Original Article

High-velocity nasal insufflation with oxygen assist module versus conventional high-velocity nasal insufflation after extubation: an open-label randomized crossover study

Suharit Visuthisakchai^, Patharapan Lersritwimanmaen^, Nuttapol Rittayamai^

Division of Respiratory Disease and Tuberculosis, Department of Medicine, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand

Contributions: (I) Conception and design: All authors; (II) Administrative support: N Rittayamai; (III) Provision of study materials or patients: All authors; (IV) Collection and assembly of data: All authors; (V) Data analysis and interpretation: All authors; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: Nuttapol Rittayamai, MD. Division of Respiratory Disease and Tuberculosis, Department of Medicine, Faculty of Medicine Siriraj Hospital, Mahidol University, 2 Wanglang Road, Bangkoknoi, Bangkok 10700, Thailand. Email: nuttapol.rit@mahidol.ac.th.

Background: The current technology of high-velocity nasal insufflation (HVNI) can be equipped with an oxygen assist module (OAM) that continuously monitors and automatically adjusts the inspired oxygen fraction (FiO_2) to maintain oxygen saturation by pulse oximetry (SpO_2) within the target range. This study aimed to evaluate the use of HVNI with OAM compared to conventional HVNI in patients after endotracheal extubation.

Methods: This randomized crossover study enrolled 16 mechanically ventilated subjects who were ready to wean. The subjects were randomized to protocol A (HVNI with OAM for 60 min, followed by conventional HVNI for another 60 min) or protocol B (conventional HVNI for 60 min, followed by HVNI with OAM for another 60 min) after extubation. In HVNI with OAM, the target SpO_2 was set at 94% with a range of 92–98%, temperature of 37 ℃ and flow rate of 40 L/min. In the conventional HVNI group, the attending physician adjusted the FiO_2 to maintain an SpO_2 of at least 94%. The primary outcome was the time in the SpO_2 range between the two groups. The secondary outcomes included FiO_2, transcutaneous carbon dioxide pressure ($PtcCO_2$), respiratory rate oxygenation (ROX) index, and hemodynamic variables.

Results: HVNI with OAM significantly maintained SpO_2 within the target range compared to conventional HVNI [99.4% (97.4–99.8%) *vs.* 5.3% (1.5–68.1%); P=0.001]. The use of FiO_2 was significantly lower and the ROX index was significantly higher at the end of the study in the HVNI with OAM group than in the conventional HVNI group [0.22 (0.21–0.25) *vs.* 0.40 (0.40–0.40); P=0.001 and 22.26 (15.94–26.46) *vs.* 13.01 (10.72–14.66); P=0.001, respectively]. No differences in breathing frequency, $PtcCO_2$ or hemodynamic variables were observed between the two groups.

Conclusions: HVNI with OAM can maintain SpO_2 within the target range while using a lower FiO_2 and providing a higher ROX index than conventional HVNI in patients after extubation.

Trial Registration: This study was registered in the Thai Clinical Trial Registry (TCTR20220801007) before the inclusion of the first patient.

Keywords: Endotracheal extubation; high-velocity nasal insufflation (HVNI); hypoxemia; oxygen assist module (OAM); respiratory rate oxygenation index (ROX index)

^ ORCID: Suharit Visuthisakchai, 0000-0003-1310-3669; Patharapan Lersritwimanmaen, 0009-0001-1902-4630; Nuttapol Rittayamai, 0000-0001-6844-6314.

Submitted Aug 20, 2024. Accepted for publication Nov 22, 2024. Published online Jan 20, 2025.
doi: 10.21037/jtd-24-1345
View this article at: https://dx.doi.org/10.21037/jtd-24-1345

Introduction

Patients with acute respiratory failure often require endotracheal intubation and mechanical ventilation. When the cause of respiratory failure is corrected, patients will be assessed for readiness to wean and then proceed to the spontaneous breathing trial (1). Endotracheal extubation is performed after a successful spontaneous breathing trial; however, approximately 20% of patients develop postextubation respiratory failure that may require reintubation (2). Hypoxemia is the most common complication after endotracheal extubation, and is caused by cardiogenic pulmonary oedema, upper airway oedema, or secretion obstruction leading to many deleterious effects (3,4). Current practice guidelines recommend maintaining oxygenation within the target range depending on the patient's condition and risk of hypercapnia (5). In contrast, the harmful effects of hyperoxemia should also be considered, as many studies have demonstrated that it was associated with increased mortality (6-8).

High-flow oxygen therapy delivers a heated and humidified air-oxygen mixture at high flow and an adjustable inspired oxygen fraction (FiO_2). It provides several physiological benefits including improved oxygenation, alleviated patient's work of breathing and improved secretion clearance through several mechanisms, such as generating positive end-expiratory pressure, altering airway resistance, washing out airway dead space, and the effect of heat and humidification on mucociliary function (9). Several randomized studies have demonstrated the benefits of high-flow oxygen therapy after endotracheal extubation in low- or high-risk patients for postextubation respiratory failure (10,11). Recent clinical practice guidelines recommend the use of high-flow oxygen therapy immediately after endotracheal extubation over conventional oxygen therapy (12,13).

