Original Research Article

Role of non-invasive ventilation (NIV) for treatment of acute respiratory failure (ARF) among patients with non cystic fibrosis (CF) bronchiectasis

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Abstract

Aim: The aim of this study to evaluate the role of non-invasive ventilation (NIV) for treatment of acute respiratory failure (ARF) among patients with non cystic fibrosis (CF) bronchiectasis. **Material and methods:** This was a retrospective study conducted in the Department of Anaesthesiology, Jawaharlal Nehru medical college and hospital Bhagalpur, Bihar, India from May 2018 to February 2019. We included 100 patients with bronchiectasis and ARF who required either NIV or invasive mechanical ventilation (IMV). **Results:** There was a total of 200 patients with bronchiectasis, Among these, 100 patients were admitted with ARF. Totally 100 patients who required either NIV or IMV. The most common etiology of bronchiectasis was post-tuberculosis (50%) followed by idiopathic (20%), ABPA (15%), and immunodeficiency (5%). NIV was initiated as first line of ventilator support for 80 patients. Among these, 51(63.75%) were managed successfully with NIV. 29 (36.25%) patients failed NIV and required endotracheal intubation during the hospital stay. Reasons for NIV failure were worsening or non-improvement of ventilatory or oxygenation parameters (n=14), hypotension (n=6), worsening of sensorium (n=4), and intolerance (n=5). NIV failure occurred after a median duration of 2.77(95% confidence interval [CI] 1.51–4.24) days after the initiation. There were total 11 deaths in the study group. Among patients who failed NIV, total days (median [range]) spent on ventilator (6.6 [2–62] vs. 6.1 [3–16] days; P=0.41), duration (median [range]) of hospital stay (8 [4–64] vs. 11 [5–15] days; P=0.27), and mortality (8 [10%] vs 3 [15%]; P=0.24) were comparable to the IMV group. The causes of death among patients who failed NIV were septic shock (n=5) and ventilator-associated pneumonia (n=3). **Conclusions:** NIV is feasible for management of ARF with non-CF bronchiectasis. High APACHE may predict NIV failure among these patients.

Keywords: Acute respiratory failure, mechanical ventilation, noncystic fibrosis bronchiectasis, noninvasive ventilation.

Introduction

Although the efficacy of noninvasive ventilation (NIV) in reducing the need for endotracheal intubation and mortality has been clearly established, its failure rate remains high, exceeding 20% in patients without COPD[1,2]. A high mortality rate has been recently reported in a large group of patients who, following unsuccessful treatment with NIV, required subsequent application of invasive mechanical ventilation[2]. Non-cystic fibrosis bronchiectasis is a progressive condition generally associated with chronic bacterial infections and characterized by irreversible destruction and dilation of the airways[3].The clinical course of individuals with non-cystic fibrosis bronchiectasis is variable, with a significant proportion of patients developing transient exacerbation leading to severe acute respiratory failure (ARF) and requiring ventilatory support[4]. Although the use of NIV in bronchiectasis exacerbations may appear attractive as it can reduce ICU stay, its failure rate exceeds 25%[5]. At the same time, subsequent application of invasive mechanical ventilation, which is associated with a mortality rate of 19 –35% and prolonged ICU stay, appears problematic[6]. According to the National Institute for Health and Care Excellence guidance document issued in June 2012,extracorporeal CO2 removal should be used to remove CO2 from the blood of patients receiving mechanical ventilation who are unable to achieve adequate gas exchange at maximal tolerable ventilation pressures[7]. Sporadic case reports and short case series concerning the use of an extracorporeal CO2 removal system in patients who develop severe acute hypercapnic respiratory failure of various etiologies but do not respond adequately to NIV have been published in recent years. Extracorporeal CO2 removal has, in fact, been successfully employed, and intubation has been avoided in some cases of exacerbation of COPD,[8-12] cystic fibrosis, pulmonary fibrosis, severe asthma,[8] and bronchiolitis obliterans[13]. Despite increasing interest in the use of extracorporeal CO2 removal systems in patients who develop refractory hypercapnic ARF, its utility in the event of exacerbations in non-cystic fibrosis bronchiectasis has not been assessed. This report describes the management of a patient with exacerbated bilateral bronchiectasis, fibrothorax, and hypercapnic respiratory failure who was successfully treated by extracorporeal CO2 removal following ineffective NIV support.

