A Study on Prognostic Accuracy of Extended Sick Neonatal Score (ESNS) for Prediction of Mortality and Morbidity in Sick Newborns Admitted to NICU

Chethan ML [1], Ashwin AM [2], Sowndarya TA[3], Mounesh Pattar[4]

[1,2] Consultant Pediarician C.S.I Holdsworth Memorial Hospital, Mysuru

[3] Dept Of Community Medicine, [4] Dept of Pediatrics, Shridevi Institute of Medical Sciences and Research Hospital, Tumkur

Abstract

The neonatal period carries the highest risk of mortality per day and there is a need for a rapid, cost-effective, practical and sustainable score to determine the neonatal morbidity and mortality. We aimed to determine the prognostic accuracy of Extended sick neonatal score (ESNS) for hospital mortality. To predict Mortality and morbidity among sick new borns based on Extended sick neonatal score (ESNS)

A prospective prognostic accuracy study on newborn babies admitted in NICU, CSI Holdsworth Memorial Hospital, Mysuru, Karnataka during July 2019 to June 2020. Assuming a sensitivity of 90%, type 1 error of 5%, power of 90%, the precision of 10%, the minimum sample size was calculated as 140 and subjects recruited by convenient sampling, among which 58.57% were preterm and 41.43% full term.

In our study, 79.29% had ESNS >11 and 20.71% had ESNS <=11. In predicting hearing impairment, ESNS had sensitivity 80% (95% CI 28.36% to 99.49%), specificity 81.48% (95% CI 73.89% to 87.64%). Mortality among the study population was 2.8%.

ESNS had good specificity for ROP, hearing impairment among preterm babies. ESNS can predict ROP, hearing impairment and sepsis outcome with satisfactory sensitivity and specificity and would be useful irrespective of gestational age.

Keywords: ESNS, Retinopathy of prematurity, hearing impairment, sepsis, neonatal mortality, outcome, prematurity, scoring system

Introduction

Worldwide, preterm birth problems (7,42,400), intrapartum-related complications (neonatal encephalopathy from birth asphyxia/trauma 6,43,800), newborn sepsis (3,46,400), and other neonatal infections such pneumonia, tetanus, and diarrhoea are the primary causes of neonatal death[1]. Infectious infections, birth asphyxia, birth traumas, the effects of premature birth, and birth deformities are direct causes of newborn death. Asphyxia, infection, prematurity-related problems and birth defects are the leading causes of mortality during the early newborn period (0–7 days); infections account for the majority of late neonatal deaths (8-28 days)[2]. A significant fraction of paediatric mortality worldwide are caused by neonatal deaths. Neonatal mortality is thought to be declining at a rate of 1.7 percent annually on average, which is substantially slower than the 2.2 percent drop in under-five mortality. Neonatal fatalities increased as a percentage of all deaths from 8% (4 million) in 2000 to almost 41% (20.5 million) in 2009 as a result of the decreased neonatal mortality rate[3]. A well-known indicator of the socioeconomic and health status of the population, Infant or Neonatal Mortality Rate (IMR) is a measure of infant deaths before one year of age. Early neonatal (death occurred within the first 7 days postpartum), late neonatal (death occurred from 8 to 27 days postpartum), and post neonatal (death occurred from 28 to 365 days postpartum) are the three eras that make up the IMR[4].

Numerous sociodemographic, healthcare, biological, and other factors interact in intricate ways to determine newborn mortality. The creation of sickness severity indexes for newborn intensive care has a

Address for Correspondence:

Dr Mounesh Pattar

Shridevi Institute of Medical Sciences and Research Hospital
Tumkur, Karnataka, India
Email: Mouneshvp2@gmail.com

significant latency. This is mostly due to the fact that birth weight is a highly accurate predictor of sickness severity. Despite birth weight correction, a number of recent studies have found significant difference in survival and morbidity among neonatal intensive care units (NICUs), demonstrating the necessity of neonatal illness severity grading[5]. It is obvious that great thought must go into the variables selected for the score and their relative weights. A balance must be struck between a complex score with numerous variables that is challenging to complete and a simpler model that may be more convenient to use but is less accurate. Additionally, it is important to keep in mind that no score can accurately capture all of the complicated components that contribute to an infant's morbidity[6]. This study seeks to forecast death and morbidity among unwell babies using the Extended Sick Neonatal Score in light of these data (ESNS).This is one of the first study for predicting morbidity based on ESNS and we had a relatively small sample size due to time constraints. Though the sensitivities were satisfactory for predicting ROP, hearing impairment and sepsis, the wide confidence intervals suggest the need for a larger sample study. We recommend further studies to validate this scoring system at multiple centers.

