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Recommendations for the initial management of septic shock in children

Guillermo Kohn-Loncarica[1], Josefina Pérez[2,3], Gustavo A. González[4,5], Roberto Jabornisky[6], Luis H. Llano[7], Ana L. Fustiñana[1]

ABSTRACT

We present an update on recommendations for managing septic shock in the emergency department during the "golden hour," highlighting the importance of early recognition and rapid implementation of therapeutic measures to reduce morbidity and mortality. It includes specific diagnostic criteria (the Phoenix Sepsis Scale), which improve the identification of sepsis and septic shock, although their usefulness in the initial stage is limited. This update covers strategies for hemodynamic support, airway management, individualized ultrasound-guided fluid therapy, and the safe use of vasoactive drugs administered via peripheral routes. It emphasizes the importance of administering antibiotics within the first hour.

Incorporating these elements into institutional protocols helps optimize initial treatment in the emergency department, even in settings with limited resources. It serves as a key tool for improving the prognosis in pediatric patients with sepsis.

Keywords: *septic shock; sepsis; clinical practice guideline; pediatrics.*

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[1] Emergency Department, Hospital de Pediatría S.A.M.I.C. Prof. Dr. Juan P. Garrahan, Autonomous City of Buenos Aires, Argentina; [2] Intensive Care Unit, Hospital de Niños Dr. Orlando Alassia, Santa Fe, Argentina; [3] Sanatorio Garay, Santa Fe, Argentina; [4] Intensive Care Unit, Hospital General de Niños Ricardo Gutiérrez, Autonomous City of Buenos Aires, Argentina; [5] Hospital Médico Policial Churruca Visca, Autonomous City of Buenos Aires, Argentina; [6] Department of Pediatrics, Universidad Nacional del Nordeste, Corrientes, Argentina; [7] Intensive Care Unit, Hospital Dr. Humberto Notti, Mendoza, Argentina.

Correspondence to *Guillermo Kohn-Loncarica: gkohnloncarica@gmail.com*

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INTRODUCTION

The prognosis and clinical course of patients with sepsis are time-dependent. For every hour that shock persists, the risk of death increases 2.3-fold, and mortality rises to 80%. Early diagnosis and timely treatment improve morbidity and mortality.[1,2] In pediatric emergency departments (PEDs), the "resuscitation measures" are typically initiated during the so-called "golden hour" of treatment. Once sepsis is recognized, treatment should follow established protocols, and, if appropriate, plans should be made to transfer the child to a facility with greater resources. The objective of this paper is to present current recommendations for managing septic shock during the first hour.

METHOD FOR SELECTING THE SOURCES CONSULTED

We conducted a narrative review of the literature on resuscitation recommendations and the management of the first hour of pediatric septic shock in the PubMed/MEDLINE, Scielo, and LILACS databases, prioritizing clinical practice guidelines (including the recent publication of the Surviving Sepsis Campaign 2026 [SSC]) consensus statements, and relevant original studies published in recent years. The literature was selected based on clinical relevance and applicability.

NEW DEFINITIONS AND CRITERIA FOR SEPSIS AND SEPTIC SHOCK IN CHILDREN

In 2016, the *Third International Consensus on the Definitions of Sepsis and Septic Shock* proposed a new definition for adults called Sepsis-3. Sepsis was defined as "life-threatening organ dysfunction caused by a dysregulated host response to infection." It was agreed to simplify concepts by eliminating the terms SIRS (systemic inflammatory response syndrome), severe sepsis, and sepsis with multi-organ involvement, and "operational" clinical definitions were proposed, such as the simplification of the Sequential Organ Failure Assessment (SOFA) into a quick SOFA (qSOFA) that considers three clinical aspects: altered mental status, increased respiratory rate, and/or decreased systolic blood pressure. These criteria have been used in adults to reach a diagnosis and start treatment quickly.[3]

However, this classification is not appropriate for children due to the significant physiological differences between the two age groups. For example, in children, hypotension is a late sign, and its presence is associated with higher mortality.[4]

The adaptation of Sepsis-3 to pediatrics through the Pediatric Sequential Organ Failure Assessment (pSOFA), which included an assessment at our institution—albeit specifically for patients with higher morbidity and mortality—proved to be insensitive for early detection.[5-7]

In 2024, the Phoenix Sepsis Scale (PSS) was validated; it includes four organ dysfunctions as diagnostic criteria: respiratory, cardiovascular, coagulation, and neurological (*Table 1*). Sepsis is defined as a life-threatening organ dysfunction with a PSS score of ≥2, in the context of a confirmed or suspected infection. Septic shock is defined as sepsis (PSS ≥2) with at least 1 point in the cardiovascular category (blood lactate ≥5 mmol/L, age-appropriate hypotension, or the need for vasoactive agents).[8,9]

The PSS is used for the definitive diagnosis of sepsis and/or septic shock, and is useful for quality assessment, clinical research, and epidemiological surveillance. It should not be used as a screening tool for early detection or diagnosis, nor to trigger initial interventions.

