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RESEARCH **REVIEW ARTICLE**

Noninvasive Ventilation for Weaning from Mechanical Ventilation: A Literature Review

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ABSTRACT

The implementation of noninvasive ventilation as a weaning strategy from mechanical ventilation has been steadily rising in recent years. Unlike mechanical ventilation, noninvasive ventilation is thought to preserve diaphragmatic muscle strength, ensuring a quicker and more effective healing process. This review article aims to highlight this topic by examining past studies investigating noninvasive ventilation as a weaning strategy and comparing its performance to other methods. Additionally, we reviewed the available literature on utilizing this strategy in specific subgroups of the population. Based on our review, most studies report that noninvasive ventilation reduces reintubation risks, minimizes the requirement for antibiotics, lowers the incidence of ventilator-associated pneumonia, and leads to decreased length of intensive care unit stay. However, the results were inconclusive regarding post-extubation respiratory failure and mortality rates. This review aims to facilitate and encourage further investigations into the role of noninvasive ventilation among the general population and specific subgroups.

KEYWORDS - noninvasive ventilation, invasive ventilation, extubation, weaning

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INTRODUCTION

Mechanical ventilation (MV) is a lifesaving intervention [1]. In the United States, 39.5% of intensive care unit (ICU) patients require mechanical ventilation [2]. Protocolized and evidence-based weaning from MV is crucial to improving the number of ventilator-free days [3].

Proper diaphragmatic muscle function is essential for successful weaning from mechanical ventilation. To our knowledge, MV induces cataclysmic changes, including diaphragmatic muscle damage and atrophy. With prolonged ventilation, the impact is more significant [4], which limits satisfying weaning trials as they require intact muscles and respiratory drive to counteract the load after running a spontaneous breathing trial [5].

Extubation to noninvasive ventilation (NIV) has been proposed as a method for weaning by decreasing the load on the muscles, allowing gradual recovery, reducing sedation requirements, and lowering the risk of nosocomial pneumonia [1,6,7]. In this review article, we will examine the evidence regarding the practice of extubation to NIV following MV compared to the standard of care.

METHODS

SEARCH STRATEGY

We conducted a comprehensive literature search utilizing PubMed as our source database. The search was conducted on April 2023, in which all relevant randomized controlled trials (RCTs) and systematic reviews published between 2010 and 2023 were included, yielding ninety-one articles. Nineteen articles were included in our review. The keywords used for the search were 'weaning,' 'non-invasive ventilation,' 'invasive ventilation,' and 'extubation'.

STUDY SELECTION

We enrolled randomized and quasi-randomized trials, systematic reviews, and meta-analyses that compared NIV as a weaning strategy to invasive mechanical ventilation (IMV) and other respiratory support methods. The review article included previous studies conducted among adults with respiratory failure who required IMV. In Addition, we incorporated studies that compared NIV with other weaning methods. Furthermore, we included studies that examined the application of NIV within specific populations, such as obese individuals, those with chronic obstructive pulmonary disease (COPD), and hypoxemic non-hypercapnic patients.

OUTCOMES INCLUDED

The outcomes included reintubation rates, mortality rates, incidence of ventilator-associated pneumonia (VAP), and length of ICU and hospital stay (LOS). We also explored the duration of mechanical ventilation and the need for antibiotics.

RESULTS

LITERATURE REVIEW

SYSTEMATIC REVIEWS AND META-ANALYSES - Table 1 provides a summary of randomized controlled trials, systematic reviews, and meta-analyses. Four studies indicate that NIV reduces reintubation rates compared to IMV [8,9] and conventional oxygen therapy (COT) [10,11]. However, other studies showed that NIV does not offer significant benefits in reintubation rates compared to HFNC and standard medical care [10–13].

When discussing mortality rates, most studies found no significant differences between NIV, IMV, COT, or HFNC [10–15]. Nevertheless, three studies suggest that NIV may be advantageous in terms of mortality rates compared to IMV [8,16,17]. Regarding ICU LOS, NIV generally resulted in less time spent in the ICU, especially compared to IMV [8,13,14,16]. However, it did not show superiority over COT or HFNC [11,15]. Additionally, NIV reduced the duration of IMV and decreased the incidence of weaning failure [9,16].

