American College of Surgeons
Critical Care Review Course 2012
Pediatrics

Overview

I. Shock
II. Cardiac arrest
III. Acute Hypertension
IV. Ventilator support
V. Asthma
VI. Increased intracranial pressure
VII. Child Abuse
VIII. Brain Death
IX. End of life
X. Law and ethics

I. Shock

A. Definition

- Acute energy failure: inadequate ATP to support celluar function
- Lack of oxygen (anemia, hypoxia or ischemia), glucose substrate (glycopenia) or mitochondrial dysfunction (cellular)
- PEARL → Children are sensitive to small amounts of volume loss due to decreased volume, decreased cardiac reserve (high baseline heart rate, reduced HR compensation for decreased stroke volume)

B. Etiology

- Hypovolemic
- Cardiogenic
- Distributive
- Obstructive: cardiac tamponade, tension pneumothorax, massive pulmonary embolism

C. Clinical presentation (see tables below)

- Inadequate oxygen and nutrient delivery to meet tissue demands
- Compensated shock: perfusion to vital organs maintained, hard to detect, tachycardia may be present
- Decompensated shock: poor perfusion, tachycardia, hypotension, lethargy

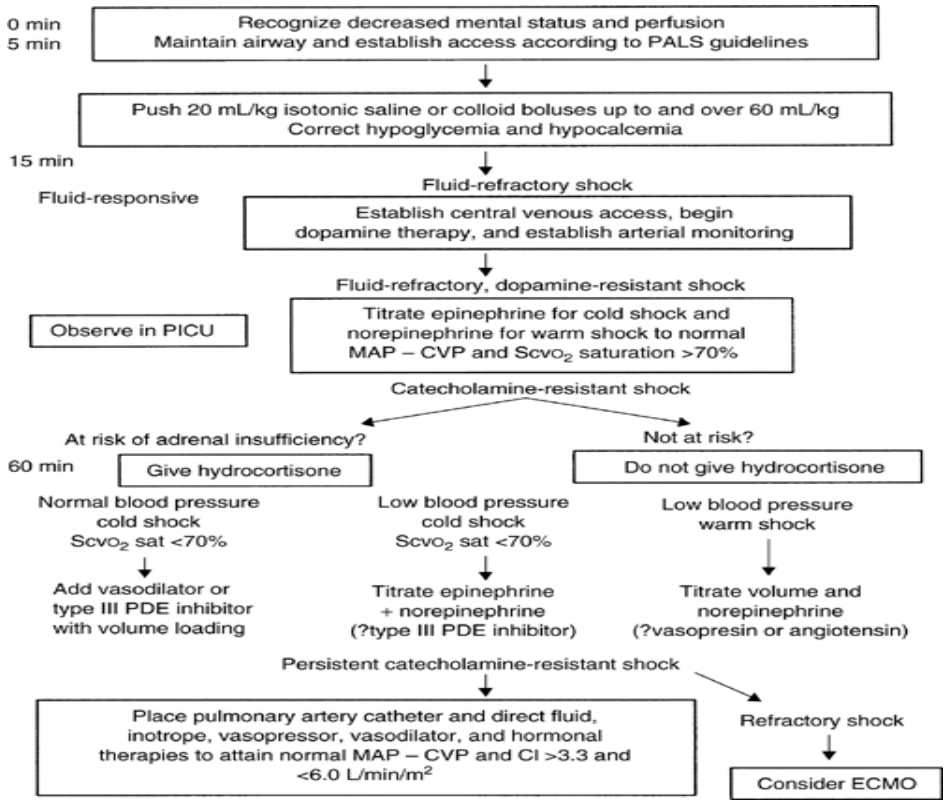
D. Resuscitation

- Peripheral, interosseous, umbilical access
- Isotonic crystalloid bolus 20 ml/kg until endpoints met
- Ionotropes/vasopressors if refractory
- Consider hydrocortisone for suspected adrenal insufficiency

E. End-points of resuscitation

- Age appropriate pulse pressure, heart rate, respiratory rate
- Cardiac index > 2
- SVO2 > 70%
- Anion gap < 16 , lactate <2 mmol/l
- Urine output > 1 ml/kg/h

