Chapter 18
PEDIATRIC AMBULATORY ANESTHESIA

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Introduction & History

Many of the first anesthetics done in the mid 19th century were for dental extractions,[1] almost always on an outpatient basis, as were many of the earliest anesthetics for surgical procedures. The first known outpatient surgical clinic was established by James Nicoll in 1899 at the Glasgow Hospital for Sick Children, where approximately 1000 outpatient surgeries were performed each year, half of which were conducted on children under three years of age.[1] In the United States of America (USA), Ralph Waters established an ambulatory surgical clinic called the Down-town Anesthesia Clinic in 1919. This clinic improved access for patients and surgeons and provided economic benefits. Improved surgical techniques, anesthesia equipment, and anesthetic medications spurred the relatively small scale outpatient surgical clinics that began to appear after World War I to grow into organized large scale outpatient surgery facilities as early as 1959. The University of California, Los Angeles established an outpatient surgical clinic in 1962 and this clinic is considered to be the forerunner of modern ambulatory surgical centers (ASC).[1] John Ford and Wallace Reed founded the first successful freestanding ASC in Phoenix, Arizona in 1969.

Ambulatory anesthesia is practiced today in numerous settings, including hospital based and freestanding ASCs, surgical and dental offices, and hospital based out-of-OR locations. This chapter will primarily discuss ambulatory anesthesia within a hospital and in freestanding ASCs. Approximately 53 million ambulatory procedures were performed in the USA in 2006, with 57.3% of those taking place in hospitals, 42.7% in freestanding ASCs. The percentage in freestanding ASCs is growing rapidly.[1] Estimates of the percentage of procedures performed on an ambulatory basis in the USA exceeds 80%.[2] This explosion of ambulatory surgery has been driven by economic factors, and by surgeon and patient preference for the ambulatory model. Those preferences occur in part because ASCs allow surgeons to work more efficiently, and ASCs reduce the time patients spend away from home undergoing surgery, and they lower exposure to hospital-acquired infections. The increase in ambulatory surgery has been facilitated by development of short acting anesthetics and by advances in antiemetic and analgesic agents, including multimodal analgesics and especially the development and use of regional anesthesia. Multimodal analgesia uses different classes of analgesics with different sites of action to provide

pain relief with fewer analgesic-related side effects.

This chapter takes a close look at which pediatric patients and which procedures are appropriate for outpatient surgery. It also looks at preoperative considerations for pediatric ambulatory surgery patients, including patient screening, fasting guidelines, and whether or not to cancel an elective ambulatory surgical case when a child has an upper respiratory tract infection. Specific intraoperative and postoperative issues important for providing quality care and for providing efficient ASC patient throughput are discussed. Finally, this chapter will hopefully help existing ambulatory surgery programs to improve, and guide the development of an ambulatory surgery program for those that do not already employ this extremely useful surgical model

Procedure Selection Criteria

Whether a procedure is suitable for an ASC depends on several factors (**Table 18-**I). The procedure must be doable in the small operating rooms often found in ASCs. There should be no need for invasive monitoring (e.g., intra-arterial or central venous lines), little or no chance that a blood transfusion would be needed, and minimal chance of intraoperative or postoperative complications that could convert a stable patient into one who requires a higher level of care. The pain caused by ambulatory procedures must be easily and reliably managed with simple oral analgesics, with regional anesthesia, or with a combination of both. Post-discharge nursing care must be simple. In general, intrathoracic, intracranial, and major abdominal surgery is not appropriate for ambulatory surgery.

Table 18-1

Standard Criteria for Surgical Procedures to Qualify as Ambulatory
Can safely be performed within spatial constraints of the particular facility
No need for invasive monitoring
Little or no chance that a blood transfusion will be required
Minimal chance of surgical or anesthetic complications
Post-operative pain manageable by simple oral regimens or regional anesthesia
Post discharge nursing must be simple

An ambulatory surgical procedure should have a very low likelihood of requiring either escalation of needed care or overnight admission to a hospital. The level of acceptable risk depends in part on how difficult it will be to transfer the patient to a center where definitive care can be provided, and on the ASC's availability to provide laboratory, radiology, and respiratory therapy when needed. Duration of the procedure is generally not a limiting factor; though there may be local governmental rules about this.[3] Procedures commonly performed at the University of Virginia's Outpatient Surgery Center are listed in **Table 18-2.**

Table 18-2

Pediatric Procedures Commonly Performed in the ASC Setting	
Diagnostic Procedures	• Upper and lower endoscopy • Flexible bronchoscopy • Auditory evoked response
Urology	• Hernioraphy/Hydrocelectomy • Hypospadius repair • Orchiopexy • Cystoscopy for stent change or deflux injection • Circumcision • Cordaee repair • Meatotomy
Otorhinolaryngology	• Examination under anesthesia • Myringotomy tubes • Adenoidectomy • Adentonsillectomy • Direct laryngoscopy/bronchoscopy ± laser ablation, typically for papillomatosis
Dental	• Extractions and restorations
Plastic Surgery	• Excision of superficial lesions • Placement of tissue expanders for congenital nevus • Otoplasty

Table 18-2 (continued)

Orthopedic Surgery	• Syndactyly Release/Polydactyly removal • Hardware removal • Anterior cruciate ligament repair • Minor tendon releases • Arthroscopy • Cast changes (T&A) is commonly done, but many anesthetists believe patients undergoing T&A should stay in the hospital overnight if the child is less than three years old, has a syndrome or neuromuscular disease, or has severe obstructive sleep apnea
General Surgery	• Hernioraphy/Hydrocelectomy • Umbilical/Periumbilical hernia repair • Excision of superficial lesions/masses • Abscess incision and drainage • Removal of hardware after pectus repair
Ophthalmology	• Examination under anesthesia • Strabismus repair • Cataract removal, placement of intraocular lens • Lacrimal duct probing ± stenting • Glaucoma procedures: goniotomy, trabeculotomy • Excision of cysts

Often the combination of patient, procedure, and factors related to the facility are taken into account when deciding whether ambulatory surgery is appropriate for a given patient. For example, tonsillectomy and adenoidectomy (T&A) is performed on an ambulatory basis for most patients, but overnight stay is typical for children less than 3 years old, those with syndromes or neuromuscular pathology, and those with severe obstructive sleep apnea syndrome (OSAS). Those subgroups are prone to respiratory complications after T&A.[4-6]

Patient Selection Criteria

Suitability of patients for ambulatory surgery is just as important as the suitability of the procedure for the ASC. Both patient age and the presence of comorbid conditions are important. In general, children having ambulatory surgery should be healthy, but those with *stable* chronic diseases can also be good candidates for ambulatory surgery. Patient age, numerous common chronic pediatric conditions, and the patient's susceptibility to malignant hyperthermia are discussed below with respect to their effect on the appropriateness for ambulatory surgery for a given child.

Patient Age

Patient age is a limiting factor for ambulatory surgery, due to the risk of post-anesthetic apnea, which occurs most commonly in premature infants, defined as those born before 37 weeks gestation.[7] It is not advisable to perform ambulatory surgery in this population of patients before they reach 50-60 weeks postconceptional age (PCA). Those choosing a cutoff age of 50 weeks postconceptional age may justify their choice based on data by Coté that showed non-anemic, former premature infants were at very low risk of post anesthetic apnea if they were over 50 weeks PCA and did not develop apnea in the Post Anesthetic Care Unit (PACU).[7] My practice is to have the patient remain in the PACU for at least two hours after surgery if they were born before 37 weeks gestation and they are between 50-60 weeks PCA. If no apnea or oxygen desaturation develops during that time, they can be discharged from the PACU. Many institutions also have an age cutoff for ambulatory surgery for infants born after 37 weeks gestational age. We require that these infants are at least 44 weeks PCA and are at least four weeks old. Some states in the USA have established age cutoffs for doing surgery on infants in free standing ambulatory surgery centers.[3]

Obstructive Sleep Apnea Syndrome

Obstructive Sleep Apnea Syndrome (OSAS) is a breathing disorder characterized by frequent, repeated, partial or complete obstruction of breathing during sleep. OSAS is associated with hypercarbia and often with hypoxemia. In the worst cases, it is associated with pulmonary hypertension, right ventricular dysfunction, cor pulmonale, hepatic congestion, and peripheral edema. Patients with pulmonary hypertension should not undergo surgery in an ambulatory setting. The greatest concern regarding allowing OSAS patients to go home after surgery is the fact that both general anesthesia and opioids worsen OSAS. The Society for Ambulatory Anesthesia (SAMBA) published guidelines for adult patients in 2012 stating that ambulatory surgery is safe for adults with OSAS if they use previously prescribed continuous positive airway pressure (CPAP) postoperatively, have optimized comorbidities, have their postoperative pain managed predominately without opioids, and are otherwise good candidates for ambulatory surgery.[8] Guidelines for ambulatory surgery for children with OSAS do not exist, but elements of

the adult guidelines are easily applied to pediatric patients. For example, although children rarely present for surgery while using CPAP, those who do (often older children) should be required to use their CPAP after surgery.

