Effect of Continuous Airway Pressure on Lung Function in Patients Undergoing Cardiopulmonary Bypass: An Observational Study

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ABSTRACT

Background: Postoperative pulmonary dysfunction remains a common complication following cardiopulmonary bypass (CPB), with atelectasis and impaired oxygenation contributing to delayed recovery and increased morbidity.

Objective: To evaluate the effect of applying 5 cm H_2O continuous positive airway pressure (CPAP) during CPB on postoperative lung function in patients undergoing cardiac surgery.

Methods: This prospective observational study included 70 adult patients undergoing elective cardiac surgery. Patients were divided into two groups: CPAP (n = 35), who received 5 cm H_2O CPAP during CPB, and no-CPAP (n = 35). The primary outcomes were PaO_2/FiO_2 ratio and driving pressure measured at predefined perioperative time points. Secondary outcomes included duration of mechanical ventilation, ICU stay, and incidence of postoperative pulmonary complications.

Results: No statistically significant differences were observed between the CPAP and no-CPAP groups in PaO_2/FiO_2 ratios or driving pressures at any time point ($p > 0.05$). Although the CPAP group showed a trend toward better oxygenation (e.g., post-CPB PaO_2/FiO_2: 286 ± 72 vs. 264 ± 68) and lower driving pressure (11.2 ± 2.1 vs. 11.8 ± 2.4 cmH_2O), these differences were not clinically significant. Mechanical ventilation duration (median 350 vs. 330 minutes) and ICU stay (48 vs. 56 hours) were also comparable between groups.

Conclusions: Intraoperative application of 5 cm H_2O CPAP during CPB did not significantly improve postoperative pulmonary function in patients with preserved baseline lung function. While minor trends toward improved oxygenation and reduced driving pressure were observed, the lack of statistically or clinically significant benefits suggests that a driving pressure of 5 cm H_2O may be insufficient. Further research is warranted to explore individualized CPAP titration or adjunctive strategies for optimizing perioperative respiratory care in cardiac surgery.

Keywords: Cardiopulmonary Bypass, Continuous Positive Airway Pressure, Postoperative Pulmonary Complications, Driving Pressure, Cardiac Surgery

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INTRODUCTION

Postoperative pulmonary complications (PPCs) are a significant source of morbidity and mortality in patients undergoing cardiac surgery. Studies report the incidence of pulmonary morbidity ranging from 3% to 16% following CABG and 5% to 7% after valve surgery, often leading to increased mortality and prolonged recovery[1,2]. These complications, such as atelectasis, pneumonia, pleural effusion, and acute respiratory distress syndromewhich is attributed to a combination of factors, including general anesthesia, surgical trauma, cardiopulmonary bypass (CPB) and fluid shifts[3,4]. Atelectasis is a particularly common complication, found in up to 90% of postoperative chest radiographs, contributing to impaired gas exchange, decreased lung compliance, and increased pulmonary shunting[5,6]. These complications are associated with prolonged recovery, increased ICU admissions, and extended hospital stays[7]. Cardiopulmonary

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bypass (CPB) further complicates respiratory function by inducing inflammatory responses, altering alveolar surfactant, and contributing to alveolar collapse[8,9].

Previous studies have examined the role of intraoperative Positive End Expiratory Pressure (PEEP)/Continuous Positive Airway Pressure (CPAP) and low-volume ventilation strategies during CPB with mixed results[10-13]. Therefore, the clinical significance of CPAP and driving pressure during CPB remains an area of ongoing investigation.

This observational study aims to evaluate the effect of applying CPAP during CPB on lung function and postoperative outcomes. Specifically, we will assess whether CPAP improves oxygenation (PaO2/FiO2 ratio), reduces driving pressure, and decreases the duration of mechanical ventilation and ICU stay. By addressing this gap, we hope to provide insights that could guide intraoperative respiratory management and enhance recovery in cardiac surgery patients.

METHODS

Study Design

This study is a prospective, observational study designed to assess the effect of continuous positive airway pressure (CPAP) during cardiopulmonary bypass (CPB) on lung function and postoperative outcomes.

