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Original Article

Effects of Endotracheal Extubation with Suctioning versus Positive Pressure in Children after General Anaesthesia, A clinical Trial

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ABSTRACT

Objective: To observe the effects of extubation with suctioning when compared with extubation with positive pressure in children after general anaesthesia.
Study Design: Randomized Control Trial (ClinicalTrials.gov: NCT05489809).
Place and Duration of Study: Main Operation Theatre (OT), PNS Shifa Hospital, Karachi Pakistan, from Mar to Aug 2022.
Methodology: Patients were randomly divided into two groups of 40 patients each. One group of patients was extubated after general anaesthesia with negative pressure/suctioning applied to the ETT. In contrast, the other group of patients was extubated by applying positive pressure to the ETT. The need for additional suctioning more than once and supplemental oxygen, if required, was documented in the first 3 minutes after extubation (primary endpoints). Additionally, hemodynamic and respiratory parameters were documented at the time of extubation and 3 minutes after (secondary endpoints).
Results: The results showed that 12(30%) patients out of 40 in the Negative Pressure Extubation-Group required additional suctioning within the first 3 minutes after extubation compared to only 3(7.5%) patients in the Positive Pressure Extubation-Group. Furthermore, 3(7.5%) patients in the Negative Pressure Extubation-Group required supplemental oxygen 3 minutes after extubation compared to only 1(2.5%) in the Positive Pressure Extubation-Group.
Conclusion: We observed that negative pressure extubation, when compared to positive pressure extubation, increased the requirement for suctioning and supplemental oxygen in the first 3 minutes after extubation.

Keywords: Extubation with suctioning, General anaesthesia in children, Negative pressure extubation, Positive pressure extubation.

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INTRODUCTION

Removal of the endotracheal tube is a routine but critical procedure performed in the Operation Theatres (OT) and Intensive Care Units (ICUs) with serious complications associated with general anaesthesia attributed to this vital step.[1] Most of these complications are minor, but they can lead to respiratory distress syndrome (RDS), which leads to prolonged hospital stay and laryngospasm that can cause hypoxic brain injury and even death, amongst many other problems.[2,3] Difficult Airway Society (DAS) guidelines recommend a step-wise approach to endotracheal extubation intending to prevent or reduce the oxygen haemoglobin desaturation to a minimum.[4,5]

Despite its significance, the best technique for removing the endotracheal tube must be clearly defined in the literature.[5] Two techniques are, however, routinely practised for endotracheal extubation.[6] Firstly, the positive pressure technique involves delivering 100% oxygen to the patient's lungs by applying positive pressure and delivering manual breaths via bag mask on the anaesthesia workstation in the OT or AMBU bag in the ICU before removing the endotracheal tube. This technique is suggested to limit atelectasis and remove tracheal secretions as the first air movement is out of the inflated lungs.[7,8] Secondly, a more routinely used technique in our clinical practice is the negative pressure technique, which involves inserting a suction catheter or applying negative pressure to the endotracheal tube while removing it from the patient's lungs. However, this technique can leak some secretions into the airway, leading to complications.[9,10]

This study assesses the difference between positive and negative pressure extubation in children after general anaesthesia. The primary clinical indicators which were used to compare the two techniques were; the need for suctioning more than once to clear the oropharyngeal airway of any secretions in the initial 3

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minutes after extubation and the need for supplemental oxygen to keep oxygen saturation more than 94%, 3 minutes after extubation. Secondary endpoints included the patient's hemodynamic parameters and any respiratory complications.

METHODOLOGY

The randomized clinical trial was conducted from March to August 2022 in the Main Operation Theatre (OT) of PNS Shifa Hospital, Karachi Pakistan, after getting the Hospital Ethical Review Committee approval (ERC/ANS/2022/2) and registration of the trial on ClinicalTrials.gov (NCT05489809). The sample size was calculated using the WHO sample size calculator taking the time difference for oxygen saturation to drop to 92% (T92) was 50 seconds (25 seconds in the NPE group vs 75 seconds in the PPE group) with a higher standard deviation (±63 seconds).[11]

Inclusion Criteria: Patients of either gender, aged 01 and 12 with ASA class I or II, who were planned for elective surgery and were to be intubated as part of intraoperative anaesthesia plan were included.

