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Risk of Mortality in Pediatric Intensive Care Unit, Assessed by PRISM-III

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Abstract: This study aimed at evaluating the mortality rate in a PICU applying PRISM-III. Two hundred and twenty one infants and children consecutively admitted to PICU of Tabriz Children's Hospital were studied during a 13 months period of time. Data required for calculating the PRISM-III score were collected during the first 24 h of PICU stay in all patients. The prediction of actual mortality by PRISM-III scoring was evaluated by the Hosmer and Lemeshow goodness-of-fit test. Receiver Operating Characteristic (ROC) curve was constructed, as well. The observed (O) short-term (during hospital stay) mortality rate was compared with the expected (E) figures as the O/E ratio. The mean value of the PRISM-III score was 14.22±9.57 (2-42). ROC analysis indicated a strong predictive power for the PRISM-III (area under the curve = 0.898) and the test was well fit to the designed study (goodness-of-fit p-value = 0.161). The observed short-term mortality rate was 9.05% and the expected mortality rate by the PRISM-III scoring was 9% (O/E ratio =1.005). The PRISM-III scoring system was highly calibrated in our institute.

Key words: Mortality risk, pediatric intensive care unit, outcome

INTRODUCTION

Risk-adjustment tools that predict death in PICUs have become established in the past 20 years (Anthony *et al*., 2006). PICU has a unique environment, because a wide spectrum of critically ill patients with really various ages, body sizes and diagnoses are admitted where undergone different therapeutic interventions including administration of a great variety of medications and doses; all mentioned conditions make every PICU potentially a high risk system. Therefore it is very important to discover all potential and actual sources of hazards for patients or factors disturbing health care quality in sick children (Scanlon *et al*., 2007). The scoring systems that have been developed as scales for evaluation of ICUs' function are helpful tools assisting basic decision making and further planning for progression. Diverse scoring systems have been already validated in PICUs. The PRISM (Pediatric Risk of Mortality) scoring systems is a modified form of PSI (Physiologic Stability Index) that can assess the severity of disease in a given population of sick children; its third revision PRISM-III has been used to compare the function of different PICUs and assess their manner of resources consumption. This scoring system that was first presented by Pollack *et al*. (1988), is based on 17 Physiologic variables which are subdivided to total 26 parameters. In a given PICU, there is a close correlation between PRISM score, the number of patients' impaired organ systems during the first 12-24 h of admission and risk of mortality. PRISM III is a risk-adjustment tool for evaluation of intensive care which provides comparative reports to participating units under a licensing arrangement (Anthony *et al*., 2006). All PICUs managers can improve their own unit performance by self-evaluation and regular periodic reassessment using PRISM scoring system and comparing its results with standard measures; and if their unit performance is under optimal level, its cause may be determined by chart review and statistical analyses (Kahn *et al*., 2006). PRISM-III is one of the best-known scoring systems for assessment of PICU performance. Although, the entity of health care quality control is not a new matter of interest, but recently, its importance is progressively increasing as various assessment methods have introduced, many preventable medical harms and adverse effects have been brought to light and pay for performance has become a general trend (Kahn *et al*., 2006; Sedman *et al*., 2005). To choose an appropriate method of assessment among several introduced ones, a researcher needs information about its constituents to estimate its efficiency and competency in evaluating a given health care system (Scanlon *et al*., 2007).

The function of our PICU in Tabriz Children's Hospital has been never assessed before by such a scoring system; therefore, this study was planned to use

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PRISM-III as an extensive system to evaluate our health care service and provide a background for further progressions in health care quality control in our hospital.

MATERIALS AND METHODS

In a cross-sectional and analytic-descriptive study on 221 infants and children who had been consecutively admitted to PICU of Tabriz Children's Hospital during a period of 13 months (convenience sampling from March 2006 to April 2007), we used PRISM-III model to evaluate its accuracy and predictive power for estimation of our PICU mortality rate and concomitantly assess the overall efficacy of our PICU therapeutic activities.

