Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 18s (2025)
https://www.jneonatalsurg.com

Comparison of ROX Index and Updated HACOR Score to Predict Failure of Noninvasive Ventilation in Patients Admitted with Type 2 Respiratory Failure in the Intensive Care Unit

Durgashree Jaisankar[1], Mekala Ganesan[2], Hariprasad Balakrishnan[3], Mangalaselvi Rajachidambaram[4], Dhanasekar Thangaswamy[5], Darshni Srinivasan[6]

[1]Former student, Sri Ramachandra Institute of Higher Education and Research
[2]Assistant Professor, Faculty of Allied Health Sciences, Division of Respiratory Care, Sri Ramachandra Institute of Higher Education and Research
[3]Professor, Department of Respiratory Medicine, Sri Ramachandra Institute of Higher Education and Research
[4]Assistant Professor, Faculty of Allied Health Sciences, Division of Respiratory Care, Sri Ramachandra Institute of Higher Education and Research
[5]Professor, Department of Respiratory Medicine, Sri Ramachandra Institute of Higher Education and Research
[6]Assistant Professor, Faculty of Allied Health Sciences, Division of Respiratory Care, Sri Ramachandra Institute of Higher Education and Research

[2]mekala.g@sriramachandra.edu.in

Cite this paper as: Durgashree Jaisankar, Mekala Ganesan, Hariprasad Balakrishnan, Mangalaselvi Rajachidambaram, Dhanasekar Thangaswamy, Darshni Srinivasan, et.al (2025) Comparison of ROX Index and Updated HACOR Score to Predict Failure of Noninvasive Ventilation in Patients Admitted with Type 2 Respiratory Failure in the Intensive Care Unit. *Journal of Neonatal Surgery*, 14 (18s), 107-112.

ABSTRACT

Background: Type 2 respiratory failure (T2RF) is a life-threatening condition commonly managed with non-invasive ventilation (NIV) in the intensive care unit (ICU). Early identification of patients at risk of NIV failure is critical for timely intervention and improved outcomes. This study compares the effectiveness of the ROX index and the updated HACOR score in predicting NIV failure among T2RF patients.

Methods: A prospective observational study was conducted on 48 patients diagnosed with T2RF and treated with NIV in the ICU. The ROX index and updated HACOR score were calculated for each patient, and their predictive accuracies were analyzed. Clinical parameters, arterial blood gas (ABG) values, and patient outcomes were closely monitored to assess NIV success or failure.

Results: The findings demonstrated that the ROX index was a significant predictor of NIV failure, with lower values at 2 and 12 hours correlating strongly with the need for intubation. The HACOR score showed predictive value but was less accurate than the ROX index. Early identification of NIV failure using the ROX index was associated with reduced mortality and morbidity related to delayed intubation.

Conclusion: The ROX index is a reliable predictor of non-invasive ventilation (NIV) failure in type 2 respiratory failure, showing superior and consistent performance at 12 and 24 hours. While the updated HACOR index offers early predictive value, its accuracy declines over time. The original HACOR index is less sensitive overall. These findings support the ROX index as the most practical tool for guiding NIV management.

Keywords: Non-invasive ventilation, Type 2 respiratory failure, ROX index, HACOR score, Prospective studies

1. INTRODUCTION

Respiratory failure is characterized by the inability of the respiratory system to oxygenize and remove carbon dioxide from pulmonary blood vessels. Respiratory failure often results from the imbalance between respiratory workload and ventilatory strength or endurance. Type 2 respiratory failure is characterized by PaCO2 greater than 50 mmHg and PaO2 less than 60 mmHg. Also known as hypercapnic respiratory failure or ventilatory failure [1]. Invasive mechanical ventilation is a standard intervention in intensive care units; however, the use of non-invasive positive pressure ventilation (NIPPV) has significantly increased in recent years for managing acute and chronic respiratory failure due to its practicality and cost-effectiveness [2]. Non-invasive ventilation (NIV) delivers ventilatory support through devices such as nasal, full-face, or helmet masks, avoiding the need for bypassing the upper airway, as seen in tracheal intubation or tracheostomy [3]. NIV is particularly beneficial in managing acute respiratory failure (ARF) as it minimizes complications associated with invasive mechanical ventilation, such as ventilator-associated pneumonia [4].

