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Effectiveness of Bilevel positive airway pressure ventilation for acute respiratory failure patients: A systematic review

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ABSTRACT

Background: It's uncertain if BiPAP helps people with acute respiratory failure. This research aims to determine if BiPAP is effective for people with acute respiratory failure. *Method:* The PRISMA guidelines were adhered to in this systematic study. Cochrane, MEDLINE, EMBASE, CINAHL for papers released between January 1997 to March 2024. Only randomized controlled studies comparing the effectiveness of continuous positive airway pressure with oxygen therapy, NIV-VAVA, or BiPAP ventilation in patients with ARF were included. Mortality, length of hospital stay, and ETI rates were the main outcomes of interest that were compared between the two groups in order to evaluate efficacy. *Result:* Eight studies totaling 524 people were enrolled in the review; 5 of the studies utilized CPAP as the control group, one used NIV-VAVA and two of the studies used oxygen. All of the articles included are randomized controlled trials that were carried out in the emergency setting or intensive care unit. Except for two studies where the underlying cause was solid tumor end stage and COPD, the underlying cause of abrupt respiratory failure in all included trials was cardiopulmonary edema. In most of the examined publications, the main outcomes were, mortality, endotracheal intubation and length of hospital stay. *Conclusion:* We conclude from our systematic investigation that NIV use in ARF parents reduce the risk of complications and mortality in cardiopulmonary edema patients, and that BiPAP beneficial as CPAP.

Keywords: Acute respiratory failure, endotracheal intubation, mortality, noninvasive ventilation, Bi-level positive airway pressure.

1. INTRODUCTION

While there are no exact measurements in the definition of acute respiratory failure (ARF), arterial O2 of less than 60 mmHg and arterial CO2 of more than 50 mmHg are commonly considered to be significant. ARF is the result of the lungs' inability to sufficiently oxygenate the arterial blood or to prevent retention of carbon dioxide (Summers et al., 2022). Endotracheal intubation (ETI) and invasive mechanical ventilation (MV) were treatment options for ARF (Esteban et al., 2000). According to study conducted by Esteban et al., (2000) ARF accounted for almost 65% of patients ventilated, making it the most common reason for invasive MV. Invasive MV increases survival rates greatly, but there are a number of potential side effects.

Side effects include ventilator-associated pneumonia (VAP), higher death rates, weaning issues with IMV, and higher health care expenses (Brochard et al., 1994). NIV effective in improving dyspnea, as well as other benefits, such as a lower risk of infection, more patient cooperation, and improved communication skills (Nava et al., 1998). When compared to invasive MV, NIV can produce the similar physiological effects, such as decreased respiratory effort and enhanced gas exchange (Vitacca et al., 2001). Additionally, NIV is less likely to cause side effects such upper airway injuries, VAP, and severe sedation that are associated with ETI and IMV. NIV may therefore result in improved clinical results for particular patient populations (Bello et al., 2012).

NIV has been considered a successful strategy to reduce mortality in patients suffering from ARF while also avoiding the need of ETI. There is evidence to support the idea that incorporating NIV into a routine care plan could improve outcomes for chronic obstructive pulmonary disease (COPD) patients experiencing exacerbations (Ram et al., 2004). It is currently unclear, though, if bi-level positive airway pressure (BiPAP) is beneficial for ARF resulting from aetiologies other than COPD. For example, certain pulmonary edoema studies Nouira et al., (2011) may not have demonstrated efficacy of NIV even in COPD patients since they did not exclude these patients the aim of this study is to ascertain the efficacy of BiPAP in patients with ARF.

2. METHOD

In this systematic review we followed PRISMA criteria. Cochrane, MEDLINE, EMBASE, and CINAHL for articles published in the period from January 1997 to March 2024. Searches were performed to find relevant research in order to choose the papers for this review. We looked through the retrieved articles' bibliographies to find relevant articles and run searches on them. Searching terms used include: "Bilevel positive airway pressure ventilation", "cardiopulmonary edoema", "acute respiratory failure" (ARF), "non-invasive ventilation" (NIV), and "noninvasive pressure support ventilation" (NIPSV). We only included randomized controlled trials (RCTs), which compare the efficacy of oxygen treatment, NIV-VAVA, or BiPAP ventilation against continuous positive airway pressure (CPAP) in individuals with ARF. The major outcomes of interest were; hospital length of stay, mortality, and ETI rates were compared between treatment groups to assess effectiveness.

