Evaluation of Prediction Effect of Perfusion Index for Supraclavicular Brachial Plexus Block in Children

Jinxu Wang (2033117988@qq.com)
Tongji Hospital of Tongji Medical College of Huazhong University of Science and Technology
https://orcid.org/0000-0001-5744-3505

Lingli Deng
Tongji Hospital of Tongji Medical College of Huazhong University of Science and Technology

Aijun Xu
Tongji Hospital of Tongji Medical College of Huazhong University of Science and Technology
https://orcid.org/0000-0003-4115-3137

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Abstract

Background: Pulse perfusion index (PI) is a reflection of blood perfusion. It has been reported that PI can be used to evaluate the effect of nerve block, but currently it is mostly focused on awake adults. In pediatric general anesthesia, it has been reported that PI can evaluate the effect of sacral block, but there is a lack of relevant research on the effect of brachial plexus blocks (BPB).

Methods/Design: This is a mono-center, prospective, single-blinded, randomized controlled trial (RCT). 104 children aged 1 month to 12 years who undergo upper limb surgery will be enrolled in this study. According to anesthesia induction and maintenance medication, they will be divided into propofol group and sevoflurane group. Record the PI values of the index finger and little finger on the blocked and non-blocked sides of supraclavicular brachial plexus block (SCB) in all children. First, analyze the two groups of patients with complete blockage respectively, and observe whether the PI values of the index finger and the little finger have the same changes by comparing the baseline values. Secondly, the cases of failed or partial block will be analyzed to understand the relationship between the PI values of the index and little fingers. Thirdly, a comparative analysis of nerve block cases in the sevoflurane and propofol groups will find that PI in what kind of general anesthesia can better judge the effect of SCB in children. So as to provide a theoretical basis for PI to estimate the effect of SCB under general anesthesia in children.

Discussion: After sevoflurane or propofol administration, changes in PI after BPB may exist in different situations at different periods. PI values in the blocked and non-blocked sides may vary with the metabolism of anesthetics. The surgery time is about 1h or so and the effects of nerve block still exist, so the PI value changes on the blocking side and the contralateral side can basically rule out the influence of general anesthetics on the PI value.

Trial registration: ClinicalTrials.gov NCT04216823. Registered on 15 July, 2020.

Introduction

Fractures are common diseases in the growth and development of children [1]. The incidence of fractures throughout childhood and adolescence is 180/1000. Naranie SM et al reported that the annual incidence of fractures accounts for 17.8% of all fractures [2]. Finger and wrist fractures are the second and third most common fractures, respectively. An epidemiological analysis of 1067 child fractures in Switzerland indicated that 76% of the fractures were upper limb fractures. Among them, 86% (694) were treated with plaster fixation or closed reduction, 11% (92) were treated with closed reduction nails or elastic stable intramedullary nails, and 3% required open reduction and internal fixation [3]. Therefore, pediatric upper limb fracture surgery is widespread. In addition, fractures cause movement limitation and obvious pain. Fully effective anesthesia and analgesia are an important part of fracture treatment.

Brachial plexus block (BCB) has a long history of being used for anesthesia and postoperative analgesia in upper limb surgery [4, 5]. There are four frequently used approaches for brachial plexus block: intermuscular groove approach, supraclavicular approach, subclavian approach and axillary approach [6,

