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Pediatric Index of Mortality 2 Score of Patients with Chest Problems in Pediatric Intensive Care Unit as an Indicator of Efficacy of Management and Personel Practice

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ABSTRACT

Background: The Pediatric Index of Mortality 2 (PIM 2) score is a predictive tool used to estimate the risk of mortality in pediatric intensive care units (PICUs).

Objective: To evaluate the utility of the PIM 2 score in predicting mortality for this patient group, alongside examining management strategies and personnel practices within a tertiary care PICU setting.

Methods: This prospective observational study was conducted at Benha University Hospital's PICU over a six-month period from August 2022 to January 2023. A total of 98 children aged one month to 16 years presented with chest problems such as bronchitis, pneumonia, bronchial asthma, aspiration, and croup. PIM 2 score was calculated based on ten critical variables such as elective PICU admission, early mechanical ventilation, systolic blood pressure, and base excess. Patient outcomes were monitored until discharge.

Results: The study involved 98 patients, with an average age of 5.41 ± 3.121 years, balanced across genders (46.9% male, 53.1% female). The average PIM 2 score was 9.58 ± 13.693, with patients' outcomes showing 86.7% survival and 13.3% mortality. A significant correlation was found between higher PIM 2 scores and mortality ($p < 0.001$). ROC curve analysis yielded a ≤15.7 PIM 2 score cut-off, predicting survival with 87.06% sensitivity and 84.62% specificity (AUC 0.902, $p < 0.001$)

Conclusions: The PIM 2 score is a reliable predictor of mortality among pediatric patients with chest problems admitted to PICU. High PIM 2 scores were significantly associated with increased mortality, underscoring the score's utility in clinical decision-making.

Keywords: Pediatric Intensive Care Unit, Pediatric Index of Mortality 2 score, Chest problems.

INTRODUCTION

The assessment and management of pediatric patients in the intensive care setting present unique challenges, requiring precise and predictive tools to guide clinical decisions and improve patient outcomes [1]. The Pediatric Index of Mortality 2 (PIM 2) score, a tool designed to predict mortality risk in pediatric intensive care units (PICUs), has emerged as a critical component in this process [2, 3].

The PIM 2 score, which developed from a wide range of physiological and clinical parameters, offers a quantitative measure to assess the severity of illness and predict the likelihood of mortality at the time of admission to the PICU [4]. This predictive capability is invaluable for clinicians, enabling the allocation of resources and the tailoring of treatments to those most in need, potentially improving outcomes in this vulnerable patient population [5].

Pediatric patients presenting with chest problems, including respiratory distress, infections, and trauma, represent a significant subset of admissions to PICUs. These conditions are often associated with high morbidity and mortality rates, underscoring the need for effective tools to assess risk and guide management strategies [6].

The PIM 2 score, by incorporating variables such as mechanical ventilation requirements and physiological measurements such as blood pressure and oxygen saturation, offers a potentially powerful means to stratify risk in this group. However, the effectiveness and predictive accuracy of the PIM 2 score in patients with chest problems specifically have not been extensively explored [7].

The use of predictive scores like PIM 2 in clinical practice also raises questions about their broader implications for management strategies and personnel practices. Evaluating the correlation between PIM 2 scores and patient outcomes in specific contexts, such as chest problems, can provide valuable insights into the efficacy of current management approaches and identify potential areas for improvement [8].

Moreover, the relationship between predictive scores and patient outcomes can serve as a benchmark for the quality of care provided in PICUs. It can reflect the effectiveness of the clinical interventions and the performance of the healthcare team managing these critically ill patients. Understanding these dynamics is essential for continuous improvement in pediatric critical care, aiming to reduce mortality rates and enhance the quality of care [9].

This study aimed to evaluate the usefulness of PIM 2 score of patients with chest problems in predicting mortality in a tertiary care PICU, to assess the associated factors in predicting mortality, and to evaluate the efficacy of management and personnel practice.

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PATIENTS AND METHODS

Study Design and Participant Selection

This prospective observational study was carried out on children presenting with respiratory and other chest-related issues admitted to the PICU of Benha University Hospital over a period of six months from August 2022 to January 2023.

Inclusion criteria were children with chest problems such as (Bronchitis, pneumonia, bronchial asthma, aspiration, and croup) aged between 1 month and 16 years who were admitted to PICU, Benha University Hospital. Controversly, patients > 16 were excluded from the study.

