Scholars Journal of Applied Medical Sciences (SJAMS) **ISSN 2320-6691 (Online)**
Sch. J. App. Med. Sci., 2013; 1(6):1082-1086 **ISSN 2347-954X (Print)**

(An International Publisher for Academic and Scientific Resources)
www.saspublishers.com DOI: 10.36347/sjams.2013.v01i06.0092

Research Article

Non invasive ventilation in patients with acute exacerbation of chronic obstructive pulmonary disease with acid base disturbances

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Abstract: ***Background*****:** Recent years have seen the emergence of non-invasive ventilation (NIV) as an important tool for management of patients with acute exacerbation of chronic obstructive pulmonary disease (COPD). Non-invasive ventilation (NIV) reduces intubation rates, mortalities, and lengths of hospital and intensive care unit stays in patients with acute exacerbation of chronic obstructive pulmonary disease (AECOPD). ***Material and Methods*****:** The is a prospective, open-labelled study conducted in the Department of TB and Respiratory Diseases, Narayana Medical College, Nellore. In total, 60 AECOPD patients with hypercapnic respiratory failure admitted to respiratory ward/ICU at Narayana Medical College from October 2012 to September 2013. During screening and prior to enrolment in the study, patients were considered eligible for the study if they are diagnosed with AECOPD as defined by the criteria of the Global Initiative for Chronic Obstructive Lung Disease (GOLD) in 2011, with post bronchodilator FEV1/FVC<0.70 and hypercapnic respiratory failure as arterial pH <7.35 and PaCO2 >50 mmHg (either or both). ***Result:*** In our study, according to ABG finding, patients were classified into three groups: the first group comprised 38 (63.33%) patients who had compensated respiratory acidosis, and the majority of them (32 patients) received medical treatment only. The second group comprised 14 (23.3%) patients, who had mixed respiratory acidosis and metabolic alkalosis. Overall, 11 patients needed non-invasive mechanical ventilation with the medical treatment. The third group comprised 10 (16.6% patients) who had combined respiratory and metabolic acidosis. Of them, 8 patients needed non-invasive mechanical ventilation with the medical treatment. The mean PO2 was 53.45 mmHg whereas mean PCO2 was 58.74 mmHg in NIV positive. On the other hand, NIV negative, PO2 was 63.32 mmHg whereas mean PCO2 was 49.36 mmHg. Total 19 patients improved and only 2 patients failed non-invasive ventilation. PO2 showed significant effect ($p<0.05$), on the other hand, PCO2 showed no significance ($p>0.05$). ***Conclusion***: Non-invasive ventilation is effective and evidence based therapeutic tool in patients with acute exacerbations of chronic obstructive pulmonary disease complicated by hypercapnic respiratory failure and acid base disturbances. It reduces the need for endotracheal intubation, thereby reducing complications and hospital costs, as well as improving survival outcome.
Keywords: Non-invasive Ventilation (NIV), Non-invasive Positive-Pressure Ventilation (NPPV), NIV to NPPV are used interchangeable, COPD, AECOPD.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is chronic progressive airway disorder characterized by airflow limitation that is not fully reversible or fixed. [1] The chronic downhill course is interspersed with episodes of acute inflammation, often due to infections, that is termed as acute exacerbations of COPD (AECOPD). [2] COPD is a major health problem and one of the leading causes of mortality and morbidity among middle-aged and elderly people both in developed and developing countries. Moreover, the prevalence of COPD is increasing and is projected to rank number three amongst all the causes of loss of DALYS (disability adjusted life years) in India by the year 2020. [3]

COPD was responsible for 1.5 million emergency department visits, 726,000 hospitalizations, and 119,000 deaths. [4] Obviously, COPD puts an enormous economic burden on the society and this is especially true for exacerbations of the disease. Andersson and colleagues (2002) estimated that almost 35%–45% of the total per capita healthcare costs for COPD are account for by exacerbations alone. Severe exacerbations requiring hospitalizations are responsible for a major chunk of these costs and among these, treatment costs of those who require endotracheal intubation and assisted ventilation with intensive care unit (ICU) admission are largest. Moreover, there are several other hazards of endotracheal intubation itself such as increased risk of infections (commonly called ventilator-associated pneumonia) and tracheal stenosis. A significant proportion of patients with AECOPD need ventilatory support although the reported figures in the literature have been highly variable and range from 9.8%–67.6%. [4] Furthermore, patients with AECOPD as compared to other causes of acute respiratory failure tend to have higher rates of ventilator dependence, weaning failures, as well as reintubation. [5]

The role of non-invasive positive pressure ventilation (NIV) in COPD is to decrease work of

breathing and improve respiratory mechanics through effects on several pathophysiologic abnormalities present in severe COPD. [6] In severe COPD, the lungs are hyperinflated because of the presence of emphysema and small airway disease that together contribute to increases in lower airway resistance. [7] Hyperinflation together with other pathobiological mechanisms related to muscle dysfunction in severe COPD lead to diaphragm muscle atrophy. [8] The combination of diaphragm muscle atrophy and the airflow obstruction central to COPD pathophysiology leads to increased respiratory muscle load.

