Preoperative Evaluation

History Taking

A detailed medical history is critical to ensuring safe and efficient care of the pediatric perioperative patient. Taking the medical history is also an opportunity to develop a rapport with both the child and parents. The pediatric pre-anesthetic history includes several components. The history of presenting illness will detail the degree and length of incapacitation secondary to the pathology for which surgery is being performed. This will often coincide with the cardiopulmonary effects of disease, guiding management and resuscitation. A pediatric past medical history begins with birth history. Birth history including gestational age at birth, mode of delivery, and antenatal care all of which will have implications well beyond the neonatal period. History of extended hospital stay or NICU stay after birth, and requirement of intubation or supplemental oxygen are pertinent, particularly to pulmonary status. Children should have completed well child visits and attainment of developmental milestones. Past medical history must lead to an assessment of cardiac and pulmonary status, including functional status. Infants and toddlers ambulate with increasing age, and school age children can be assessed based on their ability to keep up with their peers, play sports, without chest pain or shortness of breath. History should include any visits to the hospital or emergency room, current medications which the child is taking, allergies to medications, last ingestion of solids and liquids, and history of surgical procedures and/or anesthesia. If the child has had prior anesthetics, review of these records for difficulty with airway management or intravenous access will be helpful. History of recent illnesses includes coughs, colds, and ear infections in the weeks prior to surgery. Family history of anesthetics and perioperative complications, particularly malignant hyperthermia, is also pertinent.

Physical Examination
Physical examination should begin with a general observational assessment for degree of comfort, activity level, physical appearance, nutritional appearance, behavior and attitude. The experienced clinician will gain a great deal of information from these initial observations. Avoidance of eye contact or refusal to engage are likely signs of significant pre-operative anxiety. Standard measure of height and weight, temperature, blood pressure, and oxygen saturation and respiratory rate should be acquired prior to each anesthetic. Auscultation is performed of the heart with particular attention for any murmur, and the lungs for any wheeze or other abnormal respiratory sounds. Airway exam should include assessment of Mallempati score, thyromental distance, mandibular protrusion, mouth opening, neck thickness, and facial dysmorphisms.

Lab Testing

Routine laboratory testing is not necessary for most ambulatory pediatric patients. Hemoglobin measurement is necessary only in specific circumstances: an anticipation of significant blood loss, patients with hemoglobinopathy or sickle cell disease, former premature infants, infants under 6 month age, or children with the potential for significant anemia (HgB < 9.0 g/L).¹

Blood chemistry testing and urinalysis should also only be performed with specific indications, and is usually unnecessary in ambulatory children.² No single element of coagulation testing accurately predicts bleeding status, however it may be a useful adjuvant to thorough bleeding/bruising history, in some clinical scenarios including children presenting for tonsillectomy and adenoidectomy.³ The overall cost, difficulty, and unpredictability of detecting bleeding diathesis does not warrant routine testing. New evidence suggests routine laboratory testing my not impact decision making in pediatric cardiothoracic surgery.⁴ While a small percentage of adolescent females may present for surgery with an unknown pregnancy, routine testing can result in unnecessary predicaments of cultural sensitivity, and confidentiality. It is prudent to develop a clear policy which requires pregnancy testing, or alternatively allows parents to sign a waiver to decline. Additional testing such as Chest Radiography, ECG, Echocardiogram should be done when the situation warrants, either for patient or procedural indications.
**Preoperative Clinic Visit**

While the perioperative surgical home model has evolved the anesthesiologists role in adult pre-operative care, pediatric preoperative clinic visits are still largely driven by surgeon referral, as opposed to being protocol directed. This may be a result of common policies which require all children to have a clearance from their pediatrician within 30 days of surgery. The evolution of electronic screening modalities provides an opportunity to expand the anesthesiologists role in directing evaluation prior to the day of surgery.

Early intervention can lead to significant optimization in pulmonary status, allow for arrangement of pre-admission if pre-hydration is necessary, significantly decrease parent and child anxieties by allowing discussions of risks and benefits of anesthetic techniques without the urgency of moving to the operating suite.

**Ambulatory Surgery Center Criteria**

Ambulatory surgery centers have an increasing role in the contemporary care of the pediatric surgical patient, as the majority of pediatric surgery is now done on an outpatient basis. An ambulatory surgery center caring for infants and children must be integrated with a Level I, II, or III children’s surgical center.\(^5\) The safety of performing outpatient pediatric surgery is dependent of anesthetic and surgical technique, as well as appropriate patient selection. Specific areas of concern include children with URI, prior preterm infants at risk of postoperative apnea, significant cardiopulmonary disease, sickle cell disease, and children with bleeding diathesis. Many of these topics will be discussed later in the chapter, however it is important to align the age and severity of comorbidities with the expertise of the staff providing care.

Post-operative apnea risk in former pre-term infants has been well publicized since 1995\(^6\). Non-anemic infants born prior to 35 weeks’ gestational age, that are greater than 54 weeks post conceptual age, will have a 1% risk of postoperative apnea. It is reasonable to delay outpatient non-urgent surgery until preterm infants are at minimum 55-60 weeks’ post-conceptual age, otherwise providing at least 12-24 hours of post-operative apnea monitoring. Children with documented repair of basic cardiac lesions (ASD/VSD) may be appropriate for ambulatory
surgery, however patients with more complex cardiac conditions should undergo surgery at a center where appropriate expertise is available.

**Neurotoxicity and Timing of Surgery**

Beginning as early as 2003, studies began to show that early exposure to commonly used anesthetic agents lead to apoptotic mechanisms in the developing rat brain\(^7\), which was further confirmed in perinatal rhesus monkeys.\(^8,9\) Subsequent studies showed that repeated exposure to anesthesia and surgery before the age of two was associated with development of learning disabilities, and deficits in language and abstract reasoning.\(^10,11\) In 2014 the International Anesthesia Research Society and US Food and Drug Administration convened the SmartTots consortium to further evaluate the effects of anesthetics and surgery on the developing brain. The consensus view was that while early human studies seem to confirm some of the developmental deficits found in animal studies, a great deal of further research remains to be done, and it is unclear whether harmful effects were due to anesthetic medications, surgery, or the related illness. It is a reasonable goal to delay non elective surgery in children younger than 3 years of age.\(^12\) When determining timing of surgery, health care professionals and parents must weigh the risks of neurotoxicity against the developmental and other potential harms of delaying the procedure.

**Informed Consent**

Patients cannot provide legal informed consent until the age of 18 years, with exceptions of emancipated minors who may be married, have children themselves, or are economically independent. In most situations, consent for surgical procedures and anesthetics will be obtained from a parent or legal guardian. Studies show that parents have varying expectations in regards to how perioperative risks are discussed, but the majority prefer to be informed of all possible risks, including the risk of death.

The American Academy of Pediatrics holds that parents should provide informed permission for medical care, with the child providing developmentally appropriate assent. At the age of 7 children enter the concrete operations stage of development, and can begin to make
limited reasoned decisions. Assuredly as these children grown to adolescents and teenagers, they will have an increasing understanding of the risks and benefits of medical procedures, and be able to make more informed decisions. The AAP also notes that practitioners should not solicit a child’s assent if the anesthetic and procedure has already been deemed necessary, but the child should be told that fact and not be deceived. Attempting to obtain such “pro forma” consent, can in fact be damaging to the therapeutic relationship.13

NPO Guidelines

Standard NPO guidelines are as follows:

<table>
<thead>
<tr>
<th>NPO Guideline</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear Liquids</td>
<td>2 Hours</td>
</tr>
<tr>
<td>Breast Milk</td>
<td>4 Hours</td>
</tr>
<tr>
<td>Infant Formula</td>
<td>6 Hours</td>
</tr>
<tr>
<td>Solid Meal</td>
<td>8 Hours</td>
</tr>
</tbody>
</table>

These guidelines have been developed via an understanding of gastric emptying time, for prevention of pulmonary aspiration of gastric contents. Children who are unable to tolerate such NPO times, either due to intolerance of dehydration (sickle cell disease, selected cardiac lesions), or inability to maintain glucose homeostasis (selected liver and metabolic diseases) may need to be admitted for intravenous supplementation pre-operatively.

Managing Anxiety in The Pediatric Population

Undergoing general anesthesia for surgery, minor procedures, or diagnostic tests provokes anxiety in almost every patient. This problem is compounded significantly when considering pediatric patients, who for the most part lack mature and effective coping mechanisms for managing anxiety. A child’s ability to cope with stressful situations is shaped by a wide range of factors to include age, level of socialization, socioeconomic factors, and underlying personality traits and pathology. Anesthesia providers should have some insight into the developmental challenges facing the patient and a plan to work through some of the behavioral and cognitive features that may hinder a safe and hopefully uneventful anesthetic.
Jean Piaget (1896-1980) described a conceptual framework to describe the evolution of cognitive abilities from infancy to adulthood. Very briefly, he postulates that every infant is born with a rudimentary mental construct of the physical world called a schema. At the earliest stage of cognitive development this scheme is mostly reflexive and allows further assimilation of information about his physical environment. Schemata are mutable based on information gained through reflexive, and later deliberately physical and social interaction in a process called accommodation. Over the course of expanded cognitive development, information obtained constantly throws existing schemata into disequilibrium and creates progressively more sophisticated schemata. This internal dialectic carries the child into more advanced cognitive facility which Piaget describes in four distinct phases.

