Laryngeal Mask Airway Is Associated with an Increased Incidence of Adverse Respiratory Events in Children with Recent Upper Respiratory Tract Infections

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Background: The laryngeal mask airway (LMA) has been advocated as an alternative technique to tracheal intubation for airway management of children with recent upper respiratory tract infections (URIs). The authors determined the occurrence of adverse respiratory events and identified the associated risk factors to assess the safety of LMA in children.

Methods: During a period of 5 months, parents of children scheduled to undergo general anesthesia with an LMA were asked to fill out a questionnaire regarding their child's medical history and potential symptoms of URI. In addition, all episodes of adverse respiratory events in the perioperative period (laryngospasm, bronchospasm, coughing, airway obstruction, and oxygen desaturation) as well as details of anesthesia management were recorded.

Results: Among the 831 children included in the study, 27% presented with a history of a recent URI within the last 2 weeks before anesthesia. The presence of a recent URI doubled the incidence of laryngospasm (odds ratio, 2.6; 95% confidence interval, 1.3–5.0), coughing (odds ratio, 2.7; 95% confidence interval, 1.7–4.3), and oxygen desaturation (odds ratio, 1.9; 95% confidence interval, 1.2–2.8). This incidence was even higher in young children; in those undergoing ear, nose, and throat surgery; and when there were multiple attempts to insert the LMA.

Conclusion: An LMA used in children with recent URIs was associated with a higher incidence of laryngospasm, cough, and oxygen desaturation compared with healthy children. However, the overall incidence of adverse respiratory events was low, suggesting that if anesthesiologists allow at least a 2-week interval after a URI, they can safely proceed with anesthesia using an LMA.

UP to 40% of children presenting for anesthesia have a recent upper respiratory tract infection (URI).[1–3] Although there is an increased risk of perioperative respiratory complications after a recent URI,[1,4–7] anesthesiologists often proceed with their management for two reasons: It is uncertain how long to postpone the procedure after a URI, and there are adverse economic and

emotional impacts resulting from cancellation of the procedure.[2,8] Nevertheless, URI leads to airway hyperresponsiveness that results in a higher incidence of adverse respiratory events, a major cause of morbidity and mortality during pediatric anesthesia, with hypoxemia, laryngospasm, and bronchospasm being the most frequently reported courses.[9–13]

To reduce the incidence of respiratory adverse events, the laryngeal mask airway (LMA) has been suggested as an alternative to tracheal intubation in children with a recent URI.[14,15] The potential reduction in laryngeal stimulation by the LMA might explain the fewer adverse respiratory events reported,[14–17] but there are no studies systematically comparing the risk profiles of LMA use in children with and without a recent URI. Moreover, the time interval between URI and anesthesia in the reported analyses of risk factors varies largely (between 2 and 6 weeks), rendering conclusions regarding identification of individual risk factors difficult.[4,18,19]

Therefore, we prospectively evaluated the safety of LMA in children with recent URIs (less than 2 weeks before anesthesia). In addition, we characterized the risk factors leading to an increased incidence of adverse perioperative events.

Materials and Methods

After approval by our institutional scientific and ethics committee, we included over a 5-month period a cohort of children undergoing general anesthesia with an LMA for elective surgical or diagnostic procedures at the Princess Margaret Hospital for Children, Perth, Australia. These children were detected by the research fellow on the surgical list based on the kind of surgery and the potential for an LMA. After oral informed consent, all parents received a survey questionnaire on admission of the child inquiring about the occurrence of a recent URI, including the exact point in time of the URI (whether it was in the past 2 weeks) and the symptoms involved (clear or green runny nasal secretions, fever >38°C, dry or moist cough). Depending on the presence of a recent URI, the children were classified into two groups: with URI and without URI based on the confirmation by the parents of the presence of a cold independent of any other associated symptom.

In all patients, additional information was requested that might indicate other risk factors for adverse respiratory events, including a medical history of asthma or

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asthma medications within the past year; nocturnal dry cough persisting more than 2 weeks in the past year; any history of allergies or hay fever; and the possibility of passive smoking, which was defined as the exposure of the child to more than five cigarettes per day inside the house or the car. The questionnaire was collected before surgery. After clinical examination of the child, the anesthesiologist in charge, independent of the study team and unaware of the contents of the questionnaire, chose the anesthesia management with the placement of the LMA being at his complete discretion.

