Preoperative Evaluation of the Pediatric Patient

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KEYWORDS

• Pediatric • Preoperative evaluation • Premature • Congenital heart disease
• Respiratory infection • Preoperative anxiety

KEY POINTS

- Infants and children are a unique population requiring special consideration during the preoperative period.
- Former premature infants up to 48 to 50 weeks postgestational age are at an increased risk for postoperative apnea and bradycardia, requiring close postoperative monitoring.
- Infants and children with congenital cardiac disease need thorough evaluation of their current anatomy and previous surgeries to evaluate their need for further cardiac evaluation and endocarditis prophylaxis.
- Infants and children with recent upper or lower respiratory infections are at risk of respiratory complications with administration of anesthesia.
- Both patient and parental anxiety should be anticipated and addressed before the day of surgery to increase the likelihood of a smooth operative course.

INTRODUCTION

This article is intended to assist the general anesthesiologist in preparing pediatric patients for the procedure or intervention. The preoperative workup discussed mainly focuses on infants and toddler-aged children. Neonatal and premature infant preoperative evaluation is outside the scope of this article and require additional discussion and depth of conversation. In general, most preoperative evaluation of adults can be applied to children. A thorough history and physical is needed, laboratory work is done if indicated, and specialty referral when deemed necessary.[1] However, there are special considerations with pediatric patients that make them unique and warrant

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further evaluation and attention. They also have a unique physiology that must be considered. Children naturally have less cardiorespiratory reserve and may be easily prone to cyanosis, bradycardia, and cardiac arrest. Specifically, the estimated anesthesia-related cardiac arrest in noncardiac cases is 1 per 10,000 to 15,000.[2–4] Outcomes for pediatric patients undergoing anesthesia have improved over the years as a result of advances in monitoring and equipment, safer and more easily titratable anesthetic agents, and possibly the practice of subspecialization.[4] However, knowledge of frequently encountered possible complications during administration of pediatric anesthesia should direct detailed preoperative evaluation, ultimately serving as a foundation for earlier detection and possible prevention of potential perioperative problems, leading to better outcomes. The article covers the subjects of gestational age, respiratory and cardiovascular concerns, fasting guidelines, and management of preoperative anxiety, all unique for pediatric population, as well as the current hot topic of the potential neurotoxic effects of anesthetics on the developing brain.

PREOPERATIVE EVALUATION

History, Physical, and Laboratory Examinations

Although the standard adult history and physical exam can be adapted to preoperative evaluation of children, there are some topics that require further emphasis in children. Preexisting pediatrician's notes can be a valuable resource when evaluating a child in the preoperative period because parents may not remember all the medical details. Specifically, birth history is an important factor that can potentially be overlooked in an adult. It is particularly important to find out if the child was born prematurely because sequela of prematurity can affect anesthesia management and anticipated complications.[5,6] It is also prudent to investigate the patient's neurologic development, airway anomalies, surgical history, previous intubations, and general medical health (heart, lung, endocrine, renal disorders). A child with a genetic or dysmorphic syndrome should be thoroughly evaluated because anomalies in the cervical spine (eg, Down syndrome) or craniofacial dysmorphia can significantly affect anesthetic management.[7,8] Psychological issues should be addressed because they can alter how smoothly the operative course runs.[1] Children with psychological conditions may require intervention of a child life specialist to make a successful transition to the operating room.

Certain aspects of the family history are key. Specifically, a history of (1) malignant hyperthermia (MH), (2) pseudocholinesterase deficiency, (3) postoperative nausea and vomiting, (4) congenital myopathies, and (5) bleeding disorders should be explored.[1] It is extremely important that children at risk of MH be identified preoperatively. At-risk children include those with a family or personal history of MH or congenital myopathies, such as central core disease.[9,10] Children account for 52.1% of all MH reactions.[9] If an at-risk child is encountered, anesthetic management with total intravenous anesthesia should be strongly considered because it minimizes the chance of being exposed to a volatile anesthetic trigger. Succinylcholine should also be avoided because it can also be a trigger. It is essential that all anesthetizing facilities, especially ambulatory surgery centers, are prepared for the eventuality of an acute life-threatening MH event.[11] If MH is suspected intraoperatively, all volatile anesthetics should be stopped immediately and intravenous dantrolene should be given.[12] Detailed information on the management of MH can be found on *The Malignant Hyperthermia Association of the United States* Web site (https://www.mhaus.org/). To learn more about the history of MH in pediatric population, refer to article by King and colleagues.[13]

