The pediatric index of mortality 3 score to predict mortality in a pediatric intensive care unit in Palembang, South Sumatera, Indonesia

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Abstract

Background For critically ill patients in the pediatric intensive care unit (PICU), a scoring system is helpful for assessing the severity of morbidity and predicting the risk of mortality. The Pediatric Index of Mortality (PIM) 3 score consists of ten easy simple variables, so that the probability of death can be assessed prior to undergoing advanced therapies. The PIM 3 score in inexpensive and comprised of routine laboratory variables performed in PICU patients. In Indonesia, studies to validate the PIM 3 score have been limited.

Objective To evaluate the PIM 3 score for predicting the probability of death in the PICU, Dr. Mohammad Hoesin Hospital (MHH), Palembang.

Methods A prospective, cohort study was performed in the PICU, MHH, Palembang, from February to April 2016. The PIM 3 score was calculated within 2 hours of patients admission to the PICU by an android calculator application. PIM3 score and mortality were analyzed by Mann-Whitney test; calibration was performed by Hosmer-Lameshow goodness of fit test, discrimination was done by receiver operating characteristic (ROC) curve analysis; and standardized mortality ratio (SMR) was calculated.

Results During the study period there were 81 PICU patients, 69 children were included, ranging in age from 1,5 to 187 months. The overall mortality rate was 40,58%. The most common illnesses in our subjects were malignancy (17,4%), post non-thoracic surgery (14,5%), dengue shock syndrome (14,5%), respiratory disease (13%), and neurological disease (11,6%). Subjects’ PIM3 scores ranged from 1,02% to 58,84%, with means of 26,08% in non-survivors and 13,05% in survivors. The SMR was 2,24, indicating that death was underpredicted. The AUC of 0,771 (95% CI of 0.651 to 0.891) indicated that the PIM3 score had good discrimination.

Conclusion In Mohammad Hoesin Hospital, Palembang, South Sumatera, the PIM 3 can be used to predict mortality in PICU patients, but the score should be multiplied by a factor of 2.24. This recalibration is needed due to the presumed lower standard of care at this hospital compared to that of the originating PIM 3 institutions in developed countries. [Paediatr Indones. 2017;57:164-70; doi: http://dx.doi.org/10.14238/pi57.3.2017.164-70 ].

Keywords: PIM3 score; probability of mortality; PICU MHH Palembang

The hospital pediatric intensive care unit (PICU) has special staff and equipment to care for critically-ill or injured children aged 0 to 18 years (except neonates) in order to identify primary disease process and to support patients at risk for organ dysfunction.1 PICU patients often have unclear prognoses and mortality rates may be dependent on PICU staff and procedures. A scoring system for illness severity is useful for objectively predicting the outcomes and prognoses of PICU patients.2-8

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Since 1980, there are various scoring systems have been used, such as the Pediatric Risk of Mortality (PRISM), Pediatric Logistic Organ Dysfunction (PELOD), and Pediatric Index of Mortality (PIM) tests. The newest version are PRISM III, PELOD 2, and PIM 3, respectively.9-13 The first version of PIM was developed at 1997 in Australia and the United Kingdom. The second model, PIM 2, was developed using data collected from 13 PICU in 1997 and 1999 in Australia, New Zealand, and the United Kingdom.14-15 The newest iteration, PIM 3, was developed in 2010-2011 by Straney et al. Discrimination of PIM3 was 0.88, compared to as high as 0.90 in PIM 2. The PIM 3 mortality risk was 3.9% in Scotland and England, and 2.9% in Australia and New Zealand. The difference may have been due to individual PICU performance or facilities, as well as the health status of the population.13

The PIM 3 scoring system has some advantages compared to other scoring systems. The PIM 3 consists of 10 simple variables which are easy to assess, can predict mortality before patients receive advanced therapy, are from routin PICU examinations, and are not prohibitively expensive to be used in a developing country.14 In Indonesia, the PIM 3 model has yet to be validated, so we do not know if mortality predictions by PIM 3 in Indonesia are similar to those in developed countries. The objective of this study was to evaluate the utility of PIM 3 as a mortality predictor in the PICU, Mohammad Hoesin Hospital (MHH), Palembang, South Sumatera.

Methods

We conducted a prospective, cohort study in our PICU from February to April 2016. Inclusion criteria were critically ill PICU patients with reliable laboratory findings corresponding to the PIM 3 score variables, and whose parents provided informed consent. Patients who stayed in the PICU for less than 1 hours were excluded.

