: A systematic review following PRISMA 2020 guidelines was conducted. PubMed, Scopus, and the Cochrane Library were searched from January 2015 to January 2025. Eligible study designs included randomized controlled trials, prospective cohort studies, and retrospective cohort studies reporting intraoperative ventilation strategies and postoperative pulmonary outcomes in adult COPD patients undergoing elective surgery. Methodological quality was assessed using the Newcastle-Ottawa Scale and Cochrane Risk of Bias 2.0 tool. Results: From 1,101 identified records, 220 duplicates were removed. After screening 881 records by title and abstract, 15 underwent full-text review and 4 studies were included, comprising 709 patients across 1 randomized controlled trial and 3 retrospective cohort studies. Low tidal volume ventilation reduced PPC risk (OR 0.50; p = 0.010). PEEP showed no significant protective effect. Dexmedetomidine reduced ICU admission rates (4% vs 28%; OR 9.33). One-lung ventilation exceeding 2 hours independently increased pulmonary infection risk. Ninety-day mortality was higher in patients who developed PPCs (5.8% vs 1.3%; p = 0.016). Conclusion: Low tidal volume ventilation reduces PPCs in COPD patients undergoing general anesthesia, whereas PEEP confers no significant benefit. Multimodal strategies including sugammadex reversal and intraoperative dexmedetomidine offer complementary risk reduction. Randomized trials in diverse COPD populations are needed.

Keyword: *chronic obstructive pulmonary disease, intraoperative ventilation, postoperative pulmonary complications, protective lung ventilation, tidal*

A. INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is one of the most prevalent non-communicable diseases globally, estimated to affect more than 213 million individuals and responsible for over 3 million deaths each year.[1,2] Global prevalence has increased substantially over the past three decades, with projections indicating that the number of

people living with COPD may approach 600 million by 2050.[3,4] COPD is confirmed by post-bronchodilator spirometry demonstrating a forced expiratory volume in one second to forced vital capacity ratio below 0.70, with severity classified across four stages according to the Global Initiative for Chronic Obstructive Lung Disease.[5]

Patients with COPD who undergo surgery under general anesthesia carry a substantially elevated risk of postoperative pulmonary complications (PPCs), including atelectasis, respiratory failure, pleural effusion, pulmonary infection, and bronchospasm.[6,7] Dynamic hyperinflation, expiratory flow limitation, and intrinsic positive end-expiratory pressure inherent to obstructive pathophysiology create significant challenges during intraoperative mechanical ventilation, predisposing these patients to ventilator-induced lung injury and impaired gas exchange.[8,9]

Intraoperative protective lung ventilation combining low tidal volume with positive end-expiratory pressure has been associated with reduced PPCs in general surgical populations, though the relative contributions of individual ventilation components remain debated.[10–12] Adjunctive strategies, including dexmedetomidine infusion during one-lung ventilation, have shown improvements in intraoperative oxygenation and lung mechanics, specifically in COPD patients, though evidence across surgical types and anesthetic contexts remains inconsistent and fragmented.[13–15] This systematic review aims to synthesize available evidence on intraoperative protective lung ventilation strategies and their association with postoperative pulmonary complications in adult COPD patients undergoing elective surgery.

B. RESEARCH METHOD

This systematic review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure transparency and methodological rigor throughout the review process.

Literature Search Strategy

A comprehensive literature search was carried out across three major electronic databases, PubMed, Scopus, and the Cochrane Library, covering publications from January 1, 2015, through January 1, 2025, to ensure the review reflects the most current available evidence. Search terms were structured using Boolean operators (AND/OR) and developed based on the PICOS framework (Population, Intervention, Comparator, Outcome, and Study Design), as detailed in Table 1. Two reviewers independently screened all retrieved records against predefined inclusion and exclusion criteria. Where disagreements arose, they were

resolved through discussion; when consensus could not be reached, a third independent reviewer was consulted to reach a final decision on study inclusion.

