Anesthesia for Common Pediatric Emergency Surgeries

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KEYWORDS

• Pediatric • Emergency • Anesthesia

KEY POINTS

- Many surgeries in the pediatric population are deemed emergent, requiring efficient preparation for the anesthesiology team.
- The preoperative assessment is critical in determining the proper management plan of the pediatric patient involved.
- Common emergent surgeries include airway/esophageal foreign body, appendicitis, intussusception, posttonsillectomy bleed, ventriculoperitoneal shunt, and facial fractures.
- Induction, maintenance, and postoperative care for the common pediatric emergency surgeries can vary.

The majority of surgeries performed in the pediatric population are planned. There are, however, a handful of surgeries that are true emergencies and require an immediate trip to the operating room. Many of these surgeries can be complicated for the anesthesia team for many reasons. It is imperative that the anesthesia team act quickly, formulating a preoperative plan for induction, maintenance, emergence, and postoperative care for the emergent pediatric patient. Seven emergency clinical scenarios seen often by anesthesiologists are discussed and reviewed in this paper. As with any elective procedure, an appropriate preoperative evaluation must be performed by the anesthesiologist before any emergency case begins. With the exception to traumas, even though cases are deemed emergent, there should be enough time to obtain consent and conduct a proper preoperative evaluation in an efficient manner. The preoperative evaluation should include, but not be limited to, a brief medical history, allergies and current medications, previous anesthetic exposure, NPO status, a thorough airway examination, and an anesthetic specific physical examination.

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Consent can be an issue in the pediatric population, because most often the children will not understand the nature of the surgical procedure they are consenting to. Permission for medical care or surgery must therefore be obtained from the parents, guardians, or the courts, who does so with the child's best interest in mind. Typically, there is time to obtain consent for the surgical procedures, even in an emergency setting. Every effort to obtain consent and explain the risks and benefits of the anesthetic should be made.

PREOPERATIVE EVALUATION

During the preoperative period, the anesthesiologist should identify any potential diseases, physiologic/hemodynamic derangements, or congenital anomalies that could affect the anesthetic course. Most children are incapable of providing a detailed medical history; therefore, it is helpful if a parent is present to provide the child's history. Often, children are healthy and the history will be short. Other times, children can have complex diseases and parents may not be able to provide much information. Obtaining more information from medical records may be required in these situations. It is essential to question parents concerning premature birth, problems with the heart, lungs, nervous system, gastrointestinal tract, kidneys, endocrine system, or any other serious diseases/syndromes. Allergies to specific medications and current medication use should also be concluded. Many children have no history of anesthetic exposure; therefore, it is imperative that a family history of complications associated with anesthesia be elicited, with an emphasis on a history of malignant hyperthermia and succinylcholine apnea.

Preoperative fasting guidelines have been established to help prevent the aspiration of gastric contents during induction and maintenance of anesthesia. In 2011 new guidelines by the American Society of Anesthesiologists (ASA) Task Force were published. The guidelines recommend a fasting interval of 2 or more hours after the consumption of clear liquids, 4 or more hours after breast milk, 6 or more hours after infant formula, a light meal, or nonhuman milk, and 8 or more hours for solids ("2-4-6-8 rule"; **Table 1**).

The guidelines note that the ingestion of fried or fatty foods or meat may prolong gastric emptying time and recommend that both the amount and type of foods ingested be considered when determining an appropriate fasting period.[1] The ASA guidelines are intended for healthy patients undergoing elective procedures. The guidelines are not intended for children with conditions that may affect gastric emptying resulting in increased gastric volume. Fortunately, the incidence of perioperative pulmonary aspiration is rare; however, a large prospective study showed a greater frequency of aspiration in emergency procedures versus elective procedures.[2] Most patients who present for emergency surgery will be deemed to have full stomachs. An induction technique allowing for rapid securing of an airway device should be conducted, minimizing the risk of pulmonary aspiration.

With limited time in the setting of an emergency, the anesthesiologist should dictate the physical examination based on findings from the medical history gained. Even if no history was able to be obtained, the airway, lungs, and heart should always be examined. Observation of the child's color and the presence of respiratory distress should

Table 1
Guidelines for pediatric preoperative fasting

Clear Fluids	Breast Milk	Nonhuman Milk or Formula	Solids
2 h	4 h	6 h	8 h

be monitored. Along with the physical examination, a current set of vitals should be monitored before proceeding to the operating room.

