Georgetown Pediatric Anesthesiology Primer

By Mark Dobish, M.D.

Objective

The purpose of this document is to provide a brief overview of several common, basic topics in pediatric anesthesiology that are encountered routinely. A few examples are NPO times, fluid replacement, treatment of preoperative anxiety, PONV, and upper respiratory infections (URI), to name a few. In addition, this document will provide examples of the most common pediatric cases performed at Medstar Georgetown University Hospital (MGUH) and the anesthetic and surgical considerations for each. The information contained here is not meant to be comprehensive, but rather a brief introduction to the world of pediatric anesthesiology. Although we do perform liver and small bowel transplants at MGUH in pediatric patients, that will not be covered here.

The overarching goal of this rotation is to help you understand the basic management of pediatric patients undergoing surgical procedures, so that when you start your CA-2 rotations at Children's National Medical Center (CNMC), you will have some basic knowledge to draw upon as you tackle more complex cases and operating rooms with significantly faster turnover. Please refer to the "Goals and Objectives" document from Dr. Freeman for more specific information.

During the course of your CA-1 rotation you will be paired with one of the five members of the pediatric anesthesiology group by the anesthesiologist in charge. It is your responsibility, at a minimum, to chart check each patient's medical record so that you are adequately prepared for the next day and to call your attending or leave a voicemail discussing your anesthetic plan. Pay close attention to the patient's previous anesthetic records (airway, medications given, exact procedure performed) since this may alter your management. For neonates, infants, and small children also pay close attention to the birth history, as many common conditions of prematurity (chronic lung disease, necrotizing enterocolitis, etc.) may cause persistent issues in growing children. For babies coming to the OR from the neonatal ICU (NICU), it may be helpful to visit the patient or call the floor/parents and obtain your consent the night before, since parents may not be in the hospital or reachable by phone the next morning at the time of surgery.

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Part 1: Common Pediatric Anesthesiology Topics

****** Especially important topics that may appear on ITE and/or Board Exams are emphasized in bold.******

NPO Guidelines

The table below shows the fasting guidelines recommended by the American Society of Anesthesiology (ASA).

Clear Liquids*	2 hours
Breast Milk	4 hours
Infant Formula, Non-human Milk Light Meal+	6 hours
Full Meal	8 hours

*Clear liquids include water, juices (without pulp), coffee without cream, clear tea, and carbonated beverages.

+Light meal includes toast with clear liquids.

These times have been developed based on gastric emptying times after patients have consumed each of the above food groups with radioactive tracers. Meals with a high fat or protein content may prolong the fasting period. The amount as well as the type of food should be considered when determining the correct fasting time.
Certain pediatric patient populations, such as those with Sickle Cell Disease, may be admitted earlier than usual for IV placement and adequate hydration prior to surgery. Some institutions recommend admission 4 hours prior to surgery, or the evening before if the surgery is to be the first case of the day.

In addition, neonates and infants should be encouraged to continue oral intake until the required cutoff time. This will help to decrease a child's irritability in the holding area and expedite intravenous line placement following an inhalational induction. Patients coming to the OR from the NICU, PICU, or pediatrics floor should already have an IV in place and be started on maintenance fluids (with dextrose if indicated) at the required NPO cutoff time. Inhalational inductions and oral premedications are not indicated in this situation, as all medications can be given through the IV.

Preoperative Anxiolysis

Premedication is a useful adjunct in the pediatric population to allow for easy separation between patient and parent. Separation anxiety is present in nearly all children, **however this response does not manifest until the 8-10 month age range**. Therefore, premedication is not used below this age cutoff. Premedications are routinely used in the one to five year age range, however children older than this age group may have developed coping mechanisms to deal with the stress of unfamiliar situations and may be able to proceed to surgery without the addition of a premedication.

The most common premedication is oral midazolam. This is usually given as a liquid at a dose range between 0.5mg/kg - 1.0mg/kg, not to exceed a dose of 20mg in total. Special care should be given when administering this medication, as young patients may resist taking it, or spitting out part of the dose. A good technique is coaching parents how to give the medication and allow them to administer it to the child themselves. Optimal timing is usually 20 minutes prior to separation, since the medication will have minimal absorption and effect prior to this duration. Anxiolytic effects typically wane around 40 minutes.

