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Original Research Article

The Positive Predictive Value of HACOR Score (Heart Rate, Acidosis, Consciousness, Oxygenation, and Respiratory Rate) in Predicting Non-Invasive Ventilation Failure in ADHF and AECOAD

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Abstract: *Noninvasive ventilation (NIV) is widely used in acute respiratory failure due to acute decompensated heart failure and acute exacerbations of chronic obstructive airway disease. Delayed recognition of NIV failure can worsen outcomes. Early risk stratification using validated bedside tools is therefore essential.* ***Objective:*** *Noninvasive ventilation is frequently used to treat acute respiratory failure caused by acute decompensated heart failure (ADHF) and acute exacerbations of chronic obstructive airway disease (AECOAD). To prevent intubation delays, it is essential to predict NIV failure in advance. The HACOR score is a clinical instrument for this purpose, which is based on respiratory rate, oxygenation, heart rate, acidosis, and consciousness.* ***Methods:*** *A descriptive study was conducted at Dr. Ziauddin Hospital, Karachi, from December 2024 to May 2025. In total, 257 individuals had acute respiratory failure on NIV. HACOR scores were obtained at baseline and 1-2 hours after the start of NIV. The requirement for endotracheal intubation within two hours of beginning NIV is the main consequence, which is known as NIV failure.* ***Results:*** *In this research, 54.1% of the patients were diagnosed with AECOAD, with an average age of 63.1 years (SD ±9.9). Patients with elevated HACOR scores had a significantly higher likelihood of experiencing NIV failure. The HACOR cut-off values of ≥7.5 at admission and ≥5.5 after 1–2 hours showed high predictive accuracy, with both sensitivity and specificity exceeding 96%. Among the individual factors, tachycardia, low pH, lower GCS, and impaired oxygenation were strongly associated with NIV failure ($p < 0.05$).* ***Conclusion:*** *Patients with AECOAD and ADHF can benefit from the use of the HACOR score as a bedside tool to predict NIV failure. When used promptly, it can help with early intubation decision-making, leading to better clinical outcomes.*

Keywords: Non Invasive Ventilation, Chronic Obstructive Airway Disease, Respiratory Failure, Heart failure

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Introduction

The provision of positive-pressure ventilation to the lungs without an endotracheal tube is known as non-invasive ventilation (NIV). It is used to treat acute obstructive pulmonary disease (AECOPD) and acute decompensated heart failure (ADHF). (1) NIV is indicated in patients with chronic obstructive pulmonary disease (COPD), sleep apnea-hypopnea syndrome, bronchiectasis, chest wall deformity, obesity-hypoventilation syndrome, and neuromuscular disease. NIV lowers the requirement for intubation in COPD patients with hypercapnia related to acute-on-chronic respiratory failure(2). All NIV patients were managed by attending physicians, respiratory therapists, and charge nurses in accordance with current recommendations, consensus, and previously published methodologies (3, 4). The NIV is widely used to avoid intubation because it has several significant advantages over invasive ventilation (for example, maintaining the ability to swallow, cough, and communicate verbally) (5). It lowers the incidence of ventilator-associated pneumonia and eliminates the need for sedation (6). Although NIV reduces the work of breathing and prevents intubation in many patients, the failure rate of NIV is relatively high (25-49%) (7). Both PEEP and pressure support are expected to improve oxygenation during non-invasive ventilation in patients with AHRF. However, tidal recruitment during pressure support may lead to lung damage (8). Excessive tidal volume has been associated with AHRF treatment failure, which in turn is associated with higher hospital mortality rates (9).

