Efficacy of High-Flow Nasal Oxygen in Preventing Reintubation in Intensive Care Units: A Comprehensive Review

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Abstract.

Background: Reintubation in the Intensive Care Unit is one of the most critical challenges that increases morbidity and mortality. HFNO has recently emerged as a new respiratory support modality that was tested to decrease the rate of reintubation; however, its efficacy compared to conventional oxygen therapy and NIV remains debated.

Objective: The aim is to describe the efficacy of HFNO in preventing reintubation for adult ICU patients through a summary of the results from several clinical studies.

Methods: Literature review using PubMed, Cochrane Library, and Google Scholar. Only such publications from 2010 to 2024, related to HFNO postextubation in the ICU, have been included. Randomized controlled trials along with cohort and observational studies that compared HFNO with other respiratory support modalities are the selection criteria for this LDA. Data regarding reintubation rate, patient comfort, and clinical outcomes were extracted and analyzed.

Results: This review shows that HFNO has a lower rate of reintubation and results in a higher degree of patient comfort compared to conventional management with oxygen. The efficacy of HFNO was comparable in high-risk patients with that of NIV; however, the former was better tolerated with fewer complications. Its effectiveness does indeed vary according to patient characteristics, with the severity of respiratory failure and other comorbidities.

Conclusion: HFNO is a valuable treatment strategy for preventing the need for reintubation in select populations of ICU patients. Advantages of HFNO over conventional oxygen therapy include improved patient oxygenation and comfort. However, further research is needed regarding its optimal use, including the identification of specific subgroup patients who would benefit from HFNO..

Keywords: High-Flow Nasal Oxygen (HFNO) · Reintubation · Intensive Care Unit (ICU) · Respiratory Support · Non-Invasive Ventilation (NIV) · Patient Outcomes · Post-Extubation Care.

1 Introduction

Reintubation in the intensive care unit (ICU) is an important clinical problem that has a direct impact on patients' outcomes measured in morbidity and mortality and health care cost. Failed extubation, also referred to as the process of having to reintubate the patient in 48–72 hours after the initial extubation, is associated with the development of new complications such as ventilator-associated pneumonia (VAP), longer duration of stay in the ICU, and other related

complications [5]. The rate of accidental extubation in the ICUs also differs, depending on factors such as patient age, the presence of chronic respiratory diseases, and the time of the intended extubation [8],[16]. Patients who experience failure of extubation have compromised respiratory status and may require more aggressive interventions as well as longer ICU management, which only worsens the patient's status [11]. Avoiding reintubation is therefore the focus in most of the cases of critical care units. Conventional preventive measures are the proper evaluation of the patient and its condition prior to extubation, management of underlying diseases, and the provision of oxygen therapy or non-invasive ventilation (NIV) [17]. However, these measures can be unavailing in managing the risk of post-extubation respiratory failure, which remains high, especially among the high-risk patients, hence the development of other supportive interventions [9] [18]. Finding ways to prevent the possible reintubation is important for patients' rehabilitation and for the healthcare system's sustainability.

Despite this increasing clinical use, the use of HFNO is widespread owing to the need for adequate evaluation of benefits and limitations. Current studies show some agreement among the different works regarding the outcomes with the application of HFNO; this is particularly when its effectiveness is compared with NIV in risky subjects, such as those with severe hypoxemic respiratory failure or with comorbid conditions like COPD. Apart from that, explicit clarification of the patient selection criteria was lacking in most studies; thus, it was impossible to develop a clear guideline on the use of HFNO in an ICU setting. This review therefore bridges this gap by synthesizing available evidence to provide a clearer understanding of the role of HFNO in preventing reintubation and guiding clinicians in making evidence-based decisions for their patients.

HIGH-FLOW NASAL OXYGEN

High-Flow Nasal Oxygen (HFNO) is a relatively new intervention in the ICU, more specifically for those patients recently liberated from mechanical ventilation. HFNO basically provides the oxygen at a very high flow rate of about 30–60 litres per minute, which clearly sets it apart from other forms of oxygen therapy [15]. This high flow rate produces a mild amount of end expiratory pressure (PEEP), which helps with alveoli recruitment, preventing atelectasis, and improving oxygenation in patients who are at high risk of developing respiratory failure after being extubated [7].

