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Original Article

Prognostic factors of death in children admitted to pediatric intensive care unit, Cipto Mangunkusumo Hospital, Jakarta, Indonesia

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ABSTRACT

Background The primary goal of intensive care is to prevent mortality in patients with reversible critical illness, while preserving or improving functional outcome. It follows that the capability to estimate patient's risk of death is extremely important.

Objective The aim of this study was to identify the prognostic factors of death, evaluate the probability of death by using Pediatric Index of Mortality (PIM) model, and develop the new model for predicting probability of death in children admitted to PICU in accordance with characteristic of patients in the study unit.

Design Retrospective study.

Setting Pediatric intensive care unit of Cipto Mangunkusumo Hospital, Jakarta, Indonesia.

Patient Two hundreds and sixty five consecutive admissions, <18 years old, during one year period.

Results Logistic regression of 18 variables identified 6 prognostic factors of death ($p<0.05$): age, consciousness level, heart rate, platelet count, PaO2/FiO2, and use of mechanical ventilation at the first hour in PICU. PIM model predicted 17.9 deaths and this study model predicted 113.2 deaths from 200 subjects (56 died) in this study, with the area under ROC curve was 0.82 for PIM model and 0.83 for this study model.

Conclusion Both PIM model and this study model cannot predict mortality in this study unit accurately. It may due to the different characteristics between sample in this study and sample from which the PIM model was derived, or the lack of sample and variable in this study **[Paediatr Indones 2002;42:254-260].**

Keywords: *pediatric intensive care unit (PICU), probability of death, outcome assessment*

The main purpose of the intensive care unit (ICU) is to prevent mortality in patients with reversible critical illness, either by treating critically ill patients or intensively monitoring patients who are considered at risk of dying.[1-3] The capability to estimate patient's risk of death is extremely important. Such an estimation would be useful in achieving many different goals, such as assessing a patient's prognosis, evaluating therapies, assessing hospital and ICU performance, planning reimbursement, and deciding access to medical resources.[1]

Evaluation of the patient's mortality risk in the ICU is generally based on severity of illness scoring system. Almost all of the pediatric intensive care severity of illness scoring systems were developed in the United States. A well-known scoring system for the pediatric population is the pediatric risk of mortality (PRISM) scoring system, developed by Pollack *et al* in 1988.[1,4-6] The PRISM score is the objective simplification of the physiologic stability index (PSI).[4,6,7] The number of physiologic variables has been reduced from 34 to 14 and the number of ranges has been reduced

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from 75 to 23.[4] PRISM is accurate and widely accepted, but many units do not use it routinely because it is difficult to collect the large amount of information needed to calculate it. This score is calculated from the most abnormal values in the 24 hours of 14 physiologic variables plus the patient's age and operative status. Pediatric index of mortality (PIM) is a simple mortality prediction model in pediatric intensive care unit (PICU), developed by Shann *et al* in 1997. It requires the collection of only 8 variables at the time of admission to intensive care.[6] The aims of this study were to identify the prognostic factors of death in children admitted to PICU of Cipto Mangunkusumo Hospital, to evaluate the probability of death by using PIM model, and to develop the new model for predicting probability of death in accordance with characteristic of children admitted to PICU of Cipto Mangunkusumo Hospital.

Methods

This was a retrospective review of medical records of children admitted to PICU, Department of Child Health, Medical School, University of Indonesia, Cipto Mangunkusumo Hospital, Jakarta. All new patients <18 years of age, admitted to the PICU within January 1, 2000 to December 31, 2000, were included in this study. Information was collected during the first hour in PICU including all pediatric index of mortality (PIM) variables (elective admission, specified diagnosis, pupil fixed to light, base excess, PaO2, FiO2, systolic blood pressure, and use of mechanical ventilation) plus information about sex, age, diagnostic category, consciousness level, respiratory rate (RR), heart rate (HR), blood hemoglobin level , leukocyte count, platelet count, serum pH, PaCO2, serum bicarbonate (HCO3), serum potassium, blood glucose, and vital status at discharge (survival or death). These variables were taken from parameter of organ system failure (OSF)[8] criteria, PSI, and PRISM scoring system. Fractional inspired oxygen (FiO2) was estimated in unintubated patients in accordance with the literature from Shapiro[9]. Patients with length of stay less than one hour were excluded from the study.

