

PALS

Paediatric Advanced Life Support



THE UNIVERSITY OF
AUCKLAND
Te Whare Wānanga o Tāmaki Makaurau
NEW ZEALAND

**MEDICAL AND
HEALTH SCIENCES**

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Anaesthesiology

- To review some of the special considerations in paediatric resuscitation
- To understand a structured approach to the seriously ill or injured child

- Children are NOT just little adults!
- Different anatomy, different physiology and different pathology.
- Varying equipment shapes and sizes with varying ages.
- Challenging vascular access.

Survival from out-of-hospital CA

6.4% for Adults

5-12% for Children

Survival from in-hospital CA

18% for adults

27% for children

Pediatric Chain of Survival



**MEDICAL AND
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Berg M D et al. Circulation. 2010;122:S862-S875



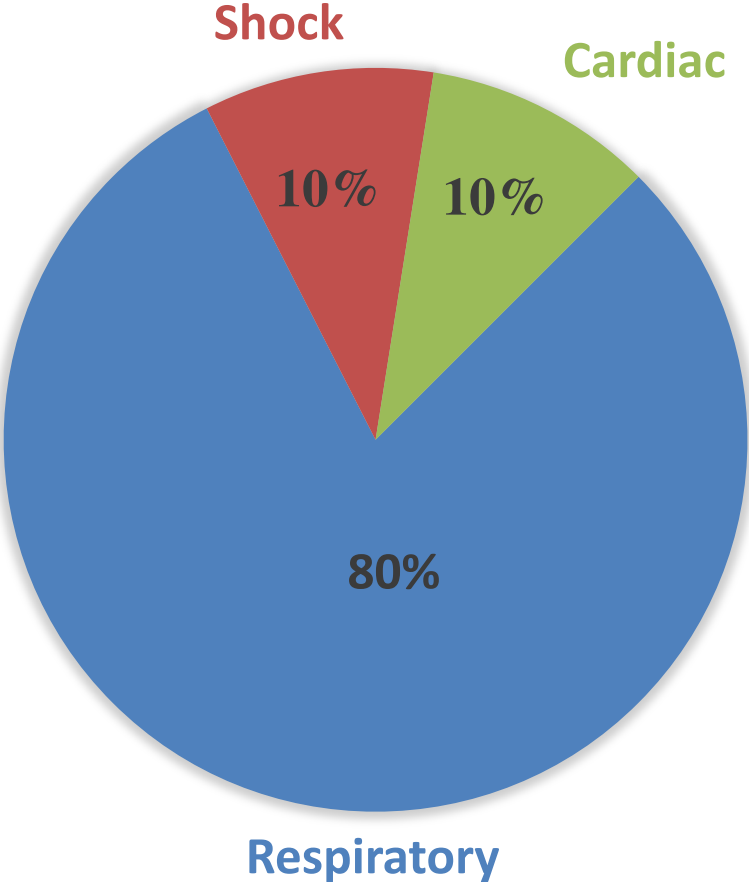
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Causes of Cardiac Arrest In Children



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SIDS	AW obstruction
Trauma	Severe Asthma
Submersion	Pneumonia
Poisoning	Metabolic Disorders
Sepsis	Arrhythmias



- Difficult compared to adults.
- Significant portion of kids respond to *AW management alone!*
- Time spent securing a vascular access at the expense of adequate AW management is a common mistake.
- General order of attempts should be:
 - Antecubital
 - Hand or foot and then
 - Intraosseous

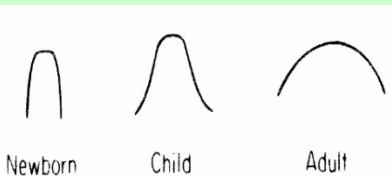
Differences between the pediatric and the adult airway

Tongue

Larger in proportion to the oral cavity than in the adult

Epiglottis

Narrower, Longer,



Larynx

Higher in the neck (C3-C4) than in the adult (C5-C6); in infants:

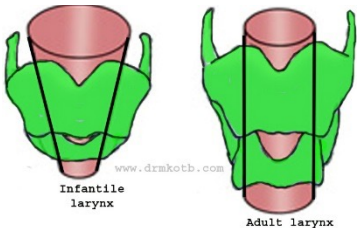
positioned more anteriorly

positioned more cephalad

(use straight blade laryngoscope for easier visualization)

Cricoid

Larynx is more conically shaped in infants (up to 8y); narrowest portion is at the cricoid ring, whereas in the adult it is at the level of the vocal cords



Differences between the pediatric and the adult airway

Trachea

Deviated posteriorly and downward (*becomes anatomically similar to the adult between 8 and 10 years of age*)
Bronchi equal angles *under age 3*

Head

Occiput relatively large compared with the adults' head
Optimal intubating position is with shoulder roll to prevent neck flexion in the supine position

Nares

Small- nasal breathing (*up to 6 months-Obligate nose breathers*)
Nasal obstruction leads to resp. failure.

Mandible

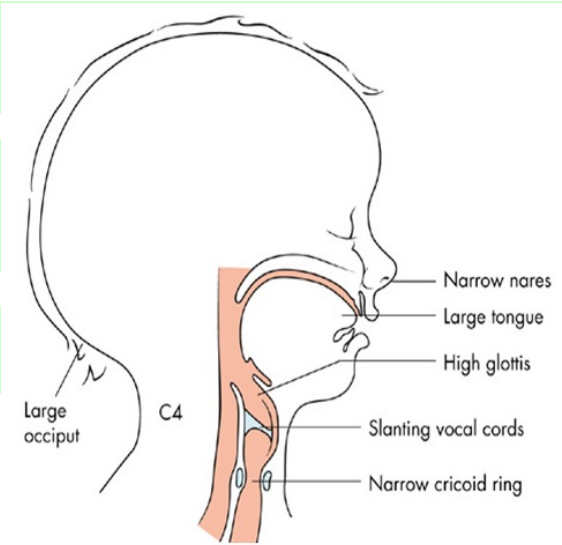
Smaller

Oral cavity

Smaller

Neck

Shorter



- Lungs still developing at birth
 - Alveolar Ventilation is X2 in neonates to meet O₂ demands
 - Achieved by high respiratory rate
- Strong laryngeal reflex
 - apnea
 - bradycardia
 - laryngospasm

