Implementation of the Pediatric Index of Mortality 3 and the pediatric Sequential Organ Failure Assessment in an intensive care unit in Mexico

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ABSTRACT

Introduction. The study objective was to analyze the Pediatric Index of Mortality 3 (PIM 3) and the pediatric Sequential Organ Failure Assessment (pSOFA) for the prediction of mortality.

Methods. Observational, prospective study; patients aged 1 month to 17.9 years were included. Assessment of area under the curve (AUC) accuracy and estimation of standardized mortality rate.

Results. A total of 244 admissions were studied: median age was 60 months. The main diagnoses were solid or hematologic neoplasms (26.5%). The mortality by admission was 18% (44/244). The AUC was 0.77 for PIM 3 and 0.81 for pSOFA; both scales showed an adequate calibration ($p > 0.05$). The standardized mortality rate was 1.91.

Conclusions. We identified that the PIM 3 and pSOFA have an acceptable discrimination power. The calibration of the PIM 3 was not adequate in patients with solid or hematologic neoplasms.

Key words: *mortality, child mortality, infant mortality, pediatric intensive care unit.*

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INTRODUCTION

The pediatric index of mortality (PIM) is a model that has been implemented to assess patient severity on admission to the pediatric intensive care unit (PICU) and for the prediction of mortality.[1,2] The pediatric Sequential Organ Failure Assessment (pSOFA) is an adaptation of the instrument used in adults to assess sepsis-related organ dysfunction.[3] Matics et al. described their use to estimate the risk for mortality in children.[4]

Both instruments include clinical and paraclinical variables, and their implementation is feasible. Although different studies have described that their predictive and discriminatory power is adequate, these instruments have not been validated in Mexican children. The study objective was to analyze the PIM 3 and pSOFA for predicting mortality at a PICU in Mexico.

MATERIAL AND METHODS

This was an observational, prospective study conducted at Hospital Civil de Guadalajara Dr. Juan I. Menchaca (HCGJIM) in Jalisco, Mexico. This hospital provides services to an open, low-resource population.

Consecutive patients aged 1 month to 17.9 years who were admitted to the PICU from December 2019 to July 2021 were studied. On admission, a complete physical examination was performed and samples for laboratory tests were collected: blood count, blood gases, glycemia, blood electrolytes, coagulation tests, liver and kidney function tests.

The risk for mortality was estimated using the PIM 3 and the pSOFA. The information was collected on admission to the unit.

For the PIM 3, the coefficients and formula proposed by Straney et al. were used.[2] The following variables were recorded: systolic blood pressure (mmHg), pupil reaction to light (mm), arterial base excess (mmol/L), invasive ventilation (any modality), fraction of inspired oxygen (FIO_2, %), oxygen pressure in arterial

blood (PaO_2, mmHg), elective admission, and diagnosis classified into low risk, high risk or very high risk. In cases with specific conditions, such as cardiorespiratory arrest events, the adjustments recommended in the latest update of the PIM 3 formula were made.

The pSOFA included the following indicators: respiration (PaO_2/FiO_2 or oxygen saturation/FiO_2), coagulation (serum platelets × 10^3/mL), liver (serum bilirubin, mg/dL), cardiovascular (mean blood pressure or administration of vasoactive drugs), central nervous system (pediatric Glasgow score), and renal (serum creatinine, mg/dL). A score of 1 to 4 points was assigned to each indicator; the maximum value for parameters was 24; a higher severity results in a higher score. The values for each age group and the score were in accordance with those published by Travis.[4]

Definitions

Discrimination. Power of the scales to correctly classify patients according to their risk for mortality. The estimated parameter was the area under the curve (AUC); a value ≥ 0.70 was considered acceptable.

Calibration. Level of agreement between observed results and individual probabilities. It was analyzed using the Hosmer-Lemeshow goodness-of-fit test; a p value > 0.05 was considered an adequate calibration.

Standardized mortality ratio (SMR). It is estimated by dividing the observed mortality rate by the estimated mortality, taking as a reference the mortality predicted by the PIM 3. Values close to a unit indicate a better correlation between predicted and observed mortality.

