

Role of the HACOR Score in Assessing Noninvasive Ventilation Success in COPD-related Respiratory Failure

Dr. Prashantkumar Kantilal Chauhan¹, Dr. Yogesh Dhandh²

¹Postgraduate Resident 3, Department of General Medicine, Venkateswara Institute of Medical Sciences, Gajraula, U. P., India

²Professor, Department of General Medicine, Venkateswara Institute of Medical Sciences, Gajraula, U. P., India

Abstract: Background: In patients with chronic obstructive pulmonary disease (COPD), early detection of noninvasive ventilation (NIV) failure is a promising technique for decreasing mortality. The objective of this study was to evaluate the efficacy of heart rate, acidosis, consciousness, oxygenation, and respiratory rate (HACOR) score in predicting NIV outcome in COPD-associated respiratory failure. Methodology: A prospective observational study was conducted on 100 COPD patients with acute respiratory failure who were initiated on NIV. HACOR score was calculated at the start of NIV and after 1-2, 12, and 24 hours. NIV failure was defined as progression to invasive mechanical ventilation or death. NIV success was defined as liberation from NIV prior to hospital day seven and not meeting criteria for failure. Results: In this study, 100 patients with COPD and respiratory failure were enrolled. Their mean age was 65.34 years [standard deviation (SD) 8.19]. Male patients were predominant (n = 81). Eighty-nine percent of patients were smokers, and the remaining had exposure to biomass fuel. At the initiation of NIV, the median HACOR score was 3 (interquartile: 2, 4). In 13% of patients, there was NIV failure. There were 17 (17%) patients whose HACOR score at initiation was ≥ 5 . In patients with a HACOR score ≥ 5 , the NIV failure rate was 76.4% and mortality was 41.1%. The area under the curve (AUC) for prediction of NIV failure by HACOR score at initiation was 0.980 (p-value < 0.05). Conclusion: The HACOR score had high sensitivity as well as specificity at initiation in the prediction of NIV failure. A higher HACOR score predicts a high chance of NIV failure. Obtaining the HACOR score at the bedside makes it convenient for assessing the efficacy of NIV in patients with COPD.

Keywords: HACOR score, Noninvasive ventilation (NIV), Chronic obstructive pulmonary disease (COPD), Respiratory failure

1. Introduction

Various guidelines on chronic obstructive pulmonary disease (COPD) strongly advise the use of noninvasive ventilation (NIV) in COPD patients with respiratory failure. NIV reduces the effort required to breathe, enhances minute ventilation, balances intrinsic positive endexpiratory pressure (PEEP), and improves gas exchange.^{1,2} NIV lessens the need for intubation for invasive mechanical ventilation in patients with hypoxemic or hypercapnic respiratory failure.^{2–5} Despite the fact that NIV decreases the requirement for intubation in COPD patients, mortality increases considerably if NIV failure occurs.^{6,7} Thus, early intubation and early identification of patients at risk for NIV failure may lower mortality.

The heart rate, acidosis, consciousness, oxygenation, and respiratory rate (HACOR) score was developed and validated by Duan et al. as a clinical prediction score for NIV failure in patients with hypoxemic respiratory failure of different etiologies. The HACOR score is a quick and convenient tool for assessing and predicting NIV failure. The authors found that the HACOR score was an effective tool for this purpose.⁸

The HACOR score is based on several easily measurable objective variables evaluated at the time of NIV initiation: heart rate, arterial pH value, level of consciousness via the Glasgow Coma Scale, oxygenation via the PaO₂/FiO₂ ratio, and respiratory rate (Table 1). This score can predict early NIV failure. A cutoff value of 5 out of a total score of 25 is used to differentiate between high and low risk of NIV failure.⁸ The objective of our study was to evaluate the

efficacy of the HACOR score in predicting NIV outcome in COPD-associated respiratory failure.

2. Methodology

It is a hospital-based prospective observational study conducted at the Venkateswara Institute of Medical Sciences, Gajraula, during the one year. The Institutional Ethics Committee and Research Review Board approved the study. All COPD patients with acute respiratory failure, initiated on NIV based on clinical decision, were included in the study. Patients with respiratory failure due to diseases other than COPD, patients with indications for emergency intubation, and patients with any contraindication for NIV were excluded from the study. The decision to initiate NIV was made by the treating physician on the basis of multiple factors: respiratory distress at rest (use of accessory muscles or paradoxical respiratory movement), arterial blood pH < 7.40, partial pressure of arterial carbon dioxide (PaCO₂) > 45 mm Hg, and partial pressure of arterial oxygen (PaO₂) < 60 on supplemental oxygen.

