INCIDENCE OF LARYNGOSPASM AND ASSOCIATED FACTORS AMONG PEDIATRIC PATIENTS WHO UNDERGO SURGERY IN TIKUR ANBESSA SPECIALIZED AND MENELIK HOSPITALS, ADDIS ABABA, ETHIOPIA,2023/2024: A PROSPECTIVE CROSS-SECTIONAL STUDY

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A RESEARCH THESIS ON THE INCIDENCE OF LARYNGOSPASM AND ASSOCIATED FACTORS AMONG PEDIATRIC PATIENTS WHO UNDERGO SURGERY UNDER GENERAL ANESTHESIA, A PROSPECTIVE CROSS-SECTIONAL STUDY IN TIKUR ANBESA SPECIALIZED HOSPITAL AND MENELIK HOSPITAL, ADDIS ABABA ETHIOPIA,2023/2024:

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Abstract

Background: Laryngospasm is a reflex closure of the upper airway caused by a spasm in the glottis muscle, which can lead to imminent respiration. Laryngospasm can happen at any stage of anesthesia. Laryngospasm causes increased morbidity and death as a result of hypoxia and hypercapnia. However, there has been little research into laryngospasm incidence and associated variables among children patients undergoing general anesthesia in Ethiopia.

Objective: To assess the associated factors of laryngospasm and its incidence among pediatric patients who undergo surgery under general anesthesia in Tikur Anbessa specialized and Menelik referral hospitals from November 1, 2023 to May 1, 2024.

Method: An institutional based cross-sectional study was conducted among pediatric patients who underwent surgery under general anesthesia in Tikur Anbessa specialized hospital and Menelik referral hospital, from November 1, 2023 to May 1, 2024. A consecutive sampling technique was utilized to recruit the study participants and data collected using a structured questionnaire. Data was entered in to SPSS software version 26 for analysis. A binary logistic regression model was fitted to assess the association between the outcome and predictor variables. A P-value less than 0.05 was used to declare statistical significance. Finaly, the results were reported in words, tables and graphs.

Result: The laryngospasm incidence was 12.8% with 95% CI= (9-16). The majority of the incidents, 84.1% occurred during emergence phase of GA. The common triggering factors identified were multiple airway attempt (AOR: 13.71, [95% CI= 5.745-32.744]), inadequate depth of anesthesia (AOR: 7.814, 95% CI= 2.746-22.239]). The complications of laryngospasm identified were desaturation in 41(93.2%), bradycardia in 11(25%), inspiratory stridor in 24(54.5%), decreased air entry in 35(79.5%), increased inspiratory effort in 31(70.4%), paradoxical breathing in 25(56.8%), cyanosis in 1(2.3%), and pulmonary aspiration in 1(2.3%) of the cases.

Conclusion and recommendation: Laryngospasm is mainly associated with multiple airway attempt, inadequate depth of anesthesia, and upper respiratory tract infection. It is recommended to maintain adequate depth of anesthesia, decrease the number of airway attempts, optimize those with upper respiratory tract infections unless the surgery is urgent.

Keywords: Laryngospasm, Incidence, pediatric patients, Ethiopia

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List of Acronyms and Abbreviations

AAU------- Addis Ababa University

ACCPM----Anesthesiology, Critical Care and Pain Medicine

AOR--------Adjusted Odds Ratio

ASA-------- American Society of Anesthesiologist

CI----------Confidence Interval

COR--------Crude Odds Ratio

CPAP-------Continuous Positive Airway Pressure

ETT--------- Endotracheal Tube

FMOH ------Federal Ministry of Health

GA----------General Anesthesia

GERD-------Gastroesophageal Reflux Disease

LMA---------Laryngeal Mask Airway

NPPE--------Negative Pressure Pulmonary Edema

OR----------Operation Room

OSA---------Obstructive Sleep Apnea

PSC----------Pediatric Surgical Cases

Sig----------Significance

SPSS---------Statistical Package for the Social Sciences

TASH-------Tikur Anbessa Specialized Hospital

URTI--------Upper Respiratory Tract Infection

1. Introduction

1.1. Background

Pediatrics patients are prone to disease that require unique surgical and anesthetic strategies. Understanding of the physiological, anatomical, and pharmacological characteristics is crucial for the safe anesthetic management of pediatric patients(1).

Laryngospasm is a reflex closure of the upper airway due to prolonged glottis musculature spasm mediated by the superior laryngeal nerve resulting in impeding respiration (3).

The common inducing factors are insufficient depth of anesthesia, hyperactive airway disease, upper respiratory tract infection, and airway irritants such as secretion, mucus, blood, suction catheter, surgical debris or other foreign body during light anesthesia (4).

Laryngospasm is more abundant in pediatrics age group than adults(2). The incidence of laryngospasm from an 11years large study done in Scandinavian was 0.79% over 136,929 anesthetics, and the incidence in the first 9 years of age was 1.7% (2). Indeed, infants are at greater risk of anesthetic related morbidity and mortality than older children; generally, the risk is inversely proportional to age(2). There was strong association of laryngospasm with the type of surgery such as esophagoscopy, hypospadias repair, upper airway and anal surgery, and those having asthma or airway infections(2).

The laryngospasm incidence from a study done in Jimma university was 28.3%, of which the majority 56.6% of cases happened during induction of general anesthesia(5). From a study done in Tikur Anbessa specialized hospital, laryngospasm incidence was 68 (21.8%) from 312 anesthetics, of which 38 (12.2%) happened during induction, 14 (4.5%) during maintenance, and 16(5.1%) during emergence of general anesthesia(6). From a study done Gondar university, laryngospasm incidence was 18.4%, of which the majority 59.6% happened during emergence of general anesthesia(5).

1.2. Statement of the problem

Pediatrics anesthesia has more risk of complications, and laryngospasm is one of the anesthetic related adverse events with the greatest cause perioperative of morbidity and mortality(2). Children have smaller residual functional capacity and a greater tendency to develop airway collapse, which makes them more susceptible to hypoxia(2). Laryngospasm may be induced by vagal stimulation due to irritation of airways from secretion, tracheal intubation, or aspiration(2).

Laryngospasm may present atypically and the precipitating factors may be difficult to recognize early. This increases the potential for patient harm and fatal complications such as pulmonary aspiration and post-obstructive pulmonary edema, which carry a significant morbidity and mortality(7).