Although oral midazolam is the most common preoperative anxiolytic, other options do exist such as ketamine (PO or IM), sufentanil (intranasal), and dexmedetomidine (intranasal). Ketamine is commonly given intramuscular at a dose range of 3-5mg/kg and intranasal sufentanil 0.25-0.5ug/kg. Intranasal dexmedetomidine is usually given at a dose of 1-2ug/kg. Most institutions do not monitor vital signs after oral midazolam, however monitoring with pulse oximetry may be prudent after administering sufentanil or dexmedetomidine.

Parental Presence on Induction (PPI)

An alternative to premedication that has gained recent popularity is parental presence on induction (PPI). This refers to the presence of one parent during an inhalational induction and provides several advantages. The biggest advantage of PPI is the ability to avoid premedication, especially during quick procedures which residual sedation may slow down flow through the PACU. The most obvious example is a desire to avoid premedication for myringotomy tubes because of this reason. Disadvantages of PPI include an increased burden on the anesthesiologist and staff to control a parent who is not familiar with the operating environment, unpredictable reactions by a parent upon seeing their child anesthetized, and parents who are overly anxious themselves.

Despite these disadvantages, several studies have shown that many parents prefer to be present during induction. **It is important to keep in mind that PPI has not been shown to be any more effective than oral midazolam.**

Upper Respiratory Infections (URI)

One of the most common issues encountered in pediatric anesthesiology is the presence of an upper respiratory infection (URI). Children under the age of four years old experience an average of eight URIs per year, with symptoms lasting on average one week but with possible persistence up to 3 weeks. Therefore, URI is the most common cause for procedural cancellation. All children presenting with signs of an URI such as runny nose, fever, cough, and general irritability should be evaluated to determine the etiology. Some conditions, such as vasomotor or seasonal rhinitis, are non-infectious in etiology and do not warrant cancellation. In contrast, similar symptoms may be indicative of an underlying viral or bacterial process **which have been shown to significantly increase the risk or adverse respiratory events such as bronchospasm, laryngospasm, and desaturation**. Symptoms of infection include persistent fevers, thick purulent sputum, and a wet cough. If the decision is made to delay surgery, there is no overall consensus on the most appropriate time to reschedule. One study of over 9,000 patients found a statistically significant decrease in respiratory events in patients presenting <2 weeks after cancellation vs. 2-4 weeks following cancellation (29% vs. 8%).

Reactive Airway Disease

A history of reactive airway disease (RAD) should be thoroughly assessed and classified as mild, moderate, or severe. An anesthesiologist should routinely auscultate a patient's lungs and elicit medication compliance. It is common practice to administer bronchodilating medications in the preoperative area if they have not already been given that day. In addition, it is wise to tailor an anesthetic to minimize complications from reactive airway disease; most notably through the use of bronchodilating medications such as volatile anesthetics or ketamine. **If appropriate, avoidance of intubation decreases the risk of exacerbating RAD if an LMA can be used safely.**

The most common complication of RAD is bronchospasm which can be accompanied by desaturation, laryngospasm, or increased airway secretions. Emergency medications including albuterol and epinephrine should be available before induction of any general anesthetic, especially if the trachea will be intubated. Asthmatics are commonly extubated deep to prevent bronchospasm from noxious stimuli during emergence.

Obstructive Sleep Apnea

Obstructive sleep apnea (OSA) is defined as complete apnea lasting for longer than 10 seconds, occurring at least 5 times an hour, and accompanied with a decrease in saturation of at least 4%. Hypopnea is defined as 50% reduction in airflow and also accompanied by at least a 4% drop in saturation. Both are diagnosed by polysomnography and can cause several systemic comorbidities including RV and LV hypertrophy, pulmonary hypertension, arrhythmias, altered mental status, and cor pulmonale. The pulmonary comorbidities result from the fact that the lung, unlike systemic vasculature, responds to hypoxia with vasoconstriction. Chronic states of hypoxia resulting from OSA cause pulmonary HTN to develop and place an increased burden on the RV. Obesity is the most common risk factor for OSA, however many patients with OSA are not obese.

