EVALUATING PEDIATRIC RISK OF MORTALITY (PRISM) SCORE IN A PEDIATRIC CRITICAL SETTING: A PROSPECTIVE OBSERVATIONAL STUDY IN CHILDREN'S MEDICAL CENTER

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Abstract - The pediatric risk of mortality (PRISM) score is a measure of illness severity based on abnormalities observed on bedside examination and laboratory assessment at Pediatric Intensive Care Unit (PICU) admission to predict mortality probability. Our study was performed on 205 patients who were admitted to PICU of Children's Medical Center (CMC) over a period of 6 months.

Data were recorded prospectively from observations at the time of admission in PICU and PRISM score was measured at admission (PRISMa) and after 24 hours (PRISM1). The mortality probability raised from 0 at low scores, approaching 1 above a PRISM score of near 40. Based on PRISMa score of 11.36, (cut-off point), patients were divided in two groups; 71% with low risk and 29% high risk of mortality, who had significant differences in length of stay in ICU, admission costs and mortality rates. Other variables such as referring from other centers, mechanical ventilation at admission, and length of stay in ICU had a significant statistical relation with mortality rate.

For data obtained, observed mortality rates were near similar to predicted. Although pre-ICU PRISM score cannot be used as a single certain predictive value, but it is useful in predicting severity of illness and mortality probability. Further investigations is required to determine the effectiveness of PRISM scores in our country.

Acta Medica Iranica 39 (3): 130-135; 2001

Key Words: Severity of illness, PRISM score, mortality prediction, outcome assessment

INTRODUCTION

The major role of intensive care unit (ICU) is life support of patients who suffer from severe physiological dysfunction. These special cares are performed by modern technology and require multidisciplinary group.

Therefore, management in ICU is expensive, so that ICU costs account for approximately twenty percent (20%) of the hospital costs (1). For this reason some efforts have been done to adjust the health care expenditures to give efficient life supports with lower costs or to admit some of the patients of Pediatric Intensive Care Unit (PICU) in the other units of hospitals which have lower expenses, provided that they don't need any special therapies or their illness is not severe (1,2).

It is very important to be able to describe how sick a group of patient is. Severity of illness scores are needed to discover the best way to organise pediatric intensive care, to assess the relationship between severity of illness and cost, and to monitor the effects of changes in practice (3-8). On the other hand, for evaluating ICU expenditures and the quality of ICU cares, determining severity of illness is necessary (9-12).

The pediatric risk of mortality (PRISM) scores is a measure of illness severity based on abnormalities observed in the bedside examination and laboratory assessment which is a revision of the physiologic stability index (PSI) (4,8,9). PSI was developed from the subjective input of experts and contains 36 variables and 76 variable ranges. The PSI was simplified using multivariable logistic regression techniques and the resulting PRISM score has only 14 variables and 23 ranges of these variables (table 1). The ranges of abnormalities are weighted using a logistic scale according to their contribution to risk of mortality (4,5,8,9). When scores are obtained after PICU admission, mortality probability can be calculated as an empirical function of the PRISM score (4,5,8,9). PRISM is based on the hypotheses that physiologic instability directly reflects mortality risk and does not depend on diagnosis (4).

Recently a third generation of PRISM score is used, which is a physiologic-based score for quantifying physiological status (13). This PRISM may be used for a variety of purposes including estimating PICU care trait mortality risk based on admission (PRISMa) and the first 24 hours of PICU staying (PRISM1), estimating risk-adjusted length of PICU stay and quantifying severity of illness for other purposes (13,14). The strength of new generation of PRISM is as a parsimonious model to predict PICU survival or death (13). The new generation of PRISM score (acute physiologic state) is more sensitive to minor physiologic changes and infact it shows the physiologic instabilities (13,15).

Mortality prediction models are often used to test the standard of care in a particular intensive care unit by calculating the standardised mortality rate of the unit's patients with the expected rate (10,11,16).