Material and Methods

It is a prospective prognostic accuracy study using STARD guidelines at CSI HMH Hospital NICU, from July 2019 to June 2020 after getting ethical committee approval. The babies were assessed within 15 minutes of delivery, by measuring SP02, heart rate, blood pressure, axillary temperature, random blood sugar, Moro's reflex and modified downe's score. Noninvasive blood pressure monitor, SPO2 probe and glucometer were used. Perfusion was assessed by checking capillary refilling time, neurological assessment by Moro's reflex and respiratory distress was scored by modified downe's score. All neonates were assessed clinically, and their final diagnosis and outcome are noted. The neonatal morbidity was measured in terms of sepsis, which was confirmed by blood culture.

Sample size estimation- Assuming a sensitivity of 90%, type 1 error of 5%, power of 90% precision of 10%, the minimum sample size was calculated as 140 using below formula

$S = (Z \text{ alpha} + Z \text{ beta})^2 \times p (100- p) / d^2$

Where Z alpha =5%. Power = 1-type 2 error = 90%

P= sensitivity - 90%

Precision = 10%

N= 140

Table 1: The Proposed Extended Sick Newborn Score (ESNS) System

Parameter	Score		
	0	1	2
Respiratory effort	Apnea	Rate > 60/min ± Retraction	Rate 40-60/min
Heart rate (beats per minute)	Bradycardia/ Asystole	>160	100-160
Mean blood pressure	<5th percentile	5-50th	>50th
Axillary temperature (°C)	<36	36.0-36.5	36.5-37.5
Capillary filling time (s)	>5	3-5	<3
Random blood sugar (mg/dL)	<45	45-60	>60
SpO2 (% in room air)	<85	85-92	>92
Moro reflex	Absent	Depressed/ Exaggerated	Corresponding to gestational age
Modified Downes' score*	>6	2-6	0-2

For quantitative variables, the mean and standard deviation were used in the descriptive analysis, while frequency and proportion were used for categorical variables. Building receiver operating characteristic (ROC) curves and figuring out the sensitivity and specificity of the cut-off indicated by the ROC analysis allowed us to assess how well each scoring system predicted pre-discharge mortality. Statistical significance was defined as a P value 0.05. The statistical evaluation was performed using IBM SPSS version 22.

Results

Table 2: Descriptive analysis of ESNS, Blood culture and Hearing Assessment in the study population.

ESNS	Frequency	Percentages
<=11	29	20.71%
>11	111	79.29%
Blood culture		
Growth	19	13.57%
No growth	121	86.43%
Hearing Assessment		
Normal	135	96.43%
Abnormal	5	3.57%

Among the study population, 29 (20.71%) participants ESNS score was <=11 and 111 (79.29%) participants ESNE score was >11. Among the study population, 19 (13.57%) participants, there was a Growth in blood culture. Among the study population, 135 (96.43%)

participants hearing assessment was normal. (Table-2).

Table 3: Predictive validity of ESNS in ROP Screening

Parameter	Value	95% CI	
		Lower	Upper
Sensitivity	87.50%	47.35%	99.68%
Specificity	69.57%	57.31%	80.08%
False positive rate	30.43%	19.92%	42.69%
False negative rate	12.50%	0.32%	52.65%
Positive predictive value	25.00%	10.69%	44.87%
Negative predictive value	97.96%	89.15%	99.95%
Diagnostic accuracy	71.43%	60.00%	81.15%
Positive likelihood ratio	2.88	0.91	18.103
Negative likelihood ratio	0.18	0.01	1.131

The ESNS score had sensitivity of 87.50% (95% CI 47.35%to 99.68%) in predicting ROP screening. Specificity was 69.57% (95% CI 57.31%to 80.08%), false positive rate was 30.43% (95% CI 19.92%to 42.69%), false negative rate was 12.50% (95% CI 0.32%to 52.65%), positive predictive value was 25% (95% CI 10.69%to 44.87%), negative predictive value was 97.96% (95% CI 89.15%to 99.95%), and the total diagnostic accuracy was 71.43% (95% CI 60.00%to 81.15%). (Table 3)

