Pain Physician 2020; 23:589-597 • ISSN 1533-3159

Randomiized Controlled Trial

The Influence of Bupivacaine Temperature on Supraclavicular Plexus Block Characteristics: A Randomized, Controlled Trial

Mohamed Younis Makharita, MD, Shimaa Abd El-Satar Shalaby, MS,
Hosam I. El Said Saber, MD, and Hanaa M. El Bendary, MD

From: Department of Anesthesiology and Surgical Intensive Care, Faculty of Medicine, Mansoura University, Mansoura, Egypt

Address Correspondence:
Mohamed Younis Makharita, MD
Professor of Anesthesiology and Surgical Intensive Care, Faculty of Medicine, Mansoura University
Mansoura 35516, Egypt
E-mail: m_younis24@yahoo.com

Disclaimer: There was no external funding in the preparation of this manuscript.

Conflict of interest: Each author certifies that he or she, or a member of his or her immediate family, has no commercial association (i.e., consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted manuscript.

Manuscript received: 03-12-2020
Revised manuscript received: 03-31-2020
Accepted for publication: 05-08-2020

Free full manuscript:
www.painphysicianjournal.com

Background: Changes in local anesthetics temperature may influence the characters of the peripheral nerve block. The effect of warmed bupivacaine on supraclavicular brachial plexus block has not yet been evaluated.

Objectives: This study was designed to evaluate the influence of warming bupivacaine 0.5% on the characteristics of supraclavicular plexus block in adult patients undergoing orthopedic surgery below the mid-arm. The primary objective was the time to onset of sensory block. The secondary objectives were the time to onset of motor block, the duration of sensory and motor blocks, and the time to the first analgesic requirement.

Study Design: Randomized, double-blind, controlled trial.

Setting: University hospital setting.

Methods: Ninety patients who underwent elective or emergency orthopedic surgery below the mid-arm were included in this study. Patients were randomly allocated into 2 groups and received ultrasound-guided supraclavicular brachial plexus block. Group I received 30 mL 0.5% bupivacaine at 23°C. Group II received 30 mL bupivacaine 0.5% warmed to 37°C. The onset of sensory and motor blocks, postoperative pain severity, the duration of sensory and motor blocks, and the time to the first analgesic requirement were evaluated in all patients.

Results: The warm bupivacaine group had a significantly accelerated onset time of sensory and motor block. The duration of sensory and motor block and the time to first requirement for analgesia were significantly longer in the warm bupivacaine group. Moreover, it significantly reduced the postoperative analgesics consumption.

Limitations: Postoperative assessment of the offset of the sensory and motor blocks of the individualized nerves was inaccessible, in addition to a small sample size.

Conclusions: Warming bupivacaine 0.5% to 37°C improves the characteristics of supraclavicular plexus block. It promotes rapid onset of sensory-motor block and provided better quality of postoperative analgesia.

Key words: Bupivacaine, local anesthetics, supraclavicular plexus block, warming

Pain Physician 2020: 23:589-597

The recommended technique for upper limb surgeries is regional anesthesia. Ideal local anesthetic (LA) should have fast sensory onset and differential offset—earlier offset of motor than sensory blockade—enabling early movements with prolonged analgesia (1). Compared with general anesthesia, brachial plexus block has many advantages: it allows ideal surgical conditions;

prolongs postoperative analgesia; reduces opioids consumption; reduces postoperative nausea, vomiting, and postoperative atelectasis; and shortens hospital length of stay (2,3).

The introduction of ultrasound (US)-guided regional anesthesia techniques to our daily anesthesia practice promotes higher success rate and enhances patient safety with lower incidence of adverse events, for example pneumothorax, intravascular injection, hematoma formation, and nervous tissue injury resulting in motor weakness or paresthesia (4,5). Adding adjuvants to the perineural LA improves the onset and duration of both sensory and motor blockade and lengthens postoperative analgesia (6-11). The addition of low doses of bicarbonate to LA produced a significant increase in the proportion of the nonionized ropivacaine, reduced the block onset time, and prolonged LA duration of action (12). A pH adjustment of LA solution used in axillary blockade hastened the onset of sensory and motor blockades (13).