The HACOR score is widely used to assess response to NIV therapy. It uses five criteria - heart rate, acidosis, consciousness, oxygenation, and respiratory rate (HACOR) – to calculate an aggregate score from 0 to 25, with higher values suggesting a larger risk of NIV failure, as shown by a Chinese study in which scores of 11 or above were associated with high or very high probability of NIV failure (4)

It is crucial to assess the response in a timely manner to prevent delays in intubation and thus mortality. A study that was conducted in Malaysia concluded good diagnostic power (86.27% at 1 hour and 87.5% at 2 hours) of the Positive Predictive value of the HACOR score for predicting NIV failure after 1 – 2 hours of NIV by using the cut-off score >7 was found to be 59.8% in predicting NIV failure in AECOPD and acute decompensated heart failure. There is a dearth of data on the application of NIV in Pakistan. Therefore, I seek to determine how reliable the HACOR score is in predicting failure of NIV in acute respiratory failure due to AECOPD and ADHF (1).

HACOR is a simple score that uses basic bedside parameters, with the only laboratory test being arterial blood gas. Patients in acute respiratory failure who are being managed with NIV need to be assessed appropriately in a timely manner to decide when to proceed to mechanical ventilation, as delayed intubation leads to increased mortality. It would be worthwhile to determine how well a tool as simple as the HACOR can predict NIV failure in respiratory failure due to AECOPD and ADHF.

Methodology

This study was a Descriptive Study conducted in the department of Pulmonology, Dr. Ziauddin Hospital, Karachi, Pakistan, from 2nd December 2024 to 2nd May 2025 after receiving approval from the

medical research and ethics committee (study code 9060824RHPUL), date 22.10.2024. To calculate the sample size, convenience sampling was used. Individuals meeting the predetermined inclusion criteria were recruited, whereas those who met the exclusion criteria were not considered. Relevant demographic and clinical information was systematically recorded for all enrolled patients. The estimated sample size was calculated using the OpenEpi sample size calculator. Using the Positive Predictive value of the HACOR score for predicting NIV failure after 1–2 hours of NIV, with a cut-off score >7, was found to be 59.8% (12). The confidence level was maintained at 95% and the margin of error was 6%. The sample size was 257.

Inclusion Criteria

- Male and female patients aged 18 – 70 times
- Patients presenting with acute respiratory failure bearing NIV due to acute pulmonary edema or acute exacerbation of COPD(13)

Exclusion Criteria

- Patients unfit to maintain airway protection due to conditions such as coma, cerebrovascular accident with bulbar involvement, pronounced disorientation, or agitation
- Hemodynamic instability (e.g., uncontrolled arrhythmia, shock)
- End-stage or unrecoverable condition where NIV was considered non-beneficial
- Massive hemoptysis
- Excessive airway secretions interfering with NIV use
- Post–cardiac arrest cases
- Cases requiring critical intubation at presentation
- Anatomical or clinical barriers to mask fitting (facial trauma, burns, disfigurements)
- Poor tolerance to NIV despite adjustments(14)

Patients diagnosed with acute respiratory failure (ARF) who initiated noninvasive ventilation (NIV) were enrolled in the study. Clinical signs of acute respiratory distress, such as the use of accessory respiratory muscles, paradoxical abdominal movements, a respiratory rate exceeding 30 breaths per minute, or arterial blood gas (ABG) parameters showing a PaO2 of 70 mmHg, PaCO2 >45 mmHg, or a PaO2/FiO2 Ratio of 300 while receiving supplemental oxygen, guided the decision to initiate NIV. Hospital procedures were followed when administering noninvasive ventilation (NIV). A face mask was used as the primary interface for connecting patients to the ventilator. The mask size was carefully selected to ensure an appropriate fit, and the head straps were adjusted to minimize air leakage. Initial ventilatory support was provided using either Continuous Positive Airway Pressure (CPAP) or spontaneous timed (S/T) mode, depending on the patient's clinical condition.