System	Compensated Shock, Mild Hemorrhage, Simple Hypovolemia (<30% blood volume loss)	Decompensated Shock, Moderate Hemorrhage, Marked Hypovolemia (30%–45% blood volume loss)	Cardiopulmonary Failure, Severe Hemorrhage, Profound Hypovolemia (>45% blood volume loss)
Cardiovascular	Mild tachycardia	Moderate tachycardia	Severe tachycardia
	Weak peripheral pulses	Thready peripheral pulses	Absent peripheral pulses
	Strong central pulses	Weak central pulses	Thready central pulses
	Low-normal blood pressure (SBP >70 mmHg + [2? age in years])	Frank hypotension (SBP <70 mmHg + [2? age in years])	Profound hypotension (SBP <50 mmHg)
	Mild acidosis	Moderate acidosis	Severe acidosis
Respiratory	Mild tachypnea	Moderate tachypnea	Severe tachypnea
Neurologic	Irritable, confused	Agitated, lethargic	Obtunded, comatose
Integumentary	Cool extremities, mottling	Cool extremities, pallor	Cold extremities, cyanosis
	Poor capillary refill (>2 sec)	Delayed capillary refill (>3 sec)	Prolonged capillary refill (>5 sec)
Excretory	Mild oliguria, increased specific gravity	Marked oliguria, increased blood urea nitrogen	Anuria



TYPES OF SHOCK, PHYSIOLOGIC RESPONSE, AND BASIC TREATMENT

Type of Shock	HR	Preload	Contractility	SVR	Treatment
Hypovolemic	↑	↓↓	+/−	↑	• High flow oxygen • Fluid resuscitation: evaluate perfusion after 60 mL/kg total volume bolused, then consider pressors
Septic (early, warm)	↑	↓↓	+/−	↓	• High flow oxygen • Fluid resuscitation • Antibiotics • Pressors (dopamine, norepinephrine, phenylephrine)
Septic (late, cold)	↑	↓↓	↓	↑	• High flow oxygen • Fluid resuscitation • Antibiotics • Pressors (dopamine, epinephrine, phenylephrine)
Anaphylactic	↑	↓↓	↓	↓	• High flow oxygen • Epinephrine (IM) • Fluid resuscitation
Neurogenic	↑	↓↓	+/−	↓↓	• Fluid resuscitation • Pressors (norepinephrine)
Cardiogenic	↑	↑	↓↓	↑	• High flow oxygen • Fluid resuscitation (5–10 mL/kg) • CHF management (CPAP/BiPAP, diuretics, ACE inhibitors) • Inotropes (milrinone, dobutamine)
Obstructive	Cause dependent	Cause dependent	Cause dependent	Cause dependent	• Therapy directed at primary etiology of shock

II. Cardiac Arrest: four phases

A. Epidemiology

- Most frequently from respiratory failure
- SIDS most common cause out-of-hospital cardiac arrest
- Most in-hospital cardiac arrest have primary cardiac disease
- CPR outcome: 5-10% survival to hospital discharge
- 10-80% of survivors have significant neurologic disability

B. Pre-arrest (protect)

- Optimize community education on child safety
- Optimize patient monitoring
- Avoid progression of respiratory failure and/or shock to cardiac arrest

C. No-Flow (preserve)

- Minimize interval to defibrillation
- Preserve cardiac and cerebral substrate

D. Low flow (resuscitate)

- Successful CPR: push hard/push fast
- Titrate CPR to end-tidal CO_2 or pulse pressure
- PITFALL → High dose epinephrine (0.05-0.2 mg/kg) **NOT** recommended for initial or rescue therapy
- Consider mechanical devices/ ECMO if no return of circulation following 20-110 minutes CPR
- Shock resistant VF should be treated with amiodarone

E. Post-resuscitation: high risk of continuing brain injury, ventricular arrhythmias, reperfusion injury

- Optimize cardiac/cerebral perfusion
- Resuscitative systemic hypothermia (24-48 hours)
- Avoid hyperglycemia/hyperthermia/hyperventilation
- Early occupational/physical therapy

III. Ventilatory support

A. Volume limited

- Delivers preset tidal volume regardless of pressure required
- Risk for barotraumas
- Alarms and pop-off valves that limit peak inspiratory pressure can minimize risk of barotrauma

B. Pressure limited

- Gas flow delivered until preset pressure is reached

- Gas flow delivery held for set inspiratory time
- Reduces risk of barotrauma
- Useful for neonatal and infant support (<10 kg)
- Permits delivery of small tidal volumes