Regarding post-extubation respiratory failure, no significant advantage was observed with the use of NIV [10]. However, one study indicated lower rates of post-extubation respiratory failure with HFNC and NIV, without one being superior [11].

Furthermore, NIV demonstrated significantly lower rates of VAP when compared to IMV [9,14,17]. Nevertheless, one study suggested that HFNC is equally effective as NIV [11]. In contrast, another study proposed that HFNC might be better regarding ventilator adverse effects compared to NIV [15].

Considering specific subpopulations, the COPD patient group was the most studied. NIV consistently showed significantly better outcomes regarding reintubation rates, mortality rates, ICU LOS, duration of IMV, and VAP [8,16,17].

RANDOMIZED CONTROLLED TRIALS - First, discussing the reintubation rate as the primary outcome, four studies found a significant drop in the rate of reintubation within seven days [18–21] and within 72 hours in one study [22] when comparing HFNC to NIV [18–22]. In contrast, Perkins et al. found an increase in the reintubation rate in patients who were weaned into NIV compared to MV. [23] Also, not far from the reintubation rate, the total time on MV was lower in the NIV group in three RCTs [23–25].

Adult patients who underwent mechanical ventilation required much lower antibiotics when using NIV. [23] Moreover, the adverse effects of prolonged mechanical ventilation, such as VAP and tracheotomy, were found to be much lower in the NIV group. [24] Regarding post-extubation respiratory failure, the patients who had early NIV during the first 48 hours of extubation showed a lower rate of respiratory failure [26].

In addition, one study found that NIV ventilation use decreased the hospital and ICU length of stay [24]. However, a single study showed positive results of NIV on mortality rate when compared to HFNC [21]. Furthermore, two studies focused on COPD with the majority of patients diagnosed before the beginning of each study; the first one showed that the use of NIV significantly decreased reintubation rate when used alongside HFNC [20], contrary to the other study described similar outcomes in terms post-extubation respiratory failure and reintubation rate. Still, HFNC had lower susceptibility to ventilator-associated adverse events and the need for airway interventions [27].

In obese or overweight patients, NIV with HFNC decreased the risk for post-extubation respiratory failure, reintubation, and overall lower mortality rate compared to HFNC alone. [21] In patients who underwent cardiac surgery, using NIV as a weaning method shortened the ICU and hospital length of stay, decreased time on MV, pneumonia incidence, and the necessity for procedural tracheotomy [24]. The application of NIV as a treatment for post-extubation failure showed no benefits compared to conventional oxygen therapy [28-30].

DISCUSSION

In our review, multiple studies had consistently shown that extubation to NIV is associated with a lower reintubation rate, reduced mortality, and resulted in shorter time on MV when compared to standard of care. Additionally, NIV decreased the need for antibiotics.

When compared to utilizing a high-flow nasal cannula (HFNC) following extubation, NIV yielded similar results regarding post-extubation respiratory failure and reintubation rates. Furthermore, HFNC exhibited a lower susceptibility to ventilator-associated adverse events and the need for airway interventions. However, we could not definitively determine the efficiency of NIV in preventing post-extubation respiratory failure and mortality rates.

When considering specific subpopulations, NIV proved beneficial for COPD patients, significantly reducing weaning time, ICU LOS, the risk of reintubation, and the development of acute respiratory failure. On the other hand, among obese and overweight patients, NIV lowered the incidence of post-extubation respiratory failure and mortality rates. Also, NIV decreased time on MV, the incidence of pneumonia, and hospital and ICU LOS among patients who underwent cardiac surgery extubating from MV.

In this literature review, we encountered some limitations. We could not conclude the efficacy of NIV in preventing post-extubation failure and mortality rates. Furthermore, our search on PubMed was limited to articles published after 2010; other search engines may provide valuable articles relevant to the review topic. However, related studies before 2010 were scarce. Finally, there is a strong possibility of bias when conducting a literature review by selectively choosing articles from top-tier journals.

CONCLUSION

In summary, multiple studies have found that using non-invasive ventilation after extubation is linked to a lower rate of reintubation, reduced mortality, need for antibiotics, and shorter mechanical ventilation duration compared to standard care [8-11,13,14,16,17-25]. However, the efficiency of NIV in preventing post-extubation respiratory failure and mortality rates remains inconclusive [8,10-17,21,26].

