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Evaluation of the Performance of PRISM III and PIM II Scores in a Tertiary Pediatric Intensive Care Unit

Üçüncü Basamak Çocuk Yoğun Bakım Ünitesinde PRISM III ve PIM II Skorlarının Performansının Değerlendirilmesi

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Abstract

Introduction: The most commonly used scoring systems for the assessment of predicted mortality (PDR) in the pediatric intensive care unit are the "pediatric risk of mortality" (PRISM) and the "pediatric index of mortality" (PIM) scores. The aim of this study is to evaluate the calibration and discrimination of PRISM III and PIM II scores in predicting mortality in a tertiary university hospital pediatric intensive care unit in Turkey.

Methods: Demographic data of patients hospitalized in the pediatric intensive care unit between January 1, 2015 and December 31, 2018 were scanned form the electronic records. PRISM III and PIM II score, PDR, and standardized mortality rate (SMR) were calculated. In order to show the discrimination of the scores, the area under the ROC curve (AUC) was calculated and the significance limit was accepted as 0.80. Hosmer-Lemeshow Goodness-of-fit test was used to evaluate the calibrations and p>0.05 was considered significant.

Results: After exclusions 825 patients included in the study. The mean value of the PRISM III was 9.5±6.8 and the mean value of the PIM II score was 1.9±8.2. The calculated SMR was 1.03 according to the PRISM III score and 0.76 according to the PIM II score. In the ROC analysis performed to evaluate the discrimination, the AUC values for PRISM III PDR and PIM II PDR were; 0.908±0.017 (p<0.001), 0.855±0.024 (p<0.001), respectively. When PRISM III and PIM II PDR values were analyzed in groups, the difference between predicted and observed mortality was not statistically significant (p=0>0.05).

Conclusion: In this study, it has been shown that the discrimination and calibration of the PRISM III and PIM II score is good in predicting mortality in a tertiary pediatric intensive care unit where medical and surgical patients are accepted.

Keywords: Mortality, score, PRISM, PIM, discrimination, calibration

Öz

Giriş: Çocuk yoğun bakım ünitesinde beklenen mortalitenin değerlendirilmesinde en yaygın kullanılan skorlama sistemleri "pediatric risk of mortality" (PRISM) ve "pediatric index of mortality" (PIM) skorlarıdır. Bu çalışmanın amacı, PRISM III ve PIM II skorlarının Türkiye'de üçüncü basamak bir üniversite hastanesi çocuk yoğun bakım ünitesinde mortaliteyi öngörmede kalibrasyonunun ve diskriminasyonunun değerlendirilmesidir.

Yöntemler: Çocuk yoğun bakım ünitesine 1 Ocak 2015-31 Aralık 2018 tarihleri arasında yatan hastaların demografik verileri elektronik kayıtlardan tarandı. PRISM III ve PIM II skoru, tahmini ölüm oranı (PDR), standardize mortalite oranı (SMR) hesaplandı. Skorların diskriminasyonlarını gösterebilmek için ROC eğrisi altında kalan alan (EAA) hesaplandı ve anlamlılık sınırı 0,80 kabul edildi. Kalibrasyonlarını değerlendirmek üzere Hosmer-Lemeshow Goodness-of-fit testi kullanıldı ve p>0,05 anlamlı kabul edildi.

Bulgular: Çalışma dışı bırakılan hastalar çıkarıldıktan sonra 825 hasta çalışmaya dahil edildi. PRISM III ortalama değeri 9,5±6,8 ve PIM II skorunun ortalama değeri 1,9±8,2 idi. Hesaplanan SMR, PRISM III skoruna göre 1,03 ve PIM II skoruna göre 0,76 idi. Diskriminasyonu değerlendirmek için yapılan ROC analizinde PRISM III PDR ve PIM II PDR için EAA değerleri; sırasıyla 0,908±0,017 (p<0,001), 0,855±0,024 (p<0,001) bulundu. PRISM III ve PIM II PDR değerleri gruplar halinde incelendiğinde, öngörülen ve gözlenen mortalite arasındaki fark istatistiksel olarak anlamlı değildi (p=0>0,05).

