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Impact of General Anesthesia on Post Operative Respiratory Complications in Obese Patients Undergoing Intra-Abdominal Surgeries

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ABSTRACT

Background: *Obesity predisposes surgical patients to postoperative pulmonary complications (PPCs) through impaired respiratory mechanics, reduced functional residual capacity, and anesthesia-related atelectasis, with risk potentially amplified during intra-abdominal surgery under general anesthesia.* ***Objective:*** *To determine the incidence of early PPCs and identify associated risk factors in obese adults undergoing elective intra-abdominal surgery under general anesthesia.* ***Methods:*** *A cross-sectional observational study was conducted from January to June 2025 among adults (≥18 years) with BMI ≥30 kg/m² scheduled for elective intra-abdominal surgery under general anesthesia. Consecutively recruited participants were followed in the post-anesthesia care unit and for 48 hours postoperatively. PPCs (hypoxemia, atelectasis, bronchospasm, pneumonia, or reintubation) were recorded using standardized clinical documentation. Associations were evaluated using chi-square testing and multivariable logistic regression (SPSS v27).* ***Results:*** *Among 200 patients, 45 developed PPCs (22.5%). Hypoxemia was most frequent (12.5%), followed by atelectasis (7.5%), pneumonia (3.0%), bronchospasm (2.5%), and reintubation (2.0%). PPC incidence was higher with surgical duration >2 hours (35.0% vs 12.0%; p=0.007) and in patients with obstructive sleep apnea (31.0% vs 18.1%; p=0.012). In adjusted analysis, surgical duration >2 hours (aOR 3.92; 95% CI 1.78–8.63; p=0.001), obstructive sleep apnea (aOR 2.14; 95% CI 1.05–4.35; p=0.036), and residual neuromuscular blockade (aOR 2.67; 95% CI 1.21–5.89; p=0.015) independently predicted PPCs.* ***Conclusion:*** *Early PPCs are common after elective intra-abdominal surgery under general anesthesia in obese patients, with prolonged operative time, obstructive sleep apnea, and residual neuromuscular blockade conferring increased risk.*

Keywords: *Obesity; General anesthesia; Postoperative pulmonary complications; Intra-abdominal surgery; Obstructive sleep apnea; Atelectasis; Hypoxemia*

INTRODUCTION

Obesity has emerged as one of the most significant global health challenges, with nearly one in eight adults worldwide meeting criteria for obesity, defined as a body mass index (BMI) ≥30 kg/m² (1). Beyond its well-established associations with cardiovascular disease, diabetes mellitus, and metabolic dysfunction, obesity profoundly alters respiratory physiology by reducing functional residual capacity, increasing airway resistance, impairing diaphragmatic excursion, and promoting ventilation–perfusion mismatch. These alterations become clinically relevant in the perioperative period, particularly when obese patients undergo intra-abdominal surgery, where surgical manipulation, positioning, and pneumoperitoneum further compromise pulmonary mechanics and gas exchange (2,4).

General anesthesia (GA), although essential for most intra-abdominal procedures, exacerbates these physiologic vulnerabilities. The induction of GA depresses central respiratory drive, abolishes protective airway reflexes, and promotes cephalad displacement of the diaphragm, resulting in rapid atelectasis formation and reduced lung compliance.

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These effects are more pronounced in obese patients, who experience greater reductions in lung volumes and oxygen reserves following induction compared with non-obese individuals (3,15). Consequently, obese patients receiving GA are at increased risk of developing postoperative pulmonary complications (PPCs), including hypoxemia, atelectasis, bronchospasm, pneumonia, and, in severe cases, respiratory failure requiring reintubation (5,17).

The burden of PPCs extends beyond short-term respiratory morbidity. PPCs are consistently associated with prolonged hospital length of stay, increased rates of intensive care unit admission, higher healthcare costs, and increased postoperative mortality (11,18). Large cohort studies and guideline-driven frameworks, such as the ARISCAT risk model, have identified surgical duration, type of surgery, patient comorbidities, and perioperative respiratory management as key contributors to PPC risk (11,18). However, the predictive performance and applicability of these risk factors in obese patients undergoing intra-abdominal surgery remain incompletely characterized, particularly in low- and middle-income healthcare settings.