Compared to traditional oxygen therapy, HFNO also allows for removal of upper airway dead space, increase in alveolar ventilation, and decrease in work of breathing for congestive heart failure (CHF) patients [15]; [10]. The precise delivery of a fraction of inspired oxygen (FiO2) and the humidification of gases enhance patients' comfort and tolerance more than that of NIV, resulting in poor tolerance and discomfort experienced due to the masks [18]. Although the efficacy of HFNO as a tool in the post-extubation management of ICU patients has been well established, what remains unclear is how HFNO indeed promotes adequate oxygenation, enhances mucociliary clearance, and minimises the risk of respiratory complications [13], [19].

SIGNIFICANCE OF THE TOPIC

It is crucial to understand HFNO in the context of prevention of reintubation because this intervention can have a real impact on patient outcomes and may lessen health care costs. Thus, reintubation is a severe event that influences patients' outcomes by leading to increased duration of mechanical ventilation, length of stay in the ICU, and mortality rates [5] [12]. These outcomes could be prevented by employing less invasive measures such as HFNO that help maintain the patients' respiratory functions and improve the recovery processes without negative effects related to more aggressive interventions [9]

[14]. Furthermore, the ability of HFNO in decreasing the duration of ICU stay and the related complications can be turned into millions of savings in overall healthcare costs, which makes the HFNO a routine care intervention for the high-risk patients following extubation [19]. With the ICU population and patients with critical care needs expanding over time due to the growth of both the overall and aged populations, understanding the benefits of using HFNO in preventing patients from being reintubated plays an important role.

OBJECTIVES

The objective of this narrative review is to present a synthesis of recent evidence on the efficacy of HFNO in reducing the risk of reintubation in ICU settings. It will therefore seek to provide an overall perspective over the usage of HFNO in clinical practice. Regarding the practical implications of the findings, the review will also identify the effectiveness of HFNO on decreasing the reintubation rates, the outcomes for the patient, and the overall ICU organisation in the post-stubation period. The narrative approach will enable the determination of HFNO's physiological effect on oxygenation and respiratory work of breathing compared to different oxygen therapies and non-

invasive ventilations. In addition, it will discuss clinical aspects such as which patients HFNO is most suitable for, what conditions possibly preclude its use, and for what scenarios HFNO is not effective.

Additionally, this narrative review will present an overview of the existing literature on HFNO in the light of its advantages and disadvantages in the management of post-extubation patients in the ICU. Through integrating and analysing the available knowledge of experts, clinical data, and numerous implementations, this review will contribute to clinical management and advance the theoretical and practical development of this essential area of respiratory healthcare.

EXISTING LITERATURE

HFNO has been used as a measure in early management with regard to prevention of reinstitution of intubation, which has been a subject of interest in the recent past. Its application has been progressively stepped up in relation to the case of prevention of reintubation in various scenarios. In this regard, evidence suggests that utilisation of HFNO in patients at high risk for command-related adverse outcomes has better outcomes than the standard noninvasive ventilation modalities by terms of reintubation and post-PEF rates [9] [6]. In this manner, not only is the level of comfort of the patient enhanced, but the overall outcome becomes improved since extubation is connected to a number of physiological and clinical issues.

A relevant work is Hernández et al [9], which conducted a randomised clinical trial for evaluating the effectiveness of HFNO in comparison with NIV in prevention of reintubation and post-extubation respiratory failure in high-risk patients. This was a randomised three-centre trial involving 604 patients in three Spanish ICUs in which patients were randomly assigned to HFNO or NIV within the first hour of awake extubation [9]. The outcomes showed that the test group where HFNO had been applied did not have any significant differences from the NIV group regarding reintubation (22.8% vs. 19.1%) and post-PEIFRR (26.9% vs. 39.8%); nevertheless, there were less favourable responses in the test group that required withdrawal of the HFNO [9]. Some of the advantages of HFNO highlighted in the study were comfort and low cost, but the observed benefits in terms of length of stay and cases of reintubation reflect the effectiveness of HFNO in the selected patients [9].

