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An observational study to evaluate the outcome of patients admitted in pediatric intensive care unit (PICU) using pediatric risk of mortality (PRISM-III) score in a tertiary care hospital of West Bengal

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ABSTRACT

Background: Pediatric risk of mortality (PRISM III) score is used across the globe to predict the mortality of hospitalized children by an objective method based on 17 variables measured during first 24 h of admission in pediatric intensive care unit (PICU). **Aims and Objectives:** We have done this study to evaluate the cause, management and outcome of PICU admissions and also to find out the statistical significance of PRISM III score in predicting mortality. **Materials and Methods:** This observational prospective study was conducted for a period of 1 year in the PICU of a district Medical College of West Bengal among children 1–12 years age. They were divided into 4 groups according to the PRISM III scores of 1–10, 11–20, 21–30, and >30 and outcome in all the groups were recorded and analyzed. **Results:** Respiratory (25%), neurological (20.1%), and infectious (17.3%) etiology were major cause of PICU admission. About 17.4% patients needed mechanical ventilation, 31.2% Continuous Positive Airway Pressure and 66% patients inotropic support. Out of 144 cases, 117 discharged and 27 expired. Percentage of death is 100%, 44.4%, 21.6%, and 4.6% among child with PRISM III score of >30, 21–30, 11–21, and ≤10, respectively. Significant increase in mortality noted with increase in number of organ failures. Specificity and positive predictive value increases with higher PRISM III score and sensitivity and negative predictive value is more with low PRISM III score. **Conclusion:** PRISM III score can be used as a triage tool in limited resource settings for early initiation of intense management to high risk and salvageable cases.

Key words: Child mortality; Pediatric intensive care units; Pediatric risk of mortality score

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INTRODUCTION

Pediatric intensive care unit (PICU) plays a key role in effective pediatric emergency and critical care management and can significantly reduce the childhood mortality and morbidity of a country.[1,2] The first 24 h of hospitalization is considered most critical as an estimated 33% of patients die in this golden period. A number of critical illness scoring systems have been devised to assess the illness severity related mortality, identifying children with poor outcome and remove the pediatrician's subjective bias regarding the mortality risk.[3-8] These scoring systems have been widely used in PICUs to identify which child needs urgent care, to prioritize the specialized care as needed and to evaluate different management protocols in relation to the outcome.[1,2,9-12] Among the different severity of illness scores used in PICU, the pediatric risk of mortality (PRISM) score is the most relevant and best

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known score in modern era.[13] PRISM or Pediatric Risk of Mortality score is devised by Pollack et al., to predict the mortality of hospitalized children that contains 14 physiologic variables based on abnormalities observed at the bedside examination and laboratory assessment.[14] It was later modified to PRISM III score consisting of 17 variables which are measured during first 24 h of admission in PICU.[3] This score gives the treating physician an objective method to predict patient's outcome and risk of mortality, so that he can modify his management protocol according to the need of the patients. A PICU that performs a periodic self-assessment-using PRISM III can also determine its performance in comparison to the reference population. PRISM III scoring is still not practiced widely in different PICUs in West Bengal and adequate data is lacking regarding its utility especially from peripheral Medical Colleges. With this background we have designed this study to predict the outcome of patients admitted in the PICU of Burdwan Medical College hospital in an objective way by using PRISM III score in 1st 24 h so that we can manage the critically sick child on the priority basis to reduce childhood mortality.

Aims and objectives

We have planned this study to (1) find out the common causes of PICU admission and their treatment related factors in our set-up, (2) calculate the PRISM III score of all the PICU admissions and to find out any relationship between PRISM III score and outcome, and to (3) evaluate the statistical significance of PRISM III score in predicting mortality.

