



# Pediatric Sepsis

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# Disclosures

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# Objectives

1. Know who is at **RISK** for pediatric sepsis
2. Learn how to rapidly **RECOGNIZE** pediatric sepsis
3. Learn how to rapidly **TREAT** pediatric sepsis
4. Learn the **GOALS** of pediatric sepsis care
5. Recognize the potential **COMPLICATIONS/PITFALLS** of pediatric sepsis care

# Introduction

- Sepsis is an overwhelming infection of the body that leads to organ failure and death.
- Sepsis is the leading cause of death in hospitalized children killing almost 5,000 U.S. children annually (more than cancer).
- More than 18 children die from sepsis each day in the US.

# Introduction

- Costs to treat 1 severe sepsis case ranges from \$65k-\$85k.
- Average hospital length of stay is 31.5 days.
- Nearly half return to the hospital at least once after surviving sepsis.
- Sepsis accounts for 1/6 of all pediatric health care spending –\$5 billion annually.



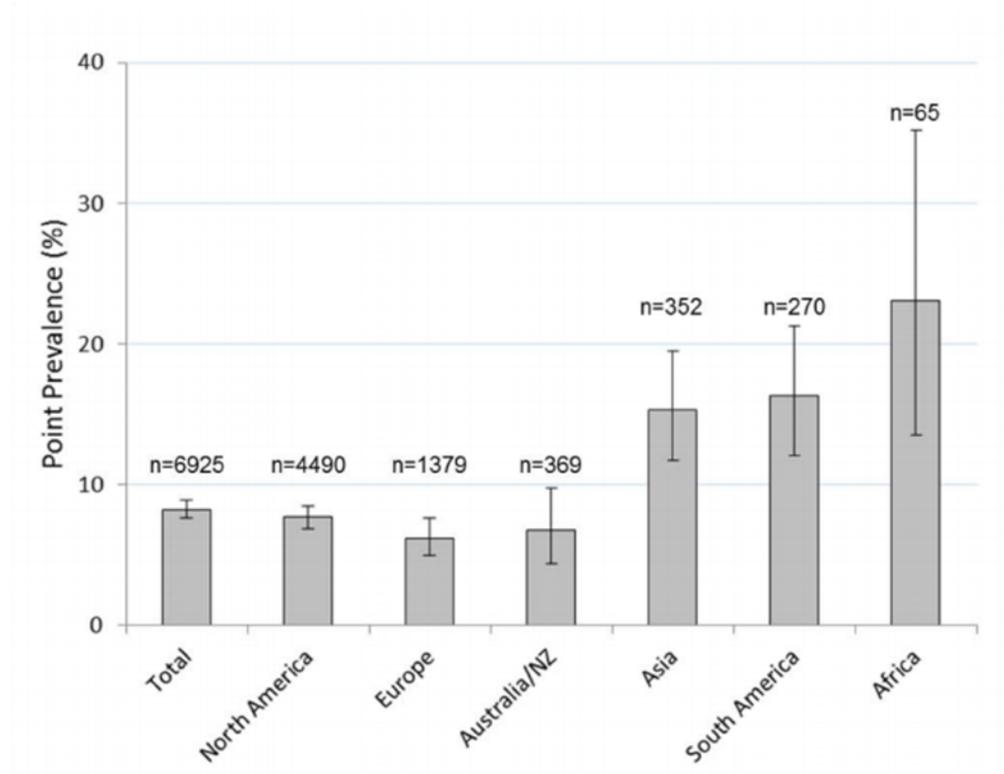
# What is Sepsis

- Sepsis is the body's overwhelming and life-threatening response to infection which can lead to tissue damage, organ failure, and death.
- It is difficult to predict, diagnose, and treat.
- Why EMS: Every minute counts. Administration of fluids and antibiotics saves lives.



# Severe Sepsis Prevalence by Continent

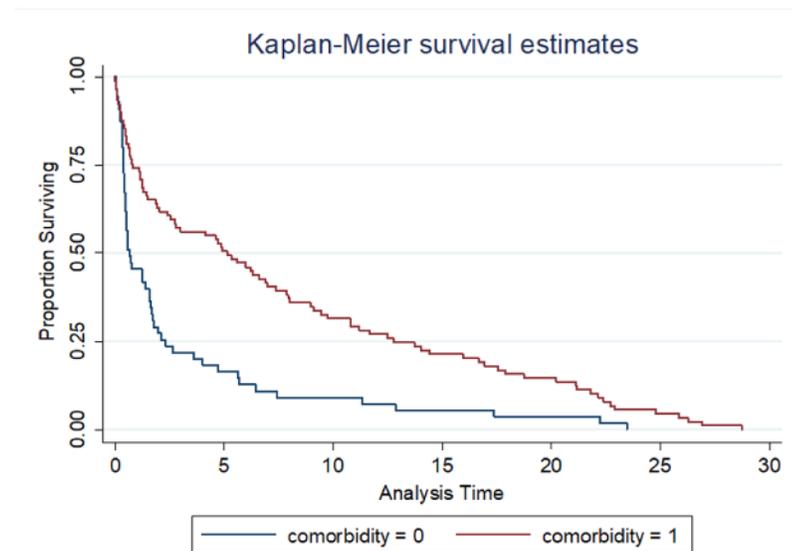
- North America
- Prevalence among hospitalized children= 7.7%
- Mortality = 21%



Among all patients with sepsis/ septic shock that died, 36.8% (53/144) died within 24h and 50.7% (73/144) died within 48h.

