Summary: The care of emergency problems involving the airway, breathing, or circulatory systems (ABC) can be challenging in any patient population or setting. These can be particularly challenging when managing pediatric patients in an austere environment. The recent combat operations in Iraq and Afghanistan have provided a generation of military surgeons with a large body of experience in providing care for severely ill or injured pediatric patients. Many of these issues are not specific to the combat environment, and may be encountered at any facility or setting not ideally equipped and staffed for high-level pediatric care. Although the general approach to these emergent problems should follow a similar approach to that outlined for adults, there are many subtleties that must be appreciated in pediatric patients that can greatly impact the efficacy, risk of complications, and ultimate outcomes. This syllabus highlights the key issues, concerns, and practical advice for the provider who is faced with managing ABC problems in the emergency pediatric. Specific focus will be paid to high yield "tips and tricks" and also to "potential pitfalls" in each area.

The Setting: A Desert is a Desert

- Remote, rural location
- Limited personnel and resources
- No pediatric specialists (YOU are the peds doc)
- Not equipped or supplied for pediatric care
- Limited options for immediate transfer or help
- Severe injury/illness that needs immediate intervention
- Co-existing malnutrition, other diseases

Is this at all applicable to the U.S.?
I. Key Points and Pitfalls for Pediatric ABC Emergencies

AIRWAY
1. A patent airway is hard to improve upon – if the patient is moving air and maintaining oxygen saturation, don’t rush to attempt intubation unless you are fully prepared
2. Don’t forget simple maneuvers first – suction, chin lift/jaw thrust, and oral/nasal airway
3. Bag-valve-mask ventilation works great in almost all pediatric patients and can provide completely adequate temporary oxygenation and ventilation
4. Don’t compromise exposure, evaluation, and ability to intubate due to c-spine concerns. Remove the collar and do what you have to do to secure the airway
5. Expect bradycardia with intubation, and either give atropine or have it ready
6. A surgical airway will fail without adequate lighting and a good assistant to retract/expose
7. A needle cricothyrotomy can buy you time with oxygenation but will not provide good ventilation. Avoid open cricothyrotomy in children if at all possible
8. Have a “difficult airway” cart prepared and available for airway emergencies
9. A Broselow tape is one of the most important aids to emergency pediatric care

BREATHING
1. Assessment for breathing emergencies in children is challenging – look for tachypnea, nasal flaring, intercostal retractions, and abdominal breathing
2. Lung sounds can be present even with a significant pneumothorax, particularly in intubated patients receiving positive pressure ventilation
3. Suspected tension physiology should prompt immediate decompression with either a needle thoracostomy or chest tube
4. The treatment for a “sucking chest wound” is a chest tube first, then deal with the wound
5. A normal upright chest x-ray effectively rules out a pneumothorax or hemothorax as the source of any respiratory distress or hemodynamic instability
6. Ultrasound for pneumothorax and hemothorax is easily integrated into the FAST exam, and can be more reliable than even chest x-ray
7. Chest tubes can kink, clog, or be in the wrong position (or even wrong body cavity); always confirm position on xray and troubleshoot to endure adequate function

CIRCULATION
1. Hypotension is a very late finding in children with circulatory shock; do not rely on a normal blood pressure as a marker of stability
2. Marked or worsening tachycardia is a red flag that there is ongoing bleeding or volume losses
3. A rapid prioritized search for the source of shock can be done in minutes (see Appendix A)
4. Control of active bleeding is the top priority in combat trauma injuries
5. Bradycardia indicates the patient is about to arrest; intervene immediately
6. Start resuscitation in synchrony with the diagnostic workup for patients with signs of shock
7. A balanced resuscitation with plasma, PRBCs, and PLTs will help avoid major coagulopathy and may carry a survival benefit
8. Tamponade is readily identified with ultrasound, and should prompt either immediate drainage or open surgical exploration
II. Priorities of Care in the Pediatric Trauma or Emergency

A. Is it as easy as ABC?

- Standard ATLS teaching emphasizes primary importance of A – airway first
- Reasoning is that death from hypoxia typically more rapid than hemorrhage
- Is somewhat artificial as a team approach may do A, B, and C simultaneously
- Will also be highly dependent on the mechanism of injury, the setting, the number of other casualties, and the local resources/equipment/expertise
- For most civilian settings, blunt trauma or acute surgical illness, Airway comes first

For combat trauma, explosions, amputations, active external bleeding, C comes first!

