ORIGINAL ARTICLE

HFNC Oxygen Therapy vs COT in Prolonged Upper Gastrointestinal Endoscopy Inside the ICU: A Prospective, Randomized, Controlled Clinical Study

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Abstract

Aims and background: Hypoxemia is a common and serious complication occurring during deep sedation for prolonged upper gastrointestinal endoscopy (UGE). We evaluated and compared the efficacy of high-flow nasal cannula (HFNC) oxygen therapy vs conventional nasal cannula oxygen therapy (COT) in preventing hypoxemia in patients admitted to the intensive care unit (ICU) and who underwent prolonged (>15 minutes) UGE under deep sedation.

Materials and methods: Seventy patients aged 20–60 years with American Society of Anesthesia (ASA) I, II, or III who were admitted to the ICU and were scheduled for an anticipated prolonged UGE were included. They were randomly assigned to be administered either oxygen through a standard nasal cannula (COT group) or oxygen through an HFNC (HFNC group). The primary outcome was any occurrence of at least moderate hypoxemic episodes [oxygen saturation (SpO_2) < 90%] of any duration.

Results: Regarding the occurrence of hypoxemic episodes, 18 patients (51.4%) in the COT group experienced hypoxemia with 11 (31.4%) experiencing mild hypoxemia, six (17.1%) experiencing moderate hypoxemia, and only one patient (2.9%) experienced severe hypoxemia, with a total of seven patients (20.0%) whose SpO_2 was <90%. Conversely, only two patients (5.7%) in the HFNC group had mild hypoxemia, and no patients had SpO_2 < 90%. Additionally, nine patients in the COT group experienced clinically significant hypoxemia, whereas no patients in the HFNC group ($p = 0.001$).

Conclusion: High-flow nasal cannula (HFNC) oxygen therapy was safe, well tolerated, and significantly decreased the incidence of hypoxemic episodes, compared to COT, among high-risk ICU patients who underwent prolonged UGE under propofol deep sedation.

(Registered at ClinicalTrials.gov with ID: NCT06350864)

Keywords: Conventional nasal cannula oxygen therapy, High-flow nasal cannula oxygen therapy, Hypoxemia, Intensive care unit, Randomized clinical trial, Sedation, Upper gastrointestinal endoscopy.

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Highlights

Hypoxemia is a common deep sedation-related adverse event (SRAE) that may occur during prolonged upper gastrointestinal endoscopy (UGE). It carries severe hazards, especially among high-risk intensive care unit (ICU) patients. The use of high-flow nasal cannula (HFNC) oxygen therapy significantly decreased the incidence and severity of hypoxemic episodes, compared to conventional nasal cannula oxygen therapy (COT), in those patients.

Introduction

Conventional nasal cannula oxygen therapy is believed to be the standard method for maintaining oxygenation and preventing hypoxemia during brief UGE; nevertheless, weak evidence exists to support using COT for prolonged UGE in high-risk ICU patients.

Sedation is considered an essential components of modern practice for endoscopy. The joint British statement recommends using deep sedation for prolonged endoscopy. Propofol has been used to achieve deep sedation with rapid recovery, but it can also contribute to the occurrence of hypoxemia.[1]

Hypoxemia is the most frequent sedation-related adverse event (SRAE) that occurs during UGE.[2] Severe and/or extended hypoxemia may induce cardiac ischemia, dysrhythmia, neurologic injury, or cardiac arrest.[3]

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High-flow nasal cannula device is a modern technique of delivering warmed and humidified oxygen at a high-flow rate (up to 60 L/min), that is greater than the maximum flow rate of COT (i.e. 15 L/min).[4] Additionally, HFNC washes out dead space of the nasopharynx and generates a low amount of positive end-expiratory pressure (PEEP) that prevents pulmonary atelectasis.[5] It has been used extensively in the ICU for COVID-19 pneumonia and even demonstrated successful outcomes in an outside-of-ICU setting among patients with severe COVID-19 pneumonia.[6]

We aimed to evaluate the efficacy of the HFNC oxygen therapy vs COT in preventing hypoxemia in the patients admitted to the ICU and who were scheduled for prolonged UGE under deep sedation.

