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Noninvasive Ventilation Interfaces in the Treatment of Acute Respiratory Insufficiency: A Critical Review

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Abstract

Background: Noninvasive ventilation (NIV) is an important therapeutic modality for the treatment of acute respiratory failure (ARF). In this review, we critically analyze randomized controlled trials on the most used NIV interfaces in the treatments of ARF. **Methods**: The searches were conducted in the Medline, Lilacs, PubMed, Cochrane, and Pedro databases from June to November 2021. The inclusion criteria were Randomized clinical trials (RCTs) published from 2016 to 2021 in Portuguese, Spanish, or English and involving adults (aged ≥ 18 years). The eligibility criteria for article selection were based on the PICO strategy: Population—Adults with ARF; Intervention—NIV Therapy; Comparison—Conventional oxygen therapy, high-flow nasal cannula (HFNC) oxygen therapy, or NIV; Outcome—improvement in ARF. The search for articles and the implementation of the inclusion criteria were independently conducted by two researchers. **Results**: Seven scientific articles involving 574 adults with ARF due to various causes, such as chest trauma, decompensated heart failure, coronavirus disease 2019 (COVID-19), and postoperative period, among others, were included. The interfaces cited in the studies included an oronasal mask, nasal mask, full-face mask, and helmet. In addition, some favorable outcomes related to NIV were reported in the studies, such as a reduction in the rate of orotracheal intubation and shorter length of stay in the ICU. **Conclusions**: The most cited interfaces in the treatment of ARF were the oronasal mask and the helmet.

Keywords

Noninvasive Ventilation, Respiratory Insufficiency, Respiration, Artificial, Continuous Positive Airway Pressure

1. Introduction

Noninvasive ventilation (NIV) involves providing ventilatory support without invasive methods, such as orotracheal intubation or tracheostomy. [1] [2] It can be used for the treatment of acute respiratory failure (ARF) associated with acute exacerbation of chronic obstructive pulmonary disease (COPD) [3], acute pulmonary edema (APE) [4], postoperative period [5], palliative care for patients with cancer [6], thoracic trauma [7], and for the prevention of post-extubation ARF in patients at high risk of failure respiratory. [8]-[10]

The success of NIV therapy depends on careful patient selection, the selected interface, ventilation mode, appropriate equipment, and a team of trained professionals. The interface is crucial for effective therapy. [1] [11] There is evidence in the literature reporting the superiority of one interface over the other, with each type having its characteristics. [12]

There are several types of interfaces available for NIV, such as nasal cannula, oral mask, nasal mask, oronasal mask, helmet, and full-face mask, the last four being the most used in the adult population. [13]

The world is currently affected by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic, in which countless people developed hypoxemic ARF and required noninvasive ventilatory support [14]. The pandemic resulted in a significant increase in the use of NIV, leading to global insufficiency in the availability of medical supplies to meet the demands of high complexity hospital beds. [15]

In this review, the most used NIV interfaces in the treatment of ARF were critically analyzed.

2. Methods

This is a state-of-the-art review of the literature on the most used NIV interfaces in the treatment of ARF. [16]

The development of this research consisted of bibliographic research, screening, inclusion and analysis of the article. Articles were searched from June to November 2021 in electronic databases such as Medline, Lilacs, PubMed, Cochrane, and Pedro. The inclusion criteria were Randomized clinical trials (RCTs) published in Portuguese, Spanish, or English and involving adults (aged ≥ 18 years).

This study included articles published from 2016 to 2021 to summarize the scientific evidence about NIV interfaces most used in the treatment of adults with ARF in recent years.

We included only RCTs because, in the hierarchy of evidence, systematic review studies with or without meta-analysis that include RCTs generally provide more robust evidence about the effectiveness of an intervention or treatment. [17]

This systematic review study was conducted according to the recommendations of the PRISMA Transparent Reporting of Systematic Reviews and Meta-analyses. [18]

The PICO strategy (P—population; I—intervention; C—comparison; O—

outcomes) was used to formulate the guiding question: "Which NIV interfaces are used in the treatment of adults with ARF?"

