Single Versus Triple Injection Ultrasound-Guided Infraclavicular Block: Confirmation of the Effectiveness of the Single Injection Technique

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BACKGROUND: The optimal site for local anesthetic placement during ultrasound-guided infraclavicular block remains controversial.
METHODS: Patients were randomized to receive lidocaine 2% 30 mL as a single injection posterior to the axillary artery ($n = 51$) or a triple injection ideally adjacent to each brachial plexus cord ($n = 49$). Pinprick sensory and motor block (3 = no block, 0 = complete block) were assessed to 20 minutes in the 4 distal nerve territories.
RESULTS: The single injection group was not significantly inferior (single versus triple injection median [interquartile range] 20-minute aggregate block score: 5 [2–9] vs 7 [3.5–11]) but also demonstrated superiority (2-tailed test, $P = 0.043$). The single injection technique was associated with a small reduction in procedural time.
CONCLUSIONS: The optimal site for local anesthetic placement during ultrasound-guided infraclavicular block is a single point injection posterior to the axillary artery. (Anesth Analg 2010;111:1325–7)

The optimal site for local anesthetic placement during ultrasound-guided infraclavicular block remains controversial. Early descriptions involved selective targeting of each brachial plexus cord[1,2]; however, subsequent experience has suggested that a high success rate can be achieved when local anesthetic is administered in a procedurally simpler, single point position, posterior/dorsal to the axillary artery.[3,4]

We hypothesized that a single infraclavicular injection posterior to the axillary artery would provide brachial plexus blockade as good as a triple injection, ideally targeting each brachial plexus cord. Our secondary end points included procedural time, procedural pain, and surgical anesthesia success.

METHODS

With IRB approval and written informed consent, adult ASA physical status I to III patients scheduled for elective wrist/hand surgery in the practices of 2 of the investigators (MJF and PW) were recruited. Previous exclusion criteria were applied.[5]

Block Technique and Randomization

One of 2 experienced operators (MJF or PW) placed all blocks. Midazolam 2 mg and alfentanil 0.5 mg were administered immediately before block placement. Randomization was by computer-generated random number in pre-prepared opaque envelopes.

All blocks were performed with 18-gauge Tuohy needles (BBraun, Bethlehem, PA), a high-resolution ultrasound machine (SonoSite M-Turbo; SonoSite, Bothell, WA) and 30 mL lidocaine 2% with epinephrine (1/200,000).

Single Injection Group

A 4- to 7-MHz curvilinear probe (SonoSite C11) was placed in the deltopectoral groove in the sagittal plane with a medial-to-lateral position dictated by where the best image of the middle third of the axillary artery was obtained.[3,4] After subcutaneous infiltration, the 18-gauge Tuohy needle was advanced using in-plane needle-probe alignment, with the bevel facing dorsally, to a position posterior to the axillary artery. This end point necessitated a distinct give as the septum posterolateral to the axillary artery was penetrated. At this point, all of the local anesthetic was deposited; however, some needle manipulation was permitted in a cephalocaudad direction but not extending beyond the cephalocaudad borders of the artery to promote a shallow "saucer-shaped" spread dorsal to the artery.

Triple Injection Group

The technique was similar to the single injection group with the following modifications.[2] Ideally, the operator's objective was to selectively surround each sonographically imaged brachial plexus cord with approximately 10 mL of local anesthetic; however, if a cord could not be imaged, local anesthetic placement was on an arbitrary basis according to an imaginary clock face in the following sequential order: posterior cord at 6 o'clock, lateral cord at 8 o'clock, and medial cord at 2 o'clock (in the triangular anterior space between axillary artery and vein). The needle bevel faced dorsally for each of the 3 positions; however, when manipulation was performed close to the artery, the bevel was directed away from the artery. After lidocaine placement, some patients had catheters placed for anticipated painful surgery.

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Accepted for publication July 1, 2010.

Funded by the principal investigator.

Disclosure: The authors report no conflicts of interest.

Reprints will not be available from the author.

