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Anesthesia for pediatric ambulatory surgery

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Children are excellent candidates for ambulatory surgery. Most children are healthy, and most surgical procedures performed on children are simple and are associated with prompt recovery. It is not surprising, therefore, that up to 50%–60% of pediatric surgery in the United States is performed on an ambulatory basis [1,2]. Avoiding hospitalization is particularly advantageous for preschool children, who benefit from minimizing separation from than parents, and for infants, who are spared the exposure to the potentially contaminated hospital environment.

Patient selection criteria

A successful ambulatory surgery program requires that well-defined patient selection criteria be established and strictly adhered to by all surgeons who have admitting privileges in the facility. The primary factors that must be considered when selecting a child for ambulatory surgery are the condition of the patient, the attitude of the parents, and the type of surgical procedure to be performed. These factors must be balanced with the capability of the surgical facility and the ability of its staff to deal with any expected or unexpected complications.

The patient

The child should be in good health; if not, any systemic disease must be under good control. Today, many patients with chronic medical conditions present for surgical procedures that are usually considered appropriate for ambulatory surgery. In these cases, an understanding of the underlying pathophysiology and thorough preoperative evaluation will help guide the anesthesiologist as to the appropriateness of choosing an ambulatory setting in each individual patient. Some of these conditions are discussed below.

Premature infants. Premature infants are not suitable candidates for ambulatory surgery because of potential immaturity of the respiratory center, temperature control, and gag reflexes. Recent studies have reported a high incidence of perioperative complications such as apnea in these infants.

The age at which a former premature infant (expreemie) attains physiologic maturity and no longer presents an increased risk for postoperative apnea remains controversial, and is best considered individually.

It is generally considered that infants of less than 46 weeks postconceptual age (PCA) or with a preoperative history of apnea are at greatest risk, although some authors have reported apnea in infants as old as 60 weeks PCA. Many anesthesiologists admit to a hospital or to a 23-h recovery facility all ex-premature infants who are younger than 50–55 weeks PCA so that they may be monitored postoperatively for apnea, bradycardia, and oxygen desaturation [3]. If the infant was extremely premature or has bronchopulmonary dysplasia, anemia, or other neonatal problems, this period may need to be extended. It seems prudent to have a high index of suspicion when dealing with these infants, and to err on the side of recommending postoperative inpatient care and monitoring. Infants who develop apnea in the recovery room should also be admitted and monitored.

Children with runny nose. A child who presents with a runny nose may have a completely benign, noninfectious condition (e.g., seasonal or vasomotor rhinitis), in which case elective surgery may safely be performed. On the other hand, the runny nose may be a prodrome to, or actually be, an infectious process, in which case elective surgery may need to be postponed. Since an estimated 20%–30% of all children have a runny nose a significant part of the year, every child with a runny nose must be evaluated on an individual basis.

The preanesthetic assessment of these patients consists of a complete history, a physical examination, and an interpretation of certain laboratory data. Early in the clinical course of disease, the history will be the most important factor in the differential diagnosis. Specifically, allergic problems should be actively sought. Parents can usually tell whether their child's runny nose is "the usual runny nose" or something different that may require cancellation of elective surgery. Parents of ambulatory patients can be instructed to call in on the morning of surgery if the child develops symptoms of upper respiratory tract infection (URI) so the findings can be reviewed, and if a decision to cancel surgery is made, they are spared a wasted trip to the hospital.

If surgery is postponed because of simple nasopharyngitis, it can usually be rescheduled in one to two weeks. If a flulike syndrome that involves both the upper and lower respiratory tract is present, surgery should be postponed until at least a month after the child has recovered.

Children with asthma. Asthma is the most common chronic disease of childhood, affecting 5%–10% of children in the United States, and the incidence is on the rise. It is therefore not unusual for patients with asthma to present for what is usually a minor surgical procedure in an ambulatory setting. The decision whether to accept and proceed with such patients depends on the severity and frequency of the symptoms and the adequacy of pharmacological control. Children with mild asthma who have infrequent symptoms and do not require continuous medication are excellent candidates for ambulatory surgery. When children with moderate asthma (those who require daily medication to control their symptoms) are scheduled for ambulatory surgery, they should continue their medication until (and including) the morning of surgery [4]. A β-agonist should be administered in the holding area by a nebulizer to young children or by an inhaler if the patient is older. If the patient is wheezing or has coexisting URI, persistent cough, or tachypnea on the day of surgery, it is best to reschedule the procedure.