Materials and Methods

Design, Ethical Approval, and Participants

This was a prospective, randomized, comparative, open-label, controlled clinical trial study that received ethical approval from the Research Ethics Committee (REC) of the Faculty of Medicine, Ain Shams University, Cairo, Egypt (approval code: FWA000017585–FMASU R11/2024, 01-18-2024) and was registered at ClinicalTrials.gov with ID: NCT06350864, 04-5-2024 (https://clinicaltrials.gov/study/NCT06350864). Before the start of the study, all participants were consented both verbally and in written form.

It was conducted on seventy patients in ICUs of Ain Shams University Hospitals, Cairo, Egypt, from April 10, 2024 to September 20, 2024. Inclusion criteria were patients aged 20–60 years who were admitted to the ICU, American Society of Anesthesiologists (ASA) physical status class I, II, or III, and were scheduled for UGE procedures with an anticipated procedure time > 15 minutes by the complex nature of the procedure or pathology recurrence. Patients with respiratory and/or heart failure, shock with severe uncontrolled hematemesis, aspiration risk, allergy to propofol, body mass index > 35 kg/m^2, suspected difficult airway or high risk of SRAEs were excluded.

Randomization and Blinding

The ICU specialist sent a request for randomization to an admin, and then the admin sent an opaque envelope delivered to the responsible anesthesiologist containing the patient assignment to the groups. Randomization was done by using simple random (probability) sampling by using random number tables generated via a computer. The consented and enrolled 70 patients were randomly allocated into two parallel arms and equivalent (1:1 ratio) groups, either the COT group (35 patients) or the HFNC group (35 patients).

Due to the nature of the intervention device (HFNC), neither the patient nor the anesthesiologist can be blinded regarding the technique. However, the data collector (ICU specialist) was unaware of the allocation of treatment before gaining access to the record form of the case.

Study Procedures and Interventions

All patients fasted for 8 hours. A pre-procedural full patient assessment was performed. The anesthesiologist checked the standard patient monitoring via a GE Healthcare monitor (Careescape B650, General Electric, Boston, Mass, USA) including; an electrocardiogram, pulse oximeter (SpO_2), and blood pressure (non-invasive). Then, the intravenous (IV) cannula was secured. Diluted 4 mg ondansetron was given slowly IV as an antiemetic premedication.

After the patient was positioned in the left lateral position, enrolled participants were randomly assigned to either the COT group administered an oxygen flow of 5 L/min [fraction of inspired oxygen (FiO_2) approximately 0.4] via an adult-sized standard nasal cannula (Ultramed™, Cairo, Egypt), or to the HFNC group who administered an oxygen flow of 30 L/min via an adult-sized Vapotherm™ Precision Flow HI-VNI Technology HFNC device (NH 03833, USA). The FiO_2 was set to 0.4, the temperature was set to 37 °C, and the humidity was set to 100%.

Upper Gastrointestinal Endoscopy and Anesthesia Protocols

All UGE procedures were performed bedside in the ICU by a consultant gastroenterologist and anesthetic management was delivered by a specialist anesthetist.

After verifying the preparedness of the endoscopy team, all patients underwent deep sedation with monitored anesthesia care. Slow (3–5 minutes) injection of 0.5–1 mg/kg IV propofol [Propofol® 1% (i.e. 10 mg/1 mL), MCT Fresenius Kabi, Egypt]. It was titrated to reach a level of deep sedation which is defined as a Ramsay sedation scale (RSS) score equal to or more than four (≥4), where the patient is asleep with either brisk (score 4), sluggish (score 5) or no (score 6) response to light glabellar tap or loud auditory stimulus. Incremental 10–20 mg boluses were similarly titrated to maintain an RSS of ≥4. Both the anesthesiologist and the endoscopist provided the standard care, except for the patient's assigned oxygen delivery device and flow rate except in emergencies.

Diagnostic and/or therapeutic UGE was performed via Pentax™ Medical (Hamburg, Germany). Therapeutic gastroscopy included hemostasis as injection of bleeding peptic ulcers with adrenaline, either heater probe coagulation or argon plasma coagulation to control a bleeder vessel or variceal band ligation.

