Making Sure that Kids Survive Sepsis: What's New, What's Old, and What's Different About Pediatric Sepsis

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Disclosures / Funding

No commercial conflicts of interest.

Professional panels: IPSO Steering Committee, SCCM Surviving Sepsis Guidelines, SCCM Pediatric Sepsis Definitions taskforce

Current funding:

- AHRQ K08 HS025696 (Scott)
  Enhancing Quality in Pediatric Sepsis with Shock Prediction and Early Electronic Decision Support (EQUIP with SPEED)
- NICHD R01 HD087363 (Alpern)
  PED Screen: Pediatric Sepsis EHR Registry, Clinical Outcomes, and Prediction Model

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Objectives

The attendee will be able to:

1. Diagnose pediatric septic shock and assess hemodynamics
2. Develop an approach to the use of intravenous fluids and vasoactive agents in pediatric septic shock
3. Understand the 2020 pediatric Surviving Sepsis diagnosis and treatment algorithm, and apply it to their clinical setting

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Surviving Sepsis Campaign International Guidelines for the Management of Septic Shock and Sepsis-Associated Dysfunction in Children

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Joseph Carcillo, MD[16]; Enitan D. Carrol, MB ChB, MD, F
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Koen F. M. Joosten, MD, PhD[24]; Poonam Joshi, PhD[25]; Ol
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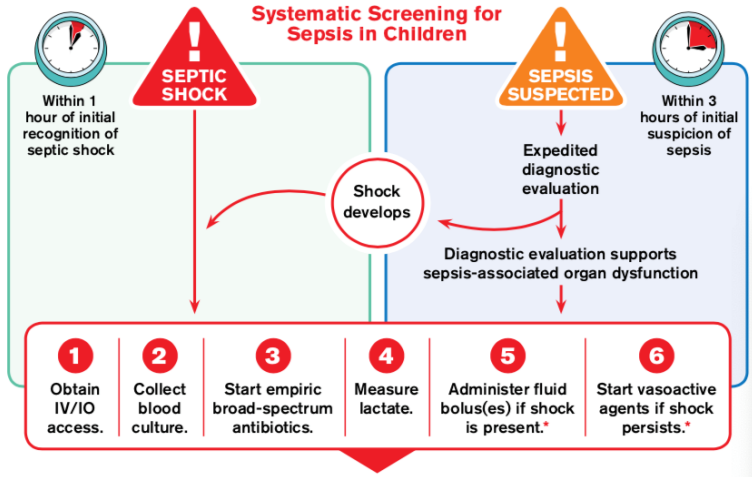
These guidelines are simultaneously being published in *Pediatric Critical Care Medicine* (DOI: 10.1097/PCC.0000000000002198) and *Intensive Care Medicine* (DOI: DOI: 10.1007/s00134-019-05878-6).

DOI: 10.1097/PCC.0000000000002198

Initial Resuscitation Algorithm for Children

Surviving Sepsis Campaign



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Case: Primary Care Presentation

- 7-year-old unimmunized boy
- 6 days increasing fatigue, 'not acting right'
- No fever. No rhinorrhea, no cough, no sore throat.
- 1-day L leg pain, L shoulder pain
- On further history… Cut L finger while cooking 1 week prior, treated with triple antibiotic ointment

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Case: Primary Care Presentation

7-year-old unimmunized boy, 6 days increasing fatigue, 'not acting right'

- Physical exam: T= 36.8 HR = 136 RR = 22 BP = 92/64
- Crusted lesions around mouth
- Dry mucus membranes
- L upper extremity erythematous, tender, cut on hand well-healed
- UA negative, rapid strep +, referred to local ED
- Concern for osteomyelitis

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Case: Primary Care Presentation

Potential risk factor

7-year-old unimmunized boy, 6 days increasing fatigue, 'not acting right'

Physical exam: T= 36.8 HR = 136 RR = 22 BP = 92/6
Crusted lesions around mouth
Dry mucus membranes
L upper extremity erythematous, tender, cut on hand well-healed

Worrisome overall health, potential systemic process

Potential bacterial infection, multiple sites

UA negative, rapid strep +, referred to local ED
Concern for osteomyelitis

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Case: Critical Access Emergency Department

7-year-old unimmunized boy with history of cut, L arm pain

- T: 38.2 HR: 162 RR: 20 Pulse ox: 91%
- Alert, interactive
- Dry MM
- Erythema to L arm and leg, tender, limited ROM at shoulder
- CBC: 4.6>13.7<181
- Blood culture pending
- 20 mL / kg NS
- Plan for transfer to tertiary hospital for osteomyelitis evaluation

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Case: Critical Access Emergency Department

7-year-old unimmunized boy with history of cut, L arm pain

- T: 38.2 HR: 162 RR: 20 Pulse ox: 91%
- CBC: 4.6>13.7<181
- Blood culture pending
- 20 mL / kg NS
- Plan for transfer to tertiary hospital for osteomyelitis evaluation

What else do you want prior to transfer?

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Case: Critical Access Emergency Department

7-year-old unimmunized boy with history of cut, L arm pain

- T: 38.2 HR: 162 RR: 20 Pulse ox: 91%
- CBC: 4.6>13.7<181
- Blood culture pending
- 20 mL / kg NS
- Plan for transfer to tertiary hospital for osteomyelitis evaluation

Does this patient have sepsis?

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Pediatric Definitions

Infection

- Suspected or proven infection caused by any pathogen OR a clinical syndrome w/ probability of infection

Sepsis

- SIRS in the presence of infection

Severe Sepsis

- Sepsis + CV dysfunction OR ARDS OR ≥2 other organ dysfunction

Septic Shock

- Sepsis and CV organ dysfunction (hypotension, pressors or elevated lactate)

Goldstein *PCCM* 2005

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Pediat

Infection

- Suspe
- w/ pro

Sepsis

- SIRS in

Severe Sepsis

- Sepsis + CV dysfunction O

Septic Sho

- Sepsis

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rgan dysfunction

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The authors reply:

We would like to thank Nakagawa and Shime (1) for their thoughtful letter regarding our 2005 article

tant issues. First, the consensus conference article was meant as "a consensus definition of the pediatric sepsis continuum including systematic inflammatory response syndrome (SIRS), infection, sepsis, severe sepsis, septic shock, and multiple organ dysfunction syndrome to aid in standardization of observational studies and evaluation of therapeutic interventions in clinical trials" (2) and not as diagnostic criteria to guide clinical management. This is an important distinction

that the 2005 consensus definitions are due for revision and updating. Although it was not our original intent, the criteria have been used in guidelines and protocols for clinical diagnosis and management. The appropriateness of this requires further investigation with high-quality clinical studies adding further to the work of Nakagawa and Shime (1).

Dr. Goldstein received grant support (grants for pediat-

The letter by Nakagawa and Shime (1) is timely and suggests that the 2005 consensus definitions are due for revision and updating. Although it was not our original intent, the criteria have been used in guidelines and protocols for clinical diagnosis and management. The appropriateness of this requires

pediatrics. *Pediatr Crit Care Med* 2005; 6:2–8

DOI: 10.1097/PCC.0000000000000025

Pediatric Critical Care Medicine

Goldstein *PCCM* 2014

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"Sepsis 3.0"

Life-threatening organ dysfunction caused by a dysregulated host response to infection

Seymour *JAMA* 2016

VIEWPOINT

Defining Pediatric Sepsis

In conclusion, there is thus an urgent need to translate Sepsis-3 into definitions adapted for the specific disease characteristics, susceptibilities, and patterns of pediatric sepsis. Failure to re-

JAMA Pediatrics | Original Investigation | CARING FOR THE CRITICALLY ILL PATIENT

Adaptation and Validation of a Pediatric Sequential Organ Failure Assessment Score and Evaluation of the Sepsis-3 Definitions in Critically Ill Children

Travis J. Matics, DO; L. Nelson Sanchez-Pinto, MD, MBI

Children's Hospital Colorado

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What is Organ Dysfunction and Why Should I Care?

CV:	Hypotension, lactate, vasopressor use
Resp:	New positive-pressure ventilation
Neuro:	Altered mental status
Renal:	Acute kidney injury
Hepatic:	Elevated LFTs
Heme:	DIC, low platelets

*precise cutpoints vary and subject to change!

Children's Hospital Colorado

Goldstein *PCCM* 2005, Matics *JAMA Pediatrics*, Weiss *PCCM* 2020

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PEDIATRIC CRITICAL CARE

Acute Kidney Injury in Pediatric Severe Sepsis: An Independent Risk Factor for Death and New Disability

Fitzgerald, Julie C. MD, PhD[1,2]; Basu, Rajit K. MD, MMI[3]; Akcan-Arikan, Ayse MD[4]; Izquierdo, Ledys M. MD[5]; Piñeres Olave, Byron E. MD[6]; Ha... Akash FRCPCH[9]; Williams, Duane MD... MS[1,2]; Thomas, Neal J. MD, MSc[13]; Wei... PRevalence, OUtcomes, and Therapie... Investigators Network **Author Info**...

Critical Care Medicine: December 201...
doi: 10.1097/CCM.0000000000002007...

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Disseminated Intravascular Coagulation Is an Independent Predictor of Adverse Outcomes in Children in the Emergency Department with Suspected Sepsis

Leonora R. Slatnick, MD • Dianne Thornhill, PhD • Sara J. Deakyne Davies, MPH • ...
Halden F. Scott, MD, MSCS • Marilyn J. Manco-Johnson, MD • Beth Boulden Warren, MD, MS, MSCS

Validation of the Vasoactive-Inotropic Score in Pediatric Sepsis

Amanda M. McIntosh, MD[1]; Suhong Tong, MS[2]; Sara J. Deakyne, MPH[3]; Jesse A. Davidson, MD, MPH[4]; Halden F. Scott, MD[5]

Pediatric Critical Care Medicine

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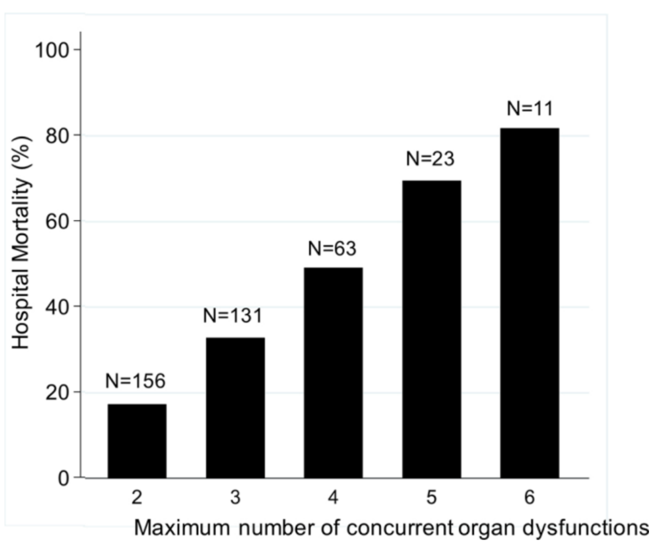
Why is organ dysfunction important?