Sonuç: Bu çalışmada, ülkemizde tıbbi ve cerrahi hastaların kabul edildiği üçüncü basamak bir çocuk yoğun bakım ünitesinde PRISM III ve PIM II skorunun diskriminasyon ve kalibrasyonunun iyi olduğu gösterilmiştir.

Anahtar Kelimeler: Mortalite, skor, PRISM, PIM, diskriminasyon, kalibrasyon

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Introduction

Since the mid-1990s in Turkey, the number of pediatric intensive care units, which are structured independently of adult and neonatal intensive care units, has started to increase rapidly. In the following decade, it officially became a minor program in medical education and the education program was clearly defined. In this process, the minimum standards of the new intensive care units to be opened in the national health system have been defined and continuously inspected.[1] The main purpose of an intensive care unit is to reduce mortality.[2] For this reason, one of the defined standards is to evaluate the expected mortality rates in intensive care units with standard scoring systems and compare them with the actual mortality rates. The increase in infrastructure opportunities, the reflection of technological developments on patient care, and the increase of qualified health personnel have revealed the need to recalibrate and discriminate the scoring systems used in the evaluation of mortality. In addition, scoring systems are important to eliminate bias by selecting patients with similar disease severity when conducting clinical trials.[2,3] If the observed mortality number and distribution is similar to the number and distribution estimated from the results of the scores, it can be said that the performance of the institution is equivalent to the institutions in which the validity of these scores has been demonstrated elsewhere in the world.[4] The most commonly used scoring systems for the evaluation of mortality in the pediatric intensive care unit are the "pediatric risk of mortality" (PRISM) and the "pediatric index of mortality" (PIM) scores.[2] The PRISM III score uses the patient's most abnormal variants (PRISM III-24 score) during the first 12 or 24 hours in the intensive care unit, and it predicts possible mortality during this hospitalization.[5] The PIM II score estimates the risk of death from data available at the time of admission to the intensive care unit and has therefore been reported to be suitable for continuous monitoring of the quality of pediatric intensive care.[6] The aim of this study is to evaluate the calibration and discrimination of PRISM III and PIM II scores in predicting mortality in a tertiary university hospital pediatric intensive care unit in Turkey.

Materials and Methods

Patients and Data

The data of patients hospitalized in the Akdeniz University Pediatric Intensive Care Unit between January 1, 2015 and December 31, 2018 were scanned from electronic records. Their age, gender, underlying disease, reason for hospitalization in the intensive care unit, duration of invasive and non-invasive ventilation, length of stay in the intensive care unit, tracheostomy requirement and prognosis were recorded. Predicted death rate (PDR) was recorded using the PRISM III and PIM II scores, as well as the logarithmic formulas recommended for these scores.[7,8]

Standardized mortality rate (SMR) was calculated by dividing the mean of the PDR values obtained from the scores for both scoring systems by the actual mortality rate. Ideally, the SMR is expected to be close to 1. When this value was above 1, it was interpreted that the mortality predicted by the test was higher than the actual value, and when it was below 1, it was interpreted that the test predicted mortality (PDR) less than the actual value.

Features of the Unit Where the Study was Performed

Akdeniz University Pediatric Intensive Care Unit is an independent 8-room unit separated by an automatic door system. Two of these rooms are full isolation rooms. All beds are equipped with centrally connected advanced monitor system and advanced ventilators. During the period of the study, 1 lecturer, 1 minor specialist, 3 research assistants, one of whom was a senior, and 14 nurses worked in the unit. All medical and surgical patients aged 1 month to 18 years, including trauma, congenital heart surgery, and organ transplantation, are accepted. Advanced treatments such as high-frequency oscillatory ventilation, continuous renal replacement therapy, and extracorporeal membrane oxygenation (ECMO) are performed. The possibility of using ECMO is limited for economic reasons (less than 5 per year).

Exclusion Criteria

Patients who were hospitalized in the intensive care unit for less than 24 hours, whose cardio-pulmonary arrest status could not be stabilized at the end of the first 2 hours after admission, whose data could not be reached, who had undergone bone marrow transplantation or who had known chromosomal anomalies were excluded from the study.[3,9,10]

Statistical Analysis

Statistical evaluation was performed using the Statistical Package for Social Science (SPSS) 23 software. Descriptive statistics were made by using frequency and percentage (%) for categorical variables and by using mean and standard deviation (SD) values, and the median, minimum and maximum values for numerical variables. The chi-square test was employed to compare categorical variables with each other, while the Mann-Whitney U test was used for the analysis of numerical variables. A p-value below 0.05 was considered significant.

