The efficiency of high-flow nasal cannula for adult patients with coronavirus disease 19 in Jeddah, Saudi Arabia

Majid S. Al-Thaqafy, Saleh Alzahrani, Abdulwahab Alghamdi, Saleh Alselemi, Khalid Alshebani, Bussma Ahmed Bugis, Alaa Bugis, Ali S. Al-Shareef

Abstract:

CONTEXT: Early use of a high-flow nasal cannula (HFNC) provides positive outcomes for preventing the risk of intubation. However, the efficiency and usage of HFNC in the case of coronavirus disease 2019 (COVID-19) among adult patients with multiple risk factors remain debatable and require more investigation.

AIMS: The aim of this study was to determine the efficiency of HFNC in preventing the possible risk of intubation.

SETTINGS AND DESIGN: This study was an observational cross-sectional study that was conducted at a selected hospital in Jeddah, Saudi Arabia, from July 2020 to August 2021.

METHODS: The data were collected from patients’ medical records through the hospital health information system. Adult COVID-19 patients who used HFNC were included, while those who used bilevel positive airway pressure or continuous positive airway pressure without any trials of HFNC and neonatal or pediatric patients were excluded. The exposure of HFNC setting which included variables such as percentages of the fraction of inspired oxygen and the duration of using HFNC were measured to find the relation with respiratory rate oxygenation (ROX) index as a measurement of patient outcome.

STATISTICAL ANALYSIS USED: The data were analyzed by using the online calculator socscistatistics.com for prevalence statistics, and correlation tests of significance. Prevalence statistics were presented in mean, median, frequencies, and percentages. Statistical tests were used to measure correlations of key variables. P < 0.05 of ANOVA and t-tests was considered statistically significant.

RESULTS: A total of 159 adult COVID-19 patients using HFNC were included, and most of these patients were male. The median age was 64 years. Most of patients were reported to have hypertension and diabetes mellitus. The majority (94.34%) of patients were successfully weaned from HFNC and shows effective intervention with a mean of 7.53 of ROX score. Appropriate implementation of HFNC might be a successful intervention for preventing the risk of intubation.

CONCLUSIONS: According to the success rate of HFNC, which was considered a positive outcome, there might be a promising intervention for HFNC to prevent the risk of intubation and decrease the mortality rate.

Keywords: Coronavirus disease 2019, efficiency, endotracheal intubation, high-flow nasal cannula, noninvasive ventilation, oxygen therapy

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

How to cite this article: Al-Thaqafy MS, Alzahrani S, Alghamdi A, Alselemi S, Alshebani K, Bugis BA, et al. The efficiency of high-flow nasal cannula for adult patients with coronavirus disease 19 in Jeddah, Saudi Arabia. Ann Thorac Med 2022;17:214-9.
and heated oxygen at a flow rate that can reach up to 60 L/min. This device has the ability to be controlled independently, allowing for greater confidence in the delivery of supplemental oxygen. The use of HFNC therapy revealed great results in clinical practice and clinical applications for treating conditions such as acute hypoxemic respiratory failure and respiratory failure, pre-and postextubation oxygenation, use in the emergency department, and preventing intubation of patients.\[1\]

Coronavirus disease 2019 (COVID-19) is a highly contagious sickness brought about by the severe respiratory virus SARS-CoV-2. The illness was first distinguished in December 2019 in Wuhan, China and has since spread around the world, progressing to the COVID-19 pandemic. There was an epidemiological relationship between a fish market in Wuhan where wild creatures were offered, which was shut on January 1, 2020, and COVID-19. The first case of unknown pneumonia was reported to the World Health Organization on December 31, 2019, with the Wuhan Municipal Health Commission saying they were investigating the circumstance intently.\[2\] Respiratory support is considered a revolutionary treatment for critically ill COVID-19 patients with the requirement of adequate oxygen supplementation, specifically HFNC.\[3\]

There are some risk factors associated with HFNC. HFNC utilizes humidification to permit the conveyance of up to 100% oxygen at stream paces of up to 60 L/min; in any case, there is a concern that this may aerosolize respiratory microorganisms.\[4\] Outside of the intensive care unit (ICU), HFNC was linked to improved Visual Analogue Scale scores, breathing frequency, and saturation, but it was also linked to a high mortality rate.\[5\] A study conducted using HFNC and conventional oxygen devices in an emergency room (ER) revealed the effectiveness of HFNC to reduce the respiratory rate. However, the need for mechanical ventilation, the length of stay, and mortality were similar between HFNC and conventional oxygen devices because of these critical cases.\[6\]