- **Hypoxia** and **hypercarbia** will *depress* respiratory drive in the infant rather than stimulate as in adults.
- Neonate respiratory muscles are weak and fatigued easily
- *O₂ requirement 2x adult (6 ml/kg)*
- *CO₂ production 2x adult*

- lower FRC

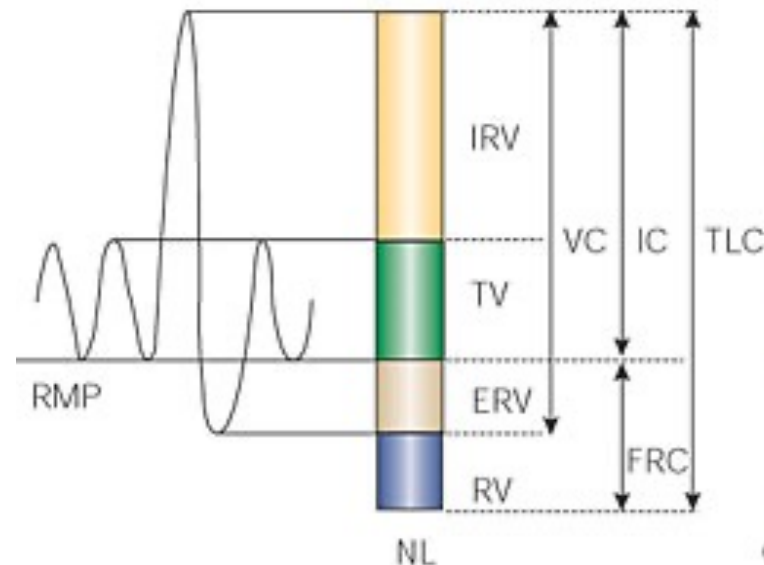
(Balance between outward recoil of rib cage and inward recoil of the lungs)

- lower closing volume

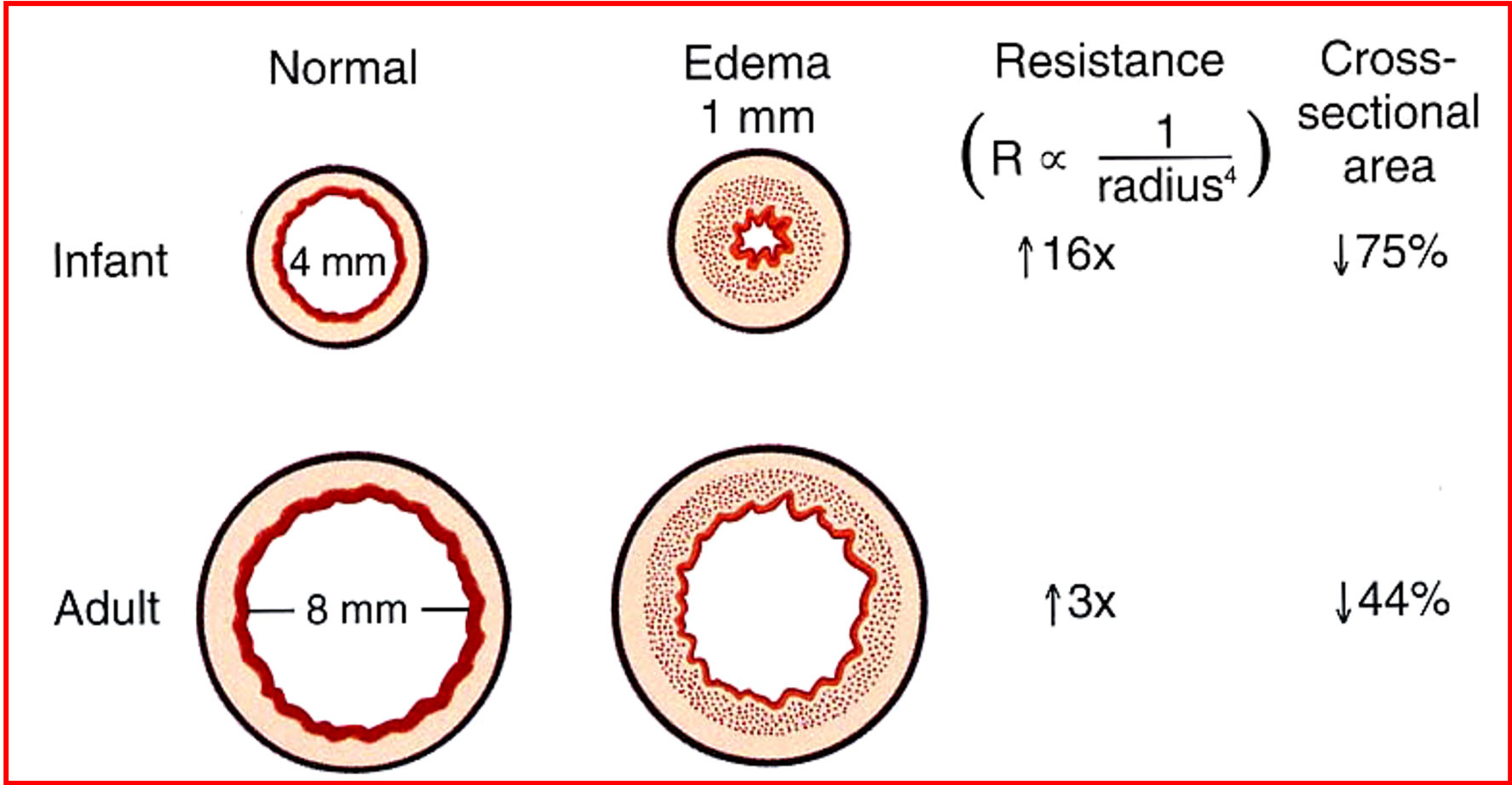
- lower lung compliance (small Alveoli)

