Advancements in Health Research

Advancements in Health Research 2026; 3:132
doi:10.4081/ahr.2026.132

Postoperative respiratory depression and pulmonary complications: serious but underappreciated

Joseph V. Pergolizzi, Jr.,[1] Giustino Varrassi,[2] Robert B. Raffa[1,3]

[1]Enalare Therapeutics Inc., Mullica Hill, NJ, USA; [2]Fondazione Paolo Procacci, Rome, Italy; [3]Temple University (Emeritus), Philadelphia, PA, USA

Abstract

Postoperative pulmonary complications represent one of the most consequential but underappreciated sources of peri- and post-operative morbidity and mortality. Among these, postoperative respiratory depression, characterized by inadequate ventilatory drive, hypoxemia, and hypercapnia following anesthesia and surgery, has emerged as a subtle, but serious threat to patient safety.

Key words: postoperative pulmonary complications; postoperative respiratory depression; postsurgical recovery.

Correspondence to: Robert B. Raffa, Enalare Therapeutics Inc., 107 Gilbreth Pkwy, Mullica Hill, NJ 08062-4446, USA. E-mail: robert.raffa@gmail.com

Introduction

Despite advances in anesthetic technique, monitoring technology, and postoperative care, postoperative pulmonary complications (PPCs) continue to affect an estimated 2% to 40% of surgical patients, depending on the population studied and the definition applied, and are responsible for a disproportionate burden of prolonged hospitalization, intensive care unit (ICU) admission, and acute and prolonged morbidity and mortality.[1-3]

The pathophysiology of postoperative respiratory depression (PORD) is multifactorial, encompassing residual neuromuscular blockade, opioid-induced respiratory depression (OIRD), upper airway obstruction, and impaired hypoxic ventilatory response. These mechanisms frequently coexist and potentiate one another in the post-anesthesia care unit (PACU) and general ward environment, where continuous monitoring is often inadequate.[4] This commentary examines the clinical consequences of PORD and other PPCs, with a focus on patient outcomes, economic burden, and the desirability of perioperative respiratory monitoring and management.

Epidemiology and definitions

The lack of a generally accepted definition for PORD and other PPCs complicates efforts to quantify their true incidence and impact. Broadly, PPCs encompass a spectrum of disorders including postoperative hypoxemia, atelectasis, pneumonia, respiratory failure, bronchospasm, and PORD. The LAS VEGAS study, a prospective multinational observational study involving over 6,000 patients across 146 hospitals in 29 countries, found that at least one PPC occurred in nearly 11% of cases,[5] and PPCs are implicated in increased 30-, 60-, and 90-day mortality.[2,3] PORD, specifically, although estimated to impact a comparatively small proportion of postoperative patients, it still involves a substantial number of individuals due to the high volume of surgical procedures carried out annually. Furthermore, observational studies using continuous electronic monitoring instead of traditional intermittent assessments suggest that the true incidence may be even substantially higher.[6] Together, these findings underscore the need for standardized definitions and reliable surveillance infrastructure.

Opioid-induced respiratory depression

Opioids remain the cornerstone of perioperative analgesia, but their capacity to suppress respiratory drive constitutes the most clinically serious of their adverse effects. OIRD arises from mu-opioid receptor agonism within the pre-Bötzinger complex and other brainstem nuclei, resulting in decreased respiratory rate, tidal volume, and blunted responsiveness to hypercapnia and hypoxia.[7] The danger is compounded because patients may appear comfortable and arousable, despite significant ventilatory suppression. Critically, inadequate monitoring has been identified as a contributing factor.[6] Established risk factors for OIRD include obstructive sleep apnea (OSA), obesity, advanced age, comorbid pulmonary disease, and the concurrent use of sedatives, benzodiazepines, or other CNS depressants. For example, the STOP-Bang questionnaire has been validated as a screening tool for OSA in surgical patients and correlates with increased susceptibility to postoperative respiratory events. Nevertheless, clinicians frequently underestimate individual patient vulnerability, and institutional protocols for high-risk patients remain inconsistent.

