Pediatric Shock

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NATIONWIDE CHILDREN'S
When your child needs a hospital, everything matters.℠

Objectives

- Define shock and understand pediatric shock physiology
- Recognize signs and symptoms of shock in children
- Discuss initial management in the ED based on shock phenotype

Definition


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Definition

"… life-threatening condition of circulatory failure, causing inadequate oxygen delivery to meet cellular metabolic needs and oxygen requirements, producing cellular and tissue hypoxia."

Stages of Shock

- Compensated
- Hypotensive
- Irreversible

Stages of Shock

- Compensated: Vital organ function maintained, HR elevated, BP wnl
- Hypotensive
- Irreversible

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Stages of Shock

- Compensated: Vital organ function maintained, HR elevated, BP wnl
- Hypotensive: Signs/Sx of organ dysfunction, low BP
- Irreversible: Progressive organ damage, high morbidity/mortality

Pathophysiology

What determines oxygen delivery to tissues?

- Cardiac output
- Oxygen content of blood
- Balance between blood flow and metabolic demand

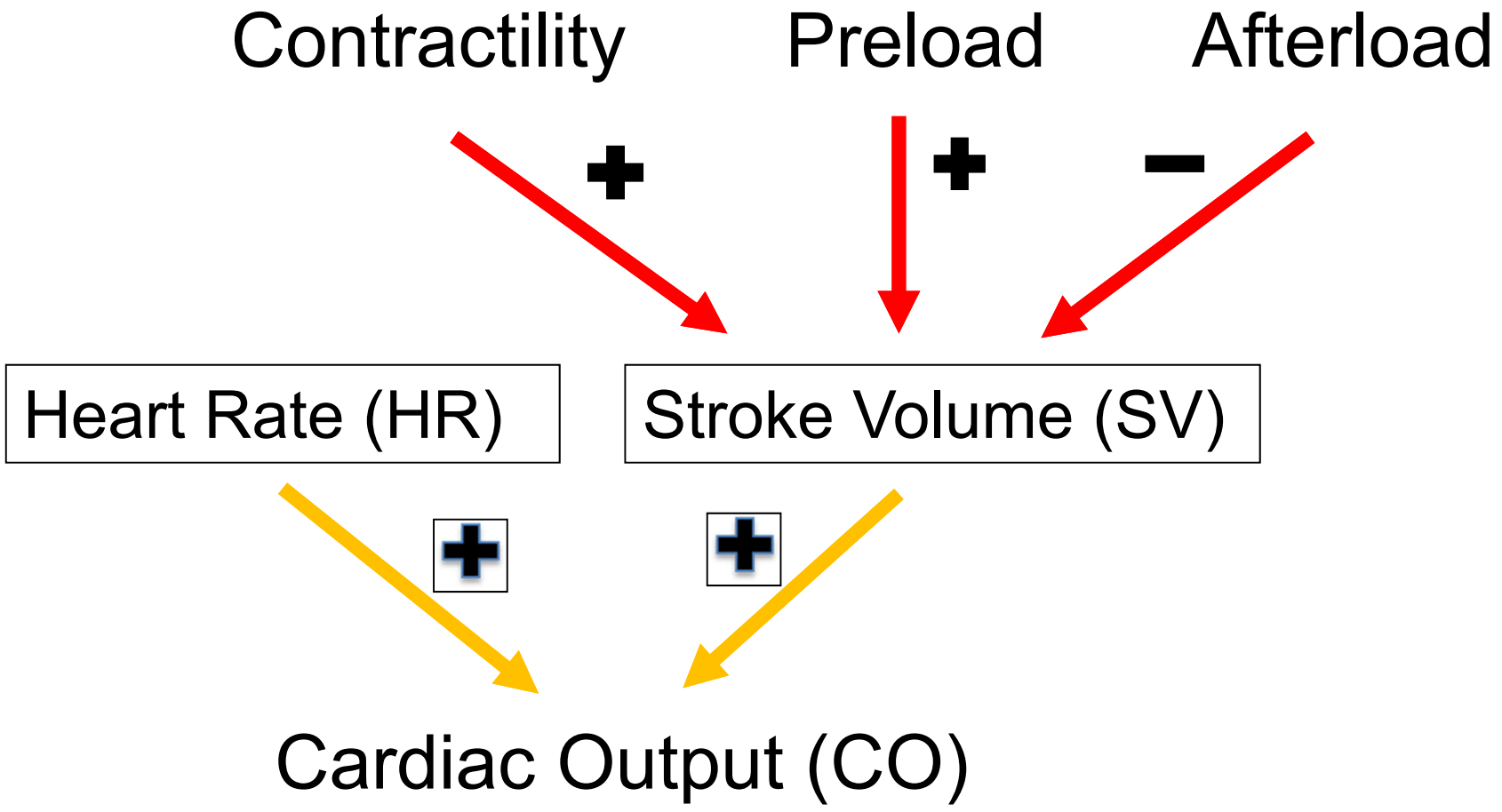
What determines oxygen delivery to tissues?

