Chapter 31

Pediatric Care

Introduction

The military surgeon needs to be familiar with the unique challenges that pediatric population patients present, not only in war, but also in noncombat military operations other than war scenarios. For US Army military medical units, the humanitarian augmentation medical equipment set, requested by the hospital commander through command channels, provides medical supplies and equipment for a population of 10,000 people.

Anatomical and Physiological Considerations

- **Fluid, electrolyte, and nutrition.**
  - Normal fluid requirements in children are estimated via a weight-based nomogram (Table 31-1) or a length-based method (Table 31-1), such as the Broselow Pediatric Emergency Tape.

Table 31-1. Hourly Fluid Requirements for Children

Weight (kg)	Hourly Volume	Fluid
Up to 10 kg	10 mL/kg	D5¼NS + 20 mEq KCl/L
11–20 kg	40 mL + 2 mL/kg over 10 kg	D5½NS + 20 mEq KCl/L
>20 kg	60 mL + 1 mL/kg over 20 kg	D5½NS + 20 mEq KCl/L

  - Fluid resuscitation is best performed with isotonic fluids at 20 cc/kg boluses. (See Evaluation and Diagnosis.)
  - Total fluid requirement should be adjusted for a goal urine output of 1–2 cc/kg/h.
  - Daily caloric and protein requirements are estimated by weight and age (Table 31-2).

Table 31-2. Daily Caloric and Protein Requirements for Children

Age (yrs)	Body Weight (kcal/kg)	Protein (g/kg Body Weight)
0–1	90–120	2.0–3.5
1–7	75–90	2.0–2.5
7–12	60–75	2.0
12–18	30–60	1.5
>18	25–30	1.0

- Breast milk is always the first choice when initiating oral intake in infants. Alternatively, infant formulas contain 20 kcal/oz. An estimate of the amount of formula needed to provide 120 kcal/kg/d is:

  Infant's weight (kg) × 22-30 = Amount (in cc) of formula needed q4h.

- **Pulmonary.**
  - In all children, it is important to recall that the most common cause of cardiac arrest is respiratory arrest. Hypoxemia can lead to bradycardia with hypoperfusion and then cardiac arrest in rapid succession.
  - Newborns tend to be obligate nasal breathers; thus, nasal airways should be avoided if possible.
  - The child's larynx is positioned more anterior in the neck, making it more difficult to visualize during intubation and necessitating a more forward position of the head.
  - The acceptable range of PaO_2 (60–90 mm Hg) correlates to oxygen saturations of 92%–97%. A premature infant's oxygenation saturation should never exceed 94% to avoid retinopathy of the premature.
  - Infants breathe mostly with their diaphragm; thus, increases in intraabdominal pressure or other problems that limit diaphragmatic movement can significantly inhibit respiration.
- **Cardiovascular.**
  - Vital signs by age group (Table 31-3).

Table 31-3. Normal Vital Signs for Age

Age	Weight (kg)	Respiration Rate	Pulse	BP (Systolic)
Premie	<3	40–60	130–150	42 ± 10
Term	3	40	120–140	60 ± 10
1–5 years	~10–20	20–30	100–130	95 ± 30
6–10 years	20–32	12–25	75–100	100 ± 15
Adolescent	50	12–18	70	120 ± 20

- Cardiac stroke volume in children is relatively fixed. Therefore, bradycardia or relative bradycardia can significantly decrease cardiac output. Stimulation and oxygen therapy are corrective for more than 90% of significant bradycardias in infants.

Limit peripheral IV access attempts to 2 within 90 seconds for the child in shock, then immediately proceed to saphenous vein cutdown or intraosseous infusion. (See Chapter 7, Shock, Resuscitation, and Vascular Access.)

- **Burns.**
  - An infant or child's head tends to encompass more of the body surface area, with the lower extremities being a smaller percentage. The area of the hand represented by the palm and fingers can be used to estimate 1% of total body surface area for burn calculations (Fig. 31-1).
- **Gastrointestinal.**
  - Reflux is a common finding, especially in the newborn period. This predisposes some children to difficulty with digestion and frequent emesis.

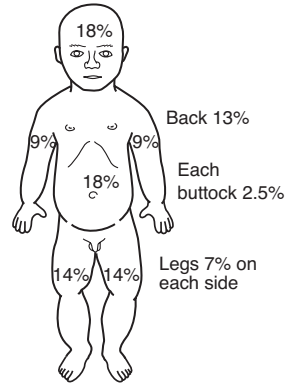

Fig. 31-1. Body surface area percentages for infants and children.