IDENTIFYING HIGH-RISK PATIENTS IN THE EMERGENCY DEPARTMENT

The timely detection of children with sepsis poses a challenge for emergency departments. Triage assesses the "pediatric evaluation triangle" (risk factors, comorbidities, and abnormal vital signs) and determines the primary reason for the visit. Having a dedicated triage area allows patients to be categorized according to their severity and optimizes care. In recent years, numerous tools for the early detection of sepsis have been developed and incorporated into the triage process, primarily in the United States, the United Kingdom, and Australia. These tools integrate clinical variables, vital signs, and risk factors, and demonstrate high sensitivity in identifying sepsis. However, their positive predictive values are often low due to the low prevalence of the disease in the countries where they were developed, leading to a considerable number of false alarms. More recently, models tailored to resource-limited settings have been developed, with promising initial results. In addition, many tools have incorporated parents' level of concern and the physician's clinical judgment as additional elements and predictors of sepsis.[10]

Therefore, when initiating treatment for a child

Table 1. Phoenix Sepsis Scale[a] (adapted from Schlapbach LJ et al.[8])

Variables	0 points	1 point	2 points	3 points
Respiratory (0-3 points)	PAFI ≥400 or SAFI ≥292[b]	With any respiratory support[c]: PAFI <400 or SAFI <292	With IMV PAFI 100-200 or SAFI 148-220:	With IMV: PAFI <100 or SAFI <148
Cardiovascular (0-6 puntos)	Without vasoactive drug Lactate <5 mmol/L	**1 point for each** (maximum 3) One vasoactive drug[d] Lactate 5-10.9 mmol/L[e]	**2 points for each** (maximum 6) ≥2 vasoactive drugs[d] Lactate >11 mml/L[e]	
Mean blood pressure by age (mmHg)[f,g]				
<1 month	>30	17-30	<17	
1-11 months	>38	25-38	<25	
1-<2 years	>43	31-43	<31	
2-<5 years	>44	32-44	<32	
5-<12 years	>48	36-48	<36	
12-17 years	>51	38-51	<38	
Coagulation[h] (0.2 points)	Platelets ≥100,000/µl INR ≤1.3 D-dimer ≤2 mg/L FEU Fibrinogen ≥100 mg/dl	**1 point for each)** (maximum 2) Platelets <100,000/µl INR >1.3 D-dimer >2 mg/L FEU Fibrinogen <100 mg/dl		
Neurological[i] (0-2 points)	Glasgow Coma Scale >10[j] with responsive pupils	Glasgow Coma Scale ≤10[j]	Unresponsive pupils (bilateral)	

FEU: fibrinogen equivalent units, IMV: mechanical ventilation, INR: international normalized ratio of prothrombin time, PAFI: ratio of partial pressure of oxygen to inspired oxygen fraction, SAFI: ratio of oxygen saturation measured by pulse oximetry to inspired oxygen fraction (only when oxygen saturation is <97%).

[a] The score can be calculated even if some variables are missing (for example, if lactate is not measured and/or vasoactive agents are not used, a cardiovascular score can still be determined based on blood pressure). Unmeasured variables do not contribute points to the score.

[b] SAFI: The ratio is calculated only if oxygen saturation is 97% or less.

[c] A 1-point respiratory dysfunction score can be assigned to any patient receiving oxygen, high-flow oxygen therapy, noninvasive positive pressure ventilation, or mechanical ventilation, and includes a PAFI <200 and a SAFI <220 in children not receiving mechanical ventilation.

[d] Vasoactive agents include any dose of epinephrine, norepinephrine, dopamine, dobutamine, milrinone, and/or vasopressin.

[e] The reference range for lactate is 0.5 to 2.2 mmol/L. Lactate may be arterial or venous.

[f] Age is not adjusted for prematurity, and the criteria do not apply to newborns or individuals aged 18 or older.

[g] Preferably use measured mean arterial pressure (MAP) (invasive arterial pressure if available, or noninvasive oscillometric pressure). If this is not available, a calculated MAP (1/3 × systolic blood pressure + 2/3 × diastolic blood pressure) may be used as an alternative.

[h] Reference ranges for coagulation variables: platelets 150 000-450 000/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] Neurological dysfunction was assessed in both sedated and non-sedated patients, as well as in those receiving or not receiving IMV support.

[j] The Glasgow Coma Scale measures the level of consciousness based on verbal, ocular, and motor responses (range: 3-15; a higher score indicates better neurological function).

with suspected septic shock, a set of factors must be considered in conjunction with a clinical picture of suspected or confirmed infection associated with signs of tissue hypoperfusion (abnormalities in capillary refill, pulse, extremity temperature, sensory function, and urine output).

HEMODYNAMIC SUPPORT DURING THE FIRST HOUR

The main objectives are to normalize heart rate, capillary refill time, pulses, limb temperature, blood pressure (BP), and urine output.[11]

The age-adjusted shock index: heart rate/systolic blood pressure (SIPA) is useful for predicting the need for resources such as

transfusions, admission to a pediatric intensive care unit (PICU), mechanical ventilation, and mortality.[12] Cut-off values differ by age: >1.2 for children aged 1 to 6 years; >1.0 for children aged 7 to 12 years; and >0.9 for those over 12 years of age. Monitoring changes in the SIPA (for example, with measurements at admission and at 24 hours) can help assess response to treatment.

