Feasibility of an Infraclavicular Block With a Reduced Volume of Lidocaine With Sonographic Guidance

NavParkash S. Sandhu, MD, Charanjeet S. Bahniwal, MD, Levon M. Capan, MD

Objective. A successful brachial plexus block requires a large volume of a local anesthetic. Sonography allows reliable deposition of the anesthetic around the cords of the brachial plexus, potentially lowering the anesthetic requirement. Methods. Fifteen sonographically guided infraclavicular blocks were performed in 14 patients with 2% carbonated lidocaine with epinephrine through a 17-gauge Tuohy needle. The amount of lidocaine injected at several points around each cord was based on satisfactory spread observed sonographically. A 19-gauge catheter was then placed with its tip between the posterior cord and axillary artery, and tip position was confirmed by observing the spread of 1 to 2 mL of injected air. Lidocaine was injected through the catheter if necessary to prolong the blocks.

Results. Surgery was performed in all patients without general anesthesia, rescue blocks, or infiltration. A hero-in user was given an additional 50 µg of fentanyl before the block. One patient required 5 mL of lidocaine through the catheter for an incomplete radial nerve block 5 minutes after initial injection. Seven patients received additional midazolam (mean, 2.5 mg) for alleviation of anxiety despite excellent blocks. The mean ± SD volume of lidocaine for the initial block was 16.1 ± 1.9 mL (4.2 ± 0.9 mg/kg). In 4 patients, additional lidocaine 1 hour after an initial successful block increased the total volume to 19.5 ± 7.1 mL (5 ± 1.9 mg/kg). The mean times to perform the block, onset of the block, and achieving surgical anesthesia and the duration of surgery were 10.8 ± 3.3, 2 ± 1.3, 5.9 ± 2.6, and 92.7 ± 54.4 minutes, respectively. Conclusions. A successful infraclavicular block in adults with 14 mL of lidocaine is feasible with the use of sonography. The reduced volume does not seem to affect the onset but shortens the duration of the block. Key words: brachial plexus; lidocaine; local anesthetic; regional anesthesia; sonography.

Abbreviations
LES, lidocaine, epinephrine, and sodium bicarbonate

A brachial plexus block is usually performed either by eliciting paresthesias or by electrical stimulation of the motor nerves. In the infraclavicular approach, 1 of the cords or branches of the plexus is electrically stimulated by a block needle to induce twitches in the muscles supplied by that nerve, and then a large volume of a local anesthetic is injected, with the expectation that it will spread to the other 2 cords. Lidocaine has been used in dosages varying from 7 to 18 mg/kg body weight in volumes of 30 to 60 mL. The injected local anesthetic preferentially spreads to areas of low resistance and may not necessarily reach all the nerves of the brachial plexus in a sufficient quantity to produce effective blockade. This may be the reason for the relatively high failure rate (14%) of infraclavicular blocks.
With a recently reported technique using sono-
graphic imaging to identify individual nerve
cords, to guide the block needle, and to visualize
the spread of the anesthetic around the nerves,
we achieved a high success rate using 30 to 40 mL
of 2% lidocaine. Considering that the local anes-
thetic solution is deposited in close proximity to
the nerves, it seems reasonable to expect a suc-
cessful block with even lower volumes of the
local anesthetic. This study was performed to
determine the smallest possible volume of lido-
caine with which a successful brachial plexus
block would be achieved. The end point of injec-
tion would be determined by successful distribu-
tion of the local anesthetic around each cord
shown by imaging.