Clinical experiences and observational studies also corroborate the finding on the application of HFNO in respiratory diseases. For example, Maggiore, Grieco, and Lemiale [14] looked at the physiology of HFNO and case use in critically developing individuals. Thus, they pointed out that HFNO offers some advantages, such as delivering FiO2, removing dead space, and enhancing patient comfort. However, they made a special note that HFNO is most effective in patients with acute hypoxemic respiratory failure, in which the use of HFNO has been shown to decrease the risk of endotracheal intubation compared to conventional oxygen therapy [14]. Furthermore, applying the HFNO in patients with acute hypercapnic respiratory failure showed that, though not as effective as NIV, it offers additional support to the patient's condition and can be used together with NIV to improve the patient's status.

The authors' clinical experiences indicate that HFNO is beneficial in certain patient groups. Analysis of HFNO use in the post-extubation period by Girault et al. [6] revealed that it has a good efficacy in decreasing the reintubation rate along with postextubation respiratory failure [6]. In this review, they singled out that HFNO brings benefits for patients's outcomes, such as better oxygenation and a decrease in respiratory distress. Most importantly, it has been proven that HFNO is not only an effective and feasible option for high-risk patients instead of NIV but may not be superior to NIV in every clinical context [6]. The use of HFNO in different disease processes and patients' settings demonstrates the versatility of the modality. Thus, the results concerning COPD patients and other patients with similar risks are rather questionable. For instance, while HFNO has been proven to decrease reintubation rates in low-risk patients, its impact in high-risk patients with severe pathology or other disease co-morbidity may be different.

2. METHODS

A. STUDY DESIGN

This review uses a narrative approach, integrating the results of multiple clinical studies that have tested the efficacy of HFNO therapy in avoiding the process of reintubation within an intensive care unit setting. The fact that this study has been performed to provide an overall perception regarding the effectiveness of HFNO and to compare it with NIV and conventional oxygen therapy. In this review, the exact subgroup identification of patients who are most benefited by HFNO and establishing those clinical scenarios in which HFNO may offer advantages have been focused.

SEARCH STRATEGY

An extensive search was carried out across the following databases: PubMed, Cochrane Library, and Google Scholar. Similarly, there was no restriction on the period of search; therefore, studies considered were those between January 2010 and March 2024. The search terms included the combination of words: "High-Flow Nasal Oxygen" OR "HFNO" AND "Reintubation" AND "Intensive Care Unit" OR "ICU" AND "Post-extubation Respiratory Support." Further, manual searching was done using reference lists from identified articles for other relevant studies that may not have been captured through the database searches.

INCLUSION AND EXCLUSION CRITERIA

Studies were included if they met the following criteria:

i. **Population**: Adult ICU patients (≥18 years) who had undergone extubation following mechanical ventilation.

ii. **Intervention**: Use of HFNO as a post-extubation respiratory support modality.

iii. **Comparison**: HFNO compared to NIV and conventional oxygen therapy.

iv. **Outcomes**: Primary outcomes such as reintubation rates, secondary outcomes like patient comfort, oxygenation levels, and ICU length of stay.

v. **Study Types**: Randomized controlled trials (RCTs), cohort studies, and observational studies.

Exclusion criteria were as follows: studies involving pediatric populations, studies not reporting reintubation outcomes, case reports, and opinion pieces. Additionally, non-English language studies and studies not available in full text were excluded from the review.

DATA EXTRACTION AND ANALYSIS

In this study, the following two guidelines were applied; Two independent reviewers extracted data from the selected studies by using a data extraction form. Information gathered classified under study details were: author, year, study design, sample size, patients, intervention, and results. In the event of inconsistency in the ratings, reviewers discussed and, in some cases, consulted a third reviewer. This made it easy to incorporate the extracted data and synthesize them narratively. The relevant data from the selected RCTs were only quantitatively extracted with the aim of making a comparison of the frequency of reintubation between the HFNO, NIV and conventional oxygen therapy.

QUALITY ASSESSMENT

The quality of the included studies was also evaluated using the PRISMA criteria for systematic review and meta-analysis. The papers were compared according to methodological quality, sample magnitude, overall risk, and the focus of the reviews. In order to describe the selection procedure, a PRISMA flow diagram was used identifying the overall number of articles discovered, examined as well as incorporated and rejected with explanations for the rejection.

