Pediatric Trauma

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Objectives

- Understand the differences between children and adults
  - Epidemiology
  - Evaluation
  - Management
  - Anatomy
  - Physiology
- Review the principles of evaluation: ABCD
- Learn to utilize pediatric specific resuscitation tools
- Special pediatric trauma considerations:
  - The abused child
  - Drowning

- Nothing to disclose

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Epidemiology

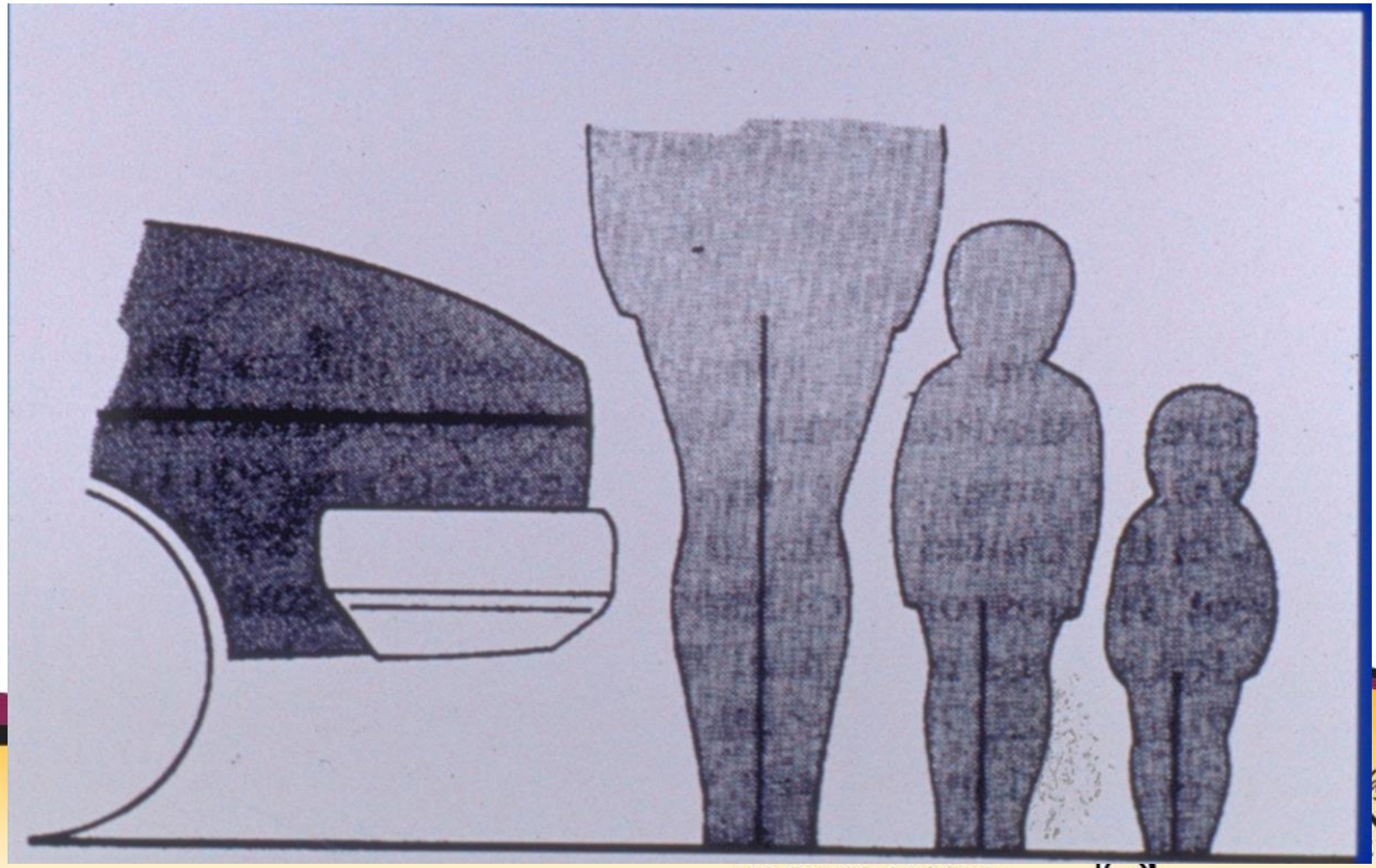
10 Leading Causes of Injury Deaths by Age Group Highlighting Unintentional Injury Deaths, United States – 2010

	Age Groups										
Rank	<1	1-4	5-9	10-14	15-24	25-34	35-44	45-54	55-64	65+	Total
1	Unintentional Suffocation 905	Unintentional Drowning 436	Unintentional MV Traffic 354	Unintentional MV Traffic 452	Unintentional MV Traffic 7,024	Unintentional Poisoning 6,767	Unintentional Poisoning 7,476	Unintentional Poisoning 9,662	Unintentional Poisoning 4,451	Unintentional Fall 21,649	Unintentional MV Traffic 33,687
2	Homicide Unspecified 154	Unintentional MV Traffic 343	Unintentional Drowning 134	Suicide Suffocation 168	Homicide Firearm 3,889	Unintentional MV Traffic 5,558	Unintentional MV Traffic 4,552	Unintentional MV Traffic 5,154	Unintentional MV Traffic 4,134	Unintentional MV Traffic 6,037	Unintentional Poisoning 33,041
3	Homicide Other Spec., classifiable 82	Homicide Unspecified 163	Unintentional Fire/Burn 89	Unintentional Drowning 117	Unintentional Poisoning 3,183	Homicide Firearm 3,331	Suicide Firearm 2,914	Suicide Firearm 4,092	Suicide Firearm 3,387	Unintentional Unspecified 4,596	Unintentional Fall 26,009
4	Unintentional MV Traffic 76	Unintentional Fire/Burn 151	Homicide Firearm 58	Homicide Firearm 107	Suicide Firearm 2,046	Suicide Firearm 2,594	Suicide Suffocation 1,839	Suicide Poisoning 2,061	Unintentional Fall 2,011	Suicide Firearm 4,276	Suicide Firearm 19,392
5	Undetermined Suffocation 39	Unintentional Suffocation 134	Unintentional Suffocation 31	Suicide Firearm 80	Suicide Suffocation 1,824	Suicide Suffocation 1,910	Homicide Firearm 1,673	Suicide Suffocation 1,965	Suicide Poisoning 1,382	Unintentional Suffocation 3,400	Homicide Firearm 11,078
6	Unintentional Drowning 39	Unintentional Pedestrian, Other 103	Unintentional Other Land Transport 26	Unintentional Suffocation 48	Unintentional Drowning 656	Suicide Poisoning 787	Suicide Poisoning 1,279	Unintentional Fall 1,283	Suicide Suffocation 1,130	Adverse Effects 1,544	Suicide Suffocation 9,493
7	Undetermined Unspecified 35	Homicide Other Spec., classifiable 84	Unintentional Pedestrian, Other 20	Unintentional Fire/Burn 46	Homicide Cut/Pierce 420	Undetermined Poisoning 580	Undetermined Poisoning 712	Homicide Firearm 1,097	Unintentional Suffocation 613	Unintentional Poisoning 1,402	Suicide Poisoning 6,599
8	Adverse Effects 22	Unintentional Natural/ Environment 52	Adverse Effects 14	Unintentional Other Land Transport 42	Suicide Poisoning 371	Unintentional Drowning 476	Unintentional Fall 493	Undetermined Poisoning 955	Homicide Firearm 533	Unintentional Fire/Burn 1,088	Unintentional Suffocation 6,165
9	Unintentional Fire/Burn 22	Homicide Firearm 43	Unintentional Natural/ Environment 14	Unintentional Poisoning 40	Undetermined Poisoning 282	Homicide Cut/Pierce 438	Unintentional Drowning 409	Unintentional Drowning 578	Undetermined Poisoning 480	Suicide Poisoning 709	Unintentional Unspecified 5,688
10	Unintentional Natural/ Environment 22	Unintentional Struck by or Against 37	Unintentional Poisoning 14	Unintentional Firearm 26	Unintentional Other Land Transport 221	Unintentional Fall 299	Homicide Cut/Pierce 349	Unintentional Suffocation 464	Unintentional Fire/Burn 479	Suicide Suffocation 648	Unintentional Drowning 3,782

Data Source: National Center for Health Statistics (NCHS), National Vital Statistics System.
Produced by: Office of Statistics and Programming, National Center for Injury Prevention and Control, CDC using WISQARS™.

Centers for Disease Control and Prevention
National Center for Injury Prevention and Control

Auto vs. Pedestrian Injury



Mechanisms of Injury in Children

- Most serious injuries involve blunt trauma to the head
  - Often cause airway and breathing problems due to changes in mental status
- Blunt vs. penetrating trauma
  - Blunt injury about 85% of all trauma injuries
  - Penetrating injury only about 10% of all trauma
  - With blunt trauma, external signs often obscure

High Risk

- Motor vehicle crashes
  - Unrestrained passenger
  - Pedestrian
- Moderate (5-15ft) and high falls (+15ft)
- Diving injuries
- Bicycle crashes without helmet use

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Lower Risk

- Motor vehicle crashes
  - Restrained passenger (seat belt, properly fitted car seat)
- Low falls
  - Age dependent, around 2-4 feet
- Bicycle crashed with properly fitted helmet.