HFNC essentially decreased the respiratory rate, the heart rate, hear rate, dyspnea score, supraclavicular withdrawal, thoracoabdominal asynchrony, and expanded heartbeat oximetry. These upgrades were seen as early as 15 min after the start of HFNC for the respiratory rate and heartbeat oximetry. The PaO₂ and PaO₂/FiO₂ increased fundamentally after 1 h of HFNC in comparison with baseline.\[7\] In all methods of treatment in medicine, there are infections and contraindications. The contraindications for HFNC are upper airway obstruction, central apnea, asthma, blocked nasal passages/choanal atresia, trauma/surgery for the nasopharynx, and pneumothorax.\[8\] ICU physicians utilize HFNC as a treatment for acute respiratory failure, despite these patients’ moderately low expectations for progress, particularly in instances of hypercapnia.\[9\]

Clinical practices showed some degrees of heterogeneity related to the efficiency of HFNC. Despite the physiological advantages of HFNC, further imminent observational investigations are needed for HFNC results and day-by-day reports.\[10\] There are some recent studies that are highly related to HFNC providing humidified and heated medical gas at various ranges of flow up to 60 L/min, which can lead to variations in physiological effects, such as a reduction of anatomical dead space and positive end-expiratory pressure (initially 5 cm H₂O), with strong humidification results.

Several studies and recent random clinical trials revealed outcomes related to HFNC, which decreased the risks of reintubation. A recent meta-analysis showed HFNC oxygen therapy improvement, which decreases the rate of intubation of patients and prevents mortality, especially in the ICU. Limitations and risks of HFNC are possible. One of the main drawbacks is the cost of treatment compared to low-flow nasal cannula, increased difficulty of the preparation to initiate care, reduced mobility, the possibility of the inadequate sealing of passages leading to air leakage and the loss of the positive impact of airway pressure, and the potential to delay intubation.\[10\]

Potential risk factors for noninvasive ventilation are often limited to the use of HFNC. This involves patients with consciousness alterations, facial injuries, and excessive aspiration with a risk of secretions and hemodynamic instability. However, recent studies have claimed that HFNC does not necessarily lead to increased amounts of respiratory particles among COVID-19 patients.\[11\] In addition, the main goal for HFNC is to treat patients and keep the oxygen saturation (SpO₂) above 95% for nonchronic pulmonary disease patients.\[12\] Specific strategies during the application of HFNC must be performed to verify the delivery of aerosolized medications in an ideal way, especially in the presence of COVID-19.\[13\]

Moreover, according to a study conducted by Ari et al.,\[14\] health care providers should increase the dose of aerosolized medications whenever they increase the flow rate of a high flow device. HFNC helped patients who were suffering from COVID-19 by reducing their length of stay in the ICU; therefore, it is a preventable method for reaching conventional devices.\[15\] For patients who were intubated and required mechanical ventilation, HFNC helped patients to maintain recovery through their critical condition, but occasionally, there is a lack of
availability of mechanical ventilation; as a result, HFNC can be a replacement therapy and can be used in addition to conventional devices.\textsuperscript{[16]}

For instance, patients with both acute respiratory distress syndrome and COVID-19 received some benefits from using HFNC by reducing their need for mechanical ventilation and substantially decreasing the rate of mortality.\textsuperscript{[17]} A previous study revealed that diabetic patients with COVID-19 could benefit from using HFNC based on their statistical analysis results.\textsuperscript{[18]} Another study examined obesity and other risk factors related to HFNC. It was associated with a reduction in functional residual capacity (FRC) and major breathing issues, including increased work of breath and ventilation-perfusion mismatch. HFNC had some clinical benefits for obese patients, such as reversed reduction of FRC. In addition, it led to improvements in respiration efficiency by increasing alveolar ventilation.\textsuperscript{[19]} Another retrospective observational study focused on the influence of using HFNC and found a positive impact related to cardiovascular diseases.\textsuperscript{[20]} Furthermore, another application of HFNC is providing adequate ventilation with humidification to result in high and positive outcomes for asthma patients.\textsuperscript{[21]} According to a recent study, the use of HFNC for patients diagnosed with hypertension in long-term conditions improved respiratory status. For instance, when patients were exposed to hypoxemic problems defined by a partial pressure of oxygen <80 mmHg, their conditions improved after HFNC exposure.\textsuperscript{[22]} The aim of this study was to focus on the efficiency of HFNC in adult COVID-19 patients in Jeddah, Saudi Arabia.

