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A comparison of CRIB, CRIB II, SNAP, SNAPII and SNAP-PE scores for prediction of mortality in critically ill neonates

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Abstract

Background: Clinical Risk Index of Babies (CRIB), Score for Neonatal Acute Physiology (SNAP), an update of the Clinical Risk Index for Babies score (CRIB II) and Score for Neonatal Acute Physiology - Perinatal Extension (SNAP-PE) are scoring devices developed in neonatal intensive care units. This study reviewed these scoring systems in critically ill neonates to determine how well they could predict mortality.

Methods: This prospective cohort study was conducted at the neonatal intensive care units of Mofid and Mahdieh hospitals between March 2006 and May 2009. We evaluated CRIB, CRIB II, SNAP, SNAPII and SNAP-PE score for each neonate and the final scores were then obtained. The predictive accuracy of these parameters were expressed as area under the receiver operative characteristic curve, sensitivity, specificity, positive predictive value and negative predictive value.

Results: Of 404 neonate evaluated 53% were male. Primary diagnoses were respiratory distress syndrome, gastrointestinal obstruction, sepsis, prematurity, and neuromuscular diseases. The authors detected mortality in 20.5% and found a significant difference in scoring systems between survived and death groups. The mean CRIB score in survived neonates was 2.57±3.66 and in death neonates 8.43±4.66 (p value<0.001). We also found that the SNAP score had the highest area under the curve and the highest sensitivity, specificity, positive predictive value, negative predictive value and we had the lowest score for CRIB II.

Conclusion: We concluded that the neonatal scoring systems could be a useful tool for prediction of mortality in NICUs and SNAP can predict the mortality better than the others.

Keywords: CRIB, CRIB II, SNAP, SNAPII, SNAP-PE, mortality, neonates, outcome, scoring system

Introduction

During 1993 four scoring systems for assessing neonatal mortality risk were introduced as follow: the national institutes of health neonatal network model [1], SNAP (Score for Neonatal Acute Physiology) [2], SNAP-PE (Score for Neonatal Acute Physiology - Perinatal Extension) [3] and CRIB (the Clinical Risk Index of Babies) [4]. Then SNAP II (Simplified newborn illness severity and mortality risk scores) and CRIB II (an update of the Clinical Risk Index for Babies score) were developed later in NICUs and introduced as robust indices of

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neonatal risk, to predict mortality and morbidity in newborns [4-5]. Although they are useful tools to measure differences of risk due to initial disease severity, the large number of variables of SNAP (26 variables) scoring system makes it cumbersome and preclude its routine use. The CRIB and CRIB II scores were constructed by converting into integers the regression coefficients of independent ranges or categories of four and six routine clinical variables in a logistic model for hospital death [6-7]. Therefore in past years various scoring systems have been developed to predict neonatal morbidity and mortality and these neonatal risk scores have been developed in order to assure a more accurate evaluation of results obtained by different NICU's. Unfortunately, mortality rates, even if they are risk adjusted, can no longer be the only index of the performance of neonatal intensive care units. With innovations in supporting therapy and monitoring technology, there has been a profound reduction in the mortality rate of low birth weight infants. Professionals within the tertiary care neonatal systems differ on what is defined as extra uterine viability and this can result in emotional and controversial judgments. We have to recognize that mortality can no longer be used as the only valid endpoint for making comparisons. The quality of the survivors must also be assessed. Complications that predict adverse long term sequel must be defined and taken into considerations [8]. It is noteworthy that throughout the years an effort has been made to adapt the scores to the specific neonatal problems and to make them easier to use. Today risk-adjusted severity of illness is frequently used in clinical research and quality assessments. Although there are multiple methods designed for neonates, they have been infrequently compared and some have not been assessed in large samples [1-3]. It was planned to study these issues prospectively in Iranian babies admitted in Mofid and Mahdieh hospital's NICUs to distinguish how well they could predict neonatal mortality and compare them to each other. Therefore this cohort study was conducted in two tertiary level neonatal units to evaluate the role of CRIB, CRIB II, SNAP, SNAPII and SNAP-PE scores in prediction of mortality in neonates.

