Paediatrica Indonesiana

p-ISSN 0030-9311; e-ISSN 2338-476X; Vol.60, No.6(2020). p.328-33; DOI: 10.14238/pi60.6.2020.328-33

Original Article

Pediatric Index of Mortality 3 score as a predictor for the outcomes of critically ill patients

Gusti Ayu Nyoman Yulia Sitta Dewi, Dyah Kanya Wati, Made Gede Dwi Lingga Utama, Ketut Suarta, I Gusti Ngurah Sanjaya Putra, Made Sukmawati

Abstract

Background The ability to predict mortality in critically ill patients is important for assessing patient prognosis, evaluating therapy, and assessing intensive care unit quality. The *Pediatric Index of Mortality* (PIM) 3 is a scoring system to predict outcomes in order to assist clinical decision-making.

Objective To assess the ability of PIM 3 to predict outcomes of critically ill PICU patients.

Methods This prospective cohort study included 150 children aged 1 month to 18 years who were admitted to the pediatric intensive care unit (PICU), Sanglah Hospital, Denpasar, Bali. Subjects were grouped into two based on ROC curve PIM score ≥48 and <48. The PIM 3 score was consisted of 10 variables, with a re-diagnosis classification of the PIM 2 score. Bivariate analysis was conducted to both groups to find the distribution of mortality in both groups, followed by homogenity test on variables gender, age, nutritional status, lenght of stay and mechanical ventilation. Variables which made the cut on bivariate test were included in multivariate analysis.

Results The optimal PIM 3 score limit in predicting mortality was ≥48, with area under the curve (AUC) 76% (95%CI 0.69 to 0.85). Multivariate analysis revealed a 2.48 times increased risk to mortality in patients with PIM 3 score ≥48 (95%CI 1.6 to 3.7). In addition, PICU length of stay ≤7 days was a significant risk factor for mortality.

Conclusion The PIM 3 has a good ability to predict the outcome of critically ill PICU patients. Critically ill patients with PIM 3 score ≥48 have a higher risk of mortality compared to those with PIM 3 < 48. **[Paediatr Indones. 2020;60:328-33; DOI: 10.14238/pi60.6.2020.328-33**].

Keywords: *pediatric index mortality 3 scores; critically ill; prognosis outcomes; pediatric intensive care units*

Critical illness is a life-threatening disturbance in the body's homeostasis, often comprising any severe problem of the airway, breathing, or circulation, or acute deterioration of the conscious state.[1-3] Mortality prediction in critical illness is important for prognosis estimation, therapy evaluation, and monitoring PICU quality. Physicians may evaluate the patient condition inconsistently or inaccurately, hence, a quantitative clinical score provides a more objective method of assessment.[4] Such scoring systems are used to assess disease severity and prognosis, as well as help in clinical decision-making.

The pediatric index of mortality (PIM) is one of the most commonly used scoring systems to predict mortality. It is simple, requires less data compared to the other tools, and has no licensing fee. The original PIM score was revised into the PIM 3 version, using

From Department of Child Health, Universitas Udayana Medical School/ Sanglah Hospital, Denpasar, Bali, Indonesia.

Corresponding author: Dyah Kanya Wati, Department of Child Health, Medical Faculty of Udayana University / Sanglah Hospital, Denpasar, Bali, Indonesia, Pulau Nias Street, Denpasar - 80114, Indonesia. Telp. +62-361-244038; Fax. +62-361-244038; Email: yulia.sittadewi@gmail.com.

Submitted March 20, 2020. Accepted November 13, 2020.

large amounts of data from the *Australian and New Zealand Paediatric Intensive Care Registry* and the *Paediatric Intensive Care Audit Network National Report 2009-2011*.[5]

Study on the usefulness of PIM 3 as a predictor of death in critically ill children in the PICU has been limited. As such, we aimed to assess the ability of PIM 3 to predict outcomes of critically ill PICU patients at Sanglah Hospital, Denpasar, Bali.

