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Original Article

Effects of sevoflurane combined with sufentanil on the outcome of children with indirect inguinal hernia

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Abstract: Objective: To explore the effects of sevoflurane combined with sufentanil on awakening time and pain degree in children with indirect inguinal hernia undergoing day surgery with laryngeal mask airway. Methods: Totally 167 children with indirect inguinal hernia treated in our hospital from March 2017 to December 2019 were chosen as study objects and divided into a research group (RG, 97 cases, patients were anesthetized with sevoflurane combined with sufentanil with laryngeal mask airway) and a control group (CG, 70 cases, patients were anesthetized with intravenous ketamine without intubation). Anesthesia indexes [anesthesia induction time, postoperative awakening time, stay time in postanesthesia care unit (PACU)] were observed. Heart rate (HR), mean arterial pressure (MA) and oxygen saturation (SpO_2) were observed before anesthesia induction (T0), during laryngeal mask airway placement (T1), during skin cutting (T2) and at the end of surgery (T3). The face, legs, activity, cry, consolability behavioral tool (FLACC) was used to evaluate pain degree, Ramsay sedation score to evaluate sedation, and pediatric anesthesia emergence delirium (PAED) to evaluate agitation. Adverse reactions between the two groups after surgery were observed. Results: The anesthesia induction time, postoperative awakening time and PACU stay time in RG were notably shorter than those in CG. After intervention, HR and MAP of children in RG were remarkably better than those in CG at T1, T2 and T3. FLACC score and PAED score in RG were remarkably lower than those in CG, while Ramsay score in RG was evidently higher than that in CG. The incidence of adverse reactions in RG was remarkably lower than that in CG after intervention. Conclusion: Sevoflurane combined with sufentanil is a safe and effective anesthesia scheme for children with indirect inguinal hernia undergoing day surgery with laryngeal mask airway, with high awaking quality and reduced postoperative postoperative pain.

Keywords: Sevoflurane, sufentanil, laryngeal mask airway, children with indirect inguinal hernia undergoing day surgery, awakening time, pain degree

Introduction

Indirect inguinal hernia in children is one of the most common diseases in pediatric surgery [1]. Children's indirect inguinal hernia is mostly caused by the failure to occlude the peritoneal processus vaginalis in the process of testicular descent in embryonic stage, which can occur in newborn stage and is a congenital disease [2]. Epidemiological investigation shows that indirect inguinal hernia in children is more common than in men, 2-3 times more on the right side than on the left side, and rare on both sides, accounting for about 5-10% [3]. The main clinical manifestation is that there is a reducible lump in groin and scrotum. When the intra-abdominal pressure increases due to crying or other reasons, the lump can obviously increase, and the lump can shrink or disappear completely when children are quiet, supine and sleeping [4]. Children may have symptoms such as lower abdominal distension, abdominal distension, abdominal pain, poor absorption function and decreased immune regulation function, which may affect the normal development of reproductive system, result in intestinal obstruction, intestinal necrosis and other serious complications, and may be life-threatening if not handled in time [5]. Clinical diagnosis is made by X-ray, B-ultrasound and other imaging examinations combined with clinical manifestations [6]. The vast majority of indirect inguinal hernias are not self-healing, so surgical treatment is the most reliable and effective

treatment at present [7]. Day surgery refers to the surgery in which patients with certain indications are selected and hospitalized, operated, briefly observed after surgery, recovered and discharged within one working day. Patients will not stay overnight in the hospital [8]. With the development of anesthesia technology, operation technology and nursing concept, day surgery is widely used in pediatric surgery [9]. Compared with adults, children have their own special vital signs and relatively poor tolerance, so the requirements of surgical anesthesia management are more stringent [10]. In addition, time of day surgery is short, and the turnover is fast, which requires high efficiency anesthetic drugs [11]. Therefore, it is of great clinical significance to explore a safe and effective anesthesia method for children with indirect inguinal hernia undergoing day surgery.