In cases of hypoxemia or acute heart failure, bilevel noninvasive ventilation (NIV) in spontaneous/timed (S/T) mode is the method of choice. This method is employed for type 2 respiratory failure and work of breathing, as well as for Continuous Positive Airway Pressure (CPAP). The S/T mode is utilized explicitly for patients exhibiting hypercapnia or significant reliance on accessory respiratory muscles, which is indicative of increased work of breathing. The initial positive end-expiratory pressure (PEEP) was 5–10 cmH2O, but it can be increased to 15 cmH2O depending on the patient's response and tolerance. By adjusting the fraction of inspired oxygen (FiO2), oxygen saturation remained above 92%. In addition to other treatments tailored to the patients' medical conditions, noninvasive ventilation (NIV) was provided. These treatments included magnesium sulfate, aminophylline, isosorbide dinitrate, and intravenous antibiotics, depending on the underlying cause of respiratory issues. In cases where patients experienced discomfort during NIV, the healthcare team, which included physicians, respiratory therapists, and nurses, evaluated the humidifier, mask fit, air leaks, straps, breathing circuit, and machine settings to improve patient comfort. In patients who were unable to tolerate it, NIV was discontinued if these adjustments were insufficient. There were no delays in initiating intubation when it was necessary. Invasive mechanical ventilation was promptly initiated in patients who met the criteria for intubation. Conversely, patients who did not meet these criteria received oxygen therapy. Once their respiratory issues were resolved, patients who responded well to NIV were gradually weaned off the machine. Failure to correct blood acidity, persistent respiratory distress, inability to maintain oxygen levels (PaO2/FiO2) above 100 mmHg, severe conditions such as coma or inability to keep an open airway, hypotension that is unresponsive to fluids or medication, and apnea or cardiac arrest were all grounds for intubation.

The primary outcome of this study was non-invasive ventilation (NIV) failure, defined as the need for endotracheal intubation either during NIV use or within 2 hours of its initiation. This study specifically focused on identifying the predictors of early NIV failure, with failure classified based on whether the patient required invasive mechanical ventilation shortly after starting NIV. In this study, death was not considered an endpoint for NIV failure.

Secondary outcomes included patient demographics (age, sex, and ethnicity), underlying medical conditions, type and cause of respiratory failure, and chest X-ray findings. Additional clinical and physiological parameters assessed included body temperature, heart rate, Glasgow Coma Scale (GCS) score, oxygen saturation, pH, PaO_2, FiO_2, and respiratory rate. The duration of ventilatory support and total length of hospital stay were recorded as secondary measures.

Data were stored and analyzed using IBM SPSS version 25.0; counts and percentages were reported for gender, AECOPD vs. ADHF, Heart rate, Acidosis, GCS, Oxygenation, and Respiratory Rate. Association of these was tested with NIV failure using Pearson's Chi-Square \ Fisher's exact test. Means with Standard deviation were reported for age (years) and HACOR scores and were compared with NIV using an independent sample t-test. The association of different HACOR cutoff values with NIV was also tested. Binary logistic regression analysis was used to estimate the risk of NIV, and the odds Ratio with a 95% confidence interval was reported using univariate and multivariate models after adjusting for age and gender. ROC analysis was also performed to identify the HACOR cutoff values for all patients and for AECOPD and ADHF cases. The area under the curve for sensitivity and specificity was also reported. P-values less than 0.05 were considered statistically significant. Bar diagrams and pie charts were also used to present the study outcomes graphically.

Results

Table 1A shows basic demographic variables for the 257 participants in the study, of whom 52% were female. The mean age group was 63.1 (SD = 9.9). Among this population, 54% patients were admitted with AECOPD, while 45.9% with ADHF. On arrival, 59.9% of patients had a heart rate >121/min, and acidosis (pH < 7.35) was present in 51.4% of individuals. 40.5% had GCS <10, 23.7% had oxygen <100, 52.1% had respiratory rate <30 and mean HACOR score was 11.5 (SD=±5.5) at 1-2hours, 57.2% cases were showing heart rate >121, 53.7% showed acidosis >7.35, 37.4% had GCS <10, 23.3% presented with oxygenation <100%, 26.5% had respiratory rate <30 and the mean HACOR score was 10.8 (SD=±5.5). On comparison of these parameters with NIV, there was a significant association with heart rate, Acidosis, GCS, and Oxygenation on arrival and 1-2 hrs ($p<0.05$), whereas the independent sample t-test did give a significant mean difference in HACOR scores on arrival and 1-2 hours with NIV status ($p<0.05$).

