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Original Article

Anaesthesia Section

PRISM-III and SNAPPE-II to Predict Outcome in Neonates undergoing Surgery under General Anaesthesia- A Prospective Cohort Study

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ABSTRACT

Introduction: Score for Neonatal Acute Physiology Perinatal Extension-II (SNAPPE-II) and Paediatric Risk of Mortality-III (PRISM-III) are scores which have been used in the Paediatric Intensive Care Unit (PICU) setting for quite some time now. However, these have never been utilised in a preoperative setting to predict outcome.

Aim: To study the risk scores PRISM-III and SNAPPE-II to predict outcome in neonates, undergoing surgery under general anaesthesia.

Materials and Methods: This was a prospective observational cohort study conducted in Lady Hardinge Medical College and Kalawati Saran Children Hospital, New Delhi, India on 100 neonates. The PRISM-III and SNAPPE-II scores were calculated preoperatively to predict the postoperative outcome. Statistical Package for the Social Sciences (SPSS) version 15.0 was used for analysis. Discriminatory capacity of scores was assessed using Receiver Operating Characteristic (ROC) curves. Specificity and sensitivity were calculated, to identify the cut-off value of the scoring system that would predict outcome. The calibration of both the scoring systems was established by using Hosmer-Lemeshow goodness of fit test.

Results: The mean age of population was 8.23±7.93 days, with 69% males and 31% females. The mortality rate was 12%. The maximum sensitivity (91.67%) and specificity (93.18%) for PRISM-III score was found at score 23, whereas best sensitivity (100%) and specificity (81.82%) for SNAPPE-II was at 26.5. The area under ROC for PRISM-III and SNAPPE-II was 0.946 and 0.944 respectively showing excellent discriminatory power. The Hosmer-Lemeshow goodness of fit showed a good calibration for the study model.

Conclusion: Both the scoring systems PRISM-III and SNAPPE-II are excellent predictors of postoperative outcomes. PRISM-III is marginally better than SNAPPE-II for diagnostic accuracy. Both scores are well-calibrated for Indian population.

Keywords: Illness severity score, Intensive care, Neonatal mortality, Scoring system

INTRODUCTION

The illness severity scores are commonly used for neonatal care mostly in critical care setting. Rapid advances in medical field have resulted in more sophisticated care for paediatric patients. However, this advancement has not always succeeded in improving the outcome [1]. The neonatal mortality rate is quite varied ranging from 6.4% (2013) developed country [2] to as high as 36.7% (2009) in developing country [3].This may be due to a number of factors like poor antenatal care, delay in surgical referral, lack of infrastructure and intensive care units [4], but the most important factor is the transitional physiology of the neonate. It differs from the older children in respect with unique cardiac physiology [5], hepatic immaturity [6], increased risk of hypoxaemia due to less intravascular reserves and high basal metabolic rate, as well as higher surface area predisposing them to hypothermia [7]. Therefore, estimating illness severity preoperatively and assessing prognosis is beneficial in improving postoperative outcome in neonates.

The lack of consistency, reliability, and accuracy in physician's subjective opinions concerning patient status necessitates quantitative clinical scores [8]. Illness is characterised by deviation of a physiological variable away, from its normal range. Various scoring systems were developed to quantify the severity of illness. Most of the available scoring systems like Waterston criteria, Montreal classification for aesophageal atresia with or without tracheo-oesophageal fistula [9], Breaux scoring for babies with congenital diaphragmatic hernia [10] are disease specific, hence, cannot be generalised to all surgical newborns.

PRISM-III and SNAPPE-II are extensively used in paediatric ICU and are very well-calibrated for paediatric population. PRISM-III, an updated third-generation physiology-based scoring system, was developed in 1996 at the Children's National Medical Centre in Washington, DC based on the data collected at 32 Paediatric Intensive Care units using 11,165 admissions [11]. PRISM-III has 17 physiologic variables subdivided into 26 ranges and eight other risk factors and is population independent.

In 1993 Richardson DK et al., [12] developed a score to predict mortality in neonates admitted to Neonatal Intensive Care Unit (NICU) and called it Score for Neonatal Acute Physiology (SNAP). It is a physiology-based score which includes 34 variables, including routinely done vital signs and laboratory test results [13-15]. It was validated prospectively on 1643 admissions (114 deaths) in three NICUs. It was used for describing populations, stratifying risk in epidemiologic and clinical trials and projecting resource utilisation. In 2001, Richardson DK et al., [16], reduced the number of variables from 34 to 6 to create much simpler version SNAP II score and also developed SNAPPE-II by adding three important variables to original six variables of SNAP-II. They found that that SNAPPE-II had excellent discrimination of survivors from non survivors. They observed that SNAP-II and SNAPPE-II were much easier to use as compared to their older versions robust illness severity and mortality risk scores applicable to infants of all birth weights. Harsha SS and Archana BR, studied 248 newborns admitted to NICU and found that SNAPPE-II was a good predictor of mortality, irrespective of gestational ages [17].