The sensorimotor phase encompasses cognitive development from birth to roughly the acquisition of language abilities. Information gained from purely physical interaction allows a limited and concrete understanding of the physical world. This phase of development includes the appearance of object permanence; the acknowledgment that physical objects exist independently of observation in a visual or auditory context. A child in this phase of development exhibits rapidly advancing fine and gross motor development as well as improved vocalization, which will eventually lead to capacity for more symbolic cognitive development.

The pre-operational stage signals a transition into more symbolic and intuitive cognition. This stage roughly coincides with fluid verbal ability through early schooling (ages 2-7). This stage is characterized by highly egocentric interpretation of the environment, but more sophisticated ability to represent this environment by use of symbology. Often this is manifest in play. For example, a four-year old child may pretend the coins in her mother’s purse are cookies and may play at eating them. Children at this age are less capable of forming logical conclusions about their environment and manage explication of natural phenomena often through magical or animistic thinking. For example, a child might think the sun on a clear day is happy, or that there is a monster under the bed. Childhood myths such as Santa Claus or the Tooth Fairy are commonly integrated into the schemata of a young child’s cognition because no logical counterpoint can be constructed.
The **concrete operational stage** is the developmental stage encompassing progression to logical thought and the erosion of purely egotistical perspective on the child’s environment and coincides with early school age to early adolescence. A child in this developmental stage will be able to employ inductive reasoning about her environment by repeated, direct observation. For example, a child may avoid a neighbor’s dog since she has seen three other children bitten when they attempted to pet it. A child will be able to engage her environment through a perspective other than her own. This ability shifts her cognition from a purely subjective quality to one that is more objective and expansive. It also allows for more enhanced moral development. It should come as no surprise that children in this age group become more involved in group activities such as organized athletics, scouting, and church youth groups.

The **formal operational** stage is the culmination of adult cognition starting in early adolescence and leading into adulthood. This stage delineates the ability to think in purely abstract terms separate from physical reality and is characterized by the ability to problem solve using both inductive and deductive rationale. Hypothetical thinking is well developed at this stage. Metacognition, or the ability to identify and modulate modes of thought, is an important feature of the formal operational stage. Formal Operational cognition allows independent living and encompasses everything from running a household budget to performance of high order mathematics, engineering, or philosophy. There is some contention over whether many, or even most adults reach this level of cognition development.\textsuperscript{14}

A thorough grounding in cognitive progression by itself does not allow a holistic approach to engaging pediatric surgical patients. Social development of the child is also an important aspect to consider when engaging a child into a therapeutic relationship. Sigmund Freud’s theory of psychosexual development is the first modern interpretation of the development of personality; each concrete stage of personality development is driven by expression of libido through specific, anatomic sensory exploration to include oral, anal, phallic, and culminating in latent sexual expression and genital maturity. Freud’s theory is conceptually still highly influential and represents at least foundational insight into personality development, but has largely been abandoned for more comprehensive rationale into the personal and social development of children. In the 1930s Erik and Joan Erikson posited a theory of psychosocial
development that is heavily influenced by Freud and is rooted in both sensory and social input, but sets aside sexual fixation as a prime impetus toward development of the personality. Healthy emotional development is essential for healthy cognitive development and vice versa. The Erikson theory identifies eight developmental stages in which a specific existential crisis must be resolved or reconciled to develop a corresponding virtue. We will consider only the developmental stages associated with development to adolescence for brevity.

The accumulation of virtues through all stages results in the complete, mature personality. Whereas Piaget’s theory of development of cognition almost describes an inevitable progression through each stage, Erikson formulates a binary, “make or break” quality to each stage of development. These should not be used as competing, stand-alone models to understand the development of the mind of a child, but rather it is useful to appreciate how cognition and emotion develop in parallel, interacting and enhancing each other to form the whole personality.

Trust vs Mistrust: For the first year of a child’s life she is completely dependent on parents and caregivers to provide love, food, warmth, and encourage stimulus. This develops a sense of safety, security, and trust. In contrast, inconsistent or unreliable caregiving produces the opposite effect, leading to a tendency for an infant to be wary, suspicious, and anxious. A more balanced parental interaction will foster a sense of security but will preserve a sense of wariness to produce a child who allows more novel experiences, but can identify when new experiences become dangerous, a concept Erikson describes as hope.

Autonomy vs Doubt: As the child grow older and more engaging of the world, a need to assert personal control develops. Often at this stage parents will allow a certain degree of autonomy for the child to make personal decisions, such as picking out clothes for the day or choosing lunch from a menu. The child becomes amenable to starting basic skills such as brushing teeth, washing hands, and completing toilet training. A parental style that encourages acceptance of responsibilities and delegates some decisions to the child enhances confidence and minimizes insecurity. Erikson calls the optimal balance between confidence and insecurity will, initiative with reasonable limits. As an example, a toddler learning to jump off a diving board will have the confidence to start at the three-foot board, but will demur at the ten-foot level.
Initiative vs Guilt: As the child enters preschool age, he has developed a sense of personal autonomy and will begin to develop an impetus to control his environment. This can be manifested in leading organized play among classmates, for example. An inability to assert increasing control over his surroundings may develop insecurity. The optimal balance instills purpose, initiative that is tempered by cooperation.

Industry vs Inferiority: This stage becomes important as the child enters elementary school and increases social interactions among peers. He will become more aware of his own abilities and accomplishments, and the praise and encouragement that come with them, as well as comparing his own abilities with those of his classmates. Children who receive a healthy amount of praise develop a belief in their own abilities, and predictably those who do not are less confident. A proper balance enhances competence without giving the child unrealistic expectations of his abilities.

Identity vs Confusion: Most evident in adolescence as the child develops an increasingly sophisticated understanding of his intimate social surroundings and those of the larger world. He will be increasingly aware of his developing sense of values and beliefs and how they are congruent with those of his peers. These values can be shaped by proper encouragement to produce a child who has a well-developed credo, and if tempered by some degree of insecurity, will lead to fidelity, an ability to live within the social norms and mores of the world at large with a personal sense of integrity while still maintaining tolerance for those of different values.15

Both Piaget and Erikson describe their respective theories of development as conspicuous and definitive steps, often correlated to chronological age. Development of the personality is not a graduated progression through well demarcated steps but a rather subtle, continuous process visited upon patients as individuals. Each patient develops his personality in entirely unique ways within the context of ethnic, religious, racial, and economic factors. As a snapshot into the generalized idea of cognitive or social development they are helpful, but it is important to understand the drawbacks of regarding their theories as a quantum progression. A basic familiarity with how personality develops is merely the start of beginning the doctor-patient relationship. The art of fostering this relationship ultimately lies with the attending physician’s
ability to communicate clearly with the patient and family in a manner that evokes trust, empathy, and safety.

**Strategies to Mitigate Behavioral Changes**

Almost all children experience some extent of preoperative anxiety. It is manifest for the anesthesia provider to mitigate any apprehension on the part of the pediatric patient for several reasons. Well managed anxiety reduces post-operative pain, minimizes anesthetic requirements, and decreases risk of post-operative delirium and longer term maladaptive behaviors such as nightmares, sleep disorders, aggression, or regressive development.\(^1\) In addition, patient and parental satisfaction are enhanced by a well-executed induction that carefully considers anxiety management.

Most practitioners of anesthesia have some facility with a qualitative appraisal of a child’s anxiety regardless of any formal training or routine interaction with children. Several quantitative methods are available to use in gaining a more useful appreciation of baseline preoperative anxiety that will guide the provider towards a more propitious outcome. The EASI temperament inventory (1975, Buss and Plomin) was developed to determine whether temperament is a heritable characteristic in children. Four factors of personality (*emotionality, activity, sociability, impulsivity*) have been validated as predictive of temperament, and thus a child’s propensity for anxiety. EASI has been modified in several iterations of personality and temperament analysis for use in larger clinical research projects since initial publication, although the inventory itself requires extensive parental survey and direct observation by well-trained clinicians and is unwieldy for use at the bedside.\(^1\) The Yale Preoperative Anxiety Scale (YPAS) was developed in the 1980s to provide clinicians with a well validated inventory of behaviors that can provide valuable information to identify a child’s emotional state before surgery.\(^1\) A major modification in the 1990s streamlined the approach and made observation less onerous on the clinician. The current Modified Yale Preoperative Anxiety Scale (mYPAS) scores 22 concrete behaviors under 5 major domains and scored at specific times during the preoperative period. Although this represents a refined inventory of behavior, it is still impractical for many providers at bedside due to limitations of operating theater production pressure, anesthesia and nursing
staff, and often the physical space of many preoperative holding areas. A short form mYPAS (mYPAS-SF) has been proposed which categorizes 21 behaviors under 4 distinct domains. These domains with scoring criteria are summarized as follows:

**Activity:** (1) The patient receives this score when she exhibits curiosity, looking around, playing with toys, engaging in age appropriate behavior, or generalized complacency. (2) The patient receives this score when she exhibits lack of play or exploration, poor eye contact, fidgeting with hands, anxious or clingy attitude with parents or caregivers, or play that has a manic or hyperactive quality. (3) The patient receives this score when she exhibits frenzied play, excessive squirming, or unfocused attention to toys or parents. (4) A patient scores highest when she actively attempts to get away, pushing with feet or entire body to avoid contact, inability to separate from care-giver, and desperate clinginess.

