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journal homepage: www.elsevier.com/locate/resinv

Original article

Clinical practice of high-flow nasal cannula therapy in COVID-19 pandemic era: a cross-sectional survey of respiratory physicians

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ARTICLE INFO

Article history:
Received 26 June 2022
Received in revised form
1 August 2022
Accepted 22 August 2022
Available online 12 September 2022

Keywords:
High-flow nasal cannula
COVID-19
Non-invasive ventilation
Respiratory physician

ABSTRACT (248 WORDS)

Background: Despite the rapid widespread use of a high-flow nasal cannula (HFNC) during the COVID-19 pandemic, its indications and appropriate use as perceived by physicians remain poorly known.

Methods: In September 2021, we sent a questionnaire to each respiratory physician from 15 institutions in Shizuoka prefecture, Japan. In this survey, we compared the perceptions of HFNC indications and interventions during implementation to those of non-invasive ventilation (NIV) and invasive mechanical ventilation (IMV). Furthermore, this study examined concerns about SARS-CoV-2 infection spread and psychological distress experienced among respondents.

Results: Of the 140 respiratory physicians contacted, 87 (62.1%) completed the survey. The results indicate that 96.5% of the respondents agreed with the indication of HFNC for COVID-19, whereas only 13.7% agreed with NIV. The physicians reported that patients with HFNC had a lower frequency of sustained sedation, physical restraint, and implementation in the ICU than that of patients with NIV and IMV. The HFNC was introduced as a respiratory modality following conventional oxygen therapy (COT) in patients with COVID-19, regardless of full or do-not-intubate codes. Additionally, they reported that patients with COVID-19 switched from COT to HFNC significantly earlier than those without COVID-19. Simultaneously, this survey revealed persistent concerns of SARS-CoV-2 infection spread and psychological distress (47.1% and 53.3%, respectively) among respiratory physicians during HFNC use.

Conclusion: Clinically, HFNC is considered useful for COVID-19 patients by most respiratory physicians. However, HFNC remains a concern for COVID-19 spread and psychological distress among several respiratory physicians, indicating the need for urgent action.

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https://doi.org/10.1016/j.resinv.2022.08.007

Abbreviations

COVID-19	coronavirus disease 2019
HFNC	high-flow nasal cannula
IMV	invasive mechanical ventilation
NIV	non-invasive ventilation
COT	conventional oxygen therapy
ICU	intensive care unit
COPD	chronic obstructive pulmonary disease
DNI	do-not-intubate

1. Introduction

High-flow nasal cannula (HFNC) oxygen therapy has been increasingly used in recent years for various medical conditions. Using a large-caliber nasal cannula, it delivers high-flow rates of heated humidified gas at controlled oxygen concentrations with less discomfort. Due to the coronavirus disease 2019 (COVID-19) pandemic caused by the novel coronavirus SARS-CoV-2, HFNC use has increased exponentially, attracting both healthcare and non-healthcare workers [1].

In recent years, there has been an increase in reports revealing the benefits of HFNC. According to existing international guidelines, HFNC should be used instead of conventional oxygen therapy (COT) in the acute hypoxemic respiratory failure [2,3]. However, since the existing evidence is based on heterogeneous populations, more quality research is needed to identify medical conditions that are more likely to benefit from HFNC. Although HFNC is considered less invasive and patient-friendly, its ability to reduce invasive procedures such as physical restraints remains unclear. Moreover, aerosol generation during HFNC use has raised concerns about the potential of spreading infectious diseases [4]. Recently, several reports have indicated that HFNC—when used properly—does not increase the risk of SARS-CoV-2 infection [5,6]. However, many healthcare workers experienced certain psychological distress during the COVID-19 pandemic, particularly those caring for patients using HFNC [7,8]. To better understand these questions, the perceptions and practices of physicians, who frequently use HFNC, are needed.

Therefore, this study aimed to conduct a web-based survey among respiratory physicians who frequently use HFNC in their daily practice. Furthermore, this survey examined the clinical indications of HFNC and medical interventions during HFNC in comparison with other respiratory devices, such as non-invasive ventilation (NIV) and invasive mechanical ventilation (IMV). In this study, we also explored the differences in HFNC management between COVID-19 and non-COVID-19 cases, as well as concerns about the risk of spreading SARS-CoV-2 infection and psychological distress among respiratory physicians induced by HFNC.