This study, was done on patients who were admitted in PICU of Children's Medical Center (CMC) during 6 months in 1998. The goal in this investigation was to assess physiologic - based severity of illness in comparison to PRISM score at the time of admission. The premise is that such a method will be better suited to detect changes in physiologic status in patients than PRISM III, which has been optimized to estimate mortality risk.

MATERIALS AND METHODS

Data were collected prospectively on consecutive patients admitted to the PICU of CMC, Tehran University of Medical Sciences, in 1998 during 6 months. This unit has 7 active beds for children more than one month old. All of the ICU beds have cardiac and respiratory monitoring and the temperature and blood pressure of each patient is controlled every hour. All of the admitted patients were evaluated and each readmission was considered as a new case. The data collection and PRISM score determination for each patient was done by the responsible physician, at the time of admission in PICU and thereafter daily. Initially the pilot study was done on 65 patients in one month to evaluate these system and solve the problems. For each patient, data which were collected and measured included age (month), sex, outcome (death or survival), primary diagnosis (based on data available within the first 24 hours), duration of illness (acute or chronic), surgical status, mode of admission at hospital (direct or referral), length of stay, and use of mechanical ventilation during the first 24 hours of care.

Physiologic data collection included; systolic and diastolic blood pressure, heart and respiratory rate, temperature, state of consciousness (Glasgow coma scale less than 8 or stupor or coma), pupillary reaction, size of pupils and their conjugation, blood sodium, potasium, BUN, calcium, glucose, direct and total billirubin, creatinin, albumin, hemoglubin, WBC and plattelet counts, PT, PTT, arterial blood gas (pH, PCO_2, PaO_2) with simultaneous FIO_2 (Table 1).

The PRISM score was determined on the basis of involvement of 7 organ systems and abnormal variables were classified from 1 to 8 relating to the severity of dysfunction. Zero score was when the accounted variable of any patient didn't meet the described range. Only the most abnormal values observed at the time of admission and during the first 24 hours of the PICU stay were used for PRISM score which were respectively PRISMa and PRISM1. The mortality probability relation with pre-ICU PRISM score represents this equation:

$$P=e^r / (1+e^r) \qquad (1)$$

The mortality probability rises from near zero at low scores (mild/survival), approaching one (severe/death) with a sigmoid curve showing intermediate risk of mortality. In this equation "r" is an empirical function of pre-ICU PRISM score :

$$r = 0.197 \text{ PRISMa} - 4.75 \qquad (2)$$

Considering patient's age and surgical condition, "r" is computed using this formula:

$$r = 0.207 \text{ PRISMa} - 0.005 \text{ age (month)} - 0.433 \text{ surgery state} - 4.782$$

Where PRISMa is PRISM at the time of ICU admission and in which operative status is 1 if the patient was postoperative and 0 if not. Mortality prediction (P) obtained using this model and comparing it with observed mortality rate in PICU with Fisher test and Chi square results in evaluating the PICU condition. In all statistical comparisons, the difference were significant when P.value < 0.05.

RESULTS

During the 6 months period, 205 patients were admitted in PICU of whom 89 were girls (43%) and the rest were boys (57%). The age of patients varied from 1 month to 14 years, with the mean age of 36 months. Most of the admitted children were under 1 year old (46%).

The diagnosis of admitted patients were different, in which cardiorespiratory diseases, metabolic disorders and gastrointestinal diseases were the most common (12% each of these groups). In those 205 patients, only 16 children were referred cases

