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Utility of the Updated HACOR Score in Predicting Non-Invasive Ventilation Failure in Acute Hypoxemic Respiratory Failure: A Prospective Observational Study from India

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Abstract: ***Background**: Non-invasive ventilation (NIV) is widely used in acute hypoxemic respiratory failure (AHRF). The HACOR score predicts NIV failure, but its utility in non-COPD AHRF is limited. The updated HACOR score incorporates additional predictors and may provide improved accuracy. **Objectives**: To evaluate the utility of the updated HACOR score in predicting NIV failure in AHRF and compare it with the original HACOR score. **Methods**: This was a prospective observational study in a tertiary-care hospital in India. Fifty adults with AHRF initiated on NIV were enrolled. Clinical and arterial blood gas analysis data were collected. HACOR and updated HACOR scores were calculated. Receiver operating characteristic (ROC) curves were used to assess predictive accuracy. **Results**: Among 50 patients, 35 (70%) had successful NIV, and 15 (30%) failed. Lower respiratory tract infection (82%) and cardiogenic pulmonary edema (40%) were common causes. 40% of NIV failures occurred within 12 hours of initiating NIV. Patients with NIV failure had higher respiratory rates (36.1 ± 6 vs. 29.4 ± 4.9/min, p = 0.01), lower PaO_2/FiO_2 ratios (218.6 ± 37.3 vs. 243.3 ± 29.0, p = 0.01 at presentation and 211.4 ± 49.4 vs. 248.0 ± 38.7, p = 0.01 at 1 hour), and higher updated HACOR scores (12.6 ± 2.1 vs. 7.4 ± 2.3, p < 0.001). **Conclusion**: The updated HACOR score demonstrated higher predictive accuracy than the conventional HACOR score for identifying NIV failure in patients with acute hypoxemic respiratory failure. Early application of the score may facilitate timely escalation of respiratory support and improve clinical decision-making in intensive care settings.*

Keywords: acute hypoxemic respiratory failure, non-invasive ventilation, Updated HACOR score, predictive accuracy, NIV failure, critical care

1. Introduction

Acute hypoxemic respiratory failure (AHRF) is a common medical emergency that often requires patients to receive ventilatory support. In such situations, non-invasive ventilation (NIV) has emerged as the preferred first-line approach, effectively reducing the complications associated with invasive mechanical ventilation (IMV). While non-invasive ventilation (NIV) can help many patients avoid the need for intubation, it is not effective for everyone. Patients who fail to respond to NIV often have poorer outcomes. Some common signs that NIV may not succeed include unstable hemodynamics, difficulty tolerating the mask due to altered consciousness, and upper airway obstruction in the lungs that limit effective gas exchange. [10] However, it is important to understand that whenever non-invasive ventilation fails, an urgent need for invasive mechanical ventilation arises. There are serious risks and complications of intubation when it is delayed. [1-3]

Early identification of NIV failure is essential, as timely recognition allows prompt escalation of respiratory support and may improve clinical outcomes. The HACOR score, which looks at heart rate, acidosis, consciousness level, oxygenation, and respiratory rate, is commonly used to predict whether NIV will succeed or fail. [4] This score also has some drawbacks, especially in non-COPD patients with acute hypoxemic respiratory failure (AHRF), where acidosis and low consciousness are not always seen clearly. [5] To overcome this, Duan and colleagues suggested the updated HACOR score. It includes baseline factors like pneumonia, ARDS, cardiogenic pulmonary edema, immunosuppression, septic shock, and the SOFA score. [6] Adding these makes the score more accurate and gives a clearer picture of the patient's condition, which helps in better decisions and management. Even though the updated score has been tested and accepted in other countries, there are very few studies from India. This shows that more local research is needed. Given the high burden of pneumonia and sepsis-driven AHRF in our setting, we conducted this study to evaluate the utility of the updated HACOR score in predicting NIV failure and to compare it with the original HACOR score.

2. Materials and Methods

Study Design and Setting
A prospective observational study was conducted in the Department of Medicine, in a tertiary care centre in New Delhi, between 2023–2025.

