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Utility of HACOR Score in Predicting Non-Invasive Ventilation Failure among Patients with Chronic Obstructive Pulmonary Disease.

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Abstract
Background: Acute exacerbation of chronic obstructive pulmonary disease (COPD) often leads to respiratory failure, where non-invasive ventilation (NIV) serves as a crucial intervention. However, predicting NIV failure early remains a clinical challenge. The HACOR score, which incorporates heart rate, acidosis, consciousness, oxygenation, and respiratory rate, offers a simple and objective method for assessing the likelihood of NIV failure. ***Objectives:*** To evaluate the utility of the HACOR score in predicting NIV failure among patients with COPD and to determine the sensitivity and specificity of the score at various time intervals following NIV initiation. ***Methods:*** This prospective observational study was conducted over 12 months in the Respiratory Intensive Care Unit of a tertiary care hospital. A total of 53 COPD patients with acute respiratory failure initiated on NIV were enrolled. HACOR scores were calculated at baseline, 1–2 hours, 12 hours, and 24 hours. NIV failure was defined as the need for invasive mechanical ventilation or death. Statistical analysis was performed using SPSS software; chi-square tests and ROC curve analysis were used to assess predictive accuracy. ***Results:*** NIV failure occurred in 17% of patients. A HACOR score ≥5 at initiation was significantly associated with NIV failure ($p < 0.001$). The score demonstrated high diagnostic accuracy, with a sensitivity of 100%, specificity of 93.2%, and area under the curve (AUC) of 0.983 at baseline. ***Conclusion:*** The HACOR score is a valid, bedside tool for early prediction of NIV failure in COPD patients. It can aid clinicians in timely escalation of care and potentially improve outcomes.

Keywords: COPD, HACOR score, non-invasive ventilation, NIV failure, respiratory failure, predictive score, acute exacerbation.

INTRODUCTION
Chronic Obstructive Pulmonary Disease (COPD) is a progressive and debilitating respiratory condition characterized by persistent airflow limitation, which is usually both preventable and treatable. COPD exacerbations, especially those resulting in acute respiratory failure, represent a major cause of hospital admissions and mortality worldwide. These acute episodes often necessitate advanced respiratory support, with non-invasive ventilation (NIV) being a widely accepted first-line intervention in appropriate cases of acute exacerbation of COPD (AECOPD) with respiratory failure[1]. Non-invasive ventilation provides ventilatory support without the need for endotracheal intubation. It has been shown to improve gas exchange, decrease respiratory muscle workload, reduce the rate of intubation, shorten hospital stay, and improve survival in patients with COPD experiencing respiratory decompensation[2]. Despite these benefits, NIV is not universally successful. NIV failure, defined as the need for invasive mechanical ventilation (IMV) or death during NIV therapy, occurs in 15–30% of patients and is associated with worse outcomes, including increased mortality and healthcare resource utilization[3]. Timely recognition of patients who are likely to fail NIV is essential to guide clinical decision-making, avoid delays in intubation, and prevent associated complications. Historically, clinicians have relied on subjective assessment and individual parameters such as gas exchange, respiratory rate, and consciousness level to evaluate NIV response. However, these isolated variables may not consistently predict outcomes in critically ill COPD patients[4].

In response to the need for a more structured and objective tool, the HACOR score was developed. The HACOR score incorporates five readily measurable parameters—Heart rate, Acidosis (pH), Consciousness (Glasgow Coma Scale), Oxygenation (PaO_2/FiO_2 ratio), and Respiratory rate—to predict the risk of NIV failure in patients with acute respiratory failure[5]. A score of ≥5, typically assessed within the first hour of NIV initiation, has been associated with a significantly higher risk of NIV failure, allowing clinicians to consider early intubation strategies[6]. Multiple studies have validated the predictive utility of the HACOR score in different populations, including those with hypoxemic respiratory failure and AECOPD[7,8]. However, there remains a gap in data regarding its prospective use specifically among Indian COPD patients, particularly in secondary and tertiary care settings with diverse patient profiles and resource limitations. Given the growing

burden of COPD and the critical need for timely escalation of respiratory support, this study aims to evaluate the effectiveness of the HACOR score in predicting NIV failure in patients presenting with acute exacerbations of COPD. By assessing its sensitivity, specificity, and diagnostic accuracy at various time points, the study will provide valuable insights into the clinical applicability of this tool in routine practice.

Aim and objectives:

- To evaluate the effectiveness of the HACOR score in predicting NIV failure in COPD patients with acute exacerbations.
- To assess HACOR score (heart rate, acidosis, oxygenation and respiratory rate) and correlate with NIV failure among patients with chronic obstructive pulmonary disease.