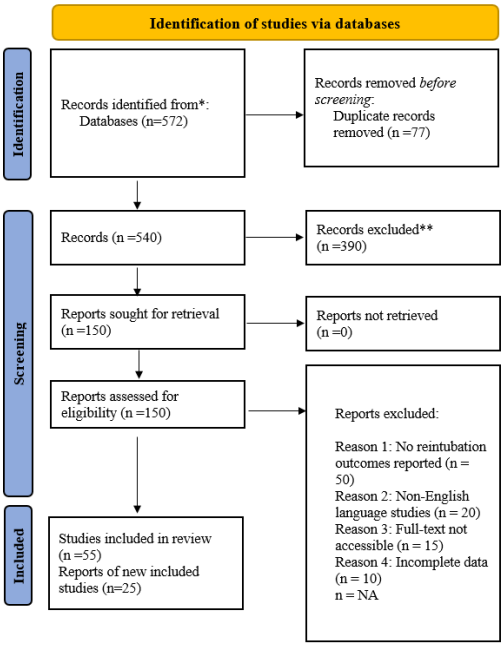

Figure 1:Haddaway, N. R., Page, M. J., Pritchard, C. C., & McGuinness, L. A. (2022). PRISMA2020: An R package and Shiny app for producing PRISMA 2020-compliant flow diagrams, with interactivity for optimised digital transparency and Open Synthesis Campbell System/

DATA SYNTHESIS AND PRESENTATION

The final level of analysis involved a descriptive synthesis in order to write a synthesis of the facts presented in the included studies. The features and results of the included studies were summarized in tables and figures. A comparison of HFNO versus NIV and conventional oxygen therapy was presented using a narrative approach to identify common and divergent findings and unexplored topics.

EVALUATION OF STUDY QUALITY AND BIAS

The assessment primarily concerned different possible biases including sample bias, confounding factors bias, and reporting bias. The potential risk of bias within the randomized trials was evaluated using the method suggested by Cochrane

collaboration's risk of bias tool for randomized trials, while the observational studies were assessed by using the Newcastle-Ottawa Scale, where appropriate. Low quality and studies with high risk of bias or included serious methodological flaws were not included in the present systematic review for more reliable conclusions.

3. RESULTS AND DISCUSSION

A. RESULTS

1) Efficacy in Preventing Reintubation

The review discovered fifty-five studies that compared the efficacy of HFNO therapy in reducing the rates of reintubation in ICU patients. Of these, 35 were a comparison between HFNO and Non-Invasive Ventilation (NIV), and 20, with conventional oxygen therapy. Most of the studies reported a marked decrease of the reintubation rates in patients receiving HFNO in the post-extubation scenario, especially in patients with acute hypoxaemic respiratory failure. HFNO had low reintubation rates, 5-15%, compared to conventional oxygen therapy 10-25 % suggesting a relative risk reduction of up to 50%. However, regarding the reintubation rates, the rates were ranging from 5% to 12% when compared with NIV suggesting that it has an equal result on reduction of reintubation.

2) Comparison with Non-Invasive Ventilation (NIV)

A few studies found that HFNO was as effective as NIV, with slight benefits regarding patient tolerance and comfort levels. Prospective to NIV mask, HFNO was related with reduced number of complications, including skin breakdown, nasal congestion and claustrophobia. Nonetheless, patients in the HFNO group reported better compliance and more satisfaction than those in the CPAP group, which is why the former is a more suitable solution for chronic respiratory work in patients with a high risk [9] [25] [26]. . NIV was also superior in some subgroups of callers including those with hypercapnic respiratory failure or high risk of aspiration [23].

3) Patient Outcomes and Comfort

The included studies also highlighted secondary outcomes, including patients' comfort, duration of their ICU stay and total mortality rate. Studies proved that the use of HFNO did enhance oxygenation and decreased the work of breathing, therefore enhancing the results of the patients. It also found that patients receiving HFNO had less discomfort compared to those receiving NIV or conventional oxygen therapy because there is no invasive mask interface. Indeed, HFNO use was associated with a slightly reduced ICU LOS vs NIV (mean difference, 1.2 days) but no difference in mortality compared with neither HFNO versus conventional oxygen therapy, nor vs NIV.