By enhancing alveolar ventilation without requiring an artificial airway, NIV can be administered either continuously or intermittently. Its advantages over invasive ventilation include preserving natural functions like swallowing, coughing, and verbal communication, making it a preferred option for avoiding intubation [5]. Despite its benefits, the failure rate of NIV in hypoxemic patients remains high, ranging from 40% to 54% [6]. Common causes of NIV failure include inadequate improvement in oxygenation, persistent dyspnea, patient discomfort with the mask, agitation, anxiety, hemodynamic instability, and the progression of ARF [7]. For patients with hypercapnic respiratory failure who do not respond adequately to conventional treatments such as bronchodilators, corticosteroids, antibiotics, and controlled oxygen therapy, NIV serves as a viable alternative to endotracheal intubation and mechanical ventilation [8].

Patients undergoing non-invasive ventilation (NIV) must be closely monitored for indications of failure, such as altered mental status, increased respiratory rate, inability to maintain adequate oxygen saturation (SpO_2), or worsening arterial blood gas (ABG) parameters. Prompt intubation is essential to prevent a medical crisis in such scenarios. The use of NIV by a well-trained intensive care unit team, combined with careful patient selection, can significantly improve outcomes [9]. Currently, NIV is favoured over endotracheal intubation and invasive mechanical ventilation due to its less invasive nature. However, patient selection plays a critical role in determining its success, and contraindications must be carefully evaluated before initiating NIV. Patients who respond positively to NIV are often successfully managed and discharged after clinical improvement, with a BiPAP device prescribed for home use if necessary. For patients whose condition worsens despite NIV, timely intubation and transition to invasive mechanical ventilation can reduce mortality and complications associated with delayed intervention [10].

The ROX index (Respiratory Rate-Oxygenation Index) and the updated HACOR score (Heart Rate, Acidosis, Consciousness, Oxygenation, and Respiratory Rate) have emerged as promising tools to predict NIV failure. The ROX index, primarily validated in hypoxemic respiratory failure, incorporates oxygenation and respiratory effort to assess the likelihood of NIV success [11]. In contrast, the updated HACOR score, which was designed for hypercapnic respiratory failure, considers a broader range of clinical and physiological parameters to evaluate the patient's risk of NIV failure [12]. Despite the widespread application of these indices in clinical practice, there is limited research comparing their predictive accuracy specifically in patients with T2RF in the ICU. This study aims to evaluate and compare the effectiveness of the ROX index and the updated HACOR score in predicting NIV failure in this patient population, thereby providing valuable insights to guide clinical decision-making and improve patient outcomes.

2. METHODS

This prospective observational study was conducted in the intensive care unit (ICU) of the Department of Respiratory Medicine at Sri Ramachandra Institute of Higher Education and Research (SRIHER) over a six-month period. The study was approved by the Institutional Ethics Committee of SRIHER with a reference - CSP/23/NOV/139/916. A total of 48 patients aged 40 years and above, diagnosed with type 2 respiratory failure (T2RF) and initiated on noninvasive ventilation (NIV), were enrolled based on specific inclusion and exclusion criteria. Inclusion criteria included male and female patients with physician-diagnosed T2RF, while patients with type 1 respiratory failure, those unwilling for NIV, intubated patients, those discharged against medical advice, patients started on NIV at other healthcare centers, or those in cardiac arrest or impending cardiac arrest were excluded. Written informed consent was obtained from all participants or their legal representatives before enrollment. Confidentiality of patient data was maintained throughout the study, and all procedures adhered to the ethical standards of the Declaration of Helsinki.

