Effectiveness of High-Flow Nasal Cannula For Tracheal Intubation In The Emergency Department

Yumi Mitsuyama (✉ goto8940@gmail.com)

Osaka University Graduate School of Medicine

Shunichiro Nakao

Osaka University Graduate School of Medicine

Junya Shimazaki

Osaka University Graduate School of Medicine

Hiroshi Ogura

Osaka University Graduate School of Medicine

Takeshi Shimazu

Osaka University Graduate School of Medicine

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Abstract

Background: Tracheal intubation in the emergency department (ED) can cause serious complications. Available evidence on the use of high-flow nasal cannula (HFNC) during intubation in the ED is limited. This study evaluates the effect of oxygen therapy by HFNC on oxygen desaturation during tracheal intubation in the ED.

Methods: This was a single-center before and after study designed to compare two groups that received oxygen therapy during intubation: one received conventional oxygen; the other received oxygen therapy using HFNC. We included non-trauma patients who required tracheal intubation in the ED. A linear regression analysis was performed to evaluate the relationship between oxygen therapy using HFNC and the lowest peripheral oxygen saturation (SpO₂) during intubation in the conventional and HFNC groups.

Results: The study population included 87 patients (conventional group, n=67; HFNC group, n=20). The median lowest SpO₂ in the HFNC group was significantly higher than that in the conventional group (94% [84–99%] vs. 85% [76–91%], p=0.006). The percentage of cases with oxygen desaturation to <90% during the intubation procedure in the HFNC group was significantly lower in comparison to than in the conventional group (40% vs. 63.8%, p=0.037). The use of HFNC was significantly associated with the lowest SpO₂ and the use of HFNC increased the lowest SpO₂ during intubation procedures by 7.7% (p=0.029).

Conclusion: We showed that the use of HFNC during tracheal intubation was associated with a higher lowest SpO₂ during the procedure in comparison to conventional oxygen administration in non-trauma patients in the ED.

Background

Tracheal intubation in the emergency department (ED) is associated with a higher incidence of serious complications and higher mortality in comparison to prepared settings, such as the operating room [1]. Mort et al. reported that 2% of critically ill patients experienced cardiac arrest during emergency intubation, and peripheral oxygen saturation (SpO₂) decreased below 70% in 83% of these cases [2]. Patients who require emergency intubation in the ED are critically ill and unstable, and it may not be easy to predict a difficult intubation because of the urgency of the situation [3]. For these reasons, the risk of hypoxemia is higher during emergency intubation in the ED, and the administration of oxygen during intubation is more important to avoid hypoxemia during the intubation procedure in comparison to during intubation in prepared settings [4].

In oxygen therapy, high-flow nasal cannula (HFNC) is used for the nasal delivery of heated and humidified oxygen at high flow rates. HFNC is widely used in the intensive care unit (ICU) for patients with acute hypoxic respiratory failure in an attempt to avoid tracheal intubation or for oxygen therapy after extubation [5]. In recent years, there have been several reports of the usage of HFNC in oxygen therapy

during intubation maneuvers [6, 7]. Oxygen therapy using an HFNC was shown to be useful in comparison to conventional oxygen administration for preoxygenation before the induction of general anesthesia [8, 9]. Vourc'h et al. showed that the usage of HFNC was not associated with an increase in adverse effects in comparison to conventional oxygen administration before intubation in the ICU [10]. Guitton et al. also showed the usefulness of the HFNC in oxygen therapy during rapid sequence intubation (RSI) in the ICU and that apneic oxygenation with HFNC could extend the time to critical oxygen desaturation [11].

Although the usage of HFNC in oxygen therapy during intubation in the ICU and operating room has been shown to be useful, available evidence on its usage during intubation in the ED is limited. Thus, we aimed to evaluate the effect of oxygen administration by HFNC on oxygen desaturation during tracheal intubation in non-trauma patients who required tracheal intubation in the ED.