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Material and methods

This was a prospective, randomized double blinded clinical comparative study conducted in the Department of Anaesthesiology, Jawaharlal Nehru medical college and hospital Bhagalpur, Bihar,

India from May 2018 to February 2019, after taking the approval of the protocol review committee and institutional ethics committee.

Inclusion criteria

- Patients with bronchiectasis
- Patients who were admitted with ARF and required either NIV or invasive mechanical ventilation (IMV)

Exclusion criteria

- Patients with bronchiectasis who required admission for reasons other than ARF were excluded.
- patients who had ARF but managed with oxygen

Methodology

The diagnosis of bronchiectasis was based on computed tomographic scan of the thorax showing typical findings[14]. Foretiology of bronchiectasis, all patients admitted under pulmonary medicine are routinely evaluated for ABPA, CF, connective tissue disease, mycobacterial infection, and immune deficiency. If the clinical and laboratory workup is negative than it is labeled as idiopathic. For this study, the final diagnoses at the time of discharge were used to classify the etiology of bronchiectasis. ARF was diagnosed based on the history of acute worsening of cough, breathlessness, respiratory distress or cyanosis and arterial blood gas (ABG) analysis showing either PaO2 <60 mmHg or PaCO2 >45 mmHg.

NIV start with inspiratory positive airway pressure (IPAP) of 8–10 cm of H2O and expiratory positive airway pressure of 4–6 cm of H2O. The patient is closely monitored for clinical stability /improvement, and IPAP is adjusted accordingly. The IPAP is increased by 2–4 cm of H2O every 5–10 min while observing the use of accessory muscles, respiratory rate, and comfort of the patient. Oxygen is given to keep oxygen saturation between 88% and 92%. If the patient does not improve even with IPAP of 20 cm of H2O or develop intolerance at any IPAP, we switch to endotracheal intubation and mechanical ventilation. Furthermore, if the patient develops any signs of failure or contraindication of NIV such as hemodynamic instability, decreased mental status, and worsening respiratory acidosis at any time during NIV treatment, we will intubate and start mechanical ventilation. Those patients who stabilized with NIV were treated with NIV for the maximum duration on day 1, allowing breaks for meals and nebulization. Once patient recovered from the acute illness, weaning from NIV is accomplished by gradually increasing the off NIV periods as recommended by the British Thoracic Society[15].

Statistical analysis

The data were summarized and analyzedusing. Data were expressed as mean ± standard deviation, median with range or in number and percentage as appropriate. Data were tested for normality using the Kolmogorov–Smirnov test. An independent sample Student's t-test was used to compare the parametric values. For comparison of categorical data, the Chi-square test/Fisher's exact test was used to establish the association. To find the early predictor of NIV failure, univariate and multivariate analyses were performed to compare various clinical and ABG parameters between patients who were successfully managed with NIV as compared to who failed NIV. One way analysis of variance analysis was done for more than two groups with Bonferroni correction. $P < 0.05$ was considered to represent statistical significance for the study

Results

There were a total of 200 patients with bronchiectasis who were admitted during the above specified period. Among these, 100 patients were admitted with ARF. Totally 100 patients who required either NIV or IMV. The most common etiology of bronchiectasis was post-tuberculosis (50%) followed by idiopathic (20%), ABPA (15%), and immunodeficiency (5%). The baseline characteristics of these patients are shown in Table 1.

