Clinical Pearls for the Crashing Pediatric Patient

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Objectives:

1. Define clinical manifestations of early shock in the pediatric patient.
2. Recognize new trends in pediatric resuscitation.
3. Discuss the new changes made to the pediatric resuscitation guidelines.

Definition

Shock develops when systemic oxygen and nutrient supply become **inadequate** to meet the metabolic demands of the body's organ systems.

- Compensated shock
- Decompensated shock
- Irreversible shock

Pediatric Shock

1) Distributive
    - **e. Septic**
        - i. Antibiotics, IVF
    - f. Anaphylactic
        - i. "Home-remedies"
        - ii. Formula
    - g. Neurogenic
        - i. Seizure
        - **ii. (Non-accidental) Trauma**
2) **Cardiogenic**
    - e. Heart lesion
        - i. Obstructive
        - ii. Cyanotic
            1. Hyperoxia test
        - iii. Prostaglandin
    - f. Anomalous coronary artery
        - i. EKG
    - g. Supraventricular tachycardia (SVT)

3) **Hypovolemic**
    e. Blood loss
        i. 10 ml/kg PRBC
    f. Fluid loss
        i. 10-20 ml/kg normal saline bolus
4) **Obstructive**
    e. Malrotation with volvulus
    f. Diaphragmatic hernia
    g. Necrotizing enterocolitis
5) Endocrine/ metabolic
    e. Congenital adrenal hyperplasia (CAH)
        i. Low sodium, high potassium
        ii. Hydrocortisone
    f. **Glucose**!!!
        i. Rule of 50
    g. Inborn error or metabolism
        i. Glucose
        ii. Lactate
        iii. Ammonia
        iv. Ketonuria

- T – trauma, non-accidental trauma
- H – heart disease, hypovolemia, hypoxia
- E – endocrine (CAH, thyrotoxicosis)
- M – metabolic
- I – inborn errors of metabolism
- S – sepsis
- F – formula (dilution or concentration)
- I – intestinal catastrophies
- T – toxins
- S - seizures

Pediatric shock: early recognition and management

a. Airway
    i. Cuffed tubes okay!
    ii. ETT size: (Age/4) + 4, decrease by ½ size if using cuffed

Anatomy

	Infant	***Adult***
Tongue	Relatively large, intraoral	Normal
Epiglottis	Floppy, anterior, cephalad	Firm
Vocal cord angle	Inclined	Flat
Glottis	C3 level	C5-C6 level
Cricothyroid Membrane	Small, narrowest point	Normal
Trachea	Small, short, collapsible	Large, stationary

b. Breathing
    i. Measure RR over 30 seconds
    ii. Increase temp by 1˚C = increase RR by 2-5

