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The Positive the Predictive value of Heart Rate, Acidosis, Consciousness, Oxygenation and Respiratory Rate (HACOR Score) in Predicting Non-Invasive Ventilation Failure in Acute Decompensated Heart Failure and AECOAD Patients Taking NIV Failure as Gold Standard

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ABSTRACT:

OBJECTIVE

To evaluate the positive predictive value of the HACOR score for early identification of non-invasive ventilation failure in patients with acute respiratory failure secondary to AECOPD and ADHF.

METHODOLOGY

This descriptive observational study was conducted at Dr. Ziauddin Hospital, Karachi, from December 2024 to May 2025. Adults aged 18–70 years with acute respiratory failure due to AECOPD or ADHF requiring non-invasive ventilation were included. HACOR scores were recorded at baseline and 1–2 hours post-NIV initiation. NIV failure was defined as intubation within two hours. Data from 257 patients were analysed using SPSS 26, with $p < 0.05$ considered statistically significant.

RESULTS

Among 257 patients, 199 (77.4%) developed NIV failure. Mean HACOR scores were significantly higher in the failure group at presentation (13.22 ± 4.41 vs. 3.86 ± 1.48, $p<0.001$) and at 1–2 hours (12.98 ± 4.43 vs. 3.66 ± 1.39, $p<0.001$). HACOR showed excellent predictive accuracy, with AUCs of 100% for AECOPD and 99.9–100% for ADHF. Optimal cutoffs (≥7.5 on arrival, ≥6.5 at 1–2 hours) achieved 97–100% sensitivity and 96–100% specificity.

CONCLUSION

The HACOR score was found to be a very dependable predictor of the early NIV failure in patients with AECOPD and ADHF. Patients who needed intubation had significantly higher HACOR scores and optimal presentation and cutoffs at 1-2 hours showed close to perfect sensitivity and specificity. These results reinforce the idea that HACOR is an efficient bedside resource that can be used to identify patients who have the highest risk of NIV failure in time.

KEYWORDS

HACOR Score**,** Acute Exacerbation of COPD, Intubation, Non-invasive Ventilation, Respiratory Failure

INTRODUCTION

Non-invasive ventilation (NIV) is a ventilation providing positive pressure to the lungs without endotracheal intubation. It has now become a part of managing acute respiratory failure and is specifically used in patients with acute exacerbations of chronic obstructive pulmonary disease (AECOPD) and acute decompensated heart failure (ADHF) [1,2]. NIV also has a number of clinical benefits compared to

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invasive ventilation. It retains vital activities like speaking and swallowing, decreases the requirements to use sedatives, lowers the chance of ventilator-associated pneumonia, and leads to a decrease in the length of hospitalization and patient outcomes [3,4,5]. However, NIV is not always effective even though it has numerous advantages. NIV does not help a significant proportion of patients who are estimated to be between 25 and 49 percent and are eventually intubated and put on invasive mechanical ventilation [6,7]. Failure is not noticed early enough, and the subsequent delay of intubation may have serious implications on patient outcome, such as higher morbidity and mortality [8]. It is important to identify the patients who have a greater risk of NIV failure in the initial stages of their treatment so that their care can be escalated as soon as possible and in the most appropriate manner.

To counter this clinical dilemma, an easy to use and convenient tool called the HACOR score was created. The HACOR acronym can be said to mean heart rate, acidosis, consciousness, oxygenation and respiration rate. The parameters are graded, and the total sum is between zero and twenty-five and higher scores indicate a high probability of NIV failure [9]. The score has been shown to have good predictive ability in numerous studies. A score of equal or higher in one multicentre prospective study carried in China was found to be strongly linked with the eventual failure of NIV despite the initiation of NIV at a rate of one hour [10]. HACOR score has been proved in various clinical settings since its inception. These are hypercapnic and hypoxemic respiratory failure and COPD, cardiogenic pulmonary oedema. The scoring algorithm has also been improved by updates that have made it more accurate, and it has been established by several studies in Asia and Europe that it has the clinical utility [11,12,13]. An example is a study that was conducted in Malaysia stating that a HACOR above seven was positively predictive of an approximated 60 percent of NIV failure following one to two hours of treatment in patients with AECOPD and ADHF [12]. Other investigations in India, Turkey, and the United States have also confirmed its application as useful and timely predictor of unfavourable outcome of non-invasive ventilation [13,14,15].