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Important physiological considerations

- Compensatory response to hemorrhage
  - Ability to maintain adequate blood pressure with vasoconstriction and HR until decompensated shock
- Temperature regulation
  - Body surface area to mass larger
  - Loose body heat more easily
- Vital signs vary with age
- Distribution of trauma impact
  - Smaller body mass to dissipate energy of impact
  - Results in potential for internal injury without external signs

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Vital signs

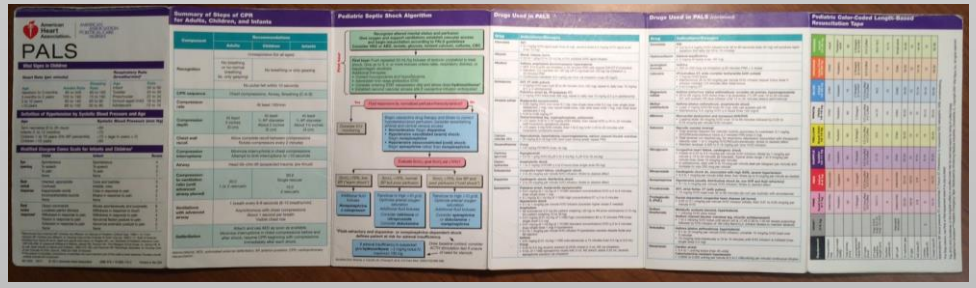
Heart Rate		
AGE	AWAKE RATE	SLEEPING RATE
Newborn to 3 months	85 – 205	80 - 160
3 months to 2 years	100 – 190	75 - 160
2 to 10 years	60 – 140	60 - 90
> 10 years	60 – 100	50 - 90

Respiratory Rate (breaths/min)	
AGE	RATE
Infant	30 - 60
Toddler	24 - 40
Preschooler	22 - 34
School-aged child	18 - 30
Adolescent	12 - 16

Hypotension by Systolic Blood Pressure and Age	
AGE	Systolic BP (mm Hg)
Term neonates (0 – 28 days)	<60
Infants (1 – 12 months)	<70
Children 1 – 10 years	<70 + (age in years x 2)
Children > 10 years	<90

Evaluation of the Pediatric Trauma Patient

- Primary Survey
  - ABCD Exposure
    - iv access: 2 attempts at a PIV
    - Intraosseous line
  - Secondary Survey
  - Adjuncts to resuscitation
    - Broselow tape
    - Code Cards



Weight Estimates

- If weight unknown and Broselow tape not available- can estimate from age:

  - Age < 8 years: (Age x 2) +8 = weight (kg)
  - Age > 8 years: Age x 3 = weight (kg)

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Treatment Priorities

- Urgent pediatric trauma patient: most critical interventions:
  - Airway management
  - Cervical spine precautions
  - Supplemental high-concentration oxygen
  - Assisted ventilation as needed
  - Shock: early recognition and intervention

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Pediatric Airway Management

- Indications for intubation
  - Airway protection
    - Glasgow coma scale < 9
  - Impending respiratory failure
  - Respiratory failure
    - Failure in ventilation
    - Failure of oxygenation
    - Fatigue
  - Impending cardiovascular collapse
  - transport

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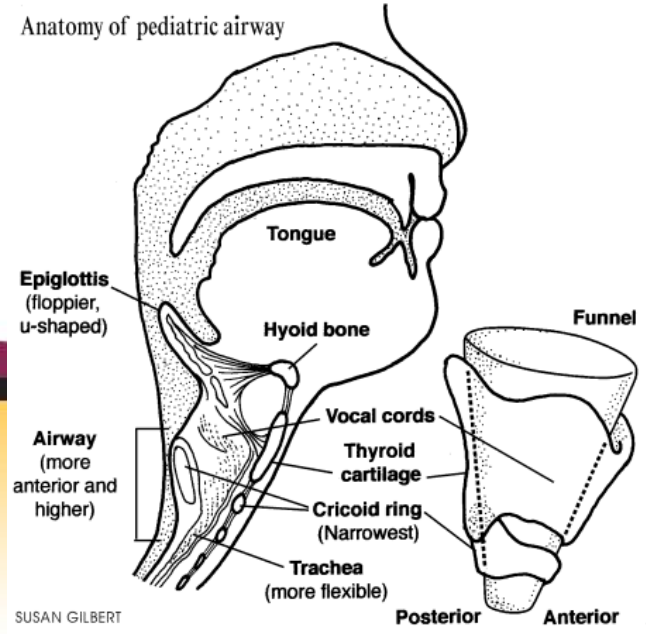
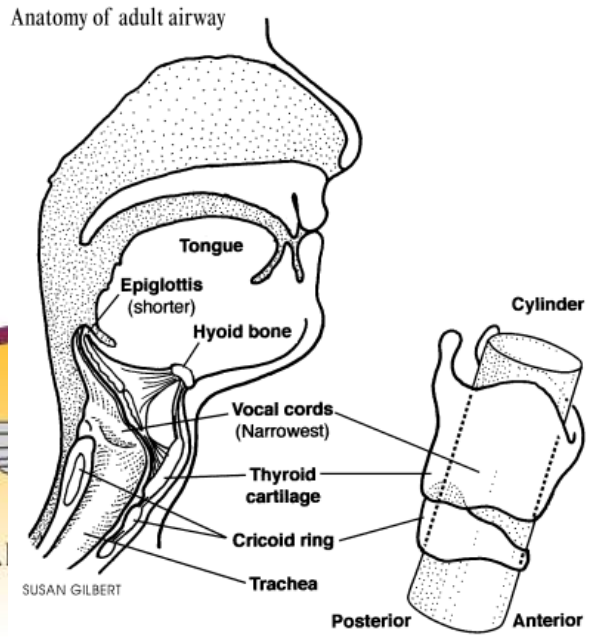
Pediatric Airway

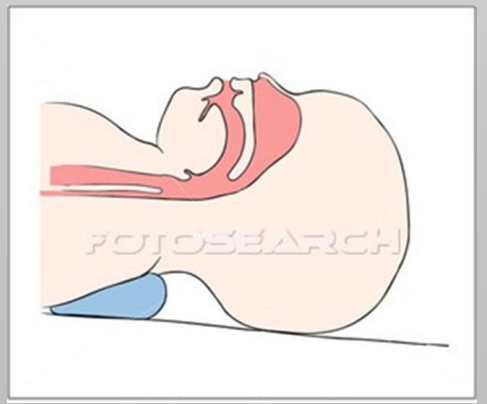
- Airway
  - More anterior vocal cords, larger tongue
  - Smaller overall diameter, cricoid ring is narrowest part
  - Shorter trachea: risk mainstem intubation/ dislodged tube
  - Smaller, narrower, and funnel shaped





Mangement – Airway/Cervical Spine Stabilization

- All else futile if airway control ineffective
  - Goal relieve anatomical obstruction, prevent aspiration, promote adequate gas exchange
- Proper immobilization essential
  - Avoid passive flexion
  - Keep plane of face parallel / sniffing position
  - Maintain neutral alignment: padding
  - Inline traction/stability



Cervical Spine Precautions

- The child has a high-risk mechanism for head or neck injury.
- The child's mental status is anything other than alert, or
- There is evidence of head or neck injury on examination.

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Cervical Spine Precautions

- A cervical collar must be applied before moving patient.
- Prior to applying collar, hold bi-manual stabilization.
- Check the back of the neck for
  - crepitus
  - tenderness
  - muscle spasm

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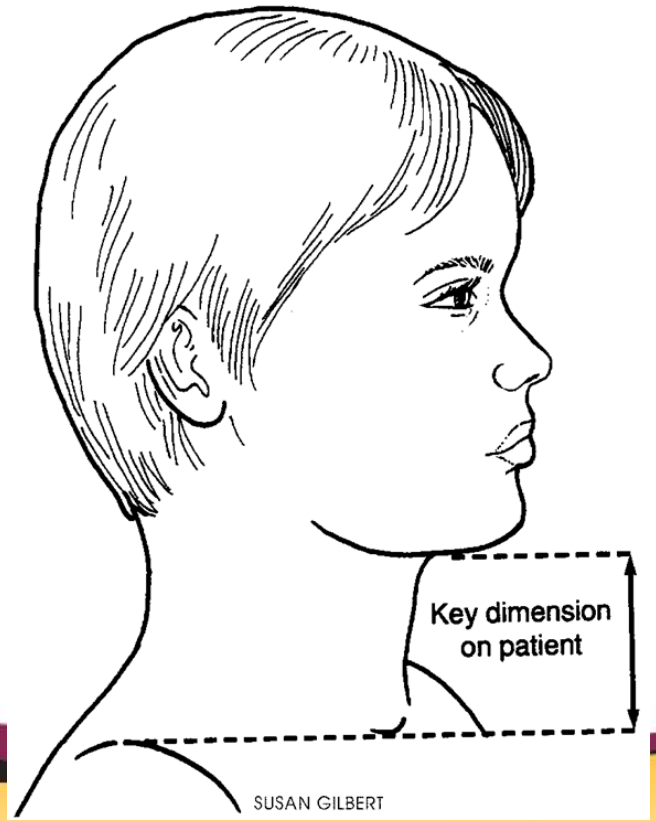
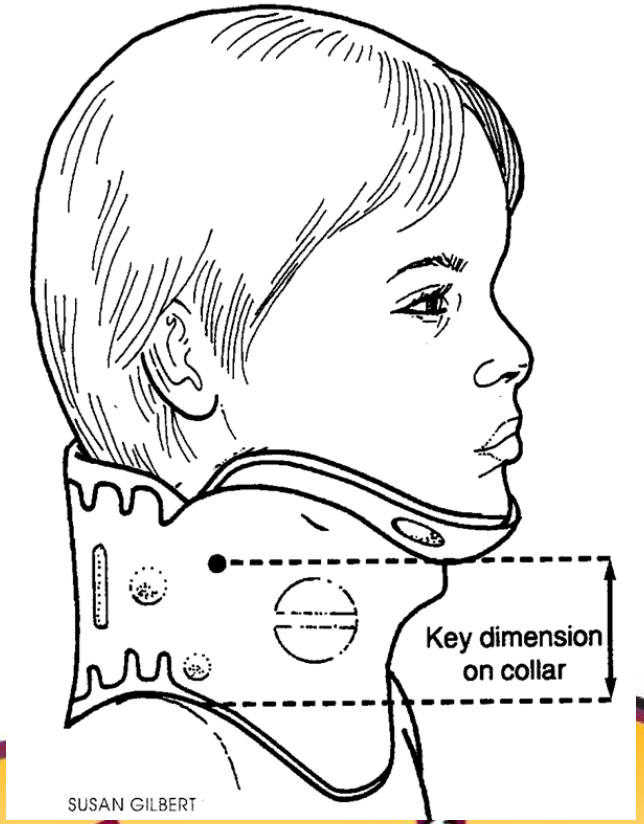
Cervical Collar Sizing

