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**Review Article**

# Anesthetic considerations and perioperative management in chronic obstructive pulmonary disease: from pre-anesthetic evaluation to safe extubation

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## ABSTRACT

Chronic obstructive pulmonary disease represents one of the most prevalent respiratory comorbidities in surgical patients and constitutes a major independent risk factor for postoperative pulmonary complications, alveolar collapse, and ventilatory failure. Anesthetic management demands a comprehensive understanding of underlying pathophysiological alterations, such as air trapping, auto-PEEP, and ventilation-perfusion mismatch. Objectives of the study were to analyze current evidence regarding pre-anesthetic optimization, selection of anesthetic techniques, intraoperative ventilatory support, and strategies for safe extubation in patients with chronic obstructive pulmonary disease. A narrative literature review of scientific articles published in biomedical databases (PubMed, Scopus, Web of Science) was conducted, focusing on perioperative pulmonary risk stratification, protective mechanical ventilation, neuromuscular blockade, and regional analgesia techniques. Preoperative optimization through smoking cessation, optimized bronchodilator therapy, and respiratory physiotherapy significantly reduces the incidence of postoperative pulmonary complications. During general anesthesia, protective ventilation strategies featuring low tidal volumes (6-8 ml/kg of predicted body weight), prolonged expiratory time to mitigate dynamic hyperinflation, and judicious PEEP titration improve gas exchange. Regional anesthetic and analgesic techniques demonstrate a distinct advantage by preserving respiratory mechanics and decreasing opioid consumption. Complete, quantitative reversal of neuromuscular blockade represents a critical cornerstone in preventing extubation failure. Successful perioperative management of patients with chronic obstructive pulmonary disease requires a coordinated strategy spanning from precise risk stratification to structured ventilatory weaning. Strict application of intraoperative protective ventilation and optimized analgesic control significantly decrease morbidity, mortality, and hospital length of stay.

**Keywords:** Chronic obstructive pulmonary disease, Postoperative pulmonary complications, Intraoperative protective ventilation, Pre-anesthetic evaluation, Extubation

## INTRODUCTION

Chronic obstructive pulmonary disease represents one of the most prevalent chronic respiratory conditions worldwide and remains a leading cause of morbidity and mortality among the adult population. In the surgical setting, the presence of this disease significantly alters the perioperative risk profile, placing patients at an increased vulnerability for adverse pulmonary and cardiovascular events.[1,2] Postoperative pulmonary complications including clinically significant atelectasis, acute bronchospasm, hospital-acquired pneumonia, ventilatory failure requiring reintubation, and prolonged mechanical ventilation weaning exceed cardiac complications in frequency among this population, directly impacting hospital length of stay as well as short- and medium-term survival.[3,4]

The underlying pathophysiology of chronic obstructive pulmonary disease presents a complex anesthetic challenge stems from the combination of irreversible expiratory airflow limitation, small-airway remodeling, loss of pulmonary elastic recoil, and destruction of the alveolar parenchyma.[5] In the anesthetized patient subjected to mechanical ventilation, the loss of inspiratory muscle tone and the abolition of spontaneous respiratory effort accentuate distal airway collapse, promoting progressive air trapping and the development of intrinsic positive end-expiratory pressure or auto-PEEP.[6,7] This dynamic hyperinflation not only impairs gas exchange by increasing physiological dead space and worsening ventilation-perfusion mismatch, but also exerts adverse hemodynamic effects by compromising venous return and elevating right ventricular afterload.[8]

Furthermore, surgical trauma induces a systemic inflammatory and metabolic response that compromises respiratory mechanics, particularly during thoracic and upper abdominal procedures where reflex diaphragmatic dysfunction and acute postoperative pain restrict tidal volumes and abolish effective cough.[9,10] Added to this scenario is the depressant effect of volatile anesthetic agents, opioids, and neuromuscular blocking agents on the respiratory drive and protective airway reflexes, which perpetuates microaspiration and secretion retention in the immediate post-anesthetic period.[11]

Given this intricate pathophysiological interplay, the modern management of surgical patients with chronic obstructive pulmonary disease has evolved from isolated reactive interventions toward a structured, comprehensive perioperative model. This approach encompasses pre-anesthetic risk stratification and pharmacological optimization, the application of intraoperative protective mechanical ventilation strategies, the judicious selection of anesthetic-analgesic techniques that preserve respiratory drive, and the implementation of rigorous extubation and post-anesthetic care protocols.[12,13] The objective of this review is to systematically analyze current scientific evidence to provide anesthesiologists with evidence-based clinical tools to optimize patient safety and mitigate the burden of postoperative pulmonary complications.

