Comparative assessment of the predictive ability of organ dysfunction scales pSOFA, PELOD 2 and Phoenix Sepsis Score in pediatric sepsis: retrospective observational study

P.I. Mironov1, Yu.S. Aleksandrovich2,*, A.V. Trembach3,4, K.V. Pshenisnov2, A.U. Lekmanov5

1 Bashkir State Medical University, Ufa, Russia
2 St. Petersburg State Pediatric Medical University, St. Petersburg, Russia
3 Children’s Regional Clinical Hospital, Krasnodar, Russia
4 Kuban State Medical University, Krasnodar, Russia
5 Pirogov Russian National Research Medical University, Moscow, Russia

Abstract

INTRODUCTION: To date, there remains an urgent need to identify clinical data that can serve as valid criteria for diagnosing sepsis in children, applicable both in global settings and in situations reflecting different clinical situations. In 2024 society critical care medicine USA experts presented the Phoenix Score Sepsis scale for this purpose. OBJECTIVE: A comparative assessment of the discriminatory ability of the Pediatric Sequential Organ Failure Assessment (pSOFA) and Pediatric Logistic Organ Dysfunction (PELOD) 2 and Phoenix Sepsis Score scales for sepsis in children in the healthcare system of the Russian Federation. MATERIALS AND METHODS: Study design: retrospective, observational, multicenter. Inclusion criteria: children over 9 months of age, under 17 years of age who have been diagnosed with septic shock. The end point of the study was 28-day mortality. Demographic and clinical data are presented as median values with interquartile ranges of means and standard deviations. Continuous variables were compared using the Mann-Whitney U test. The discriminatory power of the scales was determined by calculating the area under the receiver operating characteristic curve. RESULTS: In the first 24 hours of hospitalization, the prognosis of survival in children with sepsis was comparable for the scales...
Comparative assessment of the predictive ability of organ dysfunction scales pSOFA, PELOD 2 and Phoenix Sepsis Score... studied. None of the scoring systems were able to predict disease outcomes in shock. CONCLUSIONS: Our studies have shown that in Russian conditions the information value of the Phoenix Sepsis Score scale is comparable to the pSOFA and PELOD 2 scales. Therefore, it seems rational to use all these scales, although the Phoenix Score Sepsis system must still undergo additional external international validation in countries with limited funding.

KEYWORDS: sepsis, child, scales, prognosis

Introduction

Sepsis is defined as a life-threatening disturbance of organs function due to regulatory changes of a macro organism response to infection. Nowadays no evident and valid criteria to define a point of child transition from infection to sepsis [1]. The cause of child’s admission to intensive care unit (ICU) is a sepsis in 8% among all cases. Also, there are annual more than 4.5 million of child’s deaths due to sepsis around the world [2–4]. This is a challenge to recognize a sepsis in children so it is related to a high prevalence of febrile conditions, a low specificity of clinical infectious signs, and an existence of anatomical and physiological features [2].

The definitions of Sepsis-3 emphasizes an importance of organ dysfunction recognizing in adults so it led to increasing and expansion of trials, improving of understanding sepsis pathobiology and patient’s response to invasions [5]. In this light the specific pathophysiology phenotyping has a great importance for evident assessment of patient’s response to treatment [6, 7]. Therefore, it is very important to recognize a sepsis on early stages of organ dysfunctions in...
However recent published guideline by Surviving sepsis campaign (SSC) did not propose any specific criteria for recognition a sepsis in children [2]. This circumstance was also noted by authors of Russian recommendations on diagnosis and treatment of sepsis in children [8]. Although there were a few valid pediatric organ dysfunction scores before publishing of SSC guideline like pediatric sequential organ failure assessment (pSOFA) and pediatric logistic organ dysfunction function 2 (PELOD 2) [9]. Then the international research group (Pediatric Organ Dysfunction Information Update Mandate — PODIUM) was created and began their active work on organ dysfunctions in children [10–12].

In this light the exigency exists to identify clinical data which will be valid criteria for diagnostic sepsis in children. These criteria have to be applicable as globally as for different clinical situations [8]. Ideally sepsis criteria have to be: 1) quite sensitive so medical staff could determine a sepsis on early stages; specific to save a healthcare resources and avoid an inappropriate and excessive treatment, for example antibiotics prescribing; 2) applicable globally and adaptive locally; 3) correlating to biologically significant sepsis phenotypes to provide relevant patient’s selection for effective specific therapy and organs support.