Inclusion Criteria
- Age ≥18 years
- Acute hypoxemic respiratory failure ($PaO_2/FiO_2 < 300$)
- Preserved respiratory drive and cough reflex

Exclusion Criteria
- Pregnancy
- Facial trauma
- Immediate need for intubation
- GCS < 12
- Severe respiratory acidosis (pH < 7.25 with $PaCO_2 > 45$ mmHg)
- Hemodynamic instability unresponsive to fluids/vasopressors

Definitions
NIV failure was defined as the requirement of endotracheal intubation due to:
- Cardiorespiratory arrest
- PaO_2/FiO_2 <100 despite NIV
- Decline in consciousness/coma
- Excessive secretions or aspiration risk
- Severe fatigue or hemodynamic instability

Methodology
Fifty patients with AHRF initiated on NIV were enrolled after applying predefined inclusion and exclusion criteria. Demographic, clinical, and laboratory data were recorded. The data collected will undergo entry into Microsoft Excel and subsequent analysis using SPSS-25. Updated HACOR and HACOR scores were calculated at baseline and 1 hour, and patients' evaluations were performed at 12 hours, 24 hours, and 48 hours. NIV failure was defined as the need for intubation due to worsening hypoxemia, hemodynamic instability, or altered sensorium. Predictive performance was analyzed using ROC curves. Complete patient confidentiality was maintained throughout the study, and informed consent for participation was taken from each participant. The study was reviewed and granted approval by the Institutional Ethics Committee (IEC), MAMC and associated hospitals, New Delhi.

3. Results

The participants had a mean age of 53.68 ± 17.41 years, with a median age of 59 years. The gender distribution was nearly equal, with 56% females and 44% males. Of 50 patients, 35 (70%) had successful NIV, while 15 (30%) experienced NIV failure. In our study, the aetiologies of acute hypoxemic respiratory failure (AHRF) were not mutually exclusive; in many patients, more than one contributing factor was identified. Among these, lower respiratory tract infection (LRTI) was the most frequent cause, seen in 84% of the cases (n=41). Cardiogenic pulmonary edema accounted for 40% (n=20), followed by interstitial lung disease (ILD) and empyema, each contributing to 14% (n=7). Acute coronary syndrome (ACS) was responsible for 10% (n=5), and non-cardiogenic pulmonary edema was observed in 8% (n=4).

Non-invasive ventilation (NIV) was initiated in all patients, with CPAP being the preferred mode in 76% (n=38), while BiPAP was used in 24% (n=12). The overall NIV success rate was 70% (n=35), whereas 30% (n=15) failed and required escalation of support. Among those who failed, 40% experienced NIV failure within 12 hours, 33.3% within 24 hours, and 26.6% within 48 hours, reflecting that most failures occurred early in the course of therapy.

Comparison
Comorbidities such as diabetes mellitus, hypertension, coronary artery disease, chronic kidney disease, and chronic liver disease were similarly distributed between the two groups.

On clinical examination, patients in the failure group had higher respiratory rates (mean 34.33 vs. 30.74/min) and higher heart rates, though these did not reach statistical significance. However, systolic and diastolic blood pressures were notably lower in the failure group (mean SBP 106.07 mmHg vs. 123.6 mmHg; DBP 66.0 vs. 75.9 mmHg), suggesting hemodynamic compromise as an adverse prognostic feature.

Etiological comparison revealed that LRTI was common to almost all failures (100%) and the majority of success group patients (74.3%). Empyema, however, emerged as a significant determinant of NIV failure (33.3% vs. 2.9%, p=0.01). Other etiologies like ILD, ACS, and cardiogenic or non-cardiogenic pulmonary edema did not show significant differences in outcome.

Hematological parameters such as hemoglobin, leukocyte count, and platelets were similar between the two groups. Renal parameters (urea and creatinine) were also comparable, indicating that renal dysfunction alone did not predict NIV outcome.