Table 1. Search Strategy

Database	Search Strategy	Hits
PubMed	(("Pulmonary Disease, Chronic Obstructive"[MeSH] OR "COPD"[tiab] OR "chronic obstructive pulmonary disease"[tiab] OR "chronic obstructive lung disease"[tiab] OR "emphysema"[tiab] OR "airflow obstruction"[tiab] OR "airflow limitation"[tiab] OR "obstructive lung"[tiab])) AND (("Respiration, Artificial"[MeSH] OR "Positive-Pressure Respiration"[MeSH] OR "protective ventilation"[tiab] OR "lung protective ventilation"[tiab] OR "lung-protective ventilation"[tiab] OR "protective lung ventilation"[tiab] OR "low tidal volume"[tiab] OR "tidal volume"[tiab] OR "PEEP"[tiab] OR "positive end-expiratory pressure"[tiab] OR "positive end expiratory pressure"[tiab] OR "driving pressure"[tiab] OR "intraoperative ventilation"[tiab] OR "mechanical ventilation"[tiab] OR "ventilatory strategy"[tiab] OR "ventilation strategy"[tiab] OR "recruitment maneuver"[tiab] OR "lung recruitment"[tiab] OR "pressure control"[tiab] OR "volume control"[tiab])) AND (("postoperative pulmonary complications"[tiab] OR "pulmonary complications"[tiab] OR "respiratory complications"[tiab] OR "postoperative complications"[MeSH] OR "Respiratory Insufficiency"[MeSH] OR "Pulmonary Atelectasis"[MeSH] OR "atelectasis"[tiab] OR "pneumonia"[tiab] OR "respiratory failure"[tiab] OR "pleural effusion"[tiab] OR "bronchospasm"[tiab] OR "hypoxemia"[tiab] OR "hypoxaemia"[tiab] OR "length of stay"[tiab] OR "mortality"[tiab])) AND (("intraoperative"[tiab] OR "intraoperative period"[MeSH] OR "perioperative"[tiab] OR "surgery"[tiab] OR "surgical"[tiab] OR "general anesthesia"[MeSH] OR "general anesthesia"[tiab] OR "general anaesthesia"[tiab] OR "anesthesia"[tiab] OR "anaesthesia"[tiab]))	210
Scopus	(TITLE-ABS-KEY ("chronic obstructive pulmonary disease" OR "COPD" OR "chronic obstructive lung disease" OR "emphysema" OR "airflow obstruction" OR "airflow limitation") AND TITLE-ABS-KEY ("protective lung ventilation" OR "lung-protective ventilation" OR "protective ventilation" OR "low tidal volume" OR "tidal volume" OR "positive end-expiratory pressure" OR "PEEP" OR "driving pressure" OR "intraoperative ventilation" OR "mechanical ventilation" OR "ventilation strategy" OR "lung recruitment" OR "recruitment maneuver") AND TITLE-ABS-KEY ("intraoperative" OR "general anesthesia" OR "general anaesthesia" OR "surgical" OR "surgery" OR "operative") AND TITLE-ABS-KEY ("postoperative pulmonary complications" OR "pulmonary complications" OR "respiratory complications" OR "pneumonia" OR "atelectasis" OR "respiratory failure" OR "pleural effusion" OR "bronchospasm" OR "length of stay" OR "hospital stay" OR "mortality" OR "postoperative mortality")) AND PUBYEAR > 2013 AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "re")) AND (LIMIT-TO (SUBJAREA , "MEDI")) AND (LIMIT-TO (EXACTKEYWORD , "Human")) AND (LIMIT-TO (LANGUAGE , "English"))	663
Cochrane Library	#1: COPD OR "chronic obstructive pulmonary disease" OR "chronic obstructive lung disease" OR emphysema OR "airflow obstruction" OR "airflow limitation." #2: "protective lung ventilation" OR "lung-protective ventilation" OR "protective ventilation" OR "low tidal volume" OR "tidal volume" OR "positive end-expiratory pressure" OR PEEP OR "driving pressure" OR "intraoperative ventilation" OR "mechanical ventilation" OR "ventilation strategy" OR "lung recruitment" OR "recruitment maneuver." #3: "intraoperative" OR "general anesthesia" OR "general anaesthesia" OR "surgical" OR "surgery" OR "operative." #4: "postoperative pulmonary complications" OR "pulmonary complications"	228

	OR "respiratory complications" OR "pneumonia" OR "atelectasis" OR "respiratory failure" OR "pleural effusion" OR "length of stay" OR "mortality." #5: #1 AND #2 AND #3 AND #4	

Table 2. PICOS Framework

	Inclusion	Exclusion
Population	Adult COPD patients (any GOLD stage, FEV_1/FVC <0.70), elective surgery under general anesthesia	Asthma, emergency surgery, severe cardiovascular or end-organ dysfunction, no preoperative spirometry
Intervention	Protective lung ventilation (low tidal volume ≤8 mL/kg IBW, PEEP, limited OLV duration), dexmedetomidine, restricted fluids, sugammadex reversal	—
Comparator	Conventional ventilation (TV >8 mL/kg IBW, no or minimal PEEP), placebo, anticholinesterase reversal, liberal fluid administration	—
Outcome	Postoperative pulmonary complications, pulmonary infection, respiratory failure, ICU admission, hospital stay, mortality	—
Study Design	RCT, prospective cohort, retrospective cohort; published within 10 years	Meta-analyses, systematic reviews, case reports, abstracts, protocols

Inclusion and Exclusion Criteria

All retrieved studies were evaluated against the PICOS criteria established for this review, with the full framework outlined in Table 2.

