Signs of Inflammation in Children that can Kill (SICK score): Preliminary prospective validation of a new non-invasive measure of severity-of-illness

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ABSTRACT

Background: Signs of Inflammation in Children that can Kill (SICK score) is a new severity-of-illness score. It uses the physical signs of the Systemic Inflammatory Response Syndrome (SIRS) and its continuum - the Multiple Organ Dysfunction Syndrome (MODS). The development of the score used multiple logistic regression model coefficients converted to integer scores that have been published earlier.

Aims: The present study was done to validate the scoring system by predicting outcomes in a fresh data set.

Setting: Intensive care unit in a tertiary referral hospital

Design: Prospective

Materials and Methods: 125 admissions to the intensive care unit were evaluated so that the SICK score and the PRISM score could be calculated. In-hospital mortality was noted

Statistical Analysis: Calibration (Hosmer-Lemeshow goodness of fit) and discrimination (area under the ROC curve) were used to measure performance.

Results: Of the 125 patients studied 23 died. The area under the ROC curve was 0.76 compared to 0.80 in the development sample. Using PRISM in the validation group, the ROC was 0.78. Calibration was excellent.

Conclusion: The SICK score can predict severity of illness with nearly the same accuracy as the PRISM score. The SICK score can be calculated immediately on admission and can help to prioritize care for the more sick children who need urgent aggressive management. Larger studies, that includes all admissions to the hospital, will now need to be done.

KEY WORDS: PRISM score, multiple organ dysfunction syndrome, systemic inflammatory response syndrome

Mortality in an intensive care unit (ICU) depends on severity of illness.[1] In pediatrics, scoring systems have been developed to predict this mortality among ICU admissions.[2-6] Of these the Physiologic Stability Index (PSI) is one of the oldest.[7] PRISM score was devised to reduce the number of physiological variables required for 'severity of illness assessment'. However even this scoring system depends on laboratory results and as such is cost and labor intensive. We set out to test if a scoring system that utilizes only physical criteria (clinical signs) can be used to identify severity of illness. We felt that such a score of clinical signs, if proven to predict mortality in an ICU setting, can probably be used in the Emergency Department (ED) as a method to triage of patients there, to help prioritize care and to obviate harmful delays.

The development of the scoring system and the weights given to each variable, have been published previously.[7] Briefly, the scoring system utilizes the abnormal physical variables of the Systemic Inflammatory Response Syndrome (SIRS)[8] and its continuum - the physical signs utilized in the Advanced Pediatric Life Support (APLS).[9] The abnormal values used in the original study[7] are shown in Table 1. Table 2 shows the weights for each variable, derived in the development study. As this score, which evaluates risk of mortality, is dependent on systemic signs of inflammatory response, we are calling it the 'Signs of Inflammation in Children that could Kill' score, with the acronym, 'SICK score' The present study was done to validate that scoring system, by predicting outcomes in a fresh data set.

In the validating data set, we also looked at the mortality prediction of the PRISM score. We have evaluated how the SICK score, based on physical criteria and age of patient, performed in predicting mortality compared to PRISM score. In this initial validation study, we have used a small ICU population because the probability of death is the highest in this hospital admission sub-set. This was done as a prelude to

Table 1: Scoring of abnormal clinical variables[7]

Variable	Abnormal range
Temperature	>38°C < 36°C
Heart rate	Infant >160 per minute
	Child >150 per minute
Respiratory rate	Infant >60 per minute
	Child >50 per minute
Systolic blood pressure	Infant <65 mm Hg
	Child <75 mm Hg
SpO_2	<90%
Capillary refill time	≥3 seconds
A Alert	Anyone except A
V Responds to voice	
P Responds to pain	
U Unresponsive	

Based on SIRS and APLS[8,9]

Table 2: Weight (Regression coefficient) for each variable* developed in previous study[7]

Variable	Weight
Heart rate	0.2
Respiratory rate	0.4
Blood pressure (systolic)	1.2
Temperature	1.2
SpO_2	1.4
Capillary filling time	1.2
AVPU	2.0
Age (months)	
≥ 60	0.0
≥ 12 to <60	0.3
≥ 1 to <12	1.0
<1	2.2

*Based on multiple logistic regression analysis

a larger multicentric trial covering all admissions, to validate the score.