Methods

This prospective cohort study was conducted at the neonatal intensive care units of Mofid and Mahdieh hospitals which are two of the largest referral neonatal hospitals affiliated to Shahid Beheshti Medical University in Tehran. There are about 4400 deliveries annually in the Mahdieh hospital and about 2000 admissions to the both neonatal intensive care units each year. The Mofid hospital has a referral NICU and the Mahdieh hospital accepts referral and inborn neonates. Although there were some differences in the characters of neonates were admitted in theses two NICUs, we carried out this study in these hospitals to determine the role of scoring systems regardless of the kind of NICU. Between March 2006 and May 2009 all neonates transferred to these NICUs were enrolled for the study in a prospective manner. Demographic data and scoring systems were evaluated by fellowships of neonatology and recorded by pediatric residents at the first day of NICU admission. Birth weight was recorded for each baby as soon as it arrived in the NICUs for admission. This was done using the detailed Dubowitz score. This was done in the first 24 hours of arrival. In infants in whom their condition did not permit Dubowitz scoring or whose scoring could not be done for other reasons, post conceptional age was determined from the obstetric data. A detailed note of all the congenital abnormalities was made and scored according to the severity as in the original study on the CRIB score. All babies had saturations checked in the nursery. Blood gas was recorded at birth and further as dictated by the clinical requirements of each infant except babies whose saturation monitoring readings were normal throughout and who were not distressed. The

maximum base excess recorded in the first 12 hours was noted. The maximum and minimum fraction of inspired oxygen (FiO_2) required by the baby for maintaining the hemoglobin saturation between 88-95% in the first 12 hours were recorded. This was done by readings on the air-oxygen (O_2) blender in ventilated neonates or with a Miniox-3 meter to test oxygen concentration in babies under head box oxygen. The FiO_2 was checked when there was a change made in the flow rate of O_2 in the head box or FiO_2 was changed on the ventilator, depending upon the requirements of the baby as shown by the pulse oximeter. Each of these six parameters namely birth weight, gestational age, congenital malformations, maximum base excess, minimum and maximum FiO_2 were scored according to the scoring system of CRIB. We recorded the temperature of admission time and followed it every 4 hour in first 12 hours to determine CRIB II scoring system by these four parameters namely birth weight, gestational age, temperature and maximum base excess. We also evaluated the presence or absent of seizure and apnea in our patients and recorded them in evaluating form and checked maximum and minimum mean blood pressure (mmHg), maximum and minimum heart rate, PaO_2 and FiO_2, oxygenation index, maximum hematocrit, white blood cell (/microL), immature cell ratio (promyelocytes + myelocytes + metamyelocytes + bands-stabs)/total neutrophil count), platelet count (/microL), blood urea nitrogen, urine out put (ml/kg/hr), indirect bilirubin, maximum and minimum sodium, potassium and bicarbonate (mEq/L), maximum and minimum calcium (mg/dl) and gathered these data to determine the SNAP and SNAPII and added Apgar score, gestational age and birth weight to record SAP-PE scores. The final scores were then obtained by the arithmetic sum of individual scores of these parameters by using French SFAR site [9]. Mortality statistics reflect death prior to discharge from the NICUs. This work was funded by an operating grant from the Pediatric Infectious Research Center and the ethics committee of the Shahid Beheshti Medical University and Pediatric Infectious Research Center approved this study. This work was part of the research project and pediatric course thesis provided by Paiam payandeh MD and Masoud Zadkarami MD in pediatric department of Shahid Beheshti Medical University. All the five scores were statistically analyzed by the t test. This was done for both survivors and non survivors separately to look for any statistically significant difference between the two groups. At the end with hospital death as the dependant variable, Logistic model was used to analyze the prediction of mortality. The predictive accuracy of these receivers was expressed as area under the receiver operative characteristic (ROC) curve for each score and the results compared by SPSS version 16. A P value<0.05 was accepted as statistically significant. ROC curves help to compare the performance of different tests, by plotting sensitivity (or true positive rate) against 1-Specificity (or false positive rate). We also reported the PPV and NPV (positive and negative predictive value) for predicting of death in each scoring system. Goodness-of-fit for predicting to observed probabilities of death was assessed with the Hosmer-Lemeshow goodness-of-fit test.