The significance of each factor associated with mortality in children admitted to PICU was first analyzed by using univariate analysis. Thereafter, a multivariate analysis (forward and backward stepwise logistic regression) was applied to contribution of each prognostic factor after ruling out confounding factors. The level of significance was $p < 0.05$. The minimum sample size needed was 70 admissions for univariate analysis and 190 admissions for multivariate analysis (10 subjects for each variable).

Performance of PIM and this study model were assessed by calculating the probability of death using this study subjects. Discrimination capability was assessed through the utilization of the receiver operating characteristic (ROC) curve.

Results

During the study period, 424 patients admitted to the unit, 101 of them died (23.8%). Because of incomplete data, only 265 admissions ¾60 of them died (22.6%)-¾ eligible for this study. Characteristics of

Table 1. Characteristics of the 265 subjects enrolled in this study

Characteristic	Outcome		Hypothesis testing
	Survivors	Non survivors	
No. patient (%)	205 (77.4)	60 (22.6)	
Age (month)			
Median	17	5	p = 0.001
Range	0 – 204	0 – 154	
Sex			
Male	116 (79.5)	30 (20.5)	
Female	89 (74.8)	30 (25.2)	
PIM prob. of death (%)			
Median	1.74	8.57	p = 0.000
Range	0.16 – 63.64	0.93 – 93.64	
Length of stay (hour)			
Median	42.25	30.75	p = 0.045
Range	1.4 – 607	0.5 – 604.3	

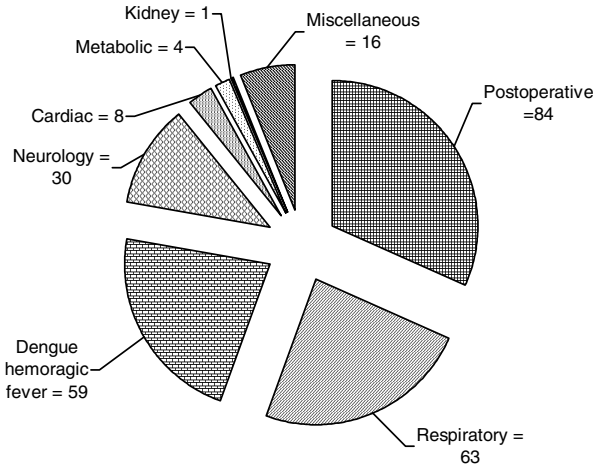

Figure 1. Diagnostic categories of 265 subjects on admission to PICU

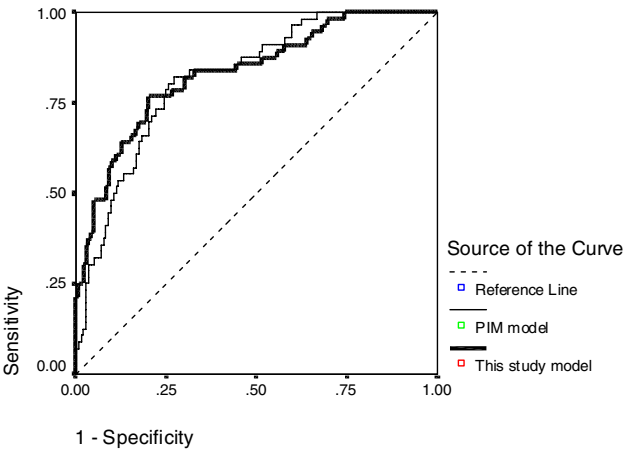

Figure 2. Area under receiver operating characteristic (ROC) curve

the 265 subjects in this study are presented in **Table 1,** and the diagnostic categories of the subject are shown on **Figure 1**. The youngest patient was one hour old and the oldest was 17 years old.

Variables that did not predict death on univariate analysis were respiratory rate, heart rate, and PaCO2 (**Table 2**).