## METHODS

It is a descriptive-exploratory study type of bibliographic review. The literature search period is from 2018 to 2026 in electronic databases such as PubMed, Elsevier, and web of science. The keywords used in the MesH search were; chronic obstructive pulmonary disease; postoperative pulmonary complications; intraoperative protective ventilation; pre-anesthetic evaluation; extubation. inclusion criteria: search terms, level of evidence, summaries and keywords, exclusion criteria: not related to the topic, outside the year limit, not available; they will be classified by year, type of study and level of evidence. For eligibility, a critical reading is carried out, level of evidence, documents available for analysis and according to the topic. A total of 30 sources were obtained for analysis and synthesis.

## RESULTS

Chronic obstructive pulmonary disease represents a leading cause of morbidity and mortality among adults and constitutes a major risk factor for postoperative pulmonary complications.[10,11] Pulmonary complications including significant atelectasis, acute bronchospasm, and ventilatory failure requiring reintubation exceed cardiac adverse events in frequency within this population, directly impacting hospital length of stay and patient survival.[12]

The underlying pathophysiology of chronic obstructive pulmonary disease presents a complex anesthetic challenge due to irreversible expiratory airflow limitation, loss of lung elastic recoil, and alveolar destruction.[13] In the anesthetized patient undergoing mechanical ventilation, the loss of spontaneous respiratory effort exacerbates distal airway collapse, promoting air trapping and auto-PEEP generation.[14,15] This dynamic hyperinflation impairs gas exchange by increasing physiological dead space and worsening ventilation-perfusion mismatch while exerting adverse hemodynamic effects by compromising venous return.[16]

Surgical trauma induces a systemic inflammatory response that alters respiratory mechanics, particularly in thoracic and upper abdominal procedures where diaphragmatic dysfunction and acute postoperative pain restrict tidal volumes.[17,18] Additionally, the depressant effects of anesthetic agents and neuromuscular blockers on the respiratory drive perpetuate microaspiration in the immediate post-anesthetic period.[19] Given this complexity, structured perioperative management decreases morbidity and mortality while optimizing patient safety.[20]

### *Pre-anesthetic risk stratification and functional optimization*

Detailed analysis of current evidence indicates that systematic identification of individual and surgical risk factors constitutes the primary step in mitigating the incidence of postoperative pulmonary complications in patients with chronic obstructive pulmonary disease.[10,11] Validated clinical risk scores, such as the ARISCAT index, assign significant weight to variables associated with the surgical procedure (thoracic or upper abdominal surgical sites, surgical duration exceeding 2 hours, and general anesthesia) as well as patient-intrinsic conditions (baseline oxygen saturation, advanced age, and recent disease exacerbation).[12,13]

Preoperative pharmacological optimization has been shown to decrease bronchial hyperreactivity and the incidence of bronchospasm during induction and endotracheal intubation.[14] Continuing inhaled

maintenance therapy with long-acting beta-2 agonists and long-acting muscarinic antagonists up to the morning of surgery prevents acute deterioration of ventilatory function.[15,16] Furthermore, implementing presymptomatic respiratory physiotherapy protocols and smoking cessation significantly reduces secretion retention and postoperative atelectasis.[17]

***Anesthetic technique selection and airway management***

The choice of anesthetic technique exerts a direct influence on respiratory mechanics and hemodynamic stability in patients with chronic obstructive pulmonary disease.[13] Regional anesthesia techniques (neuraxial or peripheral nerve blocks) offer substantial advantages by avoiding airway instrumentation, preserving inspiratory muscle tone, and drastically reducing exposure to respiratory depressant drugs.[18] In procedures where general anesthesia is mandatory, utilizing agents with bronchodilating properties (such as sevoflurane) and induction agents that stabilize bronchial reactivity proves highly beneficial.[19]