In this connection the Society of critical care medicine in USA (SCCM) had convened a task force of 35 critical care experts, specialists of emergency medicine, infectious diseases, pediatrics, nurses experts, specialists of healthcare and neonatology from Australia, Bangladesh, Brazil, Canada, France, India, Italy, Japan, Switzerland, South Africa, Great Britain and United States of America [13].

The task force group of SCCM had been using data of international survey, systematic review and meta-analysis and also the new assessment of organs dysfunction which was designed and based on a more than 3 million medical cases from 10 sites and 4 continents. Then this group recommends to use the Phoenix sepsis score for sepsis identification in children with infectious process and the value of Phoenix sepsis score 2 points and more is suggested as life threatened organ dysfunction [14]. Originally, values of eight organ-specific scores were calculated in first 24 hours from admission as it showed on organ dysfunction in children with sepsis [14].

Finally, the model was based on only four organ systems criteria (cardiovascular, respiratory, neurological and coagulation systems) as comparable to assessment with using of eight organ systems. Another four systems (such as renal, hepatic, endocrine, immune) were added to above systems (Phoenix 8 score) [15]. The septic children had average Phoenix Sepsis score value of 3 as in countries with higher-resource healthcare as in countries with lower-resource healthcare (interquartile range, IQR, 2–4) [14]. The authors of this conception consider that the new Phoenix sepsis score criteria were derived and validated by SCCM task force using large international database of lower- and higher-resource pediatric hospitals so its use has a potential to improve diagnostic sepsis and septic shock in children compared to existing criteria [16]. In the same time this score has limitations accordingly an opinion of L.N. Sanchez-Pinto et al. One of that significant limitation is a fact that only 3.1% of database were validated from lower-resource countries what limit the accuracy of this score [11]. Notably the Phoenix Sepsis score had demonstrated very low sensitivity compared to previous criteria (23 vs 77%) in one of the lower-resource hospitals. It emphasizes a necessary to continue trials before routine implementation of Phoenix sepsis score in lower-resource hospitals [11]. Furthermore, Phoenix sepsis score developers admit that the score has certain advantages over only the organ’s dysfunction system assessment published by International pediatric sepsis consensus conference (IPSSCC) in 2005 [16].

Objective

Objective of our study is the comparative assessment of discriminatory ability pSOFA, PELOD 2 and Phoenix Sepsis scores for sepsis in children.

Materials and methods

The design of our trial is retrospective observational multi-center. We used database of Republic Bashkortostan Children’s clinical hospital (37 patients), St.-Petersburg Children’s clinical hospital named N.F. Ilfatov (33 patients), Krasnodar Children’s regional clinical hospital (70 patients). The framework time of this study was from June, 1 2022 till June, 26 2023. The inclusion criteria were children from 9 months to 17 years old with sepsis and septic shock. The sepsis and shock were basically identified according Russian recommendation on diagnostic and treatment of sepsis [8]. The exclusion criteria were inborn errors of metabolism, staying in ICU less than 24 hour and renal failure with indication to renal replacement therapy during first 6 hours after admission. A total 140 children had a inclusion criteria. There were 37 children (27.1%) with septic shock. 29 patients had died (20.7%). The most frequent cause of sepsis was a pneumonia (117 children, 83.6%). Also children were included with peritonitis (12 patients, 8.2%), with infection of skin and soft tissues (6 children, 4.3%), with ENT infections such as otitis, pansinusitis (3 patients, 2.1%), with sepsis due to multiple trauma (2 patients, 1.4%). The endpoint of our trial was a 28-days mortality.

