Section: Anaesthesiology

Original Research Article

# A CASE-CONTROL STUDY INVESTIGATING THE ASSOCIATION BETWEEN PERIOPERATIVE FLUID MANAGEMENT AND POSTOPERATIVE RESPIRATORY COMPLICATIONS IN PATIENTS WITH PULMONARY DISEASE

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## ABSTRACT

**Background:** Patients with pre-existing pulmonary disease are at an increased risk of developing postoperative respiratory complications. Perioperative fluid management plays a crucial role in maintaining hemodynamic stability, but excessive fluid administration may exacerbate pulmonary complications. This study aims to investigate the association between perioperative fluid management and the occurrence of postoperative respiratory complications in this vulnerable population. **Objective:** The aim of this study was to investigate the association between perioperative fluid management and postoperative respiratory complications in patients with pre-existing pulmonary disease.

**Materials and Methods:** This case-control study included 100 patients undergoing major surgery, with 50 patients developing postoperative respiratory complications (case group) and 50 patients without complications (control group). Perioperative fluid management, including intraoperative and postoperative fluid volumes, was compared between the two groups. Postoperative respiratory complications, such as pneumonia, atelectasis, and acute respiratory distress syndrome (ARDS), were analyzed. Logistic regression was used to identify risk factors, and the length of hospital stay was evaluated.

**Results:** Patients in the case group received significantly higher intraoperative fluid volumes compared to the control group (3.2 ± 0.8 vs. 2.6 ± 0.7 liters, $p = 0.01$). The postoperative fluid volume was also higher in the case group (2.1 ± 0.5 vs. 1.7 ± 0.4 liters, $p = 0.03$). Respiratory complications occurred exclusively in the case group, with 32% developing pneumonia, 24% atelectasis, and 44% ARDS ($p < 0.001$). Logistic regression identified higher intraoperative fluid volume (OR = 2.3, 95% CI: 1.4-3.8, $p = 0.01$) and postoperative fluid volume (OR = 1.8, 95% CI: 1.1-2.9, $p = 0.02$) as independent risk factors. Patients with complications had a longer hospital stay (12 vs. 7 days, $p < 0.001$).

**Conclusion:** Excessive perioperative fluid administration is significantly associated with a higher risk of postoperative respiratory complications in patients with pulmonary disease. Careful, goal-directed fluid management strategies are essential to minimize the incidence of pneumonia, atelectasis, and ARDS, improving postoperative outcomes.

**Keywords:** Perioperative fluid management, postoperative respiratory complications, pulmonary disease, pneumonia, acute respiratory distress syndrome, atelectasis.

## INTRODUCTION

Postoperative respiratory complications are a significant cause of morbidity and mortality, particularly in patients with pre-existing pulmonary disease, such as chronic obstructive pulmonary disease (COPD), asthma, and interstitial lung disease.[1] These complications, which include pneumonia, atelectasis, and acute respiratory distress syndrome (ARDS), not only increase healthcare costs but also extend hospital stays and contribute to poor patient outcomes.[2,3]

Perioperative fluid management is a critical component of surgical care. It is essential for maintaining hemodynamic stability, preventing hypovolemia, and ensuring adequate tissue perfusion.[4,5] However, excessive fluid administration can lead to fluid overload, which may exacerbate pulmonary complications by increasing interstitial lung fluid, reducing lung compliance, and impairing gas exchange.[6,7] This risk is particularly heightened in patients with compromised lung function.

Despite the importance of optimizing fluid management, there is limited data on the relationship between perioperative fluid administration and respiratory complications in patients with pulmonary disease. Understanding this relationship is vital for developing tailored fluid management strategies that minimize the risk of postoperative complications in this vulnerable population.

This study aims to investigate the association between perioperative fluid management and the development of postoperative respiratory complications in patients with pulmonary disease. By comparing intraoperative and postoperative fluid volumes between patients who develop respiratory complications and those who do not, we seek to identify whether fluid overload is a significant contributing factor. Additionally, we aim to evaluate the impact of these complications on patient outcomes, including the need for ICU admission and the length of hospital stay. This study provides insights that may help guide fluid management practices and improve postoperative outcomes in patients with pulmonary disease.

## MATERIALS AND METHODS

### Study Design and Setting

This case-control study was conducted at the Government Medical College, Nalgonda, a tertiary care hospital, over a 12-month period from July 2023 to June 2024. The study aimed to investigate the association between perioperative fluid management and postoperative respiratory complications in patients with pre-existing pulmonary disease.