For each child, the following additional data on anesthesia management were recorded: experience of the anesthesiologist in charge (registrar or consultant), type of surgery, preanesthetic medication, induction agents (inhalation or intravenous), and maintenance of anesthesia (including use of narcotics or regional anesthesia). Furthermore, information was collected on the size and type of the LMA (classic or reinforced), the use of topical lidocaine as a lubricant, the number of attempts before successful insertion, and information on the removal of the LMA (during deep anesthesia or awake).

All adverse respiratory events, including their point in time (after induction of anesthesia, before LMA insertion, on insertion, during surgery, on or after LMA removal), were documented prospectively throughout the perioperative period by the anesthesiologist in charge of the patient. These adverse respiratory events included all episodes of laryngospasm, airway obstruction, bronchospasm, oxygen desaturation (<95%), and coughing. Laryngospasm was defined as complete airway obstruction associated with muscle rigidity of the abdominal and chest walls, unrelieved by the jaw-thrust maneuver and necessitating the application of positive airway pressure, combined with a deepening of the anesthetic level and possibly necessitating the administration of succinylcholine. Airway obstruction was defined as the presence of partial airway obstruction in combination with a snoring noise and respiratory efforts without deep desaturation (<95%). This airway obstruction was easily relieved by the jaw-thrust maneuver and eventually an oral airway. Bronchospasm was defined as the occurrence of an increased respiratory effort, especially during expiration, associated with hypercapnia and oxygen desaturation, wheeze on auscultation, and an increase in the slope of the carbon dioxide curve within the plateau phase. Finally, any episode of severe and/or sustained cough was considered as an adverse event.

After their operations, all the children were admitted to the postanesthesia care unit, and oxygen was administered if the oxygen saturation on air was less than 95%. The occurrence of any of the aforementioned adverse respiratory events and the total time of stay in the postanesthesia care unit were recorded by the recovery nurse in charge of the patient.

Table 1. Demographic and Medical History of Children with and without a Recent Upper Respiratory Tract Infection

Variable	Without URI (n = 608)	URI (n = 223)	P Value*
Age, mean (SE), yr	6.9 (0.18)	5.1 (0.27)	<0.0001*
Weight, mean (SE), kg	26.4 (0.71)	21.8 (1.01)	<0.0001*
Male sex, %	63.9	32.3	0.325
History of asthma, %	16.1	22.0	0.052
Nocturnal chronic cough, %	11.2	15.7	0.096
History of allergy, %	17.3	16.6	0.917
Passive smoking, %	17.4	21.5	0.191
Symptoms of URI, %			
Fever	3.9	18.4	<0.0001
Dry cough	9.0	32.3	<0.0001
Moist cough	6.4	29.1	<0.0001

* P value from Mann–Whitney U test; other P values from Fisher exact test. URI = upper respiratory tract infection.

Statistical Analysis

Descriptive analyses were completed using SPSS 14.0 for Windows (SPSS Inc., Chicago, IL) and by applying the Mann–Whitney U test for continuous variables and Fisher exact test for categorical variables to compare differences between the groups of children without URI *versus* children with URI. Considering that some event rates were small, statistical power was calculated and was found to be satisfactory, thus allowing a reasonable interpretation of the results. Univariate logistic regression analysis was first applied to identify the risk factors for each complication in all children. To avoid the problem of multiple testing (which greatly increases the probability of declaring false significances), univariate P values were adjusted by step-down Bonferroni method using the SAS system for Windows version 9.1 (SAS Institute, Cary, NC). To test the joint effects of potential risk factors, a multiple logistic regression analysis was used stepwise by including risk factors that were significant at a P level of less than 0.2 during univariate methods. In addition, the potential correlation between the predictor factors was also taken into account. The significance of the model and the possible interactions between the different risk factors were tested by using a likelihood ratio test. Data are shown as univariate and adjusted odds ratio (OR) with 95% confidence interval (CI). A P value less than 0.05 was considered statistically significant.

Results

During the 5-month period studied, 831 patients had anesthesia management that included an LMA insertion for elective surgical or diagnostic procedures. Table 1 summarizes the demographic data and the medical history of all children divided into the two groups. Their overall incidence of a recent URI that occurred within 2 weeks before admission to our institution was 27%.