Identifying and quantifying the potential risk factors of laryngospasm helps to reduce morbidity and mortality associated with laryngospasm. Providing trainees with the skills to prevent and manage laryngospasm effectively is very important to improve the safety of pediatric anesthesia.

The aim of this study was to quantify the laryngospasm incidence and associated factors including URT infection in both emergency and elective pediatrics surgical patients, and also to find out the change in terms of incidence over time as compared to previous studies done in our country as the number of anesthesiologists and skilled anesthesia providers are increasing in the field of anesthesia through time.

1.3. Significance of the study

In our country, despite high burden of laryngospasm among pediatric patients, little is known about it especially in those patients undergoing emergency procedures and having URTI.

Even though, previous studies done in our country on this topic were available, there was limited data regarding the incidence of laryngospasm in those patients who underwent emergency surgical procedures and those patients who had moderate to severe URT infection as most of previous studies were done on elective surgical patients.

The aim of this study was to quantify the laryngospasm incidence and identify the possible associated factors in both emergency and elective pediatrics surgical patients including those with URT infection, and also to find out the change in terms of incidence over time as the number of anesthesiologists and skilled anesthesia providers are increasing in the field of anesthesia through time as previous studies in our country showed association of laryngospasm incidence with the experience of the anesthesia provider.

This study addressed all elective and emergency patients, the association of laryngospasm incidence with the severity of URT infection and also the different types of surgical procedures.

Having adequate information about the laryngospasm incidence and the different associated factors is relevant to prevent and treat intraoperative laryngospasm.

This study could be more representative, provide adequate information for the health care service and for future area of research, and also helps to develop evidence-based laryngospasm prevention policies and public health interventions with the ultimate goal of reducing morbidity and mortality. It plays a pivotal role for the prevention, early detection and management of laryngospasm. It also helps anesthesiologists, anesthetists, hospital quality service administrators and policymakers to increase their knowledge and awareness on areas of the problem, and to look for possible alternative solutions to avoid laryngospasm.

2. Literature review

2.1. Incidence of Laryngospasm in children

An 11-years large prospective study done on 136,929 patients in Scandinavia indicated that laryngospasm incidence was 8.7/1000 patients or 7.9/1000 patients who were anesthetized(2). The incidence was higher in infants 1-3 months of age(2). Other studies showed the laryngospasm incidence in pediatric patients ranges from 0.04 to 14%(8–10). Similarly, other two studies done by Clark et al. in Lebanon and Burgoyne et al. in US, reported the laryngospasm incidence in children as 0.43/1000 cases and 1/1000 cases, respectively (9,10).

A study done in Jimma University found that the laryngospasm incidence was 53(28.3%) from 147 cases, of which 30(56.6%) happened during induction, 4(7.6%) during maintenance, and 19(35.8%) during emergence phases of general anesthesia(5). The majority of laryngospasms, 28.3% occurred in children <10 years of age, and there was no correlation between age and the laryngospasm incident (5).

Similarly, from a study done at Tikur Anbessa specialized hospital, the laryngospasm incidence was 68(21.8%) from 312 cases, of which 38(12.2%) happened during induction, 14(4.5%) during maintenance, and 16(5.1%) during emergence phases of general anesthesia(6). Most of the incidents, 88.2% occurred in children < 10 years of age. In this study there was no correlation between age and laryngospasm(6).

From a study done at Gondar University by Haile et al., the laryngospasm incidence was reported as 57(18.4%) from 310 cases, of which 34(59.6%) happened during emergence, 12 (21.1%) during maintenance and 11(19.3%) during induction of general anesthesia (11).

2.2. Associated factors of laryngospasm

Risk factors of laryngospasm can be classified into three categories: patient-related, surgery-related and anesthesia-related factors.

From different studies, pediatric populations were more susceptible(12), especially those with URTI or asthma having an irritable airway. Pediatric patients with URTI have increased incidence of laryngospasm by more than 2.91 times than those with no URTI(11,13–15).

But other studies failed to show the increment of laryngospasm in children with URTI(16). Studies done on tobacco smoke exposure proved to show it as a risk factor for pediatric laryngospasm(17,18). Other studies showed having a history of gastroesophageal reflux disease increased the risk of developing laryngospasm under general anesthesia(19).

Airway anomalies were also significantly associated factors for laryngospasm as seen in different studies(11,20). Having airway anomalies increased the risk of developing laryngospasm by more than 14.6 times than those with no airway anomalies(11).

Inadequate depth of anesthesia during induction and emergence, while holding a mask on spontaneous breathing increases the risk of developing laryngospasm (3,6,11,21). Airway irritants such as secretion, blood, mucus, suction catheter or other foreign bodies in the laryngopharynx may trigger laryngospasm during light anesthesia(5). Similarly, a study done in Jimma University showed that the main triggering factors were repetitive airway manipulations and light anesthesia accounting for 43.4% and 22.6%, respectively(5).

Endotracheal tube was shown to be associated with increased incidence of laryngospasm. Laryngospasm occurred more in the induction phase if the patient was on LMA and during emergence if the patient was on ETT(11,22). The use of face mask in URTI was associated with a low incidence of laryngospasm(14). Three recent prospective studies showed there was no statistical difference in the incidence of laryngospasm among face mask, LMA and ETT (6,23–25). However, in other two retrospective studies, LMA was shown to increase the incidence of laryngospasm (23,24).

From different studies, intravenous induction with barbiturates had increased incidence of laryngospasm(26–28). Ketamine although not usually associated with laryngospasm,

produces secretions which trigger by irritating the vocal cords(29). Among the inhalational agents, laryngospasm has been seen more with desflurane followed by isoflurane, enflurane, halothane and sevoflurane. Vagolytic premedication with anticholinergic agents to prevent laryngospasm is controversial; however, anticholinergics decrease secretions which play a role in triggering laryngospasm and thus they play an indirect role in reducing the incidence of laryngospasm(30). A study done by Mihara et al. concluded that both topical and intravenous lidocaine are effective for preventing laryngospasm in children(31).

Similarly, single bolus intravenous dexamethasone at a dose range of 0.2-0.5 mg/kg significantly reduces the incidence of postoperative airway morbidity like laryngospasm, bronchospasm, breath holding, and also postoperative inflammation and pain(32). In addition, a relatively less experienced anesthesia provider also encounters more laryngospasm(33,34).