Hypertrophied tonsils and adenoids are a major cause of OSAS or a milder form of sleep disordered breathing in children. The primary treatment for children with OSAS is T&A, and therefore a large percentage of the cases of OSAS encountered by pediatric anesthetists are children undergoing T&A. The majority of T&A procedures, with the exceptions noted above, are done on an ambulatory basis. Removal of hypertrophied tonsils and adenoids typically leads to significant improvement in the severity of the patient's apnea and her/his quality of life, but this cannot be expected to happen immediately after surgery. Postoperative T&A patients may continue to have some airway obstruction for weeks after their surgery. Furthermore, they may continue to have OSAS, especially if their preoperative OSAS was severe and if they are obese.[9,10] Therefore, morbidly obese children, and those with severe OSAS, should have their T&A performed in hospital, not on an ambulatory basis.

Pediatric patients with OSAS may come for ambulatory surgeries other than a T&A. OSAS is present in 1-3% of pediatric patients, so anesthetists should be on the lookout. The highest prevalence of OSAS occurs between 3-6 years of age, corresponding with the peak ages for hyperplasia of lymphoid tissue. The phenotype for OSAS differs in children and adults. Children with OSAS are frequently thin or even undernourished, unlike their obese adult counterparts. The global epidemic of childhood obesity[11] may be contributing to the increasing incidence of an adult type OSAS in pediatric patients.[12] If a child is obese, the anesthetist should be suspicious that he/she may have OSAS. Other physical features of a child that should raise suspicion for OSA include micrognathia, retrognathia, midfacial hypoplasia, and large tonsils. Pediatric medical conditions listed in **Table 18-3** should also prompt suspicion for OSAS. If during preoperative screening it is determined that the patient snores when asleep, he/she may have OSAS. The parents of snoring children should be asked the frequency of snoring and whether the child has night sweating, mouth breathing, and frank obstructive apnea. Affirmative answers to these questions improve the predictive value for OSAS.[13] Children with a high likelihood of having OSAS and who require general anesthesia for surgeries other than T&A, or for imaging studies, should be observed overnight unless preoperative polysomnography shows no OSAS.

Table 18-3: Syndromes and Other Diagnoses Associated with Pediatric OSAS

Syndromes and Sequences	Other Diagnoses
Beckwith Wiedemann syndrome	Achondroplasia
Craniofacial syndromes:	Arnold-Chiari malformation
Apert syndrome	Carney complex
Crouzon syndrome	Cerebral palsy
Pfeiffer syndrome	Choanal stenosis
Down's syndrome	Cleft palate following repair
Goldenhar syndrome	Craniometaphyseal dysplasia
Hallermann-Streiff syndrome	Cystic Hygroma
Klippel-Feil sequence	Hypothyroidism
Marfan syndrome	Myelomeningocele
Mucolipidosis (Sialidosis)	Obesity
Mucopolysaccharidoses:	Osteopetrosis
Hunter syndrome	Papillomatosis
Hurler syndrome	Pharyngeal flap surgery
Morquio syndrome	Sickle cell disease
Scheie syndrome	
Pierre Robin sequence	
Prader Willi syndrome	
Rubenstein-Taybi syndrome	
Schwartz-Jampel syndrome	
Treacher-Collins syndrome	

Syndromes and sequences associated with OSAS taken from Baum and O'Flaherty.[14] Other diagnoses associated with OSAS collected from multiple sources.[14-16]

Congenital Heart Disease, Acquired Pediatric Cardiac Disease, Cardiac Dysrhythmias, and Cardiovascular Implantable Electronic Devices

Children with complex congenital heart disease (CHD) are not candidates for ambulatory surgery. Those with more simple CHD, such as atrial septal or ventricular septal defects, may be reasonable candidates if their congenital heart defects have either closed spontaneously, been surgically repaired, or are hemodynamically insignificant. Generally speaking, children who have had CHD, cardiomyopathy, or myocarditis, are not candidates for ambulatory surgery unless they

no longer require pediatric cardiology follow-up care, except for patients with hemodynamically insignificant CHD.

Children with complex dysrhythmias, such as recurrent supraventricular tachycardia, who have not undergone successful ablation of the abnormal focus causing their tachycardia, are poor candidates for an ASC. Children with Long QT Syndrome should not have surgery in an ASC due to the possibility of anesthesia or surgery causing dangerous ventricular dysrhythmias.

Patients who have an implanted electronic device (CIED), such as a pacemaker (PM) or implanted cardioverter defibrillator (ICD), present a dilemma for anesthetists in ASCs. The Heart Rhythm Society (HRS) and the American Society of Anesthesiologists (ASA) produced a joint expert consensus statement in 2011 on perioperative management of patients with CIEDs.[17] Manipulation of PM or ICD function is generally not performed for patients undergoing surgery in ASCs. The HRS/ASA statement made it easier to preform ambulatory surgery in patients with CIEDs by relaxing requirements for reprogramming PMs and deactivating ICDs. Neither the HRS/ASA statement nor any other consensus statement address CIEDs in pediatric patients. Pediatric patients with CIEDs present unique problems, such as frequent lead malfunction[18] and closer proximity of electrocautery tip to the CIED by virtue of the fact that the patient is smaller. The HRS/ASA recommendation allows *monopolar electrocautery* use for procedures below the umbilicus, even when CIEDs have not been reprogrammed or deactivated. However, even surgery below the umbilicus can bring the cautery unit or its electrical exit path dangerously close to a small child's CIED. In general, children with CIEDs, other than teenagers who are otherwise healthy, are not good candidates for surgery in an ASC. The care of older children with CIEDs requiring surgery at an ASC should follow HRS/ASA guidelines for adults, including preoperative device interrogation and communication between the CIED and perioperative teams.

Diabetes Mellitus

Type 1, insulin-dependent, diabetes mellitus (T1DM), is more common than type 2, noninsulin dependent, diabetes (T2DM) in children; though prevalence of T2DM is on the rise due to the worldwide epidemic of pediatric obesity.[11] Preoperative fasting and stress make perioperative glycemic control challenging, especially if the child has T1DM. Patients with either form of DM can, however, be managed as ambulatory patients. However, the more difficult nature of perioperative glucose management dictates that special precautions are taken, especially in patients with T1DM (outlined in **Table 18-4**). Perioperative management of DM should be coordinated with an endocrinologist if one is available. As noted in **Table 18-4**, patients with T1DM are not good candidates for ambulatory anesthesia if they are very young, or if their blood glucose concentrations are chronically poorly controlled. Hemoglobin A1C is a good indicator of long-term glycemic control. A reasonable target range for hemoglobin A1C for children undergoing surgery in an ASC is 6-8.5% for 5-13 year olds and 6-8% for older children.[19]

Additionally, the child's glucose concentration should be well controlled when he/she presents to the ASC, and he/she should be able to remain in close proximity to a facility that can manage ketoacidosis if it occurs on the night of surgery. Children with DM should have their surgery early in the day (preferably first case) to minimize fasting time and to allow plenty of time for postoperative observation.