B. Is there a "golden hour" in children?

- Time to critical interventions for life-threatening A, B, or C issues are clearly associated with outcomes and the chance of survival. This is reflected in many of the terminology and expressions we use:
- Significantly less cardiorespiratory reserve in children vs adults
- Also a function of age and size, with reserve in infants < toddlers < children
- Children have "golden minutes" if a major ABC issue

C. How is the workup/evaluation different than adults?

- Basic workup and flow is the same, but need awareness of the unique issues
- Differences in injury patterns, key anatomy, and physiologic response
- Particularly important with ABC issues to avoid the common pitfalls
III. Airway/Breathing Management and Avoiding Pitfalls

A. What are the key Airway-related differences in kids?

- Many anatomic differences (see Table below), some more important than others
- All structures are smaller/shorter – so much less room for error and easier to injure
- Smaller diameter = can obstruct with small amount of edema/swelling/foreign bodies
- Nasal breathers, large tongue that can obstruct airway
- Narrowest point is at cricoid cartilage, and cricoid right at vocal cords, therefore:
  - avoid cricothyroidotomy in children, particularly younger children/infant
  - can result in subglottic stenosis and/or vocal cord injury – both devastating
- Airway more anterior than in adults, need more anterior retraction when intubating
- Less physiologic reserve and will desaturate quickly

<table>
<thead>
<tr>
<th>Anatomy</th>
<th>PEDIATRIC</th>
<th>ADULT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tongue</td>
<td>Large</td>
<td>Normal</td>
</tr>
<tr>
<td>Epiglottis Shape</td>
<td>Floppy, omega shaped</td>
<td>Firm, flatter</td>
</tr>
<tr>
<td>Epiglottis Level</td>
<td>Level of C3 - C4</td>
<td>Level of C5 - C6</td>
</tr>
<tr>
<td>Trachea</td>
<td>Smaller, shorter</td>
<td>Wider, longer</td>
</tr>
<tr>
<td>Larynx Shape</td>
<td>Funnel shaped</td>
<td>Column</td>
</tr>
<tr>
<td>Larynx Position</td>
<td>Angles posterorly away from glottis</td>
<td>Straight up and down</td>
</tr>
<tr>
<td>Narrowest Point</td>
<td>Sub-glottic region</td>
<td>At level of Vocal cords</td>
</tr>
<tr>
<td>Lung Volume</td>
<td>250ml at birth</td>
<td>6000 ml as adult</td>
</tr>
</tbody>
</table>

B. High-yield tips and techniques for pediatric Airway management

- May look or sound worse than it is
- It they are talking, they have an airway
- Often respond to suctioning and positioning
- A patent airway is hard to improve upon
- Can delay intubation until fully prepared

If not in immediate respiratory distress:

- Focus on adequate oxygenation and keeping airway clear of blood, debris, etc.
- Completion of primary survey and assessment for other life-threatening problems
- Put on supplemental oxygen immediately on arrival
- Continuous pulse oximetry and telemetry
- Little role for an immediate arterial blood gas in children
If current or impending respiratory distress:

- All hands on deck: call for help, and most experienced help available
- Should have a difficult airway cart, make sure it has some pediatric supplies as well
- Look for an immediately reversible non-airway cause (Breathing or Circulation problem)
- Try simple maneuvers first, but rapidly escalate as the clock it ticking
- **Focus on OXYGENATION!** Ventilation not as critical or immediately life-threatening

- There is often a scramble to get intubation equipment, meds, ET tube, etc., while the patient is in distress or unconscious and not moving air
- Bag-valve-mask (BVM) ventilation should be the FIRST method to rescue the patient
- Almost ALL children can be fully oxygenated & ventilated with good BVM technique:
  - lift face into mask, don't push mask into face; suction airway well
  - small breaths appropriate to age – watch chest rise and fall
  - augment patient breaths if spontaneously breathing
  - if unconscious or chemically paralyzed, give full tidal volume support
- If not moving air, then either improper technique or airway physically obstructed
- Don’t forget the TONGUE – oral (OP) or nasopharyngeal (NP) airway will solve this

