International Journal of Life Sciences, Biotechnology and Pharma Research Vol. 13, No. 9, September 2024 Online ISSN: 2250-3137
Print ISSN: 2977-0122

DOI: 10.69605/ijlbpr_13.9.2024.24

ORIGINAL RESEARCH

A Comparative study on The efficacy of apneic oxygenation during endotracheal intubation in paediatric patients undergoing elective surgeries

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Received Date: 19 July, 2024 Acceptance Date: 23 August, 2024

ABSTRACT
Background: The paediatric population's functional residual capacity is low, and oxygen consumption is high. Hence, these patients desaturate very fast. During the administration of general anaesthesia, pre-oxygenation takes care of oxygen requirement until laryngoscopy. And then, the patient will start receiving oxygen only after intubation and connecting to the breathing circuit. The concept of apneic oxygenation comes to the rescue during unanticipated difficult airways or during prolonged intubating conditions. **Methodology:** In this prospective randomized clinical trial, 116 with age, weight, and sex-matched were assigned a group using computerized random table numbers into the standard care (SC) group and apnoeic oxygenation (approx) group with 58 patients in each group. The apneic oxygenation group was provided 4ltrs of oxygen through a buccal cannula during intubation, while the Standard group was intubated without oxygenation during intubation. **Results:** The mean heart rate from baseline, immediately after preoxygenation, is not significant, but after 1 minute to 5 minutes, results were statistically highly significant. (P-value<0.0001).Mean arterial pressure and mean oxygen saturation were statistically significant. (P-value<0.0001) at 2, 3 and 5 minutes after preoxygenation. The time taken for desaturation in the ApOx group and the standard group started after 2 minutes, but it was longer in the ApOx groups compared to standard care. In the ApOx group, desaturation was observed at 3%, but in standard care groups, it was observed at 5%, and the majority of the patients were desaturated by only 1% in the ApOx group compared to the standard care group. **Conclusion:** There was a statistically significant difference observed in safe apnoea time with saturations up to 95% between the groups. Low mean oxygen saturation was observed in standard care groups compared to the ApOx group.
Key words: ediatric population, endotracheal intubation, apneic oxygenation, difficult intubation

INTRODUCTION

Endotracheal intubation is a critical procedure in the management of paediatric patients undergoing elective surgeries. It involves placing a tube into the trachea to secure the airway and facilitate ventilation. Paediatric patients are more susceptible to rapid desaturation and hypoxemia due to their smaller functional residual capacity and higher metabolic rate. Consequently, ensuring adequate oxygenation during the apneic period when the patient is not actively breathing is vital. Vital. Pre-oxygenation is the process of giving 100% oxygen to replace nitrogen in the lung while a patient is breathing normally so that the functional residual capacity (FRC) can act as an oxygen reservoir [2]. This reservoir contains about 450 ml of oxygen for a healthy adult person breathing room air, while it contains 3000 ml of oxygen for breathing 100% oxygen for a sufficient time [3]. Paediatrics, obese, septics, and obstetric patients undergoing general anaesthesia with endotracheal intubation are thought to have short apnea times, for which many clinical strategies have been used to extend the safe apnea time [4,5]. Apneic oxygenation is a technique designed to extend the safe apnea period by delivering oxygen continuously, even in the absence of active ventilation. This is typically achieved through the use of a nasal cannula or other oxygen delivery systems that provide a continuous

DOI: 10.69605/ijlbpr_13.9.2024.24

flow of oxygen. The concept is grounded in the principle that oxygen will diffuse across the alveolar membrane into the bloodstream even when the patient is not taking breaths, thereby maintaining oxygenation and delaying the onset of hypoxemia. Evaluating the efficacy of this technique during endotracheal intubation can provide valuable insights into improving perioperative care, enhancing patient safety, and minimizing the risks associated with hypoxemia and related complications.

