2012 Resident Handbook

of

Pediatric Anesthesia

## Pediatric Anesthesia Group

Department of Anesthesiology

The University of Texas Medical Branch

Galveston, Texas

**Malignant Hyperthermia**

WARNING SIGNS

**↑**ETCO2 – **↑**Temp (unexplained) –**↑**HR or Arrythmia –

Severe Acidosis –“Pink” Urine

TREATMENT

1. Call for help and MH cart.
2. Discontinue inhalational agent
3. Hyperventilate with 100% oxygen at high flows.
4. Inform surgeon—terminate procedure ASAP.
5. Dantrolene 2.5 mg/kg IV (initial dose), may repeat q 5 - 10 min up to 10 mg/kg. Mix each 20 mg bottle of Dantrolene with 50-60 ml. sterile water.
6. Place A-line, then send stat ABG's, electrolytes, glucose, CPK.
7. Initiate cooling: surface and internal.
8. Sodium Bicarbonate 1-2 meq/kg IV/ prn pH on ABG.
9. Place Foley; send urine for myoglobin.
10. Maintain UOP > 2 ml/kg/hr. May need increased IVF as well as mannitol (300 mg/kg) or furosemide (0.5-1.0 mg/kg). Note: Dantrolene vial has 3 gm. of mannitol.
11. CVP if clinical signs of RV dysfunction.
12. Procainamide (load: 1.5 mg/kg IV over 1 min., repeat every 5 min. to max. 15 mg/kg.; maintenance: 20-80 mcg/kg/min. continuous infusion) for dysrhythmias. Do not use calcium channel blockers with Dantrolene.
13. Dextrose/insulin for ↑K+--infuse 10 units regular insulin and 50 ml. D50 slowly to effect.
14. Transfer to ICU for hemodynamic monitoring.

15. Counsel patient and family.

**MH Hot Line 1-800-MH-HYPER**

**www.mhaus.org 1-800-644-9737**

Contents

Page

Malignant Hyperthermia -- Acute Treatment Inside Front Cover

Introduction 2

Preoperative Preparation

Fasting Guidelines 4

Routine Labs 4

Premedications 4

**Pediatric Room Set-up** 7

Monitoring 10

Intubation and Airway 11

Physiology

Considerations of Prematurity 15

Temperature 16

Coagulation 16

Cardiovascular Values 17

GFR 17

Respiratory Values 18

Fluid Therapy

General 19

Allowable Blood Loss 23

Blood and Component Therapy 25

Prophylactic Treatment of Nausea and Vomiting 28

Regional Anesthesia 29

Special Cases

Jehovah’s Witness 33

Latex Allergy 34

Scoliosis Surgery Protocol 36

PERCS Surgery Protocol 41

Tonsillectomy/Adenoidectomy Study Protocol 42

Typical On-Call Cases 44

SBE Prophylaxis 46

Pharmacology 47

Index of Pharmacology 53

Intubation Table Back Cover

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Preface

This handbook is the fifth revision of the original handbook compiled by Dr. Michael Herbert in 1993 and subsequently edited by Dr. Amr Abouleish. In addition, Dr. Melanie McKissack helped revised this edition as his senior project.

Purpose

The purpose still remains to provide the resident with a quick reference to aid in preparation for caring for children and to smooth the transition from adult to pediatric anesthesia. Therefore, we have made this handbook less extensive than other published handbooks or textbooks.

Introduction

As a resident at UTMB, you will care for children at all levels of your training. Your first encounter may be on call or during your ENT rotation. During your CA-2 year, you will care for children during your months at Shriner’s Burn Institute, Driscoll Children’s, and Neuroanesthesia. In addition, during this year, you will spend at least one month on the Pediatric Anesthesia rotation. With these multiple opportunities, you may find it helpful to consult this handbook throughout your training.

The handbook can be separated in two main sections:

1. Basic information and specific topics: basic information on equipment, physiology, and procedures.
2. Pharmacology: This section provides a listing of common drugs and their doses.

CA-2 -- Pediatric Anesthesia Month

During this month, you will be assigned the pediatric surgery room. On other days, you will be assigned pediatric cases if they are scheduled. *The goals and objectives of the pediatric anesthesia month, SBI, and Driscoll rotations can be found on the department’s intranet.*

Pediatric Anesthesia Faculty

Although you may care for pediatric patients with different faculty, the below are the faculty who take specialty call (Pediatric call at John Sealy or Shrine call at SBI). For Driscoll Children’s Hospital, the office manager is Carlene Rizzo and can be reached at 361-694-4449(direct) or 361-694-5445 (main office number).

Pediatric Anesthesia Cell Phone

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Preoperative Preparation

Fasting Guidelines

|  |  |  |  |
| --- | --- | --- | --- |
| Age | Clear liquids\* | Breast Milk | Milk/Formula/Solids |
| 0-6 months | 2 hours | 3 hours | 4 hours |
| > 6 months | 2 hours | 4 hours | 6-8 hours |

\*may use “2 hrs before arrival” to give leeway for change of schedules

Routine Preoperative Labs

1. Infants < 1 year old: depends on patient’s physiologic status; may need heelstick hematocrit or hemacue--discuss with faculty
2. Children > 1 year old: no routine labs for otherwise healthy children
3. Always adjust this guideline depending on illness severity and procedure planned. Note: a stat Hb/Hct can be sent to the blood gas lab after induction when the PIV is placed or use the HemaCue (available in gas lab)

Premedications

1. Purpose: to help with atraumatic separation from parents and smooth mask induction
2. Variety available: including midazolam (IN, PR, PO), methohexital (PR), ketamine (IM), dexmedetomidine, and no premedication (see next page)
3. For DSU patients and inpatients without IV’s: premedicate all patients over 9 months of age unless there is contraindication to sedation. For children 6-9 months, premedication may be needed, depending on predicted ease of separation from parents
4. In patients with sleep apnea, the premedication choice needs to be individualized
5. Most common Premedication is oral midazolam 0.5 mg/kg (up to 20 mg) mixed with Acetaminophen or Surpalta: (see table on next page).
6. For inpatients with PIV *in situ*: discuss with faculty
7. Anesthesia team has option to cancel premedication
8. ANY QUESTIONS, CALL PEDI ANESTH FACULTY

Types of Premedications

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Type | Route | Dose (mg/kg) | Onset (min) | Comments |
| Midazolam | PO | 0.5 | 20-30 | sedated, max 20 mg |
| PO | 1.0 | 10 | sedated, max 20 mg |
| IN | 0.2 | 2-3 | “stunned”, painful |
| IV | 0.1 | 2-3 | sedated |
| Methohexital\* | PR | 30 | 8-12 | asleep in holding, seizures, max 500 mg |
| Ketamine\* | IM | 4-10 | 2-4 | anesthesia, nightmares |
| None | --- | --- | --- | parent present induction |
| EMLA | topical | --- | >60 | still a needle stick even if painless; also age-dependent. Recommend for pts. > 12 yo. or individualize as needed |
| Dexmedetomidine | IN | 4 mcg/kg | 15-20 | Less painful than midazolam |
| \*Methohexital and ketamine are both general anesthesia induction agents that may be given in holding with parents present. | | | | |

P.O. Acetaminophen

Acetaminophen is administered along with midazolam to offset the bitter flavor of the latter. To allow easier administration of the p.o. acetaminophen that is ordered with the p.o. midazolam, please use the following table adapted from the acetaminophen bottle.

Children's Acetaminophen = 160 mg/ teaspoon (5 ml)

|  |  |  |
| --- | --- | --- |
| Weight  in kilograms | Weight  in pounds | Dose Acetaminophen  In teaspoons  (10-15 mg/kg) |
| <5 | <10 | (see below) |
| 5-11 | 10-24 | 0.5 |
| 11-16 | 24-35 | 1.0 |
| 16-21 | 36-47 | 1.5 |
| 22-27 | 48-59 | 2.0 |
| 27-32 | 60-71 | 2.5 |
| 33-43 | 72-95 | 3.0 |

Less than 5 kg (or < 6 months of age), do not normally order p.o. midazolam and hence no p.o. acetaminophen routinely ordered. EXCEPTION: For BMT surgery, acetaminophen is used for postoperative pain management and hence should be ordered even if midazolam is not.

Former Premature Infants for DSU

1. Premature = estimated gestational age (EGA) < 37 weeks
2. Post-conceptual age (PCA) = EGA + weeks of life
3. For otherwise healthy former premies, PCA > 50 weeks may be considered for outpatient surgery. Individualize according to the patient’s past and present status.
4. Otherwise, patient will need apnea/heart rate or pulse oximetry monitoring in the hospital for a minimum of 12 apnea-free hours.

# Pediatric Room Set-Up

**“Candy Striped Cart”**

As you will learn quickly, each of the pediatric anesthesia faculty has a preference on set-up and equipment. The following should be considered as guidelines.

\*\*NOTE: you may need to begin induction almost immediately after the child is brought to the room, so all set-up should be done prior to this time.