Monitored care of the patients in the ICU continued until proper control and management of the causes of admission to the ICU and their stabilization.

Data Collection and Recording

Patients demographic data (age, sex, ASA, BMI) and medical history, baseline SpO_2 (%), causes for admission to the ICU, types of UGE procedures and their durations (the times at which UGE entered the mouth until it exited it in minutes), anesthesia duration (time of intravenous propofol sedation in minutes), and the total propofol doses used in milligrams were recorded.

Outcome Measures

Primary Outcome

It was an incidence of at least moderate hypoxemic episodes (SpO_2 < 90%) of any period that was continuously measured by a pulse oximeter during the whole procedure.

Secondary Outcomes

They were the median lowest SpO_2, any episode of hypoxemia with its duration (less than 1 minute, 1–5 minutes, or more than 5 minutes) and severity [mild hypoxemia (SpO_2 94–90%), moderate hypoxemia (SpO_2 89–76%), or severe hypoxemia (SpO_2 equal or less than 75%)], clinically significant hypoxemia that required upper airway support or suction, to increase the oxygen flow rate and/or FiO_2, and/or to change the method of oxygen delivery. All were continuously measured by a pulse oximeter during the whole procedure. Additionally, sedation-related adverse effects (SRAEs), intra and post-procedural endoscopic complications, and adverse events (ECAEs) were recorded. The study endpoint was 24 hours after the procedure.

Sample Size

It was determined by utilizing the power analysis and sample size software program (PASS 15, NCSS, USA) and reviewing results from

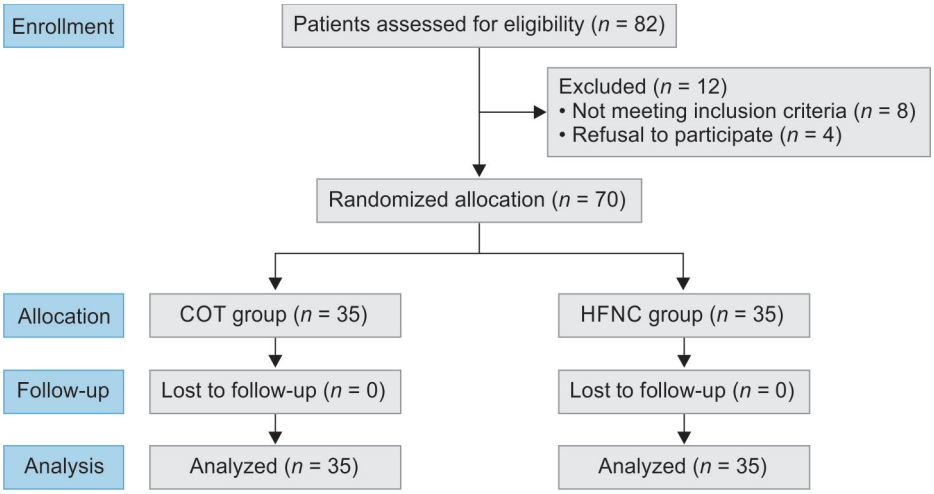

Fig. 1: Study flowchart by CONSORT

CONSORT, Consolidated standards of reporting trials; COT, conventional nasal cannula oxygen therapy; HFNC, high-flow nasal cannula

a study done by Jonathan et al.[7] Occurrence of hypoxemia (SpO_2 less than 90%) was markedly reduced in the cohort of HFNC, in contrast with 20% in the cohort of COT. Based on these findings and after a 10% adjustment for a dropout rate, a sample size of at least 35 patients per group achieved 80% power.

