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Neonatal Necrotizing Enterocolitis Early Warning Score (NEC-EWS): Development, Validation and Clinical Utility

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Abstract

Background: Necrotizing enterocolitis (NEC) is a leading cause of gastrointestinal morbidity and mortality among very preterm neonates. Early diagnosis is difficult because initial clinical manifestations are subtle and nonspecific, often preceding radiological changes. The present study aimed to develop and validate a simple bedside Neonatal Necrotizing Enterocolitis Early Warning Score (NEC-EWS) for early identification of preterm neonates at high risk of developing NEC.

Methods: This prospective observational study was conducted in a tertiary neonatal intensive care unit. Preterm neonates with gestational age <34 weeks were enrolled and followed until discharge or death. Serial clinical and laboratory parameters were recorded daily. A composite early warning score was constructed using independent predictors of NEC. Diagnostic performance was evaluated using receiver operating characteristic (ROC) curve analysis.

Results: Of 150 preterm neonates included, 18 (12%) developed NEC (Bell stage ≥II). Neonates who developed NEC had significantly lower gestational age and birth weight. A progressive rise in NEC-EWS was observed 24–72 hours prior to radiological diagnosis. A cutoff score of ≥5 demonstrated optimal diagnostic accuracy (AUC 0.84; 95% CI 0.77–0.91), with sensitivity of 83% and specificity of 78%. Higher NEC-EWS values were associated with increased disease severity, need for surgical intervention, prolonged NICU stay, and mortality.

Conclusion: NEC-EWS is a practical, dynamic, and cost-effective bedside tool for early identification of preterm neonates at risk of NEC. Its routine use may facilitate earlier intervention and potentially reduce progression to advanced disease. Multicenter validation is required before widespread implementation.

Keywords: Necrotizing enterocolitis; early warning score; preterm neonates; neonatal intensive care; risk stratification

Introduction

Necrotizing enterocolitis (NEC) remains one of the most devastating gastrointestinal emergencies in neonatal intensive care units, predominantly affecting very preterm and very low birth weight infants. Despite advances in neonatal care, NEC continues to be associated with high mortality and substantial long-term morbidity, including short bowel syndrome and adverse neurodevelopmental outcomes.[1,2] Early recognition of NEC is critical, as timely intervention

may prevent progression to intestinal necrosis and the need for surgical management.

The diagnosis of NEC is traditionally based on clinical features and radiological findings, commonly classified using the modified Bell staging system.[1] However, Bell staging primarily identifies established disease and offers limited utility in predicting early or evolving NEC. Early clinical signs such as feeding intolerance, abdominal distension, or subtle laboratory abnormalities are often nonspecific and overlap with neonatal sepsis, leading to delays in diagnosis.

Several biomarkers and advanced monitoring techniques have been investigated for early detection of NEC, including inflammatory cytokines, intestinal fatty acid–binding protein, fecal calprotectin, and near-infrared spectroscopy.[3–5] While promising, these approaches are limited by cost, availability, and lack of standardization, particularly in resource-limited settings. There is therefore a need for a simple, reproducible, bedside-applicable tool that integrates routinely available clinical and laboratory parameters to facilitate early risk stratification. The present study describes the development and validation of a Neonatal Necrotizing Enterocolitis Early Warning Score (NEC-EWS) designed to address this unmet clinical need.

Methods

Study design and setting

This prospective observational study was conducted in the neonatal intensive care unit (NICU) of DVVPF's hospital, Ahilyanagar over a 12-month period from October 2024 to September 2025. Institutional ethics committee approval was obtained prior to study initiation, and written informed consent was obtained from parents or legal guardians.

Study population

Preterm neonates with gestational age <34 completed weeks who were admitted to the NICU and initiated on enteral feeds during hospital stay were eligible for inclusion.

Exclusion criteria

1. Major congenital gastrointestinal malformations

2. Congenital abdominal wall defects, chromosomal abnormalities or major congenital anomalies

3. Major congenital heart disease

4. Spontaneous intestinal perforation without features of NEC

5. NEC diagnosed within the first 48 hours of life.

Data collection and NEC-EWS development

Baseline demographic and perinatal data were recorded at enrollment. Serial daily assessments included clinical and laboratory parameters routinely monitored in NICU practice. The NEC-EWS was constructed using five predefined parameters:

1. Increase in abdominal girth
2. Feeding intolerance with abnormal gastric residuals
3. Abnormal stool findings (occult or gross blood)
4. Thrombocytopenia
5. Elevated C-reactive protein

Each parameter was assigned a score from 0 to 2 based on severity, yielding a cumulative NEC-EWS ranging from 0 to 10. Serial NEC-EWS values were calculated daily until discharge or death.