Exclusion Criteria: Patients with anticipated difficult bag-mask ventilation or intubation on Pre Anaesthesia Assessment (PAA), patients who had to be shifted to Paediatric Intensive Care Unit (PICU) or Paediatric High Dependency Unit (PHDU) postoperatively due to intraoperative events were excluded.

The patients were randomly divided into two groups using random number tables: (1) those who were extubated while applying negative pressure or suctioning (NPE) to the endotracheal tube and (2) those who were extubated while applying positive pressure (PPE) to the endotracheal tube.

After shifting to the OT, standard intravenous access was obtained. Non-invasive blood pressure, oxygen saturation (SpO_2), and ECG monitoring were attached, and the patients were premedicated with 0.1-0.25 mg/kg Metoclopramide and 0.1-0.15 mg/kg Dexamethasone as per institutional policy. Induction of anaesthesia was performed with Propofol 1-2.5 mg/kg with or without Ketamine 2-3 mg/kg. After confirming bag-mask ventilation by end-tidal carbon dioxide ($EtCO_2$) and clinical evidence of chest rise, the patients were paralyzed with Atracurium 0.4-0.6 mg/kg and oxygenated with 100% oxygen for 3 minutes. For patients where Rapid Sequence Induction (RSI) was done, neuromuscular blockade was achieved using Rocuronium 0.6-1.2mg/kg after pre-oxygenating the patient with 100% oxygen for 3 minutes. The endotracheal tube (ETT) size was calculated using age/4+4 for uncuffed tubes and age/4+3 for cuffed tubes. After passing the ETT, $EtCO_2$ confirmed the correct placement and 5-point chest auscultation and the ETT was secured. Volume or pressure-controlled ventilation was done to maintain minute ventilation between 80-100ml/kg/min, EtCO2 between 35-45 mmHg, SaO2 more than 94% on minimum inspired oxygen of more than 30% and clinically acceptable hemodynamic parameters within 20% of the initial baseline. General anaesthesia was maintained with Isoflurane at MAC 1.2 or Sevoflurane at MAC 2.0 and Atracurium boluses of 0.08-0.1mg/kg. Pain relief was achieved with Acetaminophen 10-15 mg/kg and Nalbuphine 0.08-0.1mg/kg. The caudal block was performed according to the Armitage regime when possible so opioid-based analgesia could be avoided.

At the end of the surgery, termination of neuromuscular blockage was ensured using Neostigmine 0.5-0.7 mg/kg with Glycopyrrolate 0.08-0.1 mg/kg. Suctioning was done from the trachea through the ETT using a suction catheter and from the oropharynx through a Yankaeur or suction catheter was performed while the patient was in the surgical plane of anaesthesia. A bite block or Guedel airway was inserted to prevent the patient from biting the tube. Upon return of spontaneous breathing, the patient was given 100% oxygen. Awake extubation of the ETT was then performed using NPE or PPE technique after clinical evidence of Cough or Gag reflex and return of voluntary peripheral muscular movement, including the limbs, neck or face, was observed. Extubation was performed after ensuring the patient maintained adequate minute ventilation and was clinically and hemodynamically stable. Emergency drugs, equipment, and expertise for managing anaesthetic or surgical complications were available throughout the patients' extubation and recovery phases.