Statistical Analysis

It was performed by utilizing the statistical package for social science (SPSS) version 27 (IBM Corp, Armonk, NY, USA) after data were collected, revised, and coded. The quantitative parametric data are presented as the mean (M), standard deviations (SD), and ranges. The quantitative non-parametric data are presented as the median and interquartile range (1Q, 3Q). The Qualitative variables are presented as numbers and percentages. They were compared utilizing the Chi-squared test and/or Fisher's exact test as soon as the expected count in any cell was <5. Independent *t*-test was utilized for comparisons between 2 independent groups with quantitative data and parametric distributions, whereas Mann-Whitney test was utilized for comparisons with nonparametric distribution. The confidence interval was set to 95%, while the margin of error was set to 5%. Accordingly, the *p*-value was considered significant when $p \leq 0.05$.

Results

Eighty-two patients were screened for eligibility, with an enrollment of seventy patients who completed the whole study (Fig. 1).

Concerning the patient demographic data, medical history, and causes of admission to the ICU, no statistically significant difference between the COT group and the HFNC group (Table 1). Similarly, no significant difference between the two groups concerning the types of UGE procedures or their durations (Table 2).

Additionally, anesthesia time and the total dose of propofol used in milligrams were also comparable among the groups ($p > 0.05$; Table 3).

Regarding baseline oxygen saturation (SpO_2%), there was no significant difference between the two groups (Table 4).

Concerning the occurrence of hypoxemic episodes, a total of 18 patients (51.4%) in the COT group experienced hypoxemia with 11 patients (31.4%) experiencing mild hypoxemia (10 patients lasting <1 minute and one patient lasting for 70 seconds), 6 patients (17.1%) experienced moderate hypoxemia (all lasting < 1 minute), and only one patient (2.9%) experienced severe hypoxemia lasting <1 minute (30 seconds), with a total of 7 patients (20.0%) with $SpO_2 < 90\%$ lasting < 1 minute. Conversely, only 2 patients (5.7%) in the HFNC group had mild hypoxemia lasting <1 minute and no patients had $SpO_2 < 90\%$ (Figs 2 and 3). The statistical difference between the 2 groups was highly significant for mild (lasting < 1 minute) and moderate hypoxemia ($p = 0.001$ and 0.010, respectively). However, it was nonsignificant for mild (lasting for 2 minutes) or severe hypoxemia ($p = 0.3$ for both).

The lowest median SpO_2% was statistically significantly lower in the COT group (94%) than in the HFNC group (96%) ($p = 0.004$; Fig. 4). Additionally, 9 patients in the COT group experienced clinically significant hypoxemic episodes, whereas no patients in the HFNC group ($p = 0.001$; Fig. 3).

No significant difference between both groups regarding sedation-related adverse effects (SRAEs), with only one patient in the COT group having hypotension and one in the HFNC group having nausea (Table 5).

In terms of intra-procedural endoscopic complications and adverse events (ECAEs), only one patient in each group experienced gastrointestinal bleeding requiring intervention. Neither perforation nor intra-procedural adverse events required pausing or stopping the procedure occurred in any group. Similarly, post-procedural ECAEs were comparable in both groups ($p > 0.05$), with only one patient in each group experiencing abdominal bloating, and one patient in the COT group experiencing abdominal pain (Table 6).

Discussion

This single-center, randomized, controlled study illustrated that using HFNC oxygen therapy can significantly prevent hypoxemia among high-risk ICU patients undergoing a prolonged UGE under deep sedation compared to COT.

High-flow nasal cannula can deliver humidified oxygen with stable and high FiO_2 (up to 1.0), and a high oxygen flow (30–60 L/minute) that generates a slight PEEP and reduces carbon dioxide (CO_2) re-breathing.[8] Additionally, a physiological study of apneic oxygenation using transnasal humidified rapid insufflations

Table 1: Patient demographic data and medical characteristics, and causes of ICU admission