Lin *PCCM* 2017

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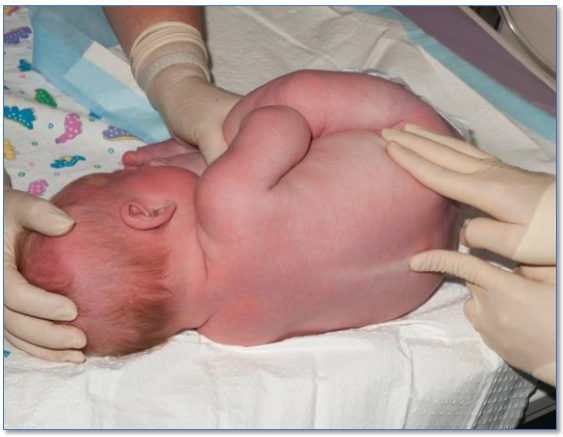
Sepsis ≠ Serious Bacterial Infection



~~"Rule Out Sepsis"~~

An informal term for a diagnostic work up to identify serious bacterial infection, often in neonatal fever

Sepsis

Life-threatening organ dysfunction caused by infection

https://www.methodsman.com/blog/a-blood-test-to-avoid-a-spinal-tap-in-an-infant-yes-please

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Suspected Infection + Organ Dysfunction

Hypotensive 8-year-old, ALL, central line; blood culture +gram negative rods

2-year-old intubated, ventilated with pneumonia

Lethargic 4-year-old, fever, and leukocytes & nitrites in her urine

16-year-old, right lower quadrant pain and fever, heart rate 140 bpm, capillary refill of 5 seconds and lactate 4.1 mmol/L

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Sepsis = Infection + Organ Dysfunction

- Start treatment for suspicion of infection
- Diagnosis does not require microbiological confirmation
- Consider de-escalation if clinical picture/labs do not support infection

CV:	Hypotension, lactate, vasopressor use
Resp:	New positive-pressure ventilation
Neuro:	Altered mental status
Renal:	Acute kidney injury
Hepatic:	Elevated LFTs
Heme:	DIC, low platelets

Goldstein *PCCM* 2005, Matics *JAMA Pediatrics*, Weiss *PCCM* 2020

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Case: Critical Access Emergency Department

T: 38.2 HR: 162 RR: 20
Pulse ox: 91%

CBC: 4.6>13.7<181

Blood culture pending

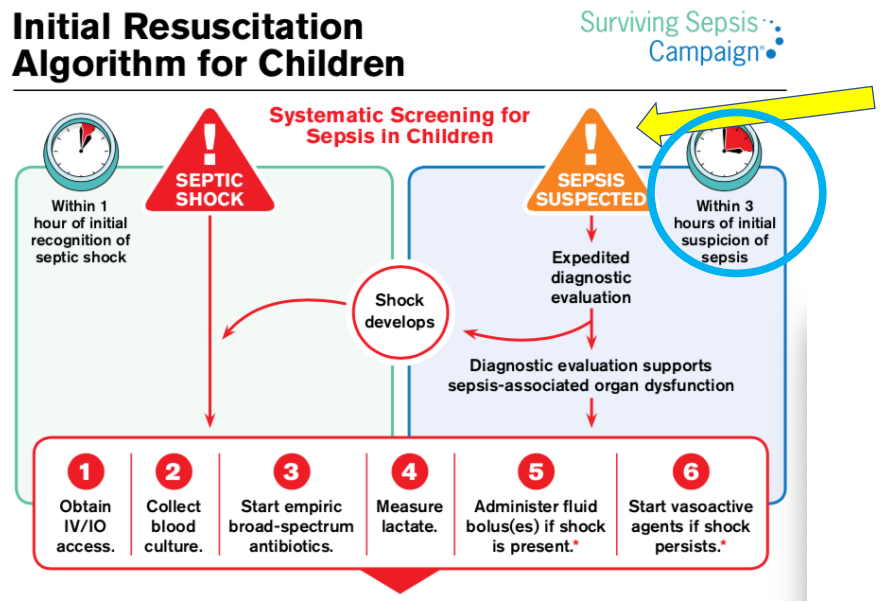
20 mL / kg NS

Does this patient have sepsis?

Organ Dysfunction

CV:	Hypotension, lactate
Resp:	New ventilation
Neuro:	Altered mental status
Renal:	AKI
Hepatic:	Elevated LFTs
Heme:	DIC, low platelets

20


Initial Resuscitation Algorithm for Children
Surviving Sepsis Campaign
Systematic Screening for Sepsis in Children
SEPTIC SHOCK
SEPSIS SUSPECTED
Within 1 hour of initial recognition of septic shock
Within 3 hours of initial suspicion of sepsis
Expedited diagnostic evaluation
Shock develops
Diagnostic evaluation supports sepsis-associated organ dysfunction
1 Obtain IV/IO access.
2 Collect blood culture.
3 Start empiric broad-spectrum antibiotics.
4 Measure lactate.
5 Administer fluid bolus(es) if shock is present.*
6 Start vasoactive agents if shock persists.*
www.sccm.org/SurvivingSepsisCampaign/Guidelines/Pediatric-Patients

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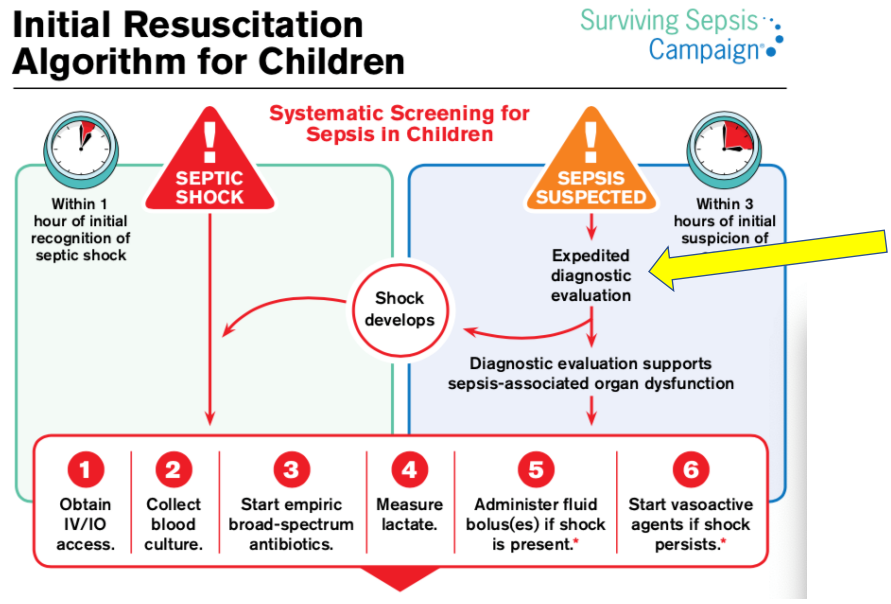
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www.sccm.org/SurvivingSepsisCampaign/Guidelines/Pediatric-Patients

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Case: Critical Access Emergency Department

7-year-old with arm pain

T: 38.2 HR: 162 RR: 20
Pulse ox: 91%

CBC: 4.6>13.7<181

Blood culture pending

20 mL / kg NS

More Information

BP: 73/37

Na 123, Cl 90, Cr 0.81

Lactate 2.6

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Critical Red Alert (Advisory: 1)

Blood Pressure: (!) 60/30 (06/02/16 1508 : Zztest, Nurse Ed D)

HYPOTENSION!

This patient has low systolic blood pressure

- This is shock! Consider and treat sepsis, hypovolemia/ hemorrhage,anaphylaxis, cardiogenic or obstructive shock.
- Notify attending immediately.

The following actions have been applied:

Completed: Chco ed trigger hypotension event from bpa

Acknowledge Reason

Attending Notified | Will Re-check Vitals

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Pediatric Hypotension

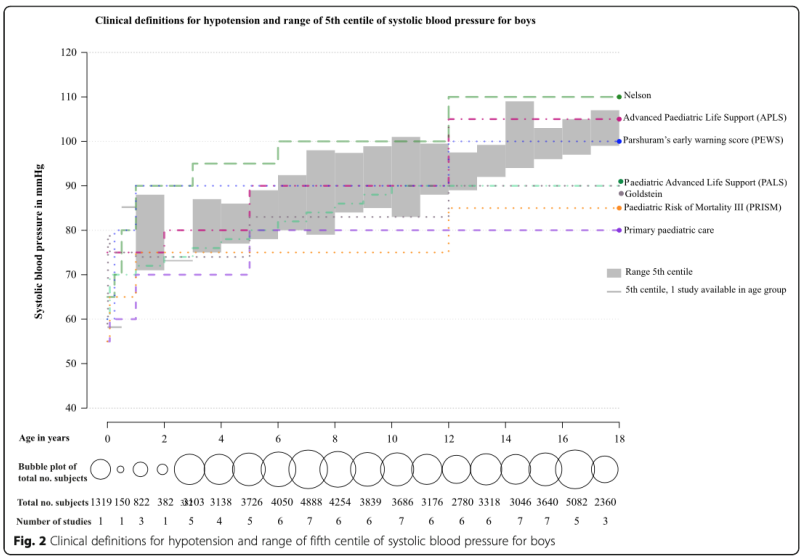

Fig. 2 Clinical definitions for hypotension and range of fifth centile of systolic blood pressure for boys