The STOP-BANG criteria is commonly used to assess high risk adult patients for OSA. A score of 3 or more indicates moderate to high risk for OSA. It is defined as follows:

- **S** - Snoring
- **T** - Tiredness during the day
- **O** - Observed to stop breathing during sleep
- **P** - Pressure (dx of HTN)
- **B** - BMI > 35
- **A** - Age > 50
- **N** - Neck Circumference (>40 cm)
- **G** - Gender (Male)

The following table describes the severity of OSA based on the apnea hypopnea index and is defined by the American Society of Otolaryngologists.

Apnea Hypopnea Index (AHI)
Mild 5 –15
Moderate 15 – 30
Severe > 30

While OSA in adults is caused by redundant soft tissue, in children the most common cause is adenotonsillar hypertrophy. Therefore, adenotonsillectomy is curative in over 75% of cases of OSA in children.

Postoperative Apnea

Another common issue in pediatric anesthesiology is the occurrence of postoperative apnea, especially in infants born prematurely. Apnea is defined as cessation of breathing for 20 seconds or longer. Prematurity is defined as being born prior to 37 weeks gestational. Premature infants are generally not suitable for ambulatory surgical procedures due to immature respiratory centers that are not appropriately sensitive to hypoxia or hypercarbia, inadequate temperature regulation, and immature gag reflexes. Other risk factors, besides a history of prematurity, that are known to cause postoperative apnea include anemia, hypoxia, hypothermia, and hypocalcemia. It is commonly believed that sedative medications and general anesthetics increase this risk. **It is therefore usually required to observe all premature infants who are less than 55 weeks post-conceptional age (PCA) for 24 hours. For infants born at term, this time period is shortened and only required until an infant has reached 45 weeks PCA.**

Down Syndrome

Down Syndrome (Trisomy 21) is one of the most common genetic conditions worldwide, with an occurrence rate of approximately 1 in 1,000 live births in the United States. It is the result of a 3rd copy of chromosome 21 which can occur through several differing genetic mechanisms (Complete duplication, Robertsonian Translocation, mosaicism). Known risk factors include advanced maternal age and a history of a prior child with Down Syndrome. Anesthetizing children with this condition presents many issues since the syndrome affects nearly every organ system. Due to a relatively longer lifespan compared to other children with chromosomal abnormalities, children with Down Syndrome present early and often for corrective procedures throughout the course of their lives. Some of the most common issues for anesthesiologists will be briefly mentioned here.

- *Cardiac* - Congenital Heart Disease including endocardial cushion defects, tetralogy of Fallot, ASD/VSD, and **bradycardia on induction of anesthesia** (typically resolved by decreasing concentration of volatile anesthetic). Check for prior echo in chart.
- *Gastrointestinal* - duodenal atresia, annular pancreas, Hirschsprung Disease
- *HEENT - Cleft Palate, **Subglottic stenosis** (*have an ETT 1 and 2 sizes smaller that what you would normally use), abnormal ear canals (longer time for BMT), **cervical**

spine instability, airway obstruction (secondary to macroglossia, trachea and airway malacia, generalized hypotonia, and tonsillar hypertrophy)

- *Hematologic* - Leukemia especially later in life

Postoperative Nausea and Vomiting

PONV is a common complication following surgery with general anesthesia and has been recognized for at least 70 years. It occurs in 20-30% of patients, however occurrence can be as high as 70-80% in certain high risk patient populations. **The four most commonly cited and validated risk factors for PONV were studied by Christian Apfel and found to be the following, each of which carries an increased risk.**

- **Female**
- **Non-smoker**
- **History of PONV**
- **Postoperative Opioids**

The presence of all 4 above categories confers a 73% risk of PONV. In addition to the above *patient-related* risk factors, the type of surgery may also increase the risk of PONV. The following types of surgeries place patients at increased risk for PONV:

- Laparoscopic Procedures
- Gynecological Surgery
- Eye Surgery
- Middle Ear Surgery

The decisions made by an anesthesiologist may mitigate PONV in certain high risk populations, most notably choosing regional or neuraxial analgesia when appropriate, or implementing a TIVA method to minimize exposure to volatile anesthetics. The pathophysiology of PONV is of particular importance for pediatric anesthesiologists. The **chemoreceptor trigger zone (CTZ)** is a part of the brain that monitors the blood and neuronal inputs from other parts of the body. Once the signal for emesis has been received, the CTZ communicates with the emesis center via the Nucleus of the Tractus Solitarius, which will then initiate the appropriate motor response. **In pediatrics, these parts of the brain are poorly developed before 2 years of age**. Therefore, PONV prophylaxis, particularly in the form of Ondansetron, is not indicated before this age.