Materials and Methods

This prospective study was done from May 2001 to August 2002 at a tertiary care hospital, with an 8 bed pediatric ICU after obtaining permission from the hospital research committee. Procedures were followed in accordance with the standards laid down in the Helsinki Declaration of 1975 as revised in 2000. Admissions to the ICU, above one month of age and up to 12 years of age, were enrolled in the study. Patients with congenital malformations were excluded. Written consent was obtained from the parents of participating children. All patients included in the study were assessed for the severity of illness using physical criteria described previously.[7]

The temperature, heart rate, respiratory rate, capillary refill time (CFT) were noted by the pediatric registrar on duty. CFT was measured on the sternum or on a digit held at the level of the heart after blanching pressure was applied for 5 seconds. Consciousness was assessed using AVPU score. Non-invasive blood pressure was recorded using blood pressure monitor (Gresby oscillomats 900; Gresby, Watford) with the cuff covering over 75% of the length of the upper arm and SpO_2 was measured with a saturation monitor (Simed S-100 C, Bothell WA 98011).

For purposes of PRISM scoring, arterialized capillary heel or arterial blood was used for determining blood gas values. Standard laboratory techniques were utilized to measure blood levels of total bilirubin, potassium, calcium, glucose, prothrombin time and partial thrombin time. The FiO_2 required to maintain SpO_2 > 90% was measured.

Statistical Analysis

The validity of the SICK score was tested by predicting outcomes in the validation data set. Its performance was assessed using goodness-of-fit tests (Hosmer-Lemeshow Chi-square). The predictive ability was tested by looking at the receiver operating characteristic (ROC). The predictive ability was also evaluated for performance of the predictor by comparing observed and expected mortality rates over the range of mortality risk strata. Comparison was also done looking at ROC using PRISM scoring in the same group.

Results

A total of 125 children admitted ICU children were studied. 23 died and 102 survived their stay in the ICU. Table 3 shows the numbers that survived and those that died at different SICK scores. With a SICK score < 1 mortality was 0%, which gradually increased to 100% with a score of ≤7. The sensitivity of triage score at 0 was 100% with 0% specificity while at score ≤7 the sensitivity was 4.75% and specificity was 100%.

Table 4 shows the number of deaths predicted at different scores. Overall 23 deaths were predicted and 23 deaths were observed. The ROC curve developed using different cut off points had 76% of area under curve, indicating good predictive ability of the score [Figure 1].

Comparisons were also made with the PRISM score. Table 5 shows the outcome of the children at various scores using the PRISM scoring system. The sensitivity gradually decreased to 0% and specificity increased to 100% as score increased to 42. The predicted and observed mortality for different scores are shown in Table 6. The sensitivity of predicting outcome using PRISM was 100% at score 4 with specificity of 7.8%. The area under the ROC curve was 78% [Figure 2]. Thus we found that the outcome of the patients admitted to pediatric ICU was predicted by SICK scoring with nearly the same accuracy as demonstrated by the PRISM score.

Table 3: Showing numbers of death at different SICK score in this validation study

Sick score	Discharge status		Total
	Improved	Died	
0	5	0	5
1	17	1	18
2	32	4	36
3	30	4	34
4	14	5	19
5	4	6	10
6	0	2	2
7	0	1	1
Total	102	23	125

Table 4: SICK score
Goodness of prediction model, with the predicted and observed survival and mortality

Sick score	Total numbers	Deaths		Alive	
		Observed	Expected	Observed	Expected
0-1	23	1	0.71	22	22.29
2	36	4	2.65	32	33.35
3	34	4	5.61	30	28.39
4	19	5	6.27	14	12.73
5->5	13	9	7.77	4	5.23

Hosmer-Lemeshow Chi-square = 2.29 3d.f.