Monitors & Machine

1. Make sure room temperature is at the correct setting.
2. Make sure there is a properly functioning, filled Sevoflurane vaporizer on the machine (check for leaks when on).
3. Set anesthesia machine settings appropriate for your patient (wt, age, and maximum PIP).
4. Monitor: should change setup to “neonate” or “pediatric”

## Pulse Oximeter

* 1. Should be placed on the left side of the bed
  2. Choose disposable probe by the recommended weight on the package (long Band-Aid probe is for children <3 kg, short Band-Aid probe for 3-20 kg, balloon probe >10 kg)

1. Non-invasive BP (NIBP)
   1. Should be placed on the right side of the bed
   2. For babies < 4 kg, neonatal cuffs and hose should be used
   3. See “Monitoring” section for size guidelines
2. EKG
   1. Use the neonatal/pediatric pads (with built-in wires)
   2. 3-leads only
3. Temperature probe. 9 Fr probe available. Site – discuss with faculty
4. Suction – pediatric Yankauer
5. Machine check – enter weight (if known) or use the formula to estimate (see back cover)

Airway

1. See back cover for recommended blades and tubes
2. Several options for circuit masks and airways should be out and available. In general, Size 2 mask for infants, Size 3 for toddlers, and Size 4 for older children (all need flavoring added)
3. Stylettes should be out or in the ETT (per faculty)
4. Tongue blades out and available
5. Lidocaine spray 1%, 2 ml in 3 ml syringe, 20 g angio cath at end  
   \*\*caution with children under 4 kg, need smaller volume

IV Setup

Most elective cases will be inhalational induction and IV started after induction, so IV-Start equipment should be located on the top of the anesthesia cart (front right corner). The only routine cases without IV access are BMTs (ear tubes).

1. IV Start equipment.
   1. IV catheters – 24, 22, 20 g. Short or spring loaded   
      (per faculty)
   2. Alcohol pad
   3. Pedi tourniquet (Penrose drain)
   4. Clear tape
   5. Opsite or tegaderm
   6. Colored Coban (available from faculty)
2. IV Fluid (500 ml LR) setup
   1. Buretrol should be used for children < 20 kg
   2. Prefill Buretrol with 10 ml/kg (for < 5 kg), 50 ml (for 5-9 kg) and 100 ml (10-20 kg)
   3. Label side of buretrol with amount initially in buretrol
   4. Use 60 dropper (“microdrip”) lines for >20 kg
   5. Stopcock, extension line (with injection ports) and t-piece
   6. Ensure ENTIRE line is free of air
   7. CLAMP ONLY AT THE T-PIECE

Drugs & Syringes

1. Emergency drugs: unlike adults, ephedrine and phenylephrine are not used routinely to manage hypotension. In children, volume is used first. For bradycardia, atropine or glycopyrrolate is used first. And then epinephrine is used for hypotension or bradycardia, or as a first-line in cases of cardiovascular collapse. Also, for inhalational inductions, IM succinylcholine (with or without atropine) needs to be available.
   1. Succinylcholine & Atropine
      1. IM dosing. For laryngospasm, the dose is 2 mg/kg IM.
      2. Draw up 2 ml (40 mg) in 3 ml syringe and place 21 g needle at the end. (this is dose for 20 kg pt. If smaller, then use only a portion)
      3. Atropine. Draw up 10-20 mcg/kg (min 100 mcg) in a TB syringe of atropine. Place 21 g needle.
      4. Have both atropine and succinylcholine syringes immediately available at all times, especially on transport to PACU or PICU.
      5. Additional setup may be requested per faculty
   2. Epinephrine: 10 ml of 10 mcg/ml dilution. Label well. (you may keep the 100 mcg/ml dilution, but not on the cart – in a drawer)
2. Flush solutions (from IV bag). 2-3 10 ml syringes of normal saline flush: draw directly from IV bag to prevent air in line
3. Post-Induction caudal solutions – if plan is for caudal, you may need to dilute 0.25% concentration. Use Preservative-free normal saline
   1. < 18 months. 0.25% bupivacaine/epi, 1 ml/kg
   2. >18 months. 0.175% bupivacaine/epi, up to 1.5 ml/kg. To make: mix 7 ml 0.25% bup/epi with 3 ml NS (preservative free)
4. Awake caudal solutions – In premature infants undergoing inguinal hernia repair, we often perform awake caudal anesthesia to reduce the need for narcotics and thus post op apneic events. The solution used is as follows:
   1. 10-ml syringe: 10 ml 0.25% bupivicaine/epi and clonidine 10 mcg (0.1 ml of 100 mcg/ml clonidine)
   2. Place 1 ml/kg of this solution into a 3-ml syringe (this is the amount you will inject into the caudal space).
   3. Monitoring

In healthy pediatric patients it may be appropriate to induce without monitors. In all other patient, or as soon as possible, monitors must be placed. Pulse oximetry and NIBP first, then ECG and temp.

Non-invasive BP (NIBP)

Neonate

* 4 Neonatal cuffs (available at bottom of cart)
* Guideline: Size = wt in kg
* Need “white BP” cord for neonatal NIBP

Infants and Children

* from 4 kg to 6 months of life: use infant cuff (orange)
* 6 months to 5 years (approximately): use child cuff (green)

CVP Catheters and Monitoring

1. Usually place single lumen intraoperatively for volume administration. When using double-lumen catheters, remember to use the larger lumen for volume.
2. Some indications: Inadequate peripheral venous access, CVP monitoring for large blood loss or fluid shifts, infusing hyperosmolar or sclerosing substances, high risk of VAE.

Choice of CVP Catheters

Rule of Thumb: CVP catheter size ≤ ETT size

French sizes and equivalent gage:

|  |  |
| --- | --- |
| French size | Equivalent gage |
| 2.5 | 21 G |
| 3.0 | 20 G |
| 4.0 | 18 G |
| 5.0 | 16 G |
| 6.0 | 14 G |
| 6.3 | 14 G |

INTUBATION

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Blades | |  | | | | | | | | | |
|  | | | | | | | 🡨 Mac 2 🡪 | | | 🡨 Mac 3 🡪 | | |
|  | | 🡨 Miller 0 🡪 | | | 🡨 Miller 1 🡪 | |  | | 🡨 Miller 2 🡪 | | | |
| Age | | Premie | | Term | 3 mo | 1 yr | | 3 yr | 5 yr | | 10 yr | Adult |
| Wt (kg) | | 1 | 2 | 3 | 5 | 11 | | 15 | 19 | | 35 | 70 |
| ETT size I.D. (mm) | | 2.5 | 2.5-3.0 | 3.0-3.5 | 3.5 | 4.0 | | 4.5 | 5.0 | | 5.5-6.5 | 7.0-8.0 |
| Depth - oral (cm) | | 7 | 8 | 9 | 10.5 | 12 | | 13.5 | 15 | | 18 | 19-23 |

\*for ages 2 - 4 years, Wis-Hipple 1.5 is an excellent blade, but not readily available at UTMB

Formulas (none are perfect)

ETT Size in ID (mm) = Age +4

4

*often need to add 0.5 size or cuff*

Depth -- oral (cm) at lips = Age + 13 = **3 X ETT size** (by above formula)

2

*Reminder: Oral Rae tubes are bent at this number*

Neonatal 1-2-3 kg 🡪 7-8-9 cm depth

Size: 2.5 ETT for < 1.2 kg, 3.0 ETT for 1.2-2.4 kg, 3.5 ETT > 2.4 kg

50 percentile wt (kg)= 9 + (2 x Age)

Laryngeal Mask Airway

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| LMA size | Wt. (kg) | Cuff Volume (ml) | FOB Size (OD, mm) | Largest ETT (ID, mm) |
| 1 | < 5 | < 4 | 2.7 | 3.5 |
| 1.5 | 5-10 | < 7 | 3.0 | 4.0 |
| 2.0 | 10-20 | < 10 | 3.5 | 4.5 |
| 2.5 | 20-30 | < 14 | 4.0 | 5.0 |
| 3 | 30-50 | < 20 | 5.0 | 6.0 cuff |
| 4 | 50-70 | < 30 | 5.0 | 6.0 cuff |
| 5 | >70 | < 40 | 7.3 | 7.0 cuff |

Pediatric Airway Differences

**Head** - Occiput is large -- gives natural sniff position

**Tongue** - larger in relation to pharynx

**Epiglottis** - narrow, omega-shaped, protruding

**Hyoid bone** - not calcified

**Larynx/Vocal Cords** - higher C3-4 (adult = C5-6) angulated, anterior

**Thyroid cartilage** - not calcified

**Cricoid cartilage** - conical, narrowest point of airway below 5 yrs

**Trachea** - deviated down and posterior

Obligate nasal breathers under 5 months

Notes on Intubation and ETT selection

Uncuffed ETT

* Placement
* The end of the ETT has three markers (1-line, 2-lines, and 3-lines)
* ETT placed with 2-lines marker beyond vocal cords and 3-lines marker visible
* Leak test
* Important to check, because the narrowest portion is at the cricoid ring instead of the vocal cords (up to 5 years)
* Close the pop-off valve and observe the pressure at which the leak is first heard
* Document, with goal of 20 to 30 cm of H2O
* May need to re-intubate with larger tube if leak <15 cm of H2O

Cuffed ETT

* Studies show no increased complication rates with cuffed ETT. Advantages include avoidance of repeated laryngoscopy to change incorrect ETT and thus less airway trauma, protects the airway from aspiration, use of low fresh gas flow, and reduced OR pollution.
* For Oral RAE tubes, one should not increase the size because of a leak with an UNcuffed ETT, but should use a cuffed ETT, because the bend of the oral RAE tube is preset. This avoids main stem intubation.
* Leak pressure – for cuffed ETT
* Cuffed ETT may be used in children <8yrs with cricoid ring still narrowest
* Cuff inflated to a leak at 20 cm of H2O
* Sometimes <1 ml of air needed
* N2O will increase the cuff pressure over time

Other Notes

1. Reintubation within one month -- always compare leak with previous value to identify any new stenosis
2. Flexion (deeper) and extension (shallower) of the head can cause considerable ETT movement
3. Resistance:

* Resistance = 8*lv*/r4; where *l*= length, *v*= viscosity, r= radius; related to 1/radius4 and length; (Poiseuille’s Law).
* Changing from 3.5 to 3.0 mm ID ETT increases resistance by nearly 50%.
* Changing from 7.5 to 7.0 mm ID ETT increases resistance by 24%.
* Turbulent flow exists at sites of luminal change (secretions and kinks) and adds to the resistance to laminar flow.