Part 2: Common Pediatric Anesthesiology Cases at Georgetown (Excluding Transplant):

Tonsillectomy and Adenoidectomy

At MGUH, there are three primary indications for T&A - obstructive sleep apnea, chronic tonsillar infections, or uniquely PANDAS (Pediatric Autoimmune Neuropsychiatric Disorders Associated with Streptococcal infections). The two former conditions are the much more common indications for T&A. PANDAS patients are usually cared for by Dr. Harley, and they may present with generalized anxiety, obsessive-compulsive behaviors, and mood swings. The pathophysiology of this disease is thought to be autoimmune in nature and triggered by a group-B streptococcal infection. While the immune response combats the infection, it also mistakenly attacks cells of the basal ganglia leading to the associated neurological symptoms. Please refer to the section under Obstructive Sleep Apnea in part 1 for a brief overview of important points regarding OSA.

Important considerations for anesthetizing children for T&A include safe and effective airway management, smooth emergence, and adequate postoperative pain control. Oral midazolam is usually given as a premedication to facilitate separation anxiety in children 1-5 years of age. This procedure usually lasts about 60-75 minutes at MGUH, so the therapeutic effect is usually minor at the time of extubation. Keep in mind this may not be true at CNMC or other practices with rapid ENT turnover, and you may consider placing an OG tube to remove any medication left in the stomach after induction. Pay close attention to the airway during induction and expect significant obstruction - place an oral airway quickly and close the APL valve to provide CPAP as necessary. Choose an appropriately sized ETT (MGUH - regular ETT taped down the middle. CNMC and elsewhere - Oral RAE tube) and inflate the cuff “just to seal”. This will prevent blood from the oropharynx entering past the pilot balloon and into the lungs. Always have a second ETT available in case of accidental extubation by the ENT team. This is most common during suspension, at which time **flexion of the neck may cause the tip of the ETT to become displaced distally into a mainstem bronchus, while excessive extension may cause accidental extubation.** Prior to the start of surgery, lower your FiO_2 < 30% if electrocautery is being used.

Approximately 20% of patients have postoperative respiratory complications including laryngospasm, bronchospasm, or obstruction. Keep in mind that despite the removal of the tissue causing obstruction, symptoms of OSA will still persist for several more weeks-months. Therefore you should expect the airway to be no better immediately following surgery. At the conclusion of the procedure, extubation may be performed “deep” (>1MAC inhalational agent, 100% FiO_2, Spontaneous Ventilation) or awake. Each has advantages and disadvantages, so many will tailor their decision based on each patient's specific comorbidities. Advantages of deep extubation include minimal “bucking” at the end of the case, quicker room turnover, and smoother emergence. Advantages of awake extubation include greater airway control, however bucking may lead to increased bleeding.

Acetaminophen IV (15mg/kg) is usually given during the procedure for pain control, **since children with OSA have an exaggerated response to opioids.** While fentanyl or morphine are still given, extra vigilance is required. Other adjuvant medications for T&A include ondansetron, dexamethasone, and dexmedetomidine (attending dependent).

T&A Complications

The most significant complication following T&A is postoperative bleeding, which comes in two varieties. Primary bleeding is any type of bleeding which occurs in the first 6-24hrs following surgery and is due to the re-opening of blood vessels in the tonsillar fossa. These bleeds are usually brisk and may cause significant blood loss. They account for approximately 75% of T&A rebleeds. The remaining 25% of rebleeds are referred to as secondary bleeding, and they typically present 5-10 days following surgery. This type of bleed is due to the scab falling off of the surgical site and is typically a slower, more indolent bleed. Nonetheless, both types of bleeds can cause significant blood loss and anemia such that a CBC should be routinely ordered on re-admission.