C. High frequency ventilation

- High frequency oscillatory ventilation (HFOV)
  - High amplitude and high frequency
  - Tidal volumes less than dead space
  - Bias gas flow maintains airway pressure
  - Minimizes barotrauma and oxygen toxicity
  - PEARL → Insure patients euvolemic due to risk for decreased venous return
- High frequency jet ventilation
  - Used simultaneously with a conventional ventilator
  - Jet injector port delivers short bursts of inspiratory gas
  - Adequate gas exchange at low airway pressures
  - Maintains lung volumes and minimizes barotrauma

IV. Acute Hypertension

A. Assessment

- Use appropriate cuff size; correlate with BP tables for age, height, weight
- Hypertensive urgency: BP elevation without end-organ damage. More common in children
  - Symptoms: Headache, blurred vision, nausea
  - Lower MAP by 20% over 1 hour and return to baseline over 24 to 48 hours
- Hypertensive emergency: elevation of BP with acute end-organ damage
  - cerebral infarction/hemorrhage, pulmonary edema, renal failure, encephalopathy, seizures
  - PITFALL → Rule out hypertension secondary to elevated ICP before lowering BP
  - Lower MAP by 1/3 over first 6 hours, then 1/3 over next 24-36 hours, then final 1/3 over next 48 hours
- Physical Examination
  - Four extremity BP, funduscopy, CV, neuro
  - Diagnostic evaluation: BUN/Cr, electrolytes, abdominal ultrasound, head CT, renal Doppler ultrasound

V. Asthma

A. Pathophysiology

- Most common cause of respiratory distress and failure
- Bronchoconstriction, epithelial cell injury-mediated neurogenic inflammation, luminal obstruction from secretions and cellular debris
- Progressive dynamic hyperinflation

- Pulmonary edema: increase RV afterload, decreased LV preload, decreased cardiac output

B. Evaluation
- General appearance, respiratory rate, degree of tachycardia, oxygen saturation
- Severe distress: lethargy, agitation, orthopnea, fragmented speech, use of accessory muscles, silent chest due to poor air movement
- Metabolic acidosis from dehydration, lactic acid production from respiratory musculature or cardiac failure

C. Pharmacotherapy
- Oxygen: mask, tent, nasal cannula supplemented face mask
- Inhaled bronchodilators (β-2 agonists) to reduce hypoxic pulmonary vasoconstriction
- Continuous albuterol (20 mg/hr max) may be needed
- Ipratropium bromide acts on muscarinic receptors, synergistic to β-2 – agonists (200-500 ug every 6-8 hours)

PEARL →
- Subcutaneous β-2-agonists may be needed in initial management
- Methylprednisolone reduces mucus production and inflammation
- Helium-oxygen promotes laminar flow but loses effectiveness at FiO2 > 50%

D. Ventilatory support
- Indications: cardiopulmonary arrest, respiratory failure
- Trial of non-invasive ventilation while preparing for intubation
- Pre-intubation volume loading, topical aerosolized lidocaine, pre-oxygenation
- Control tidal volume and respiratory rate to minimize dynamic hyperinflation

E. Refractory Disease
- ECMO should be considered for life-threatening hypoxemia; survival is high, morbidity minimized with veno-venous techniques
- Bronchoscopy only if airway obstruction from mucus/debris not responsive to mucolytics
- Respiratory acidosis can be managed with tromethamine

F. Morbidity
- Nosocomial infections: minimize by attention to detail
  - Hand washing
  - Transpyloric feeding
  - Sterile technique for all procedures
- Post-traumatic stress disorder
- Opioid/benzodiazepine dependence

- Altered sleep patterns
- Myopathy/rhabdomyolysis
- Deconditioning
- Deep venous thrombosis

VI. Increased Intracranial Pressure (ICP)

A. Assessment

- History: trauma, vomiting, fever, headache, neck pain, visual change. In infants: irritability, vomiting, poor feeding, lethargy, bulging fontanel
- Physical exam/laboratory evaluation
- Management:
  - Elevate HOB 30° (if not contraindicated)
  - Head CT
  - Normal saline or hyperosmolar solutions
    - 3% NaCL, 2-5 ml/kg or mannitol 0.25 g/kg IV
    - Hyperventilation for acute management only (pCO_2 30-35 mmHg)

PITFALL →
  - DO NOT LOWER BLOOD PRESSURE
  - Prevent hyperthermia
  - Dexamethasone to reduce cerebral edema in space-occupying lesions
  - Keep MAP > ICP
  - Avoid hypotension, hypoxia, hypercarbia, hypovolemia

VII. Child Abuse

- Multidisciplinary approach: medical professionals, social worker, community agencies
- Correlate physical findings with history