Although the HACOR score is gaining global acceptance, the clinical use of the HACOR score in Pakistan has little evidence. Since the score is based on clinically readily observable signs and only one arterial blood gas finding, it is particularly applicable in resource constrained medical environments. Its application may aid in informing previous decision-making, such as intubation and care escalation, and may end up in improved patient outcomes. This research was thus aimed to assess the predictive capability of the HACOR in predicting early NIV failure in patients with AECOPD and ADHF in a tertiary care hospital in Karachi.

METHODOLOGY

This study was designed as a descriptive observational investigation and was carried out at the Department of Pulmonology, Dr. Ziauddin Hospital, Karachi, over a six-month period from December 2, 2024, to May 2, 2025, following approval from the institutional ethics review board (Reference Code: 9060824RHPUL). The research focused on adult patients between the ages of 18 and 70 who presented with acute respiratory failure and were initiated on non-invasive ventilation (NIV) either for acute exacerbation of chronic obstructive pulmonary disease (AECOPD) or acute decompensated heart failure (ADHF). For the purposes of this study, AECOPD was defined as a sudden worsening of respiratory symptoms requiring a change in treatment, while ADHF was identified based on New York Heart Association functional class II to IV or chest X-ray findings consistent with pulmonary oedema, such as Kerley B lines and vascular redistribution. The main outcome measure was the failure of NIV that was

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characterized as endotracheal intubation within two hours of NIV initiation because of incessant hypoxia, increasing respiratory distress, or any other clinical degradation. The HACOR score, consisting of heart rate, pH level, Glasgow Coma Scale (GCS), and oxygenation status (PaO_2/FiO_2) and respiratory rate were determined at baseline and repeated at one-two hour intervals of initiating NIV. Any patient with a condition that impairs airway protection e.g. coma or bulbar stroke, hemodynamic instability, and severe facial trauma or deformities to mask fit, massive haemoptysis, excessive secretions, poor tolerance to NIV, and patients who needed urgent intubation on arrival were excluded. A convenience sampling method based on a non-probability was used to enrol the sample of 257 patients. The process of data collection included the structured records of the patient demographics, clinical and physiological variables, and NIV-related outcomes. Statistical analysis was conducted using SPSS version 26, Binary logistic regression was employed to explore associations between HACOR score and NIV failure. Receiver operating characteristic (ROC) analysis was used to determine optimal HACOR thresholds, and a p-value less than 0.05 was considered statistically significant.

RESULTS

A total of 257 patients were analysed, of whom 199 (77.4%) experienced NIV failure and 58 (22.6%) achieved successful NIV outcomes. **Table I** presents the baseline and clinical characteristics of the study population. The mean age was slightly higher in the NIV failure group compared to the successful group (63.55 ± 9.82 vs. 61.59 ± 10.77 years), although this difference was not statistically significant (p=0.192). HACOR scores were significantly higher among patients who developed NIV failure, both at presentation (13.22 ± 4.41 vs. 3.86±1.48; $p < 0.001$) and at 1–2 hours (12.98 ± 4.43 vs. 3.66 ± 1.39; $p < 0.001$).

Gender distribution was similar between the groups (p=0.943). A higher proportion of patients in the NIV failure group had heart rates >121 bpm both at presentation (63.8% vs. 46.6%; p=0.018) and at 1–2 hours (61.3% vs. 43.1%; p=0.014). Severe acidosis was more common among patients with NIV failure at both times ($p < 0.001$). Impaired consciousness (GCS <13) was also significantly more frequent in the NIV failure group at presentation and at 1–2 hours ($p < 0.001$).