Table 18-4

Recommendations for Children with Type 1 DM Undergoing Ambulatory Surgery
Age should be older than 5 years and have minimal other health issues
Surgical procedure should be minor
Baseline glycemic control should be good (Hb A1C < 8-8.5% depending on age)
Glucose control should be adequate on the day of surgery
Fasting period should minimized (place as first case in AM when possible)
Maintain close perioperative glucose monitoring
Administer prophylaxis for postoperative nausea and vomiting
Extend PACU observation time (minimum of 2 hours)
Insure that family is capable of monitoring post-discharge glucose and will keep the child in close proximity to a facility that can manage diabetic ketoacidosis (if it occurs) during the 1st night after surgery

In 2011 the Society for Ambulatory Anesthesia published a consensus statement on perioperative blood glucose management for patients with DM who are undergoing ambulatory surgery.[20] This publication provides perioperative recommendations for administering insulin and non-insulin diabetic drugs. While this document does not specifically address pediatric diabetic management, this author believes that the recommendations can largely be applied to children.

Sickle Cell Disease and Thalassemia

Patients with all types of sickle cell disease (SCD), including those with HbSS, HbSC, and HbS beta thalassemia, have a high incidence of perioperative complications related to sickling of their red blood cells.[21-23] Life threatening complications, such as acute chest syndrome (ACS) and vaso-occlusive crisis (VOC), occur in 5% and 7% of SCD patients respectively, even when they undergo low-risk surgery.[23] The incidence of ACS is 4.2% with umbilical hernia repair and 2.3% with myringotomy tube placement. There is some disagreement about whether patients undergoing minor surgical procedures can have their surgery done in an ambulatory surgery unit. Firth suggests that select patients with SCD can safely undergo minor ambulatory surgery because the reported incidence of serious complications is low and because the need for preoperative transfusion in patients undergoing ambulatory surgery is unproven.[24] Others disagree and would

transfuse the patients preoperatively and keep them in hospital for overnight observation. Decisions regarding preoperative preparation and perioperative care of SCD patients should be made with a hematologist whenever possible. Criteria for excluding SCD patients from undergoing both large and small procedures in an ASC include patients who were hospitalized with VOC in the previous year and patients with pulmonary disease. Both of these conditions increase the risk for perioperative vaso-occlusive complications.[23] Airway procedures, including T&A, should require overnight hospital admission because they are not low risk in patients with SCD.[25] If patients with SCD are released from hospital on the day of surgery, they should remain for several days near a facility that can manage ACS because the average time for patients to present with ACS is three days after surgery.[26] ACS patients that are older than five years of age typically present with cough, fever, and with chest pain.[27] While patients with SCD require many precautions, those who have only sickle *cell trait* can undergo ambulatory surgery without taking any special precautions.

Thalassemias occurs in many variants and is the most common single gene disorder worldwide.[14] Thalassemia minor, the heterozygous form of beta thalassemia, causes mild anemia without any other specific changes that this author believes affect eligibility for ambulatory surgery. Thalassemia major (Cooley anemia) is the homozygous form of beta thalassemia. It manifests as severe anemia and extramedullary hematopoiesis in facial bones; the latter may make tracheal intubation difficult. Patients with thalassemia major may have chronic iron overload from extramedullary destruction of red blood cells and chronic blood transfusion. The iron overload predisposes the patient to cardiac failure, cardiac arrhythmias, and disturbances in myocardial electrical conduction.[14] Patients with thalassemia major should be evaluated for ambulatory surgery on an individual basis, including careful preoperative evaluation, laboratory work and possible assessment by a cardiologist. In general, patients with thalassemia major are poor candidates for ambulatory surgery at an ASC, but can undergo surgery in a hospital based ambulatory surgery setting. They may be appropriately discharged home if their perioperative course in a hospital based ambulatory center was uneventful. Alpha thalassemia with two alpha chain gene deletions causes minor anemia and no special considerations for ambulatory surgery. Alpha thalassemia with three gene deletions (Hemoglobin H Disease) has implications for ambulatory surgery similar to those for Cooley Anemia. Deletion of all four alpha hemoglobin genes is incompatible with life.

Reactive Airway Disease: Asthma and Cystic Fibrosis

In the U.S. asthma is present in 20-25% of patients presenting for surgery[3] and is one of the most common pediatric comorbid conditions. In Africa the incidence is 8-20%. Whether patients with asthma can be cared for in an outpatient setting depends on the severity of their asthma and on how well their asthma is controlled. It also depends on the nature of the outpatient surgical facility. Patients who have required frequent or recent hospital admissions for their asthma (especially during the previous three months) and those who required admission to an ICU

because of their asthma are not good candidates for surgery in an ASC[3] but could be discharged home after an uneventful perioperative ambulatory surgery in a hospital setting. Well-controlled, mild, or moderate asthma usually does not prevent patients from having ambulatory surgery.

Cystic fibrosis (CF) manifests itself with a range of pulmonary and gastrointestinal diseases and with variable degrees of airway reactivity. Patients with CF may be appropriate candidates for minor ambulatory surgical procedures in a freestanding ASC, but they have a relatively high risk for being admitted to hospital after more complicated and prolonged procedures (e.g., extensive endoscopic sinus surgery).[28] Careful consideration should be given to the extent of the patient's reactive airway disease. Patients with more severe airway reactivity and those with exacerbations of their pulmonary disease probably should not undergo surgery in a freestanding ASC.

Malignant Hyperthermia Susceptibility

Patients with a family history of malignant hyperthermia (MH) or children who are thought to have had MH in the past, may have ambulatory surgery at a free standing ASC if the anesthetist can provide a trigger free anesthetic and respond appropriately to a MH event. Agents that trigger MH include: Halothane, Enflurane, Isoflurane, Desflurane, Methoxyflurane, Cyclopropane, Sevoflurane, Ether, and Succinylcholine. The Malignant Hyperthermia Association of the United States (MHAUS) (http://www.mhaus.org) is an excellent source of information about MH and its treatment. Their website and their telephone "hotline" can be consulted whenever there is concern for MH. MHAUS also has a very useful smartphone application for management of MH that is downloadable from the *iTunes app store* for a small fee.

Most patients who develop MH are phenotypically normal and have no history of susceptibility to MH. Freestanding ASCs that administer agents that can trigger MH (whether MH susceptible or not) must have the ability to respond appropriately to MH if it occurs. The ability to appropriately respond to MH includes having all necessary medications and equipment immediately available, maintaining knowledge and skills regarding how to manage a MH crisis, and having a plan in place for transfer of patients with MH to a receiving hospital. Dantrolene is the specific treatment for MH, and must be available in a quantity needed to treat MH in an adult. Low resource nations may choose to share a Dantrolene supply by storing it in a centrally located hospital in order to lower cost and manage difficulties locating Dantrolene when outside of large cities. However, it is worth noting that MHAUS recommends that 36 vials be available within 10 minutes of the decision to treat MH. Yearly practice drills on the diagnosis and treatment of MH are a good way to maintain knowledge and skills that allow the operating room team to respond quickly and appropriately to MH. Each ASC should partner with a particular receiving hospital that will accept patients having a MH crisis. The Ambulatory Surgery Foundation and MHAUS recently developed a guide for transfer of MH patients from an ASC to a receiving hospital. These guidelines are meant to aid ASCs that want to create their own specific plan.[29]

Administering a trigger free anesthetic requires the anesthetist to have familiarity with procedures for eliminating volatile anesthetic from the specific anesthetic machine that will be used. Anesthesia machines differ in the procedure and the duration required to purge the very small amounts of volatile anesthetics known to trigger MH. Some anesthesia machines require two or more hours to adequately purge volatile anesthetics if charcoal filters are not available.[30] Anesthetic machine manufacturers typically publish guidelines that describe the best way to prepare their machine for a trigger free anesthetic. Patients susceptible to MH should have their surgery early in the day to allow for observation of the patient for two hours after surgery, as recommended by MHAUS.