MATERIALS AND METHODS

This hospital-based prospective and observational study was conducted in the PICU of Burdwan Medical College and hospital for a period of 1 year from May 1, 2020, to April 30, 2021. This PICU consists of 15 beds and 4 step down beds along with a side laboratory for measuring basic blood parameters, portable X-ray machine, portable echocardiography, and ultrasonography machine. It not only covers the pediatric population of three districts of West Bengal such as Burdwan, Bankura, and Birbhum but also the surrounding districts of Jharkhand and Bihar.

The predicted sample size for this study was 144 which was calculated by using the formula $n=z^2\ p\ (1-p)/e^2$, where n- sample size, P- prevalence (10% is the point prevalence of PICU admission among the total admitted patients in general pediatric ward of Burdwan Medical College), e=margin of error which was taken as 5% in this study and z score is 1.96 with 95% confidence level. Our total sample size is 161 consecutive admissions in PICU during the study period fulfilling the inclusion and exclusion criteria from which 17 cases were either referred to higher center or leave against medical advice. Thus, we are left with 144 cases in our study for complete statistical analysis.

Inclusion criteria

(1) All the patients admitted in PICU as per guideline of Indian Academy of Pediatrics aged between 1 month and 12 years, and (2) cases which are referred from general surgery department of this hospital following major surgery. Exclusion Criteria: (1) Patients who stayed in PICU for <12 h, (2) patients who have major congenital malformations or malignancy, and (3) whose parents refused to give consent for this study.

The study was conducted after obtaining informed and written consent from the parents of the children and necessary ethical clearance from the Institutional Ethics Committee of Burdwan Medical College. All patients were investigated and managed according to the standard PICU protocol and along with that, data were collected for evaluation of PRISM III score. PRISM III scoring system is a modified version of physiologic stability index which is used to predict mortality through normal physiologic disturbances during the period of disease. It uses 17 parameters (physiological and laboratory data) and for each one the highest severity value is recorded within the 1st 24 h of admission. Following international PRISM guidelines, each patient was assigned an observation chart, on which demographic data, physiological variables and diagnostic data required to calculate PRISM III score, clinical diagnosis, treatment received, total duration of stay and outcome as either expired or survived was recorded. The most abnormal value of every parameter at the first 24 h was used to calculate PRISM III score. As per PRISM III-24 score, the 17 variables which are recorded are described under 4 major headings like (A) five cardiovascular and neurological vital signs: (1) blood pressure, (2) heart rate, (3) temperature, (4) mental status, (5) pupillary response, and (B) five acid base and blood gas findings: (6) acidosis, (7) pH, (8) pCO_2, (9) total CO_2, (10) PaO_2 (C) four blood biochemistry tests: (11) blood glucose, (12) serum potassium, (13) serum creatinine, (14) serum bun, and (d) three hematological tests: (15) white blood cell count, (16) platelet count, (17) prothrombin time (PT), and activated partial thromboplastin time (aPTT).

Oxygen saturation was monitored by pulse oximeter. PT, aPTT, glucose, blood urea, creatinine, potassium were measured by standard laboratory tests. Arterial blood gas analysis was performed in each patient. Vital signs including

blood pressure, heart rate, pupillary reaction, and mental status were recorded at regular intervals. The patients were followed up during hospital stay and the outcome as death or survival was recorded at the end of hospital stay. PRISM III score was calculated using individual pro forma assigned to each patient. The studied patients were classified into four groups according to the PRISM III scores of 1–10, 11–20, 21–30 and >30 and outcome in all the groups were recorded.

Statistical analysis

All the data were analyzed in SPSS (version 20.0). Quantitative variables were presented as mean (SD) and categorical variables as frequencies (%). Primary outcome of this study was child mortality. Performance of PRISM III score was evaluated by assessing discrimination which is used to predict the outcome (survival or expired). Mortality discrimination was assessed by Chi-squared test and $P<0.05$ was considered statistically significant. Sensitivity, Specificity, Positive, and Negative Predictive Values (NPV) of the selected PRISM Scores were calculated using the formula Sensitivity=(True Positive/True Positive+False Negative), Specificity=(True Negative/True Negative+False Positive), Positive Predictive Value (PPV)=(True Positive/True Positive+False Positive), and NPV=(True Negative/True Negative+False Negative).