Among specific subpopulations, noninvasive ventilation is particularly beneficial for chronic obstructive pulmonary disease, obese, and cardiac patients, leading to shorter time on mechanical ventilation, reducing hospital and intensive care unit length of stay [8,16,17,20,21,24,27].

In this review article, we have highlighted the pros and cons of noninvasive ventilation compared to other respiratory support methods used in weaning, especially invasive ventilation. This review aims to facilitate and encourage further investigations into the role of noninvasive venti-

lation among the general population and specific subgroups.

DISCLAIMER

This article was made possible by the support of the American people through the United States Agency for International Development (USAID). The contents are the sole responsibility of the authors and do not necessarily reflect the views of USAID or the United States Government.

AUTHORS' CONTRIBUTION

Eyad Kawar was involved in conceptualization, manuscript writing, and revision. Fouad Ziad Subieh was involved in conceptualization and manuscript revision. All authors approved this manuscript version for submission. Saba Alsmadi, Daniah Alfaqheri,and Hammam B Zaitoun were involved in data extraction, manuscript drafting and writing. Saba Alsmadi was involved in overall supervision.

Table 1. European Society of Cardiology 2019 pulmonary embolism stratification.

Reference	Intervention	Primary Outcomes	Secondary outcomes	Results
8	Efficacy of NIV after planned extubation	Reintubation rate	ICU mortality, hospital mortality, ICU length of stay and hospital stay.	Using NIV right away following a planned extubation may help lower the rates of reintubation, ICU mortality, hospital mortality, and ICU duration of stay
9	NPPV vs IPPV	Mortality rate.	ICU length of stay, overall incidence of VAP, adverse events of ventilatory support, time on MV, time on MV related to weaning and weaning failure. quality of life	NPPV dramatically reduced mortality, weaning failure, and VAP as compared to IPPV.
10	HFNC vs NPPV vs COT in Acute respiratory failure patients post extubation.	Short term mortality rates	Post extubation respiratory failure, reintubation within 72 hours	Reintubation rates were lower with HFNC compared to COT, but not NPPV. However, the rest of the outcomes showed no difference between the three methods.
11	HFNC vs COT vs NIV	Reintubation rates	Post extubation respiratory failure , HAP, mortality rate. , length of stay at ICU and hospital	The primary outcome of this study, reintubation rates, showed no significant difference between HFNC and NIV. On the other hand, NIV was found to be significantly better than COT. Additionally, both HFNC and NIV demonstrated similar efficacy in reducing post-extubation AR and HAP compared to COT. None of the methods mentioned significantly reduced ICU length of stay or mortality rates.
12	HFNC vs COT vs HFNC &NIV	Investigate whether HFNC vs COT or HFNC vs NIV resulted in a similar intubation rate	Whether HFNC versus COT had similar rates of mechanical ventilation and rates of escalation of respiratory support and mortality, and whether HFNC versus NIV had similar rates of escalation of respiratory support and mortality	HFFNC dramatically decreased the rate of intubation, mechanical ventilation, and escalation of respiratory support compared to COT, although there was no change in mortality. However, when compared to NIV, there was no significant difference in the rate of intubation, the rate of respiratory support escalation, or the rate of mortality.
13	The efficacy of NIV vs standard medical treatment	Reintubation rate, and ICU or/and hospital mortality		Compared to Standard Medical treatment, the use of NIV after extubation for patients with established respiratory failure did not reduce the reintubation rate or ICU mortality
14	Early extubation followed by NIV vs standard extubation in hypoxemic non hyper panic patients	Length on invasive mechanical ventilation	Mortality rate, VAP, time on MV, time to ICU discharge and time to hospital discharge	Early extubation with NIV appeared to reduce the length of IMV, the risk of VAP, and the time in ICU compared to the traditional weaning strategy. However, there was no significant difference in mortality rates between the two interventions.