No laboratory work is indicated for healthy children undergoing a procedure with minimal blood loss anticipated. A hematocrit test may be ordered if a great amount of blood loss is expected and may be required for infants at some institutions.[1] Bleeding time, prothrombin time and partial thromboplastin time, and platelet count have not proven to be reliable predictors of bleeding risk; therefore, they are not routinely recommended.[14–16] Routine pregnancy testing is controversial because some parents may decline the test and history alone can be unreliable in predicting the need for the test. It is recommended that, at the minimum, the test be discussed with the patient and family, although institutional guidelines may vary. The test should especially be offered to patients if it would affect their management. At the current time, there is a knowledge gap regarding the risks of anesthesia in early pregnancy.[17]

Although allergies are a part of every preoperative evaluation, special attention should be given to a known or possible latex allergy. Although the incidence of latex allergy throughout the general population has been estimated between 1% and 6%, for certain pediatric populations (eg, spinal bifida and bladder exstrophy) its incidence has been reported as high as 73%.[18,19] Specifically, those with an increased risk include pediatric patients with spina bifida, myelodysplasia, urinary tract malformations,[20–22] as well as multiple previous surgeries.[23] It has been recommended that high-risk patients with a history of multiple surgeries be also screened preoperatively for a latex allergy with not only questioning but also skin prick or radioallergosorbent testing.[23] Studies show that latex-allergic children can be safely anesthetized if exposure to latex in the medical environment is avoided, and that administration of prophylactic medications to decrease the allergic response is unnecessary.[24] Although many clinical institutions are latex-free, it is still prudent to become familiar with the common symptoms of latex allergy. For more detailed information on latex allergy; recognition of symptoms; and operative latex-free setup, precautions, and treatment, refer to the *American Latex Allergy Association* Web site (http://latexallergyresources.org/).

Former Premature Infant

Premature infants are born less than 37-weeks gestational age. The former premature infant is at an increased risk for postoperative apnea, periodic breathing, and bradycardia up to 24 hours after surgery when compared with term infants.[25] Therefore, it is generally advisable to admit these patients for 24 hours postanesthesia monitoring. This should be arranged during the preoperative assessment period. Postoperative apnea and bradycardia are associated with immaturity of the brainstem, leading to ineffective central and peripheral chemoreceptors that do not respond properly to hypoxia and hypercarbia stimuli.[26] There are some interventions that have been used to minimize postoperative apnea, including

1. The administration of perioperative caffeine
2. The use of spinal anesthesia as opposed to general anesthesia
3. Delaying surgery until 48 to 50 weeks postconception.[27]

These infants should also have their hematocrit checked because hematocrit values less than 30% in this group are associated with a higher incidence of postoperative apnea.[28] Another concern in this population is bronchopulmonary dysplasia, a chronic lung disease that premature infants may suffer from.[29] This can cause an exaggerated risk of bronchospasm and oxygen desaturation in the perioperative period within the first year of life. Affected children are also more susceptible to pulmonary vasoconstriction in response to the variety of possible assaults during anesthesia, such as hypothermia, pain, and acidosis.[30]

Congenital Heart Disease

Congenital heart disease is a common problem encountered in pediatric anesthesia and often needs special consideration during the preoperative period. Intracardiac murmurs, shunts, and the need for antibiotic prophylaxis should to be evaluated because all these can affect the anesthetic management and possible perioperative complications.