Study Design: This study is a Randomized Clinical Study conducted from May 2023 to June 2024 in the Department of Anaesthesiology, B.L.D.E.U.'s Shri. B. M. Patil Medical College, Hospital and Research Centre, Vijayapura, Karnataka, India. After receiving clearance from the institutional ethical clearance committee[BLDE(DU)/IEC/780/2022-23]. ASA I and II class of patients.Aged between 2 to 5 years. Posted for elective surgery requiring general anaesthesia were included in the study. Children undergoing dental surgeries in which nasal intubation is needed or reported nasal obstruction, Patients who have respiratory and pulmonary diseases or recent upper respiratory tract infection were excluded from the study

Sample size

The study population of 116 within the 2-5 years age group will be assigned using computerized random table numbers into two groups with 58 patients in each group to detect a difference in proportions between the two groups. Using G* power software 3.1.9.7

Statistical analysis

The data obtained were entered into a Microsoft Excel sheet, and statistical analysis was performed using a statistical package for the social sciences (SPSS Version 25). Quantitative data were presented as Mean±SD, Median and Inter quartile range, frequency, percentages and diagrams. For normally distributed continuous variables between two groups, they were compared using the Independent t-test. For not normally distributed variables, the Mann-Whitney U test will be used. Categorical variables were expressed in terms of frequency and proportion, and the association between the two groups was compared using the Chi-square test. $p<0.05$ will be considered statistically significant. All statistical tests were two-tailed

Procedure

History of underlying medical illness, previous history of surgery, anaesthetic exposure and hospitalization elicited. The general condition of a patient, Vital signs -heart rate, blood pressure, respiratory rate, Height and weight, Examination of the respiratory system, cardiovascular system, central nervous system and vertebral system. Airway assessment by Mallampatti grading. The procedure will be explained to the patient attendees. Upon arrival at the operating room suite, all the basic demographic information will be obtained. Standard monitoring devices will be connected, and baseline SPO2, Heart rate and blood pressure will be recorded before premedication. The intravenous line is secured. Premedication is done with Midazolam 0.08 to 0.1 mg /kg, ondansetron 0.15mg/kg, atropine 0.2mg/kg. In the study group (APoX), a buccal cannula with its distal end in the mouth of the patient and the proximal end connected to an oxygen source, which will be opened only for apnoeic oxygenation, will be attached to the cheek of the patient. All the patients are induced using propofol, 2mg /kg body weight. Inj atracurium 0.5mg /kg will be used to facilitate intubation. For the baseline (SC) (no buccal cannula) group, all intubation procedures are performed as usual. The apneic group patients received oxygen at 4 litres/min during the apoeic period, resulting after the preoxygenation mask was removed and until intubation was done and the tube was connected to the breathing circuit. In both the groups, peripheral oxygen saturation percentage (SpO_2), heart rate, and MAP are recorded after the patients become apneic, as judged by lack of respiratory effort by the attending anaesthesiologist, just before mask removal and the same parameters will be recorded 1 min, 2 min, 3min, 4 min and 5 min. The oxygen saturation is continuously observed on the monitor, and the time taken for it to fall by every 1% to 95% is noted. These recordings are tabulated and compared.

FLOWCHART

RESULTS

In the present study.constituting 116 participants aged between 2-5 yrs, 58 in each group posted for elective surgeries requiring intubation are assessed for the effect of apneic oxygenation in the study population. There was no statistical significance between two groups with regards to age(p=0.36).height(p=0.38), weight(p=0.35),asa grade(p=0.44).type of surgeries operated on the study population.

GROUP	AGE		HEIGHT		WEIGHT		ASA GRADE	
	MEAN	P VALUE	MEAN	P VALUE	MEAN	P VALUE	MEAN	P VALUE
APOX GROUP	3.6	0.36	80.67	0.35	10.26	0.38	GRADE-1 34 GRADE-2 24	0.40
STDRD GROUP	3.5		81.39		10.74		GRADE-1 38 GRADE-2 20	

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Mean heart rate distribution(Graph 1) from immediately after pre-oxygenation from 1 minute and to 5 minutes after pre-oxygenation between the groups were statistically highly significant between the groups. Mean heart rates were lower in the ApOx group compared to the standard care group(Table 2).

Graph 1: Mean Heart rate distribution between the groups.

