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A STUDY ON EFFECTIVENESS OF NONINVASIVE VENTILATION AS TREATMENT MODALITY FOR CHRONIC OBSTRUCTIVE PULMONARY DISEASE PATIENTS WITH ACUTE RESPIRATORY FAILURE REQUIRES MECHANICAL VENTILATION

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ABSTRACT **Objectives:** The study evaluates the effectiveness and safety of non-invasive ventilation for COPD patients with acute respiratory failure requiring mechanical ventilation. It focuses on monitoring mechanical ventilation duration, ICU stay length, overall hospital stay, and complications such as aspiration, transition from NIV to IMV, and cardio-respiratory arrest. **Methods:** This hospital-based prospective observational study was conducted in the Department of Emergency Medicine at Chirayu Medical College and Hospital, Bhopal, over one year. It included 73 COPD patients with acute respiratory failure due to COPD exacerbation, characterized by severe respiratory acidosis (arterial pH < 7.25 and $PaCO_2 \geq 70$ mmHg), a respiratory rate exceeding 30 breaths per minute, and severe dyspnea. Exclusion criteria comprised patients who refused participation, required ventilatory assistance before ICU admission, experienced respiratory arrest, were unable to tolerate non-invasive ventilation, had facial deformities, or were in hypotensive shock or with uncontrolled arrhythmias. **Results:** Total of 73 COPD patients with acute respiratory failure were assessed for treatment outcomes using non-invasive ventilation (NIV) versus invasive mechanical ventilation. The majority (80.82%) received NIV, which resulted in significantly higher mean SpO_2 levels (92.19% vs. 79.00%) and GCS scores (12.31 vs. 10.43, $p < 0.001$) compared to the invasive group. Patients on NIV experienced shorter ICU (3.81 days) and total hospital stays (5.32 days) than those treated invasively (6.36 days and 7.79 days, $p < 0.001$). All NIV patients were discharged, whereas 64.29% of the invasive group were discharged, leading to a mortality rate of 35.71% in the latter, indicating better survival rates for NIV (Chi-square = 17.37, $p < 0.001$). **Conclusion:** This study concluded that the effectiveness of non-invasive ventilation (NIV) in treating acute respiratory issues in COPD patients, successfully managing 80.82% of cases without invasive interventions. NIV improved blood gas results and GCS scores, resulting in reduced ICU and hospital stays, and achieved a 100% survival rate compared to a 35.71% mortality rate for invasive treatments, establishing its position as a first-line therapy for acute respiratory failure in this patient population.

KEYWORDS : Noninvasive Ventilation, Chronic Obstructive Pulmonary Disease, GCS, Acute Respiratory Failure

INRODUCTION

Chronic obstructive pulmonary disease (COPD) is characterized by irreversible airflow restriction and includes chronic bronchitis and emphysema. It leads to millions of hospitalizations annually and is the third largest cause of mortality in India. The severity varies among hospitalized patients, ranging from short admissions to fatalities. Globally, COPD is a major cause of illness and death, with over 300 million affected individuals. It is projected to become the third leading cause of mortality by 2030 according to the WHO.[1-3] The disease is associated with recurrent exacerbations that may result in acute respiratory failure, often necessitating hospitalization and mechanical ventilation.[4] Acute Respiratory Failure (ARF) in COPD is a severe condition characterized by hypoxemia (PaO_2 < 60 mmHg) and/or hypercapnia ($PaCO_2$ > 45 mmHg), along with respiratory acidosis (pH < 7.35).[5] It is often triggered by sudden exacerbations caused by respiratory infections, environmental factors, or treatment non-compliance. These exacerbations increase respiratory workload due to airflow limitation, hyperinflation, and muscle fatigue, leading to impaired gas exchange and the potential need for ventilatory support.[6,7]

Mechanical ventilation is a critical strategy for COPD patients with acute respiratory failure. It may be noninvasive (NIV) or invasive (IMV), with the latter necessitating endotracheal intubation or tracheostomy. Invasive mechanical ventilation (IMV) is often linked to elevated death rates, a heightened risk of ventilator-associated pneumonia (VAP), barotrauma, and extended intensive care unit (ICU) admissions.[8] Noninvasive ventilation (NIV) has become the recommended first approach for suitably chosen patients, decreasing the need for intubation and enhancing clinical outcomes.[9]

