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Influence of laryngeal mask airway (LMA) insertion anesthesia on cognitive function after microsurgery in pediatric neurosurgery

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Abstract. – OBJECTIVE: To compare the influence of laryngeal mask airway (LMA) insertion anesthesia and endotracheal intubation on cognitive function during anesthesia for neurosurgery microscopy.

PATIENTS AND METHODS: A total of 76 pediatric patients who underwent neurosurgery microscopy were selected. They were randomly divided in the LMA insertion group with 35 cases and the endotracheal intubation group with 41 cases. Before the operation, the two groups were injected with 0.02 mg/kg atropine and 2 mg/kg phenobarbital. A combination solution of 2 mg/kg ketamine and 0.1 mg/kg midazolam was then given to induce anesthesia. The inhalation of 4-6% sevoflurane was used to maintain anesthesia. The hemodynamics, complications, cognitive functions, and expression levels of serum NSE and S-100β protein after anesthesia and extubation were compared.

RESULTS: After comparing the average heart rate, average arterial pressure and average oxygen saturation of the LMA insertion group at different times, the difference was not statistically significant ($p>0.05$). At T2 and T4, compared with the endotracheal intubation group, the average heart rate and arterial pressure of the LMA insertion group were significantly reduced and the average oxygen saturation was significantly increased. The difference was statistically significant ($p<0.05$). The prevalence of complications from postoperative cognitive dysfunction (POCD) of the LMA insertion group was significantly lower than that of the endotracheal incubation group. The difference was statistically significant ($p<0.05$).

CONCLUSIONS: Compared with the endotracheal intubation group, in the LMA insertion group, the hemodynamics is more stable, the prevalence of postoperative complications and the POCD are lower during pediatric neurosurgery microscopy. The occurrence of POCD is related to the reduction of protein expression levels of NSE and S-100β during serum anesthesia and the recovery period.

Key Words:
Laryngeal mask, Endotracheal intubation, Cognitive function, Hemodynamics, Complication, NSE protein, S-100β protein.

Introduction

Laryngeal mask airway (LMA) device, placed in the cavity of the throat, with the esophagus and throat cavity closed by a gasbag, is considered an artificial ventilation path through throat. Compared with conventional endotracheal intubation anesthesia, the laryngeal mask is more convenient to be placed, with no need to expose the glottis by laryngoscopy. It also poses less effect on respiratory circulation, less damage on airway mucosa in the throat and requires a lower dosage of anesthesia. Additionally, through a laryngeal mask, the spontaneous breathing can be maintained positive and pressure ventilation can be implemented, providing new options for anesthesia management[1]. LMA is now widely used in many operation fields for senile patients[2]. It is confirmed that it exerts little effect on hemodynamics, causes fewer extubation complications and produces better preventive effects on POCD after an operation[3]. It is believed that the occurrence of POCD is related to the type of anesthesia, duration of anesthesia, the management of the trachea during anesthesia, the stress level of inflammation and the basic state of patients[4]. In pediatric neurosurgery microscopy, the demand for anesthesia is high, the period is long, the damage to nerves is large and the occurrence of POCD is high, which is 0.4-0.5%, according to statistics[5]. In this study, the values of LMA and endotracheal intubation in preventing POCD were compared.

Patients and Methods

Patients

A total of 76 pediatric patients who underwent neurosurgery microscopy in our hospital from January 2013 to January 2016 were selected in the study. A random number method was used to divide them into two groups as follows: a. the LAM insertion group with 35 cases; b. the endotracheal

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intubation group with 41 cases. In the LAM insertion group, 18 cases were males and 17 cases were females, aged from 2-13 years old with an average age of 7.5 ± 3.3 years. Disease types included 10 cases with neuroblastoma, 4 cases with gliomas, 13 cases with hemangiomas, 5 cases with vascular malformations, and 3 cases with pituitary tumors. Among them, 19 cases were ASA grade I, 13 cases were ASA grade II and 3 cases were ASA grade III. In the endotracheal intubation group, 23 cases were males and 18 cases were females, aged from 1.5-12 years old with an average age of 7.6 ± 3.5 years. Disease types included 11 cases with neuroblastoma, 6 cases with gliomas, 15 cases with hemangiomas, 5 cases with vascular malformations and 4 cases with pituitary tumors. Among them, 23 cases were ASA grade I, 16 cases were ASA grade II and 2 cases were ASA grade III. The baseline data of the two groups were comparable. The research team obtained the approval of the Ethics Committee of Xuzhou Children's Hospital and informed consents of the children patients' guardians. The patients had surgery and anesthesia indications without obvious contraindications. Patients with airway abnormalities, expected intubation difficulties, high risks of regurgitation and aspiration, upper respiratory tract infections, throat diseases and other contraindications for LMA insertion, were excluded. Patients who just underwent first aid and a tracheostomy also were excluded.