- Cardiac output = SV x HR

- Oxygen content of blood (CaO2) =

[1.34 x Hgb x SaO2) + (0.003 x PaO2)

- Balance between blood flow and metabolic demand … depends


Contractility
Preload
Afterload
+
+
−
Heart Rate (HR)
Stroke Volume (SV)
+
+
Cardiac Output (CO)

Differences

- Fluid status
  - Increased TBW
  - Increased ECF
  - Larger surface area
  - "Leaky skin"

➢ Increased risk of fluid losses

Differences

- Cardiac
  - Immature sarcoplasmic reticulum
  - Stiffer myocardium
  - Limited ability to increased HR
  - Increased parasympathetic tone

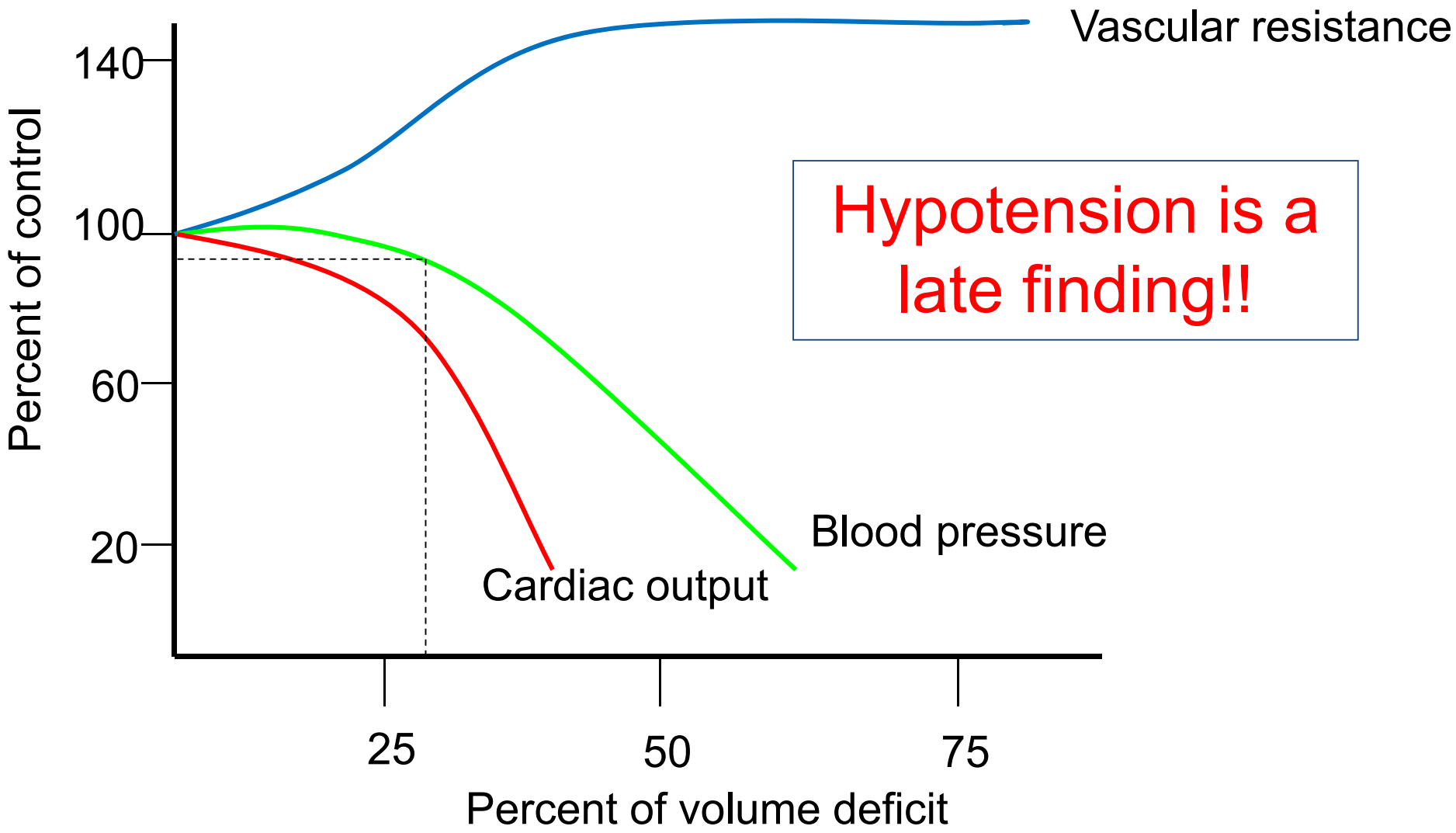
  ➢ Limited cardiac reserve

Differences

- Systemic vascular resistance (SVR)
  - Main mechanism for increasing BP
  - Significant circulating volume loss => hypotension

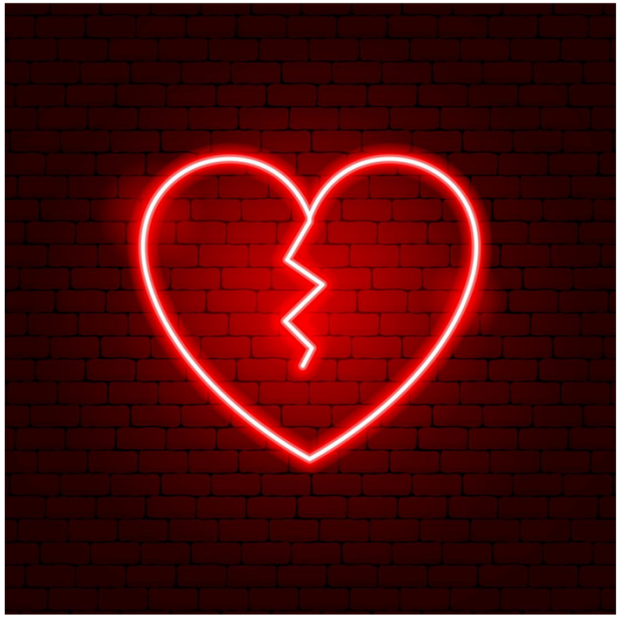
➢ Initially helpful, later can be problematic…

SVR and BP in shock



	Cold Shock	Warm Shock
Heart rate	Tachycardia	Tachycardia
Peripheries	Cool	Warm
Pulses	Difficult to palpate	Bounding
Skin	Mottled, pale	Flushed
Capillary refill	Prolonged	Blushing
Mental state	Altered	Altered
Urine	Oliguria	Oliguria