Surgeries involving upper airway were associated with a larger incidence (21-26%) of laryngospasm(12). From a study done in Jimma, the common types of procedures associated with laryngospasm were ophthalmic and ENT procedures(5). Other surgeries like appendectomy, dilatation of anal sphincter or cervix, mediastinoscopy, hypospadias surgery and skin transplant in children were also highly associated with laryngospasm(21,22). A study done TASH showed that there was no statistical association between the type of surgery with the occurrence of laryngospasm(6). Another study indicated stimulation of distal afferent nerves during esophageal procedures increased reflex laryngospasm(35).

A study done in Jimma University found out that the common complications of laryngospasm were desaturation 42(79.2%), bradycardia 37(69.8%), pulmonary aspiration 5(9.4%), negative pressure pulmonary oedema 3(5.7%), cardiac arrest and death 1(1.9%)(36). Another study done in TASH showed the most common complications were desaturation, bradycardia, pulmonary aspiration and negative pressure pulmonary oedema (6,11).

3. Objectives

3.1. General Objective

✓To determine the laryngospasm incidence and associated factors in pediatric patients who underwent surgery under general anesthesia in Tikur Anbessa specialized and Menelik hospitals from November 1,2023 to December 1, Addis Ababa, Ethiopia, 2023/2024.

3.2. Specific objectives

✓To determine the laryngospasm incidence in pediatric patients who underwent surgery under general anesthesia.

✓To identify factors associated with laryngospasm in pediatric patients who underwent surgery under general anesthesia.

4. Methodology

4.1. Study area and period

This study was conducted in Tikur Anbessa Specialized Hospitals (TASH) and Menelik referral hospital in Addis Ababa the Capital city of Ethiopia. Addis Ababa is the capital city of Ethiopia with a population of 5,461,000 according to the 2022 metro area population data in an estimated area of 530.140 square kilometers. In the city, there are twelve governmental hospitals which have functional operation rooms. Out of these, five are federal hospitals. People from different regions of Ethiopia come to those hospitals to get specialized health care services.

During the study period, TASH and Menelik hospitals were providing pediatric surgical services in different specialty and sub-specialty units including, neurosurgery, cardiothoracic surgery, pediatric surgery, urological surgery, ENT surgery and orthopedic surgery.

This study was conducted from November, 2023 to May,2024 at Tikur Anbessa specialized hospital and Menelik referral hospitals in Addis Ababa, Ethiopia.

4.2. Study design

An institutional based prospective cross-sectional study was conducted on pediatric patients who underwent surgery under general anesthesia during the study period.

4.3. Source population

All pediatric patients who were admitted for both emergency and elective surgery in TASH and Menelik referral hospital.

4.4. Study population

All pediatric patients who underwent surgery under general anesthesia during the study period in TASH and Menelik referral hospital.

4.5. Eligibility Criteria

4.5.1. Inclusion criteria

- ✓ All pediatric patients age <12 years undergoing surgery under general anesthesia.

4.5.2. Exclusion criteria

- ✓ Patients transferred to operation room intubated or from operation room to ICU intubated.
- ✓ Patients on tracheostomy tube, or operated for tracheostomy.

4.6. Sample size determination

The sample size was determined by using single population proportion formula with the following assumption.

From a previous study done at Jimma University, the proportion of laryngospasm was 28.3% with 95% CI and 5% margin of error (5).This finding from Jimma was taken to achieve the maximum sample size for our study.

$$Sample\ size\ n = \frac{\left[\left(z_{\alpha/2}\right)^2 \times p(1-p)\right]}{d^2}$$

Where: -

Z= Standard normal distribution value at 95% CI= (1.96)2

p= proportion of laryngospasm; 28.3% (0.283)

d= margin of error (0.05)

n= sample size

Therefore, n= $[(1.96)^2)\times(0.283)\times(1\text{-}0.283)]/ (0.05)^2$= 312

Adding another 10% for non-respondents, making total sample size N=344

4.7. Sampling Procedure and Technique

A convenient consecutive sampling technique was used to recruit pediatric surgical patients who underwent surgery under GA in TASH and Menelik referral hospital during the study period. The final calculated sample size was allocated proportionally to both hospitals based on their last three months average pediatric surgical cases.

4.8. Study variables

4.8.1. Dependent Variables

- ✓ Laryngospasm

4.8.2. Independent variables

- ✓ Sociodemographic characteristics –Age, sex, ASA status,
- ✓ Patient-related – URT infection, asthma, second-hand smoke, history of GERD, down syndrome, upper airway anomalies, aspiration of gastric contents, comorbidities.
- ✓ Anesthesia related- inadequate depth of anesthesia, suction catheter, oropharyngeal secretion, blood, or foreign body, airway manipulation, type of airway device, type of anesthetic agent, the experience of the anesthesia provider,
- ✓ Surgery related-type of surgery, urgency of surgery

4.9. Operational definitions

Pediatrics: includes children less than 12 years of age(37,38)**.**

Laryngospasm: is glottic closure caused by reflex constriction of the laryngeal muscles, which can occur alone or in combination with inspiratory stridor, increased respiratory effort, tracheal pull, paradoxical respiratory effort, desaturation, and bradycardia (1).

Multiple attempts of airway device: defined as at least two attempts to secure the airway(11).

Signs of inadequate depth of anesthesia: when patients manifest any of the following movements, increased respiratory rate, increased heart rate, or increased blood pressure in response to stress or painful stimuli(11).

Negative pressure pulmonary edema is a form of noncardiogenic pulmonary oedema that results from the generation of high negative intrathoracic pressure needed to overcome upper airway obstruction(11).

Aspiration is the inhalation of material into the airway below the level of the true vocal cords.

Mild URTI: recent history of URTI with in the past 2-4 weeks but no current sign or symptom(26).

Moderate URTI: any sign and symptom of URTI (runny nose and dry cough) but no wheezing, fever or irritability for one to two days (26).

Severe URTI: includes those having productive cough with purulent secretion and nasal congestion, fever, wheezing, and irritability congestion (26).

4.10. Data Collection Techniques

4.10.1. Data Collection tool

For data collection structured questionnaires were used. The English questionnaires were prepared using the literature reviews used in this study(11). Questionnaires were tested for their validation by administering a pretest and assessed for their ease of comprehension, relevance in their intended topics, effectiveness in providing useful information and the degree to which the questions were understood by different individuals.

