ULTRASOUND ARTICLE

Sensory Distribution of the Lateral Cutaneous Nerve of Forearm After Ultrasound-Guided Block
Potential Implications for Thumb-Base Surgery

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Abstract: Surgery of the wrist and hand commonly involves regional anesthesia of the median nerve and superficial radial nerve within the forearm. In this sonographic study, the contribution of the lateral cutaneous nerve of forearm (LCNF) to thumb cutaneous sensation was studied. Patients scheduled for thumb suspension arthroplasty (n = 35) were examined by ultrasound, with LCNF, median nerve, and superficial radial nerve identified. A single nerve was then injected with local anesthetic, and the area of cutaneous sensory loss mapped at 15 minutes. The remaining 2 nerves were then blocked for progression to theater. In 15 patients, the LCNF was blocked first at the antecubital fossa, where it was located posterior to the cephalic vein 9.1 (1.6) mm distal to the interepicondylar line. Bifurcation occurred further distally, 18 (2.6) mm from the interepicondylar line. In 14 of 15 cases, LCNF sensory distribution extended to the thumb base, 8.3 (7.8) mm distal to the radiocarpal joint. This study has demonstrated the LCNF to innervate the thumb base, indicating neural blockade of this nerve may be required for surgery of the basal thumb joint.

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In the forearm, individual nerve blockade of the median (MN), superficial radial (SRN), or ulnar nerves (UN) is commonly used for surgery of the wrist and hand, in contrast to general anesthesia or brachial plexus blockade. Regional anesthesia is beneficial (particularly for elderly patients), and individual nerve blockade may have advantages over the more proximal brachial plexus block by requiring a lower local anesthetic dose and avoiding unpleasant arm numbness and paresis postoperatively.[1–4] Importantly, this approach requires selective targeting of all nerves that supply the site of surgery, as well as the management of torniquet pain. Thumb suspension arthroplasty (TSP) is a common wrist procedure and involves excision of the trapezium bone (with or without partial resection of the trapezoid) at the base of thumb, followed by tendon-graft transfer to maintain length of the first ray.[5] In contrast to traditional anatomic description of thumb base innervation, we have observed that targeted MN and SRN blockade alone may result in incomplete anesthesia, and the addition of lateral cutaneous nerve of forearm (LCNF) blockade improves anesthetic success. Given the LCNF exhibits a variable pattern of distribution and anatomically may supply sensory fibers to the dorsolateral aspect of the thumb, we designed this prospective, observational study to evaluate the cutaneous distribution of ultrasound-guided LCNF blockade performed below the elbow.[6–8]

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METHODS

Following informed written consent and institutional ethics approval (The Avenue Hospital HREC 183), 35 patients scheduled for elective TSP were recruited for individual nerve study. Patients were excluded if there was a preexisting neurological deficit or they refused regional anesthesia. Before surgery, patients were placed supine and lightly sedated with midazolam (1–2 mg), and the operative arm exposed. In this observational study, the LCNF was studied in 15 patients, and for visual comparison, adjacent MN and SRN dermatomes were separately mapped in each of 10 patients. The nerve (either LCNF, MN, or SRN) was first identified by ultrasound in the forearm with relation to surrounding anatomy, and using a short-axis in-plane approach (SAX-IP), the nerve was injected circumferentially with local anesthetic (lignocaine 2%, 3–5 mL). The area of cutaneous sensory loss distal to the injection site was then mapped at 15 minutes. The subjective response to light touch, using a fine-hair brush and ice-cold metal probe, enabled the transition area of sensory loss to be marked with a surgical pen. The distal extent of numbness was related to the radiocarpal joint (RCJ; Fig. 1B), and the forearm was then photographed. A single nerve was mapped per study to avoid overlap between dermatomes. Following mapping, the remaining 2 nerves were identified midforearm with ultrasound and then blocked for progression to surgery. At the completion of surgery, the thumb base was infiltrated with long-acting anesthetic by the surgeon to ensure all patients had equal postoperative analgesia.