Warmed lidocaine to body temperature has the same effect by reducing pKa, and thus shortening the starting time of the sensory block in epidural anesthesia (14). There has been little research on the influence of changes in LA temperature on peripheral nerve block characteristics (15,16). Moreover, we could not find previous research about the effects of warmed bupivacaine on supraclavicular brachial plexus block.

The current study was designed to evaluate the influence of warming bupivacaine 0.5% on the characteristics of the supraclavicular plexus block. The primary objective was the time to onset of sensory block. The secondary objectives were the time to onset of motor block, the duration of sensory and motor blocks, and the time to the first analgesic requirement.

Methods

This randomized blind clinical trial was carried out at Mansoura University Emergency Hospital from September 2017 until April 2018. It was approved by the international review board of Mansoura University with code number: MS/17.05.143. The clinical trials.gov registry number is NCT03265886. American Society of Anesthesiologists (ASA) I and II adult patients (aged ≥ 18 years) scheduled for elective and emergent upper limb surgery below the mid-arm were included in the study. Exclusion criteria were patient refusal to participate in the study, pregnancy, coagulopathy, psychiatric disorders, and neuromuscular disorders. We also excluded patients with polytrauma, block site infection, obesity (body mass index [BMI] > 35), history of anesthetic drug allergy, and chronic opioid use.

Patient Preparation

All patients were assessed preoperatively by detailed history taking and physical examination. Basic demographic characters including age, gender, weight, and height were recorded. Investigations were requested as appropriate. The Visual Analog Scale (VAS) using a horizontal scale of 0 to 100 mm (where 0 for no pain and 100 for worst possible pain) was explained to each patient. All patients received single dose of prophylactic intravenous (IV) antibiotic. Ringer's acetate was infused at a rate of 7 mL/kg within 1 hour preoperatively.

On arrival to the anesthetic room, standard monitoring including 3 leads electrocardiogram (ECG), pulse oximetry, and noninvasive blood pressure were applied to the nonoperated arm, and oxygen was administered through a face mask at a rate of 3 L/min. Patients received 0.01 to 0.03 mg/kg IV midazolam. Baseline vital signs (heart rate and mean arterial blood pressure and oxygen saturation) were recorded.

Randomization and Drug Preparation

Patients were randomly allocated into 2 equal groups using a computer-generated random number table. The allocation sequence was concealed in sequentially numbered, opaque, sealed envelopes. Group I (operating room temperature group) (n = 45): received 30 mL bupivacaine 0.5% prepared from 2 bupivacaine 0.5% vials (each contains 20 mL bupivacaine 0.5%) put on a crash shelf in the operating room at 23°C. The extension tubes and empty syringes were put on the same crash before their usage. Group II (warm temperature group) (n = 45): received 30 mL bupivacaine 0.5%, warmed to 37°C, the extension tubes and empty syringes and 2 bupivacaine 0.5% vials (each contains 20 mL bupivacaine 0.5%) were put in an incubator device BT1020 and was set at 37°C and switched on just before the preparation of the injectate (Fig. 1).

A senior anesthetist not involved in the further study steps or data collection had determined eligibility for inclusion in this clinical trial, explained the study protocol and anesthetic technique, and obtained informed written consent from all eligible patients before being enrolled. He was responsible for preparation of the injectates used for each block in identical syringes and handled the syringes during the injection process. The anesthesiologist who performed the block was blinded to group allocation and allowed to enter

the anesthetic room after preparation of the injection solution.

