Original Article

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An Evaluation of the Efficacy of Pediatric Risk of Mortality in Determining the Prognosis of Patients Admitted to the Pediatric Intensive Care Unit of Namazi Hospital in Shiraz

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ABSTRACT

BACKGROUND AND OBJECTIVE: Neonatal period is very important and newborns are highly vulnerable in this period. Providing, maintaining and improving the health status of newborns has a special role in health services and is one of the important health indices. The aim of this study is to evaluate the efficacy of pediatric risk of mortality in determining the prognosis of patients admitted to the pediatric intensive care unit of Namazi Hospital in Shiraz.

METHODS: This prospective, cohort study was conducted among 240 patients aged 1 month to 4 years old admitted to the pediatric intensive care unit of the Namazi Hospital in Shiraz during a six month period. Participant information was collected using a researcher-made questionnaire, including demographic information, main diagnosis during hospitalization, duration of admission, use or non-use of mechanical ventilation, presence and absence of infectious disease in the patient and the variables related to the PRISM III system (0-30). The mortality rate was calculated and the results were considered as death or discharge.

FINDINGS: Of 240 patients, 123 were boys and 117 were girls with a mean age of 30.41±54.98 months. 20.37% of patients had infectious diseases, 19.9% had nervous system disease and 17.7% had respiratory system disorders, while 44 patients died during the study. PRISM scores ranged from 0 to 10 in 73.5% of the patients, from 11 to 20 in 24.9% of the patients, and from 20 to 30 in 1.6% of patients. In addition, 11.3% of deaths were observed in patients with PRISM scores from 0 to 10, and 100% of deaths were observed in patients with PRISM scores from 21 to 30.

CONCLUSION: Based on the results of this study, using the modified PRISM III system at the early childhood in the pediatric intensive care unit can predict children's mortality rates and reduce their mortality.

KEY WORDS: *PRISM, Mortality, Intensive care unit, Children.*

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Introduction

Childhood period is very important and vulnerable period. The high rate of childhood mortality is due to the high level of vulnerability in this period. Therefore, provision, maintenance and promotion of infant and child health as a vulnerable groups in health care services is one of the important indices of health and development (1). About 98% of the cases of infantile and childhood deaths in the world occur in poor countries, and two thirds of all these deaths occur in only ten countries, mostly in Asia (2), and according to the reports published by UNICEF in 2013, the average projected childhood mortality rate in Iran is 10.3 per 1,000 live births (3).

Undoubtedly, the reduction of mortality rates is the most important goal in the pediatric intensive care unit, which is possible by carefully monitoring and treating patients with a high risk of mortality (5). One of the important methods used to improve the performance of medical care in pediatric intensive care units is the use of prognostic scoring systems in the prognosis of patients. The severity of a disease is determined by the associated deficiencies and physiological disorders and the level of physiological disorders is determined by comparing the patient's condition with the normal level of each criterion.

The prediction of the risk of mortality by the physician among patients who are admitted to the intensive care unit is highly subjective and different physicians estimate the status of a patient differently. Therefore, the use of prognostic criteria and systems for mortality is considered necessary and reasonable (6–8). Clinical evaluation systems estimate the severity and deterioration of the disease unbiasedly and uniformly. In this way, they can be used as a criterion for assessing the effectiveness of the pediatric intensive care unit, and examining the evolution of a center over time and comparing different centers (9).

Since the 1980s, several systems have been used for this purpose, including GCS, APACHE, MPM, PIM and PRISM. Over the past two decades, American (e.g. PRISM) and European (e.g. PIM) scoring systems have been successfully used as two well-known PICU assessment systems in different countries (10). The PRISM system is the modified form of PSI that can predict the severity of the disease in the studied population. These systems are considered as the most valuable systems for predicting mortality in the pediatric intensive care unit. It can also be used as a benchmark for assessing the quality of treatment in a special care center (7, 8). Since these systems estimate the mortality rate based on the severity of the disease, they can be used as a criterion for comparing the quality of care in different care centers, as well as the assessment of changes in treatment facilities within a center over time (11). The PRISM system is basically a PSI system to reduce the variables required to evaluate the mortality rate in the PICU, and validate the used variables. In a study by Pollack et al. (1988), 1415 patients admitted to four PICU centers were analyzed and the PRISM system was designed with 14 primary variables and 27 secondary variables, and then another 1227 patients in six PICU centers were examined to evaluate its validity and effectiveness (22).

