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Association Between Intraoperative Fluid Management and Postoperative Respiratory Complications: An Observational Study in Patients Undergoing Major Abdominal Surgery

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ABSTRACT

Intraoperative fluid management is a critical aspect of perioperative care that can significantly impact postoperative outcomes, particularly respiratory complications. This study investigates the association between intraoperative fluid administration and the incidence of postoperative respiratory complications in patients undergoing major abdominal surgery. An observational study was conducted on 100 patients who underwent major abdominal surgery. Patients were divided into two groups based on the volume of intraoperative fluid received: Group A (≤3,800 mL) and Group B (>3,800 mL). Postoperative respiratory complications, including pneumonia, atelectasis and respiratory failure requiring mechanical ventilation, were recorded. Secondary outcomes included the length of hospital stay and mortality rates. Statistical analysis was performed to assess the relationship between fluid management and respiratory complications. Respiratory complications were observed in 25 patients (25%). Group A had 8 patients (16%) with complications, while Group B had 17 patients (34%) with complications. Pneumonia was the most common complication (12%), followed by atelectasis (8%) and respiratory failure (5%). The median length of hospital stay was 7 days in Group A and 10 days in Group B. The overall mortality rate was 2%. A significant association was found between higher intraoperative fluid administration and an increased risk of respiratory complications (p=0.03). Excessive intraoperative fluid administration is associated with a higher incidence of postoperative respiratory complications in major abdominal surgery. Optimizing fluid management during surgery may reduce these complications and improve patient outcomes.

INTRODUCTION

Intraoperative fluid management is a crucial aspect of perioperative care, directly influencing patient outcomes during and after surgery[1]. Major abdominal surgeries often require careful management of fluids to maintain hemodynamic stability, support organ function and facilitate recovery[2]. However, the administration of fluids is a delicate balance-both insufficient and excessive fluid administration can lead to adverse outcomes[3].

Postoperative respiratory complications, including pneumonia, atelectasis and respiratory failure, are common and significant contributors to morbidity and mortality following major surgeries[4]. These complications can prolong hospital stays, increase healthcare costs and negatively impact patient recovery[5]. The role of intraoperative fluid management in the development of these respiratory complications has been a subject of ongoing debate and research.

Excessive fluid administration may lead to fluid overload, resulting in pulmonary edema, impaired gas exchange and increased risk of respiratory complications[6]. Conversely, restrictive fluid management could lead to hypoperfusion and tissue ischemia, potentially compromising patient outcomes[7]. Thus, understanding the optimal fluid balance during surgery is vital for improving postoperative results and minimizing complications. This observational study aims to investigate the association between intraoperative fluid administration and the incidence of postoperative respiratory complications in patients undergoing major abdominal surgery. By analyzing the outcomes in patients receiving different volumes of intraoperative fluids, this study seeks to contribute valuable insights into the role of fluid management in surgical care and to provide evidence-based guidance for optimizing perioperative fluid strategies.

MATERIALS AND METHODS

This observational study was conducted at Osmania Medical College and Osmania General Hospital, Hyderabad, over a period of 12 months, from May 2023-April 2024. The study aimed to assess the association between intraoperative fluid management and the incidence of postoperative respiratory complications in patients undergoing major abdominal surgery.

Study Design and Participants: A total of 100 patients who underwent major abdominal surgery during the study period were included. Patients were selected based on inclusion criteria that required them to be adults (aged 18 years and above) undergoing elective or emergency major abdominal surgery. Exclusion criteria included patients with pre-existing severe respiratory conditions, chronic kidney disease, or those requiring massive transfusions or complex surgeries that deviated from standard procedures.

Data Collection: Preoperative, intraoperative and postoperative data were collected prospectively. Preoperative data included patient demographics, comorbidities (such as hypertension, diabetes mellitus, and chronic obstructive pulmonary disease) and baseline respiratory function. Intraoperative data focused on the volume of fluids administered, including crystalloids and colloids, as well as details of anesthesia and surgical duration.

Patients were Divided into two Groups Based on the total volume of Intraoperative fluid Received:

- **Group A:** Patients receiving ≤3,800 mL of fluid.
- **Group B:** Patients receiving >3,800 mL of fluid.

Outcome Measures: The primary outcome was the incidence of postoperative respiratory complications, including pneumonia, atelectasis and respiratory failure requiring mechanical ventilation. Secondary outcomes included the length of hospital stay and mortality rates. Postoperative complications were monitored and recorded for up to 30 days following surgery.

Statistical Analysis: Statistical analysis was performed using appropriate methods to assess the association between intraoperative fluid volumes and postoperative respiratory complications. Categorical variables were compared using Chi-square tests and continuous variables were analyzed using t-tests or Mann-Whitney U tests, as appropriate. A $p<0.05$ was considered statistically significant.