Tracheal intubation and laryngeal mask implantation are two general anesthesia ventilation methods commonly used in pediatric surgery. However, due to immature airway development in young children, tracheal intubation can damage children's respiratory tract, resulting in adverse reactions such as difficulty in ventilation, reducing anesthesia effect, which is rarely used in clinical practice [12]. Laryngeal mask airway is a new type of ventilation device, which has the characteristics of high success rate, simple operation and higher safety, and is widely used in clinic [13]. Traditional doctors often use ketamine for anesthesia. Due to its long response and awakening time, however, it can lead to adverse reactions such as sciatic nerve damage, which increases the risk of anesthesia, leading to less and less clinical application [14]. Sevoflurane is a new type of inhaling anesthetic, which has the advantages of short induction time, fast awakening time, aromatic smell and so on, and is more easily accepted by children [15]. Numerous domestic and international studies have found that sevoflurane has good efficacy and safety in the induction and maintenance of general anesthesia in the vast majority of patient populations, and has good effects on cardioprotective function and postoperative cognitive impairment. However, the postoperative analgesia effect of sevoflurane is not ideal, and children are prone to agitation and crying [16]. Sufentanil is a new powerful agonist of fentanyl opioid receptor, which mainly acts on μ opioid receptor, with strong analgesic intensity and long action time. It is the most effective opioid anesthetic analgesic at present, and a widely used analgesic in clinic [17]. The clinical application of sevoflurane combined with sufentanil in children with indirect inguinal hernia undergoing day surgery with laryngeal mask airway is seldom studied.

In this study, we explored the effect of sevoflurane combined with sufentanil on the awakening time and pain degree of children with indirect inguinal hernia undergoing day surgery with laryngeal mask airway, hoping to provide clinical reference value for the anesthesia scheme of children with indirect inguinal hernia undergoing day surgery.

Materials and methods

General data

Totally 167 children with indirect inguinal hernia treated in our hospital from March 2017 to December 2019 were chosen to be study objects and divided into a research group (RG, 97 cases, patients were anesthetized with sevoflurane combined with sufentanil with laryngeal mask airway) and a control group (CG, 70 cases, patients were anesthetized with intravenous ketamine without intubation).

Inclusion and exclusion criteria

Inclusion criteria: (1) All children met the diagnostic criteria of indirect inguinal hernia [18], and all of them met the surgical indications. (2) Children had never received anesthesia before. (3) Children were classified as Grade I-II according to American Society of Anesthesiologists (ASA) [19]. (4) This study has been approved by the ethics committee of our hospital, and the research subjects and their families have been informed and signed a full informed consent form.

Exclusion criteria: (1) Children had contraindications for surgical anesthesia. (2) Children were allergic to the drugs used in this study. (3) Children were complicated with severe primary organ diseases, such as cardiovascular diseases, respiratory diseases, liver or kidney insufficiency. (4) Children had coagulation dysfunction or immune system diseases. (5)

Children had severe tracheal obstruction or mouth opening disorder. (6) Children had incomplete clinical data. (7) Children had family history of mental illness.

Anesthesia method

All children were fasted for 8 hours and forbidden to drink for 6 hours before surgery, and 0.02 mg/kg atropine was injected intramuscularly 30 minutes before surgery (Tianjin Pharmaceutical Group Xinzheng Co., Ltd., Xinzheng, China, H41021257). After entering the room, all children were opened with venous access, and their vital signs, including blood pressure, oxygen saturation, heart rate (HR) and electrocardiogram, were closely monitored. Children in RG were given sevoflurane at a concentration of 8% (Shanghai Hengrui Pharmaceutical Co., Ltd., Shanghai, China, H2007-0172) until the children had no physical response to external stimuli. The anesthesia circuit was fully open. When sevoflurane was filled the threaded tube of anesthesia machine and the anesthesia mask, the mask was fixed at the nose and mouth of the children. Sufentanil (0.3 μg/kg, Yichang Humanwell Pharmaceutical Co., Ltd., Yichang, China, H20054171) was given intravenously twice before surgery. During the surgery, muscle relaxant was required to be administered intravenously at 0.03 mg/kg, and inhalation of 4% sevoflurane was maintained until 5 min before the end of the surgery. Children in CG were given 5 mg/kg ketamine (Jiangsu Hengrui Medicine Co., Ltd., Lianyungang, China, H32-022820) by intramuscular injection, and 7 mg/(kg.h) ketamine was pumped by micropump until 5 minutes before the end of surgery.

Outcome measures

Anesthesia indexes of the two groups were observed: anesthesia induction time, postoperative awakening time, and postanesthesia care unit (PACU) stay time.

The hemodynamic indexes of the two groups were observed: HR, mean arterial pressure (MAP) and blood oxygen saturation (SpO_2) were monitored before anesthesia induction (T0), during aryngeal mask implantation (T1), during skin cutting (T2), and at the end of surgery (T3).