**Vocalization:** (1) Patients scoring one point are actively reading, asking and answering questions, making comments, laughing, babbling, or perhaps too engrossed in other activities to reply. (2) A child will score two points if she responds to adults, but is generally quiet, whispers answers, or nods and shakes her head in affirmative or negative reply. (3) A child scores three points with quiet and unwillingness to respond to adults. (4) A child who is silently crying, whimpering, or moaning will be assigned a score of four. (5) An intransigent and crying child is assigned a score of five points. (6) A loudly crying child with sustained screaming through a face mask earns a score of six points.

**Emotional expressivity:** (1) A score of one is assigned to the child who is happy, smiling, of fully engaged in play. (2) A score of two is assigned to a child with neutral expression. (3) Sad, tearful, frightened children score three points. (4) Crying and extremely upset children are assigned a score of four points.

**Arousal:** (1) A child who is alert and watchful is scored one point. (2) A withdrawn, still, and quiet child is assigned a score of two points. (3) Vigilant, tense, and easily startled children are assigned a score of three points. (4) Panicked, whimpering, and aggressive children are assigned a score of four points.

The mYPAS-SF compiles scores at two points prior to surgery; the preoperative assessment and pre-induction. Each score is calculated by dividing each domain rating by highest possible rating,
adding all produced values, dividing by 4, and then multiplying by 100. Values range from 22.9 to 100, and one validation study ascertained a score of greater than 30 indicates a child may require other adjuncts to help manage preoperative anxiety. The mYPAS-SF is straightforward and easy to calculate. Assessing anxiety in the pre-induction period may, however, limit the anesthetist’s options in ameliorating anxiety or maladaptive behavior in the patient since there can be drastic alterations in the patient’s mood from initial preoperative state to the induction.¹⁹

Qualifying patients’ temperament and anxiety becomes increasingly challenging when they are developmentally delayed or differently abled. Because many of these children do not fit into a normal progression of cognitive or social development, it is imperative to emphasize the relationship with parents or guardians to manage expectations for the conduct of the anesthetic. Depending on the severity of disability, the anesthetist may require more ready use of medications to transition these patients into pre-induction. Occasionally some parents are resistant to the use of preoperative medications. When faced with prioritizing a fast and safe induction with use of medications against parental expectations, a provider should always insist on safety even if the cosmetics of the induction do not entirely meet with parental satisfaction.

**Adjunctive Management of Anxiety**

Venues for pediatric surgery and procedures vary greatly. Adjuncts available to assist the provider in managing patient anxiety likewise vary between the outpatient surgical center, community hospital, major medical center, and the purpose-built pediatric hospital. Many of these adjunctive services are resource intensive and not always available, but some familiarity with these techniques can improve an anesthesiologist’s outlook on how to manage a child’s preoperative anxiety.

*Parental Presence:* Having a parent present for induction is as widespread as it is controversial. The single most desirable aspect of this technique is that it is available everywhere. Many surgeons, anesthetists, and OR personnel are concerned that the technique interrupts the flow of the operating theater or otherwise distracts from the normal OR preparation. These complaints are often borne through institutional preference or policy. This controversy has been widely studied, and the most optimistic general assessment is that parental presence is not inferior to premedication in reducing anxiety. A well-designed and prudently used policy for
parental assistance can be helpful for transition to induction and need not add to production pressure in the operating room.²⁰,²¹

When using parental assistance to manage induction, the anesthetist must be keenly aware of not only patient anxiety, but also parental anxiety. Many parents will propose their presence in the operating room before any discussion with the anesthesia provider begins. This signals an opportunity to discuss the particulars of anesthetic delivery, most importantly dispensing with the euphemism of “going to sleep,” which is an unhelpful and inaccurate description of general anesthesia. General anesthesia appears to look like sleep to the layperson, but there are distinct physiological differences between the two states. Sleep is a complex physiologic process which is driven through circadian and homeostatic mechanism in a self-limited and ultimately restorative process. General anesthesia is disruptive of this natural process, despite accentuating some physiological signs of normal sleep such as slow wave activity. Anesthesia is not restorative and is not induced in the same way normal sleep is induced. Neither does anesthetic induction look anything like induction of normal sleep, indeed it can often be distressing to the unknowing parent who is present during induction. Emergence from anesthesia is not simply “waking up” and carries its own opportunities to distress a parent who is not savvy to common post-operative problems.

Assessing parental anxiety is often easier than assessing patient anxiety, but it is no less important than when considering parental assistance during induction. When using parental presence as an adjunct, it is preferable to discuss how to manage anxiety well in advance of the day of surgery. At some facilities, mostly pediatric hospitals or major medical centers, there may be rehearsal programs sponsored by the hospital to perform a “walk-through” to help alleviate anxiety. These programs take parents and patient alike through the administrative process, often all the way through a mock induction using a surgical mask along with an opportunity for the child to inspect an anesthesia machine. Results of these tours can be mixed.²² The same temperamental challenges a provider faces on the day of surgery can manifest on the tour day and increase anxiety, although these visits can at least improve parental satisfaction. Most providers are meeting patients and parents for the first time on the day of surgery. There can be subtle interactions between patients and parents which modulate anxiety in each, and often
parental anxiety is so evident that it arouses greater anxiety in the child. A frank discussion with parents should elicit whether their presence will alleviate their child’s anxiety. A parent who insists on parental presence to manage his own anxiety is very often sorry for his insistence unless he is properly prepared for the spectacle. In making these decisions, an anesthesiologist has a great deal of latitude and flexibility on whether to permit parental assistance. It is important to note that parental presence has not been shown definitively to reduce or eliminate postoperative maladaptive behavior in general.\textsuperscript{23,24,25} There is no question that often it is allowed by the convenience of the providers or parents, but should never interfere with safe induction. Parental presence can often reduce or eliminate pre-induction anxiety in children and can improve patient satisfaction when coordinated through a trained and experienced staff anesthesia provider.\textsuperscript{26}

Parental presence as a major feature of managing anxiety has been embraced by some large hospitals with the use of specially designed induction rooms. These rooms are designed to allow family members to be with the patient as he is induced into a state of anesthesia. Typically, these are smaller rooms with standard monitors (pulse oximetry, End Tidal CO\textsubscript{2}, EKG, and noninvasive blood pressure), gas-scavenging, and drug and airway carts, albeit in a non-sterile room inappropriate for surgical procedures. Ideally, induction rooms should allow more intimate space for the patient, anesthesia staff, and family members close to the preoperative area, but without some of the scarier accoutrements of surgery, the sight of which can be distressing to a child. They are arranged in a place that is convenient for quick and safe transport to the operating theater. The obvious limitation is cost of building and maintaining these highly specialized spaces which reserves their use almost exclusively in the hospitals that can most afford them. Despite drawbacks, induction rooms can be helpful to patients or families who require more engagement up to point of induction and probably improve patient and family satisfaction.\textsuperscript{27} They do not negate the need for an anesthesiologist to make careful appraisal on whether to allow family presence.

Technology: There has been a rapid and dramatic evolution of consumer electronics over the past two decades that has added to the resources available to the anesthesiologist for managing anxiety. Smart phones, laptops, tablets, MP3 players, and even virtual reality have become ubiquitous among disparate socioeconomic strata. The hyper-consumption of electronic
information excites a great deal of controversy surrounding “screen time” in the pediatric population which can spill over into preoperative planning. Without wading too deeply into the social ramifications of the online culture, the authors are open to the age appropriate use of electronic devices in the preoperative phase of surgery. One of the challenges of transitioning from the pre-operative phase to pre-induction phase is the propensity of a child to decompensate as the physical surrounding of the relatively calm preoperative holding area becomes the often cold, clinical, and sometimes chaotic space of the operating room during pre-induction. Electronic devices can enable older children to immerse into cognitive distraction through video games, music, or videos during the anxiety provoking induction. Use of devices coupled with parental presence can lead to a remarkably calm and uneventful induction. Electronic devices are highly portable, offer a wide variety of applications from which the child may choose, and are relatively inexpensive. Age appropriate use with parental consent is an important modality in adjunctive perioperative anxiety management.