In hepatic parameters, direct bilirubin was significantly higher in the failure group (mean 2.66 mg/dL vs. 0.57 mg/dL, p = 0.01), suggesting hepatic dysfunction as a possible marker of systemic involvement and worse prognosis. AST and ALT were elevated in both groups but without statistical difference.

Arterial blood gas comparison revealed that a lower pH and PaO_2 were strongly associated with NIV failure. The mean pH was 7.25 in the failure group versus 7.34 in the success group (p=0.02), and mean PaO_2 was 45.66 mmHg versus 52.02 mmHg (p=0.01).

Comparison between components of HACOR and updated HACOR score
At the time of NIV initiation, patients who eventually failed therapy showed more severe physiological derangements. Their arterial pH was notably lower (7.25 ± 0.15 vs. 7.34 ± 0.09, p = 0.02), reflecting greater acidosis. They also had a higher respiratory rate (34.3 ± 7.8 vs. 30.7 ± 5.8 breaths/min, p = 0.07) and lower oxygenation (PaO_2/FiO_2 218.6 ± 37.3 vs. 243.3 ± 29.0, p = 0.01). Although heart rate and SOFA scores were higher in the failure group, these differences did not reach statistical significance. Septic shock was more frequent among failures (26% vs 5.7%, p = 0.05), and pneumonia was

present in all failed cases compared to about three-fourths of successful ones. ARDS occurred only in the failure group, whereas cardiogenic pulmonary edema was more common among those who improved.

After one hour of NIV, these trends became more evident. The failure group continued to show a lower arterial pH (7.29 ± 0.10 vs 7.34 ± 0.07, p = 0.03), higher heart rate (115.5 ± 16.3 vs 103.8 ± 17.9 bpm, p = 0.03), and significantly elevated respiratory rate (36.1 ± 6.9 vs 30.1 ± 5.1 breaths/min, p = 0.001). Oxygenation remained poorer (PaO_2/FiO_2 211.4 ± 49.4 vs 248.0 ± 38.7, p = 0.01), and SOFA scores were higher (6.2 ± 3.1 vs 4.5 ± 2.3, p = 0.03).

At baseline, the mean conventional HACOR score was significantly higher in patients who failed NIV (6.13 ± 2.32 vs 2.89 ± 2.11, p < 0.001), paralleled by an even greater difference in the updated HACOR score (12.43 ± 2.73 vs 5.62 ± 3.79, p < 0.001).

After one hour, these differences persisted, with the failure group showing higher conventional (7.07 ± 3.17 vs 2.97 ± 2.35, p < 0.001) and updated HACOR scores (13.56 ± 4.40 vs 5.51 ± 3.72, p < 0.001), underscoring a consistent divergence in physiological response during early NIV therapy.

Table 1: Distribution of various demographic, anthropometric, clinical, and investigational parameters

	parameter	All patients	Failure(n=15)	Success (n=35)	P value
AGE (Years)	Mean (SD)	53.68 (17.41)	53.07±18.10	53.94±17.37	0.75
Gender	Male	22 (44.0%)	8(53.3%)	14(40.0%)	0.68
	Female	28 (56.0%)	7(46.7%)	21(60.0%)	
Anthropometry	BMI	24.401±3.71	24.88±4.05	24.19±3.60	0.55
Clinical findings	Heart rate	103.84±19.03	109.13±15.99	102.32±19.58	0.24
	GCS	14.40±0.80	14.13±0.83	14.51±0.78	0.12
	RR	31.82±6.57	34.33±7.76	30.74±5.78	0.07
	SBP	118.34±28.78	106.07±16.18	123.60±31.49	0.04
	DBP	72.98±14.45	66.0±11.46	75.97±14.70	0.02
ABG parameters	Arterial pH	7.29±0.29	7.25±0.15	7.34±0.09	0.02
	PaO2	50.11±8.33	45.66±7.18	52.02±8.14	0.01
ETIOLOGY	ILD	7(14.0%)	2(13.3%)	5(14.3%)	1.0
	LRTI	41(82.0%)	15(100.0%)	26(74.3%)	0.37
	ACS	5(10.0%)	1(6.7%)	4(11.4%)	1.0
	NCPE	4(8.0%)	0(0.0%)	4(11.4%)	0.32
	Empyema	7(14.0%)	5(33.3%)	1(2.9%)	0.01
	CPE	20(40.0%)	5(33.3%)	15(42.9%)	0.61

