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The efficiency of high flow nasal cannula for respiratory support in adults in the intensive care unit when compared to regular oxygen, non-invasive ventilation, or non-invasive positive pressure ventilation: A systematic review

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Abstract

Objective We aimed to compare the effectiveness of HFNC to NIV or NIPPV, conventional oxygen treatments, for respiratory support in adult intensive care unit patients.

Method: In compliance with The Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guideline, this systematic review study was carried out. We looked through Google Scholar, Cochrane, PubMed, and electronic databases to find randomized controlled trials that were released between 2017 and 2023.

Result and conclusion: Five randomized controlled trials (with different primary outcomes: hospital length of stay, PaO2/FIO2 ratio, post-extubation vital signs, ABG, respiratory failure three days after extubation, and 28-day mortality rate) were included in this systematic review. Among non-hypercapnic patients at high risk of extubation failure, HFNC may be more advantageous than standard oxygen in delaying the onset of respiratory failure; in terms of vital signs and ABGs, HFNC is a viable replacement for NIV in the weaning of hypercapnic COPD patients; additionally, HFNC improved patient comfort and secretion clearance.

Keywords: High flow nasal cannula; Respiratory support; Noninvasive ventilation; Intensive care unit

1. Introduction

One of the primary causes of admission to ICU is the requirement for mechanical ventilation. Patients who have recovered from a serious illness must be taken off of oxygen and allowed to breathe on their own again. Physicians must weigh the advantages of extending mechanical ventilation to allow for a better recovery against the accompanying dangers, which mostly include delirium, muscular atrophy, and lung infections, as it can be challenging to determine when a patient is ready to be extubated (1). Ten to twenty percent of extubation efforts are unsuccessful (2), and failure to extubate is linked to higher rates of morbidity and death. Therefore, methods to lower the rate of extubation failure are required (3).

HFNC, a novel oxygen delivery technique, have just entered the clinical setting (4). By use of modified nasal prongs, HFNC devices deliver a regulated blend of oxygen and air that is actively warmed and humidified at a rate of between

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30 and 60 L/min, resulting in a moderate PEEP (5). Through several methods, HFNC may aid in the prevention of extubation failure. Brief hypoxemic episodes could be lessened by the regulated oxygen concentration (5). The high flow reduces minute ventilation and respiratory rate by washing away the nasopharyngeal dead space, which lowers CO2 re-breathing (6). A modest amount of PEEP may prevent lung collapse (7), improving gas exchange and lowering breathing effort. Additionally, in individuals suffering from COPD, this degree of PEEP may balance auto PEEP, hence lowering breathing effort (8). Lastly, humidification may lessen mucus retention and enhance mucus outflow, so easing the atelectasis that is related to it (9).

Our goal was to evaluate the efficacy of HFNC for respiratory support in adult ICU patients in comparison to traditional oxygen treatment, either NIV or NIPPV.

2. Methods

This systematic review study was conducted according to The Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) statement. We searched the electronic databases, Cochrane, PubMed, and Google scholar for randomized controlled trials published in the period from 2017 to 2023. For the additional outcome variables of positive expiratory pressure, oxygenation, respiratory rate, carbon dioxide clearance, effort of breathing, and participant-reported outcomes, we included all randomized controlled studies. Studies that recruited people in the ICU who needed respiratory assistance were included in our review. We compared HFNC with alternative forms of non-invasive respiratory support, such as non-invasive ventilation or regular oxygen treatment administered by nasal cannula.

Four researchers applied the above specified parameters to individually assess studies for eligibility. Every abstract that met the initial inclusion criteria was evaluated as a full text article. The final data analysis contained the papers that both extractors determined satisfied the requirements for full text review eligibility. Consensus was used to resolve any disputes, and the appropriate author was consulted as needed. Four authors extracted data independently from the included studies. The investigators collected data and entered it into a pre-made data collection form after finishing their initial training. Abstracts included the last name of the first author, the year the study was published, the study design, study aim, outcome, the main findings, and the conclusion.

3. Results and discussion

In this systematic review we included 5 studies (Fig 1), all randomized controlled trials. The primary outcome varied between the studies (Hospital length of stay, PaO_2/F_IO_2 ratio, Post extubation vital signs, ABG, Respiratory failure 3 days after extubation and 28 days mortality rate) (Table 1).

