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# Early Detection and Initial Management of Sepsis in Pediatric Patients

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## Abstract

**Background:** Sepsis and septic shock being the most common cause of death in infants and children worldwide, Therefore, we aim to look into the pediatric sepsis that both medical students and new physicians face in the recognition, diagnosis, and management of these conditions.

**Targeted population:** Pediatric sepsis that is requiring urgent management in the Emergency Department (ED), with Emergency Physicians for teaching approach protocol.

**Aim of the study:** Appropriate identification of pediatric sepsis, severe sepsis and septic shock and their management by training protocol to Emergency Physicians. Based on the child's age, site, severity and source of infection.

**Methods:** Collection of all possible available data about pediatric sepsis at the emergency department. By many research questions to achieve these aims so a midline literature search was performed with the keywords "critical care", "emergency medicine", "Pediatric sepsis principals in emergencies", "Pediatric sepsis and management". Literature search included an overview of recent definition, causes and recent therapeutic interventions strategies.

**Results:** All studies introduced that initial diagnosis of different emergencies situations of pediatric sepsis and their interventions are serious conditions that face pediatric patients in ED.

**Conclusion:** The early recognition of sepsis in pediatric would help to start the initial management promptly, thus will prevent sepsis to complicate into worse stages and have a better prognosis.

**Keywords:** Critically ill child; Emergency physicians; Outcome; Skills

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## Introduction

Trauma in pediatric can be an important predisposing cause for sepsis which is the leading cause of death in children worldwide. Although many studies are done over adult patients, influenced those of pediatrics, but still pediatrics have their own considerations in all of the identification of sepsis and its management on different stages [1].

The rationale behind this review, is the fact that the early recognition of sepsis in pediatric would help to start the initial management promptly, thus will prevent sepsis to complicate into worse stages and have a better prognosis [2]. By going through this article, we will highlight the definition of pediatric sepsis severe sepsis and septic shock and the different ways to identify it early and manage it upon many necessary variables such as the child's age, site, severity and source of infection [3].

## Epidemiology

Sepsis is the most common cause of death in infants and children worldwide. Childhood pneumonia being the most common cause with an incidence rate of 0.29 episodes per child-year in pre-developed and 0.05 episodes per child-year in developed countries, and also the highest cause of mortality in children less than 5 year of age [1].

According to data from the 2015 SPROUT study, the point prevalence of severe sepsis globally was 8.2% (95% confidence

interval (CI), 7.6-8.9). In addition, mortality rates associated with sepsis and septic shock in patients admitted to the pediatric intensive care unit (PICU) were 5.6% and 17.0%, respectively.

The incidence of SIRS is extremely high. It has been estimated that one third of all in-hospital patients, greater than 50% of all ICU patients and greater than 80% of surgical ICU patients meet the criteria of SIRS. The more SIRS criteria a patient had, the more likely he is susceptible to develop sepsis, acute respiratory distress syndrome, disseminated intravascular coagulation, acute renal failure, and shock.

Sepsis has an estimated annual incidence of 300/100 000 or 1/100 hospital admissions for any cause the incidence of sepsis in cirrhosis is estimated to be at least 30-50% of hospital admissions. Once admitted, between 15% and 35% of cirrhotic patients develop nosocomial infections compared with an infection rate of 5-7% in the general hospital population. In addition to the factors which predispose the general population to the development of sepsis, the severity of the underlying liver disease also makes cirrhotic patients more susceptible to the development of sepsis [2].

Pediatric severe sepsis usually is community-acquired (57%) and occurs most often in toddlers (median age of 3 years with interquartile range, 0.7-11.0). The most common primary site of infection is the respiratory tract. Interestingly, one study noted the most common pathogen retrieved from blood cultures was *Staphylococcus aureus* [1].

Developing countries hold the highest burden of pediatric sepsis, of approximately of 156 million new cases of pneumonia per year, 151 million estimated cases belong to the developing countries [2].

## Definitions

**Definition of sepsis:** Sepsis (bacteremia with clinical evidence of systemic infection) can rapidly progress to multiorgan failure and death. Risk factors include prematurity, immunocompromised state, recent invasive procedures, and indwelling foreign objects such as catheters [3].

Although it's not included in the definition of sepsis, hyperglycemia, altered mental status, high lactate, and a prolonged CRT are all highly suggestive of sepsis and, therefore, should be considered when evaluating a child for sepsis.

