

Feasibility of Forearm Ultrasonography-Guided Nerve Blocks of the Radial, Ulnar, and Median Nerves for Hand Procedures in the Emergency Department

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Study objective: We determine the feasibility of forearm ultrasonography-guided nerve blocks of the radial, ulnar, and median nerves, performed by emergency physicians, to provide procedural anesthesia of the hand in the emergency department (ED).

Methods: This was a prospective study involving a convenience sample of 11 patients presenting to an adult ED with hand pathology requiring a procedural intervention. Adults 18 years and older who presented to the ED during the 3-month study period were eligible. Physicians performing the nerve blocks were attending physicians, ultrasonography fellows, or residents who had participated in a 1-hour training session. The participants underwent ultrasonography-guided nerve blocks in the forearm to provide anesthesia. Any additional anesthesia or analgesia required to perform the procedure in the anesthetized region was recorded. Subjects rated their pain on a 100mm visual analog scale before the nerve block and 15 minutes after the nerve block. The primary outcomes for feasibility were the percentage of cases completed without rescue anesthesia or analgesia and the median reduction in pain on the visual analog scale after the nerve block. Secondary outcomes for feasibility included the median time to completion of the entire nerve block procedure for each subject (from initiation of ultrasonography to completion of the last injection) and the percentage of participants wishing to have the same procedure for similar injuries in the future. Other secondary outcomes included the percentage of participants with complications during the procedure and at 3 months.

Results: All procedures (100%) were completed without additional anesthesia or analgesia. The median reduction in visual analog scale score was 5.0 cm (interquartile range 3.0, 8.0; $P=.003$). The median time to completion of nerve blocks was 9 minutes per patient (interquartile range 6 minutes 30 seconds, 10 minutes 0 seconds), with a median of 2 blocks per patient. Ten of 11 patients (92%) stated they would wish to have the ultrasonography-guided nerve block in the future for similar injuries. There were no immediate complications and no complications reported at 3 months.

Conclusion: Attending physicians, fellows, and residents can perform forearm ultrasonography-guided nerve blocks of the radial, ulnar, and median nerves quickly, without additional anesthesia and with high patient satisfaction, after minimal training. Although pilot data are suggestive, randomized controlled trials are needed to determine efficacy and safety. Ultrasonography-guided nerve blocks to provide anesthesia for hand procedures appear to be feasible in the ED. [Ann Emerg Med. 2006;48:558-562.]

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Editor's Capsule Summary

What is already known on this topic

Peripheral nerve blocks are routinely performed by emergency physicians using traditional anatomic landmarks.

What question this study addressed

This prospective feasibility study used ultrasonography to aid in the performance of radial, ulnar, and median nerve blocks of the forearm. No previous studies have explored this application of procedural ultrasonography.

What this study adds to our knowledge

Four emergency physicians performed 22 blocks on 11 patients after receiving 1 hour of training. All blocks were successful; none required rescue anesthesia or analgesia.

How this might change clinical practice

This pilot study suggests another useful application for emergency department ultrasonography, but randomized trials are needed to establish the benefit of ultrasonographic guidance.

INTRODUCTION

Patients frequently present to the emergency department (ED) with hand pain caused by fractures, dislocations, lacerations, burns, and infections. Often, painful procedures such as suturing, debridement, and reduction are required. Emergency physicians use a variety of methods to provide anesthesia for procedures and pain control in the hand. These methods include local wound infiltration, wrist blocks, hematoma blocks, intravenous regional blocks (Bier blocks), parenteral pain medications, and procedural sedation.

Ultrasonographic guidance has been used to anesthetize nerves for the 3-in-1 nerve blockade of the femoral, obturator, and lateral cutaneous nerves for fractures of the femoral neck.¹ There has been 1 case report in the anesthesia literature of 2 successful ultrasonography-guided ulnar nerve blocks for fifth-digit surgery.² The purpose of this pilot study was to determine the feasibility of a novel approach to anesthesia—forearm ultrasonography-guided nerve blocks of the radial, median, and ulnar nerves—before hand procedures in the ED.

MATERIALS AND METHODS

Study Design and Setting

A prospective observational study was conducted in an urban academic ED with 75,000 annual visits and a population of predominantly minority ethnic groups. The ED has an ultrasonographic fellowship program. The hospital's institutional review board approved the study protocol, and written informed consent was obtained from all participants.