Neonates, being unique in physiology, are the most vulnerable group of patients and hence, measurement of severity of illness in them is essential. Therefore, PRISM-III and SNAPPE-II scores were studied to evaluate, if they can predict the postoperative outcome.

MATERIALS AND METHODS

This was a prospective observational cohort study, conducted in Lady Hardinge Medical College and Kalawati Saran Children Hospital, New Delhi, India from November 2015 to March 2017. The Institutional Ethics Committee (IEC) clearance was obtained vide letter number -LHMC/ECHR/2015/114.

Inclusion criteria: All the neonates (age-≤28 days) posted for surgeries were included in the study.

Exclusion criteria: Parental refusal, those neonates who did not require Arterial Blood Gas analysis (ABG) or catheterisation, home deliveries with unknown APGAR score.

Sample size calculation: The overall neonatal mortality according to world bank 2014 report is around 29 per thousand while for neonates where surgery is performed, the incidence of mortality is between 6.4% (Catre D et al., [2] 2013) to 36.7% (Ndour O et al., [3], 2009). Therefore, assuming 21% as the incidence of neonatal mortality in cases, undergoing surgery and 10% margin of error, the minimum required sample size at 5% level of significance came as 64 patients. But for ease of calculation and considering institutional greater influx of neonatal surgical cases sample size of 100 was taken.

Study Procedure

A detailed preanesthetic check-up of all the patients was done and written informed consent was taken from the parents. Preoperative vital signs and investigations were recorded according to the parameters used in PRISM-III and SNAPPE-II and the scores were calculated. All neonates were given standard general anaesthesia according to Institutional practice with thiopentone, atracurium, fentanyl for induction and sevoflurane for maintenance. Intraoperative vital signs Electrocardiography (ECG), Heart Rate (HR), Non Invasive Blood Pressure (NIBP), SpO_2 (oxygen saturation) $EtCO_2$ (end-tidal carbon dioxide) and temperature was monitored. Warm fluids given after calculation according to body weight. Intraoperative blood loss was estimated and replaced as allowable blood loss was taken as nil. Postoperative outcome which was taken as mortality or discharge from hospital was recorded.

STATISTICAL ANALYSIS

The SPSS version 15.0 was used for analysis. The quantitative variables were expressed as mean±Standard Deviation (SD) and evaluated using unpaired t-test. The qualitative variables were expressed as frequencies/percentages and compared using Chi-square test. Discriminatory capacity of the scores was assessed using ROC curve. Sensitivity and specificity were calculated to identify the cut-off value of the scoring systems that would predict outcome. The calibration of two preoperative scoring models was established by using Hosmer-Lemeshow goodness of fit test. A p-value <0.05 was assumed statistically significant.

RESULTS

There were a total of 100 neonates with a mean age of 8.23±7.93 days. Males (69%) were more than twice the female population (31%). The observed mortality was 12%. Of the various diagnosis with which the patients presented only Necrotising Enterocolitis (NEC) contributed significantly to mortality [Table/Fig-1]. There was only one mortality below PRISM-III score of 20 [Table/Fig-2]. Majority of the survivors (93.18%) scored PRISM-III score of <23 [Table/Fig-3]. Thereafter, a linear relationship between PRISM-III score and mortality was observed. Eight out of 12 non survivors (66.7%) had a PRISM-III score of >30 which was statistically highly significant (p<0.01). The mean PRISM-III score was higher among non survivors. The maximum sensitivity and specificity for PRISM-III score was 91.67% and 93.18% at a score of 23 [Table/Fig-3]. The positive and negative predictive values for the above score was 64.71% and 98.80%, respectively.

Diagnosis	Died n (%)	Alive n (%)	p-value
TEF	2 (16.67)	21 (23.86)	0.578
NEC	5 (41.66)	3 (3.41)	0.001
CDH	1 (8.33)	3 (3.41)	0.414
IO	2 (16.67)	22 (25.00)	0.526
HD	0	9 (10.23)	0.246
Others	2 (16.67)	30 (34.09)	0.225
Total	12 (100)	88 (100)	

[Table/Fig-1]: Diagnosis of patient presenting for surgery and outcome.
Other diagnosis includes anorectal malformations, anterior abdominal wall defects; TEF: Tracheo-esophageal fistula; NEC: Necrotising enterocolitis; CDH: Congenital diaphragmatic hernia; IO: Intestinal obstruction; HD: Hirschsprung's disease

PRISM-III score	Non survivors n=12 (%)	Survivors n=88 (%)	p-value
0-10 (n=47)	0	47 (53.41)	<0.001
11-20 (n=33)	1 (8.33)	32 (36.36)	0.053
21-30 (n=9)	3 (25.00)	6 (6.81)	0.039
31-40 (n=4)	3 (25.00)	1 (1.14)	<0.001
41-50 (n=4)	3 (25.00)	1 (1.14)	<0.001
51-60 (n=3)	2 (16.67)	1 (1.14)	0.003
Mean PRISM-III score	36.83±12.39	10.75±8.79	
p-value	<0.001		

[Table/Fig-2]: PRISM-III score and outcome.