P= 0.51

Discussion

In this validation study we found the SICK score is as good a predictor of mortality as the PRISM score. The ROC in the development cohort had been 0.8. In this validation study it was 0.76. The difference in ROC between development and validation samples is similar to a study published recently on Pediatric Risk of Admission, where the ROC was 0.822 in the first study and 0.774 in the validation study.[10] Pollack *et al*[5] have shown that a similar relationship exists between physiological instability and outcome across different intensive care units. We have previously shown that PRISM score related mortality in our unit is comparable to the predicted mortality described internationally.[11] And the SICK score has some advantages over PRISM score. The SICK score can be determined immediately on presentation to the emergency department. This allows the score to be used to prioritize care in more seriously ill patients. The PRISM score on the other hand is calculated from the most abnormal values in the first 24 hours. Considering the fact that mortality depends on the quality of care received in the first 24 hours of being critically ill,[12] this window of opportunity to act aggressively in the first 24 hours is lost by the time the PRISM score is available.

WHO has developed emergency triage, assessment and treatment (ETAT) guidelines for triage in developing countries.[13] The drawback with ETAT is that it requires a specific training for the doctors and other health care staff to

Table 5: Outcome of patients with PRISM score assessment

PRISM Score	Discharge status		Total
	Improved	Died	
1	1	0	1
2	3	0	3
3	4	0	4
4	1	1	2
5	6	1	7
6	7	0	7
7	7	0	7
8	11	1	12
9	8	1	9
10	11	0	11
11	9	0	9
12	8	3	11
13	9	2	11
14	3	0	3
15	2	0	2
16	3	3	6
17	2	1	3
18	2	2	4
19	2	2	4
20	1	1	2
22	0	1	1
23	1	0	1
25	1	1	2
30	0	2	2
42	0	1	1
Total	102	23	125

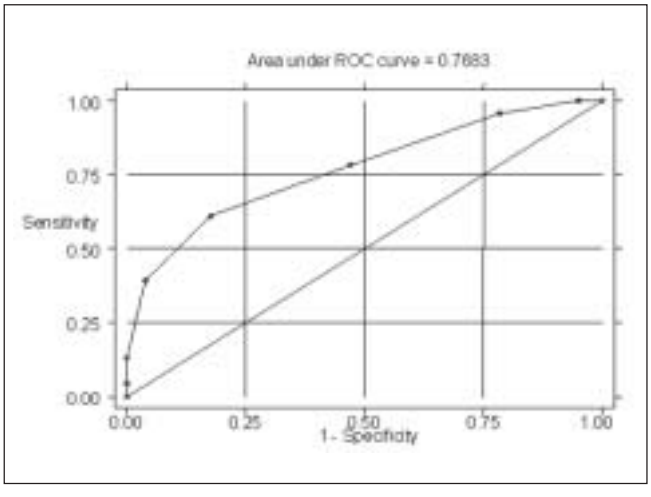

Figure 1: SICK score ROC curve in this study

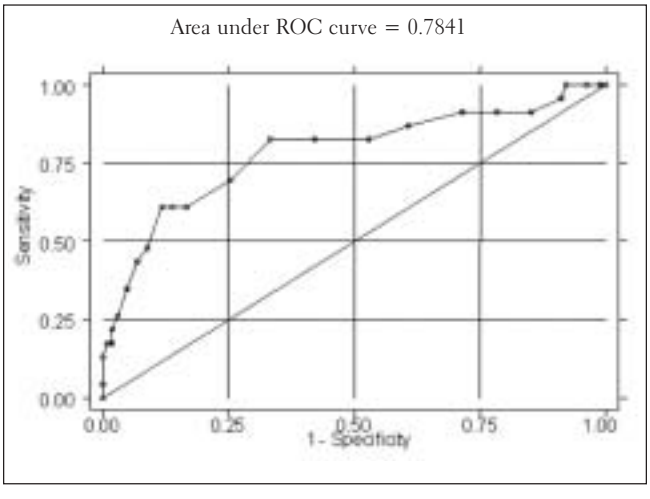

Figure 2: PRISM score

Table 6: Goodness of the prediction model for PRISM score

PRISM	Total numbers	Deaths		Alive	
		Observed	Expected	Observed	Expected
0-4	10	1	0.7	9	9.3
5-9	42	3	4.7	39	37.3
10-14	45	5	7.7	40	37.3
15-19	19	8	5.3	11	13.7
>20	9	6	4.7	3	4.3

Hosmer-Lemeshow Chi-square = 2.29 3d.f.