1. In tubes of appropriate length:

* 3.5 ETT offers less resistance than the normal neonatal airway.
* 2.5 ETT offers more resistance than the natural airway.

Extubation

Post extubation stridor

1. Usually within 1 hr of extubation
2. Harsh cough or stridor develops over 20-30 minutes
3. Associated with infants <4years, prolonged intubation, excessive head movement, tight fitting tube(no leak at 30-40cmH2O), traumatic intubation or multiple attempts, history of stridor or croup, presence of URI
4. Treatment
5. Reassurance
6. Cold humidified oxygen
7. Sedation (worse with crying/screaming)
8. Racemic epinephrine 0.25-0.5 ml; dilute to 3 mls with normal saline & humidified oxygen or air – ONLY if severe. Will need to observe for 2-4 hours
9. Decadron 1- 4 mg IV – controversial; effect delayed; give after repeated traumatic intubation attempts

Laryngospasm

1. Can occur at induction or emergence or anytime in between if no ETT present
2. More common in young infants
3. Recent URI or tobacco exposure increase the risk
4. Prevention
5. Avoid interfering with the airway in Stage 2
6. Recover the child in the lateral position allowing secretions to drain away from the cords
7. Treatment
8. 100% O2 FM
9. Gentle positive pressure on Ambu-bag, with pop-off valve closed to 20 cm of H2O
10. Jaw thrust
11. Succinylcholine 0.1-0.5 mg/kg IV (start with a low dose)

2 mg/kg IM

1. Lidocaine 1 - 1.5 mg/kg IV may help

Considerations of Prematurity

Retinopathy of prematurity

Note: Etiology is multifactorial and hyperoxia is one factor.

1. "safe" PaO2 thought to be 50 - 70 mmHg
2. corresponding SpO2 90 - 95
3. at risk patients -- up to 44 weeks post-conceptional age (PCA)
4. exacerbated by hypercarbia, hypocarbia

For anesthesia care, the risk of contributing to ROP should be considered and weighed with the ongoing care and surgical issues. When possible, reduce Fi02 as low as can be safely done.

Post Operative Apnea Guidelines

1. Delay surgery if possible until PCA >50 weeks.
2. Regional anesthesia if possible - no sedative drugs.
3. If general anesthesia, then consider caffeine 10 mg/kg IV post-induction, if not on caffeine or doxepram already
4. Former preterm infants, PCA <50 weeks, admit for minimum of 12 apnea-free hours, regardless of anesthesia type.
5. Former preterm infants, PCA >50 weeks, monitor for two apnea-free hours before discharging from PACU. \*Requires pediatric anesthesia faculty signature.
6. Patients with significant coexisting disease (history of apnea, chronic lung disease, anemia, neurological deficit) require an individualized plan.
7. Full term infants, PCA <44 weeks, admit for 12 hours minimum, regardless of anesthesia type.

Definitions

Periodic breathing = 5 - 10 secs. of no air flow (no bradycardia or hypoxemia)

(\**can be normal)*

Apnea ≥ 15 secs. of no air flow

< 15 secs. of no air flow with bradycardia or hypoxemia

Preterm < 37 weeks PCA at birth

Temperature

**Neonates and infants tend to lose body heat rapidly:**

* Large body surface area relative to body weight
* Little subcutaneous fat
* Decreased ability to produce heat

1. Set room thermostat in advance to

90o F for neonates

85o F for infants

80o F for 6-24 months old

1. Air Warming blanket (Bair Hugger) work well in maintaining temperature in infants and children.
2. Be careful that the heating hose does not touch the lower extremities
3. **Must measure core temperature when using heating blanket (not axillary)**.
4. May need to use “ambient” (cooling) setting if patient becomes hyperthermic

Neutral Temp (\*)

|  |  |  |
| --- | --- | --- |
| Prem | Term | Adult |
| 34º C/ 93.2º C | 32º C/ 89.6º F | 28º C/ 82.4º F |

\*ambient room temperature resulting in minimal O2 consumption

Coagulation Factors

Normal clotting requires 20% of the normal values of factor V and 30% of the normal values of factor VIII.

|  |  |  |
| --- | --- | --- |
|  | Full Term and Premature Neonates \* | Older children and adolescents |
| PT | 13-20 secs | 10-12 secs |
| PTT | 30-55 secs | 25-35 secs |
| INR | 1.4-2.0 | < 1.1 |

Note: Neonates have

* Factors V and VIII: 100% of adult levels
* Factors IX and XI: 19% and 35% of adult levels, respectively

Cardiovascular Values

Blood

Weight Heart Rate "Normal" Volume

Age (kg) (Beats/min) BP S/D (ml/kg)

Prem 1.0 120-180 40/20 90-100

Term 3.0 95-145 60/35 80-90

1 mo. 4.0 100-140 75/40 80

6 mo. 7.0 110-180 90/40 75-80

1 yr 10 100-160 95/50 75

5 yr 20 65-135 100/60 70-75

Adult 70 50-95 120/70 70

Glomerular Filtration Rate

At birth 15 ml/min/m2

1-2 wks 31 ml/min/m2

0.5-1.0 yr 45 ml/min/m2

1-3 yrs 55 ml/min/m2

Adult\* 68 ml/min/m2

\*Using 1.7 m2, Adult GFR = 120 ml/min

Normal urine volume output should be 0.5-1 ml/kg/hr at all ages.

Respiratory Physiology

VOLUME AND MECHANICS

Age Prem 0 yrs 1 yr 8 yrs Adult

Wt (kg) <3 3 10 25 70

Height (cms) 48 75 130 170

Resp. Rate 40-60 35-40 25 18 12

VT (ml/kg) 6-8 6-8 6-8 6-8

VD (ml/kg) 2-2.5 2-2.5 2-2.5 2

VD/VT 0.3 0.3 0.3 0.3

Min. Vent. (ml/kg/min) 130 120 80 60

V.C. (ml/kg) 40 45 60 60

FRC (ml/kg) 28 25 40 35

(5 yr)

Alveoli x 106 30 129 280 300

Specific conductance (small airways) (5 yr) (12 yr)

(ml/sec/cm H2O/g) .02 3.1 1.2 8.2 13.4

OXYGEN CONSIDERATIONS

Age 0 1 mo 3 mo 1 yr 5 Adult

Wt(kg) 3.3 4 5 11 19 70

Resting VO2

(ml/kg/min) 5-8 >5 5 4-5 3

Hgb (gm/dL) 17 14 10-11 12-13 12-13 15

PCO2 (mmHg) 30 35-40 35-40 40

PO2 (on Room air) 102 - age

(mmHg) 60-70 85 90 3

P50 O2 (mmHg) 19.4 24 26 30 29 26

Fluid Volumes

|  |  |  |  |
| --- | --- | --- | --- |
|  | Newborn | Infant | Child |
| Blood volume (ml/kg) | 85 -100 | 75 | 70 |
| Plasma volume (ml/kg) | 50 | 50 | 50 |
| Extracellular fluid (% body weight) | 45 | 30 | 25 |
| Inttracellular fluid (% body weight) | 25 | 40 | 50 |
| Total body water (%) | 80 | 75 | 65 |

Fluids & Chemistry

Age Prem Term 1 year 2 yrs Adult

Na+ 133-146 136-148 135-145 135-145 135-145

K+ 4.6-6.7 4.3-7.6 3.5-5.5 3.5-5.5 3.5-5.5

Cl - 100-117 90-114 94-105 94-105 94-105

HCO3- 20 22 20-25 20-25 22-26

Total calcium 6-10 7-12 8-11 8.5-10.5 8.5-10.5

Glucose 40-65 40-110 60-105 60-105 60-105

Total protein 3.9-4.7 4.6-7.7 5.5-7.8 5.5-7.8

BUN 9 13 5.25 5.25 5.25

CR < .5 < .5 .5-.6 0.5-0.9 0.5-1.2

Composition of Body Fluids

|  |  |  |  |
| --- | --- | --- | --- |
| **Source** | **Na+ (mEq/L)** | **K+ (mEq/L)** | **mOsm/L** |
| Saliva | 50 | 20 |  |
| Gastric | 60 | 9 | 300 |
| Bile | 145 | 5 | 300 |
| Ileum | 125 | 15 | 300 |
| Diarrhea | 60 | 30 | - |
| CSF | 140 | 4.5 | - |
| Sweat | 30 |  |  |

Fluid therapy

Maintenance

|  |  |  |
| --- | --- | --- |
| Weight (kg) | Addn. Maintenance | Total Hourly Maintenance |
| 0 - 10 kg | 4 ml/kg/hr | 4 ml/kg/hr |
| 10 - 20 kg | 2 ml/kg/hr | 40 ml/hr + 2 ml/kg/hr (>10 kg) |
| > 20 kg | 1 ml/kg/hr | 60 ml/hr + 1 ml/kg/hr (>20 kg) |

Special considerations:

* Increase by 12% / oC of fever
* In first week of life, maintenance fluid requirements are lower in the first days and then increases to baseline by 7 days.
* Glucose-containing fluids should only be used as maintenance, not volume replacement.
  + ¼ N/S + 5% D/W + 20 meq KCl/L (neonate)
  + ½ N/S + 5% D/W + 20 meq KCl/L (infant)
  + Maintenance w/ Lactated Ringers with 1% D/W will prevent both hypoglycemia and hyperglycemia in most children (excluding prem and term neonates)
    - 1% D/W : To mix: add 4ml 50%D/W in 200ml L/R   
       add 1ml 50%D/W in 50ml L/R

What is Hypoglycemia in Neonates?