PALS Systolic Hypotension

70 + Age*2

Adult 90 mmHg

Hagedoorn *et al. Critical Care* (2019) 23:380

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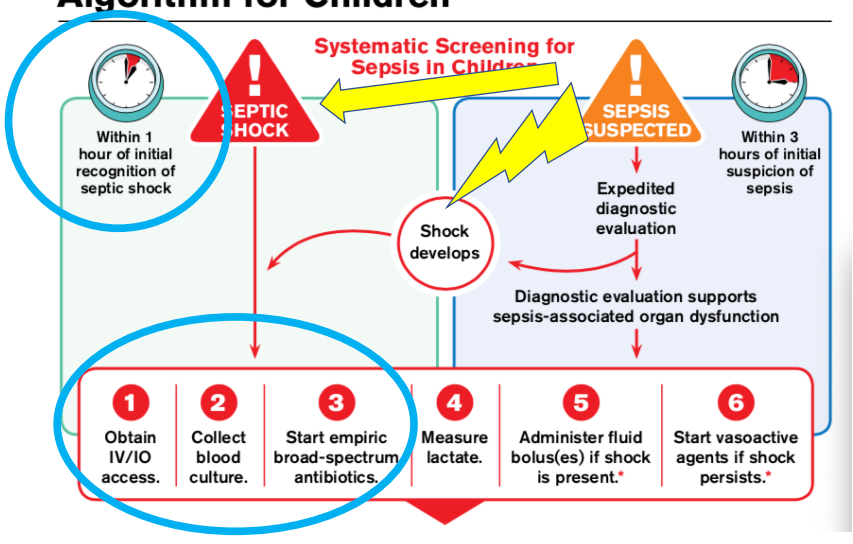
Initial Resuscitation Algorithm for Children

Surviving Sepsis Campaign



www.sccm.org/SurvivingSepsisCampaign/Guidelines/Pediatric-Patients

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Case – Critical Access ED - waiting for transport

- HR: 160s
- BP: 73/37
- Na:123, Cl:90, Cr: 0.81
- Lactate 2.6
- Ceftriaxone and Vancomycin ordered and given

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Antimicrobial Therapy

1. In children with **septic shock**, we recommend starting antimicrobial therapy *as soon as possible*, within 1 hr. of recognition (strong recommendation, very low quality of evidence).

2. In children with **sepsis-associated organ dysfunction** but without shock, we suggest starting antimicrobial therapy *as soon as possible* after appropriate evaluation, within 3 hrs. of recognition (weak recommendation, very low quality of evidence).

3. Additional recommendations: start broad/narrow coverage, stop asap, source control, specific pharmacodynamic/double coverage recommendations

Weiss *PCCM* 2020

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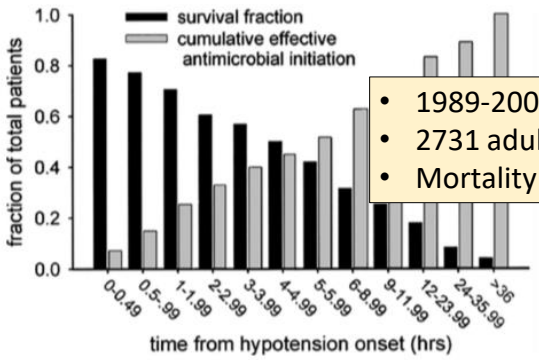
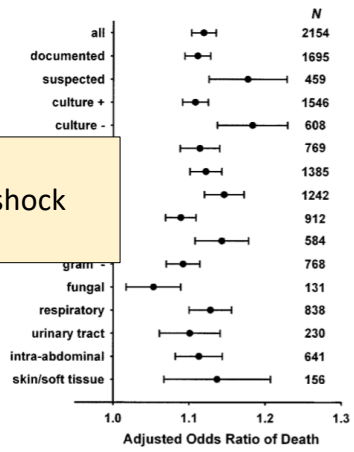
Duration of hypotension before initiation of effective antimicrobial therapy is the critical determinant of survival in human septic shock*

Anand Kumar, MD; Daniel Roberts, MD; Kenneth E. Wood, DO; Bruce Light, MD; Joseph E. Parrillo, MD; Satendra Sharma, MD; Robert Suppes, BSc; Daniel Feinstein, MD; Sergio Zanotti, MD; Leo Taiberg, MD; David Gurka, MD; Aseem Kumar, PhD; Mary Cheang, MSc



- 1989-2004
- 2731 adult patients septic shock
- Mortality 56.2%



Crit Care Med 2006 Vol. 34, No. 6

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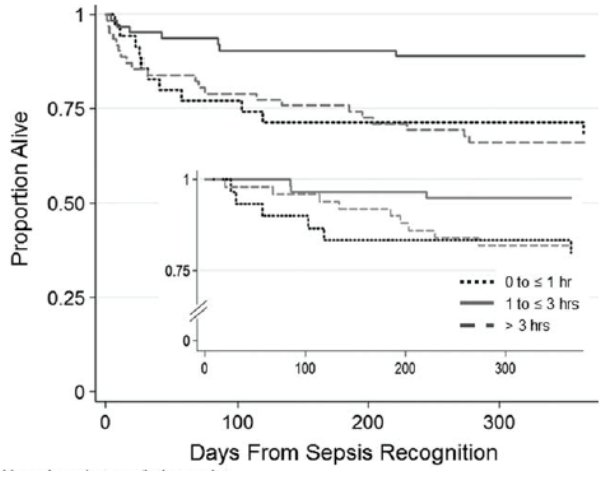

- Unexpected post-hoc finding
- Hypothesis-generating
- Possible explanations:
  - More severely ill patients
  - Early delivery may represent delayed recognition
  - Biologic plausibility for harm from very early antibiotics?

Han *Shock* 2017

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Hospital Pediatrics
AN OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

Research Article

Antibiotic Timing in Pediatric Septic Shock

Roni D. Lane, Jared Olson, Ron Reeder, Benjamin Miller, Jennifer K. Workman, Emily A. Thorell and Gitte Y. Larsen

Hospital Pediatrics March 2020, hpeds.2019-0250; DOI: https://doi.org/10.1542/hpeds.2019-0250

- 1377 Patients
- 2007-2015
- 71% Antibiotics ≤ 2 hours
- No association time to antibiotic and outcome

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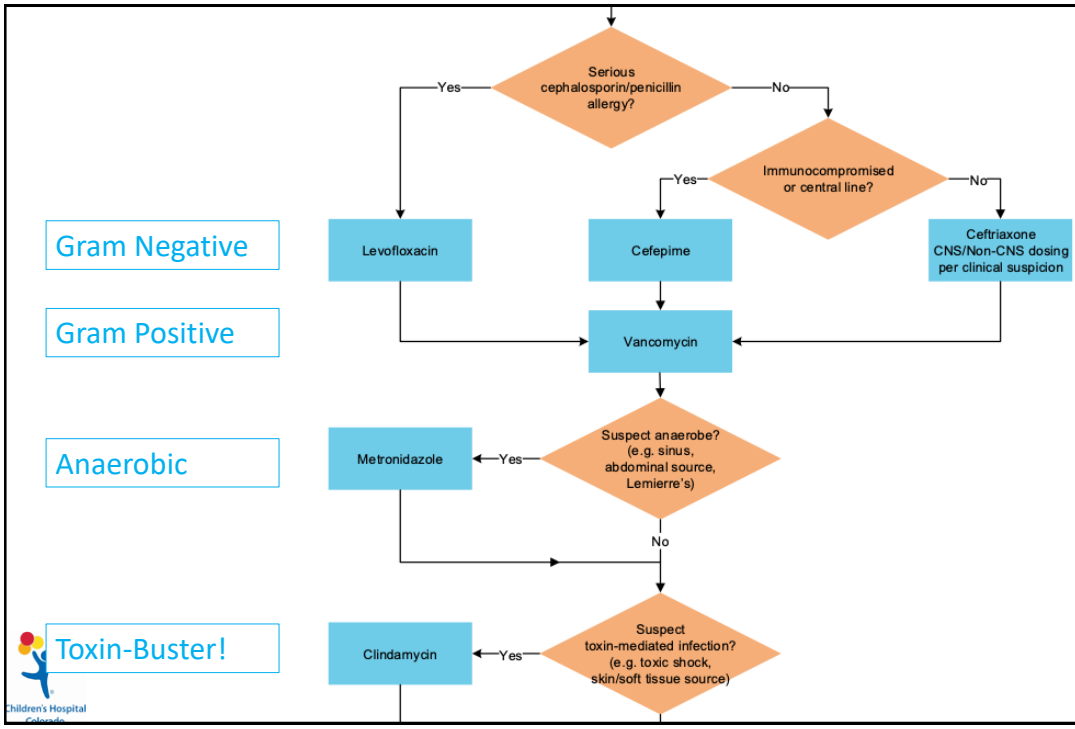

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Initial Resuscitation Algorithm for Children

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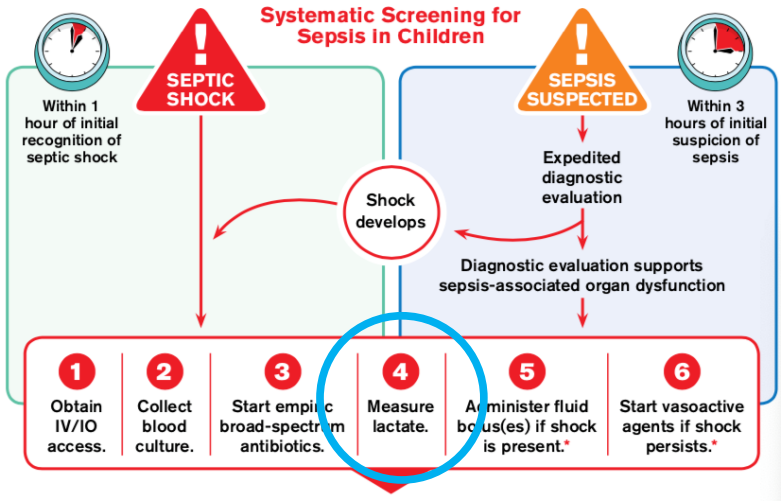

www.sccm.org/SurvivingSepsisCampaign/Guidelines/Pediatric-Patients

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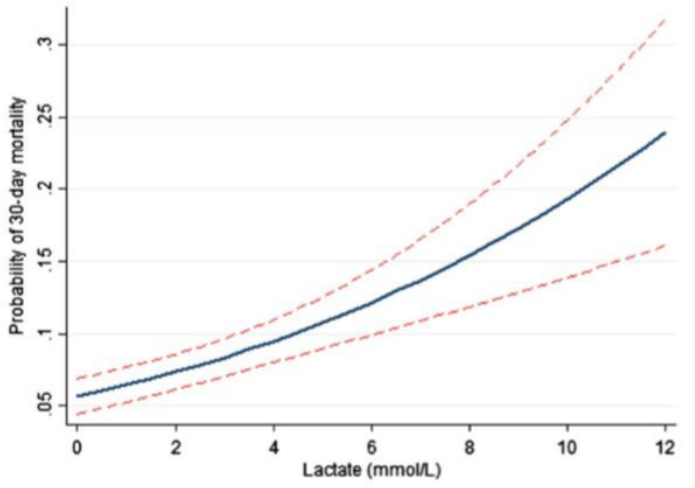
PEDIATRIC ORIGINAL

