ORIGINAL ARTICLE

Feasibility of Early Noninvasive Ventilation Strategy for Patients with Acute Onset Shortness of Breath in Emergency Department — A Prospective Interventional Study

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Abstract

Introduction: Noninvasive ventilation (NIV) has revolutionized the initial respiratory support provided to a patient in respiratory distress presenting to emergency department. Standardization of NIV practices and safety has always been a matter of concern and debate in emergency medicine. In this study, we tried to assess the clinical outcome of NIV in respiratory failures of varied etiologies.

Materials and methods: This study was conducted from August 2017 to August 2018 at our emergency department which is a tertiary care teaching institute. All patients presenting to the ED with shortness of breath were screened for acute respiratory failure and enrolled after confirming the inclusion criteria.

Results: Out of the 236 patients presenting with acute respiratory failure, 182 fulfilled the study criteria. However, 154 patients with a mean age of 55.19 + 16.73 years were enrolled in the study. Bilevel PAP was initiated in 103 patients whereas 51 patients received CPAP. 115 (74.67%) NIV trials were successful whereas 36 (23.37%) patients had to be intubated. 32 patients died among the study group among which 3 had not consented for intubation. The in-hospital mortality has been 20.77% whereas the percentage of NIV failure with consequent intubation was 25.32%.

Conclusion: In conclusion, our study shows that NIV is not only safe and efficacious but also significantly brings down the requirement of endotracheal intubations and its complications provided proper patient selection and close monitoring is assured.

Keywords: Emergency department, Noninvasive mechanical ventilation

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Introduction

Noninvasive ventilation (NIV) by a tightly fitting nasal or facial mask instead of an artificial airway has become a standard modality of treatment in acute respiratory failure. A number of prospective randomised controlled trials [1–4] and meta-analyses[5,6] have demonstrated that NIV is not only effective but also safe for selected patients with acute respiratory failure. Although a number of studies on NIV are available, mainly in the field of COPD exacerbations and acute hypoxaemic respiratory failure,[7-9] the results cannot be extrapolated to the settings of the emergency department. The studies of NIV in the ED settings[10, 11] primarily focus on the predictive value of blood gas analysis and of vital parameters taken before the treatment or shortly thereafter. Although clinically useful, this approach does not help in detecting other factors like the physiological status of the patient, presence of comorbidities, necessity of sedation, compliance to the treatment and the ventilatory mode applied, which could subsequently correlate with the eventual NIV outcome. Comprehensive knowledge on the clinical application of NIV by the emergency physicians definitely confers a lot of advantage in terms of patient selection, early initiation, continuous monitoring and judgmental discontinuation and intubation, if required.

Materials and Methods

This study was conducted from August 2017 to August 2018 at our emergency department which is a tertiary care teaching institute. All patients presenting to the ED with shortness of breath were screened for acute respiratory failure which is defined as moderate-to-severe dyspnea with use of accessory muscles of respiration.

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Criteria for initiating NIV were the ABG findings of either $pCO_2 \geq 45$ mm Hg with pH ≤7.35 or $PaO_2 \leq 60$ mm Hg with 6 liters of oxygen in addition to the clinical features of acute respiratory failure. Patient specific management plan was made in each case right at the start under expert guidance as to when the patient should be taken up for intubation, if required. The severity of underlying disease, comorbidities, patient's or families wishes in cases of terminally ill, availability of ICU beds and financial implications were all considered during decision making initially and from time to time thereafter. NIV was initiated in the ER and continued in the HDU under strict surveillance. Facial mask interface was initiated after priming in all cases and conventionally CPAP mode was tried in all hypoxemic patients and Bi level PAP in all hypercapnics. The initial settings and titrations were done as per standard NIV protocols and

Table 1: Demographic variables in NIV success and failure groups.

Variable	*Total*	*Success*	*Failure*	*Probability*
Age (in years)	55.19 ± 16.73	55.51 ± 15.96	54.26 ± 19.2	0.68
Sex(M/F)	71/83	52/63	19/20	0.25
NIV outcome	154	115 (74.67%)	39 (25.32%)	
CPAP	51	36 (70.58%)	15 (29.41%)	
BiPAP	103	79 (76.69%)	24 (23.30%)	
APACHE score	17.55 ± 5.18	16.6 ± 4.69	19.95 ± 5.7	0.01
ICU stay (in days)	3.15 ± 2.06	2.98 ± 1.91	3.66 ± 2.43	0.08
Stepdown stay (in days)	1.78 ± 2.48	2.26 ± 2.63	0.34 ± 0.99	0.00
Hospital stay (in days)	4.9 ± 3.21	5.24 ± 3.31	3.9 ± 2.69	0.02
Clinical outcome (in terms of mortality)	154	122 (79.22%)	32 (20.77%)	

considering patient's comfort. The success of NIV trial was defined as tolerance of NIV and avoidance of ETI. The clinical parameters and arterial blood gases (ABG) results were recorded at baseline and after 2 hours of NIV initiation or earlier, if clinically warranted.

