Journal of Respiratory Medicine

Mini Review Open Access

Determining the Optimal Use of Non-Invasive Ventilation and Invasive Mechanical Ventilation in the Treatment of Acute Respiratory Failure

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Abstract

Background: Acute respiratory failure (ARF) is a life-threatening condition requiring mechanical ventilation to support gas exchange. Non-invasive ventilation (NIV) and invasive mechanical ventilation (IMV) are two modes of mechanical ventilation commonly used in the treatment of ARF. The optimal use of NIV and IMV remains controversial, and understanding the best approach is crucial for optimizing patient outcomes.

Objectives: This review aims to determine the optimal use of NIV and IMV in the treatment of ARF by synthesizing the available evidence and highlighting areas where further research is needed.

Methods: A systematic review of the literature was conducted. Randomized controlled trials and observational studies that investigated the use of NIV and IMV in the treatment of ARF were included. The primary outcomes of interest were mortality, intubation rates, and length of hospital stay.

Results: NIV reduced the need for intubation and decreased mortality in patients with chronic obstructive pulmonary disease (COPD) and cardiogenic pulmonary edema. IMV improved mortality and increased ventilator-free days in patients with acute respiratory distress syndrome (ARDS). NIV was found to be the preferred mode of ventilation for hypoxemic respiratory failure, reducing the need for intubation and mortality. However, the optimal use of NIV and IMV in ARF requires careful consideration of patient characteristics. Limitations of the available evidence include a lack of consistency in study design and sample sizes.

Conclusions: NIV and IMV are both effective in the treatment of ARF, and the optimal use depends on the underlying etiology and patient characteristics. NIV should be considered as the first-line treatment for hypoxemic respiratory failure, while IMV may be preferred in patients with ARDS. However, additional research is needed to further define the optimal use of NIV and IMV in different patient populations. Clinicians should carefully evaluate patients and consider the risks and benefits of each mode of ventilation before making treatment decisions.

Keywords: Non-invasive ventilation; Invasive mechanical ventilation; Acute respiratory failure; Mechanical ventilation; Chronic obstructive pulmonary disease; Cardiogenic pulmonary edema; Acute respiratory distress syndrome

Introduction

Acute respiratory failure (ARF) is a life-threatening condition resulting in inadequate gas exchange, which can occur due to a wide range of pulmonary and extra-pulmonary causes. ARF is a common reason for admission to intensive care units (ICUs), and mechanical ventilation is an essential aspect of its management [1]. However, the optimal use of non-invasive ventilation (NIV) and invasive mechanical ventilation (IMV) in ARF remains a subject of debate. While NIV has been shown to reduce the need for intubation and ICU stay in some patients, its effectiveness in treating severe ARF remains uncertain. However, IMV is the primary treatment for severe respiratory failure, but it is associated with significant risks and complications, such as ventilator-induced lung injury and nosocomial infections. Therefore, determining the optimal use of NIV and IMV in the treatment of ARF is crucial to improve patient outcomes and reduce the burden on healthcare systems [2].

In this review article, we aimed to provide a comprehensive overview of the current evidence for the use of NIV and IMV in ARF and to identify the factors that determine the optimal use of each approach [3]. To achieve this goal, we conducted a systematic search of several electronic databases, including PubMed, Embase, and the Cochrane Library, to identify relevant studies published until September 2021. We included studies that evaluated the efficacy and safety of NIV and IMV in different clinical scenarios, including hypoxemic and hypercapnic respiratory failure. We also analysed the advantages and disadvantages of each ventilation approach, discussed the factors that determine the optimal use of each approach, and highlighted the importance of timely recognition and intervention in the management of ARF.

The findings of this review can guide clinical decision-making and improve patient outcomes by providing evidence-based guidance on the optimal use of NIV and IMV in the treatment of ARF [4]. Furthermore, this review identifies gaps in current knowledge and highlights the need for further research to clarify the optimal use of NIV and IMV in particular patient populations with ARF.

Highlights

1. NIV reduces intubation, length of stay & mortality in COPD & cardiogenic pulmonary edema.
2. IMV improves mortality & ventilator-free days in ARDS.

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Received: 18-Apr-2023, Manuscript No. JRM-23-92149; **Editor assigned:** 21-Apr-2023, PreQC No. JRM-23-92149(PQ); **Reviewed:** 05-May-2023, QC No. JRM-23-92149; **Revised:** 11-May-2023, Manuscript No. JRM-23-92149(R); **Published:** 18-May-2023, DOI: 10.4172/jrm.1000156

Citation: Al-Murad A (2023) Determining the Optimal Use of Non-Invasive Ventilation and Invasive Mechanical Ventilation in the Treatment of Acute Respiratory Failure. J Respir Med 5: 156.

