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Research Article

Comparison Of Spo_2 Stability In High-Flow Nasal Cannula Vs Face Mask During Pediatric Preoxygenation

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ABSTRACT

Background: Children are at high risk of desaturation during anesthesia induction due to limited oxygen reserves. Traditional face mask preoxygenation is effective but often poorly tolerated. High-flow nasal cannula (HFNC) offers continuous oxygen delivery, low-level positive pressure, and improved comfort, potentially enhancing oxygenation stability.

Objective: To compare SpO_2 stability between HFNC and face mask during pediatric preoxygenation.

Methods: A prospective case–control study was conducted at Yadgir Institute of Medical Sciences (April–August 2025), including 50 children (2–12 years, ASA I–II) undergoing elective surgery. Patients were assigned to HFNC (Group A, n=25) or face mask (Group B, n=25) preoxygenation with FiO_2 1.0 for 3 minutes. SpO_2 at baseline, during preoxygenation, induction, and post-intubation was recorded, along with desaturation events (SpO_2 <94%), safe apnea time, recovery time, hemodynamic stability, and device tolerance.

Results: Both groups were demographically comparable. HFNC achieved significantly higher SpO_2 after 1–3 minutes of preoxygenation ($p<0.01$) and during induction/post-intubation ($p<0.01$). Desaturation was less frequent with HFNC (4% vs 24%, $p=0.04$), with longer safe apnea time (180±20 vs 120±25 sec, $p<0.001$) and faster recovery (15±6 vs 28±10 sec, $p=0.002$). HFNC scored higher for patient comfort (4.7±0.4 vs 3.9±0.7, $p<0.001$). Hemodynamic responses were similar between groups.

Conclusion: HFNC provides superior SpO_2 stability, fewer desaturation episodes, and better tolerance compared to face mask preoxygenation in children. It represents a safe and effective alternative in pediatric anesthesia, warranting confirmation in larger multicenter trials.

Keywords*: Pediatric anesthesia, preoxygenation, SpO_2 stability, high-flow nasal cannula, face mask*

INTRODUCTION

Preoxygenation is a critical step in pediatric anesthesia, aimed at maximizing oxygen reserves and delaying the onset of hypoxemia during induction and airway instrumentation [1]. Children are particularly vulnerable to desaturation due to their higher oxygen consumption, lower functional residual capacity, and increased metabolic rate compared to adults [2]. Therefore, optimizing preoxygenation techniques in pediatric patients is of paramount importance.

Traditionally, preoxygenation is performed using a tight-fitting facemask delivering high-flow oxygen. However, this method has several limitations, including patient discomfort, poor compliance in anxious children, and the risk of air leaks that reduce oxygen delivery efficiency [3]. In recent years, High-Flow Nasal Cannula (HFNC) has emerged as a promising alternative. HFNC delivers warmed, humidified oxygen at high flow rates, which reduces dead space, provides

low-level positive end-expiratory pressure (PEEP), and maintains oxygenation during apnea through continuous oxygen insufflation [4,5].

Studies in pediatric populations have suggested that HFNC may prolong the safe apnea time, improve oxygenation, and enhance patient comfort compared to standard facemask preoxygenation [6,7]. Patel and Nouraei (2015) first described the concept of transnasal humidified rapid-insufflation ventilatory exchange (THRIVE), demonstrating that HFNC significantly extends the apneic window [8]. Subsequent pediatric trials have reported reduced incidence of desaturation and better tolerance with HFNC [9,10]. However, evidence from Indian tertiary care centers remains limited.

The present study was undertaken to compare SpO_2 stability using High-Flow Nasal Cannula (HFNC) versus standard Face Mask during pediatric preoxygenation. We hypothesized that HFNC would provide superior oxygenation stability, fewer desaturation episodes, and better patient comfort compared to the face mask in children undergoing elective surgeries under general anesthesia.

MATERIALS AND METHODS

Study Design and Setting

This hospital-based, prospective case–control study was conducted in the Department of Anesthesiology, Yadgir Institute of Medical Sciences, Yadgir, Karnataka, between April 1, 2025, and August 31, 2025. The institute serves as a tertiary care referral center catering to both urban and rural pediatric populations.

Study Population

A total of 50 pediatric patients (aged 2–12 years) scheduled for elective surgeries under general anesthesia were enrolled. Patients were divided into two groups of 25 each:

- Group A (Cases): Patients preoxygenated using High-Flow Nasal Cannula (HFNC).
- Group B (Controls): Patients preoxygenated using a standard Face Mask.

Inclusion Criteria

- Children aged 2–12 years undergoing elective surgery under general anesthesia.
- American Society of Anesthesiologists (ASA) physical status I and II.
- Informed written consent obtained from parents/guardians.

