Sultan Qaboos University Med J, February 2024, Vol. 24, Iss. 1, pp. 103–108, Epub. 28 Feb 24
Submitted 16 Apr 23
Revisions Req. 2 Jul & 13 Sep 23; Revisions Recd. 16 Aug & 28 Sep 23
Accepted 19 Oct 23
https://doi.org/10.18295/squmj.12.2023.086

BRIEF COMMUNICATION

Is High-Flow Nasal Oxygenation a Game Changer in Endobronchial Ultrasound-Guided Transbronchial Needle Aspiration?

A pilot study

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ABSTRACT: ***Objectives:*** This study aimed to compare the high-flow nasal oxygen (HFNO) and supraglottic airway device (SAD) techniques in oncological patients undergoing endobronchial ultrasound (EBUS) and transbronchial needle aspiration (TBNA) to evaluate the efficacy of HFNO in them. ***Methods:*** This pilot study was conducted at Sultan Qaboos Comprehensive Cancer Care and Research Centre, Muscat, Oman, from May 2022 to March 2023. Patients undergoing EBUS TBNA under moderate sedation were quasi-randomised into the HFNO and SAD groups. The episodes and duration of hypoxia and the lowest level of oxygen saturation were the primary outcomes measured. ***Results:*** A total of 24 patients were included in the study (10 of them were in the HFNO group and 14 were in the SAD group), with an equal number of males and females. The duration of the procedure in both groups was similar (45 ± 20 and 44 ± 17 minutes in the HFNO and SAD groups, respectively). The mean lowest oxygen saturation in the HFNO group was 93.5 ± 4.5%, which was significantly higher than that of the SAD group (90 ± 3%; P <0.001). In both groups, maximum hypoxia occurred during the early phase of the procedure. However, the HFNO and SAD groups were similar in terms of the cumulative duration of hypotension (140 versus 95 seconds, respectively) and bradycardia (25 versus 40 seconds, respectively). ***Conclusion:*** HFNO is a good alternative to SAD and could be used safely and efficiently in patients undergoing EBUS TBNA.

Keywords: Sedation; Ultrasonography; Bronchi; Needle Aspiration; Oman.

Endobronchial ultrasound-guided transbronchial needle aspiration (EBUS-TBNA), first popularised in 2002, is a common procedure performed by interventional pulmonologists.[1,2] Providing anaesthesia for such procedures has always been difficult because the patient's airway space must be shared, and in patients with poor physiological reserve and comorbidities (e.g. coronary artery disease, congestive heart failure, chronic pulmonary thrombo-embolism, etc.), maintaining an adequate depth of sedation, providing hemodynamic stability, immobilising the patient and maintaining optimal oxygenation of the patient remain challenging.[3,4] Hypoxia and its consequences during the procedure are a real threat to the life of the patient.

Globally, these procedures are traditionally performed under general anaesthesia or moderate sedation using a supraglottic airway device (SAD). High-flow nasal oxygen (HFNO) has been used for EBUS-TBNA procedures; however, currently, no study has compared the outcomes of the procedure when performed with HNFO to those performed with SAD and moderate sedation.[5,6] HFNO provides a continuous positive airway pressure (CPAP), washes out the CO_2 from the respiratory dead space and enhances oxygen diffusion into the alveolar spaces. Furthermore, HFNO reduces airway resistance and thus minimises the work of breathing. The stress response to the insertion of an airway device, dislodgement of the device during the procedure and stimulation of a hyperactive airway can all be avoided using HFNO. It also allows easy access for the pulmonologists to perform their intervention. In light of this, the current study was designed to compare the efficacy of HFNO and SAD in patients undergoing EBUS-TBNA with moderate sedation.

Methods

The quasi-randomised pilot study was conducted at Sultan Qaboos Comprehensive Cancer Care and Research Centre, Muscat, Oman, from May 2022 to March 2023 and included all patients who were assessed prior to the procedure using the American Society of Anesthesiologists grading system. Patients who had comorbidities, such as coronary artery disease, diabetes mellitus, asthma and chronic kidney disease, were optimised with respect to their clinical conditions before undergoing the procedure. The patients were divided into 2 groups: the HFNO and SAD groups. The primary outcome was the duration and episodes of hypoxia during the procedure in the 2 groups. Hypoxia was defined as an oxygen saturation (SpO_2) of less than 90%. The secondary outcomes included changes in cardiovascular parameters (blood

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pressure and heart rate [HR]) and the blood gases and discrepancies, if any, in the diagnostic yield. Diagnostic yield was defined as the percentage of patients for whom EBUS-TBNA gave a specific diagnosis. Both techniques of anaesthesia were explained in detail to the patients, in a language they understood.

