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COMPARISON OF IMPACT OF POSITIVE PRESSURE VS NEGATIVE PRESSURE EXTUBATION TECHNIQUES ON POST-OPERATIVE HEMODYNAMIC STABILITY AND OXYGEN SATURATION IN PATIENTS UNDERGOING OPEN CHOLECYSTECTOMY UNDER GENERAL ANESTHESIA

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Abstract

Background: *Post-extubation complications such as desaturation, hypertension, and tachycardia are important concerns under general anesthesia. Positive pressure extubation has long been used, while negative pressure is a newer alternative. Evidence comparing these techniques remains limited and conflicting; therefore, this study compared their impact on hemodynamic stability and oxygen saturation in open cholecystectomy.*

Objective: *To compare the frequency of complications of positive pressure versus negative pressure extubation technique during emergence from general anesthesia.*

Duration: *Three months w.e.f. 18-01-2025 to 17-04-2025.*

Methodology: *After ethical approval and informed consent, 120 patients undergoing open cholecystectomy at Sir Ganga Ram Hospital were randomized into two groups: negative pressure (n=60) and positive pressure (n=60). Extubation techniques were performed as per standard protocols, with oxygen supplementation adjusted to maintain saturation above 90%. All variables were observed and recorded by the researcher. Confounding factors were excluded, complications managed per hospital protocol, and data analyzed using SPSS version 27.*

Results: *A total of 120 patients (mean age 43.28±12.14 years; 56.7% male; 76.7% ASA-II) were included. Desaturation occurred in 10.0% vs 25.0%, hypertension in 23.3% vs 10.0%, and tachycardia in 10.0% vs 25.0% for Groups A and B, respectively.*

Conclusion: *Negative pressure extubation was associated with lower rates of desaturation and tachycardia but a higher frequency of hypertension, while positive pressure extubation showed the opposite trend. These results suggest that negative pressure provides better oxygenation outcomes, though with increased hemodynamic stimulation, requiring careful consideration in patients with cardiovascular risk.*

INTRODUCTION

The subglottic space, situated below the vocal cords and above the cuff of the endotracheal tube (ETT), typically accumulates around 15 mL of secretions daily.[1] These secretions collect above the inflated cuff and cannot be cleared without specialized suction devices.[2] Extubation, defined as the removal of the ETT, represents the final step in discontinuing mechanical ventilation and may trigger a spectrum of physiological responses, most commonly involving respiratory and cardiovascular complications.[3,4] Reported adverse events include laryngospasm (25%), desaturation (22%), and coughing (18%), while in intensive care unit (ICU) settings, hypertension (28.4%), desaturation (24.1%), and tachycardia (23.7%) are frequently observed.[5]

The manner of extubation plays an important role in determining how subglottic secretions reach the lower airways.[6] Two main approaches are used to reduce pulmonary aspiration: the negative pressure technique and the positive pressure technique.7 Negative pressure extubation involves continuous endotracheal suctioning during cuff deflation and tube removal, allowing secretions beneath the cords to be aspirated. Conversely, positive pressure extubation applies end-expiratory positive pressure during ETT withdrawal, generating airflow that propels secretions toward the laryngopharynx and oropharynx. This pressure can be created either by manual compression of a resuscitator bag or via ventilator settings.[8,9]

Despite the emphasis often placed on safe intubation, extubation is equally critical for smooth postoperative recovery, yet it remains underexplored in both literature and practice. Evidence comparing the two techniques suggests superior outcomes with positive pressure. In Argentina, Andreu et al. reported significantly fewer complications with positive pressure compared to negative pressure (65.5% vs. 76.9%, $p<0.01$).[10] Similarly, Prabhakaran et al. in India observed lower complication rates in the positive pressure group (20%) compared to the negative pressure group (42.6%, $p=0.04$).[11]

Taken together, these findings highlighted the potential benefits of positive pressure extubation in minimizing postoperative complications. Nevertheless, most available data originated from limited international studies, and evidence from local clinical settings was lacking. Thus, while positive pressure appeared promising, widespread replacement of the conventional negative pressure method required further trials conducted in diverse populations to establish stronger, region-specific evidence.