Study Site and Duration

The study was conducted at the operation theater and intensive care unit (ICU) of Shahid Gangalal National Heart Centre, Kathmandu, Nepal. All parameters were recorded intraoperatively and postoperatively[14]. The study was conducted over 2 months, starting after IRB approval (SGNHC IRC no: 15-2023)[15].

Study Population and Sample Size

Patients aged 18 to 65 years undergoing cardiac surgery with CPB at the study site were included. The total sample size is 70 patients, divided into two groups:

Group 1 (CPAP group): The first 35 patients received CPAP at +5 cm H2O during CPB.

Group 2 (no CPAP group): The second 35 patients underwent CPB without CPAP.

The sample size for this study was determined using a formula for comparing two independent means, based on data from Kirillov et al.[12], which assessed the impact of intraoperative CPAP on postoperative oxygenation (PaO_2/FiO_2 ratio).

Parameters used:

- Confidence level (Z_a): 95% (Z = 1.96)
- Power (1 – β): 90% (Z = 1.28)
- Standard deviation (SD): 75 mmHg (based on variability reported in the PaO_2/FiO_2 ratio in Kirillov et al.[12].
- Expected difference ($\mu_1 - \mu_2$): 60 mmHg (anticipated clinically meaningful improvement in PaO_2/FiO_2 ratio between groups)

Formula:

$$n = \frac{2 \times (Z_a + Z_\beta)^2 \times SD2}{(\mu_1 - \mu_2)^2}$$

$$n = \frac{2 \times (1.96 + 1.28)^2 \times 75^2}{60^2} = \frac{2 \times 10.4976 \times 5625}{3600}$$

Thus, the required sample size was approximately 35 patients per group, totaling 70 patients. This sample size ensures the study has a 90% chance of detecting a clinically significant difference in postoperative lung function (PaO2/FiO2 ratio) between the two groups if such a difference exists.

Rationale for Sample Size

Effect Size: The minimum difference in the PaO2/FiO2 ratio between the groups that would be clinically meaningful was defined based on previous research.

Group Balance: Each group will have 35 participants, ensuring comparability and reducing the risk of imbalanced outcomes between the PEEP and control groups.

Inclusion Criteria

The study included patients aged 18–65 years undergoing cardiac surgery with CPB, who provided written informed consent.

Exclusion Criteria

Patients with a history of previous cardiac or lung surgery, thoracic radiation, left ventricular ejection fraction < 20%, preoperative tracheal intubation, a cross-clamp time > 4 hours, PaO2/FiO2 ratio < 200 after 10 min of induction of anesthesia, patients with intraoperative pleural breach, serum creatinine > 1.2 mg/dL, deranged liver function tests, a history of pneumonia treated within 2 weeks before surgery, and patients with COPD and restrictive lung disease.

Ethical Considerations

The study adhered to the principles of the Declaration of Helsinki. Approval was obtained from the Institutional Review Board (IRB) of Shahid Gangalal National Heart Centre (SGNHC IRC no: 15-2023)[15]. Participation was voluntary, with informed consent obtained from all subjects. No additional risks beyond standard care were anticipated.

Procedure Flow

1. Patient Screening and Consent

   Eligible patients were identified during preoperative assessment. Written informed consent was obtained from all participants. No patients were given premedication,

and proper patient counseling was done to alleviate preoperative anxiety.

2. Intraoperative-Phase

After wheeling the patient into the operation theater, he/she had the following monitors attached, namely an electrocardiogram, blood pressure monitor, and pulse oximeter. After inserting the central line and arterial line, central venous pressure and invasive blood pressure were measured. The Patient was induced with fentanyl 5 micrograms per kg, propofol 1.5-2 milligrams per kg, and vecuronium 0.3 milligrams per kg. Heart rate and blood pressure were maintained within 80% of their baseline values. Mechanical ventilation was started before and after CPB in a volume-controlled mode with pressure that gave a tidal volume equaling 6–8 ml/kg of the patient's body weight and a respiratory rate of 12-16, which maintained end-tidal CO2 at 35–40 mmHg, and the inspiratory-to-expiratory (I:E) ratio was adjusted to 1:2. Tracheal intubation was followed by nasogastric suctioning and transesophageal echocardiography (TEE) probe insertion. Arterial blood gas (ABG) and activated clotting time (ACT) were measured, and the TEE examination was done after 10 minutes of induction. After sternotomy, heparin was given in a dose of 300–400 IU/kg through the central venous catheter to increase the activated clotting time (ACT) above 480 seconds before starting CPB. If the activated clotting time (ACT) did not reach 480 seconds, additional heparin doses of 100 IU/kg were administered to raise the ACT above 480 before initiating cardiopulmonary bypass (CPB). In cases of heparin resistance, fresh frozen plasma was given. Afterward, the ascending aorta and both vena cava were cannulated, and patients were prepared for CPB. All patients received the cardioplegic solution.

