

## Pediatric SOFA score for detecting sepsis in children

Muhammad Aulia, Silvia Triratna, Yulia Iriani, Achirul Bakri, Indra Saputra

### Abstract

**Background** The pediatric logistic organ dysfunction-2 (PELOD-2) score is recommended by the *Indonesian Pediatric Society Emergency and Intensive Care Working Group* as an indicator of life-threatening organ dysfunction for sepsis in children. However, *The Third International Consensus Definitions for Sepsis and Septic Shock (Sepsis-3)* recommended the *Sequential (Sepsis-related) Organ Failure Assessment (SOFA)* score in determining life-threatening organ dysfunction, which has not been adjusted for pediatric patients.

**Objective** To assess the accuracy of the pediatric SOFA score in diagnosing sepsis in children admitted to the pediatric intensive care unit (PICU).

**Methods** The study was conducted in children with organ dysfunction caused by infection admitted in PICU at Mohammad Hoesin Hospital, Palembang, South Sumatera. Subjects were included by consecutive sampling, according to the following inclusion criteria: all patients aged 1 month to 18 years who met organ dysfunction and two SIRS criteria, with infection according to the 2005 PSCC criteria. Laboratory tests performed included complete blood count (CBC), blood gas analysis, measurement of C-reactive protein (CRP), liver and kidney function tests. In all patients, pSOFA and PELOD-2 scores were calculated within 24 hours of admission. We compared the accuracy of pSOFA score to PELOD-2 score  $\geq 11$ .

**Results** Of 108 subjects, there were 59 males, with median age 11 (range 1-193) months. We compared the accuracy of pSOFA score to PELOD-2 score  $\geq 11$  and obtained a sensitivity of 93.3% and a specificity of 79.5%, for pSOFA cut-off score  $\geq 8$ . Pediatric SOFA score cutoff  $\geq 8$  was determined by receiver operating curve (ROC). The area under the curve (AUC) for pediatric SOFA score was 93.9% (95%CI 89.7 to 98.0%).

**Conclusion** Pediatric SOFA score  $\geq 8$  is the optimal cut-off for predicting life-threatening organ dysfunction in pediatric sepsis. [Paediatr Indones. 2021;61:1-7 ; DOI: 10.14238/pi61.1.2021.1-7 ].

**Keywords:** pediatric SOFA score; PELOD-2 score; sepsis

Sepsis is a leading cause of mortality and morbidity in infants and children. There is no gold standard for the diagnosis of sepsis, thus, the definition of sepsis is continually updated. In 2016, the latest international consensus (Sepsis-3) on sepsis was issued; it defined sepsis as life-threatening organ dysfunction caused by host immune dysregulation against infection. The sequential (sepsis-related) organ failure assessment (SOFA) score is recommended for use in determining life-threatening organ dysfunction.<sup>1</sup> This score can only be applied to adults, due to an absence of special parameters in pediatric patients. Several studies have been conducted to adapt this tool for use in children. The *Indonesian Pediatrics Society Emergency and Intensive Care Working Group* also issued a consensus statement on the diagnosis and management of pediatric sepsis. With reference to the definition of Sepsis-3, IDAI recommended use of PELOD-2 scores and set a cut-off point  $\geq 11$  as the main criterion for life-threatening organ dysfunction.<sup>2</sup>

The ideal diagnostic score for life-threatening organ dysfunction should be accurate, simple, easy

---

From the Department of Child Health, Sriwijaya University Medical School, Palembang, Indonesia.

**Corresponding author:** Indra Saputra, Department of Child Health, Universitas Sriwijaya Medical School. Jalan Jenderal Sudirman KM 3,5, Palembang, Indonesia. Telp. +62-711-354088; Fax. +62-711-351318; Email: indrasp1975@gmail.com.

Submitted May 27, 2020. Accepted October 16, 2020.

to use, minimally invasive, and inexpensive. *Pediatric SOFA* (pSOFA) is simple to use, with few variables or laboratory parameters, and score calculation is straightforward, while the PELOD-2 is more complicated with more variables. The aim of this study was to assess the accuracy of pSOFA score for detecting sepsis in children at Mohammad Hoesin Hospital.