Ethical Approval: Ethical approval was obtained from the Institutional Review Board of Osmania Medical College and Osmania General Hospital. Informed consent was obtained from all participants, ensuring confidentiality and adherence to ethical guidelines throughout the study.

RESULTS AND DISCUSSIONS

Patient Demographics and Baseline Characteristics: The study included 100 patients who underwent major abdominal surgery, as shown in Table 1.

Table 1: Patient Demographics and Baseline Characteristics

Variable	Value
Number of Patients	100
Average Age (years)	58.2 (range: 32-79)
Gender Distribution	55 Males, 45 Females
Median BMI (kg/m²)	26.8 (range: 19.5-34.2)
Comorbidities	
Hypertension (%)	30
Diabetes Mellitus (%)	25
COPD (%)	15

The average age was 58.2 years, ranging from 32-79 years. The cohort consisted of 55 males and 45 females. The median BMI was 26.8 kg/m², with values ranging from 19.5-34.2 kg/m². Comorbid conditions were common, with 30% of patients having hypertension, 25% having diabetes mellitus and 15% suffering from chronic obstructive pulmonary disease (COPD).

Intraoperative Fluid Management: Patients were divided into two groups based on intraoperative fluid management (see Table 2).

Table 2: Intraoperative Fluid Management

Fluid Administration	Group A (≤3,800 mL)	Group B (>3,800 mL)	Total
Number of Patients	50	50	100
Total Fluid Administered (mL)	≤3,800	> 3,800	Range: 1,500-6,500
Crystalloids Administered (mL)	Median: 3,200	Median: 3,200	3,200
Colloids Administered (mL)	Median: 600	Median: 600	600

Group A (n=50) received ≤3,800 mL of fluid, while Group B (n=50) received more than 3,800 mL. The total fluid administered ranged from 1,500 mL to 6,500 mL. The median volume of crystalloids was 3,200 mL in both groups, while the median volume of colloids was 600 mL in both groups.

Postoperative Respiratory Complications: Postoperative respiratory complications were observed in 25 patients (25%), as detailed in Table 3.

Table 3: Postoperative Respiratory Complications

Complication	Group A (n=50)	Group B (n=50)	Total (n=100)
Total Respiratory Complications	8 (16%)	17 (34%)	25 (25%)
Pneumonia	4 (8%)	8 (16%)	12 (12%)
Atelectasis	3 (6%)	5 (10%)	8 (8%)
Respiratory Failure (Mechanical Vent.)	1 (2%)	4 (8%)	5 (5%)

Group A had 8 patients (16%) with complications, while Group B had 17 patients (34%) with complications. The most common complication was pneumonia, affecting 12 patients (12%). Atelectasis was observed in 8 patients (8%) and 5 patients (5%) experienced respiratory failure requiring mechanical ventilation.

Secondary Outcomes: The median length of hospital stay differed between the two groups, with Group A having a median stay of 7 days compared to 10 days in Group B (Table 4).

Table 4: Secondary Outcomes

Outcome	Group A (≤3,800 mL)	Group B (>3,800 mL)	Total
Median Length of Hospital Stay (days)	7	10	Not Applicable
Mortality Rate	1 (2%)	1 (2%)	2 (2%)

The mortality rate was low, with 1 patient (2%) in each group, resulting in an overall mortality rate of 2%.

Statistical Association Between Fluid Management and Respiratory Complications: There was a statistically significant association between the amount of intraoperative fluid administered and the incidence of postoperative respiratory complications, with a p-value of 0.03 (Table 5).

Table 5: Statistical Association Between Fluid Management and Respiratory Complications

Comparison	p-value
Group A (≤3,800 mL) vs Group B (> 3,800 mL)	0.03

Patients receiving >3,800 mL of fluid intraoperatively were at a higher risk of developing respiratory complications.