PRISM-III scoring scale was applied for every included patient in his/her first 24 h of PICU admission, their calculated score recorded and then the patients' hospital course followed to determine the early outcome of his/her acute sickness (as dead or survived).

Following parameters were covered as determined by PRISM-III system for scoring:

- Cardiovascular system; including: systolic blood pressure and heart rate
- Nervous system; including: pupils' light reflex and level of consciousness
- Blood tests; including: arterial blood gas (pH, total CO_2, PaO_2 and $PaCO_2$), serum levels of sugar, BUN and creatinine, platelet and white blood cell counts, prothrombin time and partial thromboplastin time
- Body temperature

Studied patients were classified in 4 groups according to their PRISM-III scores: 1-9, 10-19, 20-29 and 30 or more. The overall mortality rate predicted by PRISM-III scoring system (P) is calculated by following equation:

$$P = e^r/1 + e^r$$

where, e is a constant value and r stands for empirical function of PRISM-III scores, that is calculated by a non-linear method of curve-fitting using the observed results.

Followings are considered as exclusion criteria:

- Death within the first 10 h of PICU admission
- Discharge from PICU in less than 24 h after PICU admission
- Elective admissions to PICU
- Newborn infants at less than 1 month and children above 12 years of age

It goes without saying that all collected data are derived from routinely needed physical examinations and Para clinical work up which are necessary for every child admitted to PICU, therefore no patient has been imposed by any excessive cost or hazard for mere study. In addition to PRISM-III scores; age, sex, the main cause and duration of PICU and total hospital admission of every patient and also the causes of death (in expired patients) were recorded.

SPSS™ version 13 and Microsoft Office Excel® 2003 were used for statistical analysis of recorded data. Categorical (qualitative) variables were sorted in Contingency Tables and compared by Chi-square test or Fisher's exact test. Quantitative variables were assessed by student t-test and one-way ANOVA. Results were considered to be statistically significant if there was $p \leq 0.05$.

The suitability of PRISM-III model for this study in our PICU was evaluated by Hosmer-Lemeshow goodness-of-fit test, which means a good suitability of test whenever P (goodness-of-fit value) is more than 0.05. The capacity of PRISM-III scoring system for discrimination between survived and expired patients (capacity of discrimination) was calculated by Receiver Operator Characteristics (ROC) curve. Whenever its under-curve surface area is close to 1, the capacity of discrimination is considered to be high. The association between r (empirical function) and PRISM-III scores was assessed by Binary Logistic Regression method.

RESULTS

Two hundred twenty one patients (mean age: 29.85±35.07 months) including: 102 infants (46.2%; age range: 2-12 and mean age: 5.20±4.37 months) and 119 children (53.8%; age range: 1-12 years and mean age: 50.97±36.08 months), 120 males (54%) and 101 females (46%), enrolled into this study.

The duration of PICU admission and patients' hospital stay were 2-34 days (mean: 5.16±4.03) and 2-39 days (mean: 10.28±7.37), respectively.

The spectrum of background disorders leading to PICU admission and the causes of death in expired patients are shown in Table 1. The results of PRISM-III scoring in different age groups for prediction of overall mortality rate and comparing it with truly observed mortality rate are mentioned in Table 2. There was no statistically meaningful difference between predicted and observed mortality rates neither in age or score groups nor in our total studied patients.

According to the results of Hosmer-Lemeshow goodness-of-fit test, the model of PRISM-III designed in

Table 1: Characteristic of background condition of patients in PICU

Background conditions	Diseases	Frequency	Percent	Total
Hospitalized	Pulmonary	66	29.86	221 (100%)
	Neurology	63	28.51	
	Cardiovascular	35	15.84	
	Poisoning	27	12.22	
	Infectious	17	7.69	
	Inborn error of metabolism	13	5.88	
Death	Multiorgan Failure	10	50.00	20 (9.05%)
	Septic shock	4	20.00	
	Gastrointestinal Bleeding	2	10.00	
	Intestinal gangrene	1	5.00	
	resistant no septic shock	1	5.00	
	Pulmonary hemorrhage	1	5.00	
	Encephalitis	1	5.00	

