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Old Laryngospasm Complication: New Treatments

Abstract

Perioperative laryngospasm is an airway emergency. It is responsible for a significant number of complications ranging from hypoxia, bradycardia, bronchoaspiration, obstructive pulmonary edema and/or cardiac arrest. It is a protective glance reflex of the glottis. It is a relatively frequent entity in the pediatric patient, which depends on multiple factors. The goal of treatment is to prevent its presentation, if it is already installed then make the diagnosis fast and timely to apply effective corrective treatment, and not allow the patient to deteriorate quickly. The treatment consists of applying effective drugs to break the spasm like propofol, magnesium sulfate, muscle relaxants and reintubation. External maneuvers include chest pressure at the top and Larson's maneuver.

Keywords: Laryngospasm; Upper Airway; Risk factors; Prevention and treatment

Review Article

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Introduction

Laryngospasm (LEP) is defined as the sustained closure of the vocal cords. It is a primitive protective airway reflex (VA), which occurs to safeguard the integrity of the airway by protecting it from tracheobronchial aspiration [1]. LEP is also defined as an exaggerated response to closure reflex or glottic muscle spasm. Essentially it is a protective reflex, which acts to prevent the entry of any foreign material into the tracheobronchial tree. The presence of this reflex results in an impediment to adequate breathing, under these conditions it becomes a sudden obstruction of upper VA. A feature of LEP is that VA closure is maintained even after the initial causal stimulus disappears. In any of the situations mentioned above, we face a partial or total loss of VA, and therefore an anesthetic urgency. 40% of VA obstructions are secondary to LEP, may result in a life-threatening complication, and is a major cause of cardiac arrest in the pediatric patient.

LEP is characterized by severe hypoxia (61%), bradycardia (6%), obstructive pulmonary edema (4%), cardiac arrest (0.5), pulmonary aspiration (3%), arrhythmias and death. It is extremely important to remember that of the complications related to anesthesia, 43% are of respiratory origin [2]. LEP is seen mainly in the child, the most frequent cause is upper VA manipulation. Its incidence varies depending on the author. Olsson and Hallen mention incidence of 1% in adults and children, doubling in infants and schoolchildren and tripling in children under three months of age. In children with VA reactivity or with asthma, their incidence increases to 10%, and may increase up to 25% in patients receiving adenotonsillectomy surgery [2]. The incidence is the highest in the child between one and three months of age. In the first nine years of age, the incidence of LEP is 1.74%. For school children it is 2.8%. Likewise, there is a higher incidence of respiratory adverse events in the obese asthmatic child, but not in obese children without asthma [3].

LEP production mechanism

Laryngeal muscles, true and false vocal cords may be involved in LEP. Most laryngeal reflexes are produced by the stimulation of the afferent fibers contained in the internal branch of the superior laryngeal nerve. These reflexes control contraction of the laryngeal muscles which protect the VA during swallowing [4].

Pathophysiology

The causes of LEP are multiple, the presence of local, mechanical, chemical or thermal stimuli, which ascend through the superior laryngeal via sensory fibers of the vagus nerve. That is, the sensitivity of the supraglottic region is given by the superior laryngeal nerve, while the sensory innervation below the vocal cords is the responsibility of the inferior or recurrent laryngeal nerve. There is a significant amount of receptors in the vocal cords as well as in the glottis and adjacent structures, but the greater density of receptors is found at the entrance of the larynx, mainly in the laryngeal face of the epiglottis.

The motor response is mainly due to the presence of three laryngeal muscles; the lateral cricoaritenoids, the thyroarytenenoids (abductors of the glottis) and the cricoaritenoids (vocal cord tensor). All innervated by the inferior or recurrent laryngeal, which is a branch of the upper laryngeal. In other words, the intrinsic laryngeal muscles responsible for the false vocal cords are the cricoaritenoid, thyroaritenoid and cricothyroid muscles.

