ORIGINAL ARTICLE

Neonatal Sequential Organ Failure Assessment Score to Predict Mortality in Neonatal Intensive Care Unit at Tertiary Care Center

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Abstract

Introduction: The Neonatal Sequential Organ Failure Assessment (nSOFA) score is a tool used to evaluate degree of organ dysfunction in critically ill neonates admitted to neonatal intensive care units. The nSOFA score is based on respiratory, cardiac and hematological parameters (total score ranges from 0 to 15). This study aims to evaluate the applicability of nSOFA score to predict neonatal mortality in NICU of Patan Academy of Health Sciences

Methods: This prospective observational study was conducted at the NICU of Patan Hospital Nepal from May 2023 to November 2024 after ethical clearance from institutional review committee (Reference number: PMP2305231729). The parameters of nSOFA score were recorded at admission and between 48-72 hours of admission. Data were entered in epi-info and analyzed using Easy R software.

Results: Among the 134 neonates enrolled, a total of 105(78.40%) survived, while 29(21.60%) died during the study period. At the time of admission, the nSOFA score, using a cutoff value of ≥4, demonstrated a sensitivity of 69% and specificity of 91.40% for predicting mortality. The corresponding positive predictive value (PPV) and negative predictive value (NPV) were 69% and 91.40%, respectively. Within 48 to 72 hours of admission, the predictive performance of the nSOFA score improved, with an area under the curve (AUC) of 0.98 (95% CI: 0.971–1). Using a cutoff of ≥5 during this period yielded a sensitivity of 75.70%, specificity of 99.0%, PPV of 96.60%, and NPV of 91.40%.

Conclusions: The nSOFA score is an important tool for predicting neonatal mortality in NICUs and can be used to guide clinical decision-making.

Keywords: *neonatal mortality, neonates, nSOFA.*

Introduction

Neonatal mortality remains a global concern, with approximately 2.3 million deaths in 2022.[1] The highest rates of neonatal deaths are in sub-Saharan Africa and South Asia.[1] Nepal being a developing nation, continues to struggle with neonatal mortality, with the Nepal Demographic and Health Survey (NDHS)

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reporting a stagnant neonatal mortality rate of 21 per 1,000 in both 2016 and 2022.[2,3] Major causes of neonatal deaths in Nepal include prematurity, birth asphyxia, infections and trauma.[4,5] Nepal's Every Newborn Action Plan (NENAP) aims to lower the neonatal mortality rate to below 11 per 1,000 live births by the year 2035.[6] Addressing this requires early identification of critically ill neonates, and the use of objective tools for severity assessment and risk stratification.[7]

In neonatal intensive care units (NICUs), various scoring systems have been developed to assess the severity of illness and predict outcomes. These include the Clinical Risk Index for Babies (CRIB), Neonatal Therapeutic Intervention Scoring System (NTISS) and Sick Neonatal Score (SNS). However, these require extensive laboratory investigations, limiting their utility in low-resource settings.[8–11] The Sequential Organ Failure Assessment (SOFA) score, originally for adults, has been modified for neonatal population to provide an objective assessment of organ dysfunction.[12]

The Neonatal SOFA (nSOFA) score is a new tool that evaluates three key physiological parameters: respiratory status, cardiovascular function, and hematologic dysfunction to predict mortality in critically ill neonates.[13] Previous studies have shown its strong correlation with mortality risk in NICU, providing an early warning system for clinical deterioration.[13–19] Traditional scoring systems like CRIB, NTISS and SNS require extensive laboratory data and might not be applicable practically.[8–11] nSOFA offers a simpler bedside-friendly alternative. It relies on such parameters that are routinely monitored such as respiratory status, cardiovascular function and inotrope use and platelet count.[13] So, it is a more feasible tool for rapid and repeated assessment in low-resource as well as high resource setting such as the NICU. Its dynamic nature also allows for the real-time monitoring of clinical deterioration or improvement, which is important for timely interventions.

Despite its potential, the nSOFA score has not been extensively studied in Nepal. This study aimed to evaluate the predictive accuracy of the nSOFA score for neonatal mortality in a tertiary NICU setting and its practicality in improving neonatal outcomes. In addition, because of the easy-to-obtain parameters of nSOFA, its applicability extends beyond the NICUs of tertiary centre. It can be used in peripheral healthcare centres, enabling early risk stratification and timely referral of critically ill neonates.