- Greater chest wall compliance

(Young infant's rib cage is highly compliant, inward recoil is often greater than outward recoil- thus tends to retract in resp. compromise)



Effect of airway oedema



- High cardiac output (ml/kg/min)
- Newborn C.O. = 4 ml/beat

Note:

the main determinant of cardiac output up to age 2Y is heart rate

Paediatric cardio respiratory normal values



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Age (years)	Resp Rate (breaths/min)	Heart rate (beats/min)	Systolic BP
<1	30-40	110-160	80-90
1-2	25-35	100-150	85-90
2-5	25-30	95-140	90-95
5-12	20-25	80-120	100-105
>12	15-20	60-100	110-120

Useful formulae



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$$\begin{aligned}\text{Weight} &= [\text{age } y + 4] \times 2 \\ &= [\text{age } y \times 2] + 8\end{aligned}$$

Measurement	Symbol	Equation	Description
<i>Minute ventilation</i>	$\dot{V}_E$	= tidal volume X respiratory rate	the total volume of gas entering the lungs per minute.
<i>Alveolar ventilation</i>	$\dot{V}_A$	= (tidal volume - dead space) X respiratory rate	the volume of gas per unit time that reaches the alveoli, the respiratory portions of the lungs where gas exchange occurs.
<i>Dead space ventilation</i>	$\dot{V}_D$	= dead space X respiratory rate	is the volume of gas per unit time that does not reach these respiratory portions, but instead remains in the airways (trachea, bronchi, etc.).

(4,2,1 rule)

Maintenance

- 0-10 kg 4ml/kg/hr.
- 11-20kg 2ml/kg/hr.
- 20kg or > 1ml/kg/hr.

Example

18 kg child

$$4 \times 10 = 40$$

$$2 \times 8 = 16$$

56 ml/hr.

23 kg child

$$4 \times 10 = 40$$

$$2 \times 10 = 20$$

$$1 \times 3 = 3$$

63 ml/hr.

- Premature = 100 ml/kg
- Full term = 85-90 ml/kg
- Infant = 80 ml/kg
- Adult = 65-70 ml/kg

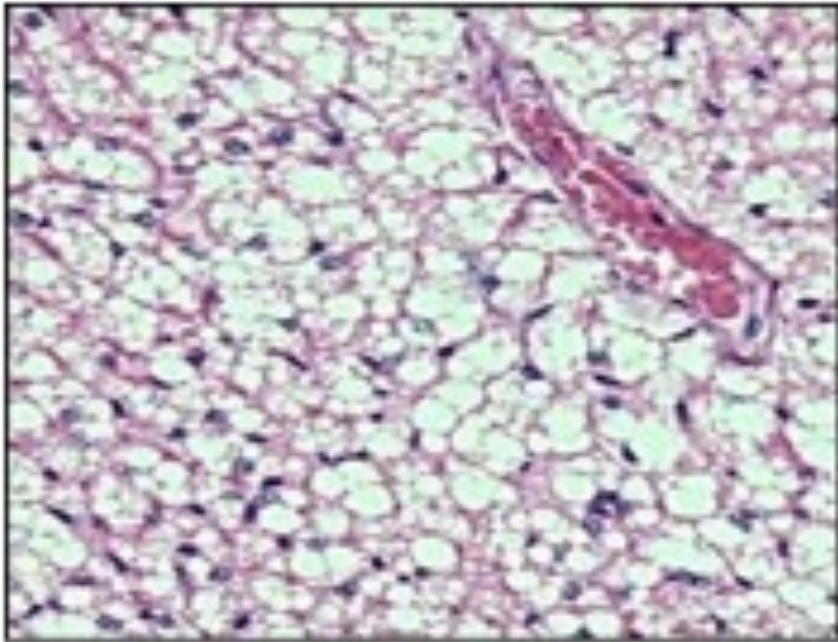
- Full term = 55%
- 3 months = 30%
- 6 months = 35%

- Prolonged PT and PTT are common but coagulation is normal

(up to age of 10y)

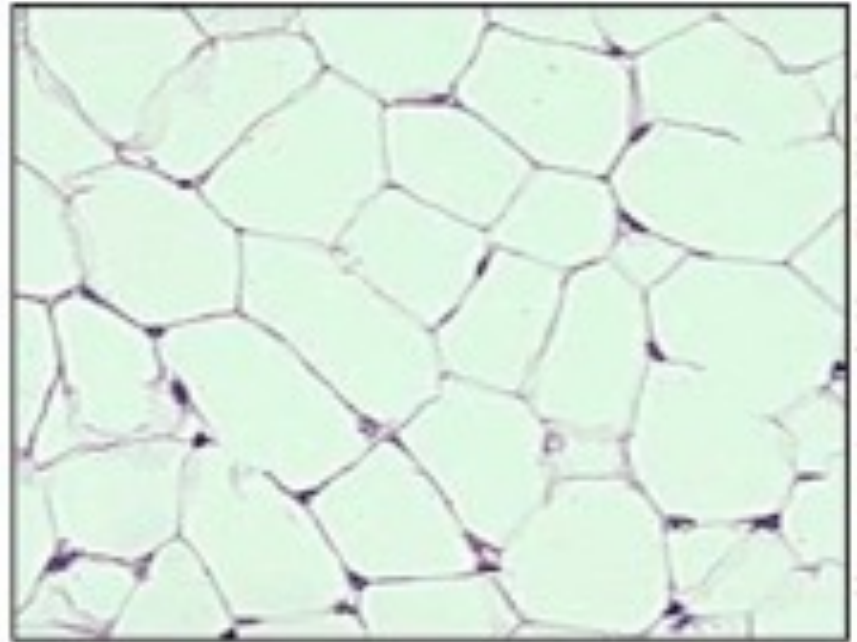
- **1 X ETT** = $(\text{age}/4) + 4$ (for uncuffed tubes)
 $(\text{age} /4) + 3.5$ (for cuffed tubes)
- **2 X ETT** = NG / Foley size (Fr)
- **3 X ETT** = depth of ETT insertion (cm) from incisor teeth)
- **4 X ETT** = Chest tube size (Fr)