* Premature Neonate 20 mg/dL
* Full Term Neonate 30 mg/dL
* After 72 hrs 40 mg/dL

Risk Factors for Hypoglycemia

* < 6 months of age
* Preoperative IV glucose solutions
* Prolonged Fast (e.g., 18 hours)
* Small for age

NPO Deficit

Deficit = Hourly Maintenance x hours NPO

Traditional: Replace during the surgery with

in 1st hour

in 2nd hour

in 3rd hour

***Do not use glucose-containing fluids. Use Isotonic Solutions (Lactated Ringers or Normal Saline)***

Intraoperative Third Space Loss

Simple ………………….…no extra fluid.

Moderate (simple laparotomy) 2-5 mls/kg/hr

Major (large visceral exposure) 5-10 mls/kg/hr

Extreme (above + multiple resections) 10-15 mls/kg/hr

Necrotizing enterocolitis 50-100 mls/kg/hr!

***Do not use glucose-containing fluids. Use Isotonic Solutions (Lactated Ringers or Normal Saline)***

Notes:

Allowable Blood Loss (ABL)

ABL = Estimated Blood Volume X Starting Hct - Acceptable Hct

Starting Hct

Estimated blood volume

Premature newborn 90 - 100 ml/kg

Full-term newborn 80 - 90

3 - 12 months 75 - 80

3 - 6 years 70 - 75

> 6 years 65 - 70

Hematocrits in healthy patients

Normal Hematocrit Acceptable

mean range Hematocrit

Premature newborn 45 40-60 35-40

Term newborn 54 45-70 35-40

3 months\* 36 28-42 25

1 year 38 34-42 20-25

6 years 38 35-43 20-25

* Remember, anemia at approx. 3 months is physiological, reflecting the falling HbF and rising HbA. The P50 may be as high as 32.

Fluid Prescription Sheet

Wt. = \_\_\_\_\_\_\_ kg Age = \_\_\_\_\_\_\_\_ Est. BV = \_\_\_\_\_\_\_\_\_\_\_\_ mls

Hct \_\_\_\_\_\_ % Acceptable Hct \_\_\_\_\_\_\_\_\_\_\_\_\_ %

Allowable blood loss (mls) =

= Est. B.V. x Starting Hct - Acceptable Hct

Starting Hct

= mls

NPO since \_\_\_\_\_\_\_, = \_\_\_\_\_\_\_ hrs

Maintenance

fluids: = \_\_\_\_\_\_\_\_\_\_\_ ml/hr of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Deficit =\_\_\_\_\_\_\_\_\_\_\_\_\_ mls of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3rd space

losses = \_\_\_\_\_\_\_\_\_\_\_ mls/kg/hr = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ ml/hr

of\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

* **Should be done on every pediatric patient**
* **Try to calculate anticipated values preoperatively to avoid the distraction of intra-op calculations**.

Blood and Component Therapy

General Comments

* Fluid Bolus = 10 ml/kg
* Resuscitative Fluid Bolus = 20 ml/kg
* Have the Blood bank do this preoperatively: Break FFP and PRBC into “Pedi Packs” of 10-20 ml/kg when patient < 15 kg -- to conserve blood products and minimize exposure to additional donors

Ordering blood BURN SURGERY

Need to know: BSA x % burned = area to be debrided (m2) x 10,000 = (cm2) to be debrided x blood loss factor = estimated blood loss

Blood loss factor per cm2 body surface area:

* Up to three days after burn = 0.5 ml/cm2
* More than three days after burn = 0.75 ml/cm2
* Infected wounds more than one week after burn = up to 1.25 ml/cm2

Specific Components

Citrated PRBC

* Hct ≅ 70%
* 10 ml/kg PRBC = increases Hct by 3%

FFP

* Contains all plasma proteins and clotting factors; has no platelets
* Indications: treatment of isolated factor deficiencies, reversal of warfarin therapy, correct coagulopathy associated with liver disease, replacement of 1-2 blood volumes
* NOTE: FFP takes 20-30 minutes to thaw before available. One needs to anticipate the need
* Dose = 10 - 15 ml/kg

Cryoprecipitate

* Contains fibrinogen, factor VIII, factor XIII
* Administer through standard blood filter for hemophilia A, von Willebrand's dz, hypofibrinogenemia and DIC
* Dose = 1 unit per 10 kg.

Platelets

* 1unit per 10 kg will increase platelet count by 50,000/mm3
* FFP also in the fluid

Problems with Massive Transfusions

If whole blood were available, clinical bleeding might not be seen with 3 blood volume "exchanges". With component therapy it is seen earlier.

Dilutional Clotting Factor Coagulopathy

* likely to occur when blood loss > 1.5 blood volumes.
* correlates with PT + PTT prolonged > 1.5 times control, which is the approximate threshold to treat.

Dilutional thrombocytopenia

* Clinical bleeding correlates with a platelet count ≤ 50,000/mm3, thus the starting count is crucial.
* If PRBC's and FFP are used to replace losses, then the platelet count will be approximately:

70% of baseline at one volume exchanges

40% of baseline at two volume exchanges

20% of baseline at three volume exchanges

Citrate toxicity (ionized hypocalcemia)

* More likely when FFP given > 1 ml/kg/min, especially through a CVP line.

Calcium

* Ca Chloride 5 mg/kg, through central lines to avoid phlebitis
* Ca Gluconate 15 mg/kg, through PIV

Hyperkalemia

* Avoid hyperventilation
* Arrhythmias worse with hypocalcemia

BLOOD PRODUCT COMPOSITION

Citrated Citrated

Normal Whole blood PRBC FFP

pH 7.4 ≅ 6.8 ≅ 6.8 ≅ 6.8

PCO2 40 ≅ 190 ≅ 190 ≅ 190

Base deficit mEq/L 0 ≅ 12 ≅ 12 ≅ 12

K+ mEq/L 3.5-5.0 > 18 > 18 4-8

Citrate --- ++ + +++

Factors V & VIII Normal <20% --- 80-100%

Fibrinogen Normal --- --- ---

Platelets 160-400K --- --- ---

2,3-DPG Normal 3% 3% ---

Hct 35-45 35-45 70-80 ---

Temperature oC 37 1-6 1-6 Cold

Postoperative Nausea and Vomiting

* Use prophylactic treatment for high risk patients and consider in moderate risk patients

Who is High Risk?

* High Risk based on Surgical Procedure
* Strabismus surgery
* Tonsillectomy or adenoidectomy
* Middle ear surgery
* Inguinal hernia
* Orchiopexy
* High Risk based on Age
* Children >3 yrs have average vomiting incidence of >40%
* Highest in preteen and teenagers

Treatment

* Pharmacology
* 5-HT3 anatgonist first choice (e.g., Ondansetron 0.150 mg/kg)
* Dexamethasone 0.5 mg/kg (max 10 mg)
* Reduce risk
* Avoid narcotics and inhalational agents
* Utilize propofol infusion and NSAID
* Postoperatively – po intake only when child wants, no forced feeding
* Hydration

Regional Anesthesia

Caudal analgesia

Landmarks for caudal analgesia are easily palpable up to age 5 or <20kg *.*Equilateral triangle is formed by the posterior superior iliac spines and the sacral hiatus.

\*\*NO sympathetic block under 5 years; similar to adult after 8 years

Placement of caudal anesthesia

* Prepare required anesthetic dosage in multiples of 10 ml syringes
* Prep area around sacral hiatus with Betadine x3
* Wear sterile gloves
* Alcohol wipe from top of prep to hiatus
* 22 or 20g angiocath into sacral hiatus
* Monitor for EKG changes
* Each faculty will have additional specifications

% & Volume of Anesthetic

* < 18 months. 0.25% bupivacaine/epi, 1 ml/kg
* >18 months. 0.175% bupivacaine/epi, up to 1.5 ml/kg.   
  To make: mix 7 ml 0.25% bup/epi with 3 ml NS (preservative free)

Level of block

* 1 ml/kg: T4-T6
* 1.5 ml/kg: T2-T4

Maximum Allowable Dose of Local Anesthetics:

Local Single Dose(mg/kg) CI (mg/kg/hr) CI (<6 mo)

Bupivacaine\* 3 0.4 - 0.5 0.2 -0.25

Lidocaine 5 1.6 0.8

Lidocaine + epi 7 N/A N/A

\*same for Ropivacaine and Levobupivacaine

CI = continuous infusionContinuous Caudal Catheters:

Repeat dose 90 – 120 mins after initial dose

Used for long surgery or postop analgesia

Can thread the catheter into the lumbar or thoracic region , and confirm with fluoroscopy.

