American Journal of Emergency Medicine 37 (2019) 489–493

Contents lists available at ScienceDirect

American Journal of Emergency Medicine

journal homepage: www.elsevier.com/locate/ajem

Brief Report

Ultrasound-guided peripheral forearm nerve block for digit fractures in a pediatric emergency department☆

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ARTICLE INFO

Article history:
Received 19 September 2018
Received in revised form 20 November 2018
Accepted 23 November 2018

Keywords:
Ultrasound-guided nerve block
Digit fracture
Children

ABSTRACT

Although ultrasound-guided peripheral nerve block (UGPNB) has recently been introduced into pediatric emergency departments (EDs), knowledge of its use is still limited among pediatric emergency physicians. Ultrasound-guided ulnar nerve block (UGUNB) is a form of peripheral nerve block available for controlling the pain caused by phalangeal injuries, but studies of its use in pediatric patients are still scarce. The aim of this case series was to describe the experience of UGUNB use for pediatric phalangeal fractures in a pediatric ED setting. In all the patients with phalangeal fractures, the ulnar nerve was successfully visualized using a hockey-stick type transducer. Approximately 0.1–0.2 mg/kg of 1% lidocaine was used as the nerve block. The procedure was effective for pain control, and fracture reduction was successfully performed without the need for rescue analgesia. This case series demonstrated that UGUNB has the potential to be a useful alternative to conventional pain management in pediatric fifth digit injuries.

1. Introduction

Phalangeal fractures are commonly encountered in the pediatric population especially among adolescents [1]. In these cases, the fracture most often occurs at the base of the phalanx. Although conservative therapy is preferred for non-displaced or minimally displaced fractures, manipulation or surgical fixation is required for more severe cases [2]. Digital nerve block or procedural sedation is often used before manipulating the fractures; however, the effect of a nerve block is sometimes unstable, and procedural sedation increases the length of emergency department (ED) stay and necessitates monitoring until the patient recovers. This is not the case with a peripheral nerve block, which is used for perioperative pain control mainly by anesthesiologists [3], who have demonstrated its safety and efficacy [4]. As the procedure gained acceptance, emergency department physicians incorporated it into procedural anesthesia in the ED setting for large laceration repair and fracture reduction [5,6]. However, only few studies have been conducted in a pediatric ED. The aim of this case series was to describe the experience of ultrasound-guided ulnar nerve block (UGUNB) use for pediatric phalangeal fractures in a pediatric ED setting.

2. Methods

2.1. Study design and patient enrollment

This study is a retrospective case-series report enrolling patients who underwent UGUNB for phalangeal injury treatment at Tokyo Metropolitan Children's Medical Center between April 2015 and March 2017. The clinical chart records of patients less than 16 years old who underwent ultrasound-guided forearm nerve block were reviewed using the search terms, “ulnar nerve block”, “median nerve block”, “radial nerve block”, and “forearm nerve block”.

2.2. Setting

Tokyo Metropolitan Children's Medical Center is located in the Tama area, a suburb of Tokyo, Japan, with a pediatric population of almost half a million. Each year, about 38,000 children visit our ED, which receives any ill or injured patients regardless of the severity of their condition (trauma patients account for almost 20% of visits). While the initial management of trauma patients is usually provided by pediatric or emergency medicine residents, board-certified emergency medicine physicians supervise trauma care and determine the indications for imaging, treatment, consultation with specialists, and patient disposition. For finger fractures, emergency physicians or on-call orthopedists usually perform a closed reduction under digital block or procedural sedation.

☆ Financial support: None.

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https://doi.org/10.1016/j.ajem.2018.11.033
0735-6757/

2.3. Ultrasound-guided ulnar nerve block (UGUNB)

UGUNB was performed by two pediatric emergency physicians (MT and TH) who completed the pediatric emergency ultrasound course certified by the World Interactive Network Focused on Critical Ultrasound (WINFOCUS) and had several years of experience using pediatric emergency ultrasound. Although blind peripheral nerve block is a common procedure for orthopedic specialists, ultrasound-guided peripheral nerve block was performed instead in order to insure the patients' safety because the emergency physicians lacked sufficient experience in the blind technique.