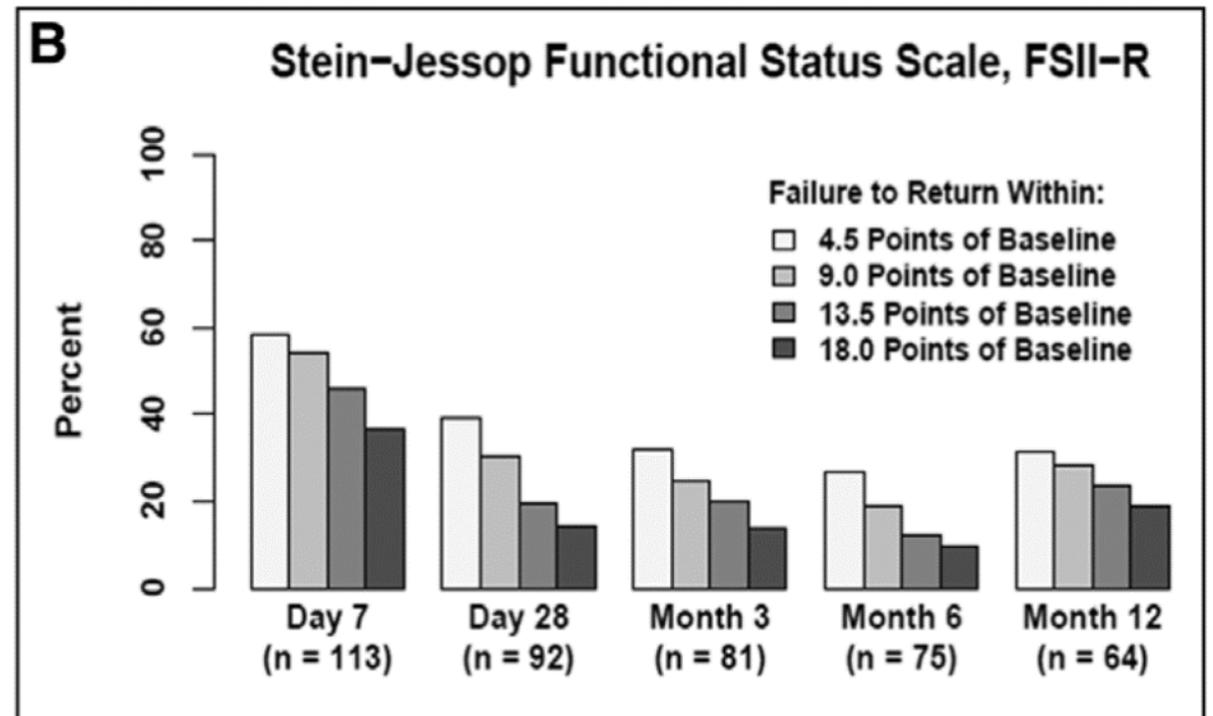
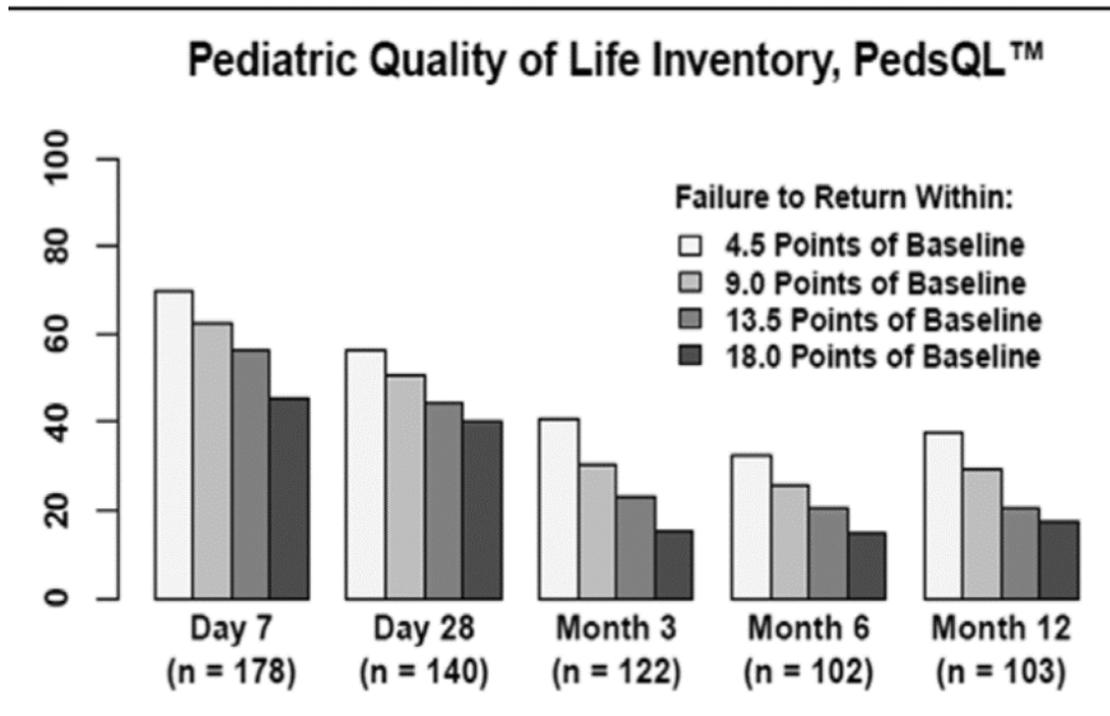
In children without comorbidities, the median time to death was 16h with 54.5% dying within 24h and 72.7% within 48h.

C) Time to death curves in children admitted to ICU: Comorbidity versus no comorbidity.



# Long Term Effects

•At 1, 3, 6, and 12 months following PICU admission for septic shock, 50%, 37%, 30% and 35% of surviving patients had not regained their baseline health-related quality of life.



# SIRS= Systemic Inflammatory Response Syndrome

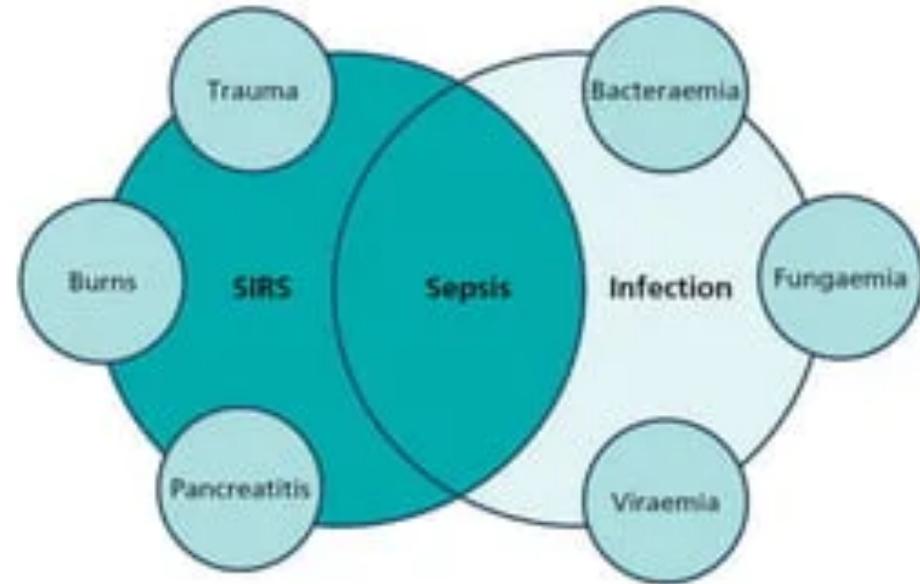
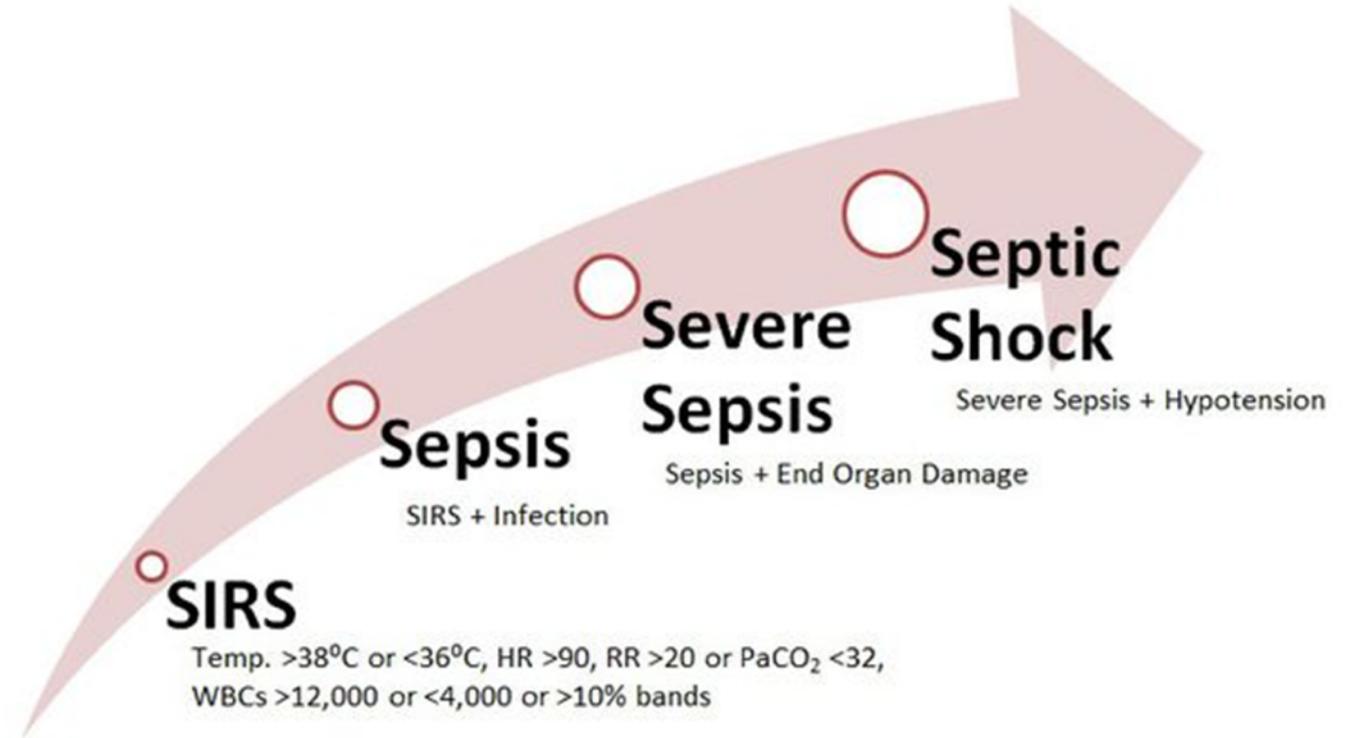