Methods

Study design

This was a single-center before and after study. This study was approved by the institutional review board of Osaka University (approval no. 19142). Since all data for this study were obtained from patient medical records, the requirement for consent from individual patients was waived.

Setting

This study was performed at the Trauma and Acute Critical Care Center of Osaka University Hospital, a 1086-bed referral and tertiary-care hospital in Osaka, Japan. Our center has 19 ICU beds and treated 1214 critical ill patients in 2018. The staff members are familiar with the use of HFNC. The study period was 1 year and 5 months, from October 2018 to March 2020. From October 2018 to September 2019, tracheal intubation was performed under conventional oxygen administration (conventional group), and from October 2019 to March 2020, tracheal intubation was performed using HFNC (HFNC group). A one-week period from September 24 to 30, 2019, was set as a washout period.

Participants

We included non-trauma patients of ≥ 18 years of age who required tracheal intubation and who were treated in the ED. Patients with non-traumatic cardiopulmonary arrest at the time of admission were excluded from the study. Furthermore, patients whose records were missing SpO₂ data and cases in the HFNC group in which HFNC was not used because equipment was unavailable were excluded from the analysis.

Procedures

In the conventional group, oxygen administration was started using a bag-valve mask (BVM) with a reservoir bag from the time when tracheal intubation was decided. Oxygen was administered at a rate of 10 L/min. Sedatives, analgesics and neuromuscular blocking agents were administered at the discretion

of the emergency physicians. In the HFNC group, a nasal interface (Optiflow™, Fisher & Paykel Healthcare, Auckland, New Zealand) connected to HFNC (Airvo™2, Fisher & Paykel Healthcare, Auckland, New Zealand) was attached to the patient from the time when tracheal intubation was decided. The inspiratory fraction of oxygen (FiO₂) was set to 1.0 with a flow of 60 L/min. The gas was heated to 37°C and humidified. The HFNC was used continuously until the tracheal tube was connected to the ventilator. Intubation equipment, sedatives, analgesics, neuromuscular blocking agents, and intubation maneuvers were performed according to the usual methods. All tracheal intubations in the ED were performed by experienced emergency physicians. Intubation was performed using a Macintosh laryngoscope or McGrath™ MAC video laryngoscope (Medtronic, Minneapolis, MN). The following medications were available for tracheal intubation in the ED: propofol, midazolam and ketamine (as sedatives), fentanyl (as an analgesic), and rocuronium (as a neuromuscular blocking agent).

Variables

Demographic variables included age, sex, and body mass index (BMI). The clinical data in the ED included SpO₂, heart rate, systolic blood pressure, respiratory rate, and Glasgow coma scale. Arterial blood gas was collected immediately after arrival at the ED. The severity of the patient's illness on admission was assessed by the Sequential Organ Failure Assessment (SOFA) score and the Acute Physiologic Assessment and Chronic Health Evaluation (APACHE) II score. The initial diagnosis on admission was noted according to the medical records. Septic shock was defined according to the Sepsis-3 criteria, and hemorrhagic shock was defined as shock with a systolic blood pressure of <90 mmHg due to bleeding, such as gastrointestinal bleeding [12]. Cardiogenic shock was extracted from the emergency physician's medical record. The primary endpoint was the lowest SpO₂ during the intubation procedure from the administration of the induction drug to tracheal tube placement. In the emergency department, SpO₂ was measured by a pulse oximeter and was automatically recorded every 3 seconds, and the lowest SpO₂ was defined as the lowest level of SpO₂ during tracheal intubation. The secondary outcome was the percentage of cases with SpO₂ <90% during intubation procedure. Length of mechanical ventilation, length of ICU stay, ICU mortality, and 28-day mortality were also evaluated.

Sample size

The sample size was estimated based on previous studies, assuming that the standard deviation of the lowest SpO₂ was 12% and that the use of HFNC would improve the lowest SpO₂ by 5% over conventional oxygen administration [10]. We calculated an alpha error of 0.05 and a power of 0.8, assuming a dropout rate of 10% (e.g., missing data) and expected to enroll 100 patients in each group. However, enrollment was terminated mid-study due to restrictions on the use of HFNC in the emergency department after March 2020 due to the novel coronavirus infection epidemic.

