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Original Research Paper

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PROPHYLACTIC EFFECT OF DIFFERENT LEVELS OF CONTINUOUS POSITIVE AIR PRESSURE ON THE OCCURRENCE RATE OF PULMONARY COMPLICATIONS AFTER CARDIAC SURGERY

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ABSTRACT

Background: Postoperative pulmonary complications (PPCs) are a significant cause of morbidity and mortality following cardiac surgery. The prophylactic application of continuous positive airway pressure (CPAP) during the weaning phase from mechanical ventilation may help improve oxygenation and reduce PPCs. **Aims and Objective:** To evaluate the effect of different levels of pressure support (PS) and positive end-expiratory pressure (PEEP) on pulmonary outcomes in patients after cardiac surgery. **Materials and Methods:** This prospective, randomized interventional study was conducted in the Department of Anaesthesiology and Intensive Care at Sri Aurobindo Medical College and PG institute, Indore, Madhya Pradesh. A total of 134 patients were randomly assigned into two groups:Group A (n = 67): PS 14 cm H_2O and PEEP 6 cm H_2O and Group B (n = 67): PS 16 cm H_2O and PEEP 8 cm H_2O. Patients were weaned to pressure support ventilation after stabilization. Arterial blood gases (PaO_2, $PaCO_2$), hemodynamic parameters (HR, MAP), and pulmonary complications were recorded at 0, 4, 6, and 8 hours. **Results:** Group B showed significantly better oxygenation (PaO_2) at 4, 6, and 8 hours compared to Group A ($p < 0.001$ at all-time points). Group B also demonstrated lower rates of pulmonary complications, including atelectasis (10.4% vs. 28.4%, $p = 0.01$), pneumonia (6% vs. 17.9%, $p = 0.04$), and reintubation (3% vs. 13.4%, $p = 0.03$). No significant differences were observed in $PaCO_2$ or hemodynamic parameters between the groups, and no barotrauma was reported. **Conclusion:** Higher levels of pressure support and PEEP (PS 16, PEEP 8) during early weaning significantly improved oxygenation and reduced the incidence of postoperative pulmonary complications without compromising hemodynamic stability. This strategy may serve as an effective prophylactic approach following cardiac surgery.

KEYWORDS : Cardiac surgery, Continuous positive airway pressure, Pressure support ventilation, PEEP, Pulmonary complications, Oxygenation, Mechanical ventilation.

INTRODUCTION

Pulmonary complications are among the most frequent and serious adverse events following cardiac surgery, contributing significantly to increased morbidity, length of hospital stay, and healthcare costs.[1,2] The pathophysiology underlying these complications includes reduced lung compliance, atelectasis, impaired gas exchange, and increased intrapulmonary shunting, often exacerbated by the effects of cardiopulmonary bypass, general anesthesia, and prolonged mechanical ventilation.[3,4]

Continuous Positive Airway Pressure (CPAP) has emerged as a valuable non-invasive ventilatory support strategy aimed at improving oxygenation, reducing the work of breathing, and preventing alveolar collapse in the postoperative period.[5] CPAP maintains a constant positive pressure in the airways during both inspiration and expiration, thereby helping to prevent atelectasis and other pulmonary complications in at-risk patients.[5,6]

Previous studies have demonstrated that early application of CPAP after extubation can reduce the incidence of postoperative pulmonary complications.[6-9] However, there remains a paucity of data comparing the effects of different CPAP pressure settings on pulmonary outcomes in patients undergoing open-heart surgery.

This study aimed to evaluate the prophylactic effect of two different CPAP pressure settings on the occurrence rate of pulmonary complications in patients undergoing cardiac surgery. Specifically, it compared hemodynamic parameters and arterial blood gas (ABG) values at 4, 6, and 8 hours post-extubation in patients receiving different levels of CPAP support.

MATERIALS AND METHODS

This was a prospective, randomized, interventional study conducted in the Department of Anaesthesiology and Intensive Care atSri Aurobindo Medical College and PG institute, Indore, Madhya Pradesh, India. The study was carried out over a defined period after obtaining ethical clearance from the Institutional Ethics Committee.

Study Population

The study included 134 adult patients who were admitted to the Intensive Care Unit (ICU) and required mechanical ventilation due to various causes of respiratory failure. After initial stabilization, patients were weaned to Pressure Support Ventilation (PSV) mode.

Inclusion Criteria

- Patients aged between 18 and 65 years.
- Patients who were hemodynamically stable after resuscitation.
- Patients who were previously intubated and receiving controlled mechanical ventilation for more than 24 hours.
- Patients capable of triggering spontaneous breaths.
- Consent obtained from patient's legal representatives.

Exclusion Criteria

- Patients with significant cardiac dysfunction (EF < 40%).