Neurologic and Neuromuscular Disease: Myopathy, Cerebral Palsy and Seizure Disorder

Children with known muscle dystrophies and myopathies should have their surgical care in a hospital for the following reasons. Patients with Duchenne muscular dystrophy and those with many other myopathies have weak respiratory muscles and impaired cough, which makes them particularly susceptible to the negative respiratory effects caused by general anesthesia.[31] This leads to problems with postoperative gas exchange. Numerous forms of myopathies are also associated with cardiomyopathy and disturbances in cardiac electrical conduction. Mitochondrial myopathies are associated with a wide variety of conditions, including increased sensitivity to anesthetics, compromised renal or hepatic function, lactic academia, and glucose instability.[32] Some patients with mitochondrial myopathy do not tolerate normal preoperative fasting protocols because even small amounts of dehydration and reduced intravascular volume significantly affect their myocardial function.

Children with early myopathic symptoms may receive diagnostic muscle biopsy in an ASC. These children should be carefully screened for serious respiratory and cardiac symptoms. Particular attention must be paid to respiratory function and the other medical issues noted above. Volatile anesthetics are often used for anesthetic induction and maintenance of anesthesia for these patients; however, use of total intravenous anesthesia (TIVA) may offer advantages. By administering TIVA, volatile anesthetics are avoided, and the chance of needing succinylcholine to treat laryngospasm on induction is smaller. This may decrease the likelihood of a hyperkalemic crisis if the patient has an undiagnosed muscle dystrophy, and of MH if the patient has a myopathy that predisposes them to MH, such as Central Core Disease or Multi-Minicore Disease.[33]

Children with mild cerebral palsy (CP) are reasonable candidates for ambulatory surgery, including surgery at a freestanding ASC, so long as other comorbid conditions do not cause excessive risk. As noted in **Table 18-3**, children with CP are predisposed to obstructive sleep apnea syndrome. If airway surgery is planned (including T&A), even patients with mild CP should remain in hospital

overnight. Children with moderate to severe CP typically have weak respiratory muscles, scoliosis and restrictive lung disease, seizure disorders, and other comorbid conditions. Their surgical care should take place in a hospital, and they should remain in hospital overnight following general anesthesia.

Seizure disorders are common, but children who have seizures are eligible for ambulatory surgery in freestanding centers if their seizures are well controlled. Efforts should be made to continue their anticonvulsant medications throughout the perioperative period, though this can be a challenge in children who refuse to take medication without food. Intravenous formulations of anticonvulsants, if available, should be substituted for oral formulations when the anticonvulsant drug cannot be given orally.

Difficult Tracheal Intubation

Children who have a history of a difficult intubation or an airway examination that indicates a high likelihood of a difficult intubation are usually managed in a hospital. The determination of where to manage these children must be made on an individual basis, taking into consideration each ASC's availability of airway equipment, airway expertise, and capability to manage a situation where one cannot intubate and cannot ventilate (**See Chapter 4**). The latter depends on ability to create a surgical airway, and manage the aftermath and transfer of a patient when complications develop. An additional consideration is the extra time involved in securing a difficult airway, which impacts the efficiency of the ASC. There are no guidelines that indicate what airway equipment should be available in an ASC. ASCs usually do not have as full an assortment of airway equipment as a hospital operating room, but should keep on hand equipment for management of unexpected difficult tracheal intubations. Examples of emergency airway equipment that can be affordable options for resource poor nations include gum elastic bougies, non-disposable lighted stylets, and disposable videolarygoscopes..

Preoperative Management

Ambulatory surgery centers have gained popularity, in part, because they provide efficient service for patients and surgeons. Low cancellation rates on the day of surgery and rapid patient throughput are cornerstones of ASC efficiency. This section discusses preoperative patient evaluation and preparation because these help avoid delays and cancellations of cases on the day of surgery. Upper respiratory tract infection (URI) is one of the leading causes of cancellation of ambulatory pediatric cases on the day of surgery. This section therefore includes a discussion of the common preoperative dilemmas of whether to cancel elective surgery when a child has a URI.

Preoperative Evaluation and Preparation

Pre-anesthesia evaluation of ambulatory surgery patients may take place in a pre-anesthesia evaluation clinic (PAEC), by phone, or may first occur on the day of surgery. Most children coming for ambulatory surgery are healthy and can therefore be evaluated with a telephone call or by a visit on the day of surgery. Patients with comorbid conditions may need to be evaluated in a PAEC that is staffed by individuals who are familiar with anesthetic concerns. That visit can help determine whether the patient is appropriate for the planned ambulatory surgery. ASCs can benefit from creation of predetermined criteria that specify for surgeons which comorbid conditions require a visit to the PAEC and which conditions completely exclude them from having ambulatory surgery. A patient should visit the PAEC whenever there is any doubt regarding whether they are appropriate candidates for the planned ambulatory surgery. No matter where the pre-anesthesia evaluation takes place, it is useful to have the family complete an intake questionnaire that includes key elements of the patient history. Components of the ambulatory pre-anesthetic history and physical examination are the same as for inpatients.

Preoperative anesthesia evaluation prior to the day of surgery can avoid day of surgery surprises, save time on the day of surgery, and help patients to prepare psychologically for their surgery. Rules for fasting, discussed in detail below, are conveyed to patients and families. Necessary discussions with the patient and family can take place in advance, therefore saving time on the day of surgery. And, in-person visits offer an opportunity to psychologically prepare the child and family for the surgery. Psychological preparation was reported to be as effective as oral midazolam for providing a calm induction of anesthesia, and had the additional benefits of reducing emergence delirium, PACU analgesic requirements, and time spent in the PACU.[34] Two of the most important elements in that preparation were teaching parents ways to distract the child and encouraging them to practice with the child at home with a disposable anesthetic mask.[34]

Preoperative laboratory testing, if indicated, can be obtained at a PAEC or at the preoperative visit with the surgeon. Routine preoperative laboratory testing is not needed for healthy children undergoing standard ambulatory surgical procedures, but may be indicated according to a patient's comorbid conditions. For example, geographic areas with prevalent SCD should routinely screen for HbS in patients who have not previously undergone that screening. Criteria for preoperative laboratory testing are best developed by each center, based on local resources and on endemic diseases in each ASC's particular geographic region. Each ASC should develop a policy on pregnancy testing for menstruating females who will undergo general anesthesia or sedation. Opinions expressed by an ASA Joint Task Force on Pregnancy Testing and in the ASA Practice Advisory for Pre-anesthesia Evaluation suggest that every menstruating patient and her family should be offered a pregnancy test, but should not forced to have one.[35] Nonetheless, ASCs in some countries may decide not to offer a pregnancy test to every menstruating patient and her

family, and the decision to do so should depend on local prevalence of teenage pregnancy, medical legal considerations, and cultural mores. Unconsented pregnancy testing is *not ethical* when dealing with competent patients. Pregnancy testing may be done on the day of surgery with an inexpensive urine dipstick, and should be done as close as possible to the day of surgery.

All families should receive a preoperative phone call 1-2 days prior to the ambulatory surgery, even if their child has already undergone evaluation in the PAEC or by phone. The phone call 1-2 days before surgery can serve as a final check that the patient does not have any comorbid condition that would exclude them from ambulatory surgery. The phone call also serves as an important reminder of the surgical appointment, provides details regarding the facility location, gives a contact phone number in case the family needs to get in touch with the facility, and provides the following crucial information. Families should be informed of the need for a legal guardian to accompany the patient if signatures for consent for surgery and anesthesia will be required. They should be told to arrive 1 - 2 hours prior to the actual scheduled surgery time, which insures adequate time for patient preparation and allows an earlier start to surgery if the schedule permits. Instructions on whether or not to take medications should be given. Rules for preoperative fasting must be clearly conveyed to the patient and family during the preoperative telephone call, as NPO violations are a leading cause of case cancelation on the day of surgery. Our institution endorses the ASA's Practice Guidelines for Preoperative Fasting rules (**Table 18-5**).[36] It may be appropriate to add 1.5 hours to those fasting times (i.e., 3.5 hours for clear liquids) to allow flexibility if a patient's surgery time can be moved forward in the schedule. Clear liquids consist of water, electrolyte solutions, and fruit juices without pulp. They also include clear tea, black coffee, and carbonated beverages. Confusion and errors may occur if patients are given too many options for clear liquids. The preoperative phone call is also an opportunity to convey that patients should wait 36 hours after a general anesthetic before doing potentially dangerous activities that require coordination and/or judgment such as driving a vehicle or riding a bicycle.