Table 2. Incidence of Respiratory Complications in the Two Groups of Children

	No URI, % (n = 608)	URI, % (n = 223)	OR	95% CI	*P* Value
Overall complications in the perioperative period					
Laryngospasm	3.1	7.6	2.558	1.305–5.016	0.007†
Bronchospasm		0.9	—	—	0.072
Airway obstruction	7.1	6.3	0.880	0.472–1.642	0.759
Oxygen desaturation	11.4	19.3	1.863	1.228–2.825	0.004†
Cough	7.5	17.9	2.730	1.728–4.313	<0.0001*
Overall‡	19.1	31.8	1.981	1.401–2.803	<0.0001*
Intraoperative complications					
Laryngospasm	3.5	6.9	2.044	1.005–4.157	0.069
Bronchospasm		1.0	—	—	0.073
Airway obstruction	4.7	4.4	0.926	0.426–2.012	1.000
Oxygen desaturation	2.6	5.0	1.972	0.861–4.513	0.107
Cough	4.6	8.9	2.008	1.071–3.766	0.034
Overall‡	9.5	15.2	1.713	1.063–2.760	0.035
Complications in the recovery room					
Laryngospasm	0.3	1.9	5.561	1.011–30.589	0.047
Bronchospasm			—	—	—
Airway obstruction	3.5	3.4	0.966	0.402–2.319	1.000
Oxygen desaturation	10.3	18.3	1.944	1.248–3.027	0.005†
Cough	4.6	14.0	3.409	1.955–5.942	<0.0001*
Overall‡	14.7	25.4	1.978	1.342–2.916	0.001*

* *P* < 0.05 after the correction by step-down Bonferroni method.   † *P* < 0.08 after the correction by step-down Bonferroni method.   ‡ Overall = percentage of individuals having at least one specific complication.

CI = confidence interval; OR = odds ratio; URI = upper respiratory tract infection.

The procedures performed were orthopedic (23%); urologic (18%); plastic surgery (14%); ear, nose, and throat surgery (ENT) (10%); ophthalmology (9%); lower abdominal (8%); and miscellaneous (18%). The anesthesiologist was a trainee in 69% of the cases. Midazolam was given in only 14% and 17% of the children with and without recent URI, respectively. The majority of children had an intravenous induction (68%), with propofol being the most commonly used agent (92%), whereas 32% had an inhalational induction with sevoflurane. Maintenance of anesthesia was mainly by volatile agents.

Most of the children received a classic LMA (89%), whereas a reinforced LMA was used in 11% of the cases with no differences between the two groups. Lidocaine gel was used in 17% and 19% of the children with and without recent URIs, respectively. The LMA sizes inserted were size 1 (0.1%), size 1.5 (6%), size 2 (44%), size 2.5 (27%), size 3 (21%), and size 4 (0.6%). The success rate of a first attempt insertion of the LMA was 90%; 8% of the LMAs were inserted on the second attempt, and 2% after that. While the children were still deeply anesthetized, 96% and 92% of the LMAs were removed from the children with and without URIs, respectively, and there was no difference between the groups.

Perioperative Adverse Respiratory Events

The incidences of adverse respiratory events in children with and without URI are shown in table 2. During the intraoperative period, there was a clear tendency to an increased risk of laryngospasm and oxygen desaturation, but the ORs did not reach statistical significance. Given the limited number of subjects, low-frequency events were likely underpowered to prove a statistical difference (*i.e.*, the power was 0.4 and 0.55 for airway obstruction and laryngospasm, respectively). However, in the recovery room, the risks for laryngospasm, oxygen desaturation, and coughing were significantly higher in children with URI.

The univariate analyses for risk factors associated with the occurrence of perioperative respiratory adverse events are given in table 3. A history of a recent URI was associated with an increased risk of respiratory complications (OR, 2.0; 95% CI, 1.4–2.8). This risk even increased in children with recent URI when multiple attempts to insert the LMA were required (OR, 4.06; 95% CI, 1.7–9.8) and when ENT surgery was performed (OR, 2.6; 95% CI, 1.1–6.5).

Multivariate logistic regression method was used only to study the risk factors for all (any) complications in case of all children. We used in the multivariate model the variables that were shown by the univariate analysis as being significant or a *P* value less than 0.2 with no missing values. These variables were URI, age, clear runny nose, green runny nose, fever, moist cough, LMA size, lignocaine, and number of attempts. Forcing these nine variables into a multivariate model gave spurious results because of possible correlations between independent variables. The correlation of these nine parameters was examined by Spearman rank correlation coefficient. High correlation was found between age and LMA size ($r = 0.763$, $P < 0.0001$) and between URI and clear runny nose ($r = 58$, $P < 0.0001$). Only one variable was kept from these pairs; also, number of attempts was not considered as an independent risk factor. The first multivariate model contained the re-

Table 3. Odds Ratios and 95% Confidence Intervals for the Risk Factors Associated with the Occurrence of Perioperative Respiratory Adverse Events

