Anesthesia management in pediatric patients with laryngeal papillomatosis undergoing suspension laryngoscopic surgery and a review of the literature

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1. Introduction

Laryngeal papillomas are benign epithelial tumors that are caused by infection with the human papilloma virus (HPV). Although papillomas can occur at any age, they most commonly affect the larynx and the upper respiratory tract of children aged 1–4 years, resulting in hoarseness, stridor, obstruction of the airway and asphyxiation if left untreated. The leading cause of HPV infection in children is due to infection from the birth canal or the blood of the infected mother [1]. Mucosa injury, chronic inflammatory stimulation, endocrinopathy, deficiencies in the immune function, malnutrition, and unclean health habits can also lead to the disease. Although papillomas rarely become cancerous, their location and marked tendency for recurrence make the disease both dangerous and troublesome. Papillomas recur often and occasionally spread to the hypolaryngeal vestibules, the epiglottis, and occasionally the trachea and lungs [2], which may also lead to head-and-neck cancers [3]. Because of the exophytic growth of the papillomas in the narrow pediatric airway, severe laryngeal obstruction may repeatedly occur. Many children are treated as outpatients and require numerous procedures throughout their childhood to remove the tumors one to two times a month as they reappear [4].
To date, although human papilloma virus vaccinations [5], intralesional cidofovir [6], and propranolol [7] may serve as new adjunctive treatments in children with aggressive recurrent respiratory papillomatosis, there are no specific and effective treatments for recurrent pediatric laryngeal papillomatosis. Surgical removal of tumors at frequent intervals to relieve the symptoms of airway obstruction remains the primary choice of management [8]. Some children with severe airway obstruction may even need a tracheotomy. The most important consideration for anesthesia is to maintain a patent airway during surgery and assure adequate ventilation and surgical exposure. As such, the excision of laryngeal papillomas poses a great challenge for both the anesthesiologist and the surgeon. Because anesthesia and surgery share the same airway, establishing an effective airway for both anesthesia and surgery is very difficult. The special measures necessary for securing the airway include thorough preoperative airway evaluation, the appropriate choice of the anesthesia induction method, and careful intraoperative and postoperative airway management.

In this report, we review the techniques and strategies used for preoperative airway management in pediatric patients with laryngeal papillomas undergoing suspension laryngoscopic surgery at our institution between January 2007 and December 2010.

2. Patient information

The anesthesia and surgical records of fifty-eight patients were reviewed. Approval was obtained from the hospital’s Human Research Committee. Informed consent was obtained from parents or legal guardians before the anesthetic and surgical procedures. The patient group consisted of 33 boys and 25 girls, with ages ranging from 2 months to 10 years (with an average of 40.5 years) and weights ranging from 6 to 22 kg (with an average of 9.5 kg). The patient group consisted of 33 boys and 25 girls, with ages ranging from 2 months to 10 years (with an average of 4.04 years) and weights ranging from 6 to 22 kg (with an average of 9.5 kg). The operation time ranged from 15 to 70 min (with an average of 20.5 min). Most patients presented with different degrees of hoarseness or aphonia, significant laryngeal stridor, and dyspnea. No tracheotomies were performed before surgery.

3. Anesthesia methods

The aim of this study was to determine how to maintain spontaneous respiration in combination with topical anesthesia of the upper airway to allow the surgeon complete access to the upper airway without interference from trachea intubation or interruption for oxygenation [9]. Anesthesia was induced by midazolam (0.1 mg kg$^{-1}$), sufentanyl (0.1–0.2 μg kg$^{-1}$), and propofol (1–2 mg kg$^{-1}$), intravenously administered after preoxygenation. Laryngeal obstruction should be attached great importance after anesthesia induction because of the laryngeal muscle relaxation, papillomas prolapse and increased secretion. Five minutes later, when the depth of anesthesia was appropriate (as determined by the presence of rapid shallow respirations and small central pupils) and the Spo2 were kept stable and safe enough, a 2% lidocaine aerosol solution was sprayed over the laryngeal area under direct laryngoscopy. The spray frequency was synchronized with the patient’s spontaneous breathing to ensure the effectiveness of the local anesthesia. At this stage, periods of laryngospasm [10] or apnea were treated by an additional propofol injection and successful manual mask ventilation. Then, the suspension laryngoscope was slowly placed into position while maintaining a low flow (1–2 l min$^{-1}$) of oxygen through a tracheal tube (ID 2.5 or 3.0) which was placed close to glottis and connected to the Jackson Rees ventilation system. Oxygen provision and auxiliary breathing could be guaranteed by this method. The airway was secured safely. Anesthesia was maintained with a target-controlled infusion of propofol (6–8 mg kg$^{-1}$ h$^{-1}$). If the operation time lasted for more than 45 min, a target-controlled, moderate infusion of remifentanil (1 μg remifentanil:1 mg propofol) was preferred.