This procedure used M-turbo™ manufactured by FUJIFILM, SonoSite Inc., Japan, with a high frequency hockey stick transducer (6–18 MHz). The patient was placed in a supine position and the probe was placed transversely on the distal and medial forearm (Fig. 2-a). From this position, the ulnar nerve was visualized above the ulna and medially adjacent to the ulnar artery. An oval and honeycomb appearance on sonography distinguishes the ulnar nerve from other anatomical features (Fig. 3-a). The skin was sterilized with an alcohol wash. Under ultrasound guidance a 23-gauge needle was inserted from the lateral side of the forearm towards the nerve by the in-plane technique (Fig. 2-b). When the needle tip was adjacent to the ulnar nerve, 0.1–0.2 ml/kg of 1% lidocaine was injected with intermittent aspiration to prevent intravascular injection (Fig. 3-b). The dosage of the analgesic was based on data from a previous article on peripheral nerve block [8]. The two operators evaluated the patient outcome after the procedure. (See Fig. 1.)

2.4. Data collection

An abstractor (MT) collected data on age, gender, body weight, mechanism of injury, diagnosis, neurovascular deficit, blocked nerve, type and dosage of analgesic, pain score (numerous rating score), additional rescue analgesia, complications, and patient outcome from the clinical records.

2.5. Ethical considerations

This study was approved by the Tokyo Metropolitan Children's Medical Center Research Ethics Board (Approval number H28b-194). In this study, we presented six cases of phalangeal fractures in which ultrasound-guided ulnar nerve block (UGUNB) was successfully used to provide anesthesia for pain control during fracture manipulation.

3. Results

We found six patients ranging from 7 to 13 years old who underwent ultrasound-guided nerve block (Table 1). Three of the patients were male, and the median body weight was 35 kg (IQR; 27.5–45 kg). Four of the six patients had a sports-related injury. The other patients sustained their injury after colliding with another person. The diagnosis was fifth proximal phalangeal base fracture in five patients and fifth proximal interphalangeal joint fracture in one patient. UGUNB was performed by MT for five patients and by TH in one patient. One-percent lidocaine was used for all the patients. All the procedures were successful and required no additional rescue analgesia, and the patients were discharged without any complications. No patients who underwent ulnar nerve block without ultrasound guidance (blind technique) was found during the survey period. The outcome measures of the patients were assessed by the operators; five patients were accessed by MT and one patient was accessed by TH.

4. Discussion

This is the first case-series demonstrating the experiences of UGUNB for phalangeal fracture reduction in a pediatric ED. UGUNB effectively reduced the pain of phalangeal fractures without any complication in pediatric patients. Peripheral nerve block is used for pain control perioperatively mainly by anesthesiologists [3], who have demonstrated the safety and effectiveness of UGPNB in a pediatric perioperative setting [4]. A study of a pediatric population demonstrated that UGPNB for trigger thumb had a significantly higher success rate than a block using the landmark method [9]. The Cochrane review of 2016 showed the safety and effectiveness of UGPNB for the pediatric population. Ultrasound guidance has reduced the rate of nerve block failure by a risk difference of −0.11 (95% CI: −0.17 to −0.05) compared to the traditional blind technique although most of the studies included in the review were conducted by anesthesiologists in a perioperative setting [10].

Similarly, ultrasound has gained popularity in the acute care setting [11], and emergency physicians have incorporated UGPNB into procedural analgesia in the adult ED setting [5]. However, studies of this technique in the pediatric ED setting are still scarce. The only case series examining UGPNB for forearm injuries published thus far newly showed that UGPNB was able to be used safety and effectively for pediatric digit injuries by emergency physicians [14]. No study has