\textbf{Methods}

The study focused on how HFNC was applied for adult COVID-19 patients to understand some of the risk factors associated with these patients, such as hypertension, obesity, diabetes mellitus, smoking, and heart and renal diseases. In general, the study focused on adult COVID-19 patients who were admitted to a selected hospital in Jeddah. In July 2020, the hospital reported the first cases of using HFNC with COVID-19 cases. Data analysis was done on 1-year data period from July 2020 to August 2021. The study investigated the use of HFNC with COVID-19 patients in ICUs, ERs, and wards at the selected hospital.

Adult COVID-19 patients at the selected hospital were considered as the study population. The included patients were adult COVID-19 patients who used HFNC and were admitted to the hospital. The excluded patients were those who used bilevel positive airway pressure (BiPAP) or continuous positive airway pressure (CPAP) without any trials of HFNC and neonatal or pediatric patients.

This study was an observational cross-sectional descriptive study. The relationship between HFNC therapy and adult COVID-19 patients at the selected hospital was investigated to ensure the improvement of the patients. In addition, this study included a noninterventional consent form.

This study was conducted through the nonprobability sampling method and convenience sampling. The selected hospital uses a specific health information system, which is an electronic system that stores and administers patients' medical records, flow sheets, dates of admission and discharge with ease of access by the medical record number. We collected the data from the hospital health information system by the availability and accessibility of the patients' medical records data from the wards of the hospital, ICUs, and ERs after obtaining all required approvals. The included patients were adult COVID-19 patients who used HFNC and were admitted to the selected hospital in Jeddah. The excluded patients from the sample size were those who used BiPAP or CPAP without any trials of HFNC and neonatal or pediatric patients.

The study sample included 159 patients. The study included categorical variables such as gender, hospital area, risk factors, and weaning devices. Moreover, the study included continuous variables such as age, percentages of the $\text{FiO}_2$, the duration of using HFNC, and respiratory rate oxygenation (ROX) index.

The data were analyzed by using the online calculator socratestatistics.com for prevalence statistics and correlation tests of significance. The data for continuous variables are presented as the mean and standard deviation if normally distributed; otherwise, the median and interquartile range are reported, and data for categorical variables are presented as frequencies and percentages. Statistical tests were used to measure correlations of key variables. $P < 0.05$ of ANOVA and $t$-tests was considered statistically significant. Finally, figures and tables are used to represent the main results.

Ethical approval was obtained from the Institutional Review Board Office of King Abdullah International Medical Research Centre as study number SP21J/073/03 on July 18, 2021. The procedures used in this study adhere to the tenets of the Declaration of Helsinki.

\textbf{Results}

During the study period from July 2020 to August 2021, a total of 159 adult COVID-19 patients using HFNC were included to assess the efficiency of HFNC in different wards, ERs, and ICUs at the selected hospital in Jeddah. The majority of the patients were males (90;
COVID-19 patients, 94.34% of them were successfully weaned from HFNC and shows effective intervention with a mean of 7.53 according to the main indicator, which is ROX score of 3.85 or more, while the rest percentage revealed ineffective intervention of HFNC. The FiO2 level was weakly associated with ROX score at $P = 0.093$, while SpO2 was associated with ROX score ($P = 0.001$) as patients with more than 95% SpO2 are more likely to score 3.85 or more at ROX index. In addition, the respiratory rate was also associated with ROX score ($P = 0.032$) as patients with higher respiratory rate are more likely to score $<3.85$ at ROX index. However, the duration of using HFNC was not statistically associated with ROX score ($P = 0.405$) as presented in Table 3. The appropriate implementation of HFNC might be a successful intervention for preventing the risk of intubation and decreasing the mortality rate among COVID-19 patients.