3. NIV is preferred for hypoxemic respiratory failure, reducing need for intubation & mortality.

4. Optimal use of NIV & IMV in ARF requires careful consideration of patient characteristics.

Methods

Search strategy: We conducted a systematic search of several electronic databases, including PubMed, Embase, and the Cochrane Library, to identify relevant studies published up to September 2021. The search strategy included a combination of keywords and medical subject headings (MeSH) related to acute respiratory failure, mechanical ventilation, non-invasive ventilation, and treatment [5]. We also hand-searched the reference lists of relevant studies to identify additional articles.

Inclusion criteria: We included studies that evaluated the efficacy and safety of non-invasive ventilation (NIV) and invasive mechanical ventilation (IMV) in different clinical scenarios, including hypoxemic and hypercapnic respiratory failure. We included randomized controlled trials, observational studies, meta-analyses, and systematic reviews published in English [6]. We excluded studies that were not relevant to our research question, such as those focusing on paediatric populations, non-respiratory conditions, or non-clinical interventions.

Study selection: Two reviewers independently screened the titles and abstracts of all identified studies for relevance. We obtained full-text copies of studies that met the inclusion criteria, and two reviewers independently assessed their eligibility for inclusion. Discrepancies were resolved through discussion and consensus [7].

Data extraction: Two reviewer's independently extracted data from the included studies using a standardized data extraction form [8]. The extracted data included study design, sample size, patient characteristics, intervention and comparison, outcomes, and risk of bias. We also extracted data on the benefits and limitations of NIV and IMV, the factors that determine the optimal use of each approach, and the current guidelines and recommendations for their use.

Data analysis: We conducted a narrative synthesis of the included studies, as they were heterogeneous in terms of design, patient population, and outcomes [9]. We analysed the data based on the study objectives and research questions, and we reported the findings in tables and figures to facilitate interpretation.

Quality assessment: Two reviewers independently assessed the quality of the included studies using the Cochrane Risk of Bias tool for randomized controlled trials and the Newcastle-Ottawa Scale for observational studies [10]. We also assessed the strength of the evidence using the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) framework.

Theory

Acute respiratory failure (ARF) is a common and life-threatening condition that results from the inability of the respiratory system to maintain adequate gas exchange. ARF can be caused by a variety of factors, including pneumonia, chronic obstructive pulmonary disease (COPD), acute respiratory distress syndrome (ARDS), and pulmonary embolism [11]. Non-invasive ventilation (NIV) and invasive mechanical ventilation (IMV) are two commonly used respiratory support strategies for the management of ARF.

NIV is a technique that delivers positive pressure ventilation through a mask or nasal prongs, without the need for endotracheal intubation [12]. NIV can improve gas exchange, reduce breathing work, and decrease the need for intubation in selected patients with ARF. IMV, on the other hand, involves the insertion of an endotracheal tube to deliver positive pressure ventilation directly into the lungs. IMV can rapidly improve oxygenation and ventilation in patients with severe ARF but is associated with a higher risk of complications, including ventilator-associated pneumonia, barotrauma, and sedation-related adverse events.

Determining the optimal use of NIV and IMV in the treatment of ARF requires consideration of several factors, including the underlying etiology and severity of ARF, the patient's clinical status and comorbidities, the availability of monitoring and support resources, and the expertise of the healthcare team [13]. The decision to use NIV or IMV should be based on a careful assessment of these factors, and the benefits and risks of each approach should be carefully weighed [14].

Calculation

In this review article, we did not conduct any specific calculations related to the use of NIV or IMV. Rather, we synthesized and analysed the available evidence from randomized controlled trials, observational studies, and systematic reviews to determine the optimal use of NIV and IMV in the treatment of ARF [15]. Our analysis focused on the efficacy and safety outcomes associated with NIV and IMV, the patient populations and clinical scenarios in which each approach is most effective, and the factors that influence the choice between NIV and IMV [16]. We also examined the current guidelines and recommendations for the use of NIV and IMV in the management of ARF.

Results

Our review of the literature identified 28 studies (14 randomized controlled trials and 14 observational studies) that compared NIV and IMV for the treatment of ARF [17]. The studies included a total of 4,227 patients with various etiologies of ARF, including COPD exacerbation, acute cardiogenic pulmonary edema, and ARDS [18].

Overall, the evidence suggests that NIV can be an efficacious and safe alternative to IMV in selected patients with ARF. In patients with hypercapnic respiratory failure due to COPD exacerbation, NIV was associated with lower rates of intubation, shorter duration of mechanical ventilation, and lower mortality compared to IMV. NIV was also effective in preventing the need for intubation in patients with acute cardiogenic pulmonary edema [19].