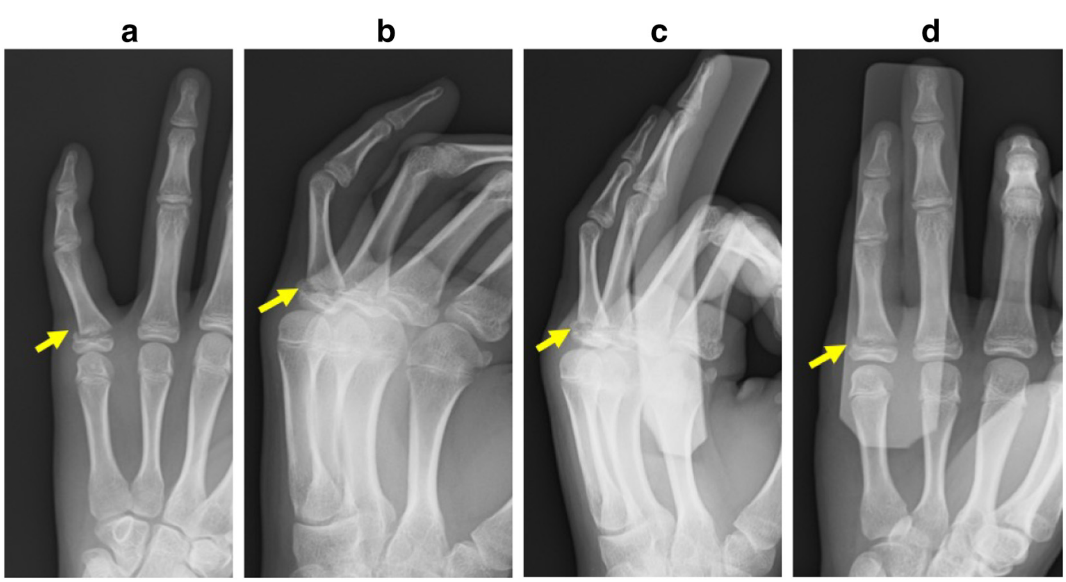

Fig. 1. a, 1-b, 1-c, 1-d: Digit X-ray findings in Case 1. A left fifth proximal phalangeal base fracture with ulnar and dorsal angulation was noted on the pre-reduction image. (1-a, 1-b) The ulnar and dorsal angulation was corrected after reduction. (1-c, 1-d).

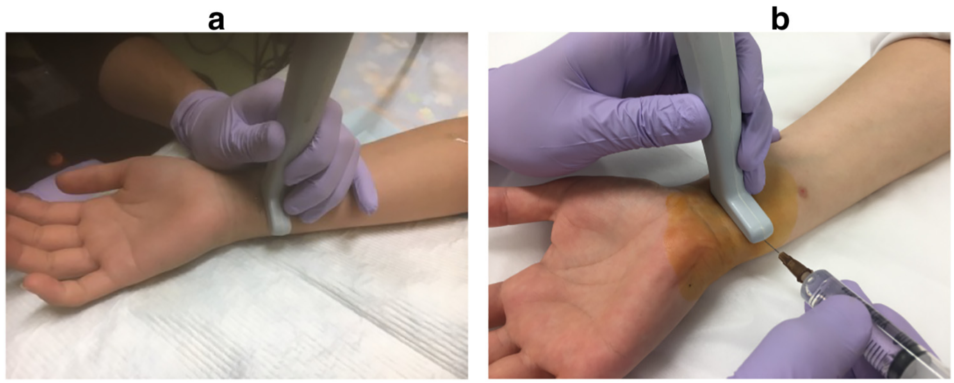

Fig. 2. Ultrasound technique. A high frequency hockey stick transducer was placed transversely on the patient's distal forearm.

compared the effectiveness of the blind and ultrasound-guided techniques for pediatric digit injuries in the pediatric ED setting.

Phalangeal base fractures are the most common type of fracture among pediatric digit injuries [1]. Although digital nerve block and procedural sedation are frequently used to manipulate displaced fractures [2], digital nerve block is sometimes ineffective [15]. In addition, procedural sedation increases the length of ED stay and necessitates monitoring until the patients recover.

The hand is innervated by the radial, median, and ulnar nerves. Although the little finger and the regions distal to the PIP joint of the second and third fingers are only innervated by the ulnar nerve and the median nerve, respectively, other regions, for example the index finger (median and radial nerves) and the ring finger (ulnar and median nerves), are innervated by multiple nerves. (Fig. 4) Thus, while a single nerve block can be ineffective depending on the injury site, the ultrasound-guided forearm nerve block is a safe and useful method of pain control in phalangeal fractures, especially fractures of the fifth digit, as long as the indications are carefully verified. All of the patients reported here were successfully analgesized using a single ulnar nerve block.

