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Effect of OES & CES on ABG & Cardiorespiratory parameters in Cardiac Surgery patients: An Experimental Study

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Abstract:

Introduction: Endotracheal suctioning (ES) is the most frequently performed invasive procedure in a cardiac surgical ICU. It is performed for aspiration of bronchial secretions from the airways of an intubated patient thereby maintaining airway patency and adequate ventilation and oxygenation. Two methods of ES are currently in practice - Open Endotracheal Suctioning technique (OES) and Closed Endotracheal Suctioning technique (CES). **Aim:** Aim of the research was to study the effect of Open and Closed endotracheal suctioning on the selected ABG values and Cardiorespiratory parameters. **Methods & Materials:** The design adopted for this study was experimental pretest post-test control group design. 30 samples who met the inclusion criteria were randomly allocated to experiment (CES) and control group (OES) using Sequentially Numbered Opaque Sealed Envelopes (SNOSE). ES was performed two hours after receiving the patient from operation theatre. The ABG values and cardiorespiratory parameters were recorded in the observation sheet immediately before the procedure and post procedure at 1 minute, 5 minutes and 15 minutes. **Results:** Subjects of both the study groups were homogenous with respect to the selected sample characteristics. Heart rate increased above baseline in both the groups, however the increase was statistically highly significant (p=0.002) in the OES. SBP significantly increased (p=0.03) post procedure in the OES group. SaO2 displayed significant difference with p=0.02 at 5 minutes after procedure in the CES. **Conclusion:** The findings of the study highlight that ABG variations and cardiorespiratory disturbances in the CES technique were less than those of the open technique.

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Therefore, to eliminate the unwanted effects of endotracheal suctioning on the ABG and cardiorespiratory parameters and to enhance the quality of nursing care and optimise patient outcome, the CES technique is recommended.

Keywords: Open endotracheal suction, Closed endotracheal suction, Arterial Blood Gases, Cardiorespiratory parameters, Cardiac Surgery, Nursing Care.

Introduction:

Coronary Artery Bypass Grafting (CABG) is a highly effective treatment for stenosis of coronary arteries. During cardiovascular surgeries like CABG, patients need to be anesthetized and intubated for mechanical ventilation support. After surgery, patients are transferred to the Cardiac Surgical Intensive Care Unit (CSICU) for close monitoring of their hemodynamic status, volume therapy, and administration of medications like positive inotropic agents and vasopressors[1].

The post operative cardiac surgery patients undergo numerous invasive procedures as part of the monitoring in CSICU. Endotracheal suctioning (ES) is one among the most frequently performed invasive procedure in CSICU. Tracheal suctioning becomes necessary to remove secretions and prevent airway obstruction and breathing difficulties caused by retained secretions[2] Despite its importance, tracheal suctioning is painful and uncomfortable and carries risks and potential complications. It increases the workload of the heart and oxygen consumption. This can be particularly concerning for post-CABG patients, as it may contribute to serious complications. These include bleeding, infection, atelectasis (lung collapse), hypoxemia (low oxygen levels), cardiovascular instability, increased intracranial pressure, damage to the tracheal mucosa and even cardiac arrest[2].

Currently, there are two main techniques for endotracheal suctioning: Open Endotracheal Suctioning (OES) and Closed Endotracheal Suctioning (CES). In the Open Endotracheal Suctioning (OES) method, the suctioning procedure involves disconnecting the ventilator circuit from the endotracheal tube (ETT). Sterile precautions are observed, and a single-use suction catheter is inserted into the artificial airway to remove secretions with external suction. However, this disconnection leads to a brief loss of positive airway pressure in the circuit, potentially causing a reduction in lung volumes. On the other hand, in the Closed Endotracheal Suctioning (CES) method, suctioning is performed without disconnecting the ventilator circuit.

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This method allows for continuous positive pressure during suctioning, helping to prevent hemodynamic disturbances. Multiuse in-line catheters enclosed in a sheath are connected to an interface in the ventilator circuit while supplying oxygen simultaneously. The manufacturer specifies the number of times the multiuse in-line catheter can be safely used[3].

Various studies have compared the physiological effects of open and closed endotracheal suctioning systems, particularly focusing on disturbances in oxygenation, ventilation, and other respiratory parameters. While most studies have favoured the closed suctioning system, the differences between the two systems were generally small and clinically insignificant[4].