	Univariate		Multivariate First Model		Multivariate Final Model	
	OR	CI	OR	CI	OR	CI
URI	**2.0***	**1.4–2.8**	1.777†	1.107–2.854	1.828†	1.3–2.6
Age	**0.9***	**0.8–0.9**	0.953†	0.915–0.992	0.95†	0.91–0.98
ENT surgery	1.3	0.8–2.2				
Asthma	1.19	0.8–1.8				
Nocturnal cough	1.20	0.7–1.9				
Allergy	0.95	0.6–1.5				
Passive smoking	0.89	0.6–1.4				
Clear runny secretions	**1.53**	**1.1–2.1**	1.052	0.657–1.682		
Green runny secretions	**1.79**	**1.0–3.2**	1.465	0.748–2.869		
Fever	1.59	0.9–2.8				
Dry cough	1.26	0.8–2.0				
Moist cough	1.46	0.9–2.3	1.052	0.626–1.768		
LMA size	**0.62**	**0.5–0.9**				
Reinforced LMA	1.18	0.7–2.0				
Lignocaine	0.69	0.4–1.1	0.702	0.443–1.113		
Number of attempts	**3.06***	**1.9–5.0**				
Consultant	0.95	0.7–1.4				
Inhalational induction	1.21	0.8–1.6				
Propofol induction	0.89	0.6–1.3				
Thiopentone induction	1.02	0.5–1.9				
Midazolam	1.35	0.8–2.2				
Opioid	**1.47***	**1.0–2.2***				
Removal of LMA						
Deep *vs.* awake	0.70	0.3–1.5				

* $P < 0.05$ after the correction by step-down Bonferroni method. † $P < 0.05$, Wald test.

CI = confidence interval; ENT = ear, nose, and throat; LMA = laryngeal mask airway; OR = odds ratio; URI = upper respiratory tract infection.

maining six variables as shown in table 1. The stepwise procedure using the likelihood ratio test confirmed that only age and URI were significantly associated with complications, whereas the other variables did not add any additional significant information to the model. Moreover, the interaction of age by URI was not significant. Several attempts have been made by forcing other variables into the model, but none significantly improved the model.

Applying a multivariate logistic regression to estimate the joint effect of possible risk factors showed that age was an independent risk factor. Therefore, younger children were more prone to adverse respiratory events, and their risk increased in the presence of a recent URI.

Discussion

This study demonstrated that in the presence of a recent URI, a high incidence of adverse respiratory events was observed in children managed with an LMA. A medical history of recent URI in the 2 weeks before anesthesia approximately doubled the risk of laryngospasm, oxygen desaturation, and coughing both intraoperatively and particularly in the recovery room. This risk was further increased in younger children and in children undergoing ENT surgery.

The timing of the peak incidence of an adverse respiratory event in relation to the occurrence of URIs remains controversial.[4,16,17,19] It has been suggested that children with nasopharyngitis should wait only 1–2 weeks after cessation of symptoms to minimize any potential morbidity,[20] whereas other studies have shown that the peak incidence of adverse respiratory events is between 2 and 4 weeks after a URI.[19] The current study, so far the largest of children with URI receiving an LMA, did not demonstrate any increase incidence of adverse respiratory events in children with a reported runny nose in the 2–4 weeks before anesthesia (18.2% *vs.* 19.4% for children with no URI; $P = 0.983$). Therefore, our results suggest that the peak of adverse respiratory events was in the children with a URI within the 2 weeks before anesthesia, when bronchial hyperreactivity is expected to be the highest because of acute airway inflammation. Although there seems to be a controversy in the literature regarding the timing for the anesthesia care after a URI in children,[20,21] the recent recommendations suggest to wait 4 weeks before proceeding.[2] Considering the high incidence of URIs in the pediatric population[20–22] and the lack of objective data on bronchial hyperresponsiveness after URI in children, the current results suggest that anesthesiologists can expect less adverse respiratory events when proceeding with anesthesia using an LMA by waiting at least 2 weeks after a URI.

The LMA has been advocated as an alternative tool for airway management in children with a URI because of its

apparent lack of laryngeal stimulation. Comparisons to date have been between LMA and/or endotracheal tube and/or facemask. There are no studies comparing large numbers of healthy patients with children exhibiting a recent URI using an LMA for intraoperative airway management. Moreover, the incidence of adverse respiratory events in children with URI is controversial. Some studies suggest that anesthesia for the patient with a URI increases the risk of laryngospasm,[23,24] bronchospasm,[5,7] atelectasis,[25] and arterial oxygen desaturation,[1,26] whereas others suggest that children with an acute, uncomplicated URI have no increased morbidity.[1,18,27] The results of the current study demonstrated that the overall incidence of adverse respiratory events was significantly lower than those reported in smaller studies of children with recent URIs.[14,15]