Table 4: Predictive validity of ESNS in predicting hearing assessment

Parameter	Value	95% CI	
		Lower	Upper
Sensitivity	80.00%	28.36%	99.49%
Specificity	81.48%	73.89%	87.64%
False positive rate	18.52%	12.36%	26.11%
False negative rate	20.00%	0.51%	71.64%
Positive predictive value	13.79%	3.89%	31.66%
Negative predictive value	99.10%	95.08%	99.98%
Diagnostic accuracy	81.43%	73.98%	87.50%
Positive likelihood ratio	4.32	0.52	24.982
Negative likelihood ratio	0.25	0.03	1.419

The ESNS score had sensitivity of 80% (95% CI 28.36%to 99.49%) in predicting hearing assessment. Specificity was 81.48% (95% CI 73.89%to 87.64%), false positive rate was 18.52% (95% CI 12.36%to 26.11%), false negative rate was 20% (95% CI 0.51%to 71.64%), positive predictive value was 13.79% (95% CI 3.89%to 31.66%), negative predictive value was 99.10% (95% CI 95.08%to 99.98%), and the total diagnostic accuracy was 81.43% (95% CI 73.98%to 87.50%). (Table 4)

Table 5: Predictive validity of ESNS in predicting Blood culture.

Parameter	Value	95% CI	
		Lower	Upper
Sensitivity	57.89%	33.50%	79.75%
Specificity	85.12%	77.51%	90.94%
False positive rate	14.88%	9.06%	22.49%
False negative rate	42.11%	20.25%	66.50%
Positive predictive value	37.93%	20.69%	57.74%
Negative predictive value	92.79%	86.29%	96.84%
Diagnostic accuracy	81.43%	73.98%	87.50%
Positive likelihood ratio	3.89	0.87	6.628
Negative likelihood ratio	0.49	0.12	0.842

The ESNS score had sensitivity of 57.89% (95% CI 33.50%to 79.75%) in predicting blood culture. Specificity was 85.12% (95% CI 77.51%to 90.94%), false positive rate was 14.88% (95% CI 9.06%to 22.49%), false negative rate was 42.11% (95% CI 20.25%to 66.50%), positive predictive value was 37.93% (95% CI 20.69%to 57.74%), negative predictive value was 92.79% (95% CI 86.29%to 96.84%), and the total diagnostic accuracy was 81.43% (95% CI 73.98%to 87.50%). (Table 5)

Discussion

In this study, extended sick neonate scores (ESNS) parameters of 140 neonates were recorded, among which 58.57% were preterm and 41.43% full term. Overall mortality among the study population was 2.8%. It has been reported that 46% are born preterm, with an overall mortality rate of 10.5% in India. In our study, 79.29% had ESNS >11 and 20.71% had ESNS <=11.

Using the ESNS system, a score <=11 for term babies, and score <=12 for preterm neonates best predict mortality. Among the pre-term's babies, 45.12% had ESNS <=12 and 54.87 had ESNS >=13. Among the preterm babies with ESNS <=12, 86.5% participants had normal ROP, 94.6% participants had a normal hearing screen, and 10.34% participants had hearing impairment, 10.34% participants had sepsis, and 2.7% expired. Among the preterm babies with ESNS >=13, 73.3% of participants had normal ROP, 100% of participants had a normal hearing assessment, 4.4% had sepsis. ESNS had good specificity for ROP, hearing impairment and sepsis among preterm babies.

The ESNS score had sensitivity of 87.50% (95% CI 47.35%to 99.68%) in predicting retinopathy of prematurity screening, specificity was 69.57% (95% CI 57.31%to 80.08%), false positive rate was 30.43% (95% CI 19.92%to 42.69%), false-negative rate was 12.50% (95% CI 0.32%to 52.65%), positive predictive

value was 25% (95% CI 10.69%to 44.87%), negative predictive value was 97.96% (95% CI 89.15%to 99.95%), and the total diagnostic accuracy was 71.43% (95% CI 60.00%to 81.15%). The sensitivity to predict ROP was 87.50%, albeit with a wide confidence interval due to the small sample size. Specificity to predict ROP was relatively low at 69.57%. In the Children's Hospital of Philadelphia (CHOP) model, birth weight and gestational age are typically considered as the best early indicators of ROP risk in preterm newborns; nevertheless, this model may be used too late to reduce the early risk of ROP[7]. The neonatologist can identify newborns at higher risk of developing ROP early on by creating a screening tool based on characteristics accessible in the first 48 hours after birth. In an effort to reduce their eventual risk factors, these infants can receive more specialised postnatal care (O2 exposure, sepsis, etc.). A more informed postnatal care plan for infants who have a high risk of ROP might be an efficient preventive measure in and of itself[8].