Despite these findings, there is still a lack of substantiated evidence regarding the superiority of either system, particularly in the context of post-CABG patients undergoing mechanical ventilation. Additionally, the impact of closed suctioning on pain in mechanically ventilated patients remains largely unexplored[5].

To address these gaps, this study aimed to compare the use of open and closed suctioning systems in post-CABG patients receiving mechanical ventilation. The primary objective was to assess the effect of Open and Closed Endotracheal Suctioning techniques on selected Arterial Blood Gas values like PO_2, PCO_2, SaO_2 and Cardiorespiratory Parameters included heart rate, MAP, SpO_2 and respiratory rate.

Materials and Methods:

The approach used for the present study is a quantitative approach to accomplish the aims & objectives of the study. This approach helps in evaluating programs, procedure, and techniques to a great extent. Design was Experimental Pre-test Post-test Control Group as shown in Table no1.

1. Control group – The study considered Open Endotracheal Suctioning as control since it is the standard practice being followed in the selected Cardiothoracic Centre.
2. Manipulation – The researcher manipulates the intervention by adopting Closed Endotracheal Suctioning for experiment group and Open Endotracheal suctioning technique for the control group.
3. Randomisation – The participants meeting the inclusion criteria were randomly allocated to control & experiment group.

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Table 1: Research Design

Groups	Pre intervention	Treatment	Post intervention
Experimental	O1	X	O2, O3, O4
Control	O1		O2, O3, O4
O1: Pre intervention observation; X: Intervention – Closed Endotracheal Suction; O2: Observation at 1 min; O3: Observation at 5 min; O4: Observation at 15 min			

The study was a single blinded study performed on post operative Cardiac Surgery patients after obtaining approval from the Institutional Ethics Committee and written informed consent from the participants pre-operatively, 30 adult patients (>18 years) under mechanical ventilation requiring endotracheal suctioning following CABG with stable hemodynamic and cardio respiratory parameters were included in the study. Exclusion criteria included patients who developed sudden hemodynamic instability.

In the present experimental study, allocation concealment was employed using Sequentially Numbered Opaque Sealed Envelopes (SNOSE) to prevent selection bias by concealing the allocation sequence of participants to the intervention group. The independent variable manipulated by the researcher was the suctioning technique, while the dependent variables included PaO2, PCO2, SaO2, heart rate, arterial blood pressure (ABP), mean arterial pressure (MAP), respiratory rate, and peripheral oxygen saturation (SPO2). The sample size was determined based on the standard deviation of PO2 before and after suction, a confidence level of 95%, and an absolute precision of 10%, resulting in the inclusion of 30 patients in both the control and experimental arms. Data were collected using a developed tool consisting of two sections: Section A described sample characteristics, including demographic details, post-operative status, and ventilator settings, while Section B recorded physiological parameters related to ABG and cardiorespiratory status.

Participants in the experimental group underwent Closed Endotracheal Suctioning, with the procedure performed using universal precautions and closed suction sets. The suction catheter was inserted into the endotracheal tube, and wall mount suction was applied at a vacuum pressure of 100-120 mmHg for 10-15 seconds for each suction pass. The control group participants underwent Open Endotracheal Suctioning with each suction performed following aseptic technique.

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Ethical considerations were maintained in accordance with human rights guidelines for nurses in research, with approval obtained from the institutional authority of the hospital. The study adhered to ethical standards, and permission was acquired from the selected hospital departments and authorities. Statistical analysis was conducted using SPSS version 23 software, with descriptive statistics used to describe sample characteristics and inferential statistics employed to compare intra-group differences in pre- and post-operative ABG values and cardiorespiratory parameters between the open and closed endotracheal suctioning groups. A significance level of $p < 0.05$ was utilized for all analyses.

Results:

Out of the total 30 participants in experiment and control group, the mean age of patients in the experiment group was 64.53±6.31 SD and that in the Control group was 58.73±12.89 SD. Based on the results obtained through Chi-square test, no significant statistical differences were observed between the two groups of closed and open suctioning systems with respect to demographic specifications (sex, age, weight, type of surgery and ventilatory parameters) ($P > 0.05$).