Methods

A prospective observational study was conducted in the NICU of a tertiary care hospital in Nepal. Ethical approval was obtained from the Institutional Review Committee (IRC) of Patan Hospital (Reference number: PMP2305231729). Study population included all neonates admitted to the NICU from May 2023 to November 2024, excluding those with known critical congenital heart disease, life-threatening congenital anomalies, those who left against medical advice, or those whose parents didn't provide consent for study. Consent was taken from the parents by on duty doctor at the study site. The data was recorded at two time points: at 0 hours of admission and between 48-72 hours of admission. nSOFA was calculated which included the parameters of respiratory function (SpO2/FiO2 ratio), cardiovascular function (use of inotropes/steroids) and hematologic function (platelet count).[19] The nSOFA scores were calculated as part of routine clinical care, and blinding to outcomes was not done. Collected data was entered in EPI-INFO and analyzed using Microsoft Excel and Easy R. Student's t-test was used to compare nSOFA scores between survivors and non-survivors. Receiver Operating Characteristic (ROC) curve was generated for nSOFA score to determine cut-off point, sensitivity, specificity, NPV and PPV to predict neonatal mortality in NICU.

Results

Among 134 neonates, 89(66.42%) were male, and 45(33.58%) were female. A majority, i.e., 95(70.90%) were preterm, and 94(70.15%) had low birth weight. Figure 1 shows that out of 134, 105(78.36%) were survivors, whereas 29(21.64%) were non-survivors.

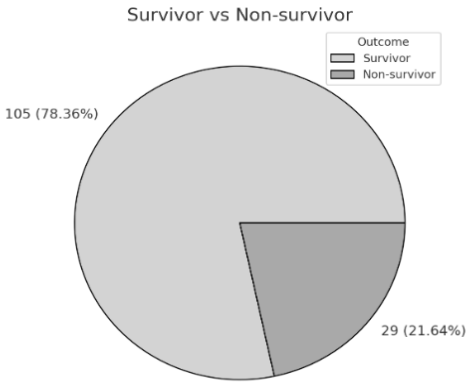

Figure 1: Outcome of enrolled neonates

Table 1: nSOFA score between Survivor and Non-survivor at 0 hr (T1) and between 48 to 72 hrs (T2) of admission (n=134).

Parameters		Outcome				p-value
		Survivor n(%)		Non-Survivor n(%)		
		Mean (± SD)	Min-Max	Mean (±SD)	Min-Max	
nSOFA	T1	2.1 (±2)	0-10	5.6 (±2.7)	0-10	<0.001*
	T2	0.9 (±1.8)	0-8	8.2 (±2.2)	4-13	<0.001*

*Statistically significant

The Table 1 shows mean nSOFA score at the time of admission (T1) among survivors was 2.1±2 and between 48-72 hours of admission (T2) was 0.9±1.8. In comparison, the mean nSOFA score in non-survivors at T1 was 5.6±2.7 and at T2 was 8.2±2.2, which was statistically significant.

Table 2: nSOFA score between survivor and non-survivor at 0 hr and between 48 to 72 hrs of admission (n=134).

		Outcome			
		Survivor n(%)		Non-Survivor n(%)	
Parameters		Mean (±SD)	Min-Max	Mean (±SD)	Min-Max
Respiratory	T1	1.8 (± 1.8)	0-8	4 (±2)	0-8
	T2	0.6 (±1.3)	0-6	4.9 (±1.8)	2-8
Cardiovascular	T1	0.2(±0.5)	0-3	1 (±0.9)	0-3
	T2	0.2(±0.5)	0-3	2.3(±0.8)	0-4
Hematological	T1	0.1(±0.4)	0-2	0.6(±0.8)	0-3
	T2	0.1(±0.5)	0-3	1(±1)	0-3

The mean scores of respiratory, cardiovascular, and haematological components were significantly higher among non-survivors than survivors at both T1 and T2 (Table 2).

Table 3: nSOFA score between survivor and non-survivor at 0 hr and between 48 to 72 hrs of admission in relation to gestational age and birth weight (n=134).

Parameters		Outcome				
		Survivor n(%)		Non-Survivor n(%)		p-value
		Mean (±SD)	Min-Max	Mean (±SD)	Min-Max	
Gestational Age						
Pre term<37 WOG	T1	2.1(±2)	0-10	4.6 (±2.4)	0-9	<0.001*
	T2	0.9(±1.7)	0-8	7.7(±1.9)	4-11	<0.001*
Term ≥37 WOG	T1	2(±2.1)	0-9	8(±1.7)	4-10	<0.001*
	T2	1(±2)	0-6	9(±2.5)	5-13	<0.001*
Birth weight (kg)						
LBW<2500g	T1	2(±2)	0-10	4.9(±2.9)	0-9	<0.001*
	T2	0.97(±1.8)	0-8	8(±2)	4-12	<0.001*
Normal ≥2500g	T1	2.1(±2.1)	0-9	8.5(±1)	7-10	<0.001*
	T2	1(±1.8)	0-6	6(±2.8)	5-13	<0.001*

