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Minireview

Use of Noninvasive Positive-Pressure Ventilation to Prevent Extubation Failure: A Concise Review

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Abstract

Invasive mechanical ventilation is crucial to intensive care of adults and children. However, in the last decades, the use of noninvasive positive pressure was certainly one of the greatest advances in mechanical ventilation, and it is steadily growing as the ventilatory support in critically ill patients. Although conflicting scientific evidence has been observed concerning its indication specially to prevent intubation or extubation failure, clinical interest by the method has progressively increased, so that it has been used in up to 20% of patients after extubation. Some studies and case series have suggested that noninvasive positive pressure may be useful as a mode of support for ventilatory weaning and after extubation in patients who develop respiratory distress in the first 48 hours after tracheal tube removal, specially those with clinical conditions considered at risk for failure. However, data from pediatric patients are scarce and less clear, which suggest no benefits when using this support on a routine basis to prevent extubation failure.

Keywords: Noninvasive positive-pressure ventilation (NPPV), extubation failure, prevention

Introduction

Invasive mechanical ventilation is crucial to intensive care of critically ill patients. However, it is associated with significant risks of morbidity and mortality, including upper airway lesions, laryngeal edema, vocal cord dysfunction, lung injury, pneumonia associated with mechanical ventilation and complications associated with sedation [1-3].

In the last decades, scientific and clinical interest by noninvasive positive pressure ventilation (NPPV) has progressively increased as a result of the benefits from its feasibility, such as frequent prevention of complications inherent to tracheal intubation (TI), reintubation, and most especially, decrease in morbidity and mortality [4,5].Despite conflicting scientific evidence on its indication, NPPV came into regular use in most intensive care units (ICUs) worldwide, with some of its indications being acceptable, and others still under investigation, as the use of NPPV after extubation [6-9].

Noninvasive Ventilation

In the late 1970's and early 1980's, two methods of NPPV using facial or nasal masks were introduced into clinical practice: 1) Continuous positive airway pressure (CPAP), to enhance gas exchanges in patients with acute hypoxemic respiratory failure; and 2) Intermittent positive pressure ventilation (IPPV), to

increase ventilation and keep respiratory muscles of patients at rest, specially patients with chronic respiratory failure from neuromuscular causes and/or chronic obstructive pulmonary disease (COPD) [10,11].

Throughout the 1980's, the use of NPPV techniques has expanded in view of literature evidence which supported its use for acute respiratory failure as an initial therapy to prevent intubation; to easy weaning of patients with acute exacerbation of COPD; to prevent intubation in patients with acute cardiogenic pulmonary edema and in immunocompromised patients. Additionally, NPPV has currently been used as a rescue therapy in the post-extubation period or to prevent reintubation [12,13].

Just as in other therapeutic procedures, NPPV has started being widely used in intensive care of adults. Therefore, most studies and scientific evidence initially predominated in this age group population. However, this fact did not preclude many ICUs from applying the method in several therapeutic indications in children, as follows: (a) acute respiratory failure; (b) chronic respiratory failure; (c) neuromuscular diseases; (d) sleep apnea; (e) congestive heart failure; (f) extubation from mechanical ventilation and (g) ventilatory support after extubation [14-17].

Despite not being an intervention based on evidence, the use of NPPV after planned extubation is part of the clinical practice worldwide to treat or prevent extubation failure. It is used in 8% to 15% of extubated patients and has emerged as a promising therapy to prevent reintubation [18-20].

NPPV for Weaning from Mechanical Ventilation

Weaning from conventional mechanic ventilation (CMV) and tracheal extubation (TE) are crucial procedures which, most of the time, comprise 40% to 50% of the whole duration of ventilation. Frequency of failure of TE reported in the literature ranges from 8% to 20% in pediatric intensive care units. Unsuccessful TE is related to airway obstruction, inability to clear secretions, apnea, sepsis, hypotension, decreased consciousness and congestive heart failure or respiratory failure. Accordingly, TE failure is an independent factor associated with a five-fold increase in children mortality [21-25].

In turn, reintubation is an invasive procedure and is associated with many life threatening complications such as cardiac arrest, esophageal intubation, right mainstem intubation, gastric aspiration, cardiac arrhythmias, atelectasis, pneumonia, pneumothorax, hypoxia, prolonged ICU and hospital stay. Besides, it is considered a risk factor for tracheostomy (18% to 60%). TE failure occurs when there is respiratory failure developed up to 48 to 72 hours after TE, and it is typically expressed by the need for reinitiation of ventilatory support and TI [25-28].

