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ORIGINAL ARTICLE

Lateral Trendelenburg with the injected side down after the block improves the efficacy of the axillary approach to brachial plexus block

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Abstract
Purpose We hypothesized that, after axillary block, positioning the patient in a lateral position with the injected side down and simultaneously in a 20° Trendelenburg position will increase the success rate and quality of the block.
Methods Fifty patients with chronic renal failure (ASA 2–3) scheduled for arteriovenous fistula surgery were included in this study. In all patients, 30–40 ml of 0.25 % levobupivacaine were injected into the axillary sheath. The block was performed as three injections (multiple injection technique) with the arm in 90° abduction and 90° flexion in the supine position. Patients were randomly allocated to two groups. Group I ($n = 25$) patients were kept in the supine position after the block. Group II ($n = 25$) patients were positioned laterally after the block with the injected arm down and in a 20° Trendelenburg position. Sensory and motor block were evaluated at 2, 4, 6, 8, 10, 15, 20, and 25 min after the administration of the block. Thus, the patients in group II were evaluated in a lateral position during the first 30 min. Throughout the surgery and the recovery period, sensory and motor block were evaluated at 30-min intervals.
Results There were no significant intergroup differences in the effects on radial, ulnar, median, and musculoskeletal nerve blockade. Thirty minutes after the injection, the patients in group II had higher levels of sensory axillary nerve blockade. Subscapular and thoracodorsal nerve motor block were not detected in group I, while 84 % of the patients in group II experienced blockade of both of these nerves ($p < 0.01$).
Conclusion We conclude that, for patients undergoing an axillary block, positioning the patient laterally with the injected side down and in a 20° Trendelenburg position increases the success rate and quality of the block.

Keywords Regional anesthesia · Axillary block · Positions · Trendelenburg

Introduction

As described in textbooks [1, 2], one of the limitations of the axillary approach to brachial plexus block (BPB) is that the axillary (circumflex) and musculocutaneous nerves are sometimes missed because they leave the axillary sheath proximal to the point of injection. Several techniques, such as a rubber tourniquet, digital pressure distal to the needle, and the use of larger volume (30–40 ml) injections, have been introduced to achieve the blockade of these nerves. When these techniques are employed, it is essential to facilitate the cephalad spread of the local anesthetic (to prevent retrograde flow). Certain methods, including positioning the arm, compression of the axillary region after local anesthesia, more proximal localization of the needle, and increasing the volume used, are applied to improve the success rate of axillary blockade [3, 4]. Orlowski et al. [5] noted that head-down and lateral

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positions encouraged the proximal spread of the local anesthetic in eight cadavers, and demonstrated that utilizing such modified positions can improve the success rate of axillary block in patients.

We therefore tested the hypothesis that placing the patient in a lateral position with the injected side down and simultaneously in a 20° Trendelenburg position after axillary block may increase the success rate and quality of the block.

Methods

After obtaining approval from the Trakya University Local Ethical Committee, Edirne, Turkey on 12 July 2007, and written consents from the patients participating in the study, 50 patients with an American Society of Anesthesiology physical status of II–III, who were aged between 18 and 80 years, and who were scheduled to undergo arteriovenous fistula surgery due to chronic renal failure were included in the study. The exclusion criteria were as follows: patients with peripheral artery disease, uncontrolled hypertension, peripheral nerve disorders, diseases affecting sensory or motor function of the upper extremity, sickle cell anemia, cardiovascular and psychiatric disorders, history of thrombo-embolic events, a history of allergic reaction to the drug that would be used in the treatment, local infection at the extremity to be operated, and patients on anticoagulant treatment.

The 50 patients included in the study were randomly divided (using sealed envelopes) into two equal groups. Patients in group I ($n = 25$) were kept in the standard supine position for 30 min after the axillary block. Patients in group II ($n = 25$) were kept in a lateral position with the injected side down and in the 20° Trendelenburg position for 30 min after the axillary block (Fig. 1). Subsequently, patients were positioned in the standard supine position again.