Pre-procedurally, 10% lidocaine was sprayed into the pharynx of patients in both groups, and the electrocardiogram (ECG), SpO_2, HR and non-invasive blood pressure (NIBP) of the patients were monitored continuously. In the HFNO group, patients received HFNO at a flowrate of 40–80 L/min, and the fraction of inspired oxygen (FiO_2), which was initially 0.3, was increased at an interval of 0.1 (depending on the oxygen demand) to keep the oxygen saturation above 90%. HFNO delivers actively heated, humidified medical gas using an air/oxygen blender at flowrates of up to 60–70 L/min, with an FiO_2 varying from 0.21–1. To deliver high-flow oxygen in this study, the nasal HI-flow Star adult system (Dräger, Lübeck, Germany) was used as a patient interface, connected to a ventilator (EVE IN, Stephan, Gackenbach, Germany). In the SAD group, patients had a SAD intubated and received oxygen at flow rates of 10–12 L; they had an FiO_2 of 0.5–0.6. Laryngeal mask airway (LMA Supreme, Teleflex Medical, Westmeath, Ireland) and I-gel (Inter surgical LTD., Berkshire, UK) were the SADs used in the current study. These were placed at the level of the laryngopharynx, allowing the bronchoscope to proceed below the level of the cords. They were all ventilated in synchrony. The EBUS scope (Pentax Medical, Tokyo, Japan) was introduced over a tight self-sealing diaphragm to prevent leaks.

All patients received premedication with glycopyrrolate 0.2 mg intravenous (IV; unless contraindicated) and dexamethasone 8 mg IV. During the procedure, the sedation level was maintained in both groups with a bispectral index score of 50. Patients were given 1 µg/kg of dexmedetomidine as loading dose and then maintained on an infusion of 0.1–0.3 µg/kg/h. Propofol (1 mg/kg) was given as an injection slowly, over 5–7 minutes, and the patients also received remifentanil at an infusion rate of 0.2–0.5 µg/kg/min. The following parameters were recorded: NIBP every 3 minutes for the first 30 minutes and then every 5 minutes thereafter. SpO_2, HR and ECG were recorded continuously. Venous blood gas (VBG) was done at the beginning and end of the procedure and whenever there was an episode of hypoxia to assess SpO_2 levels. Although the correlation between hypoxia and VBG is not direct, this gives a good indirect evidence of hypoxia.

Each EBUS-TBNA procedure was performed as per the standardised institutional protocol, i.e. for each mediastinal/hilar lesion to be examined, a minimum of 3 passes, with 15 wiggling's (quick small to and fro movements) during each pass, should be performed.

GraphPad Prism, Version 5 (GraphPad Software, San Diego, California, USA) was used for statistical analysis. The procedure-related parameters, including the episodes of hypoxia, cumulative duration of hypoxia, and the cardiovascular parameters (systolic and diastolic blood pressures, HR variations and VBG) are presented as mean ± standard deviation. Differences in the patients' demographic characteristics and procedure-related values between the SAD and HFNO groups were evaluated using the Fisher's exact test or Mann–Whitney U test.

Ethical approval was obtained from the Institutional Ethical Committee (CCRC-32-2023) and written informed consent was obtained from all patients before the study commenced.

Results

A total of 24 patients were included; 12 patients were male and 12 were female. There were 10 patients in the HFNO group and 14 in the SAD group. The mean age of patients in the HFNO group was 48 ± 18 years, while that of patients in the SAD group was 54 ± 12 years. Regarding the procedure-related parameters, the mean preoperative SpO_2 was 86 ± 4% in the HFNO group, and 88 ± 4% in the SAD group. Patients in the HFNO group had 3 episodes of hypoxia, with a cumulative duration of 120 seconds, while those in the SAD group had 5 episodes, with a cumulative of 116 seconds. The longest duration of hypoxia in the HFNO group was 45 seconds, while that in the SAD group was 28 seconds, with no statistically significant difference between the groups. The maximum systolic and diastolic blood pressure, episodes of hypotension, duration and episodes of bradycardia, VBGs, average fluid input and total dose of propofol, remifentanil and dexmedetomidine were comparable in both groups [Table 1].

