Preoperative Considerations for Pediatric Surgeries at Ambulatory Surgical Centers

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KEYWORDS

• Ambulatory surgical procedures • Pediatric anesthesia • Patient safety
• Patient selection

KEY POINTS

- Ambulatory surgery center growth drives the important need to select for healthy patients undergoing low-risk day surgeries.
- Careful patient selection criteria decrease risk for adverse events.
- Very young or premature infants, the presence of upper respiratory infections, and certain congenital syndromes increase the risk of adverse events.

INTRODUCTION

Outpatient surgeries in children have been steadily increasing, now accounting for more than half of all pediatric procedures. It is estimated that over 2.3 million outpatient surgeries are performed each year, with approximately a quarter of that taking place in ambulatory surgery centers (ASCs).[1,2] Careful patient selection is a key element in the successful operation of ASCs. Limited space and the lack of ability to monitor patients for extended periods of time make ASCs dependent on thorough preoperative evaluation. Pediatric patients are often well suited for ASCs as they are generally healthy, and most of their surgeries can be performed as day surgeries. However, there are no standard guidelines on pediatric patient selection criteria for ASCs.[3] Moreover, pediatric diseases carry unique risks as reviewed in this article

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Abbreviations	
AHI	apnea-hypopnea index
ASA	American Society of Anesthesiologists
ASC	ambulatory surgical center
BMI	body mass index
CGM	continuous glucose monitor
CHD	congenital heart disease
OSA	obstructive sleep apnea
PACU	postanesthesia care unit
PRAE	perioperative respiratory adverse event
SAMBA	The Society for Ambulatory Anesthesia
SDB	sleep disordered breathing
STBUR	Snoring, Trouble Breathing, and Un-Refreshed
URI	Upper respiratory infection

that are not encompassed in adult guidelines. This review highlights common preoperative considerations for pediatric patients undergoing procedures in ambulatory surgical centers.

Age

Although there is no standard recommended age criteria for the caring of pediatric patients in ASCs, many centers use 2 years and older as a typical cut-off, especially when the surgery requires instrumentation of the airway for controlled ventilation.[3] For procedures that can be performed with mask ventilation and/or natural airway, some centers decrease the age limit to include infants, particularly if the procedure is low risk and appropriate for the younger pediatric patient. Full-term and premature infants must still pass the age criteria for mandatory overnight hospital admission required for respiratory monitoring.

Premature infants

It is well established that premature infants are at an increased risk of postoperative apnea. This risk further increases with other coexisting factors such as degree of prematurity, anemia, presence of a large patent ductus arteriosus, medications including opioids and magnesium sulfate, and glucose and electrolyte imbalance.[4] In a multicenter randomized controlled trial it was found that the incidence and severity of immediate postoperative apnea (first 30 minutes in the post anesthesia care unit (PACU)) was lower in the spinal anesthesia group in comparison with the general anesthesia group, but the overall incidence of postoperative apnea did not vary significantly with the type of anesthesia.[5] Accepted perinatal age terminologies are illustrated in **Fig. 1**. The age at which the risk of apnea in former premature infants is reduced sufficiently to allow for same day discharge is generally considered to be between 50 and 60 week postmenstrual age.[6]

Age considerations related to tonsillectomy

Common complications after tonsillectomy that require prolonged postoperative observation or hospital admission can be classified as early (most common being primary hemorrhage and respiratory compromise) and late (secondary hemorrhage and dehydration) complications. The average risk of posttonsillectomy bleeding in children was found to be about 1.97% by a retrospective national cohort study.[7] Children younger than 3 years of age are at an increased risk for developing respiratory complications after tonsillectomy. The American Academy of Otolaryngology—Head and Neck Surgery Foundation recommends having a lower threshold for admitting children