On comparing the pre and post intervention ABG values in the control group, the study revealed that there was no statistically significant intra group variation with $p>0.05$ at 5% level of significance, among the parameters such as pH, PO_2, PCO_2, SaO_2 and HCO_3. The outcome parameters remained essentially unchanged due to the intervention.

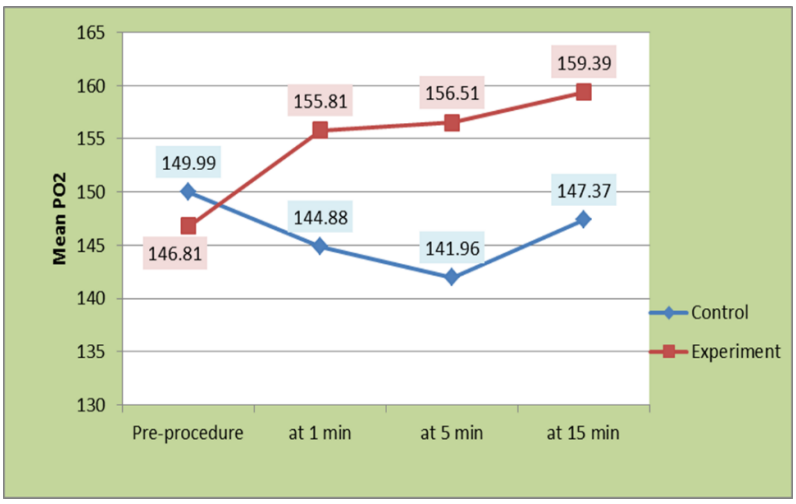

Figure 1: Comparison of pre and post intervention PO_2 level between experiment and control group

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On comparing the pre and post intervention ABG values in the experiment group undergoing closed endotracheal suction, PO_2 had a highly statistically significant difference (p=0.02) with the values remaining elevated above the initial level post suctioning also as hyperoxygenation maneuver was followed prior to intervention as shown in Figure 1. All other parameters were statistically not significant. However, the mean SaO_2 values on post hoc t-test assessment revealed a statistically significant difference with p=0.02 signifying improved gaseous diffusion after suctioning.

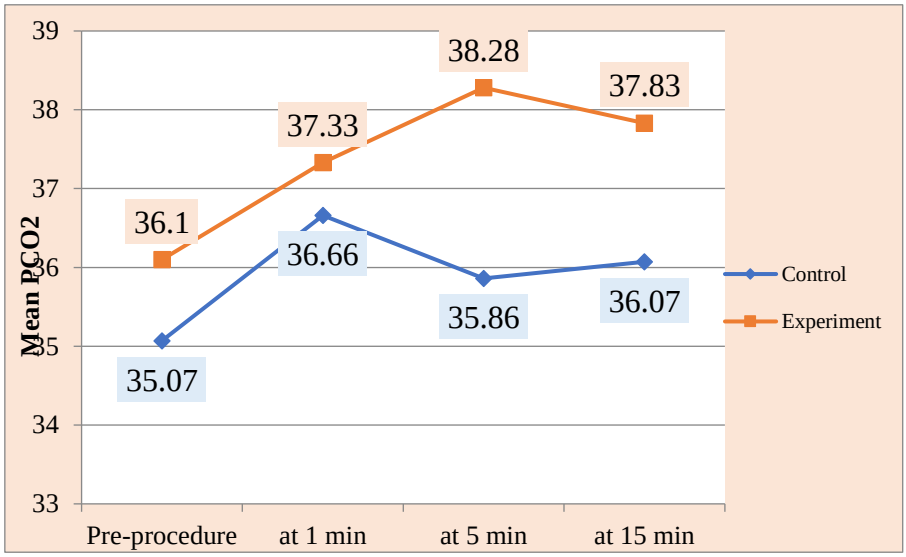

Figure 2: Comparison of pre and post intervention PCO_2 level between experiment and control group

The findings of the study revealed that after the closed suction technique PCO_2 had an upward slope with mean PCO_2 increasing from 36.10±3.23mmHg SD before intervention to 37.33±5.04 mmHg SD at 1 minute to 38.28±6.21 mmHg at 5 minute as shown in Figure 2. The increase at 5 minutes was 6% more than the baseline value. Further the levels redued to 37.83±4.00 mmHg SD at 15 minutes, which was although higher than the baseline (4.79%) but showed a reduction of 1.17% from the mean PCO_2 value at 5 minutes. None of the findings in the PCO_2 levels at different points of time were statistically significant. In line withour study, Alavi SM et al.also reported an increase in PCO_2 levels post procedure[6].