Inclusion Criteria

- Clinical signs or symptoms of acute respiratory distress (RR > 30).
- ABG showing a pH <7.35.
- ABG showing hypercapnia ($PaCO_2$ >45mm Hg) after initial O_2 supplementation with simple O_2 mask at 6 l/min
- ABG showing hypoxemia (PaO_2 <60mm Hg) after initial O_2 supplementation with simple O_2 mask at 6 L/min

Exclusion Criteria

- Inability to protect the airways (Glasgow coma scale ≤8 with impaired cough or swallowing)
- Hemodynamic instability (uncontrolled arrhythmia, need for very high doses of inotropes/vasopressors or recent myocardial infarction)
- Inability to use the interface (facial abnormalities, facial burns, facial trauma, facial anomaly)
- Severe gastrointestinal (GI) symptoms (vomiting, obstructed bowel, recent GI surgery)
- Documented cardiac disease with compromised ejection fraction
- Those who were extubated from invasive ventilation during this hospitalization.
- Impending respiratory/ cardiac arrest.
- Severe metabolic acidosis.
- Impaired mental status.
- Excessive secretions.
- Uncooperative or agitated patient.

Statistical Analysis

The descriptive analysis was performed using IBM Statistical Package for the Social Sciences (IBM SPSS Corp.; Armonk, NY, USA) version 20. All categorical parameters were presented as number (n) and percentage (%). Predictive factors for response to NIV were identified by univariate analysis (categorical variables by Spearman and continuous Pearson correlation) and logistic regression model was developed based on the identified univariate predictors. Forward selection within the regression model was stepwise, where variables were retained if their p value was <0.05.

Table 2: Clinical indications for starting NIV among the study group

Indication	*Total*	*Success*	*Failure*
Type 1 respiratory failure	39	29 (74.35%)	10 (25.64%)
Type 2 respiratory failure	78	63 (80.76%)	15 (19.23%)
Respiratory distress *	11	7 (63.63%)	4 (36.36%)
Mixed	26	16 (61.53%)	10 (38.46%)

*Moderate to severe dyspnea with the use of accessory muscles of respiration

Table 3: NIV outcome among the study participants

NIV outcome	*Frequency*	*% (n = 154)*
Failed in <2 hours	7	4.54
Failed in 2–24 hours	13	8.44
Failed in 24–72 hours	8	5.19
Failed beyond 72 hours	8	5.19
Successfully treated without intubation and discharged	115	74.67
DNR*	3	1.94

*Do not resuscitate

Results

Out of the 236 patients presenting with acute respiratory failure, 182 fulfilled the study criteria. However, 154 patients with a mean age of 55.19 ± 16.73 years were enrolled in the study who gave consent. Demographic variables in NIV success and failure groups by univariate analysis are shown in Table 1. Bilevel PAP was initiated in 103 patients whereas 51 patients received CPAP. 115 (74.67%) NIV trials were successful whereas 39 (25.32%) patients had to be intubated. Among the patients who got intubated, 13 (8.44%) had planned intubation whereas 26 (16.88%) patients had crash intubations. The APACHE score at presentation correlated well with the NIV outcome. The score was 19.95 ± 5.7 among the failure group which was significantly higher as compared to 16.6 ± 4.69 in the success group. Also the patients in the success group had a shorter duration of ICU stay as compared to those who had to be intubated. Indications for starting the assisted ventilation among the study participants are depicted in Table 2. NIV outcome among the study participants is shown in Table 3. The clinical outcome was favorable for 122 patients among whom 7 patients had to be intubated and later got discharged after recovery. Thirty-two patients died among the study group among which 3 had not consented for intubation. The in-hospital mortality has been 20.77% whereas