2. Materials and methods

2.1. Study procedures

A cross-sectional survey was conducted among respiratory physicians to examine the indications and current clinical practice of HFNC. The survey was conducted during the five waves of the COVID-19 pandemic in Japan. During this period, the Delta variant was widely spread in Shizuoka Prefecture, and the occupancy rate of beds for COVID-19 exceeded 70% [9]. This survey used an electronic questionnaire via the online software Microsoft Forms® (https://www.microsoft.com/ja-jp/microsoft-365/online-surveys-polls-quizzes). Three respiratory physicians (T.K, Y.S, and T.S.) developed the questionnaire. In September 2021, we asked respiratory physicians from 15 institutions in Shizuoka Prefecture, Japan, to complete the survey via email. One month later, nonrespondents were contacted again. The survey was conducted anonymously, and respondents were allowed to skip some questions. Considering the national policies of Japan, no ethics committee approval was required for the study protocol.

2.2. Questionnaire description

Additional File 1 presents the complete questionnaire. This questionnaire consisted of four sections. The first section asked about the respondents' characteristics (sex, years of physician experience, board-certified member of the Japanese Respiratory Society, HFNC experience, NIV, and IMV). The second section asked about the respondent's perception of HFNC indications for medical conditions and potential physiological and device benefits. As a comparison, the same questions were asked for an NIV. In the third section, we asked about medical interventions (i.e., physical restraint, sedation, the location for HFNC use, being at the bedside during induction, and arterial blood gas analysis) during HFNC implementation; the same questions were also asked for NIV and IMV. The respondents answered these questions based on their usual practice in patients with or without COVID-19. The final section addressed the daily clinical practice of HFNC in patients with COVID-19, concerns over the risk of spreading SARS-CoV-2 infection during HFNC application, and psychological distress experienced.

2.3. Statistical analysis

The respondents' baseline characteristics and survey results concerning daily practice were summarized and presented as numbers (with percentages), medians (with ranges), and means (with standard deviations [SD]), as appropriate. For comparing two or three groups (i.e., HFNC vs. NIV, HFNC vs. NIV vs. IMV, and COVID-19 vs. non-COVID-19), we used Fischer's exact test for categorical variables. In addition, Student's *t*-test or one-way analysis of variance (ANOVA) and post hoc testing for quantitative variables, as appropriate; Post hoc tests were restricted with Bonferroni correction. Significant differences were determined using a two-sided test, with the significance level set at $P < 0.05$. All statistical data were analyzed using the software EZR version 1.52 (Saitama Medical Center, Jichi Medical University, Saitama, Japan), which is a graphical user interface for R version 4.02 (The R Foundation for Statistical Computing, Vienna, Austria) [10].

3. Results

3.1. Respondents' characteristics

Of the 140 respiratory physicians contacted, 87 (62.1% response rate) completed the survey, with 75 (86.2%) males

and a median of 12 (3–36) years of physician experience. In addition, 61 respiratory physicians (70.1%) were board-certified members of the Japanese Respiratory Society, while 22 (25.3%) worked at a university hospital. Most of the respondents had prior experience applying HFNC, NIV, and IMV, with a median of 10 (0–50), 4 (0–30), and 2 (0–20) cases per year, respectively (Table 1).

Table 1 – Respondents' characteristics.

	Respondents n = 87
Sex	
Male	75 (86.2)
Female	12 (13.8)
Physician experience, years	12 (3–36)
Board-certified member of the JRS, yes	61 (70.1)
Institution	
University hospital	22 (25.3)
Community hospital	65 (74.3)
HFNC experience, yes	85 (97.7)
HFNC cases per year	10 (0–50)
NIV experience, yes	87 (100)
NIV cases per year	4 (0–30)
IMV experience, yes	85 (97.7)
IMV cases per year	2 (0–20)

Categorical variables are expressed as numbers (percentage). Quantitative variables are expressed as median (range).
JRS, Japanese Respiratory Society; HFNC, high-flow nasal cannula; NIV, non-invasive ventilation; IMV, invasive mechanical ventilation.

