Application of video laryngeal mask airway in pediatric surgery

【Abstract】: Because of the particularity of children's airway, it is more necessary to find the most suitable airway management tool. The video laryngeal mask increased the visual function on the basis of the original laryngeal mask ventilation, which could directly observe the insertion, indwelling and guiding tracheal intubation process of laryngeal mask, which was convenient for intraoperative airway management and increased clinical safety. This article describes the clinical advantages of visual laryngeal mask airway in pediatric surgery, and provides reference for clinical application.

【Key words】Laryngeal mask, pediatric surgery, pediatric airway, visualization

Introduction

Airway management is one of the core and key skills in clinical medicine especially in emergency medicine, anesthesiology, critical care medicine and pediatrics. Ensuring the patency and safety of the airway is a prerequisite for maintaining effective ventilation and oxygenation and ensuring the safety of patients. However, children, especially infants and young children, are by no means "'smaller versions" of adults. There are a series of significant and important differences in the anatomical structure, physiological function and pathological response of the airway These inherent characteristics make children not only more susceptible to airway obstruction, but also face higher risks and unique challenges in airway intervention.

Higher compared with adults, children's airway present position (laryngeal in C3-4 level), narrower diameter (the narrowest point is located in the subglottic area of cricoid cartilage level), the structure of the organization is more soft and fragile, epiglottis form special (long, soft, submit form), the tongue body is opposite bigger short head neck etc.[l] These anatomical differences have profound clinical significance: a trace amount of airway edema or secretion can lead to a geometric increase in airway resistance, leading to severe ventilatory dysfunction. The soft

structure makes it more prone to collapse, compression or injury under negative pressure or external force. The high position of the larynx and the special shape of the epiglottis significantly increase the difficulty of direct laryngoscopy to expose the glottis and tracheal intubation. In addition, children's high metabolic rate, high oxygen consumption, and low functional residual capacity make them more susceptible to rapid hypoxemia and respiratory failure in the case of airway obstruction or hypoventilation, and the disease often progresses more rapidly.

The safe and effective management of children's airway is based on a deep understanding and high attention to these unique anatomical and physiological characteristics, Any negligence or improper operation may cause catastrophic consequences, such as brain injury or even death, due to airway edema, injury improper catheter position or ineffective ventilation, This requires not only skillful operation, but also the ability to select the appropriate device (size and type), develop individualized strategies, and deal with sudden complications.

The characteristics of children's airway have special requirements for airway management tools

In the airway management of pediatric surgery, endotracheal intubation. (endotracheal intubation, ETT) has long been regarded as the standard method, but its operation complexity and related complications has become a clinical challenge. Endotracheal intubation common problems include postoperative throat discomfort laryngeal lesions, and operating failure risk [2]. With the rise of supraglottic devices, laryngeal mask airway (LMA) as an alternative is increasingly used in the pediatric field, especially in reducing complications, improving operation efficiency, and suitable for specific populations.

1)Due to the higher position of children's larynx (C3-C4 level), the epiglottis is short and stiff in a "U" shape, and the glottis Angle is sharper, which makes it more difficult to expose the laryngoscope and align the catheter with the glottis. And [3, 4]children subglottic area is the most narrow airway (cricoid cartilage level), mucosal

osteoporosis, intubation operation easy cause mucosal edema, result in postoperative hoarseness, stridor airway obstruction and even literature shows that subglottic edema risk is three times bigger than the adult (4-6). The laryngeal mucosa is fragile, and tracheal intubation can easily lead to mucosal injury, edema and laryngspasm.[7] LM can avoid direct contact with the glottis, reduce mechanical irritation. and reduce such risks [8].

2) Children have a high metabolic rate and a low functional residual capacity and oxygen saturation decreases very quickly when intubation is interrupted (literature reports that it can drop below 90% on average in 30 seconds). Repeated attempts during difficult intubation significantly increase the risk of hypoxemia [9.11]. The laryngeal mask, as a rescue airway device, can quickly establish ventilation [12].

3)Children with high vagal tone have an increased risk of bradycardia, especially preterm infants are more likely to have severe bradycardia or even cardiac arrest induced by laryngoscopic stimulation [13, 14]. In addition, children's bronchial smooth muscle is developed, and intubation stimulation is easy to induce laryngospasm and bronchospasm (the incidence of laryngospasm in children is as high as 17% in the literature), especially in children with asthma or respiratory tract infection[15,16].

4) For neonates (gestational age >34 weeks and body weight >2 kg), the trachea is thinner and more difficult to intubate, LM can be used as an alternative to Face Mask Ventilation (FM) or as a backup scheme for intubation failure, which effectively delivers Positive Pressure Ventilation (PPV) and is easier to operate [1]. Literature has shown that LMA can significantly reduce the need for postoperative mechanical ventilation in preterm infants undergoing retinal surgery and become a feasible alternative [2].