The findings of Lasocki et al. showed no change in PCO_2 compared with baseline values.The dissimilarity in the above results can be due to methodological variations in suction duration,

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measurement time and samples. Increase of PCO_2 may cause stimulation ofchemoreceptors in the aorta and carotid sinus and subsequentlyraise the arterial blood pressure[7].

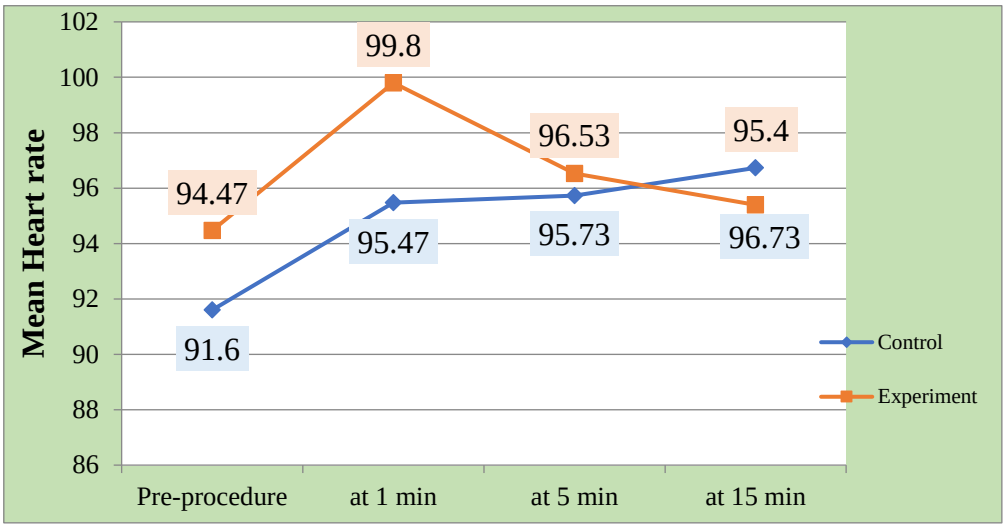

Figure 3: Comparison of pre and post intervention mean heart rate values between experiment and control group

In the current study, the mean heart rate initially rose after airway suctioning and then declined in in both the experiment and control groups as shown in Figure 3. There was a 4.58% increase in the mean heart rate among participants following closed suction in comparison to that of 4.22% among the open suctioning group. The changes in all measured points were not statistically significant ($p<0.05$), however observable differences in both the groups showed that the increase was almost similar for both the groups. It is important to mention that the recovery of heart rate to the initial level was evident in the closed suction group whereas in the open suction method the heart rate remained elevated throughout the measurement points and did not touch baseline.

Several studies have reported increase in the mean heart rate although the studies depict a more stable heart rate in the closed suction group than the open suction technique. Bourgault et al. (2006) reported an increase in the heart rate in their study population, with the change being significant with the open suctioning method in comparison with the closed suctioning method ($P<0.05$)[8]. Lee et al. also found arise in the heart rate with the open airway suctioning method, which was significant just after airway suctioning ($P<0.05$). The study findings were in

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congruence with the present study[9]. However, Valderaset al. (2004) reportedno significant differences between the closed and open suctioning techniques[10].