Child Life Services: Many large hospitals or pediatric hospitals have established specialized clinical services designed to attend to the unique requirements of hospitalized children. Child life specialists are highly trained clinicians who help oversee development and well-being of children during hospitalization. These departments are typically limited to facilities with high volume, high complexity pediatric populations with relatively long hospitalizations. Fundamentally these clinicians seek to promote normal development in the “abnormal” milieu of hospitalization while educating patients and families about health conditions, teaching and rehearsing age-appropriate coping strategies for the stresses of the hospital, assisting the patient in working through feelings or misgivings about past or future experiences, and investing the patient, siblings, and parents into an effective therapeutic relationship. Post-operatively CLS specialists can assist the anesthesiologist by practicing and coaching nonpharmacological coping strategies for use in treating pain. CLS specialists can be mobilized to perform tasks for patients in the perioperative period and are an invaluable tool for improving preoperative anxiety, patient/family satisfaction, and most importantly for grounding the care given solely on the patient.
One of the most useful ways CLS can assist the anesthesiologist is through use of play therapy. As anyone who has ever visited a playground can attest, children use play as a dress rehearsal or laboratory for solving real-time problems or working through personal anxiety. CLS specialists are trained to shape and focus play in a way that will help expiate anxiety during hospitalization. Physical signs of stress such as tachycardia, hypertension, sweating, and nervous movement have all been reduced by focused playtime. Play therapy must be executed in an age appropriate context: an infant or toddler may require more sensorimotor stimulation. School-aged children may enjoy arts and crafts activities or fantasy play, older children may respond better to games that reinforce mastery or control such as video games. Inclusion of parents in play therapy can help reveal latent anxiety from the child while also engaging the parents in helping to reduce the anxiety. CLS specialists are not in every hospital, but an anesthesiologist need not have special training to make good use of their techniques. Play enables cognitive distraction that is inwardly focused. Simple engagement and observation while the child is playing in the preoperative environment can help the anesthesiologist identify and attend to the most anxiety provoking aspects of his care and adjust his approach to anxiety accordingly.

Pharmacologic Management of Anxiety

Premedication in the adult population is a simple affair. Most adults will have some measure of anxiety regarding a surgical procedure but are emotionally well compensated to carry on through relatively simple procedures such as an IV placement, after which medications can be given quickly that are effective in anxiolysis and anterograde amnesia. For most routine pediatric practice, IV access is attempted after a mask induction when the patient is under a general anesthetic. Emotional compensation is limited by social and cognitive development in an age-related fashion which makes anxiety much more difficult to manage. Anesthesiologists and Nurse Anesthetists are sometimes at a loss to develop a therapeutic relationship with their pediatric patients despite their best efforts. In these common instances it is prudent to consider preoperative sedation. Premedication is helpful to put a nervous or obstreperous child who is unwilling or unable to participate in a therapeutic relationship into a more compliant and relaxed state. Overall, use
of premedication reduces stress in the patient, the parents or guardians, and improves patient and parental satisfaction. Depending on the drugs used, a provider can expect anxiolysis, amnesia, and analgesia. The effectiveness of common medications is dependent on the time administered and should be planned to be coincident with induction of anesthesia. Surprisingly, the use of preoperative medications in the pediatric population is likely underutilized. Improper or inexperienced appraisal of preoperative anxiety may lead a provider to conclude their patient does not require sedation. Some providers fear use of preoperative sedation may prolong anesthesia, recovery, or that the patient may develop a paradoxical reaction to the medication. Production pressure and short room turnover may minimize time available to administer preoperative medication. Preoperative sedation is extremely valuable in transitioning a nervous patient safely into anesthesia. It is incumbent on the anesthesiologist to sort through the logistic requirements and formulate sound judgment on the use of medications in the preoperative period.

The anesthesiologist must be formulating a premedication plan in parallel with his initial interaction with his patient and family. The experienced eye will discern immediately some of the personality limitations, if they are evident, that will require medication. There is a native personality substrate that will require use of medications in some patients. In others, circumstances can influence medications. Some factors that weigh heavily are developmentally delayed or special needs children, children exposed to major surgeries or multiple surgeries, and children with a history of delirium or post-operative maladaptive behavior. In other cases, it may prove wiser not to pre-medicate regardless of personality traits. Some relative contraindications may include obstructive or central sleep apnea, difficult airway, aspiration risk, altered mental status, metabolic impairment (renal or hepatic), and allergies to pertinent medications.

Part of sound judgment in administering preoperative medication requires ensuring a safe place is available to give these drugs. The preoperative holding area should be well staffed by qualified nurses who are capable of quickly communicating to attending physicians if there is an untoward reaction in a pre-medicated patient. There must be continuous monitors used after medication to include, at least, pulse oximetry, EKG, and noninvasive blood pressure along with a means to deliver supplemental oxygen. There must be fast and unobstructed access to
emergency airway equipment with a means to provide positive pressure ventilation. Some of the logistical details should either be a matter of policy, or else coordinated by the anesthesiologist. All patients who are to receive preoperative medication should be confirmed to meet Nil Per Os requirements and definite clearance for surgery. That is, they should be absolutely confirmed by anesthesia, surgery, and circulating nurses that there is no last-minute change in status that would cancel surgery (e.g. NPO, change in health status, change in availability of equipment). There should be clear communication between the preoperative holding nurses and the anesthesiologist about who will administer the drug and what time. A well-timed administration of a medication like midazolam will justify its use with a smooth induction, but if given too early or too late will defeat the purpose of giving it at all. Supervision does not stop at administration. Medicated children are fall risks and should be either in parents’ laps, or else in bed on monitors and closely supervised by nurses or resident physicians until they are brought back to the operating theater for induction. Formal leadership of the preoperative holding area varies by institution. Anesthesiologists should always be available and engaged with nursing and surgical colleagues to assure safest practices in the perioperative sphere.32

Our purposes require a review of commonly used medications given in the preoperative holding area to facilitate a child’s smooth transition into surgery whenever there are proper indications. Several medications exist for this purpose, but for brevity’s sake we will address the mainstay medications. As an aside, the preoperative holding area is an ideal place to conduct a medication review which may inform the decision to give premedication, especially if the patient is on inpatient status.

**Benzodiazepines:** This class of medications acts on the specific GABAergic ligand gated chloride channels (GABA_A) in the central nervous system to enhance selective chloride transmission. The overall effect is inhibition of neuroexcitation. As such, benzodiazepines exhibit sedative, hypnotic, anxiolytic, relaxant, and perhaps most importantly, amnestic effects through various activity in discrete neural circuits.

Midazolam is the most commonly used benzodiazepine in pediatric anesthesia and easily administered through oral, intranasal, buccal, and intramuscular means. Overall, midazolam has a reliable onset, especially when used PO (0.5 mg/kg) with peak effect somewhere 20-30 minutes
after administration. Although the mechanism of action overall favors anxiolysis, sedation, and hypnosis, on occasion this medication can cause some disinhibition and a paradoxical response in pediatric patients, increasing anxiety and maladaptive behavior. There are oral formulations which are pleasant tasting and well tolerated when the full dose can be administered. Sometimes it is necessary to use intranasal dosing, which due to the formulation is irritating to the nares, not as well tolerated, and with less reliable delivery compared to PO administration. Intranasal and intramuscular administration are far more invasive than PO dosing, and it may be counterproductive to use these modalities simply for anxiolysis. Benzodiazepines act in a dose dependent manner to suppress respiration: this underscores the importance of monitoring pulse oximetry after dosing as well as providing qualified nursing care prior to transfer to the operating room.

**NMDA Receptor Antagonists:** This class of medications constitute a much wider variation of chemical composition and structure than benzodiazepines. The most common medication for use in anesthesia is ketamine, which acts on excitatory neural pathways through allosteric antagonism of the actions of the neurotransmitters glycine and glutamate.

Ketamine has many attractive benefits when used as preoperative sedation. It provides potent analgesia in any standard route of administration and is ideal for the rapid sedation of combative or truculent patients who pose physical risk to themselves, parents, or providers. The typical mode of securing such patients relies on intramuscular dosing of between 2-4 mg/kg, a technique known colloquially as “the dart”. This technique induces a state of catalepsy and disassociation within a few minutes that essentially acts as chemical restraint. Oral administration of 4-6 mg/kg produces similar effects with a longer onset of around 25 minutes, but with less anxiety on administration. The use of the ketamine dart is typically driven by the inability to negotiate a calm separation from parents for whatever reason, and unfortunately can require more forceful administration on the part of the anesthesiologist, or the use of subterfuge. As always, keep parents or guardians apprised of the need for this technique and the immediate pharmacologic effects to preserve some degree of parental satisfaction, and be as quick as possible!
Because ketamine also has sympathomimetic, hallucinogenic, and sialorrheic effects, it may be necessary to include medications that can counteract or mitigate untoward consequences. For example, concurrent administration of IM midazolam may limit unpleasant hallucinations by its amnestic effects; as with the administration of IM atropine or glycopyrrolate to limit secretions and the administration of clonidine or dexmedetomidine to treat sympathetic changes in hemodynamics. Ketamine in any route of administration has the important advantage of not typically depressing respiratory drive, is not especially provocative of laryngospasm on the way to the operating theater, and acts as excellent adjunctive analgesia throughout the administration of general anesthesia.

**Alpha 2 Adrenergic Receptor Agonists:** Compared to NMDA antagonists and GABA\textsubscript{A} agonists, pharmacologic activation of alpha 2 receptors is relatively novel and provides an important tool in the conduct of anesthesia, not least as a premedication. By its most important action in activating the negative feedback mechanism of presynaptic sympathetic ganglia in the spinal cord and supraspinal regions of the central nervous system, alpha 2 agonists cause attenuation of sympathetic response by inhibiting transmission of norepinephrine to post-synaptic sympathetic ganglia with resulting bradycardia and hypotension; decreased transmission of nociception, and sedation. Clonidine was the first practical medication of this class and is still used primarily as an antihypertensive, but the more recent development of dexmedetomidine has garnered far more attention and excitement for its perioperative advantages.