Age adjusted rates

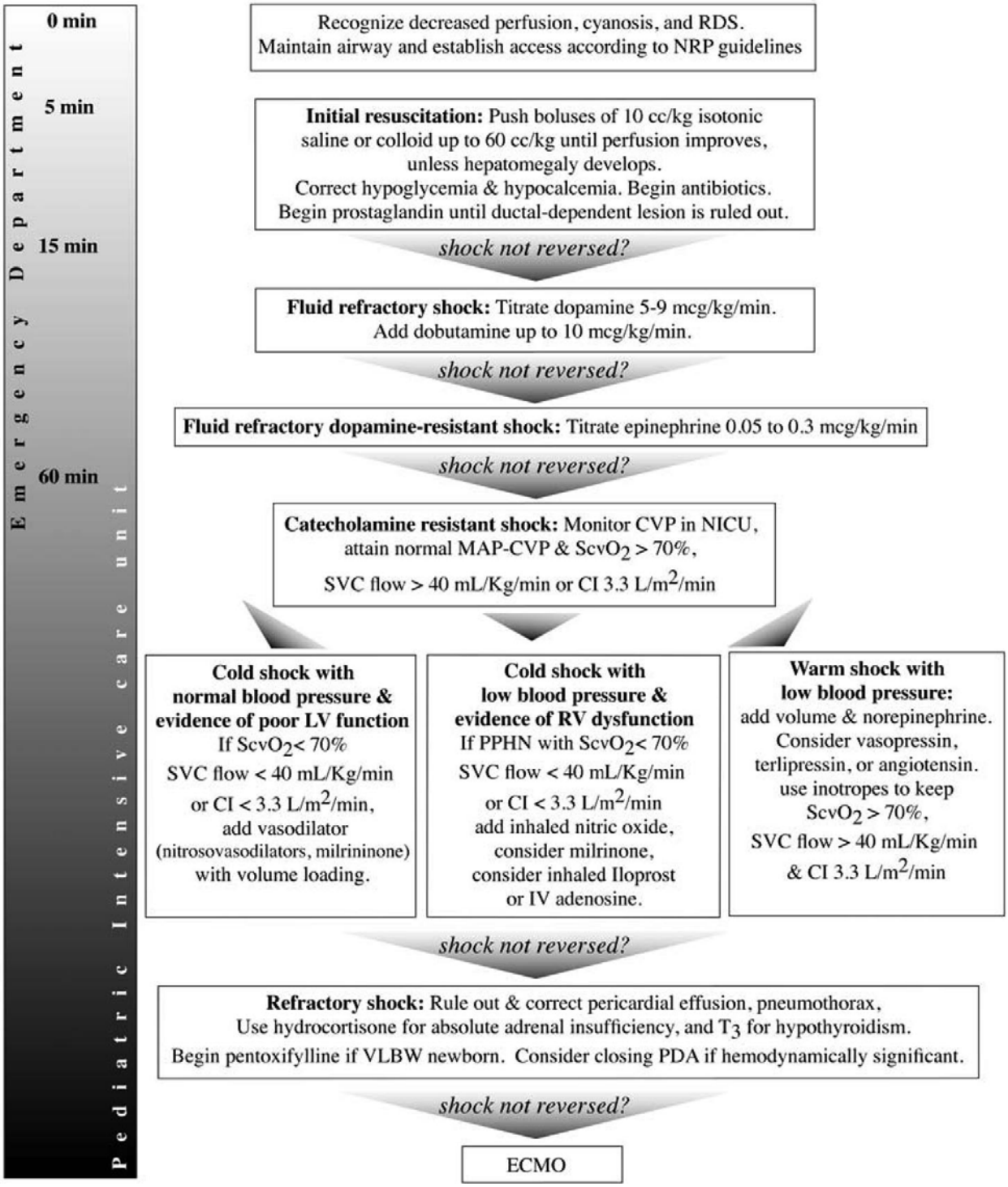
Age	***RR***	
Infant	30-60	< 60
Toddler	24-40	
Preschooler	22-34	
School-aged	18-30	< 30
Adolescent	12-16	< 15

c. Circulation
    v. (Age x 2) +90 = median 50% percentile for SBP
    vi. Early use of intraosseous access
    vii. NS bolus (20 ml/kg) EXCEPT neonates or congenital cardiac (10 ml/kg)
    viii. PRBC/ FFP 10 ml/kg (5 ml/kg in neonates)

d. **Dextrose**!!! All ill-appearing infants are hypoglycemic until proved otherwise!
    i. Rule of 50-100
        1. D_{10} 5-10 ml/kg (age < 1 year)
        2. D_{25} 2-4 ml/kg (age 1 – 8 year)
        3. D_{50} 1-2 ml/kg (age > 8 year)