According to Zochios et al. (2018), the use of high-flow nasal oxygen led to a statistically significant decrease in hospital length of stay and a decrease in ICU re-admissions. Other secondary outcomes did not exhibit any significant differences between groups. Following heart surgery, airflow restriction is a major predictor of longer hospital stays and in-hospital death (10). The following mechanisms may account for the beneficial effects of high-flow nasal oxygen on cardiac surgery and the shorter hospital stay in a study cohort: generation of low-level PEEP (11,12), washout of nasopharyngeal dead space, reduced work of breathing, and improved respiratory mechanics. The oxygen that has been heated and humidified promotes the best possible operation of the mucociliary clearance system and the airway mucosa. It also suppresses the bronchomotor response, which in turn prevents bronchospasm and enhances airway resistance (13). High-flow nasal oxygen has been demonstrated to minimize dead space ventilation in a flow- and time-dependent way, which lowers the effort required to breathe, lessens rebreathing, and improves alveolar ventilation (12).

A growing number of non-cardiac surgery settings are using high-flow nasal oxygen as a first-line therapy for acute respiratory failure. Data from well-designed and adequately powered trials support this approach, demonstrating that high-flow nasal oxygen application lowers the rate of tracheal re-intubation in low-risk patients (14) when compared to conventional oxygen therapy, confers a benefit on survival (15) and reduces the rate of tracheal re-intubation in patients with non-hypercapnic hypoxaemic respiratory failure (5).

The study conducted by Vourc'h et al. (16) found that the HNFC resulted in a two-fold decrease in the usage of NIV for treatment failure, enhanced nasal mucus dryness tolerance with high-flow oxygen therapy, and higher overall satisfaction. These outcomes are consistent with earlier research evaluating HFNC's capacity to increase oxygenation in comparison to a face mask or NIV (17). In patients undergoing cardiac surgery who had severe hypoxemia before to extubation, Maggiore et al. found that HFNC increased oxygenation, decreased the need for non-invasive ventilation, and enhanced patient comfort when compared to Venturimask (5). Also Vourc'h et al. study emphasizes, HFNC had a little impact on PaCO2. Thus far, HFNC has mostly been studied as a prophylactic measure against respiratory problems following heart surgery (17).