<table>
<thead>
<tr>
<th>Don't reach for this first….</th>
<th>Reach for this</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Image of BVM]</td>
<td>![Image of intubation]</td>
</tr>
</tbody>
</table>

- OPA length – measure from lower lip to angle of mandible
- Pull tongue anteriorly while inserting
- Avoid in awake kids
- NPA length – measure from nares to angle of mandible
- Avoid if major facial trauma/fractures
- Avoid in infants/smaller children

**If BVM solves the problem, then take a deep breath:**

- You have control of the airway, now have time to get fully prepared or to move patient
- Zoom out: Look for other immediately life-threatening injuries/problems (back to ABCDE)
- Intubate or surgical airway if everything and everyone ready to go
- If difficult airway anticipated or massive facial trauma, can move to OR and do it there
C. Intubation and surgical airway pearls in children

**Intubation**

- See Appendix B – Military Airway CPG for combat or austere environments
- ETT size: (age+4)/4 or diameter of 5th digit or width of fingernail on 5th digit
- Use a Miller blade for infants and younger children – need to lift giant epiglottis
- Use a Mac blade for older children and adolescents, switch to Miller if needed
- Cricoid pressure has little value (my opinion) and can collapse airway or obscure your view
- **BRADYCARDIA response is common!** I give atropine to all infants (0.02mg/kg) and most kids < 5 yo, and have it standing by for all others
- NO prolonged or multiple attempts – will desat quickly. Go back to BVM between attempts

**Surgical Airway and Improvised Techniques**

- No surgical airway is a chip shot, particularly in children
- Risk of iatrogenic injuries goes up as the size/age of the child goes down
- I prefer vertical midline incision – easy to extend and stays in avascular plane
- Avoid crich (see above) and go right to tracheostomy if at all possible
- Inferiorly based flap on anterior trachea (see Figure) helps guide tube in, heals well, and can also be used with traction suture to replace dislodged tube
- If no pediatric trach tubes available, then can use a standard ET tube (at least 1 size smaller than estimated)
- Improvised emergent surgical airway in austere environment – can use standard IV tubing as shown in Figure, insert "spike" into airway and then cut across reservoir at its midpoint: this will fit directly onto an AMBU bag

**D. Ensure your secure airway stays secured!**

- Inadvertent hyperventilation very common – particularly important if severe TBI present
- **SECURE all airway tubes, and then SECURE them again,** particularly for any transport
- Remember that the difference between mainstem or extubation can be 2 cm or less
- Have someone assigned to manually hold the ET or trach tube in position during patient movement. This is particularly important for infants
- Liberal use of paralytics for safe transport or evacuation to next facility
E. What are the key Breathing-related differences in kids?

- Progressive airway edema or obstruction should be ruled out first, then look for B issues
- Higher respiratory rate and lower tidal volumes – rapid/shallow breathers
- Under-developed accessory muscles in infants, obligate abdominal breathers
- Abdominal injury, massive gastric distension can both impair breathing
- Soft compliant chest wall, rib-fractures less common
- Reduced funct resid capacity (FRC) – less oxygenation reserve and more rapid desat
- Increased work of breathing and easier to fatigue, can consume 40% of cardiac output
- Physical exam difficult, particularly with crying and tachypnea
- Highly reactive airways – consider bronchospasm but should be Dx of exclusion