Materials and Methods

After Institutional Review Board approval, 15
infraclavicular brachial plexus blocks were per-
formed in 14 consecutive consenting patients
undergoing upper extremity surgery. All patients
were given midazolam (2 mg) and fentanyl (50
µg) before administration of the block. The del-
topectoral area was scanned with a 2.5-MHz
ultrasound probe (HP 77020A; Hewlett-Packard
Company, Andover, MA). A transverse image of
the axillary vessels and the 3 nerve cords poste-
rior to the pectoralis minor muscle was obtained
(Figure 1), and the position of the probe was
marked as described previously. The method
was similar to that in the previous study, with
the only difference being that 3 to 4 mL of lido-
caine was further subdivided into small boluses
injected around each cord. The deltopectoral
area was prepared with povidone-iodine and
draped in a sterile manner. The ultrasound probe
covered with a sterile sheath (Microtek Medical
Inc, Columbus MS) was placed on the previously
marked area to image the cords of the brachial
plexus. A 17-gauge Tuohy needle was introduced
through a previously anesthetized skin wheal 1 to
2 cm cephalad to the probe and advanced under
real-time imaging to the medial cord between the
axillary artery and vein. After careful aspiration
to rule out intravascular placement of the needle, 3
to 5 mL of 2% lidocaine with epinephrine
(1:200,000) and sodium bicarbonate (0.9 mEq/10
mL of lidocaine) (LES) was injected on all sides of
the cord by manipulating the needle tip (Figure 2).
The dose of LES was based on satisfactory spread
around the cord as observed sonographically. The
needle tip was then withdrawn into the pectoralis
minor muscle and redirected between the superi-
or aspect of the axillary artery and the lateral cord.
Another 3 to 5 mL of LES was injected around all
sides of the lateral cord after intravascular place-
ment was ruled out. The Tuohy needle tip was
then advanced until it was just posterior to the
axillary artery. The angle between the needle and
skin was reduced, making the shaft more horizon-
tal, and the needle was advanced until its tip was
between the artery and the posterior cord. A local
anesthetic solution, 3 to 5 mL, was injected all
around the posterior cord. A 19-gauge epidural
catheter was then advanced 4 to 5 cm beyond the
tip of the Tuohy needle to lie between the poste-
rior cord and the axillary artery. The needle was
withdrawn, and the position of the catheter tip
(Figure 3) was confirmed by injecting 1 to 2 mL of
air while observing it with real-time sonography;
the air appears as a hyperechoic area in the image
(Figure 4). If its position was unsatisfactory, the
catheter was withdrawn until its tip lay posterior
to the axillary artery; the catheter location was
tested again with 1 to 2 mL of air.

The sensory block was evaluated by pinching
the skin in the areas innervated by individual
nerves: the thenar eminence, the hypothenar
region, the dorsum of the hand, the lateral aspect
of the forearm, and the area overlying the inser-
tion of the deltoid muscle, for median, ulnar,
radial, musculocutaneous, and axillary nerves,
respectively. When a decreased response com-
pared with the contralateral side was noted, a 22-
gauge needle was used to test the sensory block.
in the same areas. A motor block was evaluated by asking the patient to flex the forearm (musculocutaneous nerve), extend the flexed forearm and wrist (radial nerve), abduct the shoulder (axillary nerve), sustain elevation of the arm (axillary nerve), and adduct the arm (medial and lateral pectoral nerves and thoracodorsal nerve). Onset of the block was defined as the time from the last injection to onset of diminished sensation and motor weakness compared with the contralateral side. Anesthesia was considered to be at the surgical level when the patient could not feel pain from the needle in tested areas of the upper extremity and was unable to move the shoulder, elbow, wrist, or a combination thereof. The time to perform the block was defined from initial imaging until placement of the catheter. If the block was not satisfactory, a 5-mL bolus of LES was given through the catheter, and the block was reassessed over the next 5 minutes. The bolus was repeated in increments of 5 mL at 5-minute intervals if the block was still not effective. A further bolus of 5 to 10 mL was administered during surgery if a successful initial block began to fade. The times to perform the block, onset of block, and surgical anesthesia, the dose of the local anesthetic needed for the initial block, and supplements, if any, were recorded. All the blocks were performed by 10 residents at different levels of training, and the ultrasound probe was held by an attending anesthesiologist.