The true vocal cords function as unidirectional valves, offering little resistance to the pressures exerted from the inside of the thorax to the VA, under these conditions the pressure is approximately 30 mm Hg, but the pressure exerted from the outside of the VA then the strings vowels can have a resistance equivalent to 140 mm Hg and up to 190 cm H_20 for the adult. This means that it will be more difficult to overcome the resistance of the vocal cords with the pressure exerted through the face mask.

It is not known what the pressure in the upper VA of the child is, but false vocal cords by their superior location also act as gates, avoiding the escape of air from the lower respiratory system, which offers an effective resistance equivalent to 30 mm Hg , which would serve to make more effective the reflex of the cough. Recent studies have shown that the shape of VA is not a funnel, as it has been affirmed in the last 60 years, but has a more elliptical shape than round, for this reason the shape and design of the pediatric tracheal tubes to tracheal tubes with "cuff" or "clogging". The most current publications support the use of cuffed tubes for the majority of the pediatric population, especially if the child is connected to a ventilator, which is also true for newborns [5].

Risk factor's

Traditionally risk factors for LEP can be classified into three categories; related to the patient, related to anesthesia and related surgery.

Factors related to anesthesia: The most important anesthetic factor is related to the level of anesthesia, a light or insufficient anesthesia, leads to a predisposition to trigger LEP. Induction and extubation of the patient are the critical moment, which leads to light anesthesia, and therefore to present pain during this stage. For example, desflurane anesthesia may produce cough during the emergency of anesthesia, particularly when the tracheal tube is withdrawn as it can be correlated with a faster awakening and early perception of a foreign body in VA. The same can occur by the presence of secretions or blood around the larynx, factors described as strong stimuli that can end in an LEP.

In pediatric anesthesia the most frequent technique for induction is the inhalation with some of the current gases. Halothane and sevoflurane are two of the inhaled gases with a lower pungency capacity for VA and there is no difference in LEP between these two agents. The absence of irritant properties of halothane and sevoflurane contrasts with the irritating properties of desflurane and isoflurane, particularly in relation to the induction of anesthesia. Halothane and sevoflurane can be used with great confidence to induce general anesthesia in a gradual manner, increasing the concentration inspired in a progressive way, resulting in a low incidence of LEP.

Desflurane on the other hand shows a very high pungency, 50% of patients receiving induction with this gas, can develop coughing by irritation of upper VA, followed by isoflurane and enflurane. Halothane is the least irritant inhaled agent of VA, although this gas is practically disused in pediatric anesthesia [6]. The intubation of the trachea is another critical moment, both by the placement of a tube in the trachea and by the maneuvers of laryngoscopy, in both situations it can trigger a strong stimulus, which induces LEP or bronchospasm.

Propofol depresses the laryngeal reflex, producing a low incidence of obstructive problems. Thiopental has been shown to increase the incidence of LEP, although the possible mechanism of action is not well known [7,8], ketamine has rarely been associated with this complication [9]. Head movements, placement of a nasogastric tube, or irritation of the vocal cords by blood, mucus, vomit, or other liquids, as well as suction catheters, are other factors that may cause upper VA obstruction. It has recently been shown that intubation of the trachea with the patient awake and without muscle relaxants, predisposes to a higher frequency of laryngoscopy, a higher incidence of complicated VA and greater failure rate for conventional intubation. The inexperience of the anesthesiologist or multiple attempts of tracheal intubation, and the placement of a laryngeal mask (ML) in an insufficient anesthetic plane, can be causes of LEP [10]. The insertion of ML causes substantially less neurocirculatory stimulation than tracheal intubation during anesthesia with inhaled gases.

There are contradictory reports regarding midazolam and its effects on LEP, some reports have shown an increase in the incidence of LEP, but other researchers have not been able to demonstrate such an assertion. In contrast, midazolam with remifentanil has shown a low incidence of LEP as in ophthalmologic surgery under general anesthesia [11]. Ketamine is associated with a 0.4% incidence of LEP most likely by an increase in the production of secretions that act as irritating factors of VA or the areas adjacent to the larynx [12].