Results

404 neonates assessed in which 53% were male and the rest of them were female. Demographic data of our study group are shown in table 1. Primary diagnoses of our patients were respiratory distress syndrome (RDS) in 56%, gastrointestinal obstruction 19%, sepsis 6%, prematurity 6%, neuromuscular 6% and others 7%. According to our data 32% of our patients had congenital malformation, 23% apnea and about 12% seizure. The mean, range and standard deviation of CRIB, CRIB II, SNAP, SNAPII and SNAP-PE scores are listed in Table 2. In this study we detected mortality in

Table 1. Demographic and Para clinical of study group

Variable	Range	Mean±SD*	SE**
Systolic blood pressure (mm/Hg)	39-100	67.6±10.2	0.51
Diastolic Blood pressure (mm/Hg)	20-70	38.9±7.7	0.38
Temperature °C	32-40	36.9±0.6	0.03
Maximum heart rate (/min)	64-189	143± 14.5	0.72
Minimum heart rate (/min)	48-162	124.1±13.4	0.67
Respiratory rate (/min)	20-102	55.9±19.1	0.95
PH	6.7-7.57	7.3±0.1	0.01
PaO_2	12.9-99.9	67.1±20.5	1.02
$PaCO_2$	11.3-137.2	42.4±13.9	0.69
HCO_3 (mEq/L)	3.7-45.4	19.2±5.7	0.28
FiO_2 (O_2 Vol.%)	21%-100%	59.8± 29.8	1.48
Maximum base exceso	(-31)- (-13.2)	-5.7± 6.3	0.31
Sodium (mEq/L)	110-171	139.4± 6.5	0.32
Potassium (mEq/L)	2.6-8.1	4.9± 0.8	0.04
Blood urea nitrogen (mg/dl)	1-71	13.2± 10	0.5
Creatinine (mg/dl)	0.2-2.7	0.7± 0.3	0.02
Blood sugar (mg/dl)	30-476	135.6± 90.2	4.49
Direct bilirubin (mg/dl)	0.1-7	0.3± 0.5	0.02
Indirect bilirubin (mg/dl)	0.3-6.2	1.6± 1	0.05
Total calcium (mg/dl)	6-12.7	9.1± 1.1	0.05
Urine out put (cc/24 hr)	15-176	84.1±26.3	1.31
GFR (cc/min/1.73m²)	8.14-85	30.2±14.4	0.71
Gestational age (weeks)	25-41	35.2±3.2	0.16
Birth weight (g.)	650-4620	2500±831	41.38
Length (cm)	29-55	47±4.2	0.21
Apgar score	3-10	8.1±1.3	0.7
White blood cell (/microL)	1300-46000	11921.4±5732	285.2
Platelet (/microL)	11000-997000	279673.8±152878	7606
Hematocrit (%)	14-78	42.8±8.4	0.41

SD*: Standard deviation, SE**: Standard error

20%. We divided our patients into two groups based on the prognosis. The first group was set as survived group and the second group as death group.

We found a significant difference in scoring systems between these two groups. The mean CRIB score in survived neonates was 2.57 ±3.66 and in death neonates 8.43±4.66 (p value<0.001). The mean CRIB II score in survived neonates was 4.52±2.48 and in death neonates 6.87±3.48 (p value<0.001). The mean SNAP score in survived neonates was 5.48±2.65 and in death neonates 17.1±5.67 (p value<0.001). The mean SNAP II score in survived neonates was 8.19±6.97 and in death neonates was 25.46±13.6 (p value<0.001). The mean SNAP-PE score in survived neonates was 9.11±8.07 and in death neonates 34.26±17.99 (p value<0.001).

We also evaluated the area under the curve for prediction of mortality by these scoring systems (Fig. 1) and reported PPV and NPV for them. The NPV, PPV, sensitivity and specificity for CRIB, CRIB II, SNAP, SNAPII and SNAP-PE scores were shown in Table 3.

Discussion

To test and compare published neonatal mortality prediction models, including CRIB, CRIB II, SNAP, SNAP II and SNAP-PE we evaluated 404 critically ill neonates and detected mortality in 20%. We found a significant difference in CRIB, CRIB II, SNAP, SNAP II and SNAP-PE scoring systems between survived

Table 2. Range, mean and standard deviation of scoring systems in study groups.