Statistical analysis

Continuous variables are shown as the median and interquartile range (IQR), while categorical variables are shown as frequencies and percentages. The Wilcoxon rank-sum test was used to test continuous

variables, while Fisher's exact test was used to test the nominal variables. A linear regression analysis, with adjustment for age, use of neuromuscular blocking agents and APACHE II score was performed to evaluate the relationship between the use of HFNC and the lowest SpO₂ during intubation in the conventional and HFNC groups. All analyses were performed using JMP 15 (SAS Institute Inc., Cary, NC, USA).

Results

Figure 1 shows a flow diagram of the present study. Sixty-seven patients in the conventional group and 20 patients in the HFNC group were included in the analysis.

Table 1 shows the patient characteristics of each group. The median initial SpO₂ was 96% (IQR 83-99%) in the HFNC group and 94% (IQR 84-99%) in the conventional group. The median Glasgow coma scale was 13 (IQR 7-15) in the HFNC group and 9 (IQR: 6-14) in the conventional group. The APACHE II score of the conventional group was significantly higher than that of the HFNC group (17 [IQR 8-24] vs. 24 [IQR 17-27], $p=0.007$). In both groups, the most frequent diagnosis was stroke, followed by pneumonia. The most frequent indication for intubation was consciousness disorder (50.0% in the HFNC group and 50.7% in the conventional group), followed by hypoxemia (30.0% in the HFNC group and 25.4% in the conventional group). In both groups, most patients were intubated using sedatives (90.0% in the HFNC group and 85.1% in the conventional group), and neuromuscular blocking agents (80.0% in the HFNC group and 67.2% in the conventional group).

Table 2 shows the outcomes. The median lowest SpO₂ in the HFNC group was significantly higher than that in the conventional group (94% [IQR 84–99%] vs. 85% [IQR 76–91%], $p=0.006$). The median length of mechanical ventilation in the HFNC group was significantly shorter than that in the conventional group (3 days [IQR 2–6 days] vs. 7 days [IQR 3–11 days], $p=0.006$). The median length of ICU stay in the HFNC group was significantly shorter than that in the conventional group (7 days [IQR 4–15 days] vs. 13 days [IQR 8–19 days], $p=0.038$). The percentage of cases with oxygen desaturation to <90% during intubation procedure in the HFNC group was significantly lower than that in the conventional group (8/20 [40%] vs. 44/67 [63.8%], $p=0.037$).

The results of the multiple regression analysis are shown in Table 3. It was adjusted for four variables: HFNC, age, use of neuromuscular blocking agents, and APACHE II score. The lowest SpO₂ in the HFNC group was significantly higher than that in the conventional group (estimated difference 7.7%, 95% confidence interval 0.803-14.675%, $p=0.029$).

Discussion

We showed that the use of HFNC increased the lowest SpO₂ during the intubation procedure by 7.7% in non-trauma patients who required tracheal intubation in the ED. The use of intermittent oxygenation with

HFNC may have reduced the occurrence of hypoxemia in non-trauma patients who required tracheal intubation in the ED and made the intubation procedure safer.

Guitton et al. reported that the use of an HFNC during intubation in 184 patients with non-severe hypoxemia in the ICU did not result in a significant difference in the lowest SpO₂ during the intubation procedure in comparison to the administration of conventional oxygen; however, it resulted in fewer instances of desaturation to <95% in the HFNC group [11]. In the present study, the percentage of cases with desaturation to <90% during the intubation procedure was lower in the HFNC group than that in the conventional group, but the lowest SpO₂ in both groups was lower than that of Guitton et al. The potential reason for the low lowest SpO₂ during the intubation procedure may be that the intubation in our study was not RSI. The use of neuromuscular blocking agents for emergency intubation in critically ill patients has been shown to increase the initial success rate of intubation [13]. The initial success rate of intubation in the ED in Japan has been reported to be 40-83%, which may be lower in comparison to North America and Korea; thus, the use of HFNC during intubation may be useful [14].