## Methods

This cross-sectional study was conducted from April to December 2019 at the PICU in Mohammad Hoesin Hospital, a tertiary care hospital in Palembang, South Sumatera. All patients aged 1 month to 18 years who met organ dysfunction and two SIRS criteria, with infection according to the 2005 PSCC criteria,<sup>3</sup> were included. Exclusion criteria were patients who died within 4 hours of PICU admission, or had multiple congenital anomalies, HIV infection, or neutropenia due to a medical condition other than SIRS. The minimum required sample size was 108 patients, with 80% power of study and 95% level of significance. At the time of admission, patients underwent physical examination and thorough history-taking. Subjects were children with suspected sepsis; subjects who met the life-threatening organ dysfunction criteria based on PELOD-2  $\geq 11$  were diagnosed sepsis, while subjects who did not meet the criteria were diagnosed no sepsis.

Nutritional status was assessed using *World Health Organization* (WHO) chart for ages under 5 years old [severely wasted ( $Z < -3SD$ ); mild to moderately wasted ( $-3SD < Z < -2SD$ ); normal ( $-2SD < Z < +2SD$ ); overweight ( $+2SD < Z < +3SD$ )] and *Center for Disease Control and Prevention* (CDC) chart for ages above 5 years old [severely wasted ( $< 70\%$ ); mild to moderately wasted (70-90%); normal (90-110%); overweight ( $> 110\%$  and BMI P85-95)].<sup>4</sup> Laboratory tests performed included complete blood count (CBC), blood gas analysis, measurement of C-reactive protein (CRP), blood glucose, and serum electrolytes, coagulation profile, as well as liver and kidney function tests. Cultures of body fluids, including blood, urine, sputum, cerebrospinal fluid (CSF), or pleural fluid, were performed based on judgment of the clinician. Other laboratory and radiological investigations were performed where indicated based on the clinical condition of the

patient. In all patients, pSOFA and PELOD-2 scores were calculated within 24 hours of admission.

Statistical analysis was performed using *SPSS software version 22.0*. Analysis by ROC curve was done to determine the optimal pSOFA cut-off point for pediatric sepsis. The Committee for Medical Research Ethics of Universitas Sriwijaya Medical School approved this study. Informed consent was obtained from all subjects' parents.

## Results

Of 122 patients who fulfilled the inclusion criteria, 108 enrolled in this study. Fourteen patients were excluded due to malignancy (5), dengue shock syndrome (DSS) (2), SLE (1), and incomplete data (6). Characteristics of subjects are shown in **Table 1**. Subjects' median age was 11 (range 1-193) months and 59 (54.6%) of the subjects were male. Respiratory dysfunction occurred in 90.7% of subjects, with pneumonia as the most common underlying infectious disease (58.3%).

All patients with sepsis had respiratory and neurological dysfunction. **Table 2** shows the distribution of organ dysfunction and pSOFA scores based on sepsis outcomes by PELOD-2 scores. Statistically significant clinical criteria were PaO<sub>2</sub>: FiO<sub>2</sub> ratio ( $P=0.001$ ), MAP ( $P=0.001$ ), and GCS ( $P=0.001$ ). Subject with sepsis were significantly had GFR decrease more than 75% ( $P=0.001$ ). The distribution of pSOFA scores in patients with organ dysfunction due to infection is shown in **Table 3**.

Thirty (27.8%) subjects had sepsis (PELOD-2 score  $> 11$ ), of whom 29 (96.7%) subjects used invasive ventilation assistance, 21 (70%) subjects had hypotension, and 18 (60%) required vasopressors. The median GCS in the sepsis group was 4 (range 3-12). Twenty-three subjects with sepsis had decreased kidney function, which was classified into AKI risk (13/23), AKI injury (2/23), and AKI failure (8/23). Seven (23.3%) sepsis subjects had thrombocytopenia. Three (10%) sepsis subjects had total bilirubin levels  $> 2$  mg/dL.