The complications of UGPNB mainly consist of systemic toxicity, neurovascular injury, and puncture site infections. [16]. Literature reporting the complication rate is scant; however, in patients who underwent regional anesthesia, the Pediatric Regional Anesthesia Network (PRAN) demonstrated that the complication rate of wrist nerve block with and without ultrasound was 0% (0/7) [17]. To the best of our knowledge, there are no clinical studies investigating the complications of ultrasound-guided nerve block in the pediatric ED setting. However, a number of case reports and a retrospective study examining ultrasound-guided nerve block performed by emergency physicians for lower limb fractures failed to find any complications [6,12,13]. The mechanism of nerve damage can be mechanical, chemical, or ischemic but in most cases can be traced to injuries caused by the needle during the injection of local anesthetics. The symptoms of ulnar nerve injury are pain, paresthesia, and motor dysfunction including the loss of intrinsic muscle function [18]. Although the prognosis of patients with nerve damage is good, and the symptoms mostly resolve within a few months [19], the injury should be monitored by ultrasound to prevent serious complications.

Real-time ultrasound guidance is effective in preventing vessel punctures leading to local anesthetic toxicity and nerve injury because the method allows the amount of local anesthetics and intrafascicular or intraneuronal injections to be reduced through direct visualization of the fracture [10]. Two large epidemiological studies in pediatric anesthesiology demonstrated that complications of peripheral nerve block were rare, ranging from 0 to 2% [17,19]. Another pediatric simulation study showed that e-learning and simulation training enhanced operators' comfort level while performing an ultrasound-guided nerve block [20]. In the present report, UGUNB was able to provide effective analgesia for all the patients without any complications as shown in Table 1. Thus, although further investigation is needed to determine the optimal manner and length of training for a sonographer, pediatric emergency physicians have been shown to be able to perform UGPNB after receiving some training.

There are several limitations to this study. First, this case series was a non-blind chart review; UGUNB was performed by two emergency physicians (MT and HT), and the one of them (MT) reviewed the data. Thus, information bias in data abstraction cannot be denied. Second, the fact that the demographics of almost all the cases happened to be very similar may limit the generalizability of our findings. The patients who

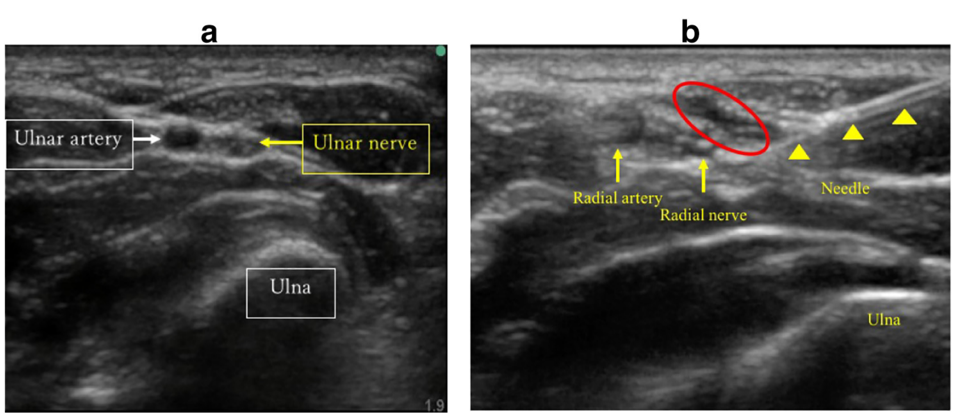

Fig. 3. -a, -b: Ultrasound anatomy. The ulnar nerve, ulnar artery, and the ulna can be seen. The ulnar nerve was visualized above the ulnar bone and medially adjacent to the ulnar artery (3-a). When the needle and needle tip with the hyperechoic appearance (triangle) was adjacent to the ulnar nerve (arrow), the analgesic was injected into the area surrounding the target nerve with an aechoic legion. (circle) (3-b).