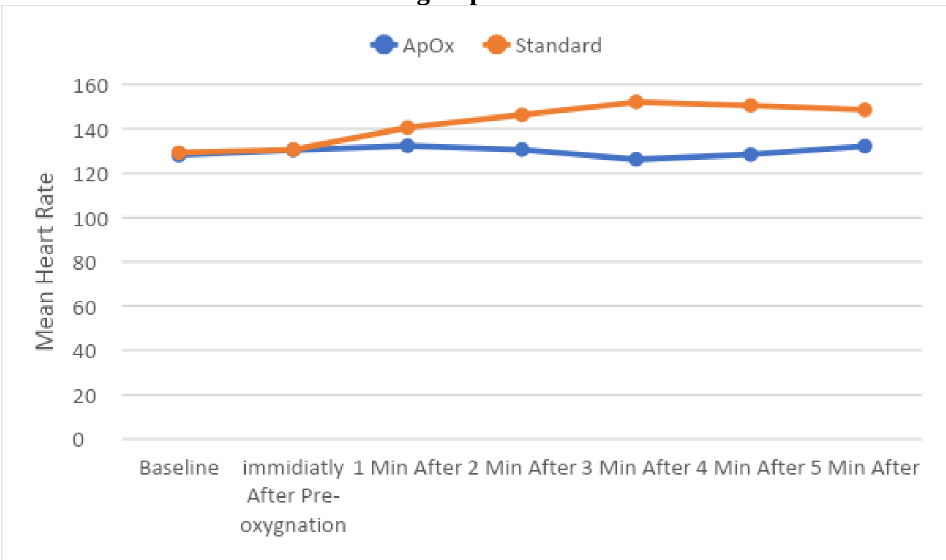
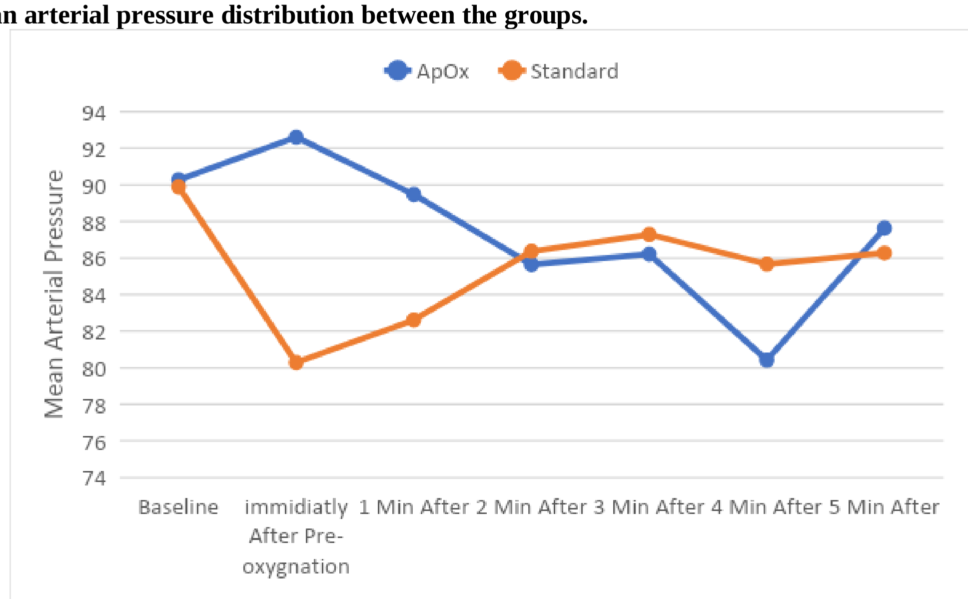


TABLE-2

Heart Rate	Group		t-test	p-value
	ApOx(n=58)	Standard (n=58)		
Baseline	128.21±2.36	129.32±3.69	1.93	0.056
Immediately After Pre-oxygenation	130.36±3.91	130.59±6.27	0.27	0.813
1 Min After	132.42±1.49	140.61±5.72	10.55	0.0001
2 Min After	130.61±2.21	146.29±4.49	23.86	0.0001
3 Min After	126.29±3.27	152.11±5.37	31.27	0.0001
4 Min After	128.42±2.22	150.52±6.42	24.77	0.0001
5 Min After	132.24±3.67	148.62±7.24	15.36	0.0001

Mean arterial pressure distribution(Graph 2) at baseline, immediately after pre-oxygenation, after 1 minute and at 4 minutes were statistically significant between the groups, and it was comparable at 2, 3 and 5 minutes after pre-oxygenation(Table 3).