Results

The demographics are shown in Table 1. All patients underwent surgery without the need for general anesthesia, propofol infusion, additional rescue blocks, or local infiltration by the surgeons. All patients received 2 mg of midazolam and 50 µg of fentanyl, except 1 patient with a history of heroin use who was given an additional 50 µg of fentanyl before administration of the nerve block. Seven patients needed additional midazolam (mean dose, 2.5 mg) during surgery for alleviation of anxiety despite excellent sensory and motor blocks. One elderly patient was given 0.6 mg of droperidol in addition to midazolam. The mean ± SD body weight of patients was 71.3 ± 13.7 kg. The mean volume of LES for the initial block was 16.1 ± 1.9 mL, and the total volume of lidocaine was 19.5 ± 7.1 mL. The mean initial and total doses of lidocaine were 4.2 ± 0.9 and 5 ± 1.9 mg/kg, respectively.

The mean times for performing the block, onset of block, and onset of surgical anesthesia were 10.8 ± 3.3, 2 ± 1.3, and 5.9 ± 2.6 minutes. The mean duration of surgery and tourniquet time were 92.7 ± 54.4 and 66.6 ± 39.7 minutes. The average dose of lidocaine was 4.2 mg/kg. One patient had a patchy block in the distribution of the radial nerve at 5 minutes and needed another 5 mL of LES through the catheter to produce a successful block, increasing the initial volume to 20 mL. This patient also required 2 more boluses of 10 mL each at intervals of 60 minutes during surgery, which lasted 195 minutes. Another patient...
patient required a bolus of 10 mL after the first hour of surgery and 5 mL during the second hour for the duration of surgery, which lasted 150 minutes. A third patient required a bolus of 10 mL at 1.5 hours after the initial dose. A fourth patient needed a bolus of 5 mL of LES 1 hour after the start of surgery. One patient had an open reduction of a fractured ulna, and a second block was performed 4 days later for reduction of a dislocated elbow (Table 1, patients 7 and 11). There were no vascular punctures. All patients were followed by a visit or a telephone call on the first postoperative day. They were seen by their surgeons in clinics for follow-up, and no complications of the blocks were communicated to us.

Discussion

Intuitively, minimizing the quantity of a local anesthetic to just above the lowest effective dose should reduce the risk of systemic toxicity. This may be especially important in patients with renal and hepatic insufficiency and autonomic neuropathy, in elderly and debilitated patients, and when simultaneous anesthesia of more than 1 region of the body is required. Our results suggest that at least 14 mL of lidocaine is required to achieve a satisfactory brachial plexus block. To our knowledge, no other study has described the use of such a small dose for an infraclavicular brachial plexus block. Fanelli et al,4 using a multiple injection technique with nerve stimulator, were able to reduce the dose of lidocaine (2%) and epinephrine (1:200,000) solution to 21 ± 4 mL for axillary and 19 ± 5 mL for interscalene blocks; however, their failure rate was 7% and 6%, respectively, in a multicentric study (n = 45 cases). Similarly, Lavoie and colleagues5 observed that the dose of the anesthetic can be reduced by multiple injections for an axillary block. Our study had a limitation of not having a control group with a nerve stimulation technique. To our knowledge, there is no study in the literature with low volumes of lidocaine used for an infraclavicular block, and it is a difficult comparison between a group with variable volumes determined on the basis of observing spread of a local anesthetic around a nerve and another group with a fixed volume administered by a nerve stimulation technique. There are studies with low volumes in axillary and interscalene blocks, which are not comparable regions to the infraclavicular area in terms of surrounding muscles and fascial layers. The use of 30- to 40-mL volumes with a nerve stimulator and success of 40% to 86%2,6 compared with our 16.1-mL volume and 100% success in 15 patients clearly proves the advantages of the sonographically guided technique.

Lavoie et al5 suggested that deposition of a local anesthetic around individual nerves of the brachial plexus may improve the success rate from 50% to 94% during an axillary block. They used a nerve stimulator to locate individual nerves. We think that moving the needle blindly trying to locate other nerves after injecting the local anesthetic increases the potential of nerve injury when some of the nerves may be partially or totally anesthetized. Our approach also uses multiple injections but without blind manipulation.
tion of the needle or nerve stimulation. We use real-time sonography to locate and guide the needle tip to individual nerves and to observe local anesthetic spread around them. The needle tip was manipulated dynamically to optimize the delivery of the local anesthetic. The needle position was changed if the spread was unsatisfactory; this is not possible with the nerve stimulation technique. Sonographic guidance also allowed us to direct the block needle to different sites around each individual cord and thus provided the ability to split 3 to 5 mL of the anesthetic solution into even smaller boluses around each nerve. All manipulations of the needle were performed through a single skin puncture.