- Infants lose heat rapidly
- Prevention of hypothermia is essential
- Infants do not shiver
 - able to shiver by 1 year
- Brown fat metabolism
 - non-shivering thermogenesis



Brown adipocytes

- Numerous smaller fat droplets
- Much higher number of mitochondria containing iron (brown)
- Contains more capillaries



White adipocytes

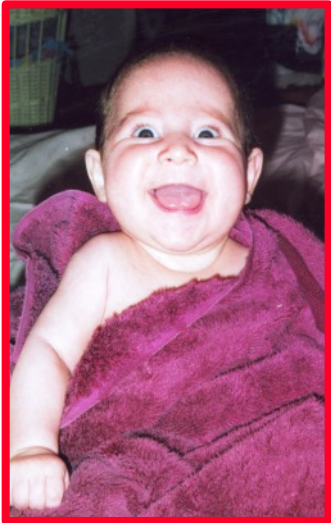
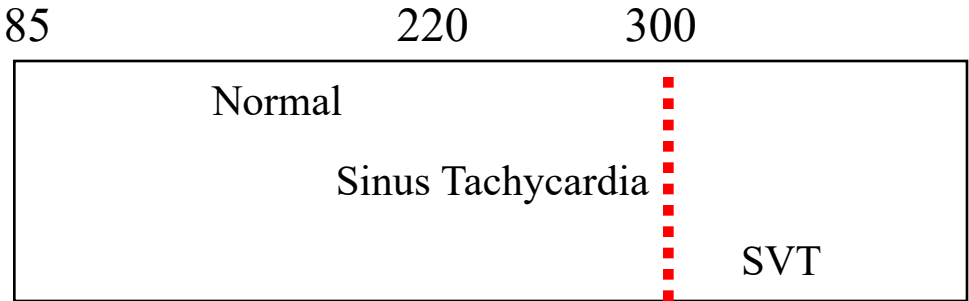
- Single lipid droplet

- Greatest loss via radiation
 - due to relatively large BSA
- Effects of Hypothermia:
 - Increased oxygen consumption
 - Increased PVR
 - Increased SVR
 - R to L shunting

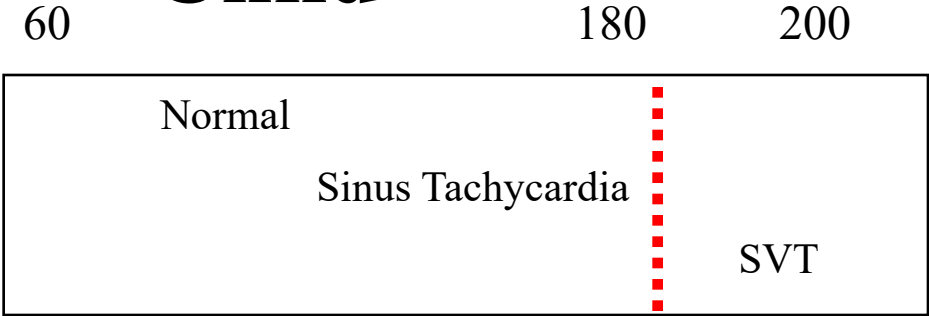
- Neonate = 60-90% Hgb F
- Hgb F
 - reduced 2,3 DPG
 - O₂ curve shifts left, ↑ affinity for O₂
 - Impairs O₂ release at the tissues
 - *Offset by increased Hct*
- O₂ curve at adult level by ***4 months***