1. Measures upon admission (minute 0)

The initial actions are:

a) Maintain a patent airway, assessing the need for endotracheal intubation.
b) Administer O_2 via a nasal cannula, simple mask, reservoir mask, high-flow cannula, noninvasive ventilation, or invasive mechanical ventilation (IMV).
c) Establish two peripheral vascular access sites or an intraosseous access site (or prepare existing catheters for use).
d) Initiate noninvasive hemodynamic monitoring: serial measurements of blood pressure, pulse oximetry, electrocardiogram, temperature, urine output, and point-of-care ultrasound (POCUS), if available and performed by trained personnel.

Once airway patency, breathing, and circulation (ABC) have been ensured, administer O_2 to correct hypoxemia, but avoid hyperoxia.[13] If there is progressive cardiopulmonary failure (bradycardia, bradypnea, hypotension) or a Glasgow Coma Scale score <8, orotracheal intubation should be performed, ensuring adequate fluid preload and, if necessary, administering vasoactive agents beforehand. In regions with limited access to a PICU, oxygen may be administered via bubble CPAP or noninvasive ventilation if IMV is not feasible.

Establish two vascular access points and obtain laboratory samples. If this cannot be achieved within the first 5 minutes or after two attempts, intraosseous access is indicated, as it is safe and easy to implement, and it enables the administration of any medication or fluid. The samples obtained allow for the detection of abnormalities requiring immediate correction, such as hypocalcemia, hypoglycemia, and hypokalemia. The laboratory provides information on organ dysfunction, including a complete blood count, transaminases, renal function, lactate, coagulation profile, electrolytes, acid-base status, procalcitonin, fibrinogen, and D-dimer. Any abnormalities will be identified and corrected.

Lactic acid is a cardiovascular component of the PSS. Elevated levels are a warning sign, and serial measurements are useful as a diagnostic criterion and as a guide for treatment or follow-up. It should not be used in isolation to guide decision-making.[14,15]

2. Fluid therapy (5 minutes)

Initiate careful fluid replacement using balanced crystalloid solutions such as Ringer's Lactate™ or PlasmaLyte™[16,17] or saline, infused over the next 30 to 60 minutes. Periodically monitor for signs of volume overload, such as hepatomegaly, pulmonary rales, cough, a third heart sound, and/or ultrasound findings. If any of these signs are present, fluid administration must be discontinued, and vasoactive agents must be initiated via peripheral or intraosseous access if central access is not available.

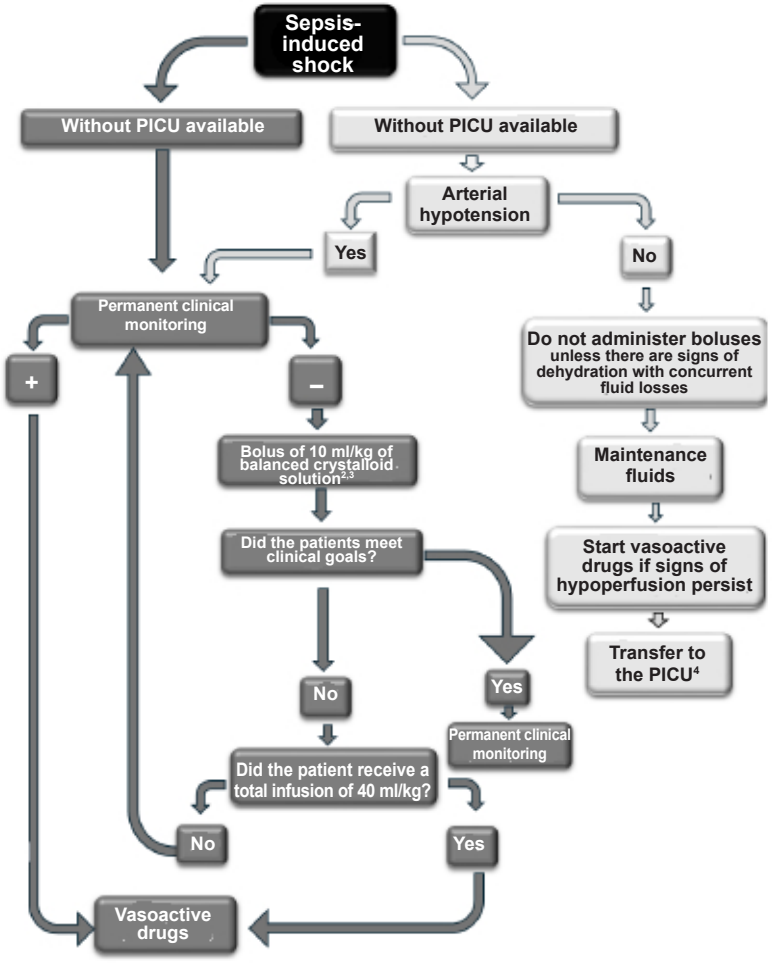
The SSC recommends considering the availability of PICU when determining treatment.[18] When PICU is available, administer boluses of 10 to 15 ml/kg up to a total of 40–60 ml/kg over 60 minutes. If PICU is not available, the approach varies depending on the presence of hypotension. In the absence of hypotension (compensated shock, with normal blood pressure), they suggest not administering fluids in boluses and initiating maintenance therapy, as rapid bolus infusion within the first hour has been shown to increase mortality compared with maintenance hydration.[19]

In contrast, in cases of hypotension (decompensated shock), they recommend administering up to 40 ml/kg as a bolus (*Figure 1*). In patients with heart failure or cardiomyopathy (malnourished patients, those with a history of myocarditis, cancer patients receiving anthracyclines, etc.), fluid administration should be initiated at a rate of 5 ml/kg while monitoring for signs of fluid overload. Peripheral edema, characteristic of capillary injury, without other signs of hypervolemia, would not contraindicate continuing the infusion.