Figure 6.1 Causes of systemic inflammatory response syndrome and sepsis.

# Progression of SIRS, when caused by an infection



# The Key is Recognition

- Shock = Insufficient blood flow to meet the body's metabolic demands
  - Hypovolemic is the most common cause of pediatric shock.
  - Cardiogenic shock is something you probably encounter more in the adult population.
  - Anaphylactic shock is associated with allergic reactions.
  - Neurogenic shock where the spinal cord is injured and cannot send signals to blood vessels to contract to keep the blood pressure up.
  - Septic shock: caused by inflammatory mediators released from the body when it is trying to fight bacteria or viruses.



# Types of Shock - Hypovolemic

Hypovolemic = decreased circulating blood volume

- Hemorrhagic
  - Dehydration (vomiting, diarrhea, poor intake, sweating, diabetes, nephrotic syndrome)
  - Burns
- Infants can compensate up to 30% loss of blood volume
    - i.e. Hypotension is a late sign

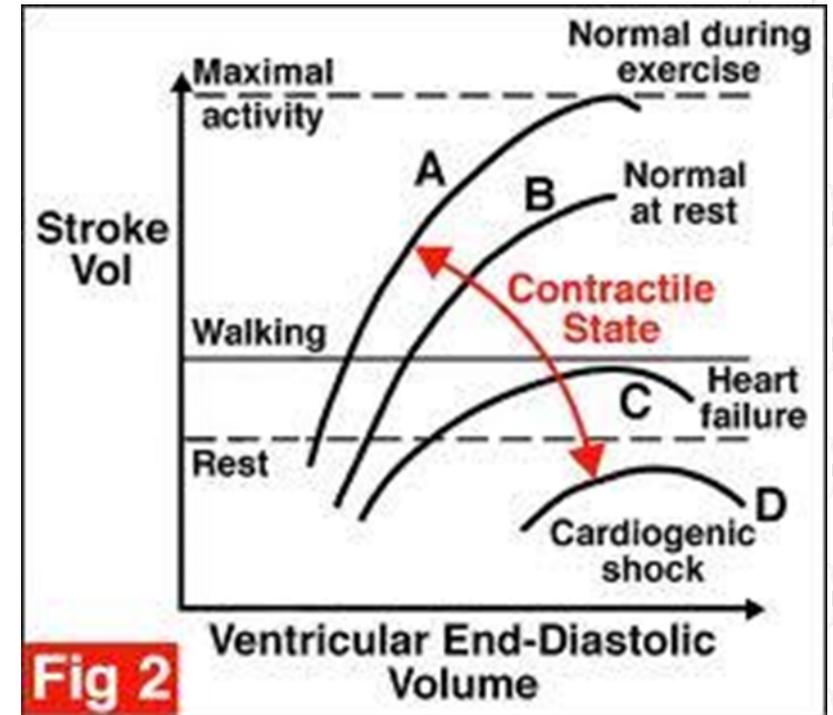
## Management

- Volume (Crystalloid and/or Colloid)



# Types of Shock - Cardiogenic

- Cardiogenic = decreased cardiac output due to myocardial dysfunction
  - Cardiomyopathy
  - Congenital heart disease
  - Dysrhythmia (SVT, long QT)
  - Ischemia
- Management
  - Minimize O2 demand
    - Alleviate agitation
    - Normothermia
    - Decrease afterload (meds, intubation)
  - Increase O2 delivery
  - Volume (carefully)
  - Improve contractility and filling (epi and milrinone)
  - Surgery



# Types of Shock - Distributive

- Distributive = loss of vascular tone (regulated by local mediators, neuronal signals and humoral mechanisms)
  - **Neurogenic** – loss of sympathetic control over cardiovascular system
    - Unopposed parasympathetic stimulation
    - Bradycardia, decreased contractility, increased venous pooling (relative hypovolemia)
    - E.g. Spinal surgery/trauma, spinal anesthesia
  - Management:
    - Volume, alpha-1 agonist
  - **Anaphylactic** – mast cell degranulation, IgE mediated response to antigen
    - Bronchospasm, inflammation, vasodilation
  - Management:
    - Airway, volume, H1 & H2 blockade, steroids, epinephrine



# Types of Shock - Obstructive

- Obstructive = inability to produce adequate cardiac output despite normal volume and myocardial function
- Causes:
  - Cardiac Tamponade
  - Tension Pneumothorax
  - Severe pulmonary or systemic hypertension
  - Congenital or acquired outflow obstructions (Coarctation of the aorta or Interrupted aortic arch)
- Management
  - Relief of the obstruction



# Types of Shock – Septic (Dissociative)

- Septic shock – loss of all 3 mechanisms to varying degrees
  - Neurogenic
    - Neurovascular dysregulation – unresponsive vascular smooth muscle
  - Hypovolemic
    - Inadequate intravascular volume for increased systemic capacitance
  - Cardiogenic
    - Hyperdynamic cardiovascular function – can progress to impaired myocardial function



# Shock

- Compensated: Normal blood pressure
- Uncompensated: Hypotension
- $CO = HR \times SV$
- Tachycardia is compensating for decreased stroke volume
- Tachycardia is one of the earliest signs of shock!!!



