International Journal of Medical and Pharmaceutical Research

Online ISSN-2958-3683 | Print ISSN-2958-3675
Frequency: Bi-Monthly
Available online on: https://ijmpr.in/

Original Article

Updated Hacor Score for Early Prediction of Noninvasive Ventilation Failure in Hypoxemic Respiratory Failure: A Prospective Observational Study

Dr Megha Jogannavar[1], Dr Karthik K. Shetty[1], Dr Nagesh Kumar T.C.[2]

[1]Junior Resident, Department of General Medicine, M.S. Ramaiah Medical College, Bangalore, India
[2]Professor, Department of General Medicine, M.S. Ramaiah Medical College, Bangalore, India

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Corresponding Author:

Dr Megha Jogannavar
Junior Resident, Department of General Medicine, M.S. Ramaiah Medical College, Bangalore, India
Email:
meghajogannavar@gmail.com

Received: 25-05-2026
Accepted: 05-06-2026
Available online: 06-07-2026

ABSTRACT

Background: Noninvasive ventilation (NIV) is widely used in acute hypoxemic respiratory failure to avoid endotracheal intubation and complications related to invasive mechanical ventilation. However, delayed recognition of NIV failure is associated with increased mortality. The HACOR score, comprising Heart rate, Acidosis, Consciousness, Oxygenation, and Respiratory rate, has been validated as a bedside tool for predicting NIV failure. Duan et al. subsequently developed the Updated HACOR score by incorporating baseline clinical variables including acute respiratory distress syndrome (ARDS), septic shock, immunosuppression, cardiogenic pulmonary edema, pneumonia, and Sequential Organ Failure Assessment (SOFA) score. Data evaluating its performance in Indian ICU settings remain limited.

Objectives: To evaluate the predictive ability of the Updated HACOR score for NIV failure in patients with hypoxemic respiratory failure and compare its performance with the original HACOR score.

Methods: A prospective observational study was conducted in the intensive care unit of a tertiary care teaching hospital between July 2023 and December 2024. Sixty-three adult patients with hypoxemic respiratory failure requiring NIV were enrolled. Baseline demographic and clinical data were recorded. Original and Updated HACOR scores were calculated at baseline, 1–2 hours, 12 hours, and 24 hours after NIV initiation. NIV failure was defined as the need for endotracheal intubation and invasive mechanical ventilation. Receiver operating characteristic (ROC) analysis was performed to assess predictive performance.

Results: The mean age of participants was 53.8±15 years and 61.9% were males. Septic shock was present in 36.5% and ARDS in 42.9% of patients. NIV failure occurred in 15.9%, 19.0%, 31.4%, and 2.9% of patients at baseline, 1–2 hours, 12 hours, and 24 hours respectively. At 1–2 hours, the Updated HACOR score demonstrated superior predictive ability compared with the Original HACOR score (AUC 0.904 vs 0.889). At 12 hours, predictive accuracy further improved (AUC 0.957 vs 0.862). A cutoff value of 15.5 for the Updated HACOR score yielded sensitivity of 91% and specificity of 86%.

Conclusion: The Updated HACOR score significantly improves early prediction of NIV failure compared with the Original HACOR score and may facilitate timely clinical decision-making in patients with hypoxemic respiratory failure.

Keywords: Hypoxemic respiratory failure; Noninvasive ventilation; HACOR score; Updated HACOR score; NIV failure.

INTRODUCTION

Acute hypoxemic respiratory failure remains one of the most common indications for intensive care admission and is associated with substantial morbidity and mortality worldwide. Conditions such as pneumonia, acute respiratory distress

syndrome (ARDS), cardiogenic pulmonary edema, and sepsis frequently lead to severe impairment of oxygenation requiring advanced respiratory support. Despite advances in critical care medicine, mortality in severe hypoxemic respiratory failure remains considerable, particularly when invasive mechanical ventilation becomes necessary.[1–6]

Noninvasive ventilation (NIV) has emerged as an important therapeutic modality in selected patients with respiratory failure. NIV improves oxygenation, reduces work of breathing, decreases the need for endotracheal intubation, shortens ICU stay, and reduces ventilator-associated complications.[7–10] However, NIV failure remains a major concern, particularly in patients with de novo hypoxemic respiratory failure and ARDS. Failure rates ranging from 20% to 70% have been reported depending on disease severity and underlying etiology.[11–13] Delayed intubation after unsuccessful NIV has been associated with significantly worse outcomes and increased mortality. Therefore, reliable identification of patients likely to fail NIV is critical. Several clinical and physiological parameters have been investigated as predictors of NIV failure, including respiratory rate, oxygenation indices, acid-base status, neurological status, and severity scores.[14–16]

