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Randomized Trial

Ultrasound-Guided Block of the Axillary Nerve: A Prospective, Randomized, Single-Blind Study Comparing Interfascial and Perivascular Injections

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Background: The ultrasound-guided block of the axillary nerve may be complicated in cases in which the posterior circumflex humeral artery (PCHA) follows an abnormal course.

Objectives: To develop a new technique that does not rely on direct visualization of the PCHA or the axillary nerve, and to compare interfascial injection and conventional perivascular injection for a block of the axillary nerve.

Study Design: A prospective randomized study.

Setting: An interventional pain-management practice in a university hospital.

Methods: A total of 56 patients received ultrasound-guided block of the axillary nerve with either interfascial injection (IF Group) or perivascular injection with nerve stimulation (PV Group). The primary outcome was procedure duration, defined as the time interval from when the transducer contacted the skin to when the needle was removed from the skin.

Results: The mean procedure time was significantly shorter in the IF Group than in the PV Group (64 seconds [SD 28.3] vs. 135 seconds [50.3], difference of –71.4 seconds; 95% confidence interval, –93.2 to –49.5) ($P < 0.001$). There were no differences in secondary outcomes, including the quality of blocks, between the 2 groups.

Limitations: The practitioner was not blinded to the group to which the patients belonged.

Conclusions: Ultrasound-guided block of the axillary nerve with interfascial injection can be performed without placing the needle near the PCHA.

Key words: Block of axillary nerve, ultrasound-guided block, posterior circumflex humeral artery, interfascial injection

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The interscalene brachial plexus block is an effective intervention for reducing postoperative pain but is related to side effects and complications. Suprascapular nerve block and a block of the axillary nerve have been introduced as alternatives to the interscalene brachial plexus block for the control of postoperative pain. An anatomic landmark technique using nerve stimulation has been developed to specifically block the axillary nerve (1). Ultrasound-guided procedures are widely used in regional anesthesia, and Rothe et al (2,3) demonstrated a method of ultrasound-guided block of the axillary

nerve in which the block needle is inserted just cranial to the posterior circumflex humeral artery (PCHA). However, in clinical practice, 2 or more vessels can be observed when the user is searching for the PCHA under ultrasound guidance, and the axillary nerve is often not sonographically visible. In addition, variation in the origin of the PCHA is common and it sometimes follows an abnormal course (4,5). Therefore, we developed a new technique that can be implemented without the need for direct visualization of the PCHA or axillary nerve and compared interfascial injection and conventional perivascular injection for a block of the axillary nerve.

Methods

The study protocol was approved by the institutional review board of Seoul St. Mary's Hospital, Catholic University (IRB No. KC14OISI0830), and registered at the Clinical Research Information Service of the Korea National Institute of Health, Republic of Korea (KCT0002999). Written informed consent was obtained from all patients. Fifty-six consecutive patients with shoulder pain aged 20-80 years were enrolled. Patients were excluded if they had allergies or contraindications to local anesthetics or contrast media, local infection, a coagulopathy, or limited range of motion related to the deltoid muscle.

Patients were allocated to one of 2 groups to receive ultrasound-guided block of the axillary nerve with either interfascial injection (IF Group) or perivascular injection with nerve stimulation (PV Group) based on sequentially numbered envelopes that were opened just before the block procedure. Randomization was conducted by a physician who was not involved in patient assessment with the use of a random computer-generated sequence. One physician, with more than 10 years' experience with blocks of the axillary nerve, could not be blinded to group allocation but did not take part in data collection (incidence of radial nerve block and complications, motor function, sensory function).