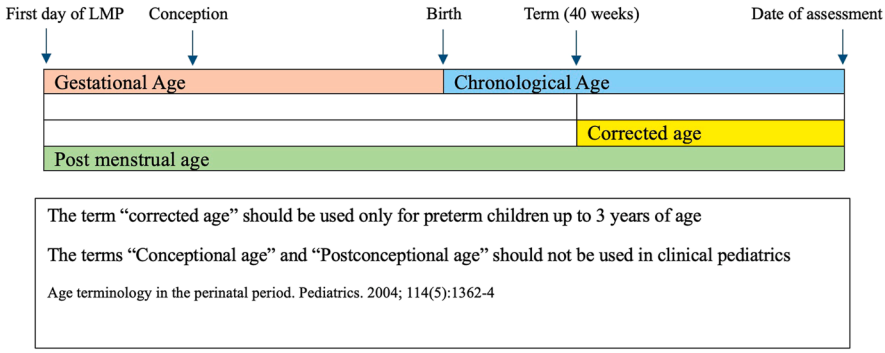

Fig. 1. Perinatal age terminologies.

younger than 3 years of age for overnight respiratory monitoring following tonsillectomy, but the published literature is conflicting on this topic, and there are no strict guidelines on overnight respiratory monitoring after tonsillectomy.[8–10] In addition, regardless of the age, children with severe obstructive sleep apnea (OSA), trisomy 21, craniofacial syndromes, and neuromuscular diseases require postoperative hospital admission for close monitoring and are not appropriate candidates for ASC-based care.[11]

Obesity

Pediatric obesity is defined based on body mass index (BMI) percentiles by the Centers for Disease Control and World Health Organization.[12] Children with BMI between the 5th and 85th percentiles are considered to have a healthy weight, whereas children over the 95th percentile are classified as obese. Pediatric obesity is further categorized as class I, II, and III, moving away from terminology such as severe and morbid obesity as outlined in **Table 1**.

Most ASCs avoid scheduling children over the 95th percentile given their increased perioperative risk profile. Obesity is a known risk factor for Perioperative Respiratory

Table 1
Pediatric obesity classification

Weight Category	BMI Percentile
Underweight	< 5th percentile
Normal weight	5th–84th percentile
Overweight	85th–94th percentile
Obesity	*≥95th percentile*
Class I obesity	≥95th percentile but <120% of the 95th percentile
Class II obesity	99th percentile or ≥120% of the 95th percentile
Class III obesity	≥140% of the 95th percentile

120% of the 95th percentile corresponds to approximately the 98th percentile or BMI Z-score ≥ 2 (ie, 2 standard deviations above the mean).

Abbreviation: CDC, Centers for Disease Control and Prevention.

Adapted from Sarah E, et al. Clinical Practice Guideline for the Evaluation and Treatment of Children and Adolescents with Obesity. Pediatrics February 2023.

Adverse Events (PRAEs) in children.[13] Children with obesity may pose challenges in airway management and are more susceptible to intraoperative and postoperative airway obstruction. They often have reduced functional residual capacity and expiratory reserve volume and high closing capacity. These physiologic changes can cause reduced pulmonary reserve, atelectasis, and postoperative hypoxemia.[14] Children with obesity are also more prone to have other coexisting pulmonary diseases such as reactive airway disease and OSA.[15,16] These may all lead to a prolonged postoperative stay which challenges the ambulatory surgery center setting that is not staffed for prolonged or overnight observation.

Respiratory Risks

Respiratory complications are the most common perioperative adverse events in the pediatric population.[17] Upper respiratory infections (URIs) increase airway reactivity and contribute to PRAEs, including laryngospasm, bronchospasm, oxygen desaturation, airway obstruction, and perioperative cough.[18] High prevalence of viral respiratory illness in children, small airway caliber, and airway risks associated with inhalational inductions puts pediatric patients at significantly higher risk for perioperative respiratory complications.