METHODOLOGY

This study was a randomized controlled trial conducted in the Department of Anaesthesia, Sir Ganga Ram Hospital, Lahore, over a period of three months following the approval of the study synopsis. A total sample size of 120 patients, with 60 cases in each group, was calculated to achieve 80% power and a 5% level of significance, considering the expected frequency of complications of tracheal extubation with suction versus positive pressure as 42.6% and 20.0%, respectively.[12] Non-probability consecutive sampling was employed to select patients who met the inclusion criteria. Operationally, complications of tracheal extubation were defined as the presence of any of the following within five minutes after extubation: desaturation, defined as SpO_2 <90% or a drop of 4 points from pre-extubation SpO_2 maintained for at least 10 seconds; hypertension, defined as systolic blood pressure >180 mmHg or an increase >20% from pre-extubation values; tachycardia, defined as heart rate >140 beats/min or an increase >20% from pre-extubation values; and tachypnea, defined as respiratory rate >35 breaths/min or an increase >50% from pre-extubation values. The inclusion criteria comprised patients of both genders, aged 18–70 years, with normal BMI, undergoing extubation after general anesthesia. Patients with difficult intubation, a history of upper airway injury or surgery, previous extubation or tracheostomy, or those who received non-invasive ventilation as a weaning method were excluded. After approval from the Hospital's Ethical Review Board, 120 patients fulfilling the inclusion criteria were enrolled after obtaining informed written consent. They were randomly assigned into two groups using a lottery method: Group A, the negative pressure group (n=60), and Group B, the positive pressure group (n=60). In Group A, traditional extubation was

performed by two operators. Without reconnection to the ventilator, a closed suction system catheter was introduced into the ETT by one operator, and suctioning was initiated. The cuff was immediately deflated by the second operator, and the ETT was removed with continuous endotracheal suction performed throughout the procedure. In Group B, positive-pressure extubation was performed by a single operator. Ventilator parameters were set to pressure support ventilation mode, with inspiratory pressure of 15 cm H_2O and PEEP of 10 cm H_2O. The cuff was then deflated, and the ETT was removed without endotracheal suction. After ETT removal, a suction catheter was introduced through the mouth to clear secretions drawn to the oropharynx by the airflow from the ventilator passing between the ETT and the larynx. Regardless of the extubation technique, supplemental oxygen was administered at the same flow level used during the spontaneous breathing trial, and the flow was adjusted to maintain SpO_2 ≥90% in case of desaturation. The researcher herself observed and recorded all study variables in a pre-designed proforma, and confounding variables were controlled through exclusion criteria. Any complications were managed according to the hospital's standard protocol free of cost. Data were entered and analyzed using SPSS version 27. Numerical variables such as age and BMI were presented as mean ± SD, while categorical variables, including ASA status, type of surgery, desaturation, hypertension, tachycardia, tachypnea, and poor respiratory mechanics, were presented as frequencies and percentages. The overall frequency of complications between the two groups was further stratified according to age, gender, type of surgery, and ASA status to identify effect modifiers. Post-stratification, the chi-square test was applied, with a p-value ≤0.05 considered statistically significant.

RESULTS

A total of 120 patients were included in the study, with a mean age of 43.28 ± 12.14 years. Among them, 53 (44.2%) were between 18–40 years, while 67 (55.8%) were 41–70 years old. There were 68 males (56.7%) and 52 females (43.3%). The mean BMI was 21.93 ± 1.80 kg/m², with 52 patients (43.3%) falling between 18.5–21.5 kg/m² and 68 patients (56.7%) between 21.6–24.9 kg/m². Regarding ASA classification, 28 patients (23.3%) were ASA-I and 92 (76.7%) were ASA-II. Most procedures were elective, accounting for 98 cases (81.7%), while 22 cases (18.3%) were performed as emergency surgeries, as given in Table 1.0.