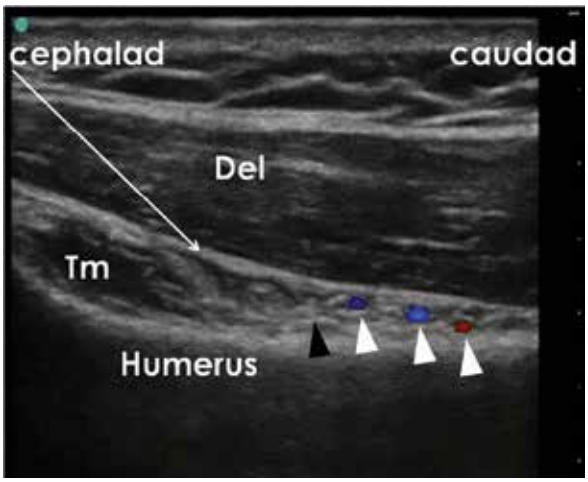

Fig. 1. *Interfascial injection. Del, deltoid; Tm, teres minor; black arrowhead, axillary nerve; white arrowheads, posterior circumflex humeral vessels; arrow, block needle.*

IF Group

Patients were prepared in a sitting position, with the shoulder resting in a neutral position. The areas of injection were disinfected with povidone-iodine on a posterior aspect of the shoulder. Using a high-frequency linear transducer (13-5 MHz, Edge ultrasound device, SonoSite, Inc., Bothell, WA), the neck and shaft of the humerus, the deltoid muscle, and the cross-section of the teres minor muscle and the PCHA were identified, parallel to the longitudinal axis of the shaft of the humerus. The block needle (UniPlex NanoLine cannula with facet tip 22 G 100 mm; Pajunk, Geisingen, Germany) was inserted from the cranial end of the transducer. Using the in-plane technique, the needle was advanced until its tip entered the interfascial space between the deltoid muscle and the teres minor muscle (Fig. 1). Interfascial plane block was confirmed in the postero-anterior fluoroscopic view after injecting 3 mL contrast medium (Iobrix, 300 mgI/mL; Taejoon Pharm, Seoul, Korea) (Fig. 2). After the contrast medium dispersed in the interfascial space between the deltoid muscle and the teres minor muscle without intravascular uptake, 8 mL of 2% lidocaine was slowly injected with aspiration for every 2 mL injected. If vascular uptake was detected, the process was repeated after changing the needle position.

PV Group

The patients were prepared in the manner described earlier. Blocks of the axillary nerve using the perivascular approach were performed using the method described by Rothe et al (2,3). Ultrasound images were obtained in the same manner as described for the IF Group. Next, the block needle (UniPlex NanoLine cannula with facet tip 22 G 100 mm; Pajunk) was inserted from the cranial end of the transducer and the needle tip was placed just cranial to the PCHA. When deltoid muscle contraction at a current of 0.5 mA (Mul-

tiStim Vario Peripheral Nerve Stimulator; Pajunk) was observed, 3 mL of contrast medium was administered. If the spread of contrast media was detected without intravascular uptake, 8 mL of 2% lidocaine was slowly injected with aspiration for every 2 mL injected. If vascular uptake was detected, the needle was repositioned.

Data Collection

The following patient data were collected: age, gender, height, and weight. The primary outcome was procedure duration, defined as the time interval from when the transducer contacted the skin to when the needle was removed from the skin. PCHA visibility and the number of visualized vessels were evaluated based on ultrasound images. After fluoroscopic confirmation, the appearance of conical structures and intravascular uptake of contrast medium were also evaluated (Fig. 2). Motor and sensory functions were assessed at 15 and 30 minutes after the block of the axillary nerve. Deltoid motor function was evaluated based on active resistance against the backward and downward pressure on the arm with the shoulder fixed at 70° abduction, 30° flexion, 30° lateral rotation, and the elbow at 90° flexion (for the anterior part of the deltoid muscle); active resistance against downward pressure on the arm with the shoulder fixed at 90° abduction and the elbow at 90° flexion (for the middle part of the deltoid muscle), and active resistance against the forward and downward pressure on the arm with the shoulder extended to 30° and the elbow at 90° flexion (for the posterior part of the deltoid muscle). Active resistive force was graded as 1, normal; 2, moderately decreased; 3, severely decreased; and 4, no force. Cold sensitivity was assessed by applying alcohol swabs to the skin on the distal part of the deltoid muscle, with the opposite arm serving as a control (6). The sensation was recorded as either cold or not cold. Pinprick sensations were assessed using a 22 G needle and recorded as either present or absent. Following the block procedures, the incidence of radial nerve blockade and complications were evaluated. Radial nerve block was evaluated by checking for weakness in extension of the hand and fingers or loss of sensation in the posterior forearm and the radial half of the dorsum of the hand.