Classification



Shock Phenotypes

- Hypovolemic
  - ✓ Blood loss, dehydration, sepsis
- Cardiogenic
  - ✓ MI, CHD, arrhythmia, cardiomyopathies
- Distributive
  - ✓ Neurologic injuries, anaphylaxis, sepsis
- Obstructive (extracardiac)
  - ✓ PE, tension PTX, cardiac tamponade, critical aortic stenosis

Categories of Shock

1. **Cardiogenic Shock**
Acute Coronary Syndrome/Ischemia, Myocarditis, Congenital Heart Disease, Toxins, SEPSIS?
(Impaired Contractility)

2. **Hypovolemic**
Hemorrhagic, Dehydration, sepsis

(Decreased Preload)

3. **Obstructive Shock**
Pulmonary Embolism, Tension Pneumothorax, Cardiac Tamponade

(Preload-"Obstruction" of Venous Return)

4. **Distributive**

Heart Rate: Sepsis, Adrenal Insufficiency, Liver failure, Anaphylaxis

Heart Rate: Neurogenic

(Decreased Systemic Vascular Resistance=Vasodilation)

Frank Lodeserto MD, "Approach to the Critically Ill Child: Shock", REBEL EM blog, October 15, 2018. Available at: https://rebelem.com/approach-to-the-critically-ill-child-shock/.

A word on septic shock…

A word on septic shock…

Initial Evaluation and Management

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Signs and Symptoms (Early)

- Tachycardia
- Mild changes to peripheral perfusion
- Acting different

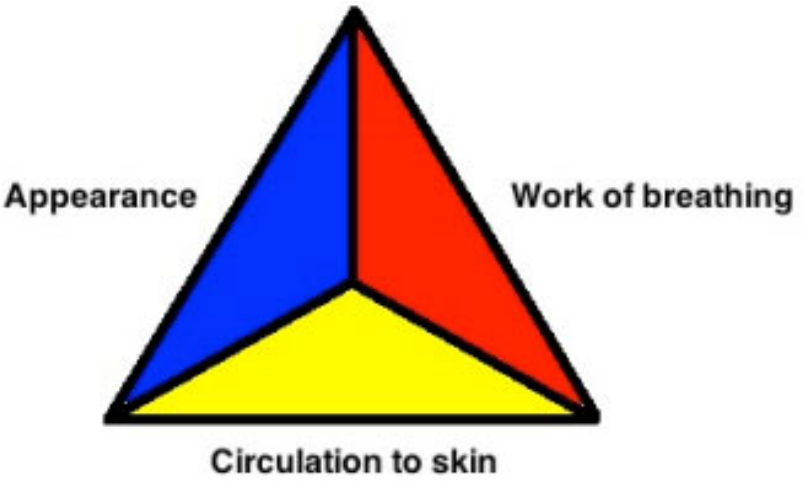
  => mildly fussy, more tired
- Normal BP

Signs and Symptoms (Late)

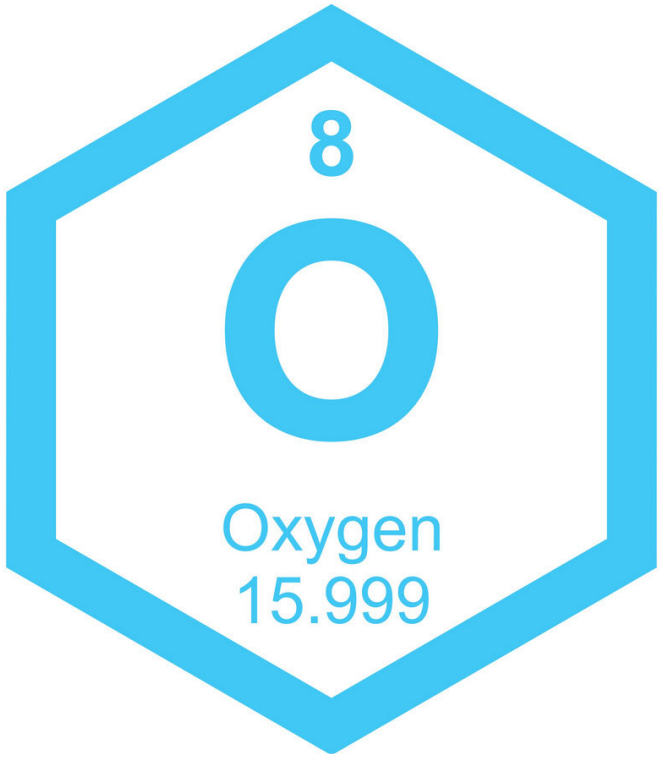
- Persistent tachyardia/bradycardia
- Pronounced changes to cap refill
- Altered mental status
- Irregular breathing pattern
- Hypotension

General Management

General Management



General Management



General Management

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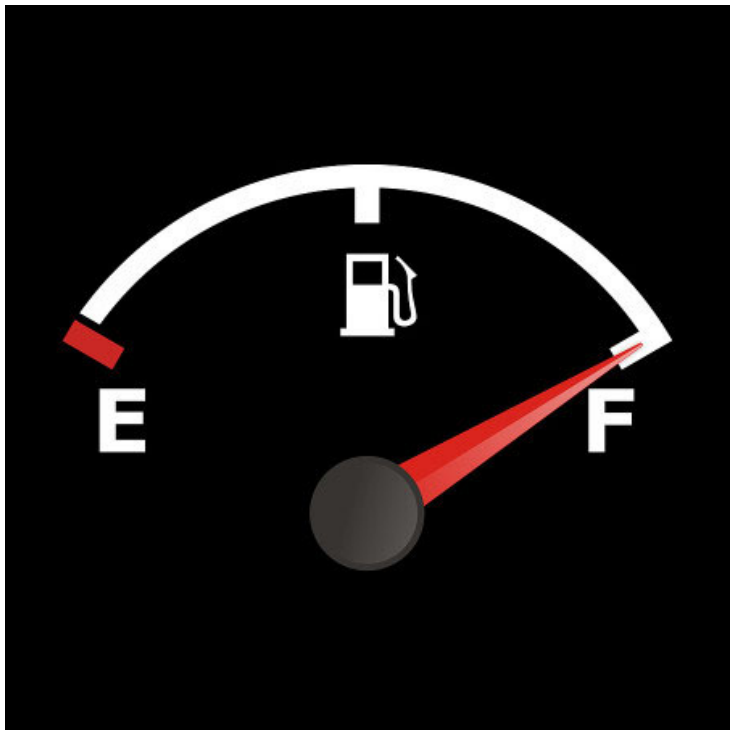
General Management