Rigid Collar Sizing

Measure from chin to shoulder for proper sizing



Properly Positioned Collar



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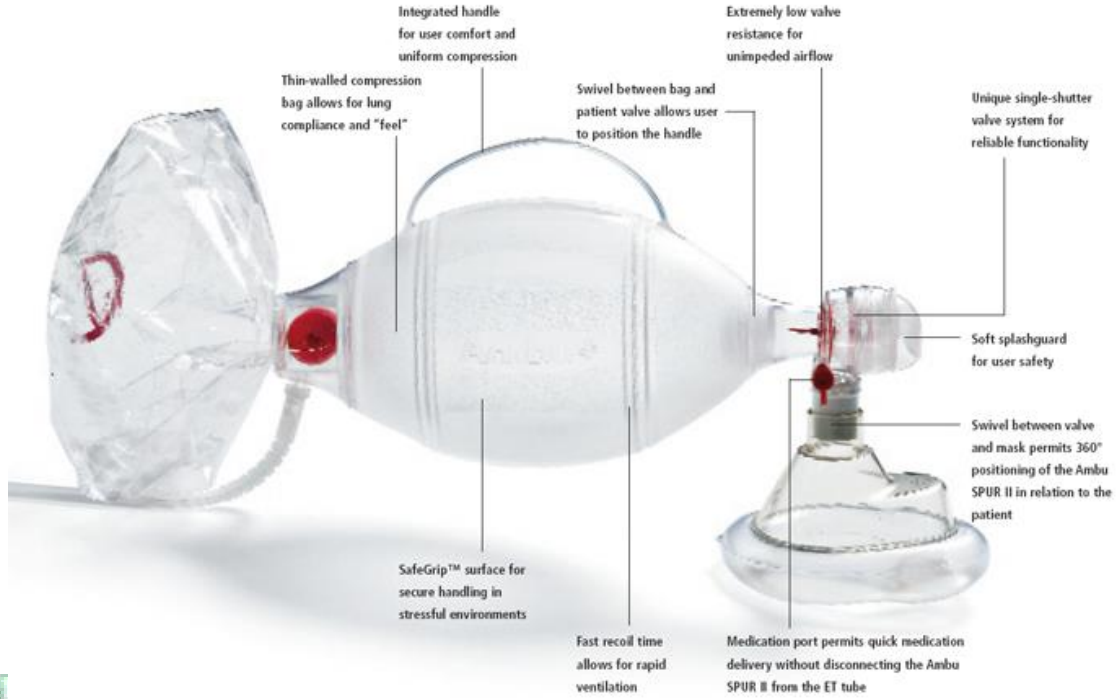
Bag Mask Ventilation



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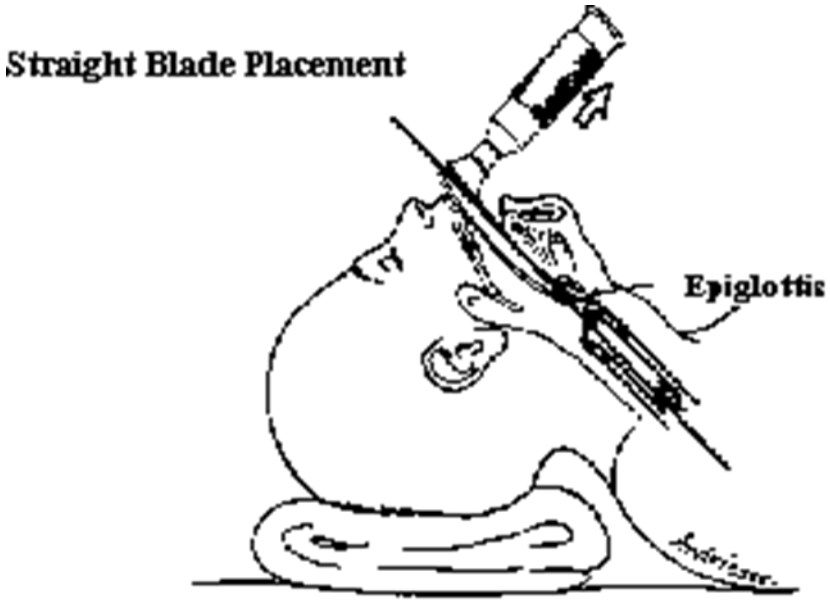
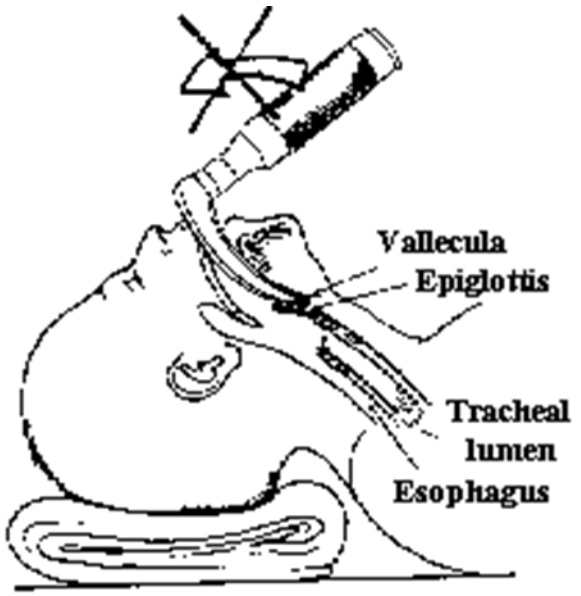
Different Blades



Miller Blade

Macintosh Blade



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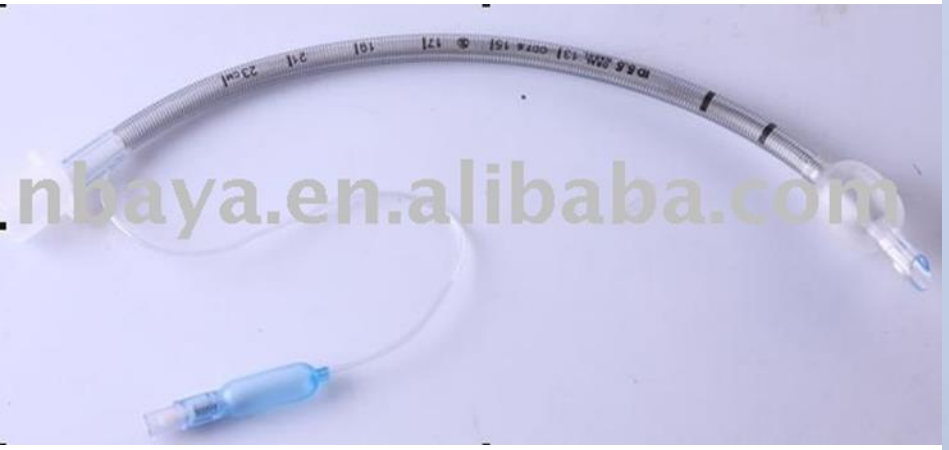
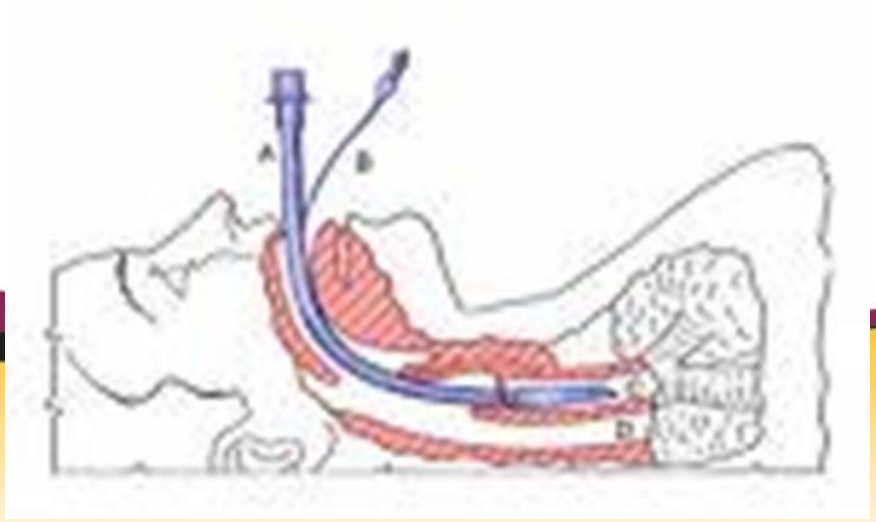
Endotracheal Tubes





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Endotracheal Tube Size

- ETT size:
  4 + (age/4) = uncuffed tube size
  3 + (age/4) = cuffed tube size
- Size of little finger
- Broselow Tape
- Depth of ETT insertion at lips = 3x ETT size

Broselow Tape Guide

Equipment	GRAY* 3-5 kg	PINK Small Infant 6-7 kg	RED Infant 8-9 kg	PURPLE Toddler 10-11 kg	YELLOW Small Child 12-14 kg	WHITE Child 15-18 kg	BLUE Child 19-23 kg	ORANGE Large Child 24-29 kg	GREEN Adult 30-36 kg
Resuscitation bag		Infant/child	Infant/child	Child	Child	Child	Child	Child	Adult
Oxygen mask (NRB)		Pediatric	Pediatric	Pediatric	Pediatric	Pediatric	Pediatric	Pediatric	Pediatric/ adult
Oral airway (mm)		50	50	60	60	60	70	80	80
Laryngoscope blade (size)		1 Straight	1 Straight	1 Straight	2 Straight	2 Straight	2 Straight or curved	2 Straight or curved	3 Straight or curved
ET tube (mm)†		3.5 Uncuffed 3.0 Cuffed	3.5 Uncuffed 3.0 Cuffed	4.0 Uncuffed 3.5 Cuffed	4.5 Uncuffed 4.0 Cuffed	5.0 Uncuffed 4.5 Cuffed	5.5 Uncuffed 5.0 Cuffed	6.0 Cuffed	6.5 Cuffed
ET tube insertion length (cm)	3 kg 9-9.5 4 kg 9.5-10 5 kg 10-10.5	10.5-11	10.5-11	11-12	13.5	14-15	16.5	17-18	18.5-19.5
Suction catheter (F)		8	8	10	10	10	10	10	10-12
BP cuff	Neonatal #5/infant	Infant/child	Infant/child	Child	Child	Child	Child	Child	Small adult
IV catheter (ga)		22-24	22-24	20-24	18-22	18-22	18-20	18-20	16-20
IO (ga)		18/15	18/15	15	15	15	15	15	15
NG tube (F)		5-8	5-8	8-10	10	10	12-14	14-18	16-18
Urinary catheter (F)	5	8	8	8-10	10	10-12	10-12	12	12
Chest tube (F)		10-12	10-12	16-20	20-24	20-24	24-32	28-32	32-38

Abbreviations: BP, blood pressure; ET, endotracheal; F, French; IO, intraosseous; IV, intravenous; NG, nasogastric; NRB, nonrebreathing.

*For Gray column, use Pink or Red equipment sizes if no size is listed.

†Per *2010 AHA Guidelines,* in the hospital cuffed or uncuffed tubes may be used (see below for sizing of cuffed tubes).