Table 1B shows the association between NIV failure and HACOR cut-off values. Results presented among cases with NIV failure on arrival, 17.6% cases had HACOR 7 – 8, and 82.4% had HACOR ≥9, whereas among NIV Success patients, 25.9% had HACOR ≤2, 39.4% had HACOR 3 – 4 were 39.4% and 31.0% had HACOR 5 -6 were 31.0%. Similarly, among 1-2 hrs of NIV failure cases, 80.9% had HACOR ≥9, and among non-NIV failure cases, 29.3% had HACOR ≤2. Fisher's exact test showed a

significant association between NIV failure and HACOR ranges on arrival and at 1-2 hours ($p < 0.01$).

Table-2A Presents the risk estimation of NIV failure using binary logistic regression, in univariate model patients with increase in heart rate, decrease in acidosis, GCS, and Oxygenation gives significant positive association of NIV failure, whereas in multivariate model after adjusting for age and gender patients with increase in heart rate, decrease in Acidosis, GCS and Oxygenation were found greater risk of NIV failure. These risks were considered statistically significant ($p<0.05$).

Table 2B reports the sensitivity, specificity, and area under the curve for NIV cases using HACOR scores as the predictor, among all cases on arrival. The suggested HACOR value was 7.50, with 100% sensitivity and 96.6% specificity. In contrast, on 1-2 hrs suggested value of HACOR was 5.50 with 100% sensitivity and 89.7% specificity, similarly for AECOPD on arrival suggested value of HACOR was 6.50 with 100% sensitivity and 96.8% specificity, whereas on 1-2 hrs suggested value of HACOR was 5.50 with 100% sensitivity and 87.1% specificity, however for ADHF on arrival suggested value of HACOR was 6.50 with 100% sensitivity and 96.3% specificity, whereas on 1-2 hrs suggested value of HACOR was 5.50 with 100% sensitivity and 92.6% specificity, for all these AUC was found nearly or equal to 100% and considered statistically significant ($p<0.05$).

