

Indications, Outcome and Complications of Non-Invasive Positive Pressure Ventilation in Acute Respiratory Failure

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Abstract

Background: The use of noninvasive positive pressure ventilation (NIPPV) in treating of respiratory failure with diverse etiology is now widely studied. The recent increase in the use of NIPPV in the critical care units has been motivated by the desire to minimize complications of invasive ventilation. The present study was conducted to study the indications, outcome and complications of NIPPV in acute respiratory failure patients.

Material and Methods: In this prospective observational study, a total 110 adult patients of respiratory failure and impending respiratory failure due to various diseases attending a tertiary care centre and admitted in intensive respiratory care unit were studied for outcome and complications of NIPPV utilization.

Results: The most common indication of NIPPV was exacerbation of COPD 37 (33.63%) followed by post extubation 30 (27.27%), asthma 14 (12.72%), ARDS 9 (8.18%) and pneumonia 10 (9.09%). NIPPV was effective in 88 (80%) and non-effective in 22 (20%). There was significant improvement which also persisted after successful weaning. Common complications observed were dry mouth in 60 (54.54%) patients, facial injury in 21 (19.09%) patients.

Discussion: NIPPV can be utilized as an effective modality in the management of ARF due to diverse etiologies. NIPPV was associated with a reduced need for invasive mechanical ventilation and significant outcome and minor complications.

Keywords: Non-invasive positive pressure ventilation; Acute respiratory failure; Outcome; Complications

Introduction

Noninvasive positive pressure ventilation (NIPPV) is defined as technique of augmenting alveolar ventilation without introducing endotracheal tube, thereby avoiding complication due to endotracheal intubation.

In spite of known impending severe complications, for many years, patients who developed respiratory failure had to be put on invasive mechanical ventilation (MV). Recently, numerous randomized controlled trials have been carried out on use of non-invasive ventilation (NIV) for patients with respiratory failure of varied etiology, such as, acute exacerbation of chronic obstructive pulmonary disease (COPD) [1,2], acute cardiogenic pulmonary oedema [3], hypoxaemic respiratory failure [4] and as an adjunct to weaning patients [5,6]. Nowadays, physicians have started to use NIV in patients with respiratory failure as much as possible instead of mechanical ventilation to avoid its complications.

The application of NIPPV in the management of patients with ARF is not associated with a 100% success rate. The failure rates of NIPPV can range from 5% to 50% in different studies depending on the etiology and severity of ARF [7-10]. Failure to identify the patients who are likely to fail NIPPV can cause inappropriate delay in intubation; this can lead to clinical deterioration and increased morbidity and mortality [8]. In many patients, application of NIV is non effective and eventually endotracheal intubation and invasive mechanical ventilation is required. Also, some patients get benefitted initially but will then deteriorate and require intubation. Thus, it becomes important to use the NIPPV in indicated cases only. Thus, the present study was conducted to study the indications, outcome and complications of NIPPV in acute respiratory failure patients.

Material and Methods

After approval from the institutional ethical committee this prospective observational study carried out in a total 110 adult patients of respiratory failure and impending respiratory failure due to various diseases (COPD, bronchial asthma, bronchiectasis, ARDS, pneumonia, pulmonary oedema, ILD) and post extubation who satisfied all the inclusion criteria attending a tertiary care centre and admitted in intensive respiratory care unit (IRCU) were studied from January 2013 to August 2014 over a period of 18 months.

Inclusion criteria

- Age more than 13 years.
- Patients with acute and impending respiratory failure with normal conscious level with able to maintain airway and mild to moderate hypoxemia.
- Patients on invasive mechanical ventilator for different etiologies who met weaning criteria were extubated early and included in study for immediate application of NIPPV.

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Exclusion criteria

- Age less than 13 years.
- Patients with altered consciousness and who were unable to control airway as NIPPV is contraindicated in those.

Relevant investigations (complete blood count, kidney and liver function tests, ECG, CXR, serum electrolytes, arterial blood gas analysis, microbiological investigations) were done in patients on mechanical ventilation in critical care unit.