Technique of US-Guided Supraclavicular Brachial Plexus Block

The supraclavicular block was performed while the patients were in the supine position with their faces to the contralateral side, at an angle of 45° from the midline and with their arms beside. After skin sterilizing and draping, the probe was insulated with sterile sleeve, and a sterile gel was used. A linear probe, with an 8- to 14-MHz frequency range, was put 3 cm cranial to the midpoint of the clavicle to identify the subclavian artery. Then 2 mL 1% lidocaine was injected subcutaneously to anesthetize the skin. Using ultrasonography, we introduced a 22-gauge spinal needle by the in-plane technique to reach the cluster of the plexus lateral to the artery. LA syringe, connected to a flushed 20-cm connection tube, was handled by the anesthesia assistant and connected to the spinal needle. The injectate was administered, and a negative aspiration was applied before every incremental injection. Adequate spread, around the brachial plexus and in the pocket between the first rib and the artery, was ensured. Block performance time, which was the time from the needle puncture until the end of injection, was recorded (3).

Block Evaluation and Intraoperative Anesthetic Management

A well-trained anesthesiologist, who was blinded to group allocation, assessed sensory and motor blocks and provided the intra- and postoperative patients' care. Sensory and motor blockade were evaluated at 2, 5, 7, and 10 minutes, and then every 5 minutes until 30 minutes after injection before the start of surgery. The sensory block was evaluated on each dermatome by pinprick and touch test, with identical contralateral testing as reference, and checked on a 3-point scale: 2 = normal sensation, 1 = loss of sensation to pinprick (i.e., analgesia), or 0 = loss of sensation to light touch (i.e., anesthesia) (3). The time to sensory block onset for each dermatome of the 4 peripheral nerves (the time elapsed from the end of injection and the loss of sensation to pinprick - sensory score = 1) was reported. The time to the onset of the limb sensory blockade was taken as time from completion of injection of LA to time of complete analgesia in all 4 nerve distributions.

Motor block was assessed as follows: finger flexion for median nerve, wrist extension for radial nerve, fingers abduction ulnar nerve, and flexion of elbow for the musculocutaneous nerve. The degree of motor block was evaluated by modified Bromage Scale: 0 = normal motor function with full extension and flexion of elbow, wrist, and fingers; 1 = decreased motor strength; and 2 = complete motor block with inability to move elbow, wrist, and fingers (17). The time to motor block onset for each of the 4 peripheral nerves (the time elapsed from the end of injection and paresis - motor score = 1) was also reported. The time to the onset of limb motor blockade was taken as time from complete injection of LA to time of motor paresis - motor score = 1 in all 4 assessed nerves.

Fig.1. *Incubator device (BT1020)*

Block success is defined as loss of sensation to pinprick (sensory score 1) in each of the median, radial, ulnar, and musculocutaneous nerve distributions. If the block failed, the patient was excluded from the study, received general anesthesia, and was replaced by the next enrolled patient. Intraoperative sedation was provided with midazolam (0.03 mg/kg) once for patient irritability or complaining touch sensation and fentanyl (1 μg/kg) for tourniquet-induced pain if needed.

Hemodynamics monitoring was assessed by continuous ECG, pulse oximetry, and noninvasive blood pressure at 5 minutes intervals until the end of surgery. The incidence of adverse effects, such as hypotension, bradycardia, and respiratory depression, were recorded. Hypotension was defined as systolic blood pressure less than 90 mm Hg or decrease mean blood pressure 20% from the basal (18). Bradycardia was defined as a heart rate slower than 50 beats per minute (19). Hypotension was treated with IV boluses of 5 mg ephedrine and

5 mL/kg normal saline solution; the same doses were repeated as required. Bradycardia was treated with IV boluses of 0.5 mg atropine and repeated as required. Respiratory depression was defined as respiratory rate less than 8 or oxygen saturation less than 90% and was treated with oxygen supplementation and managed as required (20). Intraoperative used doses of ephedrine, atropine, and volume of fluid boluses were recorded. Nausea, vomiting, pruritus, and any other adverse events were also reported.

Postoperative Assessment

At the end of surgery, patients were transferred to the postanesthesia care unit. The same well-trained anesthesiologist followed the patients during the postoperative period. The level of pain based on VAS score was assessed immediately and 1 hour after surgery in the recovery room, then later in the ward at 2, 4, 6, 8, 12, 18, and 24 hours in the orthopedic ward. Patients with VAS score greater than 30 received intramuscular diclofenac sodium 75 mg/12 hours. After 30 minutes of diclofenac injection, IV 0.5 µg/kg fentanyl was administered if VAS score was still greater than 30. Fentanyl injection was repeated, provided that at least 4 hours had passed since the last dose.