The area under the ROC curve (AUC) was calculated to evaluate how well the PRISM III and PIM II scores discriminated against the risk of death, and the significance limit was accepted as 0.80. When the AUC was higher than 0.80, it was considered

that the scores were able to discriminate adequately between the survivors and the non-survivors, and the scores had good discrimination.

In order to evaluate the calibrations of the scoring systems, the patients were divided into 5 different categories according to their risk groups, and the number of deaths, expected number of deaths, actual number of survivors and expected number of survivors were compared with the Hosmer-Lemeshow Goodness-of-fit test according to the total number of patients in the groups. In the case of p>0.05, it was evaluated that there was no statistically significant difference, and the calibration of the mortality test was considered good.

Consent was obtained for the study with the decision of the Akdeniz University Faculty of Medicine Clinical Research Ethics Committee, dated 09/04/2019 and numbered 70904504.

Results

Thirty-six patients with known chromosomal abnormalities, 55 patients who underwent bone marrow transplantation, and a total of 324 patients who were hospitalized in the intensive care unit for less than 24 hours or were unstable at the 2nd hour after cardiopulmonary resuscitation or had missing data were excluded from the study in accordance with the exclusion criteria (Figure 1). Three hundred seventy-eight (45.8%) of the patients included in the study were girls, and the mean age was 46.7 months (1-22) years. Among the reasons leading to intensive care hospitalization, respiratory failure (19.9%), trauma (18.4%), congenital heart surgery (16.1%), and postoperative follow-up (16%) were the most common ones (Table 1). Of the patients, 493 (59.75%) had a known chronic disease (Table 2). The duration of mechanical ventilation in the study group was 3.6 days (SD 6.0), and the mean intensive care unit stay was 7.1 days (SD 12.2). Tracheostomy was performed in 53 (6.42%) patients. The mortality observed in the study group was 8.60% (n=71). Mortality was 7.6% in males and 9.8% in females (p=0.265).

In the study group, the mean PRISM III score was 9.5 (SD 6.8), the mean PRISM III PDR was 8.3, and the PIM II score was 11.38. The SMR calculated according to the PRISM III score was 1.03, and the SMR according to the PIM II score was 0.76.

The area under the curve (AUC) was 0.908±0.017 (p<0.001) in the ROC analysis performed to evaluate the discrimination of the PRISM III score PDR. Similarly, when PIM II score PDRs were evaluated, AUC was found to be 0.855±0.024 (p<0.001). Since the AUC was above 0.80, it was seen that the discrimination of both scores was good (Table 3).

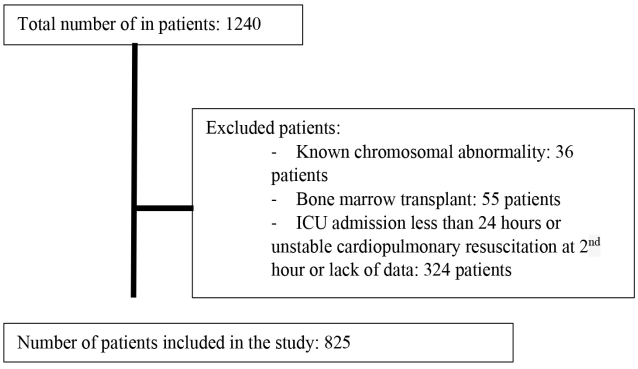

Figure 1. Selection of the study group and exclusion criteria
ICU: Intensive care unit

Table 1. Reasons for hospitalization in intensive care

Acute disease group	n=825 (%)	Mortality (%)
Respiratory failure	164 (19.9)	18 (10.97)
Trauma	152 (18.4)	12 (7.89)
Congenital heart surgery	133 (16.1)	2 (1.50)
Postoperative follow-up	132 (16)	5 (3.78)
Unconsciousness	99 (12)	6 (6.06)
Hemodynamic disorder	75 (9.1)	21 (28)
Poisonings	46 (5.6)	0 (0)
Follow-up after cardiopulmonary resuscitation	24 (2.9)	7 (29.16)