Table 4: Blood gas analysis at different time intervals

		Time of admission	*2 hours*	*12 hours*	*24 hours*	*Probability*
pH	Success	7.25 ± 0.20	7.27 ± 9.37	7.36 ± 1.68	7.39 ± 0.07	0.006
	Failure	7.08 ± 0.27	7.06 ± 9.21	7.31* ± 0.14	7.36 ± 0.13	
pO_2	Success	82.42 ± 9.37	86.62 ± 9.37	100.95 ± 55.23	90.74 ± 33.80	0.002
	Failure	76.52 ± 9.21	86.42 ± 9.21	173.33* ± 128.83	111.01 ± 32.75	
pCO_2	Success	64.01 ± 9.37	58.26 ± 9.37	58.91 ± 20.25	51.93 ± 13.44	0.108
	Failure	63.74 ± 9.21	58.67 ± 9.21	62.66 ± 19.53	36.01 ± 13.61	
HCO_3	Success	30.32 ± 9.37	30.42 ± 9.28	32.52 ± 9.72	31.75 ± 6.83	0.851
	Failure	27.30 ± 9.21	26.28 ± 7.85	27.33 ± 6.21	19.00 ± 7.48	
FiO_2	Success	0.34 ± 0.25	0.53 ± 0.28	0.47 ± 0.21	0.50 ± 0.22	0.0170
	Failure	0.35 ±0.47	0.61 ± 0.47	0.40 ± 0.16	0.46 ± 0.26	
Lactate	Success	2.23 ± 1.64	1.85 ± 1.16	1.87 ± 1.48	1.92 ± 0.59	0.051
	Failure	2.51 ± 1.49	2.70 ± 1.68	2.50 ± 1.37	2.00 ± 0.56	

*Statistically significant by posthoc analysis when compared within the group in relation to time of admission

Table 5: Correlation with NIV outcome

Variable	*Correlation coefficient*	*Probability*
pH	0.303	0.00
Timing of intubation	–0.988	0.00
Emergency of intubation	–0.911	0.00
Step down stay	0.335	0.00
Hospital stay	0.183	0.02
APACHE	–0.293	0.016
Clinical outcome	0.843	0.00

the percentage of NIV failure with consequent intubation was 25.32%. The blood gas analysis at different time intervals and correlation with NIV outcome is shown in Tables 4 and 5, respectively. The etiological diagnoses of acute respiratory failure among the study group is depicted in Figure 1. Logistic regression analysis (Table 6) showed that the patients who failed the NIV trial had a poor clinical outcome even after intubation.

Discussion

Emergency department is the most ideal place for early and effective initiation of NIV in acute respiratory failures of lesser severity. However, the presence of properly trained personnel is pivotal for successful outcome.[12] A few studies have shown that the initial twelve hours of NIV are most crucial and requires close monitoring[13] and similar conclusions could be drawn from our study where we found that patients started on NIV for the first time needed an adaptation time. Proper precounseling and NIV application techniques lead to better compliance and outcomes. Our study, conducted entirely in the emergency department, is the largest single center prospective interventional study done in the reported literature. The overall success rate of NIV in our study is 74.67% which compares favorably with that of other similar observational studies. Considering the single etiological groups, NIV failure among the COPD exacerbations was around 21.05%, whereas 25% failure was found among the acute cardiogenic