Pain score: the face, legs, activity, cry, consolability behavioral tool (FLACC) [20] was used to evaluate the pain degree of children in the two groups. The scale includes five contents of expression, leg, activity, crying and comfort, with a total score of 10 points, which can be divided into three grades: mild pain (1-3 points), moderate pain (4-6 points) and severe pain (7-10 points). A higher score indicated greater pain.

Sedation score: ramsay score [21] was used to systematically evaluate the postoperative sedation of the two groups of children, and scored 1-6 points, respectively. The higher the score was, the calmer the child was.

Agitation score: the postoperative agitation of the two groups was systematically evaluated by the pediatric anesthesia emergence delirium (PAED) score, which was recorded as 0-4 points, respectively. The higher the score was, the more serious the agitation was.

Adverse reactions between the two groups after operation were observed.

Statistical methods

SPSS20.0 (IBM Corp, Armonk, NY, USA) was applied for statistical analysis, and GraphPad Prism 7 was utilized to draw the picture of this data. Counting data was expressed by [n (%)], and comparison of counting data between groups adopted chi-square test. Mean ± standard deviation ($\bar{x} \pm sd$) was utilized for measurement data, and independent sample t test was used for comparison of measurement data between groups. Paired t test was used for comparison before and after surgery. One-way analysis of variance was adopted for data at different time points in the group, and SNK-Q method was used for pairwise comparison at different time points in the group. When $P<0.05$, the difference was statistically significant.

Results

Baseline data

In RG, there were 85 males and 12 females, with a mean age of 3.91±1.61 years, ranging from 1 to 7 years old. In CG, there were 62 males and 8 females, with an average age of 4.03±1.78 years, ranging from 1 to 6 years. There was no considerable difference in clinical baseline data such as gender, age, body

Table 1. Comparison of baseline data between the two groups [n (%)]/($\bar{x}$ ± sd)

Type	Research group (n=97)	Control group (n=70)	t/χ^2	P
Gender			0.034	0.853
Male	85 (87.63)	62 (88.57)		
Female	12 (12.37)	8 (11.43)		
Age (years)	3.91±1.61	4.03±1.78	0.454	0.650
Body mass (kg)	15.38±2.15	15.61±2.28	0.665	0.507
Place of residence			0.283	0.594
City	50 (51.55)	39 (55.71)		
Countryside	47 (48.45)	31 (44.29)		
Nationality			0.064	0.801
Han	71 (73.20)	50 (71.43)		
Minority	26 (26.80)	20 (28.57)		
Surgery time (min)	29.87±4.26	30.81±4.32	1.400	0.164
ASA grade			0.070	0.792
Grade I	67 (69.07)	47 (67.14)		
Grade II	30 (30.93)	23 (32.86)		
Types of indirect hernia			0.391	0.532
Unilateral	89 (91.75)	66 (94.29)		
Bilateral	8 (8.25)	4 (5.71)		

mass, place of residence, nationality, surgery time, ASA grade and indirect hernia type between RG and CG (P>0.05). As shown in **Table 1**.

Comparison of anesthesia indexes between the two groups

Anesthesia induction time, awakening time, and PACU stay time in RG were remarkably shorter than those in CG (P<0.05). As shown in **Figure 1**.

Comparison of hemodynamic indexes between the two groups

There was no considerable difference in HR, MAP, SpO_2 at T0, T1, T2 or T3 in RG (P>0.05). HR and MAP of children in CG were notably higher than T0 at T1, T2 and T3, and notably higher in T1 and T2 than T3. And HR and MAP of children in RG were remarkably higher than those in CG at T1, T2, and T3 (P<0.05). There was no significant difference in SpO_2 at T0, T1, T2 or T3 in CG (P>0.05). As shown in **Figure 2**.

Comparison of pain score between the two groups

FLACC score of RG was notably lower than that of CG (P<0.05). As shown in **Figure 3**.

Comparison of Ramsay score between the two groups

Ramsay score of RG was remarkably higher than that of CG (P<0.05). As shown in **Figure 4**.

Comparison of PAED score between the two groups

PAED score of RG was evidently lower than that of CG (P<0.05). As shown in **Figure 5**.

Comparison of incidence of adverse reactions between the two groups

The incidence of adverse reactions in RG was 8.24%, which was remarkably lower than that in CG (35.72%) (P<0.05). As shown in **Table 2**.

