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Original Research

Local Hematoma Block as Postoperative Analgesia in Pediatric Supracondylar Humerus Fractures



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Purpose: Supracondylar humerus fracture (SHF) is the most common type of fracture in children. The aim of this study was to evaluate the efficacy of local hematoma block with 0.25% bupivacaine as postoperative pain control in patients with pediatric SHF who underwent closed reduction pin fixation.

Methods: We performed an institutional review board–approved, prospective cohort study of 65 patients with SHF treated with closed reduction percutaneous pin fixation. For 6 months, all patients were randomly divided into 2 groups. The treatment group (35 patients) received an intraoperative local hematoma block using 0.25% bupivacaine whereas the control group (30 patients) did not receive a local hematoma block as postoperative pain management adjuvant. After surgery, all patients were prescribed opioid pain medication. To evaluate the efficacy of the hematoma block, postoperative morphine equivalent consumption and the Faces Pain Scale–Revised (FPS-R) survey were blindly recorded during postoperative day 1. Demographic data, surgical details, clinical neurovascular examination during the hospital stay, and complications were also evaluated.

Results: Comparison of the control group with the treatment group showed similar morphine equivalent consumption and Face Pain Scale–Revised Survey results. No hematoma block-associated complications were reported.

Conclusions: The result of this study do not favor the use of local hematoma block to improve pain control and decrease the need for opioid use on postoperative day 1 in pediatric SHF after patients undergo closed reduction percutaneous pin fixation. These results can lay the foundation for future studies while suggesting new, novel opioid-free pain control strategies in patients with SHF.

Type of study/level of evidence: Therapeutic II.

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One of the most common types of fractures in the pediatric population is supracondylar humerus fractures (SHF), which are responsible for 60% of elbow fractures during childhood.^{1,2} The usual mechanism of injury is a fall with an outstretched hand (extension-type injury), representing 70% of cases reported, mostly for children aged 2 to 7 years.³ In children, the distal humerus is a weak and thin bone region bordered posteriorly by the olecranon

fossa and anteriorly by the coronoid fossa, with the medial and lateral columns extending distally to the developing medial and lateral condyles and epicondyles. Pediatric SHF are characterized by a break in the thin area of bone between the olecranon and the coronoid fossae.⁴ Using the Gartland classification, this fracture is divided into 4 types^{5–9}: type I includes nondisplaced fractures with evidence of radiographic effusion or fat pad; type II refers to displaced fractures but an intact posterior periosteum in the sagittal plane; type III is characterized by displaced fractures with disruption of the anterior and posterior periosteum in the sagittal plane; and type IV consists of intraoperative detection of fractures with multidirectional instability and complete tear of the surrounding periosteum.

Declaration of interests: No benefits in any form have been received or will be received by the authors related directly or indirectly to the subject of this article.

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Currently, closed reduction percutaneous pin fixation is the reference standard treatment modality for displaced, closed injuries without vascular compromise.⁴ Despite the high prevalence of this fracture, most attention in research has been directed toward epidemiology, mechanism, and management; a paucity of studies have evaluated the development of an adequate postoperative pain management protocol.⁷

Adequate postoperative pain management allows a decrease in associated pain, thereby promoting early mobilization, shortening hospital stay, reducing hospital costs, and improving quality of life. This management should be based on multimodal and preemptive protocols that minimize opioid administration, leading to a decrease in side effects such as nausea, vomiting, dysphoria, and excessive sedation.¹⁰ Local hematoma block has been recommended as an alternative for analgesia in the management of pediatric fractures.¹¹ However, only one study examined its use in SHF patients; it showed notable pain improvement after closed reduction percutaneous pin fixation.⁷ The purpose of this study was to evaluate the efficacy of the administration of local anesthesia to the hematoma in pediatric patients who underwent operative treatment for SHF. We hypothesized that patients who would be treated with a hematoma block would require less opioid medication than those without hematoma block after operative treatment for SHF.

Materials and Methods

We conducted an institutional review board–approved, prospective cohort study of 65 patients with SHF treated with closed reduction percutaneous pin fixation. All human participant procedures in this study were performed in accordance with the ethical standards of the institutional review board. The study consisted of all patients presenting to the emergency room because of a type II or type III SHF that required closed reduction percutaneous pin fixation from June 2016 to January 2017.

Parents and patients were appropriately informed about the study protocol by the principal investigator and coinvestigators. After consent was obtained from patients and parents, subjects were randomly assigned to the control (G1) or treatment (G2) group. Randomization was organized based on calendar day numbers. Even days were assigned to the control group and odd days to the treatment group. Eligible patients in the study were selected based on the following criteria: (1) pediatric patients aged 4 to 12 years with SHF; (2) patients with Gartland type II and III fractures; (3) patients with no neurovascular compromise; (4) those with closed fractures; and (5) those with isolated trauma. Patients who did not meet inclusion criteria were excluded from the study. Gartland type IV fractures were rarely encountered and therefore were also excluded from the study. Exclusion criteria eliminated confounding bias from other trauma-related pain sources.

