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Paediatric Risk of Mortality (PRISM) III Score and Serum Lactate Levels as Predictor of Outcome in Children Admitted to the Paediatric Intensive Care Unit

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Abstract

Objective – To evaluate prognostic indicators of mortality in children admitted to the Paediatric Intensive Care Unit (PICU) and to correlate blood lactate levels with Pediatric Risk of Mortality (PRISM) III scores. **Methods** – A cross sectional study was conducted between March 2021 and October 2022 in the PICU of the P S Govindasamy (PSG) Institute of Medical Sciences and Research. On the basis of the laboratory and clinical parameters, the PRISM III score was calculated at admission. Lactate levels were measured at admission and 24 hours after admission. **Results** – The study included 107 patients of whom the majority (54.2%) were female. The median patient age was 3 years and the median duration of PICU stay was 4 days. Among the hospitalized patients, 90.7% were survivors, with female patients having an 8.8-fold higher risk of mortality compared to males (P=0.05). The serum lactate value in survivors (2.95 mmol/L) was much lower in comparison to non-survivors (3.11 mmol/L). The PRISM III value measured at the time of admission in survivors (8) was low when compared to non-survivors (16.50). The area under the curve (AUC) for PRISM III was 0.884 compared to lactate levels (0.831). **Conclusion** – A significant positive correlation was seen between the PRISM III score and lactate levels. The study indicates that monitoring patients admitted to the PICU in relation to their PRISM III score and lactate levels can improve their overall prognosis and facilitate early resuscitation.

Key Words: Mortality ▪ PICU ▪ PRISM III Score ▪ Serum Lactate.

Introduction

Pediatric intensive care units (PICU) are an essential component of a thriving medical facility and provide sophisticated care for children and adolescents (1). They play an essential role in decreasing morbidity and mortality among adolescents (2). With their specialized life-support equipment and well-trained staff, they can improve the quality of care for children, and if properly organized, they can use low-cost interventions to treat the serious complications of high-burden diseases, such as diarrhea, severe malaria, and breathing problems (3, 4).

Quantifying the severity of the illness and predicting the probability of death based on the clinical condition at the time of admission is important (1). There are predictive models or scoring systems for pediatric patients that give a score to predict the outcome and assess the patient's mortality risk in the ICU (5). One of the most important scoring systems used in the PICU is the Pediatric Risk of Mortality (PRISM) score (6). Pollack et al. came up with the PRISM score in 1988, consisting of 14 variables to identify death in the PICU. In 1996, Pollack added three new factors to PRISM and changed it to PRISM III (3). PRISM III is the modified version of PRISM, where the prognostic value of various physiological variables was

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reevaluated, and those that did not contribute substantially to mortality were eliminated (3, 7).

Lactate is a metabolite produced during anaerobic glycolysis (7, 8). Lactate is an indicator of tissue hypoperfusion and cellular hypoxia, and elevated lactate levels in the blood are substantially associated with mortality (9). Due to its strong link to mortality, hyperlactatemia has been used as a measure of tissue hypoperfusion and cellular hypoxia. Lactate can be used as a marker to establish a patient's risk level and how well they are responding to treatment. Single lactate levels recorded at ICU admission are thought to be significant predictors of subsequent organ dysfunction and mortality. Lactate accumulation in critically ill patients is a marker of altered tissue perfusion, and is linked with a poor prognosis in various patient groups. Sepsis, trauma, multi-organ failure, cardiac arrest, and elderly age are all linked with increased mortality due to lactate elevation (10). In the past, studies have evaluated the predictive value of a single lactate measurement for mortality in adults (8). In the literature, lactate as a prognostic marker of mortality in pediatric populations is controversial (9, 10).

Hence, the present study aims to evaluate the prognosis of children admitted to the PICU within the first 24 hours by using the PRISM III score and serum lactate level measured at admission and 24 hours after admission.