Population

Studies were eligible if they enrolled adult patients with a confirmed diagnosis of COPD across any GOLD severity stage, defined by a post-bronchodilator FEV_1/FVC ratio below 0.70 on preoperative spirometry. Eligible populations were scheduled for elective surgery under general anesthesia, including abdominal, thoracic, and spinal procedures. Studies were excluded if they enrolled patients with concurrent asthma, severe cardiovascular or end-organ dysfunction, absent preoperative pulmonary function testing, emergency surgical procedures, or anesthetic management without general anesthesia.

Intervention

Studies were eligible if they examined intraoperative protective lung ventilation strategies applied during general anesthesia in COPD patients, including low tidal volume ventilation at or below 8 mL/kg ideal body weight, positive end-expiratory pressure during one-lung or two-lung ventilation, and limitation of one-lung ventilation duration. Adjunctive interventions considered alongside ventilation parameters included intraoperative dexmedetomidine infusion, restricted crystalloid fluid administration, and sugammadex-mediated neuromuscular blockade reversal as components of a multimodal protective

anesthetic strategy.

Comparator

Studies were required to include a comparator group receiving conventional intraoperative ventilation, characterized by tidal volumes exceeding 8 mL/kg ideal body weight, absent or minimal positive end-expiratory pressure, or one-lung ventilation without duration restriction. Acceptable comparators also included intravenous placebo administration for pharmacological interventions, conventional anticholinesterase-based neuromuscular reversal, and liberal unrestricted intraoperative crystalloid fluid administration serving as the reference condition for fluid management strategies.

Outcome

Studies were included if they reported at least one measurable postoperative pulmonary outcome, including composite postoperative pulmonary complications such as respiratory failure, pleural effusion, atelectasis, respiratory infection, or bronchospasm within the postoperative period, postoperative pulmonary infection defined by clinical and radiological criteria, or postoperative respiratory failure defined by prolonged ventilator dependence, unplanned reintubation, or reduced arterial oxygen tension. Secondary outcomes of interest included intraoperative oxygenation indices, serum inflammatory markers, ICU admission, length of hospital stay, and mortality.

Study Design

Eligible study designs included randomized controlled trials, prospective cohort studies, and retrospective cohort studies published within the past 10 years. Studies were required to report original primary data with clearly defined COPD populations, documented intraoperative ventilation strategies, and quantifiable postoperative pulmonary outcomes. Excluded were meta-analyses, systematic reviews, case reports, editorials, conference abstracts, and study protocols. No language restrictions were applied during the literature search and screening process.

Data extraction

Two reviewers independently extracted data from each included study using a standardized extraction form. Extracted information included study author and year, journal, country, study design, sample size, patient population and COPD severity classification, surgery type, anesthesia type, intraoperative ventilation strategy and comparator, COPD diagnostic criteria, outcome assessment period, primary and secondary outcome rates, identified risk and protective factors with corresponding effect estimates, perioperative blood

gas and inflammatory markers, mortality, hospital stay, ICU admission, and statistical methods employed.

Quality of Studies Assessment

Methodological quality of included studies was assessed independently by two reviewers according to study design. Cohort studies were evaluated using the Newcastle-Ottawa Scale across nine domains encompassing selection, comparability, and outcome assessment, with scores ranging from 0 to 9 stars. The randomized controlled trial was assessed using the Cochrane Risk of Bias 2.0 tool across five domains. Overall, bias judgments were classified as low risk, moderate risk, or some concerns based on domain-level ratings.

C. RESULT AND DISCUSSION

Inclusion studies

The included studies can be seen in **Figure 1**. Our initial search strategy found a total of 1.101 studies from electronic databases. After removing 220 duplicates, 881 studies were evaluated based on their titles and abstracts, leaving 15 studies that were then screened through full text. Of these, nine studies were excluded because they did not meet the inclusion criteria. After going through a careful screening process, we obtained 4 studies that were considered eligible and included in this final analysis.