Scoring system	Range	Mean±SD	SE
CRIB	0-15	3.88±4.61	0.229
CRIB II	1-14	5.52±3.15	0.369
SNAP	0-25	8.04±5.98	0.297
SNAPII	5-62	12.04±11.42	0.568
SNAP-PE	5-92	14.71±15.23	0.758

and death groups. (p value<0.001, 0.001, 0.001, 0.001 and 0.001 respectively). We also evaluated the area under the curve, sensitivity, specificity, PPV and NPV for prediction of mortality by these scoring systems and found out that the SNAP score has the highest AUC and the highest sensitivity, specificity, PPV and NPV (0.931, 94.4%, 86.7%, 96.5% and 80% respectively) and the lowest for CRIB II. Hence we concluded that the SNAP score can predict mortality of critically ill neonates better than the other scoring systems. Kadivar et al from Iran evaluated SNAP-PE scoring system in 198 newborn and showed SNAP-PE II to be a good predictor of mortality among the NICU patients [10]. On the contrary Rautonen et al evaluated the scoring systems in preterm Finnish neonates and reported the best AUC for CRIB score [11]. Bastos reported CRIB score as a suitable and accurate method in Portuguese preterm neonates with the highest AUC in comparison to the others. They accented this score which was easily performed in clinical practice also [12]. To use easier, recently Manktelow et al validated the CRIB and CRIB II scoring systems in United Kingdom and showed better predictive characteristics for CRIB II without admission temperature [13]. In addition Rastogi et al determined the CRIB II score as a good predictive instrument for mortality in Indian preterm infants and showed that CRIB II correctly predicted adverse outcome in 90.3% (Hosmer-Lemeshow goodness-of-fit test P=0.6) [14].

On the other hand Khana et al. showed no predominance for the CRIB score than birth weight and gestational age for prediction of mortality in Indian neonates [15] and Akim et al reported no significant difference in CRIB score for prediction of complications such as drug nephrotoxicity in neonates [16]. Pollack et al evaluated neonatal mortality risk prediction models in a cohort of VLBW infants from the Washington, DC area and concluded that Published models for severity of illness over predicted hospital mortality in this set of VLBW infants and they suggested a need for frequent recalibration [17]. According to Rautonen and Bastos results CRIB is a suitable and accurate test for prediction of mortality. The simplification of this method sets it as an available and doable method in different situations. The SNAP score needs 26 variables and 37 items to evaluate a neonate correctly. Therefore it is time consuming and difficult to perform in some situation. However SNAP and SNAP-PE

Table 3. Area under the curve, sensitivity, specificity, PPV* and NPV** for prediction of mortality by scoring systems.

Scoring system	Cut off point	Area under the curve	Sensitivity	Specificity	PPV	NPV	Accuracy rate
CRIB	3.0	0.817	87.9	68.5	92.7	55.6	84.4
CRIB II	5.0	0.698	69.6	63.0	76.2	54.8	67.1
SNAP	8.0	0.931	94.4	86.7	96.5	80	92.8
SNAPII	15.0	0.901	84.8	62.8	90.8	54.4	82.7
SNAP-PE	18.5	0.918	89.8	82.4	96.2	62.2	88.6

* PPV: positive predictive value ** NPV: negative predictive value

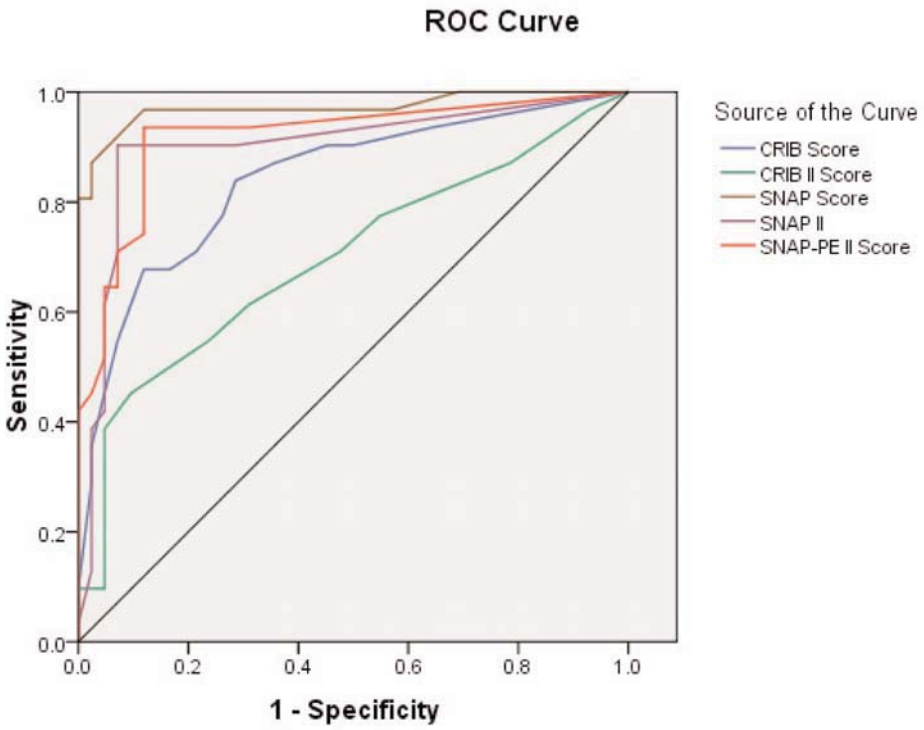

Fig. 1 Area under the ROC curve for prediction of mortality by CRIB, CRIBII, SNAP, SNAPII and SNAP-PE scoring systems.