Three-way electrocardiography (ECG) and monitoring of noninvasive blood pressure and peripheral oxygen saturation (SpO_2) were performed for the patients who did not have premedication. The nerve blocks were applied with the arm at 90° abduction and the elbow at 90° flexion in the supine position using a nerve stimulator (Stimuplex® HNS, Braun Medical, Melsungen, Germany), and the block was performed as three injections (multiple injection technique) in all patients. After sterile preparation and local infiltration with 2 ml of 1 % lidocaine, a 22-gauge, 50-mm, short-bevel insulated needle (Stimuplex® D, Braun) was advanced and connected to the nerve stimulator, which was initially set to 2 mA at 2 Hz. The total volume of the local anesthetic, 0.25 % levobupivacaine (Chirocaine®, Abott Laboratories, Istanbul, Turkey), was determined by the height of each patient (height (cm)/5 ml), and the needle was placed according to the functional anatomy: forearm pronation or thumb opposition for the median nerve, ring and little finger flexion for the ulnar nerve, and wrist extension for the radial nerve. When adequate muscular movement was obtained, the current was reduced, and if a muscular twitch persisted below 0.5 mA, one-third of the determined dose of 0.25 % levobupivacaine was administered for each nerve. This procedure was repeated for the other two nerves. After injection of the local anesthetic, the arm was brought to adduction, and finger pressure was applied by the anesthesiologist distal to the axillary groove for 1 min to facilitate proximal spread.

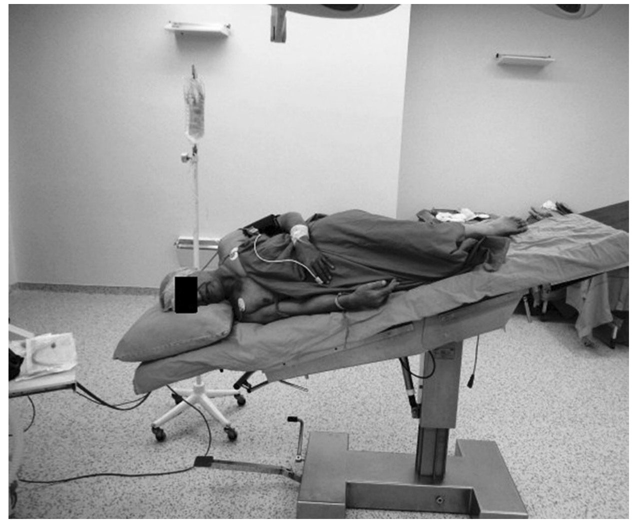

Fig. 1 20° lateral Trendelenburg position

The first anesthesiologist, who performed the block, evaluated sensory and motor block at 2, 4, 6, 8, 10, 15, 20, and 25 min after the administration of the block; he/she was then replaced with the second anesthesiologist (who was not aware of the allocation), and he/she evaluated sensory and motor block and measured hemodynamic parameters every 30 min thereafter until 6 h after surgery. The patients in group II were moved into the supine position 30 min after the block. The replaced anesthesiologists attended and evaluated sensory and motor block thereafter.

Sensory and motor block were evaluated as follows. Patients were asked to perform certain movements depending on the functional anatomy in order to evaluate motor blockade (Table 1). Depending on the patient's ability to perform the requested movements, one of the following descriptors was recorded: (1) no block = muscle movements related to the investigated nerve were not affected by the blockade (normal strength); (2) partial block = muscle movements related to the investigated nerve were partially affected by the blockade; (3) complete

Table 1 Assessment of motor function of each nerve branch of the axillary brachial plexus

Nerve	Assessment
Axillary nerve	0–90° Arm abduction against gravity (deltoid muscle)
	1: Complete block: abduction 0–29°
	2: Partial block: abduction 30–70°
	3: No motor block: abduction >70°
Musculocutaneous nerve	Elbow flexion (biceps brachii muscle)
Radial nerve	Elbow extension (triceps brachii muscle)
Median nerve	Finger flexion (flexor digitorum communis muscle): patient has difficulties in holding a glass or bottle (abductor pollicis brevis)
Ulnar nerve	Finger abduction (interosseous muscle): patient cannot firmly press his forefinger and thumb together (adductor pollicis muscle)
Subscapular nerve	Arm is bent at 90°, extending along the side of the body. Hand is extended with palm up; patient attempts to rotate his hand to respond to the resistance
	Patient cannot scratch lower back with hands or cannot wave his arm in the air (teres major muscle)
Thoracodorsal nerve	Patient cannot bring both arms medial behind the back such that they touch each other. Patient puts both of his hands on hip, takes a deep breath, and coughs. Thus, muscle contractions are investigated (latissimus dorsi muscle)

