The Hyperthermic Effect of a Distal Volar Forearm Nerve Block: A Possible Treatment of Acute Digital Frostbite Injuries?

Geethan J. Chandran, M.D.
Bryan Chung, M.D., Ph.D.
Janice Lalonde, R.N.
Donald H. Lalonde, M.D.
Halifax, Nova Scotia, and Saint John, New Brunswick, Canada

Background: The authors have observed that carpal tunnel surgery nerve blocks consisting of subfascial distal volar forearm injection of 10 cc of 1% lidocaine with epinephrine result in fingers that appear hyperemic, warm, and numb in both median and ulnar nerve distributions. The purposes of this study were to (1) determine whether forearm nerve blocks in patients undergoing carpal tunnel releases result in an objective increase in finger temperature, and (2) document the location and duration of finger anesthesia.

Methods: Thirty-nine patients undergoing unilateral carpal tunnel release were studied prospectively. An infrared thermometer was used to measure the temperature in the fingers of operative and nonoperative hands before and after injection of local anesthetic. The distal volar forearm block was performed using 10 cc of 1% lidocaine with 1:100,000 epinephrine deep to the forearm fascia between the median and ulnar nerves 1 cm proximal to the wrist crease. Before and after carpal tunnel release, bilateral finger temperatures were measured at hourly intervals. Statistical analysis included a one-sample test of proportions.

Results: The finger temperature of the operative hand was significantly warmer than the unoperated hand over the first 2 hours after the nerve block. Seventy-four percent of patients had a statistically significant increase in temperature. On average, the nerve block lasted 6.27 hours in the median nerve distribution and 5.78 hours in the ulnar nerve distribution.

Conclusions: Forearm nerve blocks produce a chemical sympathectomy that provides a significant increase in skin temperature as a result of vasodilatation in most patients. They also provide prolonged finger numbness. This could be of clinical benefit in patients with acute finger frostbite injuries. (Plast. Reconstr. Surg. 126: 946, 2010.)

Seventy percent of Canadian carpal tunnel operations are now performed with direct injection of lidocaine and epinephrine into the operative area without tourniquet and without sedation (wide awake).

While performing such procedures under local anesthetic, we have often observed that the fingers of the operated hand became red, warm, and numb. The fingers stayed warm for a long time, in addition to having anesthesia, even before surgery.

The resultant effect of regional hyperthermia from regional anesthesia may have beneficial effects in the treatment of frostbite injury of the hand by increasing blood flow to the fingers in the critical postinjury period. Certainly, rewarming of the frostbitten hand and pain control are important principles of managing patients with environmental cold injury of the hand and upper limb.

The purpose of this study was to determine

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whether the distal volar forearm nerve block (wrist block) in patients undergoing carpal tunnel release results in an objective increase in temperature of the affected digits. We wanted to document the duration of finger anesthesia after the distal volar forearm nerve block in the median and ulnar nerve distributions.

**PATIENTS AND METHODS**

Research ethics approval was obtained from the Atlantic Regional Health Corporation Research Ethics Review Committee, and informed written consent was obtained for all patients. A sample size estimation was carried out preceding the commencement of this study. The sample size needed to show a 1°C difference between hands was estimated to be 20.

Thirty-nine adult patients older than 18 years undergoing unilateral carpal tunnel release were studied. In a minor operating room under ambient room temperature, an infrared digital cutaneous thermometer (King Medical Ltd., King City, Ontario, Canada) was used to measure the temperature of both the operative and nonoperative hands at the index finger radial dorsal base before the injection of the local anesthetic (Fig. 1). The nonoperative index finger temperature was used as an internal control. The median/ulnar nerve block was performed using a distal volar forearm technique. Ten milliliters of 1% lidocaine with 1:100,000 epinephrine was injected under the superficial forearm fascia just proximal to the wrist crease ulnar to the palmaris longus tendon between the median and ulnar nerves (Fig. 2). An additional 5 to 7 cc was injected subcutaneously under the planned skin incision. A standard open carpal tunnel release was then performed. The incision was sutured with buried 5-0 Monocryl (Ethicon, Inc., Somerville, N.J.) interrupted sutures, and the hand was put in a nonsplinted soft light dressing. Temperatures of both index fingers were measured at hourly intervals by the patient starting at 1 hour after the median nerve block. These measurements were carried out for 12 hours. The patients were also instructed to record the time at which sensation returned to each finger.

The temperature differences between the operative and nonoperative index fingers were compared. The maximum peak temperature of the operative hand was determined and the difference from the nonoperative hand was determined. A one-sample test of proportions was carried out to determine the difference between the two hands. Statistical analysis was carried out using the Microsoft Excel program (Microsoft Corp., Redmond, Wash.) and the Stata 11 statistical program (StataCorp, College Station, Texas).

**RESULTS**

The average age of the study patients was 51 years. Seventy-nine percent were women. Of all the carpal tunnel releases, 53.8 percent were performed on the right side of the patient. The majority of the patients, 62.1 percent, had clinical evidence of carpal tunnel syndrome on the opposite hand. Electromyographic and nerve conduction studies showed that 67.8 percent of the patients had evidence of carpal tunnel syndrome on the opposite hand. Twenty-five percent of subjects were smokers.

The maximum temperature difference between the operated and nonoperated index fingers was calculated. Seventy-four percent of the patients studied had a peak temperature greater than 1°C in this study. A one-sample test of proportions yielded a statistically significant result ($z = 3.4; p = 0.002; 95$ percent confidence interval, 0.61 to 0.88) (Fig. 3).
Of the 29 patients who had a temperature increase of at least 1°C, the median duration was 2 hours (interquartile range, 1 to 5 hours).

