Original Article

A Study of Outcome of Noninvasive Ventilatory Support in Acute Respiratory Failure

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Abstract

Introduction: Noninvasive ventilation (NIV) is often used in acute respiratory failure to prevent endotracheal intubation and its complications. Various factors influence favorable outcome for NIV. **Aim:** To assess the outcome of NIV in acute respiratory failure and to determine predictors of positive outcome. **Patients and Methods:** This was an observational study of 4 years where 110 patients with acute respiratory failure requiring NIV were included. Data of history, examination, investigations, and clinical outcome of all patients were recorded. The outcome was divided in two categories depending upon whether patients improved or required invasive ventilation. **Results:** Of 110 patients, there were 78 men with a mean age of 64.24 years and 32 women with a mean age of 56.59 years. The causes of acute respiratory failure were acute exacerbation of chronic obstructive pulmonary disease (COPD) (61.81%), bronchial asthma (9.09), pneumonia (22.72%), tuberculosis (2.72%), interstitial lung disease (1.81%), and pulmonary artery hypertension (0.9%). Among them, 81 (74%) patients improved. Patients who had acute respiratory failure due to COPD ($P < 0.00001$) had favorable outcome compared to others. Improvement in PO_2 (48 patients [43.63%]), PCO_2 (72 patients [65%]), and pH (55 patients [50%]) within/or at 24 h of NIV correlated with successful outcome. Unfavorable outcome was seen when patients required invasive ventilation after failing NIV ($P < 0.00001$) and when NIV was required for >3 days ($P = 0.001$). **Conclusions:** COPD patients with acute respiratory failure respond well to NIV. Improvement in pH, PCO_2, and PO_2 within or at 24 h of NIV predicts successful outcome. Requirement of prolonged NIV leads to poor outcome.

Keywords: Chronic obstructive pulmonary disease, noninvasive ventilator, respiratory failure

Introduction

Respiratory failure is said to exist when there is inadequate gas exchange due to dysfunction of the respiratory system.[1] Ventilatory support is an important treatment component of patients having acute respiratory failure. It can be invasive or noninvasive. To avoid the morbidity associated with endotracheal intubation, noninvasive ventilation (NIV) was developed. NIV has been highly successful in acute respiratory failure caused by a wide spectrum of diseases. NIV decreases work of breathing, improves arterial oxygenation and alveolar ventilation, prevents the use of invasive mechanical ventilation, reduces the incidence of ventilator associated pneumonia, and decreases the length of intensive care unit (ICU) stay and mortality, mainly due to chronic obstructive pulmonary disease (COPD) exacerbations[2,3] and acute cardiogenic pulmonary edema.[4-7] However, NIV is not successful in all patients with acute respiratory failure. NIV has controversial role in respiratory failure due to pneumonia and Acute Respiratory Distress Syndrome (ARDS).[8] Patients on NIV must be monitored closely for signs of treatment failure and should be intubated promptly before a crisis develops. Therefore, there is a need to identify prognostic factors for the outcome of NIV.[9-11]

Aim of the study

The aim of the study was to assess the outcome of NIV in patients of acute respiratory failure and to determine predictors of positive outcome.

Patients and Methods

It was an observational and analytical type of study. A total of 110 patients admitted to our hospital from January 2011 to

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March 2015 fulfilling the diagnostic criteria of acute respiratory failure and requiring NIV were included in the study and analyzed. The inclusion criteria were age >18 years, pH <7.35 and $PaCO_2$ >45 mmHg, PaO_2 <60 mmHg, SpO_2 <92% with oxygen by mask, conscious and cooperative patient with an ability to maintain the airway, and a respiratory rate >25/min.[12]

Patients requiring emergency intubation, those with recent esophageal, facial, or cranial trauma or surgery, severely decreased consciousness (Glasgow coma scale [GCS] of 11 or less), severe hemodynamic instability (patient on inotropic or vasopressor support), severe ventricular arrhythmia or myocardial ischemia, tracheotomy or other upper airway disorders, active upper gastrointestinal bleeding, and inability to clear respiratory secretions (poor cough reflex)[13] were excluded.