NIV was initiated as first line of ventilator support for 80 patients. Among these, 51(63.75%) were managed successfully with NIV. 29 (36.25%) patients failed NIV and required endotracheal intubation during the hospital stay. Reasons for NIV failure were worsening or non-improvement of ventilatory or oxygenation parameters (n = 14), hypotension (n = 6), worsening of sensorium (n = 4), and intolerance (n = 5). NIV failure occurred after a median duration of 2.77(95% confidence interval [CI]1.51–4.24) days after the initiation. The comparison of total duration of stay in hospital, number of days spent on ventilatory support and mortality rate between NIV and IMV are shown in Table 2. There were total 11 deaths in the study group. Among patients who failed NIV, total days (median [range]) spent on ventilator (6.6 [2–62] vs. 6.1 [3–16] days; P = 0.41), duration (median [range]) of hospital stay (8 [4–64] vs. 11 [5–15] days; P = 0.27), and mortality (8 [10%] vs. 3 [15%]; P = 0.24) were comparable to the IMV group. The causes of death among patients who failed NIV were septic shock (n = 5) and ventilator-associated pneumonia (n = 3). Predictors of noninvasive ventilation failure: For identification of the early predictors of NIV failure univariate and multivariate regression analysis was performed using various baseline clinical and laboratory parameters of patients managed successfully with NIV and who failed NIV. The results are summarized in Table 3.

Table 1: Demographic profile of the patients

Parameters	NIV (n=80)	IMV (n=20)
Age (years), mean±SD	47.87±19.12	51.14±15.28
Gender male, n (%)	50 (62.25)	13(65)
APACHE, mean±SD	13.21±4.32	16.10±6.36
Associated COPD, n (%)	10 (12.5)	5(25)
Reason for exacerbation, n (%)		
Infective	68 (85)	16 (80)
Noninfective	12 (15)	4 (20)
Etiology, n (%)		
Posttuberculosis	40 (50)	16 (80)
Idiopathic	16 (20)	3 (15)
ABPA	12(15)	1 (5)
Immunodeficiency	4 (5)	0
Arterial blood gases at the time of admission (mean±SD)		
pH	7.29±0.077	7.15±0.12
PaCO2 (mmHg)	75.98±19.36	82.24±20.88
PaO2 (mmHg)	71.74±31.81	68.24±18.43
Bicarbonate (mmHg)	31.11±6.12	28.98±7.23
Oxygen saturation (%)	87.10±7.42	87.48±8.58

Table 2: Comparison of important clinical outcome

	Mode of ventilation		
Outcome parameters	**NIV**	**IMV**	**P value**
Days on ventilatory support, median (IQR	0 (0-3)	5 (2-10)	<0.001
Hospital length of stay (days), median (IQR	7 (6-11)	12 (6-12)	.94
Mortality, n (%)	8 (10	3 (15)	.24

IQR: Interquartile range; NIV: Noninvasive ventilation; IMV: Mechanical ventilation

Table 3: Univariate and multivariate analysis for predictors of noninvasive ventilation failure

Parameter	OR (95% CI)	Pvalue	OR (95% CI)	P value
Age (years)	1.11 (0.95-1.05)	0.81	-	-
Gender	0.61 (0.19-1.49)	0.29	-	-
APACHE score	1.17 (1.11-1.41)	0.002	1.17(1.11-1.41)	0.002
Blood gases at admission				
pH	0.021 (0.006-4.89)	0.19	-	-
PaCO2 (mmHg)	1.05(0.94-1.05)	0.47	-	
PaO2 (mmHg)	1.05(1.06-1.07)	0.03	1.05 (1.06-1.037)	0.05
Bicarbonate(mmHg)	0.98(0.94-1.08)	0.96	-	-
Oxygen saturation (%)	1.07(0.94-1.11)	0.51	-	-

CI: Confidence interval; OR: Odds ratio; APACHE: Acute physiology and chronic health evaluation