Exclusion Criteria

- Children with congenital heart disease, chronic lung disease, or upper airway abnormalities.
- Emergency surgeries.
- Patients with baseline SpO_2 <95% on room air.
- Children with an anticipated difficult airway.

Intervention and Procedure

All patients underwent routine pre-anesthetic evaluation, and standard fasting guidelines were followed. On arrival in the operating room, standard monitors (ECG, NIBP, SpO_2) were attached, and baseline vitals were recorded.

- Group A (HFNC): Preoxygenation was performed using High-Flow Nasal Cannula delivering humidified oxygen at a flow rate of 2 L/kg/min (maximum 40 L/min) with FiO_2 1.0 for 3 minutes.
- Group B (Face Mask): Preoxygenation was performed using a tight-fitting facemask connected to a circle system delivering oxygen at 6–8 L/min with FiO_2 1.0 for 3 minutes.

Outcome Measures

- Primary Outcome: Stability of SpO_2 during preoxygenation, induction, and apnea period until successful endotracheal intubation.
- Secondary Outcomes: Heart rate, mean arterial pressure (MAP), time to desaturation (SpO_2 < 94%), and ease of device use.

Data Collection and Monitoring

SpO_2 was continuously monitored and recorded at baseline, 1 min, 2 min, 3 min of preoxygenation, during induction, and immediately post-intubation. Any episode of desaturation (SpO_2 < 94%) was documented, along with the time taken for recovery.

Sample Size

A total of 50 patients were included in the study, with 25 patients in each group. The sample size was chosen based on feasibility during the study duration.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS version 21. Continuous variables were expressed as mean ± standard deviation (SD) and compared using the Student's *t*-test. Categorical variables were analyzed using the Chi-square test or Fisher's exact test. A *p*-value <0.05 was considered statistically significant.

RESULTS AND OBSERVATIONS

A total of 50 pediatric patients were included, with 25 in the High-Flow Nasal Cannula (HFNC) group and 25 in the Face Mask group. Both groups were comparable in demographic and baseline characteristics.

Table 1: Demographic and Baseline Characteristics of Study Population

Variable	HFNC Group (n=25)	Face Mask Group (n=25)	p-value
Age (years), Mean ± SD	6.4 ± 2.1	6.7 ± 2.4	0.62
Weight (kg), Mean ± SD	18.5 ± 4.2	19.1 ± 4.5	0.71
Gender (Male/Female)	14/11	15/10	0.78
ASA Physical Status (I/II)	17/8	16/9	0.77

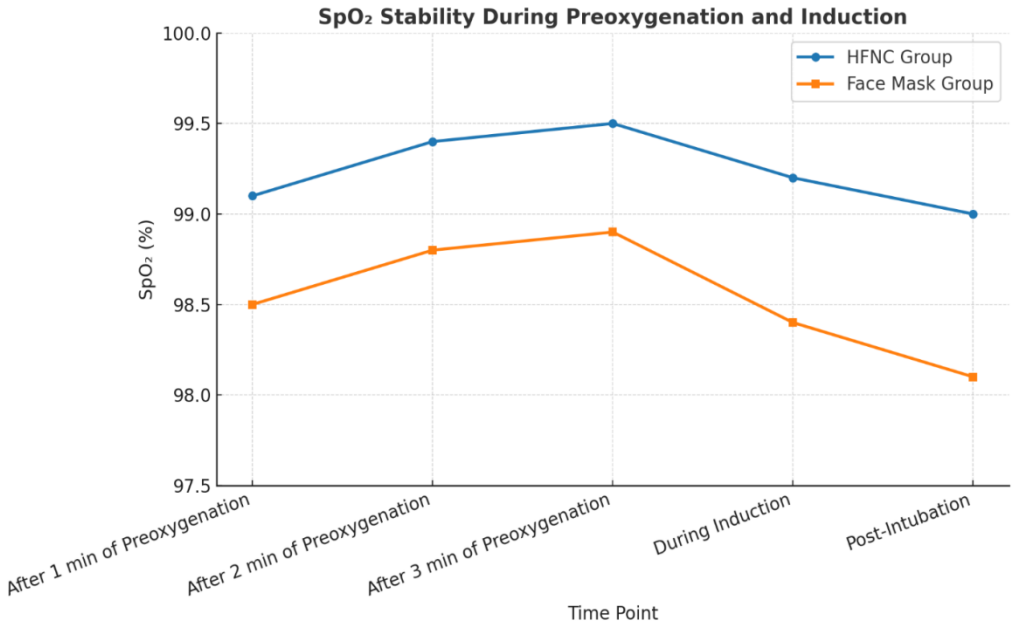
No statistically significant differences were observed between the two groups.