The discrimination of pSOFA score in this study was evaluated by calculating the AUC, by the result was 93.9% (95%CI 89.7% to 98.0%). **Figure 1** shows the ROC curve and the intersection of pSOFA score curves. The optimal cut-off point of the pSOFA score

was 8, with 93.3% sensitivity and 79.5% specificity. The pSOFA score accuracy test can be seen in **Table 4**.

**Table 1.** Subjects' characteristics

Characteristics	(N=108)
Median age (range), months	11 (1-193)
Age group, n (%)	
1-11 months	55 (50.9)
12-23 months	15 (13.9)
24-59 months	16 (14.8)
60-143 months	11 (10.2)
144-216 months	11 (10.2)
Sex, n (%)	
Male	59 (54.6)
Female	49 (45.4)
Nutritional status (W/H), n (%)	
Severely wasted	21 (19.4)
Mild-to-moderately wasted	21 (19.4)
Normal	62 (57.4)
Overweight	4 (3.7)
Glasgow coma scale (GCS), n, %	
< 11	68 (63)
≥ 11	40 (37)
Mean arterial pressure (MAP), n (%)	
Hypotensive	42 (38.9)
Normotensive	66 (61.1)
Pulse rate, n (%)	
Tachycardia	56 (51.9)
Normal	50 (46.3)
Bradycardia	2 (1.9)
Respiratory rate, n (%)	
Tachypnea	39 (34.5)
Normal	48 (42.5)
Bradypnea	26 (23)
Temperature, n (%)	
36.5-37.9°C	58 (53.7)
> 37.9°C	50 (46.3)
Underlying infection, n (%)	
Pneumonia	63 (58.3)
Septic shock	14 (13)
Encephalitis	12 (11.1)
Cerebral abscess	8 (7.4)
Meningitis	2 (1.9)
Peritonitis	6 (5.6)
Others	3 (2.7)
Platelet count, n (%)	
≥ 150,000/μL	86 (79.6)
< 150,000/μL	22 (20.4)
Creatinine level, n (%)	
Normal	59 (54.6)
Increased	49 (45.4)
Bilirubin level, n (%)	
Normal	100 (92.6)
Increased	8 (7.4)

W/H= weight for height/length

The Indonesia Pediatric Society Emergency and Intensive Care Working Group set PELOD-2 scores of 11, or 7 without lactate examination, as cut-off points in determining life-threatening organ dysfunction in children with sepsis. The pSOFA cut-off point of 8 to detect sepsis in this study showed a sensitivity of 93.3% and specificity of 79.5%, with a positive predictive value (PPV) of 63.6% and a negative predictive value (NPV) of 96.9%.

## Discussion

The majority of our subjects were in the 1-11-month age group. Increased susceptibility to infections during infancy has been associated with quantitative and functional differences in the specific immune responses generated, and a lack of preexisting immunological memory in newborns compared to adults. Dendritic cells, which have a critical antigen presenting role for both CD4+ and CD8+ T cells, are decreased and show distinct qualitative profiles in children compared to adults. Substantial differences in B-cell immunity have also been found, with lower levels in children, as well as reduced affinity and diversity of T-cell-dependent antibody responses compared to adults.<sup>5</sup> Previous studies also noted a majority of subjects aged 1-11 months.<sup>6,7</sup> However, another study in the United States noted a higher mean age of 49 months. The age difference may have been due to their 8-252-month age range of subjects.<sup>8</sup>