In recent years, the use of POCUS—performed by trained personnel—to guide fluid resuscitation has become a useful tool for identifying children in whom fluid administration could be harmful (congested inferior vena cava, pulmonary B-lines, or impaired contractile function). It then allows for an assessment of tolerance to the administered fluids.[20-22]

During the resuscitation phase of sepsis (the first 24 hours), damage to and detachment of the endothelial glycocalyx have been described as being associated with worse outcomes.[23,24]

Figure 1. Fluid management and vasoactive drugs in septic shock



PICU: pediatric intensive care unit; US: ultrasound.
1 The US findings that should be evaluated are: vena cava collapsibility, pulmonary B-lines, and cardiac contractility; 2 If balanced solutions are not available, use 0.9% saline solution; 3 The amount of fluids administered to obese patients should be adjusted to the ideal weight for height; 4 If PICU is not available, discontinue bolus infusions once blood pressure has improved.

The use of unbalanced solutions would directly contribute to the loss of the endothelium's anti-adhesive phenotype, facilitating thrombosis, capillary obstruction, tissue hypoperfusion, and increased vascular leakage of fluids, proteins, and inflammatory cells into the tissues. Fernández Sarmiento et al. demonstrated that glycocalyx degradation worsens six hours after the administration of boluses of unbalanced solutions, which is associated with increased vascular permeability, metabolic acidosis, hyperchloremia, and renal failure.[16,25,26]

However, the recent multicenter PRoMT BOLUS study, which compared balanced solutions with normal saline in children with septic shock, concluded that there are no significant differences in the most critical clinical outcomes (assessed using the indicator MAKE30 (major adverse kidney event), which measures mortality, the need for renal replacement therapy, or persistent renal dysfunction. Although there were biochemical variations (hyperchloremia in the saline group and higher lactate levels in the balanced fluids group), these had no impact on the primary outcome. The study concludes that both options are equally safe and effective for initial resuscitation.[27] It should be noted, however, that the study's external validity is limited to high-resource countries. As the authors acknowledge, nearly the entire cohort came from the United States, Canada, and Australia, with mild disease severity (mortality ~1%; <14%

required vasoactive support, and fewer than 10% were placed on mechanical ventilation). This contrasts substantially with resource-limited settings, where mortality from sepsis is higher, meaning that the results may not be transferable to critically ill patients. In Argentina, Galván et al. reported a mortality rate of 16.5%, with 37% of patients not receiving antibiotics within the first hour.[28]

Elevated procalcitonin levels are associated with endothelial and microvascular dysfunction, which contributes to increased fluid overload, the need for vasopressors, multiple organ failure, prolonged stays in the PICU, and higher mortality. This clinical phenotype suggests that endothelial injury plays a key role in the pathophysiology of sepsis, and that microcirculatory abnormalities could be a future therapeutic target.[29]

In the PED, rapid fluid infusions were associated with higher adjusted odds of death (aOR = 1.11; 95%CI 1.01-1.23), intubation (aOR = 1.25; 95%CI 1.09-1.44), and NIV (aOR = 1.20; 95%CI 1.05-1.38).[30] Therefore, controlled and adequate fluid resuscitation is recommended during the first hour, guided by ultrasound whenever possible.[18]

If the patient remains in shock after fluid administration (fluid-refractory shock) or if signs of fluid overload have appeared, vasoactive drugs are indicated within the first hour.

The lack of central vascular access has historically been a barrier to the early administration of these drugs. However, their infusion via peripheral access has been widely validated, and few side effects have been reported.[31,32] It is recommended to dilute drugs 3 to 10 times more than those administered via central access.[33-35]

3. Vasoactive support (within the first 60 minutes in fluid-refractory shock)

It has been suggested that there is not always a correlation between clinical signs of perfusion (capillary refill time, noninvasive blood pressure, extremity temperature, pulses, etc.) and the hemodynamic profile determined by parameters obtained through invasive methods, which are often not available in the emergency department.[36-38]

The SSC recommends guiding vasoactive therapy using advanced hemodynamic variables (cardiac output/cardiac index, systemic vascular resistance, or central venous oxygen saturation); therefore, in cases of fluid-refractory shock, admission to the PICU is necessary after the first hour.[18]

Furthermore, they emphasize that there is insufficient evidence to recommend a preferred first-line treatment with epinephrine or norepinephrine. Either drug may be indicated depending on the treating physician's preference, its availability, and the child's clinical profile.[18]

Adrenaline is indicated at doses ranging from 0.05 µg/kg/min to 0.3 µg/kg/min to optimize cardiac contractility due to the β-agonist effect of these doses. In comparison, norepinephrine is administered at an initial dose of 0.05 µg/kg/min to achieve α-agonist effects. Dopamine may be associated with higher mortality and is reserved as a second-line option.[18,39,40]

Once therapy with vasoactive agents has begun, titrate them by evaluating clinical response and achievement of goals. If shock persists, follow the steps recommended by local guidelines and transfer the patient to a PICU. During transport or while waiting, the child will continue to receive treatment without delaying or interrupting therapy.