Logistic regression analysis with mortality as dependent variable showed that age, consciousness level, heart rate, platelet count, PaO2/FiO2, and use of mechanical ventilation were associated with mortality in children admitted to PICU, Cipto Mangunkusumo Hospital, while the other variables were not (**Table 3**). The area under receiver operating characteristic (ROC) curve was 0.82 for PIM model and 0.83 for the model of this study (**Figure 2**).

According to the result of forward and backward stepwise logistic regression analysis of 197 subjects with 18 variables (blood glucose variable was eliminated from the multivariate analysis because the subject included in the analysis less than 190), the probability (P) of PICU death was:

$$P = e^{y} / 1 + e^{y}$$

P = Probability of PICU death.
y = – (0,016 x age) + (3,319 x consciousness level) + (0,023 x heart rate)
– (0,004 x PaO2/FiO2) + (1,344 x mechanical ventilation) – 1,687.
e = Natural logarithm = 2.7183.
Note:- Age in month.
- Consciousness level: Conscious – somnolent = 0, stupor – coma = 1.
- Mechanical ventilation: No = 0, yes = 1.

Discussion

The admissions during the study period were 424, but only 265 admissions were eligible for this study because it was a retrospective study. We found some limitations in this study such as in getting complete information from medical record and in finding the medical record itself, because there was no computerized database in the unit.

In PIM study, variables that were not associated with mortality on univariate analysis ($p > 0.1$) were serum bilirubin, HR, central venous pressure (CVP), hemoglobin level, the present of convulsions, left arterial pressure, and days in hospital before admission to intensive care (lead time). Variables that were associated with mortality were systolic blood pressure, diastolic blood pressure, RR, PaO2/FiO2, PaCO2, Glasgow coma scale (GCS), pupil response to light, PT/PTT, serum potassium, serum calcium, blood glucose, serum bicarbonate, need for mechanical ventilation, diagnosis, the present of a right-to-left cardiac shunt, estimated FiO2 concentration in unintubated patient, weight, mean blood pressure, PIP, PEEP, base excess, and plasma sodium. There were 22 variables having association with mortality and 7 variables not. Elective admission variable was not tested in univariate analysis.[6]

On univariate analysis, this study had only 18 variables, 15 variables were associated with mortality ($p < 0.05$) (age, consciousness level, systolic blood pressure, hemoglobin level, leukocyte count, platelet count, serum pH, PaO2/FiO2, HCO3, serum potas-

TABLE 2. ASSOCIATION OF INDEPENDENT VARIABLES AND MORTALITY (UNIVARIATE ANALYSIS)

Characteristic (n)	Outcome		Hypothesis testing
	Survivors	Non-survivors	
Age (month) (265)			
<1	39	21	$x^2 = 12.83$ df = 4 p = 0.012
1 – 11	48	18	
12 – 59	56	10	
60 – 119	33	9	
³120	29	2	
Consciousness level (265)			
Conscious – somnolent	197	38	OR = 14.26 (5.91:34.39) p = 0.000
Stupor – coma	8	22	
RR (breath/min) (265) [a]			
£50	166	40	$x^2 = 5.83$ df = 2 p = 0.054
51 – 70	31	17	
>70	8	3	
Heart rate (beat/min) (265) [b]			
<80	3	1	$x^2 = 5.69$ df = 2 p = 0.058
80 – 150	166	40	
>150	36	19	
SBP (mmHg) (253) [c]			
<50	0	1	$x^2 = 19.07$ df = 5 p = 0.002
50 – 64	9	8	
65 – 75	12	9	
76 – 149	172	40	
150 – 200	1	0	
> 200	0	1	
Hemoglobin (g/dl) (263)			
<5	1	3	$x^2 = 8.52$ df = 2 p = 0.014
5 – 10	35	14	
>10	169	41	
Leukocyte count (cell/mm³) (261)			
<4000	23	5	$x^2 = 7.70$ df = 2 p = 0.021
4000 – 12000	157	38	
>12000	23	15	
Platelet count (cell/mm³) (263)			
<20000	15	10	$x^2 = 10.49$ df = 3 p = 0.015
20000 – 50000	17	10	
50001 – 150000	39	7	
>150000	134	31	
Serum pH (200)			
<7.10	10	14	$x^2 = 15.56$ df = 3 p = 0.001
7.10 – 7.19	17	8	
7.20 – 7.30	41	17	
> 7.30	76	17	
PaCO2 (mmHg) (200)			
<30	40	16	$x^2 = 6.41$ df = 3 p = 0.093
30 – 45	71	27	
46 – 65	29	7	
>65	4	6	
PaO2/FiO2 (200)			
<200	20	23	$x^2 = 18.73$ df = 2 p = 0.000
200 – 300	36	13	
> 300	88	20	
Serum bicarbonate (mEq/L) (200)			
<16	46	28	$x^2 = 6.14$ df = 2 p = 0.046
16 - 32	97	28	
>32	2	0	
Serum potassium (mEq/L) (207)			
<3.0	10	4	$x^2 = 10.64$ df = 2 p = 0.005
3.0 – 5.0	116	30	
>5.0	26	21	