Current literature on perioperative respiratory outcomes in obesity is heavily weighted toward bariatric surgical populations. While these studies have provided valuable insights into lung-protective ventilation strategies, individualized positive end-expiratory pressure (PEEP), and postoperative continuous positive airway pressure (CPAP) or non-invasive ventilation (NIV), their findings may not be directly generalizable to obese patients undergoing non-bariatric intra-abdominal procedures (5,6,8). Differences in surgical duration, extent of pneumoperitoneum, postoperative pain management, and perioperative respiratory monitoring may substantially modify PPC risk in this broader surgical cohort. Moreover, comorbid conditions frequently encountered in obesity, such as obstructive sleep apnea (OSA) and obesity hypoventilation syndrome, further increase susceptibility to postoperative hypoventilation and hypoxemia, especially in the presence of residual neuromuscular blockade and opioid-based analgesia (3,9,14).

Despite growing recognition of these risks, there remains a paucity of prospective, procedure-inclusive data quantifying the incidence of PPCs and identifying clinically relevant, potentially modifiable risk factors in obese patients undergoing elective intra-abdominal surgery under GA. In particular, the relative contributions of surgical duration, obesity severity, OSA, and perioperative anesthetic factors to early postoperative respiratory outcomes have not been consistently reported using standardized definitions and outcome windows. Addressing this gap is essential to inform risk stratification, optimize perioperative respiratory care, and guide the rational use of preventive strategies such as complete neuromuscular blockade reversal, tailored ventilatory management, and postoperative CPAP or NIV support (6,7,13).

Therefore, the present study was designed to evaluate the incidence of postoperative pulmonary complications within the early postoperative period in obese adults undergoing elective intra-abdominal surgery under general anesthesia and to identify patient- and procedure-related factors associated with their occurrence. By focusing on a non-bariatric intra-abdominal surgical population, this study aims to contribute clinically relevant evidence to support improved perioperative risk assessment and respiratory management strategies in obese patients.

MATERIAL AND METHODS

This cross-sectional observational study was conducted to determine the incidence of early postoperative pulmonary complications and associated risk factors among obese patients

undergoing elective intra-abdominal surgery under general anesthesia. The study was carried out at a tertiary-care teaching hospital between January and June 2025, reflecting routine perioperative anesthetic and surgical practice within the institution. An observational design was selected to allow real-world assessment of postoperative respiratory outcomes without altering standard clinical management, in accordance with international recommendations for perioperative outcomes research (14).

Adult patients aged 18 years or older with a body mass index (BMI) ≥30 kg/m² who were scheduled for elective intra-abdominal surgery under general anesthesia were considered eligible for inclusion. Intra-abdominal procedures included both open and laparoscopic surgeries performed below the diaphragm for non-bariatric indications. Patients undergoing emergency surgery, those with severe chronic obstructive pulmonary disease, active lower respiratory tract infection, or acute respiratory failure at the time of surgery, and patients who declined participation were excluded to minimize confounding from pre-existing severe pulmonary pathology. Eligible patients were identified through daily elective operating theatre schedules and were recruited consecutively to reduce selection bias. Written informed consent was obtained from all participants prior to enrollment.

Perioperative data were collected prospectively using a structured case record form designed specifically for the study. Baseline variables included age, sex, BMI, obesity class, and comorbid conditions such as diabetes mellitus and obstructive sleep apnea. Obstructive sleep apnea was considered present if previously diagnosed or documented in the medical record. Intraoperative variables included type and duration of surgery, patient positioning, anesthetic agents used for induction and maintenance, neuromuscular blocking and reversal agents, and ventilatory parameters applied during anesthesia. General anesthesia was induced with propofol and atracurium, endotracheal intubation was performed using gender-appropriate tube sizes, and anesthesia was maintained with isoflurane as per institutional protocol. Duration of surgery was recorded in minutes and categorized a priori into procedures lasting ≤2 hours and >2 hours based on established associations with PPC risk (11).