7]. Traditionally, the supraclavicular approach is seldom used because it is prone to pneumothorax, phrenic nerve block, intravascular injection and Horner syndrome [8]. In recent years, with the development of real-time ultrasound-guided nerve blocks, anesthesiologists with extensive experience in ultrasound-guided nerve blocks can safely perform supraclavicular brachial plexus block in children under general anesthesia [9, 10]. Most regional anesthesia is performed after the child is under general anesthesia, because the uncooperative children may increase the risk of additional injury [11]. Walker BJ et al. analyzed the data of 100,000 children with regional block from more than 20 hospitals. They believed that regional anesthesia under general anesthesia was safe, and none of the children had permanent nerve damage, which was consistent with the risk of nerve block in awake adult patients [12]. However, evaluate the effect of nerve block usually requires the cooperation of the patient, and it is not suitable for patients under sedation and general anesthesia. In recent years, some scholars have discovered new objective indicators for estimating the effect of nerve block [13]. Pulse perfusion index (PI) is an indicator that reflects blood perfusion [14]. It is the ratio of pulsating blood flow to non-pulsating blood flow in peripheral tissues measured by a special pulse oximeter, and is regulated by autonomic nerves. After successful nerve block, the blocked autonomic nerve causes local vascular dilatation and increased skin temperature, as well as increased local perfusion, which will lead to changes in PI value [15].

At present, studies found that PI can be used to evaluate the effect of nerve block mostly focused on awake adults [16, 17]. And there have been studies using PI to estimate the effect of caudal block in pediatric general anesthesia [18], but there is a lack of relevant research on the effect of peripheral nerve block in children. The supraclavicular brachial plexus block (SCB) can be used for surgical anesthesia and analgesia of the upper arm, elbow, forearm, wrist, and hand below the shoulder joint. Therefore, we mainly study whether PI can be used to evaluate the effect of nerve block in children under general anesthesia with sevoflurane and propofol. In addition, SCB is the most prone to insufficiency of ulnar nerve block [8, 15]. Therefore, it remains to be studied whether the change of the PI of the little finger can reflect the ulnar nerve block effect, and then predict the success of SCB.

Methods And Design

Aim of the study

The primary aim of this study is to describe the role of PI in evaluating the predictive effect of SCB in children under general anesthesia with sevoflurane and propofol. The secondary aim is to observe whether PI could predict the success of SCB by responding to ulnar nerve block. In addition, explore which general anesthesia method combined with PI can better judge the effect of SCB in children.

Design of the study

This is a prospective observational study. It intends to observe cases of pediatric upper limb surgery performed in Tongji Hospital from May 2021 to May 2022. Groups were divided by random number table method, single blind. According to anesthesia induction and maintenance, they will be divided into propofol group and sevoflurane group. PI values of index finger and little finger in the blocked and non-blocked sides will be recorded in all children. Compare the baseline values and analyze the relationship between the changes in PI values for complete block, partial block, and block failure in each group. A comparative analysis of sevoflurane and propofol block cases will find out which general anesthesia method combined with PI can better judge the effect of supraclavicular brachial plexus block in children. The flowchart of this study is presented in Fig.1.

Sample size

According to literature reports [15], the probability of ulnar nerve insufficiency is less than 20%, the sample size is calculated: As shown in the table 1, the preliminary estimated sample size is 47 cases, and the shedding rate is assumed to be 10%. The calculation is 52 cases per group, so 104 children will be included in this experiment.

Table 1

Sample size estimation results

		Type I Error - Alpha			
		0.20	0.10	0.05	0.01
Type II Error - Beta	0.20	16 + 4	23 + 6	30 + 8	46 + 12
	0.10	21 + 6	29 + 8	**37 + 10**	54 + 14
	0.05	26 + 7	35 + 9	43 + 11	62 + 16
	0.01	37 + 10	47 + 12	57 + 15	78 + 20

Inclusion and exclusion criteria

Inclusion criteria: Children from 1 month to 12 years; ASA Class I-II; elective upper extremity surgery in children; signed informed consent.

Exclusion criteria: Refusal by family members; children with altered behavior; inflection at the puncture site; other regional anesthesia contraindications.

Interventions

The guardian signs the consent form and randomly divides the children who meet the inclusion criteria into two groups, and the random number table generated by the computer. Sevoflurane group (SEV group): Inhalation of sevoflurane (5%-8%) for induction of anesthesia, sufentanil 0.2 mg/kg, penehyclidine hydrochloride 0.01mg/kg, dexamethasone 0.1 mg/kg. Place the required type of laryngeal mask, and maintain anesthesia with 1.0 MAC value of sevoflurane + 50% oxygen. Propofol group (PRO group): Propofol 3 mg/kg, sufentanil 0.2 mg/kg, penehyclidane hydrochloride 0.01 mg/kg, dexamethasone 0.1 mg/kg are given for anesthesia induction. Place the required type of laryngeal mask, and propofol 3 mg/kg/h is given for anesthesia maintain.