The revised version of the system (PRISM III) was designed and published by the same group several years later in 1997 (11). The following studies have considered the long time required for data collection as well as the lack of examination of patients who died within the first 24 hours of admission to the PICU as defects in this system. Hence, the PIM system was introduced as a system whose required criteria are collected at the beginning of the patient's admission (13, 14). In recent years, the newer versions of the two systems, i.e. PRISM III and PIMII, have also been introduced. The first model of PIM was based on data from 5695 patients in seven PICU centers in Australia and one center in England. The second generation system (PIMII) was designed based on data from 20787 patients admitted to PICU centers in Australia, New Zealand, and England (15).

Currently, the performance of the PIM system has shown varied results in different studies, which means that the effectiveness of the system is not the same in all PICU centers, because the system was created according to the criteria of the PICU centers of the countries that designed this system, and these criteria are not the same in all PICU centers in the world. Nevertheless, the efficacy of this system has been proved in many studies in several developing countries (16). The modified PRISM III system is designed to compare the performance of various PICU centers. To use this criterion at a clinical level, we must examine whether the conditions of a center are related to the criteria of the system and whether the system has the necessary efficiency at the target center, which is highly associated with the proximity between the quality level of these centers and the centers in which this system was designed (11,17). The effectiveness of the PRISM system in predicting the risk of mortality in PICU centers has been approved in countries such as England (19), India (4, 18), South Africa (12), and Iran in Tabriz

(20) and Zahedan (10) Universities of Medical Sciences. Currently, various scoring systems such as the Glasgow Coma Scale/Score (GCS), Pediatric Trauma Scale, and Pediatric index of mortality are reviewed and approved in the pediatric intensive care units (1, 5), but the performance of the pediatric intensive care unit of Namazi Hospital in Shiraz as the largest PICU center in southern Iran has never been evaluated by such indices. Therefore, the present study was conducted to evaluate the efficacy of pediatric risk of mortality (PRISM) score in predicting the mortality rate in patients admitted to the pediatric intensive care unit of Namazi Hospital in Shiraz.

Methods

After approval by the Shiraz University of Medical Sciences with the code IRS.MED.REC.1394.s92, this prospective cohort study was conducted among all patients aged one month to seven years who were admitted to the pediatric intensive care unit of Namazi Hospital in Shiraz during a six-month period from May until October 2015. Patients who died in the first 24 hours of admission or were transferred to other parts were excluded. Diagnostic and therapeutic measures were performed according to the physician's opinion based on what was necessary for the patient and there was no additional intervention in the diagnosis and treatment of the patients.

The sample size was estimated to be 170 considering type I error, 5% and test power of 90%, and 204 patients were included in the study. Participants' information was collected using a researcher-made questionnaire including demographic information, main diagnosis during hospitalization, duration of admission, use or non-use of mechanical ventilation, presence and absence of infectious disease in the patient and variables related to the PRISM III system and was completed by a senior child protection assistant within the first 24 hours of admission. The following criteria were recorded as parameters defined in PRISM III system: 1) Cardiovascular system criteria, including systolic blood pressure, and heart beats per minute; 2) Nervous system criteria, including pupillary dilatation reflex and level of consciousness; 3) Blood test criteria, including arterial blood gases (PH, HCO_3, PaO_2, PCO_2), serum creatinine levels, platelet count; blood urea nitrogen (BUN), WBC count, PT, and PTT; and (4) Body temperature criteria: total mortality rate in patients was calculated according to the PRISM score using $p = e^r / 1 + e^r$ formula. In this formula, e is a constant and r is the experimental value calculated from PRISM. Then, the Hosmer–Lemeshow test was used to determine the relationship between the observed death and the predicted value. The patients under study were evaluated in two groups of live and dead, as observed and predicted.