block = muscle movements related to the investigated nerve were totally affected by the blockade. Motor block onset time and offset time were defined as the time that partial block was confirmed and the time that normal strength returned, respectively. Sensory block was evaluated by the pinprick test using a 27G blunt-point dental needle (pricking the skin innervated by each nerve) as follows: (1) no block = pain was experienced upon needle prick; (2) partial block = pain not experienced upon needle prick but the prick was felt; (3) pain was not experienced upon needle prick and the prick was not felt. Partial or complete block was considered sufficient for surgery. The sensory block onset time and offset time were defined as the time taken for partial sensory block to be achieved and the time required for the patient to start to feel pain upon the needle prick.

The onset time was defined as the time at which both motor and sensory block were first evaluated as 2 for the three nerves (radial, ulnar, median). Assessment of motor function was performed as follows: flexion at the elbow (musculocutaneous nerve), extension of the elbow and the wrist (radial nerve), opposition of the thumb and index finger (median nerve), and opposition of the thumb and small finger (ulnar nerve). Sensory block was assessed in the musculocutaneous nerve, radial nerve, median nerve, and the ulnar nerve radiation areas.

Statistical evaluation was performed using the STATISTICA AXA 7.1 (StatSoft Inc., Tulsa, OK, USA) statistical program. The compatibility of the measurable data with the normal distribution was evaluated using a single-sample Kolmogorov–Smirnov test, and intergroup comparisons were performed using the Mann–Whitney *U* test when the data were not normally distributed, or Student's *t* test when the data were normally distributed. In the analysis of qualitative data, Pearson's χ^2, Fisher's χ^2 test, and the two-sample Kolmogorov–Smirnov test were used. $p < 0.05$ was considered to indicate significance for all statistics.

Results

There was no significant difference between the groups in terms of demographic data (Table 2). Neither the sensory block onset time (5.2 ± 0.9 vs 5.2 ± 1.1 min) nor the motor block onset time (10.7 ± 2.0 vs 11.0 ± 3.0 min) differed significantly between the groups ($p > 0.05$). Durations of sensory and motor block were significantly longer in group II (179.6 ± 32.1 vs 135.8 ± 22.6 min ($p < 0.01$); 274.1 ± 44.4 vs 193.4 ± 36.4 min ($p < 0.01$), respectively). The levels of sensory block 30 min after axillary nerve block were found to be significantly higher in group II [19 (76 %) vs 3 (12 %) patients, $p < 0.001$] (Table 3). Complete axillary nerve motor block was significantly more common in group II than group I [16 (64 %) vs 3 (12 %) patients, $p < 0.001$]. The subscapular and thoracodorsal nerves were blocked in all patients in group II (%100), and in 4 patients (16 %) in group I ($p < 0.001$) (Table 4).

Table 2 Demographic data and durations of surgery for the groups

	Group I ($n = 25$)	Group II ($n = 25$)	*p*
Age (year)	58.5 ± 16.5	58.5 ± 12.8	1.000
Weight (kg)	67.9 ± 8.4	67.5 ± 9.4	0.875
Height (cm)	167.2 ± 6,5	167.2 ± 6.8	1.000
ASA (2/3)	21/4	19/6	0.480
Gender			
F	8 (32.0 %)	8 (32.0 %)	1.000
M	17 (68.0 %)	17 (68.0 %)	
Duration of surgery (min)	61.0 ± 11.0	61.0 ± 12.1	1.000

F female, *M* male

Data are the mean ± standard deviation or the number of patients

Table 3 Sensory block level in nerves of the brachial plexus 30 min after the injection of levobupivacaine