4.10.2. Method of Data Collection

Using a structured questionnaire, data was collected by anesthesiology residents and anesthetists from the most senior anesthesiology residents and anesthetists who were involved in the intraoperative anesthesia management, on the day of surgery. Informed consent of patients from their parents were taken on arrival in the preinduction room and they were informed that they have a right not to participate in the study and that the data collected from them were confidential. The data collection process was supervised by the principal investigator (PI). Before the actual data collection, data collectors were provided with a short debriefing about the aim of the study and the content of the data collection tool.

4.10.3. Data quality assurance

During data collection, both the principal investigator and data collector checked for the completeness of the information needed. Furthermore, the data was clean coded, filtered and checked for its completeness before starting analysis. After each day of data collection, the principal investigator stored data in a secured place on Excel.

4.10.4. Pretest

Two weeks before the actual data collection 5% of the questionnaires were tested for their validation. That was assessing their ease of comprehension, relevance in their intended topics, effectiveness in providing useful information and the degree to which the questions are understood by different individuals. The pretest was only conducted in TASH, since the population as well as the anesthesia providers were similar in both settings. The intended information was obtained by the pretested questionaries; therefore, the pretested questionaries were directly applied for the principal data collection.

4.11. Data analysis

Data was entered, coded, and cleared into excel and exported to SPSS (version 26) for analysis. The percentage and frequency distribution of data variables were analyzed by SPSS descriptive statistics section. Univariable binary logistic regression analysis was done to determine the strength of association between independent variables with the outcome variable. The model assumption has met independent observation of variables, dichotomous dependent variable, no multicollinearity with VIF 1.09 to 3.84, which is less than 10. Model adequacy passed with significance level of 0.786 with Hosmer & Leeshawn test. Independent variables with significance level of 0.25 on univariable binary logistic regression analysis were fitted in to multivariate logistic regression analysis and variables with p-value of <0.05 were considered statistically significant. Crude odds ratio (COR) and adjusted odds ratio (AOR) with the corresponding 95% confidence interval were calculated to determine the strength of association between independent variables with the outcome variable.

4.12. Ethics consideration

Ethical clearance and approval were obtained from Addis Ababa University Institutional ethical committee board, and department of Anesthesiology, Critical care and Pain medicine. A letter of support was written from the department of Anesthesiology, Critical care and Pain medicine to Menelik referral hospital for the permission to conduct and consent was obtained. Informed verbal consent was secured from every parent of the study participants before the start of the study after they were told about the objective of the study. Confidentiality and anonymity were assured.

5. Results

5.1. The characteristics of the respondents

A total of three hundred forty-four pediatric patients were participated in this study and there was a hundred percent response rate. From a total of 344 participants, 240 (69.8%) were males and 104 (30.2%) were females. The age distribution of participants in the study includes, 106 (30.8%) were birth-12 months ,140 (40.7%) were 1-5 years ,63 (18.3%) were 5-10 years, and 35 (10.2%) were 10-12 years. Most of participants 259 (75.3%) were ASA 1, and the remaining 85 (24.7%) were ASA 2 and above patients. In this study, 35 (10.2%) of participants had comorbidity, 5(1.5%) with asthma, 6(1.7%) with GERD, 12 (3.5%) with preexisting airway anomalies, 12 (3.5%) with down syndrome, 6 (1.7%) with aspiration of gastric contents, and 26 (7.6%) of participants had URTI and from those 19 (73.1%) cases were having moderate to severe URTI (table 1).

Table 1: Frequency distribution for sociodemographic and patient related variables

Variable	Category	Frequency, n (%)	presence of laryngospasm	
			Yes, n (%)	No, n (%)
Age	Birth-12 months	106 (30.8)	12 (3.5)	94 (27.3)
	>1-5 years	140 (40.7)	22 (6.4)	118 (34.3)
	>5-12 years	98 (28.5)	10 (2.9)	88 (25.6)
Sex	Male	240 (69.8)	31 (9.0)	209 (60.8)
	Female	104 (30.2)	13 (3.8)	91 (26.5)
ASA Status	ASA 1	259(75.3)	31(9.0)	228(66.3)
	ASA >=2	85(24.7)	13(3.8)	72(20.9)
Comorbidity	Yes	35(10.2)	5 (1.5)	30 (8.7)

	No	309(89.8)	39 (11.3)	270 (78.5)
Hx of asthma	Yes	5 (1.5)	1(0.3)	4 (1.2)
	No	339 (98.5)	43 (12.5)	296 (86.0)
Preexisting airway anomaly	Yes	12 (3.5)	1 (0.3)	11 (3.2)
	No	332 (95.6)	43 (12.5)	289 (84.0)
Hx of GERD	Yes	6 (1.7)	1(0.3)	5(1.5)
	No	338 (98.3)	43(12.5)	295(85.8)
Aspiration of gastric contents	Yes	6 (1.7)	1 (0.3)	5 (1.5)
	No	338	43 (12.5)	295(85.8)
Down syndrome	Yes	12 (3.5)	1(0.3)	11(3.2)
	No	332 (95.6)	43(12.5)	289(84.0)
URTI <2 weeks	Yes	26(7.6)	19(5.5)	7(2.0)
	No	318(92.4)	25(7.5)	293(85.2)
Severity of URTI	Mild or no URTI	325(94.5)	29(8.4)	296(86.0)
	Moderate to severe URTI	19 (5.5)	15(4.4)	4(1.2)

GA=General anesthesia, ETT=Endotracheal tube, LMA=Laryngeal mask airway

Hx=History, URTI=Upper respiratory tract infection, GERD=Gastroesophageal reflux disease, ASA=American society of anesthesiology

5.2. Surgical related variables.

Majority of the study participants, about 242 (70.3%) were elective surgical cases and 102 (29.7%) were emergency surgical cases. The common procedures in this study were, 137(39.8%) underwent abdominal and anal procedures, 96 (27.9%) underwent urological procedures, 111(32.3%) underwent other procedures including ENT, bronchoscopy procedures for FB aspiration and swallow, cardiothoracic, neurosurgical, orthopedic, ophthalmologic, and were neurosurgical procedures (see table 2).

5.3. Anesthetic related variables

Majority of study participants 302 (87.8%) were operated under GA with ETT, and the rest 42 (12.2%) by GA with supraglottic airway devices (LMA and face mask). Most of the study participants, about 324 (94.2%) were induced with intravenous anesthetic agents and 20 (5.8%) were induced with inhalational agents. On the other hand, majority of them 222 (64.5%) were maintained with isoflurane followed by halothane 104 (30.2%), and propofol in 18 (4.7%) of cases. Most of the study participants were premedicated with atropine in 235 (68.3%), lidocaine in 215 (62.5%), and dexamethasone 158 (45.9%), of cases (see table 3).