RESULTS

Out of 144 study cases, 81 (56.25%) were male and 63 (43.75%) female. Most of the children 62 (43.1%) were in the age group of 1–12 months followed by 43 (29.9%) in 1–5 years, 21 (14.6%) in above 10 years and 18 (12.5%) in 6–10 years age group.

Table 1: Distribution of cases according to cause of admission, management, and outcome in PICU

Variables	Frequency (n=144)	Percentage (100%)
Respiratory condition	36	25
CNS conditions	29	20.1
Infections (sepsis)	25	17.3
Gastrointestinal issues	22	15.2
Cardiovascular cause	12	8.3
Hepato-biliary cause	08	5.5
Renal cause	03	2.1
Hematological cause	01	0.1
Other causes	08	5.5
Mechanical ventilation	25	17.4
CPAP	45	31.2
Inotropic support	95	66
Survived	117	81.25
Expired	27	18.75

CPAP: Continuous positive airway pressure, PICU: Pediatric intensive care unit, CNS: Central nervous system

From Table 1, we can see that respiratory pathology was the most common cause of admission involving 36 (25%) patients followed by central nervous system (CNS) related conditions 29 (20.1%), infections (sepsis) 25 (17.3%), gastrointestinal issues 22 (15.2%), cardiovascular causes 12 (8.3%), hepato-biliary conditions 8 (5.5%), renal causes 3 (2.1%), hematological diseases 1 (0.1%), and others 8 (5.5%). 25 (17.4%) patients were put into invasive mechanical ventilation while 45 (31.2%) patients needed only continuous positive airway pressure, and 74 (51.4%) patients did not need any kind of mechanical support. 95 (66%) patients needed inotropic agents in the form of either dopamine, dobutamine, adrenaline, or noradrenaline during the course of their illness, whereas the rest of the patients does not need any kind of inotropic support. With treatment, most of the children, 117 (81.25%) were stepped down to general ward and discharged and 27 cases (18.75%) expired. Patients who got referral discharge and left against medical advice were excluded from this study.

From Table 2, out of 144 patients, PRISM III score of ≤10 was observed in 65 (45.1%) cases while PRISM III score of 11–20 and 21–30 was observed in 51 (35.4%) and 27 (18.8%) cases, respectively. PRISM III score >30 was observed in only 1 (0.7%) case. The survival rate was 95.4% in patients who had PRISM III score ≤10 while the survival rate was 78.4% and 55.6% in patients who had PRISM III score of 11–20 and 21–30, respectively. There was 100% mortality in patients who had PRISM III score >30. It indicates that with the increase in PRISM III score there was a significant increase in mortality. Thus, PRISM III score showed a significant correlation with the outcome ($P\leq0.0001$).

Table 3 shows that among 144 patients, 99 (68.8%) patients did not have any organ failure while 29 (20.1%) patients had at least one organ failure, 11 (7.6%) patients had two organ failures and 5 (3.5%) patients had three organ failures. The survival rate was 96% among patients without any organ failure. In patients with one and two organ failure, survival rate was 69% and 18.2%, respectively, while there was 100% mortality with three organ failures. It shows that there is a significant increase in mortality with the increase in number of organ failures ($P\leq0.0001$).

From (Table 4a), we can see that specificity and PPV increases with the increase in PRISM III score (highest with >30 score). On the other hand, sensitivity and NPV are more in cases of low PRISM III score. So chance of mortality is high with higher PRISM III score value. Significance of this table is discussed elaborately in discussion part.