LCNF Mapping. With the forearm supinated, ultrasound scanning of the antecubital fossa was performed, and images were digitally recorded (14-MHz linear array probe, BK 400; BK Ultrasound, Herlev, Denmark). The probe was placed lateral side to the biceps brachii tendon, and the LCNF was identified in relation to the interepicondylar line (IEL; Fig. 1A). The nerve was then mapped distally until bifurcation, and the anatomical relation to the cephalic vein recorded. Using a lateral-to-medial US-guided SAX-IP approach, the nerve was then blocked distal to the IEL, with a circumferential injection of lignocaine 2% (3–5 mL), and sensory loss mapped at 15 minutes.

MN and SRN Mapping. In separate patients, the MN or SRN was similarly located in the midforearm, and injected

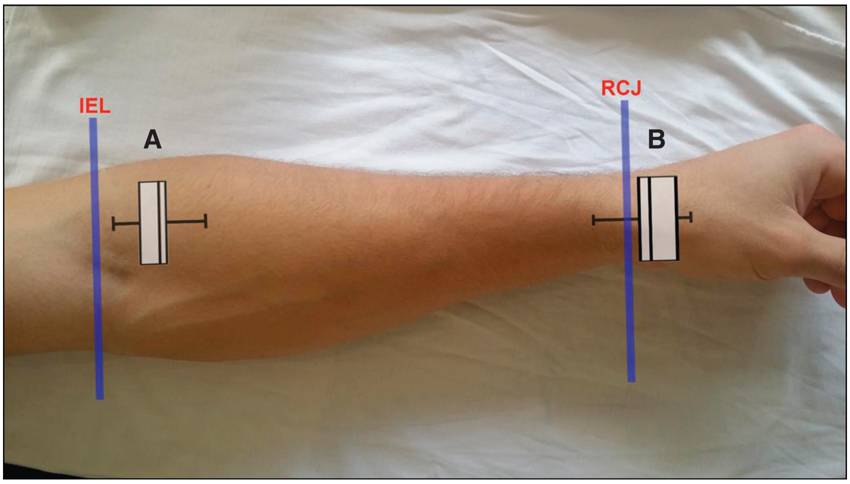

FIGURE 1. The landmarks utilized to relate ultrasonography of the LCNF and its distal cutaneous sensory distribution. A, Distribution of LCNF blockade position (box-and-whisker plot). B, Distribution of LCNF distal cutaneous innervation.

under ultrasound guidance before cutaneous mapping at 15 minutes. The MN was injected medial to lateral (SAX-IP) and the SRN lateral to medial (SAX-IP) because it was usually positioned lateral to the radial artery. Occasionally, the SRN was medially adjacent to the radial artery requiring a medial approach (Fig. 2B). In some patients, a broad linear array probe could identify MN and SRN in close proximity, enabling both nerves to be targeted using a single-injection medial-to-lateral SAX-IP approach.

RESULTS

Individual nerves were identified in all patients, and numbness was present in all following injection. Nerve mapping for each nerve is shown in Figures 3A and 2A and D.

Sonography

The LCNF was visualized without difficulty at the antecubital fossa (15/15) and in 14 of 15 cases was immediately posterior to the cephalic vein (Fig. 3B). The nerve was identified 9.1 (SD, 1.6)mm distal to the IEL (Fig. 1A), and with distal mapping, the nerve bifurcated in 9 cases, on average 18.0 (SD, 2.6)mm distal to the IEL (Fig. 3E). The MN was identified midforearm in the interfascial space between flexor digitorum superficialis and flexor digitorum profundus (Fig. 2E), and at this level, the SRN was usually positioned lateral to the radial artery and anterolateral to the radius (Fig. 2B).

Cutaneous Mapping

The LCNF innervation extended along the lateral aspect of the forearm to the distal thumb and in 93% (14/15) of cases extended 8.3 (SD, 7.8)mm distal to RCJ (Figs. 1B and 3A, E). Both the MN and SRN had extensive coverage of the thumb base (Fig. 2, A and E). In all cases, mapping for both fine touch and cold sensation were consistent.