Table 1. The pediatric risk of mortality (PRISM) score

Variable	Age Restrictions and Ranges		Scores
	Infants	Children All Ages	
Systolic BP	130-160	150-200	2
mmHg	55-65	65-75	2
	> 160	> 200	6
	40-54	50-64	6
	< 40	< 50	7
Diastolic BP			
(mmHg)		> 110	6
Heart Rate			
(beats/min)	> 160	> 150	4
	< 90	< 80	4
Respiratory Rate			
(breaths/min)	61-90	51-70	1
	> 90	> 70	5
	Apnea	Apnea	5
PaO2/FIO2*		200-300	2
		< 200	3
PaCO2**			
(mmHg)		51-65	1
		> 65	5
Glascow Coma Score@		< 8	6
Pupillary Reactions		unequal or dilated	4
		fixed or dilated	10
PT/PTT		> 1.5* control	2
Total Bilirubin Level			
(mg/dl)		> 3.5#	6
Potassium level			
(mEq/l)		3.0-3.5	1
		6.5-7.5	1
		< 3.0	5
		> 7.5	5
Calcium level		7.0-8.0	2
(mg/dl)		12.0-15.0	2
		< 7.0	6
		> 15.0	6
Glucose level			
(mg/dl)		40-60	4
		250-400	4
		< 40	8
		> 400	8
Bicarbonate level II			
(mEq/l)		< 16	3
		> 32	3

* Cannot be assessed in patients with intracardiac shunts or chronic respiratory insufficiency. Use arterial blood.

** May be assessed with capillary blood gases.

@ assessed only if there is known or suspected central nervous system dysfunction. Cannot be assessed in patients during such conditions as iatrogenic sedation, paralysis, and anesthesia. Scores less than 8 correspond to deep stupor or coma. If sedation or paralysis continues throughout the first 24 hours, the latest pre-ICU coma assessment may be used.

Greater than 1 month.

II : Use measured values

from other hospitals (8%). 13 patients were in postoperative status (6%) and 50 cases had undergone mechanical ventilation in the first day of admission (24%). The total length of stay in PICU was 844 days, with a mean of 4.1 days. For all of these patients PRISM score were determined, and the mean of

PRISM score of the patients was 9.6 (Table 1). Generally, death occured in 45 patients (21.5%). The characteristics such as age, length of stay, PRISMa and PRISM1 scores are shown in table 2, then the relation between observed and different variable were studied (table 3). Based on this table, variables which had significant relations with observed death were referral from other hospitals, previous history of surgery and mechanical ventilation (P.V < 0.05). There was a statistical relation between observed deaths and acute illness at time of admission (P.V < 0.05). Later, Fisher method was used for predicting death (table 4).

Table 2. Characteristics of pediatric intensive care unit (PICU) patients in both high (Death = 1) and low (Death = 0) risk group; [mean ± SD by groups]

Variable	Death = 0	Death = 1
age (month)	36.8 ± 44.3	29.5 ± 39.5
days in ICU	3.7 ± 4.9	5.7 ± 6.0
PRISMa	8.1 ± 5.0	15.1 ± 7.7
PRISMI	3.4 ± 2.9	17.1 ± 6.5

Table 3. Comparing variables in both high (Death = 1) and low (Death = 0) risk group of patients in pediatric intensive care unit (PICU)

Variable	Death = 0	Death = 1
sex (F,M)	72,88	17,28
age (<1year >1 year)	74,86	25,20
referral (yes, no)*	6,154	10,35
postop (yes,no)*	13,147	0,45
acute Dx (1-4)*	100,34,12,14	23,19,3,0
chronic Dx (1-6)	28,34,30,19,17,32	8,8,5,5,12,7
mechanical (yes, no)* ventilation	22,138	29,16

* P value < 0.05

1. neurologic disorders, 2. pulmonary disease, 3. metabolic disorders, 4. cardiovascular problems, 5. gastrointestinal diseases, 6. others

According to this results, referral patients from other hospitals, mechanical ventilations and length of stay in PICU had a significant statistical relation with mortality rate (table 3). These results were also confirmed by logistic regression method. To assess the efficiency of PRISM score in predicting death in patients, the statistic analysis were done which the relation between PRISMa PRISM1 and occured death, was significant (PV < 0.05). Figure 1 shows the effect of increasing PRISMa score on death probability and to define cut-off point for classification on the basis of PRISM, the discriminant analysis method is used. In such model, PRISM score was used as a variable for predicting death and it became clear that, when the PRISMa score was 11.36 or less, the case belonged to the low risk group with more survival possibility (death = 0) and otherwise it belonged to high risk group (death = 1). On the other hand, by means of PRISM1, we can draw this curve, too, in which increasing only one unit to PRISM1 causes in 1.7 increase in the mortality risk (Fig. 2).