15	NIV vs HFNC.	All-cause mortality.	Weaning failure, reintubation rate, ICU length of stay, adverse events of ventilatory support methods (delirium, abdominal distention, and aspiration), change of the respiratory parameters.	In adults who undergone MV due to respiratory failure there was no difference between the NIV and the HFNC groups in regard to the mortality rates and reintubation, while HFNC had a significantly better ventilatory adverse events than the other group, after conducting subgroup analysis due to significant heterogeneity after analyzing the reminder of the outcomes, the corrected outcomes were mostly insignificantly different.
16	NIV vs MV	Mortality at hospital discharge	Mortality at different intervals, quality of life, weaning failure, ICU no hospital length of stay	NIV showed lower mortality rates and ICU length of stay. There was a significant decrease in mortality, ICU LOS, and invasive ventilation duration specifically in the COPD subgroup.
17	Invasive weaning vs noninvasive weaning	Mortality data	Weaning failures	Noninvasive weaning decreased mortality and pneumonia without raising the chance of weaning failure or reintubation.
18 RCT	NIV vs HFNC	Reintubation within 7 days .		Patients on NIV had significantly lower rates of reintubation compared to those on HFNC.
19 RCT	HFNC&NIV vs HFNC	Reintubation within 7 days and mortality rates	Reintubation within 48 hrs.	Patients on HFNC had higher rates of reintubation
20 RCT	HFNC&NIV vs HFNC in COPD patients .	Reintubation within 7 days .	Post extubation respiratory failure, reintubation with 48 and 72 hrs, mortality in ICU.	Patients on HFNC had higher rates of reintubation.
21 RCT	NIV alternating with HFNC vs HFNC alone in obese or overweight patients	Reintubation rates within 7 days	Mortality rates and post extubation respiratory failure	The NIV group experienced less reintubation rates with 7 days, less mortality rates, and less post extubation respiratory failure. Furthermore, a significant benefit from NIV was observed in obese or overweight patients, but not in normal or underweight patients.
22 RCT	HFNC vs NIV.	Reintubation rate within the first 72 hours postextubation.	Reintubation rate within the first week postextubation, difference in the physiological parameters and the ABG measurements.	In the population of patients who received prolonged MV and were assigned to NIV as the primary weaning modality the rate of the reintubation within the first 3 days postextubation was significantly lower when compared to the second group and no significant difference in the ABG readings and the reintubation rate within the first week postextubation

23 RCT	Protocolized NIV vs IMV	Time for liberation from mechanical ventilation	Need for antibiotics, reintubation rates, and days on invasive mechanical ventilation. Reintubation or tracheostomy rates, and survival.	NIV group has lower need for antibiotics, spent less days on IMV, and had lower reintubation rates. However, there was no significant differ between the two groups regarding the primary outcome
24 RCT	Early extubation with NPPV vs IMV			The combination of early extubation and NPPV ventilation is a good alternative compared to IMV
25 RCT	Early extubation followed by NIV vs standard extubation in hypoexmic patients	Duration of invasive mechanical ventilation and length of hospital stay	Treatment failure, occurrence of sever event (intervening hemorrhagic,septic,-cardiac,renal,or neurologic episodes, pulmonary embolism or pneumothorax),rate of ventilator associated pneumonia, tracheotomy ,rate of patients requiring sedation, hospital length of stay, ICU and hospital mortality	Early extubation followed by NIV showed lower duration on IMV, but there was no difference between the two groups when considering other outcomes
26 RCT	NIV vs COT.	The rate of respiratory failure during the first 48 post extubation	Need for reintubation. ICU and 90 days overall mortality rates.	Individuals with chronic respiratory diseases who had early non-invasive ventilation done in accordance with a sequential strategy for the first 48 hours after extubation had a lower chance of respiratory failure. NIV proved to have better outcomes in preventing postextubation respiratory failure than patients who had conventional oxygen therapy, while 90 days and ICU mortality rates were similar in both groups.
27 RCT	HFNC vs NIV	Postextubation failure and reintubation rates.	Ventilatory support adverse events, intolerance, airway interventions, clinical characteristics and serial ABG readings at 1,24,48 hours postextubation.	In patient who had COPD and received MV for respiratory failure and then extubated, it was shown that there was no difference between the NIV and HFNC groups in the post extubation failure and reintubation rates, while ventilatory support adverse events, intolerance and airway intervention were all much lower in the HFNC group of patients.

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