Criteria for acute respiratory failure

At least two of the following criteria should be present:

- Respiratory distress with dyspnoea
- Use of accessory muscles of respiration
- Abdominal paradox
- Respiratory rate >25/min

Acute exacerbation of chronic obstructive pulmonary disease

- Fatigue, hypersomnolence, dyspnoea
- Oxygen saturation <88% for >10% of monitoring time despite O₂ supplementation.

Criteria for patients to put on non-invasive ventilation

- Patient able to cooperate, can control airway and secretions, with adequate cough reflex, able to co-ordinate breathing with ventilator, haemodynamically stable, Blood pH >7.1 and PaCO₂ <92 mmHg, improvement in gas exchange, heart rate and respiratory rate within first two hours and normal functioning gastrointestinal tract.

All the patients included in the study were interviewed for demographic data and detail history of their illness. All selected patients were subjected to detail physical examination. NIV-BIPAP (mode spontaneous-timed) was used in all patients.

The patients were simultaneously started on standard medical treatment and SpO₂ and arterial blood gases measured and non-invasive ventilation initiated with monitoring of pulse rate, respiratory rate, blood pressure and pulse oximetry. Arterial blood gases were measured at 1 hour and 4 hour after initiation of the non-invasive ventilation therapy.

Patients were also instructed about the procedure in detail prior to the application of NIV and were also positioned in a proper way.

Protocol used for initiation and titrate bilevel positive airway pressure [11]

NIPPV was delivered to patients in bed at an angle of >30° and in all patients a full face mask was used as an interface for delivery of positive pressure. Selected ventilator-Philips/Res-Med. and Set mode: spontaneous-timed. Started the IPAP at 8 cm H₂O and the EPAP at 4 cm H₂O. IPAP maximum time 0.15 to 0.25 sec longer than the patient's actual inspiratory time was set. IPAP maximum time should not be set longer than 50% of the respiratory cycle. Headgear applied avoiding excessive strap tension (one or two fingers under strap); encouraged patient to hold mask. Connected interface to ventilator tubing and turned on ventilator. Started with low pressures/volumes in spontaneously triggered mode with backup rate; pressure-limited: 8 to 12 cm H₂O inspiratory; 3 to 5 cm H₂O expiratory. Volume-limited: 10

ml/kg. Gradually increased inspiratory pressure with 1 to 2 cm H₂O increments (10 to 20 cm H₂O) or tidal volume (10 to 15 ml/kg) as tolerated to achieve alleviation of dyspnea, decreased respiratory rate, increased tidal volume (if being monitored), to provide more ventilator assistance and good patient-ventilator synchrony. Also increased EPAP in 1 to 2 cm H₂O increments to improve oxygenation or to relieve upper airway obstruction. If poor synchronization occurred, checked for leaks or altered IPAP maximum time to improve synchronization. Supplemental oxygen was used if baseline saturation remains low (SpO₂ <85% with finger pulse oximeter) with appropriate IPAP and EPAP settings. Readjusted straps as needed. IPAP or EPAP level was not increased beyond patient tolerance. Humidifier was added as indicated. In agitated patients mild sedation with intravenous lorazepam 0.5 mg was used. Monitored blood gases (within 1 to 2 h and then as needed). Also patient is regularly evaluated clinically and investigated as per requirement. Bronchodilators and corticosteroids as nebulisers and antibiotic agents were given where clinically indicated.

Instituted alternative management plan if PaCO₂ and pH have deteriorated after 1-2 h of NIV on optimal settings. If no improvement, continued with NIV and reassess with repeat arterial blood gas analysis after 4-6 hours. If still no improvement in PaCO₂ and pH by 4-6 h, alternative management plan was considered.

NIPPV failure was defined as the need for invasive mechanical ventilation (IMV) due to worsening of clinical features such as respiratory distress (tachypnea, tachycardia, increased work of breathing) hypotension, worsening of the level of consciousness, or laboratory evidence of worsening or persistent respiratory distress while on NIPPV.

Any deterioration of pH and increase PaCO₂, worsening of mental status, intolerance to NIV (clinical and/or laboratory evidence of deterioration at any point during NIPPV intervention), such patients were proceeded to invasive ventilation within 4 hours of starting the therapy.

Arterial blood gas analysis was done at the time of weaning and 6 hours after weaning were done. Once the patient improved clinically and corroborated by improvements in arterial blood gases, weaning was initiated. During the weaning phase, the IPAP was decreased in gradations of 2-3 cm until the IPAP was 7-10 cm. The application was then switched over to intermittent use. The time of weaning, thus, was different for each patient.