Selection of Participants

A convenience sample was enrolled of adults 18 years and older presenting to the ED during the 3-month study period with hand pain requiring a procedural intervention. Research assistants were available from 8 AM to 8 PM, and trained physicians were available when they were working in the department.

Only 1 subject with a wrist injury was enrolled. This patient was excluded from the analysis because no significant statement could be made about the ultrasonography-guided nerve block in wrist injuries. This patient had a significant reduction in the visual analog scale score but required 6 mg of morphine at the fracture reduction.

Interventions

A SonoSite iLook with a linear-array 7.5-MHz probe or a SonoSite Titan (SonoSite, Inc., Bothell, WA) with a linear-array 10-MHz probe was used for imaging. Sonographers were emergency medicine attending physicians, ultrasonographic fellows, and residents who completed standardized training in techniques to identify forearm nerves. A 1-hour training session and a minimum of 5 supervised procedures on a commercially available nerve model (BluePhantom, Kirkland, WA) were required.

Four physicians were trained: 1 attending physician, 1 ultrasonographic fellow, and 2 senior residents. Only the attending physician was credentialed in emergency ultrasonography. At the nerve block, a trained physician had to perform the ultrasonography. Either this physician or an assisting physician, who was not necessarily trained, was permitted to perform the injection of the anesthetic. All physicians had some experience with the use of emergency ultrasonography because of their participation in an academic emergency medicine residency program with an associated ultrasonographic fellowship. Only 1 physician had performed the ultrasonography-guided nerve block on ED patients before the study.

A systematic approach to ultrasonography of the forearm was developed by the authors to identify the nerve(s) innervating the injured region of the hand. The radial nerve was identified using a 2-step procedure. First, the probe was placed over the radial artery at the wrist so that the artery was seen in cross-section. Second, the probe was moved proximally to the midforearm, keeping the radial artery in the middle of the screen. The radial nerve was visualized adjacent to the radial side of the radial artery. The ulnar nerve was identified using the same 2-step procedure, starting at the distal ulnar artery. The ulnar nerve was visualized adjacent to the ulnar side of the ulnar artery. The median nerve does not have an associated median artery, except in rare anatomic variants. Therefore, in the first step, the probe was centered over the volar wrist, between the ulnar and radial arteries, and moved proximally. The median nerve was visualized in the midforearm among the flexor digitorum muscle bundles (Figure).

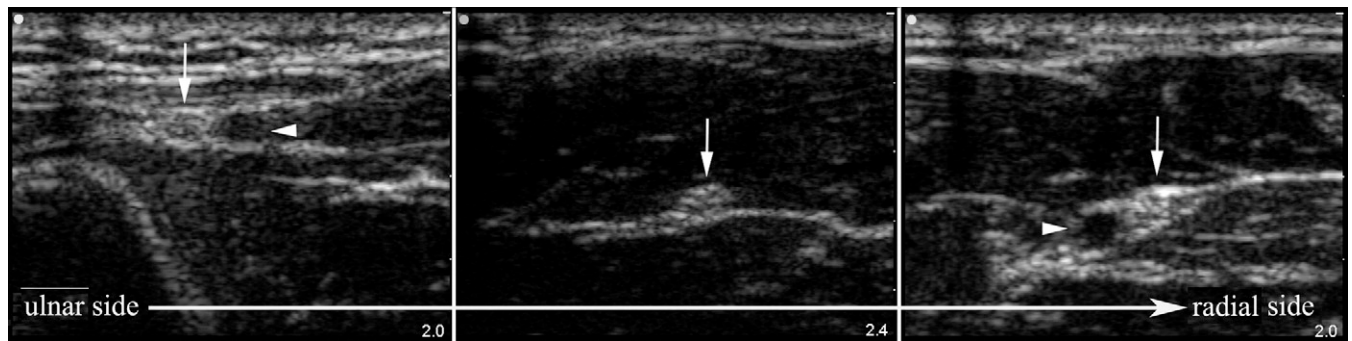


Figure. Ulnar, median, and radial nerves (arrow) and arteries (arrowheads) in the forearm.

The skin was prepared with povidone-iodine. Under real-time ultrasonographic guidance, the sonographer or an assisting physician, using a 25-gauge needle, injected 2 to 3 mL of a mixture of 1% lidocaine and 0.25% bupivacaine lateral and medial to the identified nerve.