Table 2: Baseline Vital Signs

Variable	HFNC Group (n=25)	Face Mask Group (n=25)	p-value
Baseline SpO_2 (%)	97.6 ± 1.2	97.4 ± 1.3	0.68
Heart Rate (bpm)	101 ± 7	102 ± 8	0.55
Respiratory Rate (breaths/min)	20.2 ± 2.1	20.6 ± 2.3	0.47
Mean Arterial Pressure (mmHg)	73 ± 6	74 ± 7	0.39

Table 3: SpO_2 Stability During Preoxygenation and Induction

Time Point	HFNC Group (Mean ± SD)	Face Mask Group (Mean ± SD)	p-value
After 1 min of Preoxygenation	99.1 ± 0.5	98.5 ± 0.8	0.01*
After 2 minutes of Preoxygenation	99.4 ± 0.4	98.8 ± 0.7	0.01*
After 3 minutes of Preoxygenation	99.5 ± 0.3	98.9 ± 0.6	0.002*
During Induction	99.2 ± 0.5	98.4 ± 0.9	0.004*
Post-Intubation	99.0 ± 0.6	98.1 ± 0.8	0.003*



Fig; 1 SpO_2 Stability During Preoxygenation and Induction

Table 4: Episodes of Desaturation (SpO_2 < 94%)

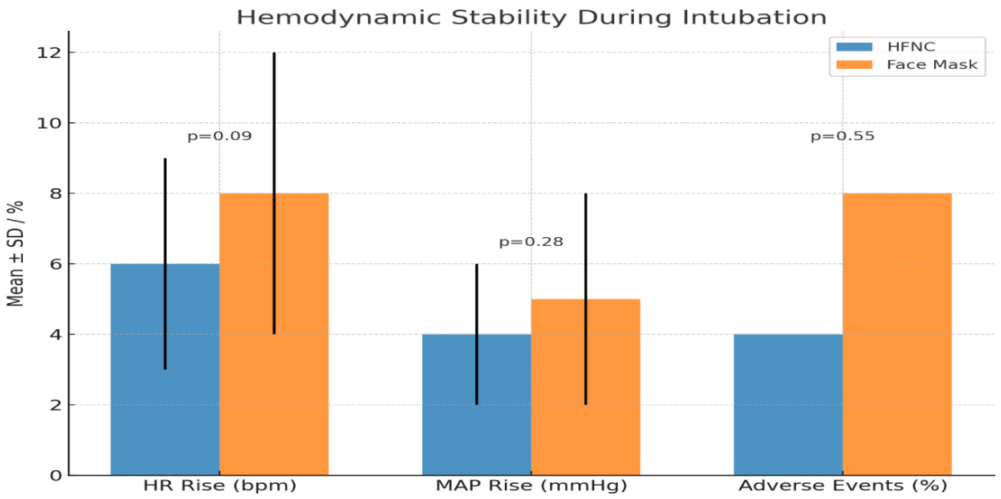
Variable	HFNC Group (n=25)	Face Mask Group (n=25)	p-value
No. of patients with desaturation	1 (4%)	6 (24%)	0.04*
Mean Time to Desaturation (sec)	120 ± 15	82 ± 20	0.001*
Mean Recovery Time (sec)	15 ± 6	28 ± 10	0.002*

Table 5: Safe Apnea Time

Variable	HFNC Group (n=25)	Face Mask Group (n=25)	p-value
Mean Safe Apnea Time (sec)	180 ± 20	120 ± 25	<0.001*
Patients maintaining SpO_2 > 94% for >2 min	23 (92%)	12 (48%)	0.002*