Pediatric Color-Coded Length-Based Resuscitation Tape

Rapid Sequence Intubation

- Pre-oxygenate with 100% oxygen
- Pre-medications:
  - Atropine: 0.02mg/kg (up to 6 yrs) (min 0.1mg)
  - Consider Lidocaine: 1mg/kg
- Sedatives:
  - *Etomidate: 0.3mg/kg*
  - Others: fentanyl, midazolam, ketamine
- Paralytics:
  - Succinylcholine: 2mg/kg
  - Rocuronium : 0.6 – 1 mg/kg

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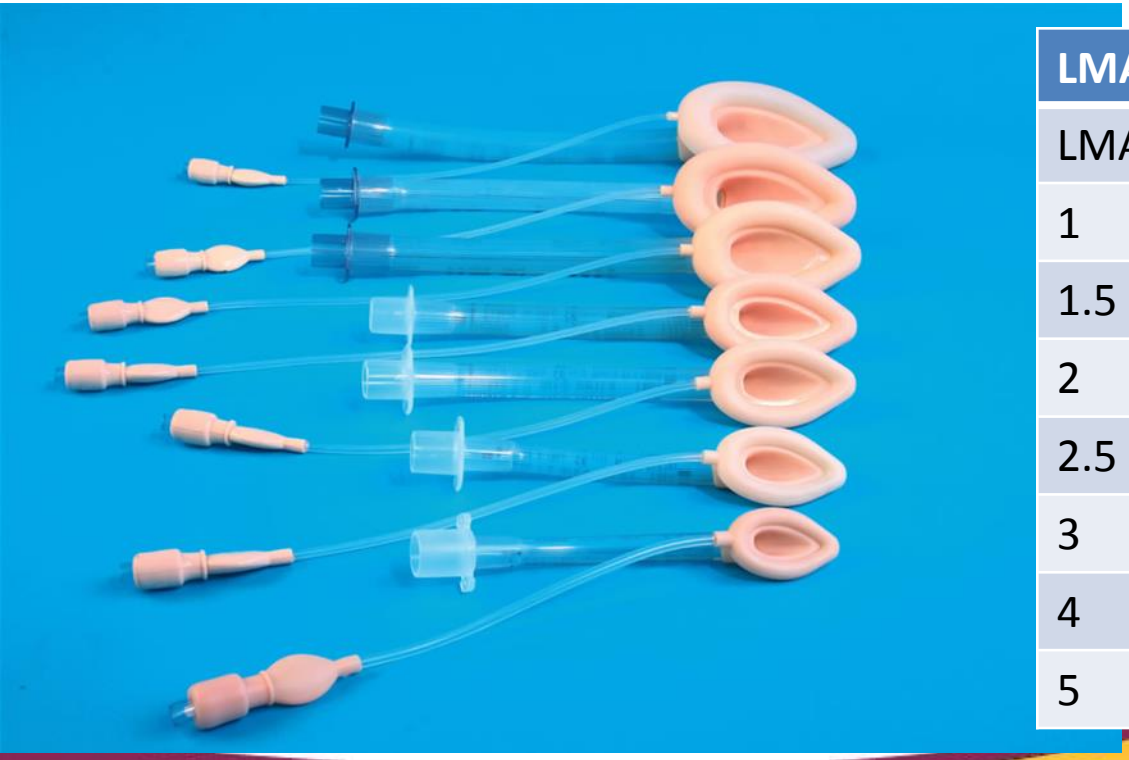
Laryngeal Mask Airway
for difficult or failed airway



LMA size and patient weight	
LMA SIZE	Patient Weight (kg)
1	< 5
1.5	5 - 10
2	10 - 20
2.5	20 - 30
3	30 - 50
4	50 - 70
5	> 70

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Breathing

- Poor compensation for associated respiratory derangements
  - Larger oxygen consumption
  - Smaller functional residual capacity
  - Less pulmonary compliance/ greater chest wall compliance
  - Horizontally aligned ribs- diaphragm breathers
- **Remember: Kids die from hypoxia and respiratory arrest!!!**

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Breathing - Management

- Inadequate ventilation
  - Abnormal respiratory pattern
  - Cyanosis
  - Clinical evidence of hypercapnia: increased sympathetic tone
- Avoid hypercarbia/hypoxia/hyperventilation
- Persistent desaturations
  - Re-evaluate for asymmetry: pneumothorax
  - Check tube position
- Consider open chest wounds

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Circulatory Status

- Children are able to maintain normal blood pressure despite significant blood loss
  - Decompensated shock (low blood pressure) represents severe blood loss
  - Hypotension is a late sign of volume depletion
- Total blood volume
  - Neonates: 90cc/kg
  - Infants/Children: 80cc/kg
- Evaluation
  - Blood pressure
  - Heart rate, irritability (mental status), respiratory rate will increase with acidosis
  - Capillary refill, skin perfusion, urine output

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Determining Blood Pressure in Children

- **Normal systolic blood pressure in children**
  90 + 2(age in years)
  Example: in a 4 year old
  90 + 2(4) = 98 systolic BP

- **Hypotension (decompensated shock)**
  70 + 2(age in years)
  Example: in a 3 year old
  70 + 2(3) = 76 systolic BP

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Fluid resuscitation

- Isotonic crystalloid for fluid boluses (Normal Saline or Lactated Ringers)

- 20 cc/kg boluses – give fluid boluses rapidly over 10-15 minutes if patient is hypotensive
- Search for source of blood loss

- If patient remains hypotensive after two 20 cc/kg boluses of isotonic crystalloid, transfuse packed red blood cells 10 cc/kg

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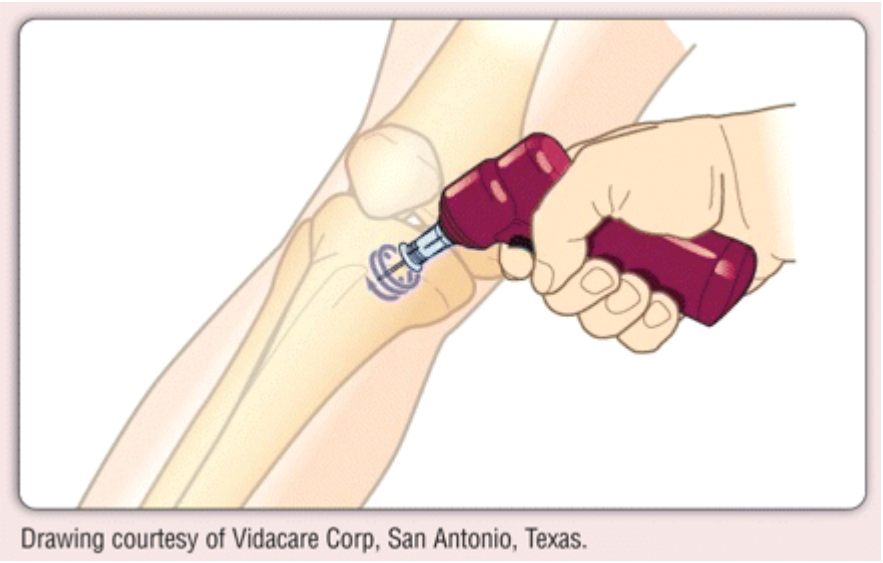
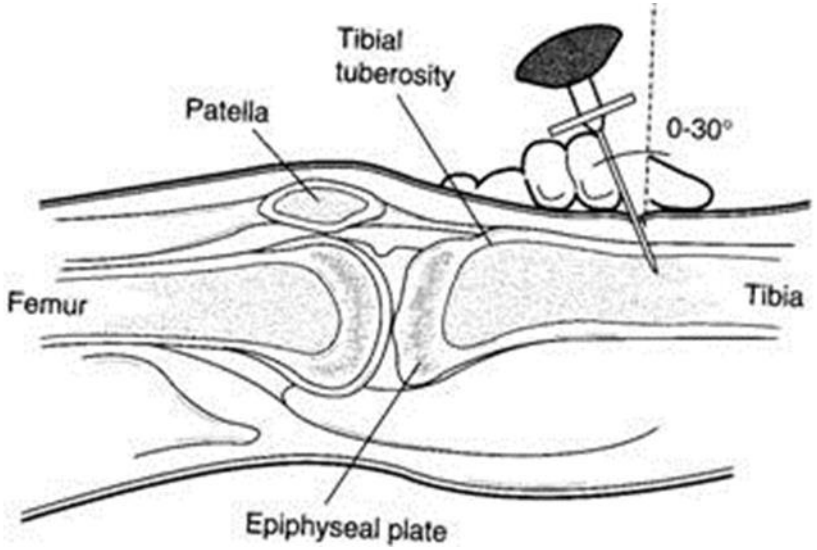
IV Access


Drawing courtesy of Vidacare Corp, San Antonio, Texas.



- Best site of insertion: proximal tibia
- Can infuse crystalloid, drugs, blood through IO needle
- Various types of needles will work
  - 16 gauge hypodermic needle
  - spinal needle,
  - bone marrow needle

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IO line technique

- Use of a 3-way stopcock will allow you to push fluids faster into a pediatric patient who needs rapid fluids

- Contraindications:
  fracture of bone,
  skin infection over site of insertion
  prior attempt in that bone

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Disability: Glasgow Coma Scale

Modified Glasgow Coma Scale for Infants and Children†

	Child	Infant	Score
Eye opening	Spontaneous	Spontaneous	4
	To speech	To speech	3
	To pain	To pain	2
	None	None	1
Best verbal response	Oriented, appropriate	Coos and babbles	5
	Confused	Irritable, cries	4
	Inappropriate words	Cries in response to pain	3
	Incomprehensible sounds	Moans in response to pain	2
	None	None	1
Best motor response‡	Obeys commands	Moves spontaneously and purposely	6
	Localizes painful stimulus	Withdraws in response to touch	5
	Withdraws in response to pain	Withdraws in response to pain	4
	Flexion in response to pain	Abnormal flexion posture to pain	3
	Extension in response to pain	Abnormal extension posture to pain	2
	None	None	1

Exposure and Temperature Regulation

- Higher body surface to mass ratio
- Children have thinner skin, smaller fat stores
  - Loose heat easily
  - Greater risk of hypothermia
- Hypothermic infants are more difficult to resuscitate
- Prevention / treatment
  - Infuse warmed IV fluids
  - Use warm blankets
  - Monitor temperature frequently
  - Keep the rig warm!