The time for the first analgesic requirement (diclofenac sodium), the number of doses of diclofenac, and the total dose of fentanyl consumed in the first 24 hours postoperatively were recorded. Patients were evaluated for the onset of sensory and motor block resolution. The duration of sensory block, defined as the elapsed time between the end of injection and the complete resolution of sensory block (sensory score = 2), was recorded. The duration of motor blockade was defined as the elapsed time between the end of injection and the complete resolution and recovery to a normal motor function (motor score 0) were reported. Any postoperative complications related to the technique such as pneumothorax, weakness and paresthesia (numbness or tingling) in the operated limb, nausea or vomiting were also recorded. Patient Satisfaction Score (5 = excellent, 4 = very good, 3 = good, 2 = fair, and 1 = poor) was recorded once daily during the first 48 postoperative hours (1).

Sample Size Calculation

A prior G-power analysis was done to estimate study sample size. Using a previous study (21) in which the mean ± standard deviation (SD) of onset of sensory block in minutes was 16.85 ± 6.67 assuming the power of the current study was 0.8 with α error 0.05 and β error 0.2, a calculated sample size of 41 patients were needed in each group to decrease the sensory block onset time by 25%, which is the least time to detect clinical effect between the 2 groups. Allowing for 10% dropout, 45 cases were included in each group.

Statistical Analysis

Statistical analysis was performed using SPSS version 22 (IBM Corporation, Armonk, NY). Data were tested for normality using the Shapiro-Wilk test. Continuous data of normal distribution are presented as mean ± SD and were analyzed with the Student t-test. Nonnormally distributed data are presented as median (interquartile range) and were analyzed with the Mann-Whitney U test. Nominal data are presented with number (%) and were analyzed with the χ^2 and the Monte-Carlo test. A P value < 0.05 was considered statistically significant.

Results

A total of 138 adult patients were assessed for eligibility; 48 patients did not fulfill inclusion criteria, whereas 90 adult patients were randomized and assigned to one of the studied groups.

All blocks were successful and none of our patients was excluded because of inadequate brachial plexus block (Fig. 2). There was no statistically significant difference between 2 groups in regard to patients' demographic data including age, gender, weight, height, and BMI (Table 1). The duration and types of surgical procedures showed no significant difference between the studied groups (Table 1).

In regard to block characteristics, the block performance times were comparable in both groups (P = 0.6) (Table 2). The onset of sensory block in the median, radial, ulnar, and musculocutaneous nerve distributions was significantly shorter in Group II when compared with Group I (P < 0.001 for all values) (Table 2). The time to onset of sensory block of the limb (the 4 peripheral nerve blocks) was significantly shorter in Group II when compared with Group I (P < 0.001) (Table 2). Furthermore, the onset of the motor block for the 4 peripheral nerves was significantly faster in Group II when compared with Group I (P < 0.001 for all values) (Table 2). The time to onset of motor block of the limb (the 4 peripheral nerve blocks) was significantly shorter in Group II when compared with Group I (P < 0.001) (Table 2). The durations of the sensory and motor block in hours were significantly longer in Group II when

compared with Group I (13.65 ± 4.39 vs. 10.01 ± 2.31, $P < 0.001$) and (12.84 ± 4.36 vs. 9.27 ± 2.37, $P < 0.001$), respectively (Table 2).

Postoperative VAS score was significantly lower in Group II at 4, 6, 8, and 18 hours when compared with Group I (P values were 0.006, < 0.001, < 0.001, and 0.002, respectively) (Table 3). Regarding the number of patients who required diclofenac analgesia, a significantly lower number of patients were reported in Group II compared with Group I at 8 and 12 hours postoperatively (15 and 27 patients vs. 33 and 43 patients), respectively ($P < 0.001$ for both values) (Table 3). Moreover, a significantly large proportion of patients (95.6%) in Group I received 2 doses of diclofenac in the first postoperative 24 hours compared with 60% in Group II (Table 4).