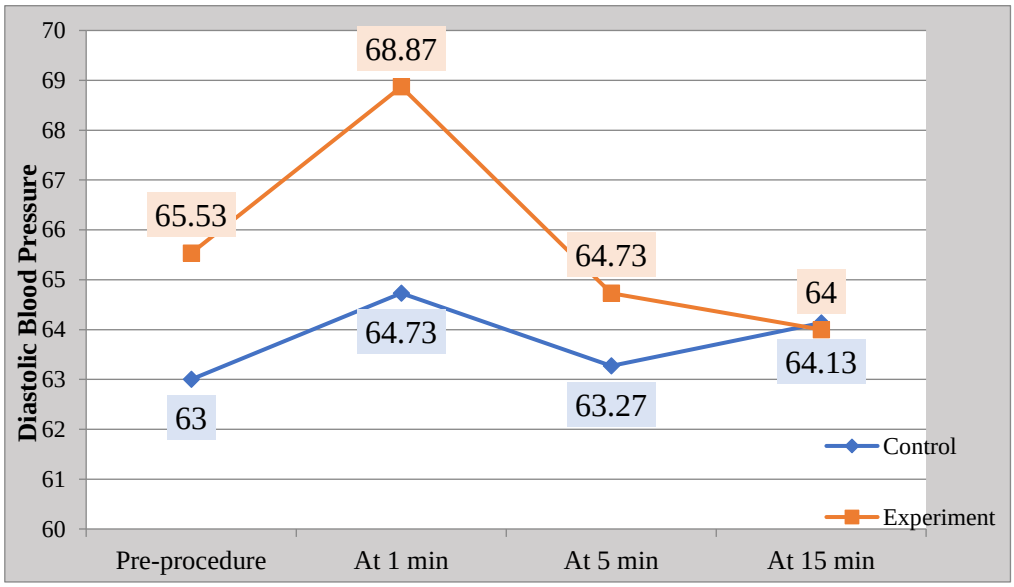

Figure 4: Comparison of pre and post intervention mean diastolic pressure between experiment and control group

Comparison of pre and post intervention DBP among participants of the experiment and control group is as shown in Fig4. The DBP increased immediately after intervention in the experiment group by 5% in contrast to that of 2.7 % in the control group. The return to baseline was more pronounced in the experiment group than in the control group. The findings of the present study are in line with that of Alavi SM et al.[6,11]

The intergroup comparison of various ABG values and cardiorespiratory parameters showed no significant statistical difference.

Discussion:

Our findings indicate that utilizing a CES system can effectively maintain oxygenation and ventilation compared to OES system. During suctioning with a closed suctioning system, mechanical ventilation support remains continuous, maintaining positive end-expiratory pressure (PEEP) with minimal fluctuations in FiO_2. This continuous support helps prevent loss of lung volume and minimizes changes in oxygenation and ventilation during suctioning. Our study findings align with previous researches, indicating better oxygen saturation with the closed system. However, this advantage was not clinically significant as both groups returned

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to pre-suctioning values after a short period. This transient effect may be attributed to the standard practice of administering 100% oxygen before suctioning.

In the present study, the researcher observed that the mean heart rate initially increased after airway suctioning and then declined in CES system however in the OES remained elevated above the baseline. This finding is consistent with several previous studies. Bourgault et al. found a significant increase in heart rate with OES compared to CES ($P<0.05$). Similarly, Lee et al. reported a significant rise in heart rate with OES, particularly immediately after suctioning ($P<0.05$). However, Valderas et al. did not find significant differences between CES and OES in terms of heart rate changes[10].

The current study showed a statistically significant increase in patient's diastolic blood pressure with a p value 0.03 at 1 minute post procedure[11]. However, by 5 minutes after intervention the DBP had achieved pre procedure mean DBP value and by 15 minutes it had decreased further by 2.33% from the baseline value. The study findings are in accordance with Jongerden et al. while the works of Lee et al. were in contrast to our findings, wherein they reported that for patients on ventilator therapy below FiO_2 60% and PEEP 8cmH_2O, open suctioning performed after delivery of 100% FiO_2 using a mechanical ventilator may not have as much negative impact on lung dynamics and hypoxemia as closed suctioning[9,12].

Conclusion:

In the critical immediate post-cardiac surgery phase, ensuring patient stabilization and preventing hypoxia are paramount. Based on the findings of our study, it is evident that the Closed Endotracheal Suctioning system (CES) induces fewer disruptions in hemodynamic and oxygen parameters compared to the Open Endotracheal Suctioning system (OES). This suggests that utilizing CES may offer advantages in maintaining patient stability and preventing hypoxia during this crucial period.

Acknowledgement: The authors express their gratitude towards the management of the College of Nursing and the selected tertiary care cardiac center, as well as all esteemed domain experts, colleagues, and authorities involved in the conduct of the study.

Ethical Statement: IEC permission obtained prior to starting the study in the selected tertiary care cardiac hospital. Informed consent taken from the participants preoperatively for the research study.

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