Factors related to the patient: There are several factors specific to the patient, with age being the most important; the smaller the child, the incidence of LEP is greater. The occurrence of LEP followed by general anesthesia is inversely related to age. Probably this is related to the anatomy of the aerial structures of the neonate and the infant. The fact of finding a larynx one or two higher vertebral segments, that is to say that the larynx has a cephalic position, an epiglottis in the form of "omega", rigid (long, firm and angular) and equally high. In the same way, less time is available for tracheal intubation, because they have a lower reserve volume of 02. Newborns (NBs), pre-pregnancies and children under one year of age are more susceptible to this complication.

The same is true of upper VA infection, which is associated with sensitization of the bronchial efferent pathways that may last up to four or six weeks. These children should receive preparative anesthetic medication with a dose of steroids to try to decrease the possibility of LEP. The anesthesiologist should pay special attention to the risk associated with VA hyperreactivity, especially if it is viral infection. Damage of respiratory epithelium may persist for several weeks; viruses are responsible for two to five times the increase in LEP [13]. For other authors the infection of the superior VA has been compared with placing a tube in the very tight trachea, which can increase up to eleven times the possibility of presenting a secondary respiratory obstructive picture. It is suggested that in those children with a history of recent VA infection in the healing phase, VA should be manipulated less invasively, for example, ML. However, the studies are contradictory since others have found a higher rate of presentation of LEP after an upper VA infection [14].

An important section is passive smoking children in the home, including those who are hyperreactors of VA and asthmatics, who have been described up to ten times greater the possibility of presenting an LEP, not forgetting the adolescent smokers, who they may also be hyperreactors of VA [15]. Obstructive sleep apnea, obesity and complicated VA, gastroesophageal reflux

disease, ASA IV patients, ie severe children, are also situations that are capable of triggering LEP [16].

Factors related to surgery: There is a very close association between LEP and type of surgery. Outstanding surgical procedures of the upper VA. Tonsillectomy and adenotonsillectomy are surgical procedures with a probability of developing this complication, 21-27%. Other types of surgery include bronchoscopy and upper gastrointestinal endoscopy, appendectomy and hypospadias, or lower urologic surgery such as cystoscopy, are also highly likely to present upper VA obstruction. Lower urinary tract procedures require a deep anesthetic plane and adequate intraoperative anesthesia, since urethral manipulation can precipitate LEP due to the activation of the Breuer-Lockhart reflex.

Cervical dilatations, and skin transplantation in children. Thyroid surgery related to upper laryngeal nerve trauma, removal of the parathyroid glands that produces hypocalcemia, patients with cerebral palsy often have swallowing and gastroesophageal reflux problems, poor cough reflex, and decreased respiratory capacity situations that also predispose to LEP, bronchospasm and bronchoaspiration [17,18].

Moment of surgery where you can present LEP

LEP can occur at any time during anesthesia, but the two most frequent periods are during intubation or extubation due to a light or superficial level of anesthesia. However, it may also occur during maintenance of anesthesia as a result of poorly conducted light anesthesia or pain anesthesia.

LEP management

Management of LEP can be divided into preventive or curative (Table 1).

Table 1: Classification of LEP grade.

Grade	
I	It is the most common grade, less risky and does not require treatment. It is a normal protection reaction
II	The arytenoepiglottic muscles are in tension and block the vision of the vocal cords. It is a more intense and lasting protection reaction. He yields with his jaw forward
III	All muscles of the larynx and pharynx are in tension, requiring the larynx to be pulled into the epiglottis, and in many cases reintubation is required.
IV	The epiglottis is trapped in the upper portion of the larynx. The use of muscle relaxants is required for resolution.
Taken from: Cavallieri BS (2014) Complicaciones anestésicas en el postoperatorio en el paciente pediátrico. En: Hernández-Cortez E (Ed.), Complicaciones de la anestesia pediátrica. Editorial Prado, México, pp. 545-560.	

