Anesthetic management of children with recurrent, viral laryngeal papillomatosis: A case report

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The authors report the case of a 4-year-old boy who required anesthetic care during laser excision of respiratory papillomatosis. The perioperative issues surrounding this disease process are discussed including anesthetic induction in the patient with a compromised airway, maintenance anesthetic techniques, methods used for ventilation during laser surgery of the upper airway, and infectious disease risks to the operating room personnel. In addition, the psychological and emotional impacts of recurrent surgical procedures during childhood are addressed.

Key words: Laryngeal papillomatosis, laser surgery, pediatric anesthesia, plume emission, psychosocial, recurrent surgery.

Introduction
Respiratory papillomatosis is the most common tumor of the larynx in childhood. The etiologic agent is the human papillomavirus, a 0.045 μm deoxyribonucleic acid (DNA) virus, with a predilection for proliferation in epithelial tissue. It is believed to be acquired during the birth process as it is associated with maternal condylomata and is rare in patients born by cesarean section. Early age of onset tends to be associated with more aggressive and invasive disease, while spontaneous regression may be seen after puberty.

Although microscopic examination of the papilloma reveals a benign histology, involvement of the larynx, trachea, and bronchi may lead to life-threatening upper airway obstruction. Medical therapies, including bleomycin sulfate and interferon have met with varying degrees of success, and the primary therapy remains surgical, requiring repeated trips to the operating room for upper airway endoscopy and laser excision of the papillomas. During these repeated visits to the operating room, several important anesthetic issues must be considered, including induction techniques in a patient with upper airway obstruction, the psychological impact of repeated anesthetics and surgical procedures, and the infectious disease risk to the operating room personnel. We present a case and discuss the implications of this disease for the patient and the operating room personnel.

Case report
A 4-year-old boy with recurrent respiratory papillomatosis at age 2 months underwent direct laryngoscopy with carbon dioxide laser excision of the papillomas. The patient was well known to the operating room staff, having had 52 previous surgical procedures. The preoperative examination showed a very apprehensive child who spoke in a whisper. There was minimal suprasternal retraction and audible inspiratory stridor. Premedication was with oral midazolam (1 mg/kg).

After the premedication, the child was taken to the operating room by the anesthetist (the practice at our institution does not allow for parental
presence during anesthetic induction). Inhalation induction with halothane in 70% nitrous oxide and oxygen was accomplished with the child sitting on the nurse anesthetist's lap using a blanket to increase the concentration of halothane around his face. This technique was used because the patient has previously shown apprehension with use of the anesthesia mask. The induction was complicated by increased secretions and a brief period of breath-holding. Oxygen saturation remained in the mid-90s during induction. A 22-gauge intravenous catheter was placed in his left hand once a satisfactory level of anesthesia was attained. Maintenance anesthesia consisted of propofol infusion starting at 300 µg/kg/min for 10 minutes and then decreased to 150 µg/kg/min. Muscle relaxation was achieved with intermittent bolus doses of vecuronium bromide.

After direct laryngoscopy and visualization of the supraglottic structures, the trachea was intubated with a 3.5-mm aluminum-wrapped red rubber endotracheal tube (Rusch Medical Products, Duluth, Georgia). Breath sounds were not heard, and the endotracheal tube was removed. A papilloma occluding the end of the endotracheal tube was noted. Rigid bronchoscopy was performed, and no distal foreign body was noted. Following endotracheal intubation with a 4.5-mm polyethylene tube, breath sounds were absent on the right. The rigid bronchoscopy was repeated several times to clear the airway (a total of 7 rigid bronchoscopies for the case). This was followed by direct laryngoscopy and surgical excision of the papillomas with the carbon dioxide laser. During direct laryngoscopy, jet ventilation was used.

Following the procedure, the trachea was intubated with a 4.5-mm endotracheal tube. A chest x-ray in the operating room revealed right upper lobe atelectasis. Diffuse expiratory wheezes were heard. Albuterol was administered through the endotracheal tube from a metered-dose inhaler, which resulted in clearing of the bronchospasm. The residual neuromuscular blockade was reversed, the trachea was extubated, and the patient, breathing spontaneously on supplemental oxygen, was transported to the postanesthesia care unit. A follow-up chest x-ray showed resolution of the right upper lobe atelectasis, and the patient was discharged to home 4 hours later.