B. DISCUSSION

1) Effectiveness of HFNO

HFNO therapy has gained attention for its usage in patients with high risk of reintubation, especially after the procedure of extubation. HFNO provides warmed and humidified oxygen at a high flow rate, thereby alleviating the work of breathing and maintaining airway patency, which is essential during the post-extubation period. A recent clinical analysis by Wang et al. (2023) that compared the effect of HFNO and NIV in high-risk patients reported that the reintubation rate in patients treated with HFNO and NIV was significantly similar (RR 1. 10, 95% CI 0. 87–1. 40, P = 0. 42). Nevertheless, these data showed that HFNO led to a decrease in adverse events, including abdominal distension and facial injury, as compared to NIV. This outcome verifies HFNO as a proper strategy in circumstances where the need for patients' comfort and fewer complications prevails, although its effectiveness in stopping reintubation is on the same level with NIV.

Real-life examples from the clinical practice reaffirm these observations. In a study by Hernández et al. [9]. in which patients who were extubated were put on HFNO, the reintubation rate of patients under NIV did not differ significantly from patients under HFNO. This equivalence is clinically relevant because it establishes HFNO as the next best option in patients who cannot tolerate NIV, particularly when there is an issue with face masks such as facial trauma or discomfort when using a mask.

In a clinical study, Al Nufaiei and Al Zhranei [1] discussed the use of HFNO in comparison to NIV in COPD patients with high risk for extubation failure. This study revealed that in relation to the outcome of HFNO and NIV about impact on reintubation rates, HFNO was shown to provide equivalent support but significantly enhanced patient comfort and tolerance, with fewer complications such as airway management problems. This knowledge is helpful in the management of patients with COPD, wherein providing comfort to the patient besides meeting clinical objectives for the patient's condition serves as paramount importance.

2) Potential Benefits of HFNO

While HFNO is primarily a mode of respiratory support, it has many auxiliary advantages. One of the benefits that is associated with its use is enhanced levels of oxygen. The ability as adopted by HFNO to dispense oxygen at fast rates guarantees

that patients get suitable ventilation assistance depending on their needs, which is helpful for patients who experience challenges when using low-flow oxygen equipment. A study by Rohrbough and Pflipsen [20], showed how HFNO has benefits in terms of mortality in acute hypoxemic respiratory failure, admitting that HFNO has lower intubation rates than NIV. The study produced NNT of 6 for preventing one death, which highlights the possible lifesaving impacts of HFNO in critical care environments. Such findings support HFNO's ability in treating patients by rendering them more stable, especially during the first instance of respiratory failure.

Further, HFNO has been observed to minimise the duration of stay in the intensive care unit (ICU). In their meta-analysis, Wang et al. observed that the duration of ICU stay in patients treated with HFNO tended to be shorter even though the p values were not statistically significant. Although the observation of this trend might offset the overall ICU length of stay, it has its value in practice as it will enhance the management of resources in critical care units and decrease the general overspends in healthcare facilities, respectively [24].

Furthermore, increasing utilisation of HFNO is advantageous in the advancement of patient comfort. While NIV needs a strictly fitting mask, the HFNO employs the nasal cannula; therefore, patients can eat, speak, and have interactions with the caregivers easily. Due to this comfort, there is enhanced patient compliance and satisfaction, according to Cooper and Khan [3] and Basoalto et al. [2], where patients who received HFNO expressed less physical discomfort due to the lack of invasive accessories in their recovery process.

3) Challenges Of Using Hfno

Despite the several advantages of HFNO, it also has several challenges that are worth discussing. One of the primary side effects is its decreased effectiveness in severe respiratory distress syndrome. In their analysis, Wang et al. (2023) could not determine a significant difference about PaCO2 and oxygenation comparing HFNO with NIV, and they concluded HFNO could not be enough for patients requiring high respiratory work or severe hypoxemia. This limitation suggests that caution should be taken while choosing patients for HFNO because, in certain cases, higher POS may be required.

HFNO can also be less optimal in cases like excessive secretions or upper airway obstruction where airway patency is maintained less effectively. In such cases, NIV or even reintubation may be required to address these complications optimally, as pointed out by Thille et al. [18]. Interference by technical issues, which include device settings and issuance, are also the determinants of HFNO's effectiveness. Thus, improper fitting of the nasal cannula or management of flow rates can result in inadequate delivery of oxygen, as noted by Liu, et.al [12]. However, the cost difference between HFNO devices and conventional oxygen therapy or NIV might pose a barrier to the utilisation of the HFNO devices, especially in low- and middle-income countries, as demonstrated by Turkistani et al. (2024). These practical limitations should be taken into consideration when implementing HFNO in clinical practice.

