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Hacor Score In Predicting Non-Invasive Ventilation Failure In Acute Hypoxemic Respiratory Failure

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Abstract

Background: *Non-invasive ventilation (NIV) is a frontline strategy for managing acute hypoxemic respiratory failure (AHRF), but its success varies. Delayed recognition of NIV failure can increase mortality. The HACOR score, incorporating heart rate, acidosis, consciousness, oxygenation, and respiratory rate, has emerged as a potential tool for early prediction of NIV outcomes.*

Methods: *A prospective observational study was conducted on 75 patients with AHRF receiving NIV at a tertiary care hospital. HACOR scores were calculated at initiation, and at 1, 12, and 24 hours. A score >5 was used as the threshold for predicting NIV failure. Outcomes were categorized as NIV success (weaning) or failure (need for intubation).*

Results: *Patients who failed NIV had consistently higher HACOR scores at all time points. A score >5 showed high sensitivity (82% at 1 hour) and specificity (88%), with strong positive predictive value (>90%). NIV failure was more common in patients with ARDS and malignancy, while pneumonia patients responded better. Early intubation in high HACOR scorers was associated with reduced hospital mortality compared to delayed intubation.*

Conclusion: *The HACOR score is a reliable, simple bedside tool for predicting NIV failure in AHRF. A score >5, particularly within the first hour of NIV, warrants closer monitoring and may prompt timely intubation to improve outcomes.*

INTRODUCTION

Acute hypoxemic respiratory failure (AHRF) is a life-threatening condition commonly encountered in intensive care units, often necessitating ventilatory support to improve oxygenation and reduce respiratory workload[(1)]. Non-invasive ventilation (NIV) has emerged as an effective first-line strategy in selected patients with AHRF, offering the advantages of avoiding intubation-related complications, preserving airway defenses, and reducing healthcare costs. However, the success of NIV is highly variable, and delayed recognition of its failure can lead to poor outcomes, including increased mortality[(2)].

To address this challenge, the HACOR score—which integrates five readily measurable clinical parameters: Heart rate, Acidosis (pH), Consciousness (Glasgow Coma Scale), Oxygenation (PaO_2/FiO_2 ratio), and Respiratory rate—has been developed as a bedside tool to predict the likelihood of NIV failure[(3)]. Originally validated in patients with chronic obstructive pulmonary disease (COPD) exacerbations and hypoxemic respiratory failure, the HACOR score has gained attention for its utility in guiding early decision-making and timely escalation of care.

This study explores the role of the HACOR score in predicting NIV failure among patients with AHRF, aiming to enhance clinical outcomes through more accurate risk stratification and earlier intervention.

MATERIALS AND METHODS

This study was a Prospective observational study conducted in Government Hospital for Chest and communicable Disease (GHCCD), Visakhapatnam on 75 patients with Acute hypoxemic respiratory

failure who were receiving NIV enrolled in our study from July 2023 – November 2023.Patients above 18 years with clinical signs and symptoms of acute hypoxemic respiratory failure(pao2<60 mmhg,RR >25/min,use of accessory respiratory muscles) were included in this study.Patients requiring emergency endotracheal intubation,presenting with hypercapnic respiratory failure were excluded from this study.

Upon admission to the respiratory intensive care unit (RICU), all patients fulfilling the inclusion criteria and consenting to participate were enrolled. The following baseline data were collected:

- Demographic details: age, sex
- Clinical history: underlying diagnosis (e.g., pneumonia, ARDS, sepsis), comorbidities (e.g., COPD, diabetes, hypertension)

The HACOR score was calculated at initiation, and then at 1 hour, 12 hours, and 24 hours after starting NIV.The score comprises five parameters:

Patients were followed up to determine NIV success (weaning off NIV without intubation) or failure (need for endotracheal intubation).

A HACOR score >5 was used as the cutoff to predict NIV failure.