AIRWAY FOREIGN BODIES

According to the National Safety Council, suffocation from foreign body ingestion and aspiration is the third leading cause of accidental death in children younger than 1 year of age and the fourth leading cause in children between 1 and 6 years of age.[3] Foreign Body aspiration is a common emergent procedure in the pediatric population, occurring most frequently in children younger than 3 years of age. These cases can be some of the most challenging for the pediatric anesthesiologist. General anesthesia is usually necessary to help remove the foreign body by bronchoscopy. Most often, the foreign body aspiration is organic in nature, such as peanuts, seeds, or other small foods. Foreign bodies are embedded more commonly in the right main bronchus than in the left, and less frequently in the larynx and trachea.[4,5] Symptoms and signs associated with bronchial aspiration include coughing, wheezing, dyspnea, and decreased air entry in the affected side, whereas dyspnea, stridor, coughing, and cyanosis are more common with laryngeal or tracheal foreign bodies.[4] Removal of a foreign body may necessitate laryngoscopy, bronchoscopy, thoracoscopy, thoracotomy, or even a tracheotomy.[2] Most commonly however, a rigid bronchoscopy is the technique most often used for the removal of a foreign body.

Preoperative Assessment

In addition to the usual preoperative assessment, physical examination should focus on the location, degree of airway obstruction, and gas exchange. A review of the latest chest radiographs is helpful in determining the location of the foreign body and for evidence of secondary pathologic changes, such as atelectasis, air trapping, or pneumonia.[3] As always, a discussion with the surgeon detailing their primary approach and backup plans should be conducted. A peripheral intravenous catheter should be placed before arrival in the operating room. Other preoperative considerations are (1) cautious premedication to avoid worsening airway obstruction, (2) intravenous anticholinergic administration (such as glycopyrolate) to decrease secretions and prevent reflex bradycardia during airway instrumentation, and (3) assessment of the risk for aspiration of gastric contents.[2]

Induction of Anesthesia

The type of induction used for foreign body aspiration must be individualized to the patient. All children should be monitored with the standard ASA monitors including a pulse oximeter, end tidal CO_2, electrocardiogram, thermometer, and automated blood pressure. A major controversy in the anesthetic management of patients undergoing bronchoscopy for foreign body removal is whether to control ventilation or to maintain spontaneous ventilation.[6,7] There are only few data available to dictate whether controlled versus spontaneous ventilation is better. The risk of controlled ventilation is to force the foreign body deeper into the small airways, and the risk for the spontaneously breathing patient is unexpected movement or cough.[8] Often, the child is preferred to be breathing spontaneously, and an inhalational induction with sevoflurane is performed.

Maintenance of Anesthesia

After induction, maintenance of anesthesia can be accomplished with a combination of an inhalational technique with boluses of propofol or a total intravenous anesthetic,

consisting of propofol with or without opioids (eg, fentanyl, remifentanil). One advantage to total intravenous anesthetic is a consistent anesthetic that is not reliant on inhalation for depth of anesthesia. To decrease the chances of laryngeal irritation and laryngospasm during bronchoscopy, lidocaine 2% to 4% could be sprayed on the larynx. Often with bronchoscopy, one can ventilate through the side port of the rigid bronchoscope. It should be noted, however, that the side port does not allow for consistent tidal volumes and gas exchange, resulting in poor ventilation, leading to hypercarbia, hypoxia, and a light anesthetic plane. During the procedure, the anesthesiologist needs to be hyper vigilant, focused on the breathing of the patient, oxygenation, and CO_2 levels. The rate of increase in end tidal $Paco_2$ in apneic infants and young children is extremely high—approximately 9 mm Hg/min for the first minute.[9] It is imperative that the anesthesiologist communicate with the endoscopist/surgeon during the procedure. Once the foreign body is removed, a joint decision should be determined as to where the child should recover.

Postoperative Care

Laryngospasm, bronchospasm, hypoxia, and pneumothorax are all complications that can be associated with the removal of foreign bodies within the intraoperative and postoperative period. Steroids with potent glucocorticoid effects are beneficial in reducing airway edema and stridor, owing to their antiinflammatory actions. Dexamethasone (0.25–0.5 mg/kg to a max of 8 mg) given every 6 to 8 hours for 4 to 6 doses has been shown to be effective in decreasing airway edema.[10] Racemic epinephrine is also used to treat airway edema. The alpha-adrenergic effects of racemic epinephrine mediate mucosal vasoconstriction and its beta effects produce smooth muscle relaxation as well as inhibition of mast cell–mediated inflammation.[10] The child should be watched in the postanesthesia care unit (PACU) after racemic epinephrine for at least 2 hours owing to rebound upper airway edema.