In children with septic shock who require vasoactive agents, the SSC and the Latin American Consensus recommend initiating their administration via peripheral venous access rather than delaying treatment until central venous access is established.[14,18] In such cases, the necessary precautions for their administration and proper dilution should be taken into account.[35]

4. Antibiotics (within the first 60 minutes)

In children with suspected septic shock, antibiotic therapy should be initiated as soon as possible—ideally within the first 60 minutes—as this improves outcomes and reduces mortality.[18] Several studies have demonstrated an association between the rate of administration and reduced mortality.[2,41,42]

In children with sepsis but without shock, it is recommended to begin treatment as soon as possible, within 3 hours of diagnosis.[43-45]

Obtain blood cultures before starting antimicrobial therapy, provided that this does not delay the administration of antibiotics.[18]

5. Metabolic issues (correct as soon as they are detected)

Metabolic disturbances could worsen the condition. A lack of intracellular glucose (hypoglycemic shock) exacerbates energy deficiency. To prevent this and optimize glucose delivery, infusion rates of 4-6 mg/kg/min are

needed to maintain blood glucose levels between 80 and 150 mg/dl. Hyperglycemia is also harmful; for levels >180 mg/dl, intravenous insulin therapy is recommended, based on experience with adults.[46]

Calcium plays a role in myocardial contractility and vasomotor tone. During sepsis, their regulation may be impaired, and these abnormalities should be corrected. Bicarbonate administration is not indicated in patients with shock and a pH >7.15, as it is associated with sodium and volume overload, as well as an increase in lactate, PCO_2, and decreased calcium ion.

The use of hydrocortisone is recommended in children with suspected adrenal insufficiency (prolonged steroid therapy, central nervous system disorders, and/or impaired adrenocorticotropic hormone production, or those with purpura fulminans). A dose of 60 mg/m^2 is recommended. [14,18,47]

Due to the risks of complications and the increased morbidity and mortality associated with red blood cell transfusions in critically ill patients, more restrictive strategies have been proposed. For children with septic shock who remain stable (defined as a mean arterial pressure more than 2 standard deviations below the normal range for their age and no increase in vasoactive medications for at least 2 hours), the recommendation is not to transfuse red blood cells if the hemoglobin concentration is ≥7 g/dl. However, no recommendations were made regarding transfusion thresholds for hemodynamically unstable children.[48,49]

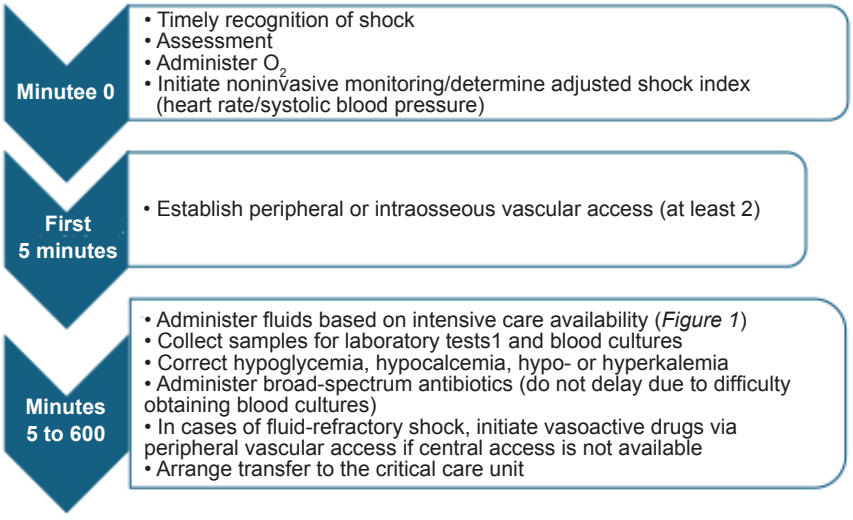
Some of the aspects mentioned—such as the use of steroids, the monitoring and interpretation of biomarkers, red blood cell transfusions, etc.—are typically carried out within the framework of the PICU, and this document does not aim to analyze them in greater detail.

Figure 2 summarizes the management of a child with septic shock.

CONCLUSION

The prognosis for sepsis in children depends largely on the speed and effectiveness of initial treatment. The first hour after diagnosis represents a critical window of opportunity to reduce mortality and its sequelae. Implementing new, specific diagnostic definitions, along with updated strategies for hemodynamic management, ultrasound-guided rational fluid administration, vasoactive drugs, and early antibiotic administration, improves clinical outcomes. Pediatric emergency departments must have clear, feasible protocols tailored to their resources to act quickly. Continuous updating, based on the best available evidence, is essential for optimizing the management of septic shock in children and ensuring timely and safe care. ■

Figure 2. Stepwise algorithm for managing septic shock during the "golden hour" in pediatric emergencies



[1] Blood gases, ionogram, serum calcium, blood glucose, lactic acid, complete blood count, coagulation panel, liver function tests, urea, creatinine, fibrinogen, and D-dimer.