METHODS

Upon admission, comprehensive data collection was initiated for each participant, including:

Demographic data including the patient's age and sex.

PIM 2 score assessment: The PIM 2 score was calculated for each child based on ten critical variables [4]. These included elective PICU admission, status post-procedure, cardiac bypass involvement, diagnosis severity (categorized as high or low risk), pupil response to bright light, the necessity of mechanical ventilation within the first hour of PICU stay, systolic blood pressure, base excess from arterial or capillary blood samples, and the ratio of FiO_2 to PaO_2. Each variable was meticulously documented for all patients.

Arterial Blood Gas Analysis: Within one hour of admission to the PICU, arterial blood gas measurements were taken, including base excess and PaO_2 levels, under the supervision of a pediatric resident.

Outcome Tracking: Continuous monitoring was maintained for each patient and their subsequent hospital stay, culminating in the documentation of their outcome, categorized as either "discharged" or " dead."

Ethical considerations:

The study was done after being accepted by the Research Ethics Committee, Benha University. All the caregivers of the patients provided written informed consents prior to the enrolment of their children. The consent form explicitly outlined their agreement to participate in the study and for the publication of data, ensuring the protection of their confidentiality and privacy. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis

Data were input into a computer and processed with the IBM SPSS software, version 20.0, developed by IBM Corp in Armonk, NY, USA. Numeric and percentage values were utilized to depict qualitative data. To assess the normality of data distribution, the Kolmogorov-Smirnov test was applied. Quantitative data were represented through their range (minimum to maximum), mean, and standard deviation. The significance level for evaluating the results was set at 5%. Various statistical tests were employed, including 1 - The Chi-square test, which was used to analyze categorical variables across different groups; 2 - The Student t-test, applied to compare normally distributed quantitative variables between two groups; 3 - The Mann Whitney test, used for comparing non-normally distributed quantitative variables between two groups. ROC curve analysis was performed for PIM 2 score to predict the outcome.

RESULTS

Age mean ± S.D. was 5.41±3.121 years. Female cases were 52 (53.1%) **(Table 1)**.

Table 1: Distribution of the studied sample according to demographic data.

Age (years)	
Range	6 months–11 years
Mean ±S.D.	5.41±3.121
Sex	n (%)
Male	46 (46.9%)
Female	52 (53.1%)

S.D.: standard deviation.

Mean ± S.D. of hospital stay was of 10.14±2.315 days and of ICU stay was 2.35±1.104 days **(Table 2)**.

Table 2: Distribution of studied sample according to hospital and ICU stay.

	Range	Mean ±S.D.
Hospital Stay (Days)	7–14	10.14±2.315
ICU stay (Days)	1–5	2.35±1.104

S.D.: standard deviation, ICU: intensive care unit.

The PIM 2 score of the studied group ranged between 0.2–56.0 with a mean value of 9.58±13.693. **(Table 3)**.

Table 3: Distribution of studied sample according to PIM 2 score.

	Number (%)
Elective admission	
No	98 (100%)
Yes	0 (0%)
Recovery post procedure	
No	98 (100%)
Yes	0 (0%)
Cardiac bypass	
No	98 (100%)
Yes	0 (0%)
High risk diagnosis	
No	48 (49.0%)
Yes	50 (51.0%)
Low risk diagnosis	
No	50 (51.0%)
Yes	48 (49.0%)
No response of pupils to bright light	
No	98 (100%)
Yes	0 (0%)
Mechanical ventilation	
No	79 (80.6%)
Yes	19 (19.4%)
Systolic Blood Pressure (mmHg)	
Range	76–140
Mean ±S.D.	111.68±15.120
Base Excess (mmol/L)	
Range	0.8–13.10
Mean ±S.D.	4.39±3.569
FiO_2	
Range	21–100
Mean ±S.D.	60.76±34.851
PaO_2 (mmHg)	
Range	83–99
Mean ±S.D.	96.63±2.645
PIM 2 Score	
Range	0.2–56.0
Mean ±S.D.	9.58±13.693

PIM 2: Pediatric Index of Mortality 2, SD: Standard Deviation, FiO2: Fraction of Inspired Oxygen, PaO2: Partial Pressure of Arterial Oxygen.