Table 4. Estimation of predictors of mortality in logistic regression analysis in pediatric intensive care unit (PICU) patients

Variable	Parameter estimate	odds ratio Q	P value
age	-0.00	0.00	0.32
sex	-0.30 ± 0.35	0.74	0.39
referral	1.99 ± 0.55	7.33	0.0003
duration	0.06 ± 0.03	1.07	0.04
PRISMa	0.17 ± 0.03	1.18	0.0001
PRISM1	0.53 ± 0.08	1.7	0.0001
ventilatoin	2.43 ± 0.39	11.37	0.0001
postop	-13.49 ± 425	0.00	0.975
acute Dx	-0.091 ± 0.2	0.91	0.64
chronic Dx	0.067 ± 0.095	1.07	0.48

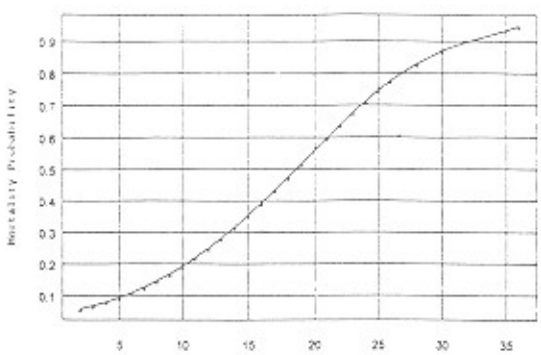

Fig. 1. Effects of PRISMa (admission) on Mortality Probability

Estimate of PICU mortality probability varying from 0 to 1 with cut-off point PRISM = 11.36.

The curve represents the equation: P = e.(1+e). Dots are computed poins on the curve for each value of PRISM score. Data were obtained from 205 patients.

Finally according to PRISMa more or less than 11.36, the patients were divided in two groups: low risk

and high risk (figure 3). 145 cases were in low risk group (PRISMa < 11.36), whose average length of stay were 3.5 days and their expenditure were less than the 60 patients who were in high risk group (PRISMa > 11.36), with a mean length of stay of 5.6 days (P.V = 0.07).

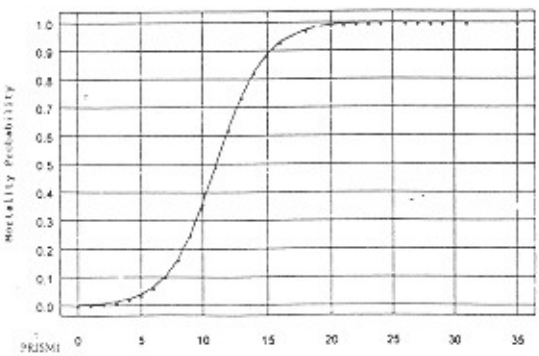

Fig. 2. Effects of PRISM1 on Mortality Probability

Estimate of PICU mortality probability varying from 0 to 1 with cut-off point PRISM = 11.36.

The curve represents the equation: $P = e^r.(1+e^r)$. Dots are computed points on the curve for each value of PRISM score. Data were obtained from 205 patients.

DISCUSSION

The PRISM score was developed by Pollack and co-workers (3,4,5). This score can describe the severity of illness on the basis of patient's physiologic dysfunction which is obtained from physical or laboratory examination (table 1) (8). The PRISM score is obtained as the sum of the individual phsiological derangement scores, in which each of them has relationship with the mortality rate (6). Pollack's observation demonstrated that the patient's age and postoperative status also contributed to their length of stay in PICU (3,8,16).