One of the most relevant anesthesia complications in children is laryngospasm. In the current study, independent of whether a URI was present, the overall incidence of laryngospasm (4%) was similar with those reported with or without the use of an LMA.[17,28–30] However, and in agreement with previous reports, the use of LMA in the presence of a recent URI increased significantly the incidence of perioperative laryngospasm with an OR of 2.6 (95% CI, 1.3–5). This OR was even higher when the child had a moist cough and/or fever as reported by the parents. Nonetheless, the incidence of perioperative laryngospasm in children with recent URIs (7.6%) was lower than that reported in the literature.[15,17] Viral infections interact with the cholinergic and nonadrenergic noncholinergic autonomic nervous systems.[31,32] This could have caused mechanical stimulation of the upper airways to enhance laryngeal reflexes leading to laryngospasm as reflected in the increased incidence when multiple attempts to insert the LMA were needed. In addition, we also found that children undergoing ENT surgery exhibit an even higher risk of laryngospasm particularly in the presence of a recent URI (OR, 4.0; 95% CI, 1.1–14),[30] probably because of the intense stimulation of the upper airway during surgery. However, although ENT surgery increased the incidence of laryngospasm, a reinforced LMA (commonly used during ENT procedures) had no significant influence on the occurrence of adverse events. Finally, age was a risk factor for laryngospasm, because younger children (and accordingly smaller LMA size) had an increased incidence (OR, 0.9; 95% CI, 0.8–0.9). Neither the method of induction nor the time of LMA removal (deep *vs.* awake) significantly affected the incidence of laryngospasm (power analysis of 0.12 and 0.25, respectively), whereas previous studies have reported controversial results.[4,33–37] This difference might be due to the limited number of patients; therefore, low-frequency events such as laryngospasm were likely underpowered to prove a statistical difference. Surprisingly, and in contrast to previous reports, the incidence of laryngospasm was similar for all

anesthesiologists. This could reflect the presence of an experienced pediatric anesthesiologist at induction and emergence from anesthesia whenever a trainee was doing the procedure and therefore might have prevented the occurrence of laryngospasm.

As reported, the use of an LMA was not associated with an increased incidence of bronchospasm despite the presence of airway hyperresponsiveness. This suggested that airway stimulation by an LMA is restricted to the upper airway and does not include the trachea, as occurs with an endotracheal tube; this favors the use of an LMA.[15] Unlike other adverse respiratory events, coughing is controversial because it is a subjective symptom and its direct impact on morbidity remains unclear. However, coughing was significantly more frequently associated with the use of a reinforced LMA, several attempts to place the LMA, and when anesthesia management was performed by a registrar. These risk factors were expected to be identified by the univariate analysis because they are often associated with minor airway mucosal trauma. Finally, we found no other risk factors related to the patient's medical history that predicted adverse respiratory events.

The most common adverse event was oxygen desaturation, which was significantly higher in children with URI (OR, 1.9; 95% CI, 1.2–2.8), where almost 20% of children required oxygen in the recovery room. Nonetheless, there were no differences in the number of children who had a recent URI and healthy children with regard to the duration of oxygen delivery and stay in the recovery room (data not shown). However, the incidence of oxygen delivery was even higher when children received premedication with midazolam or opioids during anesthesia, suggesting that respiratory depression contributed to the large number of children who required supplemental oxygen in the recovery room. It was unlikely that airway obstruction contributed to oxygen desaturation, because only a small number of children experienced this problem, which was primarily observed in younger children with the use of a small LMA.

In the current study, the choice of airway management was not randomized but decided by the anesthesiologist in charge of each patient. Consequently, different surgical factors might have influenced the decision to intubate the trachea (type of surgery, prone position) or to use another airway strategy rather than inserting an LMA. Our prospective approach was chosen to observe routine clinical practice without interfering with implemented anesthetic protocols. Moreover, we included all patients with a history of URI independent of the underlying pathogen but excluded children whose symptoms indicated lower respiratory tract infections.

In summary, LMA used in children was associated with a relatively low incidence of adverse respiratory events. However, the current study revealed that the use of an LMA

in children with a recent URI (<2 weeks) enhances the risk of adverse respiratory events, especially laryngospasm, cough, and oxygen desaturation. All adverse respiratory events were easily managed, and there were no adverse sequelae. Our results show that anesthesia management with the use of an LMA in children more than 2 weeks after a URI is a safe technique and seems to be a suitable time interval for elective surgery in such children.

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