Discussion

Indirect inguinal hernia is one of the most common developmental defects in children, with the incidence between 1-4% and higher in premature infants [23]. Unclosed processus vaginalis is the main pathological basis of indirect inguinal hernia in children, which is also the theoretical basis of surgical treatment at present [24]. The younger the onset age of indirect inguinal hernia in children is, the more likely it is to be incarcerated, and the greater the risk is. Therefore, surgery can be performed at an early stage for it is not limited by age [25]. Choosing a reasonable anesthesia method is not only the guarantee of successful surgery, but also can reduce the adverse reaction and risk of operation [26]. With the wide application of day surgery in pediatric short surgery, there is also a high demand for anesthetic effect. In recent years, inhalable, controllable and short-acting anesthetics have become the research focus of pediatric surgery anesthesia [27]. In this study, sevoflurane combined with sufentanil was used for children with indirect inguinal hernia undergoing day surgery with laryngeal mask airway, and its effects on postoperative awakening time, pain degree, agitation, sedation and adverse reactions were explored.

Anesthesia induction time, awakening time and PACU stay time are important indexes to evalu-

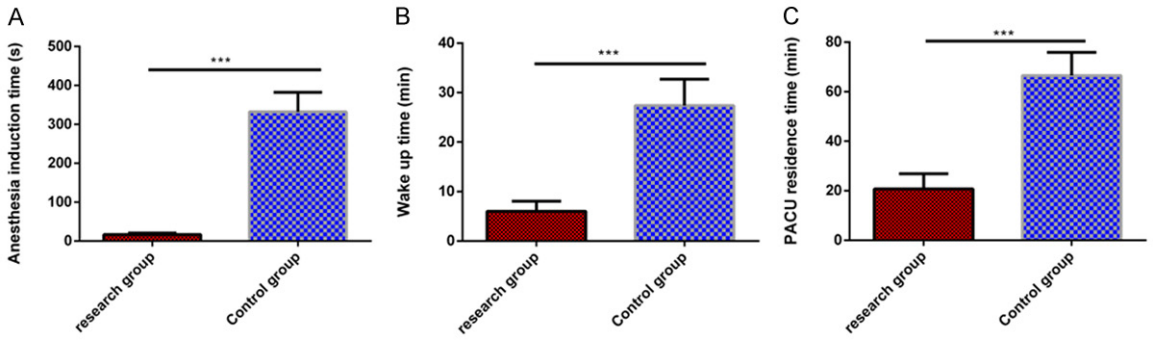

Figure 1. Comparison of anesthesia indexes between the two groups. A. Anesthesia induction time of the research group was significantly shorter than that of the control group. B. Awakening time of the research group was significantly shorter than that of the control group. C. PACU stay time of the research group was significantly shorter than that of the control group. Note: ***P<0.001.