Heart Rates in Children

Infant



Child



Palpation of Central and Distal Pulses



Prolonged capillary refill (10 seconds) in a 3-month-old with cardiogenic shock

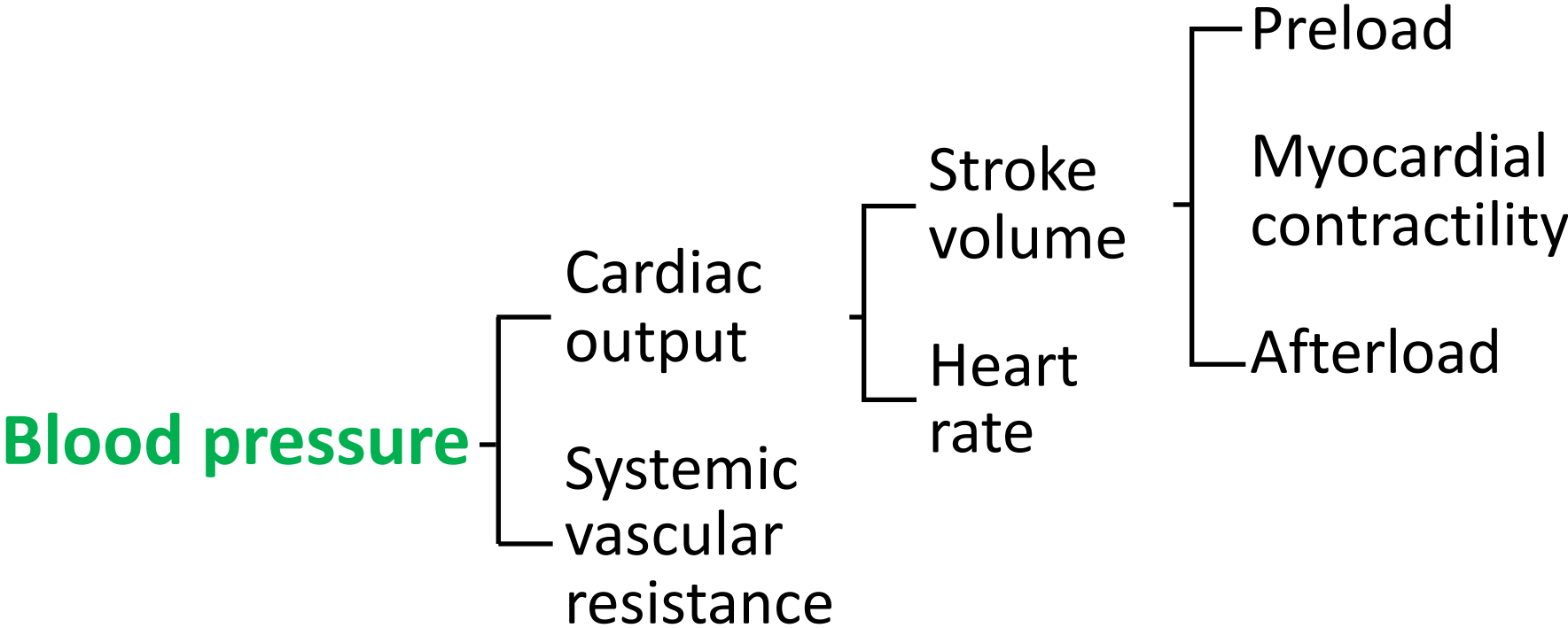


To evaluate capillary refill, elevate the extremity above the level of the heart to ensure that arterial (not venous) perfusion is being evaluated

<i>Age</i>	<i>Minimum systolic blood pressure (5th percentile)</i>
0 to 1 month	60 mm Hg
>1 month to 1 year	70 mm Hg
1 to 10 years of age	70 mm Hg + (2 × age in years)
>10 years of age	90 mm Hg

Kidneys

- Urine Output
 - Normal: 1 to 2 mL/kg per hour
 - Initial measurement of urine in bladder not helpful



- Preparation
- Primary assessment
- Resuscitation if needed / team work
- Secondary assessment
- Emergency Treatment
- Stabilisation and transfer to definitive care

PALS Systematic Approach Summary

Initial Impression

Your first quick (in a few seconds) “from the doorway” observation

Consciousness	Level of consciousness (eg, unresponsive, irritable, alert)
Breathing	Increased work of breathing, absent or decreased respiratory effort, or abnormal sounds heard without auscultation
Color	Abnormal skin color, such as cyanosis, pallor, or mottling

The purpose is to quickly identify a life-threatening problem.

Is the child unresponsive with no breathing or only gasping?

If YES:

- Shout for help.
- Activate emergency response as appropriate for setting.
- Check for a pulse.
- Begin lifesaving interventions as needed.

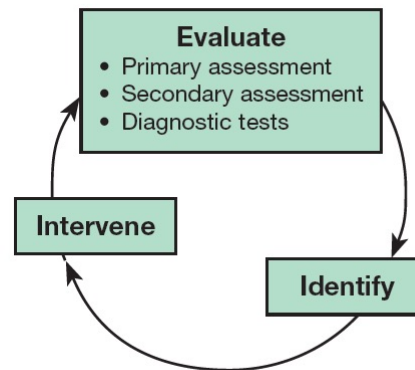
If NO:

- Continue the evaluate-identify-intervene sequence.

Use the ***evaluate-identify-intervene*** sequence when caring for a seriously ill or injured child.

- *Evaluate* the child to gather information about the child's condition or status.
- *Identify* any problem by type and severity.
- *Intervene* with appropriate actions to treat the problem.

Then repeat the sequence; this process is ongoing.



If at any time you identify a life-threatening problem, immediately begin appropriate interventions. Activate emergency response as indicated in your practice setting.

Primary Assessment	A rapid, hands-on ABCDE approach to evaluate respiratory, cardiac, and neurologic function; this step includes assessment of vital signs and pulse oximetry
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Airway

Clear	Maintainable	Not maintainable
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Breathing

Respiratory Rate and Pattern	Respiratory Effort	Chest Expansion and Air Movement	Abnormal Lung and Airway Sounds	Oxygen Saturation by Pulse Oximetry
Normal Irregular Fast Slow Apnea	Normal Increased - Nasal flaring - Retractions - Head bobbing - Seesaw respirations Inadequate - Apnea - Weak cry or cough	Normal Decreased Unequal Prolonged expiration	Stridor Snoring Barking cough Hoarseness Grunting Gurgling Wheezing Crackles Unequal	Normal oxygen saturation (≥94%) Hypoxemia (<94%)

Circulation

Heart Rate and Rhythm	Pulses		Capillary Refill Time	Skin Color and Temperature	Blood Pressure
Normal Fast (tachycardia) Slow (bradycardia)	Central Normal Weak Absent	Peripheral Normal Weak Absent	Normal: ≤2 seconds Delayed: >2 seconds	Pallor Mottling Cyanosis Warm skin Cool skin	Normal Hypotensive

Disability

AVPU Pediatric Response Scale				Pupil Size Reaction to Light		Blood Glucose	
A lert	Responds to V oice	Responds to P ain	U nresponsive	Normal	Abnormal	Normal	Low

Exposure

Temperature			Skin	
Normal	High	Low	Rash (eg, purpura)	Trauma (eg, injury, bleeding)

Secondary Assessment

A focused medical history (SAMPLE) and a focused physical exam

Focused medical history and focused physical examination

- **S**igns and symptoms
- **A**llergies
- **M**edications
- **P**ast medical history
- **L**ast meal
- **E**vents

Signs and symptoms

S&S at onset of illness

- Breathing difficulty (cough, tachypnea, respiratory effort, breathlessness, abnormal breathing pattern, chest pain on deep inhalation)
- Altered level of consciousness
- Agitation, anxiety
- Fever
- Decreased oral intake
- Bleeding
- Fatigue
- Time course of illness

Allergies

- Medications, foods, latex, etc.

Medications

- Medications
- Last dose and time of recent medications

Past medical history

- Health History
- Significant underlying medical problem
- (asthma, chronic lung disease, congenital heart disease, arrhythmia, congenital airway abnormality, seizures, head injury, brain tumor, diabetes, hydrocephalus, neuromuscular disease)
- Past surgeries
- Immunization status

Last meal	○ Time and nature of last liquid or food (including breast or bottle feeding in infants)
Events	○ Events leading to current illness or injury (onset sudden or gradual, type of injury) ○ Hazards at scene ○ Treatment during interval from onset of disease or injury until your evaluation. ○ Estimated time of arrival if out-of-hospital onset)

Identify

Identify the child's problem as respiratory, circulatory, or both. Determine the type and severity of the problem(s). The table below lists common clinical signs that typically correlate with a specific type of problem and its severity.