UPPER RESPIRATORY INFECTIONS

URI are defined as 2 of the following symptoms: rhinorrhea, sore throat, sneezing, nasal congestion, malaise, cough, or fever over 38°C.[19] Airway reactivity secondary to respiratory illness lasts longer than the manifesting symptoms. Therefore, the general recommendation for elective surgeries is to wait 2 to 4 weeks following resolutions of URI symptoms and 4 to 6 weeks if the lower respiratory tract is involved. In addition, there are other clinical factors, such as the need for the use of an endotracheal tube, airway surgery and patient factors such as history of prematurity, history of reactive airway disease, parental smoking, presence of copious secretions, and nasal congestion that can further increase the risk.[4,17]

The current signs and symptoms, Onset of symptoms, presence of Lung disease, intraoperative airway Device plan, and type of Surgery (COLDS) criteria is a validated tool that can be used to help physicians better risk stratify children with recent acute respiratory illness.[13,20] Each category awards 1, 2, or 5 points. A total score of less than or equal to 12 predicts low risk for PRAEs.

Several modifiable factors have been shown to mitigate perioperative respiratory risk. These include the use of intravenous agents, such as propofol, over inhalational agents for induction and maintenance of general anesthesia, minimizing airway instrumentation if the type of surgery allows, and ensuring the involvement of an experienced pediatric anesthesia provider.[21,22]

ASTHMA/REACTIVE AIRWAY DISEASE

Asthma is the most common chronic pulmonary disease in children. It is characterized by airway inflammation and hyperreactivity leading to wheezing, shortness of breath, and cough. Perioperative respiratory risk in a child with asthma depends on the severity of the disease and persistence of airway symptoms. The National Asthma Education and Prevention Program has classified asthma as intermittent, mild persistent, moderate persistent, and severe persistent (**Table 2**).[23]

While children with intermittent asthma may be considered low risk, children with severely persistent and poorly controlled asthma carry a high risk for intraoperative and postoperative respiratory complications. Additional co-existing factors that may

Table 2
Classification of asthma severity based on symptom frequency, exacerbations, and lung function (forced expiratory volume in one second [FEV1])

Severity	Day Symptoms	Night Symptoms	Exacerbations	FEV_1 (if ≥5 y and Reliable)
Intermittent	≤2 d/wk	None(<5 y); ≤2 nights/mo (≥5y)	0–1/y	Normal (>80% predicted)
Mild persistent	>2 d/wk, not daily	1–2 nights/mo (<5 y) 3–4 nights/mo (≥5 y)	≥2 in 6 mo or ≥4/y if needing oral steroids	Also >80% predicted
Moderate persistent	Daily	3–4 nights/mo (<5 y) >1 night/wk (≥5 y)	Frequent	60%–80% predicted
Severe persistent	Throughout the day	>1 night/wk (<5 y) often nightly (≥5 y)	Frequent, severe	<60% predicted

indicate a higher risk of PRAEs in children with asthma include presence of exercise-induced wheezing, more than 3 wheezing episodes in the past 12 months, nocturnal dry cough, rhinitis, eczema, and exposure to tobacco smoke.[24]

In general, children with moderate–severe persistent asthma, current airway symptoms, recent exacerbation of asthma within the past 4 to 6 weeks, or an upper respiratory illness within the past 2 weeks are not ideal candidates for ASCs.

OBSTRUCTIVE SLEEP APNEA

Although symptoms of sleep disordered breathing (SDB) including snoring, mouth breathing, witnessed apneas, frequent nighttime awakenings, and secondary nocturnal enuresis can be suggestive of the diagnosis of OSA, OSA requires the results of a polysomnogram to make the diagnosis. OSA is classified based on the apnea-hypopnea index (AHI) and the degrees of oxygen desaturation.[25] In the pediatric population, an AHI of 1 to 4 indicates mild, 5 to 9 moderate, and 10 or above severe OSA. Children have a higher metabolic rate of oxygen consumption and a lower functional residual capacity, and therefore a higher respiratory rate, leading to easy desaturation in the setting of apnea or hypopnea. Consequently, the AHI cut-off value for diagnosis and classification of OSA is lower in children than in adults.