scores need complete data to emerge as more accurate and in our NICUs and perhaps in some others, all the tests including in SNAP which are not routinely done in all patients and the basis of our results it was more accurate than the other scoring systems. Although we need simplified scoring systems for evaluation of neonates in NICUs, but it must also have more accurate result. Thereupon we recommend the SNAP score as the most accurate test for prediction of mortality in NICU.

Conclusion

We concluded that the neonatal scoring systems could be a useful tool for prediction of mortality in NICUs. Consequently we found out the highest AUC and the highest sensitivity, specificity, PPV and NPV (0.931, 94.4%, 86.7%, 96.5% and 80% respectively) for SNAP scoring system and the lowest for CRIB II in prediction of NICU mortality. However, all the scoring systems are important in evaluation of the other NICU modalities.

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References

1. Horbar JD, Onnstad L, Wright E. Predicting mortality risk for infants weighing 501-1500 grams at birth. Crit Care Med 1993; 21:12-18.

2. Richardson DK, Gray JE. Score for Neonatal Acute Physiology: a physiologic severity index for neonatal intensive care. Pediatrics 1993; 91:617-623.

3. Richardson DK, Phibbs CS, Gray JE. Birth weight and illness severity. Pediatrics 1993; 91:967-975.

4. International Neonatal Network. The CRIB (Clinical Risk Index for Babies) score: a tool for assessing initial neonatal risk and comparing performance of neonatal intensive care units. Lancet 1993; 342 : 193-198.

5. Dorling JS, Field DJ, Manktelow B. Neonatal disease severity scoring systems. Arch Dis Child Fetal Neonatal Ed 2005; 90(1):11-6.

6. Dorling JS, Field DJ. Value and validity of neonatal disease severity scoring systems. Arch Dis Child Fetal Neonatal Ed 2008; 93(2):80-2.

7. Courcy-Wheeler RHB, Wolfe CDA. Use of the CRIB (clinical risk index for babies) score in prediction of neonatal mortality and morbidity. Arch Dis Child 1995; 73:32-36.

8. Bard H. Assessing neonatal risk: CRIB vs SNAP. Lancet 1993; 342(21):449-450.

9. Jean-Yves Marandon. Dept. of Anesthesia. FOCH Hospital (92 Suresnes - France) [Internet page]. Cited: 2009 July 21. Available from: www.sfar.org.

10. Kadivar M, Sagheb S, Bavafa F. Neonatal Mortality Risk Assessment in a Neonatal Intensive Care Unit (NICU). Iran J Ped 2007; 17 (4):325-331.

11. Rautonen J, Makella A. CRIB and SNAP assessing the risk of death for preterm neonates. Lancet 1994; 21(343):1272-1273.

12. Bastos G, Gomes A. A comparison of 4 pregnancy assessment scales (CRIB, SNAP, SNAP-PE, NTISS) in premature newborns. Acta Med Port 1997; 10(2-3):161-165.

13. Manktelow B, Draper S, Field J. Predicting neonatal mortality among very preterm infants: A comparison of three versions of the CRIB score. Arch Dis Child Fetal Neonatal Ed 2010; 95(1):9-13.

14. Rastogi, P.K, Sreenivas, V, Kumar, N. Validation of CRIB II for prediction of mortality in premature babies. Indian Pediatrics. 2010; 47(2):145-147.

15. Khanna R, Taneja V. The Clinical Risk Index of Babies (CRIB) Score in India. Indian J Pediatr 2002; 69 (11): 957-960.

16. Akima S, Kent A. Indomethacin and renal impairment in neonates. Pediatr Nephrol 2004;19:490–493.

17. Pollack MM, Koch MA, Bartel DA. A comparison of neonatal mortality risk prediction models in very low birth weight infants. Pediatrics 2000;105(5):1051-1057.