3.2. *Physicians' perceptions of HFNC indications and its benefits*

The majority of the respondents (96.5%) agreed with the HFNC indication for COVID-19 (totally agreed, 37.9%; rather agreed, 58.6%), whereas only 13.7% agreed with the NIV indication for COVID-19 (totally agreed, 1.1%; rather agreed, 12.6%). Post-extubation and do-not-intubate (DNI) status, followed by an acute exacerbation of interstitial lung disease (AE-ILD), acute respiratory failure in immunocompromised patients, acute respiratory distress syndrome, and terminally ill cancer were the most preferred indications of HFNC. However, physicians perceived that HFNC is not indicated for acute severe asthma, COPD exacerbation, cardiac pulmonary edema, and thoracic wall deformity (Fig. 1); instead, these conditions were perceived as good indications of NIV. Moreover, while AE-ILD and terminally ill cancer were considered as good indications of HFNC, they were perceived as less suitable for NIV (Fig. 1).

Among the previously reported potential device advantages of HFNC [1], "Keeping conversation and eating ability," "Avoiding intubation," "Improvement of dyspnea," and "High tolerability" were the most agreeable according to most of the physicians. Conversely, "Secretion mobilization," "Clearance of anatomic dead space in upper airways," and "Increase of positive end-expiratory pressure and end-expiratory lung volume" in HFNC were controversial among respiratory physicians (Fig. 2).

3.3. *Differences in interventions and management between HFNC and NIV or IMV*

Fig. 3 illustrates the results of interventions during respiratory management. Patients with HFNC had a lower frequency of sustained sedation than those with NIV and IMV (HFNC: 6.0% vs. NIV; 20.5% vs. IMV; 96.6%, $P < 0.001$, one-way ANOVA). Likewise, patients with HFNC had significantly lower frequencies of physical restraint during treatment (10.8% vs. 28.0% [NIV] vs. 79.0% [IMV], $P < 0.001$). Consequently, HFNC was more less often initiated in the intensive care unit (ICU) than NIV or IMV (16.7% vs. 27.4% vs. 75.3%, $P < 0.001$).

When initiating HFNC, there were fewer direct commitments with the respiratory physician than when initiating NIV or IMV at the bedside (77.8% vs. 91.4% vs. 96.1%, $P < 0.001$). Moreover, arterial gas analyses were less likely performed around HFNC initiation than around NIV or IMV initiation (at initiation; 65.8% vs. 86.2% vs. 92.0%, $P < 0.001$ and 2 h later; 44.9% vs. 75.5% vs. 91.9%, $P < 0.001$).

3.4. *Indications of HFNC in COVID-19 in the real-world setting*

Among the 87 physicians who completed this survey, 70 (80.4%) had experience in using HFNC for patients with COVID-19. According to them, HFNC was mostly used after COT to maintain oxygenation among patients with COVID-19, accounting for 80.6% and 82.4% of patients with full and DNI codes, respectively. According to the criteria for step-up from COT to HFNC, COT was switched to HFNC significantly earlier in patients with COVID-19 than in those without. The most frequent oxygen flow rate of COT for HFNC step-up was 5 L/min and 8 L/min in patients with and without COVID-19, respectively (Fig. 4A). Meanwhile, the step-up of NIV or IMV from HFNC was not significantly different between patients with and without COVID-19.

3.5. *Persistent concerns and psychological distress about HFNC use during COVID-19*

None of the respiratory physicians who used HFNC for patients with COVID-19 had acquired COVID-19 or experienced pseudo-symptoms. However, 47.1% of them had concerns about the risk of acquiring SARS-CoV-2 infection caused by HFNC therapy during COVID-19 treatment. Notably, 53.3% of respiratory physicians experienced psychological distress resulting from HFNC therapy when caring for patients with COVID-19 (Fig. 5).

4. Discussion

This cross-sectional study revealed that most respiratory physicians agreed with COVID-19 as an indication of HFNC. According to them, HFNC can maintain patients' daily activities by reducing the need for continuous sedation and physical restraints. Consequently, HFNC was introduced as a respiratory modality following COT in patients with COVID-19. Despite the clinical utility and frequent applications of HFNC for patients with COVID-19, respiratory physicians were persistently concerned that they might be infected with SARS-CoV-2 through its use. Of note, approximately half of the study population had experienced psychological distress during HFNC care.

