

## Maintenance of airway patency with a laryngeal mask and COPA-airway during small surgical intervention in children

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### Keypoints

The development of regurgitation and aspiration is possible when conducting mechanical ventilation through the LMA because of the ingress of the gas-narcotic mixture into the stomach. Many of the complications arising from the use of LMA and COPA-airway can be avoided due to their proper use.

### Abstract

#### Introduction

The most common methods for maintaining a free airway during anesthesia in children are the traditional airway without a cuff, COPA - airway, laryngeal mask airway and endotracheal tube. In contrast to the main methods of maintaining the airway, the LMA and COPA-airway began to be widely used relatively recently. Therefore, one of the main tasks of our work was to assess the comparative effectiveness and safety, to determine the advantages and disadvantages, to develop recommendations for their use.

#### Material and methods

Depending on the type of airway control, patients were randomized into 3 groups: (n = 66) - children with an endotracheal tube, (n = 26) - children with a laryngeal mask (LMA), (n = 67) - children with COPA airway. The installation of LMA and COPA - airway we carried out only after reaching the surgical stage of anesthesia, when the laryngeal and pharyngeal reflexes disappeared.

#### Results

A study conducted on this issue shows that LMA, COPA-airway and endotracheal intubation are effective and safe means of maintaining the free flow of the respiratory tract in children with general anesthesia. The main differences between them are only in the degree of protection of the

respiratory tract from aspiration, simplicity and invasiveness of the method, and convenience and comfort for the anesthesiologist. Compared with endotracheal intubation with a cuffed tube, when the child's airway is as tight as possible and protected, when using LMA and COPA-airway, the risk of aspiration is not excluded and the probability of gas leakage increases. When using LMA and COPA-airway there is a time limit for the duration of the operation. They can be used only for short and medium duration operations.

#### Conclusions

Laryngeal mask and COPA-airway are a new concept of airway management. Compared with a face mask and a conventional duct, LMA and COPA-airway provide greater tightness between the upper respiratory tract and anesthesia apparatus, allow you to safely manage anesthesia "at a distance" reduce the release of gaseous anesthetics to the environment.

#### Keywords

LMA, COPA-airway.

#### Introduction

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### Material and Methods

Depending on the type of airway control, patients were randomized into 3 groups: (n = 66) - children with an endotracheal tube, (n = 26) - children with a laryngeal mask (LMA), (n = 67) - children with COPA airway. The installation of LMA and COPA - airway we carried out only after reaching the surgical stage of anesthesia, when the laryngeal and pharyngeal reflexes disappeared. They were removed after recovery of spontaneous breathing in the background of post-anesthetic sleep. During the study, the following parameters were compared:

1. Ease of administration (easy, difficult, impossible).

If the introduction of LMA and COPA-airway was impossible on the first attempt, then the number of reinstallation attempts was recorded.

2. Convenience for the anesthesiologist.

This took into account the need for additional measures to fix the LMA or COPA in the correct position. In this case, it was also meant whether the hands of the anesthesiologist remain free.

3. The frequency of complications in the application of LMA and COPA-airway.

### Results and Discussion

The introduction of the LMA was carried out using standard equipment, and the installation of the COPA-airway using the rotational method with a rotation in the mouth area of 180°. LMA was established on the first attempt in 16 (61.5%) patients. In the remaining 10 (38.5%) patients, administration of LMA was difficult: at the second attempt, it was successfully installed in 8 patients, and at the third attempt, in 2 patients.

There were no cases where the introduction of LMA was not possible at all. The reasons for 10 repeated attempts to install LMA were as follows:

- in 5 children the tip of the LMA cuff rested against the back wall of the pharynx when injected, and probably turned upwards. This required the removal of the mask and its reinstallation by the standard method, pointing the LMA with the index finger of the left hand in the right direction, or in a rotational way;

- in 2 patients immediately after installing the LM and inflating the cuff, there was a significant (" audible) leakage of the gas-narcotic mixture, due to either an incorrect position of the LMA or a mismatch between the sizes of the mask and laryngopharynx. Clinically, this was manifested by the impossibility of effective manual ventilation through the LMA without a pronounced discharge of the gas mixture through the mouth. When re-installing a larger or smaller LMA, the leak was successfully eliminated;

- LMA offset immediately after fixation in 3 children.