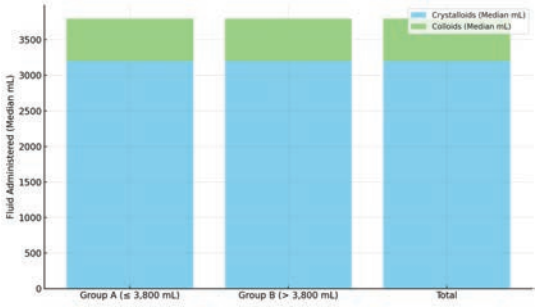

Fig. 1: Intraoperative Fluid Management

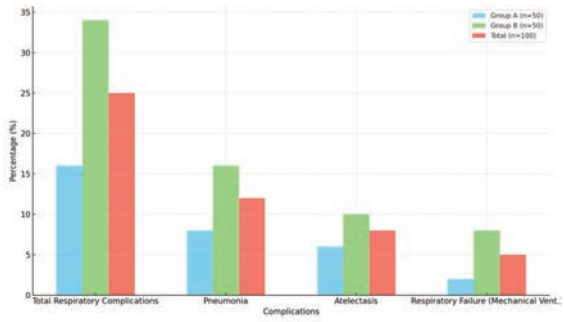

Fig. 2: Postoperative Respiratory Complications

The findings from this observational study provide important insights into the relationship between intraoperative fluid management and the risk of postoperative respiratory complications in patients undergoing major abdominal surgery. The study demonstrated a statistically significant association between higher volumes of intraoperative fluid administration and an increased incidence of respiratory complications, including pneumonia, atelectasis and respiratory failure requiring mechanical ventilation. This observation is consistent with existing literature that underscores the adverse effects of excessive fluid administration during surgery.

Comparison with Existing Literature: The pathophysiological mechanisms underlying the observed association between high intraoperative fluid volumes and postoperative respiratory complications can be attributed to fluid overload. Excessive fluid administration can lead to pulmonary edema, impaired

gas exchange and increased lung water content, all of which exacerbate respiratory dysfunction and contribute to the development of complications such as pneumonia and atelectasis. These findings align with those reported by Sim[7] who found that excessive postoperative fluid balance was associated with higher mortality and morbidity in critically ill patients with complicated intra-abdominal infections.

Furthermore, studies have demonstrated that restrictive fluid strategies may reduce the risk of postoperative complications, particularly in high-risk surgical patients. For instance, Castro[8]. Reported that a more conservative fluid management approach led to fewer pulmonary complications in patients undergoing abdominal surgeries . Similarly, Jenko[9]. Observed that different intraoperative fluid management strategies significantly influenced postoperative outcomes, with restrictive approaches being associated with better respiratory outcomes. These findings highlight the delicate balance between avoiding hypoperfusion and preventing fluid overload, which is critical in optimizing surgical outcomes.

In our study, patients who received more than 3,800 mL of fluid intraoperatively were at a significantly higher risk of developing respiratory complications compared to those who received less. This is consistent with the findings of Voldby[10]., who documented that excessive perioperative fluid administration was linked to increased complications in emergency gastrointestinal surgeries. Similarly, Neumann[11]. Found that intraoperative fluid management played a pivotal role in determining postoperative outcomes and mortality in patients undergoing cytoreductive surgery for advanced ovarian cancer.

Clinical Implications: The clinical implications of this study are significant. Anesthesiologists and surgeons should be aware of the risks associated with liberal fluid administration and consider adopting a more conservative approach, particularly in patients with risk factors for respiratory complications. The use of goal-directed fluid therapy, guided by hemodynamic monitoring, may help tailor fluid administration to the individual needs of each patient, thereby reducing the risk of adverse outcomes. This approach has been supported by multiple studies, including a systematic review and meta-analysis by Messina[12], which highlighted the benefits of goal-directed fluid therapy in reducing postoperative complications in major surgeries.

The significant difference in the length of hospital stay between the two groups in our study further underscores the impact of fluid management on patient recovery. Patients who developed respiratory complications not only had longer hospital stays but also faced potentially higher healthcare costs and a prolonged recovery period. These findings are consistent with the results of Shin[13], who observed that intraoperative fluid management significantly affected postoperative outcomes and length of stay in a large hospital registry study.

By optimizing intraoperative fluid management, it may be possible to reduce these complications, improve patient outcomes and decrease the burden on healthcare systems. As Buchholz[14]. Noted, careful management of fluid balance during and after surgery can have a profound impact on reducing complications and improving recovery, particularly in complex surgical procedures like transthoracic esophagectomy.

Study Limitations: While this study provides valuable insights, it is important to acknowledge its limitations. As an observational study, it cannot establish causality, and the findings may be influenced by confounding factors not accounted for in the analysis. Additionally, the study was conducted in a single institution, which may limit the generalizability of the results to other settings. Future research should focus on multicenter trials with larger sample sizes to confirm these findings and explore the underlying mechanisms further.

CONCLUSION

This study demonstrates a significant association between higher intraoperative fluid administration and an increased incidence of postoperative respiratory complications in patients undergoing major abdominal surgery. Specifically, patients receiving more than 3,800 mL of fluid were at a higher risk of developing pneumonia, atelectasis and respiratory failure, leading to longer hospital stays. These findings underscore the importance of tailoring fluid management strategies to individual patient needs to minimize respiratory risks and enhance recovery. Implementing goal-directed fluid therapy may be key to optimizing patient outcomes and reducing the incidence of postoperative complications.

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