Noninvasive ventilation (NIV) refers to a technique for administering ventilatory support without the use of an endotracheal tube or tracheostomy, using a mask interface (nasal, oronasal, or full-face mask) to provide positive pressure ventilation.[10] Non-invasive ventilation (NIV) may be delivered in several modalities, such as bilevel positive airway pressure (BiPAP) and continuous positive airway pressure (CPAP), based on patient requirements.[11] Non-invasive ventilation (NIV) is extensively recognized as the optimal ventilatory support for patients with chronic obstructive pulmonary disease (COPD) experiencing acute respiratory failure, according to the guidelines established by the Global Initiative for Chronic Obstructive Lung Disease (GOLD), American Thoracic Society (ATS), and European Respiratory Society (ERS).[12]

NIV (Non-Invasive Ventilation) effectively reduces intubation needs, mortality, and hospital stays in COPD patients compared to invasive mechanical ventilation (IMV). It improves gas exchange and alleviates respiratory issues, leading to better outcomes such as survival rates and shorter ICU stays. However, NIV is not suitable for all patients, especially those in severe distress. IMV, while common in managing COPD with Acute Respiratory Failure, poses risks like discomfort and infections. Although NIV is a safer alternative, patient selection and recognition of NIV failure are crucial for success. Emerging technologies and innovative ventilation methods are being explored to enhance outcomes and address challenges, especially in low-resource settings.[8-10,13] The study aims to evaluate the effectiveness and safety of non-invasive ventilation as a treatment for COPD patients experiencing acute respiratory failure who need mechanical ventilation. The objectives include monitoring the duration of mechanical ventilation, length of ICU and post-ICU stays, overall hospital stay duration, and complications such as aspiration, transition from NIV to IMV, and cardio-respiratory arrest.

METHODS

This was a Hospital based prospective observational study conducted in Department of Emergency Medicine, of Chirayu Medical College and Hospital, Bhopal over a period of one year. After approval of ethical clearance total 73 COPD patients inclusion for the study had acute respiratory failure from a COPD exacerbation, severe respiratory acidosis (arterial pH < 7.25 and $PaCO_2 \geq 70$ mmHg), a respiratory rate exceeding 30 breaths per minute, severe dyspnea demonstrated by

accessory muscle use, and worsening condition despite optimal medical management. Exclusion criteria for the study include: patients who refuse participation, those requiring ventilatory assistance before ICU admission, experiencing respiratory arrest (bradypnea), not expected to tolerate non-invasive ventilation (GCS < 8, unable to protect airway, hemodynamic instability despite resuscitation), having facial deformities, and those in hypotensive shock, with cardiac ischemia, or uncontrolled life-threatening arrhythmias.

After clinical assessment and obtaining written informed consent from the patient or their legally authorized representative, eligible participants were enrolled in the study. The diagnosis of COPD was established based on a clinical history of chronic cough lasting for three months in each of two successive years, shortness of breath, supported by physical examination and relevant investigations to exclude alternative diagnoses.

NIV was administered in the ICU setting using a full-face mask interface with minimal air leak. Ventilation was provided in pressure support mode, with initial inspiratory pressure titrated to achieve an exhaled tidal volume of 6–8 mL/kg of predicted body weight, and a positive end-expiratory pressure (PEEP) of 5 cm H_2O. The fraction of inspired oxygen (FiO_2) was adjusted to maintain SpO_2 between 88% and 92%. Ventilator settings were modified based on clinical observations, pulse oximetry, and arterial blood gas (ABG) analysis.

NIV was generally continued for 24–48 hours, with brief interruptions for oral intake, during which patients were supported with appropriate oxygen delivery device to maintain oxygen saturation around 88-92%. The decision to discontinue NIV or IMV was taken when the patient demonstrated the ability to breathe spontaneously without signs of respiratory distress, and with sustained $SpO_2 \geq 90\%$, $FiO_2 \leq 0.4$, and PSV + PEEP < 10 cm H_2O. Successful weaning was defined as maintenance of spontaneous breathing for at least 48 hours without respiratory failure, with $pH \geq 7.35$ and $PaO_2 \geq 60$ mmHg on ABG.