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Head Trauma

- Leading cause of death in pediatric trauma
- 85 – 90 % are minor GCS >12
- Larger head to body ratio
  - greater risk of injury, more falls onto head
- Initial exam may be misleading, ICH occurs over time

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Head Trauma

- Anatomical difference kids vs. adults
  - Skull bones are thinner
    - greater transmission of force to the brain
  - Infants with fontanelles/open sutures
    - Edema without ICH
  - Soft cranium
    - Parenchymal injury without fractures
  - Less myelin
    - Increased risk affect from shearing forces
  - Vascular scalp
    - can hemorrhage from scalp in small children

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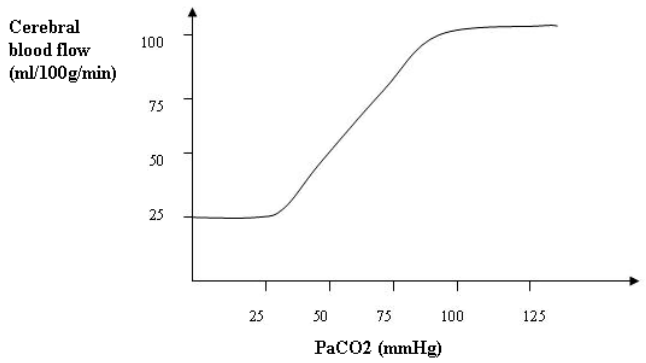
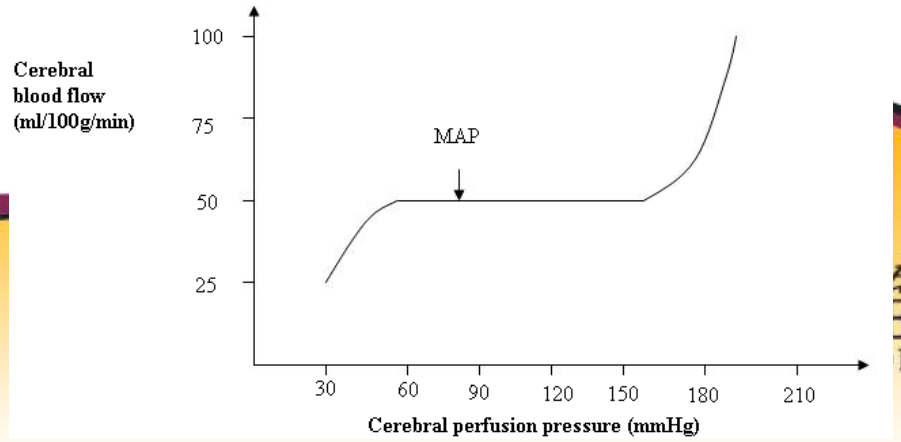
CNS Injury

- Variable Presentation
  - Altered mental status: LOC , irritability
  - Full fontanelle, split sutures, palpable deformities
  - Ecchymosis, hematomas
  - Asymmetrical, dilated or non-reactive pupils
  - Sun setting eyes, disconjugate gaze
  - Rapid deterioration vs. completely normal
    - GCS not good predictor in infants: trust overall exam

CNS Injury - Management

- Avoid hypoxic ischemic event
  - Maintain adequate oxygenation and ventilation
    - Do not hyperventilate/hypoventilate
  - Intravascular volume resuscitation
  - Maintain MAP: (CPP = MAP – ICP)
    - >70 adolescent
    - >60 child
    - >50 infant
- Isotonic fluids
- Optimal ventilation
- Control glucose load
- ICP precautions
- Osm therapy





Chest Trauma

- Occur in 6% of pediatric trauma victims
- Major contributor to mortality
- 90% related to blunt trauma
- Marker for injury severity

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Chest Trauma

- Decreased respiratory compensation to thoracic trauma
  - Young children: breathing physiology - diaphragm breathers
  - Crying can lead to stomach distension – reduced ability to move diaphragm
  - Higher metabolic demands and larger oxygen consumption
  - Smaller functional reserve capacity

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Chest Trauma

- Pulmonary Contusion
  - Most common type of thoracic injury in children
  - Injury worsens over initial 24 hours
- Rib Fractures
  - Due to flexible chest wall (cartilage), rib fractures are less common
  - Higher energy needed to cause rib fractures
- Pneumothorax / Hemothorax
  - Size of chest tube = ETT x 4 (rough estimate)
- Mediastinum is more mobile
  - Tension pneumothorax poorly tolerated
- Aortic injuries rare in children

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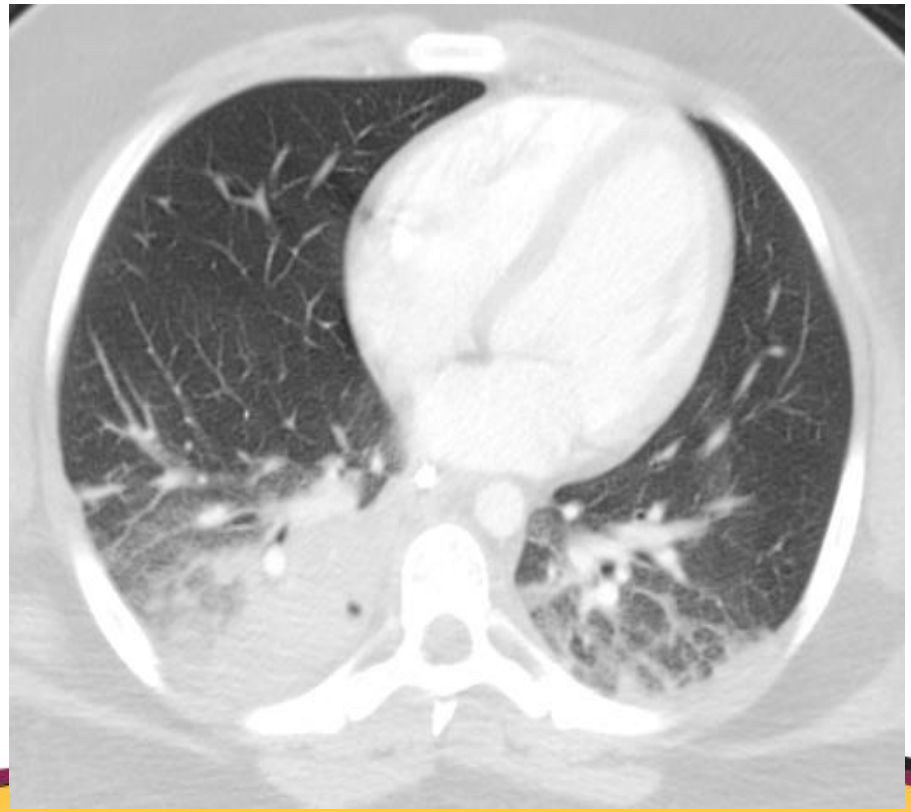
Life – threatening Injuries to the Chest

- Airway injury
- Tension pneumothorax /Massive hemothorax
  - Tension pneumo leads to hemodynamic instability
  - Tracheal deviation, acute respiratory distress, hemodynamic instability not explained by hemorrhage
- Cardiac injury and tamponade
  - Chest pain, dysrhythmias, myocardial dysfunction
  - Sudden death: Commotio Cordis
  - Cardiac tamponade: obstructs venous return and cardiac output
  - Beck's Triad: pulsus paradoxus, quiet precordium, distended neck veins
  - Unexplained tachycardia in the younger child
- Rib fractures / Flail chest: lost continuity with thorax
  - Paradoxically movement- in inspiration, out expiration
  - Requires controlled mechanical ventilation; intubation in the field

- 14 y/o thrown from bed in house explosion
  - Alert and talking at scene
  - Became dyspenic in ED
  - Intubated for respiratory failure
  - Bilateral pulmonary contusions



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Abdominal Trauma

- Ribs are more flexible in children
  - provide less protection for liver, spleen, kidneys
- Pelvic organs intra-abdominal in infants & toddlers – greater exposure to impact
- Indicators of intra-abdominal injury:
  - Abdominal tenderness (more difficult to assess in smaller children); hypotension, femur fracture, lower rib margin tenderness
  - Laboratory testing: AST, ALT, HCT, amylase, urinalysis
- FAST ultrasound exam can be used to screen for needing CT scan in a low risk patient

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Pediatric Abdominal Trauma: Kids aren't little adults

- Duodenal hematoma
  - Underdeveloped abdominal muscles + bicycle handlebars
- Small bowel perforation at ligament of Treitz, mesenteric and small bowel avulsions
  - Often diagnosed late
- Bladder rupture
  - Shallow pelvis

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Spinal Trauma in Children

- Cervical spine injuries less common than in adults
- Children have weaker neck muscles and larger, heavier head
- Location of injuries dependent on age
  - Age < 8 years: C_1 - C_2
  - Age $\geq$ 8 years: lower cervical injury C_5 - C_7
- Pseudosubluxation: C2-C3 or C3-C4
  - Common variant in children < 8 years
  - Posterior laminar line (Swischuck) < 1 mm off