Table 2: Frequency table for anesthetic related variables

Variable	Category	Frequency, n (%)	Laryngospasm	
			Yes, n (%)	No, n (%)
Type of Anesthesia	GA with ETT	302 (87.8)	34 (9.9)	268(77.9)
	GA supraglottic airway device	42(12.2)	10(2.9)	32(9.3)
Oral airway used	Yes	52 (15.1)	6(1.7)	46(13.4)
	No	292 (84.9)	38(11.1)	254(73.8)
Premedicated with atropine	Yes	235 (68.3)	29(8.4)	206(59.9)
	No	109 (31.7)	15(4.4)	94(27.3)

Premedicated with lidocaine	Yes	215 (62.5)	29 (8.4)	186 (54.1)
	No	130 (37.8)	15 (4.4)	115 (33.4)
Premedicated with dexamethasone	Yes	158 (45.9)	18 (5.2)	140 (40.7)
	No	186 (54.1)	26 (7.6)	160 (46.5)
Type of induction method used	Intravenous	324(94.2)	42 (12.5)	282 (82.0)
	Inhalational	20(5.8)	2 (0.6)	18 (5.2)
Induction agent	Ketamine	13(3.8)	1(0.3)	12(3.5)
	Propofol	133 (38.7)	18 (5.2)	115 (33.4)
	Ketofol	178(51.7)	23 (6.7)	155 (45.1)
	Halothane	20(5.8)	2(0.6)	18(5.2)
Maintenance agent used	Halothane	104(30.2)	16(4.7)	88 (25.6)
	Isoflurane	222(64.5)	26(7.6)	196(57.0)
	Propofol	18(4.7)	2(0.6)	16(4.7)
Multiple attempted airway	Yes	42(12.2)	21(6.1)	21(6.1)
	No	302(87.8)	23(6.7)	279(81.1)
Inadequate depth of anesthesia	Yes	23(6.1)	12(3.5)	11(3.2)
	No	321(93.3)	32(9.3)	289(84.1)
Oropharyngeal secretion	Yes	30(8.7)	5(1.5)	25(7.3)
	No	314(91.3)	39(11.3)	275(79.9)
	Yes	18(5.2)	6(1.7)	12(3.5)

Airway manipulation	No	326(94.8)	38(11.1)	288(83.7)
Anesthesia provider	Anesthesiology resident	187(54.4)	24(7.0)	163(47.4)
	Non physician anesthetist	157(45.6)	20(5.8)	137(39.8)

5.4. Factors associated with laryngospasm incidence

In our study, majority of the laryngospasm incidents about 34 (77.3%) of cases occurred in children less than 5 years of age. From the incidents, 12 (27.3%) occurred in birth-12 months, 22 (50%) occurred in 1-5 years, and 10 (22.7%) occurred in 5-12 years (see table 2). There was no statistically significance correlation between age and laryngospasm incidence. Overall, from the possible associated factors of laryngospasm analyzed, sociodemographic factors such as age, sex, ASA status didn't show any statistically association with laryngospasm incidence as indicated by P-value>0.05 (see table 4). From patient related factors such as comorbidity, history of asthma, exposure to secondhand smoke, preexisting airway anomalies, aspiration of gastric contents, history of GERD and down syndrome, statistical associations with the incidence of laryngospasm were not computed due to limited number of observations; therefore, it requires further large-scale study to conclude the association with laryngospasm incidence.

In our study, from the total laryngospasm incidents identified,16(4.7) cases occurred in abdominal and anal procedures, 11(3.2) cases occurred from urological procedures, 17(4.9) cases occurred from other procedures (bronchoscopy for foreign body aspiration and swallow, ENT, ophthalmologic, neurosurgical, cardiothoracic, and orthopedic procedures). There is no statistically significant association between type of surgery and urgency of surgery with occurrence of laryngospasm (see table 4 &5).

In the current study, pediatric patients having URTI were more than 31 times (COR: 31.811, 95% CI= [12.205-82.914] at increased risk of developing laryngospasm than those with no URTI (P-value=0.000). The risk of having laryngospasm was higher by more than 38 times

in those who reported moderate to severe URTI than mild to no URTI at a P-value of 0.000 (COR: 38.276, 95% CI= [11.915-122.956]) (see table 4). But multivariable logistic regression couldn't be done due to limited number of observations and further study is mandatory to have strong evidence on this association.

From the anesthetic related factors, having of multiple attempted airways were 13.7 times (AOR: 13.71, [95% CI= 5.745-32.744]), more likely to have laryngospasm than those who were not having multiple airway attempts (P-value= 0.000). Those patients who had inadequate depth of anesthesia were 7.8 times (AOR: 7.814, [95% CI= [2.746-22.239]), more likely to develop laryngospasm than those with adequate depth of anesthesia (P-value= 0.000) (see table 5).

Similarly, from anesthetic related factors, the type of airway device used, oral airway used, type of induction method and agent used, type of maintenance agent used, type of premedication given, oropharyngeal secretion, repetitive airway manipulation or suctioning during light anesthesia, and experience of the anesthesia provider are the factors that didn't show statistically significant association with incidence of laryngospasm as indicated by P-value >0.05 (see table 4)

Table 3: Binary logistic regression analysis for factors associated with laryngospasm

Variable	Category	Laryngospasm		COR (95% CI)	Sig.
		Yes, n	No, n		
Age	Birth-12 months	12	94	1	0.398
	>1-5 years	22	118	1.460(0.687-3.103)	0.325
	>5-12 years	10	88	0.890(0.366-2.164)	0.797
Sex	Male	31	209	1.038 (.519,2.076	.915
	Female	13	91	1	
ASA Status	ASA 1	31	228	1	
	ASA >=2	13	72	1.328(0.660-2.673)	0.427
URTI <2 weeks	Yes	19	7	31.811[12.205,82.914]	**.000**
	No	25	293	1	
Severity of URTI	Moderate to severe URTI	15	4	38.276[11.915,122.956]	.000
	Mild or no URTI	29	296	1	
Type of procedure	Urological procedures	16	121	1	0.627
	Abdominal and abdominal procedures	11	85	0.979(0.433-2.214)	0.959
	Others (ophthalmologic, orthopedic, cardiothoracic, ENT,	17	94	1.368(0.657-2.849)	0.403

	neurosurgical and bronchoscopy procedures)				
Premedicated with atropine	Yes	29	206	.882 (.452-1.723)	.714
	No	15	94	1	
Premedicated with lidocaine	Yes	29	186	1.185 (.609-2.305)	.617
	No	15	115	1	
Premedicated with dexamethasone	Yes	18	140	.791 (.416-1.504)	.475
	No	26	160	1	
Anesthesia provider	Anesthesiology resident	24	163	1	
	Non physician anesthetist	20	137	0.991(0.525-1.872)	0.979