Discussion

Our study results have shown that NIV as the "primary modality" of ventilatory support is feasible for treatment of ARF among patients with non-CF bronchiectasis. Its use was associated with success rate of 65%. The correction of various ABG parameters using NIV at various time intervals was comparable to that of IMV. There were total 11 deaths, 8 in NIV and 3 in IMV group. The duration of hospital stay for NIV was comparable with IMV. Selection of mode of ventilatory support during ARF among patients with structural lung disease is crucial for optimum outcome. For COPD, NIV remains the mode of the first choice[16].Patients with bronchiectasis have similar clinical features as COPD, such as cough, breathlessness, and obstructive pattern on spirometry. Many of these patients develop hypoventilation and hypercapnic respiratory failure[6].However, for management of ARF among patients with bronchiectasis NIV is not used routinely. In our study, more than 80% (80/100) patients with bronchiectasis and ARF were given NIV as the first mode of ventilatory support. High rate of NIV use in our study was probably be due to two reasons. First, our hospital is a tertiary care center and we have very good experience of NIV and Intensive Care Unit (ICU) backup, if required. Second, these patients had hypercapnic respiratory failure and there is enough evidence to support NIV use for correction of hypercapnia and respiratory acidosis[16-18].This might have led to use of NIV for bronchiectasis and respiratory failure. Studies have shown that insertion of endotracheal tube in patients with structural lung diseases such as bronchiectasis would result in complications[19].The successful use of NIV as shown in this study highlights that in almost two-third of the patients with bronchiectasis and ARF the endotracheal intubation may be avoided. Phua et al. reported their experience with NIV for management of 31 patients of non-CF bronchiectasis with ARF[6]. Their success rate of NIV was comparable to our study (67% vs. 68%). One of the reasons for not using NIV in patients with bronchiectasis may be the presence of copious amount of sputum. Inability to handle respiratory secretions is one of the contraindications for NIV use[16,17].However, it should be noted that in this study none of the patients failed NIV due to excessive secretions. These results were consistent with the previous study in which also no patient failed NIV due to inability to handle respiratory secretions[6]. Normalization of the physiological parameters such as blood gas values is also one of the goals of ventilatory support[20].Longer stay in hospital and ICU has been associated with increased chances of nosocomial infections, increased the cost of care and mortality[21,22]. Faster the normalization of these parameters and early weaning may avoid all these. IMV, due to better control on set variables, is expected to correct both ventilatory and oxygen parameters faster than NIV. However, our study has shown that the various ABG parameters at different time intervals were comparable between patients on NIV and IMV. These results indicate that the rate of correction of ABG parameters similar to IMV may be achieved with NIV without potential complications associated with endotracheal intubation. One observation in this study which needs to be discussed is the NIV failure. Failure rate of NIV described in patient with COPD and ARF was approximately 20%[23].The failure rate of NIV in our study was approximately 32% which is higher than described in patients with COPD[3].However, this rate was comparable (34% vs. 35%) to those reported by Phua et al., in patients with bronchiectasis[6].Both these studies were limited by retrospective study design therefore true association with the outcome is still not known. Overall mortality in NIV group (10%) was lower than IMV (15%). In NIV Group, eight patients died and all these had failed NIV and subsequently put on IMV. These results highlight the importance of early identification of the patients who would likely to fail NIV to avoid worse outcome. We tried to find the predictors of early NIV failure. In our study, univariate analysis showed that high APACHE score and worse PaO2 at the time of admission were associated with failed NIV, however the association was weak. When multiple regression model was applied only high APACHE score was associated with NIV failure (odd's ratio [95% CI]: 1.17 (1.11-1.41)]). These results indicate that APACHE score may be used as a predictor of NIV failure for these patients. Other studies also reported the predictors of NIV failure which included APACHE score, worse hypercapnia, and hypoxemia[16,6,24]. In our study, PaCO2 and PaO2 at baseline and at 2 h were similar in both groups. Our study also showed that the duration of hospital stay and time spent on ventilator by patients who failed NIV were comparable with the patients who received IMV as first-line management strategy. This implies that the failure of initial trial of NIV among these patients did not impart additional risk of adverse outcome in these patients. This is one of the largest studies describing the outcome of NIV use in patients with non-CF bronchiectasis and ARF.

Conclusion

NIV is feasible for management of ARF with non-CF bronchiectasis. High APACHE may predict NIV failure among these patients.

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