Table 6: Hemodynamic Stability During Intubation

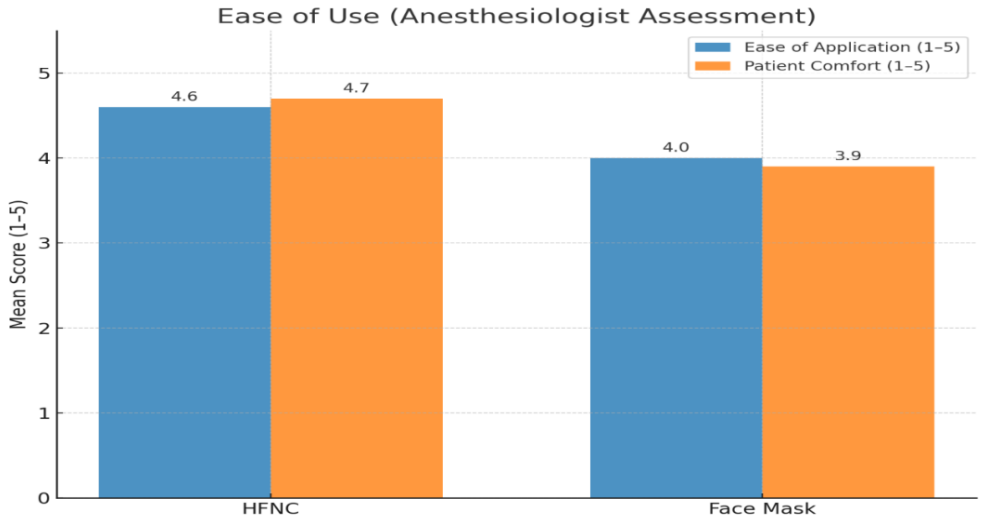
Parameter	HFNC Group (Mean ± SD)	Face Mask Group (Mean ± SD)	p-value
Heart Rate Rise from Baseline (bpm)	+6 ± 3	+8 ± 4	0.09
MAP Rise from Baseline (mmHg)	+4 ± 2	+5 ± 3	0.28
Any Adverse Hemodynamic Event (%)	1 (4%)	2 (8%)	0.55



Fig; 2 Hemodynamic Stability During Intubation

Table 7: Ease of Use (Anesthesiologist Assessment)

Variable	HFNC Group (n=25)	Face Mask Group (n=25)	p-value
Ease of Device Application (Score 1–5)	4.6 ± 0.5	4.0 ± 0.6	0.001*
Patient Comfort (Score 1–5)	4.7 ± 0.4	3.9 ± 0.7	<0.001*
Interference with Mask Ventilation	None	Mild in 6 cases	0.02*



Fig; 3 Ease of Use (Anesthesiologist Assessment)

DISCUSSION

The present prospective case–control study compared HFNC and face mask preoxygenation in 50 pediatric patients. Our findings demonstrate that HFNC provides superior SpO_2 stability, fewer desaturation episodes, longer safe apnea times, and greater patient comfort compared to the facemask.

SpO_2 Stability and Safe Apnea Time

In our study, patients in the HFNC group consistently maintained higher SpO_2 values during preoxygenation, induction, and post-intubation. Episodes of desaturation (SpO_2 <94%) were significantly lower in the HFNC group (4%) compared to the face mask group (24%). Moreover, HFNC significantly prolonged the safe apnea time (180 ± 20 sec vs 120 ± 25 sec, $p < 0.001$).

These results are consistent with Patel and Nouraei (2015), who introduced THRIVE and demonstrated that HFNC can extend apneic oxygenation in difficult airway patients [8]. Humphreys et al. (2017) similarly showed in a pediatric randomized trial that HFNC reduced the risk of hypoxemia during induction [9]. Lee et al. (2019) reported improved end-tidal oxygenation and oxygen reserves with HFNC compared to facemask preoxygenation [10].

Tolerance and Ease of Use

In our study, HFNC was rated higher for patient comfort and ease of application by anesthesiologists. Unlike the face mask, HFNC avoided anxiety related to a tight-fitting device and allowed easier management without interference in subsequent ventilation. This supports the findings of Riva et al. (2018), who reported that HFNC was better tolerated by children due to reduced claustrophobia and increased comfort [11].

Hemodynamic Stability

No significant differences in heart rate or mean arterial pressure were observed between the two groups in our study. This suggests that HFNC does not impose additional hemodynamic stress, consistent with prior studies [12].

Comparison with Contrasting Findings

Not all studies have shown the superiority of HFNC. Vourc'h et al. (2020) found no significant difference in desaturation rates between HFNC and standard facemask preoxygenation in children [13]. Variations in flow rates, patient age, and anesthetic technique may account for these differences. In our study, the flow rate was standardized at 2 L/kg/min (max 40 L/min), which may explain the greater efficacy of HFNC.

Strengths and Limitations

The strengths of our study include its prospective design, standardized protocol, and direct comparison of two preoxygenation methods in a pediatric population. Limitations include the relatively small sample size (n=50), single-center setting, and the absence of end-tidal oxygen (ETO_2) measurements, which could have provided more objective confirmation of preoxygenation efficiency.

Clinical Implications

HFNC offers a reliable, comfortable, and effective method for preoxygenation in children, particularly in those with anticipated difficult airways or risk of rapid desaturation. Incorporating HFNC into routine pediatric anesthesia practice may enhance safety during induction.

CONCLUSION

High-flow nasal cannula provided superior SpO_2 stability compared to face mask during pediatric preoxygenation, with fewer desaturation events observed. These findings support HFNC as a more effective preoxygenation strategy in children, though validation in larger studies is warranted.

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