Table 4: Factors fitted into multivariable logistic regression analysis for factors associated with laryngospasm

Variable	Category	Laryngospasm		Odds Ratio			
		Yes	No	COR (95%CI)	Sig.	AOR (95%CI)	Sig.
Type of anesthesia	GA with ETT	34	268	1		1	
	GA with supraglottic airway device	10	32	2.463(1.113-5.453)	0.026	2.517(0.959-6.602)	0.061
Urgency of surgery	Elective	24	218	0.451(0.237-0.861)	0.016	0.943(0.419-2.123)	0.887
	Emergency	20	82	1		1	
Multiple attempted airway	Yes	21	21	12.130(5.791-25.408)	0.000	13.715(5.745-32.744)	**.000**
	No	23	279	1		1	
Inadequate depth of anesthesia	Yes	12	11	9.852(4.022-24.134)	0.000	7.814(2.746-22.239)	**.000**
	No	32	289	1		1	

**Sig=Significance COR=Crude odds ratio AOR=Adjusted odds ratio URTI=Upper respiratory tract infection LMA=Laryngeal mask airway GA=General anesthesia*

5.5. Incidence of Laryngospasm

The overall incidence of laryngospasm was reported as 44[(12.8%) with 95% CI= (9,16). During the emergence, maintenance, and induction stages of GA, 37 (84.1%), 3 (6.8%), and 4 (9.1%) cases of laryngospasm occurred, respectively (see figure 3).

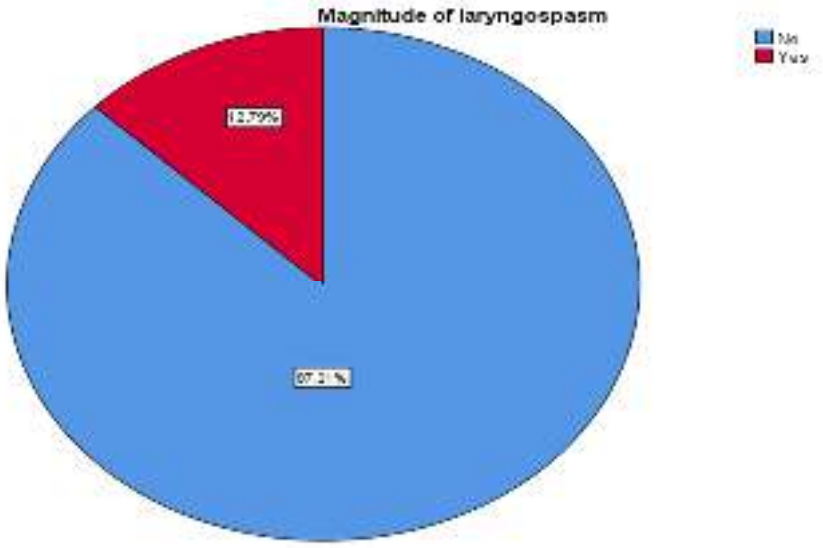

Figure 3: Incidence of laryngospasm

5.6. Complications after Laryngospasm

Among the 44(12.8%) laryngospasm events, desaturation occurred in 41(93.2%), bradycardia occurred 11(25%), inspiratory stridor occurred in 24(54.5), decreased air entry occurred in 35(79.5%), increased inspiratory effort occurred in 31(70.4%), paradoxical breathing occurred in 25(56.8%), cyanosis occurred in 1(2.3%), and pulmonary aspiration occurred in 1(2.3%) of laryngospasm cases and there was no reported incidence of negative pressure pulmonary edema and cardiac arrest.

Table 5: Complications of laryngospasm

Complication	Frequency	Percent (%)
Desaturation	41	93.2%
Bradycardia	11	25%
Inspiratory stridor	24	54.5%
Decreased air entry	35	79.5%
Increased inspiratory effort	31	70.4%
Paradoxical breathing	25	56.8%
Cyanosis	1	2.3%
Pulmonary aspiration	1	2.3%

5.7. Management and outcome of perioperative laryngospasm

Among the 44(12.8%) of laryngospasm events, majority of the incidents were managed with administration of CPAP with 100% oxygen and removing the offending stimulus for 34 (77.3%) of events, and the rest required increasing the depth of anesthesia for 18 (40.9%), administration of suxamethonium for 6 (13.6%), and endotracheal intubation for 3 (6.8%) of laryngospasm events, and all cases resolved without residual effect.

6. Discussion

The purpose of this study was to determine the incidence and risk factors for laryngospasm throughout the induction, maintenance, and emerging periods of GA. In this investigation, the total incidence of laryngospasm was 12.8% (95% CI= 9–16). This study's incidence was lower than previous studies done in our country, which could be attributed to growth in the field of anesthesia and improvements in skilled anesthesia providers; however, it was still higher than studies done by Olsson et al. (0.87%), Alan R et al. (0.04 to 14%), and Burgoyne et al. (0.1%) ((2,5,6,8,10,11). These variations could be attributed to modern refinements and advancements in anesthetic practice, surgical techniques, and the specificity of the operations in past studies.

According to a study done by Olsson et al., the incidence in children 0- 9 years of age was higher 17.4/1000 patients and within this age group infant's 1-3 months of age had the greatest incidence (more than three times the rate in any age group) (2). In this study, majority of the laryngospasm incidents about 34 (77.3%) of cases occurred in children less than 10 years of age. There was no statistically significant correlation between age and the laryngospasm occurrence. This result was similar to studies done by Haile et al.at Jimma university and Tsigereda D. at Tikur Anbessa specialized hospital (5,6).