Statistical analysis

The frequency of mortality among patients admitted to the PICU was estimated. Qualitative variables were described as frequency and percentage; whereas quantitative variables, as median and interquartile range (IQR). As hypothesis contrasting tests, the χ^2 test was used to compare proportions and the Mann-Whitney U test, to compare median values. To analyze the association between mortality and each of the parameters of the PIM 3 and pSOFA scales, a bivariate analysis was performed and odds ratios (OR) and 95% confidence intervals (CIs) were estimated. Calibration was verified using the Hosmer-Lemeshow goodness-of-fit test. The IBM SPSS® Statistics software, version 20.0, and the OpenEpi® software (http://openepi.com/Menu/OEMenu.htm) were used.

The project was approved by the Ethics and Research Committees of HCGJIM under registry no. 0362/20.

RESULTS

During the study period, 244 admissions of 207 patients were recorded; their median age was 60 months (maximum: 215, minimum: 1, IQR: 125); 57.5% (119/207) were males and 42.5% (88/207), females. The median length of stay in the PICU was 4 days (maximum: 180, minimum: 0.01, IQR: 5). In addition, 14% (29/207) of cases were admitted to the PICU more than once.

Prevalent diagnoses were solid or hematologic neoplasms (26.5% [55/207]), lower respiratory tract infections (12.6% [26/207]), genetic disorders (10.1% [21/207]), burn wounds (8.2% [17/207]), central nervous system infections (5.8% [12/207]), and chronic kidney disease (5.3% [11/207]). The most common causes for admission to the PICU were shock (31.1% [76/244]), respiratory failure (18.4% [45/244]), and status epilepticus (7.8% [19/244]).

The overall mortality for all admissions was 18% (44/244). The main causes were solid or hematologic neoplasms (38.6% [17/44]), pneumonia (13.6% [6/44]), and poisoning- or burn-related accidents (11.3% [5/44]).

In relation to the PIM 3, the bivariate analysis showed an association with mechanical ventilation, lower systolic blood pressure, higher FiO_2, and the classification of diagnosis on admission. For the pSOFA, an association with all indicators was identified *(Table 1)*.

In the discrimination analysis, the PIM 3 showed an AUC of 0.77 (95% CI: 0.70–0.84; $p < 0.001$) and the pSOFA, an AUC of 0.81 (95% CI: 0.75–0.88; $p < 0.001$).

According to the goodness-of-fit test, both scales showed an adequate calibration ($p > 0.05$) *(Figure 1)*, except in children with solid or hematologic neoplasms. In them, the correlation between estimated and observed probabilities was inadequate for the PIM 3 ($p = 0.02$).

SMR was estimated at 1.91 (95% CI: 1.16–3.21, observed mortality: 18%, expected mortality: 9.4%). The sub-group analysis showed a higher excess mortality in children with chronic kidney disease (SMR: 3.5), solid or hematologic neoplasms (SMR: 2.8), nosocomial infections (SMR: 2.7), and more than 1 admission to the PICU (SMR: 3).

DISCUSSION

We identified that the PIM 3 and pSOFA mortality assessment scales show an acceptable discrimination power in Mexican children; the results are similar to those described by different authors in Asia and Latin America.[5,6]

Arias-López et al.,[6] in a multicenter study conducted in a PICU of Argentina, described that the PIM 3 showed an adequate discrimination (AUC: 0.83) and, in the sub-group analysis, estimated a SMR of 1.54 for children with complex chronic diseases.

In infants at HCGJIM, the main cause of admission to the PICU and mortality were blood diseases and cancer. In these patients, mortality was significantly different from that predicted by the PIM 3. It is likely that the state of immunosuppression and the chronic course of these diseases favor infectious and/or metabolic complications that increase the risk of mortality during the PICU stay.