MATERIALS AND METHODS

Study Design and Setting

This was a prospective observational study conducted in the Respiratory Intensive Care Unit (RICU) of Sree Mookambika Institute of Medical Sciences, Kulasekharam, Tamil Nadu. The study spanned a duration of 12 months, during which eligible patients were enrolled and monitored.

Study Population

The study included adult patients diagnosed with chronic obstructive pulmonary disease (COPD) who presented with acute respiratory failure and were initiated on non-invasive ventilation (NIV) based on clinical judgment.

Inclusion Criteria

- Patients aged 18 years and above.
- Diagnosed cases of COPD with acute exacerbation requiring NIV.
- Patients admitted to the RICU and initiated on NIV through the BiPAP mode using a full-face mask.

Exclusion Criteria

- Patients requiring immediate endotracheal intubation.
- Those with acute comorbid conditions such as myocardial infarction, pulmonary edema, or cerebrovascular accidents.
- Individuals with contraindications to NIV, such as facial trauma or impaired consciousness (GCS < 8).
- Patients who refused consent.

Sampling Technique and Sample Size

A purposive sampling method was employed to recruit eligible patients who met the inclusion criteria. Based on prior studies, particularly the work of Singh R. et al., the prevalence of NIV failure in patients with a HACOR score ≥5 was estimated to be approximately 76.4%. Using this figure and setting an absolute precision of 10% with a 95% confidence level, the minimum required sample size was calculated to be 53 patients.

Data Collection Procedure

After obtaining written informed consent, data were collected using a structured case record form. The form included demographic details, clinical presentation, comorbidities, smoking history, and vitals. All patients were initiated on NIV as per the ICU protocol using the BiPAP mode. The HACOR score, which includes heart rate, arterial pH, level of consciousness (Glasgow Coma Scale), oxygenation (PaO_2/FiO_2 ratio), and respiratory rate, was calculated at four time intervals:

- Prior to the initiation of NIV
- At 1–2 hours after NIV initiation
- At 12 hours
- At 24 hours

Each parameter of the HACOR score was recorded and scored according to the validated scoring system. The total HACOR score ranged from 0 to 25.

Definition of Outcome

NIV failure was defined by any of the following:

- Need for invasive mechanical ventilation.
- Clinical deterioration despite NIV support.
- Hemodynamic instability unresponsive to treatment.
- Persistent or worsening dyspnea and hypoxemia.

- Death during NIV therapy.

NIV success was defined as clinical improvement resulting in weaning from NIV within 7 days without the requirement for invasive ventilation.

Variables Measured

Independent Variables:

- Age, gender, smoking history, comorbidities.
- Vital signs (heart rate, respiratory rate, blood pressure).
- ABG parameters: pH, PaO_2/FiO_2.
- GCS score.

Dependent Variable:

- NIV outcome (Success or Failure).

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS software version 21. Continuous variables were expressed as mean ± standard deviation, and categorical variables were summarized as frequencies and percentages. The chi-square test was used to assess the association between categorical variables. Receiver operating characteristic (ROC) curves were constructed to evaluate the diagnostic performance of the HACOR score at various time intervals. A p-value < 0.05 was considered statistically significant.

RESULTS

Table 1: Baseline Characteristics of the Study Population (N = 53)

Variable	Value
Age (mean ± SD)	65.3 ± 8.2 years
Gender (Male/Female)	43 (81.1%) / 10 (18.9%)
Smoking History	47 (88.7%)
Biomass Exposure	6 (11.3%)
Mean HACOR Score (Initial)	3.1 ± 1.6
Comorbidities Present	36 (67.9%)
Hypertension	22 (41.5%)
Diabetes Mellitus	18 (34.0%)

Table 2: Distribution of HACOR Scores at Different Time Intervals

HACOR Score Range	At Initiation	At 1–2 Hours	At 12 Hours	At 24 Hours
0–5	46 (86.8%)	51 (96.2%)	52 (98.1%)	49 (92.5%)
6–11	7 (13.2%)	2 (3.8%)	1 (1.9%)	4 (7.5%)
12–25	0	0	0	0
p-value	**<0.001**			

Table 3: NIV Outcome Based on HACOR Score at Initiation

HACOR Score	NIV Success (n=44)	NIV Failure (n=9)	Total
≥5	3 (6.8%)	9 (100%)	12
<5	41 (93.2%)	0 (0%)	41
Total	**44 (83.0%)**	**9 (17.0%)**	**53**

Table 4: Diagnostic Performance of HACOR Score (≥5) at Initiation for Predicting NIV Failure