Data Collection and Processing

Research assistants recorded all data on a data collection sheet developed for this study. Physicians were asked to answer the following yes/no question after completion of the intervention that required the nerve block: To perform the procedure in the anesthetized region, was additional anesthesia/analgesia required after the nerve block? The need for additional anesthesia was based on patient request during the procedure. If the patient requested additional anesthesia, a research assistant subsequently reviewed the medical record, and the time and dose of the medication were recorded.

Participants were asked to mark their pain level on a standardized horizontal linear 100-mm visual analog scale before the procedure. Fifteen minutes after completion of the nerve-block injection, the patients were again asked to rate their pain on a visual analog scale. Patients were blinded to the results of their initial score. Patients were also asked to answer the following yes/no question: In the future, if you had a similar injury, would you want this procedure again?

A research assistant recorded the time from initiation of ultrasonography to the completion of anesthetic injection for each nerve blocked in minutes and seconds by using a digital stopwatch and then rounded the time to the nearest minute. Aspiration of blood before injection of the anesthetic was recorded as a puncture of a vessel. Sharp pain radiating to the distribution of the nerve being blocked was recorded as a puncture of the nerve. Patients were contacted by phone 3 months after their ED visit to identify long-term complications of the procedure. Research assistants also recorded patient demographic information and wound description.

The primary outcome measures were the percentage of cases completed without rescue anesthesia/analgesia and the median reduction in pain after the nerve block, using a visual analog scale. There were 4 secondary outcome measures: (1) median

time from initiation of ultrasonography to completion of the nerve blocks for each subject; (2) percentage of patients who would have this procedure again for similar injuries; (3) immediate complications, including vascular or nerve puncture; and (4) complications or complaints within the 3-month follow-up period.

Primary Data Analysis

The Wilcoxon signed-rank test was used to compare visual analog scale scores before and after the nerve blocks for each patient. Medians and interquartile ranges were calculated for visual analog scale and time data. Data were analyzed using Stata/SE 9.1 (Stata Corporation, College Station, TX).

RESULTS

Eleven subjects were enrolled. The median age was 39 years (range 21 to 60 years). Four of the participants were black, 1 was Asian, 5 were Hispanic, and 1 was white. A total of 22 nerve blocks were performed: 6 radial nerve blocks, 9 median nerve blocks, and 7 ulnar nerve blocks. Nine of the 11 patients had 2 or more nerves blocked. The procedures included laceration repair, incision and drainage, foreign body removal, and fracture reduction (Table). Each of the 4 trained physicians performed a median of 2 blocks; the attending physician performed 2 blocks, the ultrasonographic fellow performed 2 blocks, 1 resident performed 2 blocks, and 1 resident performed 5 blocks.

In all cases (100%), no additional anesthesia/analgesia was required to perform the procedure in the region receiving the nerve block. The median reduction in visual analog scale pain score after 15 minutes was 5.0 interquartile range ([IQR] 3.0, 8.0; $P=.003$). Ten of 11 subjects had a clinically significant reduction in their visual analog scale pain score, defined by a reduction of greater than 13 mm.³ Patient 1, who did not have a clinically significant reduction in the visual analog scale pain score, underwent a deep, complex laceration repair without requesting additional anesthesia.

The median time to completion of the entire nerve block procedure, from time of initiation of ultrasonography for the first block to completion of injection of anesthetic for the last

Table. Age, race, injury and procedure, and nerves blocked for each patient.

Patient	Age, y	Race/Ethnicity	Injury and Procedure	Ultrasonography-Guided Nerve Block Site
1	58	White	Lac repair: deep, complex, table saw injury	R, M
2	36	Black	Boxer's fracture reduction	U
3	25	Hispanic	Lac repair: deep, simple, knife injury	R, M,U
4	22	Black	Lac repair: deep, complex, GSW	M, U
5	54	Asian	Foreign-body removal	U
6	21	Hispanic	Bennett's fracture/dislocation reduction	R, M
7	44	Hispanic	Lac repair: deep, simple, knife injury	R, M,U
8	63	Hispanic	Abscess: dorsum of hand	R, M
9	23	Hispanic	Lac repair: deep, complex, skill saw injury	M, U
10	45	Black	Lac repair: deep, simple, machete injury	M, U
11	22	Black	Lac repair: deep, complex, glass injury	R, M

GSW, Gunshot wound; Lac, laceration; M, median nerve; R, radial nerve; U, ulnar nerve.

block, was 9 minutes per patient (IQR 6, 10 minutes), with a median of 2 nerves blocked per patient. The median time for a radial block was 6 minutes (IQR 4, 7 minutes), for a median block was 3 minutes (IQR 2, 6 minutes), and for an ulnar block was 5 minutes (IQR 4, 7 minutes).