Dose: caudal or lumbar 0.1 – 0.25% 0.4ml/kg/hr

Thoracic 0.1 – 0.25% 0.3ml/kg/hr

Spinal anesthesia for neonates/ex-premie's

1. neonatal spinal needle, 22g, short bevel
2. L4-5 interspace, no higher (dural sac at S3, cord at L3; after 1 year at S1 and L1)
3. Back flexed and head extended; in lateral or sitting position
4. inject slowly
5. use TB syringe
6. add volume for dead space of needle
7. hold needle in for 5 seconds after injection complete
8. Tetracaine 0.5% in D5W = equal volumes of 1% tetracaine + D10W =5mg/ml (hyperbaric)
9. Bupivacaine 0.5%= 5mg/ml also used
10. Dosing: <5kg = 0.5-0.6mg/kg

5-15kg = 0.4mg/kg

>15kg = 0.3mg/kg

1. Premie -- 0.8-1.0 mg/kg
2. minimum dose 1 mg
3. rapid T2 - T4 block; lasts 45-60 minutes. Block starts to wear thin by 45 min. Cannot count on longer duration; be sure that surgeon is aware of the time limit and this includes prep time.
4. Time extended by adding 2.5 mcg/kg epinephrine

Epidural analgesia

For local anesthetic/opioid mixtures

Bolus Infusion (starting rate)

Age ml/kg/seg ml/kg/hr

< 1 yr 0.04-0.05 0.1-0.2

1-7 yr 0.03-0.04 0.1-0.4

> 7 yrs 0.02-0.03 0.1-0.4

Bupivacaine 0.1% + 2 mcg/ml fentanyl

Give bolus then start infusion 90 min later

Lumbar/caudal Epidural opioids

1. Morphine bolus: 30 - 40 mcg/kg q 8-12 hrs
2. Fentanyl bolus: 50-100 mcg (1-2 mcg/kg)

Intrathecal morphine

* 5 - 10 mcg/kg IT (scoliosis patients) max 200 mcg

Epidural/Intrathecal Narcotics - Side Effects and treatments

1. Respiratory depression
2. FiO2 ± assisted ventilation
3. Naloxone 1 mcg/kg IV
4. Reduce/discontinue infusion
5. Pruritis
6. Naloxone 1 mcg/kg IV
7. Diphenhydramine 0.125 – 0.25 mg/kg IV q 6 hrs up to 25 mg
8. Propofol 0.1 mg/kg X one bolus, may repeat once at 15 minutes
9. Reduce dose of narcotic bolus or decrease infusion rate
10. Nausea ± vomiting
11. Metoclopramide 0.15 mg/kg
12. Ondansetron 0.1 mg/kg IV
13. Propofol (as above)
14. Naloxone 5 mcg/kg IV
15. NPO
16. Urinary retention
17. Straight catheter
18. Naloxone 5 mcg/kg IV

Notes

**Jehovah’s Witness**

1. By UTMB policy and by case law, only a court-appointed guardian can refuse blood products transfusion for pediatric patient.
2. Hence, parents may choose not to consent for blood or may sign refusal for transfusion, but it carries no power in children.
3. Because of the emotional stress that a discussion of the above points will cause, one can tailor the preoperative interview to the appropriate discussion level:
   1. Procedure with no or very small risk of requiring transfusion
      1. if parents wish to sign refusal, allow with no further discussion
      2. OR cross out the section with “not applicable”
      3. examples: toenail removal, hernia repair, circumcision, cast change, BMT’s
   2. Procedure with possible risk of transfusion requirement:
      1. discuss with surgeon, make surgeon aware of Jehovah’s Witness parents, receive reassurance that transfusion will not be a problem
      2. examples: laparoscopy, orchiopexy, tendon release, cleft lip/palate, T&A
   3. Procedure with significant risk of transfusion requirement:
      1. contact surgeon, and note the above policy. Resolve with surgeon and parents during that visit
      2. examples: craniotomies, back surgeries, intraabdominal tumor resection, burns

\*\*\*Always notify anesthesiology faculty if the child is of Jehovah Witness parents\*\*\*

\*\*\*Document your conversation with family and surgeon and the agreed to plan in the preoperative evaluation sheet or the progress notes\*\*\*

**Latex Allergy**

# At risk groups: patients with spina bifida, congenital urologic abnormalities (bladder extrophy), history of atopy (“ABC” allergies: avocado, banana, chestnut), health care worker

Latex PRECAUTIONS: patients who are at risk for developing latex allergy are identified as “Latex Precautions” even if they have not manifested an allergy clinically. The goal is to minimize the iatrogenic exposure to latex. The management is the same as latex allergy patients.

Management: AVOIDANCE, AVOIDANCE, AVOIDANCE

Avoidance of any exposure to latex is the mainstay of managing patients with latex allergy. Since 2002, the FDA requires all manufacturers to label equipment with latex as “latex-containing”. Because of this regulation, it has been easy to identify latex-products. In addition, manufacturers have eliminated latex where they can. The good news is that for anesthesia management (in our OR) the only equipment that needs to be replaced with LATEX-FREE alternative is limited to the following:

1. Gloves. Both sterile and non-sterile gloves need be replaced.
2. Tape. The “clear tape” and “pink tape” are latex-free and should be used. Opsite and tegaderms are also latex-free.
3. Bag for anesthesia circuit. Latex-free bags are standard in the anesthesia circuit
4. IV start tourniquet. The blue tourniquets in the PIV start kits are latex free, the BEIGE TOURNIQUETS ARE NOT. Alternatively, one can use latex-free penrose drain or glove.
5. Bandaids. SHOULD NOT BE USED except if they are labeled “latex-free”

***\*Otherwise all other equipment routinely used in the OR at UTMB is   
latex-free.***

Anaphylaxis

Latex anaphylaxis:

Onset within 30 minutes after exposure to antigen (range 5-290 minutes)

Presents as rash, hypotension, bronchospasm

# Treatment of intraoperative anaphylaxis

1. Remove antigen if detected
2. 100% oxygen
3. Intravenous fluids
4. Adjust or discontinue anesthetics
5. Discontinue antibiotic infusion or blood product transfusion if in progress
6. Antihistamine

* Diphenhydramine 1 mg/kg IV (max 100 mg)
* Cimetidine 5-7.5 mg/kg IV (max 300 mg)

1. Steroids

* Dexamethasone 0.15 mg/kg IV (max 10 mg)
* Hydrocortisone 2 mg/kg IV (max 100 mg)
* Methylprednisolone 5 mg/kg IV (max 125 mg)

1. Epinephrine

* For bronchospasm: infusion at 0.5-1 mcg/kg/min
* For hypotension: bolus, begin at 1-2 mcg/kg
* For cardiac arrest: bolus, begin at 10 mcg/kg

Anesthesia for Pediatric Scoliosis Surgery

Pearls

1. Evaluate preoperative degree of respiratory (and cardiovascular) compromise, and the possible need for postop ventilation
2. Positioning problems (mostly prone)

* Airway – ETT, Postoperative stridor
* Ventilation – keep abdomen free
* Hemodynamics
* Peripheral neuropathies – shoulders < 90 degrees
* Eyes – optic neuropathy, corneal abrasions
* Pressure points – careful padding
* Vessel occlusion
* Venous air embolism

1. Blood loss in spinal surgery can be huge, and requires strategies for minimizing the loss and avoiding blood transfusion:

* Surgical speed and skill is crucial.
* Positioning with abdomen free and legs slightly down.
* Ventilate to normocapnea and avoid high airway pressures and PEEP.
* Preoperative blood donation
* Acute normovolemic hemodilution – calculate blood draw to target Hct of 25-28, replace with crystalloid/colloid, and reinfuse at the end in the reverse order. (see below)
* Intraoperative blood salvage (cellsaver)
* Deliberate hypotension (beware cord ischemia and optic neuropathy)
* Pharmacological agent that minimize blood loss.

1. Aminocaproic Acid (Amicar) 100mg/kg over 15 min (in 50 ml NS) then 10mg/kg/hr (in 250 ml NS)
2. Intraoperative neurologic monitoring

* The best test of neurologic function remains an awake patient. The “wake up test” allows for crude assessment of motor function following implantation of hardware.
* Evoked Potentials are also monitored to assess both sensory as well as motor function throughout the procedure. The scoliosis protocol outlined below curtails an anesthetic to facilitate optimal SSEP/MEP monitoring.

1. Postoperative pain management

* PCA > 6 years
* Intrathecal morphine (placed by surgeon at end of surgery or by anesthesiologist before surgery)
* Epidural catheter (placed by surgeon, can be tunneled)
* No NSAIDS for 24 hours

Protocol for Scoliosis Surgery

*Below was developed by Dr. Tarnal to allow rapid wakeup for wakeup test as well as allow for motor and sensory evoked potential monitoring. It continues to be refined. You will need to check with your faculty for any new revisions.*

Prepare (initially)

* Infusion Pump Drugs
  + Propofol (100cc bottle) + Ketamine 50mg: rate 75-150mcg/kg/min
  + Remifentanil (1mg in 100cc bag): rate .05-.5 mcg/kg/min
  + Aminocaproic Acid:
    - Loading dose 100mg/kg into 50cc bag of NS and give over 30 minutes
    - Maintenance dose: place 20cc in 250cc NS and infuse 10-15mg/kg/hr (stop infusion at time of skin closure)
* Induction Drugs
  + Gabapentin 15mg/kg PO on DSU (Pre-emptive analgesia)   
    To be prescribed by surgeons
  + Fentanyl 1-2mcg/kg
  + Lidocaine 1mg/kg
  + Propofol 2-3mg/kg
  + Rocuronium 0.6-1.2mg/kg x 1 with induction, **DO NOT REDOSE** as this will impair MEP monitoring
* Albumin 5% (2 bottles) available but not opened

Prepare (later)