The distribution of COVID-19 patients who used HFNC at different hospital areas shows the ER as the most common place where HFNC was being used with a percentage of 83%, while HFNC has been used rarely inside the ICU with a percentage of only 3% as presented in [Figure 2].

**Discussion**

Our study included 159 COVID-19 adult patients from the selected hospital in Jeddah who used HFNC. In this cross-sectional observational (analytical) study, the efficiency of HFNC was obtained and measured by including the main method, which is the ROX index. The findings for these measurements were mainly focused on the ROX index, which provided informative results that led to certain outcomes related to performing intubation or preventing it.

The findings of our study pertained to the ROX index to measure the significance of the contributing variables, such as age, gender, risk factors, and the duration of HFNC use. In the Frat et al.[23] study, the intubation rate and hazard ratio for death at 90 days were the primary and secondary outcomes, respectively, to consider the significance of the variables. Furthermore, the previous study tested the significance as a concept of the main HFNC device.

**Table 1: Gender and chronic diseases of coronavirus disease 2019 adult patients who used high flow nasal cannula (n=159)**

| Gender | Yes, n (%) | No, n (%) |
|--------|------------|-----------|
| Male   | 90 (56.6)  | 69 (43.4) |
| Female |            |           |

| Chronic disease | Yes, n (%) | No, n (%) |
|-----------------|------------|-----------|
| COPD            | 4 (3)      | 155 (97)  |
| Asthma          | 18 (13)    | 141 (99)  |
| Obesity         | 79 (50)    | 80 (50)   |
| Smoking         | 9 (6)      | 150 (94)  |
| Hypertension    | 89 (56)    | 70 (44)   |
| Diabetes mellitus| 86 (54) | 73 (46) |
| Renal disease   | 19 (12)    | 140 (88)  |
| Heart disease   | 31 (19)    | 128 (81)  |

COPD=Chronic obstructive pulmonary disease

**Table 2: Respiratory management of coronavirus disease 2019 adult patients after using high flow nasal cannula (n=159)**

| Respiratory management | n (%) | P     |
|------------------------|-------|-------|
| Nasal cannula          | 81 (51)| 0.0001*|
| Simple face mask       | 17 (11)|       |
| Non-rebreather mask    | 4 (3)  |       |
| Room air               | 7 (4)  |       |
| Mechanical ventilation | 45 (28)|       |
| Death (none)           | 5 (3)  |       |

*Statistically significant at a $P \leq 0.05$ level of ANOVA test

**Table 3: Correlation between high flow nasal cannula settings used on coronavirus disease 2019 patients and patient’s outcome**

| ROX (patient outcome) | n (%) | Mean | Respiratory rate | Oxygen saturation (%) | FiO2 | Duration of using HFNC |
|-----------------------|-------|------|------------------|-----------------------|------|-----------------------|
| 3.85 or more          | 150 (94.34) | 7.53 | 24.57             | 95.51                 | 0.57 | 6                     |
| <3.85                 | 9 (5.66)    | 2.96 | 37.33             | 91.00                 | 0.86 | 3                     |

*Statistically significant at the $\alpha \leq 0.05$ level of $t$-tests, **Statistically significant at the $\alpha \leq 0.1$ level of $t$-tests. HFNC=High flow nasal cannula, FiO2=Fraction of inspired oxygen, ROX=Respiratory rate oxygenation
A retrospective study that involved 733 patients who were confirmed to have COVID-19 reported that the median age was higher than that obtained in our study and was significantly associated with the effectiveness of HFNC; in our study, age was not significantly associated with the efficiency of HFNC.\(^{[24]}\) Moreover, the female gender revealed significant values, whereas the male gender did not. However, gender in general in our study appeared to have no significant association with HFNC effectiveness.

