ORIGINAL RESEARCH PAPER
Volume - 14 | Issue - 08 | August - 2025 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

THERAPEUTIC UTILITY OF FIBEROPTIC BRONCHOSCOPY IN PATIENTS WITH RESPIRATORY ACIDOSIS: A PROSPECTIVE OBSERVATIONAL STUDY

Pulmonary Medicine

Krati Bhardwaj Junior Resident, Department of Respiratory Medicine, Subharti Medical College, Meerut, U.P.

Mahip Saluja Prof. & Head of Department of Respiratory Medicine, Subharti Medical College, Meerut, U.P.

Ashish Kaushik Assistant Prof., Department of Respiratory Medicine, Subharti Medical College, Meerut, U.P.

Sukhbir Singh Consultant, Department of Respiratory Medicine, Subharti Medical College, Meerut, U.P.

ABSTRACT

Background: Respiratory acidosis defined by elevated partial pressure of carbon dioxide (PaCo2) and decreased blood pH levels, it is a critical manifestation of inadequate alveolar ventilation, commonly observed in patients with chronic respiratory diseases during acute exacerbations. In addition to ventilatory support, interventions that remove airway obstructions can improve gas exchange. Fiberoptic bronchoscopy (FOB) has emerged not only as a diagnostic modality but also as a therapeutic tool for airway clearance. **Objective:** To assess the changes in $PaCO_2$ levels in ABG after bronchoscopy and to evaluate changes in oxygen requirement following the procedure. **Materials and Methods:** This prospective observational study was conducted involving 25 patients diagnosed with respiratory acidosis ($PaCO_2$ > 45 mmHg, pH < 7.35). All subjects underwent FOB in a monitored setting. Arterial blood gas (ABG) parameters—specifically $PaCO_2$ and pH—along with FiO_2 requirements were recorded before and after the procedure. Patients with . Patients excluded with Hemodynamic instability, Severe hypoxemia (PaO_2 < 50 mmHg on supplemental oxygen), Recent myocardial infarction, Bleeding diathesis or thrombocytopenia, Pregnancy, Refusal to consent to maintain homogeneity of etiology. ABG values were measured at baseline, 4 hours, and 12 hours post-procedure. Changes in $PaCO_2$, pH, SpO_2, FiO_2 requirement, and heart rate were analyzed. **Results:** The mean baseline $PaCO_2$ (72.4 ± 8.5 mmHg) decreased significantly to 55.3 ± 6.7 mmHg at 12 hours post-FOB ($p<0.001$). The pH increased from 7.26 ± 0.03 to 7.33 ± 0.02, and SpO_2 improved from 85.72% to 94.32%. FiO_2 requirement reduced from 0.60 ± 0.09 to 0.42 ± 0.05. No major procedure-related complications were observed. **Conclusion:** Therapeutic fiberoptic bronchoscopy is a safe and effective intervention in selected patients with respiratory acidosis on NIV. It significantly improves ventilation and gas exchange, likely by relieving reversible airway obstruction. Its early use may help prevent intubation and hasten clinical recovery.

KEYWORDS

Fiberoptic bronchoscopy, Respiratory acidosis, hypercapnia, ABG, Therapeutic bronchoscopy, T2RF, Non-invasive ventilation

INTRODUCTION

Respiratory acidosis is a frequent and clinically significant acid-base disturbance encountered in patients with acute or chronic respiratory insufficiency. It is defined biochemically by an elevated arterial partial pressure of carbon dioxide ($PaCO_2$) and a corresponding reduction in arterial pH due to inadequate alveolar ventilation[1]. This hypoventilation may be a result of airway obstruction, restrictive ventilatory patterns, neuromuscular dysfunction, central nervous system depression, or significant parenchymal lung disease[2]. The consequences of unchecked hypercapnia range from progressive respiratory failure to acidemia-induced cardiovascular instability, making prompt recognition and management essential[3].

Among the most common etiologies of respiratory acidosis are chronic obstructive pulmonary disease (COPD) exacerbations, bronchiectasis, severe asthma, pneumonia, and neuromuscular disorders[4]. In the Indian context, COPD poses a significant public health burden, with acute exacerbations frequently resulting in hospitalization, especially among the elderly and those with multiple comorbidities[5]. During exacerbations, excessive airway secretions, bronchial inflammation, and dynamic hyperinflation impair effective alveolar ventilation, precipitating CO_2 retention and respiratory acidosis[6]. The presence of acidosis, particularly with pH <7.25, has been associated with increased rates of ICU admission, need for mechanical ventilation, and poor prognosis[7].