	Group I (*n*: 25)	Group II (*n*: 25)	*p*
Axillary nerve			
Complete block	3 (12.0 %)	19 (76.0 %)	<0.001#
Partial block	1 (4.0 %)	0 (0.0 %)	
No block	21 (84.0 %)	6 (24.0 %)	
Musculocutaneous nerve			
Complete block	24 (96.0 %)	22 (88.0 %)	1.000#
Partial block	0 (0.0 %)	2 (8.0 %)	
No block	1 (4.0 %)	1 (4.0 %)	
Radial nerve			
Complete block	23 (92.0 %)	25 (100.0 %)	0.490*
Partial block	0 (0.0 %)	0 (0.0 %)	
No block	2 (8.0 %)	0 (0.0 %)	
Ulnar nerve			
Complete block	24 (84.0 %)	25 (100.0 %)	1.000*
Partial block	0 (0.0 %)	0 (0.0 %)	
No block	1 (4.0 %)	0 (0.0 %)	
Median nerve			
Complete block	22 (88.0 %)	23 (92.0 %)	1.000*
Partial block	0 (0.0 %)	0 (0.0 %)	
No block	3 (12.0 %)	2 (8.0 %)	

* Fisher's exact test

Two-sample Kolmogorov–Smirnov test

There was no statistically significant difference between the groups in terms of sensory and motor block levels at 30 min after musculocutaneous nerve, radial nerve, ulnar nerve, and median nerve block ($p > 0.05$) (Tables 3, 4). Subcutaneous hematoma was seen in 2 patients in group I and in 1 patient in group II. There were no complications such as paresthesia and nerve damage after applying the axillary block. There was no significant difference between the groups in terms of side effects ($p > 0.05$).

Discussion

In the current study, we were able to achieve an increased success rate and longer sensory and motor block durations for the axillary, subscapular, and thoracodorsal nerves by positioning patients undergoing brachial plexus blockade (BPB) with the axillary approach laterally with the injection side down and in a 20° Trendelenburg position for 30 min after injection.

Not all of the nerves were blocked by the local anesthetic solution in the conventional axillary approach in the supine position. This was probably because of the escape of local anesthetic from the neurovascular sheath, due to variations in the anatomy of the brachial plexus [6–8].

Table 4 Motor block level in nerves of the brachial plexus 30 min after the injection of levobupivacaine

	Group I (*n*: 25)	Group II (*n*: 25)	*p*
Axillary nerve			
Complete block	3 (12.0 %)	16 (64.0 %)	<0.001#
Partial block	1 (4.0 %)	8 (32.0 %)	
No block	21 (84.0 %)	1 (4.0 %)	
Subscapular nerve			
Complete block	4 (16.0 %)	25 (100.0 %)	<0.001*
Partial block	0 (0.0 %)	0 (0.0 %)	
No block	21 (84.0 %)	0 (0.0 %)	
Thoracodorsal nerve			
Complete block	4 (16.0 %)	25 (100.0 %)	<0.001*
Partial block	0 (0.0 %)	0 (0.0 %)	
No block	21 (84.0 %)	0 (0.0 %)	
Musculocutaneous nerve			
Complete block	24 (96.0 %)	23 (92.0 %)	1.000#
Partial block	0 (0.0 %)	1 (4.0 %)	
No block	1 (4.0 %)	1 (4.0 %)	
Radial nerve			
Complete block	23 (92.0 %)	24 (96.0 %)	1.000#
Partial block	0 (0.0 %)	1 (4.0 %)	
No block	2 (8.0 %)	0 (0.0 %)	
Ulnar nerve			
Complete block	24 (96.0 %)	24 (96.0 %)	1.000#
Partial block	0 (0.0 %)	1 (4.0 %)	
No block	1 (4.0 %)	0 (0.0 %)	
Median nerve			
Complete block	22 (88.0 %)	21 (84.0 %)	1.000#
Partial block	0 (0.0 %)	3 (12.0 %)	
No block	3 (12.0 %)	1 (4.0 %)	