The children will be given a slow intravenous bolus of 0.1 mg/kg midazolam for sedation during the waiting period. After entering the operating room, routinely monitor the electrocardiogram, blood oxygen saturation and blood pressure. After induction with propofol 3 mg/kg or inhalation of sevoflurane, a laryngeal mask will be placed. Pump propofol or inhalation of sevoflurane for anesthesia maintenance, and then all children will be placed in a supine position with their head tilted to the opposite side. Under ultrasound guidance, an experienced anesthesiologist will use an in-plane needle to block the supraclavicular nerve, and give 0.25% ropivacaine 0.4 ml/kg.

Outcome measures

The age, gender, ASA classification, BMI, anesthesia time, operation time, anesthesia recovery time, duration of stay in PACU, duration of postoperative hospital stay will be recorded. PI values of index finger and little finger will be recorded before induction of general anesthesia in the operating room, immediately after laryngeal mask placement, 5 min, 10 min, 15 min after SCB, immediately after surgery, after removal of laryngeal mask when the child is awake, and the child in PACU. Record the dosages of opioids and vasoactive drugs during the operation. Evaluate the complications and quality of awakening in children. (1) Assessment of restlessness and delirium during the recovery period: 30 min after surgery in PACU. (2) Postoperative pain score. Postoperative complications: nausea and vomiting, neurological dysfunction, Horner syndrome, respiratory depression, etc.

Block effect evaluation

Complete block: There is no significant fluctuation of the heart rate, blood pressure and respiration during the whole operation (heart rate and blood pressure increased by less than 10% compared with the baseline value, and respiratory rate increased by less than 20%). Partial block: When the surgical site is innervated by non-single nerve, there is a certain innervated area that causes heart rate, blood pressure, and respiratory fluctuations (heart rate, blood pressure increase ≥ 10% from the baseline value, respiratory rate increase ≥ 20%), while there is no significant fluctuation in operation in other innervated area. Block failure: Operation in any innervated area caused significant fluctuations in heart rate, blood pressure and respiration. For partial block and failure of block, a single dose of sufentanil (0.01 mg/kg) and a pump of 0.1-0.2 mg/kg/min remifentanil for supplementary analgesia.

Statistical analyses

Analyses will be performed using SPSS statistical software (version 19.0). Categorical variables are represented by frequency, and continuous variables are represented by mean ± standard deviation or median [interquartile range]. Chi-square test or Fisher test will be used for comparison between groups of classified variables, and *t*-test, analysis of variance or rank sum test will be used for comparison between groups of continuous variables. Logistic regression model will be used to analyze the influencing factors of anesthesia effect and complications, and stepwise regression will be used to screen independent variables.

Possible benefits of participation

All children undergoing ultrasound-guided supraclavicular brachial plexus block for anesthesia can improve postoperative pain, reduce the use of postoperative analgesics, and promote the recovery. In addition, the study will also benefit children undergoing upper limb surgery in the future.

Possible adverse reactions, risks and discomforts

This study is an observational study. The possible adverse and risks are all inherent complications and risks in surgical treatment and anesthesia, and no additional adverse reactions and risks are added.