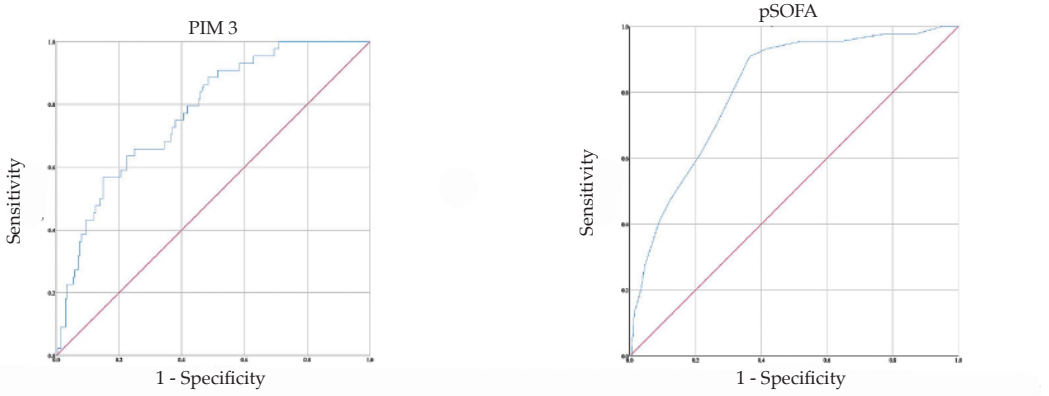
Lee OJ et al.[7] observed that, although the PIM 3 showed an adequate calibration in children with cancer, it did not have an adequate discrimination

TABLE 1. *Association of PIM 3 and pSOFA parameters with mortality in patients admitted to the pediatric intensive care unit*

PIM 3		pSOFA		
	OR (95% CI)			**OR (95% CI)**
Systolic blood pressure (mmHg)	0.97 (0.96–0.99) *	**Respiration**	Points	1.6 (1.25–2.07) *
Pupils fixed to light > 3 mm	2.33 (0.41–13.15)	**Coagulation**	Points	1.5 (1.20–1.86) *
FiO_2 x 100/PaO_2 (%)	6.81 (2.04–22.7) *	**Liver**	Points	1.35 (1.002–1.8) *
PaO_2 (mmHg)	0.99 (0.99–1.003)	**Cardiovascular**	Points	1.62 (1.34–1.96) *
Arterial base excess (mmol/L)	1.04 (0.99–1.09)	**Central nervous system**	Points	1.30 (1.01–1.68) *
Mechanical ventilation	3.90 (1.73–8.83) *	**Renal**	Points	1.38 (1.1–1.72) *
Elective admission	0.20 (0.01–3.51)			
Low-risk diagnosis	0.25 (0.05–1.07)			
High-risk diagnosis	3.1 (0.5–19.1)			
Very high-risk diagnosis	2.44 (1.2–4.9) *			
Risk for mortality PIM 3 (%)	1.05 (1.02–1.07) *	**Total, pSOFA**	Points	1.32 (1.20–1.46)

PIM 3: Pediatric Index of Mortality 3; pSOFA: pediatric Sequential Organ Failure Assessment; OR: odds ratio; CI: confidence interval; mmHg: millimeters of mercury; FiO_2: fraction of inspired oxygen; mmol/L: millimoles per liter.
* Statistically significant association $p < 0.05$.

FIGURE 1. *Discrimination power of the PIM 3 and the pSOFA for predicting mortality*



AUC: 0.77 (95% CI: 0.70–0.84 p < 0.001)
Hosmer-Lemeshow test (p = 0.12)

AUC: 0.81 (95% CI: 0.75–0.88 p < 0.001)
Hosmer-Lemeshow test (p = 0.28)

PIM 3: Pediatric Index of Mortality 3; pSOFA: pediatric Sequential Organ Failure Assessment; OR: odds ratio; CI: confidence interval; AUC: area under the curve.

power (AUC: 0.66) and, similar to our results, noted that mortality in children with these conditions was higher. In Mexico, Morales-García et al.[8] described an AUC of 0.76 and an adequate calibration for the PIM 2.

In Latin American PICUs, the average mortality is 13.3%; however, the indicator differs depending on the characteristics of the patients and the health care infrastructure in each country.[9] Similar to our results, Mohamed El-Mashad et al.[10] observed that the pSOFA is more accurate than the PIM 2 in predicting mortality.

The implementation of mortality scales allows to assess the quality of care of children admitted to the PICU,[11–14] so it is relevant to carry out multicenter studies that include a more robust sample and allow to obtain accurate results. The limitations of this study are the small number of patients and the fact that it was carried out in a single hospital.

CONCLUSION

The PIM 3 and pSOFA scales for predicting mortality have an acceptable discrimination power. In children with cancer, the PIM 3 did not show an adequate calibration. ■

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