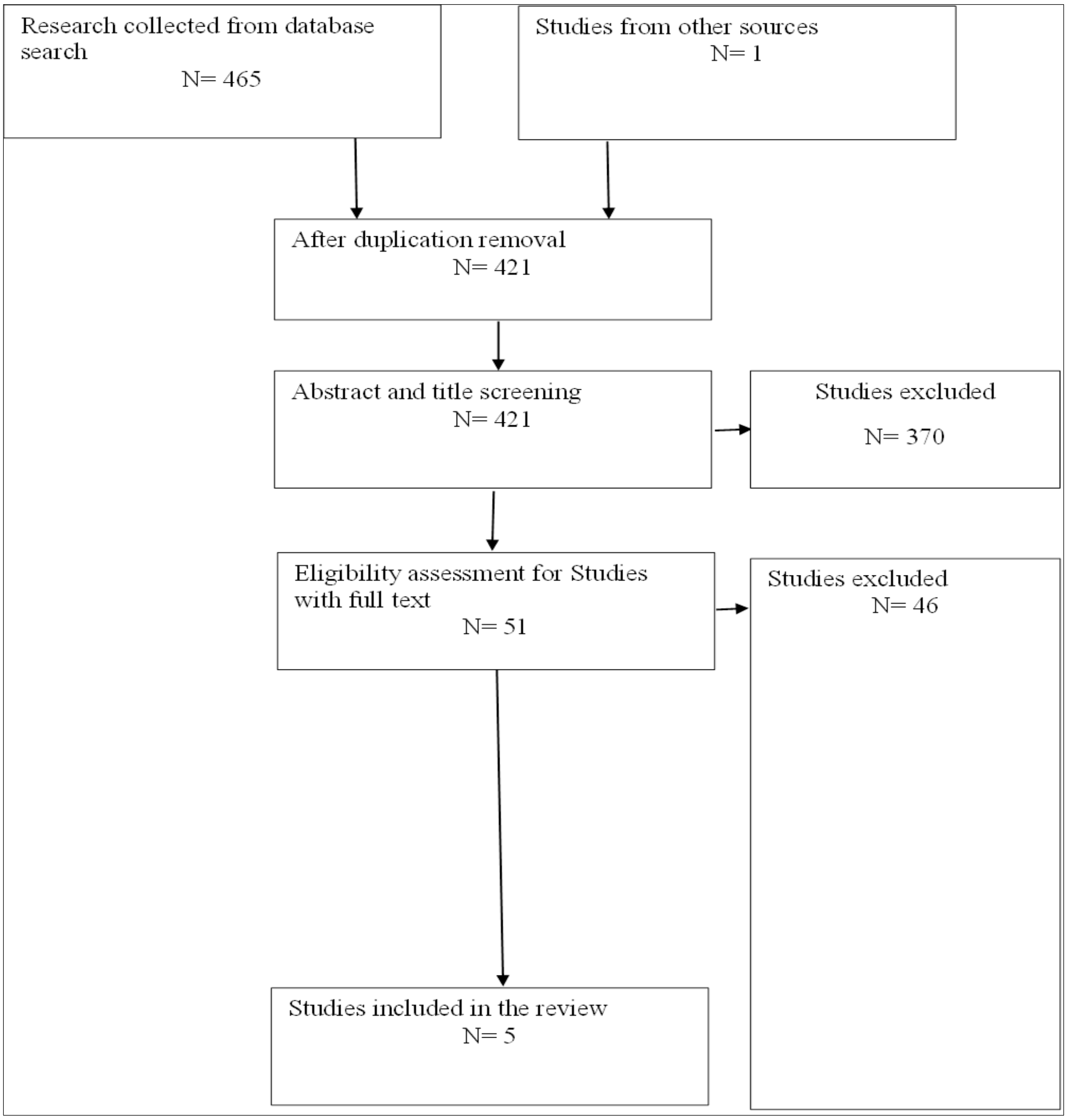

Figure 1 PRISMA consort chart of selection process

Stephan et al. observed that, in this particular context, HFNC was noninferior to NIV in terms of preventing reintubation, with NIV exhibiting a higher PaO2/FIO2ratio until 12 hours after inclusion (17). The European System for Cardiac Operative Risk Evaluation II's low score and the exclusion of patients with hemodynamic instability may be explained by the current study's decreased incidence of reintubation and death overall when compared to the latter study. The only studies showing that HFNC reduced desaturation in comparison to HFFM after heart surgery without raising the PaO2/FIO2 ratio were those conducted by Parke et al (18).

Fernandez et al. (2017) (19) found no statistically significant difference between postextubation respiratory failure with HFNC and conventional oxygen. Even yet, HFNC may be independently linked to decreased postextubation failure in four multivariable regression models after controlling for confounding factors.

In MV, extubation failure continues to be one of the most critical problems. Ten to twenty percent of patients fail to get out of protective ventilation, even with improvements in sedative techniques, early mobility, and protective breathing

(2). Furthermore, there is no doubt that extubation failure is linked to higher rates of morbidity and death. Patients who need to be reintubated may in fact have a 50% mortality rate (20). There is little doubt that the ICU case-mix affects the incidence of postextubation respiratory failure, which is higher in medical and severely ill patients and lower in patients intubated for planned surgery. Thus, while evaluating any preventative therapy, it is imperative to categorize individuals based on their level of risk. Regarding the risk variables that indicate extubation failure, there is no universal agreement (1), and several investigators have established their own standards.

Thille et al. (20) recently shown that the expertise of caregivers is not very useful in predicting extubation failure; in a highly experienced ICU, only one-third of the patients who needed reintubation were thought to be at high risk for extubation failure. Nine factors were included in their study to identify individuals who were more likely to fail.