Table 18-5: Minimum Fasting Periods for Healthy Patients of All Ages Undergoing Elective Surgery (adapted from ASA Guidelines[36])

Type of feeding	Minimum Fasting Time
Clear Liquid	2
Breast Milk	4
Infant Formula	6
Non-Human Milk	6
Light Meal*	6

**A light meal is considered to be a small amount of toast, plain rice, fruit, together with clear liquids, and without fried or other types of fatty food.*

The Child with a Upper Respiratory Tract Infection

Every day, pediatric anesthetists encounter children who present for surgery with respiratory infections. The dilemma of whether to cancel these infected patients is particularly common in ASCs, due to the sheer volume of patients they serve. Lower respiratory tract infections pose clear-cut contraindications for elective surgery. Wheezing or rales heard on auscultation of the chest imply bronchiolitis or pneumonia and should prompt cancellation of the surgery and referral of the patient to a pediatrician or family practitioner. Additionally, a child who is febrile or one who has a febrile illness and arrives for elective surgery on antipyretics, is best served by rescheduling surgery. A possible exception to cancellation of surgery for a child who is febrile would be the child who requires drainage of an infected area, such as chronic purulent otitis media or sinusitis. However, the anesthetist must be confident regarding the source of the child's fever; proceeding with surgery in a child who has fever that is part of an undiagnosed serious illness, may result in serious complications.

Pediatric viral upper respiratory tract infections (URI) are a leading cause for cancellation of cases on the day of surgery. Children under six years of age have 6-8 viral URIs every year; the number is higher for those <2 year of age and for those who spend time in day care with many other children.[37] Prior to the 1980s, anesthetists were taught to cancel elective surgery for children with URIs, mainly due to concern about possible intraoperative or postoperative respiratory complications.[38] Children who have URIs at the time of their anesthesia, and those who have had a URI up to 2 weeks before, are know to have increased risk for developing respiratory complications.[39] Some data imply that this increased risk persists for up to four weeks after a URI.[40] The risk of intraoperative bronchospasm nearly doubles and that of laryngospasm doubles or triples when a child with an active URI undergoes anesthesia and surgery.[39,41,42] However, Schreiner estimated that surgery would have to be cancelled in 130 children with URIs to prevent one laryngospasm, and that 8,000 cases would need to be cancelled in these same patients to prevent one unexpected overnight hospitalization for laryngospasm.[41] Pediatric anesthetists now recognize the additional risk of anesthetizing a child with a URI, but are far from cancelling all elective surgery for every child with a URI. Many factors go into determining when to cancel a child with a URI, including the anesthetist's comfort in managing complications, and these factors are discussed in detail below.

Viral URIs cause differing severities of disease, and occur in patients who are receiving numerous different types of surgery and who have many different comorbid conditions. Therefore, there are many possible combinations of URI severity, surgery type, and comorbid condition, and often no clear-cut answer for whether to proceed with surgery or reschedule it. Tait and his colleagues hoped to clarify the situation by identifying independent risk factors for adverse respiratory events in children with active URIs (**See Table 18-6**).[40]

Table18- 6

Independent Risk Factors for Adverse Respiratory Events in Children with Active Upper Respiratory Tract Infections
Copious secretions (e.g. productive cough or copious nasal secretions)
Need for a tracheal tube in a child under 5 years of age
History of prematurity (born at <37 weeks gestational age)
Nasal congestion
Parental smoking
History of reactive airway disease
Airway surgery

Once preoperative screening identifies a patient with an URI, anesthetists can use Tait's risk factors listed in **Table 18-6** to help identify the overall risk of proceeding. Tait's risk factors are helpful, but it is important to keep in mind that they mainly represent the least serious of respiratory events, such as coughing, breath holding, and oxygen desaturation to <90%. Those events occurred much more frequently than laryngospasm requiring succinylcholine (2.2%) and bronchospasm (5.7%). Comorbid conditions other than those on Tait's list (especially those related to the pulmonary system), whether the ambulatory surgery is urgent, and how difficult it will be to find a time when the child will be free of a URI for at least two weeks before surgery must all be considered. Patient safety should be paramount, but often factors unrelated to the patient come into play. These include how far the family traveled for the surgery, whether the patient's surgery has been cancelled before, and whether family members have taken time off from work to take the child to the hospital or ASC, The decision to proceed or postpone surgery must also take into consideration the anesthetist's comfort level and ability to manage predictable complications such as laryngospasm and bronchospasm. Generally, parents and surgeons can help with the decision to proceed or not to proceed after a brief discussion of potential complications and increased risk.

While the vast majority of children with URI's coming for ambulatory surgery can be safely anesthetized, it is difficult to predict which ones will have serious complications. If one proceeds with anesthesia and surgery in a patient with a URI, then it is important to avoid drugs that increase the risk of bronchospasm or laryngospasm, (e.g., thiopental, desflurane). A LMA or mask airway should be used rather than a tracheal tube, whenever appropriate, to avoid the increased risk of bronchospasm associated with tracheal intubation of patients with a URI.[43]

Anesthetic Management

Management of an anesthetic for ambulatory surgery is not much different from that for inpatient surgery. Details regarding anesthetic management can be found in appropriate locations throughout this textbook, including Chapter 7. Plans for treating pre-anesthetic anxiolysis should

be the same for patients coming for ambulatory surgery as they would be for all other children coming for surgery, and should include consideration for giving pre-anesthetic sedative medications (midazolam, clonidine, ketamine), the use of distraction techniques, and having a parent present during induction of anesthesia. If the parents will be present during the induction of anesthesia, they should be warned that the child may struggle, and is expected to demonstrate many features that differ from falling asleep at home, including involuntary movements, roaming or twitching eye movements, noisy breathing, abnormal breathing patterns, and body stiffening or sudden relaxation.

The ambulatory anesthetist must pay meticulous attention to prophylaxis for both postoperative nausea and vomiting (PONV) and emergence delirium (ED), and to provision of effective intra and postoperative pain management. Those elements are key for efficient throughput and quality care in the ambulatory surgery environment. Prophylaxis for PONV and ED are discussed individually in this section, while perioperative pain management is discussed subsequently in its own section and in **Chapter 20**.

Post Operative Nausea and Vomiting Prophylaxis

Postoperative nausea and vomiting (PONV) is ranked by adult patients as one of the most discomforting postoperative symptoms. PONV is also a leading cause of unanticipated hospital admissions for both children and adults who undergo ambulatory surgery.[44,45] Having PONV often increases the amount of time required for patients to recover from anesthesia, requires greater PACU nursing support, and causes patient dissatisfaction.[44] Data for children are usually limited to postoperative vomiting (POV) because young children are frequently unable to describe and report nausea.

Fortunately, prophylaxis for pediatric POV is highly effective. Single administration of either a 5-hydroxytryptamine-receptor antagonist or dexamethasone reduces relative risk (RR) of POV by 50-60%.[46] Droperidol alone decreases the relative risk of PONV by 40%,[46] but many anesthetists are reluctant to use it because of associated ventricular dysrhythmias. However, droperidol has rarely, if ever, caused this problem when administered in a dose of 10-15mcg/kg that is usually recommended for POV prophylaxis. The reductions in relative risk mentioned above compare favorably to reductions of just 25-26% in PONV relative risk seen in adults who receive single administration of either ondansetron, dexamethasone, or droperidol.[47] Children that receive prophylaxis with both dexamethasone and a 5-hydroxytryptamine receptor antagonist have an 80% reduction in the risk of POV,[46 making] it unnecessary to prophylax with additional drugs.