ESOPHAGEAL FOREIGN BODIES

Often when foreign bodies are ingested, they go unrecognized by parents and typically have no long-term effects. When the foreign bodies become retained in the esophagus or stomach, it is necessary to remove them using endoscopy. The most commonly ingested foreign body is a coin, followed by food or bones. Other foreign bodies include buttons, batteries, pins, safety pins, thumbtacks, and small toys.[11] Symptoms and signs of upper esophageal foreign body include dysphagia, drooling, gagging, and vomiting. Airway compromise can also occur and the child may exhibit symptoms of coughing or choking.

Preoperative Assessment

In addition to the usual preoperative assessment, physical examination should focus on the location of the foreign body. A potential major hazard exists if the ingested foreign body is held in the hypopharynx, and coughing or choking causes the foreign body to slip into the larynx, occluding the airway. Chest radiographs should be reviewed to determine where the foreign body ingested is located. If the child is not dyspneic, and the object is not hazardous to the esophageal or stomach mucosa (eg, disk battery), surgery should be postponed 4 to 6 hours after last meal. Although this may not be possible, the anesthesiologist should prepare for rapid securement of an airway. A peripheral intravenous catheter should be placed before arrival to the operating room.

Induction and Maintenance of Anesthesia

Upon entering the operating room all children should be monitored with the standard ASA monitors (as discussed). Before induction, the patient should be well-sedated, with the exception of a child with dyspnea. A rapid sequence induction should be performed if the patient is suspected of having a full stomach. If no intravenous access has been established, a smooth inhalational induction should be performed with endotracheal intubation after deep sevoflurane anesthesia or propofol, with or without muscle relaxation. Maintenance can be performed with an inhalational anesthetic supplemented with opioids. Special attention should be placed on making sure the endotracheal tube is secure so the endoscopist/surgeon does not accidently remove it during removal of the foreign body.

Postoperative Care

Depending on the age of the child and any intraoperative complications, most of these children can be discharged home after their PACU stay. A prospective review involving more than 50,000 general pediatric anesthetic cases revealed that the incidence of postintubation croup after esophagoscopy was 20 times higher than that of the general pediatric surgical population during the same time period (Moro, Borland, and Motoyama, unpublished observations). Dexamethasone intraoperatively or postoperatively (0.25–0.5 mg/kg to a max of 8 mg) may decrease the incidence of postoperative croup along with reducing the size of the endotracheal tube used during the surgery.[12]

APPENDICITIS

Acute appendicitis is a common condition that affects children most often between the ages of 10 to 19.[3] Signs and symptoms of appendicitis can vary quite a bit, which can account for a relatively high incidence of negative appendectomy. Children often present with right lower quadrant pain that originates in the periumbilical region. Other signs consistent with appendicitis include nausea/vomiting, anorexia, and a low-grade fever. Ultrasound and computed tomographic imaging have been used to help diagnose appendicitis. Although there is some urgency in making the diagnosis and surgically removing the appendix, the operation is never so urgent that a proper review of the patient's medical history and physical assessment cannot be performed.[13]

Preoperative Assessment

Concerns involving the electrolyte and fluid status of the child should be addressed during the preoperative period. A peripheral intravenous catheter should be placed and an attempt to correct any electrolyte disturbances and dehydration should occur before moving to the operating room.

Induction and Maintenance of Anesthesia

Upon entering the operating room, standard ASA monitors should be placed while the patient is adequately volume resuscitated. Regardless of NPO status an intravenous rapid sequence induction should be performed using Sellick's maneuver. Maintenance of anesthesia can be managed with inhaled anesthetic with supplementation of opioids and muscle relaxants.

Postoperative Care

Patients who are hemodynamically stable can proceed to the PACU where they can be monitored. Typically these children stay the night in the hospital and are monitored. Postoperative pain can be monitored and treated with intravenous medications.