The initial approach to managing respiratory acidosis involves pharmacological bronchodilation, corticosteroids, antibiotics when indicated, and supplemental oxygen. In moderate-to-severe cases, non-invasive ventilation (NIV) or mechanical ventilation is employed to improve alveolar ventilation and correct gas exchange abnormalities[8]. However, conventional therapy often fails in patients with excessive mucus plugging, retained secretions, or lobar collapse, thereby necessitating interventional procedures aimed at restoring bronchial patency[9].

Fiberoptic bronchoscopy (FOB) has emerged as a valuable tool in such cases, offering both diagnostic and therapeutic benefits. First introduced by Ikeda in 1968, the flexible fiberoptic bronchoscope allows direct visualization of the tracheobronchial tree, sampling of airway secretions or tissue, and mechanical removal of obstructive material[10]. Therapeutically, it can be employed to aspirate thick secretions, relieve airway obstruction, and facilitate re-expansion of atelectatic lung segments[11]. These interventions can lead to marked improvements in gas exchange and clinical status, particularly in patients with refractory respiratory acidosis[12].

Multiple observational studies and clinical case series have highlighted the efficacy of FOB in ventilated patients with unresolved lobar collapse, mucus plugging, or suspected endobronchial obstruction[13]. It has been shown to significantly reduce $PaCO_2$ levels, improve oxygenation indices, and accelerate weaning from mechanical ventilation[14]. The procedure also provides the added benefit of identifying infectious pathogens, which is particularly relevant in critically ill patients or those unresponsive to empirical antibiotic therapy[15].

Despite its proven benefits, the role of bronchoscopy as a frontline therapeutic intervention specifically for respiratory acidosis remains under-investigated, especially in patients on non-invasive ventilators or those with early-stage decompensation. Most existing data are retrospective, involve small patient cohorts, and are derived from ICU settings in high-resource countries[16]. In contrast, there is limited prospective research from developing nations like India, where the burden of COPD, tuberculosis-related airway damage, and pneumonia is high, and where access to advanced ventilatory support may be constrained.

This prospective study was therefore undertaken with the primary objective of assessing the therapeutic utility of fiberoptic bronchoscopy in improving ventilatory parameters—specifically arterial blood gas (ABG) values—in patients presenting with respiratory acidosis. The study analyzed changes in pH, $PaCO_2$, and PaO_2 measured at baseline, 4 hours, and 12 hours after the procedure, along with clinical improvement and radiological outcomes. By systematically evaluating these outcomes in a real-world tertiary care

setting, the present research aims to establish the physiological and clinical efficacy of bronchoscopy as an adjunctive intervention in the acute management of hypercapnic respiratory failure.

MATERIAL AND METHODS

Prospective interventional study conducted over 12 months in the Department of Respiratory Medicine, Chhatrapati Shivaji Subharti Hospital of Subharti Medical College affiliated to Swami Vivekanand University, Meerut, U.P.

Procedure: 25 adult patient with type 2 respiratory failure on NIV support were undertaken for Bronchoscopy after taking informed consent. Patients excluded with Hemodynamic instability ,Severe hypoxemia (PaO_2 < 50 mmHg on supplemental oxygen), Recent myocardial infarction, Bleeding diathesis or thrombocytopenia, Pregnancy, Refusal to consent.

All patients underwent baseline clinical evaluation, chest imaging, and ABG analysis.

FOB was performed at bedside or in the bronchoscopy suite under continuous cardiac, oxygen saturation, and blood pressure monitoring under aseptic precautions.

Pre – procedure preparation included –
- Adequate pre-oxygenation
- Nebulization with bronchodilators
- Sedation using IV midazolam &/or propofol

The bronchoscopy was introduced via the nasal or endotracheal route and Secretion suctioning and lavage were done when needed. ABG samples were taken at baseline, 4 hours, and 12 hours post-procedure

Parameters included $PaCO_2$, pH, SpO_2, FiO_2 requirement, heart rate, and systolic BP. Data were analyzed using SPSS v25.0, and a paired t-test was applied to assess significance ($p<0.05$ considered significant).

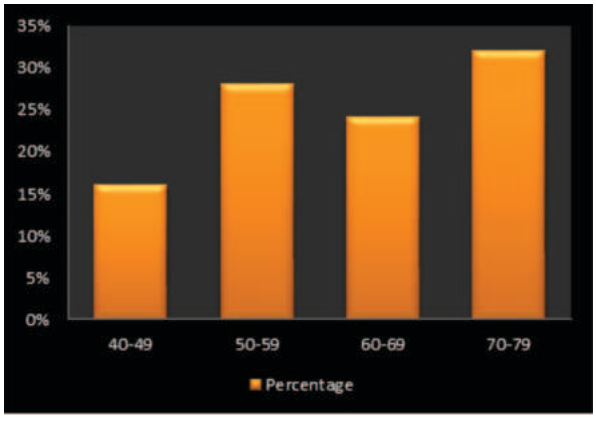
RESULT

Table 1: Distribution of Patients According to Their Age Group (N=25)

Age group (in years)	Frequency	Percentage
40-49	4	16%
50-59	7	28%
60-69	6	24%
70-79	8	32%

The majority of patients (32%) were aged 70-79 years, followed by 50-59 years (28%).