# Cardiovascular System

- Anatomic and Physiologic Considerations
  - The circulating blood volume is higher per kilogram in children than in adults
  - Altering of cardiac output (C.O.) in infants and children depends on heart rate and diastolic filling time
  - Normal heart rates in children
    - Newborn 80 – 200
    - < 2 years 80 – 180
    - 2 – 10 years 60 – 150
    - > 10 years 60 – 100



# Cardiovascular System

- Physical Examination
  - Skin color
  - Temperature
  - Capillary refill
  - Pulse character
  - Heart rate
  - Rhythm
  - Blood pressure



# Cardiovascular System

- Shock

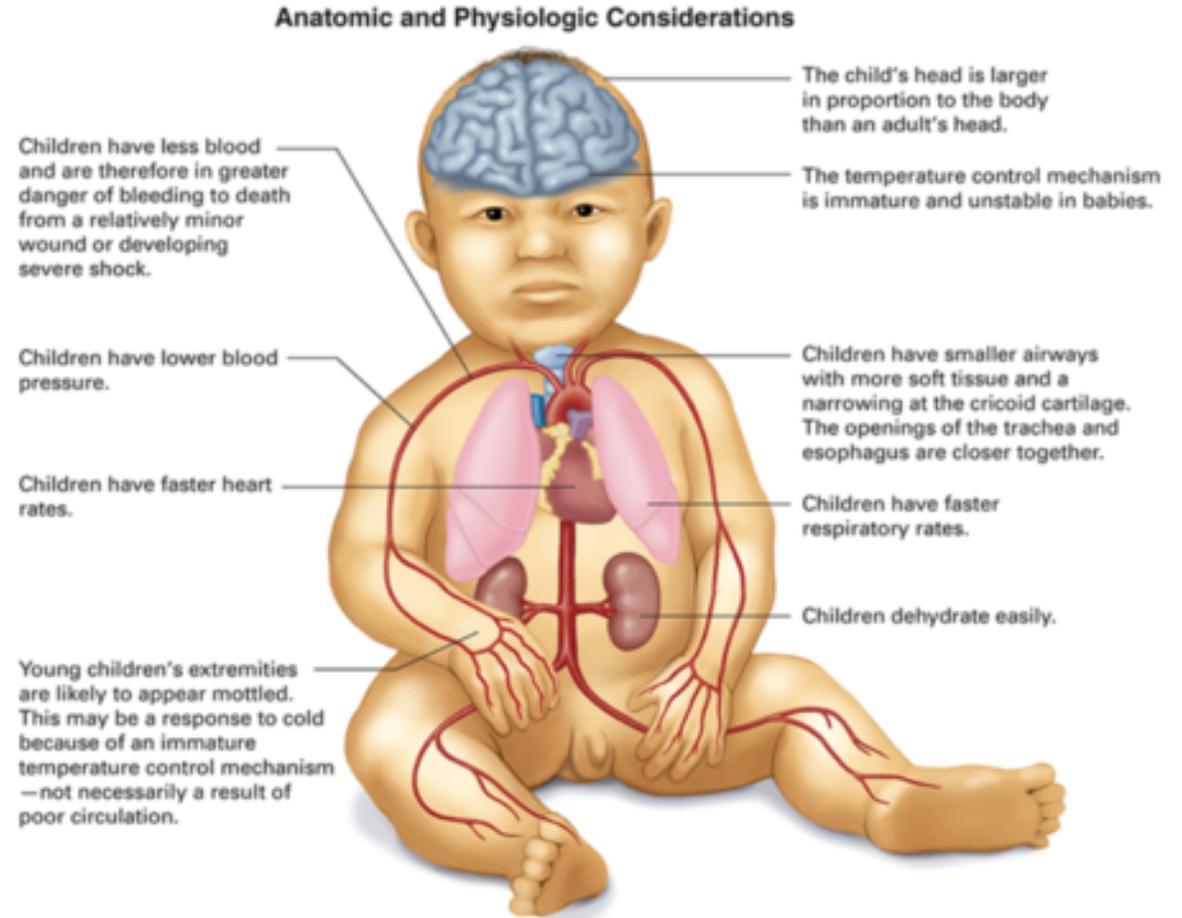
- A state of circulatory dysfunction that fails to provide sufficient oxygen and nutrients to meet the metabolic needs of vital organs and peripheral tissue
- Compensated phase
  - Increase in heart rate and systemic vascular resistance
- Decompensated phase
  - Hypotension with cool mottled extremities, weak pulse, delayed capillary refill, and obtunded sensorium



# Signs of Poor Perfusion

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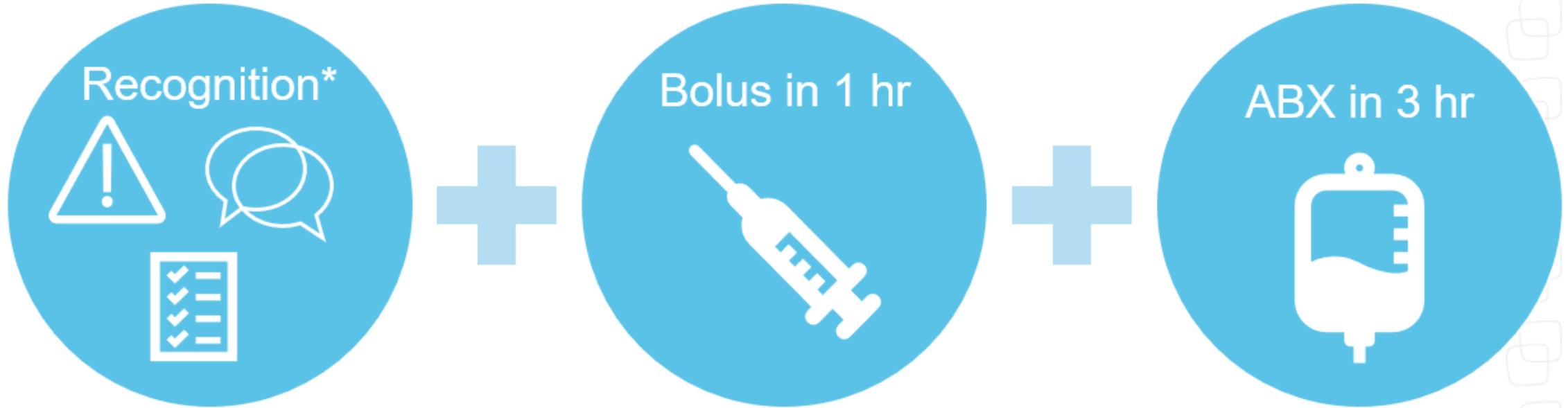
- Tachycardia
- Tachypnea
- Cool or poorly perfused extremities (delayed capillary refill)
- Abnormal mental status
- Weak or bounding pulses
- Low urine output (obtained by history)
- Hypotension is LATE finding



# Sepsis Quality Improvement



# IPSO Collaborative



If any element of bundle compliance is missing, the episode is non-compliant.

Episodes originating in outside hospital within 24 hours before time zero are excluded.