Outcome measures

The primary outcome was development of NEC defined as modified Bell stage II or higher. Secondary outcomes included requirement for surgical intervention, duration of NICU stay, and mortality.

Statistical analysis

Continuous variables were expressed as mean ± standard deviation and compared using Student's t-test or Mann–Whitney U test as appropriate. Categorical variables were compared using chi-square or Fisher's exact test. Multivariate logistic regression analysis was performed to identify independent predictors of NEC. Diagnostic performance of NEC-EWS was assessed using ROC curve analysis, and the optimal cutoff value was determined using the Youden index. A p value <0.05 was considered statistically significant.

Results

A total of 150 preterm neonates with gestational age <34 weeks were enrolled and prospectively followed. Of these, 18 neonates (12%) developed NEC (modified Bell stage ≥II). Neonates who developed NEC had significantly lower mean gestational age (29.4 ± 2.1 weeks vs 31.2 ± 2.3 weeks; p <0.01) and lower mean birth weight (1080 ± 210 g vs 1320 ± 260 g; p <0.01). There were no statistically significant

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differences between the two groups with respect to sex distribution, mode of delivery, or antenatal steroid exposure.

Table 1. Baseline Characteristics of NEC and Non-NEC Groups

Parameter	NEC group (n=18)	Non-NEC group (n=132)	p value
Gestational age (weeks)	29.4 ± 2.1	31.2 ± 2.3	<0.01
Birth weight (g)	1080 ± 210	1320 ± 260	<0.01

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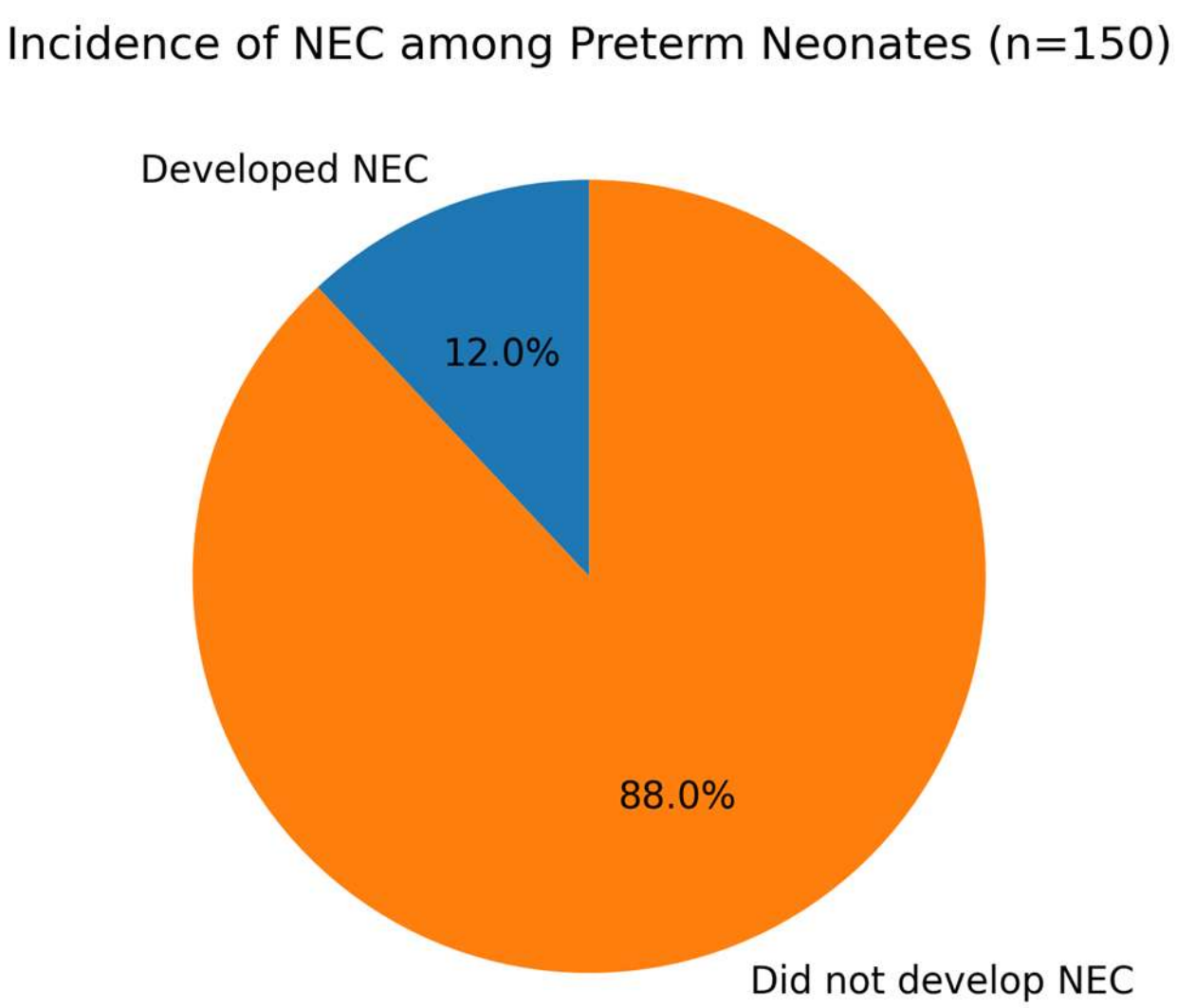