The incidence of POV in children is twice that of adults,[44] but not all pediatric patients require prophylaxis. A specific plan for POV prophylaxis should be created for each child based on his/her specific risk. Many pediatric risk factors are the same as for adults, including the use of nitrous oxide, the use of perioperative narcotics, a history of POV, the use of volatile anesthetics instead

of propofol, and the duration of surgery.[44,48] Strabismus repair is know to increase risk for POV.[48] Other specific pediatric procedures, including T&A, middle ear surgery, orchidopexy, hernia repair, and penile surgeries are believed to increase risk,[44] although evidence is lacking. Children less than two years of age were once believed to seldom develop POV, but that is not the case.[49] The risk of POV increases up to puberty and then decreases. Females become more likely than males to have POV only after puberty.[44] A simple risk assessment scale for pediatric POV has been developed by Eberhart and colleagues, and incorporates four risk factors that they found to correlate strongly with developing POV (**Table 18-7).** When their patients had 0, 1, 2, 3, and 4 of those risk factors, the incidence of POV was 9%, 10%, 30%, 55%, and 70%.

Table18-7

Pediatric Postoperative Vomiting (POV) Risk Factors
Eberhart's POV Risk Factors:[48] • **Strabismus surgery** • **Age of ≥3 years** • **Duration of surgery greater than 30 minutes** • **History of POV in patient, parent or sibling**
Risk Factors not included in Eberhart's list:[44] • **Nitrous oxide** • **Volatile anesthetic use versus propofol** • **Perioperative narcotics** • **Specific surgeries other than strabismus repair: T&A, orchidopexy, hernia repair, penile surgery, and middle ear surgery**

Eberhart's scale provides an easy way to approximate POV risk, and therefore facilitates decision making for POV prophylaxis. Patients with zero or one risk factor have a baseline risk of approximately 10%, so that single drug prophylaxis produces minimal benefit by decreasing risk to near 5%; the number needed to treat (NNT) to avoid a single case of POV would be near 20. Patients with two risk factors have a baseline risk of approximately 30% that decreases to near 15% after single drug prophylaxis (NNT ≈ 6), and marginally further (to near 6%) by adding a second drug. Children with three or four of Eberhart's risk factors may benefit from giving more than one drug for prophylaxis. The first drug will decrease the incidence of POV by 27-35% (NNT of 3 - 4) and the second will decrease it by an additional 16-21% (NNT 5 - 6). As noted above, risk factors other than those found by Eberhart might also require consideration.

When using a single drug for prophylaxis, anesthetists should consider that dexamethasone 0.05 - 0.15mg/kg (maximum of 4 mg for the purpose of POV prophylaxis) prevents POV as well as 5-hydroxytryptamine receptor antagonists and that dexamethasone is not an effective rescue

medication. Thus, dexamethasone is a logical first choice for POV prophylaxis. Ondansetron 0.05 - 0.1mg/kg (maximum of 4 mg) can be added if needed, or saved for rescue. Droperidol 10 - 15mcg/kg may be used to prevent or treat POV, but the anesthetist must take into account the need for post-administration cardiac monitoring.

Adequate hydration has been shown to reduce POV/PONV for both pediatric and adult patients.[44,50] Children 1-12 years of age that underwent strabismus repair and received no PONV prophylaxis, had a PONV incidence of 22% when they received 30ml/kg of lactated Ringers solution versus 54% after 10ml/kg.[50] The more generous hydration (30ml/kg) also reduced postoperative fever and thirst,[50] and may allow more time before patients who develop protracted POV become dehydrated.

Emergence Delirium Prophylaxis

Emergence delirium (ED), also referred to as emergence agitation, frequently occurs in children emerging from volatile anesthetics. Non-purposeful thrashing movements, uncontrollable crying, failure to make eye contact, and non-responsiveness are features that characterize ED.[51] Children with ED do not recognize familiar objects or persons. ED puts patients at risk of injuring themselves, dislodging their intravenous lines, damaging their surgical site, and may lead to a need for increased nursing support and additional recovery time. Parents who witness ED in their child may incorrectly conclude that the anesthetic was conducted improperly, may experience excessive stress, and may worry about permanent sequelae.[52]

Risk factors for ED are not as clearly delineated as those for PONV. Younger age, most notably the preschool age group, appears to have increase risk of ED,[53,54] although the potential for self injury, or injury to staff, is greatest when ED occurs in older, stronger children. Preoperative anxiety has been shown in two studies to elevate risk of ED,[55,56] but a large observational study found no relationship with the quality of separation or induction.[54] Otolaryngology procedures carry a higher risk of ED than other procedures, with a RR of 1.7.[54] Children that receive intravenous anesthesia with propofol have a very low incidence of ED.[57]

Prophylaxis for ED is highly effective, and pediatric anesthetists working in ambulatory settings should consider prophylaxis for all children who have received volatile anesthesia as their main anesthetic. Inadequately controlled pain contributes to agitated emergence from anesthesia.[58] Prevention of ED should involve strategies for insuring proper analgesia, including regional blocks, ketorolac, acetaminophen, and narcotics. Narcotics appear to have a prophylactic effect apart from their analgesic effect, as demonstrated by their ability to decrease the incidence of ED in cases where no surgery was performed; Cravero reported that the incidence of ED was decreased from 56%-to-12% by administering 1µcg/kg of fentanyl 10 minutes before emergence from sevoflurane.[59] Alpha-2 adrenergic agonists are highly effective prophylactic agents; dexmedetomidine 1µcg/kg was shown to decrease the incidence of ED from 33%-to-0% after

sevoflurane anesthesia for MRI scans, with dexmedetomidine given an average of 45 minutes prior to discontinuation of anesthesia.[60] Doses of dexmedetomidine as low as 0.15µcg/kg have also been shown to provide effective prophylaxis of ED, though not as effective as higher doses, and may be given closer to the time of emergence with less concern for delayed awakening. Clonidine 4µcg/kg given orally resulted in only 25% agitation in patients emerging from sevoflurane, compared with 60% in those that received oral midazolam 0.5mg/kg, both premedicants were given 30 minutes prior to induction.[61] Intravenous clonidine 2µcg/kg given just prior to the start of surgery reduced baseline risk of emergence agitation from 33%-to-14%, and severe emergence agitation from 10%-to-3%.[62] Propofol is also a useful prophylactic agent for ED; propofol decreased severe ED from 27%-to-5% when given intravenously in a dose of 1mg/kg at the time of discontinuation of sevoflurane.[63] Ketamine 0.25mg/kg given intravenously 10 minutes before the end of surgery decreased ED from 34%-to-17%,[64] and intravenous nalbuphine 0.1mg/kg has been shown to be a more effective prophylactic agent than the above dose of ketamine when given at the end of the surgical procedure.[65] A summary of useful prophylactic agents is given in **Table 18-8**. Agents used to treat ED include fentanyl, propofol, dexmedetomidine, and midazolam.