The eligibility criteria for article selection were based on the PICO strategy: Population—Adults with ARF; Intervention—NIV therapy; Comparison—Conventional oxygen therapy, HFNC oxygen therapy, or NIV; Outcome—ARF improvement.

The searches included controlled terms extracted from the Health Sciences Descriptors (DeCS) and the Medical Subject Headings (MeSH) thesauri, which were combined using the Boolean operators OR and AND as follows: Ventilação não invasiva AND máscara AND insuficiência respiratória AND respiração artificial AND tratamento AND pressão positiva contínua nas vias aéreas. Noninvasive ventilation OR noninvasive ventilation AND mask AND respiratory insufficiency OR respiratory failure AND respiration, artificial AND therapeutics AND continuous positive airway pressure.

The search was performed using three flows that included the descriptors, isolated or combined: Flow 1: Noninvasive Ventilation AND Mask AND Respiratory Insufficiency AND Respiration, Artificial AND Therapeutics; Flow 2: Noninvasive Ventilation AND Continuous Positive Airway Pressure AND Respiratory Failure AND Therapeutics; and Flow 3: Noninvasive Ventilation AND Respiration, Artificial AND Respiratory Failure.

The exclusion criteria were studies that did not include complete online abstracts, those including children and adolescents, conducted more than five years ago, or not related to the topic. Reference lists from systematic reviews were also explored in searching for relevant studies related to the guiding question.

The search for articles and implementation of the inclusion criteria were independently conducted by two researchers. The researchers initially read the titles of the articles identified, followed by the abstracts, and subsequently, the full texts to select the articles to be finally included in the sample. Disagreements between the two investigators were resolved by discussion and consensus.

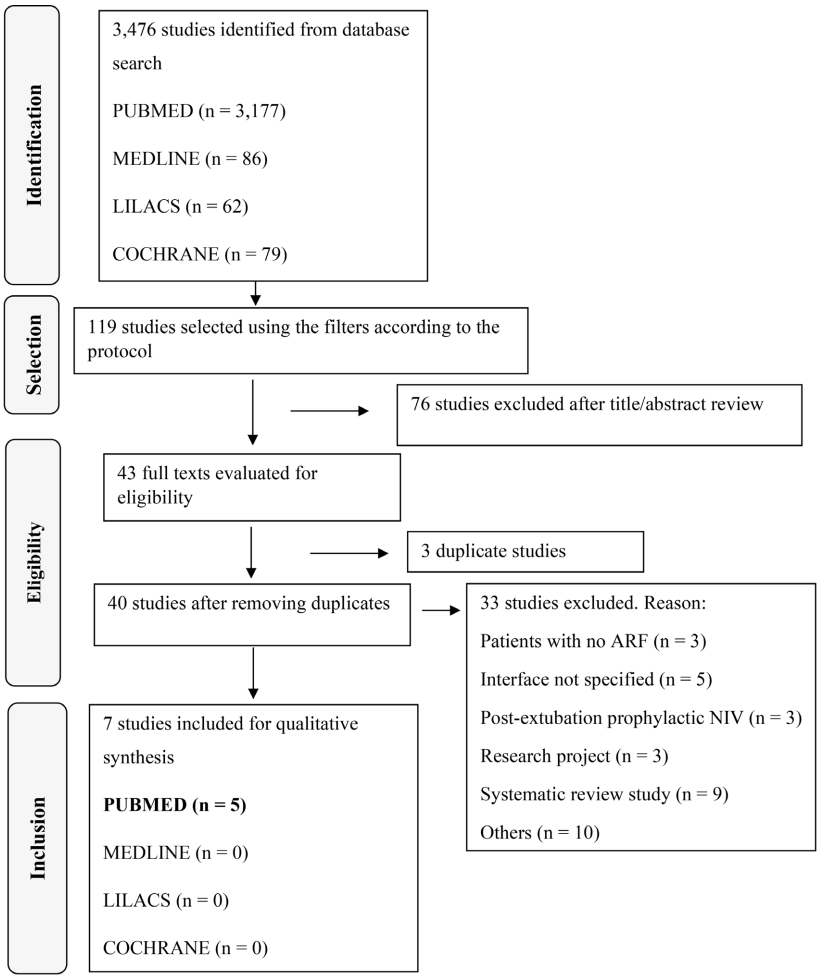
After applying the inclusion criteria, seven original studies were selected to describe the scientific evidence related to the study objective. Relevant inclusion criteria are shown below, and reasons for exclusions are shown in the PRISMA flowchart (**Figure 1**).