Graph 2: Mean arterial pressure distribution between the groups.



Online ISSN: 2250-3137
Print ISSN: 2977-0122

DOI: 10.69605/ijlbpr_13.9.2024.24

TABLE-3

Mean Arterial Pressure	Group		t-test	p-value
	ApOx(n=58)	Standard (n=58)		
Baseline	90.27±6.18	86.89±5.63	3.12	0.002
Immediately After Pre-oxygenation	92.61±6.29	80.28±6.43	10.43	0.0001
1 Min After	89.47±7.42	82.61±4.97	5.85	0.0001
2 Min After	85.64±5.7	86.37±5.47	0.7	0.48
3 Min After	86.21±7.7	87.29±5.26	0.88	0.37
4 Min After	80.42±6.87	85.67±5.55	4.52	0.0001
5 Min After	87.63±6.27	86.27±6.97	1.1	0.27

Mean oxygen saturation(Graph 3) at baseline, immediately after pre-oxygenation, 1 minute after and 2 minutes after were statistically not significant between the groups, but after 3 minutes to 5 minutes, it was statistically highly significant between the groups, and the majority of oxygen saturation were fall in standard care group compared to ApOx group as shown in below table(Table-4).

Graph 3: Mean oxygen saturation distribution between the groups.

TABLE-4

Oxygen Saturation	Group		t-test	p-value
	ApOx (n=58)	Standard (n=58)		
Baseline	100±0	100±0	0	1
immediately After Pre-oxygenation	100±0	100±0	0	1
1 Min After	99.24±0.37	99.21±0.64	0.3	0.757
2 Min After	99.47±0.51	99.37±0.75	0.83	0.402
3 Min After	99.02±0.63	95.01±0.68	32.94	0.0001
4 Min After	98.97±0.71	95.03±0.47	35.24	0.0001
5 Min After	97.14±0.66	94.87±0.88	15.7	0.0001

The mean time taken for desaturation immediately after pre-oxygenation(Graph 4) by 1% in the standard group was observed compared to the ApOx group, and this difference between the groups was statistically significant, with similarly desaturation of oxygen by 2%, 3%, 4% and 5% were observed at a lower time in standard care group compared to ApOx and these differences between the groups were statistically highly significant(Table-5).

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Graph 4: Mean time taken distribution for desaturation between the groups.

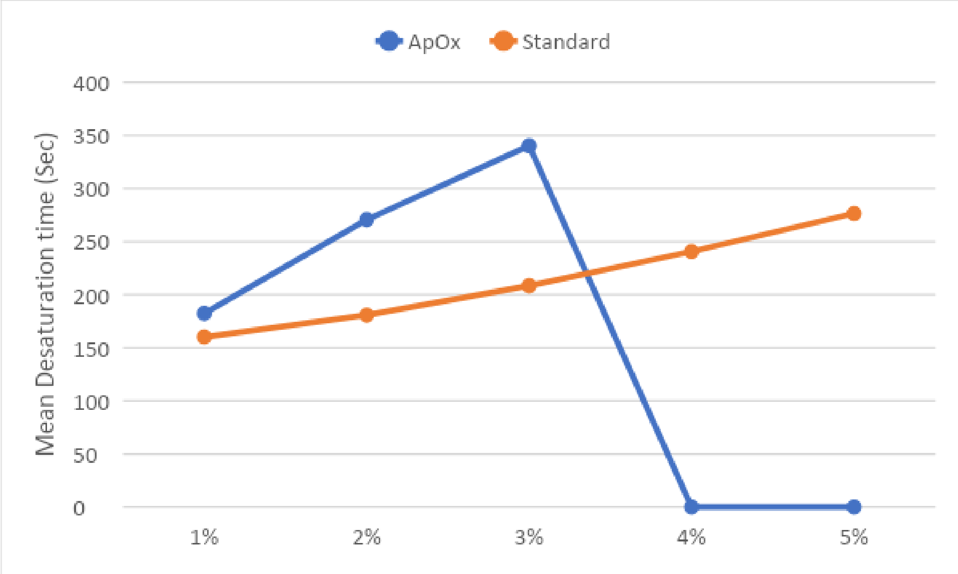

TABLE-5

Desaturation by	Time Taken(Sec)		t-test	p-value
	ApOx (n=58)	Standard (n=58)		
1%	182.3±7.42	160.20±0.66	22.59	0.0001
2%	270.64±10.67	180.76±1.67	63.38	0.0001
3%	340.18±12.79	208.42±1.81	77.68	0.0001
4%	0±0	240.67±2.24	101.1	0.0001
5%	0±0	276.41±3.76	559.86	0.0001