In predicting hearing assessment, the ESNS score had a sensitivity of 80% (95% CI 28.36%to 99.49%), also with a wide confidence interval due to the small sample size. Specificity was 81.48% (95% CI 73.89%to 87.64%). Neonatal sepsis is one of the most common diagnostic challenges in neonatal medicine today. In our study, 13.57% were noted to have neonatal sepsis. Compared to ROP and hearing assessment, ESNS had low sensitivity in predicting sepsis at 57.89% (95% CI 33.50%to 79.75%) and specificity was 85.12% (95% CI 77.51%to 90.94%). When used to predict outcomes in cases of potential newborn sepsis, SNAP-II and its component parameters were found to have excellent sensitivity and specificity. They may also be used to predict the severity of illness progression and the speed at which non-survivors deteriorate[9].

Ray et al, [10]., reported in their study that ESNS of 11 or <11 had the best sensitivity (85.9%) and specificity (89.8%). For preterms, ESNS <12 had the best sensitivity (92.3%) and specificity (76.7%). For term babies, ESNS <11 had the sensitivity of 92.6% and specificity of 93.2%.

Conclusion: Extended sick neonate scores (ESNS) parameters of 140 neonates were analyzed to find its predictability in retinopathy of prematurity, hearing impairment and sepsis status. Among the study population, 58.57% were preterm, and 41.43% full term. Overall mortality among the study population was 2.8%. It was noted that ESNS had good specificity for ROP, hearing impairment and sepsis among preterm babies. The ESNS had better sensitivity at predicting retinopathy among term babies than in preterm babies in our study. Overall, the ESNS can predict retinopathy of prematurity, hearing impairment and sepsis outcome with satisfactory sensitivity and specificity and would be useful irrespective of gestational age.

References

1. *You D, Jones G, Hill K, Wardlaw T, Chopra M. Levels and trends in child mortality, 1990-2009. Lancet. 2010; 376(9745):931–3.*
2. *Lawn J, McCarthy BJ, Ross SR. The healthy newborn; a reference manual for program managers. CDC CARE Collab Heal Initiat. 2000; 2.49-2.64.*
3. *Rammohan A, Iqbal K, Awofeso N. Reducing Neonatal Mortality in India: Critical Role of Access to Emergency Obstetric Care. PLoS One. 2013; 8(3):E57244.*
4. *De Souza S, Duim E, Nampo FK. Determinants of neonatal mortality in the largest international border of Brazil: A case-control study. BMC Public Health. 2019;19(1):1304.*
5. *Richardson DK, Tarnow-Mordi WO. Measuring illness severity in newborn intensive care. J Intensive Care Med. 1994; 9(1):20–33.*
6. *Dorling JS, Field DJ, Manktelow B. Neonatal disease severity scoring systems. Arch Dis Childhood-Fetal Neonatal Ed. 2005; 90(1):F11–6.*
7. *Neogi SB, Khanna R, Chauhan M, Sharma J, Gupta G, Srivastava R, et al. Inpatient care of small and sick newborns in healthcare facilities. J Perinatol. 2016; 36(s3):S18–23.*
8. *Eckert GU, Fortes Filho JB, Maia M, Procianoy RS. A predictive score for retinopathy of prematurity in very low birth weight preterm infants. Eye. 2012; 26(3):400–6.*
9. *Pal S, Jain A, Garg M, Sekhar JC. Predicting Outcome in Neonates with Possible Clinical Sepsis by Estimating an Early Score for Neonatal Acute Physiology-II (SNAP-II). J Trop Pediatr. 2020; 66(4):377–84.*
10. *Ray S, Mondal R, Chatterjee K, Samanta M, Hazra A, Sabui TK. Extended Sick Neonate Score (ESNS) for Clinical Assessment and Mortality Prediction in Sick Newborns referred to Tertiary Care. Indian Pediatr. 2019; 56(2):130–3.*

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