Residual neuromuscular blockade and upper airway complications

Residual neuromuscular blockade (rNMB) is also a frequently overlooked contributor to PPCs and PORD. Despite the widespread availability of reversal agents such as neostigmine and sugammadex, studies consistently show that when quantitative neuromuscular monitoring is not employed, clinically significant rNMB persists in patients on arrival to the PACU.[8] Upper airway obstruction related to rNMB, along with residual anesthetic effects, represents a direct pathway to respiratory problems in the post-anesthesia period. The laryngeal and hypopharyngeal muscles are particularly sensitive to non-depolarizing neuromuscular blocking agents, and their impaired function disrupts the normal coordination of deglutition and airway protection. Pulmonary aspiration, a serious complication of upper airway dysfunction, is associated with significant rates of aspiration pneumonitis and aspiration pneumonia – each carrying substantial morbidity and mortality, particularly in elderly and at-risk patients.

Postoperative atelectasis and pneumonia

Atelectasis is the most prevalent PPC, arising to some extent in virtually all patients undergoing general anesthesia due to the loss of functional residual capacity (FRC), diaphragmatic cephalad displacement, and absorption collapse of dependent lung units. While often clinically silent, atelectasis creates ventilation-perfusion mismatch that contributes to postoperative hypoxemia and may progress to lobar collapse and pneumonia in vulnerable patients.[9] Postoperative pneumonia, although less common than atelectasis, is the leading cause of postoperative infectious mortality.[10]

Major risk factors for postoperative pneumonia include prolonged mechanical ventilation, emergency surgery, thoracic or upper abdominal procedures, impaired cough reflex, dysphagia, and pre-existing pulmonary disease. The interplay between pain-related splinting, opioid-induced cough suppression, and reduced mucociliary clearance creates a convergent pathophysiological milieu that significantly elevates pneumonia risk in the early postoperative period. Lung-protective ventilatory strategies, early mobilization, and multimodal analgesia protocols have demonstrated efficacy in reducing PPCs in randomized controlled trials, yet their implementation remains inconsistent across institutions.

Clinical outcomes and health economic burden

The downstream consequences of PPCs and PORD are serious and far-reaching. Patients who develop PPCs face substantially prolonged hospital stays, higher rates of unplanned ICU admission, greater utilization of respiratory support, and increased short- and long-term morbidity and mortality. In a large multicenter analysis, Sabate *et al*.[11] found that PPCs were the single strongest predictor of postoperative mortality and prolonged hospitalization, exceeding the impact of cardiac complications. Patients with PPCs have ICU admission rates six-fold higher than those without, and a median hospital length of stay several days longer.

Monitoring deficiencies and systems-level failures

A recurring theme in the analysis of preventable respiratory deaths is the failure of monitoring-infrastructure to reliably detect deteriorating ventilatory status before irreversible harm occurs. Standard pulse oximetry, while valuable for detecting hypoxemia, is a lagging indicator of respiratory depression, particularly in patients receiving supplemental oxygen – a setting in which SpO_2 can remain near-normal despite significant hypercapnia and apnea.[12] Continuous capnography and acoustic respiratory rate monitoring provide earlier and more specific detection of ventilatory compromise, and the available evidence suggests that their implementation on general surgical wards significantly reduces the incidence of rescue events and unplanned ICU transfers.[12] More recently, the implementation of continuous electronic surveillance systems incorporating heart rate, respiratory rate, and oxygen saturation data has shown promise in enabling early detection of deteriorating respiratory function, though adoption remains inconsistent. A practical challenge is that nurses and physicians on general wards may experience "alarm fatigue" from false-positive rates.

Prevention strategies and clinical recommendations

Multimodal analgesia strategies that reduce reliance on systemic opioids – including regional anesthetic techniques, non-steroidal anti-inflammatory drugs, acetaminophen, gabapentinoids, and dexmedetomidine – should reduce occurrence of PPCs. And the Enhanced Recovery After Surgery (ERAS) framework, which integrates these principles with early mobilization, goal-directed fluid therapy, and standardized feeding protocols, has demonstrated reductions in PPCs and hospital length of stay across multiple surgical subspecialties.[13] Postoperatively, the implementation of continuous monitoring technologies and rapid response team protocols should be considered standard of care.