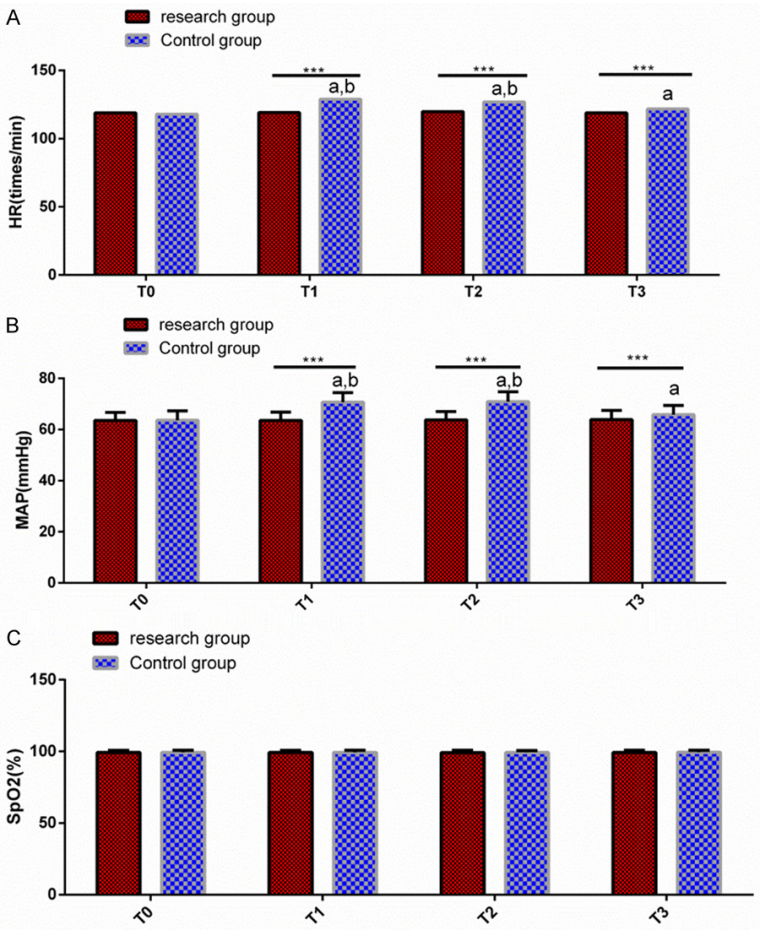

Figure 2. Comparison of hemodynamic indexes between the two groups. A. There was no significant difference in HR of the research group at T0, T1, T2 and T3. HR in control group was notably higher than T0 at T1, T2 and T3, and notably higher at T1 and T2 than T3. HR in the research group was remarkably higher than that in control group at T1, T2, and T3. B. There was no significant difference in MAP of the research group at T0, T1, T2 and T3. MAP in control group was notably higher than T0 at T1, T2 and T3, and notably higher at T1 and T2 than T3. MAP in the research group was remarkably higher than that in control group at T1, T2, and T3. C. There was no significant difference in SpO_2 at T0, T1, T2 or T3 in the control group. Note: ***P<0.001, [a]P<0.05 compared with T0 time in the same group, and [b]P<0.05 compared with T3 time in the same group.

ate the anesthetic effect and safety of drug use. In the research of Kocaturk et al. [28], compared with intravenous general anesthesia, sevoflurane, as an inhalation anesthetic, has the characteristics of short anesthesia induction time, short stay time in PACU, fast awakening time, etc., but it has a great chance of vomiting and agitation after surgery. Our study results showed that the anesthesia induction time, awakening time and stay time in PACU of children in RG were notably lower than those of the children in CG, indicating that the sevoflurane combined with sufentanil inhalation laryngeal mask airway anesthesia was considerably better than ketamine anesthesia, similar to that report of Kocaturk et al., which may be related to the physicochemical properties of sevoflurane and its easy acceptance by children. In the study of Han et al. [29], sevoflurane and ketamine were used in anesthesia of pediatric cardiac surgery separately, and sevoflurane was superior to ketamine in hemodynamics of children. In this study, we compared sevoflurane combined with sufentanil with ketamine anesthesia, and found that the

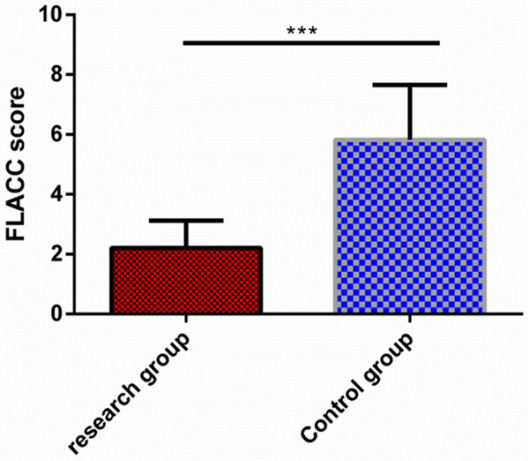

Figure 3. Comparison of pain score between the two groups. FLACC score of the research group was significantly lower than that of the control group. Note: ***P<0.001.

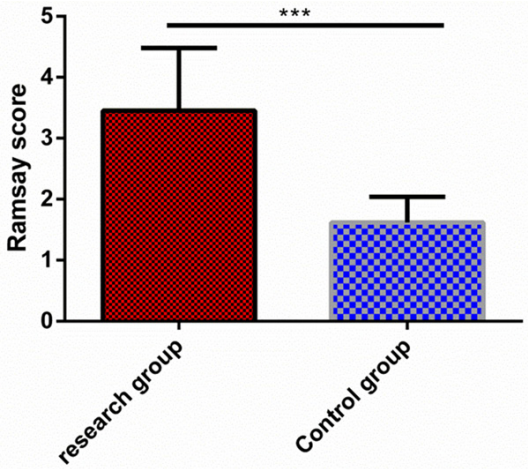

Figure 4. Comparison of Ramsay score between the two groups. Ramsay score of the research group was significantly higher than that of the control group. Note: ***P<0.001.

