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Influencing factors of emergence agitation after open reduction of fractures in children

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Abstract: Objective To investigate the risk factors for emergence agitation(EA)during the postoperative recovery period following open reduction of fractures in children, and to provide a scientific basis for the prevention and treatment of EA in children. **Methods** A retrospective study was conducted on 123 children who underwent elective open reduction of fractures at the Children's Hospital of Nanjing Medical University from October to December 2024. The Pediatric Anesthesia Emergence Delirium Scale (PAED) scores and Richmond Agitation and Sedation Scale (RASS) scores of the children were analyzed after they were admitted to the post-anesthesia care unit (PACU) postoperatively. Based on these scores, the children were grouped, and finally 100 cases were assigned to the EA-negative group and 23 cases to the EA-positive group. Multivariate logistic regression analysis was used to identify the risk factors for EA in children after orthopedic surgery. **Results** There were statistically significant differences between the two groups in terms of month of age, modified Yale Preoperative Anxiety Scale (m-YPAS) scores, proportion of combined nerve block, proportion of sevoflurane used for anesthesia maintenance, and proportion of postoperative analgesia at the end of surgery ($P<0.05$). Multivariate logistic regression analysis revealed that combined nerve block (*OR*=6.218, 95% *CI*: 1.410-27.417, *P*=0.016), sevoflurane used for anesthesia maintenance (*OR*=8.756, 95%*CI*: 1.391-55.102, *P*=0.021), and high m-YPAS scores (*OR*=1.094, 95%*CI*:1.052-1.138, $P<0.01$) were independent risk factors for EA in children after open reduction of fractures. In contrast, postoperative analgesia at the end of surgery reduced the risk of EA in these children(*OR*=0.213, 95%*CI*: 0.046-0.976, *P*=0.046). **Conclusion** Increased m-YPAS scores, anesthesia combined with nerve block, intraoperative sevoflurane maintenance, and no postoperative analgesia at the end of surgery are independent risk factors for EA in children after orthopedic surgery.

Keywords: Children; Emergence agitation; Emergence delirium; Orthopedic surgery; Sevoflurane; Postoperative pain; Patient-controlled analgesia

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Emergence delirium (ED) is an acute, fluctuating brain dysfunction manifested by patients after surgery as they transition from an anesthetized state to complete awakening. This phenomenon typically occurs when patients enter the post-anesthetic care unit (PACU). Clinical features include confusion, clouded consciousness, and disorientation, often accompanied by agitation, and patients may unconsciously remove various monitoring leads and tubes on their bodies [1].

Emergence agitation (EA) is a broader concept that encompasses the comprehensive manifestation of ED, pain, and various other adverse factors [2]. Due to poor tolerance, children require procedures and surgeries under general anesthesia (GA), resulting in a higher incidence of EA in children than in adults, reaching 13%-38% [3].

In recent years, with the continuous updating of the concept of enhanced recovery after surgery (ERAS) in children, pediatric perioperative management has been gradually optimized. The application of corresponding nerve blocks at the orthopedic surgical site has effectively reduced the usage requirements of opioid drugs and general anesthetic drugs [4-5]. However, there are few relevant research reports on whether the incidence of EA after orthopedic surgery has decreased accordingly. Although EA and ED have a certain self-limiting nature, they increase the difficulty of nursing during the emergence period in the PACU, such as increasing the risk of children falling out of bed and self-extubation. These behaviors may cause secondary injuries to children and prolong the hospital discharge time, which contradicts the ERAS concept. Therefore, predicting the occurrence of postoperative EA in children based on perioperative-related indicators is of great significance. Therefore, this study selected pediatric patients undergoing elective open reduction surgery for fractures at the Children's Hospital of Nanjing Medical University, and used logistic regression analysis to explore the influencing factors of EA occurrence in orthopedic surgery, aiming to provide a scientific basis for the prevention and treatment of EA in children.

1 Materials and methods

1.1 Study subjects

A retrospective analysis was conducted on the clinical data of children who underwent elective open reduction of fractures at the Children's Hospital of Nanjing Medical University from October to December 2024. A total of 123 patients were enrolled after direct screening according to inclusion and exclusion criteria.

Inclusion criteria: (1) Admission age within 36-96 months, and actual body weight not exceeding 25% of ideal body weight; (2) No respiratory infection or abnormal liver and kidney function; (3) American Society of Anesthesiologists (ASA) physical status classification II–III.