**Definition of systemic inflammatory response syndrome:** SIRS occurs when the body's inflammatory state is maxed up in response to an insult. Sepsis syndrome is associated with arterial vasodilatation, impairment of circulatory function, and activation of neurohumoral vasoconstrictor systems, which enhance development of renal impairment in cirrhotic patient who already have circulatory failure. This combined effect probably overcomes the compensatory action of renal vasodilators and thus leads to decreases in renal perfusion and the glomerular filtration rate. The SIRS adult criteria have been modified to make a pediatric-specific definition. In children, SIRS include two or more of the following, one of which must be an abnormal temperature or leukocyte count: [4]

1. A rectal temperature >38.5°C or <36°C;
2. Heart rate more than two standard deviations (SD) above the normal, or bradycardia in children older than 1 year of age (<10th percentile for age);
3. Respiratory rate more than two SD above normal (or $pCO_2$<32 mmHg);
4. Leukocyte count >12,000 cells/$mm^3$, <4,000 cells/$mm^3$, or >10% band forms.

**Definition of Shock:** Septic shock is sepsis with fluid refractory hypotension and signs of hypoperfusion. Shock can be cold or warm. Definitions of shock are shown in the **Tables 1 and 2** below [5].

**Definition of organ dysfunction:** The international Consensus Conference on Pediatric Sepsis, gave the list of different definitions in **Table 3**.

**Table 1** Definitions of shock [12].

| Type of Shock | Characteristics | | | |
|---|---|---|---|---|
| | Central Capillary Refill | Peripheral Pulse | Skin | Pulse Pressure |
| Cold Shock | >3 Seconds | Decreased | Cool Mottled | Narrow |
| Warm Shock | <3 Seconds | Bounding | Warm | Wide |

**Source**: Author created.

**Table 2** Criteria for organ dysfunction [13].

| Organ System | Criteria for Dysfunction |
|---|---|
| Cardiovascular | Hypotension* or |
| | Need for Vasoactive drug to maintain blood pressure in the normal range or |
| | Two of the following: |
| | • Metabolic acidosis |
| | • Elevated arterial lactate |
| | • Oliguria |
| | • Prolonged capillary refill time |
| Respiratory | $PaO_2/FiO_2$<300 or |
| | $PaCO_2$>65 or 20 mmHg over baseline or |
| | Need for >50% $FiO_2$ to maintain oxygen saturation ≥ 92% or |
| | Need for non-elective mechanical ventilation |
| Neurologic | Glasgow coma scale score ≤ 11 or |
| | Acute change in mental status |
| Hematologic | Platelet count <80,000/microliter or |
| | A decline of 50% from the highest value recorded over the previous three days or |
| | Disseminated intravascular coagulopathy |
| Renal | Serum creatinine ≥ 2 times upper limit or |
| | Two-fold increase in baseline creatinine |
| Hepatic | Total bilirubin ≥ 4 mg/dL ** or |
| | Serum glutamic pyruvic transaminase > 2 times upper limit |

*Hypotension is defined as < 5th percentile for age or systolic blood pressure < 2 standard deviations below normal for age

** Often a normal variant in newborns

**Table 3** Definitions of illness in the sepsis continuum.

| Clinical syndrome | Criteria |
|---|---|
| 'Systemic inflammatory response syndrome (SIRS) | Must have at least 2 of the following of which at least one must be abnormal temperature or abnormal leukocyte count: |
| | 1. Abnormal heart rate (HR) defined as tachycardia (HR>2 SD above normal for age in the absence of external stimulus, drugs, or painful stimuli or otherwise unexplained elevation over 0.5-4 h) or bradycardia (HR <10th percentile for age in absence of external vagal stimulus, drugs, congenital heart disease; or otherwise unexplained HR depression >05 h). |
| | 2. Tachypnea >2 SD above normal for age or mechanical ventilation for process other than anesthesia or underlying neuromuscular disease. |
| | 3. Abnormal temperature defined as fever (core temperature >38.5°C) or hypothermia (core temperature <36°C). |
| | 4. Abnormal leukocyte profile with counts either elevated or depressed for age (not due to chemotherapy) or >10% immature neutrophils. |
| Infection | A suspected infection or one proven by positive culture, tissue stain, or molecular testing caused by any pathogen or a clinical syndrome associated with high probability of infection. Acceptable evidence can include physical exam, laboratory, or radiologic findings. |
| Sepsis | Sepsis SIRS resulting from or occurring in the presence of proven infection. |
| Severe sepsis | 'Sepsis plus the following: cardiovascular organ dysfunction, acute respiratory distress syndrome (ARDS), or two or more other organ dysfunctions. |
| Sepsis Shock | 'Sepsis (defined above) and the following signs of cardiovascular organ dysfunction that remain after initial fluid resuscitation (40 mi/kg intravascularly in <1 hy: |
| | Decrease in BP (hypotension) <Sth percentile for age or systolic BP >2 SD below normal forage; OR |
| | Need for vasoactive drug to maintain BP in normal range (dopamine >5 yg/kg/min or epinephrine, or norepinephrine at any dose); OR |
| | "At least two of the following |
| | Unexplained metabolic acidosis: base deficit >5.0 mEq/L; |
| | Increased arterial lactate >2 times upper limit of normal, |
| | Oliguria: urine output <0.5 ml/kg/h |
| | Prolonged capillary refil:>5 s |
| | Core to peripheral temperature gap >3°C |