# Bundle Compliance

Recognition	<ul style="list-style-type: none"><li>• Screen OR Huddle OR Order Set</li></ul>
First Bolus	<ul style="list-style-type: none"><li>• 60 minutes</li></ul>
First Antibiotic	<ul style="list-style-type: none"><li>• 180 minutes</li></ul>

# Pediatric Septic Shock Algorithm



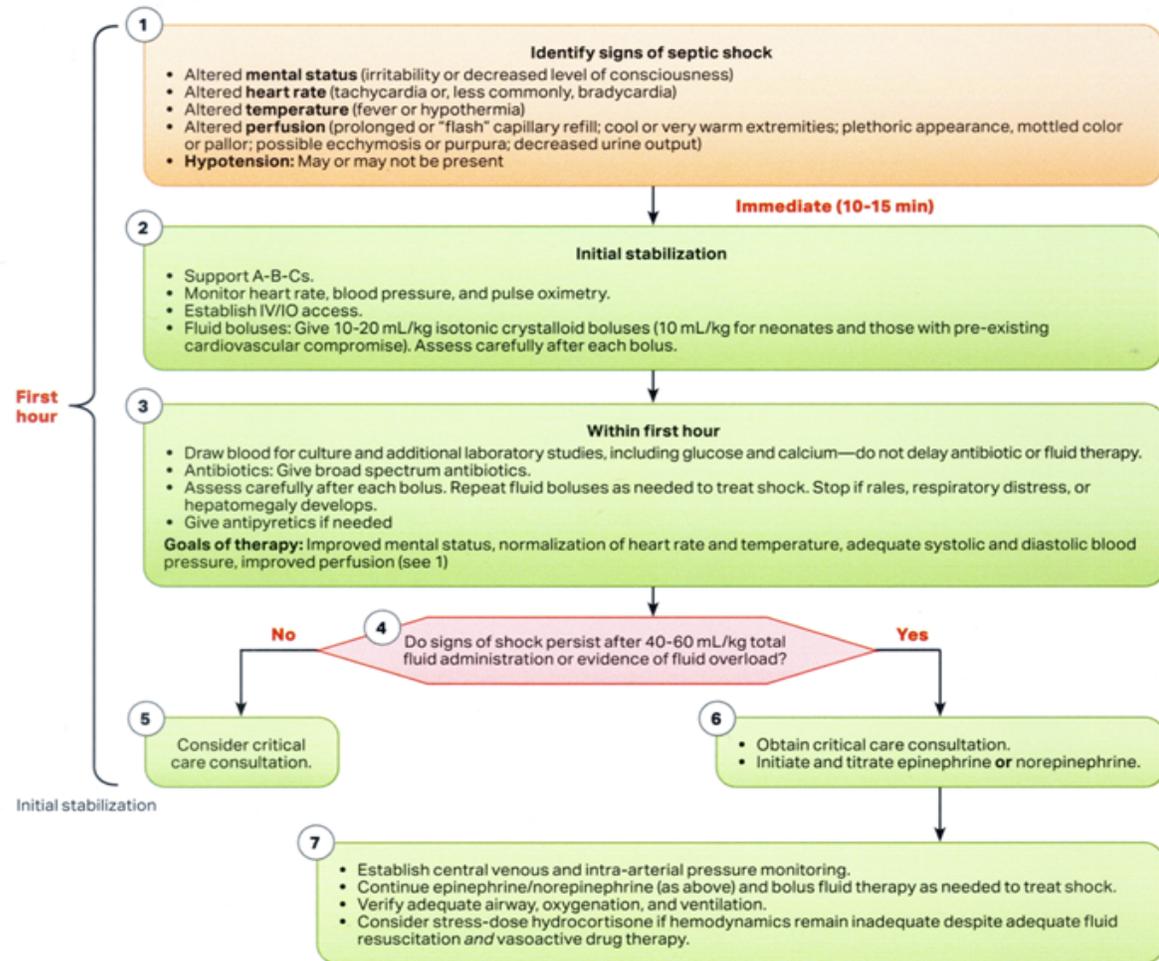
American Heart Association.

American Academy of Pediatrics



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## Pediatric Advanced Life Support



Brierley J, Carcillo JA, Choong K, et al. Clinical practice parameters for hemodynamic support of pediatric and neonatal septic shock: 2007 update from the American College of Critical Care Medicine. *Crit Care Med*. 2009;37(2):666-688. Kisson N, Orr RA, Carcillo JA. Updated American College of Critical Care Medicine—pediatric advanced life support guidelines for management of pediatric and neonatal septic shock: relevance to the emergency care clinician. *Pediatr Emerg Care*. 2010;26(11):867-869.

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### Identify signs of septic shock

- Altered **mental status** (irritability or decreased level of consciousness)
- Altered **heart rate** (tachycardia or, less commonly, bradycardia)
- Altered **temperature** (fever or hypothermia)
- Altered **perfusion** (prolonged or "flash" capillary refill; cool or very warm extremities; plethoric appearance, mottled color or pallor; possible ecchymosis or purpura; decreased urine output)
- **Hypotension:** May or may not be present



# High Risk Conditions

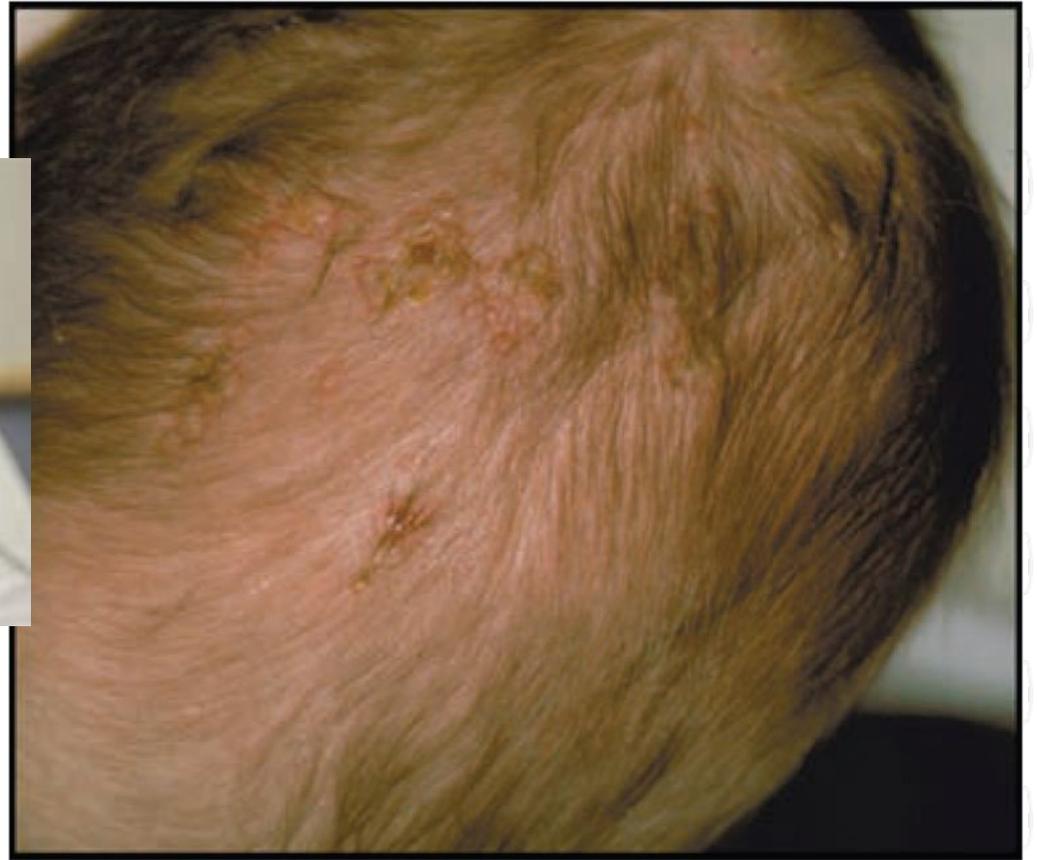
- **<60 Days Old**
- **Indwelling Medical Device/Technology Dependence:** central line, foley catheter, surgical instrumentation/patches, tracheostomy, VP shunt
- **Immunocompromised/Immunodeficiency:** Asplenia/sickle cell disease, Bone marrow or solid organ transplant, engineered cell therapy
- **Chronic renal disease**
- Disease process with associated immunocompromise (adrenal insufficiency, nephrotic syndrome, 22q heterotaxy, epidermolysis bullosa)