Table 2. Distribution of concomitant chronic diseases

Chronic disease group	n (%)	Mortality (%)
No known disease	332 (40.24)	17 (5.12)
Neurometabolic diseases	144 (17.45)	9 (6.25)
Acyanotic heart disease	143 (17.33)	6 (4.19)
Malignancy	74 (8.96)	18 (24.32)
Kidney diseases	39 (4.72)	5 (12.82)
Lower respiratory tract diseases	24 (2.90)	0 (0)
Immunodeficiency	21 (2.54)	3 (14.28)
Liver diseases	18 (2.18)	7 (38.88)
Cyanotic congenital heart diseases	17 (2.06)	3 (17.64)
Hematological diseases	13 (1.57)	3 (23.07)

Table 3. Discrimination of PRISM III and PIM II scores

Score	PDR*	#SMR	Discrimination (AUC&)
PRISM III	8.3%	1.03	0.908±0.017 (p<0.001)
PIM II	11.38%	0.76	0.855±0.024 (p<0.001)

*Actual mortality 8.60%, *PDR: Predicted death rate, #SMR: Standardized mortality rate, &Area under the curve (AUC) and p-value obtained from ROC analysis

The Hosmer-Lemeshow Goodness-of-fit test was applied to evaluate the calibration of the PRISM III score. When the PRISM PDR values of 825 patients were analyzed in groups, the difference between predicted and actual mortality was not significant (p=0.753). Calibration of the PIM II score was also similarly evaluated, and the difference between the predicted and actual mortality was similarly statistically insignificant (p=0.251). Since the p-values for both scores were insignificant, it was seen that their calibration was good (Table 4).

Discussion

Scoring systems are needed in pediatric intensive care units in order to evaluate the disease severity and response to treatment of study groups created for scientific research and to determine the expected mortality. It is seen that PRISM, PIM, PELOD and mSOFA scores are preferred in studies conducted in our country with critically ill children (Table 5). It is seen that most of these studies are retrospective, the number of patients is low, they are generally conducted on

Table 4. Calibration of PRISM III and PIM II scores (Hosmer Lemeshov Goodness-of-fit test)

	PDR %	Number of patients	Number of deaths occurred	Expected number of deaths	Actual number of survivors	Expected number of survivors
PRISM III*	0-1	129	0	0.492	129	128.508
	1-5	406	6	6.996	400	399.004
	5-15	172	15	12.784	157	159.216
	15-30	65	18	17.475	47	47.525
	>30	53	32	33.252	21	19.748
PIM II*	0-1	60	1	0.396	59	59.604
	1-5	401	10	8.404	391	392.596
	5-15	217	9	14.007	208	202.993
	15-30	56	13	10.190	43	45.810
	>30	91	38	38.003	53	52.997

According to the Hosmer Lemeshov Goodness-of-fit test result, p=0.753 for PRISM III, p=0.251 for PIM II score

Table 5. Studies evaluating mortality scores in critically ill children in Turkey and their results

Author and year of publication	The score used	Number and characteristics of patients	Design	Mortality rate	SMR*	Discrimination (AUC[&])	Calibration (Hosmer Lemeshov Goodness-of-fit test)
Anıl et al.[18]	PRISM I PIM II	277 patients between 2007-2008	Retrospective	14.7%	PRISM I: 1 PIM II: 1	PRISM I: 0.884 PIM II: 0.912	PRISM p=0.09 PIM II p=0.30
Köner et al.[13]	PIM I PIM II mSOFA[x]	373 postoperative congenital heart surgery patients between 2003-2009	Retrospective	13.4%	PIM I: 1.19 PIM II: 1.39	PIM I: 0.87, PIM II: 0.82 Baseline mSOFA: 0.92 Peak mSOFA: 0.93	PIM I: 0.0002 PIM II: 0.13
Ülgen Tekerek and Akyıldız[19]	PRISM III PIM II PELOD	454 patients in 2014	Retrospective	17%	PRISM III: 0.95	Not specified	PRISM III better than other scores in multiple binary logistic regression analysis (p<0.001)
Oymak and Bayrakci[11]	PRISM III-12 PRISM III-24 PIM II	389 patients between 2005-2006	Prospective	16%	PRISM III-12: 0.6 PRISM III-24: 0.6 PIM II: 0.4	PRISM III-12: 0.86 PRISM III-24: 0.89 PIM II: 0.84	Poor calibration of all three tests (p<0.05)
Kesici et al.[15]	PRISM III-24 PIM II OI[%]	150 patients undergoing mechanical ventilation	Retrospective	27.3%	PRISM III-24: 0.85	PRISM III-24: 0.66 PIM II: 0.52	PRISM III-24 p=0.002 PIM II p=0.68 Both tests are poorly calibrated, use of OI may be considered.
Alakaya and Arslanköylü[12]	PRISM III PELOD	372 patients between 2017-2018	Retrospective	7.8%	Not specified	PRISM III: 0.843 PELOD: 0.775	No significant difference between both tests (p=0.066), good correlations

