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# IMPACT OF EARLY INITIATION OF NON-INVASIVE VENTILATION ON CARDIOPULMONARY PARAMETERS IN PATIENTS PRESENTING TO EMERGENCY DEPARTMENT WITH SHORTNESS OF BREATH

*Original Research*

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## ABSTRACT

**Background:** Noninvasive ventilation (NIV) has been widely studied and implemented in intensive care units (ICUs), where patients benefit from continuous monitoring and specialized care. However, limited data exists regarding its utility and outcomes in emergency departments, where rapid clinical decisions are made amidst less controlled environments. Given that most patients with acute respiratory distress first present to emergency settings, evaluating the role of NIV in this context is critical to improving early interventions and outcomes.

**Objective:** To assess the effectiveness of noninvasive ventilation on cardiopulmonary parameters among patients presenting with shortness of breath in the emergency department of a tertiary care hospital.

**Methods:** This descriptive interventional study was conducted at the emergency department of Lady Reading Hospital, Peshawar, from October 1, 2024, to March 30, 2025. A total of 149 male and female patients aged 20 years and above presenting with acute shortness of breath were enrolled through non-probability consecutive sampling. NIV was administered using a face mask in patients meeting arterial blood gas criteria ($PaO_2$ <80 mmHg or $PaCO_2$ >45 mmHg with pH <7.35). Cardiopulmonary parameters including arterial pH, $PaO_2$, $PaCO_2$, heart rate, and systolic blood pressure were measured at baseline and after six hours of therapy. Data were analyzed using SPSS version 26, with paired sample t-tests applied for inferential analysis.

**Results:** The mean age of participants was 39.91 ± 5.46 years, with 71 (47.7%) males. Mean BMI was 25.15 ± 1.00 kg/m², and mean symptom duration was 8.03 ± 2.79 hours. Baseline mean pH was 7.27 ± 0.043, improving to 7.40 ± 0.022 after six hours. Mean $PaO_2$ increased from 70.55 ± 5.7 mmHg to 92.41 ± 3.41 mmHg, and $PaCO_2$ decreased from 53.15 ± 5.29 mmHg to 41.56 ± 3.20 mmHg. Heart rate dropped from 105.96 ± 10.08 bpm to 84.04 ± 5.68 bpm, and systolic blood pressure rose from 98.08 ± 11.02 mmHg to 124.89 ± 8.65 mmHg. All improvements were statistically significant ($p = 0.000$).

**Conclusion:** NIV proved effective in improving cardiopulmonary status among patients with acute shortness of breath in the emergency setting, offering a viable alternative to invasive ventilation when promptly and appropriately applied.

**Keywords:** Acute Respiratory Distress, Cardiopulmonary Function, Emergency Department, Noninvasive Ventilation, Respiratory Failure, Shortness of Breath, Tertiary Care Hospital.

# Effectiveness of NIV in Emergency Settings

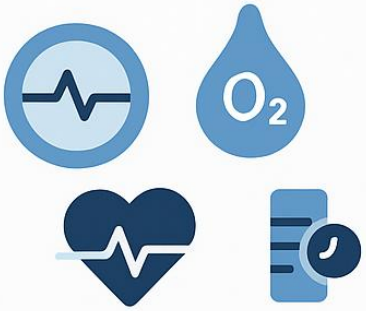
## BACKGROUND

Noninvasive ventilation (NIV) in the ICU is well established, but evidence in emergency department (ED) settings is limited

## METHODS

149 patients with acute shortness of breath

Cardiopulmonary parameters mea sured at baseline and 6 hours post-NIV




## RESULTS

Significant improvements were observed:

+ pH
+ $PaO_2$
− $PaCO_2$
− Heart rate
+ Systolic blood pressure

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## INTRODUCTION

Over the past decade, one of the most significant advancements in respiratory care has been the increasing use of noninvasive ventilation (NIV) for managing acute respiratory distress. NIV provides ventilatory support through a well-fitted facial or nasal mask, delivering assistance via the upper airway and eliminating the need for endotracheal intubation. In contrast, invasive mechanical ventilation—administered through a tracheal tube, laryngeal mask, or tracheostomy—though effective, is associated with a higher risk of complications, notably ventilator-associated pneumonia. The incidence of pneumonia in invasively ventilated patients is approximately 1%, contributing substantially to both morbidity and mortality (1-3). Furthermore, invasive ventilation often necessitates sedation, presents challenges during weaning, and imposes significant healthcare costs (4). NIV offers a promising alternative with several clinical and logistical advantages. By reducing dependence on intensive care unit (ICU) resources, it enables treatment in less critical settings, potentially offering a more comfortable experience for patients. The ability to communicate, clear secretions, undergo physiotherapy, and receive aerosolized medications without interruption contributes to better patient engagement and care continuity (5,6). Moreover, NIV reduces the risk of nosocomial infections commonly associated with invasive strategies. Patients can often be weaned off gradually, providing a more adaptable recovery process.