Table 2: Distribution of various blood investigations

	Failed (n=15)	Success (n=35)	P value
Platelets (Mean±SD)	1.68±1.24	2.0±1.42	0.60
Creatinine (Mean±SD)	2.62±2.44	3.03±4.02	0.84
Total bilirubin (Mean±SD)	3.12±5.85	1.42±2.44	0.13
Direct Bilirubin (Mean±SD)	2.66±5.87	0.57±0.50	0.01

Table 3: Comparison of individual components of updated HACOR score and HACOR score between NIV failed and success at 0 hour and at 1 hour

	At 0 hour			At 1 hour		
Components	Failed (n=15)	Success (n=35)	P value	Failed (n=15)	Success (n=35)	P value
Arterial pH (Mean±SD)	7.25±0.15	7.34±0.09	0.02	7.29±0.10	7.34±0.07	0.03
HR (Mean±SD)	109.13±15.99	102.32±19.58	0.24	115.47±16.30	103.76±17.93	0.03
RR (Mean±SD)	34.33±7.76	30.74±5.78	0.07	36.13±6.94	30.11±5.15	0.001
GCS (Mean±SD)	14.13±0.83	14.51±0.78	0.12	14±0.83	14.51±0.78	0.08
PaO2/FiO2(Mean±SD)	218.60±37.26	243.31±29.0	0.01	211.4±49.36	248.0±38.66	0.01
SOFA score(Mean±SD)	6.20±3.05	4.49±2.25	0.06	6.20±3.05	4.46±2.30	0.03
Immunosuppression	0	3	1.0	0	3	1.0
Septic shock	4	2	0.05	4	2	0.05
Pneumonia	15	26	0.37	15	26	0.37
Pulmonary ARDS	2	0	0.08	2	0	0.08
CPE	2	14	0.09	2	14	0.09
Updated HACOR score	12.43±2.73	5.62±3.79	<0.001	13.56±4.40	5.51±3.72	<0.001
HACOR score	6.13±2.32	2.89±2.11	<0.001	7.07±3.17	2.97±2.35	<0.001

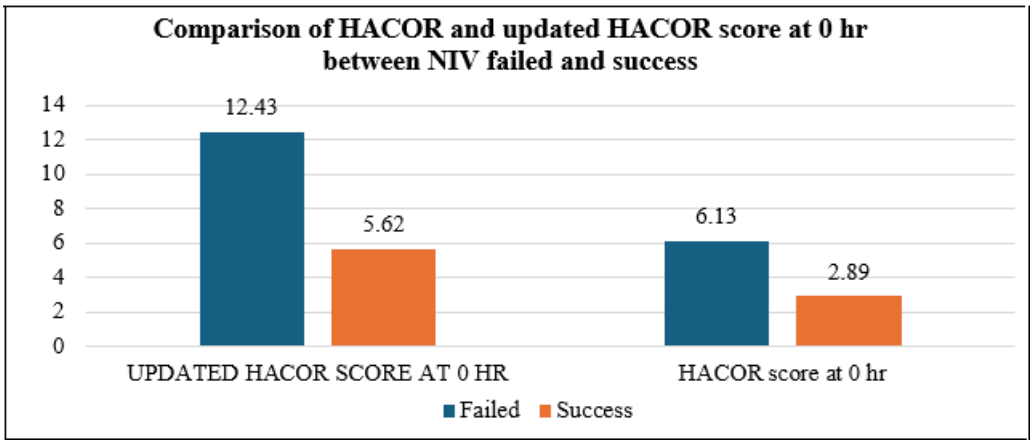

Figure 1: Showing a comparison of the mean updated HACOR score and HACOR score at 0 hr between NIV failed and success