Intervention

Group 1 (CPAP group):

During cardiopulmonary bypass (CPB) using a Dräger anesthesia machine (e.g., Fabius) to give CPAP at 5 cmH2O, the following steps were employed:

- Turn off the ventilator alarm.
- Set the Adjustable Pressure Limiting (APL) valve to MANUAL (MAN) mode.
- Maintain a low oxygen flow rate (~0.5-1 L/min).
- Adjust the APL valve to provide a continuous positive airway pressure of about 5 cmH2O.

For driving pressure

We used the ventilator's inspiratory and expiratory hold functions to measure plateau pressure and PEEP, then subtracted the latter from the former to obtain the driving pressure during CPAP 5 ventilation on a Dräger anesthesia machine.

Group 2 (No CPAP group): No CPAP was applied during CPB. During cardiopulmonary bypass (CPB), the patient's lungs are typically not ventilated, so measuring driving pressure in the usual ventilated lung context is not directly applicable. 5 respiratory cycles of ventilation (tidal volume 4 ml/kg) are applied at 15 min and 30 min of initiation of CPB to measure driving pressure by performing an end-inspiratory hold and end-expiratory hold maneuvers on the Dräger machine to get plateau pressure and total PEEP, respectively.

- Driving pressure = Plateau pressure – PEEP.

Before weaning from cardiopulmonary bypass (CPB), the attending anesthesiologist performed a lung recruitment maneuver by increasing peak inspiratory pressure (e.g., to 30 cmH_2O for 15 seconds) to reopen collapsed alveoli, then resumed ventilation with positive end-expiratory pressure (PEEP).

The patients were weaned from cardiopulmonary bypass (CPB) after achieving hemodynamic stability and administered protamine at 0.8 times the initial heparin dose to reverse anticoagulation. Following completion of the surgical procedure, patients were transferred to the intensive care unit (ICU) with continuous monitoring. Postoperative hemoglobin levels were maintained at approximately 7 g/dL in all cases.

Both groups received standard intraoperative and postoperative care, including ventilation, sedation, and fluid management, per hospital protocol.

Data Collection

Data were collected prospectively using a structured case report form (CRF). Parameters were recorded at predefined time points intraoperatively and postoperatively:

Measured Variables:

1. PaO_2/FiO_2 ratio
2. Driving pressure (plateau pressure – PEEP)
3. Duration of mechanical ventilation (minutes)
4. Length of ICU stay (hours)
5. Oxygen requirement (hours)
6. Frequency of recruitment maneuvers
7. Use of non-invasive ventilation (NIV) after extubation in hours
8. Incidence of reintubation

Time Points for Data Collection

At each of these time points, the PaO_2/FiO_2 ratio and driving pressure (calculated as plateau Pressure – PEEP) were recorded. These variables were selected as markers of oxygenation efficiency and lung mechanics, respectively.

- T1 (Pre-CPB): 10 minutes after induction of anesthesia, before initiation of cardiopulmonary bypass. This served as the baseline measurement.
- T2 (During CPB – 15 minutes): 15 minutes after initiation of CPB. This time point was selected to capture early changes in lung mechanics following initiation of bypass.
- T3 (During CPB – 30 minutes): 30 minutes after initiation of CPB. This allowed for monitoring of the sustained effects of the ventilation strategy during bypass.
- T4 (Post-CPB): 10 minutes after separation from CPB and re-initiation of mechanical ventilation. This point assessed immediate post-bypass pulmonary function.
- T5 (ICU Admission): On arrival to the intensive care unit. This represented the early postoperative pulmonary status under full ventilatory support.
- T6 (6 Hours Postoperative): Six hours after ICU admission. This point helped track recovery trends and the early effects of the ventilation strategy.
- T7 (12 Hours Postoperative): Twelve hours after ICU admission. This final time point provided information on late postoperative lung function and the overall trajectory of respiratory recovery. Intraoperative parameters, including PaO_2/FiO_2 ratio and driving pressure, were recorded at four time points (T1–T4).