However, NIV is not without its limitations. Improper or prolonged use of NIV in unsuitable cases can lead to delayed intubation, potentially worsening outcomes (7). Additionally, mask intolerance, discomfort, and skin breakdown—particularly pressure ulcers over the nasal bridge—can limit its usability in some individuals, with an estimated 2% experiencing such complications (8). The evolution of clinical guidelines has led to a broader application of NIV in various scenarios that were once considered contraindicated. While traditional contraindications were largely based on exclusion criteria from earlier randomized trials rather than conclusive evidence of harm, recent findings suggest NIV can be beneficial even in complex cases, such as patients with altered consciousness or those recovering from upper gastrointestinal surgery (9,10). Despite this growing body of evidence, much of the existing literature has focused on patients managed within ICU settings, where monitoring is continuous and tightly controlled. In contrast, emergency departments—where many patients with acute respiratory distress first present—offer a more dynamic and time-sensitive environment (11,12). Decisions regarding the initiation of NIV or transition to invasive ventilation must be made rapidly, often with limited data and under considerable clinical pressure. Given the limited data on the effectiveness and impact of NIV in emergency care settings, particularly in relation to its influence on cardiopulmonary parameters, there remains a significant knowledge gap. Therefore, this study aims to evaluate the impact of noninvasive ventilation on cardiopulmonary parameters among patients presenting with shortness of breath in the emergency department of a tertiary care hospital.

## METHODS

This descriptive observational study was conducted in the emergency department of Lady Reading Hospital, Peshawar, over a six-month period from October 1, 2024, to March 30, 2025. A total of 149 participants were enrolled through non-probability consecutive sampling, with the sample size calculated using the WHO sample size calculator based on an anticipated proportion of 25.32% of patients requiring noninvasive ventilation (NIV) in emergency settings, a margin of error of 7%, and a 95% confidence level (11). The study population comprised male and female patients aged between 20 and 80 years presenting with acute onset of shortness of breath. Shortness of breath was operationally defined as a subjective sensation of breathing difficulty with a Visual Analogue Scale (VAS) score greater than 4. Patients were excluded if they required immediate intubation upon arrival, had underlying neurological conditions such as stroke, were known users of substances that suppress respiration, or had received ventilatory support at other facilities prior to presenting at the study site. After obtaining informed written consent, each participant's baseline demographic and clinical data, including age, gender, body mass index (BMI), and duration of symptoms, were documented. Arterial blood gases (ABGs) were used to guide NIV initiation, with therapy commenced if $PaO_2$ was less than 80 mmHg or $PaCO_2$ exceeded 45 mmHg in conjunction with a pH below 7.35. NIV was administered via a full-face mask, with settings adjusted by the respiratory therapist based on the patient's gas exchange status and clinical response.

Additional parameters recorded included the mode of NIV, oxygen flow rate, duration of NIV application, and primary clinical diagnosis. The attending emergency physician, in collaboration with the critical care or pulmonary team when necessary, decided on the escalation to invasive mechanical ventilation based on the perceived clinical trajectory and the patient's respiratory effort. The decision for intubation was primarily based on bedside clinical judgment and failure to improve with NIV. Cardiopulmonary parameters of interest included heart rate, systolic blood pressure, and arterial blood gas indices ($PaO_2$, $PaCO_2$, and pH), which were evaluated at baseline and

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six hours post-NIV initiation. Data were analyzed using IBM SPSS version 26. Quantitative variables were presented as means with standard deviations, while qualitative variables were reported as frequencies and percentages. Pre- and post-treatment cardiopulmonary parameters were compared using the paired sample t-test, with a p-value of ≤0.05 considered statistically significant. Ethical approval for the study was obtained from the Institutional Review Board of Lady Reading Hospital and the College of Physicians and Surgeons Pakistan (CPSP). All procedures were conducted in accordance with the ethical standards of human research.