The inferior nature of tracheal intubation in children stems from the particularity of anatomy and physiology: narrow and vulnerable airway, low oxygen reserve and high stress response constitute the "triple vulnerability". This vulnerability magnifies the

consequences of operational errors, makes difficult airway management more urgent, and significantly increases the risk of long-term complications such as subglottic stenosis [3-6]. At the same time, because children's cricoid cartilage ring is the narrowestern point of the airway, which is round and funnel shaped, the use of cuffs may lead to malposition or high pressure of the cuff, which may cause ischemia edema or long-term damage to the cricoid cartilage ring (such as subglottic stenosis)Historical beliefs support the use of uncuffed devices to minimize the risk of such compression, although they are not completely risk-free [7, 8]. Therefore, LM, as a supraglottic device, has its unique advantages in pediatric surgery.

Compared with tracheal intubation, laryngeal mask airway has its advantages in pediatric surgery

1.Reduce perioperative respiratory complications

1) Reduce Postoperative Throat pain: Studies have shown that tracheal intubation is directly related to Postoperative Sore Throat (POST), hoarseness and mucosal injury [2, 9]. However, LMA significantly reduces such complications: in multiple studies of children undergoing adenotonsillectomy, the incidence of POST in LMA group was lower than that in ETT group [10, 11].

2) Reduction of severe respiratory adverse events (PRAEs): Respiratory adverse events included laryngospasm, bronchospasm and aspiration. In a study of laparoscopic inguinal hernia repair in children, the incidence of PRAEs was similar between the LMA group and the ETT group, indicating that even in high abdominal pressure surgery, the LMA group had similar aspiration rates with ETT. but the duration of anesthesia was shorter in the LMA group [12].Luce et al. reported lower or similar rates of major PRAEs with LMA in pediatric patients without a history of upper respiratory tract infection [12]. An animal model study further demonstrated that LMA reduces airway irritation and reduces the risk of developing laryngspasm[13].

2.It is easier and more efficient to operate

1) Short insertion time and high success rate: Pediatric intubation requires high skill and sufficient experience accumulation, so the first-pass success rate is often less than 50% [1]. In a study of adenotonsillectomy in children, the insertion time in the LMA group was significantly shorter than that in the ETT group, and the heart rate and oxygen saturation of children were more stable [10].

2) Suitable for emergency scenario: LA ventilation is more efficient than mask ventilation in neonatal resuscitation or OHCA, and LMA is easier to operate than endotracheal intubation [14, 15]. It has been emphasized in relevant literature that LMA can save lives when "Cannot Intubate, Cannot Oxygenate" (CICO) [16].

3.Better postoperative respiratory management and postoperative recovery

Preserve spontaneous breathing and reduce atelectasis formation: LM allows children to maintain spontaneous breathing, which can reduce mechanical ventilation in day surgery (such as ophthalmology or ENT) [1]. In addition, laryngeal mask airway combined with regional block anesthesia can shorten the recovery time and reduce the risk of emergence delirium (PAED) [2]. Children are more likely to suffer from atelectasis due to mechanical ventilation, LM significantly reduces the incidence of postoperative atelectasis compared with tracheal intubation. For example, in gynecological and urological non-laparoscopic surgery, LMA group has a lower atelectasis score [1.3]

2)Reduce allergic reactions: studies have shown that 60.8% of allergic reactions during pediatric anesthesia are caused by muscle relaxants [4. LM can reduce or avoid the use of muscle relaxants. Therefore, LMA can effectively avoid perioperative allergic reactions in pediatric surgical airway management.

3)Reduce postoperative ventilation dependence: One of the largest studies investigating laryngeal mask airway management during general anesthesia in

preterm infants showed that the use of laryngeal mask airway instead of tracheal intubation for airway management in preterm infants undergoing general anesthesia can significantly reduce the need for postoperative mechanical ventilation and optimize the recovery process [5]

4.Advantages of specific surgical scenarios

1)Laparoscopic surgery: Traditionally, laparoscopic surgery requires endotracheal intubation to ensure airway sealing under pneumoperitoneum pressure but new studies have shown that laryngeal mask airway can be safely used in pediatric laparoscopic surgery, In the meta-analysis of pediatric laparoscopic hernia repair, the incidence of adverse respiratory events in the laryngeal mask group is low, and it is especially suitable for short-term surgery to reduce the risk of recovery [6]

2)Minimally invasive/day surgery: In otolaryngology (such as adenotonsillectomy) or ophthalmic surgery, LMA provides an anesthetic regimen without muscle relaxants, simplifies the process and reduces drug-related side effects [7].

3)Emergency or resuscitation scenarios: The high failure rate of airway management in children makes LMA a critical rescue tool. LM is recommended as an alternative device in neonates with difficult intubation because of its high insertion success rate and operational risk [8]. Neonatal health care professionals report that itis easier to gain confidence in the use of LMA during resuscitation, although there is no standardization of LMA use [9, 10]. The importance of LMA as a basic airway device has been demonstrated in children's transport or primary care [8, 11].