Materials and Methods

Study Subjects

A cross sectional study was conducted at the PSG Institute of Medical Sciences and Research from March 2021 to October 2022. A total of 107 children, ranging in age from 1 month to 16 years, were included in the study after receiving approval from the Institute Ethical Committee.

Inclusion and Exclusion Criteria

All patients admitted to the PICU during the study period with complaints of shock, respiratory illness, seizures, and gastrointestinal disorders were considered for the study after parental consent was obtained. The study did not include children who were admitted for any trauma, who were recovering from surgery, were thought to have lactate metabolism disorders, or who died within two hours of being admitted. Those patients whose parents refused to consent were also excluded from the study.

Clinical and Laboratory Data Collection

Clinical and laboratory data were collected on the day of admission and included age, gender, diagnosis at the time of admission, and severity of illness as assessed by the Pediatric Risk of Mortality III (PRISM III) score. The PRISM III score was calculated on the basis of laboratory and clinical parameters using the PRISM III calculator by the Collaborative Paediatric Critical Care Research Network (CPCCRN) (11). Clinical data included the patient's systolic blood pressure, heart rate, temperature, pupillary reflexes, and the Glasgow Coma Scale (GCS). Laboratory data were based on parameters such as blood gas analysis, blood pH, total CO_2, pCO_2, pO_2, serum potassium, blood glucose, white blood cell (WBC) count, platelet count, blood urea and creatinine, prothrombin time (PT), and partial thromboplastin time (PTT). A COBAB B221 OMNI machine (Germany) was used to measure lactate at admission and after 24 hours. This was done using the direct ion selective electrode method. Admission lactate was measured from the blood gas sample. The blood serum lactate sample was drawn at 24 hours. Physiological status, as measured by PRISM variables and their ranges, is strongly related to morbidity and could be used to predict morbidity and mortality risk at the same time.

Ethics Statement

Study was conducted after obtaining ethical clearance from the Institutional Review Board (PSG/IHEC/2021/Appr/Exp/081).

Statistical Analysis

IBM SPSS version 24 was used for statistical analysis of data. The outcome of patients was recorded

as survivors or non-survivors. Serum lactate levels were compared between survivors and non-survivors. The correlation between the PRISM III score and lactate level was measured. Categorical data were represented as frequencies and proportions in a Microsoft Excel data sheet containing the collected information. Using the ROC, lactate levels and the PRISM III score were analyzed. A region under the ROC curve greater than 0.8 indicates a relatively accurate prediction. Using the Mann Whitney Test, the PRISM III score and serum lactate at 24 hours of admission were calculated. A P-value of less than 0.001 was statistically significant. The mean of PRISM score variables, such as systolic BP, temperature, mental status (GCS), heart rate, blood pH, and pCO2 were compared between surviving and non-surviving children using an independent t-test.

Results

Out of the 107 patients included in this study, 58 (54.2%) were female and 49 (45.8%) were male. The largest number of patients, 40 (37.28%), were under one year old; 23 (21.49%) were between one and five years old; 16 (14.9%) were between six and ten years old; and 28 (26.1%) were over ten years old. The median age of the patients was 3 years, with an interquartile range of 0.8–10 years. The largest number of patients admitted to the hospital had neurological disorders, 20 (18.69%), followed by dengue, 18 (16.8%), respiratory illness, 10 (9.3%), renal disorders, 8 (7.4%), gastrointestinal disorder, 7 (6.54%), malignancy, 4 (3.7%), and 37 (34.54%) had other disorders such as shock, fever, sepsis, and poisoning (Table 1).

Table 1. Characteristics of Patients Admitted to the PICU*

Characteristics		Frequency†	Percentage
Gender	Female	58	54.2
	Male	49	45.8
Age (years)	Up to 1	40	37.38
	1–5	23	21.49
	6–10	16	14.9
	>10	28	26.1
Diagnosis	Gastrointestinal disorders	7	6.54
	Cardiovascular disease	3	2.8
	Respiratory illness	10	9.3
	Dengue	18	16.8
	Renal disorders	8	7.4
	Neurological disorders	20	18.69
	Malignancy	4	3.7
	Others	37	34.54

*Paediatric Intensive Care Unit; †N=107.