INTUSSUSCEPTION

Intussusception most often affects children less than the age of 1. Most often, it is idiopathic in nature, and children present with abdominal pain, bloody stools, and an abdominal mass. Intussusception can also manifest with neurologic findings (lethargy, apnea, seizures, hypotonia, opisthotonus) similar to a picture of septic encephalopathy.[14]

Preoperative Assessment

Many times, children with intussusception have diarrhea and vomiting, resulting in severe dehydration. It is imperative that a peripheral intravenous line be placed before surgery to adequately hydrate the child and correct any electrolyte imbalance that exist. Plain radiographs of the abdomen will likely show multiple fluid levels. A nasogastric tube should be placed before entering the operating room and left to freely drain to help reduce the chance of aspiration. Laboratory tests should be drawn and blood should be readily available before entering the operating room. Often times these children can present in shock, which should be treated before the induction of anesthesia.[13]

Induction and Maintenance of Anesthesia

A child presenting with intussusception should be considered at risk for aspiration of gastric contents owing to the intestinal obstruction. After standard ASA monitors are placed, a rapid sequence induction should be performed after adequately hydrating the patient. If the patient is hemodynamically unstable, the anesthesiologist should use an intravenous induction agent such as etomidate or ketamine. After induction and placement of the endotracheal tube, the child should be maintained on inhalational agents with intravenous supplementation of opioids and muscle relaxant. Nitrous oxide should be avoided because it can significantly increase the size of the bowel lumen causing difficulty for the surgeon and possibly increasing intraabdominal pressures and decreasing the ability to ventilate the child adequately.

Postoperative Care

After surgery, a decision should be established whether the child should go to the PACU or to the intensive care unit for further monitoring. Typically, these patients can be extubated and monitored in the PACU before going to the floor for further observation. Abdominal surgery, however, is associated with increased intraabdominal pressure, which can cause an increase in respiratory insufficiency. The anesthesiologist should make sure the patient is awake and breathing adequately with full reversal of muscle relaxant before extubating the child.

POSTTONSILLECTOMY BLEEDING

Adenotonsillectomy is one of the most common surgeries performed in the pediatric population, with approximately 250,000 tonsillectomies performed each year in the United States alone. Although a rare occurrence (0.5%–2% of cases), postoperative bleeding can be a potentially serious complication. There are 2 types of bleeding that occur: primary bleeding and secondary bleeding. Primary bleeding occurs within the first 24 hours and is usually associated with inadequate surgical hemostasis. Bleeding is usually brisk and easily identifiable. Secondary Bleeding occurs most commonly between 5 and 10 days postoperatively, but it can occur up to 28 days postoperatively.[12] The cause of secondary bleeding can be attributed to the sloughing of eschar tissue. Bleeding is usually slow and steady over a few days.

Preoperative Assessment

Hypovolemia from blood loss and decreased oral intake owing to pain is commonly seen in children presenting for posttonsillectomy bleed. On physical examination, children commonly present with tachycardia, tachypnea, and hypotension. Capillary refill prolongation with pale skin and dry mucous membranes are other commonly seen physical characteristics. Laboratory values might show decreased hemoglobin levels; however, if the patient is severely dehydrated a normal hematocrit value might reflect dehydration. A peripheral intravenous catheter should be placed before heading to the operating room. Appropriate fluid resuscitation should begin before induction of anesthesia. All patients should be considered to have a full stomach, regardless of their NPO status. Two laryngoscopes and 2 suctions should be available and ready for use.

Induction and Maintenance of Anesthesia

A child presenting with postoperative tonsillar bleed should be considered a high risk for aspiration, and a rapid sequence induction is indicated. Before induction, it is imperative that the child be appropriately resuscitated with crystalloids or packed red blood cells, depending on the clinical signs and laboratory values. The appropriate induction medication should be chosen. If hypovolemia is an issue, etomidate or ketamine can be used effectively. If hypovolemia is not an issue, propofol may be used judiciously. Muscle relaxants should include succinylcholine or rocuronium. A difficult airway with poor visualization should be expected. It may be helpful to have an assistant hold a Yankauer suction device in the oropharynx during intubation to aid in obtaining better visualization of the airway. Placement of a cuffed oral endotracheal tube will help to protect the airway from aspiration. The patient can then be maintained on an inhalational anesthetic agent. It is helpful to obtain another large-bore intravenous catheter in case blood needs to be transfused during the procedure. Upon completion of the surgery, the patient should be fully awaken before extubation paying close attention to any rebleeding.

Postoperative Care

Patients should recover in the PACU after an awake extubation. If they were diagnosed with primary bleeding, they will continue to be at risk for rebleeding in the postoperative period. Laboratory values including coagulation studies should be drawn. Intravenous fluid administration should be continued and postoperative pain controlled. Stridor, and wheezing should be evaluated and properly treated. A chest radiograph might be indicated if wheezing is suspected to be from aspiration. Hospital admission may be indicated depending on how the child does in the postoperative period.