The patient was still deeply anesthetized at the end of the surgical intervention. The suspension laryngoscope was removed while the patient was under anesthesia. In the recovery room, humidified oxygen was administered to the patient via a face mask. The patients were sent to the recovery ward until they fully regained consciousness, sufficient spontaneous breathing, active deglutition, and a cough.

4. Monitoring

Electrocardiograms, noninvasive blood pressure measurements, and pulse oximetry were continuously recorded with a Datex-Ohmeda surgical monitor. In addition, the ventilation was observed clinically by auscultation of the lungs, skin color, and observation of thorax excursions. Side effects, such as laryngospasm and pulmonary hypertension due to upper airway obstruction, were also recorded.

5. Statistical analysis

All data are expressed as the average value ± standard deviation. All data were analyzed with SPSS for Windows 13.0 using a one-way analysis of variance (ANOVA) and the Bonferroni correction for

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Table 1
Criteria for grading laryngeal obstruction preoperatively.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Clinical symptom</th>
<th>Chest auscultation</th>
<th>Heart rate (beats/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Dyspnea and inspiratory stridor appear only in exercise; sleeping and eating are not influenced; no dysphoria</td>
<td>Clear breath sound</td>
<td>Normal</td>
</tr>
<tr>
<td>II</td>
<td>Dyspnea and inspiratory stridor appear at rest and are aggravated by exercise; sleeping and eating are not influenced; no dysphoria</td>
<td>Throat conduction sound and bronchial breath sound</td>
<td>120–140</td>
</tr>
<tr>
<td>III</td>
<td>Obvious dyspnea and inspiration laryngeal stridor; signs of cyanosis in lips, fingers, and toes; signs of a concave superciliary fossa; sleeping and eating are influenced; dysphoria</td>
<td>Breath sounds are clearly reduced</td>
<td>140–160</td>
</tr>
<tr>
<td>IV</td>
<td>Severe dyspnea, cyanosis, disorientation, coma, and exhaustion; reduction in blood pressure</td>
<td>Almost absent</td>
<td>Faint, low, blunt</td>
</tr>
</tbody>
</table>

Table 2
Criteria for tonsil hypertrophy.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Clinical symptom</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Tonsils do not exceed the pharynx palatal bow</td>
</tr>
<tr>
<td>II</td>
<td>Tonsils exceed the pharynx palatal bow</td>
</tr>
<tr>
<td>III</td>
<td>Tonsils exceed the posterior midline wall</td>
</tr>
</tbody>
</table>
using oxygen delivered by a face mask at a flow rate of 2 l min

necessary SpO2 of the two patients.

tubation was required in two patients
llaryngeal obstruction was repeatedly caused by them, a tracheot-

6.3. Intraoperative management

6.2. Anesthesia induction

Spontaneous breathing was maintained after anesthesia induction in most patients. However, six patients required tracheal intubation and controlled ventilation because of difficulties in maintaining spontaneous breathing and necessary SpO2 levels.

6.3. Intraoperative management

With spontaneous breathing maintained by a low flow of oxygen, most of the patients safely underwent papillomatosis excision with a suspension laryngoscope.

However, because the papillomas grew in the subglottics and laryngeal obstruction was repeatedly caused by them, a tracheotomy with endotracheal intubation was required in two patients respectively. After anesthesia recovery, the two patients were extubated. The appropriate concentration and flow of oxygen could be given from the place of tracheotomy to guarantee the necessary SpO2 of the two patients.