High-velocity nasal insufflation (HVNI) is a form of high-flow nasal cannula (HFNC) via a small bore nasal cannula that can generate a higher velocity of the air-oxygen mixture and higher nasopharyngeal pressure at any given gas flow rate than a conventional high-flow oxygen delivery system (14,15). Recently, the device has been equipped with an oxygen assist module (OAM) that can continuously monitor oxygen saturation by pulse oximetry (SpO_2) and automatically adjust FiO_2 according to the target SpO_2 range. The use of HVNI with OAM might promote the rational use of oxygen therapy in respiratory compromised patients after endotracheal extubation by providing enough oxygen to prevent hypoxemia and avoid hyperoxemia; however, evidence of HVNI with OAM after extubation is limited. This study aimed to evaluate the physiological benefits of HVNI with OAM compared to conventional HVNI in mechanically ventilated patients after endotracheal extubation. We present this article in accordance with the CONSORT reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-1345/rc).

Highlight box

Key findings

- In patient after endotracheal extubation, high-velocity nasal insufflation with oxygen assist module (OAM) can be used for maintaining oxygen saturation within the target range while using lower oxygen fraction than conventional high-velocity nasal insufflation.

What is known and what is new?

- High-flow oxygen therapy is recommended to use for the prevention of postextubation respiratory failure.
- Hypoxemia and hyperoxemia can occur and cause deleterious effects after extubation. Close monitoring and prompt adjustment of oxygen concentration is needed; however, it is time consuming and can increase the workload of healthcare personnel.
- High-velocity nasal insufflation with OAM significantly maintained oxygen saturation by pulse oximetry within the target range compared to conventional high-velocity nasal insufflation. The use of inspired oxygen fraction was significantly lower and the respiratory rate oxygenation (ROX) index was significantly higher at the end of the study in the high-velocity nasal insufflation with OAM group.

What is the implication, and what should change now?

- This study supports the use of high-flow nasal cannula with OAM to maintain oxygenation within target range in patients after endotracheal extubation.

Methods

Study design and participants

This proof-of-concept randomized open-label crossover physiological study was conducted in the Respiratory

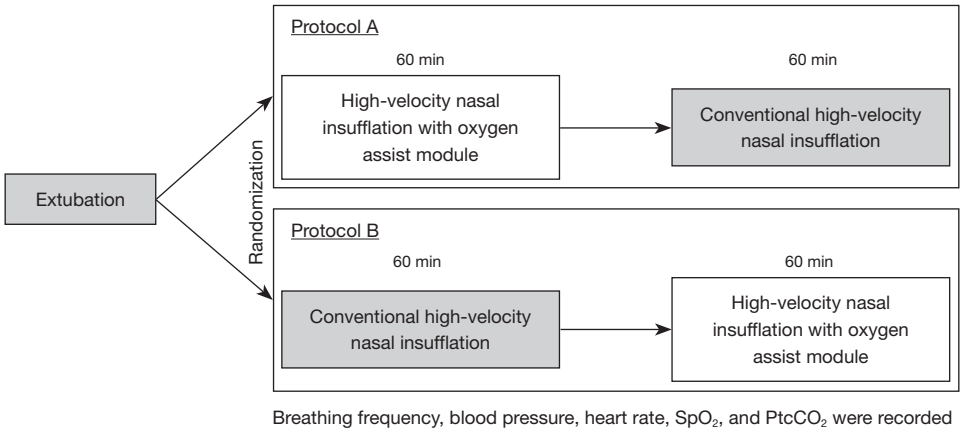

Figure 1 Study protocol. $PtcCO_2$, transcutaneous partial pressure of carbon dioxide; SpO_2, oxygen saturation by pulse oximetry.

Intensive Care Unit, Division of Respiratory Disease and Tuberculosis, Department of Medicine, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand from September 2022 to February 2023. This study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study protocol was approved by the Siriraj Institutional Review Board (certificate of approval No. Si 470/2022). The study was registered in the Thai Clinical Trial Registry (TCTR20220801007) before the inclusion of the first patient. Written informed consent was obtained from all included subjects or their relatives.

We enrolled mechanically ventilated patients aged >18 years who underwent a spontaneous breathing trial and were ready for extubation. Patients who had hemodynamic instability (systolic blood pressure >180 or <90 mmHg, diastolic blood pressure >100 or <60 mmHg, heart rate >140 or <60 beats/min, or any sign of poor tissue perfusion), breathing frequency >35 breaths/min, SpO_2 <92%, severe acid/base disturbance (arterial pH <7.3 or >7.55), uncooperative or impaired level of consciousness, tracheostomized patients and pregnant women were excluded.