Table 2: PRISM scoring difference in age group and expected and observed mortality rate

Age groups	Mean PRISM scoring	Scoring groups	Patients No.	Mean predictive mortality rate	Expected mortality	Observed mortality	O/E ratio	Logit r	P
Total	14.22±9.57 (2-42)	1-9	90 (40.7%)	0.01	0.90	0	0	[1]Mean -3.46±1.65 (-5.57-1.35)[1]	1
		10-19	73 (33%)	0.03	2.19	2	0.91		1
		20-29	30 (13.6%)	0.15	4.50	9	2		0.117
		≥30	28 (12.7%)	0.45	12.60	9	71		0.247
		Total	221(100%)	0.09	19.89	20	1.01		1
Infant	17.25±10.29 (2-42)	1-9	29 (32.2%)	0.00	0.00	0	0	[2]Mean -4.59±2.73 (-8.63-1.97)[2]	-
		10-19	34 (46.6%)	0.01	0.034	0	0		-
		20-29	19 (63.3%)	0.06	1.14	3	2.63		0.604
		≥30	20 (71.4%)	0.44	8.80	7	0.80		0.519
		Total	102 (46.2%)	0.10	10.20	10	0.98		1
Children	11.61 ± 8.07 (3-34)	1-9	61 (67.8%)	0.02	1.22	0	0	[3]Mean -3.24+1.34 (-8.63-1.97)[3]	1
		10-19	39 (53.4%)	0.05	1.95	2	1.03		1
		20-29	11 (36.7%)	0.26	2.86	6	2.09		0.387
		≥30	8 (28.6%)	0.52	4.16	2	0.48		0.608
		Total	119 (53.8%)	0.08	9.52	10	1.05		1

[1]Logit r = 0.173×PRISM III score-5.915, [2]Logit r = 0.265×PRISM III score-9.163, [3]Logit r = 0.166×PRISM III score-5.164

this study has been showed to be well fit for prediction of mortality rate in our PICU as P (goodness-of-fit value) was 0.987 for infants, 0.209 for children and 0.161 for total studied patients.

The capacity of PRISM-III scoring system for discrimination between survived and expired patients in our PICU as analyzed by ROC curve has been shown in Fig. 1; accordingly using PRISM-III model for prediction of overall mortality rate in PICU is recommended; however, this model can not be used to predict final outcome in a single patient. ROC analysis in our study indicated a strong predictive power for the PRISM-III as followings:

- For total studied patients: Under-curve surface area =0.898, p<0.001, 95% CI = 0.836-0.960
- For infants (2-12 months old): Under-curve surface area = 0.939, p<0.001, 95% CI = 0.887-0.990
- For children (1-12 years old): Under-curve surface area = 0.890, p<0.001, 95% CI = 0.807-0.972

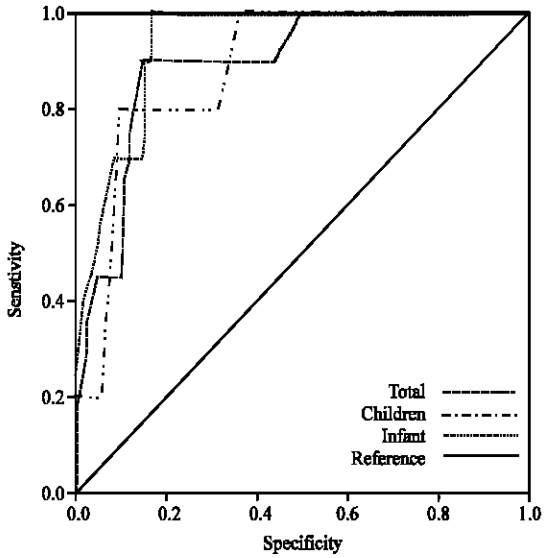

Fig. 1: ROC curve for predicting mortality with PRISM scoring

Table 3: Characteristic of alive and death patients

Variable	Alive	Death	p-value
Sex			
Male	108(53.7%)	12(60%)	0.591
Female	93(46.3%)	8(40%)	
Mean age (month)	29.45±34.88	33.83±37.59	0.596
Age group			
Infant	92(45.8%)	10(50%)	0.718
Child	109(54.2%)	10(50%)	
Mean of admission day in PICU	5.11±3.59	5.60±7.26	0.609
Mean of hospitalization day	10.61±7.21	7±8.31	0.037
Mean of PRISM Score	12.76±8.40	28.85±8.29	<0.001