PEARL →
- Shapes of bruises important: be suspicious of bruises in protected areas (buttocks, chest, abdomen, back)
- Retinal hemorrhages are pathognomonic of abusive head trauma

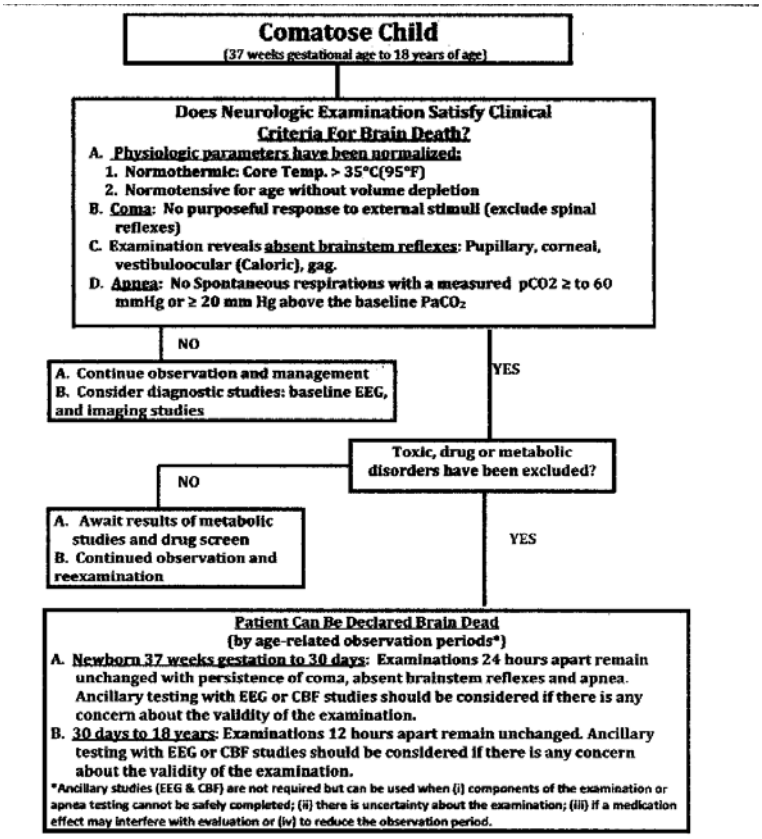
PEARL →
- Skeletal survey mandatory in children < 2 years with suspicious fractures
- Treat: medical stabilization primary goal
- Report: All healthcare workers who suspect child maltreatment must report to local police and/or child welfare agency
- Document: legible, include word-for-word history, drawings of injuries including shape, location, size, color

VIII. Brain Death

- Determine if treatable causes of coma exist (hypothermia, toxic/metabolic states, hypotension)
- Physical Exam (see algorithm)
  - Requires age dependent observation period between 2 exams
  - Coexistent coma and apnea
  - Loss of volitional ability

- Absent brainstem function
- Consistent exam throughout observation period

Age	Hours Between 2 Examinations	Recommended Number of EEGs
7 days-2 months	48	2
2 months-1 year	24	2
>1 year	12	Not needed



IX. End of Life Care

A. Analgesia

- Document signs and symptoms of suffering and rationale of the regimen chosen to treat
- Titrate to effect; no theoretical or practical maximal dose

B. Doctrine of double effect

- The action must be good or morally indifferent
- The agent must intend only the good effect and not the bad
- The bad effect cannot be a means to the good effect

- The good that is intended must outweigh the bad that is permitted
- Viable alternatives to double-effect reasoning in guiding care of patients dying in the ICU are limited

X. Law and ethics

A. Overview
- Most deaths in the PICU occur following withdrawal of care
- Parents have the authority to determine the best interests of their children
- Children should participate in decision-making commensurate with their development and should not be excluded from decision-making
- Children should provide assent to care whenever reasonable

B. Assent
- Helping the patient achieve appropriate awareness of the nature of his/her condition
- Telling the patient what to expect with tests/treatments
- Assess the patients understanding of the situation
- Solicit an expression of the patients willingness to accept the proposed care

C. Baby Doe regulations
- State regulator system to investigate cases in which medically indicated treatment is withheld from handicapped infants
- Regulatory stature; no strong clinical application
- Withholding medically indicated treatment from a disabled infant with a life-threatening condition is considered medical neglect.
- Exceptions:
    - Infant is chronically and irreversibly comatose
    - Treatment would prolong dying
    - Treatment would be futile in terms of survival