Prediction of pediatric sepsis mortality within 1 h of intensive care admission

Luregn J. Schlapbach[1,2,3*], Graeme MacLaren[4,5], Marino Festa[6], Janet Alexander[7,8], Simon Erickson[9],



Schlapbach *ICM* 2017

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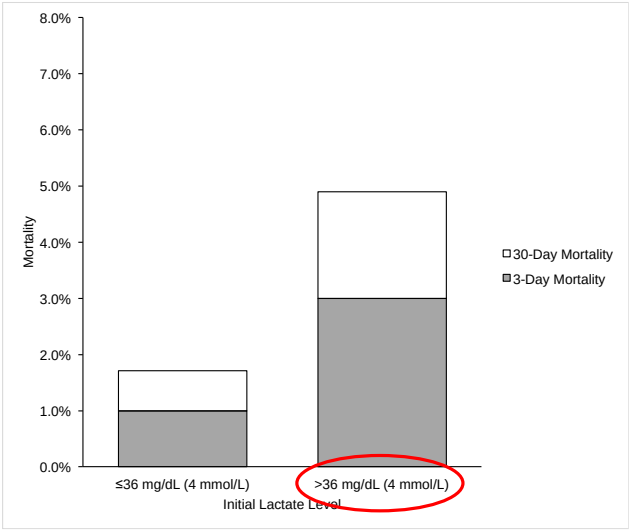
Lactate ≥ 4 mmol/L
30-Day Mortality RR= 2.90 [1.11-7.57]



Scott *JAMA Peds* 2017

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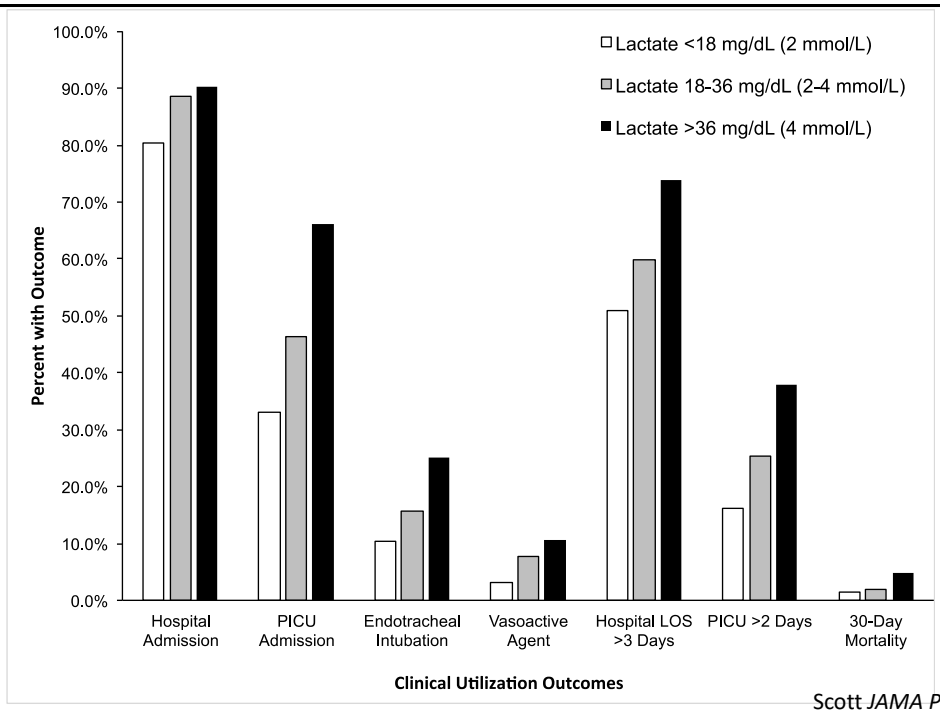

Scott *JAMA Peds* 2017

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Case – Critical Access ED - waiting for transport

- HR: 160s BP: 73/37
- Na: 123, Cl: 90, Cr: 0.81
- Lactate 2.6
- Ceftriaxone and Vancomycin ordered and given
- Now 40 mL/kg crystalloid total given
- HR:158 BP: 80/40 RR: 22 Pulse Ox 91% RA
- Alert, oriented, moaning about pain in arm
- Capillary refill 3 seconds

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Initial Resuscitation Algorithm for Children

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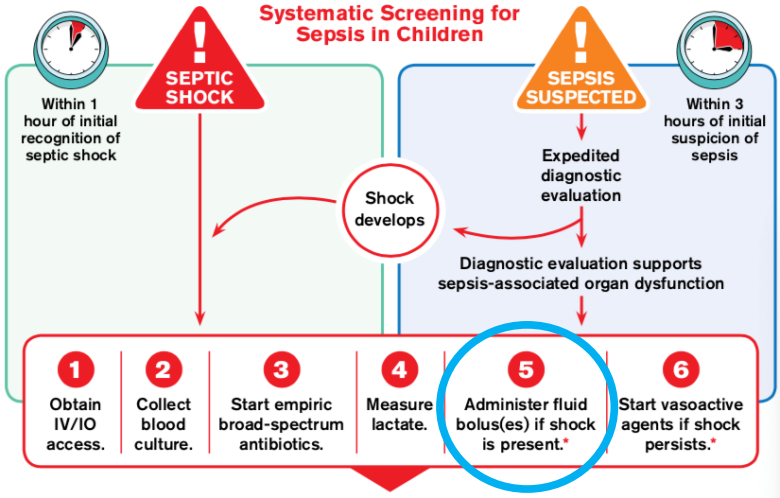

www.sccm.org/SurvivingSepsisCampaign/Guidelines/Pediatric-Patients

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Fluid Therapy

1. In health care systems with availability of intensive care, we suggest administering up to 40–60 mL/kg in bolus fluid (10–20 mL/kg per bolus) over the first hour, titrated to clinical markers of cardiac output and discontinued if signs of fluid overload develop, for the initial resuscitation of children with septic shock or other sepsis-associated organ dysfunction (weak recommendation, low quality of evidence).

Remarks: Clinical markers of cardiac output may include heart rate, blood pressure, capillary refill time, level of consciousness, and urine output. In all settings, the need for fluid administration should be guided by frequent reassessment of clinical markers of cardiac output, serial blood lactate measurement, and advanced monitoring, when available. Signs of fluid overload that should limit further fluid bolus therapy may include clinical signs of pulmonary edema or new or worsening hepatomegaly.

Weiss *PCCM* 2020

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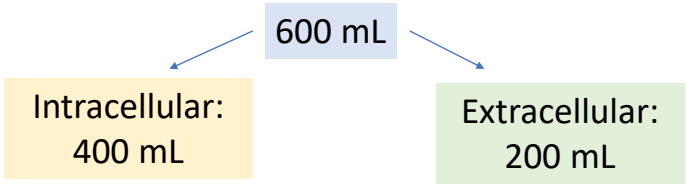
Physiologically, 60 mL/kg (sort of) makes sense

60% of human mass is water (70% in infants)

Per kg: 600-700 mL is water



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Physiologically, it makes sense

60% of human mass is water (70% in infants)

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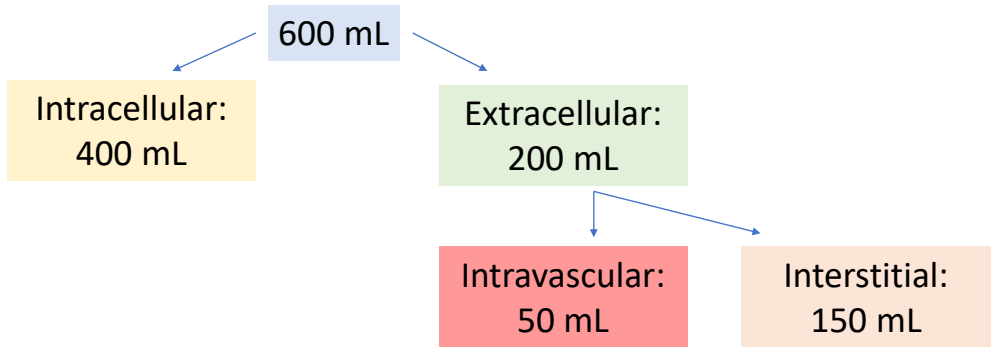

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60% of human mass is water (70% in infants)

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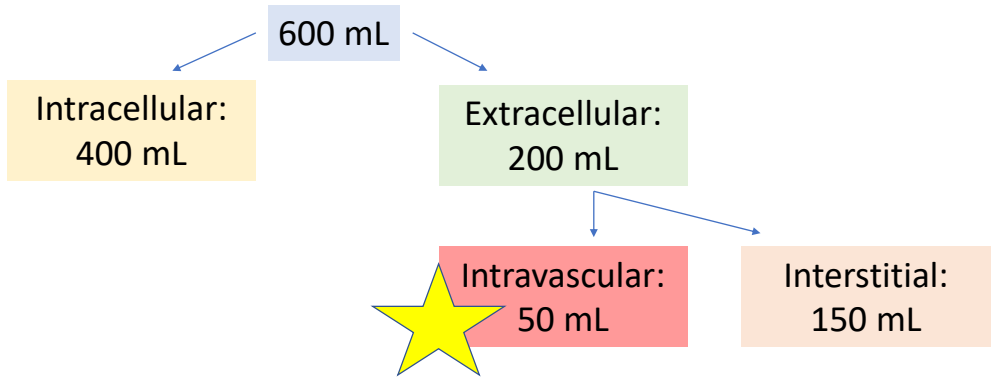

