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Systematic Review

High-Flow Nasal Cannula for Respiratory Support in Adult ICU Patients: A Systematic Review

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Abstract

Background: High-flow nasal cannula (HFNC) is increasingly used for non-invasive respiratory support in adult ICU patients, mainly after extubation and in hypoxemic respiratory failure. Out study aim to evaluate the effectiveness of HFNC compared with conventional oxygen therapy, non-invasive ventilation (NIV), or non-invasive positive pressure ventilation in adult ICU patients requiring respiratory support. **Methods:** This systematic review followed PRISMA principles. We searched PubMed, Cochrane, Google Scholar, and other electronic databases for randomized controlled trials published between 2017 and 2025. Adult ICU studies comparing HFNC with conventional oxygen therapy, NIV, or non-invasive positive pressure ventilation were included. Overall, 466 records were identified, 421 remained after duplicate removal, 51 full texts were assessed, and 5 randomized controlled trials were included. **Results:** The included trials reported heterogeneous outcomes, including hospital length of stay, PaO2/FiO2 ratio, post-extubation vital signs, arterial blood gases, respiratory failure within 3 days after extubation, and 28-day mortality. HFNC associated with shorter hospital stay and fewer ICU readmissions in postoperative cardiac patients, improved oxygenation and reduced NIV use in severe hypoxemia after cardiac surgery, and provided comparable physiological. **Conclusion:** HFNC is effective respiratory support option in selected adult ICU populations, mainly for oxygenation, comfort, and some post-extubation outcomes.

Keywords: high flow nasal cannula, respiratory support, noninvasive ventilation, intensive care unit

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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 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 CO_2 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.

Method

This systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement. The review was designed to evaluate the effectiveness of high-flow nasal cannula (HFNC) for respiratory support in adult patients admitted to the ICU, in comparison with conventional oxygen therapy, non-invasive ventilation (NIV), or non-invasive positive pressure ventilation (NIPPV). The review focused on randomized controlled trials published between 2017 and 2025.

A systematic search of the literature was conducted on PubMed, Cochrane Library, Google Scholar, and other electronic databases to identify relevant studies published during the predefined study period. The search was directed toward randomized controlled trials investigating the use of HFNC in adult ICU patients who required respiratory support. Studies were included if they evaluated HFNC against alternative non-invasive respiratory support strategies, including conventional oxygen therapy administered by nasal cannula, NIV, or NIPPV.

Studies were considered eligible if they randomized controlled trial design; adult participants admitted to the ICU; use of HFNC as the intervention of interest; comparison with conventional oxygen therapy, NIV, or NIPPV; and reporting of clinically relevant respiratory outcomes. Outcomes of interest included positive expiratory pressure, oxygenation, respiratory rate, carbon dioxide clearance, work or effort of breathing, and participant-reported outcomes. We exclude studies

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that did not involve ICU patients, did not evaluate HFNC as a primary intervention, were not randomized controlled trials, or did not provide relevant outcome data.

Study selection was carried out independently by two reviewers using the predefined eligibility criteria. After removal of duplicate records, titles and abstracts were screened for relevance. Articles judged eligible were retrieved and assessed in full text. Disagreements regarding study inclusion were resolved by discussion and consensus. Initially 465 records were identified through database searching and 1 additional record was identified from other sources. After removal of duplicates, 421 records remained for title and abstract screening. Of these, 370 were excluded, leaving 51 full-text articles assessed for eligibility, of which 5 randomized controlled trials were ultimately included in the review.

Data extraction was performed by four authors using a predesigned data collection form after initial reviewer training. The extracted data included the surname of the first author, year of publication, study design, study aim, primary outcome, main findings, and study conclusion. These data were organized into a summary table to facilitate comparison across the included studies (Tables 1-3).

Because the included studies differed in their clinical populations, comparator interventions, and primary outcomes, the findings were synthesized qualitatively rather than pooled in a meta-analysis. The primary outcomes reported by the included studies included hospital length of stay, PaO2/FiO2 ratio, post-extubation vital signs, arterial blood gases, respiratory failure within 3 days after extubation, and 28-day mortality. A descriptive comparison of the included trials was undertaken, with emphasis on the direction and clinical relevance of the reported effects of HFNC in adult ICU patients.