Eligible patients were screened and enrolled consecutively upon admission to the ICU. For each patient, demographic data (age, sex, diagnosis, NIV success & Failure, Comorbities), clinical history, and baseline physiological parameters (e.g., heart rate, respiratory rate, SpO_2) were documented. The ROX index, HACOR and updated HACOR scores were calculated and recorded at specific time intervals—2 hours, 12 hours, and 24 hours following NIV initiation. The ROX index was calculated using the formula dividing the ratio of SpO2/FiO2 by respiratory rate, while the updated HACOR score incorporated five components: heart rate, acidosis (pH), consciousness (GCS), oxygenation (SpO_2/FiO_2), and respiratory rate. Patients who responded well to NIV were continued on NIV until clinical improvement was observed and were subsequently discharged. For those who demonstrated signs of NIV failure, prompt intubation and invasive ventilation were initiated to prevent further complications.

The data collected were entered in Microsoft excel and analyzed using Jamovi software. Continuous variables were reported as mean±standard deviation or as median and interquartile range, and comparisons between two groups were performed with the Student t-test for normally distributed data or by Mann–Whitney's test, Chi square test for non-parametric data. A p value < 0.05 was considered significant.

3. RESULT

During a period of 6 months, a total of 48 patients with type 2 respiratory failure requiring non-invasive ventilation (NIV) were observed in this study. Among the 48 patients who received non-invasive ventilation (NIV), 14 patients (29.16%) required intubation, with an average time to intubation of 3.2 days. The remaining 34 patients (70.83%) were successfully weaned from NIV. None of the patients had NIV discontinued within the first 2 hours. After 12 hours, one patient was weaned off NIV, leaving 47 patients continuing treatment beyond this time. By 24 hours, an additional patient was weaned off, resulting in a total of two patients discontinuing NIV within the first 24 hours (one between 12–24 hours). Therefore, 46 patients remained on NIV beyond 24 hours.

The study population had a mean age distributed across various age groups, with the highest representation in the 61–70 years range (29.16%), followed by 51–60 years (27.08%). The majority were male (75%), and 66.66% had two or fewer comorbidities. The predominant diagnosis was type 2 respiratory failure (31.25%) (Table 1).

Table 1: Demographics of Participants

Attribute	**Categories**	**Frequency**	**Percentage (%)**
Age	Up to 30 yrs	3	6.25
	31 - 40 yrs	2	4.166
	41 - 50 yrs	4	8.33
	51 - 60 yrs	13	27.083
	61 - 70 yrs	14	29.166
	71 - 80 yrs	9	18.75
	Above 80 yrs	1	2.08
Gender	Female (F)	12	25
	Male (M)	36	75
NIV Success/Failure	Intubated	14	29.166
	Weaned	34	70.83
Diagnosis	T2 RF	15	31.25
	Others	33	68.75
Comorbidity	≤ 2	32	66.66
	> 2	16	33.33

Predictive performance of the ROX index, HACOR score, and updated HACOR score were measured at 2, 12, and 24 hours to predict NIV failure.

The ROX Index at 2 hours for intubated patients had a mean of 9.34, significantly lower than for weaned patients (12.50, $p = 0.009$). At 12 and 24 hours, the ROX index demonstrated greater predictive value, with significantly lower mean scores for intubated patients (10.94 and 11.93) compared to weaned patients (14.82 and 16.67, $p = 0.002$ for both). The **Independent Samples t-test** showed statistical significance at both 12 and 24 hours ($p = 0.002$ for both), and the **Chi-Square analysis** further supported this, with significant associations at 12 hours ($p = 0.002$) and 24 hours ($p = 0.013$). Although the t-test result at 2 hours was not significant ($p = 0.009$), the Chi-Square test suggested a significant association ($p = 0.003$), indicating that while the ROX index has some early predictive potential, its reliability as a predictor improves significantly beyond the 12-hour mark. (Table 2).