42

Physiologically, it makes sense

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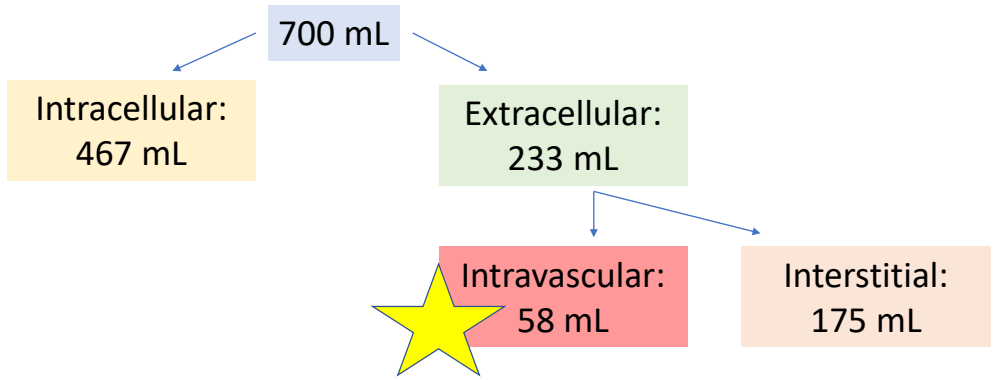

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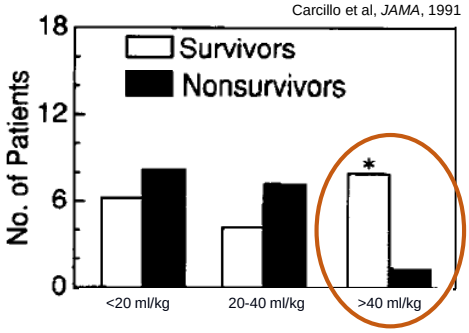
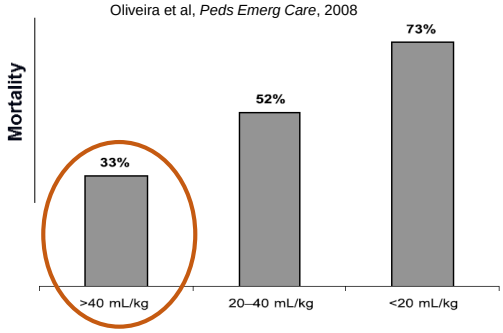
Improved outcomes with higher volumes

Carcillo et al, *JAMA*, 1991



Oliveira et al, *Peds Emerg Care*, 2008



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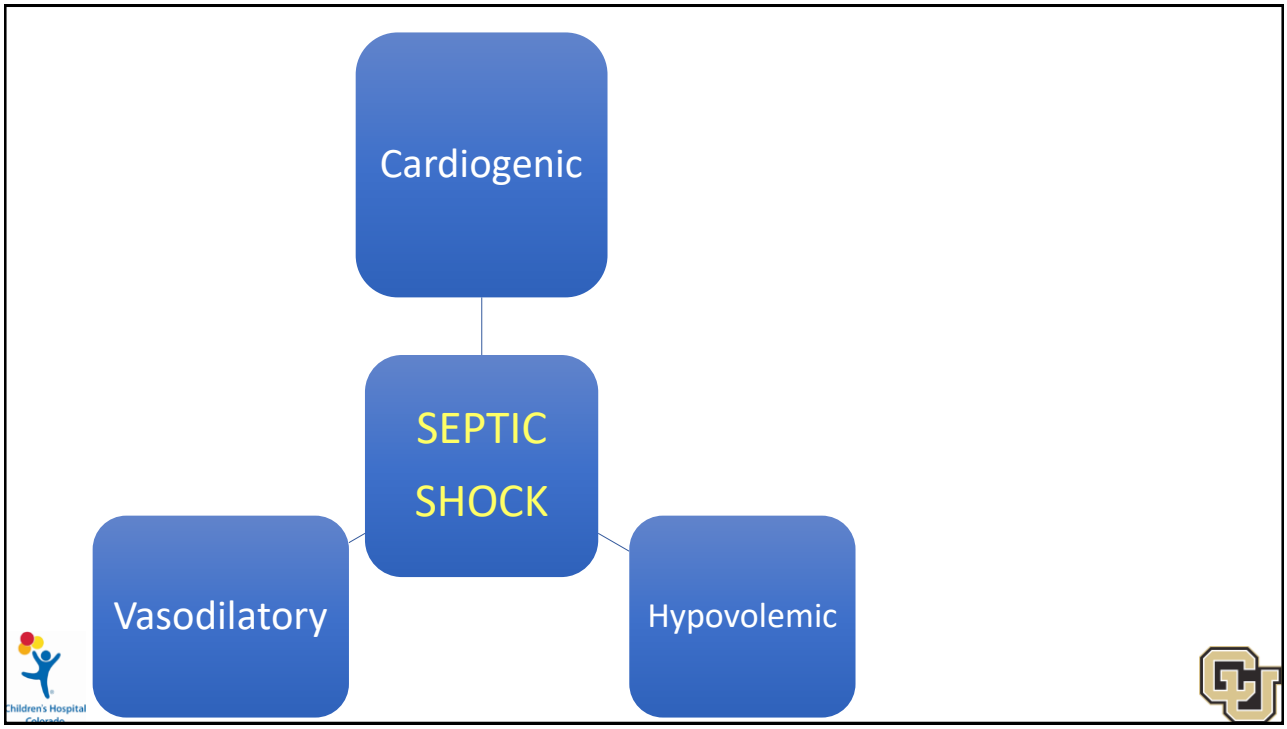
Physiologically, it DOES NOT make sense

45



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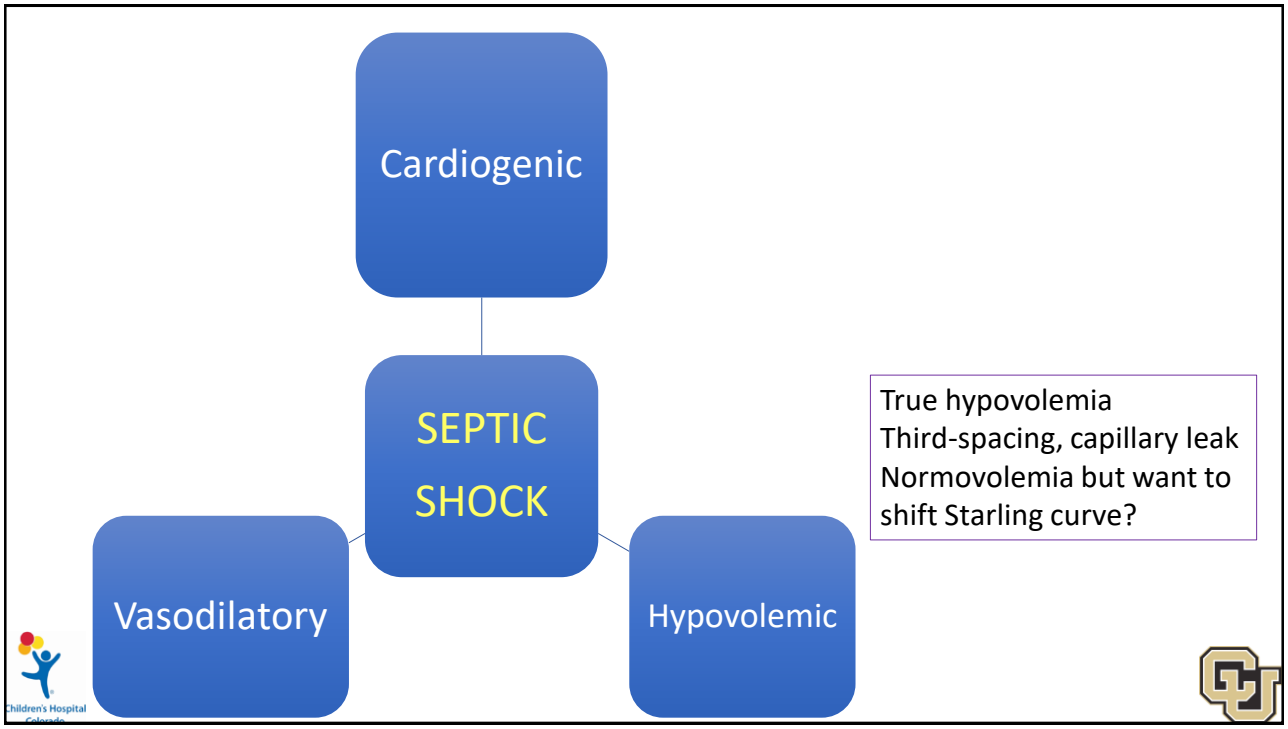
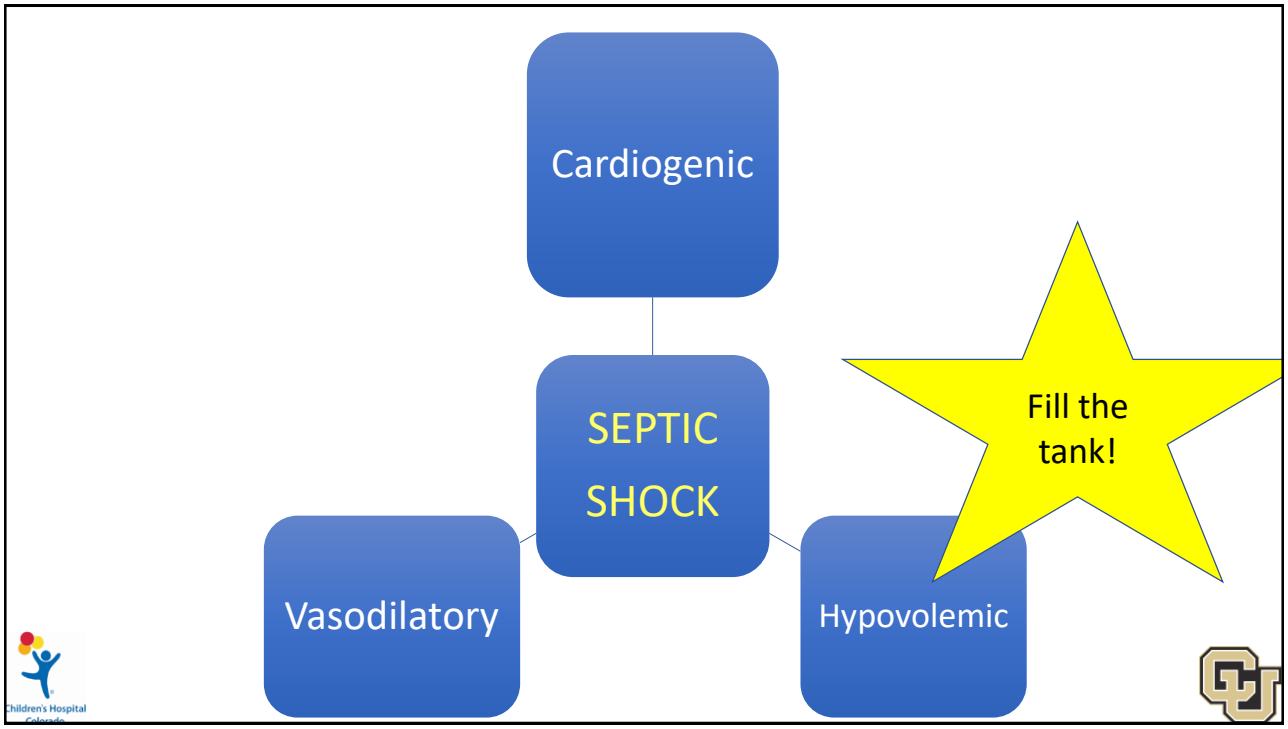
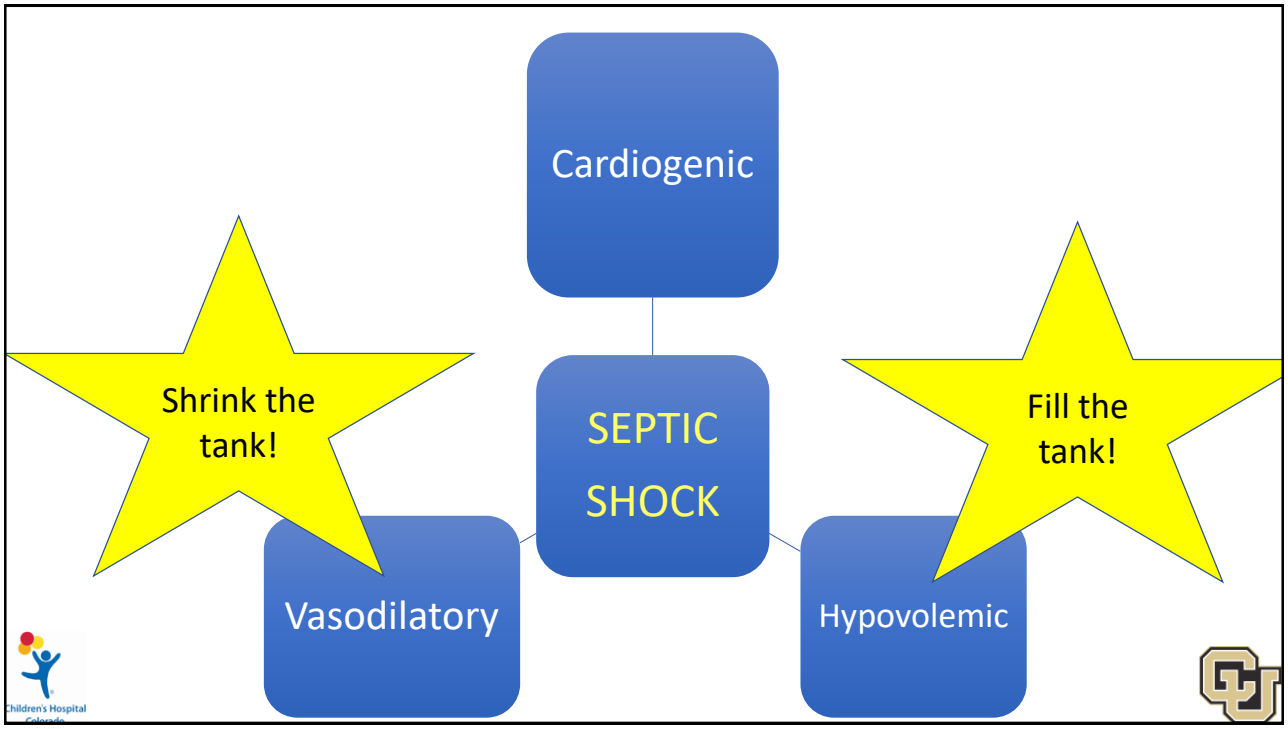

