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Research Article

High Flow Nasal Cannula use in Non-Operating Room Anaesthesia: A Prospective and Retrospective Observational Study

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ABSTRACT

Background: The clinical applications of High Flow Nasal Cannula (HFNC) are well established in the operating theatres.

Objective: The objective was to study the impact of using HFNC in a Non-Operating Room Anesthetic (NORA) setting.

Methods: This was a retrospective and prospective observational study looking at two periods (6 months and 5 months respectively in 2017 and 2018) in time-pre and post introduction of HFNC into clinical practice in sedation for gastroscopies, colonoscopies, Trans Oesophageal Echocardiograpies (TOE) and Bronchoscopies. The use of HFNC in NORA setting when introduced in 2018 was studied for a period of 5 months. Primary outcomes studied were Hypoxia during the procedure and secondary outcome was length of stay in the hospital post procedure.

Results: 98 versus 110 consecutive patients undergoing procedural sedation in NORA prior to and after the introduction of HFNC were studied. We found that the mean BMI was significantly higher in the post-HFNC group. They also had a higher incidence of comorbidities and difficult airway. Patients in the pre-HFNC group had a statistically significant lower mean lowest saturation recorded during the procedure. Patients in the post HFNC group had a shorter recovery time.

Conclusion: Previous studies have shown the benefits of HFNC in various pre and intraoperative settings. However, our study specifically targeted the role of HFNC in NORA setting. We found that HFNP makes procedural sedation a lot safer, shorter, more comfortable, and allows a wider spectrum of high-risk patients to have the procedure in the NORA setting.

Keywords: Procedural sedation; Propofol; Hypoxia; HFNP; Endoscopy; Remote anaesthesia

INTRODUCTION

The first reported use of supplemental oxygen *via* Low Flow Nasal Cannula (LFNC) during gastroscopy was studied by Bell et al. who found that nasal prong oxygenation prevented hypoxaemia during procedural sedation. Prior to this, the use of LFNC during procedures was largely limited to bronchoscopy. LFNC is limited to a flow of up to 4 to 6 liters per minute of oxygen, corresponding to an FiO_2 of 0.37 to 0.45, before resulting in nasal mucosal irritation due to drying of the nasal passages [1,2]. High Flow Nasal Cannula (HFNC) delivers humidified transnasal oxygen at a flow of up to 60 liters per minute and a FiO_2 of up to 12. Today, the use of HFNC has gained much interest, and is used in many procedures which require sedation, outside of the operating theater, including gastroscopy, colonoscopy, bronchoscopy, and Trans-Oesophageal Echocardiography (TOE).

The drugs used for sedation can cause hypoventilation and airway obstruction from loss of muscle tone which makes procedural sedation risky [3]. Procedures are increasingly becoming complex and longer owing to the advances in intervention based studies [4]. Airway access is often limited due to a shared airway or patient positioning and such procedures

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are increasingly done out of theatres, on higher risk patients, such as those with high Body Mass Index (BMIs) or cardiovascular disease. HFNC is a strategy to prevent hypoxaemia in these patients. Its ability to provide high airflow rates and control of delivered FiO_2 as well as causing minimal interference with endoscopic devices inserted through the oral route makes it an ideal oxygenation device.

The benefits of HFNC have been well studied in other settings. These include treating patients with hypoxic respiratory failure [5]. As an alternative to Non-Invasive Ventilation (NIV) and in providing apnoeic ventilation for patients with difficult airways [6,7]. Despite widespread use in clinical practice, the evidence for its use on patients undergoing procedural sedation outside the operating theatre is limited. Lucangelo et al. (n=45; prospective study) reported that patients who received HFNC, had a higher ratio of arterial partial pressures of oxygen (PaO_2/FiO_2) than those who received venturi mask, while undergoing bronchoscopy with conscious sedation [8]. Schumann et al. (n=238; retrospective study) found that the HFNC use was associated with decreased General Anaesthesia (GA) utilization and improved oxygenation for Endoscopic Retrograde Cholangiopancreatography (ERCP) and Endoscopic Ultrasound (EUS) [9]. Sago et al. (n=30 prospective) identified that minimum arterial oxygen saturation was higher with HFNC than LFNC, and that fewer airway interventions were required in the HFNC group of dental patients under sedation [10]. These observational studies, although useful, are limited by small sample sizes and their focus on single procedures.