Because of edema in the glottis and uvula caused by repeated surgical procedures and vocal cord movement, one patient suffered from laryngospasm, laryngeal obstruction, breathing difficulties, hypoxia, cyanosis, and cardiac arrest. After cardiopulmonary resuscitation, the SpO2 of the patient was maintained above 95% using oxygen delivered by a face mask at a flow rate of 2 l min⁻¹. Finally, the patient was recovered and discharged.

6.4. Postoperative situation

The dyspnea and hoarseness (such as breathlessness, stridor, three concave superexternal notch and supravacular fossa during inspiration, and lip cyanosis) of most patients were improved considerably in the postoperative period. One patient had to be sent to the ICU for comprehensive therapy because of airway obstruction caused by edema of the glottis and uvula.

7. Discussion

Laryngeal papillomas can lead to hoarseness, laryngemphraxis, and inspiratory dyspnea due to eroding of the vocal cords and airways. Removal of papillomas under the laryngoscope is one of the most widely used treatments. However, anesthesia management is often difficult in pediatric patients because of an obvious stress reaction, poor tolerance to anoxia, frequent relapse, proneness to fall off, scar contracture, and throat antrum stricture after multiple operations. Meanwhile, anesthesiologists and surgeons have to share the same narrow airway. In addition to these factors, most children suffered from different degrees of tonsil hypertrophy. This increases the difficulty of maintaining an open airway. From extensive experience, we have found that the ideal anesthesia for laryngeal papillomas removal is to ensure effective ventilation, maintain spontaneous respiration [11], maintain suitable anesthesia depth to reduce throat reflection and a cardiovascular response, and quickly awaken the patients. It is necessary to avoid any factors that can aggravate laryngeal obstruction and breathing difficulty and to resolve any possible complications.

Before administering anesthesia, adequate preoperative preparation is essential. Preoperative preparations, including examination and evaluation of the patient before an anesthesiologist’s intervention, are important for the management of the patients because induction of general anesthesia may result in total obstruction of the airway due to the laryngeal muscle relaxation, papillomas prolapse and increased secretions. All patients with laryngeal papillomas suffer from anoxia caused by different degrees of laryngeal obstruction. As a result, it is wise to assess whether airway obstruction can threaten life and prepare a plan for the related airway management in advance [12]. This plan should address the anatomy of the respiratory tract, treatment of airway injuries such as bleeding and edema, and how to treat a change from partial airway obstruction to complete one. Attention should be paid to advanced preparation of not only surgical tools for tracheal intubation and tracheotomy but also drugs and equipment for cardiopulmonary resuscitation.

With respect to premedication, it is advantageous to use moderate doses of some sedatives. However, the inhibition of respiration and the effect of the sedative on the respiratory tract must be considered. Anticholinergic drugs, such as atropine and penehydine hydrochloride, may be used to decrease secretions.

Both inhaled and intravenous anesthetics can be used to anesthesia induction. For inhalation induction, Li et al. [8] reported inhalation of 8% sevoflurane with an oxygen flow of 4 l min⁻¹. However, TIVA is preferred on most occasions because inhaled analgesics have obvious stimulation effects on the airways, and the face mask is often stressful for the patients and may cause dysphoria and/or dyspnea. Usually, midazolam, small doses of sufentanil and propofol are chosen. We do not advocate using gamma-hydroxybutyrate (GHB) or ketamine. GHB, which causes deep sedation, has a slower onset and long-lasting effects and is not suitable for short surgeries. It is difficult to manage a patient’s breathing with deep sedation. Additionally, the long-lasting effects of GHB have adverse effects on recovery because of the suppression of physiological reflexes, such as coughing. Ketamine should also be avoided because it increases respiratory secretions and tends to induce laryngospasm.