The median duration of stay of patients in the PICU was 4 days (range from 2 to 7) and 7 days in the hospital (4-13). The outcome of patients admitted to the hospital shows that 90.7% (N=97) were survivors and 9.3% (N=10) were non-survivors. The association between gender and outcome was studied, and there was no statistically significant association between gender and survival. However, female patients were 8.8 times more at risk of death compared to male counterparts (Table 2).

There was also no statistically significant difference in mean GCS between the surviving and non-surviving groups, with the non-survivors having a lower GCS score (Mean=11.5±4.27) compared to the survivors (Mean=14,59, SD=0.82). Similarly, using the Mann-Whitney U test, there was no statistically significant difference in creatinine between the non-survivors and the survivors (P=0.003). All other variables did not show a significant difference between non-survivors and survivors.

At the time of admission, the serum lactate value in survivors (2.95 mmol/L (1.83-4.48)) was lower in comparison to non-survivors (3.11 mmol/L (1.71-6.79)) but this difference was not statistically significant (P=0.581). A progressive reduction in serum lactate values in survivors (2.06 mmol/L (1.41-3.18)) was seen after 24 hours. In non-survivors, there was persistent hyperlactatemia (lactate levels between 2 mmol/L and 4 mmol/L) even following resuscitation.

The PRISM III value measured at the time of admission in survivors (8 (5.00-11.00)) was low when compared to non-survivors (16.50 (11.00-21.50)) and this difference was significant (P<0.001). A statistically significant difference (P-value of <0.001)

Table 2. Association of Gender with Outcome of Study Participants

Variable	Category	Dead N (%)	Alive N (%)	Odds ratio (95 % CI*)	P value†
Gender	Female	9 (15.5)	49 (84.5)	8.816 (1.075-72.282)	0.020
	Male	1(2)	48 (98)		

*Confidence interval; †Chi square test.

Table 3. Association of Serum Lactate and PRISM* III Score with Survival Outcome

Outcome		Median (IQR†)	P value‡
Lactate at admission	Non-survivors	3.11 (1.71–6.79)	0.581
	Survivors	2.95 (1.83–4.48)	
Lactate after 24 hours of admission	Non-survivors	5.10 (2.60–7.00)	<0.001
	Survivors	2.06 (1.41–3.18	
PRISM* III score at admission	Non-survivors	16.50 (11.00–21.50)	<0.001
	Survivors	8.00 (5.00–11.00)	

*Pediatric risk of mortality; †Interquartile range; ‡ Mann Whitney Test.

was found between survivors and non-survivors with respect to serum lactate levels (24 hours after admission) and PRISM III score at admission (Table 3).

The area under the curve (AUC) for PRISM III was 0.884, with a 95% confidence interval of 0.78–0.98. The area under the ROC curve for the PRISM III score and serum lactate levels had a significant P-value (<0.001) (Table 4).

The sensitivity and specificity of PRISM III and serum lactate values were determined, along with the positive and negative predictive values. Using this data, a ROC curve was plotted and the optimal cut-off values were obtained for determining mortality. The point at which maximum sensitivity and specificity was present was decided as the optimal cut-off value.

Fig. 1. is the ROC curve for the PRISM III scores. The x-axis shows the true negative rate (specificity), and the y-axis shows the true positive rate (sensitivity). The ROC curve shows that the sensitivity of the PRISM III scores to truly identify the patients in shock who have a poor prognosis and a higher risk of mortality above the value of 10.5, is 90% and the specificity of the PRISM III scores to identify the children who are not at risk of mortality is 69.1%.