Dexmedetomidine has the distinct advantage of providing excellent sedation and anxiolysis without significantly affecting respiratory drive. It is markedly easy to administer through transmucosal, intravenous, and intramuscular routes, as well as providing a degree of analgesia that can simplify induction of general anesthesia. Administration of 1-2 mcg/kg over 10 minutes IV gives reliable sedation and excellent separation conditions within a few minutes, but ideally should be performed under close monitoring in the preoperative hold by qualified medical personnel due to the sometimes dramatic sympatholysis that occur, especially with fast administration. Intranasal or intramuscular administration is an effective alternative when an IV is not available (2-3 mcg/kg). As with any injection, IM administration can potentially exacerbate preoperative anxiety, but onset is very predictable (15-20 min) and hemodynamic changes are
minimized by a depot effect. Intranasal administration is common, but can be less reliable secondary to typical problems of drug uptake in the pediatric population. Some practitioners use dexmedetomidine infusions in the operating room as part of a balanced anesthetic: the advantages of using this medication as preoperative sedation obviates the need for a loading dose in the OR. Any use of dexmedetomidine in the perioperative period can reduce or mitigate postoperative complications such as emergence agitation, post-traumatic stress episodes, or severe post-operative nausea.33

Emergence and Recovery

The transition of patients from the intraoperative state, whether that implies sedation or general anesthesia, requires the utmost vigilance on the part of the anesthesiologist: emergence is an extremely perilous time as the patient transitions physiologically back to a baseline state. Despite the wishful thinking or preference of surgeons, emergence has no binary quality and never progresses in an “on/off” manner. Emergence carries all of the risks of sedation such as respiratory depression, hemodynamic instability, and perhaps lack of definitive airway control with none of the benefits of quickly reversing risks. Providers must take adequate time to ensure safe transition to the post-operative recovery.

In the pediatric community, patients will recover either in the PACU (Post Anesthesia Care Unit), or else in a Pediatric/Neonatal Intensive Care Unit, depending on the overall health of the patient and the complexity of the surgery. Usually, this implies that emergence and recovery are managed by critical care nursing staff that are capable and comfortable in the care of children. Not all hospitals are created equally, and some PACUs require closer supervision and engagement by qualified anesthesia providers who can step in to fill the breech should patients encounter any untoward physiologic derangement. Ultimately, PACU nursing, anesthesia, and surgeons should work together to minimize or eliminate short and long term surgical outcomes in a spirit of harmony and cooperation: PACU nurses are the front-line sentinels to ensure this happens.

A properly equipped PACU is a purpose-built space that provides continuous physiologic monitoring, convenient and rapid access to supplemental oxygen, routine and emergency medications, ability to provide suction and positive pressure ventilation, and qualified help
immediately available. Anesthesiologists should be intimately familiar with the PACU space in order to effectively manage emergencies that arise from time to time. Proper communication is paramount to transitioning a patient to post-operative care. Effective hand-off to nursing staff requires confirmation of patient identification, a brief review of any pertinent medical conditions, description of the surgery, a clear and succinct description of the anesthetic used with pertinent medications given, confirmation of post-operative orders and guidance for management of potential problems should they arise, and perhaps most importantly, allow some time for the accepting nurse or resident to confirm facts of the case and ask any other questions about management and discharge criteria.

The *raison d’etre* of the PACU is to minimize post-operative surgical complications in all patients, a task it accomplishes by strict and vigilant observation, usually on a one-to-one nurse/patient ratio. Discharge criteria from post-anesthesia care varies widely by both practice and policy among institutions. PACUs should always consider important guidelines in assessing whether discharge is appropriate for patients, and of course be flexible enough to modify policy based on complexity of the case, overall patient health, and even social considerations.

In general, post-operative recovery requires strict observation of physiological function with special emphasis on pulmonary, cardiovascular, and neuromuscular function. These criteria are the most important initial assessments the PACU nurse attends to because they are easily observed by use of standard ASA monitors despite the possibility that the patient may not be fully awake. The use of continuous pulse oximetry and end tidal CO2 provides fast and accurate information about pulmonary status to include airway patency, ventilation, and as a sentinel for early hypoxemia. Cardiovascular status is easily monitored by EKG and periodic blood pressure. Standard monitors should always be used routinely in the PACU, but there are situations where one or more monitors may be deferred or omitted altogether provided physicians and nurses agree it is reasonable to do so. Ideally, patients should be near or at a state of euthermia and euvolemia by the time they are admitted to PACU, or else there should be mechanisms available to immediately rectify any temperature or volume derangements. Historically there has been a common preference for delaying PACU discharge until the patient tolerates clear oral intake and meets bladder voiding criteria. Periodic monitoring of oral intake and urinary output probably
reduces risk of untoward post-operative outcomes but routine “due to void” or PO tolerance milestones can be omitted on a case by case basis. Assessment of wounds and drains is a vital component of PACU recovery and should be routinely undertaken to appraise the safety of discharge to either the floor or home and to avoid adverse events in the immediate post-operative period. PACU nursing should keep the anesthesiologist and especially the surgeon apprised of any unusual blood loss in the recovery period before discharging the patient.

**PACU Discharge**

Safely transitioning pediatric patients from the PACU to ward disposition or discharge home almost always requires further pharmacologic intervention, especially when managing post-operative pain or nausea. Failure to control either complications of anesthesia can prolong hospital stays and become detrimental to patient comfort and satisfaction. Ordinarily, a well-planned anesthetic with careful consideration of type of surgery, past medical and surgical outcomes, and prudent use of analgesics and anti-emetics contribute greatly to minimizing or eliminating such problems in the PACU. Despite a provider’s best efforts, some patients require further treatment in order to meet discharge criteria.34

Assessing pain in the pediatric patient can be challenging if he is incapable of verbalizing discomfort, a very common scenario particularly in very young patients. There are several validated methods to measure pain scores in this population when direct communication is impossible. The FLACC scale is a useful measure designed to assess pain in noncommunicative patients from the neonatal period to childhood. The simple 0-10 scoring system categorizes physical characteristics along five distinct criteria (Facial expression, Leg movement, Activity, Cry, Consolation). An objective FLACC score of 5 or greater may signal to the PACU nurse or provider that more definitive intervention is required before the child may be discharged. The Wong-Baker face scale is a pictographic continuum with assigned numbers 0-10 that allows children with limited communication to associate facial expression of six distinct faces with their own subjective pain. Wong-Baker scores roughly correlate with FLACC scores in the need for drug intervention. Both scales are easy to use and validated by age and throughout cultural differences. The adolescent patient is likely to be a more reliable historian of post-operative pain
and can usually describe subjective pain in an objective way to best assist the provider in making decisions about pain control. A common method whereby the provider or nurse asks a patient to rate their pain on a scale of 0-10 can be extremely frustrating for PACU staff and patients alike. Providers may find it more helpful to characterize pain in terms of functionality in order to standardize what level of pain correlates to what level on the scale. Rather than characterize a ‘10’ as ‘the worst pain imaginable’, it might be more helpful to tell the patient that a 10 signifies the worst pain felt on day of surgery. A provider might suggest that a pain score of ‘3’ or ‘4’ represents pain that is reasonably well-controlled and does not distract the patient from reading, watching television, carrying on a conversation, or resting. This method accomplishes a realistic assessment of pain by the provider and also helps manage patient expectations of post-operative pain control.

Treatment of surgical pain improves comfort, patient satisfaction, and surgical recovery. PACUs routinely use multiple classes of analgesics to reduce post-operative pain. Opioid-based narcotics are often first-line treatment for moderate to severe pain in the PACU and are extremely effective in quickly and reliably controlling pain. The analgesic effect is mediated through mu-opioid receptors in dorsal root of the spinal cord: binding of opioids to receptors are highly specific compared to natural ligand binding from native endorphins.

The mainstay of opioid therapy in the PACU for pediatric patients is fentanyl, a highly potent, insoluble, and rapidly acting synthetic opioid. Given intravenously, fentanyl has a peak effect within 10 minutes to ease subjective pain. Fentanyl requires careful dosing because of its rapid onset and potency. For moderate to severe pain, IV dosing from 0.1 mcg/kg – 0.5 mcg/kg should be carefully titrated between every 5-10 minutes. Total dosing of fentanyl depends heavily on type and length of anesthetic, surgery, and the patient’s subjective complaints. As with all opioids, some potentially difficult side effects such as sedation, respiratory depression, pruritus, and nausea may occur, so fentanyl use requires continuous monitoring. Because fentanyl is a synthetic mu agonist, the deleterious side effects of pruritus and nausea are less severe, and perhaps completely absent compared to the use of morphine or hydromorphone, both of which are derived and refined from natural extracts.
Morphine is a longer-acting natural opioid that, when given IV, provides excellent analgesia, but is more complicated to manage in the PACU due to differences in pharmacodynamics. Morphine is more soluble than fentanyl and is significantly transported in peripheral circulation by protein binding and transport. Subsequently, onset of effect is relatively delayed compared to fentanyl. Histamine release is a common, uncomfortable side effect which can cause sometimes severe cardiovascular instability, respiratory issues in children prone to bronchospasm, and of course itching. Morphine administered IV at a range of 0.02 mg/kg to 0.1 mg/kg, depending on type of surgery and subjective pain scores provides excellent, sustained pain relief in dealing with severe somatic pain. Sustained pain relief comes at a cost to sustained deleterious side effects. PACU providers should weigh the risks and benefits of using longer acting IV opioids like morphine and hydromorphone for patients discharging home, or else out of close medical supervision due to risk of sedation, apnea, and intractable nausea. Hydromorphone is an IV opioid agonist which nicely balances the rapid onset and potency of fentanyl with the sustained analgesia of morphine. As a semisynthetic, hydromorphone carries some of the typical side effects associated more commonly with morphine, but with some reports of attenuated symptoms. This medication is more potent than morphine and recommended doses for PACU use range from 3 mcg/kg to 10 mcg/kg titrated slowly and carefully for the treatment of severe post-operative pain.