The outcome of the studied group showed that 48 (75.0%) survived, and 16 (25.0%) died. **(Table 4)**.

Table 4: Distribution of studied sample according to outcome

Outcome	n (%)
Survived	85 (86.7%)
Died	13 (13.3%)
Total	98 (100%)

There were highly statistically significant differences between survived and dead children, with a high score in dead children when compared with survived **(Table 5)**.

Table 5: Relation between PIM 2 score and outcome

	Outcomes		P value
	Died No. (%)	**Survived No. (%)**	
Elective admission			
No	13 (100%)	85 (100%)	-----
Yes	0 (0%)	0 (0%)	
Recovery post procedure			
No	13 (100%)	85 (100%)	-----
Yes	0 (0%)	0 (0%)	
Cardiac bypass			
No	13 (100%)	85 (100%)	-----
Yes	0 (0%)	0 (0%)	
High risk diagnosis			
No	0 (0%)	48 (56.5%)	<0.001*
Yes	13 (100%)	37 (43.5	
Low risk diagnosis			
No	13 (100%)	37 (43.5%)	<0.001*
Yes	0 (0%)	48 (56.5	
No response of pupils to bright light			
No	13 (100%)	85 (100%)	-----
Yes	0 (0%)	0 (0%)	
Mechanical ventilation			
No	5 (38.5%)	74 (87.1%)	<0.001*
Yes	8 (61.5%)	11 (12.9	
Systolic Blood Pressure (mmHg)			
Range	76–140	84–140	0.218
Mean ±S.D.	115.69±21.765	111.07±13.909	
Base Excess (mmol/L)			
Range	2.1–13.10	0.8–13.1	<0.001*
Mean ±S.D.	9.40±4.014	3.62±2.815	
FiO_2			
Range	21–100	21–100	0.143
Mean ±S.D.	45.15±28.213	63.14±35.291	
PaO_2 (mmHg)			
Range	83–99	90–99	0.700
Mean ±S.D.	95.92±4.591	96.74±2.232	
PIM 2 Score			
Range	5.8–56.00	0.2–47.80	<0.001*
Mean ±S.D.	21.29±11.820	6.45±10.294	

PIM 2: Pediatric Index of Mortality 2, S.D.: Standard Deviation, FiO_2: Fraction of Inspired Oxygen, PaO_2: Partial Pressure of Arterial Oxygen.

The ROC curve analysis of the PIM 2 score and patient outcomes showed that a cutoff value of ≤15.7, with a sensitivity of 87.06% and a specificity of 84.62%, can predict survival. The area under the curve (AUC) was 0.902, indicating a high level of accuracy **(Figure 1)**.

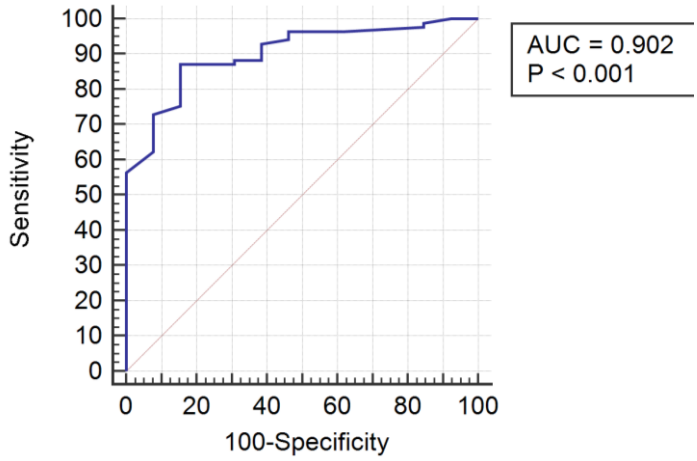

Figure 1: ROC curve analysis between PIM 2 score and outcome.

DISCUSSION

The PIM 2 score serves as a tool to predict the likelihood of death in PICUs [10]. However, its effectiveness in evaluating the risk for pediatric patients with respiratory problems has not been thoroughly investigated. Therefore, this study aimed to evaluate the utility of the PIM 2 score in predicting mortality for this patient group, alongside examining management strategies and personnel practices within a tertiary care PICU setting.

As regards demographic data, a study by **Mazhar and Hamid**, who explored the effectiveness of the PIM-2 in predicting outcomes within a PICU. They reported that the median age of the study patients was 0.5 year, ranging from 0.24 to 1.78 years, with a balanced percentage of female and male patients (53.9 and 46.1%, respectively) [7].