The choice of a specific anesthetic technique in an asthmatic child is usually dictated by the nature of the surgical procedure. Most anesthetics available today have been used successfully in asthmatics. If an endotracheal tube must be used, sufficient depth of anesthesia must be established first. Intravenous lidocaine and/or a β-agonist inhalant may be administered just before extubation. Deep extubation should be considered.

Patients may leave the facility when the usual discharge criteria are met. Children should not have any signs of wheezing when discharged. Adequate hydration should be ensured.

The procedure

The planned surgical procedure should be associated with only minimal bleeding and minor physiologic derangements. Superficial procedures are selected most often. The length of the procedure is not in itself a significant limitation. Most experts believe that almost any operation that does not require a major intervention into the cranial vault, abdomen, or thorax can be considered.

The five most frequently performed ambulatory surgical procedures at Children's National Medical Center (CNMC) during the past two years were herniorrhaphy, myringotomy, adenoidectomy with or without myringotomy, circumcision, and eye-muscle surgery. Recent experience indicates that ambulatory adenotonsillectomy is also safe and cost-effective and that there is little benefit in keeping these patients in the hospital more than a few hours after surgery to ensure adequate hydration and absence of bleeding. Young children (<3 years) who are undergoing tonsillectomy for the relief of severe airway obstruction, with or without sleep apnea, continue to suffer from the same symptoms in the immediate postoperative period and should, therefore, be admitted to a hospital or a 23-h recovery facility for close observation and monitoring postoperatively [5].

Preoperative requirements and screening

Many ambulatory surgical units actively participate in the preoperative screening of their patients. The degree of involvement varies from a simple telephone call to the parents a day or two before surgery to the establishment of a formal screening clinic to "clear" all patients before surgery. At CNMC, the parents of each child are interviewed by telephone shortly after the operation is scheduled. A second call is made 48 h or less before surgery. During the initial call, information is sought concerning past or present risk factors, such as a history of prematurity or cardiac or respiratory problems. This information helps to determine if additional preoperative evaluation or consultation is required before the day of surgery. In some cases, it may lead to a reevaluation of the appropriateness of scheduling the procedure on an ambulatory basis. During the second phone call, an assessment of the child's present health is made. NPO orders are reinforced, and practical matters related to parking, what to bring to the hospital, and expected duration of stay are explained.

On the day of surgery, all patients are screened for acute illness and NPO status. Vital signs are recorded. Any consultation reports are evaluated, and the need

for special preoperative psychological or pharmacologic treatment is considered before the child arrives at the operating room area.

Preoperative preparation

The time between the patient's arrival at the hospital and the induction of anesthesia is usually quite short. There is little time to orient the child to all the events that will take place during his or her stay. Many centers, therefore, encourage children and families to participate in presurgical preparation programs a few days before surgery, and studies have shown that children who attended these programs were much more cooperative during induction than those who did not.

Pharmacologic premedication

The value of and need for pharmacologic premedication in pediatric outpatients is controversial. Although many children do not need preoperative sedation, provided that they have received proper psychological preparation and established a good rapport with the anesthesiologist, some do. Midazolam 0.5 $mg \cdot kg^{-1}$ can be administered orally 10–30 min before induction to facilitate separation from the parents and improve the child's cooperation during induction [6]. Alternatives to midazolam include oral ketamine (6 $mg \cdot kg^{-1}$) and oral transmucosal fentanyl citrate (10–15 $\mu g/kg^{-1}$) [7]. When premedication is not used routinely, the anesthesiologist must be prepared to administer a rapidly acting preinduction agent to the occasional uncooperative or extremely frightened child.

Preinduction agents

Low-dose (2 $mg \cdot kg^{-1}$) intramuscular ketamine can be used in young children who do not cooperate with other methods of induction. The onset time is short (2–3 min), and recovery is not prolonged. When ketamine is followed by an inhaled anesthetic, there is minimal likelihood of delirium or bad dreams during recovery [8].

Rectal administration of methohexital is a commonly used technique in preschool children. A dose of 25 $mg \cdot kg^{-1}$ (10% solution) has an onset time of 6 to 10 min and produces enough sedation to peacefully separate an upset child from his or her parents [9]. Intranasal administration of midazolam (0.2 $mg \cdot kg^{-1}$) also has been reported to produce anxiolysis and sedation in preschool children, with a rapid onset (5–10 min) and no evidence of delayed recovery [10].

