Intra-Articular Bupivacaine Injection is An Ideal Method for Postoperative Pain Control in Children with Supracondylar Humeral Fracture

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Research article

Keywords: Intra-articular, bupivacaine, postoperative pain control, supracondylar humeral fracture, children.

DOI: https://doi.org/10.21203/rs.3.rs-658964/v1

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Abstract

Objective: Supracondylar humeral fracture is the most common fracture in children. Currently there are a large number of studies on supracondylar humeral fractures addressing the epidemiology of supracondylar fractures, injury mechanisms, treatments and complications, however there are few studies on how to control the pain in children after fractures and operation. Therefore, we retrospectively analyzed the effectiveness of an intra-articular injection of 0.25% bupivacaine on pain control after CRPP of supracondylar humeral fractures in children. To our knowledge, this is the largest study on the use of an intra-articular injection for pain control after surgery for supracondylar humeral fractures.

Methods: This clinical trial was designed to evaluate the efficacy of intra-articular injection of 0.25% bupivacaine as a postoperative pain control in children with supracondylar humeral fractures who underwent closed reduction and percutaneous pinning (CRPP). Subjects (n = 120) were randomized to treatment with 0.25% bupivacaine (treatment group) (n = 60) or no injection (control group) (n =71). After surgery, all patients were prescribed Ibuprofen for analgesia. The Ibuprofen doses and the times of administration were recorded. The Faces Pain Scale-Revised (FPS-R) scores were blindly recorded during postoperative day 1.

Results: The results suggested that the use of intra-articular injection of 0.25% bupivacaine improved pain control and decreased the need for Ibuprofen on postoperative day 1. FPS-R scores were also significantly lower in the treatment group as compared with those of the control group. No intra-articular injection-associated complications were reported.

Conclusion: Therefore, the intra-articular injection of bupivacaine significantly improves postoperative pain control following CRPP of supracondylar humeral fractures in children.

Introduction

Supracondylar humeral fracture is the most common fracture in children, accounting for approximately 60% of elbow fractures in children and 20% of all fractures in children [1]. Supracondylar humeral fractures can be divided into two categories: extension and flexion types, and about 97%-99% are extension type fractures [2]. Extended supracondylar humeral fractures are usually classified according to the modified Gartland classification, and surgical treatment is usually recommended for Gartland II and III supracondylar humeral fractures in children [3]. There are many surgical methods for the treatment of supracondylar humeral fractures in children [4, 5], and the standard surgical method is closed reduction and percutaneous pinning (CRPP) [6, 7]. However, children with CRPP usually experience severe pain [8]. Currently there are a large number of studies on supracondylar humeral fractures addressing the epidemiology of supracondylar fractures, injury mechanisms, treatments and complications, however there are few studies on how to control the pain in children after fractures and operation.
Intra-articular injection is a routine procedure in orthopedics. At present, in the field of adult orthopedics, such as in joint surgeries [9] and sports medicine [10,11], intra-articular injection has shown a promising effect in relieving postoperative pain. The efficacy of intra-articular injection in supracondylar humeral fracture in children has not been extensively studied yet. Only one study [12] has shown that intra-articular injection of 0.25% bupivacaine significantly reduces postoperative pain in children with supracondylar humeral fractures undergoing CRPP.

Therefore, we retrospectively analyzed the effectiveness of an intra-articular injection of 0.25% bupivacaine on pain control after CRPP of supracondylar humeral fractures in children. To our knowledge, this is the largest study on the use of an intra-articular injection for pain control after surgery for supracondylar humeral fractures.

**Materials And Methods**

A retrospective study was performed on 120 children with Gartland II and III extended supracondylar humeral fractures who underwent CRPP in our hospital from January 2015 to January 2020. The age of the children ranged from 4 to 14 years. The exclusion criteria were: open fractures, flexion-type supracondylar humeral fractures, co-existing fractures of other parts and injuries of other organs. The parents signed informed consent forms, and the study was approved by the hospital ethics committee. The baseline characteristics of patients, such as age, sex, height, weight, affected side, the number of needles and the time from admission to operation were recorded (Table I).