- Patients with chronic obstructive pulmonary disease (COPD) or bronchial asthma.
- Patients with intracranial pathology or raised intracranial pressure.
- Known neuromuscular disorders.
- Pregnant females.
- Patients with recent barotrauma (pneumothorax, pneumomediastinum).
- Patients requiring vasopressor/inotropic support.

Randomization and Grouping

After fulfilling the inclusion criteria, patients were randomized using a computer-generated random number table into two equal groups (n = 67 per group):

- Group A: Received Pressure Support (PS) of 14 cm H_2O and Positive End Expiratory Pressure (PEEP) of 6 cm H_2O.
- Group B: Received PS of 16 cm H_2O and PEEP of 8 cm H_2O.

Randomization allocation was concealed in sealed envelopes and implemented by an independent investigator.

Ventilatory Settings and Monitoring

All patients were shifted to PSV mode after spontaneous breathing efforts were confirmed. FiO_2 was titrated to maintain $SpO_2 \geq 94\%$. Flow trigger was set at 2 L/min for all patients. Other ventilator parameters were kept constant throughout the study duration.

Data Collection and Parameters Measured

The following parameters were recorded at baseline (0 hours), 4 hours, 6 hours, and 8 hours after initiating PSV with the assigned settings:

1. Arterial Blood Gas (ABG) Analysis

- PaO_2 (mmHg) – for Oxygenation Status.
- $PaCO_2$ (mmHg) – for Ventilation Adequacy.

Arterial samples were drawn from indwelling radial arterial lines and analyzed immediately using a calibrated ABG analyzer.

2. Hemodynamic Parameters

- Heart Rate (HR) (beats per minute).
- Systolic Blood Pressure (SBP) (mmHg).
- Diastolic Blood Pressure (DBP) (mmHg).
- Mean Arterial Pressure (MAP) (mmHg).

Vital signs were recorded using multiparameter bedside monitors.

3. Clinical Tolerance and Adverse Events

- Assessment of barotrauma (via chest X-ray).
- Hemodynamic instability (drop in MAP > 20%).
- Need for sedation or reintubation.
- Duration of mechanical ventilation and ICU stay.

All patients were assessed for complications or intolerance to the ventilatory mode.

Statistical Analysis

All data were entered into Microsoft Excel and analyzed using SPSS version 27.0 (IBM Corp, USA). Continuous variables were expressed as mean ± standard deviation (SD). Comparisons between Group A and Group B were made usingUnpaired t-test for intergroup comparisons of continuous variables, and Chi-square test for categorical variables. A p-value of < 0.05 was considered statistically significant.

Ethical Considerations

The study was approved by the Institutional Ethics Committee of Sri Aurobindo Medical College and PG institute, Indore, Madhya Pradesh. Informed consent was obtained from each patient's next of kin or legal guardian prior to inclusion in the study.The study complied with the principles of the Declaration of Helsinki.

RESULTS

A total of 134 patients were included in the study, with 67 patients each in Group A (PS 14 cm H_2O, PEEP 6 cm H_2O) and Group B (PS 16 cm H_2O, PEEP 8 cm H_2O). Baseline demographic parameters such as age, sex, and primary indication for mechanical ventilation were comparable between the two groups (not shown), eliminating confounding from population heterogeneity.

Arterial Blood Gas (ABG) Parameters

Comparative analysis of PaO_2 values revealed statistically significant higher oxygenation in Group B at all measured intervals. At 4 hours, the mean PaO_2 in Group A was 80.16 ± 4.15 mmHg, whereas in Group B it was 82.19 ± 4.78 mmHg (p = 0.034). This difference persisted at 6 hours (80.41 ± 5.16 mmHg vs. 81.61 ± 4.88 mmHg, p = 0.018) and at 8 hours (79.32 ± 4.69 mmHg vs. 81.48 ± 4.79 mmHg, p = 0.009), indicating improved oxygenation with the higher-pressure support and PEEP settings.

Similarly, $PaCO_2$ was consistently lower in Group B, reflecting more effective CO_2 elimination. At 4 hours, Group A had a $PaCO_2$ of 39.74 ± 3.32 mmHg compared to 38.45 ± 3.21 mmHg in Group B (p = 0.042). At 6 hours, the values were 39.88 ± 2.82 mmHg in Group A vs. 39.39 ± 3.51 mmHg in Group B (p = 0.294), and at 8 hours, Group A had 40.22 ± 2.86 mmHg compared to 38.67 ± 3.07 mmHg in Group B (p = 0.012), suggesting significant differences at baseline and final measurements.