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REFERENCES

1. Evans IVR, Phillips GS, Alpern ER, Angus DC, Friedrich ME, Kissoon N, et al. Association Between the New York Sepsis Care Mandate and In-Hospital Mortality for Pediatric Sepsis. *JAMA*. 2018;320(4):358-67. doi: 10.1001/jama.2018.9071.
2. Lane RD, Richardson T, Scott HF, Paul RM, Balamuth F, Eisenberg MA, et al. Delays to Antibiotics in the Emergency Department and Risk of Mortality in Children with Sepsis. *JAMA Netw Open*. 2024;7(6):e2413955. doi:10.1001/jamanetworkopen.2024.13955.
3. 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(8):801-10. doi:10.1001/jama.2016.0287.
4. Carcillo JA, Kuch BA, Han YY, Day S, Greenwald BM, McCloskey KA, et al. Mortality and functional morbidity after use of PALS/APLS by community physicians. *Pediatrics*. 2009;124(2):500-8. doi:10.1542/peds.2008-1967.
5. 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(10):e172352. doi:10.1001/jamapediatrics.2017.2352.
6. Schlapbach LJ, Straney L, Bellomo R, MacLaren G, Pilcher D. Prognostic accuracy of age-adapted SOFA, SIRS, PELOD-2, and qSOFA for in-hospital mortality among children with suspected infection admitted to the intensive care unit. *Intensive Care Med*. 2018;44(2):179-88. doi:10.1007/s00134-017-5021-8.
7. Fustiñana A, Yock-Corrales A, Casson N, Galvis L, Iramain R, Lago P, et al. Shock séptico en niños: ¿son aplicables los criterios de SEPSIS-3 en Urgencias? Un estudio multicéntrico en Latinoamérica. *Emerg Pediatr*. 2024;3(1):9-18.
8. Schlapbach LJ, Watson RS, Sorce LR, Argent AC, Menon K, Hall MW, et al. International Consensus Criteria for Pediatric Sepsis and Septic Shock. *JAMA*. 2024;331(8):665-74. doi:10.1001/jama.2024.0179.
9. Sanchez-Pinto LN, Bennett TD, DeWitt PE, Russell S, Rebull MN, Martin B, et al. Development and Validation of the Phoenix Criteria for Pediatric Sepsis and Septic Shock. *JAMA*. 2024;331(8):675-86. doi:10.1001/jama.2024.0196.
10. Lopera Múnera NL, Pavlicich V. Estado actual del desarrollo de las herramientas de detección inicial de la sepsis en los departamentos de Emergencias pediátricos. *Emerg Pediatr*. 2023;2(2):124-31.
11. Davis AL, Carcillo JA, Aneja RK, Deymann AJ, Lin JC, Nguyen TC, et al. American College of Critical Care Medicine Clinical Practice Parameters for Hemodynamic Support of Pediatric and Neonatal Septic Shock. *Crit Care Med*. 2017;45(6):1061-93. doi:10.1097/CCM.0000000000002425.
12. Huang KC, Yang Y, Li CJ, Cheng FJ, Huang YH, Chuang PC, et al. Shock Index, Pediatric Age-Adjusted Predicts Morbidity and Mortality in Children Admitted to the Intensive Care Unit. *Front Pediatr*. 2021;9:727466. doi:10.3389/fped.2021.727466.
13. Catalanotto FR, Ippolito M, Mirasola A, Catalisano G, Milazzo M, Giarratano A, et al. Hyperoxia in critically ill patients with sepsis and septic shock: a systematic review. *J Anesth Analg Crit Care*. 2023;3(1):12. doi:10.1186/s44158-023-00096-5.
14. Fernández-Sarmiento J, De Souza DC, Martinez A, Nieto V, López-Herce J, Soares Lanziotti V, et al. Latin American Consensus on the Management of Sepsis in Children: Sociedad Latinoamericana de Cuidados Intensivos Pediátricos [Latin American Pediatric Intensive Care Society] (SLACIP) Task Force: Executive Summary. *J Intensive Care Med*. 2022;37(6):753-63. doi:10.1177/08850666211054444.