Presence of the parents during induction

Since one of the main reasons for administering routine premedication or having to resort to using a preinduction technique is to facilitate separation of the child from the parents, some anesthesiologists find that they can reduce or even eliminate the need for such agents by allowing the parents to stay with the child during the induction of anesthesia [11]. This approach is gaining a lot of supporters, and is being requested by many parents. Some institutions have specially built induction rooms where the parents can accompany their children without having to wear special operating room attire. Others allow selected parents to wear a coverall gown or scrubs and walk with the child into the actual operating room. Studies have shown that children are less upset when the parents are present. Selection and education of the parents are essential for the success of this approach, since anxious parents can make their children even more upset.

Anesthetic agents and techniques

The choice of an anesthetic technique for pediatric ambulatory patients should ensure quick emergence at the end of surgery, prompt recovery in the post-anesthesia care unit (PACU), and rapid discharge with no or minimal pain and/or postoperative nausea and vomiting (PONV).

Inhalational techniques

Inhalational induction is a popular choice in pediatric anesthesia. Techniques that reduce the anxiety associated with inhalation induction and therefore promote patient cooperation include the use of transparent masks, painting the inside of the mask with a drop of food flavor of the child's choice, and allowing the child to sit up during the induction.

Halothane is still the most commonly used inhalational anesthetic in pediatric patients. It is usually combined with nitrous oxide to provide reasonably rapid and smooth onset, as well as quick recovery following operations lasting 1 h or less. Nausea and vomiting are not common. With prolonged administration of halothane (>1 h), recovery time is longer than when *isoflurane* is used.

Sevoflurane has solubility characteristics closer to those of desflurane than to isoflurane. The drug has a very pleasant smell, which makes it the least irritating inhalational induction agent available [12]. Sevoflurane can, therefore, be used for both induction and maintenance of anesthesia in children. Clinical experience with sevoflurane has shown the drug to result in extremely

rapid and smooth induction with no airway irritation, even when an 8% inspired concentration is used initially. Emergence and recovery times are faster than with halothane [13].

Desflurane is not indicated for the start of anesthesia induction in children because it has a high incidence of airway irritation, coughing, and laryngospasm, which results in desaturation severe enough to require emergent use of succinylcholine in many patients. Desflurane, however, can be easily introduced following other induction agents, typically halothane or sevoflurane. This results in significantly faster emergence and recovery than when halothane or sevoflurane is used [14]. Emergence excitement is common following pure desflurane (and to a lesser degree, sevoflurane) anesthesia. This can be greatly decreased by including an opioid such as fentanyl in the anesthetic regimen.

Intravenous techniques

Intravenous induction is the method of choice in many older children especially when EMLA is used to perform a painless venipuncture. The use of EMLA in outpatients requires careful planning, since at least 1 h of contact time under an occlusive dressing is required for full effect. Efforts to have EMLA applied at home by parents should be encouraged. In most cases EMLA should be applied to two potential IV sites to have a backup site available in case the first venipuncture is not successful.

When *thiopental sodium* is used in healthy unpremedicated children, a relatively large dose (5–6 $mg \cdot kg^{-1}$) may be required to ensure smooth and rapid transition to general inhalational anesthesia. Children who receive barbiturate induction tend to be sleepier and require more airway support for the first 15 min of recovery than those who receive halothane. This difference disappears by 30 min.

Recent studies on the use of *propofol* in children indicate that it results in smooth induction with a lower incidence of side effects and faster recovery than thiopental. Propofol can be used at doses of 2.5–3.5 $mg \cdot kg^{-1}$ for induction of anesthesia in children who accept venipuncture. Pain on injection can be minimized or even prevented by using the large antecubital veins for drug administration. If the hand veins must be used, lidocaine can be mixed with propofol (1–2 mg lidocaine per 1 ml propofol) immediately prior to its injection, with excellent results. When propofol induction is followed by halothane maintenance, recovery is significantly faster than when thiopental induction is followed by halothane. Recovery is fastest if propofol induction is followed by a propofol infusion for the maintenance of anesthesia [15]. Because of their higher volume of distribution and increased clearance, children require a higher infusion rate (125–300 $\mu g \cdot kg^{-1} \cdot min^{-1}$) than adults. This is especially true for younger children and during the early part of maintenance.

Propofol anesthesia has been consistently shown to be associated with an extremely low incidence of postoperative vomiting, even after surgical procedures that normally result in vomiting, e.g., strabismus surgery [16].