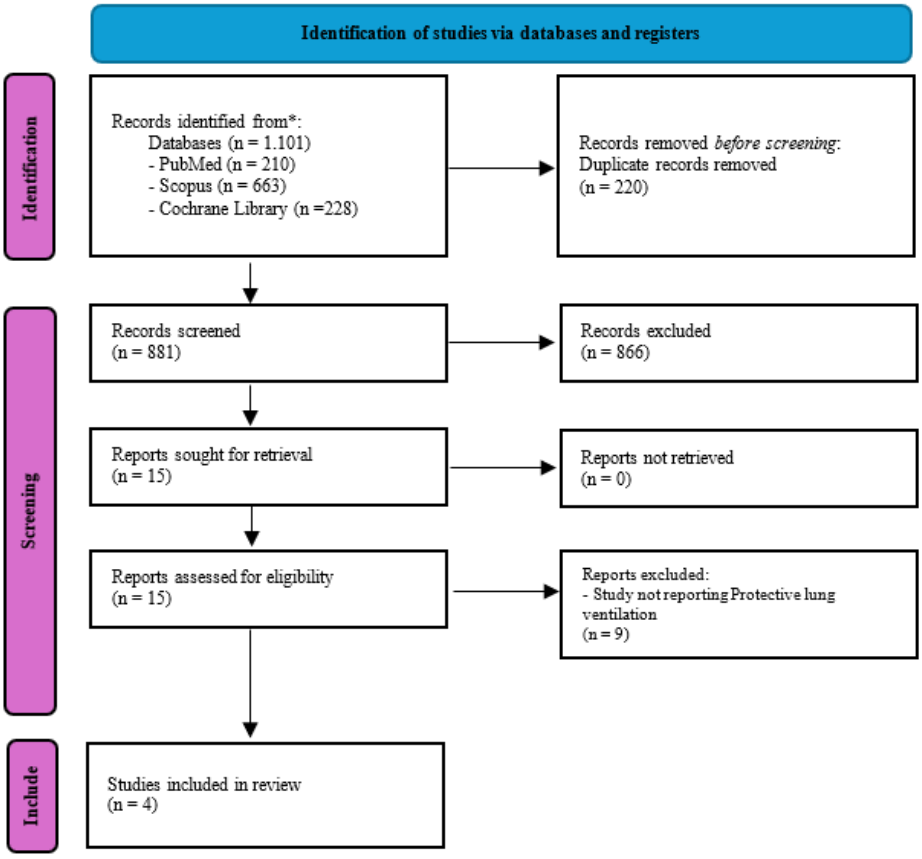

Figure 1. PRISMA 2020 Selection Study Process

Study Characteristics

Four studies published between 2016 and 2022 were included, comprising one randomized controlled trial and three retrospective cohort studies conducted in South Korea and China. Total enrolled patients across all studies numbered 709. Sample sizes ranged from 50 to 419 patients. Surgical procedures included abdominal, thoracic, and spinal surgery. All studies confirmed COPD diagnosis by spirometry using FEV_1/FVC ratio below 0.70. COPD severity ranged from mild to very severe across included populations. Detailed study characteristics are presented in Table 3.

Study Outcome

Postoperative Pulmonary Complications

Park et al. reported a composite postoperative pulmonary complication rate of 28.8%, with 121 of 419 COPD patients experiencing 200 events within 7 days postoperatively. The most frequent complications were pleural effusion at 20.2%, atelectasis at 15.0%, respiratory failure at 6.7%, respiratory infection at 3.8%, and bronchospasm at 1.9%. Lee et al. reported atelectasis in 0% of the dexmedetomidine group versus 16% in the control group, and focal

lung infiltration in 4% versus 8%, though neither difference reached statistical significance. Detailed outcomes are presented in Table 4.

Pulmonary Infection

Ji et al. reported an overall postoperative pulmonary infection rate of 16.7% across 120 patients with mild-to-moderate COPD undergoing single-lung ventilation. Patients with one-lung ventilation duration exceeding 2 hours had significantly higher infection rates compared to those ventilated for 1.0 to 2.0 hours across both mild and moderate severity subgroups. Multivariate logistic regression identified impaired lung function, one-lung ventilation duration beyond 2 hours, and smoking history as independent risk factors for postoperative pulmonary infection in COPD patients.

