Pediatric Respiratory Complication After General Anesthesia With Exposure to Environmental Tobacco Smoke in the Home: A Case Report

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In 2005, the World Health Organization estimated that 57.2% of children were exposed to environmental tobacco smoke (ETS) in the home. Studies show that children who are exposed to ETS are more prone to airway and pulmonary complications perioperatively.

A 4-year-old healthy girl, weighing 12.7 kg, who had dental caries presented for general anesthesia for a full mouth restoration. Pertinent history included a remote history of bronchitis after an upper respiratory tract infection, with no current use of inhalers or other medications. Further assessment revealed that the patient had been exposed to cigarette smoke in the home since birth by both parents. After induction of general anesthesia, the patient experienced a respiratory complication and the surgical procedure was canceled.

The literature provides numerous studies on the anesthetic risks associated with pediatric patients with long-term exposure to ETS. Research suggests the importance of a thorough anesthetic preoperative evaluation to reduce the risks of respiratory complications by educating parents on the detrimental effects of exposing their children to ETS. The purpose of this report is to present information about long-term ETS exposure in the pediatric population and to expand the body of literature on the topic.

Keywords: Anesthesia, pediatric, respiratory complications, tobacco.

Environmental tobacco smoke (ETS) is a combination of 15% mainstream smoke, which is filtered by the primary smoker's lungs, and 85% side stream smoke, which is the smoke that comes from the end of the burning cigarette.[1,2] Tobacco smoke contains more than 6,000 chemicals, many of which are potentially toxic to humans.[2] In 2005, the World Health Organization estimated that 23.9% of Americans over age 15 years smoke cigarettes,[3] and 57.2% of children were exposed to ETS in the home.[4] Studies show that children who are exposed to ETS are more prone to airway and pulmonary complications perioperatively.[5-7] These complications include laryngospasms, perioperative cough, hypoxemia, and bronchospasm.[5] This report describes an untoward event involving a healthy child with long-term exposure to ETS who underwent general anesthesia for an elective dental procedure and experienced a perioperative respiratory complication. Although cause and effect cannot be proved, an association with ETS was compelling.

Case Summary

A 4-year-old girl, weighing 12.7 kg, who had dental caries presented for dental restoration, to be performed using general anesthesia. The preoperative anesthesia evaluation revealed a healthy-appearing child, and the medical history showed a remote history of bronchitis from an upper respiratory tract infection. She was not currently taking any medications. The preoperative evaluation indicated no recent upper respiratory tract infection, nasal discharge, or cough nor any problems in utero or during childbirth. The patient had no chronic illnesses, and all immunizations were current. Further questioning of the patient's mother revealed that the patient had been exposed to cigarette smoke in the home since birth by both parents. A preoperative physical assessment revealed normal heart tones, clear lung fields bilaterally, and multiple dental caries. The patient's clothing and hair had the odor of cigarette smoke.

The patient was taken to the operating room without sedation. An inhalation induction was performed with a 70% nitrous oxide–30% oxygen (O_2) mix and with sevoflurane incrementally increased every 2 breaths from 2% to 8%. Once the patient was adequately anesthetized, the nitrous oxide was discontinued, and 100% O_2 and 8% sevoflurane was administered. The patient was easily ventilated by mask, and routine monitors were in place; a 22-gauge peripheral intravenous catheter was placed in the patient's left hand. Initial vital signs were noted as blood pressure of 88/42 mm Hg, heart rate of 132/min, respirations of 32/min, skin temperature of 36°C, O_2 saturation of 99%, and end-tidal carbon dioxide (CO_2) measurement of 30 mm Hg.

Propofol (20 mg) and fentanyl (20 µg) were administered intravenously to provide for optimal intubating conditions. The calculation of "(years of age + 16)/4" was used to determine the appropriate endotracheal tube size. A successful nasal intubation was accomplished with a grade 1 view during direct laryngoscopy and a 5.0-mm uncuffed nasal endotracheal tube (NETT). The patient had equal and bilateral breath sounds upon auscultation, a positive end-tidal CO_2 tracing, and the presence of condensation in the NETT. There was noted to be an air leak at approximately 15 cm H_2O. The NETT was secured, and manual ventilation through the tube was performed. The patient's vital signs remained stable, and tidal volumes in the 8 mL/kg range were delivered with peak inspiratory pressures of approximately 18 cm H_2O. The inhalation agent, sevoflurane, was decreased to 3%, with an end expiration of 2.3%. Oxygen and nitrous oxide were both adjusted to 1 L/min of flow.