Duan et al. developed the HACOR score incorporating Heart rate, Acidosis, Consciousness, Oxygenation, and Respiratory rate. The score demonstrated good performance for predicting NIV failure in patients with hypoxemic respiratory failure.[17] Subsequent investigations validated its utility across different respiratory conditions and clinical settings.[18–20] Recognizing that baseline clinical factors such as ARDS, septic shock, pneumonia, immunosuppression, and organ dysfunction also influence NIV outcomes, Duan et al. introduced the Updated HACOR score. This model combines six baseline clinical variables with the original five physiological components and demonstrated improved predictive performance in multicenter studies.[21] Evidence regarding the usefulness of the Updated HACOR score in Indian patients with hypoxemic respiratory failure remains scarce. Therefore, the present study was conducted to evaluate the predictive ability of the Updated HACOR score and compare its performance with the Original HACOR score in a tertiary care intensive care unit.

OBJECTIVE

To evaluate the predictive ability of the Updated HACOR score for early prediction of noninvasive ventilation failure in patients with hypoxemic respiratory failure and compare its performance with the Original HACOR score.

MATERIALS AND METHODS

Study Design: Prospective observational study.
Study Setting: Intensive Care Unit, M.S. Ramaiah Hospital, Bangalore, India.
Study Duration: July 2023 to December 2024.

Sample Size: Based on previously reported specificity of 91% for the Updated HACOR score and assuming 50% prevalence with 95% confidence level and 10% margin of error, the calculated sample size was 63 patients.

Study Population: Adult patients admitted to the ICU with hypoxemic respiratory failure requiring NIV.

Inclusion Criteria: Age ≥18 years; Hypoxemic respiratory failure requiring NIV; and ICU admission during study period.

Exclusion Criteria: Hypercapnic respiratory failure; Post-extubation NIV; COPD exacerbation requiring NIV; and Patients requiring immediate intubation.

Data Collection: Baseline data included age; sex; diagnosis; presence of ARDS; presence of septic shock; SOFA score; heart rate; respiratory rate; arterial blood gas parameters; GCS score; and PaO_2/FiO_2 ratio. Original and Updated HACOR scores were calculated at Baseline; 1–2 hours; 12 hours; and 24 hours.

Outcome Measure: NIV failure was defined as requirement of endotracheal intubation and invasive mechanical ventilation.

Statistical Analysis: Continuous variables were expressed as mean ± standard deviation and categorical variables as frequencies and percentages. Student's t-test and Chi-square test were used as appropriate. ROC curve analysis was performed to determine predictive performance. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 63 patients with hypoxemic respiratory failure requiring NIV were included in the study. Most patients were middle-aged to elderly, with a mean age of 53.8 years. Males constituted the majority (61.9%) of the study population. Bronchopneumonia was the most common diagnosis (19.1%), followed by community-acquired pneumonia and pulmonary edema (12.7% each), indicating that infectious respiratory illnesses were the predominant causes of hypoxemic respiratory failure. ARDS and septic shock were present in 42.9% and 36.5% of patients, respectively, reflecting the high severity of illness in the study cohort.

Patients exhibited significant respiratory compromise at NIV initiation, with moderate hypoxemia and elevated respiratory rates. The mean Updated HACOR score was higher than the Original HACOR score at baseline. Most NIV failures occurred within the first 12 hours of treatment, emphasizing the importance of close monitoring during the early phase of NIV therapy.

The Updated HACOR score consistently demonstrated better predictive performance than the Original HACOR score, with the highest accuracy observed at 12 hours (AUC = 0.957). At a cutoff value of 15.5, the Updated HACOR score showed excellent sensitivity (91%) and specificity (86%) for predicting NIV failure. The Updated HACOR score demonstrated superior accuracy compared with the Original HACOR score for early prediction of NIV failure, particularly at 1–2 hours and 12 hours after NIV initiation.

Table 1. Baseline Demographic Characteristics (n=63)

Variable	Frequency (%)
≤30 years	4 (6.3)
31–45 years	13 (20.6)
46–60 years	24 (38.1)
>60 years	22 (34.9)
Male	39 (61.9)
Female	24 (38.1)

Table 2. Primary Diagnoses

Diagnosis	n (%)
Bronchopneumonia	12 (19.1)
Pulmonary edema	8 (12.7)
Community-acquired pneumonia	8 (12.7)
Pleural effusion	6 (9.5)
Lobar pneumonia	7 (11.1)
ARDS	5 (7.9)
Others	17 (27.0)

Table 3. Baseline Clinical Characteristics

Variable	Value
Septic shock	23 (36.5%)
ARDS	27 (42.9%)
Median SOFA score	7

Table 4. Baseline Physiological Parameters

Parameter	Mean ± SD
Heart rate (beats/min)	120 ± 7
pH	7.30 ± 0.03
GCS	14.9 ± 0.1
PaO_2/FiO_2	179 ± 22
Respiratory rate (/min)	27 ± 3
Original HACOR	5.0 ± 1.6
Updated HACOR	11.8 ± 3.1