Children were randomly assigned to the intra-articular injection group and the control group. All children were operated under general anesthesia. Midazolam at 0.05 mg/kg, Propofol at 2 mg/kg and Fentanyl at 2 µg/kg were routinely used for sedation and anesthesia, while Remifentanil at 0.1 µg/kg/min and Sevoflurane at 1.2% were inhaled continuously to maintain a BIS between 40–60. Children were treated with CRPP under a C-arm fluoroscope. Lateral entry pinning has become the first choice for the surgical treatment of supracondylar humeral fracture [13,14]. The operations were performed by the same group of surgeons. Sixty children in the intra-articular injection group received an elbow joint injection with 0.25% bupivacaine after surgery (children younger than 7 years old were injected with 4 mL and children older than 7 years old were injected with 5 mL [12]). Seventy-one children who did not receive a bupivacaine intra-articular injection served as the control group. The injection was located in the "soft spot" between the lateral humeral epicondyle, the olecranon of the ulna and the head of the radius. After the injection, the elbow was flexed at 90 degrees and fixed with a plaster cast. Children were sent to the anesthetic resuscitation room after surgery.

When the patient returned to the ward, ibuprofen (30mg/kg) was given as a pain reliever. The first dose of ibuprofen and overall time in use of ibuprofen were recorded. Ibuprofen was used at the request of parents after surgery; the shortest interval was 4 hours. Severity of pain was measured using the Faces Pain Scalee Revised (FPS-R) [15] survey 24 hours after the surgery. The FPS-R scores were 0-2-4-6-8-10,
ranging from painless (0) to the maximum pain that can be described (10). The statistical analyzes were carried out by staff who were blinded with regards to the grouping and treatment.

Statistical analysis

The data were analyzed by the SPSS 22.0 software. Descriptive statistics including means and frequencies were calculated for each of the examined variables. The treatment outcomes of the two groups were compared using independent sample t-test for continuous data or \(X^2\) test and Fisher's exact test for categorical data. \(P < 0.05\) was considered statistically significant.

Results

In this study, there was no significant difference in the baseline information between the two groups of children (Table I). Age had no significant association with postoperative pain of supracondylar fractures (Table II). Children with a higher fracture classification (Gartland III) (Table III) and more K-wires (3 pins) (Table IV) had higher levels of postoperative pain and a higher FPS-R score. Compared with the control group, postoperative pain was significantly reduced and FPS-R scores were significantly lower in the group treated with an intra-articular bupivacaine injection (\(P = 0.003\)) (Table V). The time of the first ibuprofen dose after surgery was longer in the experimental group than that of the control group (\(P = 0.039\)) (Table I). The doses of ibuprofen applied in the injection group were significantly lower than those of the control group (\(P = 0.017\)) (Table I). No injection site infection, chondrolysis, compartment syndrome or iatrogenic injuries were observed.

Discussion

The results of this study showed that the level of fracture displacement was associated with postoperative pain. The degree of postoperative pain was correlated with the number of K-wires used. Intra-articular injection of 0.25% bupivacaine could effectively relieve pain in children after CRPP.

Postoperative pain in children with fractures is a serious problem. How to control postoperative pain in children safely and effectively is a recurrent goal of pediatric orthopedic surgeons and parents. Most children with supracondylar humeral fracture experienced severe pain after CRPP\(^{[16]}\). It was described that the pain is most intense on the first day after surgery, and there is no clinical pain on the third day after surgery\(^{[17]}\). Bupivacaine has a long half-life of up to 8 hours and studies have shown that intra-articular injection of bupivacaine could induce an analgesic effect up to 12 hours after anterior cruciate ligament surgery\(^{[18]}\). Therefore, bupivacaine injection could reduce pain in children with CRPP within 24 hours after surgery.