DISCUSSION

This study has demonstrated the LCNF to be consistently identified and blocked at the antecubital fossa and importantly has shown the LCNF to supply sensory fibers to the thumb. Because the incision site for TSP is the thumb base, then this nerve must be considered for neural blockade when performing this surgery. A key aspect of ultrasound-guided regional anesthesia is sonographic pattern recognition, and this was the approach used for neurolocation in this study.[9] The LCNF was initially identified at the lateral margin of the biceps brachii tendon, medial to the cephalic vein as it entered the forearm. We demonstrated the nerve to then become posterior to the vein as it traveled distally, with individual variation in both position and branching pattern observed. This relationship has similarly been reported in a cadaver study of 96 individual nerves.[10] The site of LCNF bifurcation is important to identify, because injection of the nerve proximal to bifurcation will provide a more complete anesthesia of the thumb and lateral forearm.

The traditional anatomic approach divides the forearm and hand into discrete dermatomal patterns relating to innervation by MN, SRN, and UN. The base of thumb is classically described as being supplied solely by the MN and SRN.[11,12] However, these distributions should be viewed as approximations because the brachial plexus and terminal branches often exhibit a dynamic and variable pattern of innervation.[13–17] Variant innervation is reported to occur in up to 25% of all forearms, with cases of partial or complete replacement of SRN by the LCNF or anastomosis of the MN and UN (eg, Martin-Gruber anastomosis) being reported.[6,7,18–20] Such anatomical variations have important clinical implications for hand surgery.

Clinical judgement requires an understanding not only of innervation at the site of skin incision, but also of underlying structures. For thumb surgery, nerve supply to the distal radius and carpal bones is an important consideration in formulating neural blockade. In TSP surgery, multiple nerves including MN, SRN, and LCNF are all in close proximity to the RCJ. Accordingly, with reference to Hilton's law, a nerve traveling in close proximity to a joint will usually innervate it.[21] While the MN, SRN, and LCNF all contribute to thumb sensation, it is possible that other nerves, such as the anterior or posterior interosseous nerve, may potentially supply the joint capsule or carpal bones.[11] Both the anterior and posterior interosseous nerves are considered to supply primarily motor fibers, originating proximally from the MN and RN, respectively. Sensory innervation by either of these terminal nerves may explain the pain experienced by some patients during block. Such distinction between dermatomal and osteotomal innervation of the wrist joint is a further aspect of TSP surgery when considering regional anesthesia.