As observed above, all the definition above is dependent on the age variable which is adjusted to an X variable of SD, which is a main difference in the identification and management of Sepsis in adults (where age doesn't count as an important variable) [6].

**Description of a problem, a lack of knowledge on a certain topic or a segment on why this is a problem:** Many studies have showed up that there is a difference in between the presentation sepsis in pediatrics than adults. This can be highlighted in the clinical features that pediatrics presents with to the ER.

Being that said, the problem is in the fast identification of sepsis in children and the prompt management, because any delay would cause a fatal subsequent complications and death.

Clinical signs may be vague in the young infant, he may present as in lethargy, poor feeding, irritability, or hypotonia. Fever is common; however, very young infants may be hypothermic. Tachypnea and tachycardia are usually present as a result of fever but also may be secondary to hypoxia and metabolic acidosis. Sepsis can rapidly transform to shock, and present as prolonged capillary refill, decreased peripheral pulses, altered mental status, and decreased urinary output. Hypotension is usually a late sign of septic shock in infants and children; sustained tachycardia for age is often the only sign available to the clinician of impending shock [7].

**Why this study is necessary:** This study is necessary because the high incidence rate of sepsis in pediatrics and the subsequent high mortality rate, where many are due to a late identification of sepsis, even a one-hour delay in the initiation of appropriate resuscitation measures in pediatric patients with sepsis was associated with increased mortality (OR, 2.29; 95% CI, 1.19-4.44) [8].

## Literature Review

This section includes collection of all possible available data about pediatric sepsis at ED. By many research questions to achieve these aims so a midline literature search was performed with the keywords "critical care", "emergency medicine", "pediatric sepsis principal's emergencies", "sepsis with cardiac arrest". Literature search included an overview of recent definition, causes and recent therapeutic interventions strategies.

So the aims and outcome of the study: initial assessment and evaluate of pediatric sepsis for both medical students and new physicians face in the recognition, diagnosis and management of sepsis patients; with cardiac arrest to recognize potentially life-threatening conditions and to convey life-saving treatment so the key note here is that initial diagnosis in suspected cases with rapid emergency interventions.

### Aim of this study

In this study, we aim to review a methodological way for an early

and more accurate detection of sepsis in the pediatric population for an early management, which gives a better therapeutic outcome and prevent the progression of sepsis to septic shock. This is showcased as secondary prevention in the **Figure 1** below [9].

A recent meta-analysis published in the New England Journal of Medicine, the researchers reported that children with sepsis who received early goal-directed therapy had no improvement in 90-day mortality (OR, 0.97; 95% CI, 0.82-1.14; P=0.68) and it was associated with increased healthcare costs.

## Study Questions

### What is the difference between sepsis in the pediatric and adult population?

One major difference in the definition of sepsis in children vs. adults are the age-specific parameters and variables for physiologic and organ related lab parameters. The healthy pediatric cardiovascular system can maintain cardiac output by employing extreme tachycardia for a prolonged period without inducing myocardial ischemia. Compared with adults, hypotension presents later in children and often lead to a non-reversible cardiovascular collapse. As a result, the pediatric consensus guidelines are designed to identify patients with compensated septic shock in the hope that early intervention will prevent cases of profound decompensation leading ultimately to death.

### How different is the response to inflammation in the developing immune system of the pediatric population vs the mature adult immune system?

A child's immune system is different from adults in the innate and adaptive immune function; Neonates are the most immune compromised, and their immune system is known by its comparatively poor innate and adaptive immune responses. The cumulative result of this immaturity is an immune system prone to a vast number of infections, particularly viruses and encapsulated bacteria. Susceptibility to severe viral infection is most prominent in children less than 2 year old due in part to unchecked viral replication caused by lower production of IFNγ and diminished cytotoxic lymphocyte responses [10].

### What are the factors influencing pediatric sepsis-related mortality?

Children <12-month old have the highest risk of death from sepsis. While older children have a higher incidence of mortality because of severe sepsis which is usually caused by viral infection and most will survive hospitalization.