* Propofol 1mg/kg in 20cc syringe (for after the wake up test)
* Duramorph 5 mcg/kg (up to 200 mcg), 24-25g Whitacre needle, 2 tuberculin syringes (handed sterile to scrub tech after rods in place)
* Acetaminophen IV (15mg/kg) given at the start of closing
* Morphine (0.1mg/kg) titrate at the end of the case for post op pain management

Equipment

* Flexometallic (armored) ETT appropriate for patient’s age/size
* Bite block (rolled 4x4 gauze to be placed between molars)
* 4 infusion pumps
* Arterial line (aseptic technique-sterile towels, chlor-prep sticks, sterile gloves)
* +/- Transesophageal Doppler (Cardio-Q) if patient >16yo
* 2 x peripheral lines, as large as possible
  + Largest bore: 1L bag of NS on blood tubing and hot line (this will be used for bolus fluid administration only).
  + Other PIV: 1L bag of LR with 10 dropper IV tubing and dial a flow. This will serve as the maintenance IV fluid line and carrier.
* Temperature probe (temp-sensing urinary catheter when possible)
* Bair Hugger (lower body)
* Prone pillow
* SSEPs monitored by electrophysiology techs –leave the ulnar side of the wrists free
* If planning to do Acute Normovolemic Hemodilution you will also need 1-3 Blood collection bags from Blood Bank (depends on volume to be drawn) and electronic scale

Plan

* Gas / Intravenous induction (depending on age)
* Intubate and ventilate
* Maintainance: TIVA (propofol/ketamine/remifentanil)
* PIVs & A-line placement using aseptic technique
* Send ABG, and Type and Screen (Hgb 9-10)/Cross (Hgb <10)
* Hemodilute (see below)
* Foley, temp probe, prone pillow
* Disconnect lines and monitors in preparation for turning prone. Be sure to cap all stop cocks and lines
* When prone start the Aminocaproic Acid loading dose
* Prior to extubation, a neurological assessment (motor activity of lower limbs) will be carried out by the surgeons. (To rule out spinal cord injury and if cause for concern will need CT imaging and surgical intervention)

Normovolemic Hemodilution

* Infuse 5% Albumin to match volume drawn – keep patient euvolemic
* Calculate Volume of blood to be to be drawn (cc):
  + >50 kg: 10cc/kg (age specific ideal body weight)
  + <50kg: [patients weight (kg)/50] x 450cc

Allowable Blood Loss= EBV x Hct(initial) – Hct(final)

Hct(initial)

Target Hgb is ≥9g/dL (minimize risk of stroke, and non-ischemic blindness)

* Prior to drawing blood you will need to assess the amount of anticoagulant needed for each blood collection bag. Each bag contains 63 ml of anticoagulant however this may exceed the amount needed for your patient.
  + Amount of anticoagulant needed:[ volume drawn/100] x 14
  + Once you calculate the amount of anticoagulant needed, you will need to remove any excess from the blood collection bag prior to phlebotomy.
* Label the blood draw bags with patient’s name, MRN and time of blood draw.
* BLOOD MUST BE ADMINISTERED WITHIN 6 HOURS OF BEING DRAWN
* ABG need to be obtained
  + Baseline (prior to performing phlebotomy)
  + Immediately after phlebotomy
  + 15min after phlebotomy

(continued on next page)

Wake-Up Test

20 minute notice:

* Volatile agent off
* Propofol/Ketamine infusion off
* Remifentanil infusion reduce to 0.03-0.05mcg/kg/min
* Get patient breathing spontaneously

Wake-Up:

* Have someone at foot of the bed watching the patient’s feet
* Ask patient to squeeze fingers then wiggle toes.
* Immediately give Propofol bolus (about 1mg/kg), then Midazolam 2mg
* If using volatile agent, resume volatile agent <.5MAC
* If using TIVA, resume Propofol/Ketamine at initial rate.
* Increase Remifentanil back to initial rate
* Ventilate to CO2 in 40’s
* Titrate Morphine IV as needed for post op pain
* Start acetaminophen IV
* Aminocaproic Acid infusion off at the start of skin closure

**Before closure surgeon injects intrathecal Duramorph** (only if ICU bed available):

Scrub tech to draw Duramorph 5 mcg/kg into TB syringe

Also 24 or 25G Whitacre spinal needle and second TB syringe to the tech.

**At the end of surgery**:

Prior to extubation, a neurological assessment (in particular motor activity of lower limbs) will be carried out by surgeons.

Extubate after satisfactory neurological assessment confirmed by surgeons.

Transfer to PACU for airway observation (and from there to PICU)

Protocol for PERCS (Percutaneous Tendon Releases) and Alcohol Nerve Injections in Cerebral Palsy Children

Background

* These children were waking up in PACU in severe pain, leg spasm, marked emergence delirium, and nausea and vomiting
* Together with Dr Yngve, we have developed a protocol (a TIVA technique) to minimize these problems and prevent complications.

Prepare

* Propofol: in 60cc syringe on an infusion pump
* Morphine 0.1mg/kg (adjust to patient’s needs)
* Decadron 0.15mg/kg
* Glycopyrrolate 10mcg/kg (only for excessive secretions)
* Zofran 0.1mg/kg
* Toradol 1.0mg/kg
* Diazepam 0.1mg/kg, max 2mg @JSH and .05mg/kg @VL, (do NOT dilute, use TB syringe, and inject into fast flowing IV at the port nearest the skin) used for spasticity, to decrease spasms post-surgery.
* NO paralytic agents (surgeon needs to localize nerves)
* Have an appropriate LMA and IV ready

Protocol

* Inhalational induction with sevoflurane and oxygen.
* Place PIV and start propofol infusion at 300 mcg/kg/min (but may need to titrate up).
* Give the morphine early, then the decadron +/- glycopyrrolate
* Turn off the volatile and place LMA.
* Spontaneous or pressure-support ventilation with oxygen and air.
* As tolerated, decrease the propofol at about 10 minute intervals after surgery starts (to about 100mcg/kg/min).
* Will be asked to assist the surgeon with nerve stimulator during surgery.
* Give the Diazepam during the case.
* Give toradol and zofran 15 -30 minutes before the end of surgery.
* Turn infusion off 15 minutes before the end of surgery, when casting starts.
* Remove LMA deep, while leg immobilizers are being applied

Protocol for T&A “Study” Patients

***\*\*Editors Note: This protocol is to be used for study patient’s only. For ALL NON-STUDY patients, it is important to discuss the case with your faculty as they may want to modify the study protocol.***

Background

Dr. Pine is doing a study of Postoperative Outcomes in Coblation versus Electrocautery Tonsillectomies in the Pediatric Anesthesia Population. He has requested that the “study” patients receive a protocol directed anesthetic which is indicated below.

Prepare

* Propofol 1mg/kg (per faculty)
* Lidocaine 1% 2 ml in 3-ml syringe with 20G angiocath to spray cords
* Fentanyl 1 mcg/kg
* Dexamethasone 0.5mg/kg max 10mg
* Ondansetron 0.15mg/kg
* Glycopyrolate 10mcg/kg, max 0.2mg
* NO paralytic agents (surgeon needs to localize nerves)
* Have an appropriate oral RAE cuffed tube ready with stylette

Protocol

* Inhalational induction with sevoflurane 8% and 70% N2O.
* Place PIV
* To facilitate intubation, Propofol 1mg/kg IV single dose
* Intubation with oral RAE cuffed ETT
* IV medications to give immediately after intubation
  + Glycopyrolate 10cmg/kg, max 0.2mg
  + Fentanyl 1mcg/kg (give in 2 divided doses once patient begins breathing spontaneously)
  + Ondansetron 0.15mg/kg
  + Dexamethasone 0.5mg/kg max 10 mg
* Maintenance with 2% Isoflurane and 70% N2O
* Adjust Isoflurane to maintain ETCO2 between 50-59
* IV Fluids replace using 4-2-1 rule and hours NPO, giving half the first hour
* Extubate awake

Post Operative

* Nausea/Vomiting: Ondansetron .15mg/kg x 1dose if needed
* IV Fluids per ENT orders
* PO Fluids: unlimited clear liquids as tolerated
* Emergence delirium and pain management in 1st 30 minutes
  + Dexmedetomidine: 0.5mcg/kg IV x 1 dose, may repeat after 5 minutes and combine with morphine .025mg/kg IV if necessary
* Pain management from 30min-90min
  + Morphine .025mg/kg IV q10 min prn, max of .1mg/kg IV

\*\*If additional medication is needed, inform Dr. Pine and they will be removed from the study

Typical Pediatric On-Call Cases

From time to time, pediatric cases will have to be done by residents who are on the “standard” on-call OR team. This may mean that you will be doing pediatric cases before you have had your pediatric anesthesia rotation as a CA-2. This section is only intended as an introduction for management of selected, basic pediatric surgeries, primarily on patients >18 months of age. Consult your on-call faculty and SR for additional details.

Room Setup

* Follow the basic setup listed earlier in this handbook
* Make sure the anesthesia tech brings you a pedi cart and circuit for the machine
* Have a range of ETTs and masks for induction
* Draw propofol in a 10 ml syringe and fentanyl in a TB syringe. This allows for more accurate dosing.
* The paralytic of choice is rocuronium at 0.6 mg/kg for intubation. Succinylcholine should be avoided due to multiple, possibly undected, risk factors in this patient population. Rocuronium should be drawn up in a 3ml syringe, and redosed according to train-of-four nerve stimulation.