Postoperative Phase

Patients were transferred to the ICU, where the PaO_2/FiO_2 ratio and driving pressure were measured at additional time points (T5–T7). Secondary outcomes (ventilation duration, ICU hours, recruitment maneuvers, NIV use, and reintubation) were also recorded.

The primary endpoints of this study were the PaO_2/FiO_2 ratio measured at key time points throughout the perioperative period: T1 (after initiation of mechanical ventilation), T2 (before cardiopulmonary bypass), T3 (post-CPB), T4 (after surgery), T5 (upon ICU admission), and T6 and T7 (6 and 12 hours postoperatively, respectively). Secondary endpoints included changes in driving pressure at the same time points as PaO_2/FiO_2 ratio, duration of mechanical ventilation and ICU stay, frequency of recruitment maneuvers during ventilation, the need for non-invasive ventilation following extubation, and the incidence of re-intubation.

Statistical Analysis

Data analysis was performed using IBM SPSS Statistics software (version 23). Before comparative analyses, the normality of continuous variables was assessed using the Shapiro-Wilk test.

- Normally distributed continuous data were expressed as mean ± standard deviation (SD) and compared between groups using the independent Sample t-test.
- Non-normally distributed continuous data were expressed as median (interquartile range) and analyzed using the Mann–Whitney U test.
- Categorical variables were presented as frequencies and percentages and compared using the chi-square test.
- A p-value of < 0.05 was considered statistically significant for all tests.

RESULTS

Baseline Demographics

The study included 70 patients, 35 in each group. The two groups were comparable in terms of age, gender distribution, and baseline characteristics such as body mass index (BMI) and comorbidities. The median age was 56 years in the CPAP group and 54 years in the no CPAP group. CPB time was normally distributed in both groups with similar means (CPAP: 88.46 ± 35.83 min vs. no CPAP: 90.09 ± 29.89 min).

Primary Outcomes

The analysis showed that while there are differences between the CPAP and no CPAP groups across various measurements, none of the differences reached statistical significance ($p < 0.05$). The closest to significance was the P/F ratio after CPB ($p = 0.086$) and NIV hours ($p = 0.082$). The PaO2/FiO2 ratio showed an initial improvement in the PEEP group at the end of surgery and during the early postoperative period. However, no significant differences were observed between groups at any time point.

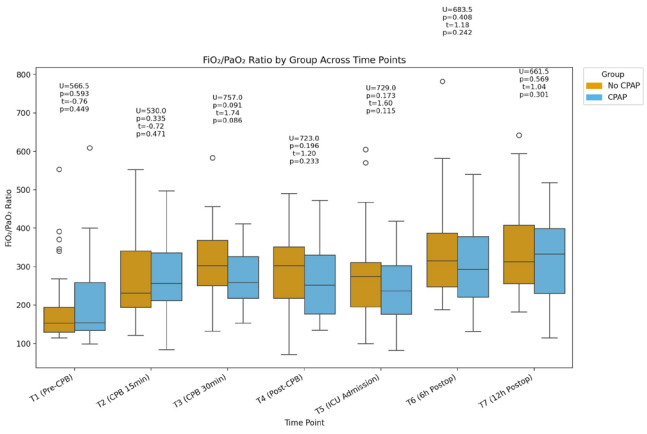

Figure 1: *FiO_2/PaO_2 Ratio by Group Across Time Points*

Title: Effect of Intraoperative CPAP on FiO_2/PaO_2 Ratio at Serial Time Points During and After Cardiopulmonary Bypass

Explanation:

This box plot (Figure 1) illustrates the changes in the oxygenation index (FiO_2/PaO_2 ratio) across seven predefined perioperative time points (T1 to T7) in patients receiving intraoperative CPAP (blue) versus no CPAP (orange) during cardiopulmonary bypass (CPB). While both groups show an overall improvement in oxygenation post-CPB, no statistically significant differences were observed between the groups at any time point. The U and t statistics with associated p-values

indicate comparable FiO_2/PaO_2 ratios, suggesting limited benefit of CPAP in enhancing oxygenation in this cohort. Notably, there is a trend toward improved oxygenation in the CPAP group at certain points (e.g., T3 and T4), which may warrant further investigation.