The introduction of the COPA-airway was also not unambiguous. So, COPA-airway was easily installed in 60 children. In the remaining 7 patients, the introduction of the COPA-airway was difficult, but at the second attempt it was successfully installed for all children. The reason for all repeated attempts at introduction was the shift of COPA immediately after fixation with head straps, which resulted in a partial obstruction of the respiratory tract.

Thus, the COPA-airway, in comparison with the LMA, is much easier to install ( $p < 0.001$ ) and, above all, it is associated with the ease of mastering the COPA introduction technique. When using LMA in the course of anesthesia, in no case was it necessary to perform any additional measures to fix it in the correct position: while the anesthesiologist's hands remained free. On the contrary, even with the correct arrangement of the COPA-airway in the oropharynx, 47.7% of cases (25 children) the anesthesiologist had to take certain actions to keep from shifting: to maintain the lower jaw, to put the roller under the neck, to turn and fix the head in a certain position, etc., therefore, LMA is definitely more convenient for the work of the anesthesiologist, COPA-airway.

Adverse reactions and complications in response to the LM installation were significantly more frequent than with the administration of COPA ( $p < 0.01$ ). So, they were observed in 9 children from the LMA group (34.6% of cases), and in total 5 from the COPA group (7.6% of cases). The most common reactions in response to the installation of LMA and COPA: breath holding (2.8% and 0.8% of cases, respectively), cough (4.2% and 1.4%) and laryngospasm (1.2% and 0%), to resolve which, intravenous esmerone (rocuronium bromide) was injected at the rate of 0.45 mg / kg.

We explained all reactions to the LMA and COPA installation with an insufficient depth of anesthesia, which was quickly eliminated by the deepening of anesthesia by injecting propofol, conducting forced manual ventilation through the LMA and COPA-airway. In the case of re-installing LMA in 3 patients (11.5%), the appearance of blood was noted. The blood on the cuff in the 1st case was associated with an injury of the mucous membrane of the posterior pharyngeal wall, and in 2 cases - with the trauma of hypertrophied palatine tonsils. And in the cases with the use of the SORA-air duct, in one case with its re-installation, no traces of blood were found on the cuff.

It was observed that breath-holding, coughing and laryngism in the setting of LMA and COPA were mainly (8.2% and 2.2%) recorded in children of the older age group, who underwent anesthesia with propofol. We explained this fact with the fact that propofol, to a lesser extent than halogen-containing inhalation anesthetics, suppresses protective reflexes during the induction of anesthesia. From this, it follows that intravenous induction with propofol in children is advisable to be deepened with one of the vapor-forming anesthetics or with an increase in the dose of propofol, and only then proceed to the installation of LMA or COPA.

From the above, it can be concluded that the installation of LMA is certainly a more invasive method of maintaining free airway compared to COPA, as at the time of its installation the probability of oropharyngeal coughing,

coughing, respiratory depression and laryngismus increases significantly.

Adverse reactions and complications were also noted during the maintenance of anesthesia. In total, they were observed in 5 patients from the LMA group (19.2% of cases) and 9 from the COPA group (13.4% of cases), with minor differences ( $p > 0.05$ ). Thus, at the stage of maintaining anesthesia using LMA and COPA-airway, 3 (11.5%) and 6 (8.9%) episodes of spontaneous dislocation with partial obstruction of the respiratory tract, respectively, were recorded, which required their repeated administration, in 2 (7, 7%) and 2 (2.9%) patients, respectively, were observed cases of gastric over-inflation due to gas mixture reflux during mechanical ventilation, successfully eliminated after the introduction of the same probe. And in one patient from the COPA group, cases of regurgitation of gastric contents without aspiration were observed. And cases of regurgitation and aspiration in the group with LMA were not observed in any patient.

Thus, adverse reactions and complications along the course of anesthesia with the use of LMA and COPA-airway are equally rare. When removing the LMA and COPA-airway, some adverse reactions and complications were also noted. So, when removing LMA, they were recorded in 5 children from the LMA group (19.2% of cases), and only in 4 children from the COPA-airway group (5.9% of cases), ( $p < 0.01$ ).