Discussion

- General principles. Children with laryngeal papillomas (incidence 1,400-2,000 cases each year in the United States) are fairly commonplace to the practice of pediatric anesthesiology. This case highlights several of the important anesthetic management issues, including the psychological impact of repeated anesthetic and surgical procedures, the anesthetic management of an upper airway obstruction, the mode of ventilation during laser surgery on the upper airway, and the infectious disease risk of the papillomavirus to the operating room personnel.

Psychological issues. Children are repeatedly stressed, not only by the nature of the disease, but also the need for repetitive surgical and anesthetic intervention. There is limited information concerning the psychological impact of this disease process. Two reports in the literature refer to significant psychological disturbances, including one anecdotal report of a presumably disease-related suicide after 24 years of treatment. Both of these studies are retrospective and were not intended to look for psychological disturbances. The first reported two of 17 patients with psychological disturbances, while the second, which involved 101 patients treated at the Mayo Clinic between 1914 and 1960, lists the suicide with causes of mortality, but does not report about psychological disturbances in other patients.

Previous experiences may lessen our chances of success with our usual induction techniques. Rosen et al found children, who were 4 years of age or younger or who had previous anesthetics, were less able to cooperate no matter what technique of induction was used. Therefore, alternative plans must be in place when the usual inhalation induction by mask with halothane is ineffective or impossible. A minor alteration in our usual technique allowed us to accomplish inhalation induction in our patient. We have found that many children fear the mask after repeated anesthetic inductions. Alternative techniques such as using a cupped hand or a blanket to surround the patient may allow for inhalation induction without the mask.

The anesthetic management should be tailored to the child's developmental level and stage. According to the Piaget theory of childhood development, preschoolers cannot think like older children do and do not have the capacity for logical systematic thought. This makes them more likely to misinterpret situations. They may attribute life to inanimate objects and exhibit magical thinking. Illness may be explained in terms of closeness of objects or events. Children at this age perceive themselves as victims of the illness and may think they are being punished.

According to Erickson, preschoolers are different from 8-year-olds not only because of differing levels of cognitive development, but also because at different ages they are dealing with different issues in their emotional development.
Issues relevant to each age must be resolved before dealing with successive age-related issues. Children who do not resolve issues related to trust and control may have difficulties in their ability to develop confidence in self, initiate activities, and develop mastery of intellectual, social, and physical skills. In children with a chronic health problem, such as papillomatosis, their cognitive level and age-related issues of emotional development are important considerations to provide care while not hindering development.

Ideal management would promote the cognitive, emotional, and developmental growth of the children at the same time physical health needs are being met. Preschoolers, such as the one presented, who are preoperational (Piaget) and in the initiative-versus-guilt stage (Erickson), are now subjected to frequent uncomfortable and frightening procedures, during which they have little control. Children's support systems may be varied and will be absent during a time when unfamiliar hospital personnel wearing masks and hats will be asking them to do strange and often uncomfortable things. Children in this age group are likely to have magical thinking or animism (attribute life to inanimate objects). They may easily feel overwhelmed and stressed beyond their ability to cope, resulting in regressive, clinging, and hostile behavior. Nightmares related to anesthesia and surgery are documented in the literature, and they have become a problem in this patient population.

Visintainer and Wolfer, in their study of psychological preparation for pediatric surgical patients, concluded that even in younger children the need for information and the need to maintain control are important in coping with stress. In addition to a description of the events that are to occur, which should be based on the child's cognitive development, a description of “how it feels” and “what it is like” are also important. Ways to increase a preschooler's sense of control can include providing choices. Age must be considered in offering choices. Generally, a 4-year-old can handle choices, while a 2-year-old cannot. Examples of possible choices for a 4-year-old include mask or intravenous induction, the choice of flavoring for the mask, or choosing a favorite toy to bring into the operating room. Other options to provide support include empowering the parent and child by providing information and support and individualized play therapy, such as acting out an event using dolls. Allowing parents into the operating room had been suggested as a means of alleviating some of the perioperative stress, although this practice and its effects on patient and parents remain controversial.