The use of NIV as a mode of weaning from CMV was reported by Ferrer et al. in a prospective randomized trial which included 43 adult patients assigned into two groups: NIV as a weaning mode, and control group (patients remained in CMV and received conventional weaning approach). The authors concluded that earlier extubation with NIV resulted in shortened length of ICU and hospital stay, less need for tracheostomy, lower incidence of complications, and also, improved survival [29].

Some differences were reported by Girault et al. in a case series with 33 adult patients diagnosed with acute COPD and receiving CMV. Patients were randomized into two groups, one group with extubation followed by NIV and the other one with CMV followed by conventional weaning. Both strategies efficiently maintained gas exchange. Weaning period was longer in the NIV group and inherent complications of the procedure were observed in the CMV group.

A meta-analysis published in 2013 by the Cochrane Library concluded that the use of NIV compared to the conventional use of weaning with CMV was able to significantly reduce mortality, pneumonia incidence associated with mechanical ventilation, length of ICU and hospital stay, total time of CMV and time of TI [31].

Another meta-analysis by Fen et al., which evaluated the effect of NIV on earlier weaning of adult patients receiving CMV for longer than 48 hours, concluded that earlier extubation and initiation of NIV improves weaning success, decreases mortality, pneumonia associated with mechanical ventilation and inherent complications in patients receiving CMV [22,30,31].

NPPV for Preventing Extubation Failure

Some studies and case series suggested that NIV may be useful as a mode of post-extubation ventilatory support, specially in patients who develop respiratory distress in the first 48 hours after tracheal tube removal [32-37]. Keenan et al studied 81 adult patients who progressed to respiratory distress in the first 48 hours after extubation and randomly assigned them into one intervention group (NIV, n= 39) and other conventional group (oxygen therapy, n= 42). Results showed that no differences between groups were found concerning reintubation rate, mortality and length of ICU and hospital stay. The authors concluded that NIV did not improve the prognosis of patients [38].

Esteban et al. studied 221 adult patients receiving CMV for at least 48 hours and who developed respiratory distress in the first 48 hours after extubation. The patients were randomly assigned into one intervention group (NIV, n = 114) and one conventional group (oxygen therapy, n = 107). Mortality was higher in the intervention group. No differences were found between groups concerning need for reintubation. In contrast, the time elapsed from the development of respiratory failure and reintubation was longer in the NPPV group. The authors concluded that the indiscriminate use of NPPV may delay reintubation and return to CMV, which contributes to increase morbidity and mortality [39].

Promising results were found in two randomized and controlled studies of patients at risk for extubation failure. One of them was a multicenter study involving 97 patients, and the other one was a double-center study involving 162 patients. In the first study, Nava et al. concluded that preventive use of NPPV reduced reintubation risk [40].

Ferrer et al. reported reduced respiratory failure after extubation, lower incidence of hospital infection and lower ICU mortality rate in patients of the NPPV group. No statistically significant differences were found between groups concerning reintubation rate, despite an existing trend towards lower value in the NPPV group [41].

Su et al. conducted a multicenter randomized trial in 406 adult patients who received CMV for longer than 48 hours. The control group received oxygen therapy via catheter or face mask, and the

study group received NPPV. The results showed that no significant reduction in reintubation or mortality rate was observed in ICU [42].

Ornico et al. conducted a randomized clinical study on 40 patients receiving CMV. Patients were allocated into two groups: NPPV (n = 20) and oxygen therapy (n = 20) for 48 hours after extubation. Reintubation rate was significantly lower in the NPPV group, and mortality was zero. No differences were found between groups concerning length of ICU and hospital stay [43].

NPPV was also effective for preventing respiratory failure and reintubation in patients with chronic respiratory failure. A randomized multicenter study conducted by Vargas et al. on 144 patients, reported lower rates of respiratory failure in 48 hours after weaning from invasive respiratory support than the rates in patients who received just inhaled oxygen [44].

The use of noninvasive support after extubation has also been reported as a rescue mode in patients in imminent reintubation using specific protocols. However, the results are not repeated when they are replicated in other studies [38,45].