All patients underwent opioid-based general anesthesia by the pediatric anesthesia service, induced initially with intravenous midazolam (0.1 mg/kg), followed by intravenous fentanyl (1 µg/kg), lidocaine (1 mg/kg), and propofol (3 mg/kg). The surgical procedure was performed within an average of 8 hours after admission (range, 2–24 hours). As routine, all fractures were managed by closed reduction after external maneuvers under fluoroscopic control and osteosynthesis consisted of percutaneous lateral condyle pinning with 2 pins.¹² No tourniquets were used during the reduction and pinning of all fractures.

The control group (G1) consisted of patients who underwent standard closed reduction percutaneous pinning without hematoma block. The treatment group (G2) underwent partial aspiration of the hematoma with a 20- or 22-gauge needle (fluoroscopy guided), followed by injection of local anesthetic (bupivacaine

0.25% without epinephrine) into the hematoma before standard closed reduction percutaneous pinning. The amount of hematoma aspirated was the same amount of bupivacaine injected into the fracture site, with a maximum of 10 mL/patient, to avoid increasing compartment pressure. All patients remained in the hospital for at least 24 hours after surgery for neurological evaluation and pain management. Bupivacaine 0.25% was selected as the anesthetic for the hematoma block instead of lidocaine or ropivacaine, because bupivacaine has not shown a reduction in cell viability of chondrocytes compared with other local anesthetics (1% lidocaine, 0.5% bupivacaine, and 0.2% ropivacaine), which can rarely cause cell necrosis at the injection site.¹³ In addition, bupivacaine has been shown to have a longer half-life (2.7–8.1 hours) compared with lidocaine's half-life (1.5–2 hours) for percutaneous surgical procedures.¹⁴

Through the 24-hour postoperative period, all patients were prescribed oral codeine and acetaminophen (0.1–0.15 mg/kg) as opioid medication every 4 hours upon the patients' request. According to the study protocol, a blind evaluation was done by the research assistant 24 hours after the procedure, recording morphine equivalent consumption and the frequency of acetaminophen with codeine given to the patient during hospitalization. Severity of pain was measured using the Faces Pain Scale–Revised (FPS-R) survey 24 hours after the surgical procedure. The FPS-R features 6 faces depicting levels of pain ranging from 0 (no pain) to 10 (worst pain imaginable).¹⁵

Demographic data, surgical details, clinical neurovascular examination for the hospital stay, and complications were also evaluated. Fisher exact test, *t* test, and analysis of variance were used to compare differences in demographic information, clinical outcomes, and subjective survey answers. To have 80% statistical power, a total of 120 subjects were required to detect a minimum significant difference of 2.31 on the FPS-R survey. This power analysis was based on a response effect size of 0.634, as described in previous studies.⁷ An α of 0.05 with a confidence interval of 95% was used, establishing $P < .05$ for statistical significance. Microsoft Excel (Microsoft Corp., Redmond, WA) and SPSS statistical software (SPSS Inc., Chicago, IL) were used for comparison and analysis of the variables studied.

All patients were reevaluated 24 hours after the surgical procedure for data collection. No patients were lost to follow-up. There were no significant differences across these 2 groups in terms of age, fracture type, time from injury to surgery, operative time, or pin configuration. A significant difference was noted between the control (G1) and treatment (G2) groups regarding the male to female ratio ($P = .043$) because of the randomization process.

Results

A total of 65 patients underwent closed reduction percutaneous pin fixation owing to SHF from June 2016 to January 2017 at our institution. Most patients were male (43 of 65; 66%). Average age of the whole group was 6 years (range, 4–11 years). After randomization, patients were divided into 2 groups: G1 (30 patients) and G2 (35 patients). Table 1 lists the demographic and clinical characteristics of patients with SHF.

A total of 12 patients (12 of 35; 34%) in G2 did not request opioid medications during the 24-hour postoperative period, in contrast to only 5 of 30 (16%) in G1. Among patients who requested opioid medication (morphine equivalent consumption), the those in G1 required higher morphine equivalents (0.14 ± 0.09 mg/kg) compared with those in G2 (0.11 ± 0.06 mg/kg), although the difference was not statistically significant (Table 1).