Table 18-8: Medications Commonly Used for Prophylaxis of Emergence Delirium in Pediatric Ambulatory Anesthesia

Medication	Route	Dosage	Timing
Fentanyl	IV	1µcg/kg	10 min PTE
Dexmedetomidine	IV	1µcg/kg	45-60 min PTE
		0.5µcg/kg	30 min PTE
Ketamine	IV	0.25mg/kg	10 min PTE
Clonidine	PO	4µcg/kg	Oral premed*
	IV	2µcg/kg	Post induction
Propofol	IV	1mg/kg	End of procedure
Nalbuphine	IV	0.1mg/kg	End of procedure

PTE = Prior to emergence
**Given 30 minutes prior to induction of anesthesia*

Perioperative Analgesia

Effective perioperative pain management is especially important in pediatric ambulatory anesthesia. Parent and patient satisfaction, and ability to efficiently move patients through the recovery process depend on successful perioperative analgesia. Inadequate postoperative pain control was the leading cause of unplanned hospital admission in a retrospective cohort of over ten thousand pediatric ambulatory surgeries.[45] Postoperative pain may play a role in problematic postoperative behavioral changes observed in nearly half of all children receiving surgery.[66]

Despite these serious consequences, parents often undertreat their child's pain after ambulatory surgery.[67,68]

Multimodal analgesia consists of administering two or more analgesic drugs acting by different mechanisms,[69] and is widely promoted for ambulatory anesthesia.[70] Multimodal strategies include combinations of opioids, non-steroidal anti-inflammatory drugs (NSAIDs), acetaminophen, local anesthetics (including regional anesthesia), ketamine, dexamethasone, alpha-2 adrenergic agonists, and gabapentinoids. Opioid analgesics remain an important component of perioperative regimens, but cause nausea, vomiting, pruritus, urinary retention, and impaired bowel function in some patients. Use of non-opioid analgesics, especially in combination, may allow opioids to be reserved for rescue analgesia. The ASA Task Force on Acute Pain Management recently updated their Practice Guidelines for Acute Pain Management in the Perioperative Setting, noting that consultants and ASA members "strongly agreed" that acetaminophen should be considered for multimodal strategies unless contraindicated. Additionally, they "agreed" that nonselective NSAIDs, COX-2 selective NSAIDs (COXIBs), and calcium channel alpha-2-delta antagonists (pregabalin and gabapentin) should also be considered unless contraindicated.[69] Those guidelines, which appear more geared for adults and for inpatients, "strongly recommend" around-the-clock (ATC) dosing of acetaminophen and NSAIDS/COX-2 inhibitors. Others note a lack of evidence for ATC dosing after ambulatory surgery. That decision should take into consideration surgery type, patient factors, risk factors of the particular drug, as well as difficulties administering nighttime doses, problems swallowing after T&A, and patient refusal of medication.[68] Analgesic medications and doses commonly used in pediatric ambulatory anesthesia are listed in **Table 18-9**.

Table 18-9: Analgesic Medications and Doses Commonly Used in Pediatric Ambulatory Anesthesia

Medication	Class	Route	Single Dosage [Maximum]
Fentanyl	Opioid	IV	0.5-1.0µcg/kg*
Morphine	Opioid	IV	0.025-0.05mg/kg*
Hydromorphone	Opioid	IV	3-8µcg/kg*
Tramadol[§]	Atypical Opioid	PO PR IV	1-2mg/kg [100mg] 1-2mg/kg [100mg] 1-2mg/kg [100mg]
Oxycodone	Opioid	PO	0.05-0.1mg/kg [10mg]
Codeine	Opioid	PO	0.5mg/kg [30mg]
Hydrocodone	Opioid	PO	0.1-0.15mg/kg [10mg]
Acetaminophen[§]	Para-aminophenol derivative	PO PR IV	10-20mg/kg [1 gm] 30-45mg/kg [1.3gm] 7.5-15mg/kg** [1gm]
Ketorolac	NS NSAID	IV/IM	0.5-0.75mg/kg [30gm]
Metamizole	NS NSAID	IV/IM PO	25-40mg/kg*** [1gm] 15/mg/kg [1gm]
Ibuprofen	NS NSAID	PO	5-10mg/kg [600mg]
Celecoxib[§]	COXIB	PO	250mg/meter^2 [400 mg]
Paracoxib	COXIB	IV	1mg/kg **** [40 mg]

IV = Intravenous; IM = Intramuscular; PO = Per Os; PR = Per Rectum; PRN = As needed; NSAID = Non selective non-steroidal anti-inflammatory drug; COXIB = Selective COX-2 inhibitor

** Titrate to effect and dose according to lean body mass to avoid overdosing*

*** Acetaminophen IV is licensed in the UK at a dose of 7.5 mg/kg (maximum of 30/mg/kg/day) for term neonates and infants up to one year of age, and at a dose of 15 mg/kg (maximum of 60mg/kg/day) for children over one year.*[71]

**** Only a single IV/IM bolus at this dose; subsequent IV/IM doses of 15 mg/kg Q8 hours. Administer by slow IV infusion over 15 minutes or more to avoid hypotension. IV administration not recommended for children <1 year old due to potential for hypotension.*

***** Recommended for children >2 years of age and over 10kg.*[72]

[§]*Medications that may be given preoperatively in oral formulation as part of a multimodal strategy*

Acetaminophen is typically included in pediatric perioperative multimodal strategies, and is frequently used at home postoperatively either ATC or as needed. It may be given orally, per rectum, or intravenously. Peak plasma levels are achieved 30 - 60 minutes after oral administration.[73] Acetaminophen 40mg/kg per rectum (PR) produces therapeutic plasma levels at 30 - 45 minutes and peak plasma levels at 2 - 3 hours after administration.[74,75] Analgesic effect depends on establishing cerebrospinal fluid levels, which occurs approximately one hour after plasma levels are established.[73] Rectal acetaminophen has a relative bioavailability of 80% compared to oral formulations, has erratic absorption and does not produce consistent therapeutic blood levels of the drug.[73,75] Nonetheless, rectal acetaminophen is widely available, cost effective, and has been demonstrated to work. Acetaminophen 40mg/kg PR administered shortly after anesthetic induction produced opioid sparing effects in the recovery room and during the first 24 hours after surgery following a variety of pediatric day-case surgeries, and also led to a substantial reduction in POV.[76] Subsequent doses of rectal acetaminophen must be decreased to 10-20 mg/kg every 6-8 hours after giving the initial large bolus noted above, and one must adhere to recommended daily maximum doses to avoid toxicity. Daily maximum doses for orally and rectally administered acetaminophen depend on age. The British National Formulary recommends a daily maximum dose for oral or rectal acetaminophen of 60mg/kg for term infants <3 months old. They recommend that infants >3 months of age receive a daily maximum of 90mg/kg for the first 48 hours and 60mg/kg thereafter. The US Food and Drug Administration (US FDA) recommends only 60mg/kg/day for children 1-2 years of age, and a daily maximum of 75mg/kg thereafter. Intravenous acetaminophen produces a rapid therapeutic level.[71] It is licensed in the UK at a dose of 15 mg/kg (every 6 hours, with a maximum of 60mg/kg/day) for children over one year old and at a dose of 7.5 mg/kg (every six hours, with a maximum of 30/mg/kg/day) for term neonates and infants up to one year of age. Pharmacokinetic studies suggest that infants 1 - 12 months of age may receive the same dosing as older children, and it is no surprise that a large percentage of UK pediatric anesthetists practice accordingly.[71] The US FDA has not approved IV acetaminophen for children under two years old. An epidemiologic association has been found between acetaminophen use and asthma prevalence and severity in children and adults. Some advocate avoidance of acetaminophen for children with asthma,[77] but no data exists regarding perioperative use and associated bronchospasm.

NSAIDs are amongst the most commonly used analgesic agents in ambulatory anesthesia and may be effective as a single agent when pain is mild or moderate. NSAIDs typically have anti-inflammatory properties that may also reduce edema. Ketorolac is a nonselective NSAID available in IV formulation, commonly administered in a dose of 0.5mg/kg IV or intramuscularly (IM). It has been advocated for numerous pediatric ambulatory surgeries, including as an equianalgesic intraoperative substitute for morphine in pediatric strabismus surgery.[78] Some studies demonstrate a reduction in opioid side effects when Ketorolac or other NSAIDS are used.[66,78] Ketorolac should not be given to patients having T&A because there is an association between its

perioperative use and post-T&A bleeding requiring surgical intervention (OR = 3.82, 95% confidence interval = 1.03-14.1).[79] Metamizole (also known as dipyrone) is a nonselective NSAID available in PO and IV/IM formulations. It is effective as both an analgesic and antipyretic but not as an anti-inflammatory agent.