Statistical Analysis

In a pilot study that used conventional perivascular injection, the mean procedure time ± standard deviation (SD), SD was estimated to be 120 ± 50 seconds. This indicated that a sample size of 50 patients was required to demonstrate a > 40 second decrease in procedure time, assuming α = 0.05 (2-tailed) and β = 0.2 (80% power) with a 1:1 allocation ratio. Assuming a 10% dropout rate, we allocated 28 patients into each of the 2 groups. Continuous data were tested for normality using the Kolmogorov–Smirnov test. Normally distributed and non-normally distributed data are presented as mean ± SD and median (range), respectively. For comparisons between 2 groups, the normally distributed data were analyzed using the Student t test and the non-normally distributed data were compared using the Mann–Whitney U test. Categorical variables are given as numbers and percentages and were analyzed using the Pearson Chi-square test or the Fisher exact test. *P* values < 0.05 were considered statistically significant. Data were analyzed using SPSS software version 18.0 (SPSS Inc., Chicago, IL).

Fig. 2. *Fluoroscopic image reveals conical structure of contrast medium.*

Results

Ninety-five patients were screened for inclusion, 5 refused consent, and 34 were excluded because they had limited range of motion in the shoulder. We recruited 56 patients who underwent ultrasound-guided blocks of the axillary nerve with either interfascial injection or perivascular injection using nerve stimulation. In all, 28 patients were allocated to the IF Group and 28 patients were allocated to the PV Group (Fig. 3).