It is vital that innocent versus pathologic nature of the heart murmurs be distinguished. At minimum, evaluation for a murmur should include a thorough medial history and a physical evaluation, as well as electrocardiogram testing. Generally speaking, if a child is acyanotic, has normal first and second heart sounds, is growing well, and has good exercise tolerance, the murmur will most likely not cause significant consequences during anesthesia. If there is a question of a significant structural heart defect, an echocardiogram and evaluation by a pediatric cardiologist should be done. Intracardiac shunts (eg, ventricular septal defect) need to be identified in the preoperative period because anesthesia agents can affect the functioning of these shunts. Understanding the basic physiology of shunts is essential for anticipation of potential perioperative circulatory problems. With a decrease in pulmonary vascular resistance, pulmonary overcirculation can occur in the presence of the left-to-right shunts leading to failure due to pulmonary overcirculation. On the other hand, pulmonary vascular resistance can also increase due to various assaults possible during anesthesia, such as hypoxia, hypercarbia, hypotension, and hypothermia. This decrease can actually cause a left-to-right shunt to reverse (to a right-to-left shunt) producing serious consequences (ie, hypoxemia). Children who have intracardiac shunts are at risk for paradoxic embolism and, therefore, should be identified preoperatively despite that stroke is less common in children than adults.[31] The need for antibiotic prophylaxis to prevent bacterial endocarditis should be evaluated in the preoperative period. Surgical procedures at risk for bacteremia, such as dental procedures, require prophylaxis in patients with certain shunts or other congenital heart defects. Those with prosthetic heart valves and/or history of endocarditis also require prophylaxis (**Box 1**). The antibiotic prophylactic regiment should be followed as outlined by the *American Heart Association* recommendations.[32–34]

In a child with known complex congenital heart disease (eg, single ventricle), the current anatomy should be evaluated, noting any previous corrective or palliative surgeries.[35] Even with surgical evaluation, there can still be residual defects capable of causing physiologic compromise. Children with congenital heart disease who present

Box 1
Endocarditis prophylaxis

Dental procedures only (no longer gastrointestinal or genitourinary)

- Prosthetic heart valves
- Previous endocarditis
- Heart transplant with abnormal heart valve function
- Complex congenital heart defects
  - Cyanotic, not fully repaired
  - Fully repaired for first 6 months after repair
  - Repaired with residual defects

Dental procedures but not gastrointestinal or genitourinary should be considered for endocarditis prophylaxis in pediatric patients with listed cardiac conditions.

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for noncardiac surgery are at increased risk of perioperative morbidity. Those high-risk children require transfer to a specialist center because full pediatric intensive care and cardiology services may be required. Involvement of the pediatric cardiac anesthesia team may be warranted for many cases. Children with low-risk for perioperative morbidity may undergo surgery at the local hospital. More detailed information about providing noncardiac anesthesia care for cardiac pediatric patient should be sought elsewhere.[36–38]

Respiratory Infection

Children can have multiple respiratory infections each year, making this condition very common in the preoperative course. The average child gets 3 to 9 upper respiratory infections per year, with each lasting between 7 to 10 days.[39] Although respiratory infections are common, they pose a considerable threat to the perioperative course. An active respiratory infection increases the risk of perioperative respiratory complications from 2-fold to 7-fold.[40] These complications include laryngospasm, bronchospasm, atelectasis, postextubation croup, and postoperative pneumonia.[41] There is a correlation between the child's age and the risk of pulmonary complications due to a respiratory infection, with children younger than 5 years being at a significantly increased risk compared with children older than 5 years.[42] There are no definitive rules for canceling a procedure based on the presence of a respiratory tract infection. However, generally speaking, signs of active lower respiratory infection, such as wheezing, productive cough, chest radiograph findings, as well as presence of systemic illness (presence of fever), should warrant canceling an elective procedure.[43] Although complications are most severe during an active respiratory infection, the take-home message for the anesthesia providers is that the airway reactivity can remain for up to 6 weeks postinfection.[42] Given this information, it is advisable to delay an elective procedure 4 to 6 weeks if deemed necessary.[42,43] One can proceed with planned surgery if minor symptoms of upper respiratory infection are present, such as clear rhinorrhea and upper airway congestion.[42] If the procedure needs to move forward despite presence of the upper respiratory infection symptoms, there are perioperative considerations. Endotracheal intubation increases the risk of respiratory complications 11-fold in children with respiratory infectious symptoms.[40] Using a mask airway instead of tracheal intubation may minimize the risk if appropriate.[44]

Asthma

Asthma is a common childhood respiratory disorder that results in a hyperreactive airway. Laryngoscopy and tracheal intubation are both potent airway stimulators. It is extremely important the preoperative history include specific details pertaining to the child's asthma. It is necessary to understand the severity of the illness, current symptoms, age of onset, current medications, prior hospitalizations, the date of the last attack, and prior need of mechanical ventilation.[45] As a rule, medical therapy should be optimized before surgery to minimize incidence of perioperative respiratory complications.[46] Even in children whose asthma is well-controlled, medical therapy should be escalated before surgery to prevent or minimize bronchospasm.[47] The therapy should be escalated according to their baseline needs. For example, in a child who takes a beta-agonist on an as-needed basis, a scheduled beta-agonist should begin 3 to 5 days before surgery.[48] If the child is actively wheezing or has had a recent asthma attack, strong consideration should be given to delaying the procedure.[49] All medications should be continued up to and on the morning of surgery, including oral steroids.