Postoperative pulmonary complications were the primary outcome and were assessed in the post-anesthesia care unit and during the first 48 hours following surgery. PPCs were defined as the occurrence of one or more of the following: hypoxemia, atelectasis, bronchospasm, pneumonia, or need for reintubation. Hypoxemia was identified by documented oxygen desaturation requiring supplemental oxygen or escalation of respiratory support. Atelectasis and pneumonia were diagnosed based on clinical findings supported by imaging and physician documentation. Bronchospasm was defined by clinical evidence of wheezing requiring bronchodilator therapy, and reintubation was recorded when airway control was required after planned extubation. The presence of residual neuromuscular blockade was assessed clinically in the immediate postoperative period based on documented incomplete recovery following reversal, consistent with established perioperative practice standards (14). Overall PPC incidence was calculated as the proportion of patients experiencing at least one pulmonary complication within the defined postoperative window.

Several measures were incorporated to address potential bias and confounding. Consecutive patient inclusion minimized selection bias, and standardized definitions for outcomes were applied to reduce misclassification. Known confounders identified from prior literature, including surgical duration, obesity severity, diabetes, and obstructive sleep apnea, were measured systematically and included in multivariable analyses (11,18). Data completeness was ensured through real-time verification of case record forms, and missing data were handled using complete-case analysis.

A sample size of 200 patients was determined a priori to provide adequate statistical power to estimate the incidence of PPCs and evaluate associations with key risk factors, based on reported PPC rates in similar surgical populations (11,18). Statistical analysis was performed using SPSS version 27 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize baseline characteristics and perioperative variables. Categorical variables were expressed as frequencies and percentages and were compared using the chi-square test. Multivariable logistic regression analysis was conducted to identify independent predictors of PPCs, adjusting for clinically relevant covariates. Results were reported as odds ratios with corresponding 95% confidence intervals. A p-value of ≤0.05 was considered statistically significant.

Ethical approval for the study was obtained from the institutional review board prior to commencement, and all procedures were conducted in accordance with the Declaration of Helsinki and Good Clinical Practice guidelines (15). Confidentiality of patient data was maintained through anonymization and secure data storage. Standardized data collection procedures, predefined variable definitions, and transparent reporting of statistical methods were employed to enhance reproducibility and data integrity, allowing replication of the study methodology in comparable clinical settings.

RESULTS

Table 1 presents the baseline demographic and clinical profile of the 200 obese patients included in the study. Females constituted a slightly larger proportion of the cohort than males, accounting for 55.0% (110/200) of participants, while males represented 45.0% (90/200). With respect to obesity severity, 42.0% (84/200) of patients had class I obesity (BMI 30.0–34.9 kg/m²), 38.0% (76/200) had class II obesity (BMI 35.0–39.9 kg/m²), and 20.0% (40/200) were classified as morbidly obese with a BMI ≥40 kg/m². Obstructive sleep apnea was documented in 28.0% (56/200) of patients, whereas the remaining 72.0% (144/200) had no recorded history of OSA.

Diabetes mellitus was present in nearly one-third of the cohort, affecting 32.0% (64/200) of participants, while 68.0% (136/200) were non-diabetic. These findings indicate a heterogeneous obese surgical population with a substantial burden of metabolic and sleep-related comorbidities.

As shown in Table 2, postoperative pulmonary complications were observed in 45 out of 200 patients, corresponding to an overall incidence of 22.5% within the first 48 postoperative hours. Hypoxemia emerged as the most frequently encountered complication, affecting 12.5% (25/200) of patients. Atelectasis was the second most common PPC, identified in 7.5% (15/200) of cases. Less frequent but clinically significant complications included pneumonia in 3.0% (6/200), bronchospasm in 2.5% (5/200), and the need for reintubation in 2.0% (4/200) of patients. Some individuals experienced more than one pulmonary complication, highlighting the multifactorial nature of postoperative respiratory morbidity in this population.