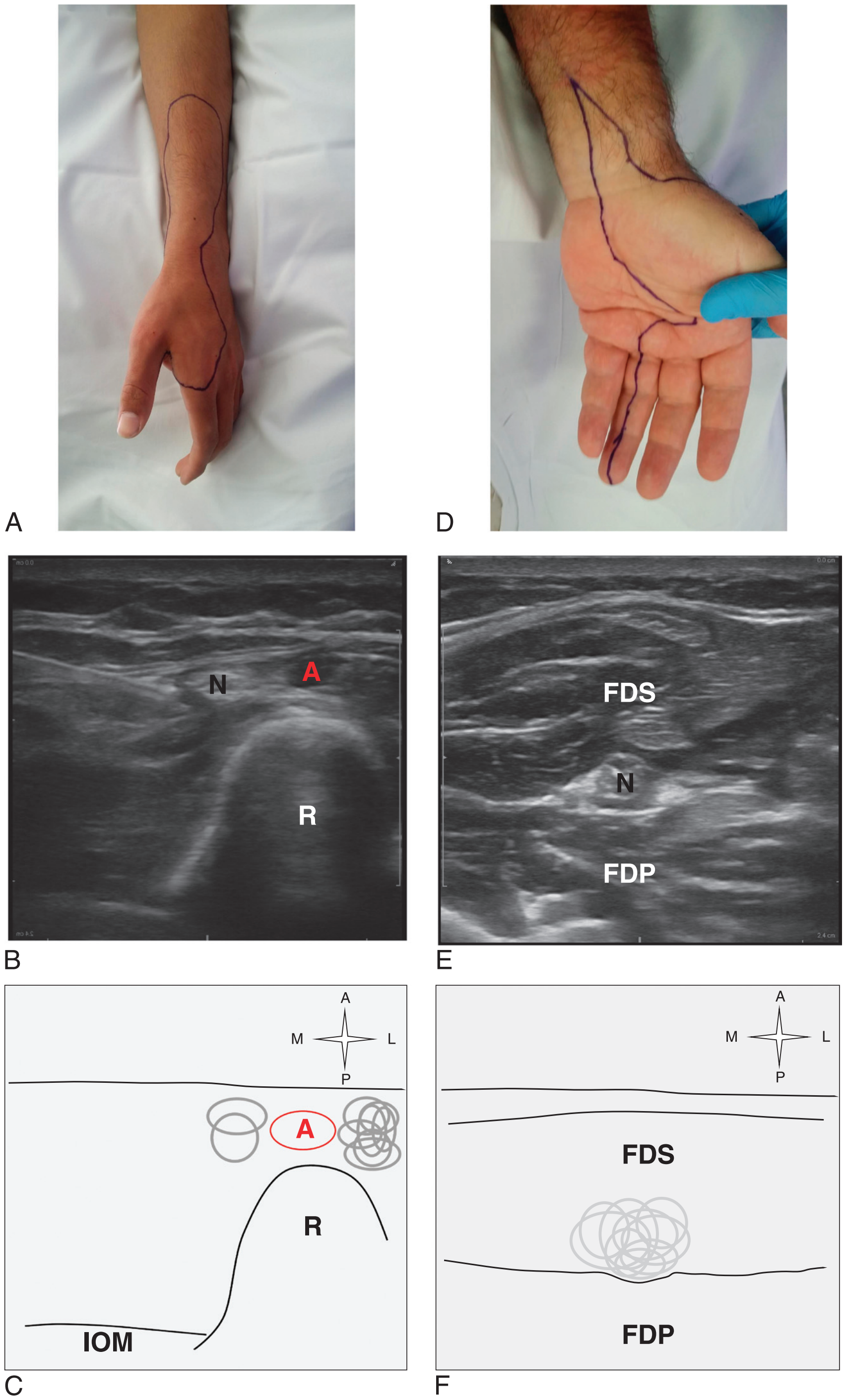

FIGURE 2. The MN and SRN. A, Sensory mapping of the SRN. B, Ultrasonography of the SRN (medial to radial artery variation. N indicates SRN; A, radial artery; R, radius. C, Composite diagram of SRN position in relation to the radial artery and the radius. A indicates radial artery; R, radius; IM, interosseous membrane; ○, SRN (n = 10). D, Sensory mapping of the MN. E, Ultrasonography of the MN at the midforearm. N indicates median nerve; FDS, flexor digitorum superficialis; FDP, flexor digitorum profundus. F, Composite diagram of MN position at the midforearm. FDS indicates flexor digitorum superficialis; FDP, flexor digitorum profundus; ○, MN (n = 10).

Although this study demonstrated consistent thumb numbness with LCNF anesthesia, our technique of tactile mapping using a cold metal probe onto the skin has some limitation. In chronic pain studies, for example, calibrated instruments are sometimes used to accurately map areas of cutaneous sensation or allodynia following treatment. These provide an accurate stimulus intensity that can be consistently repeated and quantified with respect to force and heat intensity. Despite this