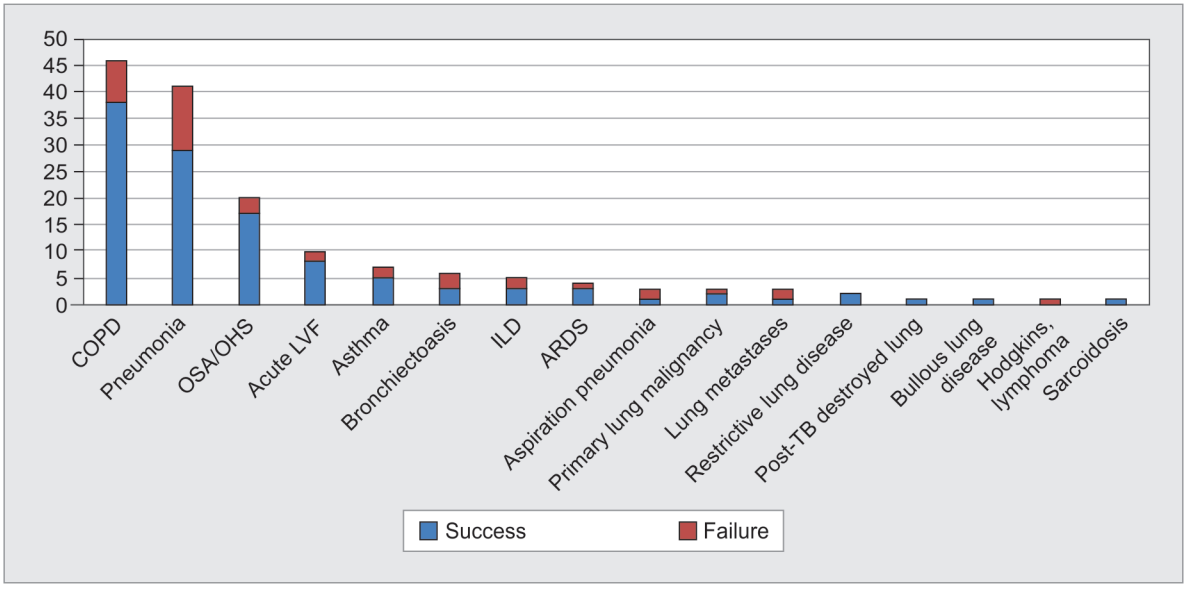

Fig. 1: Etiological diagnoses of acute respiratory failure

Table 6: Logistic regression analysis on NIV outcome

Parameter	Odds ratio	95% confidence interval		Coefficient	p
		Lower	Upper		
Clinical outcome	15.667	4.876	50.334	0.843	0.000

pulmonary edema group. This data was comparable with similar studies done elsewhere among the same etiological groups.[14-16] For severe community acquired pneumonia, NIV failure has been reported between 21 – 66% in different studies.[17,18] The NIV failure rate in the community acquired pneumonia group in our study was 41.37%. Considering that the basal patient characteristics in our study were not very different from aforementioned studies, we could conclude that NIV use in emergency is not only safe but also offers outcomes comparable to those obtained in the intensive care settings. Groff et al.[19] have mentioned the use of pharmacological sedation to improve the adaptation phase but however could not correlate its use with the success or failure of NIV. However, we have not used any pharmacological agent for sedation in our study.

Patients with type 1 respiratory failure were started on CPAP and those with type 2 on BiPAP, conventionally. Ventilatory mode was not preferentially chosen in cases of mixed respiratory failures or those patients who were started on NIV therapy for respiratory distress even though their ABGs have not decompensated by then. We could conclude that there was no significant difference in terms of NIV outcome or mortality among the two modes of ventilation. The outcome of NIV in acute respiratory failure secondary to pneumonias is not comparable to those with COPD exacerbations or cardiogenic pulmonary odema as seen in other similar studies. Our study highlights certain important differences among the various etiological groups with reference to the severity at presentation, clinical outcome, duration of hospital stay and ICU stay.

In emergency, patients with acute respiratory failure is often started on NIV before making a clinical diagnosis with certainty. It is therefore important to identify the factors which correlate with the outcome of NIV irrespective of the etiology of respiratory failure. Reduction in mortality by NIV has been established by various studies in different disease conditions. The relative risk of 0.52 for acute exacerbation of COPD [20] and 0.55 for acute cardiogenic pulmonary edema, [21] 0.46 (ICU mortality, 18% vs. 39%) for heterogeneous severe hypoxemic failure [22] and 0.11 (ICU mortality, 6% vs. 53%) for early ARDS in experienced hospitals.[23] Nevertheless, for other etiologies such as pneumonia, interstitial lung disease and bronchial asthma, mortality reduction by NIV has not yet been established. Therefore, our data showing an overall reduction in mortality of heterogeneous etiologies is useful in establishing the role of NIV in emergency practice.

The most important aspect is that this study not only reaffirms the feasibility of NIV in the emergency settings but also establishes its benefits in terms of better outcomes, shortened duration of stay and avoidance of endotracheal intubation and its associated complications. In conclusion, our study shows that NIV is practicable in the ED with safety and clinical results comparable to those obtained in general or respiratory intensive care units, provided that an adequate level of motivated and trained personnel is available. Furthermore, it indicates some quick factors that correlate well with the probability of in-hospital death or need for ETI. Such factors can contribute for better selection of patients for NIV in the ED and identification of those more appropriately amenable to be hospitalized in the ICU. The main limitation in our study was the uneven distribution of patients with different etiologies of acute respiratory failure.

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