Definitions and Outcome Measures

- Success of NIV was defined as avoidance of endotracheal intubation and improvement in ABG parameters and clinical status within 48 hours.
- NIV Failure was defined by the need for intubation due to any of the following:

1. GCS < 8 or inability to protect the airway.
2. Failure to achieve a PaO_2/FiO_2 ratio > 100 mmHg.
3. Persistent or worsening dyspnea.
4. No improvement in clinical signs of respiratory muscle fatigue.
5. Hemodynamic instability not responsive to fluid resuscitation or vasopressors.
6. Worsening respiratory acidosis (pH < 7.25 after 2 hours of NIV).
7. Persistent hypoxemia (PaO_2 < 60 mmHg despite $FiO_2 \geq 0.6$).

Patients meeting these failure criteria were transitioned to Invasive Mechanical Ventilation (IMV). Primary outcome measures focus on the success of Non-Invasive Ventilation (NIV), characterized by avoidance of endotracheal intubation and sustained clinical and arterial blood gas (ABG) improvement within 48 hours. Secondary outcomes include the duration of ICU and total hospital stays, in-hospital mortality, and complications associated with NIV such as aspiration, gastric distension, and mask-related pressure ulcers.

The statistical analysis was performed with SPSS version 25.0. The data were presented in the form of mean (standard deviation) and percentage (%). The chi-square test was used to compare categorical variables, while the independent t-test was used to assess discrete variables between groups. A p-value of 0.05 was considered statistically significant.

RESULTS

Most COPD patients with acute respiratory failure were treated effectively with non-invasive ventilation (80.82%), while 19.18% required invasive mechanical ventilation. The gender distribution was predominantly male (93.22% in NIV and 100% in invasive), with no significant age difference (mean ages of 61.44 years for NIV and 64.14 years for invasive). Farming was the common occupation in both groups (62.71% in NIV, 64.29% in invasive), and the religious distribution showed 93.22% Hindus in non-invasive and 85.71% in invasive cases, with no significant differences in any category. Smoking status reported 93.22% smokers in the non-invasive group and 100% in invasive, also not significant. All patients exhibited respiratory distress without prior hospitalization, making further statistical analysis unnecessary. (Table 1)

Table 1: Distribution of Occupation, Religion, Smoking Status, Accessory Muscles and History of Recent Hospitalization, Patients Receiving Non-invasive and Invasive Ventilation

		Non-invasive Ventilation (N=59)		Invasive Ventilation (N=14)		Chi Sq.	p-Value
		n	%	n	%		
Gender	Male	55	93.22	14	100.00	0.12	0.727
	Female	4	6.78	0	0.00		
Age (yrs) Mean±SD		61.44±10.46		64.14±9.45		-0.88	0.380
Occupation	Farmer	37	62.71	9	64.29	8.67	0.798
	Mechanic	3	5.08	2	14.29		
	Businessman	3	5.08	0	0.00		
	Caterer	1	1.69	0	0.00		
	Daily Wage Worker	5	8.47	2	14.29		
	Painter	1	1.69	0	0.00		
	Civil contractor	0	0.00	1	7.14		
	Plumber	1	1.69	0	0.00		
	Railway Officer	1	1.69	0	0.00		
	Shopkeeper	1	1.69	0	0.00		
	Teacher	1	1.69	0	0.00		
	Tyre Mechanic	1	1.69	0	0.00		
	Housewife	1	1.69	0	0.00		
	Factory Worker	1	1.69	0	0.00		
Religion	Hindu	55	93.22	12	85.71	0.14	0.705
	Muslim	4	6.78	2	14.29		
Smoker	yes	55	93.22	14	100.00	0.12	0.727
	No	4	6.78	0	0.00		
Use of accessory muscles	yes	59	100.00	14	100.00	-	-
	No	0	0.00	0	0.00		
History Of Recent Hospitalization (1month)	yes	0	0.00	0	0.00	-	-
	No	59	100.00	14	100.00		