F. High-yield tips and techniques for pediatric Breathing management

- Desaturation will happen late in the game – an O2 sat of 90% may be impending arrest
- Decompress stomach if distended abdomen (particularly after BVM) and then re-evaluate
- Primary survey is for identifying life-threatening pathology only, focus on looking for:
  - tension PTX or HTX
  - flail chest/pulmonary contusion
  - open PTX (aka "sucking chest wound")
- Fortunately, physical exam and a chest x-ray should be all that is required (or available)
- Ultrasound is ideal for the austere environment, and can identify PTX or HTX as well (or better) than CXR in trained hands. Easily combined with FAST exam to identify most life-threatening Breathing or Circulation problems. Would strongly recommend any surgeon providing austere or rural environment care get familiar with all components of extended trauma exam (e-FAST)
- Needle thoracostomy in either 2nd IC space at MCL, or 4th-5th IC in anterior/mid axillary line
- For open or "sucking" chest wound, the important intervention is a chest tube, not spending time trying to rig up a "3-sided occlusive dressing"
- Chest tube size – use Broselow tape as guide, or use a finger to measure the width of an intercostal space, and choose a tube ½ to ¾ that diameter
- Measure externally to estimate depth of insertion – most common error is over-insertion
- Multiple improvised options for the austere environment if lack of pediatric supplies
  - simple aspiration of PTX can obviate need for tube, but observe closely for recurrence
  - cordis or triple lumen catheter can be placed as chest tube to drain PTX or HTX
  - thoracentesis kit – can be used to do simple aspiration, or leave catheter as chest tube
  - Heimlich valve or sterile glove w/tape and end of one finger cut off if no Pleuravac
IV. Circulation/Cardiovascular Management and Avoiding Pitfalls

A. What are the key Circulation-related differences in kids?

- Normal vital signs are highly age dependent for infants and small children, but...
- Bradycardia is not normal in ANY age!
  Bradycardia means impending arrest, and is the final common pathway for hypoxic arrest or hemorrhagic arrest in kids
- Heart rate < 50 is cardiac arrest, start CPR and resuscitation/search for cause
- Distress is initially manifested as tachycardia. Hypotension will occur very late even with exsanguinating hemorrhage due to greater vasomotor response in kids
- Cardiac tamponade can occur with very small volumes of bleeding if acute, but if slower or chronic accumulation an compensate and have several hundred cc’s of blood w/o tamponade
- Tamponade will cause progressively worsening tachycardia, severe anxiety or irritability, and then cardiorespiratory arrest. Jugular vein distension characteristic, but may be absent if hypovolemic from other sources of blood loss
- Lower circulating total blood volumes (approximately 70-100 cc/kg, see Figure below); as small as a can of soda in infants
B. High yield tips and techniques for Circulation-related problems.

- **C comes before A** for combat trauma, blast/explosive injuries, isolated major amputations, and active extremity or junctional bleeding.
- Visual assessment (color, mental status) and palpate femoral pulse first. If both are normal, you can take a break and have some time to do a prioritized evaluation.
- If not normal, then rapid focused assessment for source of bleeding or shock (Appendix A).
- For infants/small children, or any kid in shock, intraosseous (IO) line if no IV obtained.
  - Proximal tibia is easiest and is away from usually crowded head/torso area.
  - **Sternal IO CONTRAINDICATED in children** (< 12 years old).
- Avoid large volumes of crystalloid, give in 20 cc/kg boluses if needed.

**Hemorrhage-Related Shock**

- Start transfusion in 10 cc/kg boluses, use FFP early (1:1 to 1:2 ratio, but little data).
- Massive transfusion definitions variable: commonly cited as "one whole blood volume" transfusion/24 hrs. Recent combat data suggests > 40 cc/kg of blood products transfused.
- Remember vitamin K for newborns or any infant with coagulopathy.
- Role of TXA unclear, but some evidence of benefit in kids (PEDTRAX Study).
- Hypotensive resuscitation if active bleeding makes sense, but unproven in kids.
- In austere environment - warm fresh whole blood (FWB) is superior resuscitation and may be only product available to you that has any clotting factors.
- Having pre-screened donors as “walking blood bank” critical to successful use of FWB.
- Field/ER hemorrhage control is critical to preventing mortality or major morbidity.
- Stopping hemorrhage effectively in the field or ER is life-saving (see Figure below).
- Combat, austere, pre-hospital environment: ensure stocked with tourniquets and hemostatic dressings. Current military preference is CAT-1 tourniquet and Combat Gauze.
- Watch blood loss closely! Several lap pads full of blood can be near-exsanguination in an infant.
**Tamponade-Related Shock**