The articles were reviewed following the perspective of thematic analysis by initially reading the entire collection, followed by the identification of thematic axes and their respective units of meaning. The topics were analyzed and interpreted and then grouped based on similarities and differences in the information. The text was constructed and recorded after critical analytical reading to select the main idea of the researched study.

3. Results

A total of 3,476 studies were identified through an electronic search. After applying the filters according to the protocol, 119 studies were considered for the title and abstract review. After reviewing the titles and abstracts, 76 studies were excluded,

leaving 43 studies for reading the full-text. Of these, three studies were excluded as duplicates, and 33 were excluded for not meeting the PICO strategy. Thus, seven studies were analyzed and included in the summary of the qualitative analysis (Figure 1).



ARF: Acute respiratory failure, NIV: Noninvasive ventilation.

Figure 1. Flow diagram for study selection and inclusion.

The final sample consisted of seven scientific articles selected according to the inclusion criteria previously described in the study protocol. Of these, five were found in the PUBMED database and two in the PEDRO database. As for the countries of origin of the studies, one was conducted in China, three in the United States of America, and three in Italy. A total (including intervention and control groups) of 574 patients aged above 18 years were studied (Table 1).

The most cited interfaces in the treatment of ARF were the oronasal mask and the helmet. Three studies showed benefits of the oronasal interface such as improved oxygenation, reduced dyspnea and reduced hospital mortality. And three other studies showed that the NIV helmet also showed benefits such as reduced intubation rate, improved oxygenation and reduced dyspnea compared

to other interfaces.

Table 1. Summary of studies on NIV interfaces used in the treatment of acute respiratory failure.

Author/Year	Objective	Sample	Interface	Comparison	Outcome
Olper *et al.*, [19] 2016	To investigate CPAP reduces the number of patients with P/F < 200 after cardiac surgery	64	Oronasal mask	Conventional oxygen therapy	CPAP was effective in reducing the number of patients with P/F < 200 compared to the conventional oxygen therapy group
Patel *et al.*, [20] 2016	To determine if helmet NIV reduces the intubation rate in ARDS	83	Helmet	NIV by oronasal mask	Helmet NIV, compared to oronasal mask, significantly reduced intubation rate in ARDS
Grieco *et al.*, [21] 2019	To physiologically compare HFNC and NIV in hypoxemic ARF	15	Helmet	HFNC	Helmet NIV improves oxygenation and reduces dyspnea and inspiratory effort compared to HFNC Transpulmonary pressure oscillations, pCO_2, patient comfort was similar between therapies
Qi Liu *et al.*, [22] 2020	To assess if helmet NIV reduces the incidence of complications and improves the effectiveness of therapy in patients with ARF due to chest trauma	59	Helmet	Oronasal mask NIV	Compared to oronasal mask, the helmet NIV decreased the complications, increased oxygenation, decreased the respiratory rate, and improved tolerance
Grieco *et al.*, [23] 2021	To assess if helmet NIV can increase respiratory support-free days in COVID-19 patients compared to HFNC	107	Helmet	HFNC	There was no significant difference between groups in the number of respiratory support-free days within 28 days after randomization
Haywood *et al.*, [24] 2019	To compare HFNC with NIV in the treatment of ARF due to decompensated heart failure	42	Oronasal mask	HFNC	HFNC may not be inferior to NIV in the treatment of respiratory failure due to decompensated heart failure
Doshi *et al.*, [25] 2018	To compare HFNC with NIV with respect to therapy failure in the treatment of ARF	204	Oronasal mask	HFNC	HFNC is not inferior to NIV in the treatment of ARF from different causes in adults treated in the emergency department

Source: Survey data, 2021. CPAP: Continuous positive airway pressure; P/F: PaO_2/FiO_2 ratio; NIV: Noninvasive ventilation; ARDS: Acute respiratory distress syndrome; HFNC: High-flow nasal cannula; pCO_2: Partial carbon dioxide pressure in the arterial blood; ARF: Acute respiratory failure.