- Children are predisposed to hypoglycemia due to the low glycogen storage capacity of their liver. Full-term infants will tolerate NPO status for approximately 5 days (with an appropriate D10 solution). Premature infants will tolerate only 3 days of NPO status prior to the initiation of total parenteral nutrition.
- A child's GI tract is very sensitive to most insults, including electrolyte abnormalities and systemic illnesses. This can result in an ileus, manifest as feeding intolerance, and may precipitate necrotizing enterocolitis.
- Gastroenteritis with diarrhea, often associated with fevers, is also a very common cause of severe dehydration.

- **Hematology and blood volume.**
  - Infants have a physiological anemia during the first 3–5 months, with a hematocrit of 30%–33%.
  - Estimates of blood volume are as follows:

Age Estimate	Volume (cc/kg)
Newborn	90
Infant	80
School-age child	70

- **Renal.**
  - Infants and young children have a limited ability to concentrate urine (maximum: 400–600 mOsm/L) and a fixed ability to excrete sodium, thus causing an inability to handle excess sodium and resulting in hypernatremia if they receive too much sodium.
- **Thermoregulation.**
  - Infants and young children are predisposed to heat loss, and they compensate poorly for wide fluctuations in ambient temperatures. Children have a higher ratio of body surface area to mass, and therefore are likely to become dehydrated earlier than adults when febrile.
  - Reduce exposure and keep infants and children in a regulated warm environment.
- **Immune system.**
  - Premature infants have incomplete development of their immune system, causing a 60-fold increased risk of sepsis. All elective surgery in infants under 30 days of age requires

48 hours of prophylactic antibiotics (with anaerobic coverage added when appropriate) after the first week of life.
  - Early signs of sepsis can include lethargy, intolerance to feedings, fever, hypothermia, tachycardia, and irritability before a rise in white blood cell count.

Evaluation and Diagnosis

- Pediatric cervical spine clearance can be performed with a physical exam in children who are awake and who have no neurological deficits. If there is no midline tenderness and no pain with active motion, the spine can be cleared. Obtunded children, those with focal neurological deficits, and those with tenderness should have further imaging, which will be dictated by what is available in your facility.
- CT imaging can be a valuable tool in pediatric trauma. Try to limit the dose of radiation with the CT protocol, if possible. In children under 10 kg, contrast should be injected by hand.
- Basic ATLS guidelines should direct the initial assessment and evaluation for all children involved in traumas. It is essential to keep the patient warm because children are much more prone to heat loss than adults.
  - Modified Glasgow Coma Scale scores for children < 4 years old:

Verbal Response	Verbal Score
Appropriate words/social smile/fixes/follows	5
Cries, but consolable	4
Persistently irritable	3
Restless, agitated	2
None	1

Treatment

- The treatment algorithm shown here provides the proper sequence for the rapid sequence intubation of the pediatric patient (Fig. 31-2).

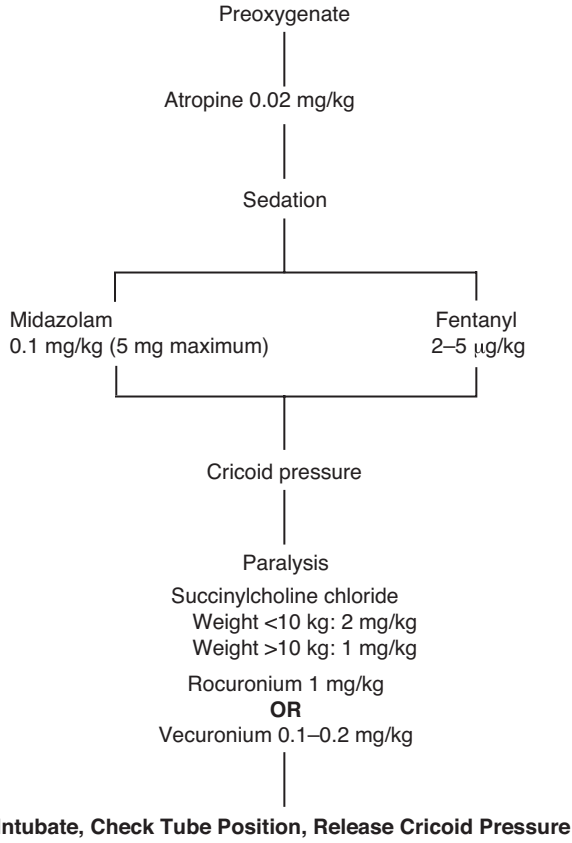

Fig. 31-2. Rapid sequence intubation for the pediatric patient.

Equipment and Supplies

- Accessory pediatric medical/surgical equipment arranged according to age and weight (Table 31-4).
- Surgical instruments.
  - If a pediatric surgical set is not immediately available, a peripheral vascular set will usually contain instruments delicate enough to accomplish most tasks in newborns.