As far as the muscle relaxants were concerned, we do not advocate using them because muscle relaxants interrupt breathing and necessitate intubation through the mouth or nasal passages. Avoiding muscle relaxants therefore prevents damage to the tumor, complete respiratory obstruction, and difficult postoperative extubation. When intubation is unavoidable, it is wise to use it

Table 3
The perioperative changes in HR, MAP, and SpO2.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Before anesthesia induction</th>
<th>At the beginning of the operation</th>
<th>10 min after the beginning of the operation</th>
<th>At the end of the operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>HR (per min)</td>
<td>134.7±25.7</td>
<td>134.6±14.9</td>
<td>140.4±18.9</td>
<td>128.2±10.7</td>
</tr>
<tr>
<td>MAP (mmHg)</td>
<td>66.9±10.1</td>
<td>68.4±9.1</td>
<td>66.3±12.1</td>
<td>65.5±9.7</td>
</tr>
<tr>
<td>SpO2 (%)</td>
<td>94.4±3.5</td>
<td>95.7±5.9</td>
<td>94.9±4.6</td>
<td>98.7±4.8</td>
</tr>
</tbody>
</table>

HR, heart rate; MAP, mean blood pressure; SpO2, pulse oxygen saturation.

* P < 0.05 vs. before anesthesia induction.
as soon as possible and choose the smallest possible tracheal catheter. Both vecuronium and cisatracurium besilate were preferred. Before inserting the laryngoscope, a 2% lidocaine solution was used to spray the throat for topical anesthesia of the mouth and throat. Five minutes later, a 2% lidocaine solution was used to spray the epiglottis and subglottic region. This step is the most crucial. If the local surface anesthesia is sufficient, the child’s reaction to the suspension laryngoscope is minimal, which reduces the occurrence of laryngospasm and helps to avoid tracheal intubation.

Continuous intravenous infusion of propofol and fentanyl was used to maintain anesthesia and provide a sufficient level of anesthesia. Remifentanil and propofol was the best anesthetic compatibility.

There are four ventilation strategies commonly used in endoscopic laryngeal surgery including spontaneous ventilation, mechanical controlled ventilation, apneic intermittent ventilation and subglottic jet ventilation [12]. It is recommendable to keep spontaneous breath during the operation. If the airway obstruction is severe, slow induction of anesthesia and careful intubation is required. Conventional ventilation via a tracheal tube is the safest technique during pediatric anesthesia, but it is inadequate for endoscopic surgery in the larynx or trachea because the tracheal tube can impede the operating field [13]. Additionally, papillomas easily grow and diffuse during the intubation process. Intermittent tracheal intubation results in hypventilation with hypercarbia. Jet ventilation carried too great a potential for airway trauma.

After the operation, blood and secretions of the laryngeal should be completely removed to avoid their aspiration into the distal airway. Oropharyngeal ventilation can be used for patients with glossocoma to maintain the SpO2 above 95%. After the patients are sent to the recovery ward, their vital signs still need continuous monitored. Treatments to prevent infection and laryngeal edema are also necessary at this stage.

Whether tracheotomy should be used to treat patients with laryngeal papillomatosis is controversial. However, intubation is necessary before performing a tracheotomy. We believe that tracheal intubation and tracheotomy are not the preferred method for treating laryngeal papillomatosis because the intubation process may promote tumor growth and diffusion. Additionally, the insertion of a catheter stimulates the occurrence of endotracheal granulation, tracheal stenosis, and tracheal obstruction. Performing a tracheotomy can also easily cause subcutaneous emphysema, pneumomediastinum or tracheoesophageal fistulas, choking, coughing, and wound infections [14]. Meanwhile, the incision site for the tracheotomy may cause the formation of a functional zone and promote the growth of papillomas around the stoma and in the trachea [15].

Grobbelaar et al. [16] reported three patients with pulmonary hypertension due to upper airway obstruction caused by laryngeal papillomatosis. Pulmonary hypertension can contribute to significant preoperative and postoperative morbidity and cause intraoperative complications. Although the patients of our research study did not have pulmonary hypertension, the preoperative diagnosis and treatment of pulmonary hypertension is essential in this population. There are two mechanisms that may lead to pulmonary hypertension. The first results from the hypoxemia and hypercarbia associated with upper airway obstruction. The second is due to the increased sympathetic activity associated with hypoxemia and hypercarbia. Preoperative echocardiography to determine whether pulmonary hypertension is present is therefore now part of our routine preoperative evaluation of children with laryngeal papillomatosis.

References