Secondary Outcomes

Driving Pressure: It remained relatively consistent between groups throughout different time points, typically around 11-12 cmH2O. As the median time of extubation was less than 12 hours, the driving pressure of all patients could not be measured at the T7 time point.

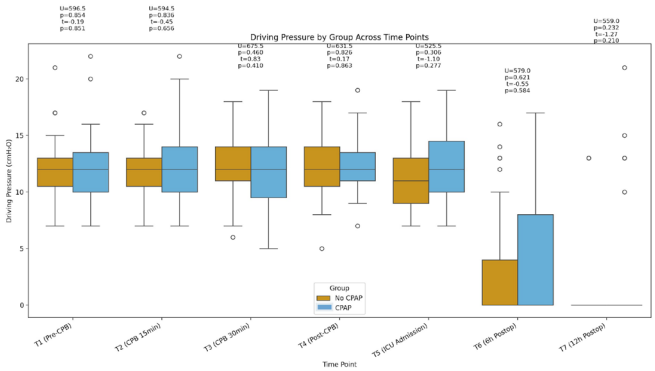

Figure 2: *Driving Pressure by Group Across Time Points*

Title: Comparison of Driving Pressure Trends Between CPAP and Non-CPAP Groups During and After Cardiopulmonary Bypass

Explanation:

This box plot (Figure 2) compares intraoperative and postoperative driving pressures between patients receiving CPAP (blue) and those not receiving CPAP (orange) at seven perioperative time points (T1 to T7). Driving pressure was defined as the difference between plateau pressure and PEEP. Throughout the measured intervals, no statistically significant differences were noted between the two groups. However, a reduction in driving pressure is observed postoperatively in both groups, with a slightly greater decrease in the CPAP group at T6. These findings suggest that intraoperative CPAP may have a modest effect on lung mechanics, potentially translating to better lung compliance or alveolar recruitment, although the differences were not statistically significant.

Table 1. Comparison of Postoperative Respiratory and Intensive Care Parameters Between CPAP and No CPAP Groups.

Variable	Group	Summary	Test used	P-value	Significant
Duration of mechanical ventilation (hours)	CPAP	Median: 350.00 (IQR: 315.00-555.00), 95% CI: 340.00 to 390.00	Mann-Whitney U	0.225	No
	No CPAP	Median: 330.00 (IQR: 312.00-532.50), 95% CI: 315.00 to 360.00			
Length of ICU stay (hours)	CPAP	Median: 48.00 (IQR: 48.00-72.00), 95% CI: 48.00 to 72.00	Mann-Whitney U	0.435	No
	No CPAP	Median: 56.00 (IQR: 48.00-75.00), 95% CI: 48.00 to 72.00			
Oxygen requirement (hours)	CPAP	Median: 48.00 (IQR: 48.00-72.00), 95% CI: 48.00 to 72.00	Mann-Whitney U	0.739	No
	No CPAP	Mean: 60.46 ± 22.48 (95% CI: 52.73 to 68.18)			
Frequency of recruitment maneuvers	CPAP	Median: 0.00 (IQR: 0.00-0.00), 95% CI: 0.00 to 0.00	Mann-Whitney U	0.658	No
	No CPAP	Median: 0.00 (IQR: 0.00-0.00), 95% CI: 0.00 to 0.00			
Use of non-invasive ventilation (NIV) after extubation (hours)	CPAP	Median: 0.00 (IQR: 0.00-0.00), 95% CI: 0.00 to 0.00	Mann-Whitney U	0.0824	No
	No CPAP	Median: 0.00 (IQR: 0.00-0.00), 95% CI: 0.00 to 0.00			

Abbreviations: CPAP: Continuous Positive Airway Pressure, ICU: Intensive Care Unit, IQR: Interquartile Range, CI: Confidence Interval, NIV: Non-Invasive Ventilation, U: Mann-Whitney U test, h: hours, U and p: Mann-Whitney U test statistic and p-value, t and p: t-test statistic and p-value.