Patients aged 60 years and above constituted 64% of the study population, reflecting the increased prevalence of respiratory acidosis in the elderly.



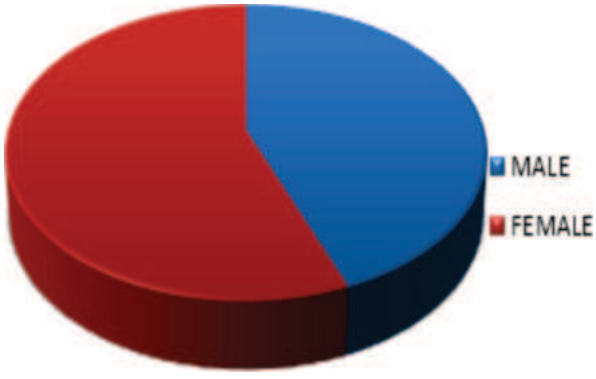
Graph 1: Distribution of Patients According to Their Age Group (N=25)

Table 2: Distribution of Patients According to Their Sex (N=25)

Gender	Frequency	Percent
Female	14	56
Male	11	44
Total	25	100.0

Out of 25 patients, 56% were female and 44% were males, indicating female predominance.

This may reflect rising exposure of women to risk factors like biomass fuel smoke, indoor air pollution, and passive smoking, particularly in rural areas.



Graph 2: Distribution of Patients According to Their Sex (N=25)

Table 3 : Effect of Bronchoscopy on ABG :

Timepoint	Mean pH	Std Dev (pH)	Mean PCO_2 (mmHg)	Std Dev (PCO_2)
Baseline	7.25	0.04	65.2	6.5
4 Hours Post-FOB	7.30	0.03	58.4	5.7
12 Hours Post-FOB	7.34	0.03	52.6	5.3

A steady rise in pH post-bronchoscopy indicated correction of academia.

$PaCO_2$ levels showed a progressive decline, reflecting improved ventilation following airway clearance.

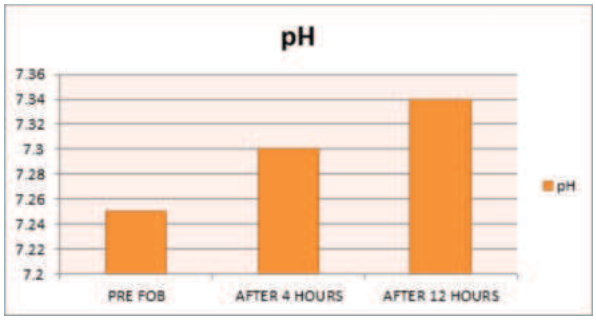
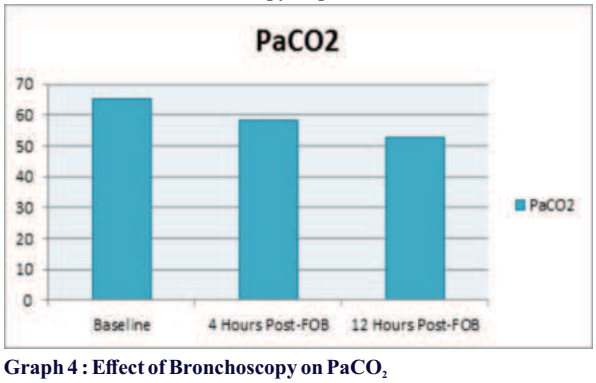


Chart 3 : Effect of bronchoscopy on pH



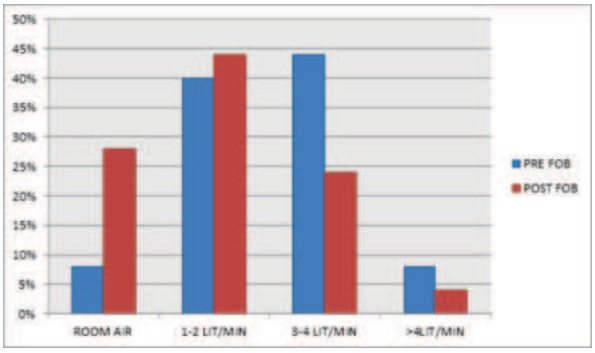
Graph 4 : Effect of Bronchoscopy on $PaCO_2$

Table 4: Distribution On The Basis Of Oxygen Requirement :

Oxygen requirement	Pre-FOB	Percentage	Post –FOB	Percentage
Room air	2	8 %	7	28 %
1-2 lit/min	10	40 %	11	44 %
3-4 lit/min	11	44 %	6	24 %
>4 lit/min	2	8%	1	4 %
Total	25	100 %	25	100%

A significant reduction in oxygen requirement was observed. Pre procedure only 8 % of patients were maintaining on room air, while this increased to 28% post-FOB.