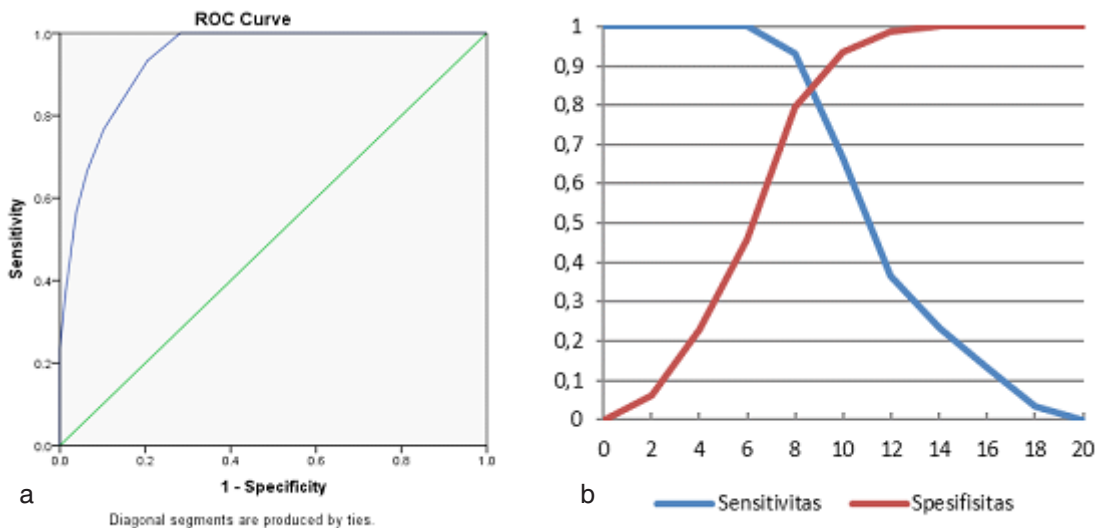
There was no significant difference between the groups in subjects' gender, with 54.6% boys and 45.4% girls. Previous studies also showed no significant differences between the gender, although slightly more boys had sepsis (54.7% and 52.7% respectively).<sup>7,8</sup>

Pneumonia was the most common disease or the most source of infection, found in 63 (58.3%) subjects. A study also showed that the most common location of infection was the respiratory system (73.3%).<sup>9</sup> A meta-analysis showed respiratory infections in 61% of children and 41% of infants.<sup>10</sup> Another study also found pneumonia to be the etiology in 40% of cases.<sup>11</sup> Environmental factors and highly infectious airborne pathogens cause airway infections. Endothelial damage in sepsis is caused by attachment and migration of pro-inflammatory cytokines to the vasculature. This

**Table 2.** Distribution of organ dysfunction and pSOFA scores based on PELOD-2 score

Characteristics	Sepsis (PELOD-2 $\geq$ 11) (n= 30)	No sepsis (PELOD-2 <11) (n= 78)	P value
Age group, n (%)			0.713
12-23 months	3 (10)	12 (15.4)	
24-59 months	6 (20)	10 (12.8)	
60-143 months	2 (6.7)	9 (11.5)	
144-216 months	4 (13.3)	7 (9)	
Sex, n (%)			0.144
Male	13 (43.3)	46 (59)	
Female	17 (56.7)	32 (41)	
Nutritional status (W/H), n(%)			0.346
Severely wasted	9 (30)	12 (15.4)	
Mild-to-moderately wasted	4 (13.3)	17 (21.8)	
Normal	16 (53.3)	46 (59)	
Overweight	1 (3.4)	3 (3.8)	
Organ dysfunction*, n(%)			
Respiratory (n= 98)	30 (30.6)	68 (69.4)	0.040
Neurologic (n= 84)	30 (35.7)	54 (64.3)	0.001
Cardiovascular (n= 42)	21 (50)	21 (50)	0.000
Renal (n= 50)	23 (46)	27 (54)	0.000
Hematologic (n= 15)	7 (46.7)	8 (53.3)	0.078
Hepatic (n= 8)	3 (37.5)	5 (62.5)	0.523
pSOFA score, n (%)			0.000
0-4	0 (0)	12 (15.4)	
5-8	2 (6.7)	50 (64.1)	
9-12	17 (56.7)	15 (19.2)	
13-16	7 (23.3)	1 (1.3)	
17-20	4 (13.3)	0 (0)	