Prevention

Preventive measures include recognition of all risk factors discussed above. In neonates, infants and young children, VA reflexes are stimulated to a much greater degree during the induction of anesthesia with inhaled. It is therefore advisable to use inhaled gases with a low pungency during induction. The rapid inhalation technique requires high gas bolus accompanied by equally high levels of oxygen, which can lead to frequent irritation of the VA, accompanied by coughing and salivation, in addition to suppressing breathing. The 6/6 induction technique described for some inhaled, particularly in the absence of anesthetic medication can trigger a higher incidence of LEP. Induction techniques with large inhaled boluses and oxygen for the purpose of rapid induction of less than 40 seconds may result in LEP. In unmedicated adults, the irritation of VA is much greater with 2 MACs of desflurane than with 2 MACs of isoflurane or sevoflurane. There are several reasons to state that the best induction procedure is with propofol. Especially in children with a history of asthma or hyperreactors [19].

Pretreatment with morphine or fentanyl seems to reduce the incidence of cough and irritation of VA by 10% [20]. Intravenous inducers such as propofol, produces laryngeal reflex depression [21]. The use of atropine is controversial, reducing the frequency of LEP by its anti-inflammatory effect by reducing the amount of pharyngeal secretions. However, intense dryness of the mouth, increased heart rate, and body temperature, in addition to increased consumption of cardiac oxygen, are therefore bothersome for the child. Therefore, administration of atropine alone is indicated in special situations such as RN or the premature, with greater activity of the parasympathetic tone. The use of muscle relaxants reduces the risk of LEP. Lidocaine 1 to 2 mg/kg, can work both preventive and corrective of LEP. Its application before removal of the tracheal tube has been investigated since 1970, a recent well-conducted study has shown that the application of lidocaine to 1.5 mg/kg, two minutes before extubation, reduces the incidence of LEP and cough, and that lidocaine acts at the central level and increases anesthetic depth. LEP can decrease 30% vs 19% with respect to controls [22]. Recently Qi X and co-workers performed a meta-analysis to demonstrate the efficacy of both intravenous and topical lidocaine. They demonstrated that both are effective in preventing LEP during general anesthesia in the child [23].

Administration of magnesium sulfate 15 mg / kg i.v prior to intubation of the trachea has resulted in a decrease in the incidence of LEP in children. The protective effect of magnesium seems to be related to muscle relaxation and increased anesthetic depth,

further studies are required. Oral benzodiazepine medication decreases the upper airway reflex and therefore decreases the incidence of LEP [24]. Of course, it includes removing any possible triggers, such as secretions and blood, until you are sure that the larynx is kept completely clean.

Technique of not touching

Tsui et al. [23] showed that using the no-touch technique, the incidence of VA obstruction decreases. Basically it is an extubation technique with the patient awake, which consists of aspirating any type of secretion even with the patient in a good anesthetic plane, then placing the patient in any of the lateral decubitus, then discontinuing the anesthesia, until the patient patient to wake up completely and then withdraw the tracheal tube smoothly without causing jolts and without stimulating the larynx and only ventilate with 100% oxygen with face mask [25]. This maneuver suggests that the tracheal tube be removed while the lungs are inflated by positive pressure, which decreases the adductor response of the laryngeal muscles and thereby reduces the incidence of LEP.

Treatment of LEP

In the effective management of LEP requires a correct diagnosis and a quick and aggressive intervention of the anesthesiologist. Many authors recommend first to manipulate VA, then remove those factors that act as irritants and finally administer pharmacological agents [26]. The first step in the management of LEP is the recognition of those patients who have risk factors for LEP, take the most appropriate precautions, individualising each case in particular.

The diagnosis of certainty can only be made, if we can visualize the closed glottis or vocal cords, in the vast majority of cases this is not possible. We can infer the diagnosis by the clinical data of the patient. The LEP is divided into partial and complete, in the first case there is a certain air supply to the lungs, and from the clinical point of view is recognized by the presence of an inspiratory stridor. In the case of complete LEP there is no entry of air to the lungs manifested by inability to breathe and absence of breathing noises.