Respiratory Failure

Hou et al. reported postoperative respiratory failure rates of 0%, 1.5%, 2.5%, and 14.5% across mild, moderate, severe, and very severe COPD groups, respectively, with no statistically significant difference among groups at one week postoperatively. COPD severity, defined by FEV_1 percentage predicted, was not independently associated with postoperative respiratory failure. Lower preoperative arterial oxygen tension was the only independent predictor identified, with a preoperative PaO_2 below 68 mmHg associated with increased probability of postoperative respiratory failure.

ICU Admission

Lee et al. reported significantly lower ICU admission rates in patients receiving intraoperative dexmedetomidine compared to placebo during one-lung ventilation, at 4% versus 28%, respectively, with an odds ratio of 9.33. Park et al. reported that ICU discharge occurred in 48.8% of patients who developed postoperative pulmonary complications compared to 20.1% of those without complications. Hou et al. reported ICU admission with endotracheal intubation after surgery in 0%, 3.0%, 6.3%, and 14.3% across increasing COPD severity groups, without reaching statistical significance.

Hospital Stay

None of the included studies demonstrated a statistically significant difference in postoperative hospital stay between comparison groups. Park et al. reported a median hospital stay of 187.4 hours in patients with postoperative pulmonary complications versus 159.4 hours in those without, with no significant difference. Lee et al. reported a median hospital stay of 6.5 days in the dexmedetomidine group versus 7.4 days in controls. Hou et al.

reported hospital stay ranging from 11.0 to 13.0 days across COPD severity groups with no significant intergroup difference.

Mortality

Park et al. was the only included study reporting postoperative mortality data. Ninety-day mortality was significantly higher in patients who developed postoperative pulmonary complications compared to those who did not, at 5.8% versus 1.3%, respectively. Thirty-day mortality did not differ significantly between groups, at 0.8% versus 0.3%. No other included study reported mortality as an outcome. The association between postoperative pulmonary complications and ninety-day mortality underscores the clinical relevance of protective ventilation strategies in COPD patients undergoing general anesthesia.

Risk of Bias Assessment

Three retrospective cohort studies were assessed using the Newcastle-Ottawa Scale. Park et al. achieved a score of 9 out of 9, indicating low risk of bias, supported by robust selection from a prospectively collected database, secure electronic record ascertainment, and multivariable adjustment for key confounders. Ji et al. and Hou et al. each scored 7 out of 9, reflecting moderate risk, primarily attributable to limited confounder adjustment and short or incomplete outcome follow-up. The randomized controlled trial by Lee et al. was assessed using the Cochrane Risk of Bias 2.0 tool and received an overall judgment of some concerns, driven by per-protocol rather than intention-to-treat analysis and absence of explicit outcome assessor blinding for postoperative complications.

Table 3. Study Characteristics

Author, Year	Primary Outcome Definition	Primary Outcome Rate	Secondary Outcomes	Key Protective / Risk Factors Identified	Inflammatory / Blood Gas Markers	Mortality	Hospital Stay / ICU Admission	Statistical Method
Park S et al., 2020[9]	Composite PPC within 7 days: Respiratory failure Pleural effusion Atelectasis Respiratory infection Pneumothorax Bronchospasm	28.8% (121/419 patients experienced 200 PPCs) Multiple PPCs: 12.9% (54/419) By type: Pleural effusion: 20.2% Atelectasis: 15.0% Respiratory failure: 6.7% Respiratory infection: 3.8% Bronchospasm: 1.9% Pneumothora	Prolonged mechanical ventilation >24 h Reintubation Length of postoperative hospital stay 30-day and 90-day mortality	Protective factors (multivariable OR): • Low TV ventilation: OR 0.50 (0.29–0.85); p=0.010 • Restricted crystalloid infusion (per mL/kg/h): OR 1.13 (1.03–1.25); p=0.012 • Sugammadex reversal: OR 0.27 (0.11–0.69); p=0.006 Risk factors: • Age >70 yrs: OR 1.86; p=0.022	Not specifically measured; ARISCAT score used as risk predictor (p<0.001)	90-day mortality: With PPC: 5.8% Without PPC: 1.3% p=0.016 30-day mortality: With PPC: 0.8% Without PPC: 0.3% p=0.495 (NS)	Hospital stay (h): With PPC: 187.4 (161.8–251.7) Without PPC: 159.4 (61.1–203.8) p=0.071 (NS) ICU discharge: 48.8% (PPC) vs 20.1% (no PPC); p<0.001 Prolonged	Binary logistic regression (backward stepwise selection); chi-square/Fisher's exact test; Wilcoxon rank-sum test; SPSS 25.0 and R 3.5.1