There are several studies involving postoperative pain of supracondylar humeral fractures in children. Except for oral and intravenous analgesics\(^{[19]}\), hematoma block is another commonly used pain control
method for children with fractures. Bear et al. [20] performed local hematoma block with 1% lidocaine for children undergoing closed reduction of distal radius fracture, and Herrera et al. [21] performed intraoperative hematoma block with bupivacaine at the fracture site for children undergoing femoral elastic intramedullary nail. The results showed that hematoma block could relieve pain and reduce the dose of postoperative morphine, codeine and other analgesics. In a recent study, Astacio et al. [22] performed a 0.25% bupivacaine local hematoma block in children with humeral supracondylar fracture after CRPP. Compared with the control group, postoperative use of morphine doses and pain score were not significantly different between groups, therefore the author suggested that hematoma block is not an effective method to relieve postoperative pain of supracondylar humeral fracture [22]. Intra-articular injection has shown good results in the treatment of pain after orthopedic surgery in adults. However, it is rarely used in children. Only one randomized controlled study [12] showed that intra-articular injection of 0.25% bupivacaine could significantly reduce postoperative pain in children with supracondylar humeral fracture after CRPP. Because the fracture line of supracondylar humeral fracture is located within the elbow joint capsule [12, 23], bupivacaine injected into the joint could be applied to the fracture site to provide an analgesic effect.

However, there are some limitations of intra-articular injections. One is the risk that intra-articular injections may cause chondrolysis. Although bupivacaine, lidocaine, ropivacaine and levobupivacaine are all toxic to cartilage, bupivacaine was shown to be the least cytotoxic [24]. Indeed, a single injection of bupivacaine in the articular cavity does not have harmful effects on chondrocytes [25], therefore, the intra-articular injection of bupivacaine is considered safe. Similar to the results of previous studies, there was no case of chondrolysis in our study.

Another risk is postoperative osteofascial compartment syndrome. Osteofascial compartment syndrome is a rare but catastrophic complication after fracture in children. It often occurs in children with elbow fracture [26], and the incidence is less than 0.5% [27]. Early detection is the key to avoid the occurrence of osteofascial compartment syndrome. In the control group, one child developed osteofascial compartment syndrome and ischemic contracture of the forearm, and neurotenolysis was performed 3 months after operation. The clinical symptoms of osteofascial compartment syndrome in children are not typical, especially for those children with fractures complicated with nerve injury. Attention is therefore recommended to the occurrence of fascial compartment syndrome in order to avoid limb disabilities in children [28]. Although studies have shown that ultrasound-guided regional block and one additional shot of brachial plexus block [29] can relieve postoperative pain in children with supracondylar humeral fracture, these may increase the risk of osteofascial compartment syndrome. We speculate that a small dose of bupivacaine injected into the joint capsule does not increase the risk of osteofascial compartment syndrome.

Ibuprofen is the most commonly used painkiller for children in our hospital. Because of its efficacy and safety, ibuprofen is a good choice for pain relief after musculoskeletal trauma in children [30]. Compared with other drugs such as morphine, acetaminophen and codeine, ibuprofen can effectively relieve pain.
after fracture in children, with fewer side effects and higher satisfaction of children and parents. Therefore, it is recommended to use ibuprofen for postoperative pain management\textsuperscript{[31, 32, 33]}. One of the indicators for evaluating the efficacy of intra-articular injection was the postoperative doses of ibuprofen. The results showed that an intra-articular injection with 0.25% bupivacaine could significantly reduce the postoperative doses of ibuprofen.

The main limitation of this study is that this is a retrospective study. In addition, the surgeon was not blinded. In order to reduce possible bias, we blinded the staff responsible for statistical analysis. In the future, we will conduct a randomized controlled study to evaluate the analgesic efficacy of intra-articular bupivacaine in children with supracondylar humeral fractures with a larger sample size.

In conclusion, the intra-articular injection of 0.25% bupivacaine is a safe and effective method to significantly reduce postoperative pain following CRPP of supracondylar humeral fractures in children.

**Declarations**

- Ethics approval and consent to participate

Ethics approval and consent to participate in present study was approved by the Ethics Committee of Affiliated Hospital of Chengde Medical College

  - Consent for publication

Not applicable.