4. Discussion

The results of the present review indicate that the interfaces used in the treatment of adult ARF in the included studies were an oronasal mask, nasal mask, full-face mask, and helmet. The most used interfaces were the oronasal mask and helmet. To our knowledge, this is the first systematic review that analyzed the NIV interfaces used in the treatment of ARF in the last five years.

Currently, the oronasal mask is the most used interface in the treatment of ARF, being the most indicated in acute situations, as it allows the supply of higher flow and pressure.[8] [26] Therefore, it is indicated that mild and moderate ARF increase the changes in gases and reduce the work of breathing. [27]

The helmet has advantages, such as good tolerance and patient interaction with the environment, lower risk of skin lesions, and effective use of higher positive end-expiratory pressure (8 - 12 cm H_2O) with minimal air leakage during prolonged treatment without interruptions. [28] [29]

As for effectiveness, NIV was non-inferior compared to other therapies (conventional oxygen therapy and HFNC) in the treatment of ARF. The most important NIV-related outcomes reported in the studies include reduced orotracheal intubation rate, improved oxygenation, reduced dyspnea, reduced hospital mortality, and shorter ICU stay.

Doshi *et al.* [25] compared NIV with HFNC in patients with ARF secondary to various causes, and the interface used was the oronasal mask, with inspiratory and expiratory positive airway pressures (IPAP/EPAP) of 10 cm H_2O and 5 cm H_2O, respectively. No significant difference in treatment failure was observed between the groups. In another study, the HFNC was scored as superior to NIV in terms of comfort, tolerance, simplicity of use, and monitoring by the physicians. [24]

Olper *et al.* [18] also used the oronasal interface to evaluate the effectiveness of continuous positive airway pressure (CPAP) of 10 cm H_2O in reducing the number of patients with hypoxemic ARF after cardiac surgery with a P/F ratio < 200 mm Hg and concluded that the therapy was effective. In a recent study, Grieco *et al.*, [22] evaluated patients with ARF due to COVID-19 using the helmet interface. Compared to the HFNC group, there was no statistically significant difference in the need for NIV in the helmet group during the 28-day period. However, the helmet group had a lower intubation rate. Grieco *et al.* [20] developed a physiological study that also compared the helmet interface with HFNC in hypoxemic ARF. The study showed that the helmet was better in terms of improved oxygenation, reduced dyspnea, and reduced inspiratory effort. Patel *et al.* [19] compared the helmet with the oronasal mask in patients with ARDS. Helmet NIV significantly reduced the intubation rate in these patients. In addition, helmets were also associated with fewer days of ventilatory support, shorter ICU stays, and lower 90-day mortality.

Similarly, Qi Liu *et al.* [21] also compared the helmet and oronasal mask interfaces in patients with ARF due to thoracic trauma. Their study showed that the helmet reduced the rates of NIV-related complications. In addition, it provided better oxygenation and was associated with lower respiratory rate and greater tolerance to NIV.

This review has some limitations, such as the inclusion of only articles published from 2016 to 2021 in Portuguese, English, or Spanish. This strategy might have failed to include relevant articles in the final review sample. Another limitation was not using tools to assess the methodological quality and risk of bias, as these are considered important for assessing the quality of included studies.

However, the results provide healthcare professionals with an overview of the primary NIV interfaces currently used in the treatment of ARF secondary to various causes, evidences clinical applications, and the main outcomes about the effectiveness of this therapy in diverse scenarios, including a global response to

the COVID-19 pandemic. We also inform you that this study did not receive any financial support.

5. Conclusion

The interfaces used in the treatment of ARF were oronasal mask, nasal mask, full-face mask, and helmet. The most cited interfaces were the oronasal mask and the helmet. NIV was effective in the treatment of ARF, not being inferior to other therapies (conventional oxygen therapy and HFNC). New studies must be carried out to confirm the findings of this research. Others studies should be carried out to confirm the findings of this research.

Conflicts of Interest

The authors have declared that there are no competing interests.

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