Devices

The HVNI device (Precision Flow Hi-VNI, Vapotherm, New Hampshire, USA) comprises a built-in oxygen/air blender with adjustable FiO_2 from 0.21–1.00, a flow generator that can generate a flow rate of 5–40 L/min and a heat and humidifier system. The air-oxygen mixture is delivered through a single-limb breathing tube to a small-bore nasal cannula (ProSoft cannula, Vapotherm, New Hampshire, USA). The OAM (Vapotherm, New Hampshire, USA) is an automatic control system that uses a feedback control algorithm to track the oxygen saturation of a patient using the Masimo SET SpO_2 monitoring system (Masimo, California, USA) and automatically adjusts the FiO_2 delivered to maintain a target SpO_2 value and target range SpO_2 through the HVNI device (Precision Flow Hi-VNI, Vapotherm, New Hampshire, USA).

Study protocol

Patients who successfully passed the spontaneous breathing trial and were ready for extubation were randomized using a sealed opaque envelope to receive one of the following two treatments after endotracheal extubation. Protocol A: subjects were assigned to receive HVNI with OAM (temperature of 37 ℃, flow rate 40 L/min, and FiO_2 was automatically adjusted by OAM throughout the duration of treatment with a target SpO_2 of 94% and an acceptable SpO_2 range of 92–98%) and then conventional HVNI [temperature of 37 ℃, flow rate 40 L/min, and FiO_2 was initially set at 40% and allowed to be adjusted within the first 5 minutes to maintain SpO_2 of at least 94% according to standard clinical procedures of our hospital and standard international guidelines (5)] for another 60 minutes or Protocol B: subjects started with conventional HVNI for 60 minutes and then HVNI with OAM for another 60 minutes (*Figure 1*). During conventional HVNI, the OAM was switched to the standby mode; however, the Masimo SET SpO_2 monitoring system (Masimo, California, USA) was continuously monitored SpO_2 and FiO_2 during the study period of conventional HVNI.

Baseline demographic and clinical data were collected

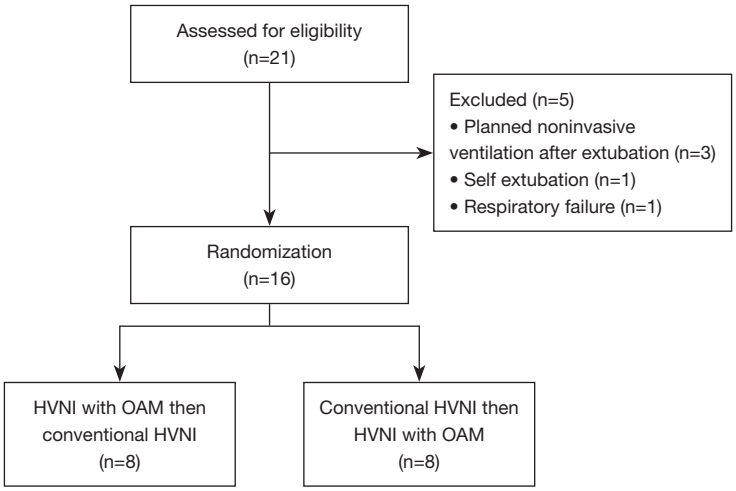

Figure 2 CONSORT flow diagram. HVNI, high-velocity nasal insufflation; OAM, oxygen assist module.

including significant medical history, comorbidities, cause of admission, Sequential Organ Failure Assessment (SOFA) and Acute Physiologic and Chronic Health Evaluation (APACHE) II scores. During the study intervention period, SpO_2 and FiO_2 were continuously monitored every 1 second with the OAM device. Blood pressure, heart rate, and breathing frequency were recorded immediately after the implementation of the intervention and then at 5, 10, 15, 30, and 60 minutes. Transcutaneous carbon dioxide pressure ($PtcCO_2$) was also recorded using a SenTec Digital Monitoring System (SenTec, Therwil, Switzerland) at each time point. The respiratory rate oxygenation (ROX) index at each time point was calculated using the following equation: (SpO_2/FiO_2)/breathing frequency (16). Time in the target SpO_2 range was analyzed by a dedicated software (Case File Analyzer, Vapotherm, New Hampshire, USA) using the data that were continuously monitored from the OAM device. At the end of the study, all subjects were followed for 48 hours after endotracheal extubation.

Outcomes

The primary outcome was the time spent in the target SpO_2 between HVNI with OAM and conventional HVNI. The secondary outcomes were the ROX index, FiO_2 use, $PtcCO_2$, breathing frequency, and hemodynamic variables between the two groups.

Statistical analysis

According to the literature review, no clinical studies on the use of HVNI with OAM in adults were found and there was only one randomized crossover study in preterm infants that demonstrated a median time spent in the target SpO_2 range of 49% in the HVNI group (17). With a type I error of 0.05 and a power of 90%, the calculated sample size was 14 subjects. We increased the sample size to 16 subjects to compensate for an estimated dropout rate of 15%.

All data analyses were performed using PASW Statistics version 23 (SPSS, Inc., Chicago, IL, USA). The Shapiro-Wilk test was used to assess the normality of the data. Categorical variables were reported as frequency and percentage. Continuous variables were reported as mean ± standard deviation or median [interquartile range]. For normally distributed continuous data, the paired *t*-test was used. Nonnormally distributed continuous data were compared using the Wilcoxon signed-rank test. The interaction between the order of intervention (HVNI with or without OAM) and the time in the target SpO_2 range was evaluated using general linear model repeated measures. $P<0.05$ was considered statistically significant.