This table summarizes postoperative clinical parameters associated with respiratory function and critical care utilization in patients who received intraoperative continuous positive airway pressure (CPAP) compared to those who did not (no CPAP group). The outcomes include duration of mechanical ventilation, ICU length of stay, oxygen requirement duration, frequency of recruitment maneuvers, and use of non-invasive ventilation (NIV) following extubation. Data are expressed as medians with interquartile ranges (IQR) and 95% confidence intervals (CI). Statistical comparison using the Mann-Whitney U test revealed no significant differences between groups for any parameter ($p > 0.05$), suggesting that the application of CPAP during cardiopulmonary bypass was not associated with early improvements in postoperative respiratory outcomes or ICU course.

A Chi-square test was done for categorical variables (smokers and reintubation) with respect to the CPAP group: there was a statistically significant difference in the distribution of smokers between the CPAP and no CPAP groups ($p = 0.014$, Cramér's $V = 0.293$, small effect size, $N = 70$). This imbalance in smoking status could be relevant, as smoking is a known risk factor for impaired lung function and may influence perioperative respiratory outcomes. No reintubation events occurred in either group.

DISCUSSION

This observational study investigated whether administering 5 cm H_2O of continuous positive airway pressure (CPAP) during cardiopulmonary bypass (CPB) influences postoperative lung function, with particular attention to driving pressure and the PaO_2/FiO_2 (P/F) ratio.

Our results showed no statistically significant differences between the CPAP and no-CPAP groups at any time point, although trends favored better oxygenation and slightly lower driving pressures in the CPAP group. However, these physiological trends did not translate into clinical benefits such as reduced mechanical ventilation duration or shorter ICU stays. These findings align with meta-analyses indicating that CPAP improves alveolar-arterial oxygen gradients but does not significantly affect clinical outcomes like hospital length of stay in low- to intermediate-risk cardiac surgery patients[13,16,17].

Rationale for Using 5 cm H_2O CPAP

The selection of 5 cm H_2O CPAP during CPB was a deliberate balance between promoting alveolar recruitment and maintaining hemodynamic stability. While higher PEEP or CPAP levels may more effectively recruit alveoli and improve oxygenation, they risk increasing intrathoracic pressure, which can impair venous return and complicate the surgical field during cardiac surgery[18,19]. Given the hemodynamic vulnerability of patients on CPB, a conservative CPAP level of 5 cm H_2O was chosen to maintain functional residual capacity and reduce atelectasis without causing cardiovascular compromise. This approach is supported by prior studies, including Kirillov et al., and institutional protocols favoring low-level PEEP in patients with preserved lung compliance[9,12,20].

CPAP, Driving Pressure, and Lung Mechanics

Driving pressure (DP), defined as the difference between plateau pressure and PEEP, is increasingly recognized as a key indicator of lung stress and a predictor of ventilator-induced lung injury (21). Elevated DP reflects increased stress on aerated lung units and correlates with worse postoperative pulmonary outcomes[22]. In our study, driving pressure remained stable around 11–12 cmH_2O in both groups throughout the perioperative period, suggesting preserved lung compliance despite the inflammatory and mechanical insults of CPB.

Theoretically, CPAP reduces driving pressure by preventing alveolar collapse and increasing the volume of aerated lung units, thereby distributing tidal volume over a larger functional lung area. However, the addition of PEEP also increases plateau pressure, which can offset reductions in driving pressure[23]. This balance likely explains why no significant differences in driving pressure were observed despite trends toward more consistent lung mechanics in the CPAP group. Similar stability in driving pressure has been observed in patients with obstructive sleep apnea receiving CPAP, where improved cardiac mechanics did not immediately translate into clinical changes[24].

Although no statistically significant improvements were observed, the numerical trends suggest that 5 cm H_2O CPAP may confer subtle physiological benefits such as better alveolar recruitment and more stable lung compliance post-CPB. These findings are consistent with previous literature reporting mixed results for low-level intraoperative PEEP, where benefits on oxygenation are often modest and clinical outcomes are unchanged[25,26]. The lack of significant differences in secondary outcomes—mechanical ventilation duration, ICU stay, and non-invasive ventilation use—further suggests that low-level CPAP alone may be insufficient to impact short-term clinical endpoints in patients with relatively preserved lung function. Additionally, standardized postoperative recruitment maneuvers applied to both groups may have attenuated intraoperative CPAP-related differences[27].