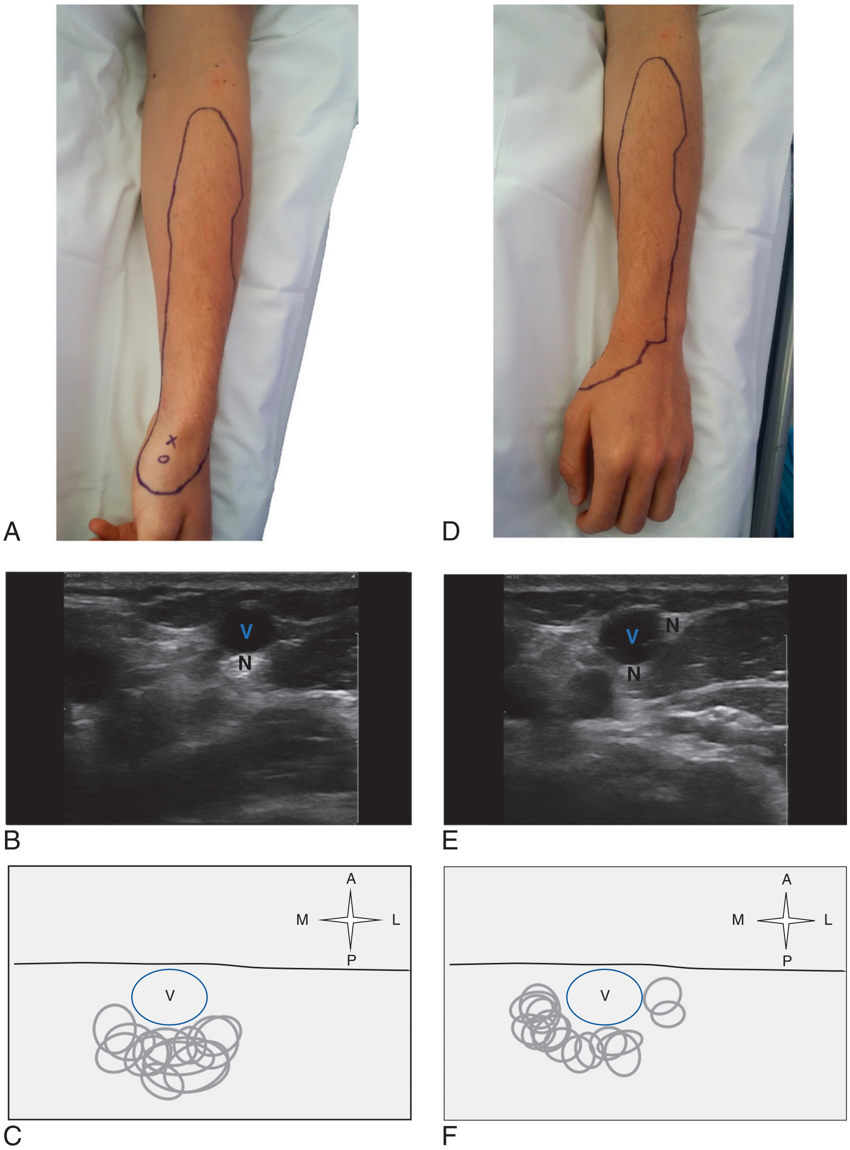

FIGURE 3. The LCNF. A, Sensory mapping of the LCNF. X indicates radiocarpal Joint; O, 1st carpometacarpal joint. B, Ultrasonography of the LCNF at the blockade site (distal to IEL). N indicates LCNF; V: cephalic vein. C, Composite diagram of LCNF position in relation to the cephalic vein. (v) Indicates cephalic vein; ◯, LCNF; A, anterior; P, posterior, L, lateral; M, medial. D, Sensory mapping of the LCNF demonstrating dorsal extension. E, Ultrasonography of the LCNF bifurcation. F, Composite diagram of LCNF position at bifurcation in relation to the cephalic vein. (v) Indicates cephalic vein; ◯, LCNF (n = 15).

limitation, the area of numbness as assessed by our technique was felt to be adequate in discerning cutaneous loss of sensation.

Nerve block in the forearm can provide surgical anesthesia for many types of hand and wrist surgery. In experienced hands, nerves are easily identified, and multiple injections are well tolerated by patients requiring minimal sedation. This targeted approach, involving anesthesia of 1 or more of the MN, SRN, UN, and LCNF, is appropriately termed a "forearm block." In ambulatory surgery, the use of brachial plexus anesthesia with a short-acting local anesthetic enables return of limb sensation in the immediate postoperative period, which some clinicians feel is necessary before discharge. Alternatively, the forearm block also provides complete surgical anesthesia for many hand procedures, with rapid recovery and early discharge. This peripheral block may also provide prolonged postoperative analgesia with long-acting local anesthetic injection, without upper-arm anesthesia and heaviness. Upper-limb torniquet pressure is generally well tolerated in sedated patients, although this is limited by the duration of surgery. With appropriate discussion of the surgical plan and expected duration of surgery, forearm anesthesia can be used in many hand procedures.

In summary, ultrasound examination of the antecubital fossa identifies the LCNF in close relation to the biceps brachii tendon and cephalic vein. Anesthesia of this nerve produces cutaneous numbness of the lateral forearm extending to the RCJ and thumb. For TSP surgery, complete surgical anesthesia requires neural blockade of MN and SRN, as well as the LCNF, together constituting the "forearm block."

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