\*1 patient could had more than 1 organ dysfunction



**Figure 1.** a. ROC curve of pSOFA score; b. Intersection curve of pSOFA score = 8

**Table 3.** pSOFA criteria and life-threatening organ dysfunction

pSOFA criteria	Outcomes		P value
	Sepsis (PELOD-2 ≥ 11) (n= 30)	No sepsis (PELOD-2 < 11) (n= 78)	
Respiratory, n(%)			0.000
PaO <sub>2</sub> :FiO <sub>2</sub> ratio			
≥ 400	0	6	
300-399	0	4	
200-299	0	9	
100-199 (with respiratory supporta, IMV:NIV)	13 (12:1)	53 (42:11)	
<100 (with respiratory supporta, IMV:NIV)	17 (17:0)	6 (6:0)	
Hematologic, n(%)			0.126
Platelets, 10 <sup>3</sup> μL			
≥ 150	23	63	
100-149	0	7	
50-99	3	5	
20-49	3	3	
<20	1	0	
Hepatologic, n(%)			0.286
Total bilirubin, mg/dL			
< 1.2	22	67	
1.2-1.9	5	6	
2.0-5.9	3	5	
6.0-11.9	0	0	
> 12.0	0	0	
Cardiovascular, n(%)			0.000
MAP with vasopressor, μg/kgBW/minute			
Normotension	9	57	
Hypotension	3	17	
with dopamine/dobutamine ≤ 5	6	3	
with dopamine > 5 or epinephrine/norepinephrine ≤ 0.1	10	1	
with dopamine > 15 or epinephrine/norepinephrine > 0.1	2	0	
Neurologic, n(%)			0.000
GCS			
15	0	15	
13-14	0	9	
10-12	1	19	
6-9	10	23	
<6	19	12	
Renal, n(%)			0.000
Creatinine level, mg/dL			
Normal	3	28	
Decrease GFR < 25%	4	23	
Decrease GFR 25-50%	13	23	
Decrease GFR 50-75%	2	1	
Decrease GFR >75%	8	3	

Note: respiratory support can be invasive (IMV, invasive mandatory ventilation) or noninvasive (NIV, noninvasive ventilation).

**Table 4.** Comparison of pSOFA and PELOD-2 scores for detecting sepsis

pSOFA score, n(%)	Sepsis (PELOD-2 ≥ 11) (n=30)	No sepsis (PELOD-2 < 11) (n=78)	P value
≥ 8	28 (93.3)	16 (20.5)	0.001
< 8	2 (6.7)	62 (79.5)	

process must be preceded by an interaction between the activated PMNs and the endothelium. In certain organs, for example the lung, adhesion and migration through the endothelium can occur independently. Hence, the most common organ dysfunction in sepsis patients tends to be related to the respiratory system.<sup>9</sup>

The ROC curve analysis of pSOFA scores revealed an AUC of 93.9% (95%CI 86.7% to 96.8%), indicating a high level of discrimination for detecting life-threatening organ dysfunction in pediatric sepsis. The consensus for diagnosis and management of child sepsis was set by *Indonesian Paediatrics Society* (IPS) to be PELOD-2 score  $\geq 11$ , as the cut-off criterion for life-threatening organ dysfunction. We compared the accuracy of pSOFA score to PELOD-2 score  $\geq 11$  and obtained a sensitivity of 93.3% and a specificity of 79.5%, for pSOFA cut-off score  $\geq 8$ .

We aimed to determine the optimal pSOFA cut-off point to predict sepsis in children in order to reduce mortality. The positive predictive value of pSOFA score  $\geq 8$  was 63.6%, indicating that such patients were suspected to have sepsis, while NPV was 96.9%. Hence, pSOFA  $>8$  can be used to diagnose sepsis, help with early detection, and thus, limit mortality. A previous study also showed an optimal cut-off point of 8, with AUC of 88%.<sup>6</sup> Another study reported an AUC value of 87.1% For pSOFA cut-off point of  $\geq 7$ , with sensitivity of 81.3% and specificity of 77.9%.<sup>7</sup> These differences may have been to the differences of population. A limitation of our study was not performing serial SOFA scores compared to previous studies.<sup>6</sup>

In conclusion, the pediatric SOFA score is useful for predicting sepsis in the general PICU population. Pediatric SOFA score can be used an alternative tool to determine life-threatening organ dysfunction for diagnosis of sepsis in patients with infection. In this study, we find the pSOFA score with cut off point 8 for diagnosing sepsis in children. Prospective multicenter studies are required for a better assessment of the pediatric SOFA score.