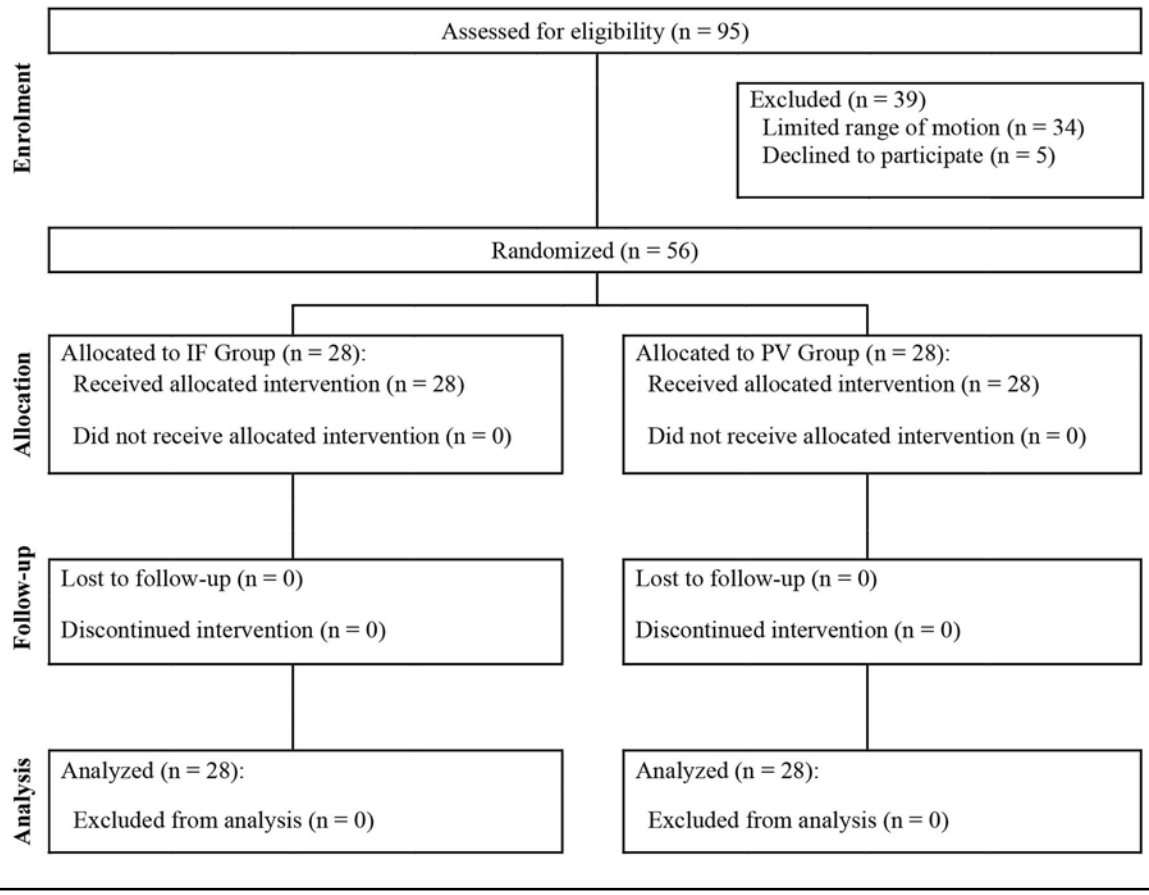

Fig. 3. *Flow chart according to Consolidated Standards of Reporting Trials statement (CONSORT).*

Age, gender, height, weight, and body mass index are presented in Table 1.

The mean procedure time was significantly shorter in the IF Group than in the PV Group (64 ± [SD 28.3] seconds vs. 135 ± [SD 50.3] seconds, respectively) (P < 0.001). There were no differences in the visibility of the PCHA between the groups (96.4% vs. 100%, respectively) (P = 1.000). The number of visualized vessels were similar between the groups. More than 2 blood vessels were observed in 17 patients (60.7%) in each group. There were no significant differences in the appearance of conical structures between the groups (85.7% vs. 82.1%, respectively) (P = 1.000). There were only 2 (7.1%) cases of intravascular uptake in the PV Group, but there were no significant differences between the groups. There were no significant differences in complications between the groups (1 of 28 patients [3.6%] vs. 5 of 28 patients [17.9%], respectively) (P = 0.193). All complications, except for one instance of radial nerve weakness in the PV Group, were resolved within 30 minutes (Table 2). There were no significant differences between groups in the success of the block of the axillary nerve as assessed by loss of pinprick sensation as well as the presence of motor block of the deltoid muscle when assessed 30 minutes after blocks (Table 3).

Discussion

We did not find any significant differences in motor or sensory outcomes between the 2 techniques of the block of the axillary nerve. However, procedure duration was significantly shorter in the IF Group than in the PV Group. We found that interfascial injection between the deltoid and teres minor muscle reduced the time required to perform the block of the axillary nerve and was as effective as perivascular injection.

Locating the PCHA under ultrasound guidance may

Table 1. *Demographic characteristics*.

Demographic Variables	IF Group (n = 28)	PV Group (n = 28)
Age (years)	60.7 ± 11.6	59.4 ± 9.4
Male/female*	12 (42.9)/16 (57.1)	14 (50)/14 (50)
Height (cm)	160.8 ± 9.4	163.8 ± 8.8
Weight (kg)	64.6 ± 11.8	66.6 ± 10.1
BMI (kg/m^2)	24.9 ± 3.7	24.9 ± 4.2

*Values are expressed as the frequency (%); otherwise, values are expressed as the mean ± SD. Abbreviations: BMI, body mass index.

Table 2. *Block outcomes*.