15. de Souza DC, Jabornisky R, Kissoon N. Utility of Lactate Levels in the Diagnosis and Prognosis of Septic Shock. *Pediatr Emerg Care*. 2024;40(10):736-45. doi:10.1097/PEC.0000000000003181.
16. Fernández Sarmiento J, Salazar Peláez LM, Villar Centeno JC. Alteraciones del endotelio y su glicocálix en niños con sepsis que reciben reanimación hídrica con soluciones cristaloides. [Antioquia, Colombia]: Universidad CES; Marzo 2022. [Accessed on June 8, 2026]. Available from: https://hdl.handle.net/10946/5764
17. Alcalá Lozano SC, Erazo Vargas SC, Gómez Cortes LB. Asociación entre uso de soluciones balanceadas y lesión renal durante la reanimación hídrica en niños con sepsis. Universidad del Rosario. doi:10.48713/10336_20167. [Accessed on June 8, 2026]. Available from: https://repository.urosario.edu.co/items/a432bdd2-241b-4ca0-b385-75628c97246a
18. Weiss SL, Peters MJ, Oczkowski SJW, Belley-Cote E, Buysse C, Choong KLM, et al. Surviving Sepsis Campaign International Guidelines for the Management of Sepsis and Septic Shock in Children 2026. *Pediatr Crit Care Med*. 2026;27(4):379-434. doi:10.1097/PCC.0000000000003927.
19. Maitland K, Kiguli S, Opoka RO, Engoru C, Olupot-Olupot P, Akech SO, et al. Mortality after Fluid Bolus in African Children with Severe Infection. *N Engl J Med*. 2011;364(26):2483-95. doi:10.1056/NEJMoa1101549.
20. Ranjit S, Kissoon N, Argent A, Inwald D, Ventura AMC, Jaborinsky R, et al. Haemodynamic support for paediatric septic shock: a global perspective. *Lancet Child Adolesc Health*. 2023;7(8):588-98. doi:10.1016/S2352-4642(23)00103-7.
21. Kattan E, Castro R, Miralles-Aguiar F, Hernández G, Rola P. The emerging concept of fluid tolerance: A position paper. *J Crit Care*. 2022;71:154070. doi:10.1016/j.jcrc.2022.154070.
22. Ranjit S, Natraj R. Hemodynamic Management Strategies in Pediatric Septic Shock: Ten Concepts for the Bedside Practitioner. *Indian Pediatr*. 2024;61(3):265-75.
23. Johansson P, Stensballe J, Ostrowski S. Shock induced endotheliopathy (SHINE) in acute critical illness - a unifying pathophysiologic mechanism. *Crit Care*. 2017;21(1):25. doi:10.1186/s13054-017-1605-5.
24. Milford EM, Reade MC. Resuscitation Fluid Choices to Preserve the Endothelial Glycocalyx. *Crit Care*. 2019 9;23(1):77. doi:10.1186/s13054-019-2369-x.
25. Flórez Mercado S, Alarcón Forero LC, Fernández Sarmiento J. Daño del glicocálix endotelial en niños con sepsis que reciben bolos de cristaloides no balanceados. [Cundinamarca, Colombia]: Universidad de La Sabana; 2022. [Accessed on June 8, 2026]. Available from: https://intellectum.unisabana.edu.co/handle/10818/52321
26. Fernández-Sarmiento J, Salazar-Peláez LM, Acevedo L, Niño-Serna LF, Flórez S, Alarcón-Forero L, et al. Endothelial and Glycocalyx Biomarkers in Children With Sepsis After One Bolus of Unbalanced or Balanced Crystalloids. *Pediatr Crit Care Med*. 2023;24(3):213-21. doi:10.1097/PCC.0000000000003123.
27. Balamuth F, Weiss SL, Long E, Thompson GC, Artis AS, Campos AB, et al. Balanced Fluid or 0.9% Saline in Children Treated for Septic Shock. *N Engl J Med*. 2026; Online ahead of print. Apr 24. doi:10.1056/NEJMoa2601969.