Category	Assigned points
Heart rate (beats per minute)	
<100	0
100-119	1
139	2
≥140	3
pH (Acidosis)	
≥7.35	0
7.30-7.34	2
7.25-7.29	3
7.20-7.24	4
<7.20	8
Consciousness (GCS)	
15	0
14	2
13	4
12	6
≤11	11
Oxygenation (PaO_2/FiO_2)	
≥150	0
101-149	1
≤100	2
Respiratory rate (breaths/min)	
<30	0
30-34	1
35-39	2
≥40	3

[Table/Fig-1]: HACOR scoring system [4].
GCS: Glasgow coma scale; PaO_2: Partial pressure of oxygen; FiO_2: Fraction of inspired oxygen

STATISTICAL ANALYSIS

Microsoft (MS) Excel 2019 and Statistical Package for the Social Sciences (SPSS) software version 24.0 were used. All values were presented as means, standard deviations and percentages. The ROC curve were made. The dependent variables were the components of the HACOR score, while the independent variables included age, sex and co-morbidities.

RESULTS

VARIABLES OF HACOR SCORE

Table 1: Heart Rate (bpm)

Time Point	Successful NIV (Cut off < 5)	NIV Failure (Cut off ≥ 5)	P Value
Before NIV	110 ± 24	122 ± 24	<0.01
1 hour of NIV	102 ± 22	117 ± 24	<0.01
12 hours of NIV	98 ± 13	110 ± 18	<0.01
24 hours of NIV	87 ± 17	105 ± 20	<0.01

Table 2: Respiratory Rate (breaths/min)

Time Point	Successful NIV (Cut off < 5)	NIV Failure (Cut off ≥ 5)	P Value
Before NIV	28 ± 7	34 ± 8	<0.01
1 hour of NIV	27 ± 7	36 ± 10	<0.01
12 hours of NIV	23 ± 13	38 ± 13	<0.01
24 hours of NIV	22 ± 10	30 ± 6	<0.01

Table 3: Glasgow Coma Scale (GCS) Score

Time Point	Successful NIV (Cut off < 5)	NIV Failure (Cut off ≥ 5)	P Value
Before NIV	14.8 ± 0.8	14.5 ± 1.8	<0.01
1 hour of NIV	14.9 ± 0.5	14.1 ± 1.9	<0.01
12 hours of NIV	14.5 ± 1.2	14.2 ± 0.8	0.41
24 hours of NIV	14.9 ± 0.9	14.1 ± 1.1	0.02

Table 4: pH Levels in Successful vs. Failed NIV Groups

Time Point	Successful NIV (Cut off < 5)	NIV Failure (Cut off ≥ 5)	P Value
Before NIV	7.44 ± 0.02	7.36 ± 0.08	0.04
1 hour of NIV	7.45 ± 0.06	7.34 ± 0.12	<0.01
12 hours of NIV	7.43 ± 0.08	7.34 ± 0.10	0.01
24 hours of NIV	7.40 ± 0.07	7.29 ± 0.14	<0.01

Table 5: PaO_2/FiO_2 Ratio (mmHg) in Successful vs. Failed NIV Groups

Time Point	Successful NIV (Cut off < 5)	NIV Failure (Cut off ≥ 5)	P Value
Before NIV	179 ± 84	135 ± 64	<0.01
1 hour of NIV	201.53 ± 66.9	133 ± 69	<0.01
12 hours of NIV	222 ± 80	175.6 ± 63.1	<0.01
24 hours of NIV	256 ± 80	171 ± 68	<0.01

Differences between the two groups were analyzed with independent samples t tests.

Demographics of patients with noninvasive ventilation failure and success

Demographics	NIV success	NIV Failure	p
Age (years)	65 ± 10	65 ± 15	0.51
Male gender (%)	29 (54%)	14 (63%)	0.03
Diagnosis			
Pneumonia	24 (46%)	6 (27%)	0.01
Lung cancer	12 (28%)	7 (31%)	0.02
ARDS	8 (15%)	9 (40%)	<0.01
ILD	4	1 (4%)	0.08
Others	4	1 (4%)	0.25

Independent samples t-test, chi-square test, p values <0.05 were calculated for above variables.
Variables are presented as mean±SD. Categorical variables are reported as numbers and percentages.