Blood glucose (mg/dl) (98)			
<40	1	4	$x^2 = 10.20$ df = 4 p = 0.037
40 – 60	4	4	
61 – 120	33	13	
121 – 250	25	5	
251 – 400	6	3	
>400	0	0	
Elective admission (265)			
No	147	55	OR = 0.23 (0.09:0.61) p = 0.001
Yes	58	5	
Fixed pupil to light (265)			
No	203	53	OR = 13.41 (2.71:66.42) p = 0.000
Yes	2	7	
Specified diagnosis (265)			
No	201	55	OR = 4.57 (1.17:17.59) p = 0.016
Yes	4	5	
Mechanical ventilation (265)			
No	184	29	OR = 9.37 (4.75:18.46) p = 0.000
Yes	21	31	

Abbreviations: RR = respiratory rate; SBP = systolic blood pressure; PaCO2 = arterial carbon dioxide tension; PaO2 = arterial oxygen tension; FiO2 = inspired oxygen concentration.
[a] = Respiratory rate category for infant: £ 60, 61–90, > 90.
[b] = Heart rate category for infant: < 90, 90-160, > 160.
[c] = Systolic blood pressure category for infant: < 40, 40-54, 55-65, 66-129, 130-160, > 160.

TABLE 3. RESULTS OF LOGISTIC REGRESSION AMONG 197 SUBJECTS WITH 18 VARIABLES

	B	SE	Wald	df	Sig.	Exp(B)
Age	- 0.016	0.007	5.429	1	0.020	0.984
Consciousness level	3.319	0.709	21.906	1	0.000	27.638
Heart rate	0.023	0.009	6.462	1	0.011	1.023
Platelet count	0.000	0.000	20.507	1	0.000	1.000
PaO2/FiO2	- 0.004	0.002	7.315	1	0.007	0.996
Mechanical ventilation	1.344	0.503	7.141	1	0.008	3.836
Constant	- 1.687	1.453	1.347	1	0.246	0.185

sium, blood glucose, elective admission, fixed pupil, specified diagnosis, and use of mechanical ventilation), and 3 variables were not associated with mortality (RR, HR, PaCO2). All of these variables plus base excess included for further analysis (multivariate analysis) except blood glucose.

Aragao found associations between death and: (1) Age below 2 years old; (2) use of mechanical ventilation and CVP; (3) presence of hospital acquired infection; (4) length of hospital stay of 2 days or less; and (5) class 4 clinical severity according to the Clinical Classification System (CCS), in children admitted to the PICU, in a referral hospital in Brazil, from June 1996 to January 1997.[10]

Logistic regression in this study resulted in 5 variables that could predict the probability of PICU death, i.e., age, consciousness level, HR, PaO2/FiO2, and use of mechanical ventilation. In PIM model, there were 7 variables, i.e., elective admission, specified diagnosis, fixed pupil, absolute [SBP-120], absolute [BE], 100xFiO2/PaO2, and use of mechanical ventilation.

PIM model predicted 17.9 deaths and this study model predicted 113.2 deaths on 200 subjects of this study (56 died). Using a mortality risk of 0.5 as cutoff value, PIM model had the sensitivity of 8.9%, specificity of 98.6%, and positive likelihood ratio of 6.4. Meanwhile, this study model had the sensitivity of 85.7%, specificity of 51.4, and positive likelihood ratio of 1.8. The area under ROC curve was almost similar for models, 0.82 for PIM model and 0.83 for this study model.