*Standardized mortality rate, [&]Area under the curve (AUC from ROC analysis), [%] Oxygenation index, [x]Modified-sequential organ failure assessment score, SMR: Standardized mortality rate

Table 6. Examples and results of studies evaluating mortality scores in critically ill children in different countries

Author and year of publication/country	The score used	Number and characteristics of patients	Design	Mortality rate	SMR*	Discrimination (AUC&)	Calibration (Hosmer Lemeshov Goodness-of-fit test p-value)
Niederwanger et al.[17] 2020/Austria	PRISM III PRISM IV PIM II PIM III PELOD II	2019-2020 398 sepsis patients	Retrospective	13.6%		PRISM III: 0.75 PRISM IV: 0.7 PIM II: 0.78 PIM III: 0.76 PELOD II: 0.75	
Varma et al.[4] 2017/ India	PRISM III	2009-2011 723 patients	Prospective	14.8%	PRISM III: 0.98	PRISM III: 0.86	PRISM III: 0.638
Gonçalves et al.[3] 2015/Portugal	PRISM III PELOD II	2011-2012 556 patients	Prospective	5.21%	PRISM III: 0.94 PELOD II: 1.31	PRISM III: 0.92 PELOD II: 0.94	PRISM III: 0.282 PELOD II: 0.022
Slater et al.[20] 2003/ Austria, New Zealand	PIM PIM II PRISM PRISM III	2000-2001 26966 patients	Prospective	4.2%	PIM: 0.86 PIM II: 0.97 PRISM: 0.53 PRISM III: 0.77	PIM: 0.89 PIM II: 0.90 PRISM: 0.90 PRISM III: 0.93	PIM: <0.0001 PIM II: <0.025 PRISM: <0.0001 PRISM III: <0.0001
Tyagi et al.[21] 2018/ India	PIM II PIM III PRISM III	350 patients 18-month period	Prospective	39.4%	PIM II: 1.06 PIM III: 1.09 PRISM III: 0.9	PIM II: 0.728 PIM III: 0.726 PRISM III: 0.667	PIM II: 0.474 PIM III: 0.059 PRISM III: 0.747
Visser et al.[22] 2013/ Holland	PIM PIM II PRISM PRISM III	2006-2009 12040 patients	Retrospective	3.42%	PIM: 0.81 PIM II: 0.85 PRISM: 0.52 PRISM III: 0.87	PIM: 0.83 PIM II: 0.85 PRISM: 0.88 PRISM III: 0.90	
Nasser et al.[23] 2020/ Egypt	PRISM III PIM III	2015-2016 100 patients	Prospective	17%	PRISM III: 2.11 PIM III: 2.44	PRISM III: 0.987 PIM III: 0.973	PRISM III: 0.0001 PIM III: <0.0001
Jung et al.[24] 2018/ Korea	PIM II PIM III PRISM III	2009-2015 503 patients	Retrospective	19.8%	PIM II: 0.84 PIM III: 1.11	PIM II: 0.796 PIM III: 0.826 PRISM III: 0.775	PIM II: 0.249 PIM III: 0.337 PRISM III: 0.498
Zhang et al.[25] 2021/ China	PRISM III PELOD II	2014-2019 1253 patients	Retrospective	8.9%		PRISM III: 0.858 PELOD II: 0.721	PRISM III: 0.368 PELOD II: 0.276