It was found that the groups' mean safe apnea time (sec)(Graph 5) differed statistically significantly and that group ApOx's apnea duration, during which the level of oxygen saturation did not fall below 95%, was longer than that of the Standard care groups(Table-6).

Graph 5: Safe Apnoea time (Sec) distribution between the groups.

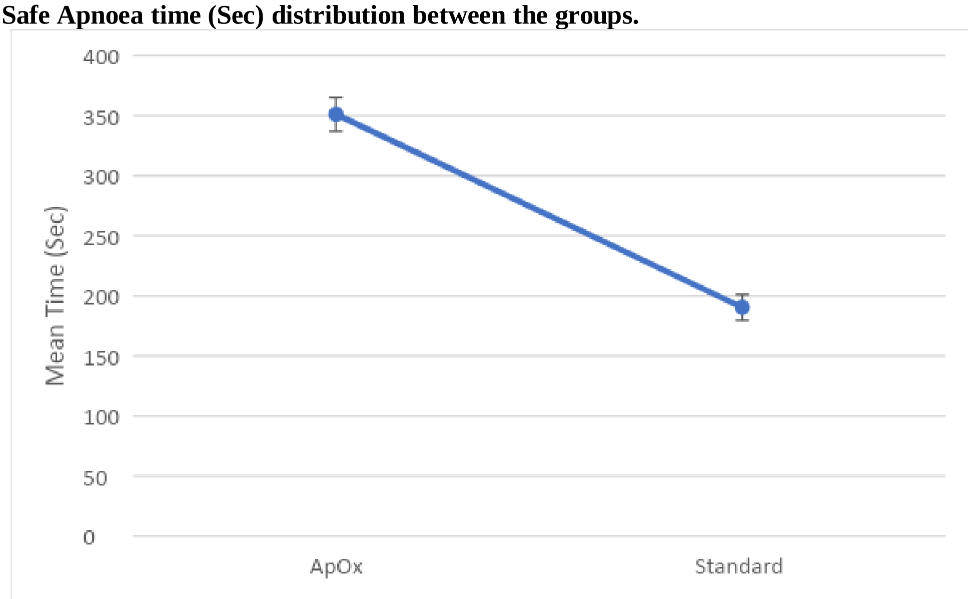

Table 6: Safe Apnoea time (Sec) distribution between the groups.

Safe apnoea time (Secs)Height (Cm)	Mean	SD	t-test	P - value
ApOx (n=58)	351.21	4.27		<0.0001
Standard(n=58)	190.42	0.64	8.79	