* Pearson's chi-squared test

Two-sample Kolmogorov–Smirnov test

Septa in the plexus limit the spread of local anesthetic in the sheath; therefore, multiple injections of small volumes are key to achieving a successful blockade in BPB performed in the standard supine position [9–11]. We used the multiple injection technique in our study. On the other hand, it is known that the proximal spread of the local anesthetic plays a key role in the efficacy of the axillary approach to BPB [12]. Yamamoto et al. [12] investigated the radiographic spread of local anesthetic in 80 adult patients using local anesthetic mixed with contrast agent through an indwelling catheter. The authors aimed to compare the influence of the use of compression maneuvers and the position of the arm on the central spread of the local anesthetic and the block quality in BPB. Although they found that digital compression suppressed peripheral spread, it did not improve the central spread, and the quality of the block was unaltered. As the authors also found that maintaining the arm at 0° abduction promoted the central spread of the contrast agent, they concluded that the central spread of the local anesthetic is facilitated by performing the injection without abduction of the arm [12].

Ababou et al. [4] carried out a study in which the standard supine position was employed with the arm in abduction or adduction. The authors reported that when the arm was in adduction after selective injection, the local anesthetic spread more quickly due to the change in the pressure on the neurovascular bundle, and this affected both the onset time and the quality of the block [4]. On the other hand, Koscielniak-Nielsen et al. [3] found no statistically significant differences in onset time, spread of analgesia, motor block, or success rate when the arm position was varied. The authors used the single injection method along with the placement of a catheter and the use of a tourniquet. They concluded that proximal flow of the local anesthetic–contrast agent mixture was not facilitated by arm adduction; neither was it necessary for the development of a successful block [3].

In our study, the arm was kept beneath the body, which may exert extra pressure on the area injected with local anesthetic and promote the spread of local anesthetic proximally. In contrast to the above two studies, we used the multiple injection technique [3, 4]. Our results also support those of Vester-Andersen et al. [13], who suggested relaxing the neurovascular sheath by adducting the patient's arm [13].

Although we have explored the influence of the arm position and the multiple injection technique, the aim of our study was to investigate the effect of body position on the quality of BPB. To examine the effect of body position on the spread of local anesthetic and axillary block quality, Orlowski et al. [5] conducted a study comprising both cadaveric-based and patient-based investigations. Eight cadavers were allocated to two groups: a supine group and a Trendelenburg group. CT scans were performed with contrast. Five cadavers were placed in a lateral position and simultaneously in a 15° Trendelenburg position. CT scan confirmed that, for up to 50 ml of contrast, the contrast spread along the brachial plexus sheath in the Trendelenburg group. In the clinical arm of the study, patients were allocated to a supine group or a lateral 20° Trendelenburg group. Blockade of the axillary, thoracodorsal, and subscapular nerves was observed in the Trendelenburg group, but these nerves were not blocked in the patients in the supine group. The authors concluded that placing patients in the lateral position with a 20° Trendelenburg tilt caused the local anesthetic to diffuse more proximally and increased the success rate of blockade. They reported success rates of 50, 86, and 89 % for the axillary, thoracodorsal, and subscapular nerves, respectively, in the lateral 20° Trendelenburg position [5]. Our results support those of Orlowski et al. [5] with respect to the increase in the blockade success rate in the lateral 20° Trendelenburg position. Moreover, we investigated the durations of motor and sensory block in our study. We found significantly higher durations of both sensory and motor block in the lateral 20° Trendelenburg group. This is the original result of our study. We suggest that using a head-tilt position may have had a positive effect on the duration and quality of block and the duration of analgesia. We used the multiple injection method but not a tourniquet, whereas Orlowski et al. [5] used single injection. We believe that we increased the success rate by using multiple injection, and enhanced the proximal diffusion of the local anesthetic by applying pressure distal to the injection site while the patient was in the lateral 20° Trendelenburg position.