# High Risk Conditions

- HIV/AIDS
- **Immunosuppressive** agents such as: Azathioprine (Imuran), Long Term corticosteroids days, Methotrexate, Mycophenolate Mofetil (CellCept), MPS (Myfortic), Rituximab, tacrolimus (Prograf)
- **Malignancy**
- Neutropenia
- **Severe developmental delay** (pre-existing condition that limits mental status evaluation)
- Surgery, invasive procedure or hospitalization within the last 60 days







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**Immediate (10-15 min)**

### Initial stabilization

- Support A-B-Cs.
- Monitor heart rate, blood pressure, and pulse oximetry.
- Establish IV/IO access.
- Fluid boluses: Give 10-20 mL/kg isotonic crystalloid boluses (10 mL/kg for neonates and those with pre-existing cardiovascular compromise). Assess carefully after each bolus.

# IO access: Indications

- Venous access: for infusion of intravenous fluids and drugs, including vasoactive drugs
- *“Do not delay establishing IO access in the critically ill or injured child if no IV access is already in place” –PALS*



# IO

- – May be used in any age patient
- – All pediatric resuscitation drugs may be given through IO
- – May be quicker and more easily performed than umbilical vein catheterization.
- – The marrow space functions as a non-collapsible vein.
- – Absorption from the medullary cavity to the systemic circulation is rapid
- – Tibia is preferred site because of the well developed marrow cavity, even in neonates



# Contraindications for IO

- **Absolute contraindications:**
  - – Fractured or injured bone at insertion site. Access would be ineffective, as any administered fluid would infiltrate and not enter venous circulation.
  - – Vascular compromise proximal to the desired site. Same as above.
- **Relative contraindications:**
  - – Infection of overlying soft tissue or bone (cellulitis, osteomyelitis).
  - – Osteogenesis Imperfecta, or similar bone disorders.
  - – Presence of right-to-left intracardiac shunt (risk of fat/air/marrow emboli).

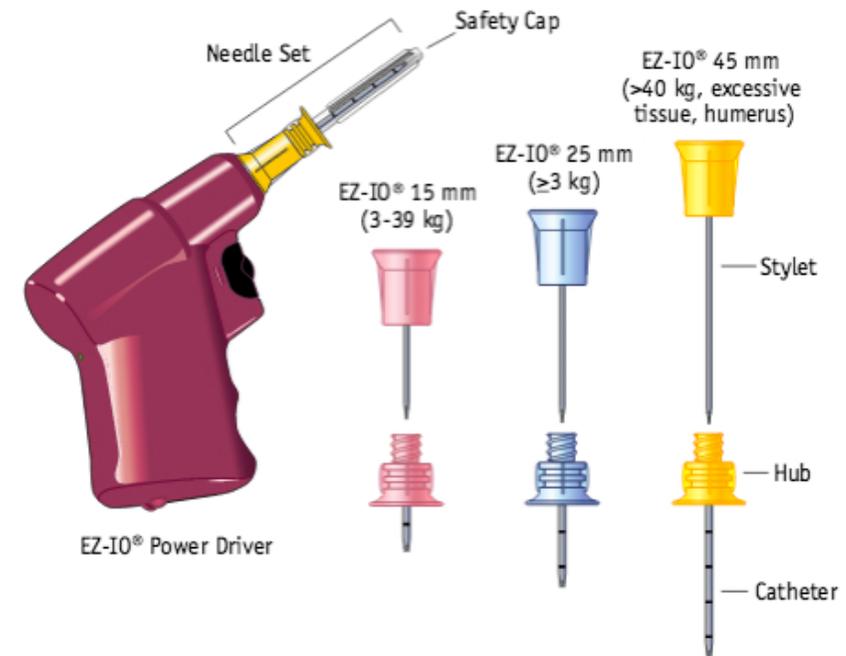


Needle Set Selection  
Size Matters!  
unless you just  
delivered the baby,  
**avoid the pink set**

#### EZ-IO® NEEDLE SETS: DESCRIPTION

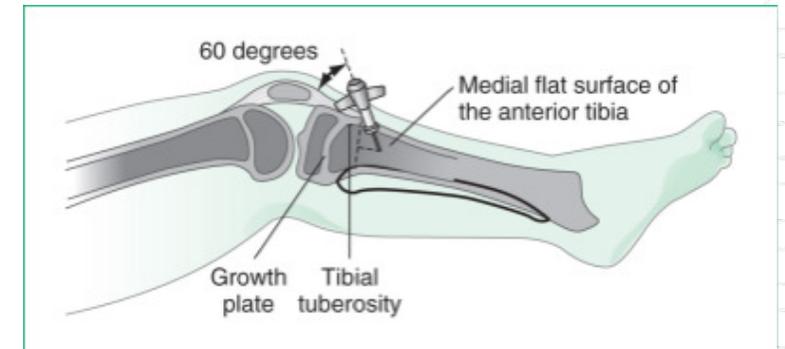
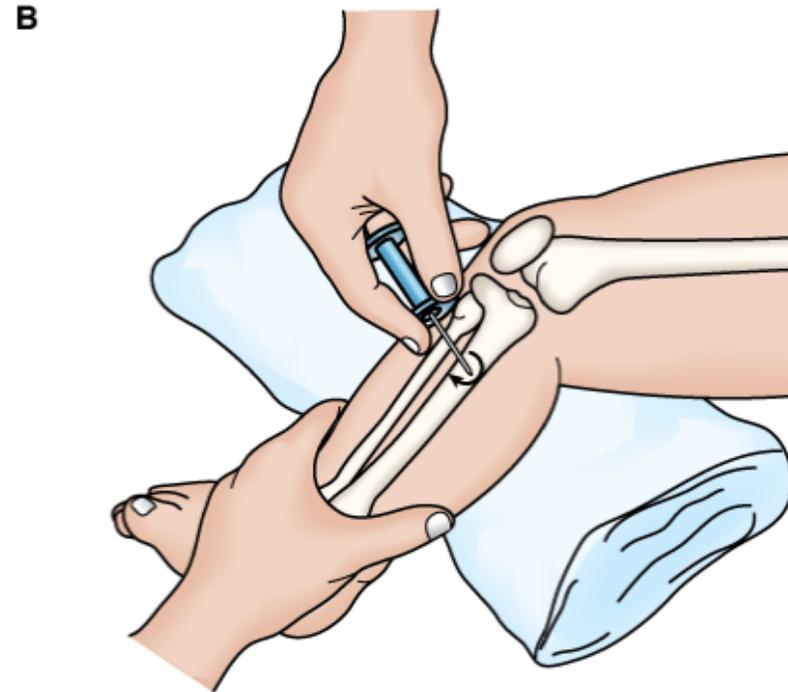
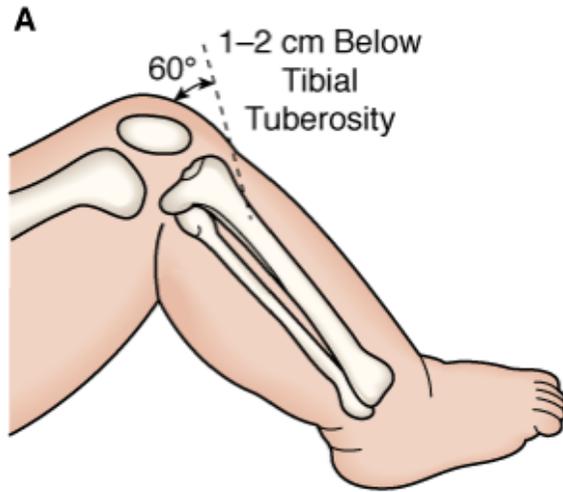
- Comprised of Catheter with Luer-lock connection, Stylet, Safety Cap.
- 15 gauge, 304 stainless steel in 15 mm, 25 mm and 45 mm lengths.
- Sterile, non-pyrogenic, in protective packaging.
- Intended for use with EZ-IO® Power Driver.