### Study Population

A total of 100 patients undergoing major surgical procedures were enrolled in the study. Patients were selected based on the inclusion and exclusion criteria outlined below. The participants were divided into two groups:

**Case Group (n = 50)**: Patients who developed postoperative respiratory complications such as pneumonia, atelectasis, or acute respiratory distress syndrome (ARDS) during the first seven postoperative days.

**Control Group (n = 50)**: Patients who did not develop any postoperative respiratory complications.

### Inclusion Criteria

1. Patients aged 18 years or older.
2. Patients with a pre-existing diagnosis of pulmonary disease, including chronic obstructive pulmonary disease (COPD), asthma, or interstitial lung disease.
3. Patients undergoing major elective or emergency surgeries under general anesthesia.

### Exclusion Criteria

1. Patients with severe renal or heart failure.
2. Patients with pre-existing systemic infections.
3. Patients who underwent minor surgeries or surgeries under local anesthesia.

### Data Collection

Data on perioperative fluid management, including intraoperative and postoperative fluid volumes, were collected from patient medical records. Other variables, including demographic information, type of pulmonary disease, type of surgery, and anesthesia details, were recorded. Postoperative respiratory complications were diagnosed based on clinical, radiological, and laboratory findings.

### Fluid Management

**Intraoperative Fluid Management**: The total volume of fluids administered during surgery was recorded for each patient.

**Postoperative Fluid Management**: The total fluid volume administered during the first 24 hours post-surgery was documented.

### Outcome Measures

The primary outcome was the development of postoperative respiratory complications, including pneumonia, atelectasis, and ARDS. Secondary outcomes included oxygenation status (PaO2/FiO2 ratio), need for ICU admission, and length of hospital stay.

### Statistical Analysis

Data were analyzed using descriptive and inferential statistics. Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables as percentages. Independent t-tests were used to compare continuous variables between the case and control groups, while chi-square tests were used for categorical variables. Logistic regression analysis was performed to assess the association between fluid volumes and respiratory complications, adjusting for potential confounders. A p-value < 0.05 was considered statistically

significant. Data analysis was performed using SPSS version 26.0.

**Ethical Considerations**

The study was approved by the Institutional Ethics Committee of Government Medical College, Nalgonda. Informed consent was obtained from all patients before their inclusion in the study. Confidentiality and anonymity of the participants were maintained throughout the study.

## RESULTS

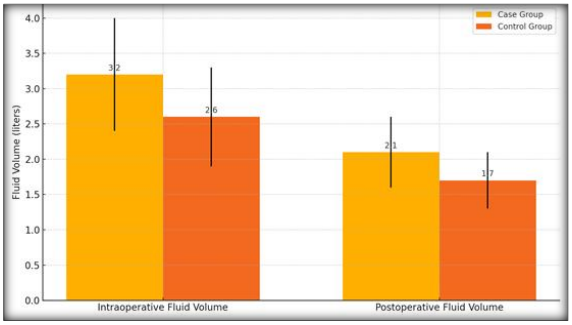


**Figure 1: Perioperative Fluid Management**

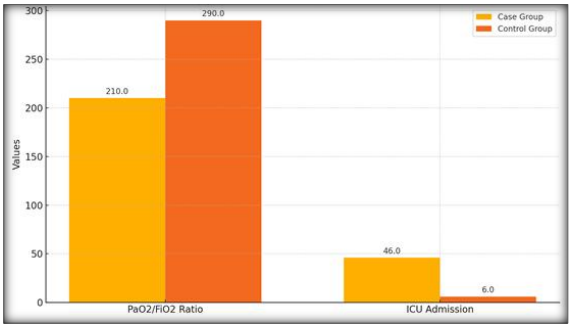


**Figure 2: Oxegenation Status and ICU Admission**

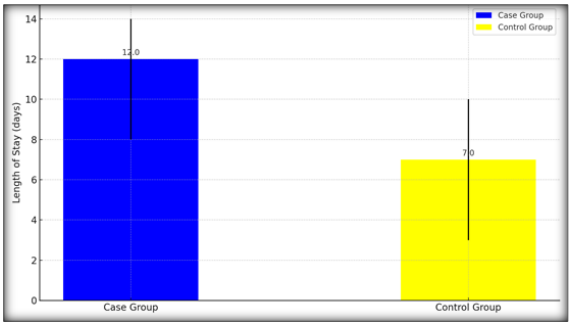


**Figure 3: Length of Hospital Stay (Case vs Control)**

In this case-control study investigating the association between perioperative fluid management and postoperative respiratory complications in patients with pulmonary disease, 100 patients were enrolled and divided equally into two groups. The case group consisted of 50 patients who developed postoperative respiratory complications, while the control group included 50 patients who did not. The findings from the study are summarized below.