The onset time and time to surgical anesthesia in our patients were 2.0 ± 1.3 and 5.9 ± 2.6 minutes, respectively. These times are comparable with those obtained in a previous study that used sonographic guidance with a lidocaine dose of 9.3 mg/kg.

Ootaki et al.7 used lidocaine 7.3 at mg/kg and first tested their blocks at 30 minutes after injection. The earliest onset and the reason for choosing 30 minutes for first testing their blocks are not clear, but we suspect that their blocks had delayed onset.7 The possible reason for this delayed onset could be periarterial deposition of lidocaine, rather than identification and blocking of individual cords. Kapral et al.,8 also using a sonographically guided single injection of bupivacaine, reported onset times of 40 minutes for supraclavicular and axillary brachial plexus blocks. Using a nerve stimulator and single-injection technique, Borgeat et al.2 obtained

Table 1. Patient Information

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age, y</th>
<th>Sex</th>
<th>Weight, kg</th>
<th>Surgical Procedure</th>
<th>Surgical Time, min</th>
<th>Volume, mL</th>
<th>Initial Dose, mg/kg</th>
<th>Bolus Volume, mL</th>
<th>Total Volume of Lidocaine, mL</th>
<th>Total Lidocaine, mg/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>65</td>
<td>M</td>
<td>80.7</td>
<td>Transposition of ulnar nerve</td>
<td>125</td>
<td>14.3</td>
<td>3.1</td>
<td>10</td>
<td>24.3</td>
<td>5.4</td>
</tr>
<tr>
<td>2</td>
<td>38</td>
<td>M</td>
<td>78</td>
<td>Wound closure 3 digits</td>
<td>35</td>
<td>16</td>
<td>3.6</td>
<td>NA</td>
<td>16</td>
<td>3.6</td>
</tr>
<tr>
<td>3</td>
<td>48</td>
<td>M</td>
<td>71.7</td>
<td>Ulnar nerve repair</td>
<td>89</td>
<td>15</td>
<td>3.7</td>
<td>NA</td>
<td>15</td>
<td>3.7</td>
</tr>
<tr>
<td>4</td>
<td>18</td>
<td>M</td>
<td>77</td>
<td>Plating of radius Fx</td>
<td>75</td>
<td>15</td>
<td>3.5</td>
<td>NA</td>
<td>15</td>
<td>3.5</td>
</tr>
<tr>
<td>5</td>
<td>22</td>
<td>M</td>
<td>64</td>
<td>Excision of volar cyst</td>
<td>27</td>
<td>16.5</td>
<td>4.6</td>
<td>NA</td>
<td>16.5</td>
<td>4.6</td>
</tr>
<tr>
<td>6</td>
<td>62</td>
<td>M</td>
<td>86</td>
<td>ORIF of radius Fx</td>
<td>105</td>
<td>18.8</td>
<td>3.9</td>
<td>NA</td>
<td>18.8</td>
<td>3.9</td>
</tr>
<tr>
<td>7</td>
<td>65</td>
<td>M</td>
<td>91</td>
<td>ORIF ulnar Fx</td>
<td>135</td>
<td>17.8</td>
<td>3.5</td>
<td>NA</td>
<td>17.8</td>
<td>3.5</td>
</tr>
<tr>
<td>8</td>
<td>45</td>
<td>M</td>
<td>72</td>
<td>Repair tendons and median nerve</td>
<td>145</td>
<td>16</td>
<td>4</td>
<td>NA</td>
<td>16</td>
<td>4</td>
</tr>
<tr>
<td>9</td>
<td>50</td>
<td>F</td>
<td>49.9</td>
<td>Arteriovenous fistula</td>
<td>100</td>
<td>15</td>
<td>5.4</td>
<td>5</td>
<td>20</td>
<td>7.2</td>
</tr>
<tr>
<td>10</td>
<td>60</td>
<td>F</td>
<td>76.2</td>
<td>External fixator radius Fx</td>
<td>195</td>
<td>21</td>
<td>4.8</td>
<td>20</td>
<td>41</td>
<td>9.6</td>
</tr>
<tr>
<td>11</td>
<td>65</td>
<td>M</td>
<td>91</td>
<td>Reduction of dislocation, mobilization of elbow ORIF ulnar Fx, pinning of Fx femur</td>
<td>10</td>
<td>15</td>
<td>2.9</td>
<td>NA</td>
<td>15</td>
<td>2.9</td>
</tr>
<tr>
<td>12</td>
<td>89</td>
<td>F</td>
<td>45.3</td>
<td>ORIF ulnar Fx</td>
<td>120</td>
<td>15</td>
<td>5.9</td>
<td>NA</td>
<td>15</td>
<td>5.9</td>
</tr>
<tr>
<td>13</td>
<td>20</td>
<td>M</td>
<td>60</td>
<td>Removal of hardware elbow</td>
<td>60</td>
<td>16.5</td>
<td>4.9</td>
<td>NA</td>
<td>16.5</td>
<td>4.9</td>
</tr>
<tr>
<td>14</td>
<td>25</td>
<td>M</td>
<td>65.8</td>
<td>Arthrodesis 2nd digit, completion amputation 5, repair 3rd digit</td>
<td>150</td>
<td>14</td>
<td>3.8</td>
<td>15</td>
<td>29</td>
<td>7.9</td>
</tr>
<tr>
<td>15</td>
<td>30</td>
<td>M</td>
<td>61</td>
<td>Release contracture thumb</td>
<td>20</td>
<td>16</td>
<td>4.7</td>
<td>NA</td>
<td>16</td>
<td>4.7</td>
</tr>
<tr>
<td>Mean</td>
<td>46.8</td>
<td></td>
<td>71.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>21.0</td>
<td></td>
<td>13.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