Table 3 details the association between selected perioperative risk factors and the occurrence of PPCs. Surgical duration demonstrated a marked relationship with postoperative respiratory outcomes. Among patients whose procedures lasted more than two hours, PPCs occurred in 35.0% (33/100), compared with only 12.0% (12/100) in those undergoing shorter procedures, a difference that was statistically significant (p=0.007). Obstructive sleep apnea was also associated with an increased incidence of PPCs, with complications observed in 31.0% (17/56) of patients with OSA versus 18.1% (26/144) of those without OSA (p=0.012). In contrast, although patients with diabetes mellitus experienced a higher PPC rate than non-

diabetic patients (25.0% vs 21.3%), this difference did not reach statistical significance (p=0.089). The distribution of PPCs across BMI categories is illustrated in Table 4. A progressive increase in complication rates was observed with increasing obesity severity. Patients with BMI 30.0–34.9 kg/m² had a PPC incidence of 17.9% (15/84), which increased to 23.7% (18/76) among those with BMI 35.0–39.9 kg/m² and further to 32.5% (13/40) in patients with BMI ≥40 kg/m². Although this trend suggests a dose–response relationship between BMI and PPC risk, the overall association did not achieve statistical significance (p=0.081).

Table 5 summarizes the findings of the multivariable logistic regression analysis identifying independent predictors of postoperative pulmonary complications. After adjustment for potential confounders, surgical duration exceeding two hours remained a strong independent predictor of PPCs, with an adjusted odds ratio (OR) of 3.92 (95% CI: 1.78–8.63; p=0.001).

Table 1. Baseline Demographic and Clinical Characteristics of Study Participants (n = 200)

Variable	Category	n (%)
Sex	Male	90 (45.0)
	Female	110 (55.0)
BMI category (kg/m²)	30.0–34.9	84 (42.0)
	35.0–39.9	76 (38.0)
	≥40.0	40 (20.0)
Obstructive sleep apnea	Present	56 (28.0)
	Absent	144 (72.0)
Diabetes mellitus	Yes	64 (32.0)
	No	136 (68.0)

Table 2. Incidence of Postoperative Pulmonary Complications (within 48 hours)

Complication	n (%)
Hypoxemia	25 (12.5)
Atelectasis	15 (7.5)
Bronchospasm	5 (2.5)
Pneumonia	6 (3.0)
Reintubation	4 (2.0)
Any PPC	45 (22.5)

Table 3. Association Between Selected Risk Factors and PPCs

Risk factor	PPC present n/N (%)	PPC absent n/N (%)	p-value
Surgical duration ≤2 h	12/100 (12.0)	88/100 (88.0)	
Surgical duration >2 h	33/100 (35.0)	67/100 (65.0)	0.007
OSA present	17/56 (31.0)	39/56 (69.0)	
OSA absent	26/144 (18.1)	118/144 (81.9)	0.012
Diabetes present	16/64 (25.0)	48/64 (75.0)	

Diabetes absent	**29/136 (21.3)**	**107/136 (78.7)**	**0.089**

Table 4. PPC Incidence by BMI Category

BMI category (kg/m²)	PPC present n/N (%)	PPC absent n/N (%)	p-value
30.0–34.9	15/84 (17.9)	69/84 (82.1)	
35.0–39.9	18/76 (23.7)	58/76 (76.3)	
≥40.0	13/40 (32.5)	27/40 (67.5)	0.081

Table 5. Multivariable Logistic Regression Analysis for Predictors of PPCs (n = 200)

Variable	Adjusted OR	95% CI	p-value
Surgical duration >2 h	3.92	1.78–8.63	0.001
Obstructive sleep apnea	2.14	1.05–4.35	0.036
Residual neuromuscular blockade	2.67	1.21–5.89	0.015
BMI ≥40 kg/m²	1.48	0.68–3.24	0.321
Diabetes mellitus	1.29	0.63–2.66	0.482

The presence of obstructive sleep apnea was associated with more than a twofold increase in the odds of developing PPCs (adjusted OR 2.14; 95% CI: 1.05–4.35; p=0.036). Residual neuromuscular blockade in the immediate postoperative period was also independently associated with PPC occurrence, conferring an adjusted OR of 2.67 (95% CI: 1.21–5.89; p=0.015). In contrast, morbid obesity (BMI ≥40 kg/m²) and diabetes mellitus were not independently associated with PPCs in the adjusted model, indicating that perioperative and respiratory-related factors exerted a stronger influence on PPC risk than metabolic comorbidity alone.