Outcomes	IF Group (n = 28)	PV Group (n = 28)	Difference (95% CI)	*P* Values
Procedure time(s)*	64 ± 28.3	135 ± 50.3	−71.4 (−93.2 to −49.5)	< 0.001
PCHA visualization	27 (96.4)	28 (100)	−3.6% (−10.5 to 3.3)	1.000
Number of visualized vessels			−3.6% (−28.9 to 21.7)	0.783
0	1 (3.6)	0 (0)		
1	10 (35.7)	11 (39.3)		
≥ 2	17 (60.7)	17 (60.7)		
Conical structure	24 (85.7)	23 (82.1)	3.6% (−15.6 to 22.8)	1.000
Intravascular incidence	0 (0)	2 (7.1)	−7.1% (−16.6 to 2.4)	0.491
Radial nerve block	0 (0)	1 (3.6)	−3.6% (−10.5 to 3.3)	1.000
Complication†	1 (3.6)	5 (17.9)	−14.3% (−30.1 to 1.5)	0.193

*Values are expressed as the mean ± SD; otherwise, values are expressed as the frequency (%). †All complications were related to dizziness, except for one case of radial nerve weakness in the PV Group. Abbreviations: CI, confidence interval.

increase the time required to perform the block of the axillary nerve, particularly if it is difficult to locate because it follows a variant course, or there are 2 or more arterial branches, or because low resolution is achieved in ultrasound imaging. In one case in the present study, we were unable to visualize the PCHA using ultrasound. Similarly, in the Rothe et al (2) study, the PCHA could not be visualized in 1 of 12 volunteers. Mohandas Rao et al (4) reported a case in which the PCHA originated from the axillary artery and passed through the lower triangular space rather than the quadrilateral space. Olinger and Benninger (5) reported that the PCHA originates from the deep brachial artery in 8.4% of cases, and that in 85.7% of such cases it passes through the triangular space. When the PCHA passes through the triangular space rather than the quadrilateral space, it is farther away from the axillary nerve at the site of the humerus.

Several studies have suggested that the needle tip should be placed just cranial to the PCHA during ultrasound-guided block of the axillary nerve (2,3,7). However, this may be difficult when the PCHA is not clearly detected or when 2 or more vessels are visible. In the present study, 2 or more vessels were observed by ultrasound in 60.7% of cases. Furthermore, the axillary nerve itself is not easy to distinguish using ultrasound (2,3,8). Here, we found that interfascial injection for the block of the axillary nerve does not require both the PCHA and the axillary nerve as landmarks and is not affected by anatomic variation in the PCHA.

Despite the generalization of ultrasound-guided block for regional anesthesia, research has continued to focus on blind techniques for the block of the axillary nerve owing to anatomic limitations (1,8-13). According to a cadaveric study, in 65% of cases the axillary nerve splits into anterior and posterior branches within the quadrilateral space (14). Therefore, Kim et al (10) proposed using blind techniques to perform complete blocks of the axillary nerve in the quadrilateral space

Table 3. *Motor and sensory function of the axillary nerve.*

Outcomes	IF Group (n = 28)	PV Group (n = 28)	*P* Values
Motor function*			
Anterior			
Baseline	1	1	1.000
15 minutes	3 (1-4)	3 (2-4)	0.423
30 minutes	4 (2-4)	3.5 (2-4)	0.742
Middle			
Baseline	1	1	1.000
15 minutes	3 (1-4)	3 (2-4)	0.607
30 minutes	4 (2-4)	4 (2-4)	0.484
Posterior			
Baseline	1	1	1.000
15 minutes	3.5 (1-4)	4 (2-4)	0.539
30 minutes	4 (2-4)	4 (2-4)	0.059
Decreased sensitivity to pinprick or cold			
Pinprick			
Baseline	0 (0)	0 (0)	1.000
15 minutes	23 (82.1)	27 (96.4)	0.193
30 minutes	26 (92.9)	27 (96.4)	1.000
Cold			
Baseline	0 (0)	0 (0)	1.000
15 minutes	25 (89.3)	27 (96.4)	0.611
30 minutes	27 (96.4)	28 (100)	1.000