The application of traditional laryngeal mask airway in pediatric surgery has limitations

Although LMA has so many advantages in the application of pediatric surgery due to the blind insertion of LMA, it is often easy to cause malposition hypoventilation, regurgitation and aspiration, postoperative sore throat, glottic edema and other related complications or adverse events. Therefore, how to safely and effectively place the

LMA in the appropriate anatomical position, ensure good ventilation in children during surgery, and avoid the occurrence of adverse events such as glottic edema and laryngeal injury are important links in the application of LMA in pediatric surgery airway management.

In recent years, with the continuous progress and change of anesthesia technology, laryngeal mask has added video function on the basis of the original ventilation, and realized the visualization of laryngeal mask, Compared with the traditional laryngeal mask, the visual laryngeal mask has the advantages of visualization of placement, accurate positioning, small damage to the laryngeal soft tissue, high oropharyngeal leak pressure (OLP), and good sealing. [7]. In the process of LMA insertion, the placement of LMA can be observed under the guidance of the video endoscope, which can improve the accuracy of LMA insertion and ensure the correct placement of LMA. At the same time, the built-in camera can reduce the number of attempts at blind insertion, reduce the occurrence of adverse events such as laryngspasm and glottis injury, ensure the establishment of surgical airway in children and reduce the use of postoperative analgesics. In addition, when the displacement of the LMA occurs, such as air leakage, reflux and aspiration, the position of the LMA can also be adjusted and negative pressure suction can be performed under the video endoscope to avoid the occurrence of aspiration pneumonia. At the same time, the high OLP and good sealing of visual LMA can also be used to build a safe and effective airway in children undergoing laparoscopic surgery, and expand the clinical application of LMA.

Visual laryngeal mask has unique advantages in pediatric surgery

1. Precise placement and reduction of the risk of malposition

The common laryngeal mask is inserted by blind insertion method, and the literature indicates that its malposition rate is as high as 50%-80%, which may lead to hypoventilation or the risk of aspiration [2]. However, visual LMA is equipped with

an embedded camera to achieve accurate positioning under visual guidance [3, 4], and significantly reduce misalignment caused by anatomical abnormalities (such as airway stenosis or variation in children)[2, 5]. Literature has confirmed that visualization technology can directly observe the position of glottis to ensure that the sealing ring of laryngeal mask is fitted to the laryngeal structure and improve the sealing [4].

2.Reduce complications and improve safety

The unique laryngeal anatomical characteristics of children, including hypertrophy of the tongue, relatively positioned larynx and epiglottis, hypertrophy and U-shaped and forward movement, make the blind insertion of LMA difficult. The success rate of insertion is low and repeated adjustment of LMA may also cause complications such as glottic edema and mucosal damage in children with unique physiological and anatomical characteristics such as soft cartilage and vocal cord and laryngeal mucosa tissue damage [6]. Visual laryngeal mask can avoid rough intubation and reduce mucosal injury through direct visual operation [7]. At the same time, accurate positioning can optimize Oropharyngeal Leak Pressure (OLP), reduce intraoperative gas leakage, and maintain stable ventilation [2, 8], especially suitable for laparoscopy and high pneumoperitoneum pressure [9].

3. Effectiveness in dealing with a difficult airway

Video LMA can be used as a reliable rescue tool in children with difficult airway situations, such as excessive tongue and mandibular retrusion. The literature emphasizes that it can replace fiberoptic bronchoscopy to guide intubation [4, 10] and quickly establish a safe airway. For example, in neonatal resuscitation, the rate is low due to the lack of confidence of medical staff in the operation of ordinary laryngeal mask [11, 12], while visualization technology can improve the success rate of operation and the confidence of medical staff [13].

4. Value of teaching and training

The real-time video feedback of visual LMA can help train medical staff, especially those with less experience, to master the correct insertion technique. It has been pointed out in literature that medical students need several optimization adjustments when operating the common laryngeal mask on an adult model [14], while the visualization system can shorten the learning curve and improve the operation proficiency in pediatric emergency scenarios [15].

5.Advantages of continuous monitoring during operation

Visual LMA allows continuous monitoring of LMA position and airway status during the whole operation 2, 4]to avoid LMA displacement caused by body position changes or surgical operations. This is particularly important in long-term surgery. which can provide timely intervention for potential ventilation disorders (such as laryngspasm and secretion obstruction), while the ordinary LMA lacks this function.

Summary

Airway management is essential in pediatric surgery, and appropriate airway management tools are the most advantageous assistant for anesthesiologists. The emergence of visual laryngeal mask makes up for the shortcomings of traditional laryngeal mask, and magnifies the advantages of simple placement, quick learning and few postoperative complications of laryngeal mask, The application of video laryngeal mask in pediatric surgery not only ensures the stability of the airway, but also reduces the postoperative discomfort of children, accelerates the postoperative recovery of children, and shorts the length of hospital stay. At the same time, it also expands the clinical indications of laryngeal mask airway in pediatric surgery, improves the proportion of day surgery in elective surgery in children's hospital. optimizes hospital operation, and reflects good clinical economic value.

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