Compared variables between survived and expired patients are shown in Table 3, as it can be seen there is no statistically meaningful difference in mean age, sex distribution and average length of PICU admission between these two groups. However, mean hospital stay is significantly longer in survived patients and mean PRISM-III score is significantly higher in expired patients. The mean value of the PRISM-III score was 14.22±9.57 (Range: 2-42) for total studied patients. The observed (O) short-term mortality rate was 9.05% and the expected (E) mortality rate by the PRISM-III scoring was 9% (O/E ratio =1.005).

DISCUSSION

We evaluated the function of PICU (of Tabriz Children's Hospital) in this study by means of PRISM-III scoring systems. There are many studies that reported a strong correlation between PRISM score and the number of patients' impaired organs during the first 12 to 24 h of admission, which gives a predictive power to this model of prognostication to determine the standard risk of mortality in a given PICU (Kahn *et al*., 2006; Pollack *et al*., 1997a).

We studied the total hospital course of 221 infants and children from PICU-admission to final short-term outcome of their management based on PRISM-III scoring systems (24 h form); the observed mortality rate was 9.05% (20 out of 221 children died) while the mean score of PRISM-III for total 221 PICU admissions was 14.22±9.57 (score range: 2-42) which predicted a total death number of 19.89 (the expected mortality rate was 9%), therefore the observed and predicted numbers of deaths were similar (the ratio of observed/expected mortality rates (O/E ratio) was almost equal to 1). As mentioned in results, the capacity of PRISM-III scoring system for discrimination between survived and expired patients in our PICU as analyzed by Receiver Operating Characteristic (ROC) curve showed a strong predictive power for the PRISM-III (Under-curve surface area = 0.898); however, this model can not be used to predict final outcome in a single patient.

The results of Hosmer-Lemeshow goodness-of-fit test showed that the model of PRISM-III designed in this study has been well fit for prediction of mortality rate in our PICU as P (goodness-of-fit value) was 0.161 for total studied patients.

PRISM-III model has been used for evaluation of PICUs' function in a few studies worldwide: Choi *et al*. (2005) studied 303 PICU admissions in Hong Kong, their short-term observed mortality rate was 2.64% while expected mortality rate, predicted by PRISM-III was 3.37% (O/E = 0.78). This study showed: ROC under-curve surface area = 0.910 and goodness-of-fit test value = 0.395 (Choi *et al*., 2005).

In Gemke's study on 300 PICU admissions in Netherlands, short-term observed and expected (predicted by PRISM-III) mortality rates were 6.6 and 6.96%, respectively, (O/E = 0.95). In this study ROC under-curve surface area and goodness-of-fit test value were 0.78 and 0.21, respectively (Gemke and Van Vught, 2002).

In a large study by Pollack *et al*. (1997b) on 11165 children admitted to 32 PICUs in USA; short-term observed and expected (predicted by PRISM-III) mortality rates were 4.86 and 4.84%, respectively, (O/E ≅1). In this study ROC under-curve surface area and goodness-of-fit test value were 0.950 and 0.137, respectively. There was no statistically meaningful difference between observed and predicted number of deaths.

In another large study by Slater andd Shann (2004b) on 26966 children admitted to PICUs of Australia and New Zealand; short-term observed mortality rate was 4.25% but predicted mortality rate by PRISM-III was less than observed rate (O/E = 1.3), while ROC under-curve surface area was reported to be 0.93; it means that PRISM-III model has been appropriate for evaluation of their PICUs as the capacity of this scoring system has been high enough in their study to discriminate between survived and expired patients, however the discrepancy between observed and expected mortality rates may be due to unjustified increased mortality probably resulted from suboptimal health care quality (Slater and Shann, 2004).