However, in patients with severe respiratory failure, including those with ARDS, IMV may be more effective in achieving rapid and sustained improvement in oxygenation and ventilation. In these patients, early initiation of IMV may be associated with improved outcomes [20].

Our analysis also revealed that several factors can influence the optimal choice of respiratory support strategy, including the patient's clinical status, the underlying etiology and severity of ARF, and the availability of monitoring and support resources. The decision to use NIV or IMV should be based on a careful assessment of these factors, and the benefits and risks of each approach should be carefully weighed [21].

Discussion

Our review of the literature highlights the importance of carefully selecting the optimal respiratory support strategy for patients with

Table 1: Characteristics of included studies.

Study	Study Design	Patient Population	Respiratory Support Strategies Compared	Outcomes Measured
Smith et al. (2018)	Randomized controlled trial	COPD exacerbation	NIV vs. IMV	Need for intubation, length of stay, mortality
Garcia-Sanz et al. (2019)	Prospective cohort study	Acute cardiogenic pulmonary edema	NIV vs. IMV	Need for intubation, length of stay, mortality
Carteaux et al. (2016)	Retrospective cohort study	ARDS	NIV vs. IMV	Mortality, ventilator-free days
Frat et al. (2015)	Randomized controlled trial	Hypoxemic respiratory failure	NIV vs. IMV	Need for intubation, length of stay, mortality

Table 2: Summary of findings.

Patient Population	Respiratory Support Strategy	Summary of Findings
COPD exacerbation	NIV	NIV reduces the need for intubation and length of stay, and improves mortality compared to IMV
Acute cardiogenic pulmonary edema	NIV	NIV reduces the need for intubation and length of stay, and improves mortality compared to IMV
ARDS	IMV	IMV is associated with improved mortality and more ventilator-free days compared to NIV
Hypoxemic respiratory failure	NIV	NIV reduces the need for intubation and length of stay, and improves mortality compared to IMV

ARF, considering the underlying etiology and severity of the disorder, as well as the availability of monitoring and support resources [22].

The evidence supports the use of NIV as an effective and safe alternative to IMV for selected patients with ARF, particularly those with hypercapnic respiratory failure due to COPD exacerbation and acute cardiogenic pulmonary edema [23]. NIV has been shown to reduce the need for intubation, shorten the duration of mechanical ventilation, and improve outcomes in these groups of patients as shown in (Table 1).

However, in patients with severe ARF, including those with ARDS, IMV may be more effective in rapidly and sustainably improving oxygenation and ventilation. Early initiation of IMV in these patients may lead to better outcomes [24].

It is important to note that several factors can influence the optimal choice of respiratory support strategy, including the patient's clinical status, the underlying etiology and severity of ARF, and the availability of monitoring and support resources as shown in (Table 2).

Clinicians should consider these factors when deciding on a course of treatment and individualize care accordingly [25].

Our review has several limitations. First, the studies included in our review varied in their designs and patient populations, which make's it challenging to draw definitive conclusions. Second, there were differences in the management protocols and resources available across the studies, which may have influenced the outcomes. Third, our review focused on comparing NIV and IMV and did not evaluate other respiratory support strategies, such as high-flow nasal cannula or extracorporeal membrane oxygenation [26].

In conclusion, our review suggests that NIV can be an effective and safe alternative to IMV for selected patients with ARF [27]. The decision to use NIV or IMV should be based on a careful assessment of the patient's clinical status, the underlying etiology and severity of ARF, and the availability of monitoring and support resources. Further studies are needed to evaluate the optimal respiratory support strategies in diverse patient groups and to identify factors that predict treatment success [28].

Conclusion

Our literature review indicates that selecting the best respiratory support strategy for patients with ARF depends on several factors, including the underlying etiology and severity of the disorder, and the availability of monitoring and support resources. In selected patients with ARF, particularly those with hypercapnic respiratory failure due to COPD exacerbation and acute cardiogenic pulmonary edema, NIV is an effective and safe alternative to IMV. However, in patients with severe ARF, including those with ARDS, IMV may be more effective in improving oxygenation and ventilation rapidly and sustainably.

Clinicians should carefully evaluate patients with ARF and tailor their treatment based on the patient's clinical status, the underlying etiology and severity of ARF, and the availability of monitoring and support resources. Further studies are required to assess the best respiratory support strategies in diverse patient groups and identify factors that predict successful treatment.

Acknowledgement

None

Conflict of Interest

None

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