Bi-level positive airway pressure (BiPAP) ventilatory mode was used with a face mask and was managed according to protocol. NIV failure was defined as progression to invasive mechanical ventilation or death. The HACOR score was assessed before and at 1–2, 12, and 24 hours after the initiation of NIV.

Sample Size and Statistical Analysis

The sample size was calculated at a 95% confidence level and an α error of 0.05, assuming the prevalence of NIV failure (with a HACOR score greater than 5) was 50.2%. At an

Volume 14 Issue 10, October 2025

Fully Refereed | Open Access | Double Blind Peer Reviewed Journal

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absolute allowable error of 10%, the required sample size was 96 subjects, which was rounded to 100 subjects as the final sample size, with a 5% attrition rate. The data were presented as mean and standard deviation (SD) or as median and interquartile range, as appropriate. Statistical analysis included Student's t-test for parametric data and the Chi-squared test or nonparametric tests for nonparametric data. The predictive ability for NIV failure was evaluated using the area under the receiver operating characteristic curve [area under the curve (AUC)]. A p-value of <0.05 was considered statistically significant.

3. Results

In this study, 100 patients were enrolled, and their data were analyzed. Their mean age was 65.34 years (SD 8.19). There was no impact of age on NIV outcome (p-value: 0.19). Male patients were predominant (n = 81), with 19 female subjects. Both groups had similar NIV outcomes. Smoking was very common among enrolled subjects; 89% were smokers. There was no difference in NIV outcome based on smoking status (p-value: 0.69).

Table 1: Heart rate, acidosis, consciousness, oxygenation, and respiratory rate score⁸

Parameters	HACOR score
Heart rate	
≤120 beats/minute	0
≥121 beats/minute	1
pH (for acidosis)	
≥7.35	0
7.30–7.34	2
7.25–7.29	3
<7.25	4
Glasgow Coma Scale (for consciousness)	
15	0
13–14	2
11–12	5
≤10	10
PaO ₂ /FiO ₂ ratio (partial pressure of arterial oxygen/fraction of inspired oxygen) for oxygenation	
≥201 mm Hg	0
176–200 mm Hg	2
151–175 mm Hg	3
126–150 mm Hg	4
101–125 mm Hg	5
≤100 mm Hg	6
Respiratory rate	
<30/minute	0
31–35/minute	1
36–40/minute	2
41–45/minute	3
≥46/minute	4

Noninvasive ventilation was used in all patients as initial breathing support. NIV was successful in avoiding intubation and invasive ventilation in 87% of patients. In 13% of patients, there was NIV failure.

The HACOR score was calculated in all enrolled patients at the stipulated time intervals (Table 2). At the initiation of NIV, the median score was 3 (interquartile: 2, 4). There were 17 patients whose HACOR score at initiation was ≥5. There was significantly higher NIV failure in patients with a HACOR score ≥5 at the initiation of NIV (Table 3).

Table 2: Heart rate, acidosis, consciousness, oxygenation, and respiratory rate score and proportions of cases

HACOR score	At initiation	At 1–2 hours	At 12 hours	At 24 hours	Test of significance
0–5	89 (89%)	99 (99%)	100 (100%)	96 (96%)	Cochran's Q =24.667 DOF—3 p-value < 0.001
6–11	11 (11%)	1 (1%)	0	4 (4%)	
12–25	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Total	100 (100%)	100 (100%)	100 (100%)	100 (100%)	

Table 3: Prediction of NIV failure based on HACOR score at initiation with cutoff ≥ 5

HACOR score	NIV outcome			
	NIV failure		NIV success	
	N	%	N	%
≥ 5	13	100	4	4.6
< 5	0	0	83	95.4
Total	13	100	87	100

The AUC was highest for the HACOR score at initiation, followed by the HACOR score at 24 hours, 1–2 hours, and lowest at 12 hours. Thus, the sensitivity of the HACOR score is highest at initiation and lowest at 24 hours. Similarly, the specificity of the HACOR score is highest at initiation (Tables 4 and 5).

