Adding sufentanil to ropivacaine in pediatric brachial plexus block fails to improve analgesi a : A randomised controlled trial

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Research Article

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Abstract

Background

Most studies had used sufentanil and ropivacaine for intrathecal anesthesia in adults or children but few studies had used sufentanil and ropivacaine for peripheral nerve block, especially in children. Brachial plexus block was one of the most commonly used nerve block methods in children. Therefore, the purpose of this study was to investigate whether 0.1μg/kg sufentanil combined with 0.25% ropivacaine can improve analgesia and prolong analgesia in children compared with ropivacaine alone.

Methods

80 children, ASA I, aged 5-10 years old, undergoing upper limb surgery, were randomly divided into two groups: RS group(0.25% ropivacaine combined with 0.1μg/kg sufentanil) and R group (0.25% ropivacaine alone). The dosage of 0.25% ropivacaine administered in each group was 0.5ml/kg. After general anesthesia, all children underwent ultrasound-guided brachial plexus block and were performed by the same experienced anesthetist. The primary outcome measures were the FLACC score at 2, 4, and 6 h after surgery and the duration of analgesia in each group. Secondary outcome measures were the changes in vital signs during surgery in each group, the incidence of postoperative agitation, the postoperative awake time and the duration of stay in PACU.

Results

The FLACC scores at 2, 4 and 6 hours after surgery and the duration of analgesia showed no statistically significant difference. There were no statistically significant differences in the changes in vital signs during surgery in each group. The incidence of postoperative agitation was significantly lower in RS group than R group(20% vs 45%, $P<0.05$). Comparison of the postoperative awake time and the duration of stay in PACU showed that there were no significant differences respectively.

Conclusion

Compared with 0.25% ropivacaine alone, 0.1μg/kg sufentanil combined with 0.25% ropivacaine for pediatric brachial plexus block did not improve analgesia and prolong analgesia, but reduced postoperative agitation in the children.

Trial Registration

Registration of Chinese Clinical Trial Registry(Date:19/04/2020, Number:ChiCTR2000032071).

Background

With the development of ultrasound technology, the use of peripheral nerve blocks was becoming more common in the pediatric population. Even though ultrasound guidance could further reduce the risk of

nerve injury, accidental entry into blood vessels, bleeding and other factors, the concentration or dosage of local anaesthetic drug should be carefully selected due to the small diameter of nerve fibers, thin nerves, and short distance between adjacent Ranvier's node in children[1, 2].

Therefore, how to prolong the analgesic time of nerve block had been widely concerned. In clinical practice, the analgesic effect was often prolonged by continuous administration through peripheral nerve catheterization or adding other drugs to local anesthetic drugs. Due to difficulties with catheter care in the pediatric population with features such as poor cooperation and compliance, and frequent adverse effects of peripheral nerve catheterization, the clinical use of catheterization was limited[3, 4]. Previous studies had shown that dexamethasone or dexmedetomidine combined with local anaesthetics could prolong analgesia, but the mechanism of action was not clear[5, 6] .

With the discovery of peripheral opioid receptors, a large number of studies had shown that local anesthetics combined with opioids could improve the analgesic effect of regional block, prolong the duration of analgesia, and reduce the use of local anesthetics[7–9]. However, most of these studies had used sufentanil and ropivacaine for intrathecal anesthesia in adults or children[10–12], and few studies had used sufentanil and ropivacaine for peripheral nerve block, especially in children. Brachial plexus block was one of the most commonly used nerve block methods in children, it was mainly used in upper limb surgery by injecting local anesthesia around the brachial plexus[13]. Therefore, the purpose of this study was to investigate whether 0.1μg/kg sufentanil combined with 0.25% ropivacaine can improve analgesia and prolong analgesia in children compared with ropivacaine alone.

Methods

After obtaining our Institutional Ethics Committee approval of, parents of each child read and signed a informed consent form before enrolment in the study. We studied 80 children, ASA I, aged 5–10 years old, undergoing unilateral internal fixation for upper limb fractures. The exclusion criteria were bilateral upper limb surgery, previous history of allergy to local anaesthetics, neuromuscular disease, preoperative history of upper respiratory tract infection, coagulopathy and communication difficulties. All children were randomly divided into two groups: RS group (0.25% ropivacaine combined with 0.1μg/kg sufentanil)and R group (0.25% ropivacaine alone). The dosage of 0.25% ropivacaine administered in each group was 0.5ml/kg. A randomization protocol was created by a specific investigator using random number generator software. Information about the groups, to which the children had been randomized, was kept in prepared non-transparent envelopes. All patients, PACU nurses and postoperative follow-up personnel were blinded to group allocation.