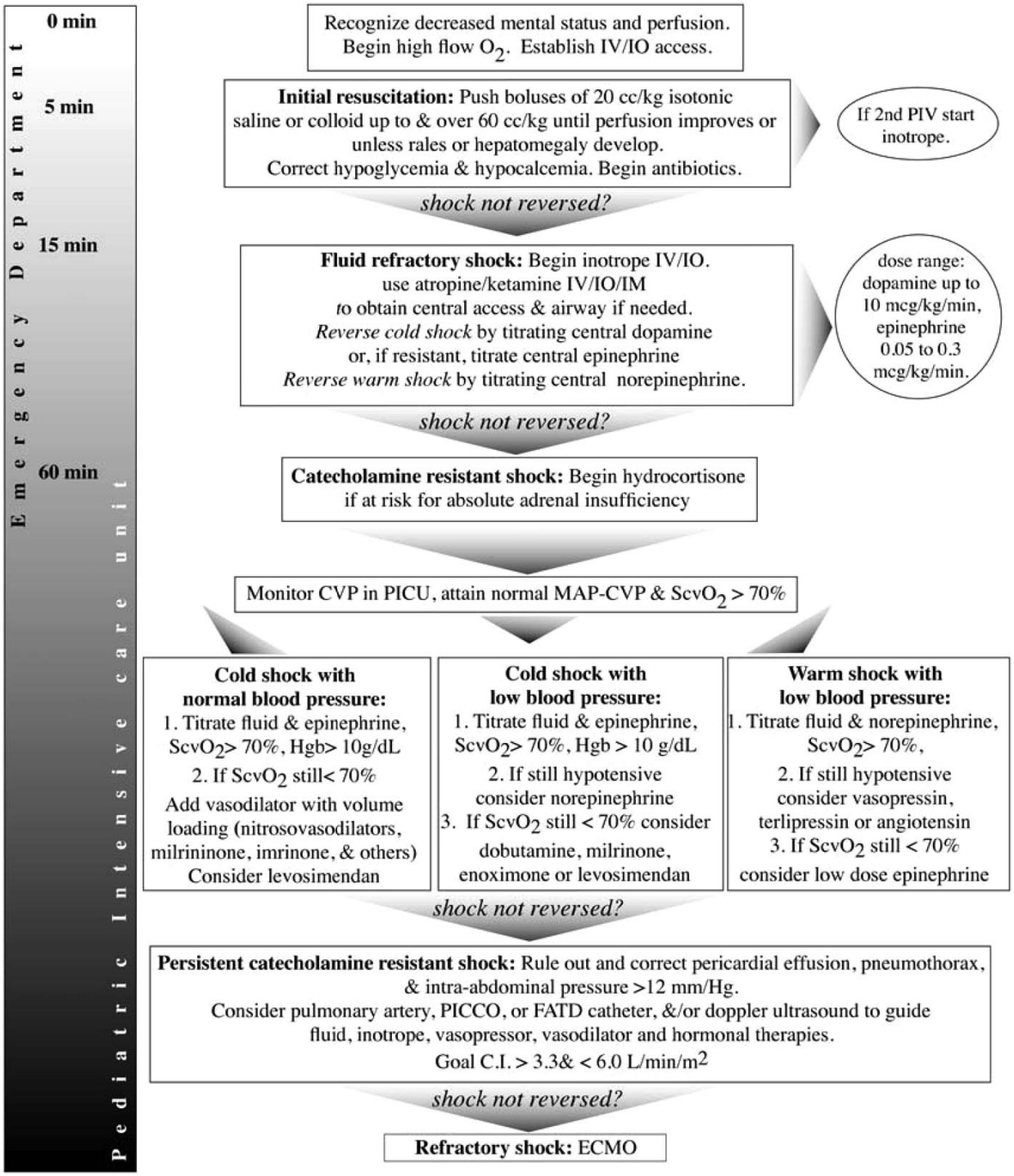
e. Vital signs
    i. Always measure in kilograms!!!

Newborns



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 Feb;37(2):666-88.

Infants and Children



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SIRS: Age-specific vital signs and laboratory values

Age group	Tachycardia	Bradycardia	Respiratory rate	WBC x $10^3/mm^3$	Systolic BP mmHg
Newborn	>180	<100	>50	>34	<65
Neonate	>180	<100	>40	>19.5 or <5	<75
Infant	>180	<90	>34	>17.5 or <5	<100
Toddler	>140	-	>22	>15.5 or <6	<94
Child	>130	-	>18	>13.5 or <4.5	<105
Adolescent	>110	-	>14	>11 or <4.5	<117

Table 3. International pediatric sepsis consensus conference: definitions for sepsis and organ dysfunction in pediatrics. Goldstein B, Giroir B, Randolph A; International Consensus Conference on Pediatric Sepsis. Pediatr Crit Care Med. 2005 Jan;6(1):2-8.