In patients who experienced type II fractures, morphine equivalent consumption was similar between G1 (0.10 mg/kg) and G2

Table 1
Demographic and Clinical Characteristics of Patients With Supracondylar Humerus Fractures Based on Surgical Intervention

| Variables | Control (n = 30) | Bupivacaine (n = 35) | Total (n = 65) | P Value |
|--|---------------------|-------------------------|-------------------|------------|
| Age, y | 6.0 ± 1.9 | 6.5 ± 2.05 | 6.24 ± 1.98 | .51 |
| Sex (%) | | | | |
| Male | 16 (53.3) | 27 (77.1) | 43 (66.2) | .04 |
| Female | 24 (46.7) | 8 (22.9) | 22 (33.8) | |
| Fracture type (%) | | | | |
| Type II | 18 (60.0) | 13 (37.1) | 31 (47.7) | .07 |
| Type III | 12 (40.0) | 22 (62.9) | 34 (52.3) | |
| Postoperative pain medication received (%) | | | | |
| None requested | 5 (16.7) | 12 (34.3) | 17 (26.2) | .11 |
| Acetaminophen with codeine | 25 (83.3) | 23 (65.7) | 48 (73.8) | |
| Mean amount of opioid received (morphine equivalent [mg/kg]) | | | | |
| Type II | 0.10 ± 0.09 | 0.07 ± 0.07 | 0.09 ± 0.08 | .14 |
| Type III | 0.14 ± 0.08 | 0.10 ± 0.10 | 0.12 ± 0.09 | .08 |
| Total | 0.12 ± 0.09 | 0.09 ± 0.06 | 0.11 ± 0.08 | .11 |
| Frequency of pain medication received (%) | | | | |
| 0 dose | 5 (16.7) | 12 (34.3) | 17 (26.2) | .11 |
| 1 dose | 15 (50.0) | 13 (37.1) | 28 (43.1) | |
| 2 doses | 5 (16.7) | 8 (22.9) | 13 (20.0) | |
| 3 doses | 5 (16.7) | 2 (5.7) | 7 (10.7) | |
| Time from initial injury to surgery (%) | | | | |
| < 12 h | 23 (76.4) | 28 (79.3) | 51 (78.5) | .77 |
| 12–24 h | 7 (23.6) | 7 (20.7) | 14 (21.5) | |
| FPS-R survey | | | | |
| 0 (no pain) | 13 (43.3) | 18 (51.4) | 31 (47.7) | .71 |
| 1–2 (little pain) | 11 (36.7) | 10 (28.6) | 21 (32.3) | |
| 3–4 (a little more pain) | 4 (13.3) | 6 (17.1) | 10 (15.4) | |
| 5–6 (even more pain) | 2 (6.6) | 1 (2.9) | 3 (4.6) | |
| 7–10 (whole to worse pain) | 0 | 0 | 0 | |
| Mean FPS-R survey score | | | | |
| Type II | 0.9 ± 1.4 | 0.8 ± 1.3 | 0.9 ± 1.3 | .76 |
| Type III | 2.5 ± 1.9 | 1.8 ± 1.8 | 2.1 ± 1.9 | .13 |
| Total | 1.6 ± 1.8 | 1.4 ± 1.7 | 1.5 ± 1.7 | .65 |

(0.07 mg/kg). The difference between G1 (0.14 mg/kg) and G2 (0.10 mg/kg) regarding patients who experienced type III fractures was not statistically significant (Table 1).

Of 30 patients in G1, 13 (43%) reported 0 on the FPS-R scale compared with 18 of 35 (51.4%) in G2. A nonsignificant difference was noted in mean FPS-R scores between G1 (0.9 ± 1.4 and G2 (0.8 ± 1.3) in type II fractures. The same pattern was found regarding mean FPS-R scores between G1 (2.5 ± 1.9) and G2 (1.8 ± 1.8) for type III fractures (Table 1).

Discussion

Many studies have emphasized that almost half of children experience severe pain after closed reduction percutaneous pin fixation.¹⁶ In the current study, 48 of 65 patients (74%) reported moderate postoperative pain, particularly those with Gartland type III fractures, which reinforces the need to improve postoperative pain control. At the time of this study, acetaminophen with codeine was the most common medication used for postoperative pain control in our center. However, effective April 20, 2017, the Food and Drug Administration restricted the use of acetaminophen with codeine in children aged less than 12 years. This type of opioid medication is associated with multiple undesirable side effects: nausea, vomiting, sedation, and/or respiratory depression.¹⁷ The American Academy of Pediatrics now recommends different classes of opioids and nonopioids that are likely to have fewer side effects.¹⁸

Based on the restriction in the use of codeine as pain medication, we explored other pain management protocols after the operative treatment of SHF. Hematoma block has been presented as an opioid alternative because it is a safe, cost-effective analgesic

method that requires less equipment for sedation. The use of hematoma block has shown better patient satisfaction and pain control management compared with singular procedural sedation in reducing pediatric distal radius fractures.¹⁹ However, only one study focused on the use of hematoma block after pediatric SHF, showing promising results in reducing the patient's pain levels.⁷ The current study revealed that patients treated with a hematoma block were less likely to request narcotic pain medication after surgery. Although our results were not statistically significant, this can likely be explained by the lack of power in a small study group and merits further study in a larger patient population.