The SNAPPE-II score of 0-20 resulted in no mortality, as SNAPPE-II score increased mortality started rising at SNAPPE-II score of 61-80 there was 41.67% of total mortality [Table/Fig-4]. The mean SNAPPE-II score for non survivors was greater than three times that of survivors. This difference was statistically very highly significant (p<0.001). SNAPPE-II score at which, both the sensitivity (100%) and specificity (81.82%) was maximum was a cut-off score of 26.5 [Table/Fig-5]. The positive and negative predictive value for above cut-off was 42.86% and 100%, respectively. The sensitivity of SNAPPE-II score was 100% and was greater than that of PRISM-III score (91.67%) [Table/Fig-6]. However, specificity of PRISM-III score was more than SNAPPE-II (93.18% vs 81.82%).

Positive predictive value of PRISM-III was greater than that of SNAPPE-II (64.71% vs 42.86%) but the negative predictive value was comparable for both the scores. Overall, diagnostic accuracy of PRISM-III was greater than SNAPPE-II (93% vs 84%). The Area Under the ROC (AUROC) [Table/Fig-7] of PRISM-III was 0.946 (CI=0.885-1.000) and SNAPPE-II was 0.944 (CI=0.898-0.989) (p=0.001) this shows that both SNAPPE-II and PRISM-III had excellent discriminatory power when applied preoperatively, to differentiate survivors from non survivors.

Scoring system		Non survivors n (%)	Survivors n (%)	p-value	Sensitivity	Specificity	PPV	NPV
PRISM-III score	<23	1 (8.33)	82 (93.18)	<0.001	91.67%	93.18%	64.71%	98.80%
	≥23	11 (91.67)	6 (6.82)					

[Table/Fig-3]: PRISM-III score cut-off score, Positive Predictive Value (PPV), Negative Predictive Value (NPV).

SNAPPE-II score	Non survivors n=12 (100%)	Survivors n=88 (100%)	p-value
0 -20 (n=64)	0	64 (72.73)	<0.001
21-40 (n=21)	4 (33.33)	17 (19.32)	0.263
41-60 (n=8)	3 (25.00)	5 (5.68)	0.021
61-80 (n=7)	5 (41.67)	2 (2.27)	<0.001
Mean SNAPPE-II score	52.17±17.51	14.94±15.75	
p-value	<0.001		

[Table/Fig-4]: SNAPPE-II score and outcome.

PRISM-III and SNAPPE-II can be used preoperatively to predict neonatal outcome after surgery. There seems to be no study that, utilises these two scores outside of critical care setting in predicting outcome in neonates. However, there are several studies which have used these scores individually in critical care settings, but not preoperatively.

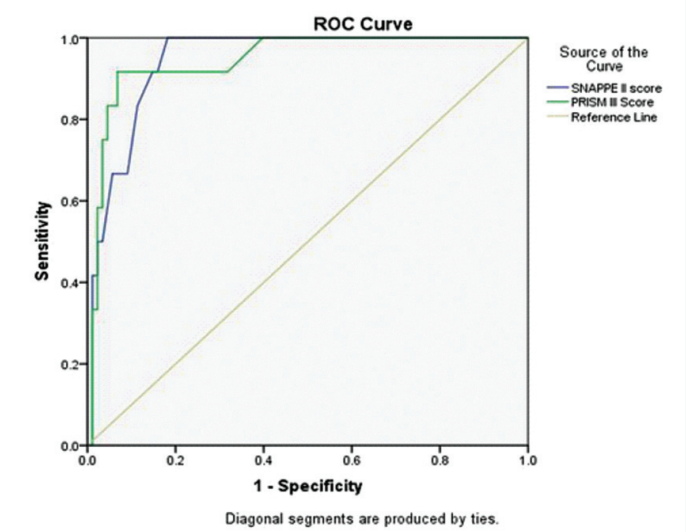
[Table/Fig-8,9] tabulates the studies reporting individual risk scores to estimate to the readers how comparable the mean scores/ cut-off values for these scores can be used, preoperatively (novel application) as compared to a critical care setting [18-21].