Antiemetics

Routine antiemetic prophylaxis is seldom needed in pediatric patients. For children undergoing procedures known to be associated with a very high incidence of postoperative vomiting, e.g., eye-muscle surgery, propofol has been shown to be very effective in preventing this complication. Although some of the traditional antiemetic drugs are at least partially effective, their use is associated with significant side effects, such as prolonged recovery and extrapyramidal symptoms (droperidol 50–75 $\mu g \cdot kg^{-1}$) or gastrointestinal disturbances (metoclopramide 0.15 $mg \cdot kg^{-1}$). More recently, ondansetron has been shown to be an effective antiemetic for both the prevention and treatment of postoperative vomiting in pediatric ambulatory patients. A single IV dose (0.1 $mg \cdot kg^{-1}$ for children <40 mg; 4 mg for children >40 kg) is recommended for both indications. Ondansetron is especially indicated in children undergoing such vomiting-prone procedures such as tonsillectomy or strabismus surgery, where more conventional antiemetics have little or no effect [17].

For patients with persistent postoperative vomiting, our current approach is to stop any attempt at offering oral fluids and ensure adequate intravenous hydration. Intravenous metoclopramide 0.15–0.2 $mg \cdot kg^{-1}$ or ondansetron 0.1 $mg \cdot kg^{-1}$ is administered. Occasionally rectal promethazine 0.5 $mg \cdot kg^{-1}$ (Phenergan 12.5–25 mg), or prochlorperazine 0.1 $mg \cdot kg^{-1}$ (Compazine 2.5–5 mg) is administered in the hospital and/or given to the parents to use at home.

Perioperative fluid management

Preoperative fasting

The need for a prolonged period of fasting (e.g., NPO after midnight) before induction of anesthesia in otherwise healthy children has been recently questioned [18]. Studies have shown that children who are allowed to drink clear liquids until 2–3 h before induction of anesthesia do not manifest an increase in gastric volume or acidity over those who fast overnight. Accordingly,

most pediatric anesthesiologists have now liberalized NPO requirements for their patients. Solid food, which includes milk, formula, and milk products, is still not allowed on the day of surgery. Breast-fed infants, however, are allowed to nurse up to 4 h preoperatively. Children may drink clear liquids (up to 10 ml·kg^{-1}) until 2–3 h before the posted surgical time. It is important to note that these guidelines apply to *clear liquids only* (not solids) in otherwise healthy children. Possible benefits of shorter fasting times include minimizing thirst and discomfort while awaiting surgery, less hypovolemic-induced hypotension during induction, and less concern about hypoglycemia.

The need for routine administration of intravenous fluids during pediatric ambulatory anesthesia is controversial. Children undergoing very brief surgical procedures (e.g., myringotomies) may not need any parenteral fluid administration as long as they are not excessively starved preoperatively, and are expected to be able to ingest and retain oral fluids soon after they are awake. For most other children, intraoperative maintenance fluid administration can be calculated based on the child's body weight according to standard formulas.

Intravenous fluid therapy during and after surgery is specifically indicated in longer operations (more than 30–60 min), in procedures known to be associated with a high incidence of postoperative nausea and vomiting (e.g., strabismus surgery), and in young children who have been fasting for a prolonged period of time. If continuing postoperative loss through vomiting or inability to tolerate oral intake is anticipated, it is advisable to start making up that anticipated deficit early on so that the child will be well hydrated when ready to go home and it will not be necessary to delay discharge while "catch-up" fluid administration is instituted. Adequate parenteral hydration also obviates the need for forcing children to ingest oral fluids before they are allowed to go home. Recent studies confirm that children who are forced to drink before leaving the facility have a higher incidence of vomiting, and are discharged home later, than children who are allowed to drink only when they are thirsty enough to request a drink [19].

Postoperative analgesia

The need for analgesics following surgery depends upon the nature of the procedure and the pain threshold of the patient. It does not depend upon whether the child is an outpatient or an inpatient. Whenever possible, regional blocks or local infiltration should be used to supplement general anesthesia and to limit the need for narcotics during recovery. Postoperative pain or discomfort can be managed by one or a combination of the following methods.