The assessment of discriminatory ability of pSOFA, PELOD 2 and Phoenix Sepsis scores performed on admission day in ICU. It related to determination by SCCM experts an informative significance of Phoenix Sepsis score during first 24 hours from child’s admission [14]. The content of Phoenix Sepsis score is presented in Table 1.
Table 1. The Phoenix Sepsis Score [14]a

<table>
<thead>
<tr>
<th>Variables</th>
<th>0 points</th>
<th>1 point</th>
<th>2 points</th>
<th>3 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiratory, 0–3 points</td>
<td>PaO₂:FiO₂ &gt; 400 or SpO₂:FiO₂ &gt; 292b</td>
<td>PaO₂:FiO₂ &lt; 400 on any respiratory support or SpO₂:FiO₂ &lt; 292 on any respiratory supportbc</td>
<td>PaO₂:FiO₂ 100–200 and IMV or SpO₂:FiO₂ 148–220 and IMVb</td>
<td>PaO₂:FiO₂ &lt; 100 and IMV or SpO₂:FiO₂ &lt; 148 and IMVb</td>
</tr>
</tbody>
</table>

Cardiovascular, 0–6 points

- No vasoactive medicationsd
- 1 vasoactive medicationd
- ≥ 2 vasoactive medicationsd

<table>
<thead>
<tr>
<th>Lactate &lt; 5 mmol/lc</th>
<th>Lactate 5–10.9 mmol/l</th>
<th>Lactate ≥ 11 mmol/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age basedf mean arterial pressure, mm Hgf</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 1 month</td>
<td>&gt; 30</td>
<td>17–30</td>
</tr>
<tr>
<td>1 to 11 months</td>
<td>&gt; 38</td>
<td>25–38</td>
</tr>
<tr>
<td>&lt; 2 year</td>
<td>&gt; 43</td>
<td>31–43</td>
</tr>
<tr>
<td>2 to &lt; 5 years</td>
<td>&gt; 44</td>
<td>32–44</td>
</tr>
<tr>
<td>5 to &lt; 12 years</td>
<td>&gt; 48</td>
<td>36–48</td>
</tr>
<tr>
<td>12 to 17 years</td>
<td>&gt; 51</td>
<td>38–51</td>
</tr>
</tbody>
</table>

Coagulation, 0–2 pointsh

- Platelets ≥ 100 × 10³/μL
- Platelets < 100 × 10³/μL
- International normalized ratio ≤ 1.3
- International normalized ratio > 1.3
- D-dimer ≤ 2 mg/l FEU
- D-dimer > 2 mg/l FEU
- Fibrinogen ≥ 100 mg/dl
- Fibrinogen < 100 mg/dl

Neurological, 0–2 pointsi

- Glasgow Coma Scale score > 10; pupils reactivei
- Glasgow Coma Scale score ≤ 10i
- Fixed pupils bilaterally

PHOENIX SEPSIS Criteria

- Sepsis Suspected infection and Phoenix Sepsis Score ≥ 2 points
- Sepsis shock Sepsis with ≥ 1 cardiovascular point(s)

FEU — fibrinogen equivalent units; IMV — invasive mechanical ventilation; INR — international normalized ratio of prothrombin time; MAP — mean arterial pressure; PaO₂:FiO₂ — arterial partial pressure of oxygen to fraction of inspired oxygen ratio; SI — conversion factor: to convert lactate from mmol/L to mg/dL, divide by 0.111; SpO₂ — oxygen saturation measured by pulse oximetry (only SpO₂ of ≤ 97 %).

a The score may be calculated in the absence of some variables (eg, even if lactate level is not measured and vasoactive medications are not used, a cardiovascular score can still be ascertained using blood pressure). It is expected that laboratory tests and other measurements will be obtained at the discretion of the medical team based on clinical judgment. Unmeasured variables contribute no points to the score. Ages are not adjusted for prematurity, and the criteria do not apply to birth hospitalizations, neonates whose postconceptional age is younger than 37 weeks, or those 18 years of age or older.

b SpO₂:FiO₂ ratio is only calculated if SpO₂ is ≥ 97 %.

c The respiratory dysfunction of 1 point can be assessed in any patient receiving oxygen, high-flow, noninvasive positive pressure, or IMV respiratory support, and includes a PaO₂:FiO₂ ratio of less than 200 and a SpO₂:FiO₂ ratio of less than 220 in children who are not receiving IMV. For children receiving IMV with a PaO₂:FiO₂ less than 200 and SpO₂:FiO₂ less than 220, see criteria for 2 and 3 points.

d AVs and vasopressors can include any dose of epinephrine, norepinephrine, noradrenaline, dopamine, dobutamine, milrinone, and/or vasopressin (for shock).

e Lactate reference range is 0.5 to 2.2 mmol/L. Lactate can be arterial or venous.

f Age is not adjusted for prematurity, and the criteria do not apply to birth hospitalizations, children whose postconceptional age is younger than 37 weeks, or those 18 years of age or older.