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Spinal Trauma

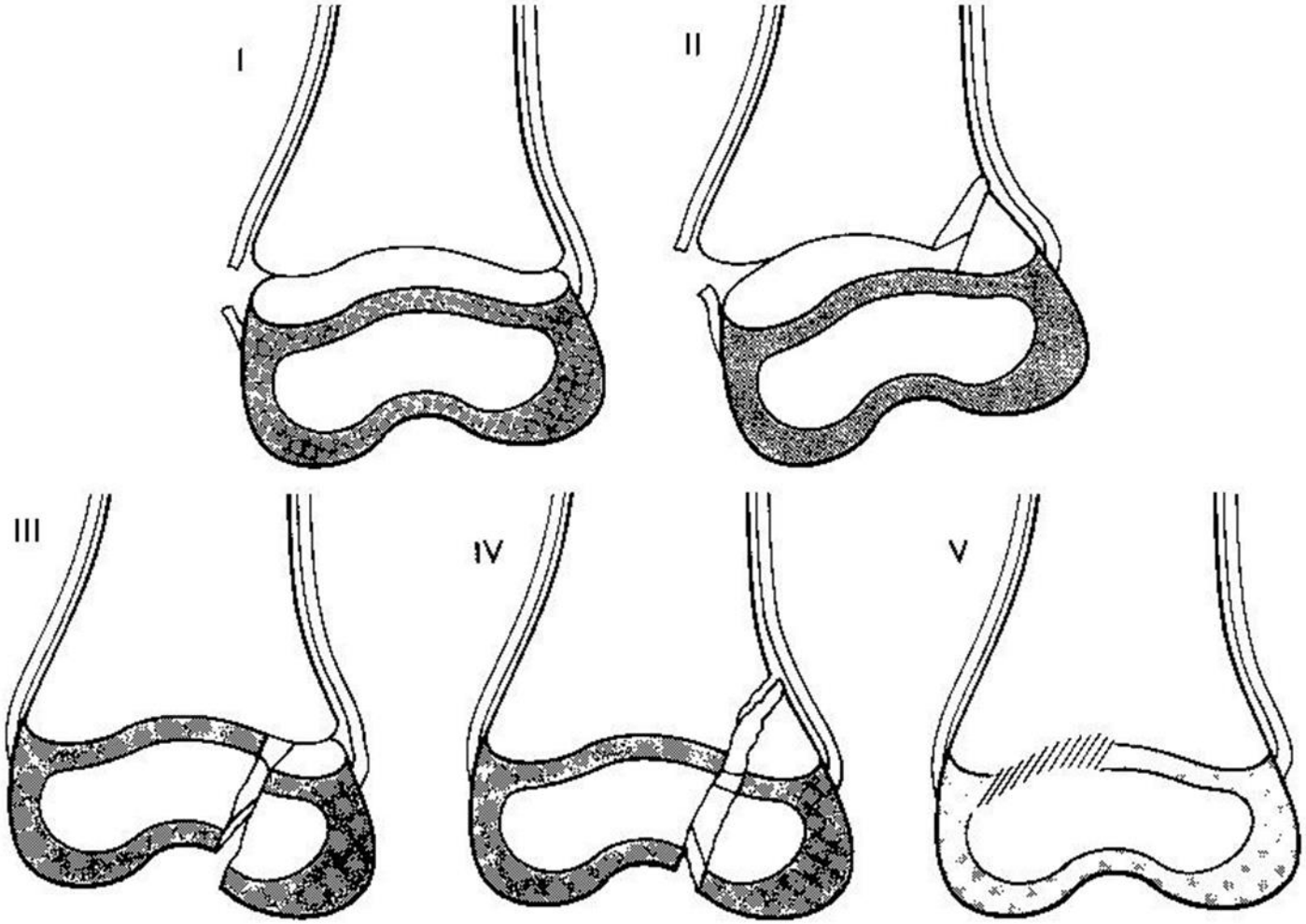
- SCIWORA: Spinal Cord Injury without Radiographic Abnormality
  - Less rigid anatomy of pediatric spinal column
  - Sudden forceful neck flexion/extension -> potential for spinal cord injury
  - Age up to 15 years
  - Suspect if there are bilateral paresthesias (electric shock sensation), or brief motor or sensory deficits
  - Similar to “Central Cord Syndrome” in adults
  - Neurologic symptoms are more prominent in the upper extremities than lower extremities
  - Treatment with methylprednisolone is controversial

Pediatric Orthopedic Injuries

- Children have different fracture patterns
- Growth plates
  - Complicates radiologic assessment
    - Salter Harris system of classification
- Ossification centers
  - Also makes radiologic assessment difficult

Torus or buckle fracture of distal radius

Growth Plate Fractures: Salter Harris Classification System



Non-accidental Trauma: Abuse

- Always consider abuse when the history is inconsistent with the traumatic findings
- Specific injuries:
  - Rib fractures in an infant
  - Distal metaphyseal fractures
  - Spiral long bone fractures in a child who cannot walk
  - Retinal hemorrhages on fundiscopic exam
  - Unusual burn patterns

Ten History "Red Flags" for NAT

1. Injury unexplained by history
2. Absent, changing, or an evolving history
3. Delay in seeking medical care
4. Unusual affect of caregiver
5. Triggering event causing loss of control in caregiver
6. Unrealistic expectations of child
7. Crisis or stress in child's environment
8. Social or physical isolation of child or the family, caregivers
9. Pattern of increasing severity or escalation of event over time
10. Prior history of abuse of caregiver as child

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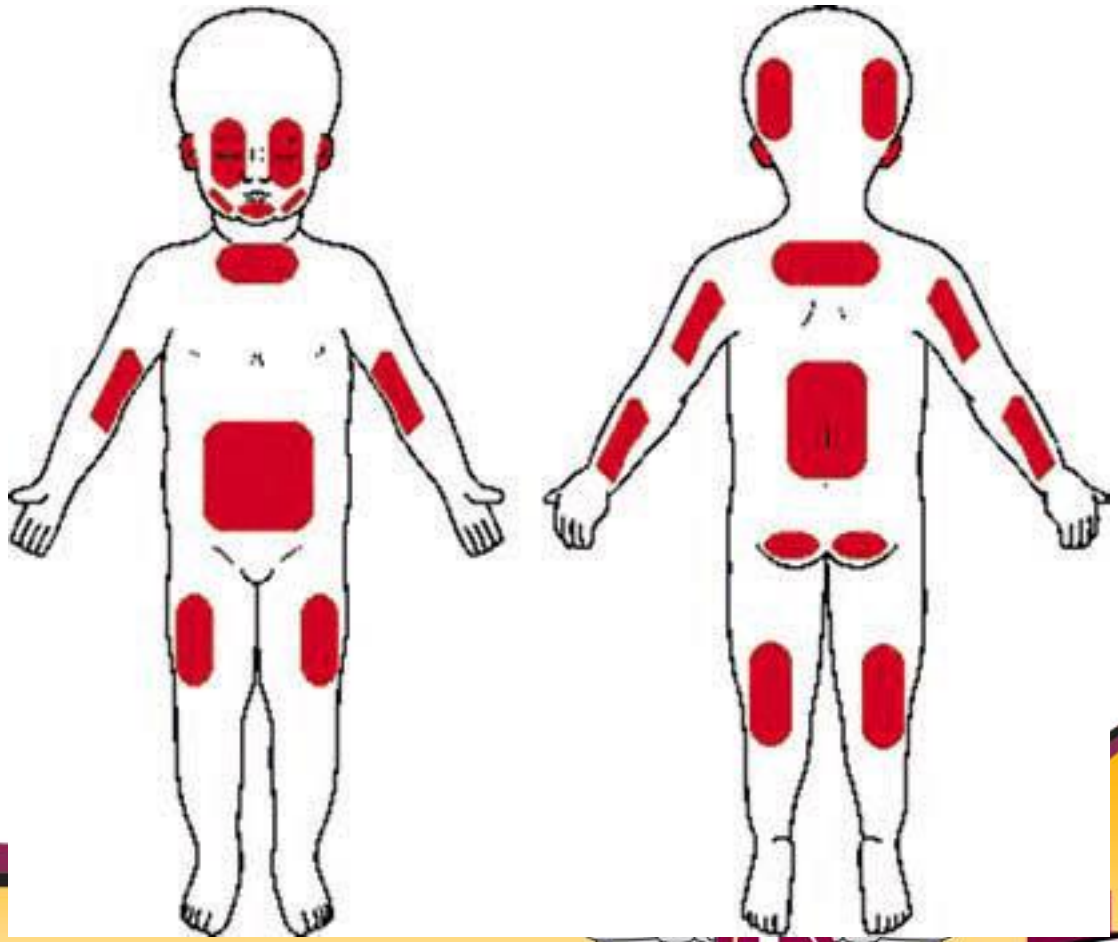
From Sirotnak: Western States Pediatric Trauma Conference

Abusive Bruising Patterns



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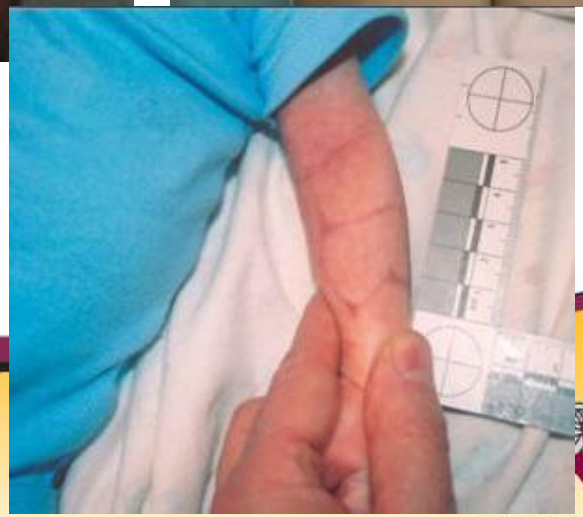
Maguire S Arch Dis Child Educ Pract Ed 2010;95:170-177

Bruises with recognizable patterns



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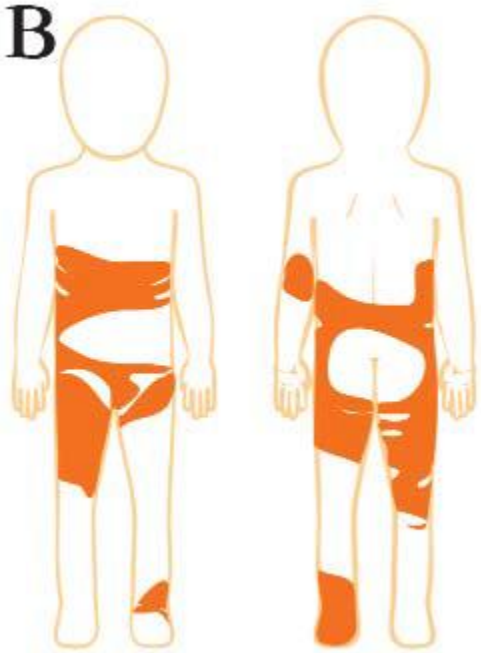
Pattern of abuse related burns



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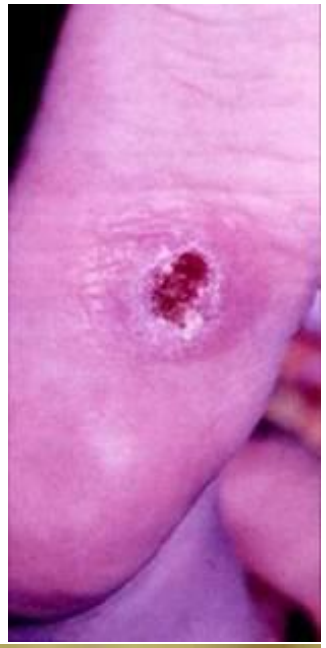
Inflicted Burns