NIPPV for weaning from invasive mechanical ventilation [12]

If the patient of acute respiratory failure was intubated on the basis of clinical and laboratory deterioration the weaning criteria as following were evaluated:

- Improved underlying illness.
- Respiratory function:
 - Respiratory rate <35 breaths/minute
 - FiO₂ <0.4, SaO₂ >90%, PEEP <10 cm H₂O
 - Tidal volume >5 ml/kg
 - Vital capacity >10 ml/kg
 - Minute volume <10 ml/min
- Gas exchange stability (PaO₂ ≥ 60 mmHg with SaO₂ ≥ 90% and FiO₂ ≤ 40%),
- Pulmonary mechanics stability (control of pulmonary edema, atelectasis, secretions and bronchospasm).

Absence of infection or fever.

Cardiovascular stability (like hemoglobin \geq 8 g/dl, no severe arrhythmia), optimal fluid balance and electrolyte replacement.

Hemodynamic stability (absence of vasopressors or vasopressors in doses \leq 5 μ g/kg/min)

Neurologic stability (Glasgow coma scale $>$ 10).

Prior to trial of weaning, there should be no residual neuromuscular blockade and sedation should be minimised so that cooperative and in a semi-recumbent position.

Weaning failure

Weaning failure is defined as the failure to pass a spontaneous-breathing trial or the need to reintubation within 48 hours following extubation. For studying NIPPV as a weaning method-1) included adults, with respiratory failure, invasively ventilated for at least 24 hours; 2) Immediate application of NPPV (BiPAP) after extubation. Patients with contraindications to NPPV were excluded. Patients needing intubation after extubation i.e. weaning failure or extubation failure patients were applied with NIPPV- BiPAP.

In present study effectiveness of NIV means improvement in ABG parameter and non-effectiveness means worsening of ABG parameter. All the study patients were followed up until discharge. Patients taking discharge against medical advice were excluded.

Collected data with the help of proforma was entered in MS EXCEL 2007 spread sheet and then analysed by SPSS 19 version software by Mann-Whitney U Test, the level of significance was 95% C.I ($\alpha=0.05$) and Power of the study (β) was taken as 0.80.

Results

Of the total 110 patients in study, there were 68 (61.81%) male and 42 (38.18%) female patients with the mean age of study population 49.40 (\pm 9.89) years. Majority 48 (43.63%) of the patients were in the age group of 55-74 years. The commonest indication of NIPPV in present study was COPD in 37 (33.63%) cases followed by post extubation 30 (27.27%), asthma 14 (12.72%), ARDS 9 (8.18%) and pneumonia 10 (9.09%) (Tables 1-4).

Out of 110 patients taken on NIPPV, 18 (16.36%) patients required ventilation for $<$ 12 h, 30 (27.27%) patients required for 12-24 h, 44 (40%) patients required for 24-48 h. Prolonged mechanical ventilation

Diseases	No. of patients (%)
COPD	37 (33.63%)
Post-extubation	30 (27.27%)
Asthma	14 (12.72%)
Pneumonia	10 (9.09%)
ARDS	09 (8.18%)
Pulmonary edema	06 (5.45%)
Bronchiectasis	03 (2.72%)
ILD	01 (0.90%)
Total	110 (100 %)

Table 1: Indications for NIPPV.

Outcome	Number of patients	Percentage (%)
Effective	88	80%
Non Effective	22	20%
Total	110	100%

Table 2: Outcome of nippv in present study.

Diseases	Total cases on NIPPV	No. of cases Required Invasive Ventilation
COPD	37	06 (16.21%)
Asthma	14	01 (7.14%)
Bronchiectasis	03	00 (0%)
ARDS	09	05 (55.55%)
Pneumonia	10	02 (20%)
Pulmonary edema	06	02 (33.33%)
ILD	01	00 (0%)
Post-extubation	30	06 (20%)
Others	00	00 (0%)
Total	110	22 (20%)

Table 3: Disease-wise distribution of patients and their outcome on NIPPV.