Type		Severity
Respiratory	• Upper airway obstruction • Lower airway obstruction • Lung tissue disease • Disordered control of breathing	• Respiratory distress • Respiratory failure
Circulatory	• Hypovolemic shock • Distributive (eg, septic, anaphylactic) shock • Obstructive shock • Cardiogenic shock	• Compensated shock • Hypotensive shock
Cardiac Arrest		

Respiratory

Signs	Type of Problem	Severity
- Increased respiratory rate and effort (eg, retractions, nasal flaring) - Decreased air movement - Stridor (typically inspiratory) - Barking cough - Snoring or gurgling - Hoarseness	Upper airway obstruction	Respiratory distress - Some abnormal signs but no signs of respiratory failure Respiratory failure <i>One or more of the following:</i> - Very rapid or inadequate respiratory rate - Significant or inadequate respiratory effort - Low oxygen saturation despite high-flow oxygen - Bradycardia (ominous) - Cyanosis - Decreased level of consciousness
- Increased respiratory rate and effort (eg, retractions, nasal flaring) - Decreased air movement - Prolonged expiration - Wheezing	Lower airway obstruction	
- Increased respiratory rate and effort - Decreased air movement - Grunting - Crackles	Lung tissue disease	
- Irregular respiratory pattern - Inadequate or irregular respiratory depth and effort - Normal or decreased air movement - Signs of upper airway obstruction (see above)	Disordered control of breathing	

Circulatory		
• Tachycardia • Weak peripheral pulses • Delayed capillary refill time • Changes in skin color (pallor, mottling, cyanosis)	• Cool skin • Changes in level of consciousness • Decreased urine output	Signs of poor perfusion
Signs	Type of Problem	Severity
• Signs of poor perfusion (see above)	Hypovolemic shock Obstructive shock	Compensated shock • Signs of poor perfusion and <i>normal</i> blood pressure Hypotensive shock • Signs of poor perfusion and <i>low</i> blood pressure
• Possible signs of poor perfusion (see above) <i>or</i> • Warm, flushed skin with brisk capillary refill (warm shock) • Peripheral pulses may be bounding • Possible crackles • Possible petechial or purpuric rash (septic shock)	Distributive shock	
• Signs of poor perfusion (see above) • Signs of CHF	Cardiogenic shock	

Diagnostic Tests

Laboratory, radiographic, and other advanced tests that help to identify the child's physiologic condition and diagnosis

Intervene

On the basis of your identification of the problem, intervene with appropriate actions. Your actions will be determined by your scope of practice and local protocol.

After identification of the problem, stabilize the patient for transfer:

- Plan early
- Contact the receiving hospital or department early
- Special considerations for transportation
 - Airway management
 - Drugs needed in transit
 - Type of transport or? retrieval

A child with breathing difficulty

- Most common illnesses in the paediatric group
- Range from self limiting to life-threatening emergencies
- Smaller airways, smaller reserve, compliant chest wall, muscles of respiration fatigued
- quickly

Respiratory distress:

Increased work of breathing

1. Upper airway obstruction
2. Lower airway obstruction
3. Lung tissue disease
4. Disordered control of breathing

Respiratory failure:

Inadequate oxygenation or ventilation:

- Tachycardia
- Skin pallor.....cyanosis (late sign)
- Agitation....drowsiness...unconsciousness
- hypotonia



Shock

Early signs (compensated)

- Increased heart rate
- Poor systemic perfusion

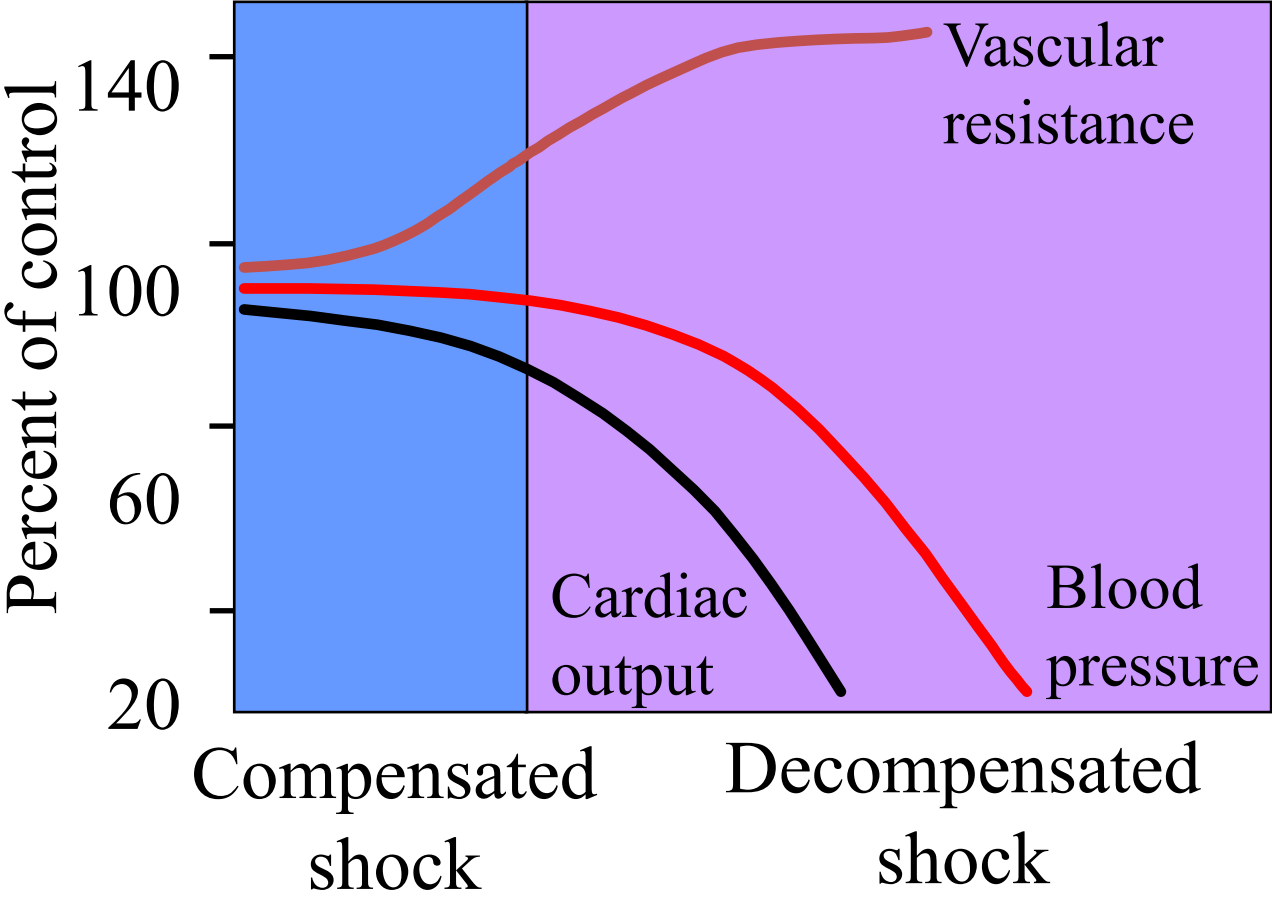
a serious medical condition where the tissue perfusion is insufficient to meet demand for oxygen and nutrients