Methods

This prospective cohort study included children aged 1 month to 18 years who were admitted to the PICU, Sanglah Hospital, Denpasar, Bali, from February to December 2018. Subjects were rated by the PIM 3 within 1 hour of PICU admission. Nutritional status was defined based on Waterlow's criteria using the following formula: body weight/ideal body weight x 100%. Subject then classified as obese (>120%), overweight (110-120%), well nourished (90-110%), moderate malnutrition (70-90%), and severe malnutrition (<70%).

The PIM 3 components are shown in **Table 1**. Patients with brain stem death, incomplete data, or death within 1 hour of PICU admission were excluded. Subjects were followed until PICU discharge and evaluated on the outcome of survived *vs.* died. The PIM 3 score calculation was done with formulation in **Figure 1**.

The minimum required sample size was calculated to be 150 patients using a formula for unpaired categorical comparative analysis, with beta 80% and alpha 0.05.[6] Data analysis consisted of descriptive statistical analysis, determining the PIM 3 cut-off score by observing the AUC from the receiver operating characteristic (ROC) curve, as well as bivariate and

Table 1. The full outline of unresponsiveness score[7]

PIM 3 components
1. Systolic blood pressure (SBP) (mmHg). (cardiac arrest=0, 30=shock/pre-shock, unknown=120)
2. Pupillary reactions to bright light (>3 mm and both fixed=1, other or unknown=0)
3. ([FiO2 x 100]/PaO2). PaO2 mmHg, FiO2 at the time of PaO2 if oxygen via endotracheal tube or headbox (FiO2 or PaO2 unknown, [(FiO2 x 100)/PaO2] = 0.23) (unknown = 0)
4. Base excess in arterial or capillary blood, mmol/L (unknown =0)
5. Mechanical ventilation at any time during the first hours in ICU (no = 0, yes = 1)
6. Elective admission to ICU (no = 0, yes = 1)
7. Recovery from surgery or procedure is the main reason for ICU admission [0] No [1] Yes, recovery from a bypass cardiac procedure [2] Yes, recovery from a non-bypass cardiac procedure [3] Yes, recovery from a non-cardiac procedure
8. Low-risk diagnosis. Record the number in brackets. If in doubt record 0. [0] None [1] Asthma is the main reason for ICU admission [2] Bronchiolitis is the main reason for ICU admission [3] Croup is the main reason for ICU admission [4] Obstructive sleep apnea is the main reason for ICU admission [5] Diabetic ketoacidosis is the main reason for ICU admission [6] Seizure disorder is the main reason for ICU admission
9. High-risk diagnosis. Record the number in brackets. If in doubt record 0. [0] None [1] Spontaneous cerebral hemorrhage [2] Cardiomyopathy or myocarditis [3] Hypoplastic left heart syndrome [4] Neurodegenerative disorder [5] Necrotizing enterocolitis is the main reason for ICU admission
10. Very high-risk diagnosis. Record the number in brackets. If in doubt record 0. [0] None [1] Cardiac arrest preceding ICU admission [2] Severe combined immune deficiency [3] Leukemia or lymphoma after first induction [4] Bone marrow transplant recipient [5] Liver failure is the main reason for ICU admission

PIM3val = [3.8233 * pupils] – [0.5378 * elective] + [0.9763 * mech. vent.] + [0.0671 * absolute BE] – [0.0431 * SBP] + [0.1716 * (SBP * SBP/1000)] + [0.4214 * (100*FiO2/PaO2)] – [1.2246 * recov. card. byp. pr.] – [0.8762 * recov. non-byp. card. pr.] – [1.5164* recov. non- card. pr.] + [1.6225* VHRdiag] + [1.0725* HRpr] – ([2.1766* LRdiag] – 1.7928.