Variables	*COT group (n = 35)*	*HFNC group (n = 35)*	*Used test value*	*p-value*
Age (year) (M ± SD)	52.51 ± 7.13	53.06 ± 7.89	−0.302[a]	0.8
Range	38–66	42–66		
Males/females	20/15	21/14	0.059[b]	0.8
ASA				
I	5 (14.3%)	4 (11.4%)	0.146[b]	0.9
II	16 (45.7%)	16 (45.7%)		
III	14 (40.0%)	15 (42.9%)		
BMI (kg/m$^{2)}$				
M ± SD	25.86 ± 3.48	26.51 ± 3.73	−0.762[a]	0.4
Range	22–34	20–32		
Medical conditions				
Cigarette smoking	2 (5.7%)	3 (8.6%)	0.215[b]	0.6
Diabetes mellitus	6 (17.1%)	5 (14.3%)	0.108[b]	0.7
CKD	1 (2.9%)	2 (5.7%)	0.348[b]	0.6
CLD (cirrhosis)	20 (57.1%)	22 (62.9%)	0.238[b]	0.6
COPD or BA	1 (2.9%)	1 (2.9%)	0.000[b]	1.0
ISHD	4 (11.4%)	5 (14.3%)	0.128[b]	0.7
Hypertension	10 (28.6%)	8 (22.9%)	0.299[b]	0.6
Causes of ICU ad.				
HDI	10 (28.6%)	9 (25.7%)	0.072[b]	0.8
DCL and/or HE	4 (11.4%)	5 (14.3%)	0.128[b]	0.7
Follow-up	18 (51.4%)	19 (54.3%)	0.057[b]	0.8
Acute kidney injury	3 (8.6%)	2 (5.7%)	0.215[b]	0.6

Values are presented as mean ± SD, range, number, or number (%). Ad, admission; ASA, American Society of Anesthesia; BA, bronchial asthma; BMI, body mass index; CKD, chronic kidney disease; CLD, chronic liver disease; COPD, chronic obstructive pulmonary disease; COT, conventional nasal cannula oxygen therapy; DCL, disturbed conscious level; HDI, hemodynamic instability; HE, hepatic encephalopathy; HFNC, high-flow nasal cannula; ISHD, ischemic heart disease; [a]Independent *t*-test; [b]Chi-squared test

Table 2: Types and durations of (UGE) procedures

UGE procedures	*COT group (n = 35)*	*HFNC group (n = 35)*	*Used test value*	*p-value*
Type of UGE				
Diagnostic UGE	16 (45.7%)	17 (48.6%)	0.057[a]	0.8
Therapeutic UGE	19 (54.3%)	18 (51.4%)		
Type of procedures				
Gastroscopy (G)	20 (57.1%)	21 (60.0%)	0.391[a]	0.8
Endoscopic US (EUS)	13 (37.1%)	11 (31.4%)		
Combined G and EUS	2 (5.7%)	3 (8.6%)		
Endoscopy time in seconds[b]				
Mean ± SD	1901 ± 571	1853 ± 467	0.385[c]	0.7
Range	1020–2700	1200–2820		

Values are presented as number (%), mean ± SD, and range. COT, conventional nasal cannula oxygen therapy; HFNC, high-flow nasal cannula; US, ultrasound; [a]Chi-squared test; [b]Time was measured in minutes and converted into seconds for clarity; [c]Independent *t*-test

Table 3: Anesthesia times in seconds and total propofol doses used in milligrams

	COT-NC group (n = 35)	*HFNC group (n = 35)*	*Used test value*	*p-value*
Anesthesia time in seconds[a]				
Mean ± SD	2021 ± 571	1973 ± 467		
Range	1140–2820	1320–2940	0.385[b]	0.7
Propofol total doses in mg				
Mean ± SD	500.09 ± 221.35	498.89 ± 192.72		
Range	161–860	150–853	0.024[b]	1.0

Values are presented as mean ± SD, range. COT, conventional nasal cannula oxygen therapy; HFNC, high-flow nasal cannula, Mg: milligrams. [a]Time was measured in minutes and converted into seconds for clarity; [b]Independent *t*-test