Serial evaluation of NEC-EWS revealed a characteristic temporal pattern. In neonates who subsequently developed NEC, the NEC-EWS showed a gradual and consistent rise over time, whereas scores remained low and stable among neonates who did not develop NEC. In 72% of NEC cases, the score began to rise 48–72 hours prior to radiological confirmation, while in the remaining cases, a rise was observed at least 24 hours before imaging changes became apparent.

Analysis of individual NEC-EWS components demonstrated that early clinical signs such as increasing abdominal girth and feeding intolerance were often the first abnormalities to appear, followed by abnormal stool findings. Laboratory abnormalities, particularly thrombocytopenia and elevated C-reactive protein, typically emerged closer to the time of clinical diagnosis.

On multivariate logistic regression analysis, all five components of NEC-EWS remained independently associated with NEC development ($p < 0.05$). Receiver operating characteristic curve analysis demonstrated strong discriminative ability, with an area under the curve of 0.84 (95% CI 0.77–0.91). A cutoff score of ≥5 provided optimal diagnostic performance, yielding sensitivity of 83%, specificity of 78%, positive predictive value of 36%, and negative predictive value of 97%.

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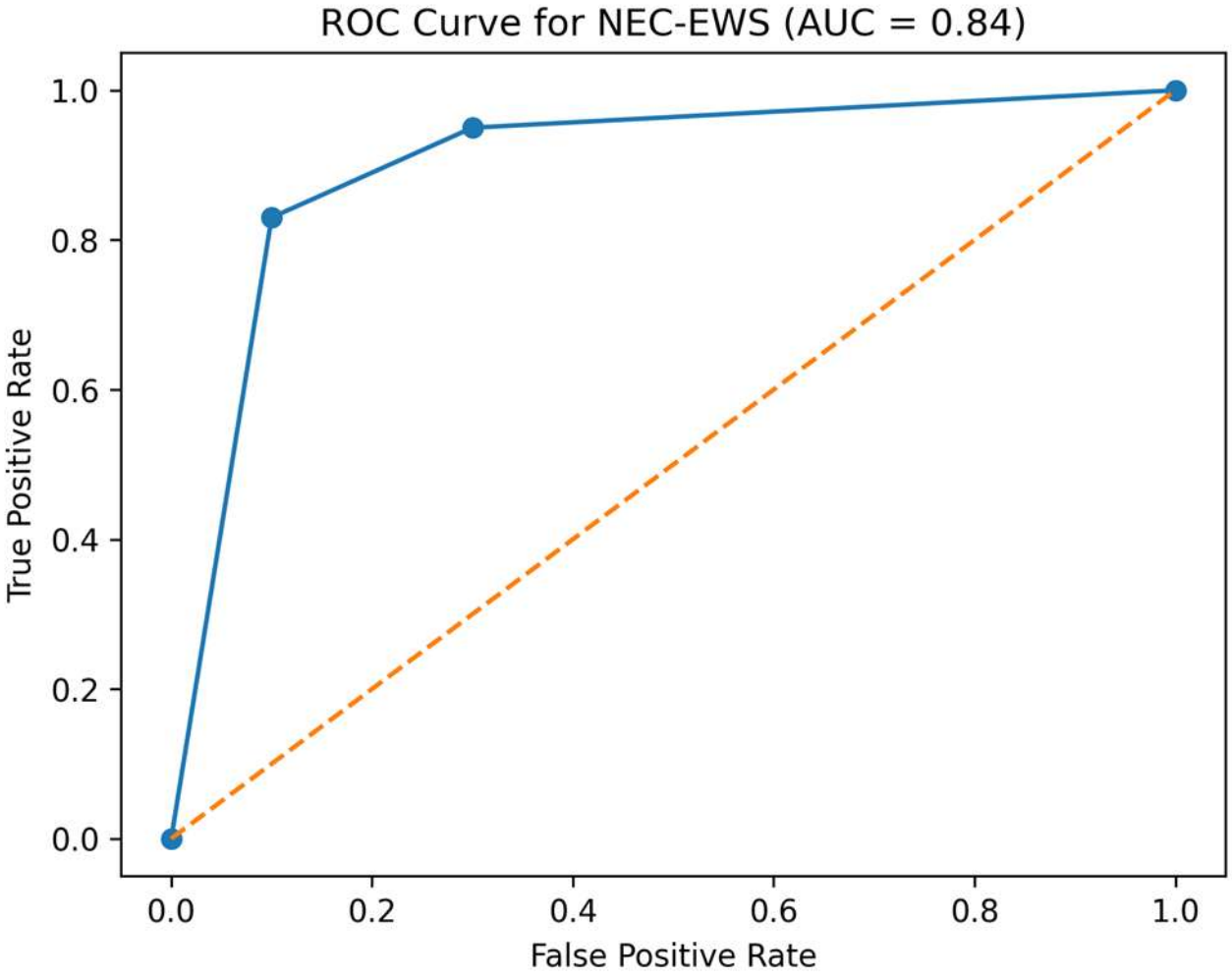