- Do FAST exam liberally - for penetrating truncal trauma primary reason is to assess the pericardium (Figure below)
- If +pericardial fluid and exam evidence of tamponade, do not delay to do a pericardial window. If equivocal u/s or high suspicion and stable patient, then do a window
- If already doing a laparotomy, do trans-diaphragmatic pericardial window
- Non-traumatic effusions in kids usually infectious or malignant, and may see advanced cases in austere/third-world setting. Always suspect tuberculosis (the great pretender)!
- For tamponade or instability + pericardial fluid on imaging after trauma:
  - in usual high-resource environment, standard is median sternotomy and repair
  - aspiration or perc drain placement can temporize until you can get to the OR
- **Percutaneous drainage ONLY may be option in highly select group – see below**
- In austere environment need to consider resources, skillsets, equipment, sterility, likelihood of complications, and access to follow-up care. This risk:benefit analysis may tip toward alternative interventions or nonoperative management (Figure below)

**Nonoperative Management of Traumatic Hemopericardium?**

- Based on the premise that hemodynamically stable patients with hemopericardium likely have small injuries that do not require repair, and only require drainage of blood
- 2004 prospective study of stable pts with hemopericardium from penetrating injury
  - 71% had a non-therapeutic sternotomy or thoracotomy
  - remaining 29% had full thickness injury but no bleeding at exploration
  - 7 other patients managed with pericardial drain only – all successful
- 2013 randomized trial of 111 pts with penetrating chest trauma, hemodynamically stable, but hemopericardium. Randomized to sternotomy or subxiphoid window and drain only (SWD)
  - All SWD successful and did not require surgery; shorter hospital and ICU stays
  - 93% of surgery group had non-therapeutic sternotomy, 1 postop death
  - 7 other patients managed with pericardial drain only – all successful
- SWD may be done in highly select and STABLE patients by an experienced surgeon, but requires VIGILANT observation & IMMEDIATE SURGERY if deterioration or re-bleeding
REFERENCES AND RESOURCES

Best reference to take care of pediatric patients in austere environments is a Broselow tape and accompanying color-coded pediatric supply cart or bag:


Never doubt that a small group of thoughtful, committed citizens can change the world: indeed, it’s the only thing that ever has. Margaret Mead
APPENDIX A. Approach for rapid identification of the cause of shock in the unstable pediatric patients.

- **Chest**
  - Chest Xray
  - Ultrasound (pericardial and pleural)
  - Bilateral chest tubes or needle aspiration

- **Abdomen**
  - FAST exam
  - Bedside diagnostic peritoneal aspiration (DPA)

- **Pelvis**
  - Physical exam (instability, scrotal/perineal hematoma)
  - Pelvis Xray
  - FAST exam

- **Extremity**
  - Exam (hemorrhage, thigh swelling)

- **Other**
  - External survey (scalp, neck, back, perineum)
  - Blood loss in field
  - Spinal cord injury (neurogenic shock)

- **Unidentified**
  - Laparotomy (fully examine retroperitoneum)
  - Pericardial window
## Appendix B: US Military Trauma Airway Management CPG (2015 revision)

### TRAUMA AIRWAY MANAGEMENT

#### Airway Assessment

- All trauma airways are potentially high-risk. Anticipate a difficult airway.
- Identify critical team members and verbalize role assignments.
- Initiate pre-oxygenation (1,2).
- Consider Ketamine (0.5-1.0 mg/kg IV/IO) for delayed sequence intubation if combative or otherwise uncooperative patient (3,4,5).
- Recall that the neutral position ("C-spine stabilization") degrades the laryngoscopic view.