The most common adverse reactions in response to the onset of LMA and COPA-airway, such as breath holding (3.9% and 0% of cases, respectively) and laryngospasm (1.0% and 0.5%) were successfully purchased by intravenous the introduction of esmerone 0.45 mg / kg. In addition, in 6 children (11.1%), when removing LMA, "biting" of its tube took place with its teeth, which was due to the patient's rapid waking up. To prevent airway obstruction, LMA was moved from the laryngopharynx to the oral cavity, and when the children opened their mouth, it was removed without complications. All the above-mentioned adverse reactions resulted from too late

removal of the LMA and the COPA-airway against the background of partially restored defensive reflexes.

When removing LMA and COPA-airway at the end of anesthesia, 2 children from the LMA group (7.7%) and 6 (9.0%) from the COPA-airway group showed the appearance of blood on the cuff as a result of oropharyngeal injury at the time of their installation. Considering 2 cases of blood appearance detected after the initial failed attempt to inject LMA, the total number of the traumatic LMA and COPA-airway installation was 3 (11.5%) and 9 (15.1%), respectively, the differences are unreliable ( $p > 0.05$ ). Oropharyngeal trauma in 7 patients showed soreness and sore throat in the postoperative period (when examining the oropharynx in these patients, redness was observed on the back of the pharynx without bleeding), and the remaining 5 were asymptomatic.

Consequently, the likelihood of adverse reactions or complications when extracting LMA is significantly higher than when using COPA-airway.

Based on the above, the following conclusions can be drawn:

1. Induction by inhalation anesthetics allows creating conditions for easy, fast and non-traumatic installation of LMA and COPA-airway with small amounts of adverse reactions and complications. Conversely, with the induction of propofol, the likelihood of breath holding, coughing and laryngospasm in response to the administration of LMA and COPA increases, so before installing them it is advisable to deepen the anesthesia with one of the inhalation anesthetics or increase the dose of propofol.

2. COPA-airway has a number of advantages over the installation of LMA, because its installation is a little easier and does not require special skills, its introduction and removal are much less likely to cause complications, trauma of the oropharynx also decreases. Nevertheless, you need to know that at the stage of maintaining anesthesia, the COPA-airway requires more close attention to itself than the LMA, since it is necessary to carry out additional measures for its fixation in the correct position. But LMA and COPA-airway have significant advantages

over traditional oropharyngeal and nasopharyngeal duct without a cuff with the following features: 1) so the presence of a special connector (15 mm) and a retaining strap gives you the opportunity to refuse to use the face mask, while leaving the anesthesiologist's hands free; 2) cuff reduces the risk of aspiration.

3. All cases of complications arising from the removal of LMA and COPA-airway were the result of their too late extraction against the background of partially restored defensive reflexes. Therefore, the removal of LMA and COPA-airway should be carried out only in the state of medication sleep, when these reflexes are still suppressed, provided that by this moment the child has recovered adequate independent breathing.

Sufficient sealing of the entrance to the larynx minimizes the risk of aspiration during anesthesia, therefore, the tightness of the respiratory tract is one of the main criteria for judging the efficacy and safety of methods for maintaining their free flow.

Tightness at the level of the entrance to the larynx in our work was assessed by the presence or absence of gas mixture leaks from under the swollen cuff of the endotracheal tube, LMA or COPA. Since all other types of outflows from the breathing circuit were approached to a minimum, the leakage from under the cuff was calculated using the formula  $VT_{in} - VT_{ex}$ , where  $VT_{in}$  and  $VT_{ex}$  are the tidal volume detected by the flow sensor on the inhalation and expiratory hose. If  $VT_{in} = VT_{ex}$ , then there is no gas mixture discharge. When  $VT_{in} > VT_{ex}$ , the endotracheal cuff, LMA, or COPA-airway was inflated with an additional amount of air, trying to eliminate any leaks. The reset value was also determined as a percentage, using the formula  $(VT_{in} - VT_{ex}) / VT_{in} \times 100$ . When using an endotracheal tube with a cuff ( $n = 26$ ), the airways were sufficiently sealed ( $VT_{in} = VT_{ex}$ ) in a larger number of patients (99.1%). Unrecoverable leakage of the gas mixture due to inconsistencies in the size of the endotracheal tube and larynx were detected in 2 patients.