Respiratory effort Includes inspiratory stridor, which can progress to complete obstruction in which case it will progress to complete respiratory effort. The thorax presents ineffective respiratory movements with paradoxical movements between the abdomen and the thorax. There is suprasternal and/or supraclavicular retraction with exaggerated abdominal movements, in addition to oxygen desaturation with or without bradycardia. In the case of a complete LEP there is respiratory silence. The capnography will show a flat wave. Absence of movement in the rebreathing bag. Then general signs appear, such as desaturation, bradycardia, cyanosis, and arrhythmias to end in cardiac arrest. If obstruction of VA does not respond to the placement of a Guedel cannula. The possibility of regurgitation or the presence of blood in the larynx may be present.

Emergency management LEP

The first maneuver to try to solve LEP is the firm and vigorous mobility of the mandible back with neck and head extension, i.e subluxation of the joint temporomandibular, also known as Esmarch-Heiberg maneuver. It involves pushing the jaw up and forward with the head slightly extended to retract the tongue from the back of the pharynx, which favors the mobility of the tongue towards the anterior part and allows the laryngeal passage to open. Placement of a Guedel cannula of a correct size for the child's age may be sufficient, depending on the degree of LEP. If it is possible to open your mouth you can place a nasal cannula through the nose, carefully placed so as not to cause nasal bleeding. Simultaneously the application of CPAP with 100% oxygen via face mask, in extreme cases can be used with two hands. It is very important to try not to pass too much air to the stomach, as this can cause regurgitation and/or vomiting, and facilitate bronchoaspiration.

Propofol breaks the LEP in 77% of cases, a sub-hypnotic dose of 0.25 to 0.8 mg / kg is sufficient. Side effects are relatively benign. However, the patient may be apnea, cyanotic and bradycardic for when propofol is applied, which may increase cardiovascular depression. Propofol offers more advantages than succinylcholine [1]. If the LEP is not resolved, the next step is the application of succinylcholine. It is considered as the gold standard to solve this complication. Low succinylcholine doses of 0.1 mg/kg have been reported to be effective in LEP. With this dose, ventilation is preserved during emergency situations [27].

Administration of succinylcholine should usually be accompanied by atropine. For when we give this medicine, it is very possible that the child, besides cyanotic, is bradycardic. Succinylcholine is dangerous in a myocardium that is suffering from hypoxia and bradycardia and may end up damaging the heart. Atropine can counteract this depressant effect of succinylcholine and hypoxia. Atropine also decreases pharyngeal secretions. It is recommended that succinylcholine and atropine be administered before the oxygen saturation is below 85%.

If it is not possible to have a permeable intravenous route, then we can use an alternate route, such as intramuscular or intraosseous intramuscular route, the intralingual dose is at least 2 mg/kg. The intramuscular route has the disadvantage that its absorption is irregular and a higher incidence of arrhythmias has been reported, the exact cause is not known. The intramuscular dose of succinylcholine requires a higher dose up to 4 mg/k, its disadvantage being that it requires at least one minute for total rupture of the LEP. In the absence of succinylcholine, a non-depolarizing muscle relaxant such as rocuronium can be administered. A dose of 1.2 mg intravenously is sufficient to rapidly break down LEP. The problem may arise when the child does not have a permeable intravenous pathway, for which the deltoid muscle can also be specifically used intramuscularly. Lynne and colleagues demonstrated that the required dose of rocuronium to achieve 100% complete relaxation of vocal cords in children under one year is 1 mg/kg in only 2.5 minutes and 1.8 mg/kg in older children [28].