**1. Baseline Characteristics**

The demographic and clinical characteristics of the patients were similar between the case and control groups (Table 1). The mean age of patients in the case group was 65.3 ± 10.5 years, compared to 64.7 ± 9.8 years in the control group ($p = 0.62$). The proportion of males was comparable in both groups (60% vs. 58%, $p = 0.82$). The distribution of pulmonary diseases (COPD, asthma, interstitial lung disease) was similar across the two groups ($p = 0.77$).

**2. Perioperative Fluid Management**

Patients in the case group received a significantly higher mean volume of intraoperative fluids compared to the control group (3.2 ± 0.8 liters vs. 2.6 ± 0.7 liters, $p = 0.01$). Postoperatively, the case group also received more fluids during the first 24 hours (2.1 ± 0.5 liters vs. 1.7 ± 0.4 liters, $p = 0.03$). (Table 2)

**3. Postoperative Respiratory Complications**

The incidence of respiratory complications was significantly higher in the case group compared to the control group (Table 3). Among the case group, 32% of patients developed pneumonia, 24% developed atelectasis, and 44% experienced acute respiratory distress syndrome (ARDS). None of these complications were observed in the control group ($p < 0.001$ for all complications).

**4. Oxygenation Status and ICU Admission**

The case group exhibited significantly lower postoperative PaO2/FiO2 ratios compared to the control group (210 ± 55 vs. 290 ± 65, $p < 0.001$) (Table 4). Furthermore, 46% of patients in the case group required ICU admission, whereas only 6% of the control group needed ICU care ($p < 0.001$).

**5. Association Between Fluid Management and Respiratory Complications**

Multivariate logistic regression analysis identified that higher intraoperative fluid volume was associated with an increased risk of postoperative respiratory complications (odds ratio [OR] = 2.3, 95% confidence interval [CI]: 1.4-3.8, $p = 0.01$). Similarly, higher postoperative fluid volume was also associated with a greater risk of complications (OR = 1.8, 95% CI: 1.1-2.9, $p = 0.02$). (Table 5)

**6. Length of Hospital Stay**

Patients in the case group had a significantly longer median length of hospital stay compared to the control group (12 days, interquartile range [IQR] 8-16 vs. 7 days, IQR 5-10, $p < 0.001$). (Table 6)

**Table 1: Baseline Characteristics**

| Characteristic | Case Group (n=50) | Control Group (n=50) | p-value |
|---|---|---|---|
| Age (years, mean ± SD) | 65.3 ± 10.5 | 64.7 ± 9.8 | 0.62 |
| Gender (% male) | 60% | 58% | 0.82 |
| Pulmonary Disease Type (COPD, asthma, ILD) | Comparable (p = 0.77) | Comparable (p = 0.77) | 0.77 |

**Table 2: Perioperative Fluid Management**

| Variable | Case Group (n=50) | Control Group (n=50) | p-value |
|---|---|---|---|
| Mean intraoperative fluid volume (liters) | 3.2 ± 0.8 | 2.6 ± 0.7 | 0.01 |
| Mean postoperative fluid volume (liters) | 2.1 ± 0.5 | 1.7 ± 0.4 | 0.03 |

**Table 3: Postoperative Respiratory Complications**

| Complication | Case Group (%) | Control Group (%) | p-value |
|---|---|---|---|
| Pneumonia | 32 | 0 | < 0.001 |
| Atelectasis | 24 | 0 | < 0.001 |
| ARDS | 44 | 0 | < 0.001 |

**Table 4: Oxygenation Status and ICU Admission**

| Variable | Case Group (n=50) | Control Group (n=50) | p-value |
|---|---|---|---|
| Postoperative PaO2/FiO2 ratio (mean ± SD) | 210 ± 55 | 290 ± 65 | < 0.001 |
| ICU Admission (%) | 46 | 6 | < 0.001 |

**Table 5: Association Between Fluid Management and Respiratory Complications (Logistic Regression)**

| Variable | Odds Ratio (OR) | 95% Confidence Interval (CI) | p-value |
|---|---|---|---|
| Higher intraoperative fluid volume | 2.3 | 1.4-3.8 | 0.01 |
| Higher postoperative fluid volume | 1.8 | 1.1-2.9 | 0.02 |