A higher mortality among male patients, suggested by studies in adult patients and animals, appears less prominent in children, although males are more likely to be hospitalized in infancy for severe infections. The incidence of malignancies and other chronic respiratory and cardiac conditions in children rises with age and contributes to sepsis-related mortality; the majority of older children hospitalized with sepsis have underlying conditions impairing their immune or cardiorespiratory systems. Site of infection is important in prognosis, with endocarditis and CNS infections leading the highest mortality rates (21.1% endocarditis, 17.1% CNS infections) [11]. In addition, certain organism has a worse prognosis than others do, particularly fungi, and infections with antibiotic-resistant bacteria, including MRSA, gram-negative bacilli, and nosocomial pathogens [12].

### Describe steps of the right technique of this method point by point

**First initial investigations for sepsis in the pediatric population:**

This happens first by identifying the risk factors first: Risk factors for adult sepsis and septic shock are similar to those in pediatrics **(Table 4)**. Infants younger than 1 month of age also is an important risk factor to pay attention at, especially because newborns initially may appear normal on exam [13].

i. **Try to identify the cause by careful history:** The typical presentation varies with the age of the patient, that's why it's better to ask the parents about the stable situation of the patient. Febrile children will be slightly hypoactive; therefore, it is important to pinpoint the state and activity of the child with and without the fever. Older infants and children typically present with a fever and a localized source of infection. Complete history to rule out Infections/sepsis, NSAID use and high doses of diuretics or other drugs, GI fluid losses and GI bleeding, diabetes and arterial hypertension or urinary tract obstructions.

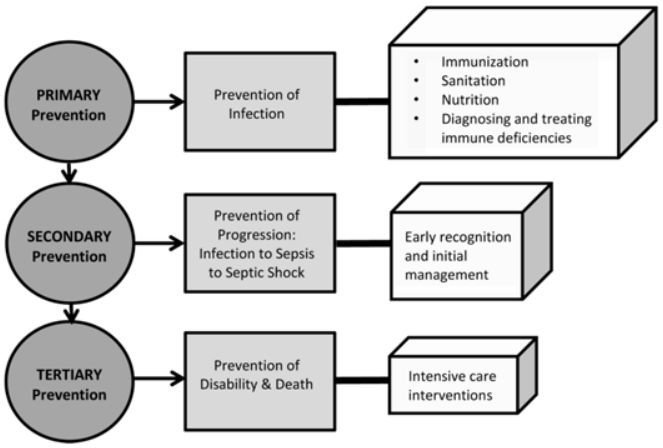


**Figure 1** Depiction of primary, secondary, and tertiary pediatric sepsis prevention efforts (modified, with permission from Dr. Bala Totapally).

**Table 4** Risk factor for pediatric sepsis.

| |
|---|
| • Age <1 month. |
| • Serious injury (e.g., major trauma, burns or penetrating wounds). |
| • Chronic debilitating medical condition. |
| • Host immunosuppression. |
| • Large surgical incisions. |
| • Indwelling vascular catheters. |
| • Urinary tract abnormalities with frequent infection. |

Careful recording of the patient's data regarding (vital signs, daily weight, fluid intake and output, past and current laboratory data, and medications) should be documented. A careful analysis by the history and physical examination is the most classical clinical approach to the early diagnosis of the cause of acute kidney injury. It is also important to ask about vaccination status and history and any recent surgery or trauma.

ii. **Perform a careful physical examination:** Vital signs are crucial to identify critically ill patients. In children they vary by age, it's important to assign each age to its correspondent normal or stable vital signs. See the table below for values. Patients should be monitored carefully for urine output, fluid balance, arterial blood pressure and central venous pressure to help with the management of fluid balance and prevent volume overload. The presentation of septic patients may be atypical in pediatrics, such as an isolated tachycardia or can present as severe and typical a fulminant hypotension, hypoperfusion signs and altered mental status. Persistent tachycardia is always missed, as it can be attributed to crying and fever (persistent means that tachycardia will be there even though other possible attributing factors dissipate). Hypotension is always a late presentation in children. However, hypotension in children with a suspected source of infection is confirmatory for the presence of septic shock (**Tables 5-7**).

iii. **Perform an extensive diagnostic evaluation [14]**:

**Complete blood count with differential:** This test can reveal leukocytosis or leukopenia, thrombocytosis (since platelets are an acute inflammatory marker), or thrombocytopenia. In the latter, consider DIC and complete the workup to confirm its presence with elevation of prothrombin time, partial thromboplastin time, international normalized ratio, D-dimer, and decreased fibrinogen. Full investigations should be ordered as complete blood picture, electrolytes, serum creatinine, urine sodium and osmolality, urine analysis for protein, casts and cells, renal ultrasound. if proteinuria and/or hematuria are present additional investigations should be undertaken to rule out renal parenchymal diseases. Renal biopsy should be considered if there is strong suspicion of glomerulonephritis. Bacterial infection should be identified early by blood, urine and ascetic fluid culture and treated with antibiotics