Parameter	Value	95% Confidence Interval
Sensitivity	100%	70.1–100%
Specificity	93.2%	81.3–98.6%
Positive Predictive Value (PPV)	75.0%	47.6–91.2%
Negative Predictive Value (NPV)	100%	90.5–100%
Diagnostic Accuracy	94.3%	—

Table 5: HACOR Score ROC Analysis at Various Time Points

Time Point	Area Under Curve (AUC)	95% CI	p-value
At Initiation	0.983	0.962 – 1.000	<0.001
At 1–2 Hours	0.612	0.448 – 0.774	0.19
At 12 Hours	0.562	0.384 – 0.740	0.47
At 24 Hours	0.659	0.477 – 0.841	0.07

DISCUSSION

The present prospective study evaluated the predictive utility of the HACOR (Heart rate, Acidosis, Consciousness, Oxygenation, Respiratory rate) score in determining non-invasive ventilation (NIV) failure among patients with acute exacerbations of chronic obstructive pulmonary disease (AECOPD). Using a sample size of 53, the findings demonstrate a strong association between elevated HACOR scores and increased risk of NIV failure. Notably, all patients who experienced NIV failure had an initial HACOR score ≥5, reinforcing the score's predictive value. Our study aligns with the foundational research by Duan et al., who first proposed the HACOR score as a bedside tool for early detection of NIV failure across different types of acute respiratory failure. In their derivation and validation cohorts, a score ≥5 demonstrated high sensitivity and specificity in predicting NIV failure within the first few hours of initiation[5]. Similarly, in our cohort, the HACOR score at initiation showed excellent diagnostic accuracy (AUC = 0.983), and a cutoff of ≥5 yielded a sensitivity of 100% and specificity of 93.2%. The high predictive power of the HACOR score at baseline suggests that early physiological derangements are critical determinants of NIV outcome. This observation is consistent with the findings of Singh et al., who reported a 76.4% NIV failure rate among COPD patients with a HACOR score ≥5 at initiation. Their study also demonstrated an exceptionally high AUC (0.980), closely resembling our results[8].

In contrast to time-dependent changes in the HACOR score, our study found that its discriminative ability decreased at later intervals (1–2h, 12h, 24h), a trend mirrored in other investigations. For instance, a study by Carrillo et al. found that while HACOR score values at multiple time points could distinguish between success and failure groups, the greatest predictive value remained within the first hour of NIV application[9]. This supports the notion that early assessment is crucial in identifying patients at risk of deterioration. Our results also resonate with the findings of Pratapa Reddy et al., who applied the HACOR score to a COPD population and found that patients with a score ≥5 had a significantly higher risk of NIV failure and mortality. Their reported sensitivity and specificity of 89.5% and 86.3%, respectively, reinforce the robustness of our own observations[7]. In addition to predicting failure, the HACOR score may help guide clinical decisions regarding timely escalation of respiratory support. Early identification of high-risk patients could prompt pre-emptive intubation or closer monitoring, thus reducing the risks associated with delayed intervention. Duan et al. emphasized this approach, demonstrating reduced mortality when intubation was performed early in patients with high HACOR scores[10].

Importantly, our study reaffirms the utility of a simple, bedside scoring system in resource-constrained environments where advanced monitoring tools may not be readily available. The HACOR score, derived from routinely available clinical parameters, can be calculated rapidly and repeatedly, enhancing its practicality and relevance in acute care settings. However, several limitations must be acknowledged. First, the study was conducted in a single tertiary care center, limiting the generalizability of results. Second, the relatively small sample size, although statistically adequate, restricts subgroup analyses, especially with regard to co-morbidities. Third, the study excluded patients with other systemic illnesses and emergency intubations, potentially underestimating the full spectrum of NIV failure. Despite these limitations, the consistency of our findings with multiple external validations strongly supports the reliability of the HACOR score in the early prediction of NIV failure in AECOPD. Future research should focus on multicentric studies with larger cohorts and explore whether dynamic changes in HACOR score after NIV initiation offer additional prognostic information.

CONCLUSION

The HACOR score is a reliable and practical tool for predicting non-invasive ventilation failure in patients with acute exacerbation of COPD. A score of 5 or more at the initiation of NIV is significantly associated with a higher likelihood of treatment failure, thereby offering clinicians an opportunity to make timely decisions regarding escalation of care.

The score's reliance on simple bedside parameters makes it especially valuable in real-world settings, including those with limited access to advanced diagnostic resources. Incorporating the HACOR score into routine practice may enhance early identification of patients at risk and potentially reduce morbidity and mortality by guiding earlier interventions such as elective intubation or closer monitoring.

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