In regard to the time for the first analgesic requirement (diclofenac sodium), significantly longer time (in hours) were reported in Group II in comparison to Group I (13.94 ± 4.59 vs. 10.60 ± 2.77, $P < 0.001$) (Table 4). Also, significantly lower 24-hour fentanyl consumption was reported in Group II postoperatively when compared with Group I ($P = 0.002$) (Table 4).

High patient satisfaction scores (at least good) were reported in all patients at 24 and 48 hours postoperatively with no statistically significant difference between the 2 studied groups (Table 5).

No significant difference was noted in the number of patients who required intraoperative fentanyl (5 in Group I vs. 4 in Group II, $P = 0.7$). Furthermore, 8 patients in Group I vs. 6 patients in Group II required intraoperative midazolam ($P = 0.6$).

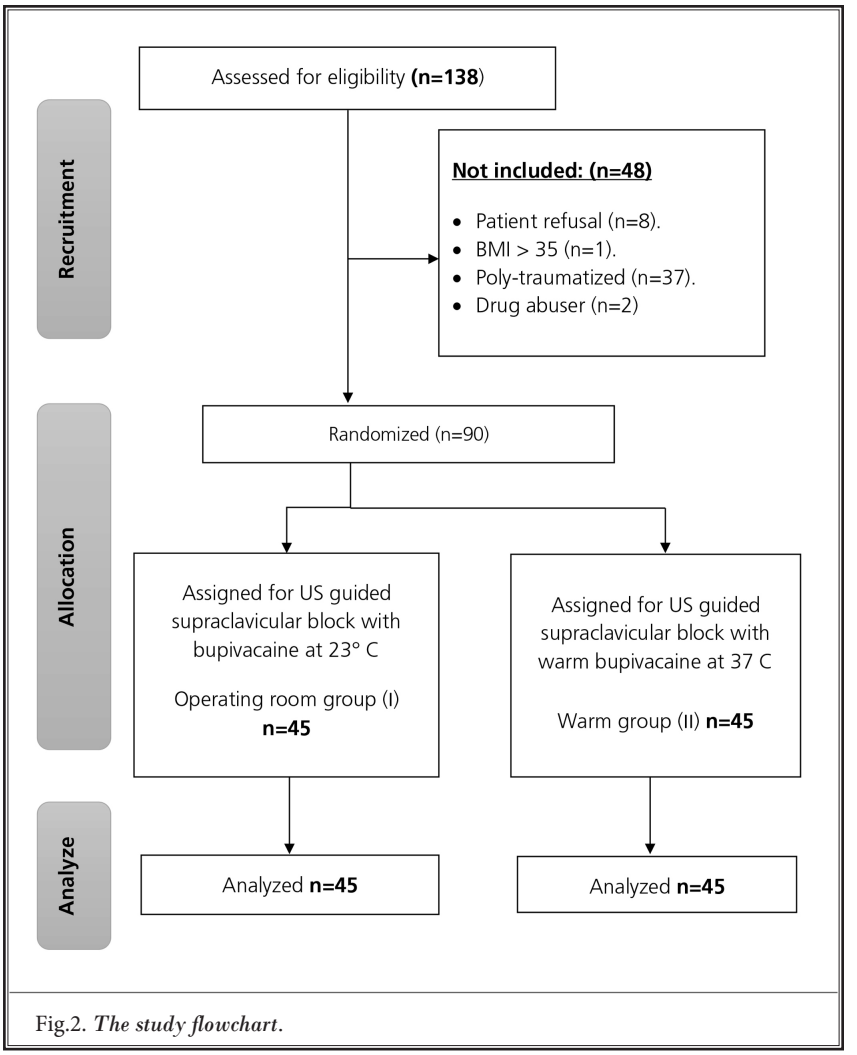

Fig.2. *The study flowchart.*

Perioperative hemodynamic stability was noticed in all patients in the studied groups. Adverse events such as hypotension, bradycardia, nausea, and vomiting were not detected. Finally, no serious complications were detected in both groups, namely pneumothorax and weakness and paresthesia in the operated limb.