Hypovolemic Shock

- Most common form
-  circulating blood volume
- History is key
- Clinical signs
- Crystalloid => blood (in trauma)
- Replace ongoing losses
- Treat underlying cause (if possible)


E
F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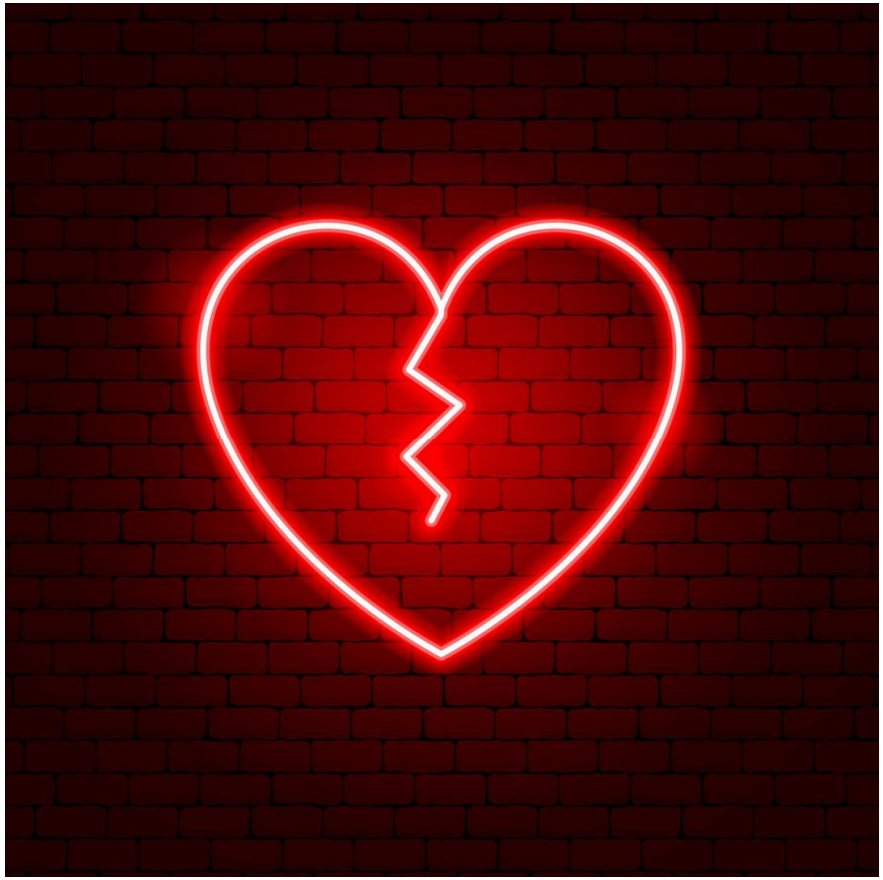
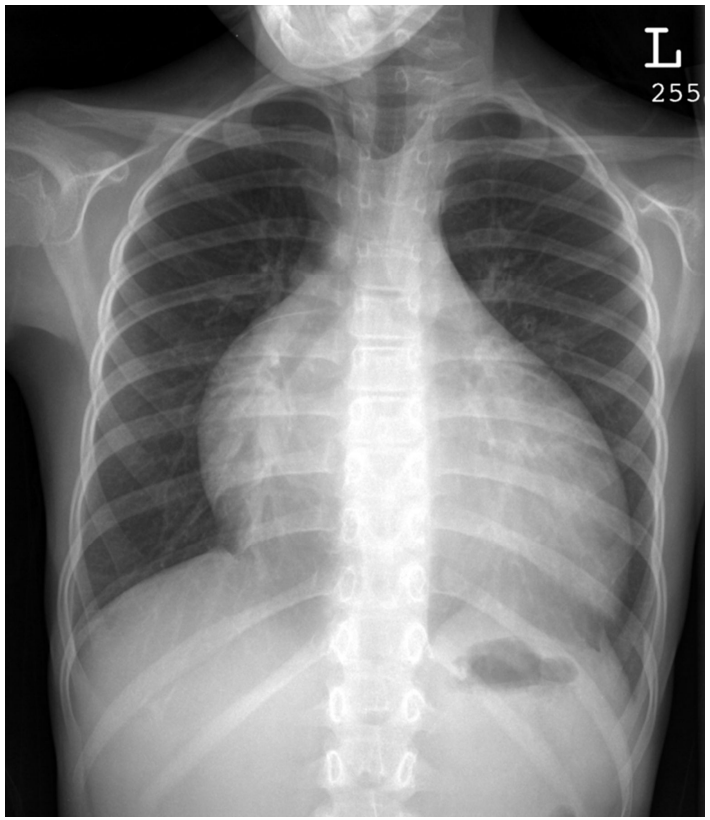
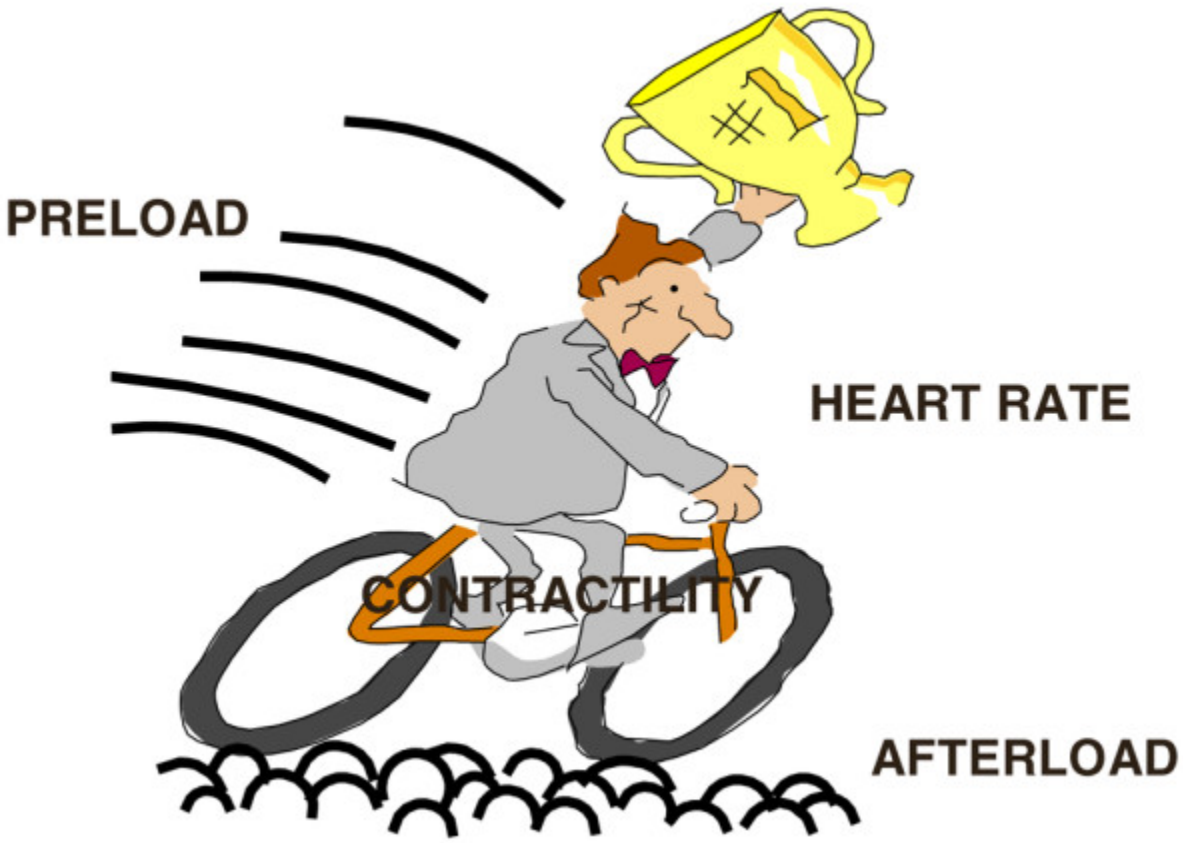