In 10 of the 11 cases (92%), participants reported that they would wish to have this procedure again for a similar injury. For patient 2, the answer to this question was not recorded.

No immediate complications, including vascular puncture or direct nerve injection, were reported for the 22 nerves blocked. Ten of the 11 patients (92%) had telephone follow-up 3 months after the procedure, and none reported any complaints, including persistent numbness, weakness of the anesthetized region, or signs of infection in the forearm. Patient 2 had a disconnected phone line and could not be contacted.

LIMITATIONS

A limitation of this study is the small sample size and uncontrolled design. The study was not powered to detect the failure rate for blocking individual nerves or the rate of infection or nerve damage. This study does not control for operator variability among sonographers or clustering by physician, because of the small sample size and the absence of sonographers' names on the data collection form. Providers were instructed to deliver rescue anesthesia on patient request, but use of rescue anesthesia might vary by physician, procedure, and patient pain tolerance. In addition, delivery of pain medications before the block was not recorded. Physicians in this study had been exposed to emergency ultrasonography because of the presence of an ultrasonographic fellowship at the study site; therefore, ED providers unfamiliar with ultrasonography might require additional training before performing the ultrasonography-guided nerve block.

DISCUSSION

This pilot study introduces forearm ultrasonography-guided blocks of the radial, ulnar, and median nerves as a means of anesthetizing the hand. No repeated nerve block injections or

additional local injections of anesthetic were required. The median reduction in pain on the visual analog scale after the nerve blocks was clinically significant,³ and no patients requested additional anesthesia.

The median time to completion of the ultrasonography-guided nerve block(s) from ultrasonography to completion of the last injection was 9 minutes per patient when performed by physicians who had received 1 hour of training and a practice session. Although all physicians were familiar with emergency ultrasonography, only 1 had performed the ultrasonography-guided nerve block before the study. The authors believe that the ultrasonography-guided nerve block is a potentially feasible ED procedure, given the preliminary promising data demonstrating minimal need for rescue anesthesia, significant pain reduction, a reasonable amount of time to complete the nerve blocks, and patient satisfaction with the procedure. In addition, practitioners at various levels of training performed the procedure. Finally, in this small study, no complications were reported immediately or at 3 months.

Although there are several "blind" methods for providing anesthesia in the wrist and hand (including digital blocks, wrist blocks, hematoma blocks, and local infiltration), we believe that real-time ultrasonographic guidance to block the nerves of the forearm has 4 potential advantages. First, it may reduce injury to vascular structures. The vasculature is directly visualized, and infiltration of the anesthetic agent can be appreciated adjacent to the vessel as the injection is performed. Second, it allows direct visualization of the nerve innervating the painful region of the hand, potentially minimizing points of skin puncture and the risk to surrounding structures and allowing early visual confirmation that the nerve has likely been anesthetized. Third, there may be a reduced risk of compartment syndrome compared with Bier blocks and wrist blocks. Finally, by performing the nerve block in the forearm, proximal to the injury, the physician can avoid injecting through or adjacent to damaged tissue, potentially preventing further damage to the region that needs repair.

In summary, to our knowledge this is the first report of forearm ultrasonography-guided nerve blocks to provide anesthesia for hand procedures in ED patients. These ultrasonography-guided nerve blocks appear to be feasible in the ED setting. Although the pilot data are suggestive, randomized and controlled trials are needed to determine efficacy and safety.

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Author contributions: OL, DP, and AG conceived the study. OL and DP designed the trial. OL, DP, CM, RW, and SW conducted patient enrollment and supervised the conduct of the trial and data collection. OL drafted the manuscript, and all authors contributed to its revision. RG performed all data analysis. DP and OL take responsibility for the paper as a whole.

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