Factors such as American Society of Anesthesiologists (ASA) physical status, type and duration of surgery, and age are well-known predictors of unanticipated hospital admission after surgery.[26] A large retrospective study involving over 800,000 children identified OSA as an additional significant risk factor. In this study, the rate of unanticipated admission following ambulatory surgery was more than twice as high in children with OSA, with an adjusted odds ratio of 2.27.[27]

Unfortunately sleep study centers are limited with long wait times. This can lead to potential underdiagnosis of OSA in children if diagnosis is relied solely on polysomnogram. Snoring, Trouble Breathing, and Un-Refreshed (STBUR) is a 5 question screening tool that can be used to identify children with SDB. It is essential to recognize these children as they are more opioid sensitive and carry a higher risk for perioperative respiratory complications.[28,29] Children with symptoms of SDB per STBUR (≥3 symptoms) have a 2-fold increased likelihood of PRAE compared with children without SDB.[30] This tool can also be used to identify children at low risk for prolonged PACU stay due to SDB given its high specificity and negative predictive value.[31]

STBUR Questionnaire

Does your child

1. *S*nore more than half of the time?
2. *S*nore loudly?
3. Have any *T*rouble breathing or struggling to breathe?
4. Stop *B*reathing during the night?
5. Feel *UnR*efreshed in the morning after a night of sleep?

Cardiac disease

Children with congenital heart disease (CHD) are at an increased risk for perioperative complications with the highest risk seen in infants less than 1 year of age.[32,33] American College of Surgeons-National Surgical Quality Improvement Program classifies congenital cardiac lesions as minor, major, or severe as described in **Table 3**.[34] Additional factors that impact risk stratification include the degree of hemodynamic disturbance, the extent of intracardiac mixing in children with cyanotic heart disease, child's functional status, and current cardiac medications used.[35]

Children with major and severe CHD have increased risk of mortality after noncardiac surgery when compared to children without CHD. On the other hand, there was no difference in postoperative outcomes in children with mild CHD compared to children without CHD.[36] Children with minor CHD should be able to safely undergo procedures at an ASC, while children with major and severe CHD risk will need a more thorough risk stratification and have a low likelihood of being ideal candidates for ASCs.

Malignant hyperthermia

The Society for Ambulatory Anesthesia (SAMBA) and the ASA committee state that malignant hyperthermia (MH)-susceptible adult patients can be safely cared for in the ASC setting, given the very low likelihood of MH with the use of a nontriggering anesthetic technique.[37] Most pediatric ASCs do not exclude MH-susceptible patients. Although the pathophysiology of MH is similar in children and adults, it is vital to recognize that pediatric patients are almost twice as susceptible to MH compared to adult patients.[38] Reported rates of incidence of MH in the pediatric population vary between 3.8 per 100,000 (0.0038%) and 10.4/100,000 (0.0104%).[39,40]

Table 3
Congenital heart disease classification

Classification	Definition
Minor	Unrepaired asymptomatic acyanotic CHD (or) repaired CHD with no residual hemodynamic abnormalities and no requirement for medication. Examples: A small to moderate VSD without symptoms, or an ASD.
Major	Unrepaired symptomatic acyanotic CHD (or) repaired CHD with residual hemodynamic abnormalities. Examples: Tetralogy of Fallot with free pulmonary regurgitation, or hypoplastic left heart syndrome including stage 1 palliation.
Severe	Uncorrected cyanotic congenital heart disease, documented pulmonary hypertension, ventricular dysfunction requiring medication, or heart transplant listing.

Abbreviations: ASD, atrial septal defect; CHD, congenital heart disease; VSD, ventricular septal defect.

Adapted from ACS-NSQIP (American College of Surgeons National Surgical Quality Improvement Program).

Early recognition and prompt treatment are critical in improving survival following an MH crisis. ASCs should have a workflow in place for efficient transfer of patients to a higher level of care when needed. There is no need for extended monitoring in the PACU for MH-susceptible patients following a nontriggering anesthetic. However, patients and families should be educated on alarm signs that would warrant immediate return to a hospital.