Cardiogenic
SEPTIC SHOCK
Vasodilatory
Hypovolemic
True hypovolemia
Third-spacing, capillary leak
Normovolemia but want to shift Starling curve?

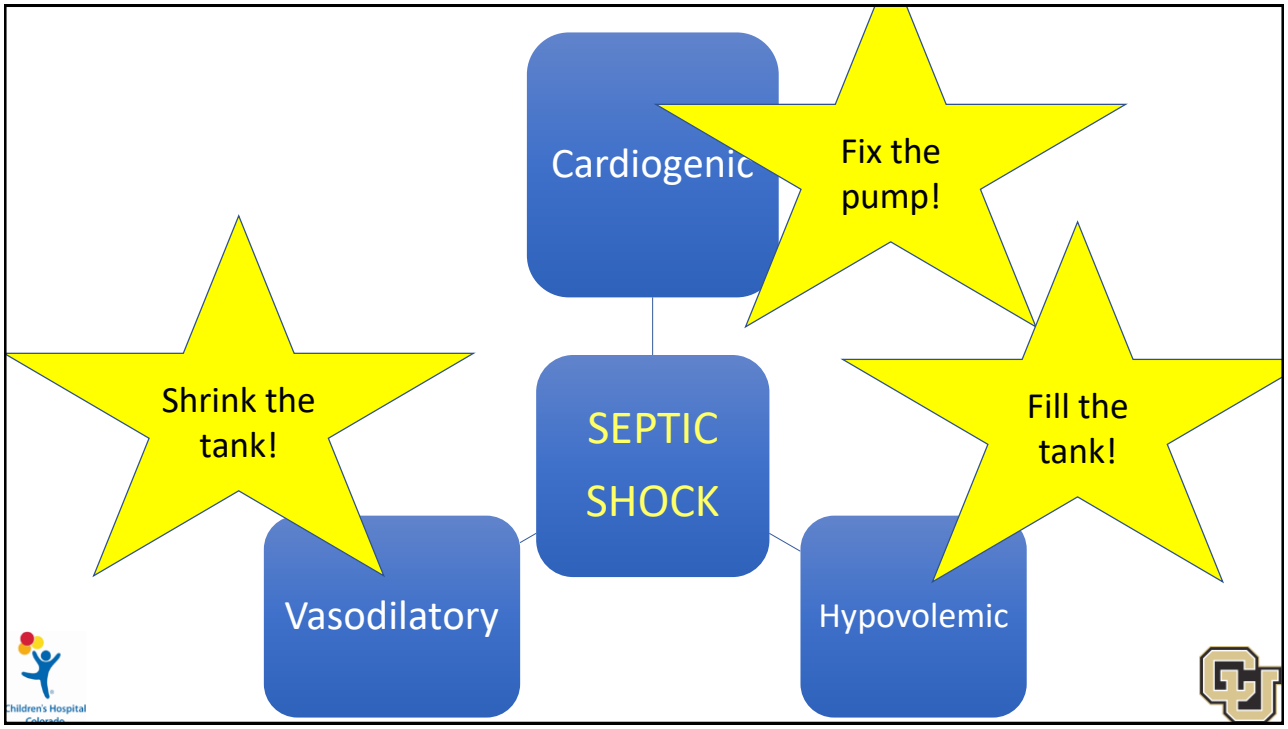
47


Cardiogenic
SEPTIC SHOCK
Vasodilatory
Hypovolemic
Fill the tank!

48


Cardiogenic
Shrink the tank!
SEPTIC SHOCK
Fill the tank!
Vasodilatory
Hypovolemic

49


Cardiogenic
Fix the pump!
Shrink the tank!
SEPTIC SHOCK
Fill the tank!
Vasodilatory
Hypovolemic

50

SQUEEZE TRIAL

A Trial to Determine Whether Septic Shock Reversal is Quicker in Pediatric Patients Randomized to an EGD Fluid-Sparing Strategy vs. Usual Care

Melissa Parker, McMaster University

Usual care (no vasoactives until after 60 mL/kg)

Vs. Vasopressor with 5-10 mL boluses

(After 1-3 L) Vasopressors first vs. fluid first in adult hypotensive septic shock

N: 2320 planned

3/7/2018 – projected 6/2021

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So what am I supposed to give my patient?

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PALS Fluid Recommendations

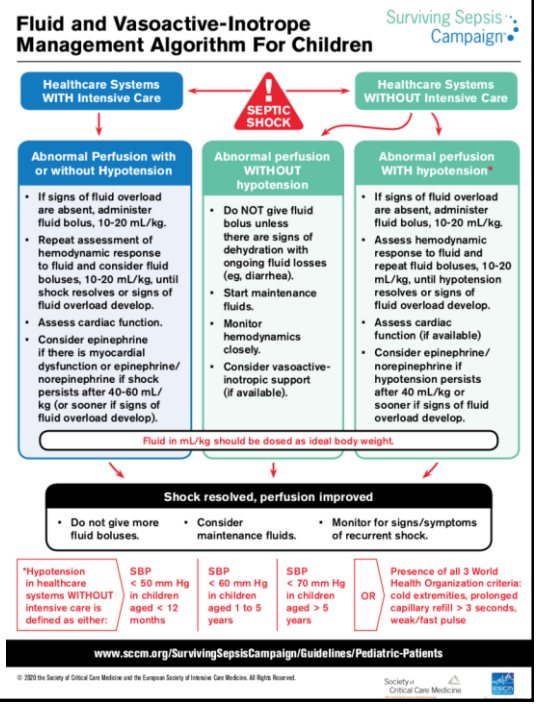
Administration of an initial fluid bolus… in shock is reasonable (Class IIa, LOE C-LD)

When caring for children with severe febrile illness in settings with limited access to critical care resources… administration of bolus intravenous fluids should be undertaken with extreme caution (Class IIb, LOE B-R)

Fluid not safe for all patients in all settings
- e.g. shouldn't have 'standing orders'

Increased emphasis on
- Individual patient assessment and reassessment
- Consideration of vulnerabilities to fluid
  - Nutrition status
  - Diseases (i.e. anemia, malaria)
  - Critical care resources

de Caen *Circulation* 2015



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Case – waiting for transport

Ceftriaxone and Vancomycin ordered and given

Now 40 mL/kg crystalloid given

HR:158 BP: 80/40 RR: 22 Pulse Ox 91% RA

Alert, oriented, moaning about pain in arm

Capillary refill 3 seconds

An additional 20 mL/kg crystalloid given (60 mL/kg total)