The mortality risk PIM3 score = ePIM3val / (1 + ePIM3val)

Figure 1. Formulation for PIM 3 score calculation

Notes: mech. vent.=mechanical ventilation, BE= base excess, SBP=systolic blood pressure, recov. card. byp. pr.=recovery from cardiac bypass procedure, recov. non-byp. card. pr.=recovery from non-bypass cardiac procedure, recov. non-card. pr.=recovery from non-cardiac procedure, VHRdiag=very high risk diagnosis, HRpr= high risk procedure, LRdiag=low risk diagnosis

multivariate analyses. The bivariate analysis to assess the risk of mortality was done by cross-tabulation in the form of risk ratio by Chi-square test. In addition, multivariate analysis was performed to assess the pure effect of PIM score in predicting mortality by logistic regression test. Results with P values <0.05 were considered to be significant.[6] Data were recorded and analyzed by *SPSS 19*. This study protocol was approved by the Ethics Committee of the Medical Faculty at Udayana University/Sanglah Hospital Denpasar, Bali.

Results

During the study period 150 patients met the inclusion criteria, while 3 patients were excluded due to brain stem death, incomplete data, or death within 1 hour of admission. Characteristics of subjects according to PIM 3 score group are shown in **Table 2**. Patients with PIM 3 score below the optimal cut-off score (83 subjects) predominated. The PIM 3 score ≥48 group mostly had subjects aged 10-18 years (22.4%), well-nourished nutritional status (43.2%), and used mechanical ventilation support (79.1%). The PIM 3 score <48 group mostly comprised subjects aged 1 month to 2 years (50.6%), and those with moderate malnutrition (50.1%). However, both groups were mostly male, with length of stay ≤7 days. In addition, respiratory problem disease predominanted the PIM 3 score ≥48 group, while surgery patients predominated the PIM 3 score < 48 group. Subjects with PIM 3 score >48 had 2.48 times higher mortality risk than those in the PIM 3 score <48 group (**Table 3**).

A homogeneity test revealed that all variables had the same distribution with regards to PIM 3 (**Table 4**). Bivariate analysis showed that nutritional status, length of stay, and mechanical ventilation were significantly different between the died and survived groups, with P value <0.25 (**Table 5**). Mechanical ventilation support had a very wide CI so it was excluded from multivariate analysis to avoid a multicolinearity effect. Multivariate analysis of PIM 3 score ≥48 and length of stay ≤7 days revealed that both had significantly increased risks of mortality (**Table 6**).

The optimal PIM 3 score for predicting mortality was ≥48, with AUC value of 76% (95%CI 0.69 to 0.85), as shown in **Figure 2**.

Table 2. Characteristics of subjects based on PIM 3 score

Characteristics	PIM 3 score	
	≥ 48 (n=67)	< 48 (n=83)
Age, n (%)		
1 month to <2 years	28 (41.8)	42 (50.6)
2-10 years	24 (35.8)	30 (36.1)
>10-18 years	15 (22.4)	11 (13.2)
Gender, n (%)		
Male	43 (64.2)	48 (58)
Female	24 (35.8)	35 (42)
Mechanical ventilation support, n (%)		
Yes	53 (79.1)	36 (43.3)
No	14 (20.9)	47 (56.7)
Nutritional status, n (%)		
Obese	4 (5.9)	6 (7.2)
Overweight	2 (2.9)	4 (4.8)
Well-nourished	29 (43.2)	25 (30.1)
Moderate malnutrition	27 (40.3)	42 (50.1)
Severe malnutrition	5 (7.5)	6 (7.2)
Length of stay, n (%)		
≤7 days	48 (71.6)	59 (71.1)
>7 days	19 (29.6)	24 (28.9)
Type of disease, n (%)		
Respiratory	21 (31.3)	17 (20.8)
Cardiovascular	1 (1.5)	16 (19.3)
Neurological	12 (17.9)	4 (4.8)
Hematology and oncology	9 (13.4)	1 (1.2)
Endocrine and metabolic	1 (1.5)	0 (0)
Gastrointestinal	1 (1.5)	0 (0)
Kidney and urinary tract	3 (4.5)	2 (2.4)
Infections	9 (13.4)	7 (8.4)
Surgery	8 (11.9)	36 (43.4)
Others	2 (3)	0 (0)