Authors check titles and abstracts, independently and chose which studies to include according to the inclusion criteria. After going through a similar dual-review process and reviewing the titles and abstracts of potentially include papers, full texts were retrieved. Discussion was done between two reviewers and communication with a third reviewer to allay any doubts about the study choices. Each reviewer extracted the data from the included studies on their own. Lead supervisor was contacted to settle any disputes over data extraction. Information extracted from the studies include, the study design, sample size, NIV specifics, method used in the control group, and main findings. Primary outcomes were; duration of hospital stay, the mortality rate following use of BiPAP, and the requirement for an ETI. The length of stay in the intensive care unit (ICU), treatment-related problems, and gas exchange after the start of NIV were the secondary outcomes of interest.

3. RESULTS

We included 8 studies in the review all were randomized controlled trials conducted in the emergency department or ICU, with a total of 524 participants, CPAP was used in the control group in 5 studies Moritz et al., (2007), Mehta et al., (1997), Bellone et al., (2005), Rusterholtz et al., (2008), Nouira et al., (2011), oxygen in two studies Nava et al., (2013), Nava et al., (2003) and NIV-VAVA in one study (Tajamul et al., 2020). For all included studies the underlying cause of acute respiratory failure was the cardiopulmonary edema except for Nava et al., (2013) and Tajamul et al., (2020) the underlying cause was Solid tumor end stage and COPD respectively.

Endotracheal intubation, mortality and hospital length of stay were the primary outcomes in 3 studies Moritz et al., (2007), Nava et al., (2003), Mehta et al., (1997), Endotracheal intubation and mortality in 2 studies Bellone et al., (2005), Rusterholtz et al., (2008), Endotracheal intubation and in hospital mortality in one study Nouira et al., (2011), Gas exchange improvement and hospital length of stay in one study Tajamul et al., (2020) and mortality in one study Nava et al., (2013) (Table 1). Mehta et al., (1997) reported that in individuals with acute pulmonary edoema, BiPAP improves breathing and vital signs more quickly than CPAP. BIPAP is linked to a greater incidence of myocardial infarctions (Table 2). Even in patients who were hypercapnic, CPAP and BiPAP both seemed to be useful in quickly alleviating respiratory distress; nonetheless, their effects on patient outcomes were identical (Moritz et al., 2007).

In case of acute pulmonary edoema and hypercapnia, NIPSV was successful as CPAP; however, resolution time was not increased (Bellone et al., 2005). NIPSV improves respiratory failure during cardiopulmonary edema more quickly than CPAP, but it has no effect on the primary clinical result for the general population or for patients with hypercapnia in particular subgroups (Nouira et al., 2011). In COPD patients exacerbation, NIV-NAVA was linked to improved patient-ventilator synchronisation and a decrease in asynchrony events compared to NIPSV. It also had comparable effects on gas exchange improvement, NIV duration, hospital length of stay, and NIV failure rate (Tajamul et al., 2020). In terms of efficacy and tolerability, proportional assist ventilation (PAV) was not more effective than CPAP when it came to noninvasive ventilation in patients with severe cardiogenic pulmonary edoema (Rusterholtz et al., 2008). In cancer patients end stage diseas, dyspnea and the amount of morphine required effectively lower by NIV more than oxygen (Nava et al., 2013).

Table 1 Characteristic of included studies

Citation	Number of participants	Control group	Type of control	BiPAP group	Underlying disease	Outcomes
Nava et al., 2013	100	47	Oxygen	53	Solid tumor end stage	Mortality
Moritz et al., 2007	57	28	CPAP	29	Cardiopulmonary edema	Endotracheal intubation, mortality and hospital length of stay
Nava et al., 2003	64	31	Oxygen	33	Cardiopulmonary edema	Endotracheal intubation, mortality and hospital length of stay
Mehta et al., 1997	27	13	CPAP	14	Cardiopulmonary edema	Endotracheal intubation, mortality and hospital and ICU length of stay
Bellone et al., 2005	36	18	CPAP	18	Cardiopulmonary edema	Endotracheal intubation and mortality
Rusterholtz et al., 2008	36	19	CPAP	17	Cardiopulmonary edema	Endotracheal intubation and mortality
Nouira et al., 2011	200	101	CPAP	99	Cardiopulmonary edema	Endotracheal intubation and in hospital mortality
Tajamul et al., 2020	40	20	NIV-VAVA	20	COPD	Gas exchange improvement and hospital length of stay