The goal of NIV in COPD is to offset this diaphragmatic dysfunction and achieve control of spontaneous breathing with near-abolition of diaphragm activity and decreasing respiratory muscle load thus reducing chronic hypercapnia. Although the direct impact that impaired gas exchange has on work of breathing is unclear, there is evidence that hypoxemia can impact skeletal muscle strength and endurance and that chronic hypercapnia can induce skeletal muscle dysfunction. [9] In addition, emerging data indicate that chronic hypercapnia suppresses innate immunity and that a reduction in CO_2 levels may have a mechanistic effect in reduction of COPD exacerbations leading to hospital admissions. [10]

MATERIAL AND METHODS

The is a prospective, open-labelled study conducted in the Department of TB and Respiratory Diseases. In total, 60 AECOPD patients with hypercapnic respiratory failure admitted to respiratory ward/ICU at Narayana Medical College from October 2012 to September 2013.

During screening and prior to enrolment in the study, patients were considered eligible for the study if they are diagnosed with AECOPD as defined by the criteria of the Global Initiative for Chronic Obstructive Lung Disease (GOLD) in 2011, with post bronchodilator FEV1/FVC<0.70 and hypercapnic respiratory failure as arterial pH <7.35 and PaCO2 >50 mmHg (either or both). [11]

Inclusion criteria

- Patients of either gender with more than 40 years old.
- Acute exacerbation with hypercapnic respiratory failure is known or diagnosed COPD patients.
- Patients are willing to participate in the study.

Exclusion Criteria

- Patients whose age < 40 years.
- Excessive amount of respiratory secretions or weak cough, upper airway obstruction, recent oral, facial, or cranial trauma or surgery.
- Recent gastric or esophageal surgery, severe abdominal distension, active upper gastrointestinal bleeding.
- Cardiac or respiratory failure; arterial oxygen tension/fraction of inspired oxygen (PaO_2/FiO_2) < 150 mmHg.
- Severe hemodynamic instability despite fluid repletion and use of vasoactive agents.
- Lack of cooperation, and refusal to receive NPPV.
- Patients with altered sensorium with severe respiratory acidosis and requiring intubation/ventilation.

STATISTICAL ANALYSIS

The continuous data variables as means ± standard deviations or medians and interquartile ranges, when appropriate, and categorical variables as proportions. Continuous variables will be compared using an appropriate parametric (Student's *t* test) or nonparametric (Mann–Whitney *U* test) method. Categorical variables will be compared using a chi-square test or Fisher's exact test, if appropriate.

RESULTS

In our study, the most of the patients the age group of >60 years i.e., 31 out of 60 (51.6%), followed by 51-60 years, i.e., 17 out of 60 (28.3%) and least were 12 patients in age group of 40-50 years in Table 1.

Table-1: Distribution of different age groups of patients

Age in years	No. of patients	Percentage
40-50	12	20.0
51-60	17	28.3
>61	31	51.6
Total	60	100

Table-2: Distribution of gender

Gender	No. of patients	Percentage
Male	49	81.6
Female	11	18.3
Total	60	100

In table 2, maximum number of patients were male 49 (81.6%) and female 11 (18.3%) in our study.

Table-3: Arterial blood gases finding of the studied group

Acid–base disturbance	Need for non-invasive ventilation		p-value
	NIV Positive (N=23)	NIV Negative (N=37)	
Compensated respiratory acidosis (n=38)	6 (27.2)	32 (85.3)	<0.0001
Mixed respiratory acidosis and metabolic alkalosis (n=14)	11 (39.3)	3 (9.7)	
Combined respiratory and metabolic acidosis (n=10)	8 (33.3)	2 (4.8)	
PO2	53.45±8.7	63.32±8.9	<0.0001
PCO2	58.74±8.1	49.36±6.2	<0.0001

In table 3, according to ABG finding, patients were classified into three groups: the first group comprised 38 (63.33%) patients who had compensated respiratory acidosis, and the majority of them (32 patients) received medical treatment only. The second group comprised 14 (23.3%) patients, who had mixed respiratory acidosis and metabolic alkalosis. Overall, 11 patients needed non-invasive mechanical ventilation with the medical treatment. The third group comprised 10 (16.6% patients) who had combined respiratory and metabolic acidosis. Of them, 8 patients needed non-invasive mechanical ventilation with the medical treatment. The mean PO2 was 53.45 mmHg whereas mean PCO2 was 58.74 mmHg in NIV positive. On the other hand, NIV negative, PO2 was 63.32 mmHg whereas mean PCO2 was 49.36 mmHg.