Table 4: Oxygen saturation (SpO_2 as %) and occurrence of hypoxemia

SpO_2/occurrence of hypoxemia	*COT group (n = 35)*	*HFNC group (n = 35)*	*Used test value*	*p-value*
Baseline SpO_2 (%)	98 (97–98)% 96–100%	98 (96–99)% 96–100%	0.356[a]	0.7
SpO_2 < 90% of any duration	7 (20.0%)	0 (0.0%)	7.778[b]	0.005[c]
Lowest SpO_2 (%)	94 (90–98)% 73–100%	96 (95–98)% 91–100%	−3.005[d]	0.004[c]
Any episode of H	18 (51.4%)	2 (5.7%)	17.920[b]	<0.001[c]
Mild hypoxemia				
Total number (%)	11 (31.4%)	2 (5.7%)	7.652[b]	0.006[c]
<1 minute	10 (28.6%)	0 (0.0%)	11.667[b]	0.001[c]
1–5 minutes	1 (2.9%)	0 (0.0%)	1.014[b]	0.3
>5 minutes	0 (0.0%)	0 (0.0%)	–	–
Mod hypoxemia				
Total number (%)	6 (17.1%)	0 (0.0%)	6.563[b]	0.010[c]
<1 minute	6 (17.1%)	0 (0.0%)	6.563[b]	0.010[c]
1–5 minutes	0 (0.0%)	0 (0.0%)	–	–
>5 minutes	0 (0.0%)	0 (0.0%)	–	–
Severe hypoxemia				
Total number (%)	1 (2.9%)	0 (0.0%)	1.014[b]	0.3
<1 minute	1 (2.9%)	0 (0.0%)	1.014[b]	0.3
1–5 minutes	0 (0.0%)	0 (0.0%)	–	–
>5 minutes	0 (0.0%)	0 (0.0%)	–	–
Clinically significant H	9 (25.7%)	0 (0.0%)	10.328[b]	0.001[c]

Values are presented as median (1Q, 3Q), range, and number (%). COT, conventional nasal cannula oxygen therapy; HFNC, high-flow nasal cannula; H, hypoxemia; Mod, moderate. [a]Mann-Whitney test; [b]Chi-squared test; [c]$p < 0.05$, indicating statistical significance; [d]Independent-test

ventilatory exchange (THRIVE) during laryngeal surgery revealed that this technique kept the patients well-oxygenated for a period of up to 30 minutes.[9] Accordingly, HFNC oxygen therapy may be a noninvasive and efficient tool for oxygenation for prolonged procedures.

In our study, during the procedure, almost similar FiO_2 was delivered to both groups by setting the HFNC FiO_2 to 0.4 and the conventional nasal cannula oxygen therapy (COT) to a fixed flow

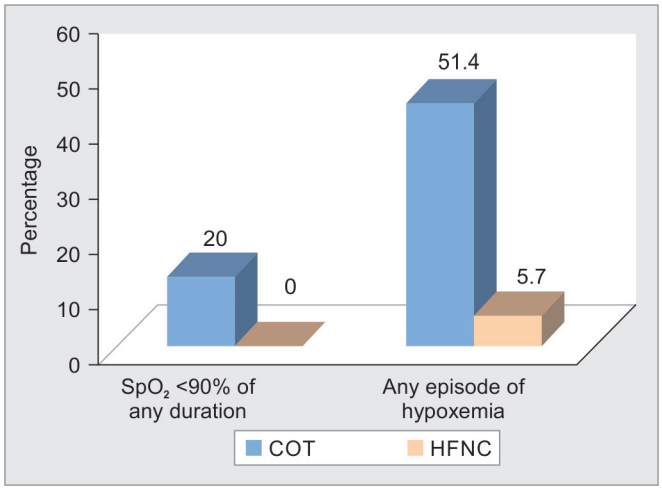

Fig. 2: Comparison between the COT group and HFNC group regarding the percentage of patients with SpO_2 < 90% of any duration, and the percentage of patients with any episode of hypoxemia

COT, conventional nasal cannula oxygen therapy; HFNC, high-flow nasal cannula; SpO_2, oxygen saturation in peripheral arterial blood