When using LMA ( $n = 26$ ), the airways were completely sealed ( $VT_{in} = VT_{ex}$ ) in 83.5% of cases. There were no

cases of spontaneous voluntary rupture of the LMA cuff during anesthesia. Non-recoverable leaks of the gas mixture at the compound level " LMA cuff - the entrance to the larynx " immediately after the LMA was installed in the correct position were observed in 5 patients from the LMA group (19.2%, n = 26). In a subgroup of children on mechanical ventilation (n = 12), gas mixture leaks from under the LMA cuff were detected in 2 children at the time of their transfer to forced breathing apparatus. In this case, the discharge of the gas mixture from under the cuff LMA was so significant that in some children it became audible. At the same time, in 10 patients there was a moderate swelling of the stomach due to the throw of the gas mixture there, which was eliminated after the installation of the gastric probe.

And in the subgroup of children with preserved spontaneous breathing, no additional leaks from under the LMA cuff were observed at the stage of anesthesia maintenance.

Thus, when conducting ventilator ventilation through the LMA in children, cases of insufficient sealing of the entrance to the larynx are much more common than with independent breathing through the LMA. This can be explained as follows. During self-inhalation, a negative airway pressure develops, which "presses" the LMA cuff to the entrance to the larynx, sealing the system. Conversely, the ventilator creates positive pressure while inhaling, as a result of which the LMA cuff can "move away" from the entrance to the larynx with possible leakage of the gas mixture.

When using the COPA-airway (n = 67), the airways were completely sealed ((VT<sub>in</sub> = VT<sub>ex</sub>) in only 32.3% of cases. There were no cases of spontaneous rupture of the COPA cuff during anesthesia).

Unremovable gas mixture leaks from under the swollen cuff of the COPA-airway immediately after its installation were found in 17 patients (26.1%), and overdosing occurred in 3 children against the background of forced manual ventilator stomach with regurgitation of gastric contents without clinical signs of aspiration. In addition,

in 8 patients a leak of a gas mixture was found associated with the spontaneous dislocation of the SORA-air duct at the stage of anesthesia maintenance, which required its repeated administration.

Based on the above, the following conclusions can be drawn:

1. Endotracheal intubation has been and remains the most reliable way to maintain free airway. If the tube size is chosen correctly, then when inflating its cuff the entrance to the mountain in children is completely sealed in most cases (99.1%). And this allows to achieve maximum protection of the tracheobronchial tree from aspiration.

2. Unlike the endotracheal tube with a cuff, cases of insufficient tightness of the entrance to the larynx when using LMA are quite common (16.5%). The probability of leakage of the gas mixture increases when conducting mechanical ventilation through the LMA (p < 0.05), and the higher the peak pressure during inspiration, the greater the leakage with the possible injection of the gas mixture into the vessel. Compared with the LMA cases, incomplete sealing of the respiratory tract when using the COPA-airway are much more common (67.7%). Thus, unlike the endotracheal tube with a cuff, LMA and COPA-airway do not in all cases provide complete protection of the respiratory tract.

Recommendations for use laryngeal mask and COPA-airway in children:

Methods of installing a laryngeal mask. During the study, we used the standard LMA technique and technique with a 90 ° rotation in children with hypertrophied tonsils. In all cases, before applying the LMA, it was checked for the presence of visible defects; a control inflation of the cuff was performed. The following air volumes were used for this: size 1 - 6 ml, size 2 - 15 ml, size 2.5 - 21 ml, size 3 - 30 ml. Before installing the cuff was completely blown away. On the surface of the cuff was applied lubricant Katedzhel.