Table 1A: Association of NIV Failure with Studied Parameters

Variables		***NIV Failure***						***p-value***
		Total (N=257)		***Yes (n=199)***		***No (n=58)***		
		n	***%***	***n***	***%***	***n***	***%***	
Gender[1]	Male	123	47.9	95	47.7	28	48.3	0.94
	Female	134	52.1	104	52.3	30	51.7	
Age (years)[2]	Mean± SD	63.1	9.9	63.57	9.73	61.57	10.78	0.18
AECOPD VS ADHF[1]	AECOPD	139	54.1	108	54.3	31	53.4	0.91
	ADHF	118	45.9	91	45.7	27	46.6	
Heart Rate on Arrival[1]	<120	103	40.1	72	36.2	31	53.4	0.018*
	>121	154	59.9	127	63.8	27	46.6	
Heart Rate 1-2 hrs	<120	110	42.8	77	38.7	33	56.9	0.014*
	>121	147	57.2	122	61.3	25	43.1	
Acidosis on Arrival[1]	>7.35	132	51.4	85	42.7	47	81.0	<0.01*
	7.30-7.34	29	11.3	25	12.6	4	6.9	
	7.25-7.29	48	18.7	43	21.6	5	8.6	
	<7.25	48	18.7	46	23.1	2	3.4	
Acidosis 1-2 hrs[1]	>7.35	138	53.7	89	44.7	49	84.5	<0.01*
	7.30-7.34	35	13.6	29	14.6	6	10.3	
	7.25-7.29	43	16.7	42	21.1	1	1.7	
	<7.25	41	16.0	39	19.6	2	3.4	
GCS on Arrival[1]	15	79	30.7	27	13.6	52	89.7	<0.01*
	13-14	34	13.2	30	15.1	4	6.9	
	11-12	40	15.6	38	19.1	2	3.4	
	<10	104	40.5	104	52.3	0	0.0	
GCS 1-2 hrs	15	79	30.7	27	13.6	52	89.7	<0.01*
	13-14	28	10.9	24	12.1	4	6.9	
	11-12	54	21.0	52	26.1	2	3.4	
	<10	96	37.4	96	48.2	0	0.0	
Oxygenation (PaO2/FiO2) on Arrival[1]	>201	47	18.3	29	14.6	18	31.0	<0.01*
	176-200	55	21.4	32	16.1	23	39.7	
	151-175	40	15.6	29	14.6	11	19.0	
	126-150	19	7.4	17	8.5	2	3.4	
	101-125	35	13.6	31	15.6	4	6.9	
	<100	61	23.7	61	30.7	0	0.0	
Oxygenation (PaO2/FiO2) 1-2 hrs[1]	>201	45	17.5	27	13.6	18	31.0	<0.01*
	176-200	59	23.0	36	18.1	23	39.7	
	151-175	40	15.6	29	14.6	11	19.0	
	126-150	19	7.4	17	8.5	2	3.4	
	101-125	34	13.2	30	15.1	4	6.9	
	<100	60	23.3	60	30.2	0	0.0	
Respiratory Rate on Arrival[1]	<30	54	21.0	42	21.1	12	20.7	0.35
	31-35	134	52.1	100	50.3	34	58.6	
	36-40	56	21.8	44	22.1	12	20.7	
	41-45	11	4.3	11	5.5	0	0.0	
	>46	2	0.8	2	1.0	0	0.0	
Respiratory Rate 1-2 h1	<30	68	26.5	56	28.1	12	20.7	0.19
	31-35	130	50.6	96	48.2	34	58.6	
	36-40	46	17.9	34	17.1	12	20.7	

	41-45	11	4.3	11	5.5	0	0.0	
	>46	2	0.8	2	1.0	0	0.0	
HACOR Score On Arrival[2]	Mean± SD	11.1	5.5	13.22	4.41	3.86	1.48	<0.01*
HACOR Score 1 -2 hrs[2]	Mean± SD	10.8	5.5	12.98	4.43	3.66	1.39	<0.01*
1: Pearson Chi-Square test / Fisher's exact test, 2: Independent Sample t-test **p<0.05 was considered statistically significant*								

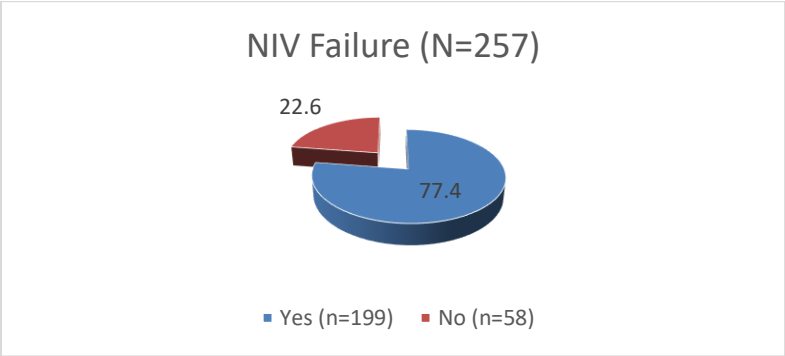

Figure 1: NIV failure rates

Table 1B: Association of NIV Failure with HACOR

HACOR		*NIV Failure*				*p-value*
		Yes		*No*		
		n	*%*	*n*	*%*	
on Arrival	≤2	0	0.0	15	25.9	<0.01*
	3 - 4	0	0.0	23	39.7	
	5 - 6	0	0.0	18	31.0	
	7 -8	35	17.6	2	3.4	
	≥9	164	82.4	0	0.0	
on 1-2 hrs	≤2	0	0.0	17	29.3	<0.01*
	3 - 4	0	0.0	23	39.7	
	5 - 6	0	0.0	18	31.0	
	7 -8	39	19.6	0	0.0	
	≥9	160	80.4	0	0.0	
*p<0.05 was considered statistically significant						