Table 5. NIV Failure Rates Over Time

Time Point	NIV Failure n (%)
Baseline	10 (15.9)
1–2 hours	12 (19.0)
12 hours	16 (31.4)
24 hours	1 (2.9)

Table 6. ROC Analysis of Original and Updated HACOR Scores

Time Point	Original HACOR AUC	Updated HACOR AUC
Baseline	0.522	0.404

1–2 hours	0.889	0.904
12 hours	0.862	0.957
24 hours	0.485	0.500

Table 7. Diagnostic Performance of Updated HACOR Score

Time	Cutoff	Sensitivity (%)	Specificity (%)
1–2 hours	15.5	91	86
12 hours	15.5	91	86

DISCUSSION

Early recognition of NIV failure remains one of the most important challenges in the management of hypoxemic respiratory failure. Delayed intubation has repeatedly been associated with higher mortality, prolonged ICU stay, and increased incidence of complications.[13–16] Therefore, reliable bedside tools capable of identifying high-risk patients early are of substantial clinical value.

In the present study, the mean age was 53.8 years, with most patients belonging to the 46–60-year age group. Male predominance was observed, accounting for nearly two-thirds of the study population. Similar demographic characteristics have been reported in previous studies evaluating NIV outcomes in acute respiratory failure.[17,18] Bronchopneumonia, community-acquired pneumonia, pulmonary edema, and ARDS constituted the major underlying etiologies. ARDS was present in 42.9% of patients, while septic shock was identified in 36.5%. These findings are clinically important because both ARDS and septic shock are recognized independent predictors of NIV failure.[19-21]

The Original HACOR score evaluates physiological deterioration through five bedside variables. Previous studies by Duan et al., Bai et al., and Guia et al. demonstrated that increasing HACOR scores strongly correlate with NIV failure and the need for intubation.[17–20] However, physiological variables alone may not adequately capture the influence of disease severity and underlying pathology. The Updated HACOR score addresses this limitation by incorporating baseline variables including SOFA score, pneumonia, ARDS, cardiogenic pulmonary edema, septic shock, and immunosuppression.[21] These factors significantly influence respiratory reserve and response to NIV.

Our findings demonstrated that baseline HACOR measurements were poor predictors of NIV failure, with low AUC values for both scoring systems. However, predictive performance improved substantially after initiation of NIV. At 1–2 hours, the Original HACOR score yielded an AUC of 0.889 whereas the Updated HACOR score demonstrated a higher AUC of 0.904. At 12 hours, the difference became even more pronounced, with AUC values of 0.862 and 0.957 respectively. These results closely parallel those reported by Duan et al., who observed significantly greater predictive accuracy for the Updated HACOR score across multiple validation cohorts.[13,21] The superior performance likely reflects the incorporation of baseline disease severity variables that influence NIV outcomes independent of physiological response.

The Updated HACOR score achieved sensitivity of 91% and specificity of 86% at a cutoff value of 15.5. Such high sensitivity is particularly useful in clinical practice because it minimizes the risk of missing patients who are likely to fail NIV and require invasive ventilation.

The present findings support the concept that combining dynamic physiological assessment with baseline clinical severity provides more accurate risk stratification than either approach alone. Early application of the Updated HACOR score may allow clinicians to identify high-risk patients, intensify monitoring, and consider timely intubation before catastrophic deterioration occurs.

Limitations: Single-center study; Relatively small sample size; Intubation decisions were made by treating physicians; Observational design limits causal inference; and External validation in larger multicenter cohorts is required.

CONCLUSION

The Updated HACOR score demonstrated superior predictive accuracy compared with the Original HACOR score for identifying noninvasive ventilation failure in patients with hypoxemic respiratory failure. Assessment at 1–2 hours and 12 hours after NIV initiation provided excellent discrimination, with the Updated HACOR score achieving high sensitivity and specificity. Incorporation of baseline clinical risk factors alongside physiological parameters improves early recognition of patients at risk of NIV failure and may facilitate timely escalation to invasive mechanical ventilation.

ACKNOWLEDGEMENT

The authors acknowledge the support of the Department of General Medicine, M.S. Ramaiah Medical College and Hospital, Bangalore, for facilitating this study. The authors also wish to thank Dr. Shailendra Vashistha (Assistant Professor, Transplant Immunology – HLA Lab, Dept of IHTM, GMC, Kota) and the VAssist Research team (www.thevassist.com) for their contribution in manuscript editing and submission process.

Conflict of Interest: None declared.
Source of Funding: Nil.

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