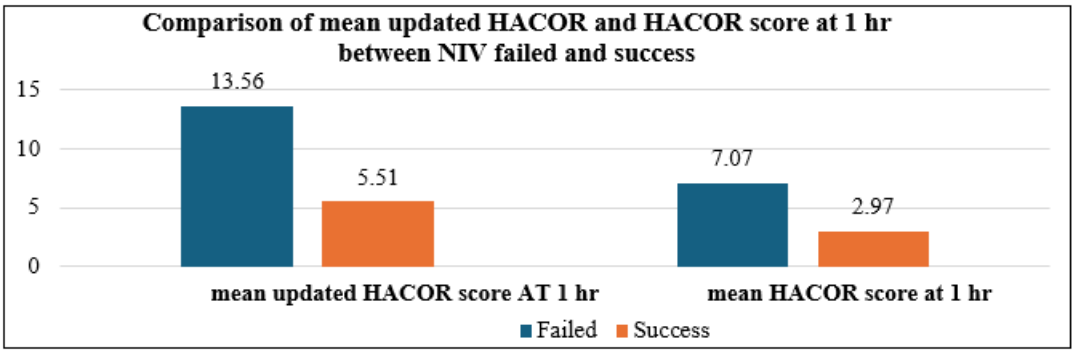

Figure 2: Showing a comparison of the mean updated HACOR score and HACOR score at 1 hr between NIV failed and success

Table 4: Univariate logistic regression analysis to predict outcome

	P value	Adjusted odd ratio	95% C.I.for odds ratio	
			Lower	Upper
HR 0 hr	0.250	1.020	0.986	1.056
RR 0 hr	0.038	1.124	1.007	1.255
SOFA0hr	0.041	1.290	1.010	1.647
Pa02/FiO2	0.021	0.977	0.957	0.996
pH 0 hr	0.035	0.003	0.000	0.664
HACOR score	0.001	1.877	1.300	2.710
Updated HACOR 0 hr	0.000	2.028	1.376	2.988
HR 1 hr	0.050	1.038	1.000	1.078
RR 1 hr	0.006	1.192	1.052	1.351
SOFA1hr	0.040	1.289	1.011	1.644
Pa02/FiO2 1 hr	0.012	0.980	0.965	0.996
pH 1 hr	0.054	0.001	0.000	1.135
HACOR score 1 hr	0.001	1.660	1.246	2.212
Updated HACOR 1 hr	0.001	1.935	1.303	2.873

Table 5: Statistical characterstics of the HACOR and updated HACOR score

Parameter	SCORE AT 0 HOUR					SCORE AT 1 HOUR		
	Updated HACOR score		HACOR score		Updated HACOR score		HACOR score	
	Value	95% CI	Value	95% CI	Value	95% CI	Value	95% CI
AUC	0.93	0.84-1.0	0.84	0.73-0.96	0.93	0.83-1.0	0.84	0.71-0.97
P-value	<0.001		<0.001		<0.001		<0.001	
Cut off value	8.75		4.5		10.5		5.5	
Sensitivity	93.33%	68.05% - 99.83%	73.33%	44.90% - 92.21%	93.33%	68.05% - 99.83%	73.33%	44.90% - 92.21%
Specificity	94.29%	80.84% - 99.30%	82.86%	66.35% - 93.44%	91.43%	76.94% - 98.20%	85.71%	69.74% - 95.19%
Positive Likelihood Ratio	16.33	4.22 - 63.16	4.28	1.94 - 9.42	10.89	3.66 - 32.40	5.13	2.16 - 12.22
Negative Likelihood Ratio	0.07	0.01 - 0.47	0.32	0.14 - 0.75	0.07	0.01 - 0.49	0.31	0.13 - 0.73
Positive Predictive Value	87.50%	64.41% - 96.44%	0.32	45.42% - 80.15%	82.35%	61.06% - 93.28%	68.75%	48.04% - 83.96%
Negative Predictive Value	97.06%	83.22% - 99.55%	87.88%	75.55% - 94.45%	96.97%	82.77% - 99.53%	88.24%	76.22% - 94.61%
Accuracy	94.00%	83.45% - 98.75%	80.00%	66.28% - 89.97%	92.00%	80.77% - 97.78%	82.00%	68.56% - 91.42%