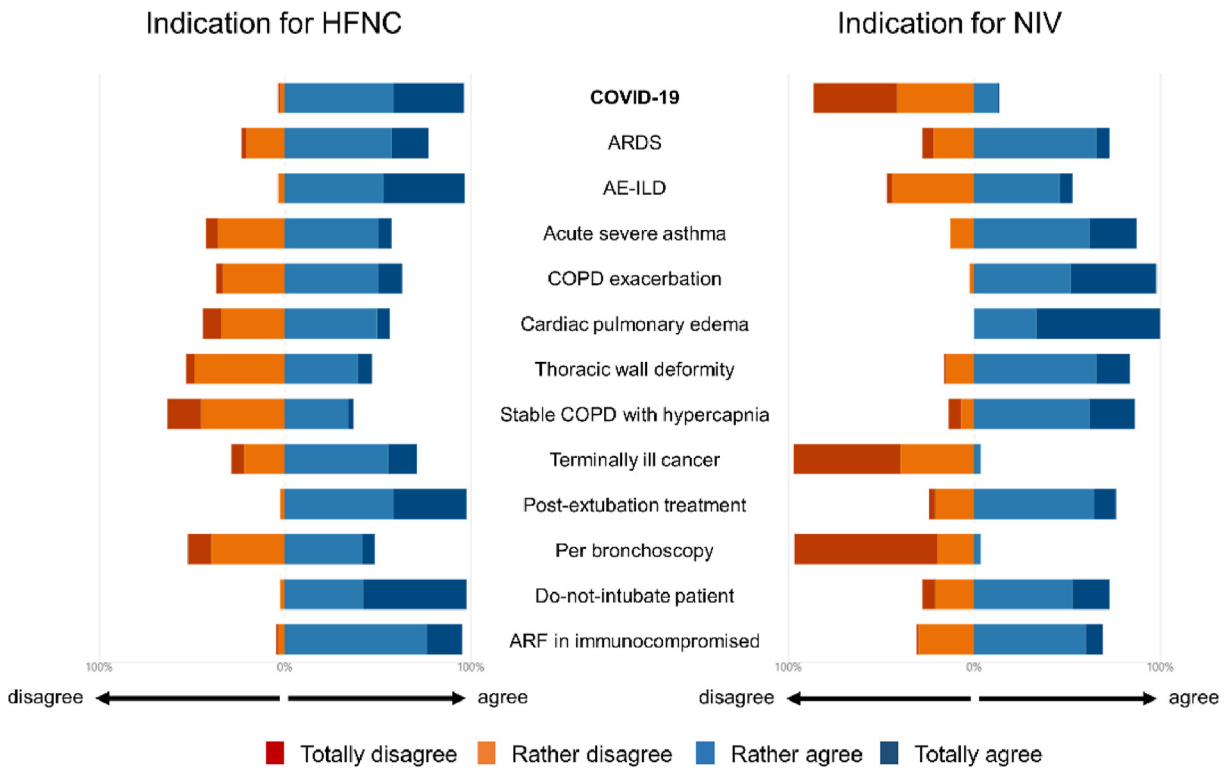

Fig. 1 – The proportion of agreement among respiratory physicians on various potential indications for HFNC and NIV. HFNC, high-flow nasal cannula; IMV, invasive mechanical ventilation; NIV, non-invasive ventilation; COVID-19, coronavirus disease 2019; ARDS, acute respiratory distress syndrome; AE-ILD, acute exacerbation of acute interstitial lung disease; COPD, chronic obstructive pulmonary disease; ARF, acute respiratory failure.