Acetaminophen

Acetaminophen (10–15 mg·kg^{-1} or 60 mg per year of age) is the most commonly used mild analgesic for pediatric ambulatory patients. For young children, it is often administered rectally (up to 45 mg·kg^{-1}) before the child awakes from anesthesia [20]. Acetaminophen can be combined with codeine for more effective control of moderately severe pain and/or discomfort. Acetaminophen with codeine elixir contains 120 mg acetaminophen and 12 mg codeine per 5 ml. The usual dose is 5 ml for children aged 3–6 years and 10 ml for children aged 7–12 years.

Nonsteroidal anti-inflammatory drugs (NSAIDs)

NSAIDs such as ketorolac have proved effective in relieving postoperative pain following minor operations in children. Early administration immediately following induction seems to provide optimal postoperative analgesia. More studies are required to determine the optimal dose and route of administration of ketorolac, as well as its efficacy as an analgesic following more painful ambulatory surgical procedures in children.

Potent narcotic analgesics

When narcotics are indicated in the recovery period, a short-acting drug should be chosen. Intravenous use allows more accurate titration of the dose and avoids the use of "standard" dosages based on weight, which may lead to a relative overdose. If remifentanil is used intraoperatively, planning for postoperative analgesia must be started before the patient awakes. Fentanyl, up to a dose of 2.0 μg·kg^{-1}, is our drug of choice for intravenous use. Meperidine (0.5 mg·kg^{-1}) and codeine (1.0–1.5 mg·kg^{-1}) can be used intramuscularly if an intravenous route is not established.

Regional analgesia

Regional anesthesia can be combined with light general anesthesia to provide excellent postoperative pain relief and early ambulation, with minimal or no need for narcotics. By placing the block before surgery starts but after the child is asleep, one can reduce the requirement for general anesthetic agents during surgery, which in turn may result in a more rapid recovery, earlier discharge, more rapid return of normal appetite, and less nausea and vomiting.

The types of blocks that can be used safely in the pediatric ambulatory surgical patient are limited only

by the skill and interest of the anesthesiologist. Generally, the techniques chosen should be simple to perform, have minimal or no side effects, and not interfere with motor function and early ambulation.

Ilioinguinal and iliohypogastric nerve block can be performed by infiltration of 0.25% bupivacaine solution (in doses up to $2\,mg \cdot kg^{-1}$) in the region medial to the anterior superior iliac spine. This block has been used successfully to provide excellent postoperative analgesia for pediatric ambulatory patients following elective inguinal herniotomy or orchiopexy.

Dorsal nerve block of the penis can be performed by simple injection of 1–4 ml of 0.25% bupivacaine without epinephrine deep to Buck's fascia 1 cm from the midline. This has been shown to provide over 6 h of analgesia following circumcision with no complications. Alternative approaches to penile block are a midline injection or subcutaneous infiltration, which presumably blocks the nerve after it has ramified into the subcutaneous tissue. Topical application of lidocaine on the incision site at the conclusion of surgery has also been shown to be effective.

Caudal block provides excellent postoperative analgesia following a wide variety of surgical procedures, such as circumcision, hypospadias repair, orchiopexy, and herniotomy. By using bupivacaine, 0.25% solution at a dose of $0.5–0.7\,ml/kg^{-1}$, no motor paralysis is produced. If a larger volume is indicated, the use of a 0.125% solution is recommended. Caudal block has been extensively used in our ambulatory surgical unit, with most children discharged home free of pain between 1 and 2 h postoperatively. Analgesia (as measured by subsequent need of a mild oral analgesic) lasts 4 to 6 h with this technique.

Discharge criteria

Rapid recovery and early ambulation are major objectives in ambulatory surgery. When dealing with pediatric outpatients, we must guarantee safe discharge not only from the recovery room but also from the hospital. In our institution, all children recover from anesthesia in the same recovery area. Ambulatory patients are then transferred to a special short-stay recovery unit.

In order to provide uniform care and to ensure a complete legal record, many institutions have developed specific discharge criteria for ambulatory patients. At CNMC, discharge criteria include the following: appropriateness and stability of vital signs; absence of respiratory distress; ability to swallow oral fluids, cough, or demonstrate a gag reflex; ability to ambulate consistent with the developmental age level; absence of excessive nausea, vomiting, and dizziness; and a state of consciousness appropriate to the developmental level. Recent studies suggest that children should not be required to drink before discharge from the hospital.

Every child, regardless of age, must have an escort home. The escort is given written instructions concerning the child's home care and a telephone number to call to request further advice or to report complications. Staff counsel all parents about postoperative care; many units have also designed handouts that specify the care that should be provided and the signs that might herald a complication.

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