VENTRICULOPERITONEAL SHUNT

Hydrocephalus, the most common pediatric neurosurgical condition, involves a mismatch of cerebrospinal fluid production and absorption, leading to increased intracranial cerebrospinal fluid volume. The majority of cases of hydrocephalus result from obstruction of cerebrospinal fluid flow or inability to absorb cerebrospinal fluid appropriately.[13] Hydrocephalus can be further classified into 2 categories based on whether cerebrospinal fluid can flow around the spinal cord in its usual matter. Nonobstructive/communicating hydrocephalus allows for this normal flow, whereas obstructive/noncommunicating hydrocephalus impairs or inhibits normal cerebrospinal fluid flow. Symptoms of obstructive hydrocephalus include lethargy, vomiting, cranial nerve dysfunction, and bradycardia. If not treated quickly, death can ultimately occur.

Unless the etiology of the hydrocephalus can be definitively treated, treatment entails surgical placement of a ventricular drain or ventriculoperitoneal shunt.

Preoperative Assessment

Concerns involving the neurologic status of the child should be addressed during the preoperative period. Many of these patients present with lethargy and an altered mental status. Vomiting often occurs, resulting in electrolyte imbalances and dehydration. A peripheral intravenous catheter should be placed in an attempt to correct any electrolyte disturbances and for preparation of a rapid sequence induction.

Induction and Maintenance of Anesthesia

The approach to patients with symptomatic hydrocephalus should be directed at controlling intracranial pressure and rapidly relieving the obstruction.[15] After the preoperative assessment, the patient should be brought to the operating room where the standard ASA monitors should be placed, and a rapid sequence induction performed. After placement of the endotracheal tube, hyperventilation to an end-tidal CO_2 of about 25 to 30 mm Hg should be instituted immediately to help decrease intracranial pressure. The patient can then be maintained on inhalational agents with intravenous supplementation of opioids and muscle relaxants.

Postoperative Care

After surgery, a decision should be established whether the child should go to the PACU or to the intensive care unit for further monitoring. Typically these patients can be extubated and monitored in the PACU before going to the floor for further observation. The patient's mental status should be monitored because of the possibility of the reobstruction of the shunt, leading to life-threatening hydrocephalus.[15]

FACIAL FRACTURES

Trauma to the facial skeleton may result in 1 or more fractures and may require surgical fixation. Typical facial fractures include zygoma fractures, Le Fort II, Le Fort III, mandible, orbital, nasal, and panfacial fractures.[15] Other injuries are commonly associated with facial trauma. In 1 study, 25% of patients diagnosed with facial fractures had associated injuries, including limb, brain, chest, spine, and abdominal injuries. Up to 10% of these patients had a brain injury.[16] Of concern is the fact that many of the brain injuries can be missed because many of these patients exhibit no signs or symptoms of having any brain injury. Facial fractures involving the midface commonly result in airway compromise because of the displacement of the midface posteriorly into the oropharynx.[17]

Preoperative Assessment

In addition to the usual preoperative assessment, a complete trauma assessment should be conducted with particular attention paid to any airway pathology. Blood and secretions should be identified because of their ability to further obstruct the airway. Patients should be believed to have full stomachs, which provides a challenge for the anesthesia team. Children not properly fasted require either a rapid sequence induction or a sedated fiberoptic intubation. All patients with suspected or known cervical injuries require cervical immobilization.[17] A peripheral intravenous catheter should be placed before entering the operating room to allow for any sedation or possible rapid sequence induction.

Induction and Maintenance of Anesthesia

Depending on the extent of the trauma and injury to the facial bones, the anesthesia team needs to determine how difficult intubating the patient might be. With a full stomach, a rapid sequence induction should be performed; however, if the intubation seems to be challenging, an awake fiberoptic intubation may be necessary. Blood and other secretions make a fiberoptic intubation very difficult, if not impossible with the limited visibility. It is a good idea to have an ear, nose, and throat surgeon at the bedside during induction in case a tracheostomy needs to be performed. After securing an airway, the patient can be maintained with inhalational agents with supplementation of opioids and muscle relaxant.

Postoperative Care

After surgery, a determination needs to be made whether the patient should be further monitored in the intensive care unit or the PACU. The patient should be fully awake before extubating with good grip strength and a sustained head lift.

SUMMARY

The anesthesiologist must be prepared on a daily basis to care for children who need emergency surgery. An appropriate perioperative plan must be formulated and executed to ensure successful management of the child. This article outlines how to prepare and effectively manage common pediatric emergency surgeries.

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