**Table 5** Age-adjusted range of normal vital signs.

| Age | HR | SBP | Definition of Hypotension as per SBP | DBP | RR |
|---|---|---|---|---|---|
| < 1 month | 110-160 | 65-85 | <60 | 45-55 | 35-55 |
| 1-3 months | 110-160 | 65-85 | <70 | 45-55 | 35-55 |
| 3-6 months | 110-160 | 70-90 | | 50-65 | 30-45 |
| 6-12 months | 90-160 | 80-100 | | 55-65 | 22-38 |
| 1-3 years | 80-150 | 90-105 | <70+(age in years × 2) | 55-70 | 22-30 |
| 3-6 years | 70-120 | 95-110 | | 60-75 | 20-24 |
| 6-12 years | 60-110 | 100-120 | | 65-85 | 16-22 |
| >12 years | 60-110 | 110-135 | | 65-85 | Dec-20 |

**HR:** Heart Rate in Beats Per Minute; **SBP:** Systolic Blood Pressure mmHg; **DBP:** Diastolic blood Pressure in mmHg; **RR:** Respiratory Rate in Breaths Per Minute.
**Source:** Author adapted.

**Table 6** Physical exam signs by organ system.

| Organ | Sign |
|---|---|
| Cardiovascular | Tachycardia or bradycardia (rare) |
| | Hypotension (late) |
| | Cold, pale extremities |
| | Capillary refill time (CRT) >2-3 seconds or flash CRT |
| | Bounding or weak pulses |
| | mottled Skin |
| | Discrepancy between peripheral and central pulses |
| | Decreased urine output |
| | Dry mucous membranes |
| | sunken eyes |
| Respiratory | Tachypnea, apnea (especially in infants), grunting, nasal flaring, hypoxia |
| Mental status | Sleepiness, lethargy, agitation, fussiness, acting abnormal per parents |

**Source:** Author created.

**Table 7** Suspected sources, symptoms and signs for pediatric Sepsis.

| Suspected Source | Signs and Symptoms |
|---|---|
| Upper respiratory tract | Rhinorrhea, hoarseness, muffled voice, sore throat, dysphagia |
| | Pharyngeal inflammation plus exudate + swelling and lymphadenopathy |
| Lower respiratory tract | Productive cough, pleuritic chest pain |
| Urinary tract | Fever, urgency, dysuria, loin or back pain, incontinence |
| Genital tract | Vaginal or urethral discharge, lower abdominal pain, scrotal pain |
| Wound or burn | Inflammation, edema, erythema, purulent discharge |
| Skin/soft tissue | Erythema, edema, lymphangitis |
| Central nervous system | Signs of meningeal irritation: neck stiffness, headache |
| Gastrointestinal | Abdominal pain, distension, diarrhea, and vomiting |
| Joint | Pain, warmth, decreased range of motion, limp, crepitus in necrotizing infections |

**Source:** Author adapted.

**Glucose:** The presence of hypoglycemia or hyperglycemia has been associated with poor short-term outcomes in multiple studies.

**Electrolytes:** Several electrolyte derangements secondary to the underlying illness can accompany sepsis and septic

shock. Among them are hyponatremia or hypernatremia from severe dehydration hypophosphatemia, hypocalcaemia, and hypomagnesaemia may be present. In addition, it is important to keep an eye on calcium levels.

**Anion gap**: Calculate the anion gap (AG) using the following formula: AG=$Na^+$-($HCO_3^-$+$Cl^-$). In children, an anion gap >14 to 16 mEq/L is considered high, and in neonates, a high anion gap is >16 mEq/L. Patients might present with respiratory alkalosis due to tachypnea, or respiratory or metabolic acidosis.

**Urinalysis:** The presence in urine of pyuria, nitrites, or leukocyte esterase is suggestive of a urinary tract infection.

**Serum total bilirubin and alanine aminotransferase:** A total bilirubin ≥ 4 mg/dL or alanine aminotransferase >2 times the upper limit of normal for age indicates liver dysfunction in the setting of sepsis.

**Blood gas (Arterial or venous):** A blood gas may assist with evaluation of three important factors: tissue oxygenation, adequacy of ventilation, and acid-base disturbances.

**Microbiology:** When possible, draw the cultures before initiating antibiotic therapy but do not delay antibiotics in a critical child; all patients require a blood culture. The other cultures depend on the age of the child, the presentation, and the suspected source of infection.