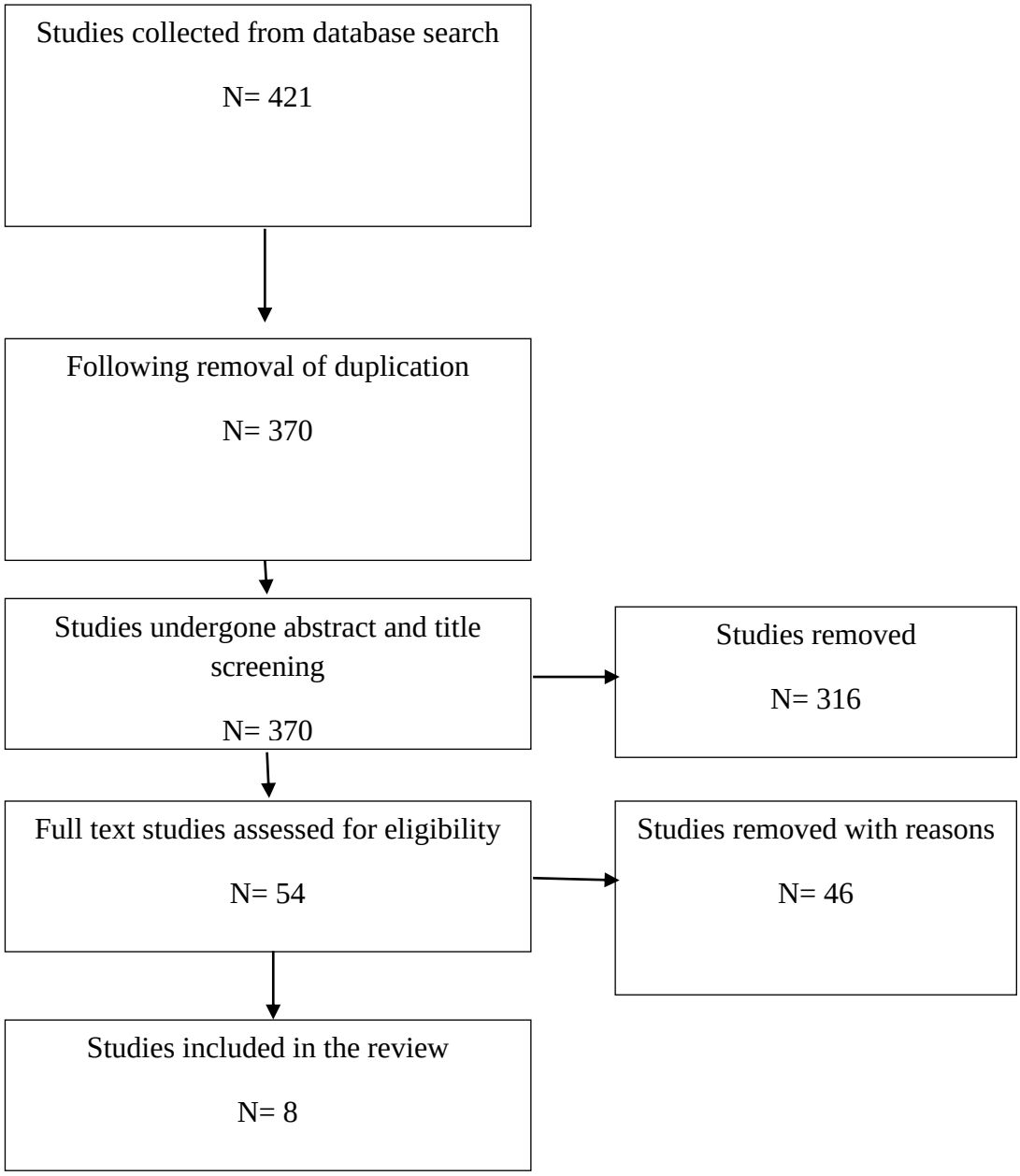

Figure 1 PRISMA consort chart of selection process

Table 2 Method and main findings of included studies

Citation	Method	Main findings
Nava et al., 2013	Patients were assigned at random by the authors to either oxygen treatment or NIV. The authors' method of randomization was a computer-generated sequence. Subcutaneous morphine was administered to patients in both groups at an amount sufficient to lower their dyspnea score on the Borg scale by at least one point. The main	Dyspnea diminished more quickly in NIV group; the greatest improvement was shown in individuals who were hypercapnic and within the first hour of treatment. In comparison to the oxygen group, the NIV group received a lower overall dose of morphine within the first 48 hours.