The Malignant Hyperthermia Association of the United States recommends that all anesthetizing locations where triggering agents (volatile anesthetics and succinylcholine) are utilized should maintain a fully stocked MH cart with dantrolene.[41] Although in class B facilities (facilities where procedures are performed with intravenous sedation and/or analgesia only), SAMBA has proposed that succinylcholine may be stocked without the need to stock dantrolene, if succinylcholine is used solely for emergency purpose.[42]

Diabetes mellitus

Type 1 diabetes mellitus (DM) is more common in the pediatric age group. The use of insulin pumps is associated with improved long-term glycemic control in patients with type I DM.[43] When continuous subcutaneous insulin infusion via an insulin pump is combined with a continuous glucose monitor (CGM) as an automated insulin delivery system, the incidence of acute events related to hypoglycemia and hyperglycemia are reduced. Although insulin pumps are not approved for perioperative use, there is emerging literature that they can be continued perioperatively in minor procedures that are anticipated to last for 2 hours or less and where rapid recovery and return to baseline oral intake is expected.[44,45] If the pump is continued, consultation with the patient's endocrinologist for settings (such as switching to exercise mode) for the perioperative period is crucial for maintaining glycemic control. For major procedures lasting over 2 hours, it is recommended that the insulin pump be stopped and removed, and insulin be supplemented in the form of an intravenous infusion.

The accuracy of glucose reading on the CGM can be altered by various intraoperative factors including profound hypoperfusion, hypothermia, and certain medications such as acetaminophen which can cause a falsely elevated value overestimating the glucose level in the patient. Hence, it is recommended that a CGM be used to monitor the trend in the glucose level with hourly validation by measuring point-of-care blood glucose level.[43] In addition, if the insulin pump or the CGM is planned to be continued intraoperatively, the device's location should be taken into consideration in relation to the surgery such that it is in a nondependent site and away from the surgical field.

It is recommended that all patients with DM should ideally have a preoperative endocrine assessment of glycemic control and come with a patient-specific perioperative blood glucose control plan. They should be scheduled as the first case of the day whenever possible to avoid prolonged fasting times and reduce the risk of hypoglycemia. All patients with DM, including those with a CGM, should have preop blood glucose level checked. If the glucose level measures over 250 mg/dL, urine or serum ketones should be checked to rule out diabetic ketoacidosis. If the glucose level measures less than 70 mg/dL, appropriate protocols should be in place to treat with dextrose per orally or intravenously. Intraoperatively, blood glucose should be checked hourly, increasing to every 30 minutes if there is any intervention done, or 15 minutes if there is a change of over 80 mg/dL.[44]

Congenital syndromes

Syndromic pediatric patients can present a wide range of challenges for perioperative care. In general, syndromes that affect anesthetic management are those that have craniofacial, airway, pulmonary, cardiac, muscular, neurologic, and behavioral manifestations.

Trisomy 21, or Down's syndrome, is the most common genetic syndrome encountered in children. It can affect multiple organ systems impacting airway management and cardiopulmonary status and therefore the anesthetic risk.[46] These children are often not ideal candidates for ASCs.

Common syndromes associated with difficult airways can be broadly classified as those with micrognathia (Pierre Robin, Treacher Collins syndrome, Goldenhar syndrome), midface hypoplasia (Apert, Crouzon, and Pfeiffer), macroglossia (Trisomy 21, Beckwith-Wiedemann, and mucopolysaccharidoses such as Hunter's and Hurler's), and cervical spine abnormalities (Klippel-Feil, Turner, and Noonan's).[47] Any child with known or anticipated difficult airway is best managed in a hospital setting where access to advanced airway support and other airway experts like pediatric otolaryngologists are readily available.

Duchenne's and Becker's muscular dystrophy are the most common types of muscular dystrophy in children. While patients with muscular dystrophy do not specifically carry an increased susceptibility to malignant hyperthermia compared to the general population, they can develop rhabdomyolysis and hyperkalemia when exposed to inhalational agents and succinylcholine.[48] Children with myopathy also have a high incidence of cardiopulmonary symptoms that can be exacerbated with anesthetic agents. Therefore, only patients with very mild disease presenting for low-risk surgery should be considered, if at all, for an ambulatory setting.

Neurologic diseases

Epilepsy is the most common central neurologic disorder in children affecting 0.5% to 1% of the pediatric population.[49] Children with epilepsy can vary widely in the presentation of seizures and response to therapy. Certain subtypes of epilepsy require specific rescue medications that may not always be readily available in the ambulatory surgery setting. In addition, children with epilepsy can also have associated developmental and psychological comorbidities that can further complicate perioperative care.