Thus, we conducted this study in patients receiving HFNC outside the operating suite undergoing sedation for gastroscopy, colonoscopy, bronchoscopy, and TOE, with retrospective chart review of the same cohort prior to the introduction of HFNC. The objective was to study the safety and potential advantages of using HFNC in the setting of Non-Operating Room Anesthesia (NORA).

Objective was to study intra and post procedural safety of pre-specified hypothesis was that the HFNC reduces the incidences of Hypoxia during the procedure and reduces the time patient needs to stay in the recovery following the procedure due to curtailment of respiratory depression and hypoxia and earlier recovery to baseline.

METHODOLOGY

This was retrospective and prospective observational study based at Nepean Hospital, NSW, and Australia. Ethics approval for this study; (was provided by the Nepean Blue Mountains Local Health Department Human Research Ethics Committee, Nepean Hospital, Derby st, Kingswood NSW 2747 Australia (Chairperson Prof Ian Seppelt) on the 9th May 2018. The Study Reference and protocol number attributed by ethics committee was PID 00067–ETH 00071. Written informed consent was obtained from all patients.

The retrospective group included patients who had undergone procedural sedation for gastroscopy, colonoscopy, bronchoscopy, or TOEs from July 2015 to December 2015, prior to the introduction of HFNC in remote anaesthesia (pre-HFNC).

The prospective group enrolled patients over a period of 5 months, from June 2018 to October 2018 and included all patients who were commenced on HFNC during the provision of anaesthesia for these procedures, regardless of whether it was an elective or emergency case (post-HFNC). Patients with any of the following were excluded: C-spine injury, untreated pneumothorax, nasal obstruction and those in whom Continuous Positive Airway Pressure (CPAP) was contraindicated (respiratory arrest or unstable cardiorespiratory status, uncooperative patients, impaired swallowing, trauma or burns involving the face). Patients who were unable to provide consent were also excluded (patients under the age of 18 years and those with an intellectual disability). Written informed consent was obtained from all patients. Primary outcomes studied were Hypoxia during the procedure and secondary outcome was length of stay in the hospital post procedure.

All patients were commenced on HFNC with monitoring of blood pressure and oxygen saturation, prior to sedation. Intravenous sedation was then administered, which consisted of varying combinations of opioids, midazolam and propofol. Once the procedure was completed, the patient was disconnected from the HFNC in endoscopy suite and commenced on low flow oxygen (nasal prongs or a Hudson mask) in the recovery area. Monitoring was continued throughout the process, until the patient was discharged from the recovery area.

Data collected in both groups included: age, sex, BMI, relevant comorbidities (chronic respiratory disease including obstructive and/or restrictive disease and obstructive sleep apnea), Mallampati grade, patient position, procedure, duration of surgical procedure (defined as duration from insertion of endoscope to removal), HFNC settings (flow rate and FiO_2), duration of HFNC, level of oxygen saturation (before, during and after the procedure) apnoeic episodes and duration, need for escalation to additional airway interventions/ventilation strategies, amount of sedation used and duration of recovery (defined as time from admission to discharge from recovery room).

In the post-HFNC group, data was collected by thorough review of the patient records, observed monitoring, as well as from data recorded by the nurses in recovery. In the retrospective group, data was collected from medical records. Continuous, normally distributed data are presented as means along with Standard Deviations (SDs) and range whereas categorical data are presented as numbers and percentages. The significance of differences between two groups was assessed using student T test with $P<0.05$ being considered as statistically significant. Data were analyzed using SPSS statistical software (IBM Corp. Released 2020, IBM SPSS Statistics for Windows, Version 27.0. Armonk, NY: IBM Corp).

RESULTS

A total of 98 patients underwent gastroscopies, colonoscopies, bronchoscopies, or TOEs, between July 2015 to December 2015, before the introduction of HFNC (pre-HFNC) whilst 110 patients underwent these procedures with use of HFNC between June 2018 to October 2018 (post-HFNC).