Physiological comparisons between patients receiving non-invasive ventilation (NIV) and invasive ventilation revealed no significant differences in blood pressure. However, SpO_2 levels were significantly higher in the NIV group (73.83%) compared to the invasive group (66.93%, p=0.002). The invasive group had a higher respiratory rate (35.50/min vs. 33.64/min, p=0.063), but these were not statistically significant. Significant differences were observed in arterial blood gas parameters: NIV patients had a higher mean pH (7.19 vs. 7.12, p=0.002) and lower mean pCO_2 (66.29 mmHg vs. 73.07 mmHg, p=0.017), along with a higher mean pO_2 (70.16 mmHg vs. 61.07 mmHg, p=0.001). Invasive ventilation patients exhibited more severe ABG derangements, including respiratory acidosis and hypoxemia. Random blood sugar and serum electrolyte levels showed no significant differences. (Table 2)

Table 2: Comparison of Physiological and Hematological Parameters, Including Hemoglobin (Hb), Total Leukocyte Count (TLC), Arterial Blood Gas (ABG) Parameters, Random Blood Sugar (RBS), and Serum Electrolyte Levels (Sodium and Potassium), in Patients Receiving Non-invasive Versus Invasive Ventilation.

	Non-invasive Ventilation (N=59)		Ventilation (N=14)		t	p-Value
	Mean	±SD	Mean	±SD		
SBP (mmHg)	130.14	15.38	127.79	23.25	0.46	0.645
DBP (mmHg)	78.63	9.31	76.21	9.80	0.86	0.391
Spo2 on arrival	73.83	6.66	66.93	8.70	3.28	0.002
RR (/min)	33.64	3.24	35.50	3.59	-1.89	0.063

HR (beats/min)	116.54	12.25	120.07	7.54	-1.03	0.307
Temp	97.72	1.04	97.59	0.83	0.44	0.665
Hb	13.01	1.66	13.81	1.68	-1.62	0.110
TLC count	13013.78	2476.61	13975.14	4370.91	-1.11	0.271
pH	7.19	0.08	7.12	0.05	3.28	0.002
pCO2	66.29	9.77	73.07	6.70	-2.45	0.017
pO2	70.16	8.67	61.07	9.51	3.45	0.001
RBS	147.59	57.27	140.86	43.92	0.41	0.683
Na	136.93	8.08	135.29	3.05	0.75	0.458
K	4.18	0.90	4.10	0.44	0.30	0.767

Non-invasive ventilation (NIV) was associated with significantly higher mean SpO_2 levels (92.19 ± 1.69%) compared to invasive ventilation (79.00 ± 3.19%), with a statistically significant difference ($t = 21.69$, $p < 0.001$). Additionally, mean Glasgow Coma Scale (GCS) scores were higher in the NIV group (12.31 ± 1.45) versus the invasive group (10.43 ± 1.09), also showing a significant difference ($t = 4.53$, $p < 0.001$). These results indicate that NIV leads to better oxygenation and higher consciousness levels, while invasive ventilation correlates with greater clinical severity. (Table 3)

Table 3: SpO_2 on NIV Support and Glasgow Coma Scale (GCS) Scores Between the Two Ventilation Groups

	Non-invasive Ventilation (N=59)		Ventilation (N=14)		t	p-Value
	Mean	±SD	Mean	±SD		
sPO2 on NIV support	92.19	1.69	79.00	3.19	21.69	<0.001
GCS	12.31	1.45	10.43	1.09	4.53	<0.001

The comparison of mechanical ventilation duration showed a mean of 2.69 ± 1.04 days for the non-invasive group and 3.50 ± 2.62 days for the invasive group, with no statistically significant difference ($t = -1.85$, $p = 0.068$). In terms of ICU stay, the non-invasive group had a shorter mean of 3.81 ± 1.21 days, while the invasive group had 6.36 ± 2.06 days, showing a highly significant difference ($t = -6.09$, $p < 0.001$). The total hospital stay was also significantly lower in the non-invasive group (5.32 ± 1.20 days) compared to the invasive group (7.79 ± 2.12 days), with a highly significant difference ($t = -5.88$, $p < 0.001$). (Table 4)