Data were analyzed using Student's t-test, One-way analysis of variance, Chi-square, Hosmer–Lemeshow test, ROC curve analysis and Logistic regression model. It should be noted that the Hosmer–Lemeshow test was used to evaluate the calibration power of the discharged group from the dead group by the PRISM III system, ROC curve analysis was used to evaluate the accuracy of the PRISM III system in predicting the mortality risk in this analysis.

The more the area under the curve (AUC) is close to 1, the more the predicted mortality rate is consistent with the observed value. The value of 0.70 to 0.79 is considered as acceptable power audit and values greater than 0.8 are considered as appropriate and good, and 0.9 is considered as excellent power (21, 22). The logistic regression model was used to determine the relationship between the experimental function r and the score obtained from the PRISM III system, and $p < 0.05$ was considered significant.

Results

Overall, 123 males (60.29%) and 117 females (39.70%) with a mean age of 30.41±54.98 months and a mean duration of admission of 9.47 days (7.2±23.44) (minimum of 2 days and maximum of 73 days) were studied. A total of 160 patients (78%) were discharged or transferred to pediatric internal ward at the end of treatment, and 44 patients (22%) died during the course of treatment. Of all samples, 74.9% of the patients had no diagnosis of infectious disease at the time of admission, and they were not infected within the first 24 hours, and only 25.1% had diagnosis of infectious disease, or got infected within the first 24 hours after admission. 46.8% of patients required mechanical ventilation during the hospitalization period.

The mean PRISM III score in patients who died was 22(12.2±65.47), while it was 78(5.1±72.54) in the discharge group, and there was a significant correlation between PRISM III score and hospitalization outcome. Moreover, PRISM III score was significantly higher in patients requiring mechanical ventilation compared to those who did not need mechanical ventilation. Finally, there was no significant relationship between PRISM III

score and other variables (Table 1). In order to evaluate the relationship between PRISM III score and type of disease, patients were divided into nine groups. The highest number of admissions in pediatric intensive care unit of Namazi Hospital was respectively related to infectious diseases (20.37%), neurological disorders (19.9%) and respiratory system disorders (17.7%), while poisoning and traumatic patients (1.3%) constituted the smallest number of patients in this unit (Table 2). The highest mean PRISM III score was associated with patients with hematological disorders and cancers (15 patients, 2.10±2.11) and the lowest score was associated with traumatic and poisoned patients (3 patients, 3.1±0.4).

Table 1. PRISM and factors affecting it in patients admitted to the pediatric intensive care unit of Namazi Hospital in Shiraz

Variables	Subgroup	N(%)	PRISM Mean±SD	P-Value
Patient's outcome	Discharge	78	5.1±72.54	<0.001
	Death	22	12.2±65.47	
Gender	Boy	61	7.1±34.64	0.815
	Girl	39	7.1±04.22	
Infectious disease	Yes	25.1	7.2±76.98	0.646
	No	74.9	7.2±34.11	
Use of mechanical ventilation	Yes	46.8	9.2±35.63	0.002
	No	53.2	5.1±7.1	
Average age (month)		30.54	7.2±23.36	0.366
Average duration of stay (days)		9.41	7.2±23.44	0.263

Table 2. PRISM and diagnosis in patients admitted to the pediatric intensive care unit of Namazi Hospital in Shiraz

Diagnosis	N(%)	PRISM Mean±SD	PRISM range	Percentage of death
Infectious disease	47(20.37)	6.1±96.26	0–19	21
Respiratory system	41(7.17)	6.1±84.12	0–27	23
Nervous system	46(19.9)	6.0±55.9	0–22	20
Metabolic disorders	33(14.3)	8.1±09.99	0–17	6.1
Digestive system and liver	15(6.5)	9.2±07.2	3–20	43
Immune system disorders	4(1.7)	4.0±00.89	0–7	25
Hematologic and cancer	15(6.5)	10.2±2.11	2–21	33
Poisoning - Trauma	3(1.3)	3.0±1.45	0–7	0
Cardiovascular system	27(11.7)	7.1±6.2	0–19	25