Cardiogenic Shock

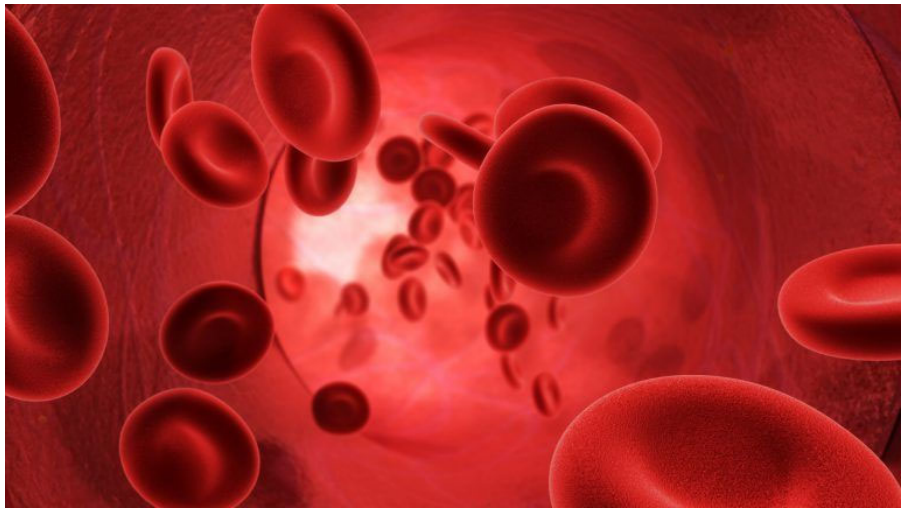
- Hx and exam are key
- CXR
- Correct dysrhythmias
- Oxygen is ok
- Judicious resuscitation




PRELOAD
HEART RATE
CONTRACTILITY
AFTERLOAD

Distributive Shock

- Hx and PE
- Hypotension more common
- Abnormal vascular tone
- Functional hypovolemia