F indicates female; Fx, fracture; M, male; NA, not applicable; and ORIF, open reduction and internal fixation.
onset times of 22 ± 6 (SD) minutes with infraclavicular blocks, which are faster than those reported by Ootaki et al² and Kapral et al⁸ but longer than ours, although the use of different local anesthetics and doses makes comparison difficult.²³⁷⁸

Gaertner et al⁶ prospectively compared an infraclavicular block by single- and multi-stimulation techniques using a mixture of 2% lidocaine and 0.5% bupivacaine. They used a single 30-mL injection in 1 group and 10 mL of the local anesthetic for each of 3 cords after confirming the needle position with 0.5 mA or less of electric stimulation in a second group with 40% and 72% absolute success, respectively. Their success for a single injection was lower than previously reported by Borgeat et al²; perhaps the lower volume (30 versus 40 mL) may have accounted for the difference.

Conventional blocks have onset times varying from 15 to 30 minutes. From our results, it appears that onset of the block is related to the precise deposition of the local anesthetic in close proximity to each individual nerve of the brachial plexus rather than to the total dose or volume injected.

The reduction in lidocaine dosage, however, decreases the duration of the block and hence brings about the need for placing an indwelling catheter to administer additional boluses when surgery is prolonged. The short block duration may be advantageous because it may permit rapid recovery and discharge from the postanesthesia care unit. The sonographic technique provides the ability to repeat the block in the same location, an advantage over the nerve stimulator technique, in which the block can only be repeated at a distal site. Additional boluses were administered in 4 patients to prolong anesthesia for surgery that required more time than expected. These additional doses, combined with an initial supplement of a local anesthetic given to 1 patient before the start of surgery, raised the total mean dose of lidocaine to 5 mg/kg. None of the patients showed signs of toxicity, although we did not measure plasma levels.

At the time this study was conducted, we had only a 2.5-MHz transthoracic echocardiography probe in our department, which gives very grainy images of nerves (Figures 1–3). Later we acquired a sonography machine with a variable-frequency 4- to 7-MHz curvilinear C11 probe (SonoSite, Inc, Bothell, WA) for giving peripheral nerve blocks, which gives a better resolution; Figures 4–6 were obtained with a 7-MHz SonoSite probe.

References