Table 4: Diagnostic parameters of HACOR score at initiation for predicting NIV failure

Parameter	Value	95% confidence interval
Sensitivity	100%	77.9–100%
Specificity	95.4%	88.7–98.2%
PPV	76.4%	52.74–90.45%
NPV	100%	85.58–100%
Diagnostic accuracy	96%	90.16–98.43%

Seven patients died during the course of hospitalization. Six of these patients had a HACOR score greater than 5 at the initiation of NIV. There was significantly higher mortality in patients with a HACOR score > 5 at initiation (Table 6).

Table 5: Area under the curve of HACOR score at different time intervals

Variable	Area under curve	Confidence interval		Standard error	p-value
		Lower bound	Upper bound		
HACOR score (at initiation)	0.983	0.962	1.000	0.011	0.000
HACOR score (at 1–2 hours)	0.611	0.448	0.774	0.083	0.198
HACOR score (At 12 hours)	0.562	0.384	0.740	0.091	0.473
HACOR score (At 24 hours)	0.659	0.477	0.841	0.093	0.066

Table 6: Prediction of mortality based on HACOR score cutoff of ≥ 5

HACOR score	Mortality		Total
	Yes	No	
HACOR score < 5	0	83	83
HACOR score ≥ 5	7	10	17
Total	7	93	100

Chi-squared test (p-value: < 0.05)

4. Discussion

Noninvasive ventilation has been a popular and successful method for treating acute respiratory failure in patients with an acute exacerbation of COPD. Previous research has shown that the use of NIV results in lower rates of intubation and invasive ventilation, leading to a reduction in morbidity due to less invasive ventilation. However, NIV failure may cause intubation to be delayed, which could increase mortality. Hence, various clinical scoring techniques were evaluated for early prediction of NIV failure.

Noninvasive ventilation failure rates have been reported to range from 25 to 59% in patients with hypoxemic respiratory failure.^{9,10} In our study, the failure rate was only 13%, which is lower compared to the values reported in previous studies. However, this is comparable to the failure rate of 18% seen in a study involving only COPD patients.

In 2017, Duan et al. designed a scoring system combining the following parameters: tachycardia, tachypnea, severe hypoxemia, acidosis, and impaired consciousness, and called it the HACOR score. The diagnostic accuracy for predicting NIV failure was 94% using a cutoff score of 5 at 1 hour of initiation of NIV. In this study, the NIV failure rate was 18.4% in the cohort with a HACOR score of ≤ 5 , while the mortality rate was 21%. In the group with a HACOR score > 5 , the NIV failure rate was 87% and the mortality rate was 65%. The HACOR score was also higher in the group requiring early intubation.⁸

In our study, there was no NIV failure or mortality in patients with a HACOR score of < 5 . In patients with a HACOR score ≥ 5 , the NIV failure rate was 76.4% and the mortality rate was 41.1%. This was very similar to the results reported in the studies mentioned above.

In our study, the HACOR score at the initiation of treatment demonstrated good diagnostic accuracy in predicting NIV failure, with high sensitivity and specificity. This is consistent with the validation studies of the HACOR score. We conclude that the HACOR score can be effectively used in the Indian setting and will serve as a valuable tool for clinicians in deciding on the use of NIV in patients presenting with acute exacerbation of COPD. Early and elective intubation in patients with a high HACOR score will help to reduce mortality. Additionally, avoiding intubation in patients with a low HACOR score can reduce complications associated with invasive ventilation, such as ventilator-associated pneumonia, diaphragmatic weakness, laryngeal edema, prolonged ICU care, and increased duration and cost of hospitalization.

In our study, we found that most patients with a low HACOR score improved after the initiation of treatment. Even in patients with NIV failure, the subsequent HACOR scores at different time intervals were not significantly different between those with NIV success and failure. Hence, according to our study, the HACOR score may not be useful for assessing the progression of severity during hospitalization.

5. Conclusion

The HACOR score measured at the initiation of NIV had high sensitivity and specificity for predicting NIV failure. A higher HACOR score predicts a greater chance of NIV failure. Obtaining the HACOR score at the bedside makes it convenient for assessing the efficacy of NIV in patients with COPD. In high-risk patients identified by a HACOR score of ≥ 5 assessed at the initiation of treatment, elective and early intubation will result in decreased hospital mortality. Hence, the HACOR score is a rapid, simple, and effective bedside tool for the assessment of COPD patients receiving noninvasive ventilatory support.

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