There was no statistically significant difference in SpO_2 and HR between both groups [Figures 1 and 2]. The SpO_2 and HR fell in both groups in the 4th, 5th and 6th minute of the procedure, after which SpO_2 remained above 94%. The lowest SpO_2 distribution in both groups is presented in Figure 3.

The lowest SpO_2 in the HFNO group (excluding preoperative levels) was 88%, while that in the SAD group was 82%. The mean lowest SpO_2 was 90 ± 3 % and 93.5 ± 4.5 % in the SAD and HFNO groups, respectively (P <0.001). The pulmonologist was able to get an adequate yield in 23 of the 24 patients.

Table 1: Characteristics of oncological patients undergoing endobronchial ultrasound and transbronchial needle aspiration using high-flow nasal oxygen and supraglottic airway device techniques (N = 24).

Characteristic	Mean ± SD or n		*P* value
	HFNO	SAD	
Demographic			
Age in years	48 ± 18	54 ± 12	
Male	6	6	0.370
Female	4	8	0.190
Weight in kg	55 ± 16	61 ± 14	0.320
BMI in kg/m^2	24 ± 6	21 ± 3	0.270
Duration of procedure in min	45 ± 20	44 ± 17	0.170
SpO_2			
Preoperative SpO_2 in %	86 ± 4	88 ± 4	0.280
SpO_2 range in %	88–99	82–100	
Minimum SpO_2 in %	93.5 ± 4.5	90 ± 3	<0.001
Episodes of hypoxia (= 90%)	3	5	0.320
Cumulative duration of hypoxia in seconds	120	116	0.260
BP			
Maximum systolic BP in mmHg	110 ± 23	142 ± 46	0.320
Maximum diastolic BP in mmHg	82 ± 18	82 ± 18	0.260
Episodes of hypotension	2	1	0.450
Cumulative duration of hypotension in seconds	140	95	0.115
Heart rate			
Maximum heart rate in beats/min	106 ± 28	94 ± 18	0.230
Minimum heart rate in beats/min	52 ± 11	58 ± 8	0.018
Episodes of bradycardia (= 45 beats/min)	1	2	
Cumulative duration of bradycardia in seconds	25	40	0.180
Venous blood gas			
pH	7.34 ± 1.2	7.36 ± 1.8	0.360
$PaCO_2$ in mmHg	43.3 ± 7.2	44.4 ± 6.2	0.260
PaO_2 in mmHg	34.4 ± 4.2	33.8 ± 5.3	0.310
H_2CO_3 in mEq/L	23.2 ± 4.6	24.4 ± 5.2	0.270
Lactate in mmol/L	1.6 ± 1.8	1.9 ± 1.1	0.119
IV fluid			
Average fluid input in mL	425 ± 62	460 ± 32	0.670
Comorbidities			
Coronary artery disease	2	2	
Hypertension	3	4	
Diabetes	7	6	
Congestive heart failure	2	0	
Cerebrovascular accidents	4	1	
Myasthenia gravis	0	1	
Significant valvular disease	3	3	
Respiratory Comorbidities	5	4	
Chronic pulmonary embolism	2	1	
Diagnostic yield			
No	0	1	0.816
Yes	10	13	
Medication			
Total propofol in mg	180 ± 32	180 ± 18	0.460
Total remifentanil in µg	350 ± 28	335 ± 18	0.350
Total dexmedetomidine in mg	7 ± 4.5	8 ± 3	0.180

SD = standard deviation; HFNO = high flow nasal oxygenation; SAD = supraglottic airway device; BMI = body mass index; SpO_2 = oxygen saturation; BP = blood pressure; $PaCO_2$ = partial pressure of carbon dioxide; PaO_2 = partial pressure of oxygen; IV = intravenous

Discussion

This pilot study compared the use of HFNO and SAD for moderate sedation during EBUS-TBNA. It demonstrated that HFNO with moderate sedation was as efficacious as SAD in maintaining oxygen saturation.