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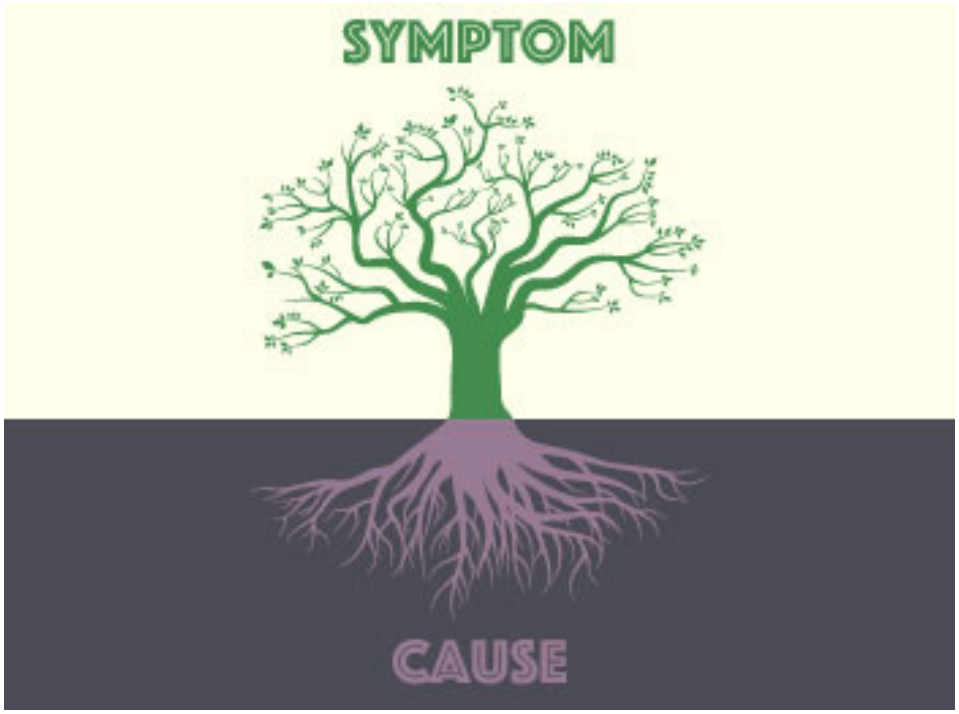
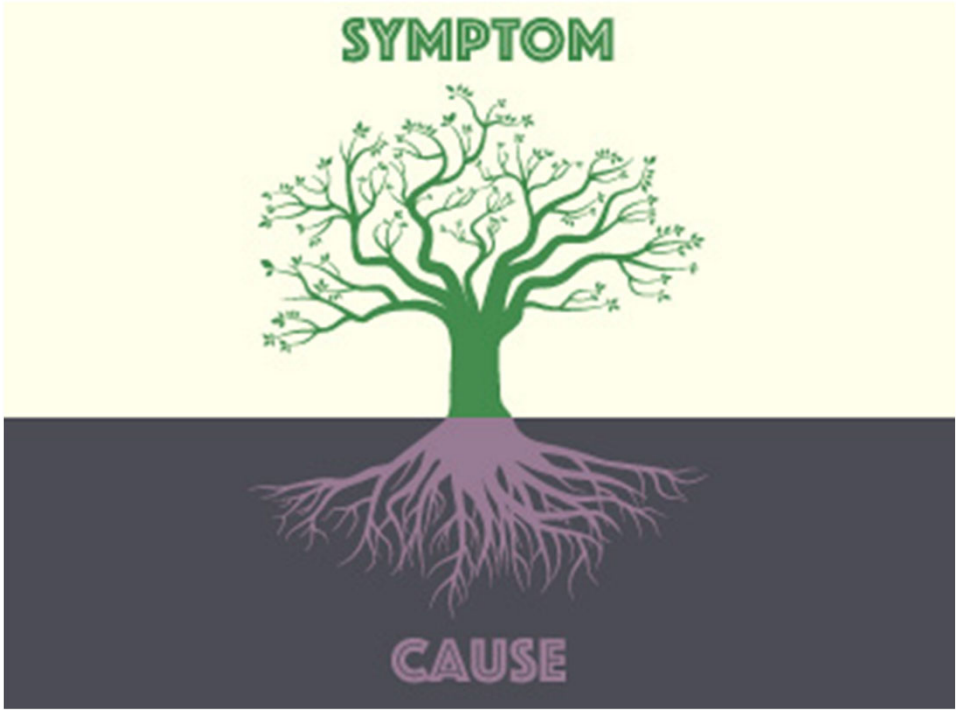

SYMPTOM
CAUSE

Obstructive Shock

- Mechanical obstruction to blood flow
- PE, tamponade, critical AS
- Prostins if indicated
- RARE in kids

Obstructive Shock

- Mechanical obstruction to blood flow
- PE, tamponade, CHD
- RARE in kids



Septic Shock

- Fever or hypothermia
- Tachycardia and tachypnea
- Peripheral pulses diminished or bounding
- Cap refill prolonged or instantaneous
- High or low WBC
- Increased lactate or other evidence of decreased organ perfusion


RECOGNITION

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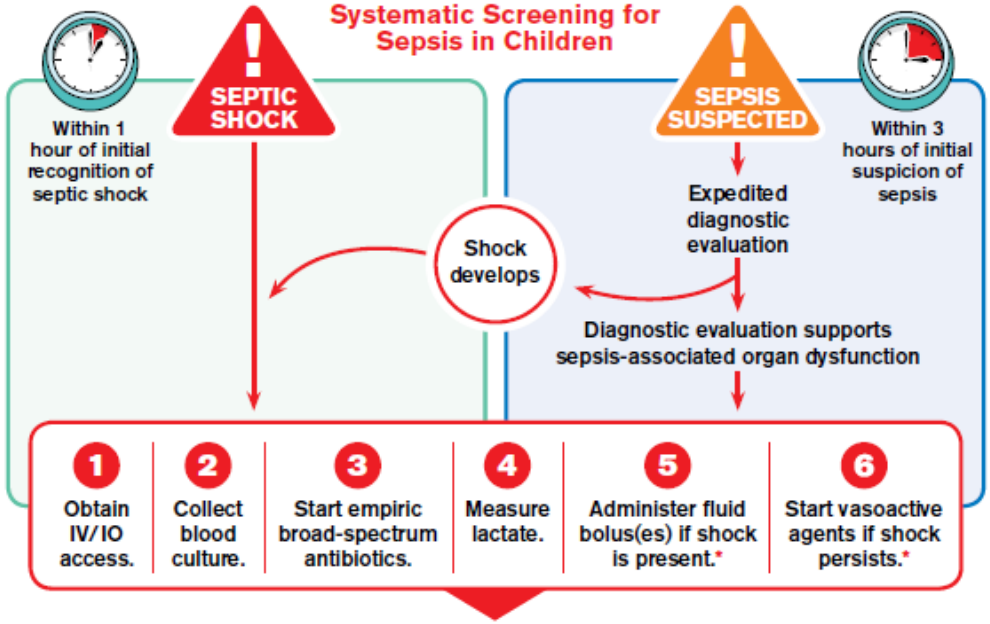
ONLINE SPECIAL ARTICLE