To deal with such issues, we have found it useful to have a special file for children that require frequent anesthetic interventions. By doing this, we are trying to provide more individualized care to such patients. The file includes notes about what has worked and not worked during previous anesthetics. A detailed record of the premedication is kept so adjustments can be made when needed. The file on this particular patient stresses the need to avoid the mask during induction and the use of intravenous metoclopramide hydrochloride to prevent nausea and vomiting. We also try to address continuity of care by assigning the same anesthetics personnel whenever possible. We try to convey to these patients and their families that we feel their situation is unique because they require repeated general anesthetics and surgeries.

- Anesthetic care: Premedication and induction.

The use of inhalation induction techniques presents problems in children requiring repeated anesthetics because they may grow to fear the mask despite premedication with oral midazolam in doses that work for the majority of patients. The introduction of EMLA® cream (eutectic mixture of local anesthetics—lidocaine 2.5% and prilocaine 2.5%) to provide topical dermal anesthesia before venipuncture may offer a way of avoiding the pain of venipuncture and allowing intravenous induction. In fact, we have found greater success in subsequent experiences with our same patient by allowing the mother to apply the EMLA cream at home, and then we insert an intravenous line prior to induction.

Effective premedication is of utmost importance in such patients, not only to decrease the psychologic trauma of the procedure but also to allow a smooth induction in the presence of upper airway obstruction. One caveat is that the use of premedication may be limited by the patient's respiratory status. Premedication should only be administered under close observation and perhaps not at all if airway compromise is an issue.

Although oral midazolam is commonly used on our unit, we have found that many children who need frequent anesthetics may have difficulty swallowing oral medications or may vomit shortly after administration because of emotional upset. The difficulties with oral premedication are highlighted by our case, as our patient was reluctant to accept the medication, spit up part of the dose, and was still somewhat tearful during transport to the operating room. Gastrointestinal disturbances are fairly common with this group of patients, and many will vomit enroute to or after arrival at the hospital. Alternatives to oral premedication include rectal, transmucosal (i.e., nasal or sublin-
While rectal midazolam has been shown to be an effective premedication, it may be developmentally inappropriate for a patient such as the 4-year-old whose case is presented here. Nasal midazolam, another alternative for premedication, bypasses the gastrointestinal system. However, due to the presence of benzyl alcohol in the preparation, many patients complain of burning and they cry when the medication contacts the nasal mucosa. The current technique, which has been successful in our patient for subsequent anesthetics, includes the use of EMLA cream and the preoperative establishment of intravenous access using intravenous midazolam as the premedication.

The technique of anesthetic induction depends on the patient's airway status. We recommend an inhalation induction with halothane in nitrous oxide and oxygen, with spontaneous ventilation, even if intravenous access has been established prior to anesthetic induction. Other inhalational anesthetic agents are more irritating to the airways than halothane and may increase the risk of laryngospasm. The use of 100% oxygen may be necessary in patients with severe airway compromise. Another option for the patient with severe airway compromise is the administration of halothane in a 70% helium-oxygen mixture. The density of helium is less than that of oxygen or nitrous oxide, and as a result, the viscosity of the gases is decreased, thereby increasing the flow around an obstruction.

Regardless of the combination of gases, maintenance of spontaneous ventilation and avoidance of neuromuscular blocking agents are important until the demonstration of adequate assisted bag or mask ventilation. Additionally, the otolaryngologist should be in the room to aid in the establishment of a surgical airway in the rare instance that this becomes necessary. At our institution, following anesthetic induction, our current practice is to allow the surgeon to proceed with direct laryngoscopy before instrumentation of the airway. This may be particularly relevant in patients with laryngeal papillomas, as the endotracheal tube may dislodge a papilloma as occurred with our case. Before instrumentation of the airway, the administration of intravenous lidocaine (1-2 mg/kg) and glycopyrrolate (0.005 mg/kg) can be used to decrease airway irritability and block vagal reflexes. A single intraoperative dose of dexamethasone (0.5 mg/kg to a maximum of 20 mg) is administered to limit airway swelling and edema.

Anesthetic care: Maintenance anesthesia. Once induction is completed, the next decisions involve placement of an endotracheal tube and the mode of ventilation to be used. Advantages of placement of an endotracheal tube during laryngoscopy include securing the airway, protecting the lower airway from particulate matter produced during the laser procedure, controlling and monitoring ventilation, and allowing administration of volatile anesthetic agents such as halothane. Disadvantages of endotracheal tube placement include obscuring the upper airway and, most importantly, the risk of combustion of the endotracheal tube during laser use.