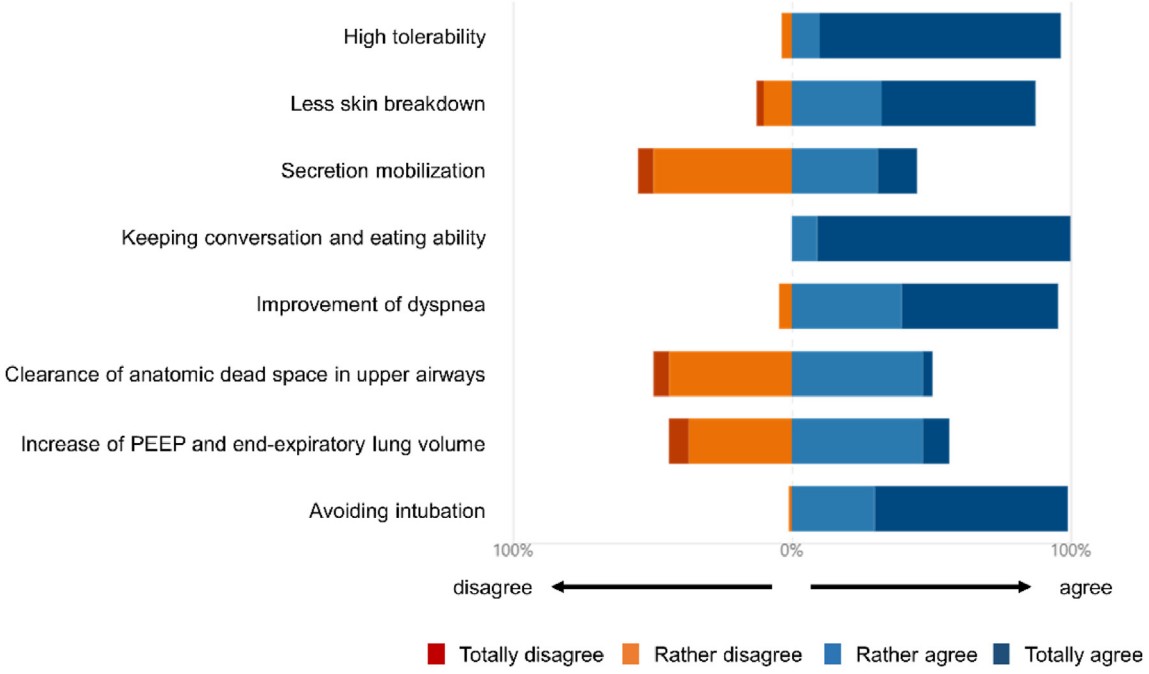

Fig. 2 – The proportion of agreement among respiratory physicians on the potential physiological and device benefits of HFNC. HFNC, high-flow nasal cannula; PEEP, positive end-expiratory pressure.

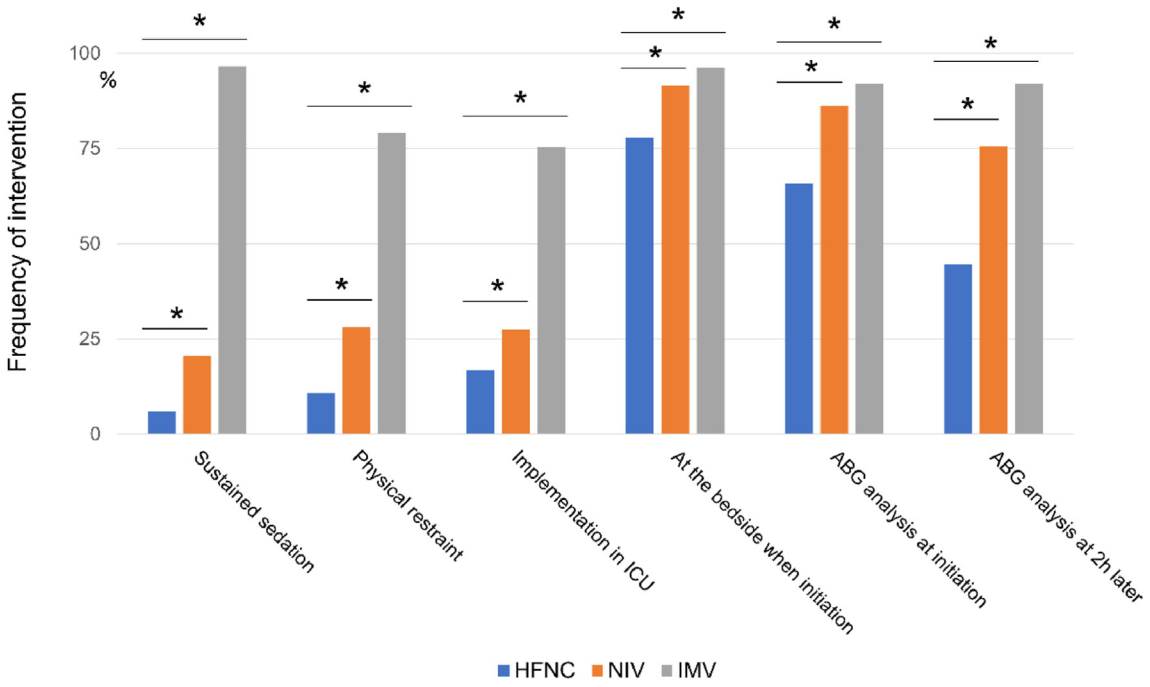

Fig. 3 – Frequency of interventions during respiratory management among patients with or without COVID-19. *P < 0.05 (P values were restricted with Bonferroni correction.)COVID-19, coronavirus disease 2019; HFNC, high-flow nasal cannula; IMV, invasive mechanical ventilation; NIV, non-invasive ventilation; ICU, intensive care unit; ABG, arterial blood gas.