Exclusion criteria: (1) History of mental illness and/or intellectual developmental disorder; (2) Long-term use of psychotropic drugs for various reasons (e.g., sodium valproate, ethosuximide); (3) Incomplete clinical data.

This study was approved by the Ethics Committee of the Children's Hospital of Nanjing Medical University (Approval number: 202401013-1). All methods were performed in accordance with relevant guidelines, regulations, and the Declaration of Helsinki.

1.2 Grouping and general data

Grouping was based on scores from the Pediatric Anesthesia Emergence Delirium Scale (PAED) and the Richmond Agitation and Sedation Scale (RASS) after surgery. Patients with a PAED score < 12 were assigned to the ED negative group, and those with a PAED score ≥ 12 to the ED positive group. Patients with a RASS score ranging from +2 to +4 were diagnosed as the EA positive group, otherwise as the EA negative group. Given the blurred clinical boundary between pediatric EA and ED, and ED can be regarded as a subset of EA, EA positive cases with a RASS score of +2–+4 and ED positive cases with a PAED score ≥ 12 were collectively assigned to the EA positive group, and the remaining cases to the EA negative group.

The study finally included 100 cases in the EA negative group and 23 cases in the EA positive group. Surgical types included 62 cases of upper limb fractures (specifically 30 cases of open reduction of radius fractures and 32 cases of open reduction of humerus fractures), 49 cases of lower limb fractures (specifically 30 cases of tibia fractures and 19 cases of open reduction of metatarsal fractures), and 12 cases of open reduction of clavicle fractures.

1.3 Anesthesia methods

1.3.1 Anesthesia induction and maintenance

After entering the operating room, all children were monitored for electrocardiogram (ECG), non-invasive blood pressure (NIBP), heart rate (HR), oxygen saturation (SpO2), and nasopharyngeal temperature. Total intravenous anesthesia (TIVA) or combined intravenous-inhalational anesthesia was used. Anesthesia induction was performed with intravenous injection of propofol (Liaoning Haisco Pharmaceutical Co., Ltd., batch number: 20231143) 2–3 mg/kg, sufentanil (Yichang Renfu Pharmaceutical Co., Ltd., batch number: 31A120212) 0.2–0.3 μg/kg, and rocuronium (Guangdong Xinghao Pharmaceutical Co., Ltd., batch number: 139230906) 0.6 mg/kg. After endotracheal intubation, mechanical ventilation was performed using a Drager anesthesia machine (Germany), with tidal volume (VT) 8–10 mL/kg, respiratory rate (RR) 20–30 breaths/min, oxygen saturation ≥ 98%, and end-tidal carbon dioxide partial pressure maintained between 35–45 mmHg. Intraoperative anesthesia was maintained with propofol 4–6 $mg\cdot kg^{-1}\cdot h^{-1}$, remifentanil (Guangdong Xinghao Pharmaceutical Co., Ltd., batch number: 139230906) 0.3–0.4 $\mu g\cdot kg^{-1}\cdot h^{-1}$, and/or combined with 3% sevoflurane (Shanghai Hengrui Pharmaceutical Co., Ltd., batch number: 23112931) inhalation.

1.3.2 Nerve block

Some children underwent ultrasound-guided nerve block during general anesthesia. For upper limb surgery, brachial plexus block was performed, with approaches including interscalene and supraclavicular routes. For lower limb surgery, nerve block mainly involved caudal block. For clavicle fracture, nerve block mainly involved cervical plexus block, with the block method being single-point injection.

1.3.3 Postoperative analgesia methods

Postoperative analgesia methods included the following two types: single intravenous bolus injection of sufentanil 0.1 μg/kg immediately after surgery, and patient-controlled intravenous analgesia (PCIA). The PCIA formulation consisted of sufentanil 2 μg/kg with tropisetron 0.1 mg/kg.

1.4 Observation indicators

Baseline data, including gender, age in months, surgical history, and body mass index (BMI), were collected by reviewing the medical records of enrolled children. Intraoperative variables, including use of sevoflurane, use of nerve block, postoperative analgesia administration, and duration of surgery, were obtained by reviewing the children's anesthesia records. The Pediatric Anesthesia Emergence Delirium Scale (PAED) [6] was used to assess postoperative EA in children. Meanwhile, the Richmond Agitation and Sedation Scale (RASS) [7] was employed to stratify the agitation-sedation status, which consists of 10 levels. In addition, the modified Yale Preoperative Anxiety Scale (m-YPAS) [8] was used to evaluate preoperative anxiety levels. Each item was assigned a score of 1–4 or 1–6 points based on the number of items and converted to a 100-point scale. Higher scores indicated more severe anxiety in children.