Myringotomy Tubes

Ear tubes are one of the quickest and most frequently performed procedures in the United States. This case is almost always performed with simple inhalational masking, with the patients head turned to the opposite side while the ear tubes are placed. Intubation, LMA, and IVs are rarely necessary unless the patient has significant medical comorbidities (i.e. Down Syndrome). Postoperative pain is usually minimal. Common pain control regiments are Ketorolac IM or Fentanyl Intranasal (same formulation as IV, administered by a TB syringe with no needle on the end).

Laryngoscopy/Bronchoscopy/Supraglottoplasty (DLB)

These procedures are commonly performed on children multiple times to evaluate common breathing issues such as apnea and stridor. They may be performed repeatedly over any length of time to evaluate for any changes and worsening or improving of symptoms. Supraglottoplasty procedures vary widely and may be as minimal as resecting small amount of tissue in the larynx region to a laryngeal tracheal resection. Considerations for these types of cases are similar to other ENT procedures, including airway fire precautions, and a consideration for a TIVA technique (propofol infusion) since this is a convenient way to deliver a stable anesthetic. Disadvantages of volatile include polluting the OR atmosphere and providers and unsteady ranges of anesthetic depth. This case usually begins with an inhalational induction for PIV placement, followed by starting a propofol infusion and turning the bed 90 degrees to the ENT team. Be sure to have a wide range of tube sizes, both cuffed and uncuffed if the tracheal diameter is to be measured.

MRI

At MGUH you may be occasionally tasked to care for patients in the MRI suite. Much of the information in this section applies equally to adults as well as children. The majority of issues in this location stem from a difficulty in easily monitoring a patient's vital signs and general inaccessibility of the patient. Once the patient is slid into the scanner, it will be very difficult to make any adjustments without stopping the scan and sliding the patient out. The high strength magnetic field will disable most conventional monitors and electronic devices. Metallic objects brought near the scanner may become missile like projectiles. Patient associated items like pacemakers, joint replacements aneurysm clips must be verified prior to induction of general anesthesia.

Your anesthetic choices are somewhat limited here since it is very cumbersome to set up a ventilator unless absolutely essential. You may use a natural airway with nasal $EtCO_2$ plus fentanyl, midazolam and/or a propofol infusion. Alternatively you may place an LMA with a propofol infusion, or place an ETT. If an ETT is used then short acting paralytics should be used as well, otherwise a resident or APC will have to stay in the room and manually bag the patient unless sugammadex is also administered.

Endoscopy

Many patients undergoing endoscopy procedures are at increased risk for aspiration. This is especially true for children at MGUH since many have a history of small bowel transplants and repeat intra-abdominal procedures. They are likely to have altered motility, increased gastric secretions, electrolyte disturbances, or possible GI bleeding. The type of airway ranging from natural with nasal $ETCO_2$, LMA, or ETT will depend on the patient's age and comorbidities. LMAs do not pose any unique considerations in children undergoing EGD, as the endoscope is small and can usually fit easily around a well seated LMA. Leaks are small and can be well tolerated for a brief period of time. Patients may also need to be rolled into a variety of positions to facilitate passage of the colonoscope, so this should be kept in mind. In smaller children, a "frog-leg lithotomy" may be used which will avoid the need to place the child on their side. Also keep in mind that in children with an already distended abdomen, insufflation pressure in the colon may place additional pressure on the diaphragm and affect ventilation.

Part 3: High Yield Multiple Choice Questions

(These questions come from Hall's Anesthesia, A Comprehensive Review)

575. What is the maximum allowable blood loss (MABL) for a 10-kg, 11-month-old infant whose starting hematocrit (Hct) is 36 and the minimal acceptable Hct is 25?

A. 110 mL
B. 245 mL
C. 350 mL
D. Cannot be calculated without additional information

575. (B) To calculate the MABL, the following formula is commonly used:

MABL= Estimated blood volume × (starting hematocrit−target hematocrit)

Starting hematocrit

The estimated blood volume (EBV) in mL/kg for a premature infant is 90 to 100 mL/kg, term new-borns is 80 to 90 mL/kg, 3-month-olds to 1-year-olds is 75 to 80 mL/kg, 3-year-olds to 6-year-olds is 70 to 75 mL/kg, and older than 6 years of age is 65 to 70 mL/kg. In this case, using 80 mL/kg, the EBV for the 10-kg 11-month-old, we have an EBV of 800 mL.