The PICU's mortality rate in nine PICUs studied by Pollack *et al* in 1984 to 1985 ranged from 3.0% to 17.6%,[11] meanwhile in this study unit, from 1996 to 2000, the mortality rate was 24.7%.

Assessment of the PICU performance must be based mainly on the assessment of the number of

deaths prevented by comparing the number of observed and expected deaths by the year using the same model. ICU performance is possible to assess by comparing one ICU's performance with the performance of other ICUs. Nevertheless, patient mortality is not affected solely by the ICU activity, but also depends on many other factors, e.g., demographic and clinical characteristics of the population, hospital structure, and non medical issues (management and organization).[1]

The PIM model is simple enough for it to be widely used in pediatric intensive care. PIM has been developed in dedicated PICUs where there are high levels of consultant input, senior resident staff, and trained PICU nurses, so that it sets a high standard of care. Unfortunately, by using PIM model to our study subjects, it only predicted 17.9 deaths of 56 observed deaths from 200 subjects. It may be due to the difference of patient characteristics and unit capability.

In conclusion, prognostic factors of death in children admitted to PICU in Cipto Mangunkusumo Hospital were different from children admitted to the study unit from which the PIM model was derived. Both PIM model and this study model could not predict mortality in this study unit accurately. It may be due to the different characteristics between sample in this study and sample from which the PIM model was derived or the lack of sample and variable in this study. Further investigation is still needed to get the fix model for each unit by using more subjects and variables.

Example of probability of death calculation

Considered A child, 109.5 months old, admitted to PICU due to intracranial bleeding (specified diagnosis = yes = 1) in aplastic anemia, is an emergency admission (elective = no = 0). Vital signs on admission to PICU were stupor (stupor–coma = 1), RR 48x/minute, HR 140x/minute, systolic blood pressure (SBP) 90 mmHg, and pupils react to light. Laboratory findings were hemoglobin 2.0 g/dl, leukocyte count 5600/ul, platelet count 6000/ul, serum pH 7.280, PaCO2 13.7 mmHg, PaO2 140.5 mmHg with nasal canula oxygen 2L/minute (FiO2 = 0.28), serum HCO3 6.5 mEq/L, and BE – 16.7 mEq/L.

Calculation using PIM model

Logit = (2.357 x pupil) + (1.826 x specified diagnosis) – (1.552 x elective) + (1.342 x mechanical ventilation) + (0.021 x absolute[SBP – 120]) + (0.071 x absolute[BE]) + (0.415 x 100 x FiO2/PaO2) – 4.873.

= (2.357 x 0) + (1.826 x 1) – (1.552 x 0) + (1.342 x 0) + (0.021 x absolute [90 – 120]) + (0.071 x absolute [- 16,7]) + (0.415 x 100 x 0.28/140.5) – 4.873.

= 0 + 1.826 – 0 + 0 + 0.63 + 1.1857 + 0.0827 – 4.873

= - 1.1486

$$P = \frac{e^{logit}}{1 + e^{logit}} = \frac{2.7183^{-1.1486}}{1 + 2.7183^{-1.1486}} = \frac{0.3171}{1 + 0.3171} = 0.24$$

Calculation using this study model:

y = - (0.016 x age) + (3.319 x consciousness) + (0.023 x HR) - (0.004 x PaO2/FiO2) + (1.344 x mechanical ventilation) – 1.687.

= - (0.016 x 109.5) + (3.319 x 1) + (0.023 x 140) - (0.004 x 140.5/0.28) + (1.344 x 0) – 1.687.

= - 1.752 + 3.319 + 3.22 – 2.008 + 0 – 1.687

= 1.0920

$$P = \frac{e^{y}}{1 + e^{y}} = \frac{2.7183^{1.0920}}{1 + 2.7183^{1.0920}} = \frac{2.9802}{1 + 2.9802} = 0.75$$

The predicted probability of death to this patient according to PIM model was 0.24 and according to this study model was 0.75. In fact, This patient died at the first day in PICU.

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