*Statistically significant

Non-survivors consistently had higher nSOFA scores than survivors at both admission (T1) and 48–72 hours (T2) across all subgroups. This pattern was observed in preterm (4.6 vs 2.1 at T1; 7.7 vs 0.9 at T2), term (8 vs 2 at T1; 9 vs 1 at T2), low-birth-weight (4.9 vs 2 at T1; 8 vs 0.97 at T2), and normal-birth-weight neonates (8.5 vs 2.1 at T1; 6 vs 1 at T2), with all differences statistically significant.

The receiver operating characteristic (ROC) curve generated with nSOFA score at 0 hour and between 48 to 72 hours of admission to predict mortality among neonates (Figure 2). At 0 hour of admission, the area under the curve (AUC) for nSOFA was 0.83 (CI 95%; 0.739-0.931) which indicates 83% accuracy of nSOFA in predicting mortality. For nSOFA cutoff score of ≥4, sensitivity, specificity, positive predictive value (PPV) and, negative predictive value (NPV) for predicting mortality were 69%, 91.40%, 69% and, 91.40% respectively (Figure 2).

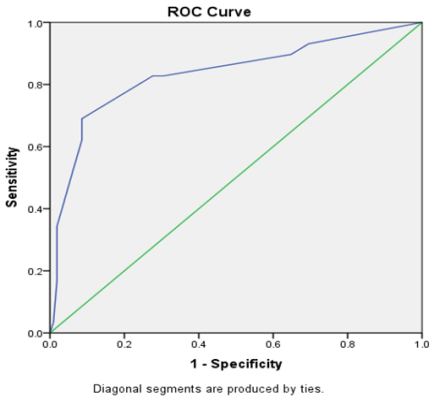

Figure 2: Receiver operating characteristic (ROC) curve generated with nSOFA score as the test variable to predict mortality at 0 hour of admission

at 48-72 hours of admission, the area under the curve (AUC) for nSOFA was 0.98 (CI 95%; 0.971-1.00) which indicates 98% accuracy of nSOFA in predicting mortality. For nSOFA cutoff score of ≥5, sensitivity, specificity, positive predictive value (PPV) and, negative predictive value (NPV) for predicting mortality were 75.70%, 99%, 96.60% and, 91.40% respectively (Figure 3).

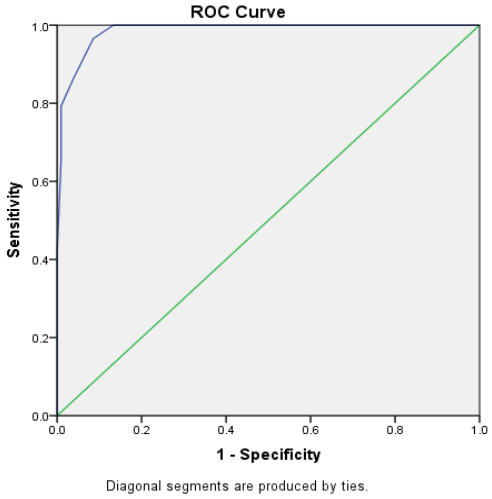

Figure 3: Receiver operating characteristic (ROC) curve generated with nSOFA score as the test variable to predict mortality at 48-72 hours of admission

Discussion

This study enrolled 134 neonates admitted to the NICU, with nSOFA parameters recorded at admission (T1) and between 48-72 hours (T2). The study showed a male predominance 89 (66%) and a high prevalence of prematurity 95 (71%) and low birth weight 94 (70%). Overall, 29 (22%) of neonates did not survive. The mean nSOFA score at T1 was significantly higher in non-survivors (5.6±2.7) compared to survivors (2.1±2), with a further increase in non-survivors at T2 (8.2±2.2), while survivors showed a decrease (0.9±1.8). The difference in scores between the two groups was statistically significant (p<0.001).

The findings of this study are in line with a prospective pilot study conducted in India, where survivors had a mean nSOFA score of 1.96±1.69 at admission and 1.16±1.48 at 24 hours, while non-survivors had significantly higher scores (7.6±2.0 at admission and 10±2.29 at 24 hours).[15] The slightly lower admission scores in our study could be due to the inclusion of all neonates in the NICU, whereas the Indian study focused only on preterm neonates with presumed or proven sepsis. Additionally, our study evaluated nSOFA at 48-72 hours instead of 24 hours, leading to a difference in mean scores at the second evaluation.