Standard installation steps:

1. Choose a LMA of the appropriate size.
2. Install LMA after sufficient anesthesia depth.

3. The head of the child was placed in the "smelling" position with the help of the other hand of the anesthesiologist.
4. LMA was held between the thumb and forefinger closer to the junction of the tube and the mask, with the aperture facing up.
5. The patient's mouth was opened by an assistant or third finger of the main anesthetist's hand.
6. The tip of the cuff was placed opposite the inner surface of the upper incisors of the patient. The mask pressed against the hard palate and advanced into the oral cavity.
7. Promotion of the mask in the lower part of the pharynx was carried out with the index finger mounted on the connection of the tube with the mask.
8. LMA was introduced to the sensation of resistance.
9. The LMA cuff was inflated with an appropriate amount of air, while it is important to hold the tube at the moment so that the mask tip cannot go deeper than the required level.
10. LMA was fixed with adhesive tape.

#### Modified method of installing a laryngeal mask:

In our daily practice, we used this technique more often, since most children have hypertrophied tonsils. At the same time, LMA was introduced into the pharynx at an angle of 90° with respect to the standard introduction, bypassing the tongue from the side. With the passage of the pharyngeal ring, the LMA was turned to its usual position and then installed according to standard techniques.

#### Criteria for proper installation of the laryngeal mask:

1. Simultaneous displacement of the cricoid and thyroid cartilage forward while inflating the LMA cuff and the appearance of an oval bulging on the neck.
2. Detection of low airway resistance with manual ventilation.
3. The appearance of air vapor on the LMA breathing tube when connected to the breathing apparatus.
4. Symmetric excursion of the chest and auscultation of breathing on both sides with manual ventilation.
5. The absence of coarse "audible" gas leakage through the mouth and in the stomach.

6. Evaluate the data of pulse oximetry and capnography. During anesthesia, it is necessary to periodically check by touch the degree of filling of the cuff to make sure that it is well inflated. It is necessary to pay attention to the fact that in the course of anesthesia with the use of gas inhalation anesthetics, their gradual diffusion into the cuff occurs, which contributes to its over-inflation and may lead to dislocation of the LMA with impaired airway patency. The position of the child on the side is not a contraindication for the use of LMA. But it must be remembered that in the lateral position, anesthesia should be deeper and more adequate in order to avoid provoking cough or laryngism. The nasogastric tube is best introduced before installing the LMA. If necessary, the introduction of the nasogastric zone can be done during anesthesia, while dissolving the cuff.

#### *Technique of introducing COPA-airway in children.*

To successfully install the COPA-airway, it is necessary to clearly follow the following techniques:

1. The introduction of the COPA-airway should be carried out with an adequate level of anesthesia.
2. It is necessary to have on hand a ready-to-use COPA-airway larger and smaller.
3. With the introduction of the COPA-airway, the Safar triad must be performed (maximum extension of the head, bringing the lower jaw forward and opening the mouth).
4. The installation of the COPA-airway requires a deeper anesthesia and should be carried out only at the surgical stage of anesthesia, when the laryngeal and pharyngeal reflexes disappear. The introduction of the COPA-airway at more superficial stages of anesthesia or upon awakening, when these reflexes are not fully suppressed, can cause a reflex swallowing act, and, as a result, the short-term closure of the vocal cords - laryngospasm. The development of this reflex does not allow the lungs to inflate until the vocal cords open, usually this happens 30-40 seconds after the introduction of the COPA-airway. But with the continuation of laryngospasm, it is necessary

to introduce rocuronium bromide (esmerone) 0.45 mg / kg.

5. With the introduction of the COPA-airway, the same methods are used as with the installation of a conventional duct, with a rotation in the mouth for 180°.

When removing the LMA and COPA-airway, remember the following points:

- Our experience shows that LMA and COPA-airway in children should be removed on the operating table only in the state of drug sleep, when there are no laryngeal and pharyngeal reflexes, provided that by the time of extraction the spontaneous adequate breathing has been restored. Therefore, the patient should not be stimulated until the LMA and COPA-airway are removed.

- If, upon awakening, the child has a trophism of chewing musculature and it is not possible to remove the LMA and COPA-airway, blow the cuff out and move them from the pharyngeal pharynx to the oral cavity and wait until he opens his mouth. Do not try to forcefully pull out the LMA and the COPA-airway from the mouth, as this may cause damage to the teeth or the cuff.

- The cuff should be blown immediately before removing the LMA and the COPA-airway. If the cuff is straightened before the restoration of effective protective reflexes, secrets from the upper parts of the pharynx, which have fallen into the larynx, can provoke reflex laryngospasm.