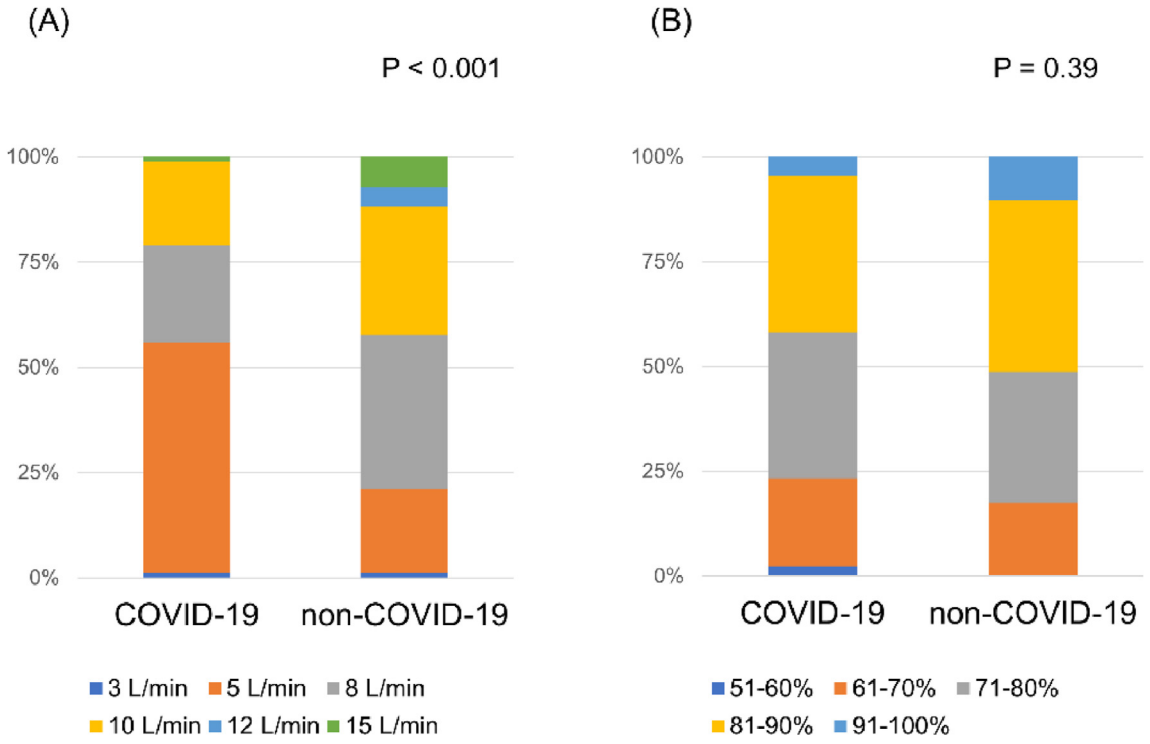

Fig. 4 – Differences in HFNC treatment strategies between COVID-19 and non-COVID-19 cases. (A) The proportion of COT oxygen flow rate to consider step-up from COT to HFNC. (B) The proportion of FiO_2 to consider step-up from HFNC to the next respiratory modality. HFNC, high-flow nasal cannula; COVID-19, coronavirus disease 2019; COT, conventional oxygen therapy; FiO_2, fraction of inspiratory oxygen.