Induction Sequence

* This will vary based on case, but in general, most children go to sleep via inhalational induction
* Initial gas flows should be O2: 2 L/min and N2O: 5 L/min
* If the patient is cooperative, slowly work in Sevoflurane, starting at 1%, and doubling the concentration every two breaths, to a desired 8% concentration
* If the patient is not cooperating/fighting, set the Sevoflurane initially at 8%, and maintain a good mask seal, following the patient’s head movements, if necessary
* Once the patient is definitively induced, turn off the N2O and ensure continued spontaneous respiration, while an IV is placed
* Suggested IV targets are hand, antecubital, or saphenous veins
* The rest of the intubation sequence will then continue, either spraying the cords with lidocaine or giving IV propofol to aid intubation

Maintenance

* Similar to adult cases
* Some advocate switching to Isoflurane after intubation, for possible reduction of emergence delirium
* Prophylactic PONV management: administer Zofran and Decadron (unless contraindicated). Especially necessary for eye and abdominal cases. Pass an OG tube for belly cases, or after prolonged pre-intubation ventilation
* Advantageous, if possible, to resume spontaneous ventilation prior to emergence and extubation
  + Allows for better titration of opioids
  + Will allow for faster emergence
* Consider caudal anesthesia for lower extremity procedures
* Ensure the patient is NOT in Stage II prior to extubation (see section on Laryngospasm)
* Bring the patient to PACU in the recovery position (lateral decubitus to relieve possible airway obstruction)
* Always travel with O2 on the patient, bring mask from induction (great to have at hand if Ambu-bagging emergently needed), and ALWAYS bring succinylcholine and atropine syringes (seconds can make the difference in PACU)

Sample Call Cases

* Laparoscopic appendectomy
* Bowel obstruction from various causes
* Testicular torsion
* Orthopedic fractures: primarily humerus, elbow, and leg (tib/fib)
* Foreign body aspiration
* Necessary to maintain spontaneous ventilation prior to intubation
* Various eye surgeries: foreign body, open globe, detached retina
* All will be via general anesthesia
* Incision and drainage of abscesses
* Either IV ketamine or gas by mask or LMA can be used
* The majority of the cases are urgent/emergent, and thus preclude the use of LMAs

S.B.E. Prophylactic Regimens

Goals of prophylactic regimens: Prophylaxis is most effective when given perioperatively in doses that are sufficient to assure adequate antibiotic concentrations in the serum during and after the procedure. To reduce the likelihood of microbial resistance, it is important that prophylactic antibiotics be used only during the perioperative period. They should be initiated shortly before a procedure and should not be continued for an extended period (no more than 6 to 8 hours). Circulation. 2007; 116:1736-1754

Prophylactic regimens for dental, oral, respiratory tract, or esophageal procedures. No follow-up doses recommended.

|  |  |  |
| --- | --- | --- |
| **Situation** | **Agent** | **Regimen** |
| Standard general prophylaxis | Amoxicillin | 50 mg/kg po, max 2.0 gm, 1h before procedure |
| Unable to take oral medications | Ampicillin, or  Cefazolin | 50 mg/kg IM/IV, max 2.0 gm  50 mg/kg IM/IV, max 1.0 gm |
| Allergic to penicillin | Clindamycin or  Cephalexin\* or  Azithromycin | 20 mg/kg po, up to 600 mg  50 mg/kg po, max 2.0 gm  15 mg/kg po, up to 500 mg |
| Allergic to penicillin and unable to take oral medications | Clindamycin or  Cefazolin\* | 20 mg/kg IV, up to 600 mg  25 mg/kg IM/IV, up to 1.0 gm |

\*Cephalosporins should not be used if have immediate-type hypersensitivity reaction to penicillins

Pharmacology

## Analgesics: Opioids & Non-Opioids

## Opioids: Intraoperative Dosing

Fentanyl IV 1 - 5 mcg/kg

Hydromorphone IV 5-10 mcg/kg

Meperidine IV 1 - 2 mg/kg

Morphine IV 0.05 - 0.1 mg/kg

Remifentanil IV Load: 1-4 mcg/kg

Infusion: 0.05 – 0.2 mcg/kg/min

Sufentanil IV Load: 0.1-0.5 mcg/kg

Infusion: 0.1-0.5 mcg/kg/min

## Opioids: PACU Dosing

Fentanyl IV 0.5 mcg/kg IV q 5 min

Morphine IV 0.025-0.05 mg/kg IV q 10 min

## Narcotic Antagonist

Naloxone IV 5 - 10 mcg/kg, repeat q 3-5 min.

## Non-Opioids

Acetaminophen PO 10 - 20 mg/kg q 4-6 hr

PR 30 - 40 mg/kg (initial dosing only)  
then 20 mg/kg q6 hr, max 100 mg/kg/d

Ketorolac IV 0.5 – 1.0 mg/kg q 6 hr, max 4 mg/kg/day

(not to be used with T & A patients)

## Antibiotics -- Intravenous

Single Intraoperative Doses Max (adult) Total daily dose

Ampicillin 50 mg/kg 2 gm 200 -300 mg/kg/day

Cefazolin 25-50 mg/kg 1 gm 50 -100 mg/kg/day

Cefotetan 25 mg/kg 1 gm 40 - 60 mg/kg/day

Cefuroxime 25 mg/kg 0.750-1.5 gm 50 –100 mg/kg/day

Clindamycin 10 mg/kg 300 mg 15-40 mg/kg/day

Gentamicin 2 mg/kg 100 mg 4-7 mg/kg/day

Penicillin G 100,000 U/kg 2 mil U 300,000U/kg/day

Vancomycin 15 mg/kg 2 gm 30 -45 mg/kg/day

Piper/Tazobac. 80mg/kg 3.375 gm 240-300 mg/kg/day

Amp/Tazobac 25-50mg/kg 3 gm 150-300 mg/kg/day

## Anticonvulsants (Status Epilepticus Dosing)

Diazepam 1 mo.-5 yo. 0.2-0.5 mg/kg IV q 10-30 min.; max. 5 mg

> 5yo. 1.0 mg/kg IV q 15-30 min.; max. 10 mg

Midazolam 0.2 mg/kg IV, max 1 mg per increment, repeat as necessary  
(Premedication dosing different)

Phenobarbital 10-20 mg/kg/dose IV,   
then 2.5 mg/kg/ bid,  
Therapeutic level 20 -40 mcg/ml

Phenytoin 10-20 mg/kg IV load (slow);   
then 2.5 g/kg/bid

Therapeutic Levels: 10 - 20 mcg/ml

## Antidysrhythmics

Esmolol IV 0.1 - 0.5 mg/kg IV push

infusion 50-200 mcg/kg/min

Labetalol IV 0.125- 0.25 mg/kg

Lidocaine IV load 1.0 mg/kg, repeat to max. 3-5 mg/kg

infusion 30-50 mcg/kg/min

Phenytoin IV 2-4 mg/kg over 5 min, up to 15 mg/kg

Procainamide IV load 2-5 mg/kg over 30 min   
 infusion 20-80 mcg/kg/min; max. 50-60 mg/kg/day

Propranolol IV 10 - 100 mcg/kg slow IV push;

max. single dose 1 mg

## Antiemetics

Ondansetron IV 0.15 mg/kg, max 4 mg

Dolasetron IV 0.35 mg/kg, max 12.5 mg

Metoclopramide IV 0.15 mg/kg, max 10 mg

Dexamethasone IV 0.5 mg/kg, max 10 mg

## Bronchodilators

Albuterol inhaled usually 2.5 mg in 2.5 ml NS given to all patients (for the preemies may use 1.25mg). This is the standard unit dose at UTMB.

Dexamethasone IV 0.15-1.0 mg/kg (max 10mg) load

Epinephrine SC 0.01 ml/kg (1:1000); max. = 0.5 ml

Hydrocortisone IV 4-8 mg/kg load

IV 8 mg/kg/24 hrs infuse or divide q 6 hr  
Ipatroppium inhaled 250 -500 mcg x 3 then q 4h by nebulizer

Metaproterenol inhaled 0.2 - 0.3 ml in 2.5 ml saline via nebulizer

## Diuretics

Furosemide IV 0.25-1 mg/kg

Mannitol IV 0.25-1 gm/kg

## Epinephrine dilutions

1:10,000 100 mcg/ml

1:100,000 10 mcg/ml

1:200,000 5 mcg/ml

1:400,000 2.5 mcg/ml

## H2 Blockers, Antacids

Cimetidine IV/PO 7.5 mg/kg

Famotidine IV/PO 1 - 2 mg/kg/day ÷ q12h, max 40 mg/dose

Ranitidine IV/PO 0.5 mg/kg

Sodium citrate PO 0.4 ml/kg, max 30 ml

## Induction / Sedative Agents

Chloral hydrate PO/PR 50 - 70 mg/kg (hypnotic dose), max 1 gm/dose

Clonidine PO 3-5 mcg/kg

Dexmedetomidine IV 0.5 -2 mcg/kg

IN 2-3 mcg/kg

Etomidate IV 0.1 - 0.3 mg/kg

Ketamine IV 1 - 2 mg/kg

IM 4-10 mg/kg

Methohexital IV 1 - 2 mg/kg

PR 30 mg/kg

Midazolam IV 0.1 -0.2 mg/kg, max 2 mg

PO 0.5 - 1.0 mg/kg, max 20 mg

Propofol IV 2-4 mg/kg

Infusion 50-200 mcg/kg/min

Thiopental IV 4-7 mg/kg

PR 20-30 mg/kg

Benzodiazepine Antagonist

Flumazenil IV 8-15 mcg/kg, titrated to effect

## Inhalational Agents - MAC

Age Halothane Isoflurane Sevoflurane

Birth 0.87% 1.4% 3.3%

2-3 yrs 1.08% 1.7% 2.8%

3-10 yrs 0.9% 1.4% 2.5%

Adult 0.76% 1.15% 2.1%

## Inotropes and Vasopressors

Digoxin: total digitalizing dose (TDD): give ½ TDD SIVP then ¼ TDD q6hr x 2.