In this study, we found no complications such as cardiac arrhythmia, infection, compartment syndrome, or joint chondrolysis. We performed serial neurological evaluations and found no motor or sensory deficits in the radial, ulnar, or median nerve distributions. Administration of local anesthetic into this area has raised concern regarding clouding the neurovascular examination of these patients, which could potentially conceal an impending compartment syndrome. A case study of a patient who underwent open reduction internal fixation for a distal radius fracture, who later developed forearm compartment syndrome after being treated with bupivacaine around the median, ulnar, and radial nerves at the proximal forearm, demonstrated that its use did not preclude the diagnosis of acute compartment syndrome.²⁰ The patient's changing pattern of symptoms, rather than his report of pain alone, was important in making the diagnosis of compartment syndrome. Georgopoulos et al⁷ performed a randomized controlled trial to study the efficacy of hematoma block in 81 patients after SHF and reported no adverse events such as compartment syndrome or persistent weakness. In parallel to the previous study, Alter et al²¹ injected at least 20 mL of local anesthetics at the surgical site during the treatment of distal radius fractures with volar locked plate fixation and reported no anesthetic complications. Moreover, ischemic and acute nociceptive pain are transmitted by different nerve fibers.²² When nociceptive pain is blocked with the use of local anesthetics, sensation and transmission of ischemic pain are preserved. If sudden and considerable breakthrough pain develops, there is a high likelihood that the patient may be developing an acute compartment syndrome.

To decrease the risk of vascular compromise further, we decided not to include epinephrine with bupivacaine owing to its vasoconstriction properties. In Gartland III fractures, a higher probability of anesthetic diffusion may exist because of more extensive soft tissue trauma, but given the low amount of anesthetic injected (less than 10 mL), replacing the same amount of hematoma aspirated, it is unlikely that forearm intercompartmental pressure would increase enough to cause a compartment syndrome. That no participants had preoperative neurovascular injury, which correlates with the degree of soft tissue injury,²³ further decreases the risk for developing compartment syndrome and may be considered a criterion for the use of local hematoma block. We found that injection into the hematoma with 0.25% bupivacaine did not affect postoperative neurological monitoring.

Joint chondrolysis, the rapid disintegration of cartilage within a joint, is a described complication of intra-articular infusion devices for localized pain control.²⁴ The exact causes of chondrolysis are not completely understood and are believed to be multifactorial. A case report of chondrolysis in elbow joints was associated with the use of ropivacaine as an intra-articular anesthetic.²⁵ The use of bupivacaine 0.25% has been found to have no effect on chondrolysis as an intra-articular anesthetic.²⁶ Furthermore, bupivacaine has a more rapid, profound, and effective (3 to 4 times) anesthetic effect on soft tissues and bones than lidocaine, as well as a longer half-life (2.7–8.1 hours vs 1.5–2 hours).^{14,27–29} Based on the evidence provided on possible chondrocyte viability and its safety and

efficacy, a standard dose of bupivacaine (0.25% without epinephrine) was considered a safe method to provide postoperative pain control.²⁸

Our data analysis of FPS-R and opioid consumption, measured as morphine equivalents, showed that both groups used similar amounts of postoperative pain medication and does not favor the use of local hematoma to decrease the need for opioid use on postoperative day 1 in pediatric SHF after patients undergo closed reduction percutaneous pin fixation. It is unclear at this stage whether results would differ with greater power; our results should be validated in a larger sample.

This study had several limitations. It did not address how the effectiveness of bupivacaine was affected by other medications or patient comorbidities. The main limitation was the lack of adequate power. Although we intended to recruit at least 60 patients in each arm to achieve 80% statistical power, data collection ended prematurely and the necessary volume of patients to attain an appropriate power of study was not achieved. This was because of Food and Drug Administration restrictions on the use of acetaminophen with codeine in patients aged less than 12 years, which was enforced mid-study and limited further enrollment. Randomized controlled trials in a larger series are necessary to evaluate further whether the routine implementation of local hematoma block after closed reduction percutaneous pinning of SHF is beneficial. Finally, surgeons administering the bupivacaine injections were not blinded to the treatment arm. Although this might have resulted in a source of bias, we minimized this by having a researcher who was blinded to the study protocol collect postoperative outcome scores.

This study failed to support the use of local hematoma block to improve postoperative pain control and decrease the need for opioid use on postoperative day 1 in pediatric SHF after patients underwent closed reduction percutaneous pin fixation. Clinicians should continue to explore new therapies for pain management in patients with SHF.

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