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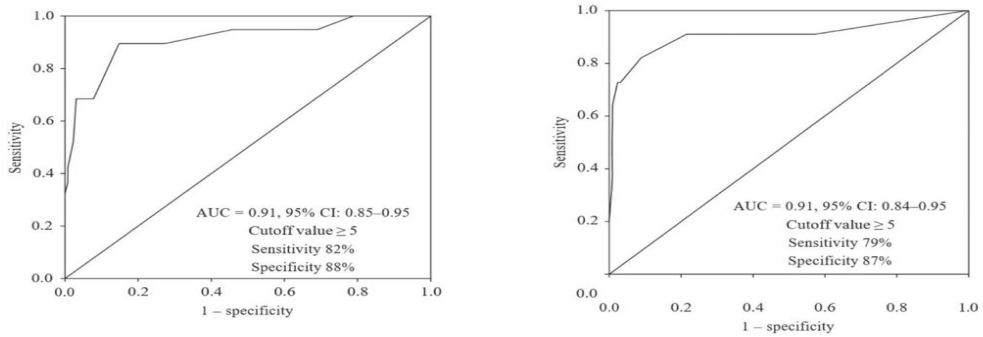
Predictive power of HACOR score assessed at 1, 12 and 24 hours in prediction of failed NIV

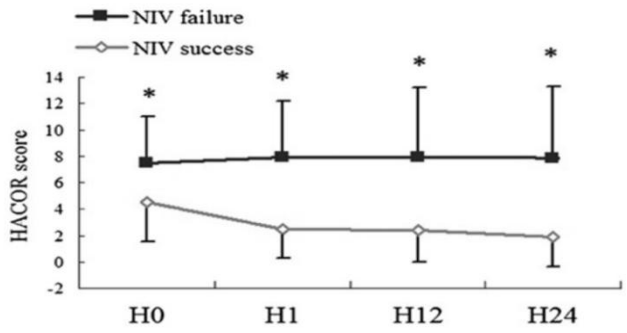
Indices	1 h	12 h	24 h
		Cut off point > 5	
Sensitivity [%]	82	79	76
Specificity [%]	88	87	85
Positive predictive value [%]	92.5	90.2	91.3
Negative predictive value [%]	71.4	72.2	70.4
Diagnostic accuracy [%]	85	84	85



ROC showing cutoff value for HACOR score to predict NIV failure. Area under the curve(AUC) value of 0.91 was obtained for 1st hr and 12 hr of NIV. And sensitivity and Specificity were 82 % and 88 %, 79% and 87 % respectively at a cut off value 5.

	NIV Success (Cut off value < 5)	NIV Failure (Cut off value ≥ 5)	P
NIV Initiation	4.5 ± 3.0	7.4 ± 3.5	<0.01
1 h of NIV	3.0 ± 2.2	7.8 ± 4.3	< 0.01
12 h of NIV	2.7 ± 2.4	7.8 ± 5.3	< 0.01
24 h of NIV	1.9 ± 2.3	7.8 ± 5.5	< 0.01

Mean with SD values of HACOR score at Baseline, 1 h, 12h, 24h.



The HACOR score in patients with NIV failure and success from initiation to 24 h of NIV

Early versus late intubation in patients with a HACOR score of >5 at 1 h of Non-invasive ventilation

NIV time points and hospital mortality	Intubation at ≤12 h	Intubation at >12 h	P
HACOR score at 1 h of NIV	11 ± 4.0	9 ± 3	<0.01
HACOR score before intubation	13 ± 4.3	12 ± 4.0	0.22
Hospital mortality	7 (31%)	11 (50%)	0.03

Values in table are presented as the mean ± SD.

DISCUSSION

In this study,age was not a significant factor influencing noninvasive ventilation (NIV) outcomes, with comparable mean ages between the success and failure groups. However, male gender was significantly more prevalent in the failure group, suggesting a possible gender-related association with NIV failure. Physiological parameters revealed that patients who failed NIV consistently had higher heart and respiratory rates at all time points, both statistically significant findings, indicating that persistent tachycardia and tachypnea may predict poor NIV response. Additionally, Glasgow Coma Scale (GCS) scores were lower in the failure group, particularly at baseline, 1 hour, and 24 hours, suggesting reduced consciousness as a potential risk factor. The failure group also showed persistent acidosis, reflected in significantly lower pH values, pointing to worsening ventilation or respiratory muscle fatigue. Furthermore, the PaO_2/FiO_2 (P/F) ratio was markedly lower in the failure group throughout the observation period, highlighting impaired oxygenation as a strong predictor of the need for invasive ventilation.