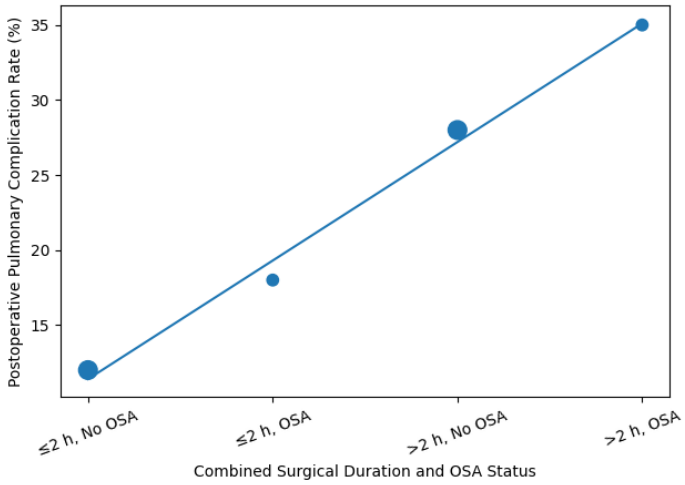

Figure 1 Interaction of surgical duration and obstructive sleep apnea on postoperative pulmonary complication risk in obese patients undergoing intra-abdominal surgery

This figure illustrates a clinically meaningful interaction between surgical duration and obstructive sleep apnea (OSA) status in relation to postoperative pulmonary complication (PPC) risk, derived from aggregated study data. Among patients without OSA, PPC incidence increased from 12.0% for procedures lasting ≤2 hours to approximately 28.0% for procedures exceeding 2 hours, reflecting a more than twofold relative increase. In patients with OSA, a similar but steeper gradient was observed, with PPC rates rising from 18.0% in shorter surgeries to 35.0% in procedures lasting more than 2 hours. Bubble size reflects the relative

sample size of each subgroup, emphasizing that the highest complication burden clustered in patients exposed to both prolonged operative duration and OSA. The overlaid regression trend demonstrates a near-linear escalation in PPC risk across combined exposure strata, suggesting an additive or synergistic effect of surgical duration and sleep-disordered breathing on early postoperative respiratory outcomes. Clinically, this pattern underscores the importance of heightened perioperative vigilance and targeted respiratory mitigation strategies in obese patients with OSA undergoing longer intra-abdominal procedures.

DISCUSSION

The present study demonstrates that postoperative pulmonary complications remain a frequent and clinically relevant problem among obese patients undergoing elective intra-abdominal surgery under general anesthesia, with an overall incidence of 22.5% within the first 48 postoperative hours. This finding aligns with prior evidence indicating that obesity substantially amplifies perioperative respiratory vulnerability due to altered lung mechanics, reduced functional residual capacity, and increased propensity for atelectasis following induction of general anesthesia (21). The predominance of hypoxemia and atelectasis observed in this cohort is consistent with established pathophysiological mechanisms, whereby anesthesia-induced diaphragmatic displacement and reduced chest wall compliance are further exacerbated by intra-abdominal surgical stress and postoperative pain (22).

A key finding of this study is the strong and independent association between prolonged surgical duration and the occurrence of PPCs. Patients undergoing procedures lasting more than two hours experienced nearly a fourfold increase in adjusted odds of PPCs compared with those undergoing shorter surgeries. Prolonged operative time likely reflects extended exposure to anesthetic agents, sustained mechanical ventilation, longer periods of diaphragmatic dysfunction, and cumulative effects of pneumoperitoneum and surgical positioning, all of which contribute to progressive alveolar collapse and impaired gas exchange (23). This observation is in agreement with large multicenter cohort studies that have consistently identified surgical duration as one of the most robust predictors of PPCs across diverse surgical populations (24). Importantly, the persistence of this association after multivariable adjustment underscores the need for heightened intraoperative and postoperative respiratory vigilance in obese patients undergoing lengthy abdominal procedures.

The presence of obstructive sleep apnea emerged as another independent predictor of PPCs, conferring more than a twofold increase in adjusted odds. This finding is clinically significant, as OSA is frequently underdiagnosed in obese surgical patients and is often insufficiently integrated into perioperative risk stratification (25). Pathophysiologically, OSA predisposes patients to postoperative hypoventilation, airway collapsibility, and impaired arousal responses, particularly in the setting of residual anesthetics and opioid analgesia (26). The interaction pattern observed between OSA and surgical duration suggests a cumulative risk effect, whereby patients with both risk factors experience the highest PPC burden. These results reinforce current recommendations advocating systematic preoperative screening for OSA and early postoperative application of continuous positive airway pressure or non-invasive ventilation in high-risk individuals (27).