Collected data at admission included age, sex, weight, length, nutritional status, diagnosis, and PIM 3 variables such as systolic blood pressure and pupillary reaction to bright light. Our variables assessed were partial oxygen tension (PaO2) and FiO2 at the same time of PaO2 if oxygen was given by endotracheal tube, non-invasive ventilation, or headbox; base excess in arterial blood gas analysis, type of mechanical ventilation at any time during the first hour of PICU admission, elective admission to PICU, recovery from surgery or a procedure was the main reason for ICU admission, presence of low-risk diagnosis, high-risk diagnosis, or very high-risk diagnosis. Definitions of these variables and the scoring method were according to PIM 3 developers’ guidelines.13

Scores were calculated using PIM 3 calculator application from Australian and New Zealand Intensive Care Society (AZNICS).16 Data was entered into Microsoft Excel 2007 and analyzed using SPSS version 16.0 software. We analyzed for an association between PIM 3 score and mortality. The performance of PIM3 score was assessed by calibration and discrimination. Calibration evaluated PIM 3 at different risks of mortality, and was assessed by Hosmer–Lemeshow table. Standardised mortality ratio (SMR) was calculated to mean probability of death and the ratio of observed to expected death rates. Discrimination evaluated how well PIM distinguished between patients who survived and died, and was assessed using the area under the curve from the ROC plot. The study was approved by the Ethics Committee of the Sriwijaya University Medical School.

Results

Over the study period, 81 patients were admitted to the PICU, but data were collected from only 69 subjects who qualified based on inclusion criteria. Of these 69 subjects, 28 (40.58%) died. Subjects’ median age was 89 months, with the highest mortality in the 60-119 month group (45.83%). The majority of subjects were boys (59.4%). About a half (43.5%) of the children had good nutritional status, while non-survivors had malnutrition and undernutrition (50%). The most common underlying disease for PICU admission was malignancy (17.4%), but the mayor cause were central nervous system and burns (8/8 and 1/1, respectively. Demographic features and clinical course of subjects related to outcome are provided in Table 1.

Subjects’ PIM 3 scores ranged from 1.02% to 58.84%, with mean and median scores of 18.34% and 13.05%, respectively. Most subjects were in the 5-20% score interval. No subjects had scores of less than
Distribution of PIM 3 scores related to outcomes

| PIM 3 score interval by group, n(%) | All patients (N=69) | Non-survivors (n=28) | Survivors (n=41) |
|-----------------------------------|---------------------|----------------------|------------------|
| 1-5%                              | 12 (17.4)           | 3                    | 9 (22)           |
| 5-20%                             | 36 (52.2)           | 11                   | 25 (61)          |
| 20-30%                            | 8 (11.6)            | 4                    | 4 (9.7)          |
| >30%                              | 13 (18.8)           | 10                   | 3 (7.3)          |

PIM 3 score related to outcome

| Outcome                | N   | Median PIM 3 score (range), % |
|------------------------|-----|------------------------------|
| Non-survivors         | 28  | 21.4 (2.7-58.8)              |
| Survivors             | 41  | 11.4 (1.0-53.9)              |

Table 3 shows the SMR calibration of the PIM 3 model based on four PIM 3 score intervals of 1-5%, 5-20%, 20-30%, and >30%. The overall SMR was 2.24. The expected mortality rate based on PIM 3 score was 18.1%, less than the actual percentage observed (40.5%).

The PIM 3 score was divided in quartiles of risk, by range interval of 14.45. The SMRs in each quartiles of risk group were >1, which meant mortality was underpredicted. The AUC curve analysis showed a good discriminatory ability of the PIM 3 score in 44.38-58.84% interval group to distinguish between survivors and non-survivors (AUC>70%) (Table 5).

Table 6 shows that SMRs in overall demographic and clinical course group were >1, except for predicting mortality in the subgroups of post-surgical procedure other than thoracic surgery, others illnesses (snake bite, diabetic ketosis, and post thoracic surgery), and respiratory system.
Table 7 and Figure 1 show the area under the curve of PIM 3 score ROC analysis. The AUC of the PIM 3 score was 0.771 (95% CI 0.67 to 0.75), and the AUC of the PIM 3 quartiles of risk was >0.7 (0.715). An AUC of 70-80% is considered to be accurate for predicting death and survival.

Discussion

Our study investigated 69 PICU patients at MHH, Palembang, South Sumatera, during a 3 months period, in order to evaluate the performance of PIM 3, in terms of calibration and discrimination ability.
Table 7. Discrimination of PIM 3 and PIM 3 quartiles of risk as related to death

| Variables                  | AUC  | SE    | 95%CI         |
|----------------------------|------|-------|---------------|
| PIM 3 score                | 0.771| 0.061 | 0.651 to 0.891|
| PIM 3 quartiles of risk    | 0.715| 0.003 | 0.585 to 0.845|

The prevalence of mortality in our PICU was 40.58%, similar to that of Honna et al (45.7%).