MABL=800 mL (36 − 25)/36 = about 245 mL

Before infusing blood, the circulating blood volume is usually expanded with crystalloids in a ratio of 3 mL of crystalloid for each mL of blood lost (Davis: Smith's Anesthesia for Infants and Children, ed 8, pp 384–385, 409; Miller: Miller's Anesthesia, ed 8, pp 2784–2785).

578. An otherwise healthy 4-year-old male patient is undergoing elective tonsillectomy. Before induction of general anesthesia, the patient is breathing at a rate of 20 breaths/min. An inhalation induction is begun with sevoflurane, nitrous oxide, and oxygen. Ninety seconds later, the patient is noted to breathe at a rate of 40 breaths/min. This rapid respiratory rate most likely represents

A. Hypoxia

B. Hypercarbia and early development of malignant hyperthermia (MH)

C. The excitement stage of anesthesia

D. Aspiration of gastric contents

578. (C) Inhalation agents are respiratory depressants. In general, they increase the respiratory rate and decrease the tidal volume (Vt) of respirations and are associated with an increase in Paco2. When inducing a child with an inhalation agent, especially below the minimum alveolar concentration (MAC) level, the respiratory pattern can vary and include breath holding, excessive hyperventilation, and laryngospasm. Although the stages of inhalation anesthesia were classically described with ether, similar stages are seen with the newer inhalation agents, but because the signs are less pronounced they are rarely described anymore. The classic stages of depth of ether anesthesia include the first stage of anesthesia (analgesia). Patients in the first stage can respond to verbal stimulation, have an intact lid reflex, have normal respiratory patterns and intact airway reflexes, and have some analgesia. The second stage of anesthesia (delirium or excitement stage) is associated with unconsciousness, irregular and unpredictable respiratory patterns (including hyperventilation), nonpurposeful muscle movements, and the risk of clinically important reflex activity (e.g., laryngospasm, vomiting, cardiac arrhythmias). The third stage of anesthesia (surgical anesthesia) is associated with a return to more regular periodic respirations and is the level associated with the achievement of MAC. MAC is noted by the absence of movement (in 50% of patients) in response to a surgical incision. As anesthesia is deepened, stage 4 (respiratory paralysis) is associated with respiratory and cardiovascular arrest. In the case cited in this question, the second stage of anesthesia is demonstrated. Note: MH triggered by the sole use of volatile anesthetics produces an elevation of carbon dioxide levels with tachypnea and tachycardia, but this is rare during the first 20 minutes of an anesthetic. Sevoflurane and desflurane seem to be less of a trigger than halothane. Mild

hypothermia, propofol, nondepolarizing neuromuscular blockers, and tranquilizers may delay or prevent MH from developing. Succinylcholine (the only depolarizing neuromuscular blocker in use today) often hastens the development of MH in susceptible patients. Aspiration of gastric contents would more likely lead to laryngospasms, wheezing, and hypoxia. (Davis: Smith's Anesthesia for Infants and Children, ed 8, pp 230–231; Miller: Miller's Anesthesia, ed 8, pp 691–692, 1294–1295; Butterworth: Morgan & Mikhail's Clinical Anesthesiology, ed 5, pp 890–891).

587. The most common cause of neonatal bradycardia (heart rate <100 beats/min) in the delivery room is

A. Congenital heart disease

B. Maternal drug intoxication (narcotics, alcohol, magnesium, barbiturates, digitoxin)

C. Postpartum cold stress

D. Hypoxemia

587. (D) Heart rates less than 100 beats/min are poorly tolerated in the neonate because of the reduced cardiac output and poor tissue perfusion that develops. Congenital heart disease, such as congenital heart block or congenital heart failure, is rare and can be diagnosed by neonatal electrocardiogram and echocardiogram. Maternal medications during labor and delivery rarely cause bradycardia; however, fetal distress as a result of hypoxia may cause it. Fever as well as maternal administration of β-mimetics (e.g., terbutaline, ritodrine) tend to cause tachycardia. Cold stress of the neonate may lead to hypoxemia, which will promote persistence of the fetal circulation, which is why a neutral thermal environment to minimize heat loss is important. However, the most common cause of neonatal bradycardia in the delivery room is respiratory failure resulting in hypoxia and acidosis. In the OR, bradycardia results from hypoxia, vagal stimulation, and the depressant effects of anesthetic agents (e.g., halothane), which can lead to cardiac arrest (Davis: Smith's Anesthesia for Infants and Children, ed 8, pp 513–514).