g Use measured MAP preferentially (invasive arterial if available or noninvasive oscillometric), and if measured MAP is not available, a calculated MAP (1/3 × systolic + 2/3 × diastolic) may be used as an alternative.

h Coagulation variable reference ranges: platelets, 150 to 450 ×10³/μL; D-dimer, < 0.5 mg/L FEU; fibrinogen, 180 to 410 mg/dL. The INR reference range is based on the local reference prothrombin time.

i The neurological dysfunction subscore was pragmatically validated in both sedated and nonsedated patients, and those receiving or not receiving IMV support.

j The Glasgow Coma Scale score measures level of consciousness based on verbal, eye, and motor response (range, 3–15, with a higher score indicating better neurological function).
The demographic and clinical data were presented as median values with interquartile ranges of mean and standard deviation, percentages and frequencies concerning feature characteristics. The continuous variables were compared with Mann-Whitney U-test using. The statistical significance was confirmed if p was less than 0.05. The discriminatory power of the scores was defined with receiver operating characteristic (ROC) analysis and determination of area under ROC curve (AUC).

**Results**

We analyzed score’s values to compare data between survivors and deceased on a Day 1 (admission day in ICU). This analysis is presented in Table 2.

These data allow to claim that all of the three evaluating systems showed an evident difference between survived and deceased children with sepsis. We performed the ROC analysis to receive more accurate information concerning discriminatory ability of scores (Fig. 1).

The AUC’s determination allowed to claim that an informative significance was a similar for all of the three scores (a significance of differences between Phoenix sepsis score and pSOFA was a 0.57, Phoenix sepsis score and PELOD2 was a 0.80, pSOFA and PELOD2 was a 0.74). Then the Phoenix sepsis score has no any advantages over pSOFA and PELOD2 scores in children with sepsis. Therefore, we decided to perform a comparative analysis of scores discriminatory ability for children with septic shock (Fig. 2).

The analysis had demonstrated no one of all scores showed predictable ability for outcomes of septic shock in children. The AUC was evaluated around 0.5 for all scores and a significance of differences between Phoenix sepsis score and pSOFA was a 0.81, Phoenix sepsis score and PELOD 2 was a 0.97, pSOFA and PELOD 2 was a 0.78.

<table>
<thead>
<tr>
<th>Scores</th>
<th>Survivors (n = 111)</th>
<th>Non-survivors (n = 29)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>pSOFA, points</td>
<td>4 [3–7]</td>
<td>9 [6–12]</td>
<td>&lt; 0.05 (0.029)</td>
</tr>
<tr>
<td>PELOD 2, points</td>
<td>4 [3–5]</td>
<td>6 [4–7]</td>
<td>&lt; 0.05 (0.032)</td>
</tr>
<tr>
<td>Phoenix Sepsis Score, points</td>
<td>3 [2–4]</td>
<td>4 [3–5]</td>
<td>&lt; 0.05 (0.048)</td>
</tr>
</tbody>
</table>

Table 2. Comparative analysis of scores on the studied scales in children who died and survived with sepsis

![Fig. 1. Discriminatory ability of the studied scales for sepsis (n = 140)](image-url)
Discussion

Our study is a retrospective clinical trial concerning a comparative assessment of PELOD 2, pSOFA and Phoenix sepsis scores possibilities to predict sepsis outcomes in children.

The SCCM’s task force group declared that Phoenix sepsis criteria have a high discriminatory ability to identify a sepsis in children accurately as for low-resource hospital as for a high-resource setting. It will facilitate an international dissemination and data collection around the world. Our outside validation of this evaluating system showed that it has a moderate discriminatory ability. Furthermore, PELOD 2, pSOFA and Phoenix Sepsis scores have a similar informative value according to our data and to data of SCCM task force group [16].