Complications	No. of Cases (n=110)	Percentage (%)
Dry Mouth	60	54.54 %
Facial Injury	21	19.09 %
Aerophagia	12	10.90 %
Claustrophobia	5	4.54 %
Retained Secretions	8	7.27 %

Table 4: Complications of NIPPV ventilator in present study.

($>$ 48 h) were required in 18 (16.36%) patients. NIPPV was effective in 88 (80%) but found non-effective in 22 (20%).

(Mann-Whitney U Test was used, Z-Score= -7.22982 . The p-value is $<$ 0.00001. The result is significant at $p <$ 0.05).

Amongst the total 110 patients, 22 (20%) patients required invasive ventilation, out of them 6 (16.21%) of Chronic Obstructive Pulmonary Disease (COPD), 1 (7.14%) of asthma, 5 (55.55%) of ARDS, 2 (20%) of pneumonia, 2 (33.33%) of pulmonary edema, 6 (20%) of post extubation patients. Out of 3 patients of bronchiectasis and 1 patient of ILD no one required invasive ventilation. This observed difference is statistically significant as Z-Score= -7.22982 . The p-value is $<$ 0.00001. The result is significant at $p <$ 0.05. Calculated by Mann-Whitney U Test and Power of the test is 0.80

A total of 39 (81.25%) of hypercapnic respiratory failure patients, 27 (75%) of hypoxic respiratory failure patients and 22 (84.61%) of mixed respiratory failure patients weaned off successfully.

Noninvasive Ventilator was not effective 4 (20%) were in the age group of 14-34 years, 5 (16.66%) in 35-54 years, 11 (22.91%) in 55-74 years and 2 (100%) were in the age group of $>$ 75 years.

Amongst the total 110 patients on NIPPV, dry mouth occurred in 60 (54.54%) patient, facial injury occurred in 21 (19.09%) patients, aerophagia in 12 (10.90%) patients, claustrophobia observed in 5 (4.54%) patients and retained secretions in 8 (7.27%) patients.

Discussion

This prospective observational study was conducted to determine the indications, complications and outcome of non-invasive mechanical ventilation in patients of respiratory failure admitted in critical care unit due to various conditions.

In present study, the commonest indication for initiation of NIPPV was COPD 37 (33.63%) followed by post-extubation 30 (27.27%) in present study. Other indications were asthma 14 (12.72%), bronchiectasis 3 (2.72%), ARDS 9 (8.18%), pneumonia 10 (9.09%), pulmonary edema 6 (5.45%), and ILD 1 (0.90%). This was similar to Chawla, Rai and Agrawal [13-15] COPD was the commonest indication as 71.4%, 64.4% and 38.1% patients had COPD respectively.

In a present study, amongst the total 110 patients, NIPPV was effective in 88 (80%) and noneffective in 22 (20%) and this was statistically significant also as Z -Score=-7.22982. The p -value is <0.00001. The result is significant at p <0.05. Calculated by Mann-Whitney U Test. Similar to study done by George et al. [16] with success rate of NIPPV was 85% and Meduri et al. [17] with 80% success rate.

The main advantage of NIPPV is avoidance of intubation and therefore does not interfere with the performance of the upper airway including eating, talking and discharge of airway secretions. Evidence collected over the past decade shows that in acute respiratory failure secondary to COPD, application of NIPPV reduces mortality and length of hospital stay. In addition incidence of ventilator-associated pneumonia, nosocomial infections such as sepsis, sinusitis decreases due to shortening of hospital stay [18-24]. Efficiency of NIPPV in the treatment of respiratory failure secondary to chronic obstructive pulmonary disease (COPD) has been shown in many published studies [25-29]. A systematic review of randomized controlled trials that compared NIPPV plus usual medical care versus medical care alone in the treatment of respiratory failure secondary to COPD exacerbation demonstrated fewer complications and shorter duration of hospital stay [30]. The results of another systematic review of 14 studies in treatment of respiratory failure due to COPD exacerbations revealed that NIPPV decreases mortality, needs for intubation, rate of treatment failure, and thus provides rapid improvement of PH, PaCO₂, respiratory rate and decreases duration of hospital stay [31]. The available data from published studies indicate benefit of NIPPV in respiratory failure due to COPD exacerbation and so is recommended at earlier stage of respiratory failure prior to development of severe acidosis. In one study, application of NIPPV in acute respiratory failure, reduced intubation and mechanical ventilation in 20% of patients [32].