Table 4: Comparison of the Duration of Mechanical Ventilation, Length of ICU Stay and Total Hospital Stay Between Non-invasive and Invasive Ventilation Groups

	Non-invasive Ventilation (N=59)		Ventilation (N=14)		t	p-Value
	Mean	±SD	Mean	±SD		
Duration of mechanical ventilation	2.69	1.04	3.50	2.62	-1.85	0.068
Length of stay in ICU	3.81	1.21	6.36	2.06	-6.09	<0.001
Length of stay in hospital	5.32	1.20	7.79	2.12	-5.88	<0.001

In a clinical study comparing ventilation methods, all patients in the non-invasive ventilation (NIV) group (n = 59) were successfully discharged with no reported mortality, while only 64.29% of those in the invasive ventilation group (n = 9) were discharged, with 35.71% (n = 5) succumbing to their illness. This difference was statistically significant (Chi-square = 17.37, $p < 0.001$), highlighting better survival rates for patients using NIV.(Table 5)

Table 5: Clinical Outcomes of Patients in Both Ventilation Groups

		Non-invasive Ventilation (N=59)		Invasive Ventilation (N=14)		Chi Sq.	p-Value
		n	%	n	%		
Outcome	Discharge	59	100.00	9	64.29	17.37	<0.001
	Death	0	0.00	5	35.71		

DISCUSSION

In this study, 80.82% of COPD patients with acute respiratory failure improved with non-invasive ventilation (NIV), significantly reducing the need for invasive mechanical ventilation, as only 19.18% required intubation. This supports Raju et al, where most patients who failed standard therapy improved with NIV.[14] Similarly, Kramer et al. noted a drop in intubation rates from 67% to 9% with NIV, and Celikel et al. reported a 93.4% success rate for NIV versus 60% for standard therapy, further corroborating our findings.[15,16]

In a study, the mean age of patients in the Non-Invasive Ventilation (NIV) group was 61.44 years, while it was 64.14 years in the Invasive Mechanical Ventilation (IMV) group, with no significant age-related differences ($p = 0.380$). This suggests that age did not influence the choice of ventilation mode. Similar results were found by some studies indicating the effectiveness of NIV across various age groups in COPD patients with Acute Respiratory Failure (ARF).[17-19]

In the study, there was no significant gender difference in the success or selection of non-invasive ventilation (NIV) and invasive mechanical ventilation (IMV), with 93.22% of the NIV group and 100% of the IMV group being male ($p = 0.727$). This finding aligns with studies by all of which found a male predominance but no correlation between gender and treatment outcomes, suggesting gender's minimal impact on NIV effectiveness.[14,18,20]

In the study, farming was the predominant occupation in both NIV (62.71%) and IMV (64.29%) groups, with no significant association between occupation and ventilation type ($p = 0.798$). The results suggest that occupational factors mainly reflect environmental exposure risks rather than directly affecting acute treatment options. Additionally, sociodemographic elements such as job type and religion similarly showed no significant impact on the decision to initiate NIV or IMV ($p = 0.705$).

In the study, both the NIV (93.22%) and IMV (100%) groups showed a high prevalence of smokers, but this difference was not statistically significant ($p = 0.727$). Although smoking is a known risk factor for COPD, it appears not to affect the acute success of ventilation methods. Raju et al. (2018) reported similar findings, suggesting that smoking history is more pertinent to disease etiology than to the effectiveness of ventilation strategies.[14]

All patients across both groups exhibited respiratory distress through the use of accessory muscles, with no prior hospitalizations within the past month. Due to the absence of variability, these parameters were excluded from statistical analysis. Relevant studies highlight accessory muscle use as a key indicator of acute respiratory failure (ARF) in COPD, supporting the initiation of non-invasive ventilation (NIV) based on clinical signs rather than sociodemographic factors.[20,21]