HR 150 BP: 82/37 Repeat lactate: 1.8 mmol/L

Transport arrives

55

Case - Transport

HR 154 BP: 78/37 Pox=89% RA → 95% with 2L NC

Alert, capillary refill 3 seconds

Started on norepinephrine via antecubital PIV

HR: 150 BP: 90/45

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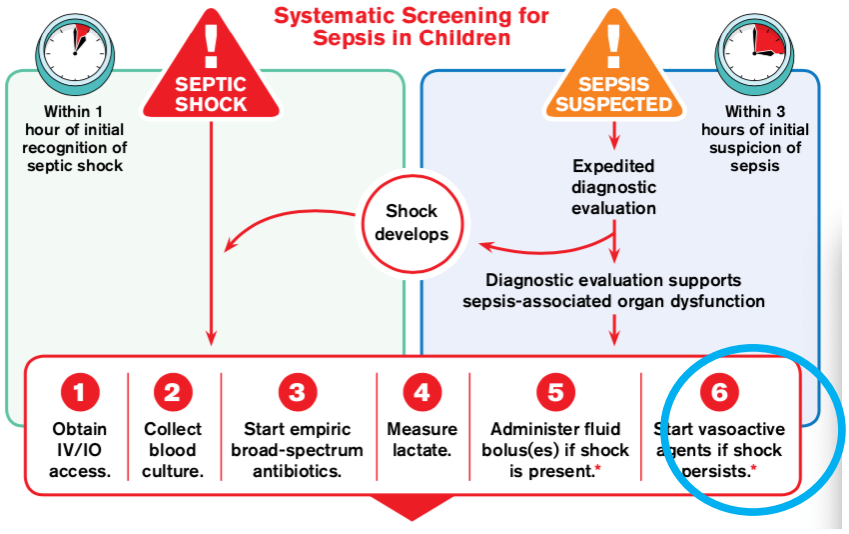
Initial Resuscitation Algorithm for Children

Surviving Sepsis Campaign



www.sccm.org/SurvivingSepsisCampaign/Guidelines/Pediatric-Patients

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Hemodynamic Monitoring

25. We suggest not using bedside clinical signs in isolation to categorize septic shock in children as "warm" or "cold" (weak recommendation, very low quality of evidence)

26. We suggest using advanced hemodynamic variables, when available, in addition to bedside clinical variables to guide the resuscitation of children with septic shock or other sepsis-associated organ dysfunction (weak recommendation, low quality of evidence)

    Remarks: Advanced hemodynamic monitoring may include cardiac output/cardiac index, systemic vascular resistance, or central venous oxygen saturation.

27. We suggest using trends in blood lactate levels, in addition to clinical assessment, to guide resuscitation of children with septic shock and other sepsis-associated organ dysfunction (weak recommendation, very low quality of evidence)

Weiss *PCCM* 2020

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Warm Shock, Cold Shock: Assessing the Hemodynamics of Sepsis

Cold shock
Vasoconstricted
Low Cardiac Output

Warm shock
Vasodilated
High Cardiac Output

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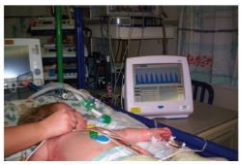
Hemodynamics of Pediatric Shock

Ceneviva, 1998: 50 PICU septic shock with PA catheters

	Percent	CI	SVR	Mortality
Cold	58%	Low	High	28%
Warm	20%	High	Low	10%
Mixed	22%	Low	Low	9%

Brierley, 2008: 30 PICU fluid-refractory septic shock, USCOM device

- Central line patients "warm shock"
- Community-acquired "cold shock"



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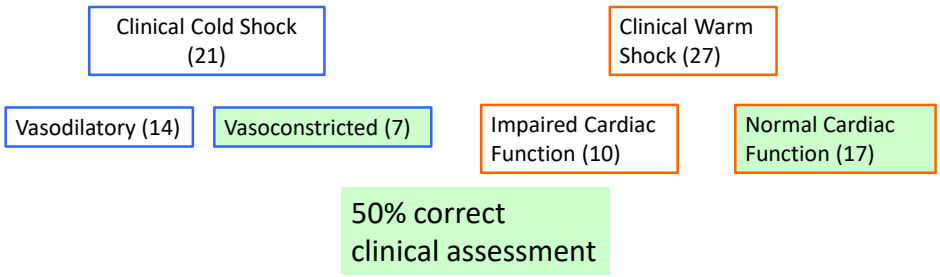

Ranjit *PCCM* 2014

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Serial Lactate Measurement

Lactate Clearance:

Decrease by ≥10%, or <2 mmol/L if initial level <2 mmol/L

Lactate Normalization:

Lactate < 2 mmol/L

Is Lactate Normalization/Clearance associated with decreased rates of prolonged acute organ dysfunction (>48 hours)?

77 children with acute organ dysfunction and infection in the ED with lactate measured

Scott *JPeds* 2015

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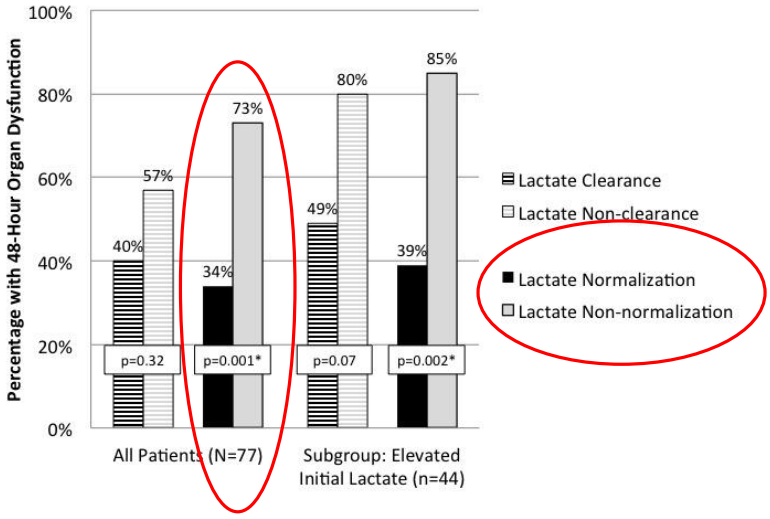

Scott *JPeds* 2015

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Vasoactive Medications

28. We suggest using epinephrine, rather than dopamine, in children with septic shock (weak recommendation, low quality of evidence)
29. We suggest using norepinephrine, rather than dopamine, in children with septic shock (weak recommendation, very low quality of evidence)
30. We were unable to issue a recommendation for a specific first-line vasoactive infusion for children with septic shock
31. We were unable to issue a recommendation about initiating vasoactive agents through peripheral access in children with septic shock.

Remarks: It is reasonable to begin vasoactive infusions after 40–60 mL/kg of fluid resuscitation if the patient continues to have evidence of abnormal perfusion. Either epinephrine or norepinephrine may be administered through a peripheral vein (or intraosseous, if in place) if central venous access is not readily accessible. Dopamine may be substituted as the first-line vasoactive infusion, administered either peripherally or centrally, if epinephrine or norepinephrine is not readily available.

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First-Line Vasoactive Agents (an ER guide)

	Inotropy	Systemic Vascular Resistance	BP	Use in Sepsis?
Norepinephrine (alpha > beta)	+	+++	↑	Most patients Premixed at all CHCO sites, more familiar in general ED's
Epinephrine (beta > alpha)	+++	+	↑	Younger Community-acquired gram positive Significant cardiogenic component
Dopamine (5-10 mcg/kg/min) Beta>alpha, dopa	++	++	↑	If desperate Problems: 'dirty drug' (variable effects at different doses), arrhythmogenic, HPA/immune effects (decreases GH, prolactin)
Vasopressin, milrinone, dobutamine… potentially useful, most sepsis should be in ICU by then…				

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First-Line Vasoactive Agents (an ER guide)

	Inotropy	Systemic Vascular Resistance	BP	Use in Sepsis?
Norer (alph				
Epin (bet				
Dop mcg, Beta>alpha, dopa				different doses), arrhythmogenic, HPA/immune effects (decreases GH, prolactin)
Vasopressin, milrinone, dobutamine… potentially useful, most sepsis should be in ICU by then…				

Fix hypotension

Don't make a dosing error

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Case – Arrival at Tertiary Hospital

HR 150 BP: 90/45 Pox= 95% with 2L NC

On norepinephrine via antecubital PIV

Alert, crying.

L shoulder decreased ROM, edema, redness. No crepitus. L third digit with crusted skin over PIP. Foot erythematous, red. L hand erythematous.

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Case – Hospital Course

To ICU:

Clinda given, IVIG x 2 (suspected toxin-mediated illness)

To OR for I&D - grew Group A Strep from murky synovial fluid, frank pus subdeltoid: pyomyositis, septic joint osteomyelitis

Multiple organ dysfunction

- Transaminases elevated, AKI – both resolved
- Norepi x 3 days
- Intubated x 2 days post op
- DIC/thrombocytopenia, transfused x 1

Rehab, discharged home

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Pediatric Sepsis

- Mortality: 7.5-25%
- Among survivors, 35% had not returned to baseline QOL by 1 year

- 5/1000 pediatric hospitalizations
- 8% prevalence in PICUs worldwide
- >75,000 pediatric US cases yearly

Hartman I2013; Balamuth *PCCM* 2014; Weiss *AJRCCM* 2015; Weiss *CCM* 2020; Zimmerman *CCM* 2020

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Standardized, Expedited Processes Save Lives in Pediatric Sepsis

Protocolized Treatment Is Associated With Decreased Organ Dysfunction in Pediatric Severe Sepsis*

Fran Balamuth, MD, PhD, MSCE[1,2]; Scott L. Weiss, MD, MSCE[3,4]; Julie C. Fitzgerald, MD, PhD[3,4]; Katie Hayes, B[S]; Jane Lavelle, M[...]