Obstructive Sleep Apnea

Obstructive sleep apnea syndrome is a sleep disorder characterized by partial upper airway obstruction and/or temporary complete obstruction. It can be central (neurologic; <5%) or obstructive (>95%) in origin, and possibly mixed in nature of presentation. It is a relatively prevalent condition in children, affecting 1% to 5% of children 2 to 8 years of age and is caused by a variety of different pathophysiologic abnormalities.[50] More common obstructive apnea results from a physical airway obstruction, whereas central apnea is the result of a lack of airflow, as well as respiratory effort.[50,51] Polysomnography is the gold standard of diagnosis and should be reviewed during the preoperative period if available.[52] Although this condition is also found in adults, there are some important differences to note in the pediatric population. In children, obstructive sleep apnea affects both sexes equally and is associated with all body types, as opposed to largely being linked to obesity in adults. In children, this condition is treated surgically, compared with more noninvasive techniques in adults, such as continuous positive airway pressure. Although these differences exist, children can suffer the same serious sequelae as adults, including cor pulmonale, pulmonary hypertension, cognitive difficulties, learning disabilities, and behavioral issues.[53] In the preoperative period, these children may require additional testing to evaluate their cardiovascular status, especially if there are signs of right ventricular dysfunction, systemic hypertension, or multiple episodes of desaturation less than 70%.[54] Furthermore, children with obstructive sleep apnea are usually more susceptible to the respiratory depressant effects of opioids,[55] which is an important fact to consider when managing postoperative pain. This has been linked to a possible increase in central opioid receptors due to chronic hypoxemia.[56] In one study, children with oxygenation less than 85% required only 50% of the postoperative morphine dose for analgesia.[53] Children with obstructive sleep apnea may also require a higher level of monitoring in the postoperative period. The intensive care or step-down unit may be required for those with severe obstructive sleep apnea, body mass index greater than 40, or very young children.[57] This requirement should be arranged in the preoperative period.

Fasting Guidelines

Fasting guidelines are designed to minimize gastric volume and, it is hoped, to reduce the risk of pulmonary aspiration; however, recent data suggest gastric fluid volume is more of a surrogate marker than a risk factor for pulmonary aspiration.[58] The following fasting guidelines are generally agreed on, but institutional guidelines may vary. Clear liquids can be given up to 2 hours before surgery and breast milk up to 4 hours before surgery. Formula, nonhuman milk, and a light meal can be given up to 6 hours before surgery and solids up to 8 hours before surgery. These guidelines allow for a smoother preoperative course and a more comfortable child.[59] The preoperative *nil per os* (nothing by mouth) instructions should be explicitly explained to the parent because they are frequently misunderstood (**Box 2**).

Patient or Parental Preoperative Anxiety

Presenting for surgery can be an overwhelming and frightening idea for both children and their parents. It is the job of the anesthesiologist to calm these fears in the preoperative period to allow for a smooth perioperative course. Factors associated with higher preoperative anxiety include younger age, the child's first surgery, problems with prior health care encounters, length of procedure, and anxious parents.[60,61] The anesthesia course should be explained in terms that are appropriate for the age

Box 2
Pediatric nil per os (nothing by mouth) guidelines

- 8 hours prior: heavy, fatty meal
- 6 hours prior: light meal, formula, nonhuman milk
- 4 hours prior: human milk
- 2 hours prior: clear liquids

These are fasting guidelines before surgical procedure for pediatric patients.
Adapted from Ferrari L. Introduction and definitions. In Ferrari L, editor. Anesthesia and Pain Management for the Pediatrician. Baltimore: The Johns Hopkins University Press; 1999. p. 1–10.