Results

Sixteen subjects after endotracheal extubation were enrolled (*Figure 2*). The median age was 52 [44–66] years and 62.5% of them were men. Pneumonia was the most common cause of acute respiratory failure (37.5%). The median duration of mechanical ventilation was 8 [3–12] days. The other baseline characteristics, ventilator settings, and physiological variables before endotracheal extubation are shown in *Tables 1,2*.

After endotracheal extubation, the time in the target SpO_2

Table 1 Baseline demographics and clinical characteristics

Characteristics	Values (n=16)
Age (years)	52 [44–66]
Male sex	10 (62.5)
Body mass index (kg/m^2)	21.3 [16.9–26.4]
Comorbidity	
Hypertension	10 (62.5)
Chronic kidney disease	6 (37.5)
Diabetes	5 (31.3)
Chronic airway disease	3 (18.8)
Cardiovascular disease	2 (12.5)
Malignancy	1 (6.3)
Cause of respiratory failure	
Pneumonia	6 (37.5)
Life-threatening hemoptysis	3 (18.8)
Extrapulmonary sepsis with ARDS	3 (18.8)
Exacerbation of chronic obstructive pulmonary disease	2 (12.5)
Massive pulmonary embolism	1 (6.3)
Diffuse alveolar hemorrhage	1 (6.3)
APACHE II score	22 [18–26]
SOFA score	5 [3–6]
Duration of mechanical ventilation (days)	8 [3–12]

Data are presented as median [interquartile range] or n (%). ARDS, acute respiratory distress syndrome; APACHE, Acute Physiologic and Chronic Health Evaluation; SOFA, Sequential Organ Failure Assessment.

Table 2 Ventilator settings and physiological variables before endotracheal extubation

Variables	Values (n=16)
Mode of ventilation	
Pressure support ventilation	14 (87.5)
Pressure control ventilation	2 (12.5)
Ventilator setting before extubation	
Inspiratory pressure or pressure support (cmH_2O)	8 [8–12]
Positive end-expiratory pressure (cmH_2O)	5 [5–5]
Inspired oxygen fraction	0.30 [0.30–0.40]
Physiological variables before extubation	
Mean arterial pressure (mmHg)	96 [93–105]
Heart rate (beats/minute)	95 [80–104]
Breathing frequency (breaths/minute)	20 [16–20]
Oxygen saturation by pulse oximetry (%)	100 [99–100]
Transcutaneous carbon dioxide pressure (mmHg)	36.5 [32.6–45.5]

Data are presented as median [interquartile range] or n (%).

range was significantly maintained with HVNI with OAM compared to conventional HVNI [99.4% (97.4–99.8%) *vs.* 5.3% (1.5–68.1%), respectively; P=0.001] (*Table 3*); however, SpO_2 was significantly higher 5 minutes after extubation with conventional HVNI compared to HVNI with OAM and was continuously higher until the end of the study period (*Figure 3*). The median use of FiO_2 was significantly lower in the HVNI with OAM group than in the conventional HVNI group after extubation [0.22 (0.21–0.24) *vs.* 0.40 (0.40–0.40), respectively; P=0.001] to 60 minutes [0.22 (0.21–0.25) *vs.* 0.40 (0.40–0.40), respectively; P=0.001] (*Table 4*). A general linear model repeated measures showed no significant interaction between the order of intervention and the time in the target SpO_2 range (F=0.07, P=0.79) indicating that the order of treatment (HVNI with OAM or without OAM) did not affect the time in the target SpO_2 range.

The ROX index in the HVNI with OAM group was significantly higher immediately after extubation compared to conventional HVNI [21.68 (18.59–26.05) *vs.* 12.00 (10.89–15.54), respectively; P=0.001] and continued to be higher than conventional HVNI at the end of the study protocol [22.26 (15.94–26.46) *vs.* 13.01 (10.72–14.66); P=0.001] (*Figure 4*).

There were no significant differences in $PtcCO_2$ and breathing frequency between HVNI with OAM and conventional HVNI throughout the study period (*Table 4*). There were no differences in mean arterial pressure and heart rate at the end of the study protocol (*Table 4*). All enrolled subjects tolerated both interventions until the end of the study and no adverse events were observed. None of the subjects required reintubation within 48 hours after endotracheal extubation.

Discussion

Our study demonstrated that the time in the target SpO_2 range was longer and the ROX index was higher with

Table 3 Percentage of time in the target SpO_2 range between HVNI with OAM and conventional HVNI

Target SpO_2	HVNI with OAM (n=16)	Conventional HVNI (n=16)	P value
Below 92% (%)	0.5 [0.0–2.4]	0.0 [0.0–0.6]	0.20
92–98% (%)	99.4 [97.4–99.8]	5.3 [1.5–68.1]	0.001
Above 98% (%)	0.0 [0.0–0.3]	94.0 [20.2–98.5]	0.001

Data are presented as median [interquartile range]. SpO_2, oxygen saturation by pulse oximetry; HVNI, high-velocity nasal insufflation; OAM, oxygen assist module.