28. Galván ME, Viqueira Guzmán C, Lanzavecchia E, Jabornisky R, Ruvinsky S, Kulik MV, et al. Segundo estudio epidemiológico de sepsis y shock séptico pediátricos en la República Argentina (ESSPED-2). *Arch Argent Pediatr*. 2025;123(6):e202510646. doi:10.5546/aap.2025-10646.
29. Beltrán Hernandez B, Fernández-Sarmiento J, Mulett H, Niño Ariza MC, Aguirre Gutierrez V, Cárdenas C, et al. Hyperprocalcitonemia and Endothelial and Microcirculatory Dysfunction in Children With Sepsis and Septic Shock: Single-Center Observational Cohort Study in Colombia, 2021-2024. *Pediatr Crit Care Med*. 2025;26(8):e1024-33. doi:10.1097/PCC.0000000000003782.
30. Mullan PC, Pruitt CM, Levasseur KA, Macias CG, Paul R, Depinet H, et al. Intravenous Fluid Bolus Rates Associated with Outcomes in Pediatric Sepsis: A Multi-Center Analysis. *Open Access Emerg Med*. 2022;14:375-84. doi:10.2147/OAEM.S368442.
31. Munroe ES, Heath ME, Eteer M, Gershengorn HB, Horowitz JK, Jones J, et al. Use and Outcomes of Peripheral Vasopressors in Early Sepsis-Induced Hypotension Across Michigan Hospitals: A Retrospective Cohort Study. *Chest*. 2024;165(4):847-57. doi:10.1016/j.chest.2023.10.027.
32. Barbash IJ. Real World Data on Peripheral Vasopressors in Septic Shock. *Chest*. 2024;165(4):762-3. doi:10.1016/j.chest.2023.11.005.
33. Kohn-Loncarica G, Hualde G, Fustiñana A, Monticelli MF, Reinoso G, Cortéz M, et al. Use of Inotropics by Peripheral Vascular Line in the First Hour of Treatment of Pediatric Septic Shock: Experience at an Emergency Department. *Pediatr Emerg Care*. 2022;38(1):e371-7. doi:10.1097/PEC.0000000000002295.
34. Fustiñana A, Yock-Corrales A, Casson N, Galvis L, Iramain R, Lago P, et al. Adherence to Pediatric Sepsis Treatment Recommendations at Emergency Departments: A Multicenter Study in Latin America. *Pediatr Emerg Care*. 2022;38(9):e1496-502. doi:10.1097/PEC.0000000000002801.
35. Segovia L, Mareco Nacarato G, Reyes N, Alvariño C, Reinoso G. Acceso vascular periférico. Colocación y cuidados de enfermería para administrar drogas vasoactivas en forma segura y eficaz en niños con sepsis. *Emerg Pediatr*. 2022;1(1):46-9.
36. Brierley J, Peters MJ. Distinct hemodynamic patterns of septic shock at presentation to pediatric intensive care. *Pediatrics*. 2008;122(4):752-9. doi:10.1542/peds.2007-1979.
37. Ranjit S, Aram G, Kissoon N, Ali MK, Natraj R, Shresti S, et al. Multimodal monitoring for hemodynamic categorization and management of pediatric septic shock: a pilot observational study. *Pediatr Crit Care Med*. 2014;15(1):e17-26. doi:10.1097/PCC.0b013e3182a5589c.
38. Razavi A, Newth CJL, Khemani RG, Beltramo F, Ross PA. Cardiac output and systemic vascular resistance: Clinical assessment compared with a noninvasive objective measurement in children with shock. *J Crit Care*. 2017;39:6-10. doi:10.1016/j.jcrc.2016.12.018.
39. Rui Q, Jiang Y, Chen M, Zhang N, Yang H, Zhou Y. Dopamine versus norepinephrine in the treatment of cardiogenic shock: A PRISMA-compliant meta-analysis. *Medicine (Baltimore)*. 2017;96(43):e8402. doi:10.1097/MD.0000000000008402.
40. Backer DD, Biston P, Devriendt J, Madl C, Chochrad D, Aldecoa C, et al. Comparison of Dopamine and Norepinephrine in the Treatment of Shock. *N Engl J Med*. 2010;362(9):779-89. doi:10.1056/NEJMoa0907118.
41. Weiss SL, Fitzgerald JC, Balamuth F, Alpern ER, Lavelle J, Chilutti M, et al. Delayed antimicrobial therapy increases mortality and organ dysfunction duration in pediatric sepsis. *Crit Care Med*. 2014;42(11):2409-17. doi:10.1097/CCM.0000000000000509.
42. Sankar J, Garg M, Ghimire JJ, Sankar MJ, Lodha R, Kabra SK. Delayed Administration of Antibiotics Beyond the First Hour of Recognition Is Associated with Increased Mortality Rates in Children with Sepsis/Severe Sepsis and Septic Shock. *J Pediatr*. 2021;233:183-90.e3. doi:10.1016/j.jpeds.2020.12.035.
43. Tang F, Yuan H, Li X, Qiao L. Effect of delayed antibiotic use on mortality outcomes in patients with sepsis or septic shock: A systematic review and meta-analysis. *Int Immunopharmacol*. 2024;129:111616. doi:10.1016/j.intimp.2024.111616.
44. Im Y, Kang D, Ko RE, Lee YJ, Lim SY, Park S, et al. Time-to-antibiotics and clinical outcomes in patients with sepsis and septic shock: a prospective nationwide multicenter cohort study. *Crit Care*. 2022;26(1):19. doi:10.1186/s13054-021-03883-0.
45. Kumar A, Roberts D, Wood KE, Light B, Parrillo JE, Sharma S, et al. Duration of hypotension before initiation of effective antimicrobial therapy is the critical determinant of survival in human septic shock. *Crit Care Med*. 2006;34(6):1589-96. doi:10.1097/01.CCM.0000217961.75225.E9.
46. Honarmand K, Sirimaturos M, Hirshberg EL, Bircher NG, Agus MSD, Carpenter DL, et al. Society of Critical Care Medicine Guidelines on Glycemic Control for Critically Ill Children and Adults 2024. *Crit Care Med*. 2024;52(4):e161-81. doi:10.1097/CCM.0000000000006174.
47. Chaudhuri D, Nei AM, Rochwerg B, Balk RA, Asehnoune K, Cadena R, et al. 2024 Focused Update: Guidelines on Use of Corticosteroids in Sepsis, Acute Respiratory Distress Syndrome, and Community-Acquired Pneumonia. *Crit Care Med*. 2024;52(5):e219-33. doi:10.1097/CCM.0000000000006172.
48. Valentine SL, Bembea MM, Muszynski JA, Cholette JM, Doctor A, Spinella PC, et al. Consensus Recommendations for RBC Transfusion Practice in Critically Ill Children From the Pediatric Critical Care Transfusion and Anemia Expertise Initiative. *Pediatr Crit Care Med*. 2018;19(9):884-98. doi:10.1097/PCC.0000000000001613.
49. Muszynski JA, Guzzetta NA, Hall MW, Macrae D, Valentine SL, Bateman ST, et al. Recommendations on RBC Transfusions for Critically Ill Children With Nonhemorrhagic Shock From the Pediatric Critical Care Transfusion and Anemia Expertise Initiative. *Pediatr Crit Care Med*. 2018;19(9S Suppl 1):S121-6. doi:10.1097/PCC.0000000000001620.