## Conflict of Interest

None declared.

## Funding Acknowledgment

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

## References

1. Singer M, Deutschman CS, Seymour CW, Shankar-Hari M, Annane D, Bauer M, et al. The third international consensus definitions for sepsis and septic shock (Sepsis-3). *JAMA*. 2016;315:801-10. DOI: 10.1001/jama.2016.0287.
2. Hadinegoro SRS, Chairulfatah A, Latief A, Pudjiadi AH, Malisie RF, Alam A. *Konsensus: Diagnosis dan Tata Laksana Sepsis pada Anak*. Jakarta: Badan Penerbit Ikatan Dokter Anak Indonesia; 2016. p.1-5.
3. Goldstein B, Giroir B, Randolph A. International pediatric sepsis consensus conference: Definitions for sepsis and organ dysfunction in pediatrics. *Pediatr Crit Care Med*. 2005;6:2-8. DOI: 10.1097/01.PCC.0000149131.72248.E6.
4. Sjarif DR, Nasar SS, Devaera Y, Tanjung C. *Rekomendasi Ikatan Dokter Anak Indonesia: Asuhan nutrisi pediatrik*. Jakarta: Badan Penerbit Ikatan Dokter Anak Indonesia; 2011. p.5-12.
5. Muenchhoff M, Goulder PJ. Sex differences in pediatric infectious diseases. *J Infect Dis*. 2014;209(suppl 3):S120-6. DOI: 10.1093/infdis/jiu232.
6. Leclerc F, Duhamel A, Deken V, Grandbastien B, Leteurtre S. Can the Pediatric Logistic Organ Dysfunction-2 Score on day 1 be used in clinical criteria for sepsis in children? *Pediatr Crit Care Med*. 2017;18:758-63. DOI: 10.1097/PCC.0000000000001182.
7. El-Mashad GM, El-Mekawy MS, Zayan MH. Paediatric sequential organ failure assessment (pSOFA) score: a new mortality prediction score in the paediatric intensive care unit. 2020;92:277-85. DOI: 10.1016/j.anpede.2019.11.001.
8. Matics TJ, Sanchez-Pinto LN. Adaptation and validation of a pediatric Sequential Organ Failure Assessment Score and evaluation of the sepsis-3 definitions in critically ill children. *JAMA Pediatr*. 2017;171:e172352. DOI: 10.1001/jamapediatrics.2017.2352.
9. Wulandari A, Pudjiastuti P, Martuti S. Severe sepsis criteria, PELOD-2, and pSOFA as predictors of mortality in critically ill children with sepsis. *PI*. 2019;59:318-24. DOI: 10.14238/pi59.6.2019.318-24.
10. Fleischmann-Struzek C, Goldfarb DM, Schlattmann P, Schlapbach LJ, Reinhart K, Kissoon N. The global burden of paediatric and neonatal sepsis: a systematic review.

- Lancet Respir Med. 2018;6:223-30. DOI: 10.1016/S2213-2600(18)30063-8.
11. Irving SY, Daly B, Verger J, Typoo KV, Brown AM, Hanlon A, *et al.* The association of nutrition status expressed as body mass index z score with outcomes in children with severe sepsis: a secondary analysis from the sepsis prevalence, outcomes, and therapies (SPROUT) study. Crit Care Med. 2018;46:e1029-39. DOI: 10.1097/CCM.0000000000003351.
  12. Vallet B. Bench-to-bedside review: endothelial cell dysfunction in severe sepsis: a role in organ dysfunction? Crit Care. 2003;7:130. DOI: 10.1186/cc1864.