Within 5 minutes of intubation, the patient returned to spontaneous but shallow respirations, with tidal volumes in the 2 to 4 mL/kg range. It was becoming more difficult to obtain tidal volumes greater than 6 mL/kg while assisting the patient's ventilatory effort. Wheezing and coarse lung sounds were auscultated through the precordial stethoscope. Nitrous oxide was discontinued, and 100% O_2 was administered at 2 L/min. On the thought that the patient's anesthetic level was inadequate, an additional 5 mg of propofol and 10 µg of fentanyl were administered intravenously. During this difficult ventilation period, vital signs included blood pressure of 78/36 mm Hg, pulse of 135/min, spontaneous respirations of 40/min, an O_2 saturation of 94%, end-tidal CO_2 measurement of 46 mm Hg, skin temperature of 36°C, and peak inspiratory pressures of approximately 45 cm H_2O. Auscultation with a stethoscope confirmed bilateral, equal breath sounds with coarse and diffuse wheezing. There was no tracheal deviation.

Initially the patient's NETT was suctioned, and a moderate amount of white phlegm was removed. Although suctioning did decrease the coarseness of the patient's lung sounds, the wheezing continued. An albuterol nebulizer treatment was given with minimal and short-term resolution of wheezing. In the few minutes following the albuterol treatment, the patient's lung sounds worsened, and a substantial increase in wheezing and coarseness was noted. Dexamethasone (4 mg) was administered intravenously. Although it was becoming easier to assist the patient's ventilatory efforts and her O_2 saturation was improving, the procedure was canceled and the patient was awakened.

The inhalation agent was discontinued, and 100% O_2 was administered. At the time anesthesia was discontinued, the patient's vital signs included blood pressure of 82/55 mm Hg, pulse of 95 beats/min, spontaneous respirations of 18/min, an O_2 saturation of 96%, skin temperature of 36.2°C, end-tidal CO_2 measurement of 44 mm Hg, and peak inspiratory pressures of approximately 36 cm H_2O.

The patient was allowed to awaken slowly. Once the patient was fully awake, the NETT and oropharynx were suctioned, and an uneventful extubation ensued. The patient was placed on mask-administered O_2 at 10 L/min and exhibited increased coughing and continuous wheezing upon auscultation.

The patient spent a total of 1 hour and 45 minutes in the dental surgical clinic. At the time of discharge, the patient's vital signs included blood pressure of 89/48 mm Hg, pulse of 120/min, spontaneous respirations of 18 breaths/min, and O_2 saturation of 95% on room air. The patient continued to wheeze and cough.

The decision to cancel the procedure and discontinue anesthesia was primarily due to lack of immediate resources should the patient experience a major complication. The dental clinic is a freestanding clinic, and in the event of a major adverse event or the need for more extensive medical care, emergency medical services (EMS) needs to be called to transport the patient to a tertiary facility. It is the policy of the clinic to provide anesthesia services only to children who are healthy the morning of the planned procedure. Approximately 30% of the cases are canceled the day of anesthesia because of symptoms of an upper respiratory tract infection, such as wheezing, congestion, or fever.

After ruling out all other possible causes of this untoward event in this patient, the author believes a major factor that could have precipitated this event was the patient's exposure to ETS in the home. The patient ultimately had her dental restoration performed in an ambulatory surgery unit in the hospital 2 months later while under general anesthesia, without major incident. At the time of the second anesthetic, the patient did experience wheezing and increased peak pressures, and she required frequent treatments with an albuterol inhaler and suctioning. The patient had an extended stay in the recovery room before being discharged home. It is the opinion of this author that the anesthetics provided at the dental clinic and the ambulatory surgery unit were similar and the only difference was that the patient was in an acute care setting and an overnight observation was available if needed.

Discussion

In healthy lungs, the bronchial epithelium is an integrated structure that consists of ciliated cells, goblet cells, and basal cells.[8] Each of these cells have a role in the body's defense against infection. Injury to the epithelium from tobacco smoke has been described in many studies.[2,6,8,9] Once the epithelium is activated by tobacco smoke, basal cells release inflammatory cytokines that may result in systemic inflammation. Other respiratory system changes seen with exposure to ETS include hypersecretion of mucus, impaired tracheobronchial clearance, and small airway narrowing, with increased closing capacity.[9] Exposure to ETS may also increase reflex sensitivity of the lower and upper airways.[9]

Primarily, ETS is a product of the burning end of the cigarette, known as sidestream smoke. Sidestream smoke contains high concentrations of more than 6,000 substances, including ammonia, cyanide, benzene, nicotine, heavy metals, and carbon monoxide as well as many carcinogens.[3-5] Carbon monoxide is of particular concern because it is an exogenous poison that binds hemoglobin with a much higher affinity than O_2 and therefore displaces O_2 from hemoglobin, leading to hypoxia.[10,11] When carbon monoxide binds with a heme site, the oxygen on the other heme sites bind with a greater affinity. This will make it difficult for the hemoglobin to release the oxygen to the tissues, shifting the oxyhemoglobin curve to the left.