- **HACOR Score:**
  At 0 hour: AUC = 0.84 (95% CI: 0.73 – 0.96), cutoff >4.5 (sensitivity 73.33%, specificity 82.86%)
  At 1 hour: AUC = 0.84 (95% CI: 0.71 – 0.97), cutoff >5.5 (sensitivity 73.33%, specificity 85.71%)

- **Updated HACOR Score:**
  At 0 hour: AUC = 0.93 (95% CI: 0.84–1.0), cutoff 8.75 (sensitivity 93.33%, specificity 94.29%)
  At 1 hour: AUC = 0.93 (95% CI: 0.83–1.0), cutoff 10.5 (sensitivity 93.33%, specificity 91.43%)

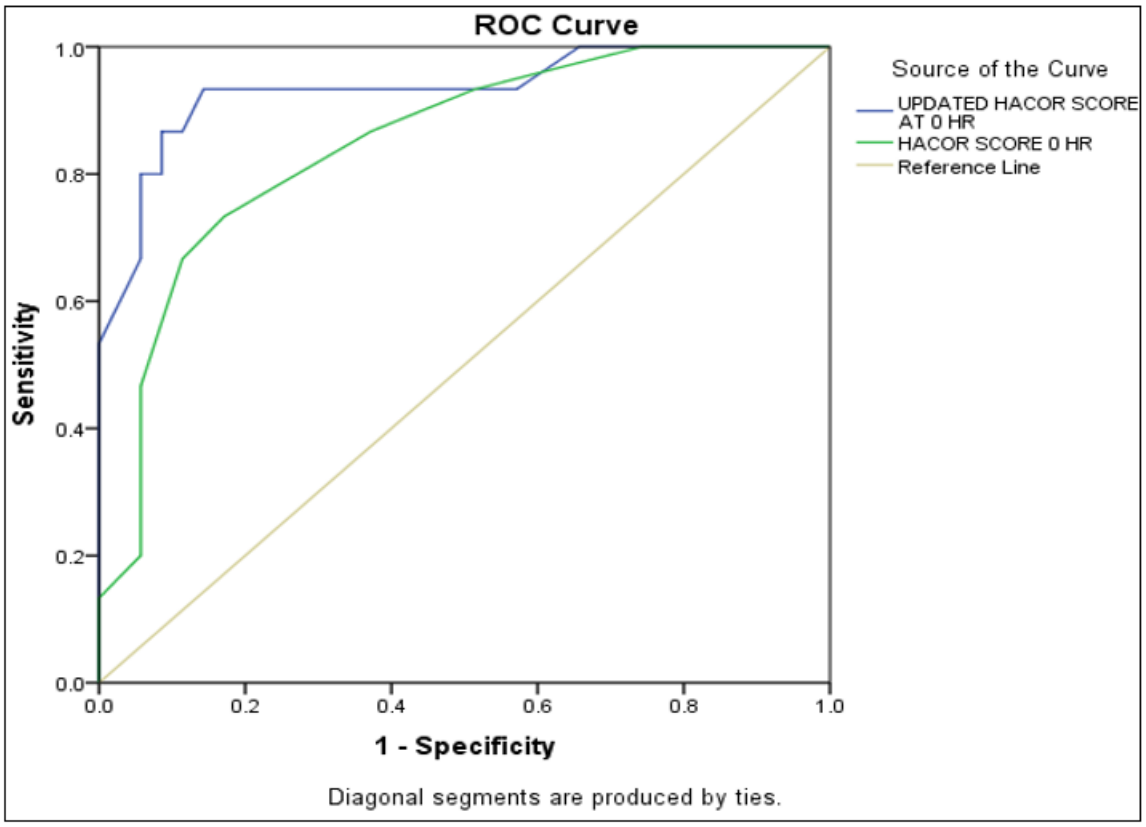

Figure 3: ROC analysis using the updated HACOR score and HACOR score at 0 hr to predict NIV failure