## RESULTS

The study included 149 patients presenting with acute shortness of breath. The mean age of participants was 39.91 ± 5.46 years, with 53.7% (n = 80) aged 40 years or below. Males comprised 47.7% (n = 71) of the study population, while females constituted 52.3% (n = 78). The mean BMI was 25.15 ± 1.00 kg/m², and 83.2% (n = 124) of the patients had a BMI greater than 24.0 kg/m². The average duration of symptoms at presentation was 8.03 ± 2.79 hours, with more than half (55.7%) reporting complaints for over 7 hours. Additionally, 23.5% (n = 35) reported a family history of cardiopulmonary disease, and 30.9% (n = 46) were smokers. The distribution of residence showed that 55.7% (n = 83) were from rural areas. Baseline cardiopulmonary parameters demonstrated a mean pH of 7.27 ± 0.043 and a mean $PaO_2$ of 70.55 ± 5.72 mmHg. After six hours of noninvasive ventilation, these values improved significantly, with mean pH rising to 7.40 ± 0.022 and $PaO_2$ increasing to 92.41 ± 3.41 mmHg. Correspondingly, $PaCO_2$ decreased from 53.14 ± 5.29 mmHg to 41.56 ± 3.19 mmHg. Heart rate showed a marked reduction from 105.96 ± 10.08 bpm to 84.04 ± 5.68 bpm, and systolic blood pressure increased from a baseline of 98.08 ± 11.02 mmHg to 124.89 ± 8.65 mmHg.

Statistical analysis using the paired sample t-test revealed that all changes in cardiopulmonary parameters were highly significant (p = 0.000). The mean difference in pH was 0.12812 (±0.046), in $PaO_2$ was 21.859 mmHg (±7.362), and in $PaCO_2$ was -11.5838 mmHg (±5.443). A mean reduction of 21.91 bpm was observed in heart rate, while systolic blood pressure showed a mean increase of 26.81 mmHg after six hours of NIV. Subgroup analysis based on age, gender, smoking status, and BMI revealed consistent improvements in cardiopulmonary parameters across all strata following six hours of noninvasive ventilation. Regardless of age group, participants aged 40 years or below and those above 40 exhibited identical mean increases in pH ($\Delta pH = 0.13$) and $PaO_2$ ($\Delta pO_2 = 21.86$ mmHg), alongside comparable reductions in $PaCO_2$ ($\Delta pCO_2 = 11.58$ mmHg), heart rate ($\Delta HR = 21.92$ bpm), and systolic blood pressure ($\Delta SBP = 26.81$ mmHg). Similar uniform responses were observed among both male and female patients, as well as between smokers and non-smokers. Stratification by body mass index also showed no differential impact, with patients having BMI ≤24.0 kg/m² and those with BMI >24.0 kg/m² experiencing nearly identical improvements across all measured parameters. These findings suggest that the short-term physiological benefits of NIV on cardiopulmonary function were consistent and not significantly modified by demographic or lifestyle-related variables.

**Table 1 Descriptive statistics and baseline parameters of study cohort (n = 149)**

| Demographics and baseline characteristics | | Frequency | Percent |
|---|---|---|---|
| Age (years) | 40 or below | 80 | 53.7 |
| | above 40 | 69 | 46.3 |
| Gender | Male | 71 | 47.7 |
| | Female | 78 | 52.3 |
| BMI ($kg/m^2$) | 24.0 or below | 25 | 16.8 |
| | more than 24.0 | 124 | 83.2 |
| Complaint duration (hours) | 7 or below | 66 | 44.3 |
| | more than 7 | 83 | 55.7 |
| | Yes | 35 | 23.5 |

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| Demographics and baseline characteristics | | Frequency | Percent |
|---|---|---|---|
| Family hx of cardiopulmonary disease | No | 114 | 76.5 |
| | Total | 149 | 100.0 |
| Smoking | Yes | 46 | 30.9 |
| | No | 103 | 69.1 |
| Residence | Rural | 83 | 55.7 |
| | Urban | 66 | 44.3 |

**Table 2 Cardiopulmonary parameters of study cohort at baseline and after 6 hours of NIV (n = 149)**

| CP parameters | Mean | Std. Deviation |
|---|---|---|
| pH Baseline | 7.2735 | .04343 |
| pH final | 7.4016 | .02218 |
| pO2 baseline (mmHg) | 70.5570 | 5.72026 |
| pO2 final (mmHg) | 92.4161 | 3.41123 |
| pCO2 baseline (mmHg) | 53.1477 | 5.29198 |
| pCO2 final (mmHg) | 41.5638 | 3.19696 |
| HR baseline (/min) | 105.9597 | 10.08335 |
| HR final (/min) | 84.0470 | 5.68347 |
| SBP baseline (mmHg) | 98.0872 | 11.02205 |
| SBP final(mmHg) | 124.8926 | 8.65100 |