Discussion

Warming bupivacaine to 37°C, in this randomized controlled trial, accelerated the onset of sensory and motor blockade in US-guided supraclavicular brachial plexus block for upper extremity orthopedic surgeries. It significantly lengthened the duration of sensory and motor block, the time for the first analgesic request, and significantly reduced the postoperative analgesic consumption.

The time for onset of the LA is dependent on the nonionized molecules. The fraction of the nonionized form is determined by the pKa and the pH of the drug solution (22). Warming of the LA reduces its pKa,

Table 1. *Patients' demographic and surgical data of the studied groups.*

		Group I (n = 45)	Group II (n = 45)	*P* Value
Age (years)		31.31 ± 9.58	33.60 ± 10.05	0.3
Height (cm)		167.91 ± 6.66	169.13 ± 7.41	0.4
Weight (kg)		79.87 ± 11.53	81.64 ± 10.42	0.5
BMI (kg/m^2)		28.36 ± 4.07	28.55 ± 3.33	0.8
Gender	Male	33 (73.3%)	37 (82.2%)	0.3
	Female	12 (26.7%)	8 (17.8%)	
ASA	I	25 (55.6%)	22 (48.9%)	0.5
	II	20 (44.4%)	23 (51.1%))	
Surgery duration (min)		109.11 ± 48.27	101.78 ± 51.05	0.5
Surgical procedures	Humeral condyle	4 (8.9%)	3 (6.7%)	0.6
	Plate radius	11 (24.4%)	11 (24.4%)	
	Plate ulna	5 (11.1%)	9 (20%)	
	Both bones forearm	11 24.4%)	10 (22.2%)	
	Hand wires	14 (31.1%)	12 (26.7%)	

Data are presented as mean ± SD or number of patients (%). **P* value < 0.05: statistically significant. Group I: operating room group. Group II: warm group.

Table 2. *Block characteristics of the studied groups.*

	Group I (n = 45)	Group II (n = 45)	*P* Value
Block performance time (min)	10.51 ± 3.52	10.87 ± 3.56	0.6
Time to sensory block onset for each dermatome (min)			
Median N	14.96 ± 5.125	5.76 ± 3.90*	< 0.001
Radial N	17.67 ± 5.741	6.64 ± 3.39*	< 0.001
Ulnar N	12.69 ± 5.39	4.98 ± 4.19*	< 0.001
Mc. N	16.91 ± 6.23	5.89 ± 3.38*	< 0.001
Time to onset of limb sensory block	18.51 ± 5.54	7.91 ± 4.03*	< 0.001
Time to motor block onset for each peripheral nerve (min)			
Median N	17.27 ± 4.21	8.62 ± 4.79*	< 0.001
Radial N	19.87 ± 5.08	9.11 ± 4.14*	< 0.001
Ulnar N	16.89 ± 4.03	6.87 ± 3.99*	< 0.001
Mc. N	19.38 ± 5.38	8.07 ± 3.27*	< 0.001
Time to onset of limb motor block	20.38 ± 4.91	10.33 ± 4.15*	< 0.001
Duration of sensory and motor block (hours)			
Sensory block	10.01 ± 2.31	13.65 ± 4.39*	< 0.001
Motor block	9.27 ± 2.37	12.84 ± 4.36*	< 0.001

Data are presented as mean ± SD. **P* value < 0.05: statistically significant. Group I: operating room group. Group II: warm group. Mc. N: Musculocutaneous nerve

Table 3. *Postoperative VAS score and number of patients who required diclofenac (N) in the studied groups.*