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DISCUSSION
Oxygen desaturation is fairly common in children undergoing general anaesthesia as they have low FRC and high oxygen demand. The efficacy of preoxygenation, the lung's functional residual capacity (FRC), and the body's oxygen intake all influence the amount of time required for desaturation to occur in apneic individuals. The length of safe apnea and the lowest SpO2 recorded during airway management were the two main outcomes used to measure the efficacy of apneic oxygenation. In This Study, the time to the first event, that is, the point at which SpO2 falls below 95% or the airway is successfully secured without desaturation, was used to determine the period of safe apnea. Nevertheless, the advantages of apnoeic oxygenation in children are crucially significant, especially given their susceptibility to hypoxemia and shorter safe apnea duration (SpO2 > 92%) during airway management due to physiological variances [5]. In the present study, we compared the time taken for a fall of oxygen saturation to 95% in patients receiving oxygen and not receiving oxygen during the pre-intubation apnoea period in children undergoing elective intubation. In the present study, mean heart rate distribution from baseline, immediately after pre-oxygenation and till 5 minutes after pre-oxygenation between the groups were statistically highly significant. In our study, desaturation of oxygen in the ApoX group was observed from 97.14% to 5 minutes, and our results were consistent with this study. This is in line with previous studies, which state that using apneic oxygenation during endotracheal intubation (ETI) is independently associated with lower odds of hypoxemia [6,7]. There is limited literature on the effectiveness of apneic oxygenation in children, as most studies focus on the adult population. Consequently, it was necessary to include a discussion of the effectiveness of apneic oxygenation in adults in the literature review. Consistent with our study in some previous studies, a randomized control trial was done on 30 surgical paediatric patients who were ASA I and II, which showed that all patients in the apneic oxygenation group maintained an oxygen saturation of 100%, whereas only six (40%) in the no apneic oxygenation group maintained this saturation, and one patient desaturated to 73% [55–59]. Another study by Olayan et al. demonstrated that apneic oxygenation did not extend the duration of safe apnea. The findings indicate that the lowest oxygen saturation in the apneic oxygenation group was higher than in the standard care group. One more study Steiner JW et al. conducted a study involving 457 paediatric patients aged 1-17 years, where they compared deep laryngeal oxygen insufflation for apnoeic oxygenation using TrueView PCD video laryngoscope or an O2 cannula attached to the side of a standard laryngoscope with standard direct laryngoscopy [8]. Researchers discovered that children in the oxygenation groups required 1% more time to desaturate than children in the traditional intubation group.
Soneru et al.[9]studied nasal cannula 5 LPM in the OR, and Napolitano et al. studied nasal cannula 5 LPM in age <12 months, 10 LPM in age 1–7 years, and 15 LPM in age ≥8 years (NEAR4KIDS consensus) in the paediatric intensive care unit (PICU) [10] in the meta-analysis conducted by Fuchs et al. Five RCTs[11-14] with six comparisons reported the lowest haemoglobin oxygen saturation during tracheal intubation for 500 children, 248 children in the apnoeic oxygenation group and 252 in the control group. The oxygen saturation level of the patients in the apneic oxygenation group was greater than that of the control group (mean difference 3.6%, 95% CI 0.8e6.5%, P=0.02). It was observed that 46, 8, 4, 0, 0, and 0 patients were desaturated by 1%, 2%, 3%, 4%, 5% and >5% respectively in group ApOx, while in standard care group 7, 11, 14, 17, 9 and 0 patients were desaturated by 1%, 2%, 3%, 4%, 5% and >5% respectively, and this distribution of these patients between the group were statistically highly significant. In a study conducted by Nisha S Shetty et al., Intervention at SpO2 <95% was part of the ethical methodology for neonates and infants undergoing emergency and elective surgeries. The time it took for SpO2 to drop by 1% (to 99%) was considered an indicator of further desaturation. The absence of any drop in SpO2 indicates that nasal oxygenation effectively prevents desaturation during prolonged apnea. Based on the oxyhemoglobin dissociation curve, a 1% drop in O2 saturation, until reaching 95%, is still associated with safe arterial partial pressures of O2. The meta-analysis by George et al. observed that two RCTs investigated the effect of humidified high-flow nasal prong apnoeic oxygenation on oxygenation desaturation. In an RCT comparing humidified high-flow apnoeic oxygenation to control in an elective surgery setting, Humphreys et al. demonstrated a significant increase (p < 0.001) in the time to desaturation across four age cohorts (0–6 months, 6–24 months, 2–5 years and 6–10 years) [15]. Riva and colleagues also demonstrated a longer safe apnoea time in children receiving either low-flow or humidified high-flow apnoeic oxygenation through a composite end-point of hypoxaemia, duration of apnoea and transcutaneous CO2 [16].

CONCLUSION
Based on the observations and findings above, as well as after consulting with other research, we have determined that apnoeic oxygenation with a buccal cannula at 4 L/min caused a 1% delay in the time to desaturation in ASA I and II infants with a normal airway who were scheduled for elective surgery under general anaesthesia. There was a statistically significant difference observed in safe apnoea time, with saturations up to 95%, between the groups. In our study, we can conclude that low mean oxygen saturation was observed in standard care groups

DOI: 10.69605/ijlbpr_13.9.2024.24

compared to the ApOx group, and this difference was statistically significant.

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