At admission (T1), our study demonstrated an AUC of 0.83 for nSOFA in predicting mortality, with a cutoff score of ≥4 yielding a sensitivity of 69% and specificity of 91.40%. This aligns with findings from a study in Ankara, Turkey, where a nSOFA score >4 at sepsis evaluation was associated with a 7-to-16-fold increased risk of mortality.[20] In comparison, the pilot study in India showed a higher AUC (0.972) and better sensitivity (90%) and specificity (98%), likely due to its exclusive focus on neonates with sepsis, who inherently have a higher risk of mortality.[15]

At 48-72 hours (T2), our study found an AUC of 0.98, indicating excellent predictive accuracy. A cutoff score of ≥5 had a sensitivity of 75.70%, specificity of 99%, PPV of 96.60%, and NPV of 91.40%. These values were comparable to the pilot study in India, which reported an AUC of 0.999, sensitivity of 100%, specificity of 98%, and accuracy of 98.30%.[15] The slightly lower sensitivity in our study might be attributed to a broader inclusion criterion encompassing all NICU admissions, rather than focusing only on neonates with sepsis.

A study conducted in Florida, USA, among bacteremic preterm with very low birth weight (VLBW), showed that mortality was significantly higher among neonates with nSOFA scores ≥4 at admission and subsequent time points. Their reported AUC values ranged from 0.77 to 0.93 at different evaluation times, which is consistent with our findings.[13] Another Brazilian cohort study on VLBW infants evaluated nSOFA at multiple time points and found the best predictive accuracy at T-6 (six hours before sepsis diagnosis), with a cutoff score of ≥5.21. In contrast, our study identified the 48–72 hour mark as the most accurate time for mortality prediction, possibly due to different patient populations and study settings.

A retrospective cohort study from Prague evaluated the applicability of nSOFA within 72 hours of birth

as a predictor for mortality and adverse outcomes in very preterm neonates. It identified a lower cutoff score (>2) with an AUC of 0.795, likely due to its focus on predicting both mortality and severe morbidities such as chronic lung disease and intraventricular hemorrhage.[17] Our study, in contrast, specifically assessed mortality, leading to higher cutoff scores (≥4 at T1, ≥5 at T2) and stronger predictive performance.

Additionally, analysis of individual nSOFA components in our study revealed worsening scores in non-survivors from admission to 48-72 hours: respiratory (4±2 to 4.9±1.8), cardiovascular (1±0.9 to 2.3±0.8), and hematologic (0.6±0.8 to 1±1). Similar trends were observed in the Indian pilot study, reinforcing the correlation between increasing nSOFA scores and higher mortality risk.[15]

Overall, our study confirms that nSOFA is a reliable and practical tool for mortality prediction in NICU settings. It is easy to implement, cost-effective, and demonstrates high accuracy, sensitivity, and specificity. Initially designed to predict sepsis-related mortality, nSOFA has now been validated across various neonatal conditions, including birth asphyxia, necrotizing enterocolitis, and respiratory distress syndrome. While our findings support its clinical utility, further multicenter studies are needed to optimize its application in different neonatal population and healthcare settings.

The nSOFA score showed a high predictive accuracy for neonatal mortality, with an increasing score correlating with a higher risk of death. The findings align with previous studies in India and the USA, supporting the use of nSOFA as a simple and effective tool for neonatal risk stratification. Based on its strong predictive accuracy and ease of implementation, our study supports the integration of the nSOFA score as a standard tool for both admission assessment and ongoing monitoring in NICUs. Its use may enhance early recognition of clinical deterioration, guide timely interventions, and improve neonatal outcomes, particularly in resource-limited settings.

Study was conducted in a single center. Potential confounding factors such as maternal risk factors and primary disease affecting neonates were not assessed. The second evaluation at 48-72 hours may introduce variability as it was not done at a single and specific point of time.

Conclusions

The nSOFA score is an important tool designed to predict mortality risk among neonates admitted to the NICU. By assessing the degree of organ dysfunction in three key systems respiratory, cardiovascular and hematologic the nSOFA score provides a comprehensive measure of a neonate's overall clinical status. An nSOFA score of ≥4 at admission and ≥5 within 48 to 72 hours of admission aids to predict increased risk of mortality. This scoring system predicts mortality regardless of the neonate's gestational age and birth weight.

Larger, multi-center studies will be essential to confirm the score's predictive accuracy in diverse clinical settings and to establish its applicability across different populations of neonates. Such research could help refine the scoring system and potentially incorporate additional variables to improve its utility in clinical practice.

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