594. A 3-year-old with a cough and sore throat, but no fever, is scheduled for tonsillectomy. Physical examination reveals minimal inspiratory wheezing. Chest x-ray reveals a small left lower lobe (LLL) infiltrate. The best course of action would be
A. Administer IV steroids and proceed
B. Delay for 10 to 14 days and treat with oral antibiotics
C. Postpone surgery for at least 1 month
D. Proceed

594. (C) This child most likely has a lower respiratory infection. The planned procedure should be delayed for a period of 4 to 6 weeks. This child may have early manifestations of pneumonia with the LLL infiltrate and should be evaluated by a pediatrician. Without a physical assessment, simply starting oral antibiotic therapy would be ill advised.
The specific time to reschedule surgery for children with upper respiratory infections (URIs) is not absolute. Generally acceptable guidelines for postponement of elective surgeries for these patients suggest 1 to 2 weeks after recovery from the acute illness. Manifestation of URI include (1) mildly sore or scratchy throat; (2) change in feeding or level of activity; (3) cough or sneezing; (4) rhinorrhea (new or change in consistency); (5) nasal congestion; (6) fever higher than 101° F (38.8° C); and (7) inflamed throat or hoarse voice. The presence of these signs and symptoms increases the likelihood of postoperative airway complications and may necessitate an overnight admission. Children with preexisting reactive airway disease, regardless of etiology, who develop URI are at higher risk of postoperative complications, and the threshold for postponing surgery should be even lower than for similar patients without comorbidities (Davis: Smith's Anesthesia for Infants and Children, ed 8, pp 1112–1114: Miller: Basics of Anesthesia, ed 5, p 555).

600. In which of the following patients would the minimum alveolar concentration (MAC) for isoflurane be the greatest?
A. A premature infant 30 weeks' PCA
B. Full-term neonate
C. 3-month-old infant
D. 19-year-old man with hyperthyroidism

600. (C) The MAC for isoflurane is greatest at age 3 months. The MAC is lower in preterm neonates compared with term neonates. The low MAC in the newborns may be related to the immaturity of the CNS and/or related to the elevated levels of progesterone and β-endorphins. The increase in MAC in the first few weeks after birth seems to be related to the falling progesterone levels. After age 3 months, the MAC of these volatile anesthetics steadily declines with aging except for a slight increase at puberty. For reasons that are unclear, the MAC for sevoflurane is similar in neonates and infants younger than 1 year (3.2%). The MAC of sevoflurane then decreases with age (1 to 12 years, 2.5%; 40-year-old, 2%) (Davis: Smith's Anesthesia for Infants and Children, ed 8, pp 190, 556; Hines: Stoelting's Anesthesia and Co-Existing Disease, ed 6, p 587).

602. An otherwise healthy 3-month-old black female infant with a hemoglobin of 19 mg/dL at birth presents for elective repair of an inguinal hernia. Her preoperative hemoglobin is 10 mg/dL. Her father has a history of polycystic kidney disease. The most likely explanation for this patient's anemia is

A. Sickle cell anemia
B. Iron deficiency
C. Undiagnosed polycystic kidney disease
D. It is a normal finding

602. (D) The most likely explanation for the "falling" hemoglobin level in this patient is that this is a normal physiologic finding. At birth, a full-term infant has a hemoglobin level of approximately 15 to 20 g/dL. A physiologic anemia occurs by age 2 to 3 months, resulting in hemoglobin concentrations of approximately 10 to 11 g/dL. After 3 months, there is a progressive increase in hemoglobin concentration, which reaches levels similar to that of adults by age 6 to 9 months. For premature infants, the anemia is more pronounced (often to as low as 8.0 g/dL), occurs earlier, and persists longer (Davis: Smith's Anesthesia for Infants and Children, ed 8, pp 398–399).