A study done in Jimma university by Haile et al. found out that the highest incidence of laryngospasm, 30 (56.6%) happened during induction, and a study done in TASH by Tsigereda D. also found that the highest incidence of laryngospasm, 38 (12.2%) occurred during induction phases of GA (6). A study done in Gondar university by Chekol et al, found that the highest laryngospasm incidence, 34 (59.6%) happened during emergence phases of GA (39). In our study, the highest incidence of laryngospasm happened during emergence which was about 37(84.1%), and the rest 3 (6.8%), and 4(9.1%) happened during maintenance and induction phases of GA, respectively. The higher laryngospasm incidence during emergence in this study might be due to the high percentage of patients were operated under GA with ETT 302 (87.8%). This suggestion was supported by a study done by Visvanathan et al. who found that the laryngospasm incidence occurred more on the induction phase if the patient was on LMA and high during emergence if the patient was on ETT (21).

In our study, pediatric patients having URTI were more than 31 times (COR: 31.811, 95% CI= [12.205-82.914] at increased risk of developing laryngospasm than those with no URTI

(P-value=0.000). The risk of having laryngospasm was higher by more than 38 times in those who reported moderate to severe URTI than mild to no URTI at a P-value of 0.000 (COR: 38.276, 95% CI= [11.915-122.956]) (see table 4). But multivariable logistic regression couldn't be done due to limited number of observations and further study is mandatory to have strong evidence on this association.

In our study, multiple airways attempts and inadequate depth of anesthesia were the main triggering factors of laryngospasm incidence.

In this study, the risk of developing laryngospasm was more than thirteen-fold increased in those having multiple airways attempts than the counterpart times (AOR: 13.71, [95% CI= 5.745-32.744]) at P-value of 0.000. This suggestion was supported by a study done by Flick et al. which identified the association between multiple attempts of airway device insertion and laryngospasm (5,20).

In our study, those patients who had signs of inadequate depth of anesthesia were 7.8 times (AOR: 7.814, [95% CI= 2.746-22.239]), more likely to develop laryngospasm than those with adequate depth of anesthesia with P-value of 0.000. In congruent with this, a study done by Olsson et al. confirmed that inadequate depth of anesthesia had a significant effect on the incidence of laryngospasm (2,5,11).

According to McKEATING et al. and McGlone et al., propofol has a lower risk of laryngospasm due to its ability to blunt airway reflexes, whereas ketamine has no effect on laryngospasm if there is an increased tendency of secretion, which can act as a trigger by irritating the vocal cords (28,29). Studies also showed that intravenous inductions with barbiturates like thiopentone were more likely to increase laryngospasm(28,29). However, inhalational anesthetic agents including desflurane and isoflurane were having higher incidences of laryngospasm(40,41). In this study, statistical associations for the anesthetic agents including thiopentone and sevoflurane with the incidence of laryngospasm were not analyzed due to the absence of reported observations; therefore, it needs further study to draw conclusion. In addition, a relatively less experienced anesthesia provider also encounters more laryngospasm (33,34). In our study, there was no statistically significant association between the incidence of laryngospasm with the experience of anesthesia provider.

The complications of laryngospasm identified from different studies were, desaturation (61%), bradycardia (6%), post obstructive negative pressure pulmonary oedema (4%),

pulmonary aspiration (3%), and cardiac arrest (0.5%) (5,6,11,38)(11)In the current study, the complications of laryngospasm identified were, desaturation 41(93.2%), bradycardia 11(25%), inspiratory stridor 24(54.5), decreased air entry 35(79.5%), increased inspiratory effort 31(70.4%), paradoxical breathing 25(56.8%), cyanosis 1(2.3%), and pulmonary aspiration 1(2.3%) of laryngospasm cases and there was no reported incidence of negative pressure pulmonary edema and cardiac arrest. This finding was congruent with the previous studies.

In our current study, among the 44(12.8%) of laryngospasm events, majority of the spasms were broken with administration of CPAP with 100% oxygen and removing the offending stimulus for 26 (59.1%) of events, and the rest required increasing the depth of anesthesia for 18 (40.9%), administration of suxamethonium for 6 (13.6%), and endotracheal intubation for 3 (6.8%) of laryngospasm events, respectively, and no child required cardiopulmonary resuscitation and all cases resolved without residual effect. The pattern of management taken was similar with the previous findings(6,11).

6.1. Limitation of the study

Some of the limitations of this study were listed below.

First, the sampling method used was convenient consecutive sampling which makes it prone to bias.

Second, this study was single centered and may not be possible to generalize to the general population at national level.

Third, some of the independent variables had inadequate observations to analyze the association with the dependent variable, and this needs further large-scale study to analyze their association with laryngospasm.

Forth, some cases were not managed independently with different levels of anesthesia providers. So, this study could not asses risk of occurrence of laryngospasm with status of anesthesia providers.

Fifth, the diagnosis of laryngospasm was dependent on the clinical signs and judgment of the anesthesia provider and there was no specification whether the laryngospasm is partial or complete.

Finally, there may be under reporting of cases by the anesthesia providers since there was no formal way of reporting incidents.

7. Conclusion

Laryngospasm can occur at any phase of general anesthesia. In this study, the overall magnitude of laryngospasm was 12.8%, and majority of laryngospasm events occurred during emergence phase of GA. Multiple attempts of airway devices and inadequate depth of anesthesia were the main triggering risk factors of laryngospasm, and also the presence of URTI was one of the triggering factors for laryngospasm incident identified in this study, but the strength of association was not strongly since there were small number of observations reported. So, added vigilance and further large-scale study is needed in patients with URTI or those who require multiple attempts at airway device insertion. Optimizing patients with URTI in the case of non-emergency surgery, maintaining adequate depth of anesthesia and decreasing frequent airway attempts is mandatory to prevent laryngospasm.

8. Recommendation

Based on the findings of this study the following recommendations were drawn. The result of the study showed that the incidence of laryngospasm in pediatric population was slightly higher especially during emergence phase. Earlier recognition and diagnosis of perioperative laryngospasm is mandatory.

At individual level, anesthesia providers should know the main triggering multiple risk factors associated to perioperative laryngospasm for effective prevention and management of laryngospasm incidents. Anesthesia providers should avoid light plane of anesthesia during airway devices insertion, extubation or any manipulation including suctioning. Patients with URTI, especially those with moderate to severe URTI should be optimized before the procedure unless the procedure is urgent. It is also mandatory to limit the number of airways attempts especially during bronchoscopy procedures.