Figure 2 shows the ROC curve for the serum lactate values. The x-axis shows the true negative rate (specificity), and the y-axis shows the true positive rate (sensitivity). The ROC curve shows that the sensitivity of the serum lactate values to truly identify the patients in shock who have a poor prognosis and a higher risk of mortality above the value of 2.6, is 80%, and the specificity of the serum lactate values to identify the children who are not at risk of mortality is 67%.

Table 4. Comparison of the Area under the Receiver Operating Characteristic (ROC) Curves for Prism* III Score and Serum Lactate Level

Variables	PRISM* III score	Serum lactate level
Area under the ROC curve (AUC†)	0.884	0.831
95% Confidence interval	0.78–0.98	0.70–0.96
Significance level (P-value‡)	<0.001	<0.001

*Pediatric risk of mortality; †Area under the curve; ‡ROC analysis.

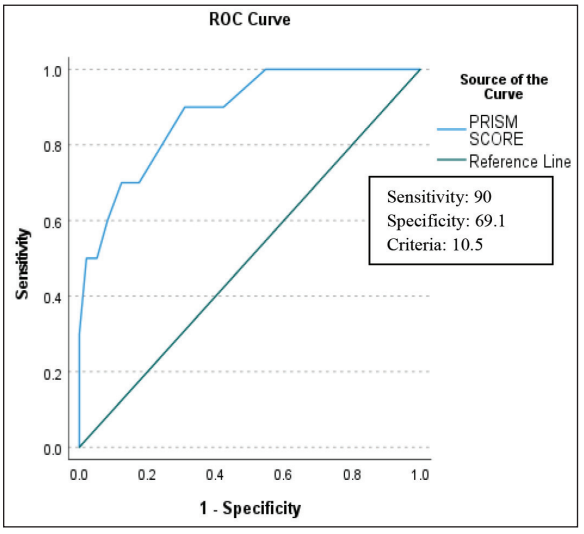

Fig. 1. *ROC Curve of PRISM score in predicting mortality. ROC=Receiver Operating Characteristic; PRISM=Pediatric risk of mortality.*

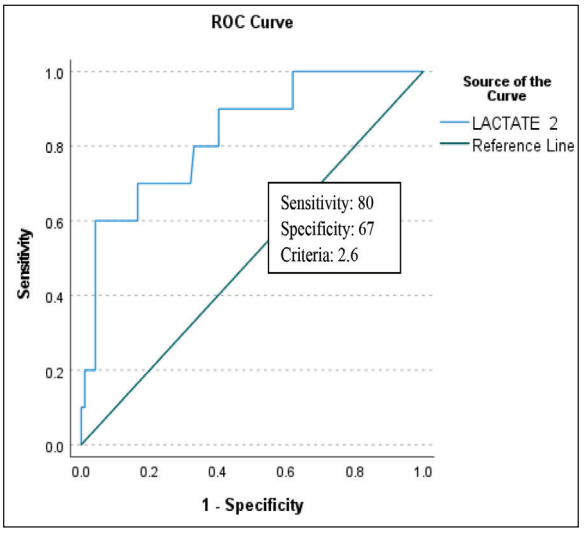

Fig. 2. *ROC Curve of lactate for predicting mortality. ROC=Receiver Operating Characteristic; PRISM=Pediatric risk of mortality.*

Discussion

This cross sectional study aimed to evaluate the prognostic indicators of mortality in children admitted to the PICU and to correlate Paediatric Risk of Mortality III (PRISM III) scores with blood lactate levels. The study included 1-month-old to 16-year-old patients admitted to the PICU. In the present study, the majority of the study participants were female children. Gender association and outcome was studied and female children were 8.8 times at risk of death compared to male children in this study, but this was not found to be statistically significant.