Our neutral findings align with systematic reviews showing that CPAP during CPB improves oxygenation indices but does not reduce mortality or ICU length of stay in elective cardiac surgery patients[28,29]. The choice of 5 cm H_2O CPAP reflects a compromise between alveolar recruitment and hemodynamic

stability; higher levels (10–20 cm H_2O) have been shown to improve de-airing efficiency and reduce pulmonary shunting but carry increased risks of hemodynamic compromise and interference with the surgical field[30,31]. The stable driving pressures observed likely result from two competing effects: CPAP prevents alveolar derecruitment, potentially lowering ΔP by increasing functional lung volume, but added PEEP elevates plateau pressure at fixed tidal volumes, neutralizing ΔP benefits. This equilibrium explains why oxygenation improvements at time points T3 and T4 in the CPAP group did not reach statistical significance.

In contrast, studies demonstrating significant CPAP benefits often involved higher CPAP levels, prolonged application (e.g., ≥4 hours/night in obstructive sleep apnea), or higher-risk populations such as patients with chronic lung disease[32,33]. Our exclusion of patients with COPD or restrictive lung disease likely limited detectable changes in driving pressure due to preserved baseline lung compliance[34].

Clinical Implications

Although our study did not find statistically significant reductions in driving pressure or improvements in oxygenation with 5 cm H_2O CPAP, the physiological trends toward better lung mechanics are clinically relevant. Maintaining lung volume with CPAP may help reduce lung strain by preventing alveolar collapse, which in turn could limit ventilator-induced lung injury during and after surgery [9,38]. However, the modest CPAP level used may have limited the magnitude of these effects[21].

Given that driving pressure is a better predictor of lung injury than tidal volume or PEEP alone[9,38], strategies that optimize driving pressure during CPB could improve postoperative pulmonary outcomes. Our findings underscore the potential value of CPAP as part of a lung-protective ventilation strategy, especially when individualized to the patient's lung mechanics and combined with recruitment maneuvers[21]. For example, meta-analyses of cardiac surgery patients suggest that CPAP-integrated ventilation bundles reduce pulmonary complications when driving pressure is actively controlled[39].

LIMITATIONS

This study's observational design limits causal inference. The sample size, although calculated for primary outcomes, may have been underpowered for secondary endpoints or subtle physiological changes. The fixed CPAP level without individualized titration does not account for inter-patient variability in lung mechanics. Postoperative pulmonary complications were not comprehensively tracked, which could have provided more sensitive outcome measures. Minor variations in ventilatory settings, despite standardization efforts, could also have influenced results[40].

CONCLUSION

In conclusion, applying 5 cm H_2O CPAP during cardiopulmonary bypass was not associated with statistically significant improvements in postoperative oxygenation or driving pressure in this observational study. However, subtle physiological trends suggest potential benefits in lung mechanics that merit further investigation. This study contributes to the evolving understanding of intraoperative lung-protective strategies and highlights the importance of individualized approaches to optimize respiratory outcomes in cardiac surgery patients.

RECOMMENDATIONS AND FUTURE RESEARCH

Future research should focus on tailoring CPAP levels during cardiopulmonary bypass through real-time monitoring of lung compliance or driving pressure. This individualized approach may help optimize alveolar recruitment while mitigating the risk of hemodynamic compromise. Randomized controlled trials with larger cohorts and extended postoperative follow-up—including detailed pulmonary complication tracking and imaging-based lung assessments, are warranted. The potential benefits of combining higher CPAP levels with recruitment maneuvers and lung-protective ventilation strategies should be explored, especially in patients with pre-existing lung disease or prolonged CPB times.

AUTHOR'S CONTRIBUTION:

Authors SB Panta and S Parajuli conceived the study, designed the experiments, and supervised the data collection. Author SB Panta performed the data analysis and wrote the initial draft of the manuscript. Author AG Amatya reviewed and revised the manuscript critically.

FUNDING:

None

DATA AVAILABILITY STATEMENT:

Data is available after approval from the corresponding author.

CONFLICT OF STATEMENT

None

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