1.5 Statistical methods

SPSS 27.0 software was used for data analysis. Count data were expressed as case (%), and analyzed using the chi-square (χ^2) test or corrected chi-square test. Continuous data with normal distribution and homogeneous variance (tested by Shapiro-Wilk test) were expressed as $\bar{x}\pm s$, and comparisons between groups were performed using independent samples t-test. Skewed continuous data were expressed as M (P_{25}, P_{75}) and analyzed using the Mann-Whitney U test. Multivariate logistic regression analysis was used to identify influencing factors. P<0.05 was considered statistically significant.

2 Results

2.1 Comparison of general data between the two groups

The m-YPAS score in the EA positive group was higher than that in the EA negative group, and the age in months was lower than that in the EA negative group, with statistically significant differences ($P < 0.05$). There were no statistically significant differences in other variables between the two groups ($P > 0.05$). **[Table 1]**

2.2 Comparison of intraoperative indicators between the two groups

The proportion of sevoflurane use and the proportion of combined nerve block use in the EA positive group were higher than those in the EA negative group, while the proportion of postoperative analgesia administration was lower than that in the EA negative group, with statistically significant differences ($P < 0.05$). There was no statistically significant difference in the duration of surgery between the two groups ($P > 0.05$). **[Table 2]**

2.3 Multivariate logistic regression analysis

Five indicators with statistically significant differences in univariate analysis were included in multivariate logistic regression analysis. The included variables were: age in months, m-YPAS score, combined nerve block use (0 = not combined; 1 = combined), sevoflurane use (0 = not used; 1 = used), and postoperative analgesia administration (0 = no analgesia; 1 = analgesia). The results showed that combined nerve block, sevoflurane maintenance anesthesia, and high m-YPAS score increased the risk of EA after open reduction of fractures in children ($P < 0.05$). Postoperative analgesia decreased the risk of EA after open reduction of fractures in children ($P < 0.05$). **[Table 3]**

Tab.1 Comparison of general data between two groups

Group	Case	Male/Female (*n*)	Surgical history (*n*)	Age (months, $\bar{x}\pm s$)	BMI (kg/m², $\bar{x}\pm s$)	m-YPAS (score, $\bar{x}\pm s$)
EA negative	100	62/38	9	67.38±20.62	16.95±3.31	45.29±15.46
EA positive	23	13/10	1	56.68±22.67	16.04±2.36	75.97±17.40
χ^2/t value		0.236	0.108	2.201	1.255	8.378
P value		0.627	0.742	0.030	0.242	<0.001

Tab.2 Comparison of intraoperative variable between two groups [case(%)]

Group	Case	Sevoflurane use	Nerve block	Postoperative analgesia administration	Operation time [min, $M(P_{25}, P_{75})$]
EA negative	100	8 (8.0)	23 (23.0)	55 (55.0)	72 (61, 84)
EA positive	23	8 (34.8)	14 (60.9)	4 (17.4)	78 (58, 89)
χ^2/Z value		9.605	12.750	10.597	1.084
P value		0.002	<0.001	0.001	0.278

Tab.3 Multivariate logistic regression analysis of factors influencing EA following open reduction of fractures in children

Variable	*β* value	*SE*	Wald χ^2 value	*P* value	Adjusted *OR* value	95% *CI*
Age (months)	-0.013	0.017	0.607	0.436	0.987	0.955–1.020
m-YPAS score	0.090	0.020	20.560	<0.001	1.094	1.052–1.138
Sevoflurane use	2.170	0.939	5.344	0.021	8.756	1.391–55.102
Combined nerve block	1.827	0.757	5.827	0.016	6.218	1.410–27.417
Postoperative analgesia	-1.548	0.778	3.963	0.046	0.213	0.046–0.976
Constant	-6.615	1.745	14.377	<0.001	0.001	

3 Discussion

This study conducted a retrospective analysis of preoperative and intraoperative variables in 123 pediatric patients. The variable of patient age (in months) showed a statistically significant difference in univariate analysis. However, multivariate logistic regression analysis indicated that patient age was not a risk factor for postoperative EA in pediatric orthopedic surgery. This contradictory result may be related to confounding factors between age and the outcome variable. The study hypothesizes that younger children, due to immature cognitive abilities and poor adaptability to unfamiliar environments, may experience fear and discomfort during the emergence period when facing unfamiliar surroundings and medical staff, manifesting as incessant crying and difficulty in being comforted.