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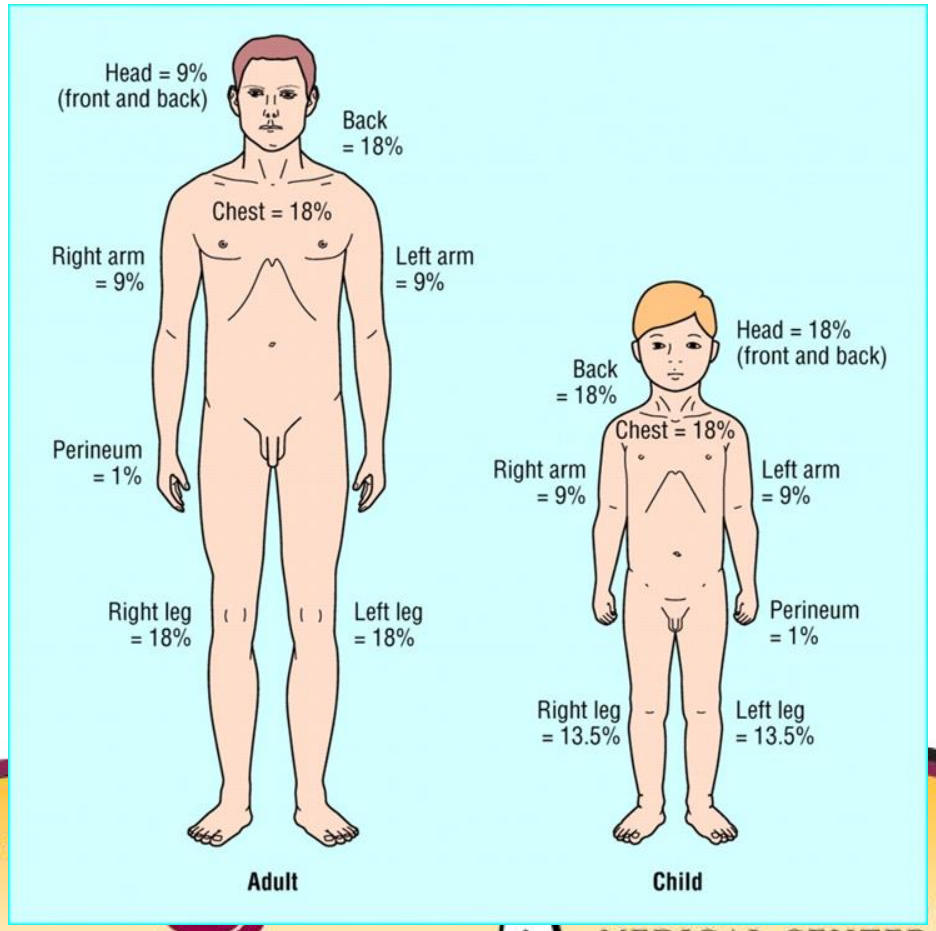
Special Considerations: Pediatric Burn Fluid Resuscitation

- Calculate Total Body Surface Area Burned (%TBSA)

- Palmar surface of hand including fingers =1%



Burn fluid resuscitation

- **Calculate Fluid Resuscitation**
  Adults (> age 15): Ringers Lactate 2-4 cc/kg x %TBSA burn
  Children (4-15 yr): Ringers Lactate 3-4 cc/kg x %TBSA burn
  Infants and Young Children (age < 4 years):
  Ringers Lactate 3-4 cc/kg x % TBSA burn
  AND ADD MAINTANCE FLUID OF D5LR

- **Administer Fluid**
  - Infuse ½ calculated volume over 1st 8 hours after burn
  - Infuse next ½ calculated volume over next 16 hours

- **Monitor Urine Output**
  - Patients > 30 kg: 30-50 cc/hr (0.5 cc/kg/hr)
  - Infants and children: 1 cc/kg/hr

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Pediatric Drowning

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Drowning Terminology

- Dry
- Wet
- Active
- Silent
- Secondary
- Near-drowning

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Drowning Terminology

- Dry
- Wet
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- Silent
- Secondary
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OUTDATED!!!!

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World Congress on Drowning

expert consensus in 2002

"'Drowning' is now defined as the process resulting in primary respiratory impairment from submersion/immersion in a liquid medium"

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M is for Maud who was swept out to sea.

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Pathophysiology of Drowning

Struggle to surface

Voluntary breath-holding

Panic!

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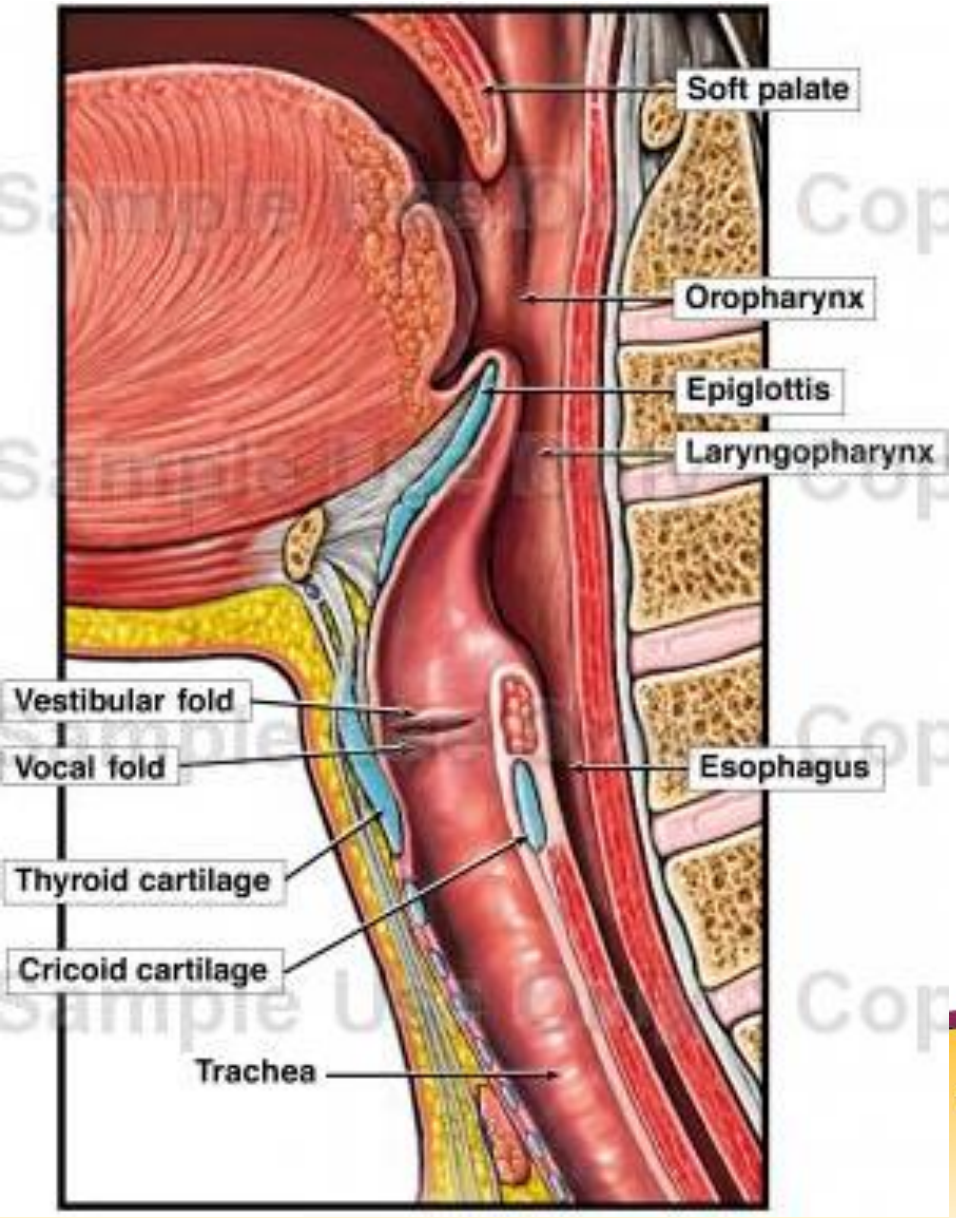

- Small aspiration
  - Laryngospasm
  - Hypoxia
- Swallow water
- Hypoxia continues
- Loss of laryngospasm*
  - Aspiration of large volumes of water
- Vomiting/aspiration of gastric contents

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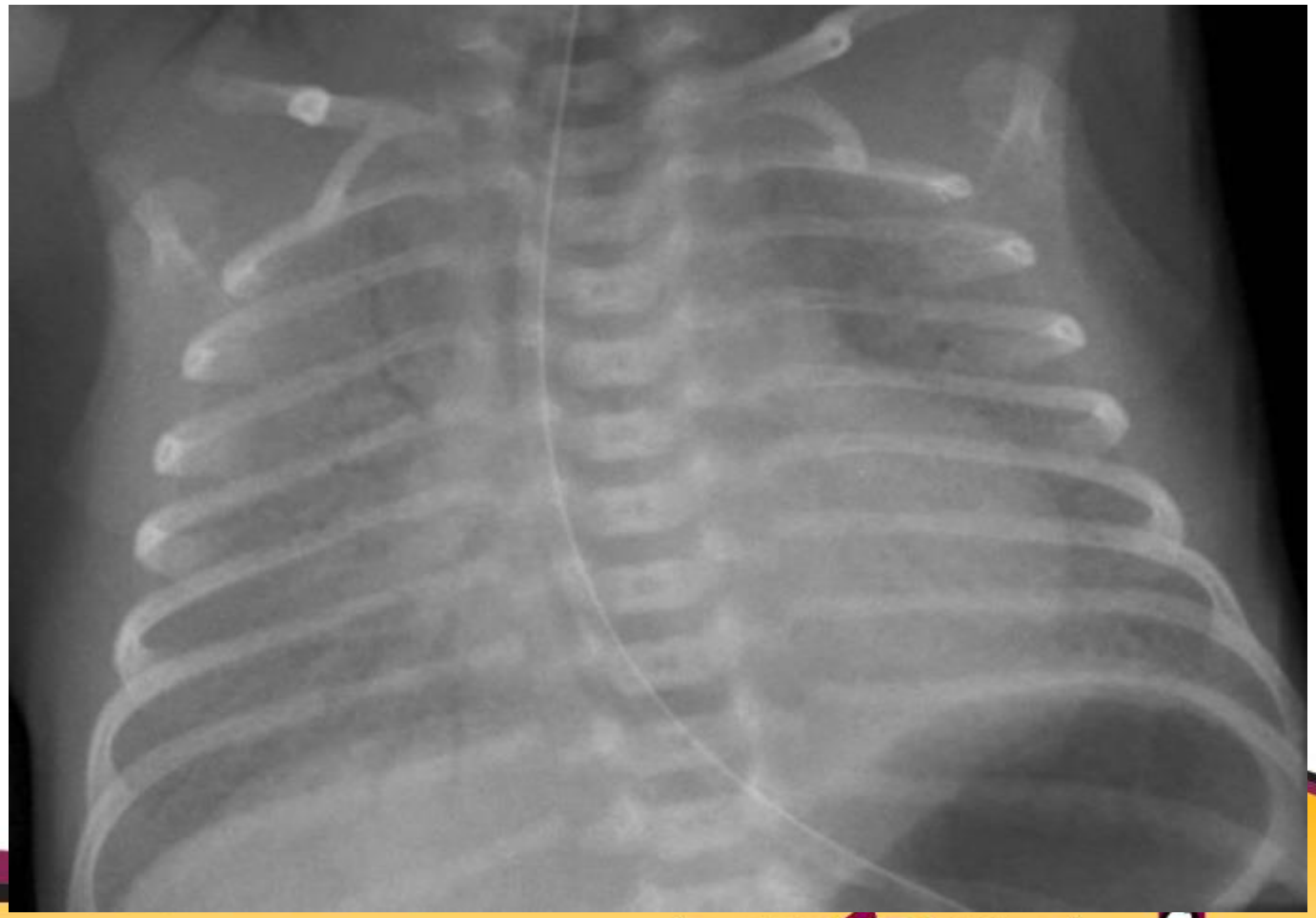
Acute Respiratory Distress Syndrome