Methods

The research was completed by surgery, nursing and anesthesia team and was in line with standard medical procedures. Patients in the two groups received an intramuscular injection of atropine of 0.02 mg/kg and phenobarbital sodium of 2 mg/kg before their operations. Ketamine of 2 mg/kg and midazolam of 0.1 mg/kg were used to induce anesthesia, which was maintained with the inhalation of 4-6% sevoflurane. The inhalation was stopped 5 min before the end of the surgery. A Drager anesthesia machine and multi-function monitor (Dreager, Lubeck, Germany), and a third-generation laryngeal mask for infants (Tuoren Medical, Beijing, China) were used. Various types of tracheal catheters were selected in accordance with the formula: internal diameter (ID) = 4 + age/4, and depth of intubation = 12 + age/2. The type of LMA was selected by a "three-finger method," whereby the width of the index finger, middle finger, ring finger of the child served as a guide, as well as the weight of the patient. The criteria of successful LMA insertion was a good raising and falling of the chest and a normal PetCO2 waveform diagram display.

Observation Indexes

Hemodynamic readings (including average heart rate, mean arterial pressure and mean oxygen saturation of T1 before intubation, T2 at 3 minutes after intubation, T3 before extubation and T4 at 4 minutes after extubation), complications (including coughing, laryngospasm, dysphoria, regurgitation and aspiration, sore throat, hoarse voice, nausea and vomiting during recovery period), cognitive function and the expression levels of serum neuron-specific enolase (NSE) and S-100β protein after anesthesia and extubation, were compared. Among them, POCD included dysfunctions related to cognition, such as confusion and anxiety, psychomotor disorder, prone to distraction, deterioration of the memory, language disorder and abnormal sensation, mental and behavioral disorders including mood disorder and aggressive behavior, as well as fatigue and sleepiness. The evaluation was made according to the clinical performance and corresponding cognition measurement tables such as the Wechsler Intelligence Scale for Children, Cambridge Neuropsychological Test Automated Battery and Bender-Gestalt Test. Serum NSE and S-100β protein were tested by ELISA method (Beijing Zhongshan Golden Bridge Biotechnology Co., Beijing, China). Tests were performed in strict accordance with the instructions.

Statistical Analysis

SPSS 20.0 (SPSS Inc., Chicago, IL, USA) was used for statistical analysis. Measurement data were expressed as the mean ± standard deviation. Comparisons between groups were tested by independent sample *t*-test. The variance analysis of repeated measure data was adopted to compare the hemodynamic index within the two groups at different times. Count data were expressed as the number of cases or the percentage (%). Comparisons between groups were tested by χ^2. $p<0.05$ indicated that the difference was statistically significant.

Results

Comparisons of Hemodynamic Indexes

Average heart rate, mean arterial pressure and mean oxygen saturation at T1 and T3 between

Table I. The 6 main kinds of anti-allergic medications enrolled in this study.

Group		LAM insertion group	Endotracheal intubation group	*t*	*p*
Average heart rate (time/min)	T1	82.6±5.4	83.1±5.6	0.127	0.865
	T2	84.0±5.3	94.5±5.7	5.634	0.021
	T3	83.2±5.5	85.6±5.8	0.235	0.636
	T4	86.3±5.3	97.8±5.4	5.756	0.020
	F	0.632	5.231		
	p	0.417	0.026		
Mean arterial pressure (mmHg)	T1	71.6±2.3	72.3±2.4	0.326	0.589
	T2	72.0±2.4	75.4±2.5	5.127	0.030
	T3	71.8±2.2	73.1±2.3	1.230	0.238
	T4	72.2±2.6	76.8±2.8	5.632	0.022
	F	0.562	5.124		
	p	0.748	0.028		
Mean oxygen Saturation (%)	T1	99.3±1.2	99.2±1.3	0.201	0.865
	T2	98.6±1.4	97.2±1.6	4.203	0.040
	T3	99.5±1.0	99.4±1.4	0.342	0.759
	T4	98.3±1.3	96.5±1.5	4.532	0.038
	F	0.421	3.865		
	p	0.637	0.042		

Note: T1, before intubation; T2, 3 minutes after intubation; T3, before extubation; T4, 3 minutes after extubation.

the two groups were compared; the differences were not statistically significant (p>0.05). The above-mentioned parameters of the LMA insertion group at different times were compared; the differences were not statistically significant (p>0.05). After the above-mentioned parameters of the endotracheal intubation group at different times were compared, it could be found that the differences were statistically significant (p<0.05). Average heart rate and mean arterial pressure at T2 increased compared with those readings at T1, but mean oxygen saturation decreased. Average heart rate and mean arterial pressure of the LMA insertion group decreased significantly at T2 and T4, compared with those readings of the endotracheal intubation group. However, mean oxygen saturation increased significantly; the difference was statistically significant (p<0.05) (Table I).

Comparison of Complication Rate

The total complication rate of the LMA insertion group was significantly lower than that of the endotracheal intubation group; the difference was statistically significant (p<0.05) (Table II).

Comparison of POCD Occurrence

The POCD occurrence of the LMA insertion group was significantly lower than that of the en-

Table II. Comparison of complication rate [case (%)].