A higher m-YPAS score was identified as one of the independent risk factors for postoperative EA. The m-YPAS score directly reflects the preoperative anxiety level of children, and multiple studies have confirmed that preoperative anxiety is closely associated with the occurrence of postoperative EA in children [9-10]. This phenomenon may be associated with painful procedures (e.g., intramuscular injection) and separation with parents before entering the operating room, which induce high psychological stress in children, thereby contributing to EA. Additionally, foreign studies have shown that preoperative sedation with midazolam does not reduce the incidence of postoperative EA in children anesthetized with sevoflurane [3], suggesting that the association between preoperative anxiety and EA may involve more complex mechanisms.

Intraoperative maintenance with sevoflurane was an independent risk factor for postoperative EA, which is also a risk factor for EA in elderly patients [11]. Compared with sevoflurane, intraoperative maintenance with propofol significantly reduced the incidence of EA (*OR*=0.25, 95%*CI*: 0.16-0.39, *P*<0.01) [12]. Due to sevoflurane's low blood-gas partition coefficient, children have a relatively short emergence time after its discontinuation. However, muscle relaxants used during anesthesia maintenance may not be fully metabolized, leading to a "sense of impending death" as children gradually regain consciousness but cannot move freely due to residual muscle relaxant effects, triggering extreme discomfort and subsequent EA. Literature has reported that low-dose fentanyl can reduce the incidence of EA in children after ophthalmic surgery [13]. However, there is currently no literature evidence supporting that sevoflurane itself directly causes postoperative EA.

Literature indicates that pain is a risk factor for postoperative EA [14-15], and this study is consistent with this view. Nerve block eliminates the upward transmission of pain electrical signals, exerts a good analgesic effect, and thereby reduces EA occurrence. However, this study found that combined nerve block was a risk factor for postoperative EA. The potential explanation is that excessive local anesthetics, while blocking pain transmission, may also block motor nerves, preventing skeletal muscles innervated by the blocked nerves from moving according to the child's consciousness. This may induce fear in children with immature cognitive abilities, thereby triggering postoperative EA. To verify this hypothesis, follow-ups were conducted with parents of older children who can communicate and underwent nerve block, inquiring about sensations in the blocked area after anesthesia emergence. The most common feedback included numbness and a heavy sensation. Such severe numbness and limb heaviness may cause significant discomfort, which may explain why retrospective case analysis showed that combined nerve block did not reduce EA incidence but possibly increased its risk. Although detailed analysis of local anesthetic dosage was not performed due to scattered data, this does not exclude pain as a risk factor for EA.

In the perioperative management of orthopedic surgery, preoperative implementation of non-pharmacological or pharmacological interventions to alleviate preoperative anxiety has a significant positive effect on preventing postoperative EA. During surgery, if surgical needs are met, moderately reducing sevoflurane dosage or rationally adjusting the ratio of muscle relaxation to sedation time can effectively decrease the probability of postoperative EA. Furthermore, when performing combined nerve block, the dosage of local anesthetics should be accurately calculated based on the child's individual conditions to ensure adequate sensory block while minimizing the impact on motor block. However, achieving this goal poses certain challenges; thus, the risk-benefit ratio must be carefully weighed before implementing combined nerve block.

This clinical trial also has limitations. First, the data were derived from a single center, limiting the generalizability of the results. Second, as a retrospective study, there may be bias in variable data. Finally, only the occurrence of EA was recorded, and long-term follow-up data were lacking, precluding analysis of the impact of influencing factors on children's long-term mental status.

In conclusion, high preoperative m-YPAS scores, combined nerve block, intraoperative maintenance with sevoflurane, and no postoperative analgesia are risk factors for postoperative EA in pediatric orthopedic surgery. Based on these influencing factors, corresponding preventive and therapeutic measures can be implemented in clinical practice.