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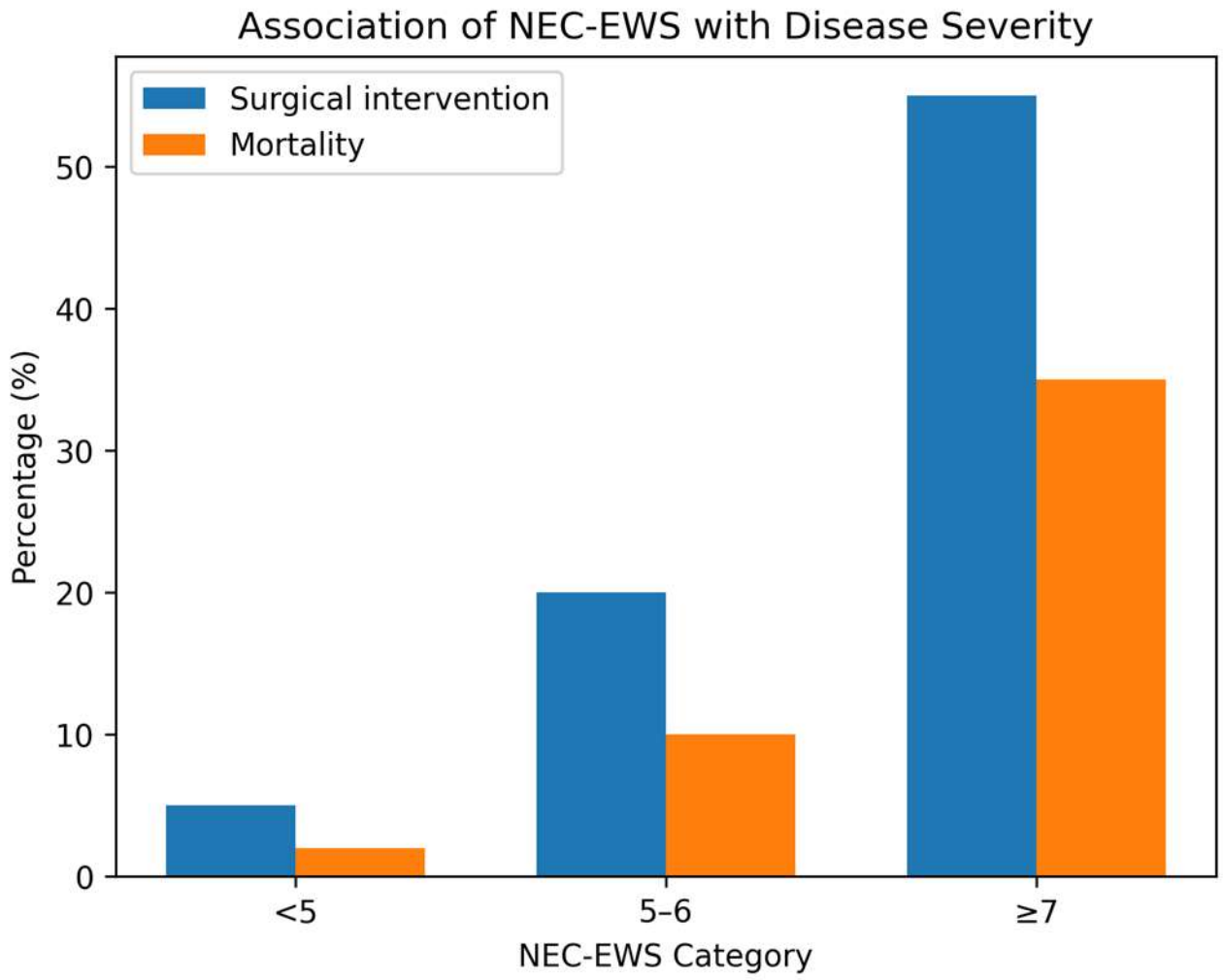