The baseline characteristics were comparable between the two groups. The mean age was 42.43 ± 12.73 years in Group A and 44.13 ± 11.56 years in Group B (p=0.445). Age distribution between 18–40 years and 41–70 years was similar (p=0.358). Gender distribution showed 51.7% males in Group A and 61.7% in Group B (p=0.269). The mean BMI was 21.92 ± 1.73 and 21.93 ± 1.88 kg/m² in Groups A and B, respectively (p=0.976), with no significant difference in BMI categories (p=0.461). ASA status showed 26.7% vs 20.0% in ASA-I and 73.3% vs 80.0% in ASA-II (p=0.388). Emergency surgeries were 20.0% in Group A and 16.7% in Group B, while elective surgeries were 80.0% and 83.3%, respectively (p=0.637). Data is given in Table 2.0.

As shown in Table 3.0, desaturation was observed in 10.0% of Group A versus 25.0% of Group B (p=0.031). Hypertension occurred in 23.3% of Group A and 10.0% of Group B (p=0.050). Tachycardia was noted in 10.0% of Group A compared to 25.0% of Group B (p=0.031). Stratified analysis showed no significant differences due to the small sample size of complications.

Table 1.0: Demographic Characteristics

Characteristics	Total (120)
Age (years)	43.28±12.14
• 18-40 years	53 (44.2%)
• 41-70 years	67 (55.8%)
Gender	

• Male	68 (56.7%)
• Female	52 (43.3%)
BMI (kg/m^2)	21.93±1.80
• 18.5-21.5	52 (43.3%)
• 21.6-24.9	68 (56.7%)
ASA Status	
• ASA-I	28 (23.3%)
• ASA-II	92 (76.7%)
Type of Sugary	
• Emergency	22 (18.3%)
• Elective	98 (81.7%)

Table 2.0: Comparison of Baseline Characteristics

Characteristics	Group A (n=60)	Group B (n=60)	p-value
Age (years)	42.43±12.73	44.13±11.56	0.445
• 18-40 years	29 (48.3%)	24 (40.0%)	0.358
• 41-70 years	31 (51.7%)	36 (60.0%)	
Gender			
• Male	31 (51.7%)	37 (61.7%)	0.269
• Female	29 (48.3%)	23 (38.3%)	
BMI (kg/m^2)	21.92±1.73	21.93±1.88	0.976
• 18.5-21.5	28 (46.7%)	24 (40.0%)	0.461
• 21.6-24.9	32 (53.3%)	36 (60.0%)	
ASA Status			
• ASA-I	16 (26.7%)	12 (20.0%)	0.388
• ASA-II	44 (73.3%)	48 (80.0%)	
Type of Sugary			
• Emergency	12 (20.0%)	10 (16.7%)	0.637
• Elective	48 (80.0%)	50 (83.3%)	

Chi Square test/ Independent sample t test, taking p-value≤0.05 as significant.

Table 3.0: Comparison of Complications between the Groups

Characteristics	Group A (n=60)	Group B (n=60)	p-value
Desaturation			
• **Yes**	6 (10.0%)	15 (25.0%)	0.031
• **No**	54 (90.0%)	45 (75.0%)	
Hypertension			
• **Yes**	14 (23.3%)	6 (10.0%)	0.050
• **No**	46 (76.7%)	54 (90.0%)	
Tachycardia			
• **Yes**	6 (10.0%)	15 (25.0%)	0.031
• **No**	54 (90.0%)	45 (75.0%)	

Chi Square test, p-value≤0.05 as significant.

DISCUSSION

Post-extubation complications, including hemodynamic instability and oxygen desaturation, remain significant concerns in patients undergoing general anesthesia. Traditionally, positive pressure extubation has been widely practiced, aiming to minimize airway obstruction and secretion-related complications.[12-14] More recently, negative pressure (suction) extubation has been introduced, with the rationale of reducing residual secretions and improving oxygenation.[7,8] However, existing evidence regarding the comparative safety and efficacy of these techniques is scarce, particularly in high-risk surgical populations.[10,11] To address this gap, the present study was designed to compare the impact of positive pressure versus negative pressure extubation on hemodynamic stability and oxygen saturation in patients undergoing open cholecystectomy under general anesthesia.