Conflict of interest None

Reference

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·论　著·

儿童骨折切开复位术后苏醒期躁动的影响因素

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摘要：目的　探讨儿童骨折切开复位术后苏醒期躁动(EA)的危险因素，为儿童EA的预防和治疗提供科学依据。**方法**　回顾性纳入南京医科大学附属儿童医院2024年10月至12月择期行骨折切开复位术患儿123例，分析患儿术后进入麻醉后恢复室(PACU)后的儿童麻醉苏醒期躁动评分量表(PAED)与Richmond躁动-镇静(RASS)评分，据此进行分组，最终确定EA阴性组100例和EA阳性组23例。采用多因素logistic回归分析儿童骨科手术术后EA的危险因素。**结果**　两组月龄、改良耶鲁术前焦虑量表(m-YPAS)评分，及联合神经阻滞、使用七氟烷维持麻醉、术毕镇痛占比差异有统计学意义($P<0.05$)。多因素logistic回归分析显示，联合神经阻滞(OR=6.218，95%CI：1.410~27.417，P=0.016)、使用七氟烷维持麻醉(OR=8.756，95%CI：1.391~55.102，P=0.021)以及高m-YPAS评分(OR=1.094，95%CI：1.052~1.138，$P<0.01$)为儿童骨折切开复位术后EA发生的独立危险因素因素，术毕镇痛会降低儿童骨折切开复位术后EA发生的风险(OR=0.213，95%CI：0.046~0.976，P=0.046)。**结论**　m-YPAS评分增加、麻醉方式联合神经阻滞、使用七氟烷维持麻醉、术毕未镇痛是儿童骨科手术术后EA发生的独立危险因素。

关键词：儿童；苏醒期躁动；苏醒期谵妄；骨科手术；七氟烷；术后疼痛；患者自控镇痛

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Influencing factors of emergence agitation after open reduction of fractures in children

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Abstract：Objective　To investigate the risk factors for emergence agitation (EA) during the postoperative recovery period following open reduction of fractures in children, and to provide a scientific basis for the prevention and treatment of EA in children. **Methods**　A retrospective study was conducted on 123 children who underwent elective open reduction of fractures at the Children's Hospital of Nanjing Medical University from October 2024 to December 2024. The Pediatric Anesthesia Emergence Delirium Scale (PAED) scores and Richmond Agitation and Sedation Scale (RASS) scores of the children were analyzed after they were admitted to the post-anesthesia care unit (PACU) postoperatively. Based on these scores, the children were grouped, and finally 100 cases were assigned to the EA-negative group and 23 cases to the EA-positive group. Multivariate logistic regression analysis was used to identify the risk factors for EA in children after orthopedic surgery. **Results**　There were statistically significant differences between the two groups in terms of month of age, modified Yale Preoperative Anxiety Scale (m-YPAS) scores, proportion of combined nerve block, proportion of sevoflurane used for anesthesia maintenance, and proportion of postoperative analgesia at the end of surgery ($P<0.05$). Multivariate logistic regression analysis revealed that combined nerve block (OR=6.218, 95% CI: 1.410-27.417, P=0.016), sevoflurane used for anesthesia maintenance (OR=8.756, 95% CI: 1.391-55.102, P=0.021), and high m-YPAS scores (OR=1.094, 95% CI: 1.052-1.138, $P<0.01$) were independent risk factors for EA in children after open reduction of fractures. In contrast, postoperative analgesia at the end of surgery

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reduced the risk of EA in these children (OR=0.213, 95%CI: 0.046−0.976, P=0.046). **Conclusion**　Increased m-YPAS scores, anesthesia combined with nerve block, intraoperative sevoflurane maintenance, and no postoperative analgesia at the end of surgery are independent risk factors for EA in children after orthopedic surgery.

Keywords: Children; Emergence agitation; Emergence delirium; Orthopedic surgery; Sevoflurane; Postoperative pain; Patient-controlled analgesia

Fund program: Jiangsu Provincial Health Development Research Center Open Project (JSHD2022055)

苏醒期谵妄(emergence delirium,ED)是手术后患者从麻醉状态过渡至完全苏醒阶段所表现出的急性、波动性脑功能障碍。该现象通常在患者进入麻醉恢复室(post anesthetic care unit,PACU)时发生。临床特征包括思维混乱、意识模糊以及定向力障碍,并常伴有躁动不安,患者可能会无意识地拔除身上的各种监护导线与管路[1]。苏醒期躁动(emergence agitation,EA)是一个更为宽泛的概念,包括了ED、疼痛以及其他多种不良因素的综合表现[2]。儿童因耐受性差,需在全身麻醉(全麻)下进行操作及手术,导致儿童EA的发生率高于成人,高达13%~38%[3]。