The use of codeine, an oral opioid which is metabolized to morphine, as a post-anesthesia and post-discharge analgesic has rapidly fallen out of favor over the past decade due to concerns about genetic variability of its metabolism. The oxidation of the prodrug between individuals is simply not reliable enough to justify its routine use, providing either scant pain relief in some patients, or else causing potentially dangerous narcotization in susceptible patients. Codeine does not play an effective role in management of postoperative pain in children and its use should be avoided in favor of more effective therapy.

A host of effective nonopioid medications plays an important role in post-surgical recovery. Nonsteroidal anti-inflammatory agents (NSAIDs) such as ibuprofen and ketorolac help relieve surgical pain through modification of cyclooxygenase (COX) leading to inhibition of prostaglandin production. Non-selective COX inhibitors have the advantage of not affecting
respiratory drive, are not sedating, and provide sustained analgesia for mild or moderate pain. A major drawback of using COX inhibitors is a propensity to disrupt normal platelet function, an unloved feature for many surgeons. Ibuprofen is a popular analgesic for mild to moderate pain and is available in oral and IV formulations for dosing at 10 mg/kg every 6 hours. Ketorolac is a highly potent COX inhibitor usually provided as IV or IM and used widely in the post-operative environment. Its use in the pediatric population is effective, but certainly equivocal in children younger than 2 years old. Ketorolac is administered IV or IM at between 0.5 – 1 mg/kg as a one-time dose, not to exceed 30 mg total. Carefully calculated dosing of NSAIDs is mandatory in pediatric patients due to the risk of post-operative bleeding, acute renal toxicity, or gastrointestinal symptoms. Surgeons should be consulted about the longer-term use of these agents.

The perioperative use of acetaminophen in children has been common practice for decades, either given in the preoperative hold by mouth, or else given in the operating room after induction per rectum. Over the past decade an IV formulation has become available which allows a more reliable uptake of the drug compared with oral or rectal delivery. Intravenous administration has one distinct advantage over oral dosing in that liver toxicity is minimized by eliminating hepatic first-pass effects. IV Acetaminophen dosing for children in the perioperative period is 15 mg/kg in the healthy patient, and may be re-dosed every 6 hours. Acetaminophen is metabolized by the liver and produces highly toxic primary metabolites which can dangerously reduce the hepatic supply of glutathione, a vital anti-oxidant. If severe enough, this hepatic dysfunction can progress to life threatening fulminant hepatic failure. Acetaminophen is an adjunct or additive in many other pain medications commonly used both as an inpatient or by prescription as an outpatient, so a careful review of current medications as well as careful dosing of acetaminophen is likewise mandatory to ensure its safe use in the pediatric population.

Intractable post-operative nausea and vomiting (PONV) represent a significant risk for delayed discharge and increase risk of hospital admission. Subjectively, nausea can be more distressing to pediatric patients and their family members than surgical pain. Uncontrolled nausea and vomiting are uncomfortable in their own right, and can worsen surgical pain in some patients secondary to potentially violent heaving. There are many options to preclude and
mitigate post-operative nausea and vomiting in pediatric anesthesia by performing a studious identification of risk factors in the population. A simplified prediction of PONV in children posits increased baseline risk when surgical times are greater than 30 minutes, patient age is three years old or greater, there is a family history of PONV, and exposure to especially emetogenic surgery such as strabismus repair.

The best preventive for PONV is risk reduction. Providers reduce risk by ensuring adequate fluid resuscitation during and after surgery, avoiding or minimize opioid use when appropriate in the perioperative period, avoiding nitrous oxide, avoiding volatile agents, and preferential use of total IV anesthesia or neuraxial/regional techniques. The cholinergic effects of neuromuscular reversal agents such as neostigmine have been implicated in PONV, but with suitable concurrent use of antimuscarinic agents, the risk of PONV in neuromuscular blockade reversal is overstated. Risk reduction by necessity must occur in the intraoperative period, and at times proves inadequate to prevent the more entrenched nausea. The PACU should have available therapeutic agents to ensure a smooth and comfortable discharge free of post-operative nausea.

Serotonin Receptor Antagonists (Ondansetron, Granisetron, Dolasetron) primarily block serotonergic transmission of pro-emetic signals in GI mucosa to splanchnic nerve and sympathetic pathways, with perhaps some minor modulation of serotonergic pathways in the chemoreceptor trigger zone. These medications are potent, first line agents for the treatment of PONV and are non-sedating with lower risk side effects such as diarrhea and prolonged QT. Ondansetron dosing is 0.1 mg/kg up to 4 mg in children, and when combined with intraoperative dexamethasone provide synergistic effects in staving off PONV.

In cases where PONV is especially severe or refractory to first-line agents, it may be necessary to employ dopaminergic receptor antagonists. There are several classes of medications which modulate emesis through dopamine transmission in the chemoreceptor trigger zone, and despite having strong effect on treating nausea, also have significant side effects which limit their use in the pediatric patient. Phenothiazines (prochlorperazine, chlorpromazine), butyrophenones (haloperidol, droperidol), and benzamides (metoclopramide) are each extremely sedating and will potentially delay discharge or necessitate admission to the hospital.
Extrapyramidal symptoms and akathisia are higher risk with dopamine antagonism which can be distressing to patients and parents at bedside. Anesthesiologists should weigh risks of exposure to a constellation of side effects of antidopaminergic drugs versus benefits of ablating PONV in the post-operative period.

**Special PACU Considerations**

Children undergoing uneventful anesthetics experience challenges in the postoperative period despite the best efforts of the anesthesia providers. The physical and emotional environment surrounding the postoperative period is a stark contrast between the usually calm atmosphere of the operating room, where the anesthesiologist for the most part is actively engaged in the cognitive processes of managing a smooth anesthetic. The postoperative period requires a refocus on managing stressors of the patient, nursing staff, parents, and perhaps other physicians which are made more complicated by the physiological derangement caused by anesthesia. This period requires the fullest engagement of both cognitive and emotional faculties on the part of the anesthesia provider.

Emergence delirium is one of the most common pitfalls of general anesthesia in the pediatric population. Because of the distress it can cause the patient, parents, nursing staff, and other patients in the PACU it requires very close management by a qualified anesthesia provider. Assessing emergence agitation (EA) is a challenge unto itself, as many consequences of anesthesia mask or mimic EA such as inadequate analgesia or nausea, as well as baseline personality traits. When we consider the very common ‘cranky’ behavior of young children as they awaken from normal sleep, we should not be terribly surprised that an exaggerated delirious response occurs after the very alien pharmacological insult that general anesthesia visits upon the normal neurological function of children. These behavioral changes certainly extend far beyond mere crankiness. Moderate and severe cases are recognized easily without aid and should be managed quickly to prevent the patient harming himself or others at bedside. Due to the dramatic nature of emergence agitation, often PACU nurses and providers form a mostly qualitative impression of the event. Having some familiarity with the quantitative criteria of EA will be helpful to guide management. There are several validated clinical scoring systems available to assist PACU staff
in assessment of EA, all of them require some gradation of specific behaviors such as combativeness, eye contact, inconsolability, disorientation, and level of purposeful movement. As a differential diagnosis, emergence delirium exists closely with other obvious causes of disruptive behavior to include uncontrolled pain, nausea, and often hunger. Sorting through these causes is simple enough, and usually benefits from a stepwise plan. Perhaps offer the child a drink of water to rule out hunger, followed by a rapid assessment of pain, if possible. Control nausea, if it exists, and then take definitive steps to reverse or treat delirium.

The etiology of emergence delirium or agitation is not well understood and is observed as correlative phenomena with all types of anesthesia; some techniques more than others. There is some thought that the risks of EA increase with the use of low-solubility volatile agents such as sevoflurane and desflurane, and that fast inductions with relatively quick emergence exacerbate symptoms of delirium.37 Perhaps the simplest and most effective approach to managing EA is preventive. Some evidence suggests that use of total IV anesthesia (TIVA) can reduce symptoms. In addition, the judicious use of medications such as dexmedetomidine, ketamine, or opioid narcotics can minimize or preclude symptoms altogether when used intraoperatively.38,39 Using these same medications in the post-operative period is still helpful, but may delay recovery. As upsetting and unruly as bouts of delirium can be to patients, parents, and nursing staff, emergence delirium is self-limited even without pharmacological intervention. The most important aspect of management is to keep the patient safe, and to attend to the aesthetics as a secondary concern. Patient safety has an underrated aesthetic quality all its own!