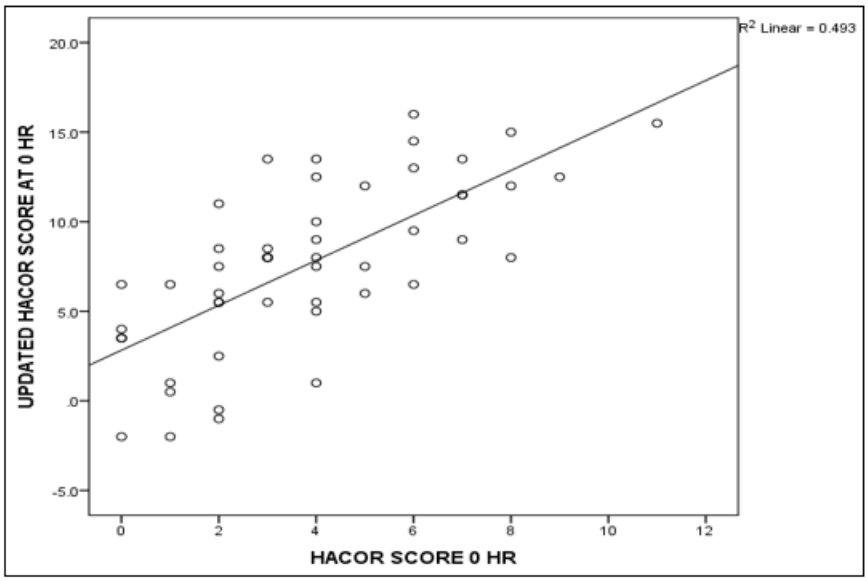

Figure 4: Scatter plot analysis using the updated HACOR score and HACOR score at 0 hr to predict NIV failure

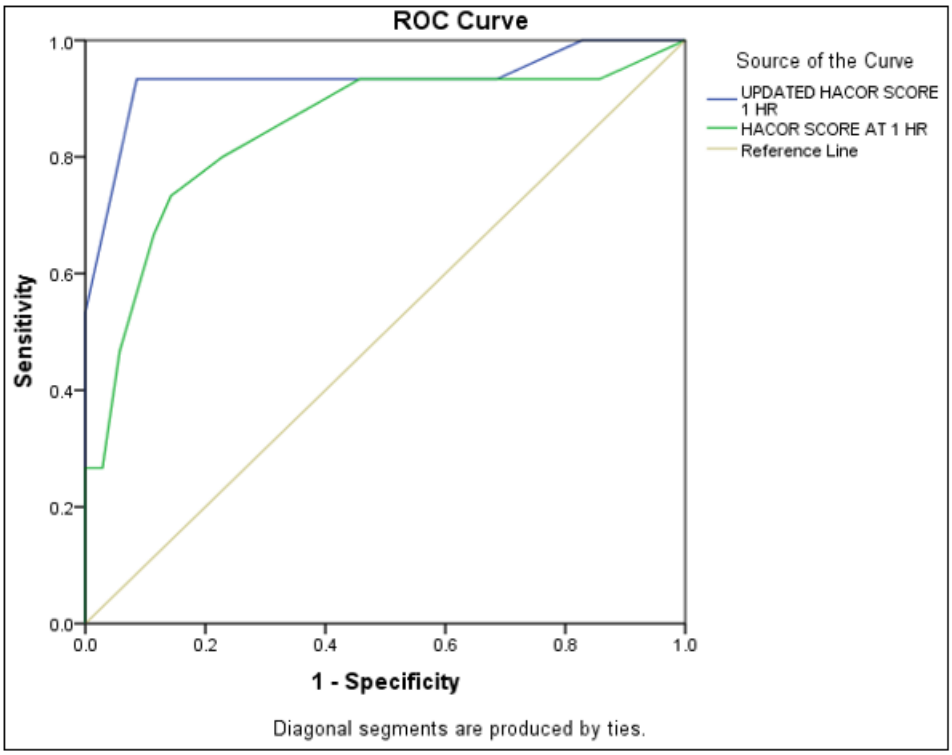

Figure 5: ROC analysis using the updated HACOR score and HACOR score at 1 hour to predict NIV failure