Table 2A: Risk Estimation of NIV Failure using Binary Logistic Regression Analysis

Risk Factors	*Univariate Model Odds Ratio (95% C.I)*	*Multivariate Model ¥ Odds Ratio (95% C.I)*
AECOPD	1.03 (0.57-1.85)	1.01 (0.55-1.84)
Heart Rate>121	2.09* (1.15-3.78)	2.54* (1.34-4.79)
Acidosis	2.83* (1.81-4.41)	2.83* (1.81-4.43)
GCS	9.06* (4.67-17.5)	8.97* (4.62-17.4)
Oxygenation (PaO2/FiO2)	1.85* (1.48-2.31)	1.95* (1.55-2.46)
Respiratory Rate	1.04(0.73-1.49)	1.02 (0.71-1.46)
Dependent Variable: NIV Failure **odds ratio considered statistically significant with p<0.05 , ¥ : Model was adjusted for age and gender*		

Table 2B: Sensitivity and Specificity for HACOR using ROC

HACOR Scores		*AUC (%)*	*Sensitivity*	*Specificity*	*P-value*	*Cut off*
Total Patients	Arrival	99.9	100	96.6	<0.01*	7.50
	1 -2 hrs	100	100	89.7	<0.01*	5.50
AECOPD	Arrival	100	100	96.8	<0.01*	6.50
	1 -2 hrs	100	100	87.1	<0.01*	5.50
ADHF	Arrival	99.9	100	96.3	<0.01*	6.50
	1 -2 hrs	100	100	92.6	<0.01*	5.50

*AUC considered statistically Significant with p<0.05

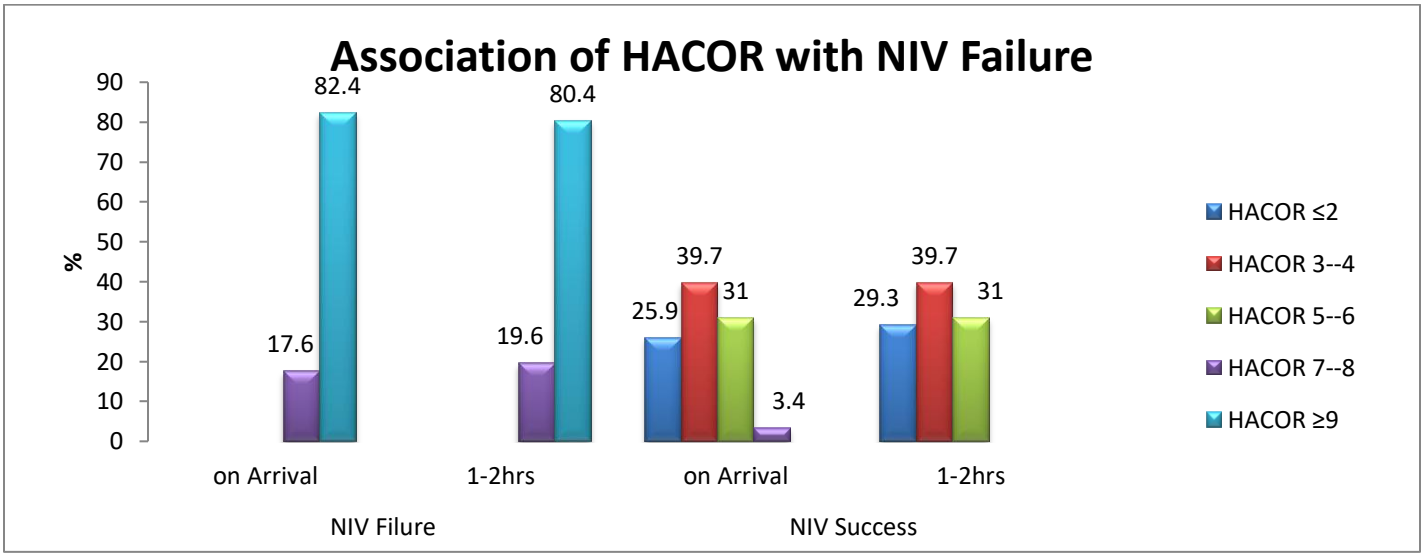

Figure 2: showing significant association of HACOR with NIV, patients with higher HACOR scores have a greater chance of NIV failure, and patients with lower HACOR scores have a greater chance of NIV success on both arrival and 1-2 hours