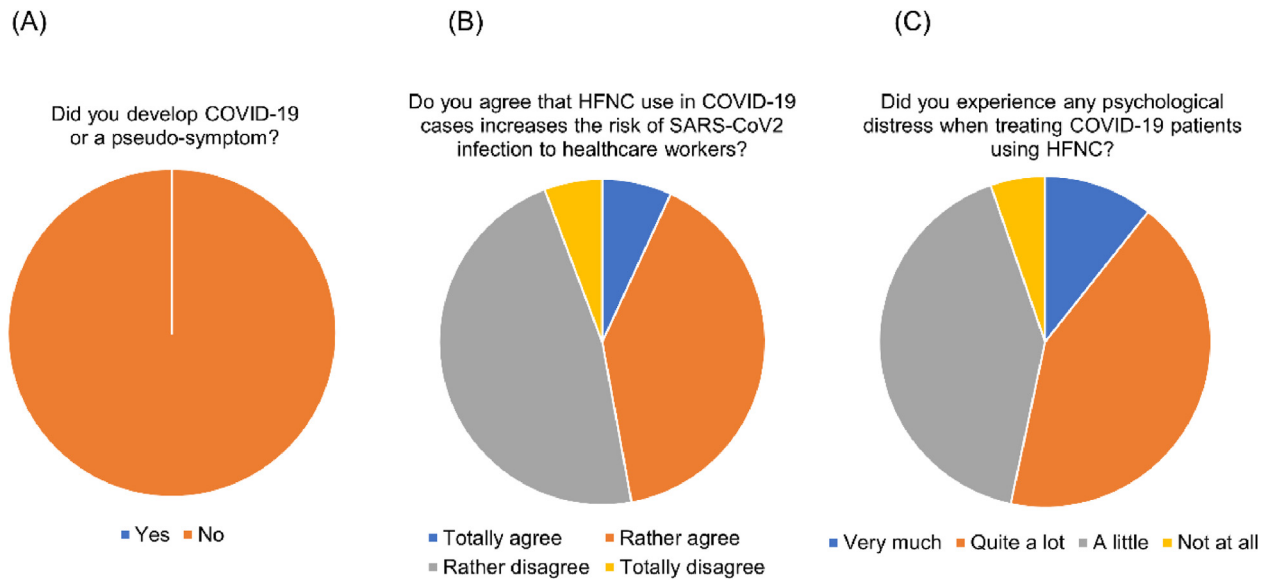

Fig. 5 – (A) The proportion of respiratory physicians who developed COVID-19 or pseudo-symptoms after caring for patients with COVID-19 using HFNC. (B) The proportion of opinion of respiratory physicians on whether HFNC use increases the risk of spreading SARS-CoV2 infection to healthcare workers. (C) The proportion of respiratory physicians who experienced psychological distress when caring for patients with COVID-19 using HFNC. HFNC, high-flow nasal cannula; COVID-19, coronavirus disease 2019.

Collectively, HFNC is clinically beneficial in patients with COVID-19. However, opportunities to provide appropriate information for physicians and coworkers who engaged in patients with COVID-19 are still limited, requiring urgent attention.

According to a randomized clinical trial, HFNC is superior to COT for reducing tracheal intubation in COVID-19 patients [11]. Furthermore, the National Institutes of Health (NIH) guidelines for treating COVID-19 recommend starting HFNC if patients fail to respond to COT [12]. Additionally, HFNC is a valuable therapeutic resource in securing ICU beds and ventilators during a pandemic [1]. Thus, HFNC plays an essential role in managing respiratory failure in patients with COVID-19. Indeed, most of our respondents, who are respiratory physicians, agreed with the utility of HFNC in this fatal condition. Subsequently, HFNC has been introduced in numerous COVID-19 cases regardless of code status. Interestingly, our survey showed the differences in HFNC management between patients with and without COVID-19; patients with COVID-19 were switched to HFNC from COT at a significantly earlier stage than those without. This approach appears to be reasonable and may represent the specific feature of COVID-19-induced respiratory failure; patients with COVID-19 can rapidly develop severe respiratory failure, leading to a higher mortality risk than those without [13].

The cross-sectional survey highlighted patient-friendly characteristics of HFNC beyond its therapeutic effectiveness, such as lower intubation rates. One of the characteristic features of HFNC therapy is that the interface is soft and easy to fit, thereby reducing the stress on the patient's face and the risk of skin breakdown [14]. Additionally, HFNC does not interfere with conversation or eating while being worn [1]. Furthermore, HFNC was recognized to be less invasive in terms of high tolerability, less skin breakdown, dyspnea improvement, and intubation elimination. However, the extent to which HFNC can reduce invasive procedures was not fully understood. Therefore, we examined the differences in interventions and management between HFNC, NIV, and IMV. In HFNC patients, the frequencies of sedation, physical restraint, and implementation in ICU were significantly lower than in NIV or IMV patients. Thus, the widespread use of HFNC is associated with the maintenance of patient's daily activities and quality of life.