The failure rates of NIPPV can range from 5% to 50% in different studies depending on the etiology and severity of ARF [7-10]. The success rate of NIPPV was 87.5% for ARF due to COPD and 61.5% for ARF due to other causes which are similar to reintubation rates described elsewhere both from India [16,18] and the European-American countries [10,19].

In the present study, amongst the total 110 patients 22 (20%) patients required invasive ventilation, out of them 6 (16.21%) of COPD, 1 (7.14%) of asthma, 5 (55.55%) of ARDS, 2 (20%) of pneumonia, 2 (33.33%) of pulmonary edema, 6 (20%) of post extubation patients. Out of 3 patients of bronchiectasis and 1 patient of ILD no one required invasive ventilation. Phua J et al. [10] reported that risk of NIV failure was lower in COPD than in other condition (19% vs. 47%) respectively. In a study done by Schettino et al. [20], intubation rate was 18%, 24%, 38%, 40% and 60%, respectively, for patients with cardiogenic pulmonary edema, acute exacerbation of COPD, acute hypercapnic respiratory failure, post extubation respiratory failure patients and acute hypoxemic respiratory failure.

In the present study, amongst the total 110 patients 22 (20%) patients required invasive ventilator, out of them 12 (54.54%) were due to worsening of ABG parameter, 8 (36.36%) were due to altered consciousness, and 2 (9.09%) were due to increase respiratory secretions. Phua et al. [10] found that NIV was more effective in preventing endotracheal intubation in hypercapnic ARF due to COPD than non-COPD conditions. In the study by Yoshida et al. [21] studied a total of 47 patients with ALI who received NIV, and 33 patients (70%) successfully avoided endotracheal intubation.

In the present study, 39 (81.25%) of hypercapnic respiratory failure patients weaned off successfully, 27 (75%) of Hypoxic respiratory failure

patients weaned off successfully and 22 (84.61%) of Mixed respiratory failure patients weaned off successfully. Wysocki et al. [22] found that intermittent positive support ventilation delivered from a ventilator through a face mask (NIPSV) reduced the need for endotracheal intubation with a success rate of 47% in patients presenting with acute respiratory failure from various etiologies.

Amongst the total 110 patients on NIV, in 30 patients NIPPV used for weaning after early extubation 6 (20%) of them required reintubation, total 19 patients were of Poisoning out of them 3 (15.7%) required reintubation, 4 of COPD 2 (50%) required reintubation, 2 patient of ARDS was given NIPPV support after early extubation 1 (50%) required reintubation. Girault et al. [23] found that it is possible to use NIV immediately as an early extubation and weaning technique in intubated (ACRF) acute-on-chronic respiratory failure patients who are difficult to wean, 13 of 17 (76.5%) in the NIV group were successfully weaned and extubated.

In present study, NIV was not effective 11 (22.91%) patients of 55-74 years. Patients with worsening of ABG parameter 12 (54.54%) followed by a poor level of consciousness 8 (36.36%) were associated with a poor response to NIPPV, ultimately requiring intubation. In a study done by Antonelli et al. [19], of the eligible 354 patients NIV failed in 30% (108/354) patients.

NIV aims to eliminate the complications of invasive MV, such as ventilator-associated pneumonia (VAP) and barotrauma. VAP rates are high in patients put on MV, with 8-28% of patients developing this problem [24].

In the present study, common complications observed were dry mouth in 60 (54.54%) patients, facial injury in 21 (19.09%) patients and claustrophobia in 5 (4.54%) patients. None of the patient in our study revealed a new infiltration on the X-ray associated with fever, tachypnea, or leucocytosis that could suggest nosocomial pneumonia. Mehta and Hill found complications such as nasal/oral dryness (10-20%), facial skin erythema (20-34%), claustrophobia (5-10%) and major complications such as aspiration pneumonia<5%, hypotension<5% and pneumothorax<5% [11].

The results of this study show that NIPPV can be utilized as an effective modality in the management of ARF due to diverse etiologies. NIPPV was associated with a reduced need for invasive mechanical ventilation and significant outcome and minor complications.

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