Table 1 Main findings and outcome of included studies

Citation	Aim	Design	Primary outcome	Main findings
Zochios et al., 2019 (21)	To ascertain if routine high-flow nasal oxygen delivery, as opposed to normal oxygen therapy, results in shorter hospital stays following heart surgery in patients who have a history of respiratory illness and are at high risk of developing pulmonary problems after the procedure.	Randomized controlled trial	Hospital length of stay	High-flow nasal oxygen was linked to fewer re-admissions to the critical care unit, with a median hospital length of stay of 7 days in the high-flow nasal oxygen group and 9 days in the standard oxygen group. The high-flow nasal oxygen group also had a geometric mean hospital length of stay that was 29% shorter. Prophylactic postoperative high-flow nasal oxygen decreased hospital duration of stay and re-admission to the critical care unit as compared to routine therapy.
Vourc'h et al., 2020 (16)	To ascertain whether HFFM or HFNC high-flow oxygen treatment is superior in cases of severe hypoxemia.	Randomized controlled trial.	PaO2/FIO2 ratio	In HFFM, 56% of patients had noninvasive ventilation due to refractory hypoxemia, whereas 28% of HFNC patients experienced this condition. When compared to HFFM, the HFNC increased satisfaction and decreased mucus dryness. Following heart surgery, patients with severe hypoxemia had greater PaO2/FIO2 at 1 and 24 hours, and noninvasive ventilation was used less frequently in HFNC patients than in HFFM patients.
Jing et al., 2019 (22)	Research examined how HFNC and NIV affected COPD patients' postextubation vital signs and ABGs.	Pilot randomized controlled trial	Postextubation vital signs ABG	Before extubation, ABGs and vital signs were comparable among groups. The pH in the NIV group was lower than the HFNC group three hours after extubation. The mean arterial pressure and pH of the patients in the NIV group were lower than those in the HFNC group 24 hours after extubation. 48 hours after extubation, no discernible changes were discovered. Comfort ratings were higher and fewer patients in the HFNC group had a bronchoscopy within 48 hours of being extubated in order to control secretion. Regarding vital signs and ABGs, HFNC is a viable substitute for NIV in the weaning of hypercapnic COPD patients. Additionally, HFNC enhanced patient comfort and secretion clearance.
Fernandez et al., 2017 (19)	To prove that, as compared to standard oxygen, HFNC lowers postextubation respiratory	Randomized	Respiratory failure 3	At enrollment, the groups were comparable, and every patient could tolerate 24-hour HFNC. Respiratory failure upon extubation

	failure in high-risk, non-hypercapnic patients.	controlled trial	days after extubation	occurred in 27% of conventional patients and 20% of HFNC patients. In 11% of HFNC patients and 16% of conventional patients, reintubation was required. Mortality or duration of stay in the ICU or hospital did not differ. According to logistic regression models, postextubation respiratory failure may be independently correlated with HFNC and cancer.
Azoulay et al., 2018 (23)	To ascertain if, in comparison to regular oxygen therapy, high-flow oxygen therapy reduces mortality among immunocompromised patients with AHRF.	Randomized clinical trial	28 days mortality	At randomization, the intervention and control groups had a median respiratory rate of 33/min vs. 32 and a Pao2:Fio2 of 136 vs. 128. In both groups, the median SOFA score was 6. There was no discernible difference in mortality between the groups on day 28. There was no discernible difference in the intubation rate between the groups. After six hours, patients randomly assigned to high-flow oxygen treatment had a lower respiratory rate and a greater Pao2:Fio2 than the controls. Patient comfort and dyspnea ratings, duration of stay in the intensive care unit, length of stay in the hospital, and ICU-acquired infections did not show any discernible differences.

List of Abbreviations

- High flow nasal cannulae, HFNC
- High flow nasal cannulae, HFFM
- NIPPV, Noninvasive positive pressure ventilation
- NIV, noninvasive ventilation
- ABGs, arterial blood gases
- AHRF, acute hypoxemic respiratory failure
- NHF, Nasal high flow
- ICU, intensive care units
- PEEP, positive end-expiratory pressure
- COPD, chronic obstructive pulmonary disease

4. Conclusion

For non-hypercapnic patients at high risk of extubation failure, HFNC may be more beneficial than standard oxygen in preventing the onset of respiratory failure. Regarding vital signs and ABGs, HFNC is a viable substitute for NIV in the weaning of hypercapnic COPD patients. Additionally, HFNC enhanced patient comfort and secretion clearance. Following heart surgery, patients with severe hypoxemia had greater PaO2/FIO2 at 1 and 24 hours, and noninvasive ventilation was used less frequently in HFNC patients than in HFFM patients. After extubation, NHF produces superior oxygenation for the same set of FiO2. This is in contrast to the Venturi mask. Better comfort, fewer desaturations and interface displacements, and a decreased incidence of reintubation are all linked to the use of NHF.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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