**Lactic acid:** When there is insufficient delivery of oxygen to the tissue, such as with hypoperfusion in sepsis and septic shock, aerobic metabolism will shift to anaerobic to continue the generation of adenosine triphosphate, for cellular survival. This anaerobic mechanism will lead to the generation of a byproduct: lactate. The normal range of lactate in children is 0.5 to 2.2 mmol/L and an elevated lactate level can be an indicator of sepsis.

**Procalcitonin:** Procalcitonin is a polypeptide prohormone of calcitonin. In the healthy population, the serum level is undetectable, but it is increased when there is a bacterial infection, probably as a result of bacterial endotoxins, making procalcitonin not only useful in detecting sepsis, but also in differentiating bacterial from viral infection.

## Management of septic shock

**First:** Early recognition through a trigger tool algorithm and checklist as in **Figure 2.**

Currently the American College of Critical Care Medicine Guidelines advice and call for early recognition and the usage of a sepsis recognition bundle named by the "septic shock identification trigger tool" [7] shown in the **Figure 2** below. It is recommended that this bundle contain a:

1. Trigger tool.
2. Rapid clinical assessment of the child.
3. Initiation of the therapeutic approach.

A large longitudinal study showed that there was a clear benefit of using a quality intervention bundle used to recognize pediatric sepsis and timely antibiotic and fluid administration. In fact, mortality was five times higher in children who did not receive bundle-compliant care (OR, 5.0; 95% CI, 1.9-14.3) compared to those who did (OR, 0.20; 95% CI, 0.07-0.53) [15].

## Initiation of goal directed therapy

Once a child is identified as being in septic shock, follow the pediatric advanced life support (PALS) resuscitation algorithm shown in the **Figure 3**, it is important to initiate IV/intraosseous (IO) access and fluid resuscitation within the first five minutes of