Table 31-4. Pediatric Resuscitation Equipment and Supplies

	Airway/Breathing							Circulation		Supplemental Equipment			
Age, Weight (kg)	**O_2 Mask**	**Oral Airway**	**Bag Valve**	**Laryngo-scope**	**ET Tube**	**Stylet**	**Suction**	**BP Cuff**	**IV Cath**	**NG Tube**	**Chest Tube**	**Urinary Cath**	**C-collar**
Premie 3 kg	Premie Newborn	Infant	Infant	0 Straight	2.5–3.0 No cuff	6 Fr	6–8 Fr	Premie Newborn	24 gauge	12 Fr	10–14 Fr	5 Fr Feeding	—
0–6 mo 3.5 kg	Newborn	Infant Small	Infant	1 Straight	3.0–3.5 No cuff	6 Fr	8 Fr	Newborn Infant	22 gauge	12 Fr	12–18 Fr	5–8 Fr Feeding	—
6–12 mo 7 kg	Pediatric	Small	Pediatric	1 Straight	3.5–4.0 No cuff	6 Fr	8–10 Fr	Infant Child	22 gauge	12 Fr	14–20 Fr	8 Fr	Small
1–3 yrs 10–12 kg	Pediatric	Small	Pediatric	1 Straight	4.0–4.5 No cuff	6 Fr	10 Fr	Child	20–22 gauge	12 Fr	14–24 Fr	10 Fr	Small
4–7 yrs 16–18 kg	Pediatric	Medium	Pediatric	2 Straight or curved	5.0–5.5 No cuff	14 Fr	14 Fr	Child	20 gauge	12 Fr	20–32 Fr	10–12 Fr	Small
8–10 yrs 24–30 kg	Adult	Medium Large	Pediatric Adult	2–3 Straight or curved	5.5–6.5 Cuffed	14 Fr	14 Fr	Child Adult	18–20 gauge	12 Fr	28–38 Fr	12 Fr	Medium

BP: blood pressure; Cath: catheter; C-collar: cervical collar; ET: endotracheal; Fr: French (gauge); IV: intravenous; NG: nasogastric; O_2: oxygen.

Commonly Used Drugs and Dosages

All doses are IV or IM.

- Phenobarbital: 10–20 mg/kg IV at a rate not to exceed 1 mg/kg/min (maximum dose: 40 mg/kg).
- Diazepam: 0.04–0.3 mg/kg/dose.
- Midazolam: 0.1 mg/kg IV (maximum: 5 mg).
- Atropine: 0.02 mg/kg IV.
- Phenytoin: 15–20 mg/kg IV; administered at 0.5–1.5 mL/kg/min as a loading dose, then 4–7 mg/kg/d IV for maintenance.
- Mannitol: 0.25–1.0 g/kg IV.
- Succinylcholine chloride: 2 mg/kg IV for <10 kg and 1 mg/kg IV for >10 kg.
- Ampicillin: 25–50 mg/kg IV q6h; 100–200 mg/kg/d divided q6h.
- Gentamicin: 4.5–7.5 mg/kg IV qd [once daily dosing (ODD)]; keep doses in manual for q8h dosing.
- Metronidazole: 7.5 mg/kg IV q6h.
- Acetaminophen: 15 mg/kg PO q4h.
- Cefazolin: 25–100 mg/kg/d divided q6h–q8h.
- Clindamycin: 15–40 mg/kg/d divided q6h–q8h.
- Hypertonic saline (3%): 5–10 mL/kg.
- Morphine: 0.1–0.2 mg/kg q2h–q4h PRN.
- Ketamine: 0.5–1.5 mg/kg IV over 1 minute >3 months; 2–4 mg/kg IM.

Surgical Management

- Basics.
  - As a general guideline, transverse incisions should be used in infants. This minimizes the risk of postoperative dehiscence, while still allowing adequate exposure.
  - Absorbable sutures, such as VICRYL or PDS (2-0), should be used to close the rectus fascia, regardless of the incision. The skin can then be closed using staples or absorbable monofilament suture (eg, MONOCRYL 4-0).

References

Fuenfer MM, Creamer KM, eds. *Pediatric Surgery and Medicine for Hostile Environments*. Washington, DC: Department of the Army, Office of The Surgeon General, Borden Institute; 2010.

Tschudy MM, Arcara KM, eds. *The Harriet Lane Handbook: A Manual for Pediatric House Officers*. 19th ed. Philadelphia, PA: Elsevier Mosby; 2012.

For Clinical Practice Guidelines, go to
http://usaisr.amedd.army.mil/clinical_practice_guidelines.html