Children, because of their smaller size and developmental stage, may be more susceptible than adults to the harmful byproducts of sidestream smoke.[4] The direct effects of these substances include airway irritation involving immunologic mechanisms and mutagenesis.[2] O'Rourke et al[5] found that the total deposition of particles in the lungs of children may be 50% greater than in adults who are exposed to ETS because of the differences in airway caliber. Children who are exposed long term to ETS are 3.5 times more likely to have airway and pulmonary complications such as laryngospasm, bronchospasms, wheezing, coughing, stridor, increased mucus production, and O_2 desaturation following anesthesia than are non–ETS-exposed children.[5]

In 1999, the World Health Organization estimated that almost 50% of children worldwide were exposed to ETS.[5] Many studies found in the literature regarding childhood exposure to ETS describe its adverse effects on the general health as well as the implications of ETS exposure on children undergoing general anesthesia.[1,5-9,12-15] Many respiratory and nonrespiratory diseases have been linked to exposure to ETS, and children are especially vulnerable to the negative health effects.[13]

Cook et al[16] and Nuhoglu et al[17] performed pulmonary function tests (PFTs) on children exposed to ETS. Both research groups found the greatest effects were on midexpiratory flow rates, with a 5% reduction, and on end-expiratory flow rates, with a reduction of 4.3%. Forced expiratory volume in 1 minute was reduced by only 1.4%.[16,17] O'Rourke et al[5] conducted a study of children exposed to ETS vs children not exposed to ETS who were undergoing general anesthesia for similar surgical procedures. For each group, PFTs were performed before general anesthesia and in the recovery room. The authors found the ETS-exposed group to have a lower mean preoperative peak expiratory flow rate, but these otherwise healthy children did not have worse outcomes.[5] In the recovery room, the ETS-exposed group's PFTs were 8% to 14% worse than preoperative values.[5] Children exposed to ETS demonstrated hyperreactive airway and increased respiratory tract infections.[7]

There are several nonrespiratory diseases, including atopic eczema, hay fever, and dental caries, which may occur in children exposed to ETS.[5] Otolaryngologic diseases such as otitis media with effusion, chronic rhinitis, adenotonsillar hypertrophy, snoring, and obstructive sleep apnea also occur more frequently in children exposed to ETS.[2,13,14] Exposure to ETS has many negative effects on the cardiovascular system, including platelet activation, endothelial dysfunction, inflammation, atherosclerosis, increased oxidative stress, decreased energy metabolism, and increased insulin resistance.[12] Patients exposed to ETS over a long time may demonstrate adverse cardiovascular effects similar to those of long-term active smokers.[12] Children who are exposed to ETS have been found to have lower levels of high-density lipoprotein (HDL) cholesterol, which may increase risk of heart disease.[18,19]

Studies have shown that there is an increased risk of respiratory complications perioperatively with children who are exposed to ETS. A study in Ireland performed by Lyons et al[7] found that pediatric patients exposed to ETS had more frequent episodes of desaturation in the recovery room compared with pediatric patients not exposed to ETS. These investigators hypothesized that increased airway resistance and greater closing capacities may result in ventilation/perfusion mismatching, increased alveolar-arterial O_2 difference, and hypoxemia.[7]

Lakshmipathy et al[15] performed a retrospective cohort study of pediatric patients having outpatient surgical procedures, finding a 10-fold increase in laryngospasm during emergence from general anesthesia in children exposed to ETS. Other respiratory complications related to ETS and general anesthesia include perioperative cough, hypoxemia, and bronchospasm.[5] Jones and Bhattacharyya[13] found ETS-exposed children to have more intraoperative, anesthesia-related airway complications. However, they found no statistically significant difference between ETS-exposed children vs non–ETS-exposed children in the recovery room.[13]

A thorough preoperative anesthesia assessment that includes questions related to exposure to ETS has the potential to improve patient outcomes and enhance patient safety.[5,13,15,20] The preoperative anesthetic assessment could include a discussion with parents and/or guardians of pediatric patients about the physiological changes that occur during anesthesia when long-term exposure to ETS is encountered. Suggestions can be made to parents concerning ways in which they can limit their child's exposure to ETS before surgery. This dialogue may go a long way in preventing the adverse sequelae caused by this ubiquitous and detrimental hazard.

The literature provides numerous studies on the risks associated with pediatric patients exposed to ETS and suggests the importance of a thorough anesthetic preoperative evaluation.[5,13,15,20] Currently, most pediatric patients do not routinely have a preoperative anesthesia assessment until the day of surgery, thereby eliminating any opportunity to limit the patient's exposure to ETS. There is a paucity of literature examining anesthesia-related interventions that may assist the anesthesia provider in caring for a patient with long-term exposure to ETS when the patient presents for the first time on the day of surgery.

This case report is not intended to represent an irrefutable cause and effect relationship between ETS and the observed patient events. Rather, it was intended to provide the anesthesia provider with information and insight into the unfortunate, yet common, situation of long-term ETS exposure in children. Another intention was to possibly stimulate further research aimed at discovering treatment modalities that improve pediatric patient care and outcomes when persistent ETS exposure is identified the morning of surgery.

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