Resuscitation Bundle in Pediatric Shock Decreases Acute Kidney Injury and Improves Outcomes

Ayse Akcan Arikan, MD[1,2], Eric A. Williams, MD, MS[1], Jeanine M. Graf, MD[1], Curtis E. Kennedy, MD, PhD[1], Binita Patel, MD[3], and Andrea T. Cruz, MD, MPH[3,4]

Managing Diagnostic Uncertainty in Pediatric Sepsis Quality Improvement with a Two-Tiered Approach

Halden F. Scott, MD, MSCS†; Allison Kempe, MD, MPH*‡; Sara J. Deakyne Davies, MPH§; Paige Krack, MBA, MS¶; Jan Leonard, MSPH*†; Elise Rolison, RRT-NPS¶; Joan Mackenzie, MS, CPNP†; Beth Wathen, MSN, PNP‖; Lalit Bajaj, MD*†¶*

High Reliability Pediatric Septic Shock Quality Improvement Initiative and Decreasing Mortality

Roni D. Lane, MD,[a] Tomohiko Funai, MS,[b] Ron Reeder, PhD,[b] Gitte Y. Larsen, MD, MPH[b]

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The Bundle is Greater than the Sum of its Parts

JAMA | Original Investigation

Association Between the New York Sepsis Care Mandate and In-Hospital Mortality for Pediatric Sepsis

Idris V. R. Evans, MD, MSc; Gary S. Phillips, MAS; Elizabeth R. Alpern, MD, MSCE; Derek C. Angus, MD, MPH; Marcus E. Friedrich, MD; Niranjan Kissoon, MD; Stanley Lemeshow, PhD; Mitchell M. Levy, MD; Margaret M. Parker, MD; Kathleen M. Terry, PhD; R. Scott Watson, MD, MPH; Scott L. Weiss, MD, MSCE; Jerry Zimmerman, MD, PhD; Christopher W. Seymour, MD, MSc

Figure 2. Risk-Adjusted Odds Ratios of In-Hospital Death in the Primary Models

Model	Total Deaths/Total No. (%) Completed Within 1 h	Total Deaths/Total No. (%) Not Completed Within 1 h	Risk-Adjusted In-Hospital Mortality, % (95% CI) Completed Within 1 h	Risk-Adjusted In-Hospital Mortality, % (95% CI) Not Completed Within 1 h	Risk Difference From Adjusted Model, % (95% CI)	Adjusted Odds Ratio for In-Hospital Mortality (95% CI)
Completion of the entire 1 h bundle within 1 h	22/294 (7.5)	17/885 (13.2)	8.7 (5.4-12.0)	12.7 (10.5-14.7)	4.0 (0.9 to 7.0)	0.59 (0.38-0.93)
Antibiotics administered within 1 h	89/798 (11.2)	50/381 (13.1)	11.1 (9.1-13.1)	13.2 (9.7-16.6)	2.1 (-1.1 to 5.2)	0.78 (0.55-1.12)
Blood cultures prior to antibiotics completed within 1 h	71/740 (9.6)	68/439 (15.5)	10.7 (8.3-13.0)	13.3 (10.5-16.0)	2.6 (-0.5 to 5.7)	0.73 (0.51-1.06)
Intravenous fluid bolus completed within 1 h	59/548 (10.8)	80/631 (12.7)	11.2 (8.3-14.1)	12.3 (9.6-15.0)	1.1 (-2.6 to 4.8)	0.88 (0.56-1.37)

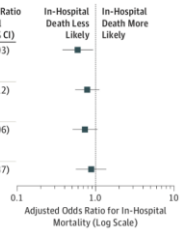
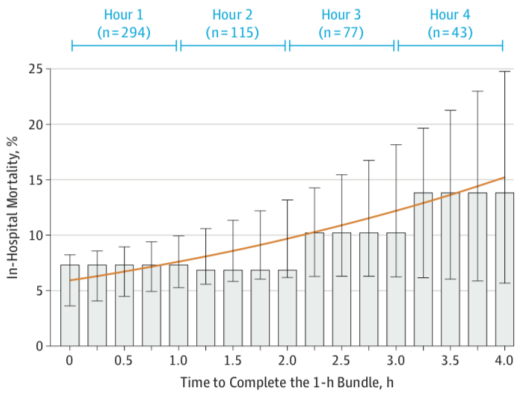


Figure 3. Crude In-Hospital Mortality and Predicted Risk of In-Hospital Death After the Time of Sepsis Protocol Initiation



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Managing Diagnostic Uncertainty in Pediatric Sepsis Quality Improvement with a Two-Tiered Approach

Halden F. Scott, MD, MSCS†; Allison Kempe, MD, MPH*‡; Sara J. Deakyne Davies, MPH§; Paige Krack, MBA, MS¶; Jan Leonard, MSPH*†; Elise Rolison, RRT-NPS¶; Joan Mackenzie, MS, CPNP†; Beth Wathen, MSN, PNP‖; Lalit Bajaj, MD*†¶*

1. High-quality, timely critical care to severe sepsis

Sepsis STAT Criteria:
Fever/suspected infection
and any of the following:

- Hypotension
- Altered mentation
- New need for positive pressure ventilation
- Lactate greater or equal to 4 mmol/L
- Acute kidney injury
- New coagulopathy
- New liver dysfunction
- Acute need for resuscitation room

In indeterminate patients

1. Expedite early evaluation and necessary treatment
2. Allow flexibility, promote stewardship

Sepsis Yellow Criteria:
Fever/suspected infection
and any of the following:

- Immunosuppression/immunocompromise (e.g. oncology patients, organ transplant patients, patients on immunomodulators)
- Central venous catheter
- Clinically concerning symptoms: changes to capillary refill, peripheral pulse quality, concerning rashes, orthostasis

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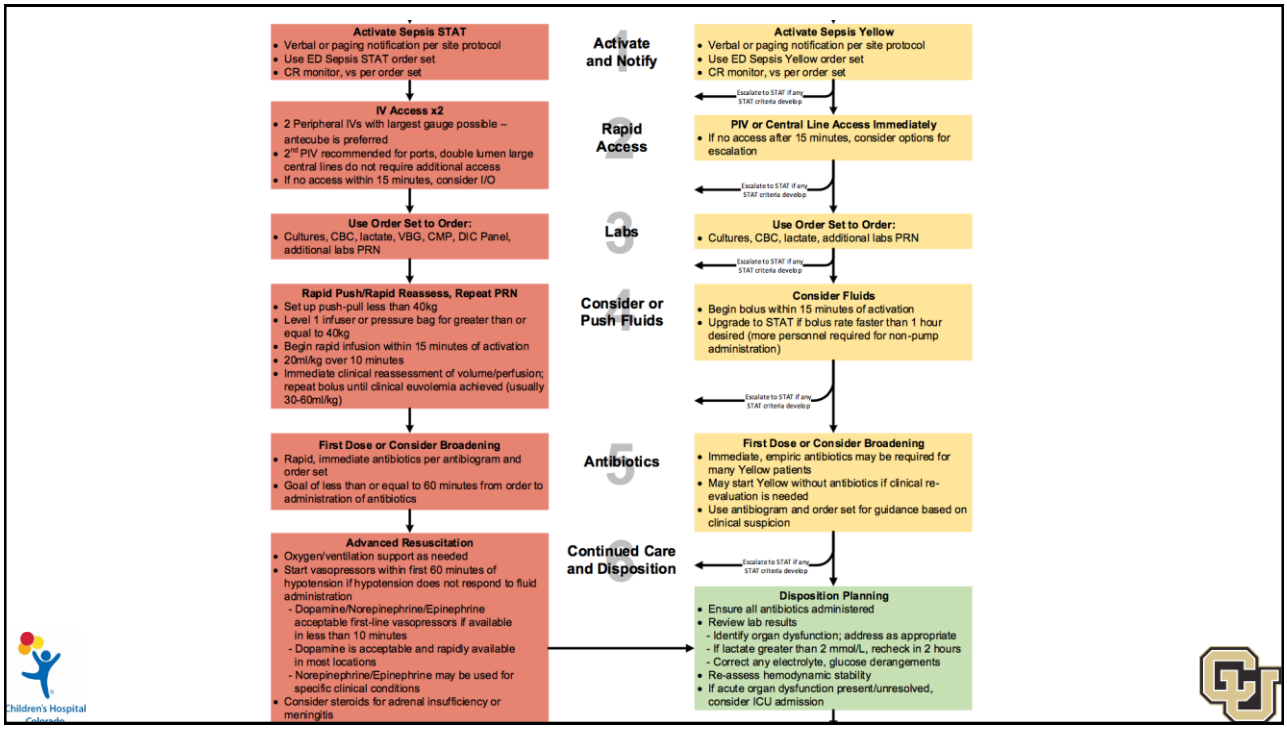

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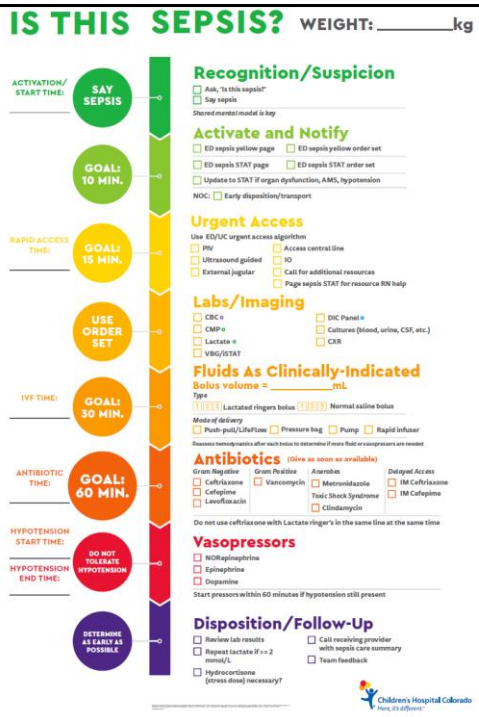

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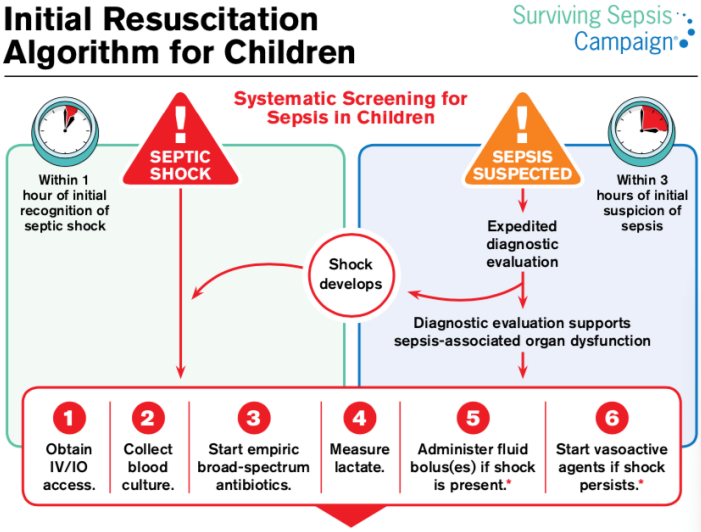

Questions?

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