#### EZ-IO® Power Driver and Needle Sets: Description



# Recommended Site for Insertion: Proximal Tibia

- The site for IO cannulation of the proximal tibia is approximately 2cm below the tibial tuberosity, 1cm medial
- • Tibia is usually is immediately beneath the skin surface and is palpable as a flat, smooth surface
- **\*Children: 2cm below the tibial tuberosity, 1cm medial**



Source: Rudolph CD, Rudolph AM, Lister GE, First LR, Gershon AA: *Rudolph's Pediatrics, 22nd Edition*: www.accesspediatrics.com  
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**Proximal humerus**  
Experience & anatomy suggest  
that this site is most suitable for  
patients 5 years of age and older

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**Distal femur**  
Not FDA approved

**Distal femur**  
Not FDA approved

**Proximal tibia**

**Proximal tibia**

**Distal tibia**

**Distal tibia**



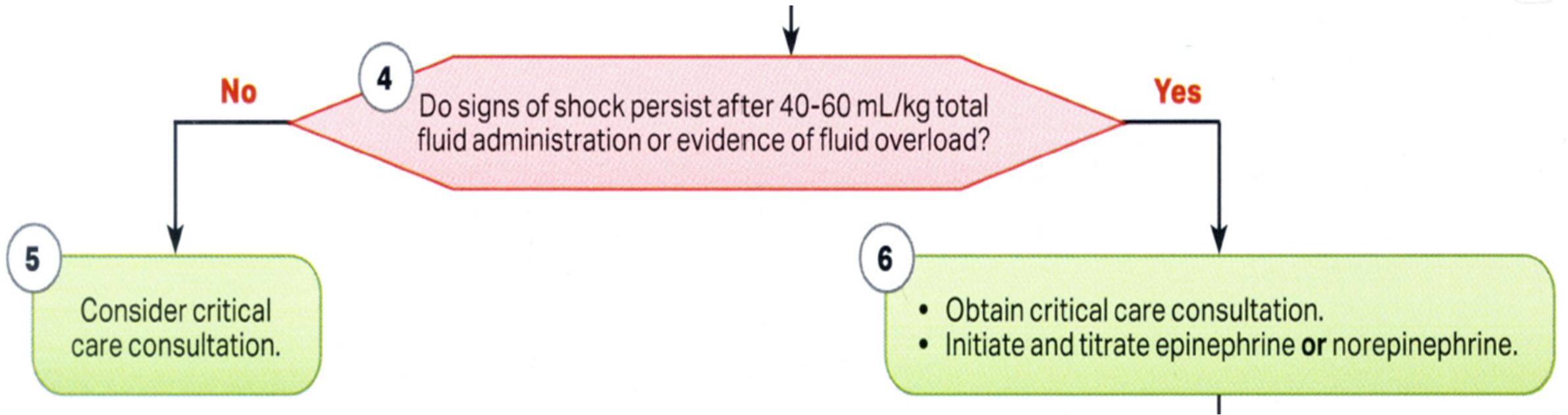
Source: Tintinalli JE, Stapczynski JS, Ma OJ, Cline DM, Cydulka RK, Meckler GD:  
*Tintinalli's Emergency Medicine: A Comprehensive Study Guide, 7th Edition*:  
<http://www.accessmedicine.com>  
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### Within first hour

- Draw blood for culture and additional laboratory studies, including glucose and calcium—do not delay antibiotic or fluid therapy.
- Antibiotics: Give broad spectrum antibiotics.
- Assess carefully after each bolus. Repeat fluid boluses as needed to treat shock. Stop if rales, respiratory distress, or hepatomegaly develops.
- Give antipyretics if needed

**Goals of therapy:** Improved mental status, normalization of heart rate and temperature, adequate systolic and diastolic blood pressure, improved perfusion (see 1)

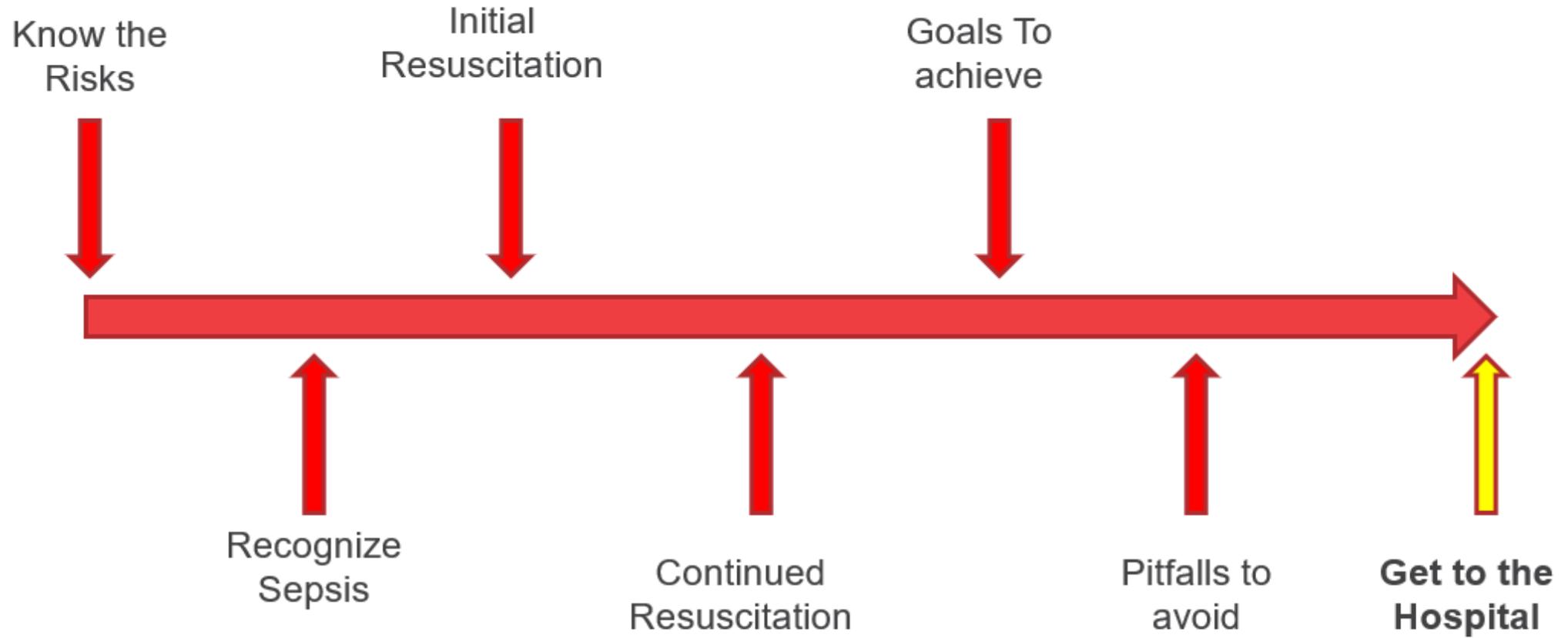


# Pitfalls/Complications to Avoid

- Not recognizing sepsis
  - Kids are generally healthy
  - Blaming abnormal vitals or mental status on situation
- Not initiating fluid resuscitation
- Not reassessing after each bolus