Result and conclusion

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

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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).

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.

Fig 1: PRISMA flow chart

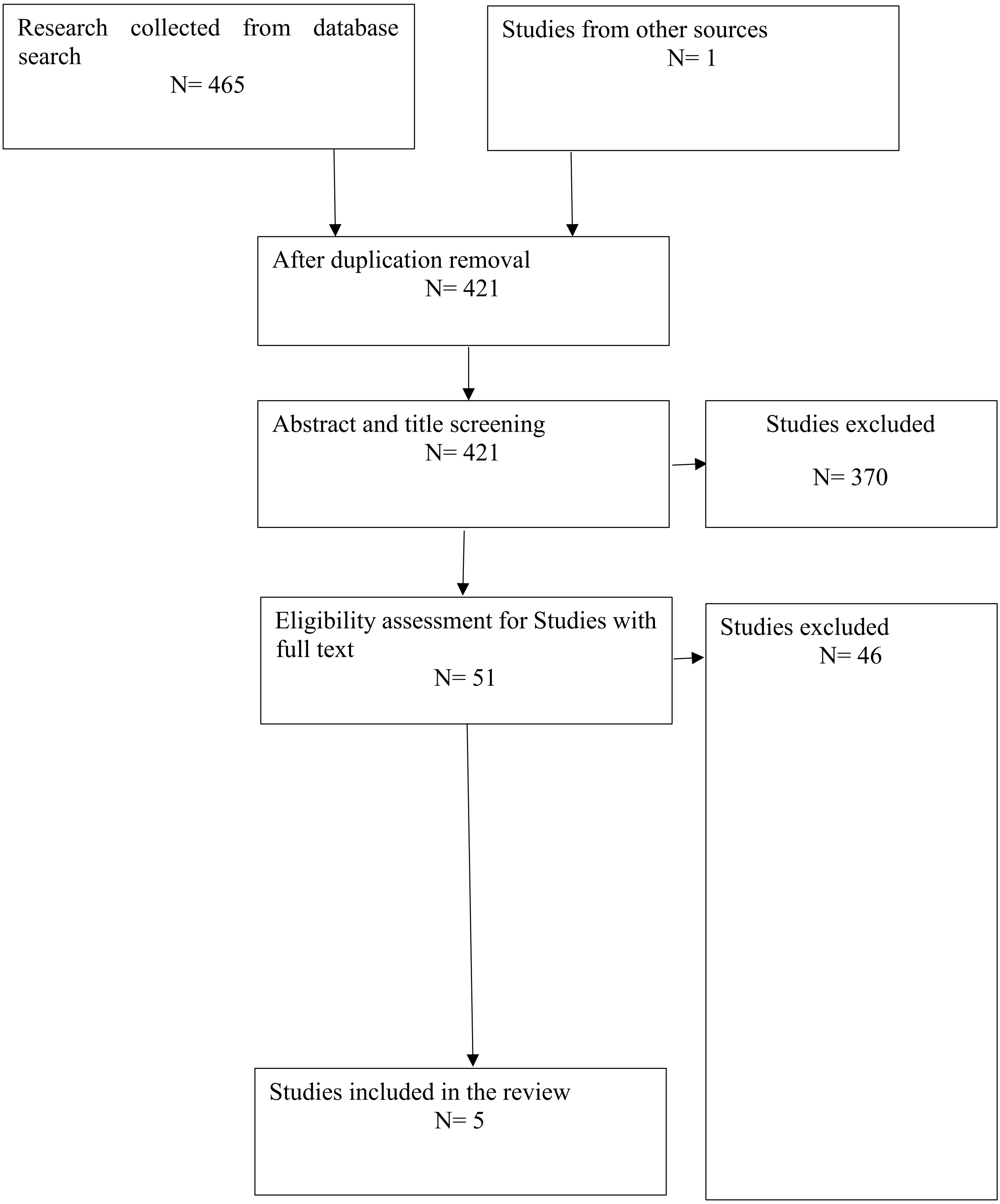

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Table 1: Study Characteristics