#### Rapid Sequence Induction (RSI) and Intubation Pathway

1. **Confirm equipment availability and function**
   - IV/IO, suction, self-inflating bag and mask, oxygen source, laryngoscope- direct and video (5), ETT with stylet and/or gum elastic bougie, oral & nasal airways, surgical airway kit, drugs, CO2 detector, monitors, other rescue equipment
2. **Pre-Oxygenate (Denitrogenate) the lungs (1,2,6)**
   - Prolongs tolerance of apneic period
   - Goal is ≈ 3 minutes of tidal volume breathing at 90% FiO2
   - With standard reservoir facemask set flow rate of oxygen as high as possible
   - Consider augmenting with nasal cannula oxygen in preparation for apneic oxygenation, leave in situ throughout procedure (8)
   - Elevate head of bed if not contraindicated
3. **Maintain cervical spine stabilization**
4. **Remove front of cervical collar**
5. **Consider cricoid pressure simultaneous w/ medication administration (9,10)**
6. **Administer medications**
   - Initiate RSI
   - **Sedative/hypnotic**
     - **Ketamine** (First Line)
       - 2 mg/kg IV/IO
     - **Etomidate** (Second Line)
       - 0.3 mg/kg IV/IO
   - Unstable patients require reduced dosage of induction agent.

#### Neuromuscular Blockade

- **Rocuronium** – 1.2 mg/kg IV/IO or
- **Vecuronium** – 0.1 mg/kg IV/IO or
- **Succinylcholine** – 1.5 mg/kg IV/IO

7. **Perform laryngoscopic tracheal intubation**
   - Following onset of neuromuscular blockade
   - Recommend gum elastic bougie as primary ETT stylet

8. **If laryngoscopic view is poor:**
   - Apply external laryngeal manipulation technique(s)
   - Consider alternative visualization method or supraglottic airway device

9. **Confirm tracheal intubation**
   - Visualize tube passing between the vocal cords (First Line)
   - Wave form or digital capnography when available (Second Line)
   - Easy chest rise, equal axillary breath sounds/absence of gastric insufflation, CO2 Calorimeter, and "fog" in ETT
   - Esophageal detector bulb or fiberoptic confirmation during cardiac arrest

10. **Provide continuing care IAW Anesthesia CPG**

#### Recommendations for Pediatric Patients

1. Train to expect pediatric patients. Have a dedicated pediatric airway cart, including Broselow tape or equivalent.
2. Pre-dose with atropine IV/IO (0.02mg/kg, minimum dose 0.1mg, maximum dose 0.5mg) in all <1 years olds, those <5 who are receiving succinylcholine, and in all who receive a 2nd dose of succinylcholine
3. Induction -
   - **Ketamine** (first line) 2mg/kg IV/IO
   - **Etomidate** (second line) 0.3mg/kg IV/IO
4. Neuromuscular blockade -
   - **Succinylcholine** 1.5mg/kg IV/IO (2mg/kg <5 years old) or
   - **Rocuronium** 1mg/kg IV/IO
5. Avoid surgical airway in <12 years old - use needle cricothyroidotomy (12-14 gauge), tracheostomy preferred over surgical cricothyroidotomy

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**Pediatric ABC Emergencies in Austere Setting**

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**Austin Trauma & Critical Care Conference 2016**
## Trauma Airway Management

### Unable to Intubate ... Can You Mask Ventilate?

<table>
<thead>
<tr>
<th>Mask Ventilation Pearls</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Skilled operator</td>
<td>Improve position, change blade/operator, laryngeal manipulation technique, gum elastic bougie.</td>
<td>Emergency pathway...seconds matter.</td>
</tr>
<tr>
<td>• Good seal</td>
<td>Attempt alternate technique: Fiberoptic, video laryngoscope, tracheal transillumination device.</td>
<td>Supraglottic airway or</td>
</tr>
<tr>
<td>• Jaw thrust</td>
<td>More than ≈ 3 attempts at intubation may abolish your ability to mask ventilate due to edema caused by laryngoscopy.</td>
<td>ADULTS: Surgical cricothyroidotomy</td>
</tr>
<tr>
<td>• Oral airway</td>
<td>Surgical airway (cricothyroidotomy or tracheostomy)</td>
<td>PEDIATRIC: Surgical tracheostomy, needle crich as temporizing maneuver</td>
</tr>
<tr>
<td>• Nasal airway(s)</td>
<td>Two operator mask ventilation</td>
<td></td>
</tr>
<tr>
<td>• Two operator mask</td>
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<td></td>
</tr>
</tbody>
</table>

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**Pediatric ABC Emergencies in Austere Setting**

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