The prevalence of PICU mortality was also similar to that from India in 2011 (46.2%), but higher than in Pakistan in 2006 (28.7%), Iran in 2008 (15%), and Egypt in 2013 (8.5%).

The PIM 3 model uses score variables to get a percentage of mortality probability. Overall, in the originating studies, the PIM 3 mortality risk were 3.9% in Scotland and United Kingdom and 2.9% in Australia and New Zealand. Validation of the PIM3 model has never been done in a developing country, but validation of the second iteration of PIM (PIM 2) was done in in Iran, Pakistan, India, and Africa.

We found that PIM 3 scores in non-survivors ranged from 2.73% to 58.84% with a mean of 26.08%. For survivors, mean PIM 3 score was 11.38%, ranging from 1.02-53.9%. Most subjects (52.17%) were in the 5-20% range. Higher PIM 3 score means higher mortality probability. Of those with PIM 3 scores >30% score, 76.9 died, while 23.1% survived. Mann-Whitney test revealed a statistically significant difference in PIM 3 score between non-survivors and survivors (P=0.0001). This mortality probability was much higher than documented rates at others PICUs where validation of ordinary prognostic scores had been undertaken. As such, the standard of care in our PICU may be worse then PICUs in developed countries. The following factors may influence PICU performance: differences of clinical characteristics, demographic population, health status, human sources (nurse to patient ratio, human exhaustion factor, subjective factors in evaluating PIM 3 score, the doctor’s ability in treat and make accurate and timely decisions related to clinical condition, as well as nursing skill in getting arterial blood specimens), and validity of the laboratory for measuring based excess.

Figure 1. ROC Curve Analysis for PIM3 Scores

The calibration of the PIM3 model using SMR was calculated by dividing the number of observed deaths by the number of expected deaths. Chi-square statistical analysis was performed with the formula: \( \Sigma(O-E)^2/E \), in which is O=observed and E=expected, for survivors and non-survivors in each interval group. Then we used Hosmer and Lemeshow test for goodness-of-fit based on the four PIM3 score interval group of 1-5%, 5-20%, 20-30%, and >30%. The SMRs for all interval was >1, ranging from 1.7-2.2, except for the 1-5% group which had SMR 7.5, indicating that the actual mortality was 7.5 times higher than expected in the 1-5% interval group. Multiple factors may have influenced these results, such as poor referral system, delayed initial therapy.
or complications which could have changed outcome, such as hospital-acquired infection, malnutrition caused by hospitalization, or ventilator-associated pneumonia. The ability of PIM 3 to predict mortality was 18.07%, which was less than the actual observed mortality of 40.5%. The overall SMR was 2.24, which meant that the PIM 3 model underpredicted deaths in our facility. As such, the mortality probability was 2.24 times higher in MHH compared to the original PIM 3 score. Other studies in developing countries like India, Pakistan, and Egypt reported SMRs from PIM 2 scores of 3.3, 1.57, and 1.92, respectively. On the other hand, a Japanese study reported PIM 2 SMR <1 (0.77), which meant the score had overpredicted mortality.

The discrimination was evaluated by AUC. Discrimination is considered to be very good for ROC >0.9, good for 0.80–0.90, and fair for 0.70–0.80. The AUC was calculated as 0.771 (95%CI 0.651 to 0.951), lower than AUC in the original places where PIM 3 score was undertaken. However, AUCs were found in developed countries as follows: Australia 0.91, New Zealand 0.90-0.93, United Kingdom 0.85, and Scotland 0.84-0.86. Studies of PIM2 in developing countries in Africa showed good discrimination with AUC values of 0.841 (95%CI 0.78 to 0.90), Pakistan 0.81 (95%CI 0.75 to 0.87), and Iran 0.795 (95%CI 0.715 to 0.875).

In conclusion, PIM 3 score has quite good calibration in our set-up. The PIM 3 score can be used in PICU, MHH, Palembang by correcting for the expected probability of death by multiplying the original PIM3 score by 2.24. This calibration needs to be done due to the presumed lower standard of care at MHH compared to the standards in the originating PIM 3 institutions. The standard of care may be influenced by multiple factors, such as clinical characteristics, demographic population, health status, human resources, medical equipment, good laboratory, and more.

**Conflict of Interest**

None declared.

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