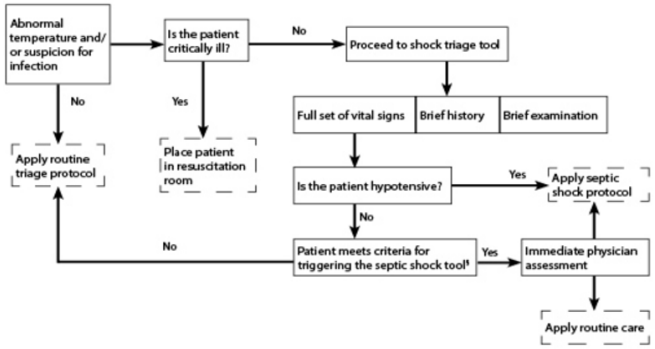


**Figure 2** Recognition phase: Check the temperature of the patient.

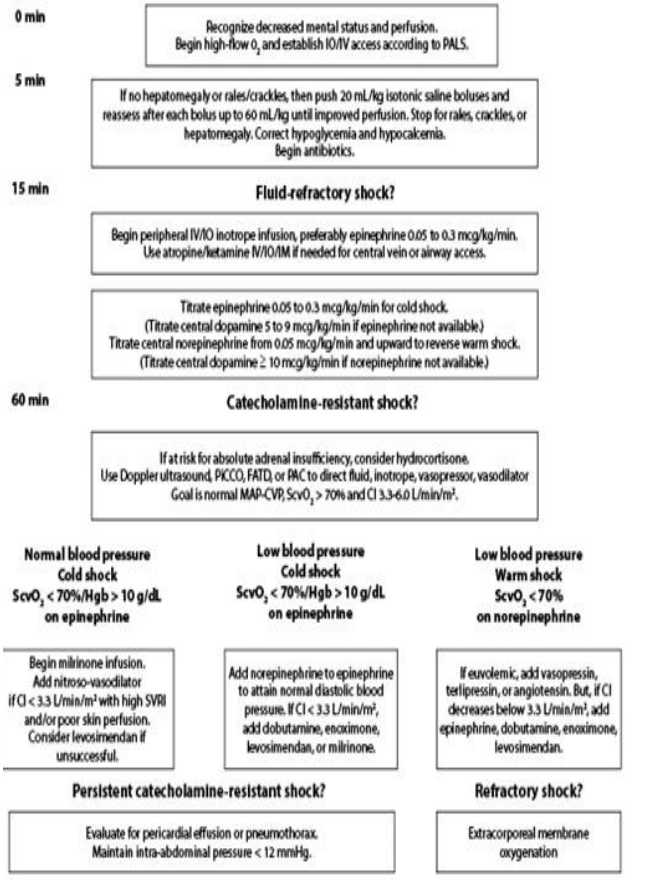


**Figure 3** Pediatric Advanced Life Support (PALS) resuscitation algorithm.

recognition. Aim for early antibiotic administration, and tailor the inotropes or vasopressors as the clinical scenario mandates. Bacterial infection should be identified; third generation cephalosporin are the initial treatment of choice. Patients with renal failure and sever sepsis may have associated relative adrenal insufficiency and may benefit from hydrocortisone administration, patients with severe sepsis and septic shock should be assigned to early goal directed therapy receiving fluid replacement, vasoactive drugs, PRBCs transfusion and inotropic drugs to achieve target level of central venous pressure (8-12 cm water), mean arterial blood pressure (65-90 mmHg) and central venous oxygen saturation at least 70%. Patients assigned to early goal directed therapy will have less sever organ dysfunction and decrease in in-hospital mortality [14].

## Other important drugs to be given in the golden hour (1st 60 min)

IV antibiotics must be given; The Surviving Sepsis Guidelines stress the importance of antibiotic administration within one hour of sepsis recognition. Early administration of antibiotics is very important to decrease mortality rates in patients with severe sepsis or septic shock. In one study, the mortality increased significantly with every one-hour delay in administration of antibiotics, but only after three hours' delay from the initial dose [3].

It is usually advised to give broad-spectrum antibiotics and start with broad-spectrum carbapenem (e.g., meropenem, imipenem/cilastatin, or doripenem) or extended-range penicillin/β-lactamase inhibitor combination (e.g., piperacillin/tazobactam or ticarcillin/clavulanate) [11]. Several third- or higher-generation cephalosporins also can be used, especially as part of a multidrug regimen [4].

- Give vancomycin to all patients with septic shock because of resistant organisms (e.g., MRSA).
- **Consider the child's age:** Children younger than 1 month of age need *Listeria monocytogenes*, Group B Streptococcus, and Gram-negative bacteria coverage, such as ampicillin and a third-generation cephalosporin (e.g., cefotaxime) or an aminoglycoside (e.g., gentamicin). A third-generation cephalosporin, such as ceftriaxone and vancomycin, may be enough for children older than 1 month of age to cover for *N. meningitides* and resistant *S. pneumoniae* and *H. influenzae*. Herpes simplex virus also may present solely as sepsis in neonates. Therefore, start acyclovir early while awaiting PCR results, especially if the infant had a seizure or has elevated liver enzymes.
- Review previous positive cultures (e.g., in children with recurrent urinary tract infections), as they may show a resistance pattern to help guide antibiotic selection.
- The presence of a central line or immunosuppression predisposes the patient to Gram-negative bacteremia as well as fungemia, and will require more Gram-negative coverage, such as piperacillin/tazobactam. Consider ordering fungal cultures, especially in patients with recurrent or prolonged fevers. However, to date there is no evidence to recommend starting antifungal treatments in the ED.
- **Site of the infection:** If the source is a skin infection, consider adding MRSA coverage with clindamycin and vancomycin. If the source is in the feet, add *Pseudomonas aeruginosa* coverage with a beta-lactam and either an aminoglycoside or fluoroquinolones. Pneumonia with empyema is also suspicious for MRSA. If there is a gastrointestinal source, add anaerobic coverage such as piperacillin/tazobactam, clindamycin, or metronidazole.
- If toxic shock syndrome is suspected, add clindamycin for toxin neutralization [16].
- **Consider the season:** During influenza season, add antiviral medications, such as oseltamivir.

## Therapeutic endpoints

The American College of Critical Care Medicine and PALS call for maintaining or restoring good perfusion, adequate heart rate for age, and respiratory support as in airway, oxygenation, and circulation within the first hour of shock recognition [12].

However, tachycardia is not specific for septic shock so should assess other parameters specifically, it's recommended to aim for the following [16].

1. CRT ≤ 2 seconds.
2. Normal blood pressure for age.
3. Normal pulses, equal peripheral and centrally.
4. Warm extremities.
5. Urine output of 1 mL/kg/hr.
6. Normal mental status.
7. Euglycemic.
8. Normal ionized calcium.

## Assessment checklist for sepsis

**Recognition phase:** Check the temperature of the patient as **Figure 4**, **Table 8** Recognition phase: at the receipt of the patient in the ER (must have at least two for a proven or suspicion of sepsis) and If the 2 or more criteria are found in the patient, note down the time and the initials, and start the golden hour initial management as in **Table 9**.