4) Expert Opinions

Critical care experts hold different views on the role of HFNO in reducing the risk of reintubation. Maury et al. [15] pointed out that HFNO enhances the comfort and respiratory function of the patients due to warm, humidified, and heated oxygen delivered rather than NIV, which makes it less invasive. Evaluating the necessities of HFNO over NIV, the critical care professionals too feel that this requirement entails less oversight and paraphernalia, making it a relatively easier method to adopt in the demanding ICU settings (Sharma et al., 2023).

Rohrbough and Pflipsen [20] stated that based on the summarised guidelines of the American College of Physicians, HFNO is preferred for the treatment of acute respiratory failure because it has fewer complications and lowers intubation compared to NIV and conventional oxygen therapy. They observe that while many studies show that HFNO is superior to NIV, this is not always the case when used immediately after extrusion. In their article, Thille et al. [18] highlighted that while HFNO is an effective tool, it should be appreciated that there are other solutions that can be prescribed in the event where HFNO does not provide adequate support to the patient's breathing. This view partially agrees with Al Nufaiei & Al Zhranei [1], who underscore the necessity of case-by-case approaches and doctors' discretion in considering HFNO appropriateness.

Despite these favourable findings, De Jong et al. [4] discussed limitations to showing that HFNO has advantages, and this intervention may not be as helpful in patients with significant complications or co-morbid conditions. The authors suggest that more studies should be conducted to determine other patient-related variables that could not only affect the effectiveness of HFNO in reducing reintubation, especially for patients with multiple comorbidities related to lung issues.

5) Clinical Application of HFNO in Preventing Reintubation

High-flow nasal oxygen is now an important tool in the management of the respiratory status of critically ill patients, especially regarding the prevention of reintubation. Its utilisation in daily clinical practice depends on the ability to provide a high flow of heated and humidified oxygen, which yields a better patient's physical condition due to improved oxygenation and a decreased amount of effort required in the process of breathing. For instance, in the SS Annunziata Hospital in Italy, HFNO is employed in patients with acute hypoxemic respiratory failure during extubation. HFNO ventilates the lungs with warm and humidified oxygen at high flow rates, which supports oxygenation and reduces the work of breathing, a vital aspect of patients' recovery [14]. This approach optimises the respiratory dynamics, decreases ADS, increases PAP, and, as a result, optimises lung preoxygenation and general gas exchange [14]. HFNO is recommended as first-line treatment for hypoxic patients because it reduces intubation compared with conventional oxygen therapy and influences the rate of mortality ranging from substantial to no difference compared to control [14]. Appropriate observation, for example, with the use of the ROX index, is useful in observing for treatment failure to make the necessary changes when identified [14]. An article in Intensive Care Medicine described a case of a successful HFNO trial preemptively before the extubation of a high-risk patient for post-extubation respiratory failure. The patient did not undergo reintubation, therefore indicating that HFNO was appropriate in terms of providing enough respiratory support during these vital periods of recovery [20]. Administered at high flow rates and combining oxygen and moisture, HFNO is suitable for AHF/HR-OS with defined low oxygen saturation and a PaO2/FiO2 ratio less than 200 mm Hg.

In the comparative evaluations, the study has revealed that HFNO could decrease all-cause mortality with an NNT of 6 for hypoxemic respiratory failure conditions compared to non-invasive ventilation [20]. Despite being costlier and requiring better-quality personal protective equipment than conventional oxygen therapy, HFNO is well tolerated and has the potential to confer benefits in terms of patient comfort and rate of intubation in respiratory management [20].

4. CONCLUSION

High-flow nasal oxygen (HFNO) has been identified as an effective intervention in the treatment of acute respiratory failure, especially about the prevention of reintubation in patients who have been 'extubated.' HFNO maintains a temperature and humidity of the delivered oxygen at flow rates up to 60 L/min, which increases oxygenation, reduces work of breathing, and increases patient comfort. It is used based on its effectiveness in decreasing endotracheal intubation rate and its complications. Published literature also supports the use of HFNO in different patients' populations. For example, a case report on 'preemptive use of HFNO to prevent reintubation in a high-risk patient' described its efficacy when HFNO was applied during critical and pivotal recovery phases [20]. Further, HFNO has been proven to lower all-cause mortality rates and the recourse to invasive mechanical ventilation as compared to standard oxygen therapy [24] [20]. Despite these benefits, there is still controversy, proving it to be superior to noninvasive ventilation (NIV) and conventional oxygen in all cases. Other research indicates that while HFNO does prevent reintubation and is better for patient comfort, it is not superior to NIV when compared to the degree of some types of respiratory failure risk [20].