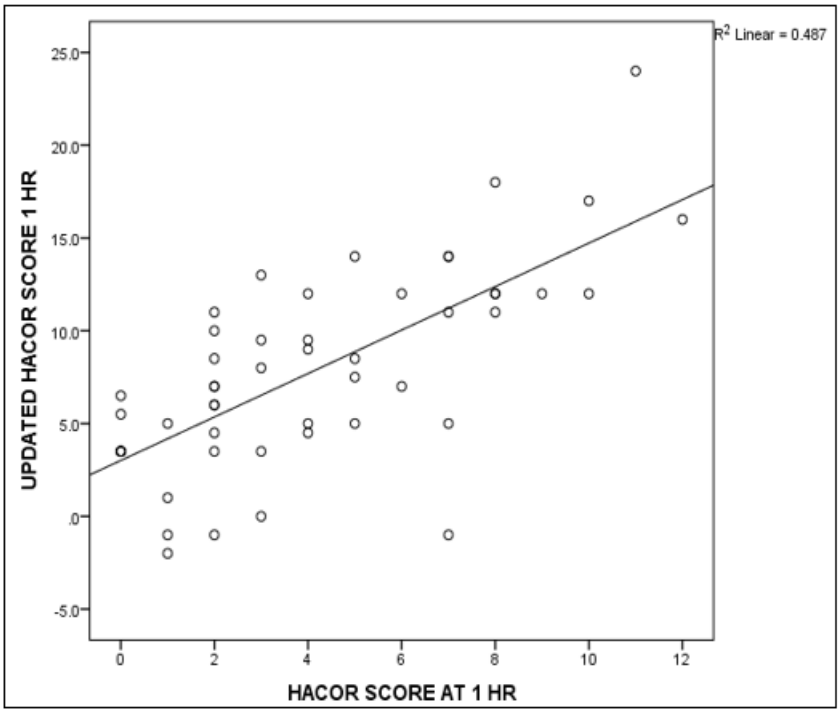

Figure 6: Scatter plot analysis using the updated HACOR score and HACOR score at 1 hour to predict NIV failure

4. Discussion

In this prospective study, the updated HACOR score outperformed the original HACOR in predicting NIV failure among patients with AHRF. NIV failure occurred in 30% of patients, consistent with prior studies, and was associated with a higher mortality risk when intubation was delayed.[7-9]

Our findings are in line with Duan et al., who reported improved predictive accuracy of the updated HACOR score by incorporating systemic severity markers such as the SOFA score and septic shock.[6] In our cohort, pneumonia and cardiogenic pulmonary edema were predominant etiologies, reflecting the Indian disease profile. Importantly, most NIV failures occurred within the first 12–24 hours, reinforcing the need for close monitoring and timely escalation.

The updated HACOR score thus offers a dynamic, bedside, and reproducible method to identify high-risk patients. This may be particularly valuable in resource-limited settings where ICU beds and intensivist support are constrained.

5. Conclusion

The updated HACOR score demonstrated excellent discrimination for predicting NIV failure in patients with acute hypoxemic respiratory failure and performed better than the conventional HACOR score at both baseline and one hour after NIV initiation. Its use may assist clinicians in identifying high-risk patients and making timely decisions regarding escalation to invasive ventilation.

6. Limitations

- Single-centre, small sample size
- Did not assess long-term mortality or ICU stay
- Requires external validation in larger multicenter Indian cohorts

Conflict of Interest:
The authors report that there are no conflicts of interest related to this work.

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