Scoring system		Non survivors N (%)	Survivors N (%)	p-value	Sensitivity	Specificity	PPV	NPV
SNAPPE-II score	<26.5	0	72 (81.82)	<0.001	100.00%	81.82%	42.86%	100.00%
	≥26.5	12 (100.00)	16 (18.18)					

[Table/Fig-5]: SNAPPE-II cut-off score, Positive Predictive Value (PPV), Negative Predictive Value (NPV).

Scores	Sensitivity	Specificity	PPV	NPV	Diagnostic accuracy
PRISM-III score	91.67%	93.18%	64.71%	98.80%	93.00%
SNAPPE-II score	100.00%	81.82%	42.86%	100.00%	84.00%

[Table/Fig-6]: Comparison of sensitivity, specificity and diagnostic accuracy of PRISM-III and SNAPPE-II scores.



[Table/Fig-7]: Comparison of ROC curve for PRISM-III and SNAPPE-II scores.

Study	Mean PRISM-III	Mean age
Bilan N et al., [18]	14.22±9.57	29.85±35.07 months
Volakali E et al., [19]	8.97±7.79	54.26±49.93 months
Present study	13.88±12.55	8.23±7.93 days

[Table/Fig-8]: Studies with respective mean PRISM-III scores and mean age [18,19].

Study	Mean SNAPPE-II	SNAPPE-II cut-off score for predicting mortality
Mia RA et al., [20]	26.3±19.84	30
Niranjan HS et al., [21]	24.84±18.28	37
Present study	19.41±19.19	26.5

[Table/Fig-9]: Studies with respective mean SNAPPE-II score and SNAPPE-II cut-off score for predicting mortality [20,21].

Calibration

The Hosmer-Lemeshow goodness of fit for PRISM-III (p=0.510, Chi-square=7.252, degree of freedom=8) and for SNAPPE-II (p=0.610, Chi-square=5.412, degree of freedom=7) showed a good calibration.

DISCUSSION

The PRISM-III, is one of the most commonly used risk score for paediatric population including neonates, whereas, SNAPPE-II is the latest version of physiology-based score specifically used for neonates. The present study is unique, as these risk scores are commonly used in PICU or NICU. This study aims to expand the application of these scores outside of critical care setting into the preoperative setting to predict postoperative outcome. Apart from predicting prognosis, these scoring systems help in evaluation of the severity of illness which can give practitioners an opportunity to intervene early in the course of the disease, counselling of parents, compare quality of care between different Institutions, and ensure optimum resource utilisation [8]. This is particularly important in resource-scanty developing countries where pressure on healthcare system is huge. This study demonstrates that, both

Hosmer-Lemeshow goodness of fit chi-square test for PRISM-III and SNAPPE-II: In the present study, the Chi-square value for PRISM-III and SNAPPE-II score was 7.252 and 5.412, the goodness of fit p-value was 0.510 and 0.610 which shows good calibration. Similar to present study observation Bilan N et al., [18], Volakali E et al., [19] and Varma A et al., [22] determined goodness of fit p-value for PRISM-II score to be 0.161, 0.989 and 0.638, respectively, which indicated that score was well fitted for prediction of mortality rate. The results of Richardson DK et al., [16] and Thimoty J et al., [23] were even better than present study. They found the overall p-value of goodness of fit for SNAPPE-II score, was 0.90 and 0.97, respectively, indicating extremely good fit. In none of the reviewed studies, the two scores were compared statistically with respect to their sensitivity, specificity and diagnostic accuracy.

Limitation(s)

As the scores were applied preoperatively, they might not accurately estimate the postoperative outcome as surgery on a neonate itself, is a stress factor which affects the internal milieu of neonate. Moreover, postoperative infections might also affect the outcome.

CONCLUSION(S)

Both the scoring systems PRISM-III and SNAPPE-II are excellent preoperative predictors of outcome after neonatal surgery. The cut-off scores for predicting mortality for PRISM-III score was 23, whereas, it was 26.5 for SNAPPE-II. PRISM-III scoring system is marginally better than SNAPPE-II scoring system for diagnostic accuracy. Both the scores were well-calibrated for Indian population. With both scoring systems, higher the scores, worse was the prognosis. Both scores provide a cut-off, which offers acceptable indices to predict outcome.

Authors recommend the application of these scoring systems from the inception of surgical intervention for early recognition of very

sick neonates and prioritisation of treatment, counselling of the parents regarding severity of illness, treatment cost and probable outcome, to optimise resource utilisation and cost containment and to compare the quality of care within and between different Institutions with respect to outcome. Further studies are needed, to substantiate and establish the role of these scoring systems to predict postoperative outcome among neonates.

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