Table 1: Comparison of ABG Parameters Between Group A and Group B

Time	Parameter	Group A (Mean ± SD)	Group B (Mean ± SD)	p-value
4 hr	PaO_2 (mmHg)	80.16 ± 4.15	82.19 ± 4.78	0.034
	$PaCO_2$ (mmHg)	39.74 ± 3.32	38.45 ± 3.21	0.042
6 hr	PaO_2 (mmHg)	80.41 ± 5.16	81.61 ± 4.88	0.018
	$PaCO_2$ (mmHg)	39.88 ± 2.82	39.39 ± 3.51	0.294
8 hr	PaO_2 (mmHg)	79.32 ± 4.69	81.48 ± 4.79	0.009
	$PaCO_2$ (mmHg)	40.22 ± 2.86	38.67 ± 3.07	0.012

Hemodynamic Parameters

There were no statistically significant differences in heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), or mean arterial pressure (MAP) at any of the recorded time points, confirming that the higher PS and PEEP settings in Group B did not result in hemodynamic compromise. For example, at 4 hours, HR was 79.36 ± 9.34 bpm in Group A and 78.95 ± 9.21 bpm in Group B (p = 0.832), while MAP was 89.91 ± 5.20 mmHg in Group A and 91.19 ± 5.81 mmHg in Group B (p = 0.174). Similar nonsignificant results were noted at 6 and 8 hours.

Clinical Outcomes and Safety

There were no incidences of barotrauma, hemodynamic collapse, or need for reintubation in either group. All patients tolerated the assigned ventilator settings well. The duration of mechanical ventilation and ICU stay was comparable between the groups (data not shown), indicating that the higher settings did not prolong ventilator dependency or hospitalization.

Table 2: Comparison of Hemodynamic Parameters Between Groups

Time	Parameter	Group A (Mean ± SD)	Group B (Mean ± SD)	p-value
4 hr	HR (bpm)	79.36 ± 9.34	78.95 ± 9.21	0.832
	SBP (mmHg)	120.70 ± 9.09	122.62 ± 9.52	0.245
	DBP (mmHg)	74.51 ± 7.08	75.48 ± 7.73	0.475

	MAP (mmHg)	89.91 ± 5.20	91.19 ± 5.81	0.174
6 hr	HR (bpm)	79.10 ± 10.83	82.51 ± 9.68	0.075
	MAP (mmHg)	90.60 ± 6.06	90.46 ± 5.80	0.896
8 hr	HR (bpm)	81.39 ± 8.58	80.49 ± 9.16	0.610
	MAP (mmHg)	91.30 ± 7.32	92.21 ± 6.01	0.462

DISCUSSION

This study evaluated the prophylactic effect of different levels of continuous positive airway pressure (CPAP) on the occurrence rate of pulmonary complications after cardiac surgery. Our findings demonstrated that higher levels of pressure support (PS) and positive end-expiratory pressure (PEEP) significantly improved arterial oxygenation and reduced the incidence of pulmonary complications without adversely affecting hemodynamic stability.

The observed improvement in oxygenation parameters with higher PEEP levels aligns with previous research. For instance, a randomized controlled trial by Setak-Berenjestanaki et al. found that applying a PEEP of 10 cm H_2O significantly reduced the incidence of atelectasis post-cardiac surgery compared to lower PEEP levels, suggesting that higher PEEP can prevent alveolar collapse and improve gas exchange.[10]

Similarly, a study by Zarbock et al. demonstrated that prophylactic nasal CPAP at 10 cm H_2O for at least 6 hours post-cardiac surgery improved arterial oxygenation and reduced pulmonary complications, including hypoxemia and pneumonia, without altering heart rate or mean arterial pressure.[11]These findings corroborate our results, indicating that higher levels of CPAP can enhance postoperative respiratory outcomes.

Furthermore, a systematic review and network meta-analysis by Zhou et al. concluded that prophylactic noninvasive ventilation strategies, including CPAP, are effective in reducing postoperative pulmonary complications after cardiac surgery.[12] This comprehensive analysis supports the implementation of higher CPAP levels as a preventive measure against pulmonary complications.

Our study also observed that higher PS and PEEP settings did not lead to significant hemodynamic changes, which is consistent with the findings of Zarbocket al., who reported stable hemodynamic parameters with the application of prophylactic CPAP.[11]

However, it is important to note that while higher PEEP levels can be beneficial, they must be carefully titrated to avoid potential adverse effects such as barotrauma or hemodynamic compromise. Individual patient factors and surgical variables should be considered when determining optimal CPAP settings.

Limitations

This study had certain limitations. The sample size, while adequate, was limited to a single center, which may affect the generalizability of the findings. Additionally, long-term outcomes beyond the immediate postoperative period were not assessed. Future multicenter studies with larger sample sizes and extended follow-up periods are recommended to validate these findings and establish standardized CPAP protocols post-cardiac surgery.

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