	Group I		Group II		*P*1 Value	*P*2 Value
	VAS (n = 45)	N	VAS (n = 45)	N		
0	0 (0–0)	0	0 (0–0)	0	1.0	….
1 h	0 (0–2)	0	0 (0–2)	0	0.2	….
2 h	0 (0–6)	0	0 (0–4)	0	0.3	….
4 h	8 (4–12)	2	0 (0–12)*	1	0.006	0.6
6 h	22 (15–26)	9	10 (0–20)*	6	< 0.001	0.3
8 h	33 (22–46)	33	18 (10–24)*	15*	< 0.001	< 0.001
12 h	22 (18–32)	43	22 (17–33)	27*	0.7	< 0.001
18 h	36 (27–44)	45	24 (20–38)*	42	0.002	0.07
24 h	22 (14–25)	45	22 (14–29)	45	0.3	….

Data are presented as median (IQ range) or number of patients. P1 value for VAS score and P2 for number of patients who required analgesia. **P* value < 0.05: statistically significant. Group I: operating room group. Group II: warm group.

Table 4. *Time to first analgesic requirements, number of doses of diclofenac, and total fentanyl consumption in postoperative 24 hours.*

		Group I (n = 45)	Group II (n = 45)	*P* Value
Duration of analgesia (h)		10.60 ± 2.77	13.94 ± 4.59*	< 0.001
Number of diclofenac doses in postoperative 24 h	Once	2 (4.4%)	18 (40%)*	< 0.001
	Twice	43 (95.6%)	27 (60%)*	
Fentanyl consumption in 24 h (µg)		78.13 ± 34.09	53.72 ± 37.89*	0.002

Data are presented as mean ± SD or number (%). **P* value < 0.05: statistically significant. Group I: operating room group. Group II: warm group.

increases the nonionized part (15,23), increases its membrane permeability, and accelerates its onset (16,24). Once the nonionized parts pass through the nerve membrane and gain access to the axoplasm, they equilibrate into ionized parts that bind to Na channels in a high concentration leading to a longer-lasting block (25).

This current study demonstrated that using warmed bupivacaine led to a significant acceleration in the onset of sensory block ($P < 0.001$) in the 4 peripheral nerves of the brachial plexus: radial, ulnar, median and musculocutaneous. Moreover, the onset of motor block was significantly accelerated in the 4 peripheral nerves ($P < 0.001$) in Group II when compared with Group I. These findings were in concordance with a previous study that demonstrated that warmed bupivacaine 0.5% to body temperature had significantly reduced both sensory and motor block onset of US-guided axillary block when compared with cold bupivacaine at 13° to 15°C (16). Similarly, warming ropivacaine to body temperature significantly fastened the onset of motor and sensory block in the radial, ulnar, medial, and musculocutaneous nerves following axillary block (26).

A recent study used Bain-mare (water bath) for warming LA, but it carries the risk of contamination (16). In the current study, dry heating of LA is a safer technique that minimizes the risk of infection (15). Moreover, the chemistry and stability of the LA solution were not affected by its warming to body temperature (15,27).

Heath et al (15) reported that warming of a mixture of 0.5% bupivacaine hydrochloride with adrenaline 1:200 000, and 1% prilocaine hydrochloride at 37°C for brachial plexus block for upper limb orthopedic surgery resulted in a significantly rapid onset of the sensory and motor block in the warm group when compared with bupivacaine at room temperature, which was in agreement with this present study results. However, in the current study, we warmed a single LA (bupivacaine alone) to body temperature. Warming LA with subsequent change in its pH rather than a mixture of LAs became the only factor to modulate the onset and duration of the block. Moreover, in the present study, US guidance rather than blind technique was used resulting in better visualization of the nerves leading to the higher success rate.

The influence of warming LAs on neuraxial block character had been showed in many studies (28,29). Liu et al (14) reported that the onset time for the sensory block at the T12, L3, and anal region dermatomes was significantly shorter after epidural anesthesia using lidocaine warmed to 37°C. Meanwhile, Arai et al (28) reported that warming hyperbaric bupivacaine 0.5% in spinal anesthesia to body temperature resulted in a significantly higher level at 20 minutes owing to the reduction of solution viscosity.