Amongst demographics characteristics, both groups had a similar mean age and proportion of male patients. However, the mean BMI was significantly higher in the post-HFNC group (34.3+8.8) compared to pre-HFNC group (29.0+4.6) in the retrospective group. Patients in the post-HFNC group were at higher risk during procedural sedation than those in the pre-HFNC group, owing to higher incidence of comorbidities (31.8% compared to 6.1% with OSA, 18% compared to 13% with COPD and 15% compared to 10% with asthma, respectively) as well as having a significantly higher proportion of patients having a difficult airway (44.7% compared to 11.2%, respectively) (Table 1).

Baseline characteristics	Pre-HFNC N=98	Post HFNC N=110	P value
Demographics			
Age (Mean ± SD)	61.6 ± 16.6	61.9 ± 15.8	0.88
Male	52.00%	56.40%	0.55
BMI (Mean ± SD)	29.0 ± 4.6	34.3 ± 8.8	<0.001
Comorbidities (%)			
Asthma	10.2%	15.5%	
COPD	13.3%	18.2%	
OSA	6.1%	31.8%	
Severe pulmonary HTN	1.0%	0.9%	0.22
Severe AS/MS	2.0%	4.5%	
IHD	11.2%	12.7%	
No. of comorbidities (Mean ± SD)	2.9 ± 3.1	1.03 ± 0.93	
Airway			
Patients with difficult airway (%)	13.70%	44.70%	<0.001
ASA grading			
1	1 (1.0%)	2 (1.8%)	
2	75 (76.5%)	23 (20.9%)	
3	22 (22.4%)	53 (49.1%)	
4	0	9 (8.2%)	

Note: HFNC: High Flow Nasal Cannula, SD: Standard Deviation, COPD: Chronic Obstructive Pulmonary Disease, OSA: Obstructive Sleep Apnoea, HTN: Hypertension, AS/MS: Aortic/Mitral Stenosis, IHD: Ischaemic Heart Disease, ASA: American Society of Anesthesiology Score.

Table 1: Baseline characteristics including demographics, comorbidities and procedures done before and after utilisation of HFNC for procedural sedation.

Details of procedures in the two groups are shown in Table 2. The location, type of procedures and patient position was comparable in pre-and post-HFNC groups. A higher portion of patients in post-HFNC group experienced apnoeic periods (29% *versus* 20.4%,) and needed additional ventilation support (3.1% *versus* 7.5%) compared to those in the pre-HFNC group, but difference was not statistically significant. Despite this, patients in the pre-HFNC group had a statistically significant (p<0.001) lower mean lowest saturation recorded during the procedure (93% compared to 96% of the post-HFNC group). Owing to the principles of LFNP and HFNC, the mean FiO_2 used in patients with HFNC was 0.90 (range 0.30-1.00) compared to 0.29 in those with LFNP. Similarly, the mean flow used to deliver oxygen in patients with HFNC was higher, at 54 L/min, compared to 4 L/min in those with LFNP.

Procedures	Pre- HFNC N=98	Post-HFNC N=110	P value
	Location		
Endoscopy	68 (69.4%)	87 (79.1%)	
Cardiology	30 (30.6%)	23 (20.9%)	
	Type (03 Most Common)		
1	Bronchoscopy	Bronchoscopy	
	-33.70%	-2.70%	
2	Gas Colonoscopy	Gas Colonoscopy	
	-24.50%	-75.50%	
3	TOE/CV (30.6%)	TOE/CV (20.9%)	
	Patient position		
Supine	2.00%	5.50%	
Lateral	98.00%	90.90%	
Patients needing additional airway/ ventilation (%)	3.10%	7.50%	0.16
	Additional graded airway interventions; (Mean ± SD)		
Patients needing =>2 sedatives	96 (98%)	91 (83%)	
Dose of sedative agents used-Propofol (Mean ± SD)	144.1 ± 40.3	302.5 ± 194.5	<0.001
	Lowest saturation % (Mean ± SD)		
Before procedure	96.7 ± 3.7	96.7 ± ± 2.0	0.92
During procedure	93.1 ± 4.0	96.5 ± 5.5	<0.001

Post procedure	95.3 ± 2.9	97.5 ± 1.8	<0.001
Patients experiencing apnoea during the procedure	20 (20.4%)	32 (29.0%)	0.18
FiO_2 used during the procedure (Mean ± SD)	0.29 ± 0.08	0.90 ± 18	<0.001
Flow used during the procedure (Mean ± SD) (L/min)	4.2 ± 0.6	54.5 ± 12.8	
Note: HFNC: High Flow Nasal Cannula; SD: Standard Deviation; TOE: Trans-Oesophageal Echocardiography, CV: Cardioversion			

Table 2: Comparison of procedures in pre- HFNC and post-HFNC groups.