609. The TRUE statement concerning thermoregulation in neonates is which of the following?
A. A significant proportion of their heat loss can be accounted for by their small surface area–to-weight ratio
B. They compensate for hypothermia by shivering
C. The principal method of heat production is metabolism of brown fat
D. Heat loss through conduction can be reduced by humidification of inspired gases

609. (C) Because of the large surface area–to-weight ratio, the thin layer of insulating subcutaneous fat, and the limited ability to compensate for cold stress, neonates and infants are at greater risk for intraoperative hypothermia than adults. Infants younger than 3 months do not produce heat by shivering; their principal method of thermogenesis is metabolism of brown fat. Heat loss can occur by radiation, conduction, convection, and evaporation. Heat loss through evaporation (not conduction) can be reduced by humidification of inspired gases. Heat loss by conduction (not convection) is reduced with the use of a warming blanket (Miller: Miller’s Anesthesia, ed 8, p 2763).

611. A 5-year-old child undergoing strabismus surgery under general anesthesia suddenly develops sinus bradycardia and intermittent ventricular escape beats but is hemodynamically stable. Which therapy is appropriate for treating this arrhythmia?
A. Tell the surgeon to stop pulling on the eye muscle
B. Tell the surgeon to do a retrobulbar block
C. Decrease the depth of the volatile anesthetic
D. Administer atropine

611. (A) The oculocardiac reflex (OCR) is commonly defined as a 10% to 20% decrease in heart rate that is sustained for more than 5 seconds. It can be induced by traction on extraocular muscles, pressure on the eye, orbital hematoma, ocular trauma, or eye pain. It is commonly seen with strabismus operations and may produce a wide variety of cardiac arrhythmias, including sinus bradycardia, nodal bradycardia, ectopic beats, ventricular fibrillation, and, rarely, asystole (1 in 2200 strabismus operations). The initial treatment of this is to stop the stimulus (i.e., tell the surgeon to stop what he or she is doing). This reflex quickly responds, and future similar stimulation typically elicits less of a response. In many cases no further treatment is necessary. Increasing the depth of general anesthesia may help to block the reflex, as may reassessing the adequacy of ventilation (because hypercarbia and hypoxemia decrease the threshold to elicit the OCR). A retrobulbar block will prevent the reflex. Infiltrating lidocaine locally into the recti muscles may be effective in preventing and treating the OCR. Atropine (0.01-0.02 mg/kg) or glycopyrrolate can be administered intravenously if the arrhythmia persists. Some advocate the prophylactic use of atropine or glycopyrrolate during strabismus surgery, especially in children (Davis: Smith's Anesthesia for Infants and Children, ed 8, pp 880–888; Miller: Basics of Anesthesia, ed 6, pp 487–488).

621. All of the following are true statements concerning physiology of newborns compared with that of adults EXCEPT

A. Newborns have a greater percentage of total body water compared with adults

B. Newborns have a higher glomerular filtration rate (GFR) than adults

C. Newborns' hearts are relatively noncompliant compared with adults

D. Newborns' diaphragms have a lower proportion of type I muscle fibers (i.e., fatigue resistant, highly oxidative fibers)

621. (B) Body composition changes dramatically during the first year of life. Total body water is about 80% for a term newborn compared with 55% for an adult woman and 60% for an adult man. Drugs that are water soluble (such as many antibiotics) will need to have higher mg/kg dose to achieve the desired blood concentrations. With the corresponding lower fat content of the preterm newborn (<5%) and term newborn (10%) compared with the adult (15+%), fat-soluble drugs that depend on redistribution will have a longer clinical effect. The GFR of newborns is low at birth and doubles or triples over the first 3 months of life, with a slower rise until adult values are reached by 1 to 2

years of age. This decrease in renal function can delay excretion of drugs that are dependent on renal clearance for elimination. The relatively noncompliant heart of a newborn gives it a limited capacity to deal with a volume load, compared with the adult. The preterm newborn has 10%, the term newborn has 25%, and the adult has 55% of type I muscle fibers (i.e., fatigue resistant, highly oxidative fibers). The lower proportion of type I fibers predisposes the newborn’s primary respiratory muscle fibers to fatigue (Miller: Miller’s Anesthesia, ed 8, pp 2763–2765; Miller: Basics of Anesthesia, ed 6, pp 547–551).