  - Availability of data and materials

All data generated or analyzed during this study are included in this manuscript.

  - Competing interests

The authors declare that they have no competing interests.

  - Funding

Supported by the Scientific Research Fund Project of Hebei Provinical Health Commission, (Project Number: 20210846). The funding body has no responsibilities in study design, the collection, analysis, and interpretation of data, the writing of the report, and the decision to submit the manuscript.

  - Authors' contributions

MH contributed to the study design and is the corresponding author. MH, YW and JZ contributed to the study design, data analysis and interpretation, and manuscript draft. MH, QW and YW contributed to the
data collection and analysis. YW, JZ, QW, and MH contributed to the literature search and manuscript revision. All authors have read and approved the final manuscript.

• Acknowledgements

We thank all of the patients involved in the study

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Tables

Table 1. Basic situation of children
|                                | Control group | Test group | P   |
|--------------------------------|---------------|------------|-----|
| Age (year)                     | 6.04±3.28     | 5.93±3.17  | 0.644 |
| Gender (male / female)*        | 47:24         | 39:21      | 0.886 |
| Weight(kg)                     | 32.51±14.93   | 28.22±10.41| 0.055 |
| Affected side (example, left / right)* | 36:35         | 29:31      | 0.787 |
| Time from admission to operation(h) | 46.61±34.76   | 32.38±29.57| 0.213 |
| Operation time(min)            | 40.42±9.81    | 31.38±6.92 | 0.971 |
| Anesthesia time(min)           | 44.44±4.43    | 46.56±4.30 | 0.579 |
| Hospitalization time(d)        | 4.40±1.48     | 3.89±0.98  | 0.435 |
| Number of cases with nerve injure before operation | 3 | 2 | 0.003 |
| Number of outer Kirschner wires* |               |            |      |
| two                            | 20            | 32         |      |
| three                          | 51            | 28         |      |
| time to first dose(h)          | 2.26±0.85     | 2.48±0.75  | 0.039 |
| Number of uses within 24 hours after surgery* | 0 | 0 | 0.017 |
| 0 dose                         | 0             | 0          |      |
| 1 dose                         | 27            | 27         |      |
| 2 dose                         | 21            | 26         |      |
| 3 dose                         | 23            | 7          |      |

*Chi-square test

Table II. FPS-R by age

| Mean | Control group | Test group | P     |
|------|---------------|------------|-------|
| 8    | 4.09          | 3.03       | P1<0.690 |
| 8    | 4.12          | 3.62       | P2<0.724 |

P using Fisher's exact test
Table III. FPS-R by fracture type

| Mean   | Control group | Test group | \( P \) |
|--------|---------------|------------|--------|
| Gartland II | 4.16         | 3.53       | \( P_1 \leq 0.008 \) |
|         | 3.28         | 3.46       | \( P_2 \leq 0.010 \) |
|         | \( P_3 \leq 0.017 \) | \( P_4 \leq 0.012 \) |        |

\( P \) using Fisher's exact test

Table IV. FPS-R by number of outer Kirschner wires

|          | Control group | Test group | \( P \) |
|----------|---------------|------------|--------|
| two      | 3.41          | 2.60       | \( P_1 \leq 0.007 \) |
| three    | 4.36          | 3.43       | \( P_2 \leq 0.028 \) |
|          | \( P_3 \leq 0.030 \) | \( P_4 \leq 0.013 \) |        |

\( P \) using Fisher's exact test

Table V. Comparison of FPS-R scores between the two groups of children

| FPS-R            | Control group | Test group | \( P \) |
|------------------|---------------|------------|--------|
| 0(no pain)       | 0             | 0          |        |
| 1-2(little pain) | 32            | 26         |        |
| 3-4(a little more pain) | 24         | 22         |        |
| 5-6(even more pain) | 9            | 10         |        |
| 7-10(whole to worse pain) | 6         | 2          |        |
| FPS-R(mean)      | 3.69          | 3.60       | 0.003  |
Using Fisher’s exact test

Figures

Figure 1

Intraoperative intra-articular bupivacaine injection