Using 1% lidocaine with 1:100,000 epinephrine for the forearm nerve block technique, the average time for the nerve block to wear off was 6.36 ± 1.72 hours in the index finger and 5.77 ± 1.94 hours in the small finger (Fig. 4). The index and small fingers were considered representative of the sensory innervation of the median and ulnar nerves, respectively.

**DISCUSSION**

Ten milliliters of 1% lidocaine with 1:100,000 epinephrine in between the median and ulnar nerves in the subfascial distal volar forearm space (wrist block) is a commonly used method of regional anesthesia in carpal tunnel surgery.\(^1\) This study showed that this nerve block also creates finger hyperemia, which increases the temperature in the anesthetized fingers by more than 1°C in 74 percent of the patients (see Video, Supplemental Digital Content 1, which demonstrates hyperemia in a patient with a distal volar forearm nerve block, [http://links.lww.com/PRS/A197](http://links.lww.com/PRS/A197)). Temperature elevation had a median duration of 2 hours. This study also showed that this simple technique generates finger numbness that lasts for approximately 6 hours in the median and ulnar nerve distributions. Digital nerve blocks with lidocaine and epinephrine have been shown to give approximately 10 hours of anesthesia.\(^7\) We hypothesize that making the fingers numb, warm, and hyperemic with this nerve block may be a good treatment for acute frostbite of the fingers, where fingers can be cold, white, and painful.

The rise in temperature shown in this study is likely a result of digital vasodilatation and local increase in blood flow as demonstrated by Herrmanns et al.\(^8\) Rakower et al.\(^9\) mapped out the pattern of digital ischemia in frostbite injury using digital plethysmography and Doppler ultrasonography. In 30 patients studied, the normal hyperdynamic digital circulation of rewarming techniques was blunted in patients at risk for digital necrosis. Intraarterial reserpine, a sympathetic antagonist, seemed to improve blood flow to the digits at risk. In their study, there was only one digital amputation.
Cutaneous temperature increase has been noted after brachial plexus blockade for regional anesthesia.\(^{10,11}\) This effect was particularly evident in the most distal part of the extremity. It has been shown that digital sympathectomy has increased blood flow to digits and skin temperature in frostbite patients. This sympathectomy has been either chemical\(^{9}\) (with intraarterial reserpine) or surgical.\(^{12}\) Brachial plexus regional anesthesia has been shown to increase the skin temperature in the distal aspect of the limb by a chemical sympathectomy.\(^{8,13}\)

In the hand, the cutaneous temperature control is modulated by the sympathetic nervous system.\(^{10}\) Blockade of the regional sympathetic nervous system and the activity of a local vasodilator system results in the regional hyperthermia that can be measured by skin temperature. Flatt reported digital artery sympathectomy for three frostbite patients.\(^{12}\) The result was a rise in skin temperature by 1.5° to 2.5°F (0.8° to 1.3°C) and long-term pain relief.\(^{12}\) Bouwman\(^{14}\) published a study of 66 patients who had sympathectomies an average of 3 days after the frostbite injury. There was no reduction in tissue loss after surgical sympathectomy, but most of the tissue damage would likely have occurred by 3 days after injury.

Current modalities of frostbite treatment include rapid rewarming in 40°C water baths, analgesia, tetanus toxoid, dressings, splinting, and elevation.\(^{2}\) It has been shown that technetium-99 triple-phase bone scanning can reliably predict areas of bone hypoperfusion and aid in determining whether or not amputation will likely be required.\(^{15}\) These patients at risk may benefit from intraarterial thrombolytic therapy. Hands treated with early thrombolysis have been shown to sustain reduced tissue loss and amputation rates.\(^{15-17}\)

This study used patients with internal controls of the nonoperative hand to minimize between-subject bias. Limitations of this study include the fact that it used patients with carpal tunnel syndrome in the study group. These patients could have inherent changes to the physiologic blood flow regulations to the digit caused by the nerve compression of the carpal tunnel itself. It is also possible that the carpal tunnel surgery itself may have helped to cause hyperemia by releasing the compression on the median nerve. However, in the operated hands, the temperature increase started even before surgery and then decreased back to the temperature of the nonoperated hand.
hands at the same time that the effects of the local anesthetic numbness effect wore off.

Another theoretical limitation of this study is that the use of epinephrine in the anesthetic block might itself cause vasoconstriction in the fingers. Our extensive experience with epinephrine use in the hand has consistently shown that epinephrine in the wrist and hand is very unlikely to vasoconstrict and blanch fingers. It has been our anecdotal observation over several years of routine carpal tunnel surgery under local anesthetic with epinephrine that epinephrine causes blanching in only the part of the hand that is injected, and not in the fingers. In fact, fingers often appear red, hyperemic, and hot despite the epinephrine in the wrist. However, this was not one of our formally measured outcomes and is an anecdotal observation.

There is also a theoretical possibility that lidocaine without epinephrine may have even had a more profound vasodilatation effect in the fingers. In that case, an even more profound warming of the fingers may have been measured. Further study on the potential nonanalgesic therapeutic uses of lidocaine with or without epinephrine would be supported by our data.

The patients measured their own digital temperatures and thus slight differences in technique and compliance may have introduced some variability in the results. Another limitation is that this study was conducted in patients with carpal tunnel syndrome, not frostbite injuries. We feel that further study in patients with frostbite injuries is warranted.

CONCLUSIONS

Regional median/ulnar nerve block with the distal volar forearm injection (wrist block) is a simple procedure to perform. It generates a hyperemia that increases the temperature in anesthetized fingers for approximately 2 hours in 74 percent of patients. The finger numbness lasts approximately 6 hours. We hypothesize that this technique, in combination with standard therapies, may have a place in the acute treatment of frostbite injuries because of its hyperemic, hyperthermic, and analgesic effects.

REFERENCES