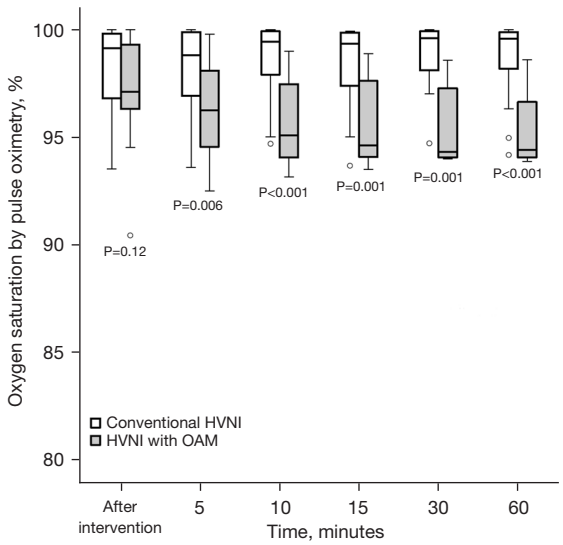

Figure 3 Oxygen saturation by pulse oximetry between HVNI with OAM and conventional HVNI. HVNI, high-velocity nasal insufflation; OAM, oxygen assist module.

HVNI with OAM than with conventional HVNI, whereas the use of FiO_2 was significantly lower with HVNI with OAM in mechanically ventilated subjects after endotracheal extubation. No significant differences were found in other physiological variables such as breathing frequency, $PtcCO_2$, mean arterial pressure, and heart rate between the two groups.

Periextubation period is crucial for mechanically ventilated patients. Postextubation respiratory failure still occurs in approximately 10–20% of patients who are ready to wean and successfully pass a spontaneous breathing trial (2,18). Conventional oxygen therapy is usually administered to prevent or correct this situation; however, maintaining oxygenation within a prespecified target range requires close monitoring and frequent manual adjustments that can increase physician or nurse workload and is time-consuming. In contrast, there is increasing evidence of the harmful effects of hyperoxemia due to oxygen overuse, such as oxygen toxicity, activation of proinflammatory cytokines, and acute lung injury (19,20). Furthermore, several clinical studies showed that hyperoxemia in critically ill patients was associated with poor clinical outcomes (6-8).

An automated oxygen controller system has been developed and used for infants and neonates (21). This allows the automatic adjustment of FiO_2 to maintain SpO_2 measured by pulse oximetry in a predetermined target range. A study by Lellouche and colleagues (22) in 10 healthy subjects who were induced hypoxemia demonstrated that automated oxygen flow titration was more efficient in maintaining SpO_2 in a target range and significantly reduced the rate of severe hypoxemia and hyperoxemia compared to constant oxygen flow. A multicenter randomized controlled study in 187 patients with hypoxemia admitted to the emergency department found that automated oxygen titration significantly improved oxygenation and reduced the duration of oxygen administration compared to manual oxygen titration (23). Another clinical study in 200 patients after major abdominal or thoracic surgery demonstrated that automated closed-loop oxygen administration promoted greater time within a target SpO_2 range and reduced the occurrence of hypoxemia and hyperoxemia compared to standard manual administration (24). In addition, two meta-analyses in patients requiring supplemental oxygen in the hospital and critically ill patients showed that automatic oxygen titration significantly reduced the length of hospital stay and the duration of weaning from mechanical ventilation (25,26).

An automatic oxygen controller has been developed for use with a high-flow oxygen device; however, evidence of the combination of high-flow oxygen therapy with closed-loop oxygen control is scarce. A proof-of-concept randomized crossover study by Harper *et al.* (27) in 42 patients with chronic respiratory disease who underwent a 6-min walk test demonstrated that the HFNC device with closed-loop oxygen controller spent more time in the SpO_2 target range than room air or a fixed oxygen concentration. In