Table 2: Distribution of cases according to Prism III score and its association with outcome

PRISM III score	Survivor (n=117)		Non-survivor (n=27)		Total (n=144)	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
≤10	62	95.4	03	4.6	65	45.1
11–20	40	78.4	11	21.6	51	35.4
21–30	15	55.6	12	44.4	27	18.8
>30	00	0.0	01	100.0	01	0.7
Mean±SD	12.55±5.87		20.40±6.46			
Statistical inference	Chi-square: 24.824, P<0.0001					

PRISM III: Pediatric risk of mortality

Table 3: Association of number of organ failure with outcome

Number of organ failure	Survivors		Non-survivors		Total
	Frequency	Percentage	Frequency	Percentage	
0	95	96.0	4	4.0	99
1	20	69.0	9	31.0	29
2	2	18.2	9	81.8	11
≥3	0	0.0	5	100.0	5
Total	117	81.25	27	18.75	
Statistical inference	Chi-square: 67.32, P<0.0001				

Table 4a: Sensitivity, specificity, and positive and negative predictive values of the selected prism scores

Prism score	Sensitivity (%)	Specificity (%)	Positive predictive value (PPV%)	Negative predictive value (NPV%)
>10	88.88	52.99	30.37	95.38
>20	48.14	87.17	46.42	87.93
>30	3.70	100	100	81.81

Table 4b: Example of calculation of sensitivity, specificity and positive and negative predictive values of the selected prism scores

Prism score	Non-survivor	Survivor	Predictive value
>10 as positive	True positive (TP) 24	False positive (FP) 55	PPV (TP/TP+FP) 30.37
≤10 as negative	False negative (FN) 3	True negative (TN) 62	NPV (TN/TN+FN) 95.38
	Sensitivity (TP/TP+FN) 88.88	Specificity (TN/TN+FP) 52.99	

In (Table 4b), it is shown how sensitivity, specificity, positive, and NPV are calculated for PRISM score >10. Their values are calculated using the same formula for PRISM score >20 and >30 also (not shown here) and plotted in (Table 4a).

DISCUSSION

The PRISM score has been devised to predict easily the outcome and risk of mortality of admitted sick child. It may help in decision making by the treating pediatrician for PICU admissions and correct identification of patients who might benefit from early interventions.[15] In 1988, Pollack et al. designed pediatric PRISM score for prediction of mortality in PICU which consisted of 14 variables.[14] It was later modified to PRISM III with an addition of three variables by Pollack et al., in 1996.[3] This PRISM III score with 17 variables was tested among 11,165 patients in 32 PICUs across the USA and yielded better results than PRISM in predicting mortality. As per PRISM III, the prediction of mortality can be assessed using 12 h (PRISM III-12) or 24 h (PRISM III-24) data. PRISM III-24 is more accurate for individual patient's mortality prediction, whereas PRISM III-12 is primarily used in qualitative studies.[3] In our study, we have used 24 h PRISM III score to detect high risk cases early and to predict outcome among admitted child in our PICU.

Analysis of demographic data shows that in our PICU, admission of male child is more than the female, though the difference is not statistically significant. This may reflect more susceptibility of males to various serious diseases or it could be because of more likelihood of a male child getting medical attention earlier as compared to female child due to still existing gender discrimination

among Indian families. This finding is similar to PICU admission data from North India in a recently published study by Makhija et al.[16] Age-wise distribution emphasizes vulnerability of early age with maximum admissions in 1st year of life (43.1%), and in age group between 1 and 5 years (29.9%). This finding highlights the importance of reduction of infant mortality rate and under five mortality rates as the goal of our health-care system of the country.