Table 1
Characteristics of the patients who underwent ultrasound-guided ulnar nerve block.

Patient number	Age (ys)	Gender	Body weight (kg)	Mechanism of injury	Diagnosis	Neurovascular deficits	Blocked nerve	Medication dosage (ml/kg)	Definitive treatment	Additional rescue analgesia	Complications	Outcome
1	8	F	26	Sprained during dodgeball	L fifth proximal phalangeal base fracture	None	Ulnar	1% lidocaine (0.19)	Manipulation	NO	None	Good
2	8	M	23	Collided with another person	R fifth proximal phalangeal base fracture	None	Ulnar	1% lidocaine (0.21)	Manipulation	NO	None	Good
3	7	M	36	Fall from a kick scooter	R fifth proximal phalangeal base fracture	None	Ulnar	1% lidocaine (0.14)	Manipulation	NO	None	Good
4	9	M	32	Sprained during dodgeball	L fifth proximal phalangeal base fracture	None	Ulnar	1% lidocaine (0.16)	Manipulation	NO	None	Good
5	9	F	32	Sprained during dodgeball	L fifth proximal interphalangeal joint fracture	None	Ulnar	1% lidocaine (0.16)	Manipulation	NO	None	Good
6	13	F	45	Collided with another person	L fifth proximal base fracture	None	Ulnar	1% lidocaine (0.11)	Manipulation	NO	None	Good

underwent UGUNB were selected by the sonograph operator; thus, selection bias may have occurred though the selection of patients who were easily treated or were amenable to the procedure. Third, the pain score (NRS) was not recorded for all the patients due to the lack of staff or documentation. For patients without the NRS, the effectiveness of UGFNB was evaluated by the presence or absence of rescue analgesia as shown in previous studies [14,15]. Fourth, we were unable to perform follow-up for long-term complications including residual parenthesis, numbness, and muscle weakness. However, none of the included patients returned to our ED due to any of these complications. Although these patients may have visited other treatment centers for complications, this is unlikely due to the fact that our hospital has not only a pediatric emergency service but also a pediatric orthopedics department servicing a wide geographical area. A large, prospective study is required to overcome these limitations.

5. Conclusions

UGUNB has the potential to be a useful alternative to conventional forms of analgesia in the treatment of pediatric fifth phalangeal fractures although the indications need to be carefully verified.

Abbreviations

UGPNB ultrasound-guided peripheral nerve block

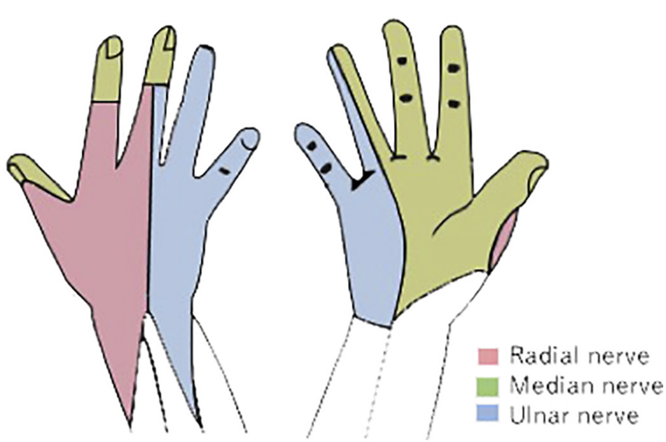

Fig. 4. Nerve distribution in the hand. The radial, median, and ulnar nerves innervate the hand.

ED Emergency department
UGUNB ultrasound-guided ulnar nerve block
PRAN Pediatric Regional Anesthesia Network

Financial support

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of interest

None.

Author's contributions

TM supervised patient care. TM and NO conceptualized the report. TM interpreted the data and wrote the first draft of the manuscript. NO and HY supervised the manuscript. All the authors reviewed and approved the final manuscript as submitted.

Presentation

This study was presented at the 121st Annual Meeting of the Japan Pediatric Society, on April 21, 2018, in Fukuoka, Japan.

Acknowledgements

We all thank Dr. Takei Hirolazu for treating the patient and Mr. James R. Valera for his assistance with editing this manuscript.

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