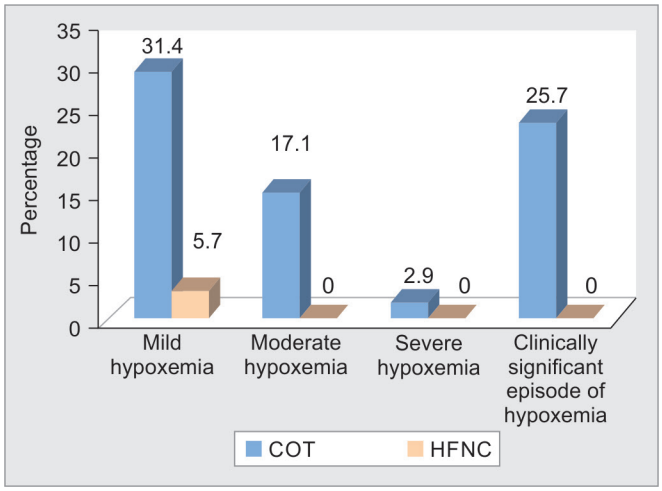

Fig. 3: Comparison between the COT group and HFNC group regarding the percentage of patients with mild, moderate, and severe episodes of hypoxemia and the percentage of patients with clinically significant episodes of hypoxemia

COT, conventional nasal cannula oxygen therapy; HFNC, high-flow nasal cannula

rate at 5 L/min which yields FiO_2 of nearly 0.4, as estimated via using a conversion table. However, HFNC oxygen therapy prevented hypoxemia suggesting that the beneficial effect of HFNC therapy was mainly due to the PEEP and the dead space washout effects.[10]

In contrast, previous studies compared HFNC with COT by setting the FiO_2 at 1.0 and the oxygen flow rate at 20–60 L/min for HFNC groups and the oxygen flow rate at 2–5 L/min for the COT groups.[11–13] The delivery of greater FiO_2 with high oxygen flow to the intervention group (HFNC), possibly underprivileged the COT. However, oxygen administration at a flow rate of less than 6 L/min via nasal catheter, or a non-re-breathing face mask, likely leads to

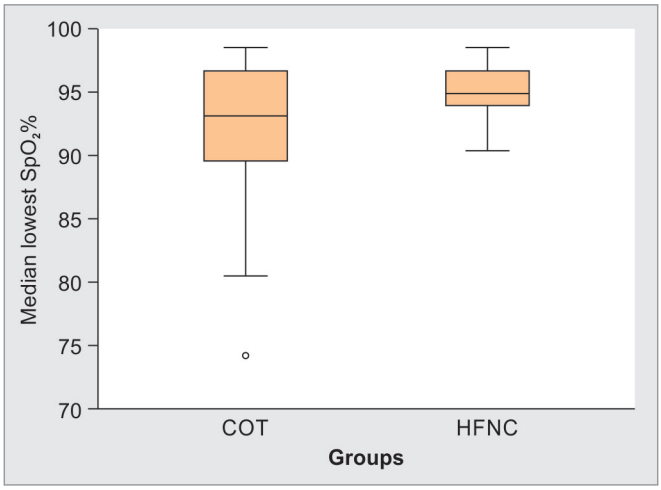

Fig. 4: Comparison between the COT group and HFNC group regarding the median lowest SpO_2%.

COT, conventional nasal cannula oxygen therapy; HFNC, high-flow nasal cannula; SpO_2, oxygen saturation in peripheral arterial blood

Table 5: Sedation-related adverse effects (SRAEs)

SRAEs	*COT group (n = 35)*	*HFNC group (n = 35)*	*Used test value*	*p-value*
Total SRAEs *n* and (%)	1 (2.9%)	1 (2.9%)	<0.001[a]	1.0
Hypotension	1 (2.9%)	0 (0.0%)	1.014[a]	0.3
Dysrhythmia	0 (0.0%)	0 (0.0%)	–	–
Seizures	0 (0.0%)	0 (0.0%)	–	–
Cardiac arrest	0 (0.0%)	0 (0.0%)	–	–
Nausea and/or vomiting	0 (0.0%)	1 (2.9%)	1.014[a]	0.3
Recovery agitation	0 (0.0%)	0 (0.0%)	–	–
Delayed recovery	0 (0.0%)	0 (0.0%)	–	–

Values are presented as numbers (%). COT, conventional nasal cannula oxygen therapy; HFNC, high-flow nasal cannula. [a]Chi-squared test

an actual FiO_2 far less than 0.5, especially in patients with low or moderate inspiratory effort.[14]