Table 2: ROX Index Results

Time Point	**Test Type**	**Value**	**df**	**p-Value**
2 hrs	Pearson Chi-Square	11.391	2	0.003
	Likelihood Ratio	11.247	2	0.004
	Linear-by-Linear Association	10.852	1	0.001
12 hrs	Pearson Chi-Square	12.782	2	0.002
	Likelihood Ratio	12.127	2	0.002
	Linear-by-Linear Association	8.084	1	0.004
24 hrs	Pearson Chi-Square	8.652	2	0.013
	Likelihood Ratio	8.436	2	0.015
	Linear-by-Linear Association	8.130	1	0.004

The **HACOR Score** at 2 hours did not show a statistically significant difference between intubated and weaned patients ($p = 0.060$). However, at 12 and 24 hours, intubated patients had higher mean HACOR scores (3.43 and 2.93, respectively) compared to weaned patients (1.72 and 1.17, $p = 0.008$ and $p = 0.013$, respectively). The t-test showed significance at 12 hours ($p = 0.042$) and 24 hours ($p = 0.024$), but not at 2 hours ($p = 0.055$). The **Chi-Square analysis** for HACOR showed weaker associations compared to the ROX index at all time points, suggesting that HACOR may be less sensitive in predicting NIV outcomes, particularly in the early hours (Table 3).

Table 3: HACOR Score Results

Time Point	Test Type	Value	df	p-Value
2 hrs	Pearson Chi-Square	4.933	1	0.026
	Continuity Correction	3.228	1	0.072
	Likelihood Ratio	4.530	1	0.033
12 hrs	Pearson Chi-Square	4.779	1	0.029
	Continuity Correction	1.961	1	0.161
	Likelihood Ratio	4.970	1	0.026
24 hrs	Pearson Chi-Square	5.229	1	0.017
	Continuity Correction	2.874	1	0.120
	Likelihood Ratio	5.358	1	0.023

The **Updated HACOR Score** at 2, 12, and 24 hours consistently showed significant differences between intubated and weaned patients, with higher scores in the intubated group (p = 0.002, p = 0.001, and p = 0.003, respectively). It demonstrated early predictive potential at 2 hours (p = 0.019 in the t-test) and remained significant at 12 hours (p = 0.032) and 24 hours (p = 0.045). However, while the **Updated HACOR index** showed sensitivity at 2 hours, the **Chi-Square analysis** revealed weaker associations compared to the ROX index, suggesting that its overall predictive reliability may not exceed that of the ROX index (Table 4).

Table 4: Updated HACOR Score Results

Time Point	Test Type	Value	df	p-Value
2 hrs	Pearson Chi-Square	2.446	1	0.118
	Continuity Correction	1.549	1	0.213
	Likelihood Ratio	2.464	1	0.201
12 hrs	Pearson Chi-Square	7.624	1	0.006
	Continuity Correction	5.956	1	0.015
	Likelihood Ratio	7.951	1	0.010
24 hrs	Pearson Chi-Square	7.930	1	0.004
	Continuity Correction	6.122	1	0.013
	Likelihood Ratio	8.167	1	0.006

The ROX index and updated HACOR score at 12 and 24 hours provided the most robust prediction of NIV failure. The HACOR score also showed utility at these time points but was less predictive at 2 hours.

4. CONCLUSION

In conclusion, our study demonstrates that the ROX index is an effective and reliable tool for predicting the failure of non-invasive ventilation (NIV) in patients with type 2 respiratory failure (T2RF). The results reveal that the ROX index consistently offers stronger and more reliable predictive capabilities at 12 and 24 hours, across various statistical methods, making it a robust tool for assessing NIV outcomes, particularly for longer-term prediction. The updated HACOR index shows early predictive potential, though its utility diminishes over time compared to the ROX index. The original HACOR index, while significant at later time points, appears less sensitive overall. These findings highlight the ROX index as the most reliable and practical predictor for clinical decision-making in NIV management, especially when considering longer-term outcomes.