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DOI: 10.1213/ANE.0b013e3181f1bbb6

Table 1. Patient and Surgical Characteristics

	Single injection (n = 51)	Triple injection (n = 49)
Sex (male/female)	27/24	22/27
Age (y)	58 (17)	53 (15)
Weight (kg)	76 (12)	83 (15)
Surgery		
Carpal tunnel release	16	9
Ganglion excision	6	10
Dupuytren release	9	5
Wrist arthroscopy	5	4
Other	15	21

Data are presented as mean (SD) or *n*.
There were no significant differences between groups.

Intraoperative Management

Most operations were conducted with patients awake, and a surgical tourniquet was used in all cases. Supplementary forearm peripheral nerve blockade was at the discretion of the operating anesthesiologist and was based on sensory blockade at 20 minutes, the intended area of surgery, and anticipated requirement for postoperative analgesia. The primary surgeon (MRB or SC), who was blinded to treatment group, determined the surgical site local anesthetic infiltration requirement, or in the case of clearly inadequate surgical anesthesia, deep sedation. Anxious patients were administered additional midazolam as required with the intention of remaining responsive to verbal commands throughout the procedure. Subjects refusing awake surgery were administered a propofol infusion with supplemental oxygen as necessary.

Data Collection

The anesthesia assistant recorded the block time, defined as the time from ultrasound probe placement on the skin until the needle exited the skin after local anesthetic administration. This time did not include the time required to infiltrate the skin, which was a separate ultrasound-guided procedure. A blinded observer immediately assessed pinprick sensory and motor block at 2, 10, and 20 minutes in the distribution of the median, radial, ulnar, and musculocutaneous nerves. Time zero was defined as the time at which the block needle exited the skin. Sensory block was graded on a 4-point scale (same sharpness = 3, reduced sharpness = 2, sensation present but not sharp = 1, or absent = 0) relative to pinprick sensation in the contralateral arm. Motor block was also graded on a 4-point scale (normal power = 3, reduced power = 2, flicker of movement only = 1, no movement = 0) relative to the contralateral arm. Surgical anesthesia success was defined as surgery without the requirement for surgical site infiltration or deep sedation (administered for intraoperative pain). Those patients who received deep propofol sedation simply because of refusal to undergo awake surgery per se were not classified as having failed surgical anesthesia.

Statistical Analysis

Categorical outcomes were compared with the χ^2 or Fisher exact test as appropriate. Ordinal outcomes were compared with the Mann-Whitney U test (e.g., median aggregate block scores at T2-20). A P value <0.05 was considered significant. A 1-sided test was used to test for noninferiority of the primary outcome; 2-sided tests were used for all other outcomes. Statistical analysis was performed using Prism 5.0c (GraphPad Software Inc., La Jolla, CA).

The sample size was based on both the logistics of our anticipated patient throughput and the aggregate block score at 20 minutes. A previous study involving a similar block in a similar group of patients but with a 3-point motor block scale had a mean/standard deviation 20-minute aggregate block score of 1.63/2.26. With this distributional assumption, recruitment of 100 patients would give the study 80% power to detect a negative (inferior) shift in aggregate block score of 1.13/16 points or, with the present study's 4-point motor block scale, approximately 1.4/20 points (1-sided unpaired t test, 5% significance level) (StatMate 2; GraphPad Software Inc.).

RESULTS

One hundred patients were recruited and all were followed per protocol. There were no significant differences in patient characteristics (Table 1). The single injection group was associated with a reduction in procedural time (P = 0.02) (Table 2). Brachial plexus blockade at 20 minutes was not significantly inferior with the single injection technique compared with the triple injection technique and was in fact superior (2-tailed test, P = 0.043) (Table 3). Block success at 20 minutes was higher in the single injection group for each individual nerve; the most significant difference was for the ulna and radial nerves (Table 3). There

Table 2. Block Placement Details

	Single injection (n = 51)	Triple injection (n = 49)	P value
Procedural time (s)[a]	117 (87–175)	158 (112–242)	0.002
Cords visible (0/1/2/3)	Not recorded	4/7/32/6	
Block-related NRPS	2 (0–3)	2 (0–3)	0.86
Paresthesia during procedure	5	6	
Elective supplementation[b]	26	22	0.25
Median	22	15	
Ulnar	15	11	
Radial	5	6	

Data are presented as median (interquartile range) or *n*.
NRPS = numerical rating pain score (0 = no pain; 10 = worst pain imaginable).
[a] The times did not include ultrasound scanning time before skin puncture.
[b] Some patients had >1 supplementary block performed.