hemodynamics of RG was more stable than that of CG, which was similar to that of Han et al. This shows that sevoflurane combined with sufentanil has less influence on the vital signs of children and is more conducive to protecting cardiovascular system, which may be related to the action of sufentanil on sympathetic nervous system. It reduces stress response, thus stabilizing hemodynamics and vital signs. Here, we also evaluated FLACC pain, Ramsay sedation and PAED agitation of children after surgery. The results showed that FLACC score and PAED score of RG were notably lower than

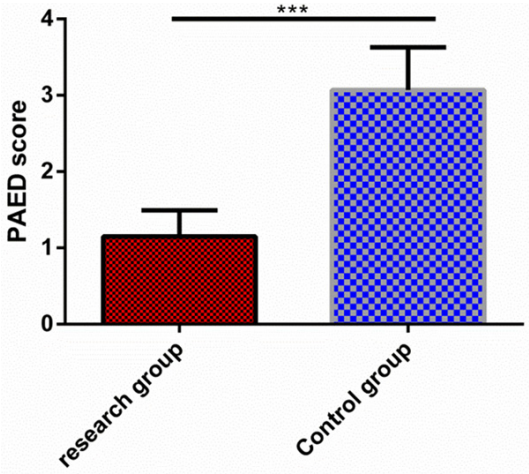

Figure 5. Comparison of PAED score between the two groups. PAED score of the research group was significantly lower than that of the control group. Note: ***P<0.001.

those of CG, while Ramsay score of RG was notably higher than that of CG, indicating that sevoflurane combined with sufentanil can better reduce postoperative pain and agitation of children and promote sedation when compared with ketamine anesthesia, which is related to the high affinity of sufentanil with the body's opioid receptors and the strong postoperative analgesic and sedative effect. In the study of Kawai et al. [30], it was reported that the incidence of sedation and agitation, RASS score and PAED score in pediatric dental surgery with midazolam combined with sevoflurane anesthesia were significantly lower than those with sevoflurane alone. In addition, Chandler et al. [31] reported that intravenous anesthesia with remifentanil and propofol in pediatric ophthalmic surgery can better reduce postoperative pain, reduce postoperative agitation and is safer than inhalation anesthesia with sevoflurane alone. Our results are similar to those of Kawai et al. and Chandler et al. Last, we found that the incidence of adverse reactions such as intraoperative body movement, pain at injection site, postoperative agitation, nausea and vomiting, laryngospasm and glossocoma in RG were lower than those in CG, indicating that sevoflurane combined with sufentanil is safer for anesthesia.

Although this study confirmed that sevoflurane combined with sufentanil can bring better anesthetic effect and clinical curative effect to children with indirect inguinal hernia undergo-

Table 2. Comparison of adverse reactions between the two groups [n (%)]

Group	Nausea and vomiting	Postoperative agitation	Injection pain	Laryngospasm	Glossocoma	Intraoperative body movement	Total incidence
Research group (n=97)	3 (3.09)	0 (0.00)	2 (2.06)	0 (0.00)	2 (2.06)	1 (1.03)	8 (8.24)
Control group (n=70)	4 (5.72)	5 (7.14)	5 (7.14)	1 (1.43)	4 (5.72)	6 (8.57)	25 (35.72)
χ^2	-	-	-	-	-	-	19.350
P	-	-	-	-	-	-	<0.001

ing day surgery with laryngeal mask airway, there is still room for improvement in this study. For example, we can further analyze the risk factors affecting the recovery of children with indirect inguinal hernia undergoing day surgery, and provide clinical basis for postoperative rehabilitation and relapse of children. Children can also be followed up to analyze the influencing factors of treatment compliance. In the future, we will gradually conduct supplementary research from the above perspectives.

To sum up, sevoflurane combined with sufentanil anesthesia for children with indirect inguinal hernia undergoing day surgery with laryngeal mask airway can significantly shorten the induction time of anesthesia, postoperative awakening time and PACU stay time, reduce the pain degree of children, reduce the occurrence of postoperative agitation, promote sedation, reduce the incidence of adverse reactions, and have higher safety.

Disclosure of conflict of interest

None.

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