Table 4 Physiologic variables between HVNI with OAM and conventional HVNI

Variables	HVNI with OAM (n=16)	Conventional HVNI (n=16)	P value
FiO_2			
After intervention	0.22 [0.21–0.24]	0.40 [0.40–0.40]	0.001
5 min	0.21 [0.21–0.26]	0.40 [0.40–0.40]	0.001
10 min	0.21 [0.21–0.25]	0.40 [0.40–0.40]	0.001
15 min	0.22 [0.22–0.29]	0.40 [0.40–0.40]	0.001
30 min	0.22 [0.21–0.27]	0.40 [0.40–0.40]	0.001
60 min	0.22 [0.21–0.25]	0.40 [0.40–0.40]	0.001
$PtcCO_2$ (mmHg)			
After intervention	38.2 [34.6–45.9]	39.7 [33.7–49.0]	0.54
5 min	38.3 [34.5–47.5]	39.2 [34.0–47.5]	0.23
10 min	38.6 [34.2–47.5]	38.9 [34.7–47.9]	0.22
15 min	39.1 [33.6–47.6]	39.5 [34.9–48.1]	0.26
30 min	40.4 [33.2–48.2]	40.7 [34.1–50.4]	0.47
60 min	42.6 [35.2–51.6]	41.6 [34.9–54.7]	0.72
Mean arterial pressure (mmHg)			
After intervention	103 [89–114]	96 [83–114]	0.11
5 min	99 [92–112]	91 [79–109]	0.008
10 min	93 [81–108]	92 [82–110]	0.98
15 min	93 [83–106]	93 [86–112]	0.65
30 min	96 [86–109]	96 [82–105]	0.62
60 min	90 [80–102]	96 [90–107]	0.002
Heart rate (beats/minute)			
After intervention	97 [89–112]	97 [82–107]	0.80
5 min	100 [90–110]	89 [80–103]	0.03
10 min	97 [88–106]	87 [76–101]	0.007
15 min	96 [86–108]	89 [75–100]	0.12
30 min	100 [88–110]	96 [81–102]	0.10
60 min	89 [74–104]	101 [83–105]	0.22
Breathing frequency (breaths/minute)			
After intervention	21 [16–22]	20 [16–23]	0.62
5 min	19 [16–22]	20 [17–21]	0.98
10 min	20 [17–21]	21 [17–23]	0.92
15 min	19 [16–22]	19 [17–23]	0.84
30 min	20 [16–22]	19 [16–22]	>0.99
60 min	20 [16–13]	19 [17–23]	0.51

Data are presented as median [interquartile range]. HVNI, high-velocity nasal insufflation; OAM, oxygen assist module; FiO_2, inspired oxygen fraction; $PtcCO_2$, transcutaneous carbon dioxide pressure.

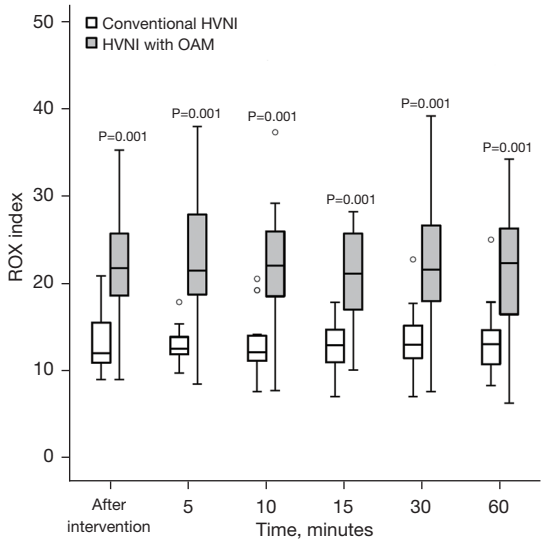

Figure 4 ROX index between HVNI with OAM and conventional HVNI. ROX, respiratory rate oxygenation; HVNI, high-velocity nasal insufflation; OAM, oxygen assist module.

addition, a small randomized crossover study in 22 patients with hypoxemia demonstrated that high-flow oxygen with automatic closed-loop oxygen control achieved better oxygenation than conventional treatment (28). Furthermore, a randomized crossover study by Roca and colleagues in 55 patients with moderate to severe acute hypoxemic respiratory failure under HFNC showed an increase in the percentage of time spent in the optimal oxygenation range with closed-loop oxygen control and a decrease in the workload of healthcare personnel compared to manual oxygen titration (29).

In our study, we used HVNI, which is a high-flow oxygen delivery system that provides a higher velocity of the air-oxygen mixture and higher nasopharyngeal pressure at any given flow rates compared to conventional HFNC (14,15). In addition, previous studies have shown that HFNC provided ventilatory support similar to noninvasive ventilation in patients with acute decompensated heart failure (30) and hypercapnic respiratory failure (31). The combination of the automated oxygen controller system with HVNI in the present study demonstrated a significantly better time in the target SpO_2 range and ROX index than the conventional HVNI. This is the first study to demonstrate the physiological benefits of HVNI with OAM in adult patients after endotracheal extubation. HVNI with OAM maintained oxygenation within the target SpO_2 range better than conventional HVNI, whereas no differences in the occurrence of hypoxemia were observed between the two interventions. In addition, conventional HVNI had significantly longer time spent with SpO_2 >98%, which may increase the risk of hyperoxemia after extubation. We also found that the ROX index, which can be used to predict the success of HFNC after extubation (32-34), was significantly higher with HVNI with OAM compared to conventional HVNI. Higher ROX index in the intervention group primarily due to lower use of FiO_2 which means that most enrolled subjects may not require higher FiO_2 after extubation and should be titrated to maintain the appropriate target SpO_2 according to the patient's status and underlying lung disease. This finding will promote the rationale for the use of oxygen therapy after extubation using an automatic oxygen controller system with high-flow oxygen therapy. However, we did not evaluate the effect of HVNI with OAM on clinical outcomes and workload of healthcare personnel, so it should be further evaluated in a larger study.