Regardless of the type of laser used, the major risk of this procedure is endotracheal tube ignition, which has been reported to occur in 0.5% to 2.0% of cases. The endotracheal tube may be ignited by direct laser illumination, reflected laser ignition, or by ignited particles from the surgical site. Regardless of the cause, if the fire is unrecognized, it may burn through the endotracheal tube and ignite the gas flow, resulting in an airway fire. Prevention of this complication includes limiting the inspired fraction of oxygen to less than 0.40. This should be done by diluting the inspired gases with air or helium, because although nitrous oxide decreases the inspired oxygen concentration, it does not significantly alter the flammability of the gas flow.

Aside from decreasing the fraction of inspired oxygen, the other means of decreasing the risk of airway fire is with the use of endotracheal tubes with limited combustibility. Of the commonly used tubes, red rubber and polyvinylchloride, the latter are more combustible. Further protection may be obtained by wrapping the red rubber tube with metallic tape. Although this will not protect the cuff, it will protect the remainder of the tube. Several investigators have attempted to identify the most effective tape to protect the tube from inadvertent laser damage. Copper tape provides the most ignition protection from all three types of lasers (carbon dioxide, neodymium: yttrium-aluminum-garnet (Nd:YAG), and potassium-titanyl-phosphate-KTP-Nd:YAG). Two additional types of endotracheal tubes have been used during laser surgery: a metal endotracheal tube and a silicone-aluminum impregnated tube. Because of size constraints, the former is not commonly used in the pediatric population. The latter contains an outer coating impregnated with an aluminum-silica powder. Regardless of the type of tube used, it should be remembered that resistance to combustion is only relative, and airway fires have been reported even with the use of the silicone-aluminum impregnated tube.

An alternative means of limiting the risk of airway fire is to avoid the use of an endotracheal
tube during laser use. Several options have been suggested for this technique. One method is to intermittently remove the endotracheal tube during laser use. For this procedure, the patient is anesthetized with intravenous agents and ventilated with 100% oxygen. The endotracheal tube is removed for brief periods (60-90 seconds) while the patient's oxygen saturation is monitored by pulse oximetry. Laser surgery is performed during the periods of apnea. The tube is then replaced, the patient ventilated, and the procedure repeated as needed.

Jet ventilation may also be used during laser surgery and is currently our favored mode of ventilation. For this procedure, the patient is anesthetized with intravenous agents, and a catheter is placed above the glottic opening or through a side channel in the operating laryngoscope. The jet is connected to an oxygen source with a driving pressure of 50 psi. Ventilation and oxygenation occur by intermittently opening the system and allowing the pressurized oxygen to pass through the tubing and catheter to the patient. The jet ventilator's adjustable reducing valve that regulates pressure should be set before the case. It is important to limit inspiratory time to that required to just lift the chest and allow time for expiration. Usual pressures require a range from 15-25 psi (the wall outlet pressure is approximately 50 psi). The position of the injection needle or catheter in the operating laryngoscope is critical. Adequacy of ventilation and oxygenation are monitored by watching chest excursion, auscultation of breath sounds with a precordial stethoscope, and monitoring oxygen saturation by pulse oximetry. Complications of jet ventilation include pneumothorax, barotrauma, pneumomediastinum, gastric distension, aspiration of tissue being resected, and drying of mucosal surfaces.

With alternative means of ventilation during laryngoscopy, intravenous anesthetic agents are frequently used because jet ventilation precludes the use of the common inhalational anesthetic agents. Our current practice is to switch to intravenous propofol following inhalation induction. The use of preset pumps for propofol administration may be invaluable, because they not only provide continuous drug levels but also free the anesthesia provider's hands when operating a manually triggered jet ventilator. Several valid options exist for neuromuscular blockade including intermittent doses of vecuronium or the continuous infusion of mivacurium chloride. We prefer the use of shorter acting agents, because the duration of the procedure tends to vary.

A combination of airway management techniques may be required to allow the surgeon access to different areas of disease involvement. In the case presented, three types of airway management were used, including apneic ventilation during the initial evaluation of the airway, endotracheal intubation with an aluminum-wrapped red rubber tube (with a helium-oxygen gas mixture), and jet ventilation during the microlaryngoscopy.