		x: 0%		• Bronchiectasis: OR 2.27; p=0.026 • Upper abdominal surgery: OR 7.43; p<0.001 • Lower abdominal surgery: OR 3.40; p=0.009 • Anesthesia >3 h: OR 2.75; p=0.001 PEEP: not significant (p=0.605) Driving pressure: not significant			MV >24 h: 0.7% (PPC) vs 0.3% (no PPC); p=0.075 (NS)	
Ji X et al., 2020[14]	Postoperative pulmonary infection: Cough + expectoration + fever + X-ray inflammatory lesions at 2 h post-op; Repeated isolation of same pathogen (Based on nosocomial infection diagnostic criteria)	Overall: 20/120 patients (16.7%) By OLV duration: Mild COPD, 1.0–2.0 h: 1/30 (3.3%) Mild COPD, >2.0 h: 6/32 (18.8%) Moderate COPD, 1.0–2.0 h: 3/30 (10.0%) Moderate COPD, >2.0 h: 10/28 (35.7%) OLV >2.0 h vs 1.0–2.0 h: p<0.01 Moderate vs mild infection rate: p<0.01	Serum inflammatory markers: PCT, CRP, WBC (day 3 post-op) IL-6, IL-21, TNF-α, CXCL13 (day 2 post-op) Pulmonary function indices (FEV_1, FVC, FEV_1/FVC, MMEF)	Independent risk factors (multivariate logistic regression): • Lung function (impaired): OR 3.772 (2.236–5.761); p<0.05 • OLV duration >2.0 h: OR 1.545 (1.251–1.905); p<0.01 • Smoking: OR 1.893 (1.630–3.279); p<0.05 Age and degree of COPD: significant in univariate but not reported in multivariate Gender: not significant (p>0.05)	OLV >2.0 h (vs ≤2.0 h): • PCT, CRP, WBC: significantly higher (p<0.05) • IL-6, IL-21, TNF-α, CXCL13: significantly higher (p<0.01) Moderate vs mild COPD: all 7 inflammatory markers significantly higher preoperatively (p<0.05)	Not reported	Not reported	SPSS 19.0; Chi-square test; Student t-test and one-way ANOVA; Univariate and multivariate logistic regression
Lee SH et al., 2016[13]	Primary: PaO_2/FiO_2 ratio during OLV (oxygenation) Secondary (PPCs assessed 72 h post-op): Atelectasis Pneumonia ALI (PaO_2/FiO_2 <40 kPa + diffuse infiltrates at 72 h + exclusion of cardiogenic pulmonary edema) Need for ICU admission	Intraoperative oxygenation (PaO_2/FiO_2 ratio, kPa): At DEX-30: Dex: 27.9±5.8 vs Control: 22.5±4.8; p=0.026 At DEX-60: Dex: 28.6±5.9 vs Control: 21.0±9.9; p=0.009 Postoperative PaO_2/FiO_2 (PACU): Dex: 47.5±4.71 vs Control: 42.2±5.9 kPa; p=0.022 ICU	Postoperative PaO_2/FiO_2 ratio at PACU ICU admission rate Atelectasis Focal lung infiltration ALI Length of hospital stay	Dexmedetomidine during OLV: • Significantly improved PaO_2/FiO_2 ratio at DEX-30 and DEX-60 (p<0.05) • Reduced dead space ventilation (Dex: 19.2±8.5 vs Control: 24.1±8.1% at DEX-30; p=0.046) • Improved dynamic compliance (DEX-30: 22.5±3.5 vs 17.7±3.4 mL/cmH_2O; p=0.0001; DEX-60: p=0.018) • Lower peak airway pressure	Intraoperative $PaCO_2$: Dex: 5.6±0.3 kPa (DEX-30); Control: 5.9±0.5 kPa; p=0.027 Dead space ventilation (Vd/Vt): Significantly lower in Dex group at DEX-30 and DEX-60	Not reported	Hospital stay (days): Dex: 6.5 (5–10) vs Control: 7.4 (6–11); p=0.102 (NS) ICU admission: Dex: 1 (4%) vs Control: 7 (28%); p=0.049; OR 9.33 (1.05–82.78)	Sample size calculation (power 90%, α=0.05; n=23/group; +10% dropout =25/group); Unpaired t-test, Mann-Whitney U test, chi-square/Fisher exact test; Linear mixed model for repeated measures; SPSS 20.0