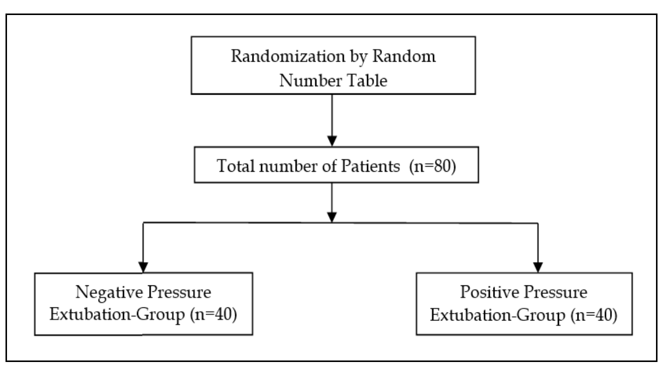

Figure: Patient Flow Diagram (n=80)

For the NPE Group, the ETT cuff was deflated after the oropharyngeal and tracheal secretions were removed for the cuffed ETT. The suction catheter was then inserted into the ETT at a depth not to extend beyond the tracheal end of the ETT, and the tube was then removed. Alternatively, the suction piping was directly connected to the ETT, which was removed after ensuring a tight seal. The negative pressures used for the NPE technique were -10 to -20 cmH2O.

In the PPE Group, after ensuring suction of oropharyngeal and tracheal secretions, the patient was allowed to breathe with the adjustable pressure limiting valve spontaneously closed between 10-20 cmH2O. The ETT cuff was then deflated, and the ETT was removed at the end of inspiration or by giving a manual breath using the reservoir bag before removing the ETT.

After removing the ETT, the oropharynx was clinically examined for the need for any additional suctioning, and suctioning was performed if required. A facemask with a tight seal was applied to assist spontaneous breathing of 100% oxygen for 1 minute. The patient was then observed for 2 minutes on room air. If the SpO_2 dropped below 94%, supplemental oxygen was given via face mask before shifting the patient to Post Anaesthesia Care Unit (PACU) if hemodynamically and clinically stable. Tracheal extubation was performed in the supine position in all cases.

The need for additional suctioning for oropharyngeal secretions and supplemental oxygen to maintain SpO_2 >94% after removing ETT in the initial 3 minutes was documented in both groups (primary endpoints). Additionally patients SpO_2, heart rate and respiratory rate were observed at the time of, and 3 minutes after extubation (secondary endpoints). Non-invasive blood pressure monitoring was removed from secondary endpoint data collection as it provided frequent erroneous readings in some younger patients due to inappropriate/ mismatched cuff sizes.

Statistical Package for Social Sciences (SPSS) version 25.0 was used for the data analysis. Quantitative variables were expressed as Mean±SD and qualitative variables were expressed as frequency and percentages. Independent sample t-test was applied to explore the inferential statistics. The *p*-value of ≤0.05 was set as the cut-off value for significance.

RESULTS

The study was conducted on 80 patients who were divided into two groups of 40 patients, each labelled as NPE and PPE Groups. Patients ' demographic data is mentioned in Table-I. The patients in both the NPE and PPE groups mostly belonged to the Paediatric surgery department. The surgical department-wise distribution of the patients in the two groups is demonstrated in Table-II.

Table-I: Demographics of Patients (n=80)

Variables		Negative Pressure Extubation-Group (n=40)	Positive Pressure Extubation-Group (n=40)
Age (years)		7.5±3.2	5.0±2.9
Gender	Males	23(57.5%)	26(65%)
	Females	17(42.5%)	14(35%)

Table-II: Surgical Departments of Patients (n=80)

Departments	Negative Pressure Extubation-Group (n=40)	Positive Pressure Extubation-Group (n=40)
Paediatric Surgery	19(47%)	23(57%)
Orthopaedics	8(20%)	4(10%)
Plastic Surgery	3(8%)	2(5%)
ENT	4(10%)	3(7%)
Neurosurgery	2(5%)	1(3%)
Urology	2(5%)	6(15%)
Dental Surgery	2(5%)	1(3%)

It was observed that 12(30%) patients out of 40 in the NPE group required additional suctioning to clear their airway of oropharyngeal secretions within the first 3 minutes after extubation in comparison to only 3(7.5%) patients out of 40 in the PPE-Group who required additional suctioning. Furthermore, 3(7.5%) patients out of the 40 in the NPE-Group required supplemental oxygen 3 minutes after extubation compared to only 1(2.5%) patient out of the 40 in the PPE-Group.