SMR: Standardized mortality rate, AUC&: Area under the curve

non-homogeneous groups, and the facilities of the units are not sufficiently comparable. Similar to this study, although the discrimination of the PRISM III score was found to be good in studies in which the PRISM III score was evaluated, the calibration of the PRISM III score was not evaluated in one of the studies, and the calibration of the test was reported to be poor in another study conducted by Oymak and Bayrakci.[11,12] In the evaluation of expected and observed mortality rates in this study, both the calibration and discrimination of PRISM III and PIM II scores were found to be good. Similar to the studies conducted in our country, the results obtained in studies conducted outside the countries where the tests were developed are not homogeneous (Table 6).

There are also differences in the discrimination and calibration results of the tests in the studies conducted on the specific groups. Köner et al.[13] reported that the discrimination and calibration of the PIM II score was good in children followed up in the intensive care unit after congenital heart surgery, whereas the discrimination of the baseline and peak mSOFA score was superior to the PIM II score in predicting mortality. No comparison was made with the PRISM score in this study.[13] In another study conducted in the USA in children followed up for surgical and medical heart disease, it was detected that the PRISM III score was good in distinguishing mortality. However, when evaluated in terms of calibration, the expected mortality was lower than the observed in cardiac pathologies with lower risk and higher than the observed in pathologies with higher risk; therefore, the calibration was not good in the study group.[14] Kesici et al.[15] reported that the calibrations of PRISM III and PIM II scores were not good in children, all of whom were followed up on mechanical ventilators, and that the use of oxygenation index as a criterion in this group might be beneficial. In a retrospective study including 338 patients in a pediatric intensive care unit in Brazil where cancer patients were followed, mortality was reported as 18.34%, SMR as 0.78 and AUC as 0.71 for PRISM III score, and SMR as 0.77 and AUC as 0.76 for PIM II score. It was concluded that they were well calibrated, but they calculated the expected mortality higher.[16]

When PRISM, PIM and PELOD scores in 398 patients followed up for sepsis were evaluated together with their current and old versions, PIM score predicted lower mortality, and AUC

area values obtained in ROC analysis with PRISM III, PIM II and PELOD II scores were 0.75, 0.78 and 0.75, respectively.[17] The group included in our study did not consist of a homogeneous disease group, and the results obtained may have been affected by the distribution of the subgroups. In order to minimize this problem, patients with proven genetic disorders who underwent bone marrow transplantation, who were shown in previous studies to have unique risk factors, were excluded from the study group in this study.

Study Limitations

The most important limitation of this study is that it is a single-centered and retrospective evaluation and updated versions of the used scores are available. PRISM IV and PIM III scores have been developed and made available. On the other hand, in a study using the same scores, it was reported that the discrimination of PRISM IV and PIM III scores was not better than the previous versions, and the AUC values (0.70 and 0.76 for PRISM IV and PIM III, respectively) were similar.[17] The results obtained in our study could not be compared with other scoring systems and newer versions of existing scores.

Conclusion

In this study, it was shown that the discrimination and calibration of PRISM III and PIM II scores were good in a tertiary pediatric intensive care unit where medical and surgical patients were accepted. Discrimination and calibration of newly developed versions of these scores and less commonly used updated scores such as PELOD II and mSOFA should be evaluated in a multicenter national study. In this way, the scientific outputs of studies conducted in different units and on relatively small groups can be interpreted more accurately and used in the development of health policies.

Ethics

Ethics Committee Approval: Consent was obtained for the study with the decision of the Akdeniz University Faculty of Medicine Clinical Research Ethics Committee, dated 09/04/2019 and numbered 70904504.

Informed Consent: Informed consent was obtained.

Peer-review: Externally and internally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: B.U.G., O.D., N.Ü.T., L.D., Concept: B.U.G., O.D., Design: B.U.G., O.D., Data Collection or Processing: B.U.G., O.D., Analysis or Interpretation: B.U.G., O.D., N.Ü.T., L.D., Literature Search: B.U.G., O.D., N.Ü.T., Writing: B.U.G., O.D., N.Ü.T., L.D.

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