Table 3. Distribution of mortality based on PIM 3 score

Variables	Outcomes		RR	95%CI	P value
	Died	Survived			
PIM 3 score, n (%)					
≥48	42 (62.7)	25 (37.3)	2.478	1.639 to 3.745	<0.001
<48	21 (25.3)	62 (74.7)	-		

Discussion

In our study, most children who died in the PICU were ≤5 years of age (40.2%). A previous study also noted that children who died in the PICU were < 5 years (77.2%).[7] Young children have less mature immune systems, which increases their mortality risk.[7] Our subjects were predominantly males (64.2%), which was similar to previous studies which reported 59.3% and 66.66% males in the PICU, respectively.[7,8]

Table 4. Homogeneity analysis of PIM 3 score to mortality based on gender, age, nutritional status, length of stay, mechanical ventilation

Variables	RR specific	Homogeneity test
Gender		
Male	2.943	
Female	1.896	0.238
Age		
≤5 years	2.325	
>5 years	2.877	0.234
Nutritional status		
Severe malnutrition	3.000	
Not severe malnutrition	2.419	1.681
Length of stay		
≤ 7 days	2.786	
>7 days	1.684	2.260
Mechanical ventilation		
Yes	1.426	
No	2.478	0.869

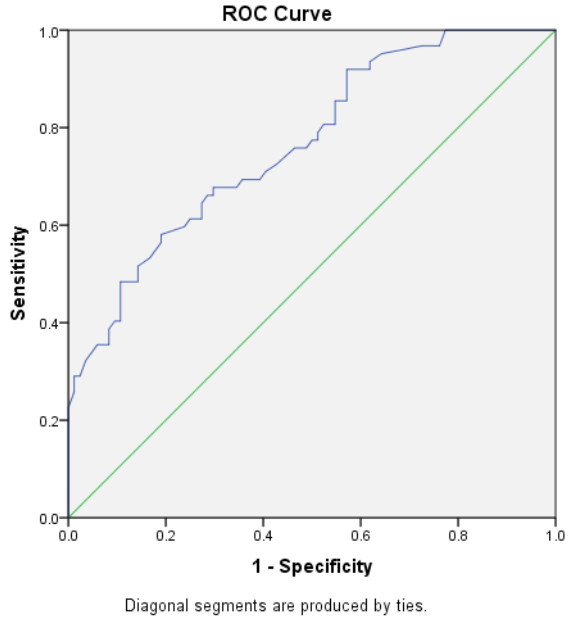

Figure 2. ROC curve of PIM 3 scores to predict mortality

Table 5. Bivariate analysis of mortality outcomes with gender, age, nutritional status, length of stay, and mechanical ventilation support

Variables	Outcomes		RR	95% CI	P value
	Died	Survived			
Gender, n (%)					
Male	40 (44)	51 (56)	1.128	0.76 to 1.67	0.547[a]
Female	23 (39)	36 (61)			
Age, n (%)					
≤ 5 years	41 (40.2)	61 (59.8)	0.877	0.595 to 1.293	0.514[a]
> 5 years	22 (45.8)	26 (54.2)			
Nutritional status, n (%)					
Severe malnutrition	7 (63.6)	4 (36.4)	1.580	0.967 to 2.579	0.203[b]
Not severe malnutrition	56 (40.3)	83 (59.7)			
Length of stay, n (%)					
≤ 7 days	49 (45.8)	58 (54.2)	1.407	0.873 to 2.266	0.137[a]
>7 days	14 (32.6)	29 (67.4)			
Mechanical ventilation, n (%)					
Yes	62 (69.7)	27 (30.3)	42.49	6.054 to 298.3	<0.0001[a]
No	1 (1.6)	60 (98.6)			

a=Chi-square; b=Fisher's exact test

Table 6. Multivariate analysis of PIM 3 score and length of stay

Variables	RR	95% CI	P value
PIM 3 score ≥48	2.867	1.070 to 7.679	0.036
Length of stay ≤7 days	6.040	2.194 to 16.627	<0.0001