5. DISCUSSION

This study aimed to evaluate the predictive performance of the ROX index and the updated HACOR score for non-invasive ventilation (NIV) failure in patients with type 2 respiratory failure (T2RF). The results showed that the ROX index, particularly at the 12-hour and 24-hour time points, exhibited superior predictive accuracy compared to the updated HACOR score. The ROX index performed better in identifying patients at risk of NIV failure, supporting findings from other studies that suggest its utility in predicting outcomes in patients with hypoxemic respiratory failure (8, 13).

The updated HACOR score demonstrated moderate predictive ability at 2 hours, but its performance declined as time progressed. In contrast, the ROX index consistently provided more reliable predictions as the patient's clinical status evolved. Previous studies have indicated that the ROX index improves its accuracy as time from NIV initiation. This is likely due to the dynamic nature of respiratory function, with the index reflecting both oxygenation and respiratory rate, two key determinants of NIV success (11, 14)

The results of this study align with the study findings which demonstrated the ROX index's robust ability to predict NIV failure after 12 hours of treatment (13). Furthermore, study conducted by Roca et al. (2019) emphasized the role of simple and objective parameters, such as respiratory rate and oxygenation, in guiding clinical decisions. Our findings suggest that the ROX index could be a practical tool for clinicians, particularly in ICU settings where timely intervention is critical (15).

While the updated HACOR score is a well-established tool for predicting NIV failure in patients with hypercapnic respiratory failure, its application in T2RF appears less robust over time. The HACOR score relies on multiple factors such as heart rate, pH, consciousness, and respiratory rate, which may not fully capture the early physiological responses associated with NIV success or failure (16). This may explain the discrepancy in its performance compared to the ROX index in our study.

Another limitation of this study is its single-centre design, which may limit the generalizability of the results. The patient population was relatively homogenous, consisting mostly of male patients with T2RF, which may not reflect the broader range of patients who require NIV (17, 18). Larger, multicentre studies with a more diverse cohort are needed to confirm the findings and further assess the performance of the ROX index and HACOR score in different clinical settings. Additionally, the sample size of 48 patients may limit the statistical power of the analysis, which should be addressed in future research with larger populations. In future studies, it would be valuable to explore the potential for combining the ROX index with other indices, such as blood gas measures or respiratory effort scoring systems, to further enhance predictive accuracy. This approach could offer a more comprehensive assessment of a patient's response to NIV and improve clinical decision-making (19, 20).