Another common PACU scenario that requires increased vigilance on the part of providers and nurses alike is the development of croup, or laryngotracheobronchitis, after general anesthesia. In the community the onset of croup has a viral etiology. In the postoperative environment it is closely associated with endotracheal intubation, particularly with respect to length of intubation, multiple laryngoscopies, inappropriate sizing of endotracheal tubes, and sometimes in conjunction with preexisting infectious or inflammatory states. In the PACU, diagnosis is most often made by clinical observation. Patients present with a dry, barking cough, sometimes with audible stridor. PACU providers should pay special attention to the child’s work of breathing and determine whether the child exhibits retractions on inspiration, especially at
rest or in a calm state. An anterior/posterior chest radiograph can confirm the classic “steeple” sign of the larynx, but generally is not required to make a definitive diagnosis. Patients with suspected croup should remain on standard monitors continuously with supplemental oxygen therapy if required.

Development of post-operative croup is by no means an inevitable complication of general anesthesia: prevention is the most effective means of improving outcomes. Anesthesiologists can lower risk by using endotracheal intubation only when necessary, and when necessary minimize the trauma of direct laryngoscopy in both number of attempts and by using as gentle an approach as possible. Careful consideration of the size of the endotracheal is of utmost importance, as too large a diameter tube will lead to a tighter fit in the trachea and may cause mucosal irritation or ischemia if left in place for too long. If an endotracheal tube is not sliding through the vocal cords with relative ease, it may be prudent to size down the tube to prevent tracheal irritation. Selecting the appropriate sized tube can be challenging for less experienced providers, as similarly aged children can have drastically differing weights and body habitus. The use of cuffed pediatric endotracheal tubes has been both helpful and problematic as preventive and provocative measures in croup. If using a cuffed tube, ensure that an air leak can be auscultated at a ventilator pressure of less than 25 cm of water to ensure fit that is tight enough to maintain the ventilator circuit without causing tracheal irritation and edema. Luer-lock manometers are available commercially to measure pilot balloon pressure to help guide the provider in properly inflating the endotracheal cuff. Even with appropriate preventive technique, carefully laid plans can be foiled by frequent head repositioning by the surgeons or other unavoidable circumstances.

The medical treatment of croup consists of two mainstays: steroid therapy and nebulized racemic epinephrine. The glucocorticoid dexamethasone taken orally, intramuscularly, or intravenously in doses 0.25-0.5 mg/kg up to a dose of 10 mg provides an effective long-term anti-inflammatory effect. The onset is relatively slow, but will cover inflammation for 24-36 hours after administration. A more acute treatment of symptoms includes the use of inhaled nebulized racemic epinephrine, which reduces laryngeal and tracheal edema by acting on alpha adrenergic receptors to reduce capillary fluid load. Racemic epinephrine takes minutes to improve
symptoms of stridor, but should not be given more than every few hours. There is a risk of rebound edema several hours after administration, so the patient with croup should be closely observed for several hours in the PACU or PICU. If stridor returns, the provider should strongly consider admission to the hospital for prolonged observation and more intensive intervention. A common treatment includes use of humidified warm or cold air, which improves patient comfort. There is scant evidence this intervention is effective in altering the course of croup, which is almost always self-limited. Severe or critical croup may require use of a helium/oxygen mixture (Heliox) which allows improved oxygenation by lowering density and viscosity of inhaled supplemental gases and maintaining laminar flow of gases into the upper airways. Patients with croup requiring this intervention must be admitted to the hospital and placed under intensive observation.

**Special Situations**

**Children with Upper Respiratory Tract Infections**

The child with an upper respiratory infection presents a unique challenge to the anesthesiologist. As these children are often presenting as outpatients, the parents have taken time off work, the surgeon wants to get their case done, and the anesthesiologist doesn’t want to unnecessarily delay or cancel a surgery while at the same time making sure the child has a safe anesthetic and surgical experience. Robust data is lacking with regard to simple uncomplicated URIs or colds having an adverse outcome on children undergoing routine outpatient surgery and anesthetic. If there are no constitutional symptoms such as fevers, decreases in appetite, or decreases in activity levels as well as no lower airway involvement noted by a productive cough or wheezing, then it is generally safe to proceed with routine outpatient anesthetics. If the child is having constitutional symptoms and a parent states their child appears ill, having them reschedule in 2-4 weeks to make sure they are not developing a more serious illness with lower airway involvement is generally preferred unless the surgeon has a compelling reason to proceed i.e. the child will suffer harm by delaying surgery. If a child has had an URI with lower airway involvement as evidenced by productive wet cough, wheezing, chest radiograph demonstrating lower airway inflammation, oxygen requirement or hospitalization needed, or the development
of pneumonia, then surgery needs to be delayed 6 to 8 weeks from the start of the illness unless the surgeon has compelling reason that the child will suffer undue harm by delaying surgery that amount of time. The concern is the airway irritating effects of volatile anesthetics, the stress of surgery and anesthesia in general worsening the patients’ pulmonary status and creating an oxygen requirement and need for hospitalization postoperatively. The lower airway inflammation of a severe URI can last 6 to 8 weeks.

Prematurity

Premature infants present varying and unique challenges to the anesthesiologist. These challenges vary based on the gestational age of the child at birth as well as their current age at the time of surgery. In addition to their gestational age, these patients may have unique pathophysiology that may have contributed to or be associated with their prematurity.

Many organ systems are not mature or fully functioning at birth in full term infants and this is only compounded in premature infants. The kidneys have a decreased ability to reabsorb sodium as well as bicarbonate, thus leading to a ‘normal’ neonatal acidosis and preponderance for hyponatremia. Higher circulating levels of ADH only compound this. Preterm infants have an immature gluconeogenesis pathway as well as decreased glycogen stores thus greatly impairing their glucose homeostasis. Hyperglycemia can cause IVH. Continuing dextrose containing intravenous fluids and regular blood glucose measurement are essential. Their lungs have a decreased amount of alveoli, decreased capillaries involved in gas exchange, and decreased or absent surfactant production. Based on their severity, these factors can combine to cause respiratory distress syndrome and lead to issues with oxygenation and ventilation perioperatively. Furthermore, immature respiratory centers in the brain predispose preterm infants to periods of apnea, termed apnea of prematurity, and this is worsened by many anesthetic and pain medications as well as physiological derangements such as hypoxia, hypercarbia, hypothermia, sepsis, hypoglycemia, and anemia. Thermoregulation is greatly impaired in the preterm infant as they have decreased amounts of heat-generating brown fat and an increased body surface to weight ratio leading to much greater heat loss via radiation and convection. Finally, preterm infants are more likely to have remnants of fetal circulation such as
a PDA, ASDs, or VSDs. These are often left to right shunts, which if severe enough can lead to pulmonary over circulation, pulmonary hypertension, and right heart failure. However, minimal and asymptomatic shunts can become right to left shunts in the setting of high airway pressures or hypoxia (via pulmonary vasoconstriction) leading to systemic hypoxia and acidosis.

**Pulmonary Issues**

**Asthma**

Asthma is a common comorbidity in children. If it is well controlled and a child has very infrequent exacerbations without any recent complications, generally no additional intervention is needed and it is safe to proceed. In the child with a recent exacerbation requiring steroids or hospitalization, it is often best to reschedule the procedure for 6-8 weeks unless the child will suffer harm by delaying their procedure for that amount of time. In addition, for the child with poorly controlled asthma with severe wheezing and coarse breath sounds with daily MDI use, it is best to postpone elective surgeries until the child has seen their pediatrician and/or a pulmonologist and optimized their asthma management. Sometimes in children with poorly controlled asthma or recent exacerbations, breath sounds may be decreased and distant with minimal wheezing. Generally, once these children are treated with an albuterol nebulizer preoperatively, their breath sounds worsen by becoming course with more wheezing. These children should be postponed until after the exacerbation or their medical management has been optimized. The inflammation of an acute flair can last up to 8 weeks.

**Cystic Fibrosis**

CF is an autosomal recessive disease that involves a defective chloride channel causing thickened secretions of various organs, primarily affecting the lungs and digestive tract. These patients have thick pulmonary secretions that are difficult to expectorate, leading to longstanding infections with progressive decline in pulmonary function. They are also prone to poor weight gain and small stature due to malabsorption as their pancreatic secretions are thickened and clog their pancreatic ducts. This eventually leads to the destruction of the pancreas causing insulin dependent diabetes. It is important to review these patient’s pulmonary
medications, ask if there have been any recent changes as this might hint at worsening of their disease, and to inquire how they feel their breathing is doing. I always ask ‘is it better than usual, worse than usual, or about the same/normal for them.’ These patients are good gauges of where they are and if they are more likely to respiratory complications related to the anesthetic. If they have developed insulin dependent diabetes, then it is important to review their insulin management, what their BG normally is when they check it, and to check BG throughout the perioperatively period.

**OSA**

Children with OSA tend to show up in 2 distinct populations in pediatrics: children with OSA presenting for adenotonsillectomy and overweight or obese teenagers with OSA as a comorbidity. For the latter, they are managed and treated as their adult counterparts i.e. bring their CPAP machine if applicable, monitored a little longer in PACU, etc.