Our study had some limitations. First, this was a proof-of-concept physiological study with a small number of enrolled subjects. Second, this study was unblinded and we had no washout period between the two interventions, which may have affected the results. Third, the duration of treatment was relatively short and may not have been sufficient to determine its effect on clinical outcomes. Forth, performance bias by medical personnel may occur in the conventional HVNI group when the enrolled subjects were in a stable condition and did not receive lowering FiO_2 administration so our findings might not be generalizable to all healthcare settings. Finally, the ROX index has been validated and used to predict the outcome of HFNC in patients with acute hypoxemic respiratory failure (16,35); however, there is growing evidence of this index to predict the risk of reintubation in patients after extubation (32-34). Further studies are needed to elucidate the clinical effects of HVNI with OAM.

Conclusions

The implementation of HVNI with OAM can maintain SpO_2 within the target range while using a significantly lower FiO_2 compared to conventional HVNI. Furthermore, HVNI with OAM provides a higher ROX index than conventional HVNI without significant differences in other physiological variables between the two groups.

Acknowledgments

The authors gratefully acknowledge Miss Khemjira Karaketklang (Department of Medicine, Faculty of Medicine Siriraj Hospital, Mahidol University) for her assistance with sample size calculation and statistical analysis.

Footnote

Reporting Checklist: The authors have completed the CONSORT reporting checklist. Available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-1345/rc

Trial Protocol: Available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-1345/tp

Data Sharing Statement: Available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-1345/dss

Peer Review File: Available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-1345/prf

Funding: Devices including OAM, disposable high-flow nasal cannula circuits, and nasal cannula were generously provided by Vapotherm Inc. (New Hampshire, USA); however, the company had no role in the conduct of the study, data analysis, or writing of the manuscript.

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-1345/coif). N.R. reports that devices including oxygen assist module, disposable high-velocity nasal insufflation circuits, and nasal cannula were provided by Vapotherm Inc. (New Hampshire, USA). The other authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. This study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Siriraj Institutional Review Board (certificate of approval No. Si 470/2022) and informed consent was obtained from all individual participants or their relatives.

References

1. Boles JM, Bion J, Connors A, et al. Weaning from mechanical ventilation. Eur Respir J 2007;29:1033-56.
2. Béduneau G, Pham T, Schortgen F, et al. Epidemiology of Weaning Outcome according to a New Definition. The WIND Study. Am J Respir Crit Care Med 2017;195:772-83.
3. Thille AW, Richard JC, Brochard L. The decision to extubate in the intensive care unit. Am J Respir Crit Care Med 2013;187:1294-302.
4. Maggiore SM, Battilana M, Serano L, et al. Ventilatory support after extubation in critically ill patients. Lancet Respir Med 2018;6:948-62.
5. O'Driscoll BR, Howard LS, Earis J, et al. BTS guideline for oxygen use in adults in healthcare and emergency settings. Thorax 2017;72:ii1-ii90.
6. Helmerhorst HJ, Roos-Blom MJ, van Westerloo DJ, et al. Association Between Arterial Hyperoxia and Outcome in Subsets of Critical Illness: A Systematic Review, Meta-Analysis, and Meta-Regression of Cohort Studies. Crit Care Med 2015;43:1508-19.
7. Palmer E, Post B, Klapaukh R, et al. The Association between Supraphysiologic Arterial Oxygen Levels and Mortality in Critically Ill Patients. A Multicenter Observational Cohort Study. Am J Respir Crit Care Med 2019;200:1373-80.
8. de Jonge E, Peelen L, Keijzers PJ, et al. Association between administered oxygen, arterial partial oxygen pressure and mortality in mechanically ventilated intensive care unit patients. Crit Care 2008;12:R156.
9. Ricard JD, Roca O, Lemiale V, et al. Use of nasal high flow oxygen during acute respiratory failure. Intensive Care Med 2020;46:2238-47.
10. Hernández G, Vaquero C, González P, et al. Effect of Postextubation High-Flow Nasal Cannula vs Conventional Oxygen Therapy on Reintubation in Low-Risk Patients: A Randomized Clinical Trial. JAMA 2016;315:1354-61.