Airway instrumentation must be performed under an adequate depth of anesthesia or with topical local anesthetics to prevent reflex bronchospasm. Complete reversal of neuromuscular blockade is a critical requirement; quantitative monitoring via train-of-four (TOF) ensures complete diaphragmatic motor recovery before attempting extubation, preventing upper airway collapse in the immediate post-anesthetic period.[20]

**Table 1: Risk stratification parameters and pre-anesthetic optimization strategies in COPD.**

| Assessment domain | Clinical parameters / variables | Evidence-based intervention | Impact on pulmonary complication |
|---|---|---|---|
| **Risk scoring (ARISCAT)** | Surgical site (thoracic/abdominal), $SpO_2$ <96%, age >60 years, emergency surgery. | Perioperative risk categorization and individualization of hemodynamic and invasive monitoring. | Accurate stratification of postoperative respiratory failure risk.[10,11] |
| **Functional testing** | Spirometry ($FEV_1$/FVC), arterial blood gas ($PaCO_2$ >45 mmHg, $PaO_2$ <60 mmHg). | Identification of baseline hypercapnia and severe functional restriction; guidance for ventilatory management. | Modification of ventilatory weaning strategy and planned extubation.[12,13] |
| **Pharmacological optimization** | Combined inhaled therapy (LABA + LAMA), systemic corticosteroids if bronchospasm is present. | Maintenance of bronchodilator therapy until surgery day; short steroid courses for hyperreactivity. | Decreased incidence of intraoperative bronchospasm and air trapping.[14,15] |
| **Respiratory conditioning** | Active smoking status, mucociliary clearance, inspiratory muscle strength. | Prior smoking cessation (>4 weeks), inspiratory muscle training, and incentive spirometry. | Significant reduction in atelectasis formation and secretion retention.[16,17] |

**Table 2: Comparison of anesthetic techniques and extubation considerations in COPD.**

| Anesthetic modality | Physiological advantages | Potential disadvantages/ risks | Extubation/reversal considerations |
|---|---|---|---|
| **Regional/neuraxial anesthesia** | Preserves spontaneous ventilation; eliminates intubation-induced bronchospasm risk; excellent analgesia.[18] | Risk of intercostal muscle block if neuraxial sensory level is excessively high. | Does not require extubation; rapid recovery of alertness and cough reflex.[18] |
| **Balanced general anesthesia** | Complete control of the airway and protective mechanical ventilation parameters.[13,19] | Respiratory drive depression, loss of cough reflex, risk of air trapping. | Requires complete reversal of neuromuscular blockade (TOF ≥0.90) and spontaneous breathing trial.[20] |
| **Multimodal/combined anesthesia** | Reduces systemic anesthetic and opioid dosages; optimizes postoperative pain control.[15] | Requires close hemodynamic monitoring due to associated vasodilation or sympathectomy. | Facilitates early extubation in the operating room and decreases prolonged mechanical ventilation needs.[20] |
| **Post-extubation support (NIV/HFNC)** | Maintains positive airway pressure, prevents atelectasis, and decreases work of breathing.[11,16] | Potential interface intolerance, mucosal dryness, or gastric distension with NIV. | Indicated for high-risk patients with residual hypercapnia or increased work of breathing.[11,16] |

## DISCUSSION

The perioperative management of patients with chronic obstructive pulmonary disease represents a complex multidisciplinary challenge whose cornerstone rests upon the anticipation and mitigation of postoperative pulmonary complications. The evidence analyzed in this review demonstrates that perioperative risk is not solely dictated by baseline spirometric severity, but rather by the dynamic interplay between preexisting parenchymal dysfunction, surgical trauma, and the depressant effects of anesthetic pharmacotherapy.[20] In this context, pre-anesthetic risk stratification using validated scoring systems, such as the ARISCAT index or ARC score, allows clinicians to objectively identify high-risk patient cohorts who stand to benefit from intensive functional optimization protocols and close post-surgical invasive monitoring.[21]