At institutional level or national level, structured laryngospasm management approach and algorithm with cognitive aids in each pediatric operation room is recommended to improve the perioperative outcome of patients. Every pediatric procedure better to be supervised by senior anesthesiologists especially during emergence and induction phases of anesthesia, when laryngeal spasm is more common. Hospital administrators and national health care leaders should give attention for this high incidence of laryngospasm in pediatric population and preventive measures should be undertaken in advance.

For future researchers, multicentered large scale researches need to be done to get more representative data at national level for developing effective preventive measures, management strategies, and quality improvement programs including refresher trainings to be drawn nationwide.

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10. Declaration of the principal investigator

I, the undersigned agrees to accept all responsibilities for the scientific and ethical conduct of the research project. I will provide timely progress reports to my adviser and seek the necessary advice and approval from my advisers in the course of the research. I will communicate timely to my advisers and all stakeholders involved.

Name of the investigator: Dr Hailemariam Mekonnen (ACCPM R3)

Signature: _____

Date: _____

Approval of the first Advisor:

Name of the advisor: _____

Signature: _____

Date: _____

Approval of the second Advisor:

Name of the advisor: _____

Signature: _____

Date: _____

11. Annex

11.1. Annex 1: Information sheet

Addis Ababa University, School of Medicine, from specialty program. A questionnaire for assessing the incidence and associated risk factors of perioperative pediatrics Laryngospasm under general anesthesia in Addis Ababa University at Tikur Anbessa Specialized Hospital and Menelik referral hospitals.

Good morning/good afternoon. My name is ----------; I come from Addis Ababa University. I am working with an investigator, Dr Hailemariam Mekonnen, doing his thesis for the partial fulfillment of a specialty certificate in Anesthesiology, critical care and pain medicine. I am interviewing incidence and associated factors of perioperative pediatrics Laryngospasm under general anesthesia. I am going to ask you some questions that are not difficult to answer. Your name will not be written in this format and never be used in connection with any of the information you are going to tell me. You are not obliged to answer any question that you do not want to answer and you may end this interview at any time you want to. However, your honest answers to these questions will help us to identify the incidence and main risk factors associated with perioperative pediatrics Laryngospasm under general anesthesia and help to solve the identified problems in the future to control and prevent it. I would like to appreciate your help in responding to these questions, and the interview will not take more than 10 minutes.

Name: Dr. Hailemariam Mekonnen

Tel- +251-905519721 /+251-987232401

Email- hailemekk0@gmail.com

11.2. Annex 2: Informed consent

I am the individual asked to be a study participant. Based on the information provided by the principal investigator, I understand that it is not necessary to write my name, the information I tell her/him will not be used for other purposes and the information obtained from me will help to identify the incidence and main risk factors associated with perioperative pediatrics Laryngospasm under general anesthesia and helps to solve the identified problems in the future to control and prevent it in the future.

So, I agree to be a study participant.

1. Yes……. 2. No……

If yes go to the next section. If no go to the next participant

Questioner code ----------

Name of data collector ----------

Signature----------

11.3. Annex 3: Questionnaire

Institution/hospital name 1. TASH 2. Menelik referral hospital 3.MRN----------

Table 6: Sociodemographic factors

No.	Factor	Response
101	Age(months/years)	1. Birth-12 months 2.1+-5 years 3.5+-10 years 4.10+-12 years
102	Sex	1. male 2. Female
103	ASA Status	1.ASA 1 2. ASA 2 3. ASA 3 4. ASA 4 5. ASA 5

Table 7: Patient-related factors

NO.	Factor	Response
201	Preexisting airway anomalies	1. Yes 2. No
202	Presence of Comorbidity	1.Yes 2. No
203	History of Asthma	1.Yes 2. No
204	Hx of GERD	1.Yes 2. No
205	Does the patient have down syndrome	1.Yes 2. No
206	Patients exposed to second-hand smoke	1.Yes 2. No
207	URTI (<2 weeks)	1.Yes 2. No
208	If yes for Q 205, then specify the severity	1.mild URTI 2.moderate URTI 3.severe URTI

Table 8: Surgical- and anesthetic-related variables of pediatric patients who underwent surgery under GA in TASH and Menelik hospitals:

NO.	Intraoperative Factors	Response
301	Type of anesthesia	1. GA with ETT 2.GA with LMA 3.GA with mask
302	Type of procedure	1.Others (ophthalmic, orthopedic, cardiothoracic, and neurosurgery) 2. Anal 3. Abdominal 4. ENT 5. Urological 6. Bronchoscopy for FB aspiration and swallow
303	Urgency of surgery	1.Elective 2. Emergency
304	Oral airway used	1.Yes 2. No
305	premedication given	1.Atropine 2. Lidocaine (IV, spray) 3. Dexamethasone
306	Type of induction method used	1.Intravenous 2.Inhalational
307	Type of induction agent used	1.Ketamine 2. Propofol 3. Ketofol 4. Halothane 5. Sevoflurane 6. Isoflurane 7. Thiopentone
308	Type of Maintenance agent used	1. Halothane 2. Isoflurane 3. Sevoflurane 4. Propofol 5. Ketamine 6. Thiopentone
309	Multiple attempted airway	1.Yes 2. No
310	Inadequate depth anesthesia	1.Yes 2. No
311	Oropharyngeal secretion	1.Yes 2. No
312	Aspiration of gastric contents	1.Yes 2. No
313	Airway manipulation or Suction device used during light anesthesia	1.Yes 2. No
314	Anesthesia provider	1.Anesthesiologist 2. Anesthesia resident 3.MSc anesthetist 4. BSC anesthetist

Table 10: Presence of Laryngospasm, management taken and patient outcome:

NO	Laryngospasm questions	Response
401	Was laryngospasm diagnosed in this patient	1.Yes 2. No
402	If yes to Q402, when did it occurred	1.Induction 2.Maintenance 3.Emergence
403	If yes to Q401, what were the complications present?	1.Desaturation 2.Bradycardia 3.Inspiratory stridor 4.Decreased air entry bilaterally 5.Increased inspiratory effort/tracheal tug 6.Paradoxical breathing 7.Cyanosis 8.Pulmonary aspiration 9.NPPE 10.Cardiac arrest
404	If yes to Q401, management of laryngospasm via	1.Removal of the stimuli 2.CPAP with 100% oxygen 3.Deepen the anesthesia 4.Muscle relaxation with suxamethonium 5.Intubation 6.Surgical airway
405	If yes toQ401, Overall Outcome	1.Resolved 2.Remain complicated 3.Death