	goals of the authors' study were to evaluate the acceptability of NIV when used exclusively, as well as how well it worked in comparison to oxygen treatment in terms of lowering dyspnea and the amount of opiates required.	
Moritz et al., 2007	Three emergency rooms hosted this prospective multicenter randomised research. In addition to conventional therapy, patients were assigned to either BiPAP or CPAP via a facemask. A combination criterion (tracheal intubation, acute myocardial infarction or death) was the primary outcome. Hospital stays, lengths of ventilation, and complications were also evaluated.	Blood gas exchange and respiratory distress significantly improved in an hour of ventilation in both groups. In both groups no discernible variations detected in the combined criteria, severe complications, ventilation time, or hospital stay. In individuals with hypercapnic conditions (PaCO2 more than 45 mm Hg), comparable outcomes were observed. Severe consequences and the combined criterion were more commonly seen in hypercapnic patients, regardless of the type of ventilator assistance utilised.
Nava et al., 2003	Patients with acute respiratory failure were randomised to receive medical therapy + O2 or NIPSV in this multicenter research conducted in emergency rooms.	Significantly faster improvements in respiratory rate, dyspnea, and PaO2/FIO2 were achieved with NIPSV. The two groups' rates of intubation, hospital deaths, and length of stay were comparable. When compared to medical therapy, noninvasive pressure support ventilation significantly accelerated PaCO2 improvement and decreased the rate of intubations in the subgroup of hypercapnic patients. Myocardial infarction was one of the adverse events that occurred equally in both groups.
Mehta et al., 1997	Randomised controlled trial. Patients exhibiting symptoms of acute pulmonary edoema in the emergency room were those with bilateral rales, accessory muscle usage, tachycardia, tachypnea, dyspnea, and characteristic chest radiograph congestion findings.	After 30 minutes, the BiPAP group showed significantly lower blood pressure, heart rate, breathing frequency, and Paco2, along with significantly higher arterial pH and dyspnea scores. Breathing frequency was the only significant improvement In CPAP group. Paco2, systolic blood pressure, and mean arterial pressure were all lower in the BiPAP group after 30 minutes than in the CPAP group. In comparison to the CPAP group and historically matched controls, the BiPAP group experienced a greater rate of myocardial infarction. The length of time spent on a ventilator, hospital and critical care unit stays, intubation rates, and death rates were comparable in the two groups.
Bellone et al., 2005	Prospective randomised controlled trial conducted in an emergency room. Patients who have respiratory failure as a	Authors not found resolution time difference between NIPSV and CPAP. After one hour of ventilation, there was a considerable drop in the

	result of arterial hypercapnia and acute pulmonary edoema randomized into NIPSV or CPAP group.	arterial carbon dioxide tension, and improvements in respiratory rate and pH were also seen. Regarding in-hospital mortality and endotracheal intubation, no discernible variations were observed.
Rusterholtz et al., 2008	A prospective, multicenter, randomised trial conducted at three intensive care units. Patients with cardiogenic pulmonary edoema (CPA) who had unresolving dyspnea, despite receiving standard therapy with furosemide and nitrates, were included in the study.	The primary outcome measure was the failure rate, which was determined by the patient's refusal, the start of severe arrhythmias, or the predetermined intubation criteria. When it came to age, sex ratio, cardiac disease type, SAPS II, physiological parameters, amount of injected nitrates, and furosemide, the CPAP and PAV groups were identical upon inclusion. In 37% of CPAP and 41% of PAV patients, failure was noted. Of them, endotracheal intubation was necessary for 21% of CPAP patients and 29% of PAV patients. The two groups' changes in physiological measures were comparable. The two groups' rates of myocardial infarction and ICU death were the same.
Nouira et al., 2011	Patients were randomly assigned to receive NIPSV or CPAP in four emergency departments as part of a prospective, randomised, controlled trial. The combined events of tracheal intubation and hospital death was the primary outcome. Resolution time, myocardial infarction rate, and length of hospital stay were examples of secondary outcomes.	In NIPSV group 5% died and 2.9% of the CPAP group. 3.9% of patients in the CPAP group and 6% of patients in the NIPSV group required intubation. In contrast to CPAP, NIPSV was linked to a faster resolution time; nevertheless, there was no difference in the incidence of new myocardial infarction in either group.
Tajamul et al., 2020	In this trial, 40 patients with acute respiratory failure and COPD were randomly assigned to receive NIPSV or NIV-NAVA in the intensive care unit. Vital signs, arterial blood gas readings, patient-ventilator asynchrony events, and asynchrony index were recorded at predetermined intervals for each subject in the two groups.	When compared to NIPSV, NIV-NAVA dramatically decreased the overall number of asynchrony events: 22 against 65, respectively. Significantly less severe asynchrony occurred in NIV-NAVA compared to NIPSV. Regarding the two groups' improvement in gas exchange and vital indicators, there was no discernible difference. The two types of ventilation were similar in terms of the rate of NIV failure, the length of time that ventilatory assistance was needed, and the length of hospital stay.