Discussion

PI has been used to evaluate the effect of brachial plexus, sciatic nerve, stellate ganglion in adults and sacral canal block in children [18-20]. Sebastiani Anne et al. reported that PI increased in successful intermuscular sulcus nerve block, which can be used as an indicator of successful block in conscious patients [19]. Abdelnasser A et al. studied 77 adult patients undergoing ultrasound-guided elective orthopaedic surgery via supraclavicular brachial plexus block. They found that at all time points, the PI value of the blocked limb increased compared with the baseline value, and the ratio of PI values was higher than that of the limbs on the unblocked side. In addition, when the PI increment and PI ratio at 10 min after injection are 3.3 and 1.4 respectively as the limit to determine the success of the block, the sensitivity and specificity for the success of the block were 100% [15]. When PI is used to evaluate the effect of sacral canal block under ketamine anesthesia in children, it is an earlier, more objective and sensitive indicator than acupuncture sensation and cremasteric reflex [18]. However, the above-mentioned research has certain limitations. The effect of nerve block is not all-or-none. Abdelnasser A et al. did not analyze the cases of block failure and did not record the changes in PI values of partial block [15]. Since the branchial plexus is a cluster of nerves, there are nerves that are relatively difficult to block for different blocking methods. Therefore, a good evaluation method should be able to accurately assess the complete, partial and failure of the block.

Pediatric nerve block is mostly performed under sedation or general anesthesia [21, 22]. Sevoflurane and propofol are currently commonly used for induction and maintenance of general anesthesia in children [23, 24], but both of them have vasodilator effect. The study found that after 25 min of intermuscular sulcus block, propofol and sufentanil were used as anesthesia induction, and sevoflurane was inhaled for maintenance. The results on the PI values of the two limbs were not significantly different, but relatively high baseline values. Sevoflurane is considered increasing the blood flow of the muscle tissue leads to an increase in the PI value of the unblocked side, and the PI value of the blocked side does not increase, which means that the vasodilatation of the regional tissue has been maximized [19]. In the study of Park SG et al., patients did not undergo regional block and used propofol anesthesia induction and sevoflurane anesthesia maintenance program. It was also found that the PI value increased after general anesthesia [25]. Both propofol and sevoflurane general anesthesia affect the PI value. Currently, there is no study to observe whether PI changes after brachial plexus nerve block after sevoflurane or propofol anesthesia induction in children. We speculate that the changes of PI after brachial plexus block may exist in different situations in different periods after the administration of sevoflurane or propofol. For example, when the vasodilator effect of propofol reaches its peak, the PI may have increased to the highest value. At this time, PI may not increase further after nerve block is given. However, PI values in the blocked and non-blocked sides are likely change with the metabolism of anesthetics. Moreover, the operation time of upper limb fractures in children can be completed in about 1 hour. After nerve block anesthesia with ropivacaine, the anesthesia and analgesia effect last 6-8 hours. We will monitor the PI values of both upper limbs at the beginning and the end of the operation, and compare the changes of PI values of the block side and the contralateral side after the operation is completed and the child wakes up, so that the influence of general anesthetics on PI values can be basically excluded.

In conclusion, we intend to evaluate the effect of nerve block by observing the influence of supraclavicular brachial plexus block on PI after the induction of general anesthesia in children, and finding whether there are still differences in PI values on the nerve block side after the operation and awakening of the children, which could be used as a guide to evaluate the requirements of postoperative analgesics in children.

Abbreviations

ASA: American Society of Anesthesiologists; BMI: Body mass index; BPB: Brachial plexus block; MAC: Minimal alveolar concentration; PACU: Post Anesthesia Care Unit; PI: Perfusion index; PRO: Propofol; RCT: Randomized controlled trial; SEV: Sevoflurane; SCB: Supraclavicular brachial plexus block

Declarations

Trial status

1. Protocol version number and date: Ethics Approval No. 2020-S134 on 15 July, 2020
2. Date recruitment began: May 2021

3. Approximate date when recruitment will complete: May 2022

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Authors' contributions

AJX developed the protocol. JXW and LLD are responsible for obtaining basic patient information and assisting in the clinical trial. LLD is responsible for participant recruitment, data collection, and data analysis. JXW and AJX drafted this manuscript. All authors have read and approved the final manuscript. All named authors adhere to the trial authorship guidelines. All authors have agreed to publication.