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

Weiss, Scott L. MD, MSCE, FCCM (Co-Vice Chair)[1]; Peters, Mark J. MD, PhD (Co-Vice Chair)[2]; Alhazzani, Waleed MD, MSc, FRCPC (Methodology Chair)[3]; Agus, Michael S. D. MD, FCCM, FAAP[4]; Flori, Heidi R. MD, FAAP[5]; Inwald, David P. MB, BChir, FRCPCH, FFICM, PhD[6]; Nadel, Simon MBBS, MRCP, FRCP[6]; Schlapbach, Luregn J. FCICM, FMH-ICU, FMH-Paeds, FMH-Neonatology[7]; Tasker, Robert C. MB BS, MA, AM, MD, FRCPHC, FRCP[4]; Argent, Andrew C. MB BCh, MMed, MD (Paediatrics)[8]; Brierley, Joe MD, MA[9]; Carcillo, Joseph MD[10]; Carrol, Enitan D. MB ChB, MD, FRCPCH, DTMH[11]; Carroll, Christopher L. MD, MS, FCCM, FAAP[12]; Cheifetz, Ira M. MD, FCCM[13]; Choong, Karen MB, BCh, FRCP(C) (methodologist)[3]; Cies, Jeffry J. PharmD, MPH, BCPS-AQ ID, BCPPS, FCCP, FCCM, FPPAG[14]; Cruz, Andrea T. MD, MPH, FAAP[15]; De Luca, Daniele MD, PhD[16,17]; Deep, Akash MB BS, MD, FRCPCH[18]; Faust, Saul N. MA, MB BS, FRCPCH, PhD, FHEA[19]; De Oliveira, Claudio Flauzino MD, PhD[20]; Hall, Mark W. MD, FCCM, FAAP[21]; Ishimine, Paul MD, FACEP, FAAP[22]; Javouhey, Etienne MD, PhD[23]; Joosten, Koen F. M. MD, PhD[24]; Joshi, Poonam PhD[25]; Karam, Oliver MD, PhD[26]; Kneyber, Martin C. J. MD, PhD, FCCM[27]; Lemson, Joris MD, PhD[28]; MacLaren, Graeme MD, MSc, FCCM[29]; Mehta, Nilesh M. MD[4]; Møller, Morten Hylander MD, PhD[30]; Newth, Christopher J. L. MD, ChB, FRCPC, FRACP[31]; Nguyen, Trung C. MD, FAAP[15]; Nishisaki, Akira MD, MSCE, FAAP[1]; Nunnally, Mark E. MD, FCCM (methodologist)[32]; Parker, Margaret M. MD, MCCM, FAAP[33]; Paul, Raina M. MD, FAAP[34]; Randolph, Adrienne G. MD, MS, FCCM, FAAP[4]; Ranjit, Suchitra MD, FCCM[35]; Romer, Lewis H. MD[36]; Scott, Halden F.

Initial Resuscitation Algorithm for Children

Surviving Sepsis Campaign



Respiratory support

Assess for Pediatric Acute Respiratory Distress Syndrome

Infectious source control — Continuous reassessment — Fluid and vasoactive titration*

Advanced hemodynamic monitoring if shock persists

- +/- hydrocortisone for refractory shock**
- Nutritional support
- Avoid hypoglycemia
- Antimicrobial stewardship

VA or VV ECLS for refractory shock or oxygenation/ventilation failure (after addressing other causes of shock and respiratory failure)

*See fluid and vasoactive algorithm. Note: Fluid bolus should be omitted from bundle if a) fluid overload is present or b) it is a low-resource setting without hypotension. Fluid in mL/kg should be dosed as ideal body weight.