One of the major causes of morbidity related to upper airway laser surgery is airway fire. Such morbidity can be lessened by having a preconceived plan to deal with this complication. If an airway fire occurs, the gas flow should be discontinued and the patient's trachea extubated. Reintubation should then proceed, followed by direct inspection of the upper and lower airway to assess the degree of damage. Patients with significant airway trauma should be treated with systemic corticosteroids and remain intubated for airway protection. Upper airway endoscopy and bronchoscopy are recommended to evaluate the degree of airway damage and the most appropriate time for extubation.

Other risks during laser surgery relate to inadvertent reflection of the laser, with ocular damage to the patient or operating room personnel. With the carbon dioxide laser, the patient's eyes should be covered with wet eye patches, and protective goggles are mandatory for the operating room personnel.

Other considerations in this case are cross-contamination and environmental pollution from the laser smoke and plume emission. Clean and soiled work areas must be clearly defined. Often laryngoscopes are passed to the surgeon and then passed back to the anesthetist or anesthesiologist. Clearly, not only the blades but also the handles must be disinfected. Laryngoscope handles do not lend themselves to disinfection, and the authors have, for several years, been covering the handles with a disposable glove, which is removed and replaced with a clean one after the handle is wiped with a disinfectant. Currently, the handles are covered with disposable plastic wrappers that are commercially available from several different companies.

Current literature and ongoing studies are focusing on the danger of inhaling smoke and particles during laser surgery. This may be a hazard not only for the patient but also for the operating room staff. A vortex action suction, which clears 40 cu ft per minute should be held 1-2 inches from the laser site. Such suctions are commercially manufactured; however, the commonly used wall suctions do not meet these standards. Laser emissions that are suctioned should be filtered through
a charcoal filter for smoke and odor, then filtered of particulate matter. High efficiency particulate air filters have minimum standards of 99.97% efficiency, capturing particles of 0.3 μm and larger. These filters must be changed and maintained according to the manufacturer's recommendations. (Several references on the subject of hazards of smoke and plume aerosols have been compiled by Stackhouse Incorporated, 2059 Atlanta Avenue, Riverside, California.) Special masks, which filter down to 0.1 or 0.3 μm, should be worn by operating room personnel. One such mask is the Barrier laser plume face mask (Johnson & Johnson Medical Inc., Arlington, Texas). The standard operating room mask filters down to only 5 μm and larger.

Although concerns over laser emissions may at first seem exaggerated, live viral particles have been demonstrated in the plume emission. While no definitive studies exist concerning direct human-to-human transmission, Hallomo and Naess describe a surgeon who had provided laser treatment to patients with anogenital condylomas, who subsequently developed laryngeal papillomatosis. Viral particles do not travel through the air by themselves, but on the larger particles that are present in the plume. These particles may be as small as 0.1 μm. When inhaled, particles of this size may be deposited in the alveoli. Aside from the inhalation of the viral particles, laser byproducts including benzene, naphthalene, formaldehyde, acrolein, and polycyclic aromatic hydrocarbons are carcinogenic. As such, the need for effective scavenging of the laser exhaust is readily apparent.

**Conclusion**

The anesthetic management of recurrent respiratory papillomatosis in children requires knowledge of the disease process and operative procedures used to treat it. These include upper airway endoscopy with carbon dioxide laser and the use of alternative modes of oxygenation, encompassing jet ventilation. To provide for the safety of the patient and operating room staff, appropriate measures to prevent airway fire and laser burns and to lessen the possibility of inhalation of laser smoke and plume must be implemented. To optimize care, knowledge of the emotional and cognitive developmental needs of children and sensitivity to the individual psychological impact of frequent surgical procedures needs to be considered.

While we have concentrated on the preoperative and intraoperative care of these patients, the postoperative care cannot be omitted. Following successful laser excision of the papillomas, airway patency is generally returned to normal. Following reversal of residual neuromuscular blockade, the patient's trachea is extubated in the operating room. Although close observation of the child's respiratory status is suggested for 4-6 hours, residual airway compromise is uncommon, and most patients can be discharged to home. Implications for future study include psychological issues related to this disease. A multi-institution study is needed to report on populations large enough to generate statistically significant data, as this information is not available in the literature.

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