Therapies adults and children with septic shock

Therapy	**Children**	**Adults**
Volume	Usually need more fluid, up to and over 60 ml/kg	Fluid resuscitation to CVP 12
Antibiotics	Early initiation of appropriate antibiotics within 1 hour	Early initiation of appropriate antibiotics within 1 hour
Inotropes and vasopressors	First line peripheral epinephrine cold shock, transition to central when able. Central norepinephrine for warm shock	First line norepinephrine ± dobutamine Vasopressin for warm shock
Vasodilators	Use for pulmonary hypertension Low CO, high SVR shock	No role
Tight glycemic control	Unresolved	Harmful
ECMO	Survival 80% neonates, 50% children	Evolving H1N1 popularizing use
Inhaled NO	Neonates with RV failure	No role
Hydrocortisone	Absolute adrenal insufficiency only; post ACTH cortisol level <18 µg/dL or baseline <5 µg/dL	Use if continue on vasopressors regardless of adrenal status

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Pediatric Basic Life Support

- Change in sequence C-A-B
- Eliminated “look, listen and feel” to assess breathing after opening airway
- Lay rescuers: check for response of abnormal breathing (eliminate pulse check)
- Health care providers: allows 10 sec for pulse check
    - 30 compressions followed by 2 breaths (lone rescuer)
    - 15:2 if two providers
- “Push hard, push fast” at least 100 per minute, allowing recoil of chest
    - Infant chest compression 1.5 in (4 cm)
    - Children – 2 in (5 cm)
- Defibrillation
    - Manual defibrillator > AED with dose attenuator > AED without dose attenuator
    - 2-4 J/kg, followed by at least 4 J/kg, up to 10 J/kg

Pediatric Advanced Life Support

- BVM recommended over ETI for out-of-hospital setting
    - Experienced providers may use LMAs
- Cricoid pressure NOT recommended
- Cuffed tubes okay!
    - Uncuffed: (age/4) + 4 = mm ID
    - Cuffed: (age/4) + 3.5 = mm ID
- Capnography recommended to confirm ETT placement and assess adequacy of CPR
- Avoid excessive ventilation (8-10 breaths per minute)
- Oxygen – increasing evidence for harm, especially in neonates
    - Avoid hyperoxemia
    - Start with 100% O_2 then titrate to maintain SpO_2 >94%
- Medications
    - Addition of procainamide as possible therapy for refractory SVT
    - Routine calcium administration NOT recommended unless clear indication
    - Etomidate may be used for RSI but NOT recommended in septic shock
    - Atropine may be added for symptomatic bradycardia but not cardio-pulmonary arrest
- Wide-complex tachycardia present of QRS width >0.09 sec
- Post-arrest Care
    - Therapeutic hypothermia may be considered in children with ROSC (large trial underway)
- Family presence during resuscitation is recommended
- New topics:
    - Specific guidance for cardiac arrest in infants with single-ventricle anatomy, Fontan or hemi-Fontan/ bidirectional Glenn physiology and pulmonary hypertension
    - Autopsies recommended for young victims of sudden cardiac arrest

Neonatal resuscitation

- Maintain A-B-C sequence
- De-emphasis on peripartum suctioning
- ET suctioning for nonvigorous neonate in meconium-stained fluid.
- Vigorous newborns do not require ET suctioning of meconium regardless of how thick the meconium is.
- Determine degree of oxygenation by pulse ox on the right wrist or arm
- Term babies should be resuscitated with room air first, then supplemental oxygen if needed by blended oxygen-air delivery
    - If bradycardic after 90 sec of resuscitation, increased oxygen to 100%
- Start CPR for HR < 60 bpm despite assisted ventilation for 30 seconds.
- Preferred method is thumb-hand technique.
- Compression:ventilation ratio 3:1 (90 compressions with 30 ventilations per cycle)
- Infants >36 weeks with moderate to severe hypoxic-ischemic encephalopathy should be offered therapeutic hypothermia

	Adults/ Adolescents	***Infants/ Children***	***Neonates***
Sequence	C-A-B	C-A-B	A-B-C
Compression rate (bpm)	100	100	90:30 events/min
Depth	>2 inches	1.5-2 inches	1/3 AP diameter
Compression:ventilation ratio - *1 rescuer* - *2 rescuers*	 30:2 30:2	 30:2 15:2	 3:1 3:1
Pause for ventilation after intubation?	No	No	Yes

Key references:

1. 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 Feb;37(2):666-88.
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7. Kattwinkel J, Perlman JM, Aziz K, et al. Part 15: neonatal resuscitation: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation.* 2010 Nov 2;122(18 Suppl 3):S909-19.