Availability of data and materials

The datasets analyzed during the current study are available from the corresponding author upon reasonable request. Any data required to support the protocol can be supplied on request.

Ethics approval and consent to participate

The protocol (Ethics Approval No. 2020-S134) and related documents were approved by the Ethics Committee of Tongji Medical College of Huazhong University of Science and Technology (NCT04216823, 15 July 2020). Informed consent will be obtained from all study participants.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Author details

Department of Anesthesiology, Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan 430030, China.

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Figures

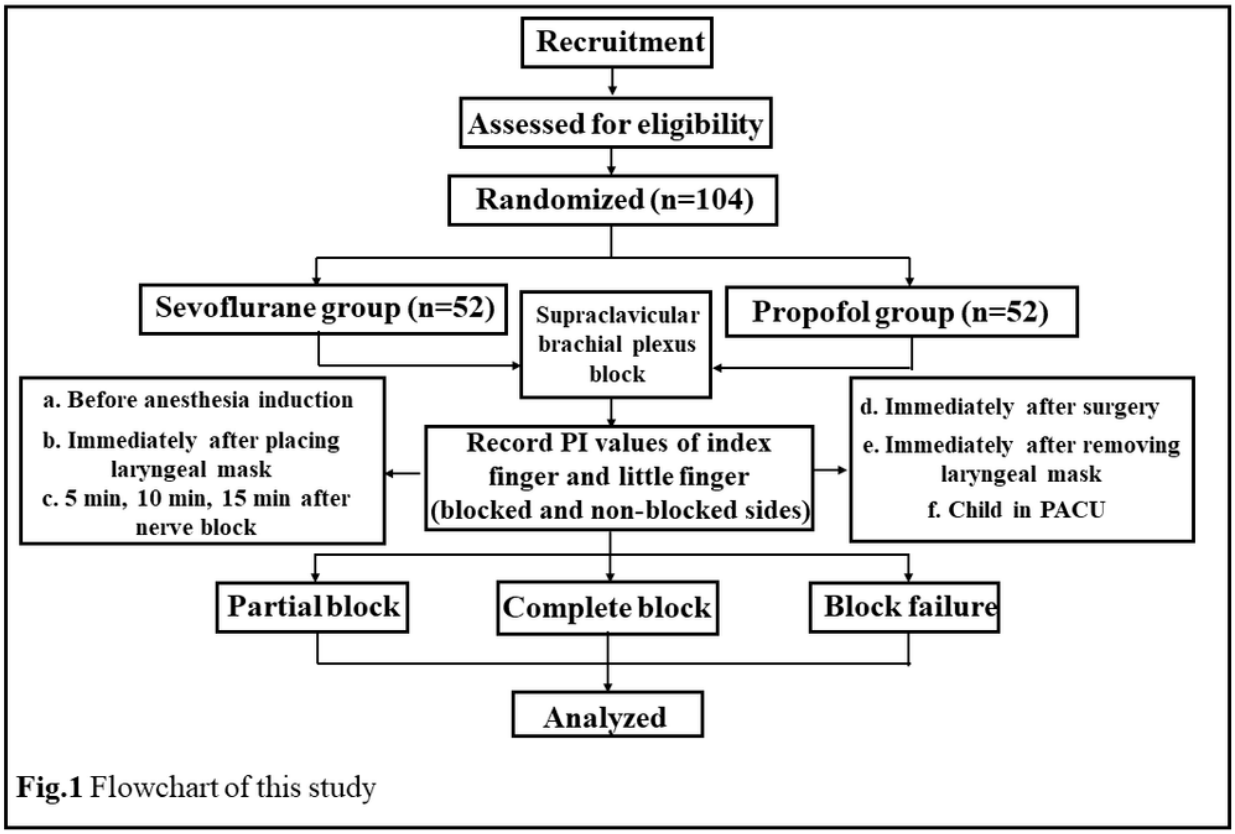

Figure 1

Flowchart of the study