11. Hernández G, Vaquero C, Colinas L, et al. Effect of Postextubation High-Flow Nasal Cannula vs Noninvasive Ventilation on Reintubation and Postextubation Respiratory Failure in High-Risk Patients: A Randomized Clinical Trial. JAMA 2016;316:1565-74.
12. Rochwerg B, Einav S, Chaudhuri D, et al. The role for high flow nasal cannula as a respiratory support strategy in adults: a clinical practice guideline. Intensive Care Med 2020;46:2226-37.
13. Oczkowski S, Ergan B, Bos L, et al. ERS clinical practice guidelines: high-flow nasal cannula in acute respiratory failure. Eur Respir J 2022;59:2101574.
14. Doshi P, Whittle JS, Bublewicz M, et al. High-Velocity Nasal Insufflation in the Treatment of Respiratory Failure: A Randomized Clinical Trial. Ann Emerg Med 2018;72:73-83.e5.
15. Miyazaki Y, Inoue S, Hirose H, et al. High-Velocity Nasal Insufflation Increases Nasopharyngeal Pressure with Flow-Dependent Manner Compared with High Flow Nasal Cannula in Adult Volunteers - A Single-Center Prospective Observational Study. Kobe J Med Sci 2021;67:E92-7.
16. Roca O, Caralt B, Messika J, et al. An Index Combining Respiratory Rate and Oxygenation to Predict Outcome of Nasal High-Flow Therapy. Am J Respir Crit Care Med 2019;199:1368-76.
17. Reynolds PR, Miller TL, Volakis LI, et al. Randomised cross-over study of automated oxygen control for preterm infants receiving nasal high flow. Arch Dis Child Fetal Neonatal Ed 2019;104:F366-71.
18. Esteban A, Frutos-Vivar F, Muriel A, et al. Evolution of mortality over time in patients receiving mechanical ventilation. Am J Respir Crit Care Med 2013;188:220-30.
19. Kallet RH, Branson RD. Should Oxygen Therapy Be Tightly Regulated to Minimize Hyperoxia in Critically Ill Patients? Respir Care 2016;61:801-17.
20. Pannu SR. Too Much Oxygen: Hyperoxia and Oxygen Management in Mechanically Ventilated Patients. Semin Respir Crit Care Med 2016;37:16-22.
21. Mitra S, McMillan D. Automated control of fraction of inspired oxygen: is it time for widespread adoption? Curr Opin Pediatr 2021;33:209-16.
22. Lellouche F, L'her E. Automated oxygen flow titration to maintain constant oxygenation. Respir Care 2012;57:1254-62.
23. L'Her E, Dias P, Gouillou M, et al. Automatic versus manual oxygen administration in the emergency department. Eur Respir J 2017;50:1602552.
24. L'Her E, Jaber S, Verzilli D, et al. Automated closed-loop versus standard manual oxygen administration after major abdominal or thoracic surgery: an international multicentre randomised controlled study. Eur Respir J 2021;57:2000182.
25. Denault MH, Péloquin F, Lajoie AC, et al. Automatic versus Manual Oxygen Titration in Patients Requiring Supplemental Oxygen in the Hospital: A Systematic Review and Meta-Analysis. Respiration 2019;98:178-88.
26. Rose L, Schultz MJ, Cardwell CR, Jouvet P, McAuley DF, Blackwood B. Automated versus non-automated weaning for reducing the duration of mechanical ventilation for critically ill adults and children. Cochrane Database Syst Rev 2013;(6):CD009235.
27. Harper JC, Kearns NA, Maijers I, et al. Closed-Loop Oxygen Control Using a Novel Nasal High-Flow Device: A Randomized Crossover Trial. Respir Care 2021;66:416-24.
28. Rose L, Schultz MJ, Cardwell CR, et al. Automated versus non-automated weaning for reducing the duration of mechanical ventilation for critically ill adults and children. Cochrane Database Syst Rev 2014;2014:CD009235.
29. Roca O, Caritg O, Santafé M, et al. Closed-loop oxygen control improves oxygen therapy in acute hypoxemic respiratory failure patients under high flow nasal oxygen: a randomized cross-over study (the HILOOP study). Crit Care 2022;26:108.
30. Haywood ST, Whittle JS, Volakis LI, et al. HVNI vs NIPPV in the treatment of acute decompensated heart failure: Subgroup analysis of a multi-center trial in the ED. Am J Emerg Med 2019;37:2084-90.
31. Doshi PB, Whittle JS, Dungan G 2nd, et al. The ventilatory effect of high velocity nasal insufflation compared to non-invasive positive-pressure ventilation in the treatment of hypercapneic respiratory failure: A subgroup analysis. Heart Lung 2020;49:610-5.
32. Lee YS, Chang SW, Sim JK, et al. An Integrated Model including the ROX Index to Predict the Success of High-Flow Nasal Cannula Use after Planned Extubation: A Retrospective Observational Cohort Study. J Clin Med 2021;10:3513.
33. Okazaki Y, Nishikimi M, Ishii J, et al. Predictive Accuracy of the ROX Index for Re-Intubation in Mechanically Ventilated Patients With COVID-19. Respir Care 2023;68:1067-74.
34. Kaur R, Alolaiwat AA, Ritz E, et al. A new index,

Respiratory Insufficiency index and Modified Early Warning Scores predict extubation failure. Can J Respir Ther 2023;59:117-22.
35. Roca O, Messika J, Caralt B, et al. Predicting success of high-flow nasal cannula in pneumonia patients with hypoxemic respiratory failure: The utility of the ROX index. J Crit Care 2016;35:200-5.

Cite this article as: Visuthisakchai S, Lersritwimanmaen P, Rittayamai N. High-velocity nasal insufflation with oxygen assist module versus conventional high-velocity nasal insufflation after extubation: an open-label randomized crossover study. J Thorac Dis 2025;17(1):333-343. doi: 10.21037/jtd-24-1345