As the musculocutaneous nerve leaves the brachial plexus at the level of the cords before reaching the axilla, the chance of blockade is very low without performing multiple injections. Often, additional infiltration of local anesthetic to the edges of the wound must be performed by the surgeon [3, 4]. Musculocutaneous nerve blockade success rates of 73–79 % have been reported from studies performed with patients in the supine position and using the single injection technique [3, 12]. On the other hand, Orlowski et al. [5] reported increased success of musculocutaneous nerve block (rates of 97 % for sensory block and 100 % for motor block) in patients in the lateral 20° Trendelenburg position. In the present study, musculocutaneous nerve sensory and motor block involvement rates of 96 % were observed in both the supine and Trendelenburg groups. This supports the opinion that radial nerve blockade alone, as obtained when the single injection method is used in the standard supine position, does not produce axillary plexus block [3, 4]. Although there are those who believe that the radial nerve cannot be blocked sufficiently with the axillary method, radial nerve sensory block involvement was determined as 100 % and motor block involvement was 94 % in the present study in the patients in the lateral 20° Trendelenburg position, while sensory and motor blockade of the radial nerve were determined as 86 % in the patients in the standard supine position ($p > 0.05$). We believe that the multiple injection technique offsets the influence of body position on radial and musculocutaneous nerve block in our study. This technique could also be the reason for the higher success rates of both musculocutaneous and radial nerve block obtained in our study when compared with the rates observed in studies using the single injection technique [5].

There are two limitations of this study. The first is incomplete blindness: the anesthesiologist who performed the BPB also performed the first 25 min of evaluations. However, it is thought that complete blinding is not possible in this kind of research. The second limitation is the lack of a sample size calculation.

In conclusion, lateral 20° Trendelenburg with the injected side down after axillary block increases block duration and axillary, subscapular, and thoracodorsal nerve blockade quality. Further investigations with larger numbers of patients in the Trendelenburg position may verify our findings.

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References

1. Cousins MJ, Bridenbaugh PO, Carr DB, Horlocker TT. Neural blockade in clinical anesthesia and pain medicine. 4th ed. Philadelphia: Lippincott Williams and Wilkins; 2008.
2. Winnie AP. Plexus anesthesia. Volume 1: Perivascular techniques of brachial plexus block. Philadelphia: WB Saunders; 1984. p. 157.
3. Koscielniak-Nielsen ZJ, Horn A, Nielsen PR. Effect of arm position on the effectiveness of perivascular axillary nerve block. Br J Anaesth. 1995;74:387–91.
4. Ababou A, Marzouk N, Mosadiq A, Sbihi A. The effects of arm position on onset and duration of axillary brachial plexus block. Anesth Analg. 2007;104:980–1.
5. Orlowski O, Bullmann V, Vieth V, Filler T, Osada N, Van Aken H, Weber TP. Perivascular axillary brachial plexus block and patient positioning: the influence of a lateral, head-down position. Anaesthesia. 2006;61:528–34.
6. Orebaugh SL, Williams BA. Brachial plexus anatomy: normal and variant. ScientificWorldJournal. 2009;9:300–12.
7. Ongoiba N, Destrieux C, Koumare AK. Anatomical variations of the brachial plexus. Morphologie. 2002;86:31–4.
8. Helayel PE, Conceicao DB, Nascimento BS, Kohler A, Boos GL, Oliveira Filho GR. Learning curve for the ultrasound anatomy of the brachial plexus in the axillary region. Rev Bras Anestesiol. 2009;59:187–93.
9. Thompson GE, Rorie DK. Functional anatomy of the brachial plexus sheaths. Anesthesiology. 1983;59:117–22.
10. Partridge BL, Katz J, Benirschke K. Functional anatomy of the brachial plexus sheath: implications for anesthesia. Anesthesiology. 1987;66:743–7.
11. Retzl G, Kapral S, Greher M, Mauritz W. Ultrasonographic findings of the axillary part of the brachial plexus. Anesth Analg. 2001;92:1271–5.
12. Yamamoto K, Tsubokawa T, Ohmura S, Kobayashi T. The effects of arm position on central spread of local anesthetics and on quality of the block with axillary brachial plexus block. Reg Anesth Pain Med. 1999;24:36–42.
13. Vester-Andersen T, Broby-Johansen U, Bro-Rasmussen F. Perivascular axillary block VI: the distribution of gelatine solution injected into the axillary neurovascular sheath of cadavers. Acta Anaesthesiol Scand. 1986;30:18–22.