Higher NEC-EWS values were significantly associated with greater disease severity. Neonates with scores ≥7 had higher rates of surgical intervention, longer duration of NICU stay, and increased mortality compared with neonates with lower scores.

Discussion

Necrotizing enterocolitis remains a major challenge in neonatal intensive care, primarily due to the difficulty in distinguishing early disease from benign feeding intolerance or neonatal sepsis. In this prospective observational study, we demonstrate that a composite early warning score derived from simple, routinely available clinical and laboratory parameters can identify preterm neonates at increased risk of NEC before classical radiological features become evident.

A key finding of this study is the identification of a clinically meaningful threshold at a NEC-EWS of ≥5. This cutoff corresponded to a sharp increase in NEC incidence and represented a transition point in disease evolution. The observation that NEC-EWS increased 24–72 hours prior to radiological diagnosis highlights a critical window during which intensified monitoring and early intervention may be possible.

The components of NEC-EWS reflect established aspects of NEC pathophysiology. Intestinal immaturity and dysmotility predispose preterm infants to feeding intolerance and abdominal distension, often the earliest clinical manifestations. Mucosal injury and ischemia–reperfusion damage lead to abnormal stool findings, while bacterial translocation and activation of the inflammatory cascade contribute to thrombocytopenia and elevated acute-phase reactants.[6,7] The independent association of each component with NEC supports both the biological plausibility and clinical relevance of the score.

Several predictive approaches for NEC have been proposed, including biomarker-based strategies and

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machine-learning models.[3–5] While these may offer high diagnostic accuracy, their routine application is constrained by cost, technical complexity, and limited availability. In contrast, NEC-EWS was deliberately designed to maximize feasibility and bedside applicability, making it suitable for routine NICU use, including in resource-limited settings.

The dynamic nature of NEC-EWS represents an additional strength. Unlike static models based on baseline risk factors alone, NEC-EWS captures evolving clinical trends, allowing early recognition of deterioration and potentially supporting timely decisions regarding feeding modification, sepsis evaluation, antibiotic initiation, and surgical consultation.

This study has limitations. As a single-center study, generalizability may be limited, and some interobserver variability in clinical assessments cannot be excluded. Moreover, while NEC-EWS predicts disease onset and severity, the study was not designed to evaluate whether score-guided interventions directly reduce morbidity or mortality. Multicenter validation and interventional studies are therefore warranted.

Conclusion

The Neonatal Necrotizing Enterocolitis Early Warning Score (NEC-EWS) is a novel, simple, and clinically meaningful bedside tool for early risk stratification of preterm neonates (<34 weeks) susceptible to NEC. By integrating routinely assessed clinical and laboratory parameters into a dynamic scoring system, NEC-EWS enables recognition of evolving intestinal pathology at a stage when targeted interventions may still prevent progression to severe disease.

A cutoff score of ≥5 emerged as a robust and biologically plausible threshold identifying neonates at substantially increased risk of NEC and adverse outcomes. Beyond predicting disease onset, higher NEC-EWS values correlated with greater disease severity, surgical intervention, prolonged hospitalization, and mortality. Routine incorporation of NEC-EWS into daily NICU practice may facilitate standardized surveillance and earlier escalation of care. Multicenter validation is required before widespread implementation.

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