Other drugs reported to be effective in the treatment of LEP are alfentanil and meperidine, especially if the triggering factor of LEP is a very painful stimulus. Doxapram at 1.5 mg/kg may suppress LEP by increasing respiratory depth. Nitroglycerin 4 µg/k, has also been reported as effective, but this drug mainly acts

on the smooth muscle and not on the skeletal muscle itself of the vocal cords [29]. The definitive treatment for refractory LEP is with upper laryngeal nerve block with local anesthetics [1].

Other maneuvers: The first maneuver is to make a gentle pressure in the midline of the thorax, trying to make a pressure to the expulsion of trapped air in the chest and to allow the opening of the vocal cords that work with opening unidirectionally. This maneuver allows to overcome a vocal cord pressure of only 30 mm Hg, while with the application of CPAP with 100% oxygen via facial mask, we have to overcome a pressure of more than 150 mm Hg (adult pressure). That is to say that with this maneuver the opening of the glottis is forced by abruptly increasing the intrathoracic pressure, allowing breathing or stimulating the vaginal reflex of Hering-Breuer. 74% of the LEPs were corrected with this maneuver against 34% who were treated with conventional treatment in children who received tonsil surgery [30].

The second form is a maneuver with limited scientific evidence regarding its therapeutic use. It is called Larson's maneuver. It is a technique described more than 40 years ago by Guadagni and later retaken by Larson. It is a bilateral maneuver that consists of placing pressure on the mastoid processes at the level of the styloid processes, between the posterior branch of the mandible and the anterior mastoid process, with a small vigorous and painful force, which breaks the LEP by the presence of pain, relaxes the vocal cords, while moving the jaw forward and up [31] (Figure 1).

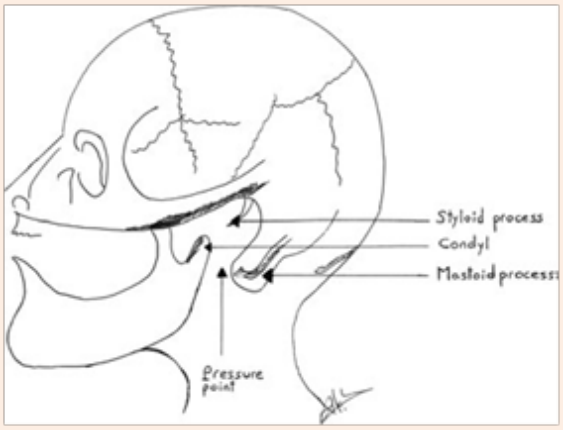

Figure 1: Larsson's maneuver.

The last step to rescue an emergency airway is to do a tracheal intubation, even with the vocal cords closed, causing a trauma in them, but rescuing the VA from urgency. The last maneuver will be cricothyrotomy or tracheostomy, as maneuvers of extreme urgency.

Follow-up after LEP

When a patient has left a severe LEP, it is recommended to be observed for two to three hours until they are sure to have one of the most frequent complications - secondary to severe LEP - acute pulmonary edema due to severe hypoxia or edema pulmonary function. It is produced by the generation of negative pressure, by attempting to breathe and to deal with a closed glottis, promoting fluid transudation to the alveolus, in addition to hypoxia increasing sympathetic stimulation, causing systemic and pulmonary vasoconstriction [32].

Conclusion

The most important thing in LEP is its prevention. The identification of risk factors in susceptible patients can help us to avoid obstruction of VA, it is a priority to allow all those maneuvers that can contribute to prevention. If LEP has already been installed with propofol in sub-hypnotic doses offers greater advantages than succinylcholine, it helps to break the spasm without myocardial depression. The administration of muscle relaxants and reintubation may be necessary advanced measures to solve the problem. The administration of muscle relaxants and hypoxia is a dangerous combination that can end in cardiac arrest if the problem is not resolved in time. Magnesium sulfate is another alternative before or after the administration of other drugs, it helps to relax the bronchial musculature. Finally, blocking the upper laryngeal nerves may be an extreme measure in those children with a history of LEP recurrence. Obstructive pulmonary edema and bronchoaspiration are two of the most frequent complications that can occur in the period of anesthesia.

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