The findings of the present study align with and add to the growing body of literature evaluating positive versus negative pressure techniques during tracheal extubation. Several investigators have compared the incidence of post-extubation complications between these two approaches, reporting variable but generally favorable outcomes with positive pressure.

Andreu et al., from Argentina, demonstrated a significantly lower complication rate when positive pressure was used, with 65.5% of patients experiencing complications compared with 76.9% in the negative pressure group ($p<0.01$). This supports the concept that applying positive pressure during extubation may reduce adverse events associated with secretion retention and airway compromise.[10] Similarly, Prabhakaran et al., in India, reported complication rates of 20% in the positive pressure group versus 42.6% in the negative pressure group ($p=0.04$), again favoring positive pressure as the safer technique.[11]

Evidence from Pakistan echoes these observations. Khan et al. found that additional suctioning within three minutes of extubation was required in 30% of patients managed with negative pressure, compared with only 7.5% in those extubated with positive pressure. Moreover, supplemental oxygen was needed in 7.5% of the negative pressure group versus 2.5% of the positive pressure group, highlighting the oxygenation advantage of positive pressure extubation. Their conclusion emphasized that negative pressure was associated with greater suctioning and oxygen requirements in the immediate post-extubation period.[15]

Farhadi et al. extended these findings into the neonatal population, where post-extubation atelectasis (PEA) was significantly lower in the positive pressure group (24%) compared with the negative pressure group (46%) ($p=0.024$). Extubation failure was also reduced (6% vs. 20%, $p=0.037$). Although no significant differences were observed for apnea, pneumothorax, or mortality within three days, the authors recommended positive pressure extubation in neonates due to the reduced incidence of PEA and extubation failure.[16]

Systematic reviews and broader analyses have generally supported these clinical findings. Liu et al., in a scoping review, concluded that positive pressure extubation had a safety profile comparable to negative pressure but offered potential advantages, including more stable vital signs, improved arterial blood gas parameters, and fewer respiratory complications.[17]

In contrast, some studies have reported neutral outcomes. Nourolahi et al. observed no significant differences between positive and negative pressure extubation in duration of intubation ($p=0.436$), need for supplemental oxygen ($p=0.785$), or length of hospitalization ($p=0.357$). Gestational age at birth influenced outcomes, but the extubation technique itself was not a determining factor.[18]

Overall, the majority of available evidence suggests that positive pressure extubation may reduce the frequency of respiratory complications and improve oxygenation compared to negative pressure. However, some conflicting reports highlight the need for larger, procedure-specific trials to establish definitive recommendations, particularly in adult surgical populations such as open cholecystectomy under general anesthesia.

CONCLUSION

Negative pressure extubation was associated with lower rates of desaturation and tachycardia but a higher frequency of hypertension, while positive pressure extubation showed the opposite trend. These results suggest that negative pressure provides better oxygenation outcomes, though with increased

hemodynamic stimulation, requiring careful consideration in patients with cardiovascular risk.

LIMITATIONS & RECOMMENDATIONS

The major strength of this study lies in its randomized design, adequate sample size, and focused evaluation of extubation techniques in open cholecystectomy under general anesthesia, ensuring comparable baseline characteristics. However, limitations include being a single-center study, short follow-up duration, and limited complication spectrum due to sample size. Future research should involve larger multicenter trials, broader surgical populations, and longer follow-up to validate findings and establish standardized extubation protocols for improved safety and patient outcomes.

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Authors Contribution

Author 1

Substantial contributions to study design, acquisition of data
Analysis & Interpretation of Data, Manuscript writing
Has given final approval of the version to be published
Agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved

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