Metamizole exerts its analgesic effect by central mechanisms and weak cyclooxygenase (COX) inhibition, and is well tolerated by the gastric mucosa.[80] It does diminish platelet aggregation, compared to a selective COX-2 inhibitor.[81] Metamizole is a popular pediatric postoperative analgesic worldwide, including in India, Indonesia, Thailand, and in many Latin American and European countries. Numerous countries (including the USA) removed it from the market due to an association with the potentially fatal complication of agranulocytosis, although the estimated risk is very low. Adult studies of single dose metamizole for postoperative pain show that 500mg PO is as effective as ibuprofen 400mg, and 2.5gm IV is as effective as Tramadol 100mg IV.[82] There is limited evidence for its use in pediatrics or in ambulatory surgery. Metamizole may cause hypotension when administered by rapid IV infusion, especially in infants. IV administration is best reserved for children >1 year of age. This drug should be slowly infused over at least 20 minutes. Recommended doses are listed in **Table 18-9**.

COXIBs provide similar analgesia to non-selective NSAIDS, with fewer concerns for inhibition of platelet function.[66,68] Celecoxib is a COX-2 inhibitor available for oral administration. It has been an effective component of multimodal pain regimens for adult ambulatory surgery,[83] but similar studies for children have not been performed. A pharmacokinetic study found that pediatric dosing of celecoxib 250mg/meter^2 of body surface area produced serum drug levels comparable to the accepted adult dosing of 400mg, and children metabolized the drug at twice the rate of adults.[84] No commercially available pediatric oral formulation of a COXIB exists. Parecoxib, an injectable precursor of its active metabolite valdecoxib, is the sole IV COXIB formulation. It appears to be available almost exclusively in the UK. Pharmacokinetic data for children 2 - 12 years old indicate that a parecoxib dose of 1mg/kg IV produces valdecoxib levels similar to adults given the accepted adult dose of 40mg/kg. Analgesic efficacy of parecoxib in children is unknown, and pharmacokinetic data for children <2 years old do not exist.[72]

Opioids are commonly used in pediatric ambulatory surgery, both intra- and postoperatively. They are indicated for severe pain, or for moderate pain when NSAIDs are contraindicated. Intraoperative opioids should be titrated to effect, using particularly small doses when dealing with patients who have, or may have OSAS. Commonly used intravenous opioids include fentanyl, hydromorphone, and morphine. Postoperative orally administered opioids commonly used include oxycodone, hydrocodone, and codeine, given alone or in formulations that combine acetaminophen. These medications are best given to children on an as needed basis (no sooner than every 6 hours) rather than ATC. Doses for both intravenous and orally administered opioids are given in **Table 18-9**. Dosing of opioids should be based on lean body weight rather than actual

weight to avoid overdosing obese children. Codeine is a pro-drug and depends on its metabolism to morphine by the liver. Ultra-fast metabolizers of codeine may develop dangerously higher morphine levels, and codeine is therefore a poor choice for postoperative opioid analgesia. Deaths have occurred postoperatively in children with OSA who received codeine after T&A, causing the US FDA to issue a recent black box warning and contraindication statement on use of codeine for postoperative pain management in children following tonsillectomy and/or adenoidectomy. Patients who receive intraoperative acetaminophen and who are prescribed postoperative combination opioid/acetaminophen drugs may benefit from a dose of oxycodone without acetaminophen prior to PACU discharge. Otherwise, they will not begin oral opioids until sufficient time (six hours) has elapsed from the time they received intraoperative acetaminophen. This may leave them with untreated pain. Opioid side effects include respiratory depression, PONV, pruritus, urinary retention, ileus, and constipation.

Tramadol is a centrally acting atypical opioid analgesic that can be administered by oral, rectal and intravenous routes. It produces analgesia as a result of weak μ-opioid agonist activity and weak inhibition of reuptake of serotonin and norepinephrine.[85] Tramadol is effective in children after adenoidectomy and after T&A,[86,87] and has negligible effect on respiration.[85] A cohort of children aged 1-8 years old undergoing T&A for OSAS had equivalent analgesia during the first 6 hours after surgery when given either 2mg/kg of IV tramadol or 0.1mg/kg of IV morphine. Those in the tramadol group had fewer decreases in oxygen saturation to <94% during the first 3 hours after surgery.[86] Overall, tramadol appears to have less opioid side effects than typical opioids, but is nonetheless associated with nausea, vomiting, pruritus and rash.[85] Tramadol is well absorbed when administered orally or rectally,[88,89] and the recommended dose for those routes is the same 1-2mg/kg used intravenously (**Table 18-9**). It is worth noting that ondansetron and other 5-hydroxytryptamine receptor antagonists may diminish the analgesic effectiveness of tramadol.[90] Also, caution is recommended when using tramadol in patients who are taking either serotonin reuptake inhibitors or monoamine oxidase inhibitors, because the combinations may lead to serotonin syndrome or seizures.

Regional anesthesia is particularly useful in ambulatory pediatric surgery. Placement of a block prior to the start of surgery permits pain control without opioids, allows the use of lower concentrations of volatile anesthesia during the surgery, and leads to rapid emergence from anesthesia with little or no pain. Techniques for regional anesthesia are discussed elsewhere in this textbook and are not elaborated on here (**See Chapter 21**). The most widely used pediatric regional technique is the caudal block. It provides excellent analgesia for lower abdominal and lower extremity surgery when using a volume of 1ml/kg, and for perineal surgery when using 0.5 - 0.75ml/kg of bupivacaine (Marcaine). Caudal block can be performed using 0.25% bupivacaine, though 0.125% has been shown to be just as effective for postoperative pain control after inguinal hernia repair and is associated with little or no muscle weakness.[91] The latter concentration results in earlier ambulation. Alternatively, 0.2% ropivacaine can be used, which also results in early ambulation.[92] A

test dose of 0.1ml/kg of local anesthetic containing epinephrine 5µcg/ml is 98% sensitive for detecting intravascular injection and should always be given prior to administration of the remaining injectate.[93] Other regional techniques commonly employed for pediatric ambulatory surgery include blockade of the dorsal nerve of the penis, and ileoinguinal/ileohypogastric block. The latter is best performed with ultrasound visualization of local anesthetic spread in the transversus abdominis plane when possible (**See Chapter 21**).[94] Brachial plexus blockade may be helpful in upper extremity or shoulder surgery when severe pain is anticipated. Femoral and sciatic blockade are commonly used instead of caudal blockade in lower extremity procedures for older patients (generally over seven years of age) or in situations when block duration of 12 - 24 hours is desired over the 4-6 hours typically provided by a caudal block. Large studies in the USA and Europe report that peripheral nerve blockade is safe; the Pediatric Regional Anesthesia Network reported 2,782 extremity blocks without any sequelae lasting longer than three months.[95] Using continuous catheters and elastomeric infusion devices can extend the duration of a peripheral nerve block. Some centers use continuous catheters for pediatric ambulatory patients. Continuous catheters are associated with more adverse events than single injections, particularly catheter related complications such as dislodgement, kinking and malfunction, as well as infection.[95] Continuous catheters are best placed in cooperative patients, who have parents who will be able to follow instructions and return easily to the facility should problems occur.

Discharge

Discharge criteria for ambulatory pediatric surgery patients include stable hemodynamic and respiratory statuses, well-controlled pain, adequately controlled nausea, and cognition at or near baseline. (**See Chapter 22**) Patients should be allowed to drink clear fluids in the recovery room if they wish, but should not be required to drink prior to discharge from the PACU.[96] Postoperative drinking should occur only when the child is ready to do so. Children also should not be required to urinate before discharge.

In general, patients should be discharged once criteria are met, rather than requiring a specific minimum PACU time. Some procedures and conditions do require more specific observation times. Most centers require a minimum of 2 - 4 hours after T&A, due to the possibility of early postoperative hemorrhage. The majority of that time can be spent in a step-down area without monitoring and with a reduced nurse-to-patient ratio. Patients who have received blood pressure support in PACU, naloxone to reverse narcotic effect, racemic epinephrine for post-intubation croup, or treatment for bronchospasm should remain in the PACU for at least one hour after the last treatment was given. Such patients should be discharged *after* the anesthetist has evaluated them. Patients should stay a minimum of a half hour after other intravenous medications. Guardians of pediatric patients should be given verbal and written instructions for postoperative care and contact information in case a complication develops. Guardians should be physically able to assist and mentally able to make decisions for the child's welfare.

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