Late signs (decompensated)

- Weak central pulses
- Altered mental status
- Hypotension

**Hypovolaemic
Distributive-septic
Cardiogenic
Obstructive**

**Hemodynamic Response
to Shock**



Shock

Decompensated Shock

Characterized by Hypotension

*Compensatory mechanisms fail to
maintain adequate cardiac output
and blood pressure*

Shock

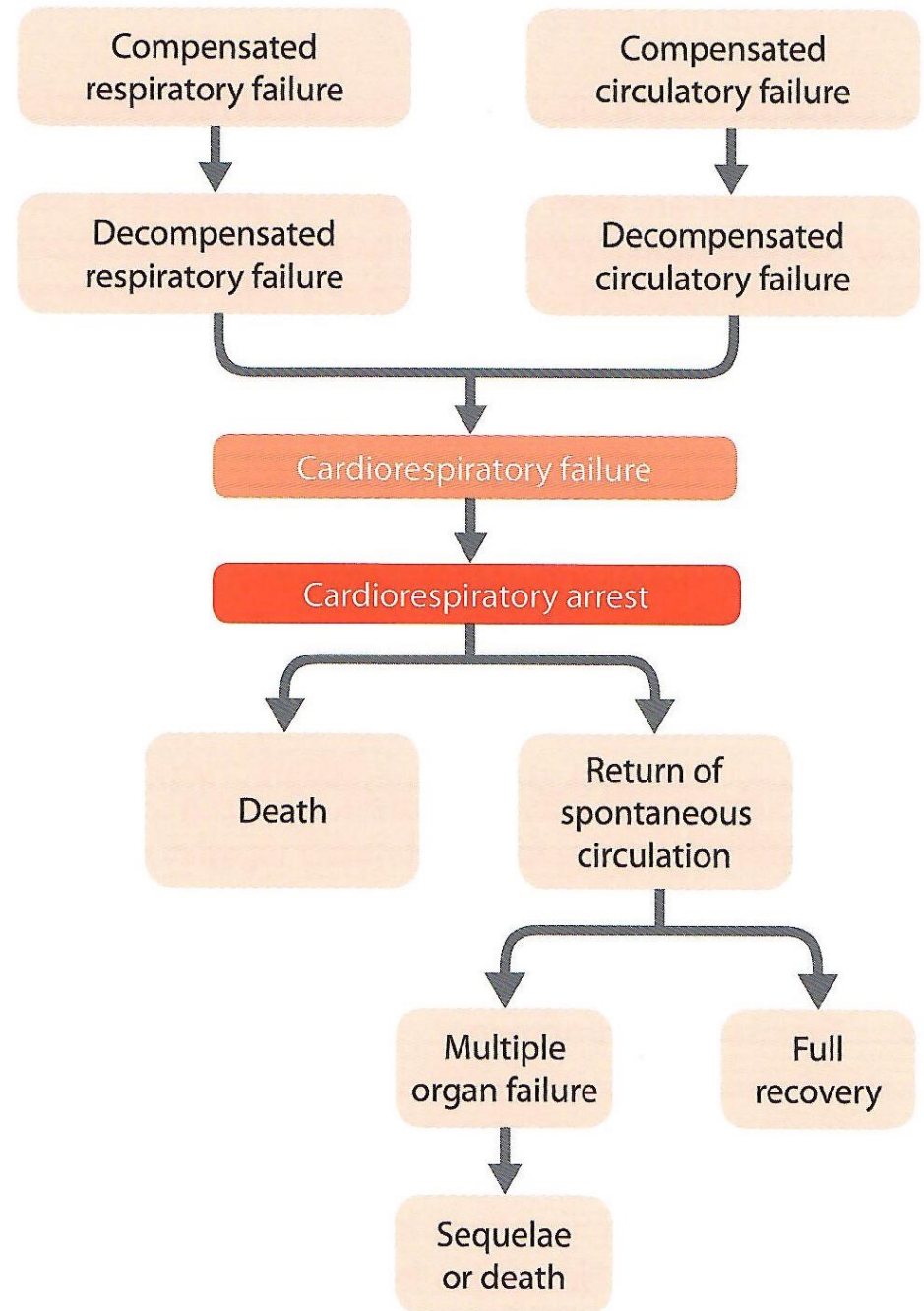
Distributive / Septic Shock Is Unique

- C.O. may be *normal, increased, or decreased*.
- Hypotension and poor end-organ perfusion may be present *despite “good” skin perfusion*.
-
- **Hypotension is still a sign of decompensation.**
- Early signs of sepsis/septic shock include
 - Fever or hypothermia
 - Tachycardia and tachypnea
 - Leukocytosis, leukopenia, or increased bands