Vourc'h M et al. reported on the use of HFNC in 124 hypoxemic patients who required intubation in the ICU and noted that the median lowest SpO₂ was 91.5% (80-96%) in the HFNC group and 89.5% (81-95%) in the conventional group (p=0.44) [10]. The reason for the 7.7% increase in the lowest SpO₂ in our study may be that the patient characteristics and settings differed from previous studies. The use of HFNC during the intubation procedure may be more useful in the ED setting than in the ICU. The effect of HFNC during intubation on the lowest SpO₂ might differ depending on the indication for intubation and there might be more appropriate population, although this was not assessed in the present study. Since Jean Mace et al. reported that the use of HFNC improved hypoxemia in patients with acute hypoxemic respiratory failure in the ED, the use of HFNC in the ED for patients at risk of hypoxemia may be useful for preventing hypoxemia [15].

In the present study, there were significant differences in the duration of mechanical ventilation and the length of ICU stay in both groups. Although John et al. reported delayed complications, such as respiratory tract infection, after emergency intubation, it is difficult to evaluate the relationship between the lowest SpO₂ during intubation procedure and the length of mechanical ventilation and length of ICU stay [16]. The APACHE II score was significantly higher and the Glasgow coma scale was lower in the conventional group than in the HFNC group, which may be because the conventional group included more critically ill patients.

Limitations

The present study was associated with some limitations. First, the number of cases was relatively small because the study had to be interrupted due to the novel coronavirus disease outbreak, which occurred during the study period. This interruption may have resulted in seasonal variations in the number of patients. The severity of disease varied in each group; however, the severity was adjusted by a multiple regression analysis. Second, because this was a before and after study, there may be unadjusted

confounding factors, such as devices and drugs used for intubation and the skill level of the physicians. However, there was no change in available devices or medications used for intubation, nor was there a change in staff members. To minimize potential confounding factors, we performed a multivariable analysis and the results from univariable and multivariable analyses were consistent. Third, the technique of the physician who performed the intubation was not analyzed. Cook et al. reported immaturity of the physician's technique was a risk factor for intubation failure and adverse events [17]. However, since all tracheal intubations in this study were performed by experienced emergency physicians, we believe this potential bias was minimal. Fourth, some cases were excluded from this study. Because of the limited amount of HFNC available in the ED, there were cases in the HFNC group for which HFNC could not be used. Finally, since we did not collect information on the assessment of difficult intubation, we were not able to adjust for the related factors.

Conclusions

We showed that the use of HFNC during tracheal intubation was associated with a higher lowest SpO₂ during the procedure than conventional oxygen administration in non-trauma patients in the ED. Our results suggest that the use of HFNC during tracheal intubation can be helpful for safer intubation in the ED.

List Of Abbreviations

ED, emergency department; HFNC, High-flow nasal cannula; SpO₂, peripheral oxygen saturation; ICU, intensive care unit; FiO₂, inspiratory fraction of oxygen; RSI, rapid sequence intubation; BVM, bag-valve mask; BMI, body mass index; SOFA, sequential organ failure assessment; APACHE, acute physiologic assessment and chronic health evaluation; IQR, interquartile range;

Declarations

Ethics approval and consent to participate

This study was approved by the institutional review board of Osaka University (approval no. 19142). The requirement for consent from individual patients was waived. The study was conducted in accordance with the Declaration of Helsinki.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

YM conceived the study. YM and JS designed the study. YM collected data. YM and SN analyzed and interpreted data. YM wrote the draft of manuscript. TS organized and supervised the study. SN, JS, HO and TS critically reviewed the manuscript. All authors approved the final manuscript.

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Tables

Tables 1-3 are available in the Supplemental Files section.

Figures

Figure 1

Patient flow in the present study.

CPA, Cardiopulmonary arrest; HFNC, High flow nasal cannula.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Tables.docx](#)