Results were reported by Leteurtre *et al*. (2004) who had studied 802 children admitted to PICUs in France; short-term observed and expected (predicted by PRISM-III) mortality rates were 9.98 and 8.33%, respectively, (O/E = 1.19). There was a statistically meaningful difference between observed and predicted number of deaths in this study and ROC under-curve surface area was reported to be 0.92.

According to the results of our study, health care quality in PICU of Tabriz Children's Hospital is on optimal

level in comparison with similar worldwide studies, particularly it is somehow better than some developed countries such as France, Australia and New Zealand (Leteurtre *et al*., 2004; Gemke *et al*., 1994) and is comparable with current state of PICU care in USA and Netherlands (Gemke and Van Vught, 2002; Slater and Shann, 2004).

The short-term observed mortality rate was about 9% in our study; similarly, it was 8.4% in study of Gemke *et al*. (1994) on 593 patients, but several studies in USA reported variable observed mortality rates from 2.95-5.1% (Orr *et al*., 1994; Castello *et al*., 1999; Pollack *et al*., 1997a, b).

In a similar study by El-Nawawy in Egypt, PICU mortality rate was 38% (El-Nawawy, 2003) and it was 35.35% in another study by Thukral *et al*. (2006) in India. In an study by Eulmesekian *et al*. (2007) in Argentina PICU mortality rate was 2.6%. By comparing our results with mentioned studies it can be claimed that short-term mortality rate of our PICU is in optimal range that is close to those of validated worldwide centers. Besides, it must be mentioned that Tabriz Children's Hospital is a tertiary referral hospital in Iran-Northwest where patients with most-severe health disturbances from neighboring cities and provinces are referred and admitted to, therefore our observed mortality rate could be acceptable according to results of PRISM-III assessment system; moreover, various factors such as: sample size, age distribution of patients and their underlying disorders that resulted in PICU admission, can affect the results of different studies. Some researchers have emphasized the role of patients' age in prediction of mortality rate by different models of assessment (Pollack *et al*., 1988). Therefore, we studied the results of PRISM-III scoring system separately in two different age groups (infants and children) in addition to the study of total patients as a single group. Present results showed that PRISM-III model has been well-fit for both studied age groups. Short-term observed and expected (predicted by PRISM-III) mortality rates were equal (O/E ≅ 1) in both age groups, it means that health care quality in our PICU is on optimal level for both infants and older children. Similar results have been reported by Tibby *et al*. (2002) from England, although their study was based on PRISM-II instead of PRISM-III.

In another study by De Leon *et al*. (2005) on 170 Mexican infants, the mean PRISM-III score and observed mortality rate in his study were 11.1±8.1 (0-39) and 24.7%, respectively. These results are at the same direction as ours.

An advantage of our study is to compare observed and expected mortality rates in different PRISM-III score groups. The results of total patients study and those of each score group were similar with an exception for the score group of 20-29, whose observed mortality rate was significantly more than expected rate (O/E = 2). More controlled studies are needed in future to clarify its causes.

A similar study in India showed almost equal observed and expected mortality rates in different PRISM-III score groups (as their difference were not significant); however, the sample size of this study in score groups of 20-29 and 30 or more were too small (Singhal *et al*., 2001).

CONCLUSION

The mean expected mortality rate in 221 studied patients as predicted by the PRISM-III scoring was 9% (about 20 deaths), it was 10% in infants (about 10 deaths) and 8% in older children (about 10 deaths); similarly, the number of observed deaths were 20 in all studied patients, 10 cases from infantile age group and another 10 cases from older children. Therefore observed and expected mortality rates were equal in both infants and older children without any statistically significant difference. These result showed that health care quality in PICU of Tabriz Children's Hospital is on optimal level for both infants and older children at present time.

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