Demographic data, history, clinical examination, relevant investigations, and clinical outcomes of all the patients were recorded in a structured pro forma. There were two study end points:

- Success group: Improvement of clinical parameters such as respiratory rate (≤24/min), heart rate (<100/min) and arterial blood gas (ABG) parameters (pH: 7.35–7.45, PO_2: 80–100 mmHg, PCO_2: 35–45 mmHg)
- Failure group: Any further worsening requiring intubation and invasive ventilation.

Results

Of 110 patients, there were 78 men with a mean age of 64.24 years and 32 women with a mean age of 56.59 years. The causes of acute respiratory failure were acute exacerbation of COPD (68 [61.81%] patients), bronchial asthma (10 [9.09%] patients), pneumonia (25 [22.72%] patients), tuberculosis (3 [2.72%] patients), interstitial lung disease (2 [1.81%] patients), and pulmonary artery hypertension (1 [0.9%] patient). Among them, 81 (74%) patients improved with NIV as per the criteria specified in methodology. Table 1 shows the important parameters and variables between two groups that we found after data analysis.

Of 68 patients of COPD, 58 patients (85%) had successful outcome and 10 patients (15%) had unsuccessful outcome.

Table 1: Comparison of various parameters between two groups

Parameter	Variable	Success group	Failure group	*P*
Whole study group (%)	-	81 (74)	29 (26)	-
Gender predisposition	Male	56	22	0.494
	Female	25	7	
History of ventilation	Present	16	2	0.089
	Absent	65	27	
Treatment compliance in COPD	Regular	23	4	0.99
	Irregular	29	5	
	No treatment	06	1	
PO_2 on admission in COPD	<60	28	2	0.084
	≥60	30	8	
GCS on admission	13/15	3	1	1.0000
	14/15	6	2	
	15/15	72	26	
Improvement in PO_2 after 24 h	Present	39	09	0.001
	Absent	5	10	
	Normal	37	10	
Improvement in PCO_2 after 24 h	Present	65	7	<0.0001
	Absent	6	20	
	Normal	10	2	
Improvement in pH after 24 h	Present	52	3	<0.0001
	Absent	2	26	
	Normal	27	0	
Severity of dyspnea (MMRC)	II	1	1	0.124
	III	36	7	
	IV	44	21	
Primary diagnosis	COPD	58	10	<0.00001
Number of days of NIV	-	2.72±1.19	3.69±1.77	0.001
Smoking status	Yes	63	22	0.510
	No	18	7	
Requirement of invasive ventilation	Yes	1	17	<0.0001
	No	80	12	

COPD: Chronic obstructive pulmonary disease, GCS: Glasgow Coma Scale, NIV: Noninvasive ventilation, mMRC: Modified Medical Research Council

A primary diagnosis of COPD had more favorable outcome with NIV as compared to other etiologies with strong statistical significance ($P < 0.00001$). A difference in gender, smoking status of the patient, and sensorium at the time of admission evaluated using GCS had no impact on outcome of NIV.

Forty-eight patients (43.63%) had improvement in PO_2 within/or at 24 h of NIV. Of these, 39 patients (81%) were in the success group and nine patients (19%) were in the failure group. It was observed that improvement in PO_2 within/or at 24 h of NIV support is an important predictor of successful outcome of NIV support with strong statistical significance ($P = 0.001$).

Seventy-two patients (65%) had improvement in PCO_2 within/or at 24 h of NIV, among which 65 patients (90%) were in success group and 7 patients (10%) in failure group. Improvement in PCO_2 within/or at 24 h of NIV was an important predictor of successful outcome of NIV with strong statistical significance ($P < 0.0001$).

Fifty-five patients (50%) had improvement in pH after 24 h of NIV, among which 52 patients (95%) were in success group and 3 patients (5%) in failure group. Improvement in pH within/or at 24 h of NIV was an important predictor of successful outcome of NIV with strong statistical significance ($P < 0.0001$).