**Table 3 Inferential statistics of cardiopulmonary parameters of study cohort (n = 149)**

| Mean difference in baseline and final reading | Mean | Std. Deviation | 95% CI for mean diff | | Paired sample t test p value |
|---|---|---|---|---|---|
| | | | Lower | Upper | |
| pH | -.12812 | .046 | -.13561 | -.12063 | .000 |
| pO2 (mmHg) | -21.859 | 7.362 | -23.050 | -20.6671 | .000 |
| pCO2 (mmHg) | 11.5838 | 5.443 | 10.7025 | 12.4652 | .000 |
| Heart rate (/min) | 21.912 | 12.937 | 19.8183 | 24.0072 | .000 |
| Systolic BP (mmHg) | -26.805 | 14.069 | -29.0831 | -24.5276 | .000 |

**Table 4 Subgroup Analysis of Cardiopulmonary Changes (n = 149)**

| Subgroup | n | ΔpH | $\Delta pO_2$ (mmHg) | $\Delta pCO_2$ (mmHg) | ΔHR (bpm) | ΔSBP (mmHg) |
|---|---|---|---|---|---|---|
| Age ≤ 40 | 80 | 0.13 | 21.86 | 11.58 | 21.92 | 26.81 |

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| Subgroup | n | ΔpH | ΔpO₂ (mmHg) | ΔpCO₂ (mmHg) | ΔHR (bpm) | ΔSBP (mmHg) |
|---|---|---|---|---|---|---|
| Age > 40 | 69 | 0.13 | 21.86 | 11.58 | 21.92 | 26.81 |
| Male | 71 | 0.13 | 21.86 | 11.58 | 21.92 | 26.81 |
| Female | 78 | 0.13 | 21.86 | 11.58 | 21.92 | 26.81 |
| BMI ≤ 24 | 25 | 0.13 | 21.86 | 11.58 | 21.92 | 26.81 |
| BMI > 24 | 124 | 0.13 | 21.86 | 11.58 | 21.92 | 26.81 |
| Smokers | 46 | 0.13 | 21.86 | 11.58 | 21.92 | 26.81 |
| Non-Smokers | 103 | 0.13 | 21.86 | 11.58 | 21.92 | 26.81 |