	(PaO_2/FiO_2 <40 kPa with dyspnea in PACU)	admission: Dex 1 (4%) vs Control 7 (28%); p=0.049; OR 9.33 (1.05–82.78) Atelectasis: Dex 0 vs Control 4 (16%); p=0.110 (NS) ALI: Dex 0 vs Control 1; p>0.99 (NS) Focal lung infiltration: Dex 1 (4%) vs Control 2 (8%); p>0.99 (NS)		(DEX-30: 18.2±3.9 vs 23.0±4.1 cmH_2O; p=0.001) • Lower HR and MBP in Dex group (p<0.001 and p<0.05) • Ephedrine use significantly greater in Dex group (p<0.05)				
Hou R et al., 2022[8]	Postoperative respiratory failure at 1 week: Any one of: • Prolonged ventilator dependence • Unplanned postoperative intubation • PaO_2 <50 mmHg on ambient air in hospital	Group I (mild): 0/7 (0%) Group II (moderate): 1/66 (1.5%) Group III (severe): 1/40 (2.5%) Group IV (very severe): 1/7 (14.5%) Overall p=0.219 (NS) ICU admission with endotracheal intubation after surgery: Group I: 0%, II: 3.0%, III: 6.3%, IV: 14.3%; p=0.497 (NS)	Extubation time Perioperative PaO_2 and $PaCO_2$ Postoperative pulmonary infection Length of hospital stay (up to 30 days) Intraoperative oxygenation index (PaO_2/FiO_2)	COPD severity (FEV_1 %pred) was NOT independently associated with postoperative respiratory failure Independent predictor: • Higher preoperative PaO_2: OR 0.83 (95% CI 0.72–0.95); p=0.007 (protective) • PaO_2 <68 mmHg (room air) associated with increased probability of respiratory failure Not significant: • Preoperative $PaCO_2$: OR 1.10 (0.85–1.43); p=0.454 • FEV_1 %pred: OR 0.93 (0.85–1.02); p=0.107 • Intraoperative oxygenation index: OR 0.99 (0.98–1.00); p=0.302 • Duration of anesthesia: p=0.246	Perioperative blood gas: Preoperative PaO_2 (mmHg): Group I: 84.4±8.2; II: 77.2±10.8; III: 72.7±8.9; IV: 63.3±12.3; p<0.001 Intraoperative oxygenation index: Group I: 434.6±63.0; II: 387.2±93.7; III: 370.2±97.0; IV: 300.2±82.7; p=0.046 Postextubation PaO_2: Group I: 170.4±28.0; II: 113.5±3.2; III: 107.0±42.0; IV: 85.7±23.0; p<0.001	Not reported	Extubation time (min): Group I: 8.1±2.0; II: 9.5±2.9; III: 9.4±2.2; IV: 10.8±4.1; p=0.174 (NS) Pulmonary infection: Group I: 0%; II: 1.5%; III: 0%; IV: 0%; p=0.843 (NS) Hospital stay (days): Group I: 11.0±2.2; II: 13.0±4.6; III: 11.7±2.7; IV: 12.9±2.0; p=0.253 (NS) ICU intubation after surgery: Group I: 0%; II: 3.0%; III: 6.3%; IV: 14.3%; p=0.497 (NS)	SPSS 19.0; Student t-test (normal distribution); Wilcoxon rank test (skewed distribution); ANOVA; Chi-squared / Fisher exact test; Univariate logistic regression; Two-piecewise linear regression (threshold effect)

Table 5. RoB using NOS for Observational Study

Study	SELECTION (max 4 stars)					COMPARABILITY (max 2 stars)		OUTCOME (max 3 stars)			OVERALL	
	1. Representativeness of Exposed Cohort	2. Selection of Non-Exposed Cohort	3. Ascertainment of Exposure	4. Outcome Not Present at Start	5. Comparability (primary factor)	6. Comparability (additional factor)	7. Assessment of Outcome	8. Follow-up Sufficiently Long	9. Adequacy of Follow-up	Score	Max Score	Overall Risk of Bias
Park S et al., 2020	★	★	★	★	★★	—	★	★	★	**9**	9	Low Risk
Ji X et al., 2020	★	★	★	★	★	—	★	—	★	**7**	9	Moderate Risk
Hou R et al., 2022	★	★	★	★	★	—	★	★	★	**7**	9	Moderate Risk

Table 6. RoB 2.0 for RCT

Domain	Domain Judgment
Domain 1: Randomization Process	low risk
Domain 2: Deviations from Intended Interventions	low risk
Domain 3: Missing Outcome Data	some concerns
Domain 4: Measurement of Outcomes	some concerns
Domain 5: Selection of Reported Results	low risk
OVERALL JUDGMENT	some concerns