Takakuwa *et al.* conduced a prospective study comparing HFNO with a nasal cannula during EBUS-TBNA under midazolam sedation and found that the mean SpO_2 was higher in the HFNO group.[6] They also

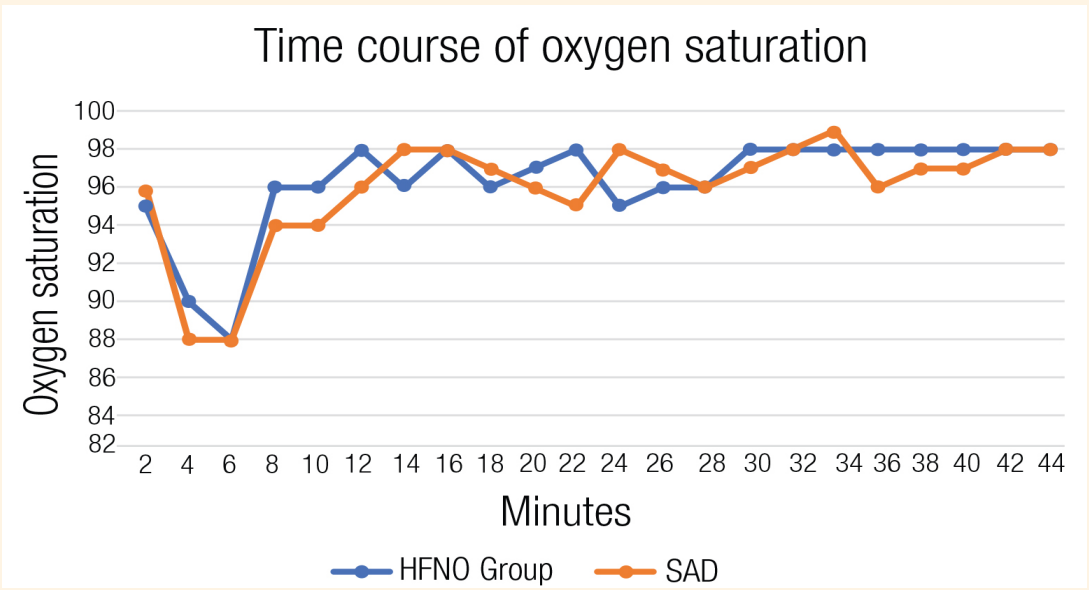

Figure 1: Time course of changes in oxygen saturation during endobronchial ultrasound-guided transbronchial needle aspiration in the two groups.
HFNO = high flow nasal oxygen; SAD = supraglottic airway device

found that the maximum FiO_2 required to maintain an adequate SpO_2 in the HFNO group was 0.45; this was 0.6 in the current study. Many studies have proven the utility of HFNO to maintain oxygen saturation while performing interventional bronchoscopic procedures.[7–10] Several studies have proven that moderate sedation with a SAD provides equivalent or even better maintenance of oxygenation when compared with general anaesthesia.[11]

Miyagi *et al.* and Simon *et al.* reported that bronchoscopy was well tolerated when HFNO was used for the prevention of mild to moderate hypoxemia.[12,13] In the current study, the usefulness of HFNO in preventing hypoxemia during EBUS-TBNA was assessed in subjects who had preprocedural respiratory impairment. The mean lowest SpO_2 in the HFNO group was 93.5 ± 4.5%, and the minimum SpO_2 was 88%, which were significantly higher than those in the SAD group at 90 ± 3% and 82%, respectively. The total duration of hypoxia was shorter in the SAD group, which can be attributed to the fact that positive pressure ventilation quickly corrected the hypoxia