A critical insight highlighted in recent literature is the re-evaluation of pulmonary function testing. While forced spirometry has historically served as the gold standard diagnostic tool, current evidence discourages its unindicated routine use during general pre-anesthetic evaluation, reserving it exclusively for patients with unoptimized symptoms, suspected baseline hypercapnia, or planned lung resection procedures.[22] Preoperative arterial blood gas analysis, conversely, emerges as an independent predictor of higher sensitivity for morbidity and mortality when revealing chronic carbon dioxide retention ($PaCO_2$ >45 mmHg) or severe hypoxemia, enabling clinicians to anticipate the need for early non-invasive ventilatory support following surgery.[23]

In terms of preoperative optimization, smoking cessation and the continuation of combined bronchodilator regimens (long-acting beta-2 agonists paired with long-acting muscarinic antagonists) represent indisputable pillars. Smoking cessation at least 4 to 8 weeks prior to surgery significantly decreases mucous hypersecretion and bronchial hyperreactivity, thereby facilitating ciliary clearance during the post-anesthetic period.[24] Similarly, the implementation of presymptomatic chest physiotherapy and inspiratory muscle training has been shown to decrease postoperative atelectasis incidence and shorten length of stay in intensive care units.[25]

Intraoperatively, the implementation of protective mechanical ventilation stands as the most effective strategy to prevent ventilator-induced lung injury (VILI). The use of low tidal volumes (6 to 8 ml/kg of predicted body weight) coupled with low respiratory rates and extended I:E ratios (1:3 to 1:5) effectively prevents dynamic hyperinflation, air trapping, and auto-PEEP generation.[26] Judicious titration of extrinsic PEEP, adjusted to 70-80% of measured auto-PEEP, stabilizes collapsible airways without causing overdistension or compromising right ventricular preload, which is particularly relevant during prolonged surgical procedures.[27]

The choice of anesthetic-analgesic technique exerts a decisive impact on pulmonary outcomes. Pure or combined regional techniques (neuraxial and abdominal/thoracic wall blocks) offer a distinct advantage by minimizing systemic opioid consumption, preserving diaphragmatic tone, and facilitating prompt operating room extubation.[28] When general anesthesia is mandatory, using volatile agents with bronchodilating properties, such as sevoflurane, favors bronchial stability.[29]

The extubation phase demands rigorous vigilance. Complete reversal of neuromuscular blockade, confirmed via quantitative monitoring reaching a TOF ratio ≥0.90, is essential to prevent upper airway collapse and acute postoperative respiratory failure.[30] Integrating proactive post-extubation strategies, such as the early application of non-invasive ventilation or high-flow nasal cannulas in patients with residual hypercapnia, closes a continuum of care that optimizes patient safety and minimizes morbidity and mortality associated with chronic obstructive pulmonary disease.

## CONCLUSION

The perioperative approach for patients with chronic obstructive pulmonary disease demands a comprehensive, structured strategy spanning from precise pre-anesthetic risk identification to post-surgical ventilatory and analgesic support. Functional optimization via continuous bronchodilator therapy, smoking cessation, and chest physiotherapy significantly decreases the incidence of postoperative pulmonary complications. Intraoperatively, strict application of protective mechanical ventilation characterized by low tidal volumes, low respiratory rates, extended expiratory times, and individualized extrinsic PEEP titration stands as the most effective intervention to prevent dynamic hyperinflation, air trapping, and ventilator-induced lung injury. Furthermore, favoring regional anesthetic techniques or opioid-sparing multimodal analgesia regimens preserves chest wall mechanics and optimizes pain control without depressing central respiratory drive. Lastly, complete, quantitatively verified neuromuscular blockade reversal, combined with the proactive implementation of non-invasive ventilatory support in the immediate post-anesthetic period, proves decisive in ensuring safe extubation, decreasing reintubation rates, and reducing overall morbidity and mortality in this high-risk population.

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