Table-4: Outcome and characteristic of the group that needed NIPPV from the start

Acid–base disturbance	Studies groups non-invasive ventilation (N=21)		p-value
	Improved (N=19)	Failed (N=2)	
Compensated respiratory acidosis	6 (28.5)	0 (0)	<0.0001
Mixed respiratory acidosis and metabolic alkalosis	8 (38.0)	1 (50)	
Combined respiratory and metabolic acidosis	5 (23.)	1 (50)	
PO2	53.6±6.2	42.2±6.2	<0.05
PCO2	58.3±6.7	56.3±7.7	>0.05

In table 4, total 19 patients were improved and only 2 patients failed non-invasive ventilation. Whereas, PO2 were significant effect ($p<0.05$), on the other hand, PCO2 showed no significance.

DISCUSSION

NIV reduces the need for intubation, mortality rates, and lengths of hospital and intensive care unit (ICU) stays in cases of acute or acute-on-chronic hypercapnic respiratory failure. [12] NIV has proven to be useful for breathing support, but complications such as air leaks, skin breakdown, and discomfort result in treatment failure. [13] The use of non-invasive ventilation (NIV) in patients suffering from an acute exacerbation of chronic obstructive pulmonary disease (COPD) complicated by hypercapnic respiratory failure is widespread, supported by a strong evidence base and benefits from clinician consensus on its value. Its use in other conditions in COPD patients is more controversial. This study will initially discuss recent developments around patient selection and weaning from NIV during an acute episode. This study was followed by an update on the use of NIV in patients with persistent hypercapnia, its use as an adjunct to an exercise training programme and in the palliative care setting. Finally, the use of humidified oxygen via nasal cannulae was discussed as a more recent potential alternative to NIV in these patients.

Non-invasive Positive-Pressure Ventilation (NPPV) is increasingly used in the care of patients with AECOPD, and several lines of evidence strongly support its use in these patients. [14] However, it still fails in approximately 15% of AECOPD patients; in these cases, mortality is not reduced. [15] Plant et al. conducted a randomized controlled trial that indicated a 15% failure rate of NPPV in patients with mild to moderate respiratory acidosis in the general ward setting. [16] In addition, Contou et al. performed an observational cohort study in an experienced ICU and reported an NPPV failure rate of 15% in COPD patients with acute hypercapnic respiratory failure. [17] In addition, a meta-analysis by Ram et al. showed that the intubation rate was 16.4% in such patients when they received NPPV. [18]

There are four possible ways to explain NPPV failure in the conventional approach, i.e., using low-intensity NPPV. The main reason for NPPV failure is that, despite NPPV use, pH and PaCO2 continuously worsen in conventional low-intensity NPPV, and then consciousness may be difficult to recover in a small percentage of AECOPD patients. [19] Another reason is that, despite significant improvement in ventilatory status, PaCO2 is difficult to normalize and can easily increase when there is a slight change in a patient's clinical situation, which often triggers NPPV failure. [20] Moreover, it remains to be seen whether

continuously elevated PaCO2 is harmful to the internal environment or vital organs. Further, a minority of patients with AECOPD tolerate conventional NPPV poorly, to the point where it is discontinued, possibly because of inadequate pressure support provided by low-intensity NPPV. Ultimately, in such cases, endotracheal intubation is required. [21] Thus, enhancing the pressure-support intensity of NPPV might be of critical importance to reduce the need for intubation, in turn reducing the mortality rate.

High-intensity NPPV is a novel therapeutic option which can be used to maximally decrease severely elevated PaCO2 to normal levels. [22] In theory, high-intensity NPPV may be more efficient than low-intensity NPPV for augmenting alveolar ventilation and offsetting the extra dead space caused by the face mask, and reducing the inspiratory work of breathing and alleviating dyspnea in a way that provides more comfort during NPPV. Confalonieri M et al. reported that, in patients with stable hypercapnic COPD, improvements in PaCO2 levels, lung function, and breathing pattern were achieved using high-intensity NPPV. [23] Plant PK et al. also directly compared high-intensity NPPV with the conventional approach of low-intensity NPPV in patients with stable hypercapnic COPD, and found that high-intensity NPPV was superior in terms of controlling nocturnal hypoventilation, thus improving dyspnea during physical activity, lung function, and health-related quality of life. [24]

Limitations of the study

First, the study is being performed in patients with mild to moderate respiratory acidosis, which suggests that the results may not be generalizable to the whole population. Further study will be required to assess whether our findings can be extended to other subgroups and the whole population. Second, several confounding factors associated with general therapy for AECOPD (e.g., the use of bronchodilators, corticosteroids, and antibiotics; fluid administration; thromboembolism prophylaxis; treatment of associated conditions) are only suggested and are not protocolized.

CONCLUSION

Non-invasive ventilation has been very much useful in the management of acute exacerbations of chronic obstructive pulmonary disease with respiratory acidosis and acid base disturbances. People with acute exacerbations of chronic obstructive pulmonary disease with acid base disturbances in those patients NIV reducing need of endotracheal intubation, thereby reducing complications and hospital costs, as well as improving survival outcome.

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