Patients were given no premedication. They were monitored with electrocardiogram and pulse oximetry, and their blood pressure were measured non-invasively after arrivingat the operating room. After an intravenous infusion of saline 0.9% was established, the anaesthesia was induced with propofol 2 mg/kg. When the patient's consciousness disappeared, 6% sevoflurane was inhaled by the mask, and the oxygen flow was adjusted to 5 L/min. After loss of the eyelash reflex and jaw relaxation, a laryngeal

mask was placed and fixed, preserving the patient's spontaneous breathing. The anesthesia was maintained using 3% sevoflurane. All patients underwent ultrasound-guided intermuscular groove brachial plexus block and were performed by the same experienced anesthetist. A 5–10 MHz line type ultrasound probe was selected to discern target nerves and surrounding anatomy. The probe was placed above the clavicle and the structures of the anterior medial scalenus and beaded brachial plexus was obtained on ultrasound images. A 21G puncture needle was selected and inserted into the plane along the long axis of the probe. The drug was administered when the tip of the needle was near the brachial plexus. No other opioids were used during the operation. When the patient's plaster was fixed at the end of the procedure, sevoflurane was stopped and inhaled with oxygen 5 L/min, and the laryngeal mask was removed and admitted to the PACU when the MAC decreased to 0.6. During surgery if HR or MAP increasesd more than 20% of the baseline value, sevoflurane concentration could be increased to deepen anesthesia. Atropine 0.01mg/kg or ephedrine 0.3mg/kg was given if the reduction of HR or MAP was greater than 20% of the baseline value. Postoperative agitation was assessed by the Ramsay Scale[14]. Sedation with propofol 1 mg/kg if agitation occurred in PACU. Postoperative pain was measured by the FLACC score[15] (Face, Legs, Activity, Cry, Consolability scale: Each item was 0 to 2 points, and the total score was 10 points. 0 was relatively comfortable, 1 ~ 3 was mild discomfort, 4 ~ 6 was moderate pain, 7 ~ 10 was severe pain). If the score was greater than 4, a treatment of 0.5mg/kg ketorolac tromethamine was given.

The primary outcome measures were the FLACC score at 2, 4, and 6 h after surgery and the duration of analgesia in each group. Secondary outcome measures were the changes in vital signs during surgery in each group, the incidence of postoperative agitation, the postoperative awake time and the duration of stay in PACU. All adverse events were recorded. The sample size was calculated based on our preliminary experiment that enrolled 10 cases in each group. The duration of analgesia was 341.7 ± 53.5 for RS group and 307.4 ± 50.6 for R group. Using standard sample size calculation formula to achieve a power of 0.8 at $\alpha = 0.05$, there should be at least 36 patients included in each group to detect a significant difference. To account for any patient dropouts or missing data, we planned to enroll 40 patients per study group. SPSS 18.0 was used for statistical analysis. Measurement data were expressed as mean ± standard deviation and inter-group comparisons were used for Group t test. Count data were expressed as percentage and the chi-square test was used for the comparison between groups. $P < 0.05$ was considered statistically significant.

Results

A total of 80 children were included in this study and each group had 40 children. There were no differences between two groups in age, weight, sex and duration of operation(Table 1). The effect of brachial plexus block of all children were perfect, and there were no need to increase sevoflurane concentration during operation. There were no statistically significant differences in MAP, HR, SpO_2, RR, $PetCO_2$, tidal volume and end-expiratory sevoflurane concentrations between two groups after entering the operating room, after anesthesia induction and at the beginning of the operation(skin incision)(Table

2,3,4). Comparison of the postoperative awake time, the duration of stay in PACU and the duration of analgesia showed that there were no significant differences respectively (Table 5). The FLACC scores at 2, 4 and 6 hours after surgery also showed no statistically significant differences (Table 6).

Table 1

Comparison of groups（$\bar{\chi}\pm S$，P＞0.05

	RS Group	R Group
Age（years）	7.5±1.2	7.5±1.3
Weight（kg）	27.8±5.1	24.6±5.5
Sex (male/female）	28/12	26/14
Duration of operation（min）	39.3±8.1	42.5±6.1

Table 2

Comparison of vital signs after entering the operating room（$\bar{\chi}\pm S$）.P＞0.05

	RS Group	R Group
RR（/min）	17.9±7.2	20.0±5.3
MAP（mmHg）	83.7±8.2	79.7±7.7
HR（/min）	95.9±13.9	94.2±16.1
SpO_2（%）	99.8±0.4	99.5±0.9

Table 3

Comparison of vital signs after anesthesia induction（$\bar{\chi}\pm S$）.P＞0.05

	RS Group	R Group
RR（/min）	26.1±4.5	30.6±5.9
Tidal Volume（ml）	111.8±22.0	109.0±24.8
End-expiratory sevoflurane concentrations (%)	2.3±0.3	2.6±0.3
$PetCO_2$（mmHg）	57.6±6.5	55.1±6.0
MAP（mmHg）	53.6±6.2	56.9±7.0
HR（/min）	95.8±13.1	101.1±12.0
SpO_2（%）	99.5±0.2	99.3±0.4

Table 4

Comparison of vital signs at the beginning of the operation（$\bar{\chi}$±S）. P＜0.05

	RS Group	R Group
RR（/min）	36.1±6.3	34.5±8.7
Tidal Volume（ml）	100.2±20.4	94.2±20.6
End-expiratory sevoflurane concentrations (%)	2.6±0.4	2.9±0.3
$PetCO_2$（mmHg）	46.2±5.5	48.2±6.0
MAP（mmHg）	58.6±8.5	65.8±7.6
HR（/min）	99.2±11.4	103.2±13.6
SpO_2（%）	99.6±0.4	99.5±0.6