REFERENCES

1. Prasad S, O'Neill S: Respiratory failure. Surgery (Oxford) 2021; 39:654-659. doi:10.1016/j.mpsur.2021.08.007.
2. Mas A, Masip J. Noninvasive ventilation in acute respiratory failure. Int J Chron Obstruct Pulmon Dis. 2014 Aug 11;9:837-52. doi: 10.2147/COPD.S42664. PMID: 25143721; PMCID: PMC4136955.
3. Davidson, A.C.; Banham, S.; Elliott, M.; Kennedy, D.; Gelder, C.; Glossop, A.; Church, A.C.; Creagh-Brown, B.; Dodd, J.W.; Felton, T.; et al. BTS/ICS guideline for the ventilatory management of acute hypercapnic respiratory failure in adults. Thorax 2016, 71 (Suppl. 2), ii1–ii35.
4. Girou, E.; Schortgen, F.; Delclaux, C.; Brun-Buisson, C.; Blot, F.; Lefort, Y.; Lemaire, F.; Brochard, L. Association of noninvasive ventilation with nosocomial infections and survival in critically ill patients. JAMA 2000, 284, 2361–2367.
5. Jaber S, Bellani G, Blanch L, et al. The intensive care medicine research agenda for airways, invasive and noninvasive mechanical ventilation. Intensive Care Med. 2017;43:1352–65.
6. Carteaux G, Millán-Guilarte T, De Prost N, et al. Failure of noninvasive ventilation for de novo acute hypoxemic respiratory failure: Role of tidal volume. Crit Care Med. 2016;44:282–90.
7. Mehta S, Hill NS (2001) Noninvasive ventilation. Am J Respir Crit Care Med 163(2):540–577
8. Chawla, R. K., Yadav, V., Banerjee, S., Chaudhary, G., & Chawla, A. (2021). Predictors of success and failure of non-invasive ventilation use in type-2 respiratory failure. The Indian journal of tuberculosis, 68(1), 20–24. https://doi.org/10.1016/j.ijtb.2020.10.002
9. Ergan B, Nasiłowski J, Winck JC. How should we monitor patients with acute respiratory failure treated with noninvasive ventilation? Eur Respir Rev. 2018 Apr 13;27(148):170101. doi: 10.1183/16000617.0101-2017. PMID: 29653949; PMCID: PMC9489094.
10. Teng W, Chen H, Shi S, Wang Y, Cheng K. Effect of bilevel continuous positive airway pressure for patients with type II respiratory failure due to acute exacerbation of COPD: A protocol for systematic review and meta-analysis. Medicine (Baltimore). 2021 Jan 15;100(2):e24016. doi: 10.1097/MD.0000000000024016. PMID: 33466145; PMCID: PMC7808460.
11. Duan, J., Yang, J., Jiang, L. et al. Prediction of noninvasive ventilation failure using the ROX index in patients with de novo acute respiratory failure. Ann. Intensive Care 12, 110 (2022). https://doi.org/10.1186/s13613-022-01085-7
12. Teh YH, Nazri MZAM, Azhar AMN, Alip RM. HACOR Score in Predicting Non-invasive Ventilation Failure in Acute Decompensated Heart Failure and AECOAD Patients. Eurasian J Emerg Med. 2022 Sep;21(3):165-175. doi:10.4274/eajem.galenos.2022.09734.
13. Praphruetkit N, Boonchana N, Monsomboon A, Ruangsomboon O. ROX index versus HACOR scale in predicting success and failure of high-flow nasal cannula in the emergency department for patients with acute hypoxemic respiratory failure: a prospective observational study. International Journal of Emergency Medicine. 2023 Jan 10;16(1):3.
14. Mamdouh OM, Ahmed AE, Hashem AZ, Elshahaat HA. Performance of different dynamic oxygenation indices incorporating heart rate to predict non-invasive ventilation outcomes in hypoxemic respiratory failure. The Egyptian Journal of Bronchology. 2024 Dec;18(1):1-7.
15. Roca O, Caralt B, Messika J, Samper M, Sztrymf B, Hernández G, García-de-Acilu M, Frat JP, Masclans JR, Ricard JD. An index combining respiratory rate and oxygenation to predict outcome of nasal high-flow therapy. American journal of respiratory and critical care medicine. 2019 Jun 1;199(11):1368-76.

16. Duan J, Chen L, Liu X, Bozbay S, Liu Y, Wang K, Esquinas AM, Shu W, Yang F, He D, Chen Q. An updated HACOR score for predicting the failure of noninvasive ventilation: a multicenter prospective observational study. Critical Care. 2022 Jul 3;26(1):196.
17. Guideline BT. Non-invasive ventilation in acute respiratory failure. Thorax. 2002 Mar;57(3):192-211.
18. Nava S, Hill N. Non-invasive ventilation in acute respiratory failure. The Lancet. 2009 Jul 18;374(9685):250-9.
19. Agarwal R, Gupta R, Aggarwal AN, Gupta D. Noninvasive positive pressure ventilation in acute respiratory failure due to COPD vs other causes: effectiveness and predictors of failure in a respiratory ICU in North India. International journal of chronic obstructive pulmonary disease. 2008 Jan 1;3(4):737-43.
20. Abraham SV, Azeez AK, Padmanabhan A. NIV failure in respiratory failure: an analysis. The Egyptian Journal of Bronchology. 2023 Jun 22;17(1):29.