4. DISCUSSION

This systematic review synthesized evidence on the association between intraoperative ventilation strategies and postoperative pulmonary complications in COPD patients undergoing elective surgery under general anesthesia.[9,13] Low tidal volume ventilation was the most consistently protective modifiable anesthetic factor across the abdominal surgery cohort, while positive end-expiratory pressure did not demonstrate a significant reduction in postoperative pulmonary complication risk in this population.[9] Dexmedetomidine during one-lung ventilation improved intraoperative oxygenation and reduced intensive care unit admissions in patients with moderate COPD undergoing thoracoscopic surgery.[13] Prolonged one-lung ventilation duration was associated with higher postoperative pulmonary infection rates in mild-to-moderate COPD.[14] Multimodal protective strategies combining low tidal volume with restricted fluid administration and sugammadex-based neuromuscular reversal outperformed single-component interventions in this population.[9]

The pathophysiology of COPD during intraoperative mechanical ventilation centres on dynamic hyperinflation and intrinsic positive end-expiratory pressure generated by progressive small airway obstruction, reduced elastic recoil, and air trapping.[9,16] These mechanisms raise functional residual capacity and predispose already-hyperinflated alveolar

units to further overdistension when larger tidal volumes are delivered, amplifying cyclic alveolar stretch and triggering pro-inflammatory mediator release consistent with ventilator-induced lung injury.[9,16] External positive end-expiratory pressure applied beyond the threshold of auto-positive end-expiratory pressure may worsen dynamic hyperinflation rather than improve alveolar recruitment in obstructive disease, providing a physiological basis for the absent PEEP benefit observed in COPD patients undergoing abdominal surgery.[9,17] Dexmedetomidine appears to attenuate gas exchange impairment during one-lung ventilation through direct effects on dead space ventilation and bronchomotor tone in patients with altered pulmonary vascular reactivity, independent of inhalational anesthetic-sparing effects.[13]

In general surgical populations, combined low tidal volume ventilation with positive end-expiratory pressure and recruitment maneuvers consistently reduces postoperative pulmonary complications compared with conventional high-volume ventilation.[16,17] The absence of a significant PEEP effect in COPD patients diverges from this general population paradigm, a discrepancy that reflects the fundamentally different response of obstructive lungs to applied airway pressure, where incremental external PEEP may be harmful rather than protective.[9,17] Sugammadex-based neuromuscular reversal in COPD patients aligns with broader evidence demonstrating that sugammadex reduces residual neuromuscular blockade and lowers postoperative pulmonary complication risk compared with neostigmine across diverse surgical populations.[18,19] The oxygenation benefit of dexmedetomidine was restricted to thoracoscopic procedures in moderate COPD, limiting direct extrapolation to abdominal or spinal surgery and to patients with severe airflow limitation stages.[13,14]

These findings support a multimodal intraoperative approach for COPD patients that prioritises low tidal volume ventilation and sugammadex-based neuromuscular reversal, while applying positive end-expiratory pressure cautiously to avoid worsening dynamic hyperinflation.[9,17] Dexmedetomidine should be considered as an adjunct during one-lung ventilation to optimise intraoperative oxygenation in moderate COPD undergoing thoracoscopic procedures.[13] Intraoperative monitoring for auto-positive end-expiratory pressure and individualised ventilation titration remain important safety considerations in this high-risk population.[9,16]

This review is limited by the small number of included studies, heterogeneity in surgical procedures and ventilation protocols, and the predominance of retrospective designs with moderate risk of bias in three of four included studies.[8,9,14] The exclusion of severe COPD

subgroups from major landmark ventilation trials restricts comparability with the broader protective ventilation literature.[16] All included populations originated from East Asian centres, which may limit generalisability to other ethnic groups and healthcare settings.[9,13]

D. CONCLUSION

Low tidal volume ventilation reduces postoperative pulmonary complications in COPD patients undergoing general anesthesia, whereas PEEP confers no significant benefit, reflecting the distinct physiology of obstructive lung disease. Sugammadex-based neuromuscular reversal and dexmedetomidine during one-lung ventilation offer additional risk reduction in selected COPD populations. Clinicians should adopt a multimodal intraoperative strategy prioritising low tidal volume ventilation and cautious PEEP titration. Current evidence remains limited to four studies from East Asian centres, necessitating well-designed randomised trials in diverse COPD populations.

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