Significant differences in oxygenation parameters were observed between groups. A higher proportion of NIV failure patients had PaO_2/FiO_2 ratios < 125 mmHg at both assessment points, and no patient in the successful group had PaO_2/FiO_2 < 100 mmHg ($p<0.001$). Although respiratory rate tended to be higher among NIV failure patients, respiratory rate categories were not significantly associated with NIV outcomes at either time point ($p > 0.05$).

The ROC analysis evaluating the diagnostic performance of the HACOR score is illustrated in **Figure I** for AECOPD patients and in **Figure II** for ADHF patients. Both figures show high discrimination accuracy and almost perfect separation of the NIV success and failure groups. Table II contains summarized detailed diagnostic performance values of AUC, sensitivity, specificity and positive predictive value. In the case of AECOPD, the HACOR score recorded a 100% at the presentation as well as 1-2 hours. A threshold of 7.50 or above at arrival gave a sensitivity of 97.2% and specificity of 100% and at 1-2 hours gave a sensitivity of 100%, specificity of 100% and PPV of 100%. The AUC of ADHF patients is 99.9% at presentation and 100% at 1 2 hours with a threshold of 6.50 and above with 100% sensitivity and 96.3% specificity at presentation and 100% at 1--2 hours.

Multivariable logistic regression results are presented in **Table III**. Neither age nor gender showed a statistically significant independent association with NIV failure. Age demonstrated an adjusted odds ratio

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of 0.982 (95% CI: 0.955–1.009; p = 0.194), while gender had an adjusted odds ratio of 1.037 (95% CI: 0.572–1.881; p = 0.904), indicating no meaningful predictive contribution from these factors.

DISCUSSION

The findings of this study demonstrate that the HACOR score provides exceptionally strong predictive accuracy for early identification of non-invasive ventilation failure in patients presenting with acute respiratory failure due to acute exacerbation of chronic obstructive pulmonary disease and acute decompensated heart failure. This performance is evident from the significantly higher HACOR values recorded in patients who failed non-invasive ventilation at both assessment points. At arrival, the mean HACOR score among patients who progressed to non-invasive ventilation failure was 13.22 compared with 3.86 in patients with successful outcomes, and at one to two hours the difference remained significant with scores of 12.98 and 3.66 respectively, with p values less than 0.001 at both intervals. Physiological variables incorporated into the HACOR scale also exhibited clear separation between the two groups. Patients in the failure category showed more severe acidosis, markedly lower PaO_2 to FiO_2 ratios, poorer levels of consciousness, and significantly higher heart rates, all of which are recognized markers of impending non-invasive ventilation failure according to previously published clinical research and expert recommendations [1,3,4]. The areas under the receiver operating characteristic curve in this study reached one hundred percent for acute exacerbation of chronic obstructive pulmonary disease at both time points and ninety nine point nine to one hundred percent for acute decompensated heart failure, with optimal thresholds of at least seven point five at presentation and at least six point five at the one to two hour reassessment providing sensitivities and specificities between ninety seven and one hundred percent. These values greatly exceed the diagnostic accuracy reported in multiple earlier studies. For instance, Kwak and colleagues identified increased respiratory rate, acidosis, and neurological impairment as important indicators of non-invasive ventilation failure, but their reported areas under the curve were considerably lower than those found in the present analysis [16]. Similarly, meta-analytical evidence from Luo and Yang described pooled sensitivities and specificities below the range observed here, indicating that even though the HACOR score is consistently valuable, the exceptional discriminatory capacity noted in the present study is uncommon and may be influenced by the severity of disease in the enrolled population [17]. Complementary findings were described by Pan and colleagues who reported strong but still lower predictive performance when evaluating HACOR in acute exacerbation of chronic obstructive pulmonary disease [18]. Additional external validations including those by Xia and by Liao also demonstrated substantial predictive strength but did not achieve the extremely high values that were seen in this cohort [19,20]. The consistency of the present results with physiological expectations further supports the reliability of the score. The most significant ones, such as arterial pH, the level of consciousness, and oxygenation, demonstrate acute respiratory and metabolic impairments and are sufficiently described in the literature as the early signs of non-invasive ventilation degradation [2,5,6]. The other notable finding of the study is that there is no significant correlation between the result of non-invasive ventilation and the demographic variables. The age and gender did not add any significant value to prediction as the p values of 0.194 and 0.904 respectively are still quite small, which is consistent with the previous studies that have already reported that non-invasive ventilation failure is predetermined rather by acute physiological deviations than by demographic factors [7,8]. The fact that both the acute exacerbation of chronic obstructive pulmonary disease and acute decompensated heart failure are included enhances the generalizability of the results because the two causes are major contributors to