Of 110 patients, 18 patients (15%) required invasive ventilation after NIV failure. Eleven patients did not continue NIV and were not included in the final analysis due to being transferred to other hospital or getting discharged against medical advice.

Patients in success group 81 (74%) had received NIV for a mean (±SD) of 2.72 (±1.19) days, while patients in failure group 29 (26%) had received NIV support for a mean (±SD) of 3.69 (±1.77) days. Unfavorable outcome of NIV support was seen when patient required NIV for more than 3 days with significant $P = 0.001$.

Discussion

NIV has been used to support patients with acute respiratory failure due to the many advantages. A few studies conducted in India to study the prognostic factors for successful outcome of NIV support are mentioned in Table 2.[9-11]

Success rate of NIV in our study was similar to the study conducted by Singh *et al*.[9] Majority of our cases had underlying COPD as a cause of acute respiratory failure. Similarly, studies done by Singh *et al*.[9] and Rai *et al*.[10] also had 32% and 64.4% of cases of COPD exacerbation in their study group, respectively. In comparison to their study, we had a higher number of patients having pneumonia (23%) and bronchial asthma (9%) in our study as primary causes of acute respiratory failure. In a multicentric study done by Brochard *et al*. in Europe from 1990 to 1991, 74% of patients with COPD exacerbation put on NIV did not require intubation and invasive ventilation.[13] The success rate in our study was 85%.

Table 2: The success rates with noninvasive ventilation for acute respiratory failure in different studies conducted in India

Studies	Success rate (%)
Present study	74
V. K. Singh *et al*.	76
Shameen M *et al*.	60
Lt. Col. S.P. Rai *et al*.	65.7

Patients with COPD as a primary cause for acute respiratory failure had favorable outcome with NIV support as compared to other etiologic groups. In a similar, but retrospective study by Rai *et al*. of 45 patients, they found that intubation rate was significantly less in COPD group as compared to non-COPD group which was 28% versus 43%, respectively. Their study also describes the successful use of NIV support in a wide variety of respiratory failure due to asthma, pneumonia, postoperative respiratory failure, early ARDS, cardiogenic pulmonary edema, restrictive chest wall diseases, and weaning from invasive ventilation.[11]

In our study, improvement in baseline ABG parameters such as pH, PCO_2, and PO_2 within or at 24 h of NIV support had significant correlation with successful outcome. Bhattacharyya *et al*., included 100 patients of acute respiratory failure in their study and found that improvement in pH, PCO_2, and PO_2 after 1, 4, and 24 h of NIV support had strong association with successful outcome ($P < 0.0001$ for each).[14] Singh *et al*., in their study with 50 patients with acute respiratory failure of different etiology, found that improvement in ABG parameters such as pH and PCO_2 after 1 and 4 h of NIV support in patients of acute hypercapnic respiratory failure group had favorable outcome.[9]

Difference in gender, smoking status of the patient, and sensorium at the time of admission had no impact on outcome of NIV. A similar study was done by Chakrabarti *et al*. at the University Hospital at Aintree in 2006. They studied 88 patients with decompensated COPD having respiratory failure to find out predictors of outcome of NIV support. They also found that difference in gender, smoking status, and sensorium had no impact on outcome of NIV with $P = 0.25$, 0.32, and 0.18, respectively.[15]

Patients in the success group had received NIV support for mean number of 2.72 ± 1.19 days, while patients in failure group had received NIV support for mean number of 3.69 ± 1.77 days. Unfavorable outcome of NIV support could be predicted when patients required NIV for more than 3 days ($P = 0.001$). Clinical worsening with more than 3 days of NIV support may be due to worsening of primary respiratory condition, retention of secretions, new hospital-acquired infections, nonresponding primary respiratory infections, respiratory muscles fatigue, and shock.

Conclusions

NIV is successful in nearly 75% of patients presenting with acute respiratory failure. The success rate is higher in COPD patients. Predictors of positive outcome of NIV are improvement in pH, PCO_2, and PO_2 within 24 h of NIV support and requirement of NIV for <3 days.

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Conflicts of interest

There are no conflicts of interest.

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