The PRISM III score is a valid measure of illness severity in the first 24 hours after admission and reflects a child's clinical picture in the early admission period. In the present study, the median PRISM III score was significantly higher in non-survivors (16.50 (11.00–21.50)), i.e., the PRISM III score was significantly associated with survival outcome. The median PRISM III score among survivors was 8.00 (5.00–11.00). It was comparable to the study by Gupta A et al. (8), where the mean PRISM III score in survivors was 8.8 and in non-survivors 18.06. The PRISM III score was significantly higher in patients who died (P=0.001), i.e., the PRISM III score was significantly associated with survival outcome in patients admitted to the PICU. The patient survival rate in the present study was 90.7%, but a few other studies showed the survival rate as 67% by Gupta A et al. (8), 50% by Jat et al. (12), and 24% by Chanderashekher et al. (9). Therefore it is recommended that mortality risk is assessed using PRISM III at admission, as it is simple to use.

The area under the ROC curve for the PRISM III score for predicting death in the present study was 0.884 (0.78–0.98). Similar findings under the ROC curve for the PRISM III score were seen in the studies by Jat et al.. (12) (0.909) and Bai et al. (0.82) (13). The area under the ROC curve for serum lactate level for predicting death in the present study was 0.831 (0.70–0.96). Similar findings under the ROC curve for serum lactate level were seen in the study by Gupta A et al. (0.845 (0.758–0.932)) (8), Jat et al. (0.8) (12), and Bai et al. (0.79) (13). These findings are indicative of a correlation between lactate levels and mortality. It suggests that it was a better predictor of mortality in patients than the serum lactate level, whose AUC was 0.831 with a 95% confidence interval of 0.70–0.96.

In a study by Bai Z et al. (13), the median blood lactate level measured in critically ill patients was

3.2 mmol/L (2.2–4.8 mmol/L). Similarly, in a study by Chanderashekher et al. (9), the mean lactate level among survivors was 2.28, and in a study by Gupta A et al. (8), it was 2.77±1.77 mmol/L, which was comparable to the present study, where blood lactate was 2.95 mmol/L (1.83–4.48 mmol/L). In a retrospective cohort study by Morris KP et al. (14), admission lactate in PICU non-survivors (6.6 mmol/L (SD=5.6)) was higher than in survivors (3.0 mmol/L (SD=2.5)), with a positive association with mortality. A study by Raksha SS et al. (7) also showed a similar finding (4.017 mmol/L (SD=0.291)) as that of the present study. In both studies, serum lactate levels were correlated with mortality scores to determine which was better as a prognostic indicator. The findings from these studies suggested that higher lactate levels were associated with high mortality. Patients with low lactate levels should be considered for additional monitoring, as serial lactate values may provide better prognostic information. The presence of elevated lactate levels may be interpreted as a warning sign of a treatable condition, such as the onset of septic shock, implying that "there is still room" to increase the extent to which treatment is administered. Thus, we conclude that high serum lactate values at the time of admission and persistent hyperlactatemia are associated with increased mortality.

In the present study, a moderately positive correlation existed between PRISM III and lactate level at presentation (r-value 0.301; P-value 0.002). It may be inferred that both the PRISM III score and serum lactate level are good predictors of survival outcome, with PRISM III being slightly better than lactate. In this study, there were patients with a variety of diseases, indicating that the PRISM III was effective for a wide spectrum of morbidities. However, the present study was limited by the fact that it was conducted at a single location and by the small sample size, which did not meet the calculated sample size. The criteria for PICU admission vary greatly, which another limitation of this study. Before generalizing the results of the present investigation, caution is required. It is necessary to conduct a larger study that includes institutions from various locations and a larger sample size.

Conclusion

PICUs play a key role in saving the lives of critically ill young patients. Various tools or scales, such as PRISM III and serum lactate levels, are vital in predicting mortality and identifying the urgent care needs of a patient admitted to the PICU. The present study demonstrated that most patients who died had a higher PRISM III score and serum lactate level than survivors. There was a significant positive correlation between the PRISM III score and lactate level measured at admission and 24 hours after admission. As a risk factor for a poor prognosis in the pediatric ICU, the admission lactate level can be used to stratify critically ill patients. When critically ill patients are admitted to the hospital, testing for lactic acid is recommended. Focusing on the association between admission lactate and all-cause mortality in the pediatric ICU will improve our ability to diagnose, treat, and improve the prognosis of critically ill children.