Similarly, **Abo-El Ezz *et al.*** found that the ages of the participants varied from 1 month to 15 years, with a gender distribution of 84 (42%) male and 116 (58%) female patients [11]. Furthermore, **Mohamed *et al.*** evaluated the predictive ability of PIM-2, PIM-3 and pediatric risk of mortality IV (PRISM IV) in a resource-limited PICU. They revealed that the median age of their studied cases was seven months with IQR (3 – 24) months; 250 (55.4%) cases were males, and 201 (44.6%) cases were females [12].

Regarding hospital and ICU stay, our results were in agreement with **Youssef *et al.***, who demonstrated that the median (interquartile range) of length of hospital stay among their studied population was 6 (3–10) days [13]. Also, **Mohamed *et al.*** reported that the median length of PICU stay among their studied population was four days [12].

The present study revealed that the PIM 2 scores of the studied group ranged from 0.2 to 56.0, with a mean value of 9.58±13.693. Regarding the outcomes of the studied population, this study showed that 85 (86.7%) cases were survivors, and 13 (13.3%) cases were deceased. In alignment with our findings, **Mazhar and Hamid** reported that 108 (70.12%) cases in their study population were survivors, and 46 (29.8%) cases were dead [7]. Similarly, **Abo-El Ezz *et al.*** found that 126 (63%) cases in their study population were survivors, while 74 (37%) cases did not survive [11]. **El-keiy *et al.*** reported that 68 (68%) patients in their study population survived and 32 (32%) patients died [14]. Furthermore, **Youssef *et al.*** indicated that 290 (91.5%) cases in their study population were survivors, with 27 (8.5%) cases died [13].

Concerning the association between the PIM 2 score and patient outcomes, **Mazhar and Hamid** demonstrated significant variations in base excess levels between the surviving and dead patients [7]. **Abo-El Ezz *et al.*** observed a notable difference in the PIM-2 mortality risk, with non-survivors presenting a higher average score (68.37±30.560) compared to survivors (13.8±14.44) [11]. Additionally, **El-keiy *et al.***, also reported a significant increase in PIM-2 mortality probability among non-survivors compared to survivors [14].

Likewise, **Youssef *et al.*** identified a significant distinction in PIM-2 scores between survivors and non-survivors, highlighting a marked association between elevated PIM2 scores and a higher likelihood of non-survival (2.39 ± 5.49 in survivors versus 41.38 ± 36.06 in non-survivors, P = 0.001) [13].

Regarding the ROC curve analysis between PIM 2 score and outcome, our work aligns with **Mazhar and Hamid**, who identified an AUC of 0.75 (95% CI: 0.67–0.84) for their PIM-2 model, with a p-value of <0.001 and measures of sensitivity and specificity at 54.3% and 83.3%, respectively. Their results suggest the PIM-2 score's limited utility as a mortality screening tool, though its high specificity indicates reliable survivor prediction capabilities [7]. **Abo-El Ezz *et al.*** showed the AUC for the PIM-2 score was 0.763, with a specificity of 75.7%, signifying the score's satisfactory discriminative power in distinguishing between survivors and non-survivors [11]. Also, **Youssef *et al.*** reported an AUC of 0.796 (95% CI: 0.675–0.916, P < 0.001), indicating proficient discrimination between survivors and non-survivors [13].

Moreover, **Mohamed *et al.***, found a cut-off value of 14.2, with a specificity of 87.5%, a sensitivity of 59.6%, and an AUC of 0.694, alongside a significant p-value of <0.001, underscoring the PIM 2 score's capability to predict mortality effectively [12].

Finally, this study had some limitations as it was single center with a relatively small sample size of only children, which may not capture the full spectrum of variability in pediatric patients with chest problems. The observational nature of the study means causal relationships cannot be firmly established between PIM 2 scores, management strategies, and patient outcomes. Future research should include larger, multi-center studies to validate the findings and explore the PIM 2 score's applicability across different PICU settings and broader pediatric populations.

CONCLUSION

The PIM 2 score is a reliable predictor of mortality among pediatric patients with chest problems admitted to the PICU. High PIM 2 scores are significantly associated with increased mortality, underscoring the score's utility in clinical decision-making and resource allocation.

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