近些年,随着儿童加速康复外科(enhanced recovery after surgery,ERAS)理念的不断更新,儿童围手术期管理逐渐得到优化,骨科手术部位相应神经阻滞的应用有效减少了阿片类药物及全麻药物的使用需求[4-5]。因此,基于围手术期相关指标预测患儿术后EA的发生具有重要意义。为此,本研究选取择期行骨折切开复位手术患儿,探讨影响骨科手术EA发生的影响因素,旨在为儿童EA的预防和治疗提供科学依据。

1　资料与方法

1.1　*研究对象*　回顾性分析南京医科大学附属儿童医院2024年10月至12月择期行骨折切开复位术患儿的临床资料,按照纳入和排除标准直接筛选入组后的研究对象123例。纳入标准:(1)入院月龄36~96个月,实际体质量不超过理论体质量的25%;(2)无呼吸道感染及肝肾功能异常;(3)美国麻醉医师协会(ASA)分级Ⅱ~Ⅲ级。排除标准:(1)患儿既往存在精神疾病和(或)智力发育障碍病史;(2)各种原因长期服用精神类药物,如丙戊酸钠、乙琥胺等;(3)临床资料不完善。本研究已获得南京医科大学附属儿童医院伦理委员会批准(202401013-1)。所有方法均遵循相关指南、法规和赫尔辛基宣言进行。

1.2　*分组及一般资料*　根据术后儿童麻醉苏醒期躁动评分量表(Pediatric Anesthesia Emergence Delirium Scale,PAED)得分分组,PAED<12分为ED阴性组,PAED≥12为ED阳性组。Richmond躁动-镇静(Richmond Agitation and Sedation Scale,RASS)评分为+2~+4分范围内诊断为EA阳性组,否则为EA阴性组。鉴于临床上儿童EA与ED的界限模糊,且ED可视为EA的一个子集,因此在分组时,将RASS评分为+2~+4分的EA阳性病例与PAED评分≥12分的ED阳性病例一并归入EA阳性组,其余则归入EA阴性组。

研究最终纳入EA阴性组样本共计100例,EA阳性组共23例。手术类型包括上肢骨骨折62例,具体分为桡骨骨折切开复位30例,肱骨骨折切开复位32例;下肢骨骨折49例,具体分为胫骨骨折30例,跖骨骨折切开复位19例;锁骨骨折切开复位12例。

1.3　*麻醉方法*

1.3.1　麻醉诱导与维持　患儿入室后监测心电图、无创血压、心率、血氧饱和度及鼻咽温度,采用全凭静脉或静吸复合麻醉,麻醉诱导采用静脉注射丙泊酚(辽宁海思科制药有限公司,批号:20231143)2~3 mg/kg、舒芬太尼(宜昌人福药业有限责任公司,批号:31A120212)0.2~0.3 μg/kg及罗库溴铵(广东星昊药业有限公司,批号:139230906)0.6 mg/kg。气管插管后行机械通气(德国Drager麻醉机),潮气量8~10 mL/kg,呼吸频率20~30次/min,维持血氧饱和度≥98%,呼气末二氧化碳分压在35~45 mmHg。术中麻醉维持使用丙泊酚4~6 mg·kg^{-1}·h^{-1},瑞芬太尼(广东星昊药业有限公司,批号:139230906)0.3~0.4 μg·kg^{-1}·h^{-1}和(或)联合七氟烷(上海恒瑞医药有限公司,批号:23112931)3%吸入。

1.3.2　神经阻滞　部分患儿在接受全麻术中采取了超声下神经阻滞,上肢手术神经阻滞采取臂丛神经阻滞,阻滞方法涵盖了肌间沟途径与锁骨上途径。下肢手术神经阻滞主要采取骶管阻滞,锁骨骨折神经阻滞主要采取颈丛神经阻滞,阻滞方式为单点法。

1.3.3　术毕镇痛方式　术毕镇痛方式涉及以下两种,手术结束即刻单次静脉推注舒芬太尼0.1 μg/kg与患者静脉自控镇痛(patient-controlled intravenous analgesia,PCIA),PCIA配方为舒芬太尼2 μg/kg联合托烷司琼0.1 mg/kg。