Contraindications to the use of laryngeal mask and COPA-airway in children:

In the course of our own research and analysis of numerous available literature, the following contraindications to the use of LMA and COPA-airway in children were identified:

- with a high risk of regurgitation (full stomach, intestinal obstruction, diaphragmatic hernia, pyloric stenosis, etc.).

- with a pathological process in the pharynx (abscess, hypertrophy of the tonsils, etc.).

- during long traumatic operations with muscle relaxation and mechanical ventilation.

- with high airway resistance and low lung dispensability (chest trauma, bronchospasm, pulmonary edema, etc.).

What problems can we face when using a laryngeal mask and COPA-airway?

- LMA and COPA-airway provide only partial protection of the tracheobronchial tree from aspiration of gastric contents, globular secretion and blood.

- With an inadequate level of anesthesia, partial or full larynges can develop.

- During anesthesia, partial or complete obstruction of the airway may occur due to spontaneous displacement of the LMA and the COPA-airway.

- With forced ventilation of the lungs through the LMA and the COPA-airway with high peak inspiratory pressure, over-inflation of the stomach may occur with hypoventilation of the lungs and possible regurgitation of gastric contents.

Our numerous experience in pediatric surgery shows that the routine use of LMA in micro endoscopic endonasal interventions, in adenoid and tonsillectomy in children is not appropriate because:

1) LMA does not always provide reliable sealing of the entrance to the larynx, especially during mechanical ventilation through the LMA, which increases the risk of blood aspiration;

2) if during the operation LMA dislocation occurs and there is a need for emergency tracheal intubation, the blood accumulated in the hypo pharyngeal pharynx can complicate visualization of the entrance to the glottis and, therefore, tracheal intubation;

3) the presence of hypertrophied palatine tonsils in a child can also impede the installation of LMA with their inevitable trauma and blood flow;

4) there is also a potential danger of damage or complete rupture of the LMA cuff by the adenotome with subsequent aspiration of blood;

5) bloated cuff LM also complicates the work of the surgeon due to poor visibility of the surgical field and thus the operation.

Therefore, we believe that laryngeals - operations are an absolute contraindication to the use of LMA in children. Thus, a study conducted on this issue shows that LMA, COPA-airway and endotracheal intubation are effective and safe means of maintaining the free flow of the respiratory tract in children with general anesthesia. The main differences between them are only in the degree of protection of the respiratory tract from aspiration, simplicity and invasiveness of the method, and convenience and comfort for the anesthesiologist. Compared with endotracheal intubation with a cuffed tube, when the child's airway is as tight as possible and protected, when using LMA and COPA-airway, the risk of aspiration is not excluded and the probability of gas leakage increases. When using LMA and COPA-airway there is a time limit for the duration of the operation. They can be used only for short and medium duration operations. However, LMA and COPA-airway has a number of significant advantages over endotracheal intubation, they are less invasive, do not usually require the introduction of muscle relaxants, can be used at more superficial levels of general anesthesia and are an alternative for difficult intubations, especially in children.

### Conclusion

Laryngeal mask and COPA-airway are a new concept of airway management. Compared with a face mask and a conventional duct, LMA and COPA-airway provide greater tightness between the upper respiratory tract and anesthesia apparatus, allow you to safely manage anesthesia "at a distance" reduce the release of gaseous anesthetics to the environment. Mastering the installation of LMA and COPA-airway compared to the tracheal tube is much faster. Hemodynamics and intraocular pressure are less susceptible to changes during their installation. When using LMA, intubation of one bronchus or esophagus is impossible, the risk of injury and damage to the pharynx and larynx is reduced, the risk of damage to the teeth is eliminated, and pharyngitis is less common. The most terrible complication with the use of LMA may be regurgitation and aspiration, the risk of which increases

with inadequate installation of LMA, with its dislocation during surgery. The development of regurgitation and aspiration is possible when conducting mechanical ventilation through the LMA because of the ingress of the gas-narcotic mixture into the stomach. Many of the complications arising from the use of LMA and COPA-airway can be avoided due to their proper use.

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