The proportion of patients requiring higher oxygen flows (3-4 L/min) dropped from 44% to 24%, and those needing >4lit/min halved from 8% to 4%. This suggests an improvement in ventilation and oxygenation status following bronchoscopy.



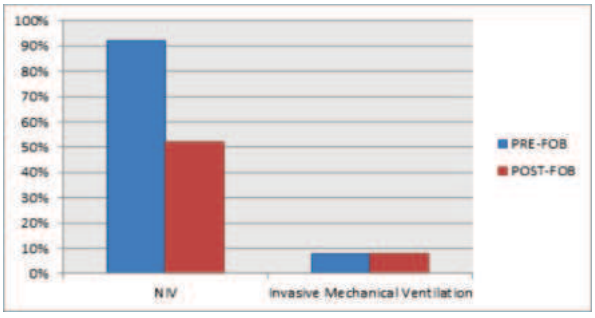
Graph 5: Distribution On The Basis Of Oxygen Requirement

Table 5 : Distribution On The Basis Of Ventilator Support:

Ventilator support type	Pre-FOB	Percentage	Post-FOB	Percentage
NIV	23	92%	13	52%
Invasive Mechanical Ventilation	2	8%	2	8%
Total	25	100 %	25	100%

Interpretation:

Out of 23 patients on NIV before bronchoscopy, 13 remained on NIV at 12 hours post-FOB while 10 (43.5%) were successfully weaned, reflecting significant improvement in ventilator status.



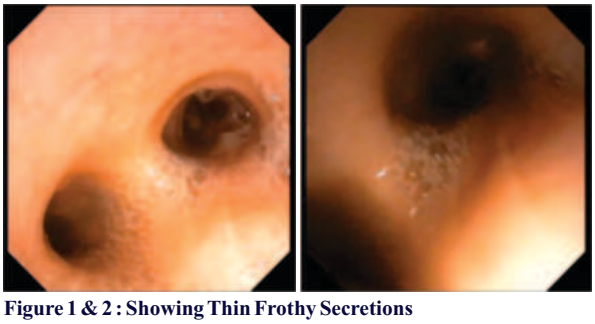


Figure 1 & 2 : Showing Thin Frothy Secretions

DISCUSSION

This study confirms the therapeutic potential of bronchoscopy in managing respiratory acidosis. Similar studies have demonstrated the efficacy of bronchoscopy in secretion removal, reduction in $PaCO_2$. While there was a transient rise in $PaCO_2$ in some cases at 4 hours, a significant improvement was consistently observed by 12 hours.

Respiratory acidosis is a frequent ICU concern, often resulting from ineffective ventilation due to airway obstruction or secretion retention. FOB, by enabling targeted airway clearance, can reverse hypo-ventilation and enhance gas exchange.[22-23]

In our study, a significant improvement in $PaCO_2$ and pH was observed within hours of the procedure, which aligns with studies by Singh et al., Mehta et al., and Agarwal et al.[23-25] These studies also demonstrated improved ABG parameters following therapeutic bronchoscopy in critically ill patients.

The reduction in ventilatory and oxygen support post-bronchoscopy supports the role of FOB in improving clinical stability. Aggarwal et al. reported a shorter duration of mechanical ventilation in patients undergoing early therapeutic FOB.[23] Our findings reinforce this and add to the limited Indian data supporting this approach.

The safety of FOB was reaffirmed by the absence of complications, consistent with other published literature.[26-28] However, the limited sample size and lack of a control group remain important limitations of our study. Larger randomized trials are warranted to validate these findings.

CONCLUSION

Fiberoptic bronchoscopy proved to be a valuable therapeutic tool in patients with respiratory acidosis, particularly those with suspected mucus plugging, aspiration, or secretion retention. In our prospective study, significant improvements in arterial blood gas parameters, oxygenation status, and reduction in ventilatory support were observed within hours of the procedure.

The intervention was not only effective but also safe, with no major complications noted. These findings suggest that timely use of therapeutic bronchoscopy can contribute to faster clinical stabilization, reduced ventilator dependency, and overall better patient outcomes in appropriately selected cases.

Bronchoscopy is especially helpful in patients who fail to improve with standard therapy and have excessive secretions. In our study, the reduction in oxygen requirement post-FOB suggests clinical improvement as well.

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