Discussion

In this study, NIV failure, defined as the need for intubation or in-hospital mortality, was considered the gold standard outcome. The HACOR score demonstrated a substantial positive predictive value for identifying patients at risk of NIV failure in both AECOAD and ADHF groups. Positive predictive values exceeding 90% indicated that elevated HACOR thresholds (≥7.5 at baseline and ≥5.5 after 1–2 hours) reliably forecast NIV failure. These findings align with previous COPD research(15, 16) and extend its utility to cardiogenic cases (1, 18).

The discriminative ability of HACOR in our cohort was notable. ROC analysis showed AUC values consistently above 0.85 at both time points, closely matching results from earlier studies by Duan et al. (15, 16) and external validations, in which reported AUC values ranged from 0.71 to 0.90 (17). For patients with acute heart failure, a HACOR score ≥7 within the first 1–2 hours almost perfectly predicted NIV failure, with near-complete sensitivity and specificity (1). This consistency highlights HACOR's reliability as a bedside tool across different patient populations.

Regression analysis further reinforced the construct validity of HACOR, as each of its components—heart rate, degree of acidosis, level of consciousness, oxygenation status, and respiratory rate—contributed independently to the risk of NIV failure. Among these, acidosis and impaired consciousness (as measured by GCS) were the strongest predictors, consistent with prior literature emphasizing their critical role in respiratory compromise(15, 16).

The clinical significance of these results is considerable. Early risk stratification using HACOR, both at initiation and after 1–2 hours of NIV, can guide timely escalation to invasive ventilation. Avoiding delays in intubation is particularly important in high-risk patients, as earlier studies have shown that early intubation reduces mortality in COPD patients with elevated HACOR scores (16).

Our study has several strengths, including the use of standardized criteria for NIV failure, assessment at two distinct time points, and evaluation in two clinically essential but high-risk groups. However, limitations include its single-center design, relatively small sample size (especially in the ADHF subgroup), and lack of adjustment for specific confounders such as comorbidities and patient adherence to NIV. Larger, multicenter studies are needed to further validate these findings, particularly in the ADHF population (1, 18).

In summary, HACOR is a practical and reliable bedside scoring system for anticipating NIV failure in acute exacerbations of COPD and decompensated heart failure. By enabling timely recognition of patients unlikely to benefit from continued NIV, HACOR can support clinical decision-making and improve outcomes by promoting early intubation when indicated(18).

Conclusion

The HACOR score is a practical and straightforward predictor of early NIV failure in patients with AECOAD and ADHF. Monitoring this score at baseline and again within the first 1–2 hours of NIV allows clinicians to identify non-responders quickly. By facilitating timely decisions regarding invasive ventilation, HACOR can reduce treatment delays, minimize complications, and improve survival in acute care settings.

Declarations

Data Availability statement
All data generated or analysed during the study are included in the manuscript.

Ethics approval and consent to participate
Approved by the department concerned. (IRBEC-MMS-033-24)

Consent for publication
Approved

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Conflict of interest

The authors declared no conflict of interest.

Author Contribution

R (Resident)
Manuscript drafting, Study Design,
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Review of Literature, Data entry, Data analysis, and drafting articles.
AH (Chairman)
Conception of Study, Development of Research Methodology Design
KZ (HOD and Consultant)
Study Design, manuscript review, and critical input.
FM (Resident),
Manuscript drafting, Study Design,

NPG (Resident)
Conception of Study, Development of Research Methodology Design

All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the study's integrity.

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