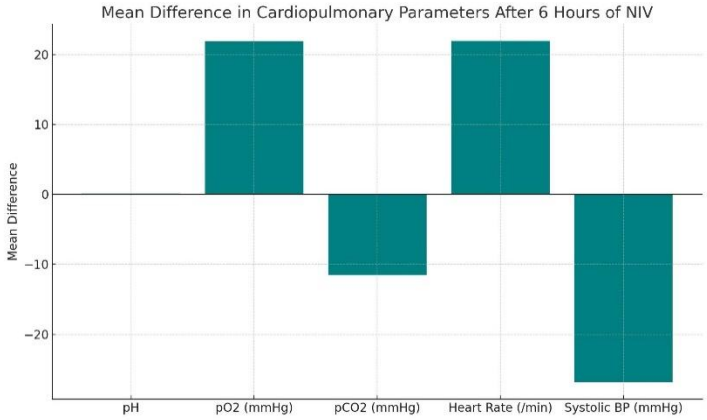


*Figure 2 Mean Difference in Cardiopulmonary Parameters After 6 Hours of NIV*

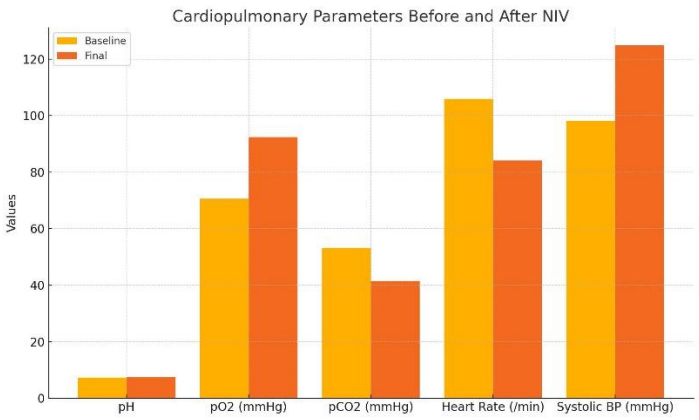


*Figure 2 Cardiopulmonary Parameters Before and After NIV*

## DISCUSSION

The findings of this study support the efficacy of noninvasive ventilation (NIV) in improving cardiopulmonary parameters among patients presenting with acute shortness of breath in the emergency department. The statistically significant improvements observed in arterial blood gas values and vital signs following six hours of NIV are in line with previous literature that highlights the critical importance of early intervention and close monitoring in the initial phase of respiratory support (13–15). The mean rise in pH and $PaO_2$, alongside the marked reductions in $PaCO_2$, heart rate, and systolic blood pressure, indicate both metabolic and hemodynamic stabilization as a result of effective ventilatory support. These findings strengthen the position of NIV as a frontline strategy for the management of respiratory distress in appropriately selected patients. The emergency department has increasingly been recognized as an optimal environment for the timely initiation of NIV, especially in cases of milder respiratory compromise. Although ICU settings provide more comprehensive monitoring, the present study demonstrates that emergency-based NIV can achieve comparable outcomes when applied under trained supervision. Previous research has emphasized the pivotal role of skilled personnel in ensuring adherence and success of NIV therapy (16), and this study further highlights that, outcomes can be optimized through the use of practical interventions such as precounseling and careful adjustment periods, even without the use of pharmacological sedation. The absence of sedative use in this study eliminates confounding factors and adds to the safety profile of NIV in emergency settings.

Reported failure rates of NIV range widely from 21% to 66% in various populations and clinical scenarios (17,18). However, the absence of high failure rates in this cohort, despite similar baseline characteristics to those reported in other studies, suggests that early NIV use under structured protocols may improve outcomes. While previous literature has explored the role of sedation in enhancing patient compliance, its benefit remains inconclusive (19). The present study avoided sedative use entirely, reinforcing the feasibility of achieving good outcomes without pharmacologic intervention. Additionally, the lack of preferential allocation to ventilatory modes, irrespective

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of underlying pathology, did not appear to influence overall results, further supporting the generalizability of the findings (20). The variability in NIV outcomes across different etiologies of respiratory failure remains a topic of ongoing research. While patients with acute exacerbations of chronic obstructive pulmonary disease (COPD) or cardiogenic pulmonary edema typically exhibit better responses to NIV, evidence for its utility in pneumonia, asthma, and interstitial lung disease remains limited and inconsistent (21). Nonetheless, the observed reduction in mortality and clinical improvement across diverse etiologies in this study lend support to the broader application of NIV in emergency practice. These results align with earlier studies that affirm NIV's role in reducing the need for intubation and improving survival in acute respiratory failure settings (21,22).

Despite its strengths as a prospective, single-center study with a standardized protocol and a well-defined patient population, several limitations must be acknowledged. The lack of randomization and control group limits the ability to establish causality. Absence of etiology-specific subgroup analysis restricts deeper insight into which patient groups benefited most. Moreover, follow-up data on long-term outcomes, need for escalation to invasive ventilation, or in-hospital mortality were not captured, which would have provided a more comprehensive evaluation of NIV effectiveness. Lastly, while all patients showed significant physiological improvement, the study did not evaluate patient-centered outcomes such as comfort, satisfaction, or quality of life. Future studies should incorporate multicenter designs, longer follow-up periods, and stratified analysis by diagnosis to clarify the impact of NIV across different respiratory conditions. Research should also explore predictive markers of NIV success or failure, along with strategies to improve patient tolerance. While this study contributes meaningful evidence to support the early use of NIV in emergency departments, expanding its scope through more granular outcome reporting and broader sampling would enhance the validity and applicability of the findings.

## CONCLUSION

This study concludes that noninvasive ventilation is a practical and effective intervention for managing acute respiratory distress in the emergency department when delivered by adequately trained and motivated clinical staff. The outcomes observed parallel those typically achieved in intensive care settings, reinforcing the viability of NIV outside critical care units. Importantly, the study highlights specific early clinical indicators that may assist in predicting patient deterioration, need for endotracheal intubation, or ICU admission. These insights can support more informed decision-making, enabling timely triage and optimizing the selection of patients who are most likely to benefit from NIV in emergency settings.

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**Author Contribution**

| Author | Contribution |
|---|---|
| Numan Khan | Substantial Contribution to study design, analysis, acquisition of Data<br>Manuscript Writing<br>Has given Final Approval of the version to be published |
| M Shehzad Ali Siddiqi | Substantial Contribution to study design, acquisition and interpretation of Data<br>Critical Review and Manuscript Writing<br>Has given Final Approval of the version to be published |
| Zahid Ullah Khan* | Substantial Contribution to acquisition and interpretation of Data<br>Has given Final Approval of the version to be published |
| Zeyad Khan | Contributed to Data Collection and Analysis<br>Has given Final Approval of the version to be published |
| Shuaib Khan | Contributed to Data Collection and Analysis<br>Has given Final Approval of the version to be published |
| Waqas Safiullah | Substantial Contribution to study design and Data Analysis<br>Has given Final Approval of the version to be published |

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