IV premature 20 mcg/kg

neonate 30 mcg/kg

<2 yrs 30-50 mcg/kg

2-10 yrs 15-30 mcg/kg

>10 yrs 10-15 mcg/kg

Therapeutic Levels: 0.8 - 2.0 mcg/L

Dobutamine IV 5-10 mcg/kg/min, max. 40 mcg/kg/min

Dopamine IV 3-20 mcg/kg/min

Epinephrine IV 0.1-1.0 mcg/kg/min

Milrinone IV load 50 mcg/kg over 10 min.

Infusion 0.375-0.750 mcg/kg/min

Norepinephrine IV 0.1-1.0 mcg/kg/min

Phenylephrine IV 0.1-1.0 mcg/kg/min

IV Push Doses

Ephedrine 0.1 mg/kg

Epinephrine 1 - 10 mcg/kg

Phenylephrine 1 - 2 mcg/kg

**PEDIATRIC RESUSCITATION DOSES**

Atropine IV 20 mcg/kg, min 0.1 mg

Epinephrine IV 10 mcg/kg 0.1 ml/kg of 1:10,000

Calcium chloride IV 5 mg/kg

Lidocaine IV 1 mg/kg q 5-10 min to 4 mg/kg

Dextrose IV 0.5 g/kg

Naloxone IV 10 mcg/kg

Na bicarbonate IV 1-2 mEq/kg (4.2%)

Adenosine IV 0.05 mg/kg rapid IV push, increase by 0.05 increments, up to max dose of 12mg

Defibrillation 2J/kg, then 4J/kg

## Muscle Relaxants - Intubating Doses

Cis-Atracurium IV 0.1 mg/kg

Mivacurium IV 0.2-0.3 mg/kg

Pancuronium IV 0.1 mg/kg

Rocuronium IV 0.6-1.2 mg/kg

Succinylcholine IV 1-2 mg/kg

IM 4-5 mg/kg

Vecuronium IV 0.1 mg/kg

## Reversal agents & Adjuncts

Edrophonium IV 0.5 - 1 mg/kg

& Atropine IV 15 - 20 mcg/kg (min 0.1 mg)

Neostigmine IV 50 - 70 mcg/kg

& Glycopyrrolate 10 mcg/kg (or EQUAL VOLUMES OF EACH)

## Parasympathetic antagonists

Atropine IV/IM 10 - 20 mcg/kg (min 0.1 mg)

Glycopyrrolate IV 5 - 10 mcg/kg

Scopolamine IV 5 - 10 mcg/kg

## Steroids

Dexamethasone IV 0.5 mg/kg, max 10 mg

Hydrocortisone IV 2 mg/kg q6h

## Vasodilators

Labetalol IV 0.125-0.25 mg/kg

Nitroglycerin IV 0.5 - 10 mcg/kg/min

Phentolamine IV 50-100 mcg/kg

Infusion: 10-20 mcg/kg/min

Prostaglandin E1 IV 0.1 mcg/kg/min

Na Nitroprusside IV 0.5-10 mcg/kg/min

## Miscellaneous

Dantrolene IV 2.5 mg/kg to 10 mg/kg max.

Dextrose IV 0.25 - 0.5 gm/kg IV (=1 -2 ml/kg of 25% Dextrose)

Diphenhydramine IV 0.125 - 0.25 mg/kg q 6 hrs

Insulin IV 0.02 - 0.1 units/kg/hr.

Ca Gluconate IV 15 mg/kg

Caffeine IV 10 mg/kg

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Acetaminophen | 4,6,37, 40, 47 |  | Insulin | Inside cover,54 |
| Adenosine | 51 |  | Ipatroppium | 49 |
| Albuterol | 49 |  | Isoflurane | 50 |
| Aminocaproic acid | 36,37,38 |  | Ketamine | 4,5,37,38,40,45,50 |
| Amoxicillin | 46 |  | Ketorolac | 47 |
| Ampicillin | 46,47 |  | Labetalol | 48,52 |
| Atropine | 9,45,51,52 |  | Lidocaine | 8,14,29,37,42,44,48 |
| Bupivacaine | 9,29,30,31 |  | Mannitol | 49 |
| Caffeine | 15,52 |  | Meperidine | 47 |
| Calcium Chloride | 51 |  | Metaproterenol | 49 |
| Calcium Gluconate | 51 |  | Methohexital | 4,5,50 |
| Cefazolin | 46,47 |  | Methylprednisolone | 35 |
| Cefotetan | 47 |  | Metoclopramide | 48 |
| Cefuroxime | 47 |  | Midazolam | 4,5,6,37,40,48,50 |
| Cephalexin | 47 |  | Milrinone | 51 |
| Chloral hydrate | 50 |  | Mivacurium | 52 |
| Cimetidine | 35 |  | Morphine | 31,37,40,41,43,47 |
| Cis-Atracurium | 52 |  | Na bicarbonate | inside cover, 51 |
| Clindamycin | 46,48 |  | Naloxone | 31,47,51 |
| Clonidine | 9,50 |  | Neostigmine | 52 |
| Dantrolene | inside cover, 52 |  | Nitroglycerin | 52 |
| Dexamethasone | 28,35,42,48,49,52 |  | Nitroprusside | 52 |
| Dexmedetomidine | 4,5,43,50 |  | Norepinephrine | 51 |
| Dextrose | inside cover,51,53 |  | Ondansetron | 28,31,42,43,48 |
| Diazepam | 41,48 |  | Pancuronium | 52 |
| Digoxin | 51 |  | Penicillin G | 47 |
| Diphenhydramine | 31,52 |  | Phenobarbital | 48 |
| Dobutamine | 51 |  | Phentolamine | 52 |
| Dolasetron | 48 |  | Phenylephrine | 51 |
| Dopamine | 51 |  | Phenytoin | 48 |
| Doxepram | 15 |  | Procainamide | inside cover, 48 |
| Edrophonium | 52 |  | Propofol | 28,31,37,41,45,50 |
| EMLA | 5,45 |  | Propranolol | 48 |
| Ephedrine | 9,51 |  | Prostaglandin E1 | 52 |
| Epinephrine | 9,14,30,35,49,51 |  | Ranitidine | 49 |
| Esmolol | 48 |  | Remifentanil | 47 |
| Etomidate | 49 |  | Rocuronium | 52 |
| Famotidine | 49 |  | Scopolamine | 52 |
| Fentanyl | 31,37,42,44,47 |  | Sevoflurane | 50 |
| Flumazenil | 50 |  | Sodium citrate | 49 |
| Furosemide | 48 |  | Succinylcholine | 9,14,44,45,52 |
| Gentamicin | 47 |  | Sufentanil | 47 |
| Glycopyrrolate | 52 |  | Tetracaine | 30 |
| Halothane | 50 |  | Thiopental | 49 |
| Hydrocortisone | 35,48,52 |  | Vancomycin | 47 |
| Hydromorphone | 47 |  | Vecuronium | 52 |

INTUBATION

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Blades | |  | | | | | | | | | |
|  | | | | | | | 🡨 Mac 2 🡪 | | | 🡨 Mac 3 🡪 | | |
|  | | 🡨 Miller 0 🡪 | | | 🡨 Miller 1 🡪 | |  | | 🡨 Miller 2 🡪 | | | |
| Age | | Premie | | Term | 3 mo | 1 yr | | 3 yr | 5 yr | | 10 yr | Adult |
| Wt (kg) | | 1 | 2 | 3 | 5 | 11 | | 15 | 19 | | 35 | 70 |
| ETT size I.D. (mm) | | 2.5 | 2.5-3.0 | 3.0-3.5 | 3.5 | 4.0 | | 4.5 | 5.0 | | 5.5-6.5 | 7.0-8.0 |
| Depth - oral (cm) | | 7 | 8 | 9 | 10.5 | 12 | | 13.5 | 15 | | 18 | 19-23 |

\*for ages 2 - 4 years, Wis-Hipple 1.5 is an excellent blade, but not readily available at UTMB

Formulas (none are perfect)

ETT Size in ID (mm) = Age +4

4

*often need to add 0.5 size or cuff*

Depth -- oral (cm) at lips = Age + 13 = **3 X ETT size** (by above formula)

2

*Reminder: Oral Rae tubes are bent at this number*

Neonatal 1-2-3 kg 🡪 7-8-9 cm depth

Size: 2.5 ETT for < 1.2 kg, 3.0 ETT for 1.2-2.4 kg, 3.5 ETT > 2.4 kg

50 percentile wt (kg)= 9 + (2 x Age)

Laryngeal Mask Airway

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| LMA size | Wt. (kg) | Cuff Volume (ml) | FOB Size (OD, mm) | Largest ETT (ID, mm) |
| 1 | < 5 | < 4 | 2.7 | 3.5 |
| 1.5 | 5-10 | < 7 | 3.0 | 4.0 |
| 2.0 | 10-20 | < 10 | 3.5 | 4.5 |
| 2.5 | 20-30 | < 14 | 4.0 | 5.0 |
| 3 | 30-50 | < 20 | 5.0 | 6.0 cuff |
| 4 | 50-70 | < 30 | 5.0 | 6.0 cuff |
| 5 | >70 | < 40 | 7.3 | 7.0 cuff |