For the children presenting for adenotonsillectomy secondary to OSA, they can provide a unique challenge to the anesthesiologist. Children under the age of 3 for T&A are automatic overnight admits for observation regardless of OSA status. Children with OSA under age 3 are more likely to need more invasive respiratory support postoperatively and may benefit from ICU admission in select circumstances. These children are more sensitive to the respiratory depressant effects and the obstructive effects of opioid analgesics. In addition, they have up regulation of central opioid receptors related to the chronic recurrent hypoxia of OSA and this translates into an increased analgesic sensitivity to opioids; decreasing usual weight-based dosages by half is a good starting point for these patients. Multimodal analgesia is also valuable in this patient population.

**Cardiac Lesions**

Congenital cardiac disease covers a broad-spectrum lesions and malformations from remnants of fetal circulation such as a PDA to complex lesions such as hypoplastic left heart syndrome or tetralogy of fallot. We will cover some of the more common lesions in this chapter.
The two most common remnants of fetal circulation that may remain present in newborns and more likely in preterm infants are PFO and PDA. PFO or patent foramen ovale is an opening between the right and left atrium designed to shunt blood right to left during intrauterine life when the lungs are filled with amniotic fluid and not responsible for performing oxygenation or ventilation. Once the infant is born and the lungs are filled with air, PVR (pulmonary vascular resistance) drops and the PFO should functionally close. If it remains open, there is often minimal left to right shunting. If the lesion is large enough or other medical problems exist (sepsis, extreme prematurity, etc.) then the degree of shunting can be more significant. Echocardiogram is the best test for evaluation. PDA or patent ductus arteriosus is normal connection between the pulmonary artery and aorta that is designed to shunt blood from the right ventricle to the systemic circulation during fetal circulation. Again, PVR is elevated for a variety of reasons and the lungs are not performing oxygenation or ventilation. This duct constricts and functionally closes soon after birth but can remain open after birth for a variety of reasons, in which case there will be left to right shunting. Echocardiogram is the best test to determine the degree of shunting. Both of these lesions result in pulmonary over circulation and can lead to congestive heart failure with poor systemic perfusion if severe enough.

Atrial septal defects (ASD) and ventricular septal defects (VSD) are abnormal openings between the membranes/muscle separating the atria and ventricles respectively. The often result in left to right shunting, the degree of which depends on the size of the defect and the presence of any other comorbidities/lesions. Echocardiogram and cardiac catheterization are used evaluate and in some cases for treatment with occlusion devices. In some cases, open-heart surgery is indicated. The concern with these lesions is pulmonary over-circulation leading to pulmonary hypertension and right heart failure.

Finally, children can be born with a variety of defects that lead to single ventricle physiology, the scope of which is beyond this chapter. These lesions are repaired in a staged fashion and the two stages that are most likely to be encountered in patients presenting for non-cardiac surgery are the Glenn and Fontan stages/repairs. Note both of these stages use passive venous flow for pulmonary blood flow/perfusion. For the Glenn repair, a patient has a single ventricle that provides systemic flow; venous return to the heart is separated in that the IVC
drains to the common atrium and the SVC drains to the pulmonary artery thus providing blood flow to the lungs that then flows into the common atrium. There is mixing of oxygenated and deoxygenated blood in the common atrium and patients’ normal oxygenation saturation is roughly 85% on room air. The Fontan repair follows the Glenn repair. At this stage the IVC is redirected from the common atrium to the pulmonary artery, thus all venous return flows passively to the lungs and from there to the common atrium to the common ventricle where it is then pumped systemically. These patients have a typical oxygen saturation of 95-100% on room air. It is important to review the most recent cardiologist note and echocardiogram for these patients to assess function and any residual lesions or defects.

Sickle Cell Disease

Autosomal recessive genetic defect that leads to red blood cells that can distort into a sickle shape under times of stress. These red blood cells have a shorter lifespan and often die early leading to sickle cell anemia. Hypoxia, hypothermia, acidosis, anemia, dehydration, and stress from illness can precipitate a sickling crisis. A crisis is often marked by pain as the sickled red blood cells block blood flow in a given area. It is very important to minimize anxiety in these patients, keep them well hydrated often times with preoperative IV fluids, maintain normothermia, avoid hypoxia and hypercarbia as well as other forms of acidosis, and to transfuse preoperatively for Hgb less than 8.

Neurologic Disorders

Seizure Disorder

There are numerous seizure disorders with numerous causes that are too many to count or give a one size fits all recipe for management. The important information to ascertain during your preoperative assessment are what medications the patient is currently taking, have there been any recent changes in dose or medications, how often are they having seizures, the appearance of their seizures, and any relevant triggers. If their seizures are well controlled, then it will generally be safe to proceed with elective surgeries. If they are having a change in frequency or other sign that their seizures are not well controlled, then surgery should be delayed.
if possible while the child follows up with their neurologist to medically optimize their seizure management. The primary concerns for caring for the patient with epilepsy are the possibility of anesthetic agents to modulate or potentiate seizure activity as well as the potential for interaction of anesthetic drugs with antiepileptic medications.53

Cervical Spinal Instability

Children with trisomy 21 (Down Syndrome) are susceptible to atlantoaxial instability with or without subluxation. The incidence increases with age through adulthood. Patients may be symptomatic with cervical extension. C-spine radiographs have been used as a screening tool but the instability with subluxation can be present with normal radiographs.54 Extra care should be taken with airway instrumentation to minimize cervical spine extension and torque.

Cerebral Palsy/Developmental Delay

Cerebral Palsy results from injury to the fetal or infant brain resulting in persistent pathologic disorders of movement and/or posture. These patients are often on multiple medications related to spasticity and there is the potential for interactions with various anesthetic agents. Comorbidities often include GERD, epilepsy, and impaired respiratory mechanics with decreased/impaired lung function. Vascular access and positioning can be quite challenging perioperatively.55

Diabetes Mellitus

Historically most children with diabetes were type 1 or insulin dependent type, however with increasing rates of childhood obesity, more and more teenagers are being seen and treated with metabolic syndrome, prediabetes, and type 2 diabetes. These patients are often obese and on oral glycemic medications. Management of these medications perioperatively mirrors adult guidelines.

The child with type 1 diabetes can present unique challenges with regards to blood glucose management. Since children are constantly growing and experiencing ongoing changes in metabolic needs and processes, their insulin requirements are an ever-changing target. Often
their BG is allowed to run a wider and higher range compared to their adult counterparts. It should be routine to inquire what their BG range normally is as well as any recent changes to their insulin regimen during your preoperative exam so as to avoid hypoglycemia, hyperglycemia, or large variability in blood glucose levels perioperatively. It is important to check BG throughout the perioperative period and have IV insulin readily available to treat levels greater than 200-250.

**Malignant Hyperthermia Risks**

Malignant Hyperthermia is most often an autosomal dominant genetic disorder involving a ryanodine receptor in the sarcoplasmic reticulum, gene located on chromosome 19. There are multiple defects identified and varying penetrance. The triggering agents are volatile anesthetic gases and the depolarizing neuromuscular relaxant succinylcholine. Patients can have had prior anesthetics and not triggered. A history of anesthesia with no reaction does not rule out MH. Genetic testing is available but a contracture test involving a muscle biopsy is still the gold standard. The only muscular dystrophies associated with true MH are central core disease and King-Denborough disease. Other muscular dystrophies/myopathies often result in a hyperkalemic cardiac arrest that will have some symptom overlap with MH but a separate disease process.

The use of these medications in a patient with a susceptibility to MH results in massive release of calcium into the muscle resulting strong and sustained muscle contractions and hypermetabolism leading to muscle rigidity, elevated heart rate, fever/hyperthermia, acidosis, hyperkalemia, DIC, and multiorgan failure. MH is treated with Dantrolene and the Malignant Hyperthermia Association of the United States (MHAUS) should be contacted to assist with treatment of any patient thought to be experiencing MH.

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5 Children’s Surgery Verification, Quality Improvement Program. Optimal Resources for Children’s Surgical Care, V. 1. American College of Surgeons.
32 Campbell K, Torres L, Sayer S. Anesthesia and Sedation Outside the Operating Room. Anesthesiology Clinics 2014:3.
34 Practice Guidelines for Postanesthetic Care: An Updated Report by the American Society of Anesthesiologist Taskforce on Postanesthetic Care Anesthesiology, Committee on Standards and Practice Parameters. Feb 2013: 118(2).
38 A Prospective Cohort Study of Emergence Agitation in the Pediatric Postanesthesia Care Unit Anesthesia and Analgesia 2003: 96.
46 Continuing Education in Anaesthesia Critical Care & Pain, June 2009:9(3)73–77. https://doi.org/10.1093/bjaceaccp/mkp010
47 Woods BD, Sladen RN. Perioperative considerations for the patient with asthma and bronchospasm. BJA Dec 2009:103(1)i57–i65.
50 Abraham, R. The Changes in the Circulation After Birth: Their Importance in Congenital Heart Disease. Circulation. 1970;41:343-359
51 DiNardo JA. Anesthesia for Cardiac Surgery. 3rd edition.
55 Prosser DP, Sharma N. Cerebral palsy and anaesthesia. Continuing Education in Anaesthesia Critical Care & Pain, June 2010:10(3) 72–76.