1.4 观测指标 通过回顾入选患儿的病例,收集一般资料,包括患儿性别、月龄、手术史及身体质量指数(BMI)。回顾患儿麻醉记录单了解患儿术中变量,包括是否使用七氟烷、是否联合神经阻滞,术毕是否镇痛以及手术时间。采用PAED量表[6]对患儿术后EA情况进行评估。采用RASS量表[7]对躁动-镇静状态进行分级。术前焦虑程度的评估采用改良耶鲁术前焦虑量表(modified Yale Preoperative Anxiety Scale, m-YPAS)[8],根据项目数量对各项目进行1~4分或1~6分的赋值,并转换为100分制,得分越高则患儿焦虑程度越严重。

1.5 统计学方法 采用SPSS 27.0软件分析数据。计数资料以例(%)表示,行χ^2检验或校正χ^2检验;计量资料经Shapiro-Wilk检验符合正态分布且方差齐,以$\bar{x}\pm s$表示,组间比较采用独立样本t检验;偏态分布的计量资料以$M(P_{25}, P_{75})$表示,采用Mann-Whitney U检验。影响因素分析采用多因素logistic回归分析。$P<0.05$为差异有统计学意义。

2 结果

2.1 两组一般资料比较 EA阳性组m-YPAS评分高于EA阴性组,月龄小于EA阴性组($P<0.05$)。其余资料组间差异无统计学意义($P<0.05$)。见表1。

2.2 两组术中相关指标比较 EA阳性组使用七氟烷占比、联合神经阻滞占比高于EA阴性组,术毕镇痛占比低于EA阴性组($P<0.05$)。两组手术时间差异无统计学意义($P>0.05$)。见表2。

2.3 多因素logistic回归分析 对单因素分析中差异有统计学意义的5项指标进行多因素logistic回归分析。纳入的变量包括月龄、m-YPAS评分、是否联合神经阻滞(未联合赋值为0,联合赋值为1)、是否使用七氟烷(未使用赋值为0,使用赋值为1)、术毕是否镇痛(未镇痛赋值为0,镇痛赋值为1)。结果显示:联合神经阻滞、使用七氟烷、m-YPAS评分高会增加儿童骨折切开复位术后EA发生的风险($P<0.05$);术毕镇痛会降低儿童骨折切开复位术后EA发生的风险($P<0.05$)。见表3。

表1 两组一般资料比较

Tab.1 Comparison of general data between two groups

组别	例数	男/女(例)	手术史(例)	月龄(月, $\bar{x}\pm s$)	BMI(kg/m², $\bar{x}\pm s$)	m-YPAS(分, $\bar{x}\pm s$)
EA阴性组	100	62/38	9	67.38±20.62	16.95±3.31	45.29±15.46
EA阳性组	23	13/10	1	56.68±22.67	16.04±2.36	75.97±17.40
χ^2/t值		0.236	0.098	2.201	1.255	8.378
P值		0.627	0.754	0.030	0.242	<0.001

表2 两组术中指标比较 [例(%)]

Tab.2 Comparison of intraoperative indicators between two groups [case(%)]

组别	例数	使用七氟烷	联合神经阻滞	术毕镇痛	手术时间[min, $M(P_{25}, P_{75})$]
EA阴性组	100	8(8.0)	23(23.0)	55(55.0)	72(61,84)
EA阳性组	23	8(34.8)	14(60.9)	4(17.4)	78(58,89)
χ^2/Z值		9.605	12.750	10.597	1.084
P值		0.002	<0.001	0.001	0.278

表3 影响儿童骨折切开复位术后发生EA的多因素logistic回归分析

Tab.3 Multivariate logistic regression analysis of factors influencing EA following open reduction of fractures in children

指标	β	SE	Wald χ^2	P值	校正OR值	95%CI
月龄	−0.013	0.017	0.607	0.436	0.987	0.955~1.020
m-YPAS评分	0.090	0.020	20.560	<0.001	1.094	1.052~1.138
使用七氟烷	2.170	0.939	5.344	0.021	8.756	1.391~55.102
联合神经阻滞	1.827	0.757	5.827	0.016	6.218	1.410~27.417
术毕镇痛	−1.548	0.778	3.963	0.046	0.213	0.046~0.976
常量	−6.615	1.745	14.377	<0.001	0.001	