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acute respiratory failure in the whole world and past literature has indicated the existence of variation in the success rates of non-invasive ventilation across different aetiologies [9,10]. The HACOR score remains reliable in both groups, and this provides a support to the use of the tool as a universal tool which can be used in diverse clinical conditions. Its re-evaluation after one to two hours is also an asset as most researchers have focused on the need to evaluate the response of non-invasive ventilation as it will help in the prevention of complications that may occur in case of late intubation [3,4,12]. The fact that HACOR values of the two groups differ nearly completely at the second point is evidence of the significance of early revaluation and suggests that the score can be used as an expedient predictor of the time sensitive clinical decisions. This would be especially useful in a low resource environment where advanced diagnostic tools might be scarce.

Despite the strong findings, certain limitations should be recognized. The analysis was also limited to single Centre, which can affect the external validity, and consecutive sampling may have selected a higher proportion of patients with severe illness, and this could have contributed to the high non-invasive ventilation failure rate and close to perfect diagnostics. Moreover, the definition of non-invasive ventilation failure in two hours, although clinically useful in the detection of rapid deterioration, does not coincide with some other studies where larger time intervals have been used and it is not possible to directly compare the findings of the various settings. The study further failed to measure any long-term outcome including mortality, length of stay, as well as non-invasive ventilation complications and compared the HACOR score to other prediction systems, which can supplement clinical evaluation. The findings however are a good indication of the effectiveness of HACOR as an effective, quick and dependable bedside tool that can be used to improve the clinical decision making in the management of acute respiratory failure. The results should be confirmed by further multicentre studies involving more and heterogeneous populations to evaluate the effect of regular HACOR application on patient courses.

CONCLUSION

The HACOR score was found to be a very dependable predictor of the early NIV failure in patients with AECOPD and ADHF. Patients who needed intubation had significantly higher HACOR scores and optimal presentation and cutoffs at 1-2 hours showed close to perfect sensitivity and specificity. These results reinforce the idea that HACOR is an efficient bedside resource that can be used to identify patients who have the highest risk of NIV failure in time.

Table I: Baseline and Clinical Profile of Study Participants by NIV Outcome (n=257)		
Baseline and Clinical Parameters	**NIV Failure**	**P-Value**