Several perioperative factors can increase the risk of seizures in the postoperative period. These include sleep deprivation, missed doses of antiepileptic drugs, use of anesthetic medications that may lower seizure threshold, and emergence from anesthesia. Children with frequent seizures at baseline are particularly at high risk to have breakthrough seizures in the perioperative period.[50]

Careful preoperative evaluation and patient selection is therefore vital when considering surgery in the ambulatory care setting. Families should be advised to administer the child's regular antiepileptic dose the morning of surgery, and to bring both scheduled and rescue medications to help ensure medication compliance and reduce the risk of perioperative seizures.

Preoperative testing

Blanket preop laboratory testing is no longer recommended but rather should be tailored to specific tests needed for the patient's condition. Common preoperative testing done on the day of surgery in ASCs include blood glucose testing for children with DM and mandatory pregnancy testing in female children after the age of menarche. Point-of-care testing equipment is available for both.

Experience of anesthesia personnel

Anesthesiologists with subspecialty training and board certification in pediatric anesthesia should ideally manage pediatric patients in the perioperative setting. The Accreditation Council for Graduate Medical Education requires a minimum of 240 cases for the 1 year duration of the pediatric anesthesiology fellowship.[51]

However, anesthesiologists, at multispecialty ASCs with mixed patient populations, have a variable degree of exposure to and experience with pediatric patients. The annual number of pediatric anesthesia cases performed by an anesthesiologist has been shown to correlate with the incidence of perioperative complications.[52] When anesthesiologists managed less than 100 and 100 to 200 pediatric patients annually, the risk of complications was more than 5 fold and 2 fold, respectively, compared to anesthesiologists who managed more than 200 pediatric anesthesia cases annually. Most complications were related to airway management; however, other complications may arise from lack of understanding of the unique physiologic characteristics of the various developmental stages throughout the age spectrum of pediatric patients. The role of experience was further underscored by the Pediatric Difficult Intubation registry.[53] Since airway management and inadequate ventilation are the leading complications in pediatric patients, experience with and preparation for routine and unexpected scenarios are crucial. It has been shown in 2 retrospective cohort studies that direct laryngoscopy is more difficult in infants under 1 year of age.[54,55] Besides age, ASA PS III and IV classification, being underweight, and Mallampati III and IV findings (when such examination can be performed) were also found to increase the risk of difficult laryngoscopy.[54,55] Based on these data, it was concluded that experience of anesthesiologists is a significant factor in decreasing the risk of complications related to airway management. Therefore, the experience of the anesthesia staff at a given ASC should be taken into consideration while determining the policies for managing children, especially those with different syndromes, at the facility.

SUMMARY

Pediatric patients often make ideal candidates for ambulatory surgery centers as they are generally healthy and typically undergo quick same day surgeries. However, the safety and success of ambulatory surgeries rely on careful patient selection criteria and the level of training and experience of staff in the perioperative care of children. While no national guidelines currently exist in selecting appropriate patients, establishing well-defined selection criteria is essential for ensuring safe perioperative care. Certain patient groups are at an increased risk for perioperative complications; therefore it is essential to evaluate each patient carefully. The considerations outlined in this article can serve as a foundational model for developing effective patient selection protocols.

CLINICS CARE POINTS

- Very young or premature infants should not be taken care of at free-standing ASCs due to their high risk of postoperative apnea regardless of type of anesthesia used.
- Children with obesity are at an increased risk of perioperative respiratory complications. A BMI above the 95th percentile is a reasonable threshold for reconsidering suitability for ambulatory surgery.
- Children with active upper respiratory infections should have their procedure delayed until symptoms have clinically improved.
- Pediatric patients with MH susceptibility do not need to be excluded from ASCs.
- Children with mild congenital heart disease may be appropriate ASC candidates depending on their functional status and after consultation with pediatric cardiology.
- Children with DM benefit from preoperative consultation with endocrinology to establish a patient-specific glucose management plan.

DISCLOSURES

The authors have nothing to disclose.

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