Author (year)	Country	Study design	Population	Sample size (n)	Intervention	Comparator
Zochios et al. (2018) (21)	UK & Switzerland	Randomized Controlled Trial	Adult cardiac surgical patients at high risk for respiratory complications	100 (HFNO: 51, Oxygen: 49)	Prophylactic high-flow nasal oxygen (HFNO)	Standard oxygen therapy
Azoulay et al. (2018) (23)	France (32 ICUs)	Randomized Clinical Trial (HIGH Trial)	Adult immunocompromised patients with acute respiratory failure	776 (HFNC: 388, Oxygen: 388)	Continuous high-flow nasal oxygen (HFNC)	Standard oxygen therapy
Jing et al. (2019) (22)	China	Pilot Randomized Controlled Trial	COPD patients with hypercapnia during weaning from invasive ventilation	42 (HFNC: 22, NIV: 20)	High-flow nasal cannula (HFNC)	Non-invasive ventilation (NIV)
Thille et al. (2015)	France	Prospective Observational Study	Medical ICU patients after planned extubation	225 patients	Observational monitoring	Standard Care
Vourc'h et al. (2019) (16)	France	Randomized, single-center, controlled study	Cardiac surgery patients with severe hypoxemia	90 patients	HFNC (45 L/min)	High-flow face mask (HFFM)
Fernandez et al. (2017) (19)	Spain	Randomized multicenter trial	High-risk non-hypercapnic patients after extubation	155 (HFNC: 78, Oxygen: 77)	HFNC for 24 hours	Conventional oxygen

Table 2: Participant Demographics and Clinical Baseline

Author (year)	Participants	Primary condition / severity
Zochios (2018)	Adults	Post-cardiac surgery with pre-existing respiratory disease
Azoulay (2018)	Median 64	Immunocompromised; Median Respiratory Rate 32–33 per minute
Jing (2019)	COPD Patients	COPD with persistent hypercapnia at the time of extubation
Thille (2015)	Medical ICU Patients	Patients intubated for more than 24 hours
Vourc'h (2019)	Cardiac Surgery Patients	Oxygen saturation below 96% with Venturi mask 50%
Fernandez (2017)	High-risk patients	Non-hypercapnic; passed spontaneous breathing trial

Table 3: Clinical Outcomes

Author (year)	Primary outcome results	Reintubation / respiratory failure	Mortality (day 28 or ICU)	Length of stay (LOS)
Zochios (2018)	Median Hospital LOS: 7 days (HFNO) vs. 9 days (Oxygen)	Lower ICU re-admission rate in the HFNO group		29% lower Hospital LOS in HFNO group
Azoulay (2018)	28-day mortality rates	Rates of intubation or mechanical ventilation by Day 28	Primary outcome was 28-day mortality	ICU and hospital LOS were secondary outcomes
Jing (2019)	pH at 3 hours: 7.45 (HFNC) vs. 7.42 (NIV)	Postextubation respiratory failure was the primary assessment goal		
Thille (2015)	Reintubation within 7 days: 14%	14% failure rate observed in the total cohort		Ventilation for more than 7 days was a risk factor for failure

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Author (year)	Primary outcome results	Reintubation / respiratory failure	Mortality (day 28 or ICU)	Length of stay (LOS)
Vourc'h (2019)	PaO2/FiO2 at 1 hour: 137.8 (HFNC) vs. 113.4 (HFFM)	Assessed as management for severe hypoxemia		The higher PaO2/FiO2 ratio in HFNC persisted at 24 hours
Fernandez (2017)	Respiratory failure at 72h: 20% (HFNC) vs. 27% (Oxygen)	Reintubation: 11% (HFNC) vs. 16% (Oxygen)	Secondary outcome	ICU and Hospital LOS were secondary outcomes

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.

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

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