Good results have also been reported by alternating noninvasive ventilation with high flux nasal oxygen immediately after extubation. This procedure led to a significant reduction in reintubation rate compared to that using high-flow nasal oxygen alone [46,47].

Some meta-analyses on the use of NPPV in patients undergoing cardiac and thoracic surgeries reported beneficial effects of this support to prevent extubation failure, reduce pulmonary complications and increase survival of these patients [48-51].

On the contrary, Pieczkoski et al. analyzed ten randomized controlled clinical trials and reported that the preventive use of NPPV was unable to reduce incidence of atelectasis, pneumonia, reintubation and length of ICU stay. In another recent meta-analysis, Wu et al. evaluated eight studies in which NPPV did not improve survival or did not reduce incidence of atelectasis and pneumonia, reintubation rate and incidence of cardiac complications.

Also, length of ICU stay was not shortened. For the authors, these benefits are related with improvement in the relationship between arterial partial pressure of oxygen and fraction of inspired oxygen [52-53].

NPPV for Preventing Extubation Failure in Pediatrics

In pediatrics, data are limited and less clear, but successful rates higher than 60% have been frequently reported. In a retrospective observational cohort study, Essouri et al evaluated for five years the use of NPPV in 114 children. The authors reported that invasive mechanical ventilation was prevented in 77% of cases. Specifically in patients with respiratory failure after extubation (n = 61), the success of NIV was 67% [54].

Mayordomo-Colunga et al conducted a prospective observational study in 36 children who remained in CMV for longer than 12 hours. A total of 41 episodes of NPPV were reported. Patients were allocated into an elective NPPV group (at high risk of developing respiratory failure after extubation) and into a rescue NPPV group (patients who developed respiratory failure over 48 hours after extubation). With statistically significant differences, the elective NPPV group presented more success to prevent reintubation than the rescue NPPV group; the overall success was 65.9%. The authors concluded that NPPV is a useful intervention to prevent reintubation in patients at risk for failure when applied just after TE, and NPPV is at higher risk of failure when applied late, that is, after the onset of respiratory failure55.

Similarly, Lum et al conducted a prospective observational study in 278 children randomly allocated into a weaning NPPV group and a rescue NPPV group after extubation. Overall, the success of NPPV was 79.1%, and reintubation was prevented for five days; 75.8% of these patients had no need for reintubation throughout the hospital stay. The authors concluded that NPPV is a feasible strategy which provides effective respiratory support to prevent intubation or to shorten duration of CMV in patients [56].

Yaman et al. conducted a prospective observational study on children aiming at preventing TI and reintubation after extubation (rescue) as the first line treatment for respiratory failure. A total of 160 episodes of NPPV were observed and the total success was 70%. The elective NPPV group presented more success (74.2%) than the rescue NPPV group (64.8%), with no statistically significant differences, however. The authors concluded that NPPV plays an important role in pediatric ICU to prevent TI and reintubation [57].

In a randomized study on 108 patients, Fioretto et al. could not determine NPPV efficacy for preventing reintubation in children with ARF after extubation. Conversely, in a randomized controlled trial involving 50 children with ARF aged between one month and 13 years, Yanez et al. reported a reduction in the need for tracheal intubation and improvement in respiratory distress and hypoxemia in the NPPV group compared to that in the conventional therapy group [58,59].

The capability of NPPV to prevent reintubation in patients with respiratory failure after planned extubation is controversial. Just as Fioretto et al, Keenan et al randomized 81 adult patients to receive NIV or inhaled oxygen and they observed that NIV had no effect on reintubation or mortality rates [11,45,60]. Similar results were obtained by Esteban et al. in a multicenter randomized trial in 221 adult patients40. On the other hand, Nava et al conducted a study on 97 adult patients and concluded that preventive initiation of VNIPP reduced the risk for reintubation. Ferrer et al. observed that early initiation of NPPV prevented respiratory failure after extubation [41,61-63].

Children who do not undergo the spontaneous breathing trial; who require increased ventilatory parameters or changes in mode just before extubation; who have chest wall deformities and neurological diseases are at higher risk of respiratory failure after extubation with no response to noninvasive ventilation [32,62-66].

Results in newborns are also conflicting. To date, NPPV was supposed to be the best mode after extubation to allow newborn infant to have a smooth transition from the invasive to noninvasive mode. However, recent studies reported no reduction in extubation failure using NPPV in this population [67-70].

Conflict of Interest

The authors declare no conflict of interest.

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