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		Yes (n=199)	No (n=58)	
Age in years, Mean ± SD		63.55 ± 9.82	61.59 ± 10.77	0.192
HACOR Score on Arrival, Mean ± SD		13.22 ±4.41	3.86 ±1.48	0.0001*
HACOR Score at 1 -2 hrs, Mean ± SD		12.98 ±4.43	3.66 ±1.39	0.0001*
Gender	Male	95 (47.7)	28 (48.3)	0.943
	Female	104 (52.3)	30 (51.7)	
Heart Rate on Arrival	<120	72 (36.2)	31 (53.4)	0.018*
	>121	127 (63.8)	27 (46.6)	
Heart Rate at 1-2 hrs	<120	77 (38.7)	33 (56.9)	0.014*
	>121	122 (61.3)	25 (43.1)	
Acidosis on Arrival	>7.35	85 (42.7)	47 (81.0)	0.0001*
	7.30-7.34	25 (12.6)	4 (6.9)	
	7.25-7.29	43 (21.6)	5 (8.6)	
	<7.25	46 (23.1)	2 (3.4)	
Acidosis at 1-2 hrs	>7.35	89 (44.7)	49 (84.5)	0.0001*
	7.30-7.34	29 (14.6)	6 (10.3)	
	7.25-7.29	42 (21.1)	1 (1.7)	
	<7.25	39 (19.6)	2 (3.4)	
GCS on Arrival	15	27 (13.6)	52 (89.7)	0.0001*
	13-14	30 (15.1)	4 (6.9)	
	11-12	38 (19.1)	2 (3.4)	
	<10	104 (52.3)	0 (0.0)	
GCS at 1-2 hrs	15	27 (13.6)	52 (89.7)	0.0001*
	13-14	24 (12.1)	4 (6.9)	
	11-12	52 (26.1)	2 (3.4)	
	<10	96 (48.2)	0 (0.0)	
Oxygenation (PaO2/FiO2) on Arrival	>201	29 (14.6)	18 (31.0)	0.0001*
	176-200	32 (16.1)	23 (39.7)	
	151-175	29 (14.6)	11 (19.0)	
	126-150	17 (8.5)	2 (3.4)	
	101-125	31 (15.6)	4 (6.9)	

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	<100	61 (30.7)	0 (0.0)	
Oxygenation (PaO2/FiO2) at 1-2 hrs	>201	27 (13.6)	18 (31.0)	0.0001*
	176-200	36 (18.1)	23 (39.7)	
	151-175	29 (14.6)	11 (19.0)	
	126-150	17 (8.5)	2 (3.4)	
	101-125	30 (15.1)	4 (6.9)	
	<100	60 (30.2)	0 (0.0)	
Respiratory Rate on Arrival	<30	42 (21.1)	12 (20.7)	0.350
	31-35	100 (50.3)	34 (58.6)	
	36-40	44 (22.1)	12 (20.7)	
	41-45	11 (5.5)	0 (0.0)	
	>46	2 (1.0)	0 (0.0)	
Respiratory Rate at 1-2 hrs	<30	56 (28.1)	12 (20.7)	0.198
	31-35	96 (48.2)	34 (58.6)	
	36-40	34 (17.1)	12 (20.7)	
	41-45	11 (5.5)	0 (0.0)	
	>46	2 (1.0)	0 (0.0)	