3 讨论

本研究对123例患儿的术前及术中相关变量进行了回顾性分析,患儿月龄这一变量在单因素分析中差异有统计学意义,但多因素logistic回归分析结果却得出该变量并不是儿童骨科手术术后EA发生的风险因素。这一矛盾结果可能与月龄和结局变量之间存在混杂因素有关。本研究推测,低月龄患儿由于认知能力和对陌生环境的适应性较差,在苏醒期可能因面对陌生环境和医务人员而产生恐惧与不适,表现为哭闹不止且难以安抚。

较高的m-YPAS评分是术后EA的独立危险因素之一。m-YPAS评分直接反映了患儿术前焦虑程度。多项研究已证实术前焦虑与儿童术后EA的发生密切相关[9-10]。原因可能与患儿在进入手术室前接受的肌肉注射等疼痛性操作以及与父母的分离有关,这些因素导致患儿心理和精神上的高度紧张,从而促进了患儿EA的发生。另外,国外的研究表明,即使术前使用了咪达唑仑进行镇静,也无法降低术中使用七氟烷患儿术后EA的发生率[3],表明术前焦虑与EA之间的关联可能涉及更为复杂的机制。

术中使用七氟烷维持是术后EA发生的独立风险因素,亦是老年患者术后EA发生的危险因素[11]。相比于七氟烷,术中使用丙泊酚维持麻醉可显著降低EA的发生率(OR=0.25, 95%CI: 0.16~0.39, P<0.01)[12]。由于七氟烷具有较低的血气分配系数,其停止使用后

患儿的苏醒时间相对较短。然而,在麻醉维持期间使用的肌松药尚未完全代谢,导致患儿在意识逐渐恢复的同时,身体却因肌松药的残余作用而无法自由活动,这种"濒死感"会引发患儿极度不适,从而触发EA。有文献报道,使用小剂量芬太尼可以降低眼科手术术后患儿EA的发生率[13]。然而,目前尚无文献证据支持七氟烷本身直接导致术后EA。

文献表明,疼痛是术后EA发生的危险因素[14-15],本研究与该观点一致。神经阻滞消除了疼痛电信号的上传,发挥很好的镇痛效果,从而减少了EA发生。然而,本研究发现联合神经阻滞是术后EA发生的危险因素。分析其原因,可能是因为过量的局麻药在阻断痛觉传递的同时,也阻滞了运动神经,导致受阻滞神经支配的骨骼肌无法随患儿意识活动,进而可能引发认知能力尚未完全成熟的儿童产生恐惧感,从而诱发术后EA。为了验证这一假设,本研究对接受神经阻滞且年龄较大、能够正常交流的患儿进行回访,询问麻醉苏醒后神经阻滞区域的感觉。反馈中最为常见的描述是麻木和沉重感。这种严重的麻木感和四肢沉重感可能给患儿带来极大的不适,这或许解释了为何回顾性病例分析显示联合神经阻滞并未降低EA的发生率,反而可能增加其风险。尽管由于局麻药使用数据的分散性,本研究未对其进行详细分析,但这并不排除疼痛可能是EA发生的危险因素。

在骨科手术的围手术期管理中,术前对患儿实施非药物或药物干预以缓解术前焦虑,对于预防术后EA的发生具有显著的积极效应。在手术过程中,若能确保手术需求得到满足,适度降低七氟烷的使用量,或合理调控肌松与镇静时间的比例,均能有效降低术后EA的发生率。此外,实施联合神经阻滞时,应根据患儿的个体状况精确计算局麻药的剂量,力求在确保感觉阻滞充分的同时,最小化对运动阻滞的影响。然而,实现这一目标存在一定的挑战性,因此在采取联合神经阻滞前,必须仔细权衡其风险与收益比。

本项临床试验亦存在一些局限性。首先,试验数据仅源自单一中心,这限制了试验结果的普适性。其次,作为一项回顾性研究,其变量数据可能存在偏倚。最后,本次试验仅记录了患儿EA发生情况,缺乏对患儿长期随访数据,未能分析影响因素对儿童远期精神状态的影响。

综上所述,术前m-YPAS评分高、联合神经阻滞、应用七氟烷维持麻醉和术毕未镇痛是儿童骨科手术术后EA发生的危险因素,基于这些影响因素,临床实践中可采取相应的预防和治疗措施。

利益冲突 无

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