The distribution of primary diagnoses revealed notable differences in NIV outcomes. Pneumonia was significantly more common in the success group (46% vs. 27%; P = 0.01), indicating a better response to NIV in these patients. In contrast, ARDS was significantly more prevalent in the failure group (40% vs. 15%; P < 0.01), highlighting its strong association with NIV failure, likely due to severe hypoxemia and poor lung compliance. Lung cancer was present in both groups, but a slightly higher failure rate (31% vs. 28%; P = 0.02) suggests malignancy may be linked to poorer outcomes. Diagnoses such as interstitial lung disease and other conditions (e.g., pulmonary embolism, post-operative respiratory failure) showed no significant differences between groups, indicating limited predictive value for NIV success or failure.

Predictive Power of HACOR Score at 1, 12, and 24 Hours in Prediction of Failed NIV

The present study evaluated the predictive performance of the HACOR score (>5 cut-off) in identifying NIV failure in patients with acute hypoxemic respiratory failure (AHRF), demonstrating high sensitivity (82% at 1 hour, declining slightly to 76% at 24 hours) and consistently strong specificity (88–85%) across all time points. The high positive predictive value (PPV >90%) suggests that a score >5 reliably predicts NIV failure, while the moderate negative predictive value (NPV ~70%) indicates that a lower score does not entirely exclude risk. These findings align with Duan et al.'s original study[3], where a HACOR score >5 strongly predicted NIV failure in AHRF patients, and early intubation based on this score reduced mortality. Duan's subsequent validation in COPD patients[4] further supported the score's reliability in predicting early NIV failure (<48 hours) and improved outcomes with early intervention.

Guia et al.'s[6] study in COVID-19 patients using CPAP showed that the HACOR score (82.03% accuracy) was comparable to the PaO_2/FiO_2 ratio, though the latter slightly outperformed it, suggesting that while HACOR is useful, oxygenation indices may be superior in certain viral pneumonias. Ding et al[5]. assessed non-COPD patients with varied underlying conditions and found HACOR highly sensitive and specific across time points (e.g., 90% sensitivity and 85% specificity at 1–2 hours), reaffirming its utility across diverse AHRF populations. Similarly, Magdy et al[7]. extended the HACOR application to patients on high-flow nasal cannula (HFNC), concluding that a score <6 at 1 hour indicated a lower risk of failure, thereby supporting its broader applicability beyond NIV.

At NIV initiation, patients who eventually succeeded on NIV had a mean HACOR score of 4.5 ± 3.0, whereas those who failed had a significantly higher score of 7.4 ± 3.5. This early difference persisted and even widened over time. At 1 hour, the mean score dropped to 3.0 ± 2.2 in the success group, while it

remained elevated in the failure group (7.8 ± 4.3). A similar trend continued at 12 hours (2.7 ± 2.4 vs. 7.8 ± 5.3) and 24 hours (1.9 ± 2.3 vs. 7.8 ± 5.5), indicating progressive improvement in successful cases and persistent high scores in failure cases.

These findings underscore that a persistently elevated HACOR score (≥5) correlates strongly with NIV failure, while declining scores are associated with successful weaning.

Patients intubated within 12 hours had a higher mean HACOR score at 1 hour (11 ± 4.0) compared to those intubated after 12 hours (9 ± 3), and this difference was statistically significant ($P < 0.01$), indicating that more severe patients were intubated earlier. Interestingly, despite higher early scores, these patients had a lower hospital mortality (31%) than those intubated later (50%), a difference that was also statistically significant ($P = 0.03$). The HACOR score immediately before intubation was similar between groups (13 ± 4.3 vs. 12 ± 4.0; $P = 0.22$), suggesting that delaying intubation did not allow for clinical improvement and may have contributed to worse outcomes.

Limitations

It is a single center study and sample size is small.The study was conducted over only 5 months which may not capture seasonal variations or long term outcomes and also cannot differentiate between acute and chronic conditions.The etiological diagnosis could not be arrived for some patients.

CONCLUSION

The HACOR score is a useful and easy-to-use tool to predict the failure of non-invasive ventilation (NIV) in patients with acute hypoxemic respiratory failure. A score greater than 5, especially within the first hour of NIV, is strongly linked with a higher risk of NIV failure. Early identification using the HACOR score can help doctors make timely decisions, such as intubation, which may improve patient outcomes and reduce hospital mortality.

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