In evaluating the mortality rate in each group, patients with gastrointestinal and liver disorders had the weakest prognosis among patients admitted to the intensive care unit (43% mortality at the end of the admission period). In contrast, patients diagnosed with trauma and poisoning had the lowest mortality during the period (0%). There was no statistically significant relationship between type of disease and PRISM III scores. Table 3 shows the Hosmer–Lemeshow test results to determine the relationship between observed mortality and predicted value. In this test, the P value below 0.005 indicates appropriate calibration power of the PRISM III system in predicting mortality and life in the study subjects. In the present study, a p-value of 0.786 was obtained, indicating that the PRISM III system has an appropriate calibration power in predicting mortality in this clinical center. Subsequently, the data were divided into three groups based on the PRISM III score, and in each group, the observed mortality rate was compared with the predicted value.

The PRISM III score range was considered between 0 and 10 in the first group, between 11 and 20 in the second group, and between 21 and 30 in the third group, and the number of patients in the first to third group was 151 patients (74.4%), 49 patients (24.1%) and 3 patients (1.5%), respectively, among which 17 patients (11.3%), 24 patients (49%) and 3 patients (100%) died in the first to third group, respectively. There was a significant correlation between PRISM III score and increased mortality rates. The ROC curve analysis indicated the accuracy of the PRISM III system in predicting the

mortality risk. In this study, the AUC value of 83.2% and the frequency of 74.4% to 91.7% (95% Confidence Interval) were confirmed to match the predicted mortality rate with the observed values (p<0.001) (Fig 1). Logistic regression model to determine the relationship between the PRISM III score and death outcome indicated the numerical relationships to be 1.303±0.51, which indicates that for each one unit increase in PRISM III score, the mortality risk increased by 0.3 units (p<0.001).

Table 3. Comparison of observed mortality rate and predicted value based on Hosmer–Lemeshow test

Group	Discharge		Death		Total value
	Observed	Predicted Mean±SD	Observed	Predicted Mean±SD	
1	22	21.3±45.54	0	0.0±54.09	22
2	19	18.2±21.77	0	0.0±78.21	19
3	13	13.2±27.86	1	0.0±75.14	14
4	13	13.3±03.55	1	0.0±96.16	14
5	25	25.4±52.28	3	2.0±47.98	28
6	19	20.3±88.98	5	3.1±11.22	24
7	18	19.3±25.65	6	3.1±74.25	24
8	16	14.3±05.45	5	6.1±95.68	21
9	10	8.2±58.2	8	9.2±42.14	18
10	4	4.1±76.01	15	4.0±23.99	19
Total value	159	172	44	31	

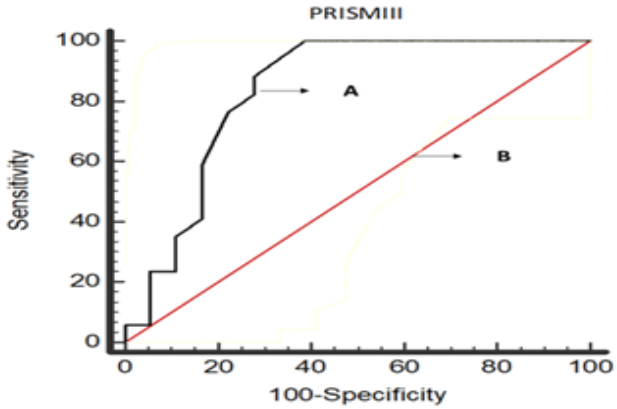

Figure 1. ROC curve on the diagnostic efficiency of the PRISM III scoring system in patients admitted to the pediatric intensive care unit. In this picture, line A represents the mortality rate predicted by the PRISM III scoring system and line B represents the observed mortality rate. The AUC (area under the curve) of the PRISM III scoring system is 83.2% with 95% Confidence Interval (74.4-91.7%). In addition, the sensitivity and specificity are 0.629 and 0.232, respectively