Our sepsis identifying based on Project of Russian clinical recommendation for diagnostic and treatment of sepsis in children. All children of this trial had a ≥ 2 points of Phoenix Sepsis score on admission day in ICU. It gives an evidence concerning similar approaches to identifying of infectious generalization [14]. Moreover, the new criteria developing was performing with using of pSOFA, PELOD 2 subscores and PODIUM group achievements [15]. For example, the most effective criteria of cardiovascular and neurological dysfunctions appropriate to a subscores of PELOD 2, hematological/coagulation, respiratory and renal dysfunctions appropriate to pSOFA score and immune and endocrine dysfunctions to PODIUM [14]. Meanwhile, we were surprised by that the SCCM task force group compared the new Phoenix sepsis score criteria to IPSCC recommendations (2005) concerning sepsis identification. In the same time, SCCM task force group had developed a conceptual definition of pediatric sepsis as a suspected infection in presence of life-threatening organ dysfunctions. Also, the task force group had used organ dysfunctions criteria according to “Sepsis-3” conception which related to a higher risk of mortality [14].

We estimated no one analyzed score could predict a survival of children with sepsis at early time (first 24 hours) staying in ICU. It confirms by results of recent published report by A.V. Trembach et al [17]. It is clear that the Phoenix sepsis score’s variables threshold was used for identifying of life-threatening organ dysfunctions in children with infection. These thresholds do not provide a screening of children with high risk sepsis development or an early recognition of children with suspected sepsis. The Phoenix sepsis score criteria is presented as simplification of complicated biological processes which lead to a sepsis in children in presence of heterogeneity of original child’s state as mac-

<table>
<thead>
<tr>
<th>Scores</th>
<th>Area under curve</th>
<th>Standard deviation</th>
<th>Asymptotic values</th>
<th>Asymptotic confident interval 95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phoenix Sepsis Score</td>
<td>0.494</td>
<td>0.119</td>
<td>0.950</td>
<td>0.260, 0.727</td>
</tr>
<tr>
<td>pSOFA</td>
<td>0.500</td>
<td>0.102</td>
<td>1.000</td>
<td>0.300, 0.700</td>
</tr>
<tr>
<td>PELOD 2</td>
<td>0.535</td>
<td>0.106</td>
<td>0.730</td>
<td>0.328, 0.743</td>
</tr>
</tbody>
</table>

Fig. 2. Discriminatory ability of the analyzed scales for septic shock in children (n = 38)
ro-organism and microorganism in context Sepsis-3 conception [16]. The SCCM task force group did not try to describe a certain signs of macro-organism dysregulation and to confirm results by collection higher level biological resolution data, e.g. included genomics and proteomics. The limitations of this study are a retrospective design and a small number of patients. Despite this our results confirm the SCCM group opinion that sometimes Phoenix Sepsis score system has no advantage compared to pSOFA and PELOD 2 scores as a system of organ dysfunctions assessment [15]. Furthermore, an availability of resources and a local medical practice may affect the identification of infection, e.g. microbiological testing, sensitivity to antibiotics.

**Conclusion**

Our trials showed that Phoenix sepsis score, pSOFA score and PELOD 2 score were similar in Russian settings. Should we currently recognize a sepsis in children based on only Phoenix sepsis score? At this time pSOFA score has a high dissemination in pediatric ICU in Russia with using not only for septic children. Furthermore, Phoenix sepsis score requires to determine a lactate level, D-dimer, international normalized ratio, fibrinogen. These tests are available in large hospitals and ICU of third level of Russian Federation healthcare. Thereby, we conclude that the well-known pSOFA and PELOD 2 scores have to be currently used along with the Phoenix sepsis score. Although, the Phoenix sepsis score will have to be undergone by additional external international validation in countries with low-resourced healthcare.

**Disclosure.** The authors declare no competing interests.

**Author contribution.** All authors according to the ICMJE criteria participated in the development of the concept of the article, obtaining and analyzing factual data, writing and editing the text of the article, checking and approving the text of the article.

**Ethics approval.** This study was approved by the local Ethical Committee of Kuban State Medical University (reference number 19 — 16.04.2013).

**Funding source.** This study was not supported by any external sources of funding.

**Data Availability Statement.** The data that support the findings of this study are available from the corresponding author upon reasonable request.

**Author’s ORCID:**

Mironov P.I. — 0000-0002-9016-9461  
Aleksandrovich Yu.S. — 0000-0002-2131-4813  
Trembach A.V. — 0000-0002-4968-5296  
Pshenisnov A.V. — 0000-0003-1113-5296  
Lekmanov A.U. — 0000-0003-0798-1625

**References**


Comparative assessment of the predictive ability of organ dysfunction scales pSOFA, PELOD 2 and Phoenix Sepsis Score...