*Values are expressed as the median (minimum-maximum); otherwise, values are expressed as the frequency (%). Active resistive force was graded as 1, normal; 2, moderately decreased; 3, severely decreased; and 4, no force

rather than on the humerus. In the present study, conical structures on fluoroscopic images were observed in 85.7% of cases in the IF Group after the injectate containing contrast medium and local anesthetic was administered. The injectate would be expected to spread more medially to the anteromedial surface of the subscapularis muscle over time (1). Contrast medium patterns on conical structures indicate that the injectate has spread into the quadrilateral space, which provides the basis for interfascial injection to block the axillary nerve before it divides into 2 branches (1,8). We observed no significant differences between the 2 groups in the appearance of conical structures, which indicates no differences in the effects of the 2 block techniques.

Intravascular injection may occur unintentionally when injecting local anesthetic in the vicinity of the PCHA during the block of the axillary nerve. There were no significant differences in intravascular injection between the 2 groups in the present study, but 2 cases of intravascular injection occurred in the PV Group. Such cases may be associated with increased incidence of dizziness. In the PV Group, one patient (3.6%) exhibited loss of motor and sensory function in the area innervated by the radial nerve. This incidence is similar to other studies, in which similar losses of function occurred at a rate of 8.3% (2) (1 of 12 cases) and 1.4% (8) (4 of 280 cases). Although we hypothesized that the incidence of radial nerve block would be higher in the PV Group because of the proximity of the PCHA to the radial nerve when the PCHA travels through the triangular space, there were no significant differences between the 2 groups. Local anesthetic (particularly when using 15 mL solution) may spread more medially to any proximal branches and eventually cause posterior cord anesthesia (8).

We were not able to precisely identify the variant course of the PCHA using ultrasound guidance, although we attempted to evaluate the number of vessels around the humeral neck. However, the present study shows that the block of the axillary nerve can be carried out using interfascial injection without the need to precisely identify the PCHA and the axillary nerve.

This study had a few limitations. First, we used 8 mL of local anesthetic to minimize complications following the protocol of Rothe et al (2). However, many previous studies have used 15 mL of local anesthetic (1,3,8,9,12,13,15). Further research to determine the ideal volume and concentration of local anesthetic is required, despite several studies showing that 15 mL of local anesthetic can be safely used. Second, the inability to "blind" the operator with regard to the approach performed might be a bias. To minimize the bias, the evaluator who could not recognize the group to which the patients belonged participated in data collection. Third, a 1-minute dif-

ference in the performance time between the groups may seem clinically insignificant despite the statistical significance, but greater difference in performance time may be shown in novices, not experts. It should be noted that successful blocks can be obtained without wasting time searching for blood vessels or nerves.

The effects of combined blocks of the suprascapular nerve and the axillary nerve for analgesia after shoulder surgery have been previously reported (9,13,16), and some studies have suggested that this combination provides better pain relief than interscalene brachial plexus block (12,15). Therefore, blockade of the axillary nerve is clinically useful, and interfascial injection may be helpful when there are difficulties performing the block of the axillary nerve owing to factors such as anatomic variation.

Conclusions

The present study shows that the block of the axillary nerve using interfascial injection can be an effective alternative to perivascular injection that avoids the need to visualize the PCHA and axillary nerve.

Acknowledgements

Author contributions: J.S. Kim and S.A. Oh collected the data. E.D. Kim and Y.H. Kim had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analyses. E.D. Kim, J.W. Baek, and Y.H. Kim designed the study protocol. E.D. Kim, J.W. Baek, and Y.H. Kim managed the literature searches and summaries of previous related work and wrote the first draft of the manuscript. E.D. Kim and Y.H. Kim provided revision for intellectual content and final approval of the manuscript.

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