Discussion

In this study, the mortality rate of children admitted to the pediatric intensive care unit of Namazi Hospital in Shiraz was 44 patients (22%), and these statistics were 24.5% in India, 2.7% in Utah state (in the U.S.) and 6.2% in Japan (21 – 23). The results showed that the PRISM score in the dead group was significantly higher than that of the discharged group. The predicted death by the PRISM system was 15.2%, while the observed value was 21.6%. These observations indicate that the estimates of PRISM system regarding the mortality rate in this center is lower than the observed value, and in other words, the mortality rate in the patients in this center is more prevalent than the centers in which the PRISM system was designed. The results of the Hosmer–Lemeshow test showed a significant consistency between the mortality risk predicted by the PRISM system and the observed value, in other words, the system had appropriate power in differentiating the two groups of death and discharge. In addition, the numerical value of the area under the curve in the analysis of the ROC curve was 83.2%, indicating the

consistency between the predicted mortality rate and the observed value. Moreover, for each one unit increase in PRISM score, the mortality risk increased by 0.3 units. In evaluating the effectiveness of PRISM and PIM systems in a PICU center in India, the observed mortality rate was 24.3%, which was equal to the predicted value of the PRISM system, while the PIM system predicted the mortality rate to be 7.88% in this study (4).

In a study by Costa et al. in a PICU center in Brazil, the mean PRISM score for total samples was 8%, in the death group was 15%, and in the discharge group was 7%, which was higher than the findings of the present study (mean score of 7.23%, 12.65% in the death group, and 5.72% in the discharge group). Although the mortality rate in this study was higher than the present study, but comparing the PRISM score in the two centers indicates that in the present study, patients with lower severity of illness were more likely to die compared to the above-mentioned center (8).

Carroll et al., in a different study, showed that PRISM system during the first 24 hours after liver transplant in children is a determining factor in predicting the period required for staying in the intensive care unit (26). Choi et al. examined the efficacy of two PIM and PRISMIII systems in Hong Kong on 303 patients over the course of two years. The three main diagnoses in hospitalized patients were respiratory diseases, post-surgical disturbances, and nervous system diseases.

The number of deaths during this study was only eight, while the predicted value of PRISM and PIM systems was 10.2% and 13.2%, respectively. In this study, PRISM and PIM systems estimated the mortality rate at a higher level than the observed value (27), while in our study, the observed mortality rate was higher than the predicted one. The lack of proper prediction of the PRISM system regarding mortality rate at a center does not mean lack of proper performance of the center, but it may indicate the difference in the performance of this center compared to the center in which the PRISM system was designed based on its criteria (furthermore, Namazi Hospital as the center for the referral of patients requiring liver transplantation who basically have higher mortality may eventually show a higher mortality rate in PICU). The lower number of deaths observed in the Hong Kong center compared to the predicted value indicates that the center is more efficient in treating and rescuing patients compared to the center in which the PRISM system was designed, whereas in centers where the observed mortality rate is higher that the predicted value, the therapeutic power is lower than the center in which the system was designed.

The present study showed that there is no significant relationship between the type of disease and PRISM scores, which is consistent with observations of Costa et al. in Brazil and the findings of Moreno et al. in Singapore (8, 30). In their study in Houston in U.S., Typpo et al. examined multiple organ dysfunction syndrome (MODS) and its association with the prognosis of patients among 44693 patients from 28 PICU centers during two years. The mean mortality rate was 2.8% in all centers and the mortality rate in this group of patients was significantly higher than other patients (mortality rate of 10% vs. 1.2%). Such association between the type of disease and the mortality rate reduces the functionality of the PRISM system. Some studies have shown that what is estimated in the PRISM system is higher than the real observed rate of mortality.

According to these studies, PRISM is not a suitable measure for predicting mortality rates in some specific groups such as post-traumatic patients, patients with acute renal failure and patients with falciparum malaria (31), which is not consistent with the results of the present study. Overall, it can be concluded that using the modified PRISM III system at the first moments of children's admission in the pediatric intensive care unit can predict the mortality rate and reduce mortality by timely modification and treatment.

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