The mean procedure duration was significantly higher in the post-HFNC group compared to pre-HFNC group (63 min *versus* 52 mins; p=0.008). This probably could be explained by the fact that the use of HFNP facilitated deeper sedation allowing a more complete and thorough study compared to the LFNP period when there was higher incidence of oxygen desaturation. Conversely, mean recovery time was significantly shorter (p=0.036) in the group that used HFNC (104 mins) compared to the LFNC group (118 mins)

DISCUSSION

The results of this study show that HFNC can be used effectively in a variety of procedures and patients, even in those with multiple comorbidities and difficult airways. Through the delivery of humidified transnasal oxygen at high flows, HFNC is able to provide physiological dead space washout of the upper airway, resulting in higher FiO_2 delivery and improving ventilation and oxygenation [2]. There was a larger number of high-risk patients (various comorbidities including higher BMIs and/or difficult airway) in the HFNC group compared to those who underwent procedural sedation prior to implementation of HFNC. This may have also contributed to the higher incidence of apnoea in the HFNC group. Despite this, there were fewer desaturations in the HFNC group (6% recorded a saturation of <90% at any point during the procedure, compared to 17% in the LFNC group). This is a result of apnoeic oxygenation, which is possible with HFNC due to the generation of Positive End-Expiratory Pressure (PEEP) from flows greater than 20 L/min [7,11].

The significantly higher mean procedure time with HFNP could probably be explained by the fact that the use of HFNP facilitated deeper sedation allowing a more complete and thorough study compared to the LFNP period when there was higher incidences of oxygen desaturation. This explains the higher mean cumulative Propofol dose used in the post HFNC group.

The use of HFNC in procedural sedation also resulted in shorter recovery time by approximately 14 minutes. This may be explained by improved ventilation, adequate opioid analgesia as well as the prevention of atelectasis through PEEP [12]. Complications of HFNC, although rare, include pressure sores associated with the cannula, abdominal distension, increased risk of aspiration and eye irritation [13]. However this study failed to capture data on the same. This study included all procedures done under procedural sedation, outside of the operating theatre, in order to capture a larger sample size, with a hope to provide advice on further applications of HFNC. However, this in itself became a limitation of the study. Having the study across three departments (bronchoscopy, endoscopy suite and cardiology department), meant that results and data, may not have been standardized due to differing resources, skilled personnel, and patient cohort. A large portion of the procedures performed under sedation in the HFNC group were gastroscopies/colonoscopies (75% compared to 24.5% in the LFNC group). The study was performed over two different time periods changes in interventional procedures-advances in technology and ability to perform more invasive interventions, change in proceduralists, changes in resources available and improved nursing and medical training programmes might have rendered better and safer operating conditions in the HFNC group. Both these factors potentially could have introduced bias.

Data on intraoperative hemodynamics would have been useful to look at the implications of heavier sedation in the HFNP group. The doses of individual sedative/analgesics used was not consistently documented and this hampered the ability to infer the implications of the depth of sedation. The lack of a consistent use of a blender allowed for the wide range in FiO_2 with a predominance of 100% FiO_2 used during the HFNC therapy.

CONCLUSION

In conclusion, we found that utilisation of HFNP makes procedural sedation a lot safer, shorter, more comfortable, and allows a wider spectrum of high-risk patients to have the procedure in the NORA setting allows a longer procedure time, while shortening recovery times. However, more research can be done to determine patient satisfaction and ease of use for the operator in order to further promote adoption of HFNC in more clinical settings. This study did not collect data on patient satisfaction or ease of use amongst nurses and doctors, which would greatly impact the readiness and compliance to using HFNC. Data on proceduralist's experience would have been useful with regards to conducting a thorough procedure safely without the stress and demands of a rapid turnaround list in a remote setting.

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