A. PERSONAL INSIGHT AND EVALUATION

Considering the analysed studies, the use of HFNO seems to be a beneficial modality in preventing reintubation within selected patient populations. Its effectiveness in providing high-flow, humidified oxygen that enhances the patient's oxygenation and decreases his respiratory work makes it a useful modality, especially for any patient who is likely to develop respiratory failure after being extubated. However, the studies indicate that although HFNO offers better patient comfort and a lower risk of reintubation than conventional oxygen, it is not superior to NIV, especially in cases of severe respiratory failure.

Therefore, in my view, HFNO should be regarded as the best practice in selected situations, such as when used as a primary strategy in patients who are at a high risk of experiencing reintubation. Considering its positive effects on the frequency of reintubation and the level of patients' comfort, its utilisation is justified, although it should be used in combination with other approaches, such as continuous monitoring and other types of non-invasive support tools.

B. GAPS IN CURRENT RESEARCH AND FUTURE DEVELOPMENTS

Nevertheless, there are several limitations in the current research that should be highlighted: First, the efficacy of HFNO versus NIV in different patient

groups should be better compared to establish the potential advantages of each approach and outcomes of patients' treatment in different conditions. Furthermore, less consideration has been given to the chronic effects of HFNO on the length of stay in the ICU, mortality among patients, as well as the comfort of the patients.

Further studies should aim at finding out which patient subsets would benefit from HFNO and customising settings and algorithms for this form of support, as well as how HFNO can be incorporated with other forms of intervention. Other related factors could include developments in the technological aspect of the HFNO, for instance, better nasal cannula designs and flow delivery, which may increase the effectiveness of the technology and patient benefits. These research deficits and fostering new HFNO applications will be critical in further expanding understanding of the device's role in the reduction of ICU reintubations and respiratory care management.

Recommendations

Taking into perspective the examined literature, High-Flow Nasal Oxygen (HFNO) is a useful therapeutic resource aimed to address patients as potential candidates for reintubation after extubation. It makes oxygenation better, reduces the amount of effort the patient must use when breathing, and increases patient comfort because of high flow rates of humidified and heated oxygen. Based on these positive outcomes, HFNO should be utilised in the management of patients having ARF, specifically in cases of acute hypoxemic respiratory failure, when combined with other noninvasive interventions, including noninvasive ventilation [22]. The application of HFNO into clinical practice should utilise the patient-specific rates of mean airway flow, temperature, and concentrations of oxygen. Measures such as the ROX index can be used in forecasting treatment outcomes and appropriate management to prevent cases such as reintubation.

Based on the reviewed study and to enhance the applications of HFNO and fill the existing gaps in the literature, the following suggestions for future research and clinical practice are recommended. First, there is a need for subsequent research studies that will aim at comparing the efficacy of HFNO with other therapeutic interventions like NIV and conventional oxygen therapy. Further studies should also involve different patient populations or different severity of acute hypoxic respiratory failure to delineate the strengths and weaknesses of HFNO. This also involves assessing its impact on controlling mortality rates, the duration that patients stay in the ICU, and the general health status of the patients.

Moreover, exploring the benefits of HFNO in the broader context of the post-COVID-19 patient, including on patient outcomes and quality of life, will facilitate a better understanding of the impact of the technique. The implementation of guidelines and policies regarding the use of HFNO and research on equipment innovations can result in better practices in HFNO usage in clinical practice. It is also necessary for future research to investigate whether there are further ways to apply HFNO in combination with other interventions like corticosteroids or prone positioning. A better understanding of these areas of HFNO research will not only help to optimise the actual use of HFNO but will also advance the creation of a set of standard guidelines for using the method. In the end, the fine-tuning of HFNO strategies and a combination of other therapeutic procedures will create the best approach to patients' treatment, reduce the possibility of reintubation, and enhance outcomes in the ICU.

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