The estimates of PICU mortality reported by Pollack and co-workers were obtained by assuming a relationship between death and illness severity, which demonstrated good mortality prediction performance in a seperate group of PICU patients (14).

In our study, we have made most of the same assumption for the pre-ICU setting, as did Pollack and co-workers. But in this study, in addition to PRISM score at admission, PRISM score after 24 hours of admission was considered, too. Simultaneously the relation between individual variables were assesssed too (table 3 and 4).

To determine the significant relations between these variables and mortality rate, many different statistical methods were used (logistic regression, discriminant analysis, Fisher test). Our data indicate that hospital mortality probability of infant and children can be estimated by observations of illness severity (PRISM score). In this study the predicted mortality rate (based on PRISM score) did not have any statistical differences in comparison with observed mortality rate (P.value = 0.001). The difference between mortality rates was dependent to patient's different physiologic dysfunction, which was determined by the PRISM score. The efficacy of this score as a predictor of death did not have any relation to age, the type of illness and length of stay in PICU, but it had a close relation with referral from other hospitals, mechanical ventilation at the admission day and surgical status (P.V<0.05). In fact this study demonstrates that physiologic unstability (accountable by PRISM score) is the primary variable with influence on children's mortality rate, and making decision on needs of patients to be admitted in PICU should not be done on the base of patient's age or primary diagnosis, which was confirmed in previous studies too (3-9, 17-19). This can help to assess the effectiveness of treatment on the basis of severity of illness and meanwhile estimates his/her length of stay and cost (7). Therefore it became clear that when the PRISMa score is considered, the patients with a score less than 11.36 are in low risk group and their possibility of death is declined, with a sensivity of about 70% (figure 1 and 2). In comparison, the PRISM1 (PRISM after 24 hours admission) has more sensivity (90%) and patients with PRISM1 score less than 10 are in low risk group. In another study a PRISM score of about 10 could differentiate low risk groups from high risks (13).

The ability to estimate mortality possibility at ICU admission may have clinical use in the care of individual patients. After stabilization of a sick child in hospital, an objective estimate of mortality risk would allow the identification of high risk patients whose problems will need more specialized cares or may need to be transported to a more equipped hospital (16,18).

It should be noted that, this study must not justify triage decision or to exclude patients from recieving intensive cares because of their low pre-ICU PRISM score. All of the patients in this study, whether with low PRISM score or high, were admitted in PICU. Estimating mortality rate in one patient's group cannot be extended to other groups, because there are many different factors other than clinical signs, which have

effect on patients outcome and a multiplicity of factors must be considered by experienced clinicians in decision, other than PRISM score.

On the other hand, any error in measuring a variable (more or less than actual amount), can effect the PRISM score. Specially, measuring of PRISM scores less than true amounts, would cause a severe limitance on performance of this score, by predicting mortality rate more than reality and placing more patients in high risk group. Also, the effect of treatment on PRISMa score cannot be ruled out. An effective treatment on the patient who was very ill at admission with high PRISM score, can result in no death, in spite of his high possibility of death. In these conditions PRISM1 score is more suitable (14). Also admitted patients, specially those who are ill, are exposed to secondary incidents, which can result in increasing mortality rate (11,19).

In conclusion PRISMa score ability in predicting mortality rate and classification of patients into high and low risk groups, can be used as a good predictor to determine the severity of illness and consequently it has a great effect on decision about admission and treatment in PICUs. By using this method some patients can save their money and time, by admitting in other suitable and cheaper units of hospitals. On the other hand the effectiveness of intensive cares which are done in PICUs and their therapies can be assessed and controlled. Therefore, it can improve the quality of PICUs, so that the rate of usefullness and effectiveness of PICUs can be easily determined.

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