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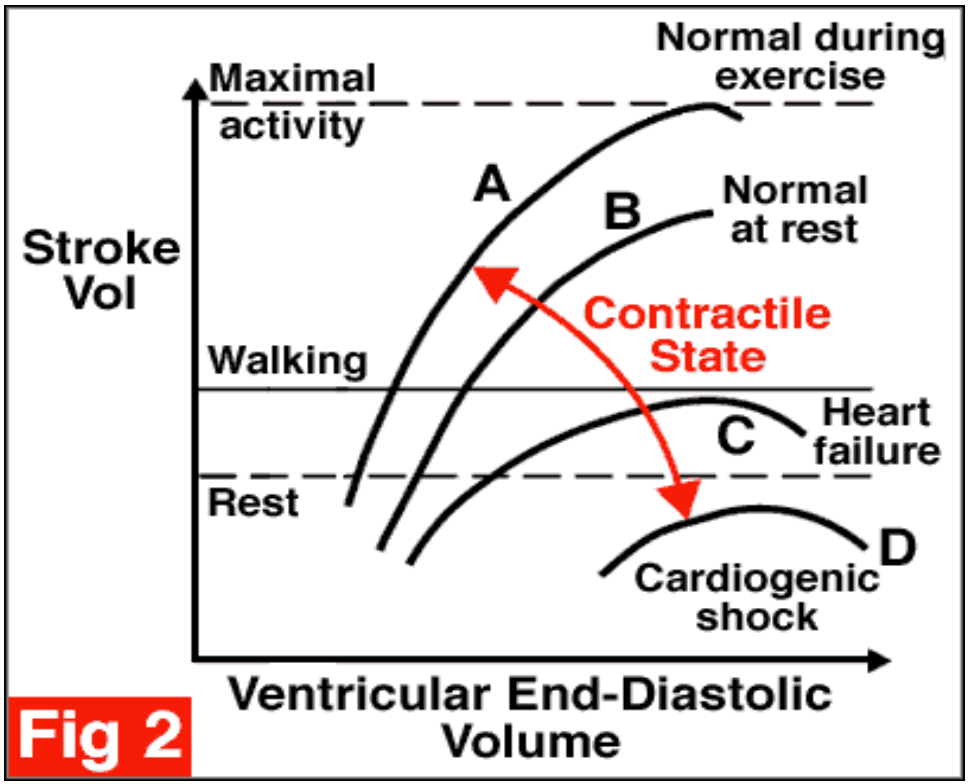
Cardiovascular impairment

- Hypoxia
  - ↓Cardiac Output
  - ↑Right/Left filling pressures
  - ↑SVR, PVR
  - ↓↓CO
  - ↓MAP
- Hypothermia
  - Diuresis
  - Exacerbates ↓CO



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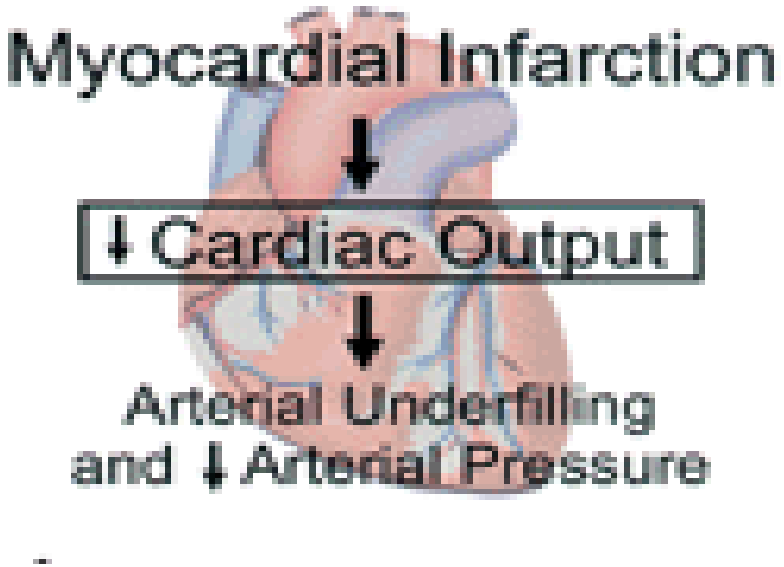

- Myocardial ischemia
  - Cardiac injury
    - Coronary arterial vasospasm
    - Focal myocyte injury
- Cerebral hypoxia and ischemia
- Diffuse end-organ injury

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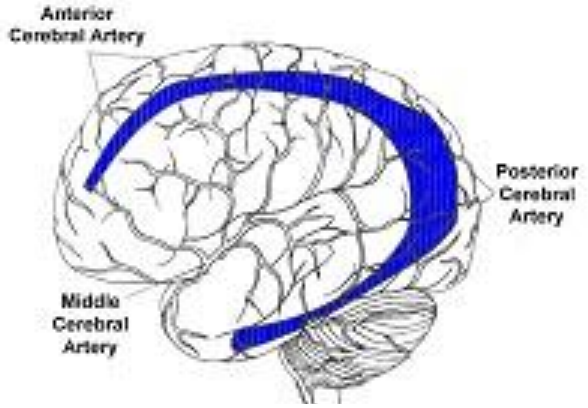
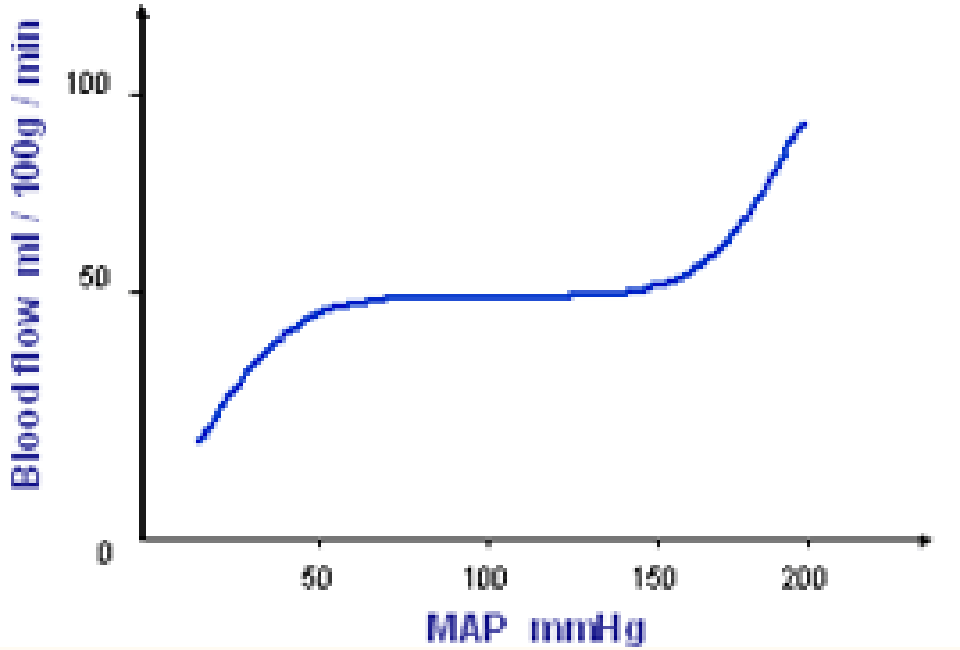
CNS Injury

- Hypoxia
  - Occurs early
  - Global insult
- Ischemia
  - ↓ CO
  - ↓ MAP
  - ↓ cerebral blood flow
- Majority of injury occurs with initial insult





Cold Water Drowning <10 C

- Stories of prolonged immersion with complete recovery
- Rare
- Unknown mechanism
  - Mammalian dive reflex
    - Apnea
    - Bradycardia
    - Intensive vasoconstriction
- Benefits in humans not clear…

OUTCOMES

- Four defined clinical outcomes:
  - Full recovery
  - Neurological impairment
  - Persistent vegetative state
  - Death

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Scene

- Limited data
- Reports of survivors who received CPR
- Hypothermia poor predictor

- Conclusions:
  - Even severely hypothermic patients should have resuscitation initiated

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ED:
Several studies, limited data

- Orlowski's scoring system:
  - Age < 3yrs
  - Submersion > 5 min
  - Resuscitation delayed > 10 min
  - Coma at ED
  - Arterial pH < 7.1
- 2 or less factors: 90% full recovery
- 3 plus: 5%

- Christensen's clinical classification
  - Physical exam (apnea and coma)
  - CPR in ED
  - pH < 7.0
- 93% overall accuracy
- But could not accurately discriminate intact from poor outcome

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ED:
Conclusions

- Resuscitation initiated in all patients in ED

- Risk/Benefit?
  - Loosing patients with unpredicted good outcome
  - Prolonging death or survival of patients with devastating neurologic outcomes
- Need to have accurate information about event when deciding how aggressive to be

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PICU

- Bratton: spontaneous, purposeful movements within 24 hours of submersion = good outcome!
  - If no such movements, severe deficit or death

- GCS $\leq$ 5 on arrival to ICU: predictive of poor neurologic outcome
- GCS > 5 at ED or ICU: highly predictive of good neurologic outcome
- Repeated clinical neuro exams help prediction of outcome

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Outcome Summary

- Precise neurologic prognosis difficult early
- What suggests poor outcome?
  - Prolonged CPR
  - Fixed and dilated pupils
  - GCS of 3
- What suggests good outcome?
  - Scoring in ED
  - **Spontaneous, purposeful movements w/in 24hrs**

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Conclusions

- There are many differences in the anatomy, physiology and assessment of the pediatric trauma patient
- The ABCDE's however, remain similar
- Pediatric tools can help in the initial care
- Child abuse must always be on the radar
- Drowning events are common and devastating in the pediatric population

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