No significant differences in systolic and diastolic blood pressures were observed between the NIV and IMV groups, with mean SBP of 130.14 mmHg and 127.79 mmHg respectively ($p = 0.645$), and DBP of 78.63 mmHg versus 76.21 mmHg ($p = 0.391$). Heart rate and temperature also showed no statistical difference. However, the NIV group had a significantly higher SpO_2 on arrival (73.83%) compared to the IMV group (66.93%) ($p = 0.002$), indicating that patients with better initial oxygenation are more likely to succeed with NIV.[21]

In our study, the respiratory rate was slightly higher in the IMV group, although this difference was not statistically significant. This aligns with Kumar and Kumar (2024), who reported mean respiratory rates of 35.95 ± 4.26 in NIV and 37.20 ± 2.44 in IMV.[18] Schmitt et al. (2022) highlighted that elevated initial respiratory rates (>30/min) might indicate more severe disease without ruling out NIV effectiveness.[22] Additionally, ABG values showed that NIV patients had significantly better pH (7.19 vs. 7.12; $p = 0.002$), lower pCO_2 (66.29 vs. 73.07 mmHg; $p = 0.017$), and higher pO_2 (70.16 vs. 61.07 mmHg; $p = 0.001$), corroborating findings from Celikel et al. (1998) and Raju et al. (2018) regarding the benefits of NIV for acid-base balance and gas exchange.[14,16]

In this study, key parameters such as haemoglobin, total leukocyte count, random blood sugar, serum sodium, and potassium levels exhibited no significant differences between groups and did not impact the choice or success of ventilation. Findings align with Buddha et al. (2019) and Masa et al. (2016), indicating these markers, while indicative of health status, do not directly relate to NIV outcomes.[23,24] In our study, patients on non-invasive ventilation (NIV) demonstrated significantly higher SpO_2 levels (92.19%) compared to those on intubated mechanical ventilation (IMV) (79.00%) during support ($p < 0.001$). The Glasgow Coma Scale (GCS) was also notably higher in the NIV group (12.31 vs. 10.43; $p < 0.001$), indicating improved neurologic and respiratory function. Previous

studies have emphasized the importance of improved SpO_2 and GCS as indicators of positive NIV outcomes and noted that patients with preserved consciousness and adequate oxygenation are more suitable candidates for NIV.[18,20,22]

In our study, the mean duration of ventilation was longer in invasive mechanical ventilation (IMV) (3.50 days) compared to non-invasive ventilation (NIV) (2.69 days), although this difference was not statistically significant ($p = 0.068$). In contrast, ICU stay (6.36 vs. 3.81 days) and total hospital stay (7.79 vs. 5.32 days) were significantly less in the NIV group ($p < 0.001$). These results align with previous findings by Sohal et al., Lightowler et al., and Chawla et al., who noted that early NIV use leads to reduced healthcare resource utilization and complications, as well as shorter hospitalizations.[20,21,25]

In our study, the NIV group had a 100% discharge rate with no mortality, while the IMV group experienced a 35.71% mortality rate ($p < 0.001$). This highlights the prognostic value of NIV in acute respiratory failure (ARF). Previous studies also indicate lower death rates with NIV compared to IMV, confirming its effectiveness and life-saving potential for patients with COPD-associated ARF.[20,26]

This study has several limitations, including its single-center design and small sample size, which may affect the generalizability of results. Selection bias is a concern as patients with more severe illness were more likely to receive invasive ventilation. The research did not assess long-term outcomes or quality of life post-discharge, nor did it analyze factors such as comorbidities and prior use of home NIV. Future multicentric studies with larger populations and longer follow-up are recommended to validate these findings.

CONCLUSION

This study demonstrates that non-invasive ventilation (NIV) is highly effective for treating patients with chronic obstructive pulmonary disease (COPD) experiencing acute breathing issues, successfully managing 80.82% of cases without resorting to invasive mechanical ventilation. Patients treated with NIV displayed significantly better blood gas results upon admission and throughout treatment, leading to improved outcomes and higher Glasgow Coma Scale scores. Moreover, NIV reduced ICU and hospital stays, contributing to better resource utilization and achieving a 100% survival rate compared to a 35.71% mortality rate in the invasive group. The findings advocate for NIV as a first-line treatment for eligible COPD patients with acute respiratory failure, highlighting its safety, effectiveness, and favorable outcomes over invasive options.

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