**Table 6: Length of Hospital Stay**

| Group | Median Length of Stay (days) | p-value |
|---|---|---|
| Case Group (n=50) | 12 (IQR 8-16) | < 0.001 |
| Control Group (n=50) | 7 (IQR 5-10) | < 0.001 |

# DISCUSSION

This study aimed to investigate the association between perioperative fluid management and the occurrence of postoperative respiratory complications in patients with pre-existing pulmonary disease. Our findings reveal that excessive perioperative fluid administration is significantly associated with a higher incidence of complications such as pneumonia, atelectasis, and acute respiratory distress syndrome (ARDS), highlighting the critical need for careful fluid management in this vulnerable population. These results align with previous studies emphasizing the relationship between fluid overload and adverse outcomes, further supporting the importance of goal-directed perioperative fluid strategies (Miller et al,[8] 2021; Lusquinhos et al,[9] 2023).

Perioperative Fluid Management and Respiratory **Complications**

Our results indicate that patients in the case group, who developed postoperative respiratory complications, received significantly higher volumes of intraoperative and postoperative fluids compared to those in the control group. This is consistent with findings from Miller et al,[8] (2021) and Kubo et al,[12] (2022), who reported that fluid overload can exacerbate pulmonary complications by increasing lung interstitial fluid, reducing lung compliance, and impairing gas exchange. Patients with pre-existing pulmonary conditions, such as COPD, asthma, and interstitial lung disease, are particularly vulnerable to these effects, as their compromised lung mechanics and gas exchange are further impaired by fluid overload (Diaz-Fuentes et al,[10] 2016).

The role of perioperative fluid overload in promoting conditions like pneumonia and ARDS is especially concerning in major surgeries, where large fluid volumes are often necessary to maintain hemodynamic stability. These findings are supported by previous research linking excessive fluid administration with postoperative respiratory complications in surgical patients with pulmonary disease (Stocking et al,[13] 2021).

**Oxygenation and ICU Admission**

Postoperative oxygenation status, as measured by the PaO2/FiO2 ratio, was significantly lower in patients who developed respiratory complications, underscoring the negative impact of fluid overload on gas exchange. Eikermann et al,[11] (2019) similarly found that fluid overload is associated with impaired oxygenation and higher rates of postoperative respiratory problems. Additionally, the greater proportion of patients in the case group requiring ICU admission suggests that these complications not only lead to poorer clinical outcomes but also increase the burden on healthcare resources. This aligns with findings from Stocking et al,[13] (2021) and Baar et al,[14] (2022), who demonstrated that fluid overload contributes to prolonged ICU stays and higher postoperative mortality rates.

**Implications for Clinical Practice**

The results of this study highlight the importance of optimizing perioperative fluid management to reduce the risk of postoperative respiratory complications in patients with pulmonary disease. Clinicians should adopt a goal-directed fluid management strategy, avoiding fluid overload while ensuring adequate perfusion. This approach has been recommended by Lusquinhos et al,[9] (2023), who advocate for the use of dynamic monitoring

tools, such as stroke volume variation and cardiac output measurements, to guide fluid therapy more precisely during surgery. By tailoring fluid management to the individual needs of patients, healthcare providers can minimize the risk of respiratory complications and improve postoperative outcomes (Miller et al,[8] 2021).

**Limitations and Future Directions**

This study has several limitations. First, the sample size was relatively small, which may limit the generalizability of the findings. Second, the study was conducted at a single center, and variations in surgical and anesthetic practices across different institutions could influence outcomes. Additionally, we did not account for other factors, such as the type of surgical procedure and anesthesia depth, which may also contribute to respiratory complications.

Future studies should focus on larger, multicenter trials to validate these findings and explore additional strategies for fluid management in patients with pulmonary disease. Furthermore, research on the use of restrictive or balanced fluid regimens and their impact on postoperative outcomes in this population is warranted.

## CONCLUSION

This study reveals that higher intraoperative and postoperative fluid volumes are significantly associated with an increased risk of postoperative respiratory complications, including pneumonia, atelectasis, and ARDS, in patients with pre-existing pulmonary disease. Patients receiving excessive fluid volumes also exhibited poorer oxygenation and required more frequent ICU admissions. These findings highlights the need for careful fluid management, particularly in patients with compromised lung function. Tailored, goal-directed fluid strategies are crucial for minimizing respiratory complications and improving postoperative outcomes in this vulnerable population. Clinicians should prioritize individualized fluid therapy to enhance patient safety and reduce ICU stays.

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