4. DISCUSSION

The purpose of our research is to evaluate the effectiveness of BiPAP in ARF patients. Eight research, all of which were randomized controlled trials carried either in emergency rooms or intensive care units, were included in the study. The underlying cause of acute respiratory failure was cardiopulmonary edoema in all included studies, with the exception of Nava et al., (2013) and Tajamul et al.,

(2020), where the underlying cause was COPD and solid tumour end stage, respectively. The majority of the included studies' main outcomes were hospital duration of stay, death, and endotracheal intubation. Finding the breathing modality that provides the best therapeutic effect for patients with acute heart failure would be helpful, as the American Heart Association has advocated using NIV in this setting (Ponikowski et al., 2016).

BiPAP may be more physiologically advantageous than CPAP in helping ACPO patients' respiratory muscles, which could reduce dyspnea and fatigue (Ursella et al., 2007). Our study, which found no differences between CPAP and BiPAP with regard to mortality and ETI, did not demonstrate that these physiological improvements translated into improved main outcomes. Nonetheless, based on positive outcomes in a few trials employing BiPAP, it was anticipated that individuals with hypercapnic hypoplasia might benefit from it for physiological reasons (Nava et al., 2003). In a 2013 systematic review that comprised 32 papers, Vital et al., (2013) non-invasive positive pressure ventilation (NPPV) was found to be dramatically decreased inpatient mortality when compared to routine medical treatment. NPPV did not affect the length of hospital stay; however, it did shorten the time in the critical care unit by one day.

NPPV doesn't increase the incidence of acute myocardial infarction significantly, according to the authors, as compared to usual medical care. When compared to traditional medical care, the scientists also found that NPPV usage was associated with fewer adverse outcomes (Vital et al., 2013). NIV is helpful as a first-line intervention additional to standard care to lower the risk of death and endotracheal intubation in patients admitted with ARF due to an acute exacerbation of COPD, according to a systematic review study by Osadnik et al., (2017), when NIV is used in an ICU or ward environment, the level of improvement for these outcomes seems to be comparable for patients with milder vs more severe acidosis.

In another systematic review published by Masip et al., (2005) NIV lowers mortality and the requirement for intubation in individuals suffering from acute cardiogenic pulmonary edoema. When comparing CPAP with NIPSV, there are no appreciable variations in clinical outcomes, despite the higher degree of data supporting CPAP. The CPAP pressures employed by the articles that made up our review were largely the same as those used in earlier reviews on other respiratory faliure condition. Furthermore, for NIV interfaces, the majority of the included studies employed face mask, which is in line with other systematic reviews that document the beneficial effects on patients with ARF (Vital et al., 2013; Masip et al., 2005; Moran et al., 2017).

5. CONCLUSION

Our systematic study leads us to the conclusion that BiPAP appears to be just as effective as CPAP, and that NIV lowers ETI rate and death in patients with cardiopulmonary edoema. This suggests that CPAP, which is more widely used in settings other than ICU when compared to BiPAP in most countries, can be used safely to manage patients with ARF caused by cardiopulmonary edema.

Abbreviation

BiPAP: Bilevel positive airway pressure
PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses
NAVA: Neurally adjusted ventilatory assist
NIV: Non-invasive ventilation
CPAP: Continuous positive airway pressure
ARF: Acute respiratory failure
ETI: Endotracheal intubation
MV: Mechanical ventilation
VAP: Ventilator-associated pneumonia
ICU: Intensive care unit
PAV: Proportional assist ventilation
NIPSV: Noninvasive pressure support ventilation
NPPV: Non-invasive positive pressure ventilation

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Conflict of interest

The authors declare that there is no conflict of interests.

Ethical approval

Not applicable.

Informed consent

Not applicable.

Data and materials availability

All data sets collected during this study are available upon reasonable request from the corresponding author.

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