# Summary and Take Away Message

As per all the recent studies, early recognition of signs of sepsis and septic shock in the adult and in the pediatric population more specifically may have a dramatically impact on the prognosis and mortality of the patient. SIRS criteria. Systemic inflammatory response syndrome (SIRS) is the body's response to an infectious or noninfectious insult. Although the definition of SIRS refers to it as an "inflammatory" response, it actually has pro- and anti-inflammatory components.

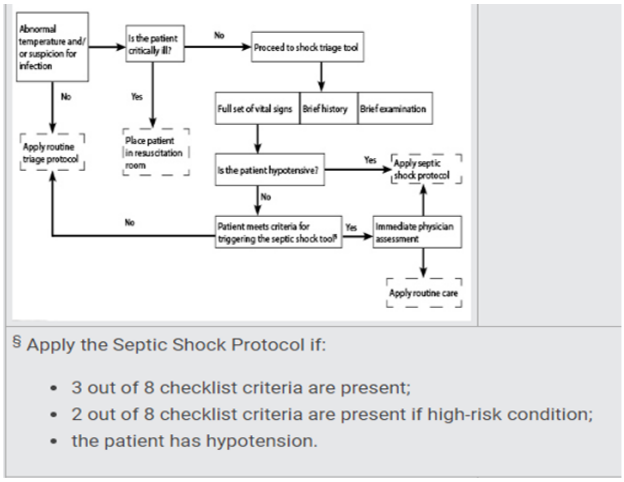


**Figure 4** Recognition phase: Check the temperature of the patient.

**Table 8** Recognition phase at the receipt of the patient in the ER (Must have at least two for a proven or suspicion of sepsis).

| Early Recognition | | |
|---|---|---|
| Criteria | Met | Not met |
| Check the Temperature below 36c or above 38.5 | - | - |
| Auscultate for Inappropriate tachycardia | - | - |
| Assess for Altered mental state (AVPU, or sleepiness, irritability, lethargy, floppiness) | - | - |
| Check for Prolonged peripheral perfusion | - | - |

**Table 9** Initial management.

| Initial Management Phase in the Golden Hour 1st 60 min | | | |
|---|---|---|---|
| Procedure | Done | Not done | Not required |
| Give high flow oxygen | - | - | - |
| Obtain intravenous or intraosseous access and take blood tests: Blood glucose, culture, blood gases. | - | - | - |
| Give IV antibiotics (broad Spectrum as per the local policy) | - | - | - |
| Consider Inotropic support: If physiological parameters are not restoring after more than 40ml/kg of fluids (dopamine and adrenaline can both be given IV or IO. | - | - | - |

Infection microbial phenomenon characterized by an inflammatory response to the presence of microorganisms or the invasion of normally sterile host tissue by those organisms. Sepsis the systemic response to infection; this response is manifested by two or more of the SIRS criteria as a result of infection. Bacteremia the presence of viable bacteria in the blood. Severe sepsis associated with organ dysfunction, hypoperfusion or hypotension; hypoperfusion and perfusion abnormalities may include, but are not limited to, lactic acidosis, oliguria or an acute alteration in mental status. Septic shock sepsis with hypotension, despite adequate resuscitation with fluids, along with the presence of perfusion abnormalities that may include, but are not limited to, lactic acidosis, oliguria or an acute alteration in mental status; patients who are on inotropic or vasopressor agents may not be hypotensive when perfusion abnormalities are measured.

Hypotension a systolic blood pressure of 90 mmHg or a reduction of 40 mmHg from baseline in the absence of other causes for hypotension. Multiple organ damage MODS presence of altered organ functions in an acutely ill patient such that homeostasis cannot be maintained without intervention.

Unfortunately, the recognition of sepsis or septic shock in pediatrics might be a bit tricky due to multiple variables that presents just differently than adults. Age by months play a big role in the susceptibility and the validity of the diagnosis.

Understanding different presentations and clinical features with the usage of the Bundle Trigger algorithm and checklist will help for a faster initial recognition for the patient, thus decreasing the chances of progression or complications later on.

It's important to note that management in pediatrics is different than adults too, and the American College of critical care has set up a specific algorithm to follow.

## Recommendations

- Never take tachypnea or fever as simple precipitating clinical feature or symptom, it should be taken seriously as it can progress silently into septic shock and lead to death.
- Pediatric patient has the ability to compensate a shock much longer than adults do, but decompensating happens in a more sudden fashion than adults happen and is much lethal.
- Pediatric patient would need a longer monitoring time (more than adults would), especially in cases of fever and tachypnea.
- Any hospital must have a Sepsis recognition bundle trigger tool, to accelerate Sepsis recognition and start initial management.
- The American college of critical care medicine always is updating HCP's around the world about the new algorithms for management and diagnosis, those need to be followed because of their relevance.

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