In this study, most common causes of PICU admission were related to respiratory pathology, CNS related pathology and infections (sepsis) followed by gastro intestinal pathology, cardiovascular diseases, etc. This is very similar to the study done by Roy et al., where infection and respiratory diseases are the commonest indications of PICU admission.[17] In the present study, overall mortality among PICU admission was 18.75% (27 out of 144) which is comparable to other PICUs in recent times as reported by Singhal et al., Madaan et al., and Hassan et al., with mortality rates of 18%, 12.5%, and 17%, respectively.[9,18,19]

In the present study, number of organ failures at the time of admission showed a significant correlation with the outcome. This observation indicates that as the number of organ failures increases the mortality rate increases. Tan et al. also found this association of multiple organ dysfunction syndrome (MODS) with poor outcome. They demonstrated that the presence of MODS on the 1st day of hospitalization was related to higher mortality and prolonged length of stay in the intensive care unit.[20]

The mean PRISM III score among survivors and non-survivors was 12.55 and 20.40, respectively, in our study. The survival rate was 95.4% in patients who had PRISM score ≤10 while the survival rate was 78.4% and 55.6% in patients who had PRISM score of 11–20 and 21–30, respectively. There was 100% mortality in patients who had PRISM score >30. This observation indicates that increase in PRISM score is significantly associated with an increase in mortality and this was consistent with the previous studies done by Singhal et al. and El-Nawawy et al.[9,21] Bellad et al. reported an overall mortality of 16.7% with 89.2% accuracy at PRISM cut-off score of 15.[22] Costa et al. observed median PRISM III score s significantly lower in patients who survived (P<0.01).[23] Madaan et al. in their study also observed PRISM score to be significantly higher among expired cases as compared to survived ones (7.58±5.03 vs. 20.63±3.41; P<0.01).[18] Hassan et al., in their study observed that PRISM score >8 as a significant predictor of mortality (Chi-square value of 29.615 and a Odds Ratio of 9.28).[19] Dey in their study observed PRISM as a sensitive predictor of outcome at a cut-off point of 13.5.[24]

As per Table 4, for PRISM III score >10 the sensitivity (Sn) is 88.88% that means among the non-survivors, 88.88% have PRISM III score more than 10. Sensitivity score is used for screening purpose and with such a high sensitivity we must initiate prompt management with any child with more than 10 PRISM III score to prevent mortality. NPV is also high (95.38%) here, that means among the child with score 10 or less, 95.38% have survived indicating that score 10 or less is prognostically good. So >10 score may be an effective cut off point to allocate resource accordingly as we need more focus in PICU management with those child. On the other hand, specificity (Sp) and PPV increases with higher PRISM III score. With PRISM III score >30 we found PPV 100%, that mean among children with score >30, 100% died. Specificity is also 100% with >30 score, means among survivors, 100% have score 30 or less. Thus, chance of survival is nil with PRISM III score >30 in our study and we can focus more in other salvageable children in a limited resource settings. Among children with score >20, 46.42% died (PPV 46.42%) and among the survivors, 87.17% have score 20 or less (specificity 87.17%). So PRISM III score >20 is a cutoff point below which chance of survival is more according to our study. So PRISM III score 10 or less is alert or green zone, 10–20 high risk or yellow zone, 20–30 danger or orange zone and >30 critical or red zone and we can use PRISM score as an important triage tool in emergency critical care units with limited resource set-up.

Limitations of the study

This is a hospital-based study involving small number of study sample. So results of this study may not be applicable to other PICUs as well. More widespread multicenter study is needed to conclude that PRISM III score can significantly predict the mortality in a developing country like India as shown by other studies across the globe.

CONCLUSION

Our study reveals that PRISM III score is a good indicator of the initial severity of illness because a higher PRISM III score is associated with higher mortality. In a country with limited resources like India where enough critical care facility may not be available to each and every patient, triaging is vital for effective patient management due to the financial constraints. In that perspective, PRISM III 24 score can serve as a useful guide to detect mortality risk of critically sick children so that we can provide care to those who are most in the need of immediate care and will

be benefitted most from it. Timely intervention of those sick child is critical because late detection and management may increase the number of organ failure which may also have adverse effect on the outcome, as shown in our study. Hence, PRISM III scoring should be routinely practiced as a triage tool and also prognostic indicator in every critical care settings of resource limited countries to reduce the overall childhood mortality and morbidity.

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