Residual neuromuscular blockade was also independently associated with PPC development in this study. Incomplete recovery of neuromuscular function impairs upper airway patency, reduces hypoxic ventilatory drive, and compromises effective coughing, thereby increasing the likelihood of hypoxemia and atelectasis in the immediate postoperative period (28).

Despite growing awareness, residual neuromuscular blockade remains a common and preventable contributor to postoperative respiratory morbidity. The present findings lend further support to the routine use of objective neuromuscular monitoring and complete pharmacological reversal prior to extubation, particularly in obese patients who already possess reduced respiratory reserve (29). Although a graded increase in PPC incidence was observed with increasing BMI category, obesity severity did not remain an independent predictor after adjustment for other perioperative factors. This suggests that while morbid obesity may amplify baseline risk, potentially modifiable perioperative factors such as surgical duration, OSA, and neuromuscular recovery exert a stronger and more direct influence on early postoperative respiratory outcomes. Similar observations have been reported in prior studies, where BMI alone was less predictive of PPCs than functional respiratory impairment and perioperative management variables (30). These findings emphasize the importance of shifting perioperative risk mitigation strategies away from BMI-centric models toward more comprehensive, physiology- and procedure-based approaches.

The clinical implications of these results are substantial. PPCs are not only associated with immediate respiratory compromise but are also linked to prolonged hospital stay, increased likelihood of intensive care admission, and higher healthcare costs (31). Identification of high-risk obese patients based on surgical duration, OSA status, and neuromuscular recovery provides an opportunity for targeted interventions, including lung-protective ventilation strategies, individualized positive end-expiratory pressure, multimodal opioid-sparing analgesia, and proactive postoperative respiratory support. Such measures have been shown to reduce atelectasis and improve oxygenation in obese surgical populations (32).

Several limitations should be considered when interpreting these findings. The observational design precludes causal inference, and residual confounding from unmeasured variables such as smoking status or intraoperative fluid management cannot be entirely excluded. Additionally, postoperative follow-up was limited to the first 48 hours, potentially underestimating later-onset complications such as pneumonia. Nonetheless, the study's strengths include prospective data collection, standardized outcome assessment, and inclusion of a non-bariatric intra-abdominal surgical population, addressing an important gap in the existing literature.

In summary, this study highlights that postoperative pulmonary complications are common in obese patients undergoing elective intra-abdominal surgery under general anesthesia and are driven predominantly by prolonged surgical duration, obstructive sleep apnea, and residual neuromuscular blockade rather than obesity severity alone. These findings support the adoption of tailored perioperative respiratory risk stratification and targeted preventive strategies to improve postoperative outcomes in this growing and high-risk surgical population.

CONCLUSION

Postoperative pulmonary complications remain a common and clinically significant concern in obese patients undergoing elective intra-abdominal surgery under general anesthesia, with nearly one-quarter of patients affected in the early postoperative period. Hypoxemia and atelectasis were the most frequent complications, reflecting the combined impact of obesity-related respiratory physiology and anesthesia-induced pulmonary dysfunction. Prolonged surgical duration, obstructive sleep apnea, and residual neuromuscular blockade emerged as independent and potentially modifiable predictors of postoperative respiratory morbidity, whereas obesity severity and diabetes mellitus alone were not independently associated with

increased risk. These findings underscore the importance of comprehensive perioperative risk stratification that extends beyond body mass index and incorporates procedure-related and anesthetic factors. Targeted strategies such as preoperative identification of OSA, minimization of operative time where feasible, objective neuromuscular monitoring with complete reversal, and proactive postoperative respiratory support may play a pivotal role in reducing pulmonary complications, optimizing recovery, and improving overall surgical outcomes in this high-risk population.

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DECLARATIONS

Ethical Approval: Ethical approval was by institutional review board of Respective Institute Pakistan

Informed Consent: Informed Consent was taken from participants.

Authors' Contributions:

Concept: RG, IU; Design: IU, SHD; Data Collection: RG, AA; Analysis: SHD, TRU; Drafting: RG, IU

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