of the child, taking into consideration their level of development. For example, preschool aged children are concrete thinkers and will take literally what you say to them. Adolescents may not adequately express either their fears or questions directly. It is important to clearly explain the anesthesia course and indirectly calm these fears without the adolescent having to explicitly state them.[45] Parents are often most concerned with the anesthesia aspect of the surgical procedure. In the preoperative period, parents should be educated about the anesthesia course and common complications. Major adverse events include laryngospasm, bronchospasm, drug reactions, pneumonia, hypoxemia, and dental trauma. Laryngospasm (1.7% of cases) is the most common complication. Some minor risks include oral trauma, sore throat, nausea, vomiting, cough, and hoarseness (**Table 1**).[62] It is often helpful to give parents perspective when discussing risks. For example, the risk of an adverse event in a healthy child undergoing an uncomplicated surgery is 1 in 200,000.[63]

There is much controversy over parents' presence at induction. Some possible benefits of the practice include decreased need for preoperative sedation, avoiding separation anxiety when going to the operating room, increasing child compliance with induction, and increasing parental satisfaction. However, there are potential drawbacks to the practice, including disrupting or crowding the operating room, potential adverse reaction by the parents, and slowing the induction process. Although there are potential benefits to the process, randomized controlled trials suggest the practice is not beneficial.[64–66] When comparing parental presence to traditional preoperative sedation with oral midazolam, patients who have received midazolam were less anxious and more amenable during induction. The reaction of the parent should also be considered because an anxious parent accompanying the child to the operating room may cause the patient to be more anxious.

Table 1
Pediatric complications of anesthesia

Minor	Major
• Oral trauma	• Laryngospasm
• Sore throat	• Bronchospasm
• Nausea and vomiting	• Drug reactions
• Cough	• Pneumonia
• Hoarseness	• Hypoxemia

Summary of some minor and major common pediatric complications of anesthesia administration.
Adapted from Ferrari LR. Introduction and definitions. In: Ferrari LR, editor. Anesthesia and pain management for the pediatrician. Baltimore (MD): Johns Hopkins University Press; 1999; with permission.

Effects of Anesthesia on the Developing Brain

The effects of anesthesia on the developing brain are an area of much interest that has been a subject of concern and considerable research interest. This topic has been the focus of 3 public hearings by the US Food and Drug Administration (FDA) since 2007, including an FDA Science Board meeting in November 2014. These served to better inform the public and practitioners about the most recent findings, and to foster a discussion between parents and physicians about the potential risks posed when using anesthesia in young children.[67,68] Although in vitro and animal research studies from roundworms to nonhuman primates support evidence of neurotoxicity in the presence of anesthetic agents,[69] the impact of surgery on anesthetic-induced brain injury in the developing brain has not yet been adequately addressed. A retrospective study done at the Mayo Clinic showed children who received more than 2 anesthetics before age 4 were at an increased risk for developing learning disabilities.[70] In another retrospective study, greater behavioral problems were seen in children who had anesthesia before 24 months compared with those who had not received anesthesia.[71] However, the overall literature consensus is that clinical data, comprising largely of retrospective cohort database analyses, are inconclusive, in part due to confounding variables inherent in these observational epidemiologic approaches.[69] In contrast, a twin study showed no discrepancies in learning capability between twins: one who had received anesthesia before age 3 years and one who had not received anesthesia.[72,73] This places even greater emphasis on prospective approaches to this problem, such as the ongoing General Anesthesia and Awake-Regional Anesthesia in Infancy (General Anesthesia compared to Spinal Anesthesia; GAS) trial[74–77] and the Pediatric Anesthesia Neurodevelopment Assessment (PANDA) study.[78,79] The resulting data do not show any long-term sequelae from early anesthesia exposure in otherwise healthy infants. It is advisable to present the parent with the current data but to note that more extensive human studies need to be done to fully understand the short-term and long-term consequences of anesthesia administration in pediatric patients.

SUMMARY

Preoperative planning for infants and children encompasses many of the same steps as adults; however, there are important differences to be noted. In addition to the traditional history and physical examination, attention should be paid to the child's overall development and the presence of any syndromes. A careful personal or family history of MH should be elicited, as well as risk factors for latex allergy. Due to their immature physiology and development, these age groups are more susceptible to certain conditions that can dramatically affect anesthesia management. Notably, any recent or current respiratory infection can have drastic effects perioperatively, leading to higher anesthetic complications. It is also prudent to investigate a history of former prematurity, congenital heart disease, and asthma. An especially unique concern for this age group is parental, as well as patient, anxiety. There are several techniques used to calm these anxieties and each plan should be tailored to the individual family. By taking these special considerations into account, the preoperative evaluation of the pediatric patient can be accomplished, allowing a successfully operative course.

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