Concerning the occurrence of hypoxemic episodes in our study, only two patients (5.7%) in the HFNC group had mild hypoxemia that lasted < 1 minute, and no patients had SpO_2 < 90%. Conversely, 18 patients (51.4%) in the COT group experienced hypoxemia, with a total of seven patients who had SpO_2 < 90% lasting < 1 minute, and nine patients had clinically significant hypoxemic episodes that needed suction of secretions (eight patients) or to increase the flow rate and/or FiO_2 and/or to change the method of oxygen delivery (one patient) in case of hypoxemia episodes.

Similar to our results, in a study involving three hundred 79 patients with moderate to high risk of hypoxemia, who underwent UGE under deep sedation, HFNC decreased the occurrence of oxygen desaturation in comparison with COT. $SpO_2 \leq 92\%$ happened in 9.4% of the patients in the HFNC group, and 33.5% of the patients in the COT group ($p < 0.001$). Additionally, oxygen desaturation of more than 1 minute, and/or maneuvers to support or suction upper airways were significantly less common in the

Table 6: Intra and post-procedural ECAEs

	COT group (n = 35)	*HFNC group (n = 35)*	*Used test value*	*p-value*
Intra-procedural ECAEs				
Gastrointestinal bleeding requiring intervention	1 (2.9%)	1 (2.9%)	<0.001[b]	1.0
Perforation	0 (0.0%)	0 (0.0%)	–	–
Intraprocedural AEs[a]	0 (0.0%)	0 (0.0%)	–	–
Post-procedural ECAEs				
Total number (%)	2 (5.7%)	1 (2.9%)	0.348[b]	0.6
Abdominal pain	1 (2.9%)	0 (0.0%)	1.014[b]	0.3
Abdominal bloating	1 (2.9%)	1 (2.9%)	0.000[b]	1.0
Gastrointestinal bleeding	0 (0.0%)	0 (0.0%)	–	–
Nose, mouth, throat dryness/pain	0 (0.0%)	0 (0.0%)	–	–
Headache	0 (0.0%)	0 (0.0%)	–	–

Values are presented as numbers (%). COT, conventional nasal cannula oxygen therapy; HFNC, high-flow nasal cannula. [a]AEs, adverse events requiring to pause or to stop the procedure; [b]Chi-squared test

HFNC group than in the COT group [7.3 vs 14.9% ($p = 0.02$), and 11.1 vs 32.4% ($p < 0.001$), respectively].[15]

Both oxygen administration methods in our study seem to be safe, as there was an overall low incidence of SRAEs with no significant differences between the groups. However, Nay et al.[15] revealed increased SRAEs in prolonged procedures recognized by the ProSed2 trial.[16] This increase might be a result of the greater number of patients (379) and/or being at moderate to high risk of hypoxemia. Also, Chang et al.[17] reported tension pneumocephalus that was induced by HFNC in a patient with an unrecognized traumatic fracture base of the skull.

There are some limitations of this study. First, it was a single-center study, consequently; further prospective multicenter studies are needed to validate and generalize our findings, especially in patients at increased risk for hypoxemia. Second, the intervention (HFNC) device nature prevented the blinding process. Even though, to minimize bias, the collector of data was blinded to treatment allocation. Third, we could not assess the ventilation adequacy by measuring the end-tidal carbon dioxide ($EtCO_2$), since there is no reliable capnography available yet during the utilization of HFNC.

Finally, the high cost of the cartridge used in the HFNC device could be an obstacle to its vast use for a large number of UGE procedures. So, it can be preserved for high-risk patients for hypoxemia.

Conclusion

High-flow nasal cannula oxygen therapy was well tolerated, safe, and significantly reduced the incidence of hypoxemia including clinically significant episodes compared with COT among high-risk ICU patients who underwent a prolonged UGE under propofol deep sedation with spontaneous breathing.

Clinical Significance

The results of this clinical trial show that HFNC oxygen therapy can be used to prevent hypoxemia among high-risk ICU patients who underwent a prolonged UGE under propofol deep sedation.

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