Table 3. Sensory and Motor Block Onset

	Single injection (n = 51)	Triple injection (n = 49)	P value
Sensory block score			
T2	10 (8–12)	11 (9–12)	
T10	5 (3–8)	6 (4–7.5)	0.16
T20	2 (1–5)	3 (1–5)	0.28
Aggregate block score			
T2	21 (19–24)	22 (19–23.5)	
T10	12 (7–15)	14 (9–16)	0.12
T20	5 (2–9)	7 (3.5–11)	0.04
Complete sensory block at T20			
Median	24 (47)	24 (49)	0.85
Ulnar	34 (67)	24 (49)	0.07
Radial	26 (51)	18 (37)	0.15
Musculocutaneous	22 (43)	17 (35)	0.39
Complete sensory and motor block at T20			
Median	52 (51)	42 (43)	0.25
Ulnar	62 (61)	42 (43)	0.01
Radial	45 (44)	27 (28)	0.02
Musculocutaneous	41 (40)	31 (32)	0.21

Data are presented as median (interquartile range) or n (%).

Sensory block score = sum of sensory block scores for each of the 4 individual nerve territories; aggregate block score = sum of sensory and motor block scores for each of the 4 individual nerve territories; complete sensory block = number of assessments, for each nerve, fulfilling the criteria for complete sensory blockade; complete sensory and motor block = number of assessments, for each nerve, fulfilling the criteria for complete sensory and motor blockade (i.e., the theoretical maximum score possible for the single injection group for each nerve was 102) (100%).

P values are 2 tailed.

was no difference between groups in the requirement for patient requested sedation. There were no differences between groups in the requirement for conscious (single = 7, triple = 9, P = 0.59) or deep (single = 13, triple = 9, P = 0.47) sedation or of intraoperative block failure (single = 2, triple = 7, P = 0.09). There was 1 inadvertent vascular puncture in the triple injection group. No patient developed central nervous system or cardiac toxicity and there were no pneumothoraces evident clinically.

DISCUSSION

The results of this study are similar to those of 2 similar recent studies, involving both experienced[6] and trainee operators,[7] in that a single point injection posterior to the axillary artery produced similar quality brachial plexus block compared with both a triple[6] or double injection technique.[7] The posterior cord has also been recently confirmed as the preferred cord to target.[8]

Ulnar and radial nerve sparing with the triple injection technique is consistent with the medial and posterior cord orientation posterior to the axillary artery (neither nerve has any lateral cord contribution)[9]; only 30% of the lidocaine dose was administered posterior to the artery with the triple injection technique, compared with close to 100% with the single injection technique. Desgagnes et al.[6] found no difference in sensory block onset for all 4 nerves, for a similar single versus triple injection comparison. We speculate that the difference between studies lies with the current study's reduced interoperator variability and higher differential block testing sensitivity.

The study further raises questions regarding our assumption of sonographic brachial plexus cord visualization, or of the plexus cord positions (6, 8, and 2 o'clock)[2] when they were not all imaged. Indeed, the presumed position of the cords in relation to the axillary artery has become controversial.[2,10]

Our results may have been affected by the use of a (large-bore) 18-gauge Tuohy needle (for a single injection block),[2] or the placement of catheters in some patients, which may have altered lidocaine spread. In addition, the operating anesthesiologist and assistant were not blinded, which may have had an effect on the secondary outcomes.

In conclusion, this study provides important confirmation that the optimal site for local anesthetic placement during ultrasound-guided infraclavicular block is a single point injection posterior to the axillary artery. The previously advocated triple injection technique (ideally aiming to target each cord) cannot be recommended.

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