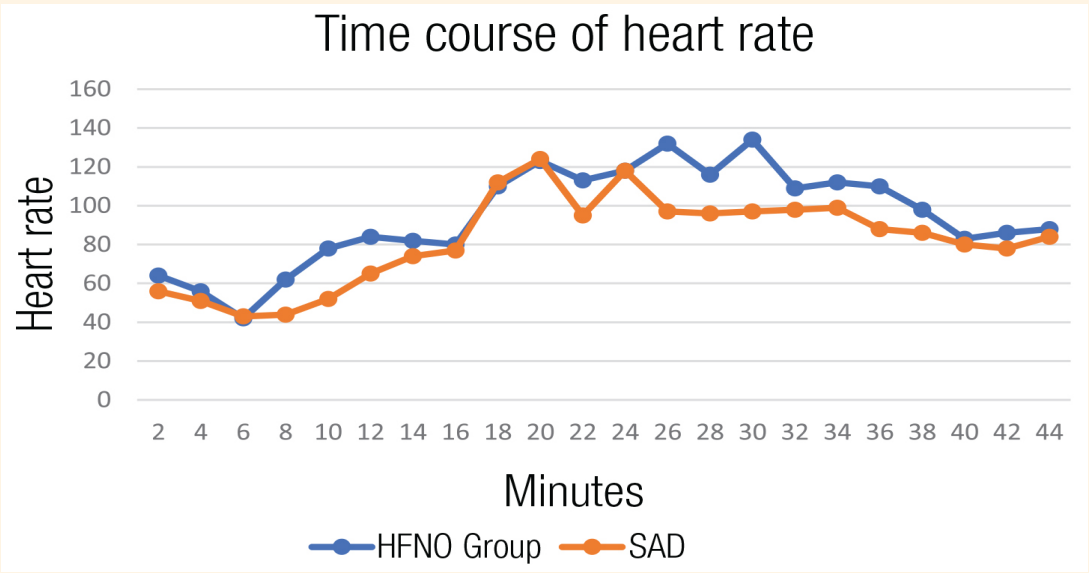

Figure 2: Time course of changes in heart rate during endobronchial ultrasound-guided transbronchial needle aspiration in both groups.
HFNO = high flow nasal oxygen; SAD = supraglottic airway device

Figure 3: Comparison of the lowest oxygen saturations between the HFNO and SAD groups showing a higher mean lowest oxygen saturation in the HFNO group

HFNO = high flow nasal oxygen; SAD = supraglottic airway device

in patients in this group, while there was a time lag between increasing the FiO_2/flow rate and the increase in saturation in the HFNO group.

In the current study, the fall in SpO_2 occurred between 4–6 minutes after the procedure commenced in both groups. Desaturation in the early phase of bronchoscopic procedures has been reported in multiple studies, consistent with the current study's results.[6,12] Similarly, the fall in HR was also noted in the first 3–7 minutes of the procedure. This may be due to the concurrent development of hypoxia. There is always a real concern about raising the end-tidal carbon dioxide ($EtCO_2$) level during the procedure. In the current study, partial pressure of CO_2 ($PaCO_2$) was monitored through VBG, which was less in the HFNO group compared to the SAD group; however, the difference was statistically insignificant. This may be because with the SAD method; there is ineffective ventilation due to leakage of gases through the entry point of the EBUS scope on the catheter mount and also because the EBUS scope being inside the supraglottic airway reduces the space available for ventilation. Hence, there was ineffective maintenance of $EtCO_2$. Some studies have reported lesser retention of CO_2 in the HFNO group compared to the nasal oxygen supply group, but no study has compared SAD with HFNO.[6,8,10]

There is always the possibility of a drop in CPAP when HFNO is applied with the mouth open. Hence, further studies monitoring $EtCO_2$ and $PaCO_2$ are required. Casal *et al.* compared patients undergoing EBUS with SAD under general anaesthesia and those undergoing EBUS under moderate sedation and found that the yield was similar.[11] The current study found comparable diagnostic yield in both groups, which is an objective method of assessing the ease of operability.

This study is subject to certain limitations. The small sample size used will likely prove unable to mask biases and affect the accuracy of hypoxia and hypotension during the procedure. Invasive blood pressure monitoring would have given better results for the hypotension episodes. However, the invasiveness of these procedures might be argued in terms of risk–benefit for the study.

Conclusion

HFNO could decrease the incidence and episodes of hypoxia during EBUS-TBNA considerably more than SAD under moderate sedation. Hence, it can be safely used in clinical practice. HFNO reduces airway resistance, and the stress response inserting of an airway device, dislodging the device during the procedure and stimulation of a hyperactive airway can all be avoided using HFNO. HFNO also provides easy access for the pulmonologist to carry out their intervention. However, further research involving a greater number of patients is required to confirm these findings.

AUTHORS' CONTRIBUTION

PRR was involved in the conception and design, collection and assembly of data, data analysis and interpretation, manuscript writing and administrative support. SSPM contributed to the conception and design, collection and assembly of data, data analysis and interpretation and manuscript writing. AAM was involved in the conception and design, collection and assembly of data and data analysis and interpretation. RK also contributed to the conception and design, data analysis and interpretation, manuscript writing and administrative support. SMB was involved in the conception and design, provision of study materials or patients, data analysis and interpretation and manuscript writing. All authors approved the final version of the manuscript.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

FUNDING

No funding was received for this research.

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