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Conflict of Interest: The authors declare that they have no conflict of interest.

Data Statement: The data that support the findings of this study are available from the corresponding author upon request.

Consent to Participate: All participants provided informed consent prior to participation in the present study.

References

1. Simalti AK, Garg P. Clinical Profile and Validity of PRISM III among Children Admitted in A PICU Over One Year. Ann Pediatric Child Health. 2020;8(2): 824-8. doi: 10.38124/IJISRT20APR695.
2. Shakil KMD, Kumar PD, Sreenivasa B, Sivachand T. Outcome of Patients Admitted to PICU and NICU in Relation to PRISM III Score in a Tertiary Care Hospital. Asian Journal of Clinical Pediatrics and Neonatology. 2020;8(4):13-8. doi: https://doi.org/10.47009/ajcpn.2020.8.4.4
3. Mirza S, Malik L, Ahmed J, Malik F, Sadiq H, Ali S et al. Accuracy of Pediatric Risk of Mortality (PRISM) III Score

in Predicting Mortality Outcomes in a Pediatric Intensive Care Unit in Karachi. Cureus. 2020;12(3): e7489. doi: 10.7759/cureus.7489.

4. Slusher TM, Kiragu AW, Day LT, Bjorklund AR, Shirk A, Johannsen C et al. Pediatric Critical Care in Resource-Limited Settings-Overview and Lessons Learned. Front Pediatr. 2018;6:49. doi: 10.3389/fped.2018.00049.
5. Patel S, Vasavada H, Patel P, Brijeshkumar P, Parth S. Study of PRISM III Score as A Predictor of Mortality in PICU. J Pediatr Crit Care. 2019;6(3): 21-4.
6. Akhtar H, Ehsan S, Imran M, Aqeel KM. PRISM score as a predictor of mortality among pediatric intensive care units. International Journal of Endorsing Health Science Research. 2021;9(4):511-7.
7. RakshaSS, Krishnappa J, Shashidhar KN. Blood Lactate Levels and PRISM III Scores for Prognosis of Shock during Paediatric Emergencies: A Prospective Observational Cross-sectional Study. Journal of Clinical And Diagnostic Research. 2022;16(2):23-7.
8. Gupta A, Sharma A, Sharma R, Charurvedi A. Blood lactate level as a predictor of outcome in pediatric septic shock and its correlation with PRISM III score. IOSR Journal of Dental and Medical Sciences. 2020;19(5):20-4.
9. Chandrashekar C, Prabhakar M, Santhoshkumar M, Harish RK. Blood lactate as a predictor of mortality in critically ill children. Sri Lanka Journal of Child Health. 2018;47(1):40-3.
10. Yue C, Zhang C, Ying C. Admission serum lactate is associated with all-cause mortality in the pediatric intensive care unit. Am J Transl Res. 2022;14(6):4124-31.
11. Kuhn G. Collaborative Pediatric Critical Care Research Network. (Internet) (Cited on 2023 March 12). Available from: https://www.cpccrn.org/
12. Jat KR, Jhamb U, Gupta VK. Serum Lactate levels as predictor of outcome in paediatric septic shock. Indian J Crit Care Med. 2011;15:102-07.
13. Bai Z, Zhu X, Li M, Hua J, Li Y, Pan J et al. Effectiveness of predicting in hospital mortality in critically ill children by assessing blood lactate levels at admission. BMC Paediatrics. 2014;14:83-91.
14. Morris KP, McShane P, Stickley J, Parslow RC. The relationship between blood lactate concentration, the Paediatric Index of Mortality 2 (PIM2) and mortality in paediatric intensive care. Intensive Care Medicine. 2012;38:2042-6.