Conclusions

The convergence of opioid-related ventilatory suppression, residual neuromuscular blockade, anesthesia-induced atelectasis, and inadequate postoperative monitoring creates a negative impact on surgical patients, particularly those at high baseline risk. The evidence clearly demonstrates that PPCs drive prolonged hospitalization, ICU utilization, larger health economic costs, and excess acute and delayed morbidity and mortality. Addressing this problem requires coordinated action by anesthesiologists, surgeons, nurses, hospital administrators, and policymakers to implement validated risk stratification tools, evidence-based perioperative protocols, and robust continuous monitoring systems. Only through a diligent comprehensive systems-level approach can the field meaningfully reduce the burden of postoperative respiratory harm and fulfill its fundamental obligation to patient safety.

References

1. Fernandez-Bustamante A, Frendl G, Sprung J, et al. Postoperative pulmonary complications, early mortality, and hospital stay following noncardiothoracic surgery: a multicenter study by the perioperative research network investigators. JAMA Surg 2017;152:157-66.
2. Miskovic A, Lumb Ab. Postoperative pulmonary complications. Br J Anaesth 2017;118:317-34.
3. Raffa RB, Pergolizzi JV, Jr., Dungan GC, Miller TL. Mortality 30, 60, and 90 days after discharge is greater in patients who experienced postoperative respiratory depression and pulmonary complication. Cureus 2025;17:e79913.
4. Overdyk FJ, Carter R, Maddox RR, et al. Continuous oximetry/capnometry monitoring reveals frequent desaturation and bradypnea during patient-controlled analgesia. Anesth Analg 2007;105:412-8.
5. Neto AS, Da Costa LGV, Hemmes SNT, et al. The LAS VEGAS risk score for prediction of postoperative pulmonary complications: an observational study. Eur J Anaesthesiol 2018;35: 691-701.
6. Lam T, Nagappa M, Wong J, et al. Continuous pulse oximetry and capnography monitoring for postoperative respiratory depression and adverse events: a systematic review and meta-analysis. Anesth Analg 2017;125:2019-29.
7. Dahan A, Aarts L, Smith Tw. Incidence, reversal, and prevention of opioid-induced respiratory depression. Anesthesiology 2010;112:226-38.
8. Murphy GS, Szokol JW, Marymont JH, et al. Intraoperative acceleromyographic monitoring reduces the risk of residual neuromuscular blockade and adverse respiratory events in the postanesthesia care unit. Anesthesiology 2008;109:389-98.
9. Lumb AB, Slinger P. Hypoxic pulmonary vasoconstriction: physiology and anesthetic implications. Anesthesiology 2015; 122:932-46.
10. Chughtai M, Gwam Cu, Mohamed N, et al. The epidemiology and risk factors for postoperative pneumonia. J Clin Med Res 2017;9:466-75.
11. Sabate S, Mazo V, Canet J. Predicting postoperative pulmonary complications: implications for outcomes and costs. Curr Opin Anaesthesiol 2014;27:201-9.
12. Taenzer AH, Pyke JB, McGrath SP, Blike GT. Impact of pulse oximetry surveillance on rescue events and intensive care unit transfers: a before-and-after concurrence study. Anesthesiology 2010;112:282-7. Erratum in: Anesthesiology 2020;132:602.
13. Ljungqvist O, Scott M, Fearon KC. Enhanced recovery after surgery: a review. JAMA Surg 2017;152:292-8.

Received: 2 March 2026; Accepted: 2 April 2026.

Contributions: All authors (Joseph V. Pergolizzi, Jr., Giustino Varrassi, Robert B. Raffa) contributed equally to the conceptualization, methodology, analysis and interpretation of data, writing—original draft, and writing—review & editing of this manuscript. All authors read and approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

Conflict of interest: the authors declare no competing interests, and all authors confirm accuracy.

Publisher's note: all claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article or claim that may be made by its manufacturer is not guaranteed or endorsed by the publisher.