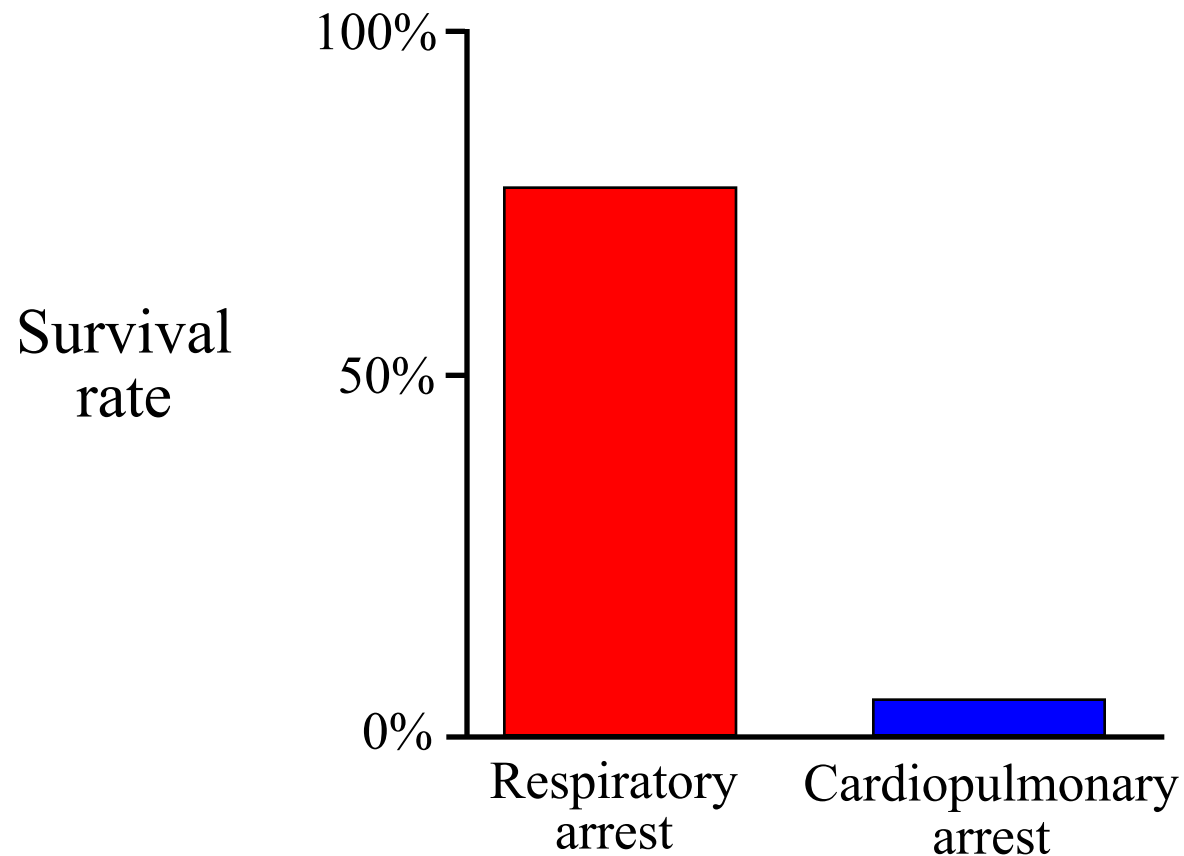
Cardiopulmonary failure produces signs of **respiratory failure** and **shock**:

- Agonal respirations
- *Bradycardia*
- Cyanosis and poor perfusion

Progression of Respiratory Failure and Shock



Respiratory Arrest vs Cardiopulmonary Arrest in Children



- Evaluate general appearance

- Assess ABCDE

- Classify physiologic status

Respiratory

- Respiratory distress
- Respiratory failure

Circulatory

- Compensated shock
- Decompensated shock

Combination

- Cardiopulmonary failure

- Begin management: support ABC

A 3-week-old infant arrives in the ED:

- CC: Severe vomiting and diarrhea
- Physical exam: Gasping respirations, bradycardia, cyanosis, and poor perfusion

- *What is the patient's physiologic status?*
 - Cardiorespiratory failure

- *What are the initial interventions?*
 - Open the airway and assist ventilation while delivering oxygen.
 - Monitor heart rate.
 - Assess the patient's response, particularly noting changes in heart rate, color, and respiratory effort.
 - Evaluate oxygenation with pulse oximetry if available.
 - Establish vascular access rapidly.

Case Progression

- Response to intubation and ventilation with Fio_2 of 1.00:

Heart rate: 180 bpm

Blood pressure: 50 mm Hg systolic

Pink centrally, cyanotic peripherally

No peripheral pulses

No response to painful stimuli

- *What is the child's physiologic status now?*
 - Decompensated shock

- *What are your next priorities?*
 - Obtain vascular access rapidly if this has not been achieved.
 - Provide rapid fluid bolus, 20 mL/kg NS or lactated Ringer's.

Response to Therapy

- Vital signs improved
- Perfusion still poor

*What intervention would
be appropriate now?*

Answer:

Administer another rapid fluid bolus, then reassess.

Trauma

- **Airway and Breathing** problems are more common than **Circulatory shock**
- Use the PALS ABC approach plus
 - Airway + cervical spine immobilization
 - Breathing + pneumothorax management
 - Circulation + control of bleeding
- Identify and treat life-threatening injuries



http://www.dartcenter.org/media/images/articles/beslan_child1.jpg

Toxicology

- **Airway obstruction, Breathing depression, and Circulatory dysfunction** may be present
- Use the PALS ABC approach, plus watch for
 - Airway: reduced airway protective mechanisms
 - Breathing: respiratory depression
 - Circulation: arrhythmias, hypotension, coronary ischemia
- Identify and treat reversible complications
- Administer antidotes

- Children are different from adults
- Structured approach
- Preparation / Team work
- A,B,C,D,E.....and glucose
- Recognising potential respiratory, circulatory and neurological failure
- Stabilisation and transfer