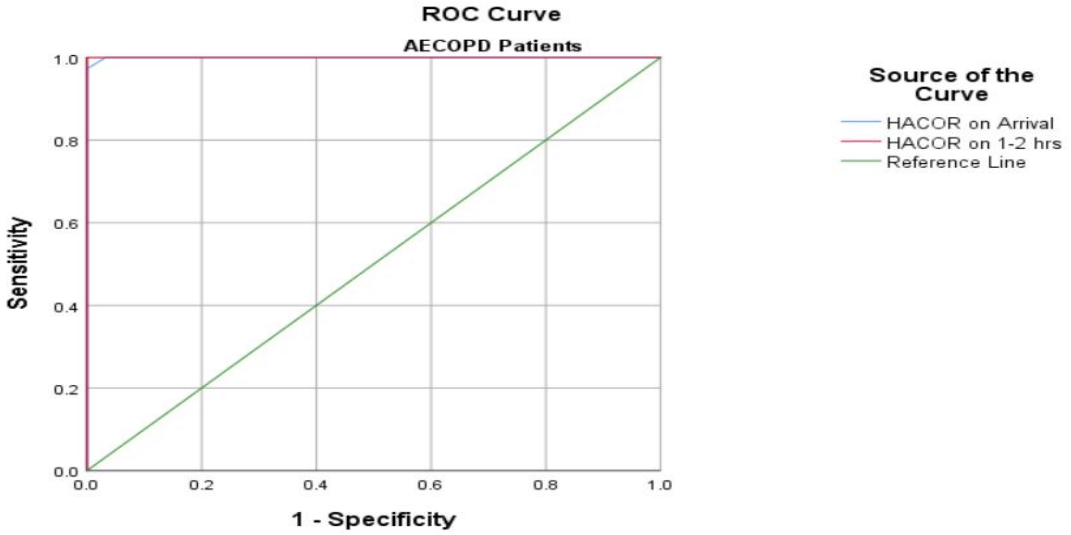

FIGURE 1

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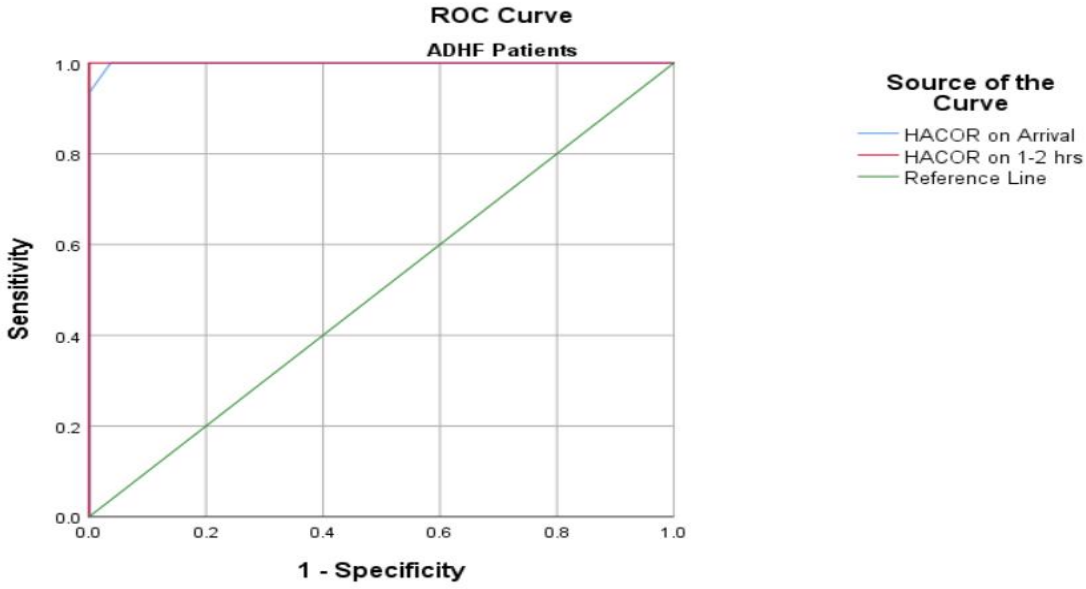

Table II: Diagnostic Performance of HACOR Score in Predicting NIV Failure among Study Groups

HACOR Scores		AUC (%)	Sensitivity	Specificity	PPV	P-value	Threshold
AECOPD	Arrival	100	97.2	100	100	<0.01*	≥7.50
	1 -2 hrs	100	100	100	100	<0.01*	≥6.50
ADHF	Arrival	99.9	100	96.3	98.9	<0.01*	≥6.50
	1 -2 hrs	100	100	100	100	<0.01*	≥6.50

Table III: Multivariable Logistic Regression Model of Age and Gender as Predictors of NIV Failure

Predictor	Unadjusted Odd Ratio (95% CI)	P-Value	Adjusted Odd Ratio (95% CI)	P-Value
Age (years)	0.982 (0.956 – 1.009)	0.194	0.982 (0.955 – 1.009)	0.194
Gender	0.979 (0.545 – 1.757)	0.943	1.037 (0.572 – 1.881)	0.904

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