In a prospective cohort study with 191 patients, the prevalence of disease was related to chronic respiratory disease, while hypertension was the most common risk factor in our study. Furthermore, an immunosuppression risk factor was concluded to have a significant association with the efficiency of HFNC. Moreover, our study revealed no significant association for any risk factor while using HFNC.\(^{[25]}\)

In our study, the use of HFNC outside ICUs, specifically in the wards, revealed better outcomes of weaning with certain oxygen devices, such as a nasal cannula, simple facemask, and nonrebreather mask, with a decreased mortality rate based on a significant \(P\) value. However, in another observational study, the usage of HFNC with 111 patients outside the ICU resulted in better outcomes regarding vital signs but was associated with a high mortality rate.\(^{[9]}\)

A retrospective cohort study that focused on the efficiency of HFNC in 32 COVID-19 patients who suffered from severe hypoxemic respiratory failure, old age, and weight loss revealed that the survival rate was 25%.\(^{[26]}\) Moreover, the success rate of using HFNC in our study was 69%, as measured by the rates of nonintubated patients who were used weaning devices, such as a nasal cannula, nonrebreather mask, and simple face mask. The failure rate of using HFNC in their study was 75% of the total sample size, which was caused by the nature of the study that focused on vulnerable patients.

Furthermore, our study revealed that the failure rate of HFNC was lower than that in their study, specifically a 31% failure rate for the total sample size. However, there is a similarity regarding the most common comorbidities, including hypertension, that affect the percentages and results related to the significant \(P\) value of their study, while in our study, hypertension was not significantly associated with using HFNC.

### Conclusion

Our study included a variety of strengths. One of these strengths is the presence of multiple risk factors, such as diabetes mellitus, hypertension, asthma, COPD, obesity, smoking, and heart failure. All these factors can be used as predictors by physicians, respiratory therapists, and health care providers for the success and failure of HFNC among adult COVID-19 patients. Another strength is that there are few recently published research studies related to the usage of HFNC among adult COVID-19 patients in the Kingdom of Saudi Arabia; thus, our study might contribute to positive outcomes with these few published studies.

However, our study contains some specific limitations, including the lack of a large sample size to manipulate the data. Another limitation is that our study was conducted at a single center; thus, generalization of the data and assembly decisions regarding other centres cannot be achieved.

### Financial support and sponsorship

Nil.

### Conflicts of interest

There are no conflicts of interest.

### References

1. Sharma S, Danckers M, Sanghavi D, Chakraborty RK. High flow...
nasal cannula. In: StatPearls. Treasure Island (FL): StatPearls Publishing; 2021.

2. Chauhan S. Comprehensive review of coronavirus disease 2019 (COVID-19). Biomed J 2020;43:334-40.

3. Kim ES, Lee H, Kim SJ, Park J, Lee YJ, Park JS, et al. Effectiveness of high-flow nasal cannula oxygen therapy for acute respiratory failure with hypercapnia. J Thorac Dis 2018;10:882-8.

4. Loh NW, Tan Y, Taculod J, Gorospe B, Teope AS, Somani J, et al. The impact of high-flow nasal cannula (HFNC) on coughing distance: Implications on its use during the novel coronavirus disease outbreak. Can J Anaesth 2020;67:893-4.

5. Marjanovic N, Guénézan J, Frat JP, Mimoz O, Thille AW. High-flow nasal cannula therapy: Clinical practice in intensive care units. Ann Emerg Med 2020;38:1508-14.

6. Marjanovic N, Guénézan J, Frat JP, Mimoz O, Thille AW. High-flow nasal cannula therapy: Clinical practice in intensive care units. Ann Emerg Med 2020;38:1508-14.

7. Sztrymf B, Messika J, Bertrand F, Hurel D, Leon R, Dreyfuss D, et al. Beneficial effects of humidified high flow nasal oxygen in critical care patients: A prospective pilot study. Intensive Care Med 2011;37:1780-6.

8. The Royal Children’s Hospital Melbourne. The Royal Children’s Hospital Melbourne. Available from: https://www.rch.org.au/rcrhpcl/hospital_clinical_guideline_index/High_Flow_Nasal_Prong_HFNP_oxygen_therapy_Sugar_Glider_Medical_Care/. [Last accessed on 2022 Apr 11].

9. Besnier E, Hobeika S, NSeir S, Lambiote F, Du Cheyron D, Saunef B, et al. High-flow nasal cannula therapy: Clinical practice in intensive care units. Ann Intensive Care 2019;9:98.

10. Agarwal A, Basmaji J, Muttalib F, Granton D, Chaudhuri D, Chetan D, et al. High-flow nasal cannula for acute hypoxemic respiratory failure in patients with COVID-19: Systematic reviews of effectiveness and its risks of aerosolization, dispersion, and infection transmission. Can J Anaesth 2020;67:1217-48.