The majority of our subjects had moderate malnutrition (46%), similar to a previous study which noted that 48.9% of PICU patients had moderate malnutrition.[10] Malnutrition can alter intestinal barrier function, wound healing processes, and muscular function, as well as play a role in disease prognosis. High prevalences of acute and chronic malnutrition have been reported in PICU settings (24%-53%).[11] Malnutrition tends to increase morbidity and mortality, length of stay, duration of ventilator usage, and maintenance costs.[12]

Of 89 subjects (59.3%) requiring mechanical ventilation support, 53 subjects (59.6%) had PIM 3 score ≥48 and 36 subjects (40.4%) had PIM 3 score <48. A study reported that 50.7% of patients received mechanical ventilation.[13] While mechanical ventilation is a life-saving method, it has can lead to complications such as barotrauma, ventilator-associated pneumonia, pneumothorax, or ventilator-induced lung injury. Mortality in mechanically-ventilated adult patients was reportedly 58.3%, with 2.67 times higher mortality risk compared to patients without mechanical ventilation.[14]

Length of PICU stay not only reflects the severity of disease and patient health status,[15] but also the quality and capability of the PICU. Longer length of stay increased mortality rate by 10 times.[12] In our study, 49% of those with PIM 3 score ≥48 group had length of stay ≤7 days and 71.6% had length of stay <7 days. Length of stay can be affected by severity of disease, nosocomial infection, as well as refusal of mechanical ventilation or resuscitation while in the PICU.[16]

Diagnosis at the time of PICU admission is important for prognosis. A previous study found that the most common diagnosis at PICU admission was respiratory disease (24.56%), followed by neurological disease (21.05%), cardiovascular disease (15.78%), and infectious disease (14%).[17] The most frequent diagnosis in our subjects was surgery (29.33%), followed by respiratory disease (25.33%), neurological disease (16%), cardiovascular disease (17%), infectious disease (16%), hemato-oncological disease (6.67%), other diseases (2%), metabolic endocrine disease (1%), and gastro-hepatological disease (1%). Surgery was predominant because Sanglah Hospital is the largest hospital in Eastern Indonesia. As such, the hospital caseload is largely surgical, hence, we used surgery as a disease classification.

Of the 63 subjects who died, 42 subjects had PIM 3 score ≥48 and 21 subjects had PIM 3 score <48, with RR value of 2.478 (95% CI 1.639 to 3.745; P<0.001). Therefore, the PIM 3 score cut-off of 48 was statistically significant and can be used as a mortality predictor.

Bivariate analysis revealed that nutritional status, length of stay, and mechanical ventilation had significantly different mortality outcomes, with P <0.25. However, mechanical ventilation support had a very wide CI so we included it into multivariate analysis to avoid multi-collinearity effect. Multivariate analysis showed that PIM 3 score ≥48 had a mortality risk of 2.867 times (95%CI 1.070 to 7.679; P=0.036) and length of stay <7 days had a mortality risk of 6.040 times (95%CI 2.194 to 16.627; P<0.0001). In conclusion, critically ill PICU patients with PIM 3 score ≥48 have a 2.48 times higher risk of mortality than those with PIM 3 score <48. Hence, the PIM 3 is a useful tool for predicting mortality in such patients.

Conflict of Interest

None declared.

Acknowledgements

We thank our colleagues from the Department of Child Health, Udayana University Medical School/Sanglah Hospital who provided insight and expertise that greatly assisted the study.

Funding Acknowledgements

The authors received no specific grants from any funding agency in the public, commercial, or not-for-profit sectors.

References

1. WHO. Updated guideline: Paediatric emergency triage, assessment and treatment: care of critically-ill children. Geneva: WHO; 2016. p.7.
2. Gulla K, Sachdev A. Illness severity and organ dysfunction scoring in pediatric intensive care unit. Indian J Crit Care

Med. 2016;20:27-35. DOI: 10.4103/0972-5229.173685.