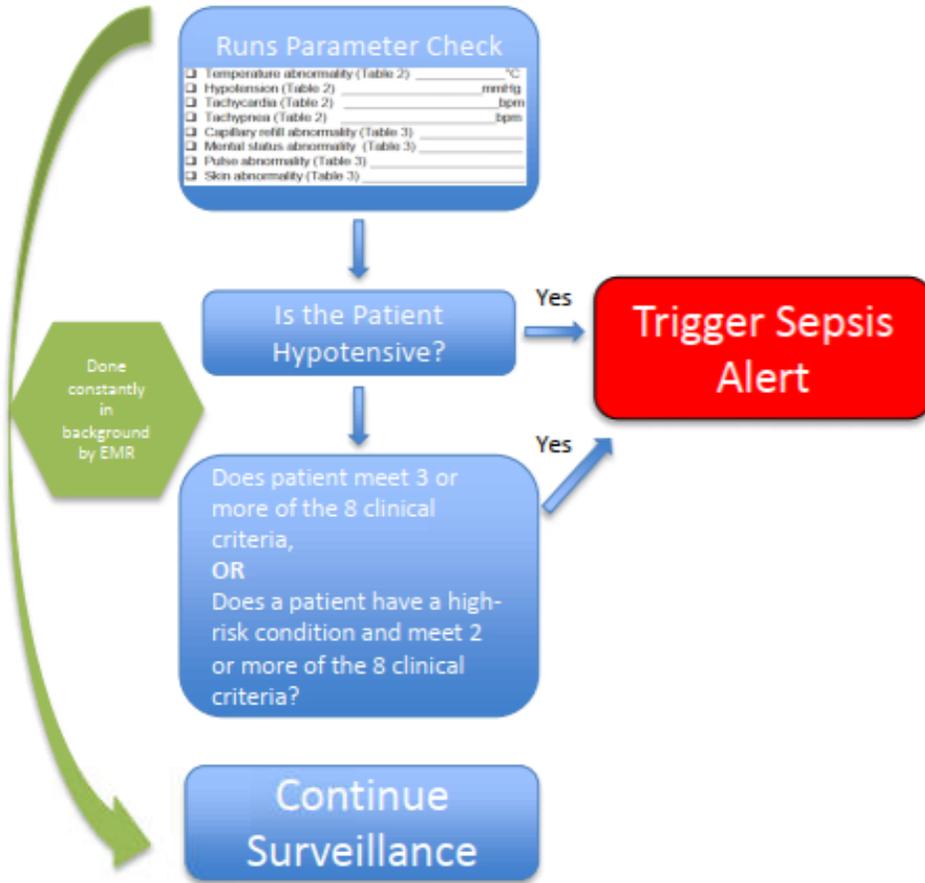


# Timeline



# PEDIATRIC SEPTIC SHOCK Best Practice Alert

## Electronic TRIGGER TOOL



- Runs Parameter Check**
- Temperature abnormality (Table 2) \_\_\_\_\_ °C
  - Hypotension (Table 2) \_\_\_\_\_ mmHg
  - Tachycardia (Table 2) \_\_\_\_\_ bpm
  - Tachypnea (Table 2) \_\_\_\_\_ bpm
  - Capillary refill abnormality (Table 3)
  - Mental status abnormality (Table 3)
  - Pulse abnormality (Table 3)
  - Skin abnormality (Table 3)

**Table 1. High Risk Conditions**

- Malignancy
- Asplenia (including SCD)
- Bone marrow transplant
- Central or indwelling line/catheter
- Solid organ transplant
- Severe MR/CP
- Immunodeficiency, immunocompromise or immunosuppression

**Table 2. Vital Signs (PALS)**

Age	Heart Rate	Resp Rate	Systolic BP	Temp (°C)
0 d - 1 m	> 205	> 60	< 60	<36 or >38
≥ 1 m - 3 m	> 205	> 60	< 70	<36 or >38
≥ 3 m - 1 r	> 190	> 60	< 70	<36 or >38.5
≥ 1 y - 2 y	> 190	> 40	< 70 + (age in yr × 2)	<36 or >38.5
≥ 2 y - 4 y	> 140	> 40	< 70 + (age in yr × 2)	<36 or >38.5
≥ 4 y - 6 y	> 140	> 34	< 70 + (age in yr × 2)	<36 or >38.5
≥ 6 y - 10 y	> 140	> 30	< 70 + (age in yr × 2)	<36 or >38.5
≥ 10 y - 13 y	> 100	> 30	< 90	<36 or >38.5
> 13 y	> 100	> 16	< 90	<36 or >38.5

**Table 3. Exam Abnormalities**

	Cold Shock	Warm Shock	Non-specific
<b>Pulses (central vs. peripheral)</b>	Decreased or weak	Bounding	
<b>Capillary refill (central vs. peripheral)</b>	≥ 3 sec	Flash (< 1 sec)	
<b>Skin</b>	Mottled, cool	Flushed, ruddy, erythroderma (other than face)	Petechiae below the nipple, any purpura
<b>Mental status</b>			Decreased, irritability, confusion, inappropriate crying or drowsiness, poor interaction with parents, lethargy, diminished arousability, obtunded

# Concerning Clinical Findings- Triage Trigger

Neurologic: altered mental status (Anxiety, restlessness, irritability, inappropriate crying, drowsiness, confusion, lethargy, obtundation) stiff neck, headache

Cardiovascular: cool extremities, delayed capillary refill (> 3 seconds), diminished pulses, mottling or flushed, warm extremities, bounding pulses, flash capillary refill (< 1 second)

Pulmonary: cough, increased work of breathing, new or increasing oxygen requirement

Skin/Soft Tissue: petechial and/or purpuric rash, erythroderma, cellulitis

Abdominal: pain, peritoneal signs, distended abdomen

Renal: decreased urine output, dysuria, flank pain, urinary frequency

Musculoskeletal: red, swollen, painful joint



# Why Is Pediatric Sepsis Important

10%-20% Mortality Rate

#1 cause of inpatient hospital mortality

Majority of previously healthy patients who die do so within 24 hours of admission

Quality of life severely impacted as 1/3<sup>rd</sup> of patients many never return to baseline

Sepsis is treatable, sepsis deaths are preventable, and the high costs of advanced treatment are avoidable



**Suspect**  
**SEPSIS**



**Save Lives**



# Questions



# References

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