Table-III: Comparison of Mean Pulse rate, Saturation and Respiratory Rate (n=80)

Variables		Negative Pressure Extubation-Group (n=40)	Positive Pressure Extubation-Group (n=40)	*p* -value
Pulse/min	At extubation	105.27±25.77	111.10±16.67	0.084
	After 3 mins	120.65±18.36	119.57±16.33	0.785
Saturation(%)	At extubation	99.83±0.38	99.80±0.41	0.573
	After 3 mins	98.88±1.26	98.90±1.08	0.402
Respiratory Rate/min	At extubation	23.85±5.11	24.52±4.64	0.323
	After 3 mins	21.37±4.41	21.95±4.67	0.507

Patients' pulse, saturation, and respiratory rates were observed at the time of extubation and after 3 minutes. The comparison of the mean hemodynamic and respiratory parameters of the patients in both groups is mentioned in Table-III.

DISCUSSION

In our clinical trial, we observed that the NPE technique, when compared to PPE, increased the need for suctioning and supplemental oxygen in the first 3 minutes after extubation. These results were comparable to previous studies done on extubation techniques.[9,11]

It is postulated that during general anaesthesia, secretion accumulates above the endotracheal tube's cuff. At the time of extubation, the patient can aspirate these secretions.[12] In a study by Mehta, it was demonstrated that if the ETT cuff was placed just below the vocal cords and/or the patient positioned in a head-down position during extubation with suctioning, the risk of aspiration could be avoided.[13] However, different studies have shown that applying suctioning or negative pressure to the ETT during extubation removal of air from the lungs occurs due to the negative pressure applied to the ETT. This leads to a decrease in lung volumes, which can cause hypoxemia, especially in neonates and critical care patients.[14,15] To avoid this complication, various techniques involving extubation with positive pressure have been proposed.[16,17]

In a study comparing positive pressure extubation with negative pressure extubation on adult patients, no statistically significant difference was found between the onset of arterial desaturation measured through pulse oximetry or the need for supplemental oxygen between the two groups.[9] However, in another study on paediatric patients, Guglielminotti *et al*. demonstrated that oxygen saturation fell to 92% after extubation, three times longer in patients who underwent positive pressure extubation compared to negative pressure extubation.[11] This difference is likely because of the reduced functional residual capacity and oxygen reserves in younger patients. Furthermore, this effect on the decrease in oxygen haemoglobin saturation is augmented using negative pressure extubation technique in these patients, leading to a more rapid fall in SpO_2.

Various studies have additionally demonstrated that giving 100% oxygen to the patient before extubation leads to postoperative complications such as atelectasis and unwanted variability in gaseous exchange.[18,19] Our study exposed both groups to 100% oxygen while spontaneously breathing before extubation.

LIMITATIONS OF STUDY

There were several limitations in our study. Firstly, secretions that accumulated above the ETT cuff were suctioned before and after the removal of ETT in both groups. In some patients, additional suctioning, often multiple times, was required after extubation to clear any residual secretions. There was no documentation of the number of times additional suctioning was required after the first suctioning, which was done immediately after removing the ETT. Additionally, the amount of secretions removed was not measured in the two groups. A radiographic dye could have been used to demonstrate which extubation technique is better in preventing the chances of pulmonary aspiration. Lastly, the observer who recorded the patient's hemodynamic and respiratory parameters was aware of the extubation technique used, as these recordings were made immediately before and 3 minutes after extubation.

CONCLUSION

In our clinical trial we observed that NPE, when compared to PPE, increased the requirement for suctioning and supplemental oxygen in the first 3 minutes after extubation.

Conflict of Interest: None.

Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

KAK & TM: Conception, study design, drafting the manuscript, approval of the final version to be published.

BY & MZA: Data acquisition, data analysis, data interpretation, critical review, approval of the final version to be published.

SM & FL: Data acquisition, drafting the manuscript, approval of the final version to be published.

Authors 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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