3. UKK Emergensi dan Rawat Intensif Anak IDAI. Rawat Intensif. In: Latief A, Pudjiadi AH, Kushartono H, Malisie RF, editors. Pelayanan Emergensi, Rawat Intermediet dan Rawat Intensif Anak. Jakarta: Badan Penerbit Ikatan Dokter Anak Indonesia; 2016. p.1-36.
4. Bhadoria P, Bhagwat A. Severity scoring in paediatric intensive care units. Indian J Anaesth. 2008;52:663-75.
5. Straney L, Clements A, Parslow RC, Pearson G, Shann F, Alexander J, *et al.* Paediatric index of mortality 3: an updated model for predicting mortality in pediatric intensive care. Pediatr Crit Care Med. 2013;14:673-81. DOI: 10.1097/PCC.0b013e31829760cf.
6. Dahlan S. Prognostik. In: Dahlan S, editor. Besar sampel dalam penelitian kedokteran dan kesehatan. 4th ed. Jakarta: Epidemiologi Indonesia; 2016. p.7.
7. Hao TK, Son NH. Mortality Pattern at Pediatric Intensive Care Unit Of Hue Central Hospital, Vietnam. Biomed J Sci & Tech Res 11(5)-2018. BJSTR. MS.ID.002155. DOI: 10.26717/ BJSTR.2018.11.002155.
8. Sudarmadji S, Wati DK, Sidiartha L. Faktor risiko pada lama rawat dan luaran pasien perawatan di unit perawatan intensif anak RSUP Sanglah Denpasar. Sari Pediatri. 2016;17:455-62. DOI: 10.14238/sp17.6.2016.455-62.
9. Jyothi KA, Ankireddy K. A study on clinical profile and outcome of patients in PICU (paediatric intensive care unit) at tertiary care unit. Int J Contemp Pediatr. 2019;6:757-60. DOI: 10.18203/2349-3291.ijcp20190725.
10. Assa N, Wati D, Subanada I, Soetjiningsih S, Kardana M, Sukmawati M. Full outline of unresponsiveness score as a predictor of outcomes in critically ill pediatric patients. 2020;60:77-2. DOI: 10.14238/pi60.2.2020.77-82.
11. Chen MY, Yang YJ. Being underweight is an independent risk factor for poor outcomes among acutely critically ill children. Nutr Clin Pract. 2018;33: 4338. DOI: 10.1177/0884533617712225.
12. Correia, MITD, Waitzberg, DL. The impact of malnutrition on morbidity, mortality, length of hospital stay and cost evaluated through a multivariate model analysis. Clinical nutrition.2003;22:235-9. DOI: 10.1016/S0261-5614(02)00215-7.
13. Mukhtar B, Siddiqui NR, Haque A. Clinical characteristics and immediate-outcome of children mechanically ventilated in PICU of Pakistan. Pak J Med Sci. 2014;30;927-30. DOI: 10.12669/pjms.305.5159.
14. Azevedo LCP, Park M, Salluh JIF, Rea-Neto A, Souza-Dantas VC, Varaschin P, *et al.* Clinical outcomes of patients requiring ventilator support in Brazillian intensive care units: a multicenter, prospective, cohort study. Crit Care. 2013;17:R63. DOI: 10.1186/cc12594.
15. Gonzalez-Cortés R, López-Herce-Cid J, Garcia-Figueruelo A, Tesorero-Carcedo G, Botran-Prieto M, Carrillo-Álvarez A. Prolonged stay in pediatric intensive care units: mortality and healthcare resource consumption. Med Intensiva. 2011;35;417-23. DOI: 10.1016/j.medin.2011.04.004.
16. Kirk AH, Sng QW, Zhang LQ, Wong JJ, Puthucheary J, Lee JH. Characteristics and outcomes of long-stay patients in the pediatric intensive care unit. J Pediatr Intensive Care. 2018; 7: 1-6. DOI: 10.1055/s-0037-1601337.
17. Indradjaja A, Suparyatha IB, Hartawan IN. The association between serum albumin levels and mortality in pediatric intensive care unit of Sanglah Hospital Denpasar. MEDICINA. 2014;45:13-8.