**Hydrocortisone may produce benefit or harm.

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

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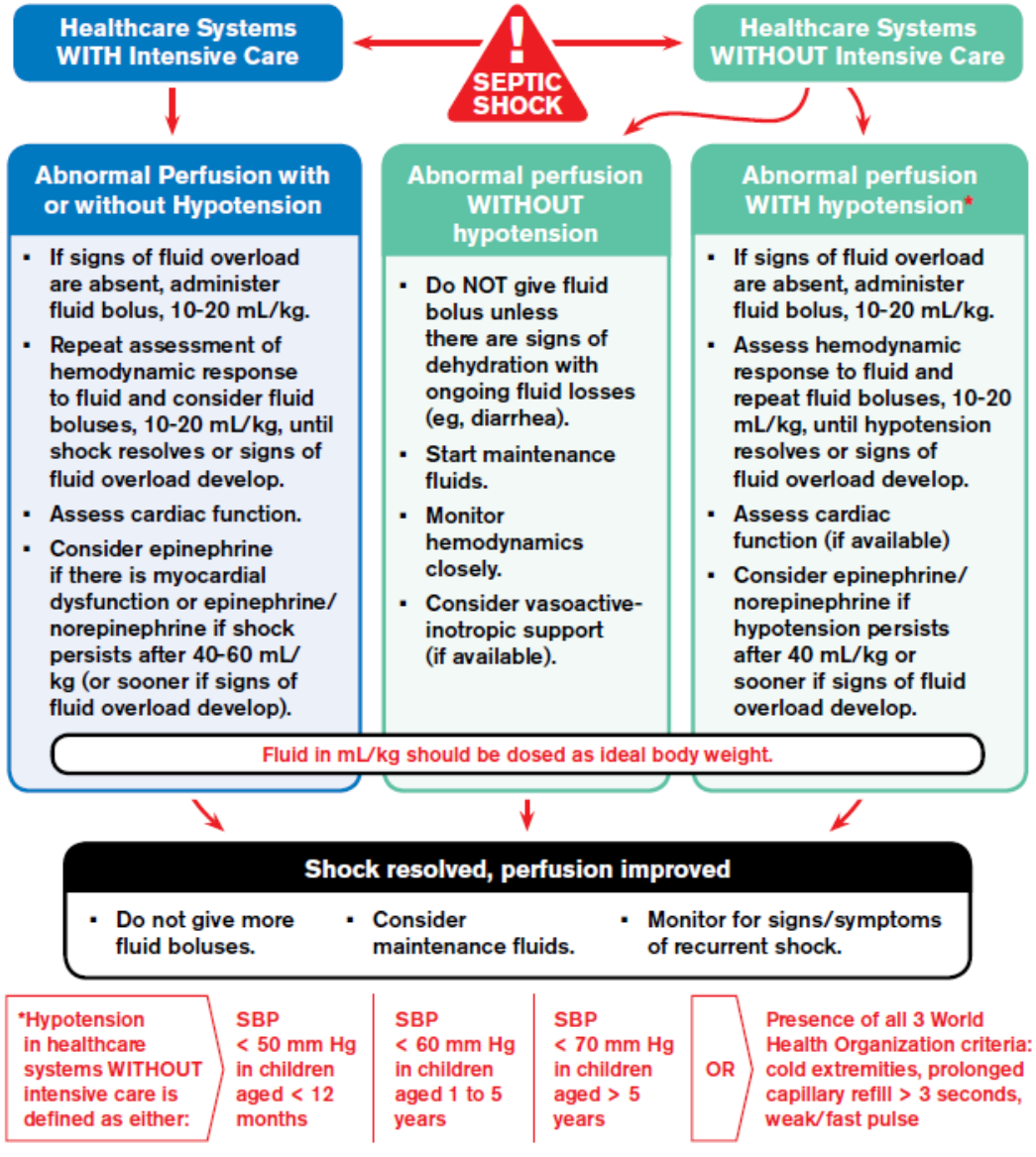
Fluid and Vasoactive-Inotrope Management Algorithm For Children

Surviving Sepsis Campaign



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

Take Home Points

- Kids compensate well until they don’t
- Hypotension is a late sign
- Early recognition is key
- Septic shock can look like anything
- New sepsis guidelines 2020

References

- Frank Lodeserto MD, "Approach to the Critically Ill Child: Shock", REBEL EM blog, October 15, 2018. Available at: https://rebelem.com/approach-to-the-critically-ill-child-shock/. Accessed September 5, 2020.
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Recognition of Shock Flowchart

	Clinical Signs	Hypovolemic Shock	Distributive Shock	Cardiogenic Shock	Obstructive Shock
A	Patency	Airway open and maintainable/not maintainable			
B	Respiratory rate	Increased			
	Respiratory effort	Normal to increased		Labored	
	Breath sounds	Normal	Normal (± crackles)	Crackles, grunting	
C	Systolic blood pressure	**Compensated Shock → Hypotensive Shock**			
	Pulse pressure	Narrow	Variable	Narrow	
	Heart rate	Increased			
	Peripheral pulse quality	Weak	Bounding or weak	Weak	
	Skin	Pale, cool	Warm or cool	Pale, cool	
	Capillary refill	Delayed	Variable	Delayed	
	Urine output	Decreased			
D	Level of consciousness	Irritable early Lethargic late			
E	Temperature	Variable			

Management of Shock Flowchart

Management of Shock Flowchart

- Oxygen
- Pulse oximetry
- ECG monitor
- IV/IO access
- BLS as indicated
- Point-of-care glucose testing

Hypovolemic Shock
Specific Management for Selected Conditions

Nonhemorrhagic	Hemorrhagic
• 20 mL/kg NS/LR bolus, repeat as needed • Consider colloid	• Control external bleeding • 20 mL/kg NS/LR bolus, repeat 2 or 3x as needed • Transfuse PRBCs as indicated

Distributive Shock
Specific Management for Selected Conditions

Septic	Anaphylactic	Neurogenic
Management Algorithm: • Septic Shock	• IM epinephrine (or autoinjector) • Fluid boluses (20 mL/kg NS/LR) • Albuterol • Antihistamines, corticosteroids • Epinephrine infusion	• 20 mL/kg NS/LR bolus, repeat PRN • Vasopressor

Cardiogenic Shock
Specific Management for Selected Conditions

Bradyarrhythmia/Tachyarrhythmia	Other (eg, CHD, Myocarditis, Cardiomyopathy, Poisoning)
Management Algorithms: • Bradycardia • Tachycardia With Poor Perfusion	• 5 to 10 mL/kg NS/LR bolus, repeat PRN • Vasoactive infusion • Consider expert consultation

Obstructive Shock
Specific Management for Selected Conditions

Ductal-Dependent (LV Outflow Obstruction)	Tension Pneumothorax	Cardiac Tamponade	Pulmonary Embolism
• Prostaglandin E_1 • Expert consultation	• Needle decompression • Tube thoracostomy	• Pericardiocentesis • 20 mL/kg NS/LR bolus	• 20 mL/kg NS/LR bolus, repeat PRN • Consider thrombolytics, anticoagulants • Expert consultation