In addition, this study examined the frequency of arterial blood gas analysis and direct commitment with respiratory physicians during HFNC initiation at the bedside. In contrast to NIV or IMV, HFNC was frequently initiated without the need of a respiratory physician at the bedside, and the frequency of arterial blood gas analysis was lower during HFNC initiations. Therefore, HFNC has both advantages and disadvantages in the management of the respiratory disease; while HFNC is a patient-friendly and easy-to-use device, it also carries the risk of lacking appropriate follow-up by respiratory physicians. Management of HFNC does not require high medical expertise as compared to NIV or IMV [15]. However, unduly delaying intubation in patients with HFNC reportedly increases mortality [16]. Physical assessment is important during HFNC care; thoracoabdominal asynchrony, increased respiratory rates, respiratory distress, and decreased P/F ratio were reported to be associated with a high risk for HFNC failure [17]. Therefore, all physicians involved in HFNC need to be aware of these signs and monitor their patients more carefully before and after HFNC implementation.

A significant finding in this study is the respiratory physicians' persistent concerns about SARS-CoV-2 infection spread and psychological distress caused by HFNC, accounting for 47.1% and 53.3%, respectively. These concerns were raised possibly because HFNC might increase viral aerosolization and environmental contamination [4]. Previously, HFNC was listed as an aerosol-generating procedure on the Public Health

England and the NIH websites [12,18]. However, recent studies demonstrated that the practical use of HFNC in patients with COVID-19 is safer against cross-contamination than normal breathing or COT [5,19]. In response to these reports, the application of HFNC has rapidly expanded in Japan, albeit with full preparations (i.e., recommended with full personal protective equipment and under negative pressure room) [20]. In the present study, all physicians remained unaffected by COVID-19. Despite these reports, approximately half of the respiratory physicians still had concerns about the SARS-CoV-2 infection spread and psychological distress caused by HFNC. Importantly, the frontline nurses, who are more often in closer contact with the patients, have been reported to be at higher risk of prolonged psychological distress than physicians [21]. Collectively, these results highlighted the insufficient opportunities to provide appropriate information as well as the necessity of psychological care for every staff engaged in COVID-19 care. These unmet needs should be addressed urgently.

This study has several limitations. First, the survey was conducted in limited regions of Japan, and the sample size was relatively small. Therefore, the results might not completely represent physicians' perception of HFNC. Additionally, the results might have been influenced by the COVID-19 infection status of the region. Second, considerable differences might exist between responses to questionnaire and the actual daily practice. Third, time lags occurred during the conduction of this survey. Recently, two randomized trials were published; one showed the superiority of HFNC over COT in terms of intubation rate and clinical recovery time, while the other did not show any differences in intubation rate or mortality between HFNC and COT [11,22]. Therefore, the survey results could be affected depending on the circumstances.

5. Conclusions

Respiratory physicians perceived HFNC as a good indication for COVID-19. Furthermore, they recognized the advantages of HFNC, which included high patient tolerability and maintenance of patients' daily activities by reducing sustained sedation and physical restraint. Consequently, HFNC was introduced as an initial respiratory device following COT in patients with COVID-19. However, numerous respiratory physicians had concerns about getting infected with SARS-CoV-2 and experienced psychological distress resulting from HFNC use in patients with COVID-19. Collectively, this study showed that HFNC is clinically useful in patients with COVID-19 and that the abovementioned concerns need to be addressed urgently in practice.

Ethics approval and consent to participate

Approval of the study protocol by an ethics committee was not required according to national policies in Japan and therefore not obtained.

Consent for publication

Not applicable.

Availability of data and materials

The data that support the findings of this study are available from the corresponding author (T.K.), upon reasonable request.

Funding

No financial support was provided for this study.

Author contributions

T.K. Conception and design, Data collection, Data analysis and interpretation, and Manuscript writing. Y.S. Conception and design, Data analysis and interpretation, Manuscript writing, and Final approval of the manuscript, Y.I., H.H., M.K., K.F., T.F., N.E., Y.N., N.I. Data analysis and interpretation, T.S. Conception and design, Data analysis and interpretation, Manuscript writing, and Final approval of the manuscript.

Conflict of interest

All authors declare no actual or potential conflicts of interest.

Acknowledgment

The authors would like to thank all the respiratory physicians who participated in this study. The authors would like to thank Enago (www.enago.jp) for the English language review.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resinv.2022.08.007.

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