Table 5

Comparison of postoperative conditions（$\bar{x}\pm S$）. P＞0.05

	RS Group	R Group
Postoperative awake time（min）	23.2±2.2	23.2±2.1
The duration of stay in PACU（min）	30.1±4.0	27.8±3.6
Analgesia duration(min)	331.4±51.1	326.9±56.7

Table 6

Comparison of postoperative FLACC scores（$\bar{x}\pm S$）. P＞0.05

	RS Group	R Group
postoperative 2h	0.3±0.1	0.3±0.1
postoperative 4h	0.8±0.2	1.0±0.3
postoperative 6h	2.2±1.0	2.6±1.3

The incidence of postoperative agitation was significantly lower in RS group than R group(20% vs 45%, P<0.05). No adverse reactions such as respiratory depression, nausea and vomiting occurred in the two groups.

Discussion

We have confirmed that 0.1μg/kg sufentanil combined with 0.25% ropivacaine for pediatric brachial plexus block could not prolong the analgesic time and improve the analgesic effect. Sufentanil was a

common opioids widely used for regional block due to its high lipid solubility[16]. However, the current clinical studies on peripheral nerve block with sufentanil mainly focused on adults and were relatively rare in children[9, 10, 17, 18]. There was no report on the dosage of sufentanil for brachial plexus block in children, and it had been reported in adult studies that the dosage of 0.2μg/kg could prolong the analgesia time[19]. Therefore, considering the physiological characteristics of children and our previous anesthesia experience, the dosage of sufentanil was selected as 0.1μg/kg in this study.

The commonly used concentration of ropivacaine in children with peripheral nerve block was 0.2%~0.3%. Bosenberg et al believed that 0.2% ropivacaine could achieve analgesia, while 0.3% ropivacaine would lead to a higher incidence of motor nerve block in children[20]. In order to meet the need of postoperative analgesia and reduce motor nerve block, 0.25% ropivacaine was selected for peripheral nerve block in this study.

In this study, there were no significant differences in respiration, circulation and end-expiratory sevoflurane concentrations between two groups before and after operation, indicating that the anesthesia effect of two groups was similar and the effect of brachial plexus block was perfect. There were no significant differences in postoperative analgesic time and FLACC score between two groups, indicating that 0.1μg/kg sufentanil combined with ropivacaine did not prolong the analgesic time and improve the analgesic effect. The reason for the negative results in this study may be related to the fact that sufentanil dosage were too small. Previous studies have shown that high-dose sufentanil 0.5μg/kg combined local anaesthetic for paediatric epidural anaesthesia could significantly prolong analgesia[11]. The difference between the two groups in the incidence of postoperative agitation was statistically significant. It meaned that 0.1μg/kg sufentanil was beneficial to reduce the occurrence of agitation in the awakening period of children, which was similar to the results of previous studies[21].

The present study had the following limitations: Firstly, the method of postoperative pain assessment in children was single and could not evaluate the pain situation comprehensively. The two groups of children included both pre - and post-school years, and the differences in the cognitive levels were large, and only FLACC score were selected to evaluate the children's postoperative pain, possibly reducing the assessment accuracy[22]. Secondly, the children were all treated with plaster immobilization postoperatively, so they were only evaluated for analgesic efficacy, and motor nerve blocks were not evaluated in each group. Thirdly, the peripheral effects of sufentanil could not be accurately assessed because no comparison was made with the same dosage of sufentanil administered intravenously. Finally, the small sample size of this study could not be able to obtain positive results, which requires further verification with a large sample size.

Conclusions

Compared with 0.25% ropivacaine alone, 0.1μg/kg sufentanil combined with 0.25% ropivacaine for pediatric brachial plexus block did not improve analgesia and prolong analgesia, but reduced postoperative agitation in the children.

Abbreviations

ASA: American Society of Anesthesiologists

FLACC: Face, Legs, Activity, Cry, Consolability scale

PACU：Postanesthesia care unit

MHz: Megahertz

MAC: Minimum alveolar concentration

HR: Heart rate

MAP: Mean arterial pressure

SpO_2: Pulse oxygen saturation

RR: Respiratory rate

$PetCO_2$: End-tidal carbon dioxide partial pressure

Declarations

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Contributions

YN and JL helped to conduct the study and write the manuscript. LQC and CCZ helped in patients' recruitment, data collection, data analysis. XWL conducted the study and helped to analyze the data. JL helped to design the study and was a major contributor in writing the manuscript. All authors read and approved the final manuscript.

Ethics declarations

Ethics approval and consent to participate

The study was approved by the Ethical Committee of The Second Affiliated Hospital and Yuying Children's Hospital of Wenzhou Medical University (Zhejiang, China) (Ref: 2017–54) on the basis of the Declaration of Helsinki. Parents of each child read and signed a informed consent form before enrolment in the study.

Consent for publication

Not applicable.

Competing interests

The authors have indicated that they have no conflicts of interest regarding the content of this article.

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