P= 0.51

be implemented. It has been our hope that the SICK score could be tested and found useful even in the emergency department to prioritize care and identify patients who would benefit from transfer urgently to an ICU. It is also hoped that this clinical score may inform decisions about admission to the hospital or safe discharge home, from the ED. This form of triage in the ED setting is sometimes referred to as 'super-triage'.[12] The score was developed to ultimately help in triage. However before it can be used for this purpose the score must be tested in the ED setting. For the present, it is more appropriate to refer to this as SICK score rather than a Triage score.

A drawback of our study is that the SICK scoring in our study, was done by different doctors on duty in the PICU and we have not looked for interpersonal variability. The scoring however involves measurements that are quite basic in medical practice like counting the pulse rate and interpersonal variability is likely to be low. Another drawback is that it is not a blinded study in as much as the pediatricians involved in the care of the patients, were aware of the abnormal variables in the child they were treating and also the underlying hypothesis of the study. To mitigate this, the actual weights were calculated at the end of the study, after the data on all the patients had been collected. In clinical situations in the future, it is expected that the score will be used to initiate more aggressive treatment and reduce mortality in the long run. This study can only be considered as very preliminary. It needs to be tested now in a large multi-center study covering all hospital admissions and later, covering all children presenting to health care workers.

References

1. Fery-Lemonnier E, Landais P, Loirat P, Kleinknecht D, Brivet F. Evaluation of severity scoring systems in ICU's-translation, conversion and definition ambiguities as a source of inter-observer variability in Apache II, SAPS and OSF. Intensive Care Med 1995;21:356-60.
2. Shann F, Pearson G, Slater A, Wilkinson K. Pediatric Index of mortality (PIM): A mortality prediction model for children in intensive care. Intensive Care Med 1997;23:201-7.
3. Giunning K, Rowan K. ABC of intensive care: Outcome data and scoring systems. Br Med J 1999;319:241-4.
4. Yeh TS, Pollack MM, Ruttimann UE, Holbrook PR, Field AI. Validation of a physiologic stability index for use in critically ill infants and children. Pediatr Res 1984;18:445-51.
5. Pollack MM, Ruttimann UE, Getson PR. The Pediatric risk of mortality (PRISM) score. Crit Care Med 1988;16:1110-6.
6. de Courcy, Wheeler RH, Wolfe CD, Fitzgerald A, Spencer M, Goodman JD, et al. Use of the CRIB(clinical risk index of babies) score in prediction of neonatal mortality and morbidity. Arch Dis Child Fetal Neonatal Ed 1995;73:F32-6.
7. Kumar N, Thomas N, Singhal D, Puliyel JM, Sreenivas V. Triage score for severity of illness. Indian Pediatr 2003;40:204-10.
8. Sun D, Aikawa N. The natural history of the systemic inflammatory response syndrome and the evaluation of SIRS criteria as a predictor of severity in patients hospitalized through emergency services. Keio J Med 1999;48:28-37.
9. Advanced Life Support Group. The structured approach to the seriously ill child. *In*: Advanced Pediatrics Life support. The Practical approach. BMJ Books, 3rd ed. Editors. Mackway-Jones K, Molyneux E, Phillips B, Weeteska S. Panther Publishers: Bangalore; 2001. p. 71-8.
10. Chamberlain JM, Patel KM, Pollack MM. The Pediatric Risk of Hospital Admission score: a second-generation severity-of-illness score for pediatric emergency patients. Pediatrics 2005;115:388-9.
11. Singhal D, Kumar N, Puliyel JM, Singh SK, Srenivas V. Prediction of mortality by application of PRISM score in an intensive care unit. Indian Pediatrics 2001;38:714-9.
12. Terregino CA, Reid JC, Marburger RK, Leipold CG, Ross SE. Secondary emergency department triage (super triage) and trauma team activation: effects on resource utilization and patient care. J Trauma 1997;43:61-4.
13. Grove S, Tamburlini G, Molyneux E, Whitesell P, Campbell H. Development and technical basis of simplified guidelines for emergency triage assessment and treatment in developing countries. Arch Dis Child 1999;81:473-7.