11. Sullivan ZP, Zazzeron L, Berra L, Hess DR, Bittner EA, Chang MG. Noninvasive respiratory support for COVID-19 patients: When, for whom, and how? J Intensive Care 2022;10:3.

12. He G, Han Y, Fang Q, Zhou J, Shen J, Li T, et al. Clinical experience of high-flow nasal cannula oxygen therapy in severe COVID-19 patients. Zhejiang Da Xue Xue Bao Yi Xue Ban 2020;49:232-9.

13. Ari A, Moody GB. How to deliver aerosolized medications through high flow nasal cannula safely and effectively in the era of COVID-19 and beyond: A narrative review. Can J Respir Ther 2021;57:22-5.

14. Ari A, Fink JB. Aerosol drug delivery to tracheotomized patients with COVID-19: Pragmatic suggestions for clinicians. Can J Respir Ther 2021;57:49-52.

15. Gürün Kaya A, Öz M, Erol S, Çifçi F, Çiledağ A, Kaya A. High flow nasal cannula in COVID-19: A literature review. Tuberk Toraks 2020;68:168-74.

16. Gershengorn HB, Hu Y, Chen JT, Hsieh SJ, Dong J, Gong MN, et al. The impact of high-flow nasal cannula use on patient mortality and the availability of mechanical ventilators in COVID-19. Ann Am Thorac Soc 2021;18:623-31.

17. Panadero C, Abad-Fernández A, Rio-Ramírez MT, Acosta Gutierrez CM, Calderon-Alcala M, Lopez-Riolobos C, et al. High-flow nasal cannula for Acute Respiratory Distress Syndrome (ARDS) due to COVID-19. Multidiscip Respir Med 2020;15:693.

18. Aguirre-García GM, Ramonfaur D, Torre-Amione G, Ramírez-Elizondo MT, Lara-Medrano R, Moreno-Hoyos JF, et al. Stratifying risk outcomes among adult COVID-19 inpatients with high flow oxygen: The R4 score. Pulmonology. 2021 Oct 12;82531-0437/21/00196-3. doi: 10.1016/j.pulmoe.2021.10.001. Epub ahead of print.

19. Papazian L, Corley A, Hess D, Fraser JF, Rat JF, Guitton C, et al. Use of high-flow nasal cannula oxygenation in ICU adults: A narrative review. Intensive Care Med 2016;42:1336-49.

20. Bonnesen B, Jensen JS, Jeschke KN, Mathioudakis AG, Corlateanu A, Hansen EF, et al. Management of COVID-19-associated acute respiratory failure with alternatives to invasive mechanical ventilation: High-flow oxygen, continuous positive airway pressure, and noninvasive ventilation. Diagnostics (Basel) 2021;11:2259.

21. Nishimura M. High-flow nasal cannula oxygen therapy in adults: Physiological benefits, indication, clinical benefits, and adverse effects. Respir Care 2016;61:529-41.

22. Prakash J, Bhattacharyya PK, Yadav AK, Kumar A, Tudu LC, Prasad K. ROX index as a good predictor of high flow nasal cannula failure in COVID-19 patients with acute hypoxemic respiratory failure: A systematic review and meta-analysis. J Crit Care 2021;66:102-8.

23. Frat JP, Thille AW, Mercat A, Girault C, Ragot S, Perbet S, et al. High-flow oxygen through nasal cannula in acute hypoxemic respiratory failure. N Engl J Med 2015;372:2185-96.

24. Xie J, Wu W, Li S, Hu Y, Hu M, Li J, et al. Clinical characteristics and outcomes of critically ill patients with novel coronavirus infectious disease (COVID-19) in China: A retrospective multicenter study. Intensive Care Med 2020;46:1863-72.

25. van Steenkiste J, van Herwerden MC, Weller D, van den Bout CJ, Hansen EF, Toraks 2020;68:168-74.

26. van Steenkiste J, van Herwerden MC, Weller D, van den Bout CJ, Ruiter R, den Hollander JG, et al. High-flow Nasal Cannula therapy: A feasible treatment for vulnerable elderly COVID-19 patients in the wards. Heart Lung 2021;50:654-9.