Group	Case	Coughing	Laryngospasm	Dysphoria	Sore Sore throat	Regurgitation and aspiration	Hoarseness	Nausea and vomiting	Total complication rate
LAM insertion group	35	1 (2.9)	1 (2.9)	1 (2.9)	1 (2.9)	1 (2.9)	0	1 (2.9)	6 (17.1)
Endotracheal intubation group	41	3 (7.3)	2 (4.9)	3 (7.3)	2 (4.9)	3 (7.3)	1 (2.4)	2 (4.9)	16 (39.0)
χ^2									4.395
p									0.036

Table III. Comparison of POCD occurrence [case (%)].

Group	Case	Dysfunction related to cognition	Mental and behavioral disorder	Fatigue and sleepiness	POCD incidence
LAM insertion group	35	0	0	2 (5.7)	2 (5.7)
Endotracheal intubation group	41	1 (2.4)	3 (7.3)	5 (12.2)	9 (22.0)
χ^2					4.021
p					0.045

dotracheal intubation group; the difference was statistically significant (p<0.05) (Table III).

Comparison of Serum NSE and S-100β Protein Expression Levels

NSE and S-100β protein levels of the LMA group during anesthesia and the recovery period were significantly lower than those of the endotracheal intubation group; the differences were statistically significant (p<0.05) (Table IV).

Discussion

Limited by physical development, children have poor stress-reaction ability. During intravenous anesthesia, airway management is hard to achieve, thus leading to respiratory depression. The difficulty in airway management is the main reason for anesthesia-related death and poor prognosis in patients[6]. LMA has been ranked as a primary aid for a difficult respiratory tract, which is unable to ventilate or intubate, by the American Society of Anesthesiologists (ASA)[7]. The wider application of LMA is limited because it has less seal reliability than intubation, cannot completely prevent the reflux of gastric contents and cannot bear high pressure in airways[8]. At least one study has pointed out that the total occurrence rate of aspiration after general anesthesia is 1.4-6.5/10,000 and the fatal rate is 5%[9]. Therefore, intubation should be prepared when using LMA. Moreover, the effect of using local anesthesia or a single analgesic for pediatric patients is not ideal. Under the support of LMA, the intravenous-combined anesthetic is painless, and the sedative effect is good, which is worthy of wide promotion[10]. The laryngeal mask has been developed from a standard design for intubation and esophagus drainage to a supreme type for optimal placement. The design of the latter has prevented regurgitation and fault aspiration[11]. The latest Microcuff, with an endotracheal tube, can ensure adequate ventilation, without increasing postoperative complications. This will further expand the scope of application of LMA[12]. Through the study results, it could be seen that the differences in the comparison of readings in average heart rate, mean arterial pressure and mean oxygen saturation of the LAM insertion group at various times were not statistically significant, which indicated the disturbances of hemodynamics caused by LMA insertion were low[13]. At T2 and T4, the average heart rate and arterial pressure of the LMA insertion group decreased significantly when compared with those of the endotracheal intubation group, while the average oxygen saturation significantly increased. The difference was statistically significant, suggesting it was safer to use LMA insertion than endotracheal intubation. The prevalence of

Table IV. Comparison of serum NSE and S-100β protein expression levels (μg/L).

	NSE		S-100β	
Group	During anesthesia	During recovery period	During anesthesia	During recovery period
LMA insertion group	7.2±2.0	7.3±2.1	2.5±1.3	2.6±1.2
Endotracheal intubation group	8.4±2.2	9.2±2.6	4.3±1.2	5.0±1.5
t	4.527	6.235	4.869	5.527
p	0.039	0.018	0.034	0.025

complications and POCD of the LMA insertion group were significantly lower than that of the endotracheal intubation group; the difference was statistically significant. Postoperative extubation complications are key factors on the quality of recovery of children patients after an operation[14]. The occurrence of POCD is an important factor affecting the long-term intellectual development of children, which should not be overlooked by the medical community[15]. The levels of NSE and the S-100β protein level of the LMA insertion group during the anesthesia and recovery periods were significantly lower than those of the endotracheal intubation group; the differences were statistically significant. NSE is a neurochemical marker of brain damage, which can be used to detect cerebral ischemic injury at an early stage, especially for the early diagnosis index of a subclinical brain injury[16]. NSE is stable in body fluid, and has no cross-reaction with non-neuronal enolase. Cooper proved that NSE can be used as a biochemical index of neuronal damage, and is an effective indicator for detecting the quantity of neuron death[17]. The S-100β protein is an acidic calcium-binding protein that mainly exists in Schwann cells, a variety of glial cells, and is a specific protein for brain tissue. The S-100β content increase in cerebrospinal fluid and blood signifies response proteins of brain injury in acute periods, which correlates with the degree of brain damage and prognosis[18]. Moreover, the serum level of S-100β in brain injury patients is positively correlated with the content of NSE[19], which suggests that the higher level the serum S-100β is, the more severe the brain inflammation and neuronal damage, and the higher the incidence of POCD will be.

Conclusions

Compared with endotracheal intubation, hemodynamic readings were more stable and the prevalence of postoperative complications and POCD was lower when LMA insertion was used in pediatric neurosurgery microscopy. The occurrence of POCD was related to the reduction of protein expression levels of NSE and S-100β in serum anesthesia and the recovery period.

Conflict of interest

The authors declare no conflicts of interest.

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