Table 5. *Patients' satisfaction score at 24 and 48 hours postoperatively.*

Patient Satisfaction Score		Group I (n = 45)	Group II (n = 45)	*P* Value
Satisfaction score at 24 h	Poor	0 (0%)	0 (0%)	0.7
	Fair	0 (0%)	0 (0%)	
	Good	0 (0%)	1 (2.2%)	
	Very good	2 (4.4%)	3 (6.7%)	
	Excellent	43 (95.6)	41 (91.1)	
Satisfaction score at 48 h	Poor	0 (0%)	0 (0%)	0.8
	Fair	0 (0%)	0 (0%)	
	Good	0 (0%)	1 (2.2%)	
	Very good	4 (8.9%)	5 (11.1%)	
	Excellent	41 (91.1)	39 (86.7)	

Data are presented as number of patients (%). *$P < 0.05$: statistically significant. Group I: operating room group. Group II: warm group.

The duration of sensory and motor block following injection of 30 mL bupivacaine in the supraclavicular approach at room temperature had been documented in previous studies. Kaur et al (1) reported 8.5 ± 0.77 and 8.45 ± 0.75 hours for sensory and motor block duration, respectively. Meanwhile, Venkatesh et al (21) reported 11.58 ± 3.03 hours for sensory and 12.94 ± 3.09 hours for motor blocks.

In the present study, a significant prolongation in the duration of sensory and motor blocks in hours was found in Group II ($P < 0.001$ for both values) when compared with the Group I (13.65 ± 4.39 vs. 10.01 ± 2.31, $P < 0.001$) and (12.84 ± 4.36 vs. 9.27 ± 2.3, $P < 0.001$), respectively. In agreement with the current results, a previous study showed that warming bupivacaine from 16°C to 37°C produced significant lengthening in the mean sensory and motor block duration in US-guided axillary block by approximately 20% (16).

Regarding the time for the first analgesic requirement in supraclavicular brachial plexus block using 30 mL bupivacaine in room temperature, the duration of effective analgesia was reported as 8.5 and 11 hours (1,30). The current study showed that there was a significant prolongation in the duration of postoperative analgesia in Group II when compared with Group I (13.94 ± 4.59 vs. 10.60 ± 2.77, $P < 0.001$). This was in agreement with Trabelsi et al (16) who reported a comparable prolongation (27%) in the duration of analgesia for the axillary block, 11 hours with warmed bupivacaine to 37°C versus 8 hours with cold bupivacaine at 16°C. Subsequently,

in the present study, the total 24-hour fentanyl consumption was significantly lower with warming bupivacaine to body temperature.

The current study had some limitation. First, the cast and dressings covering the operated limb made the postoperative assessment of the offset of the sensory and motor blocks, in a matter of individualized nerves, inaccessible. Second, the current study investigated the effect of only a single warming temperature on the supraclavicular block characteristics. Therefore we recommend further studies using different warming temperatures to achieve the optimum warming temperature. Third, the present study had a small sample size in a single center. Further multicenter studies are recommended to endorse the results of this study.

Conclusions

Injection of warm bupivacaine 0.5% in US-guided supraclavicular brachial plexus block for upper extremity orthopedic surgeries accelerated the onset of sensory and motor blockade. It significantly lengthened the duration of sensory and motor block, duration of effective analgesia, and significantly reduced the postoperative analgesic consumption.

References

1. Kaur H, Singh G, Rani S, et al. Effect of dexmedetomidine as an adjuvant to levobupivacaine in supraclavicular brachial plexus block: A randomized double-blind prospective study. *J Anaesthesiol Clin Pharmacol* 2015; 31:333-338.
2. Patil KN, Singh ND. Clonidine as an adjuvant to ropivacaine-induced supraclavicular brachial plexus block for upper limb surgeries. *J Anaesthesiol Clin Pharmacol* 2015; 31:365-369.
3. Parrington SJ, O'Donnell D, Chan VW, et al. Dexamethasone added to mepivacaine prolongs the duration of analgesia after supraclavicular brachial plexus blockade. *Reg Anesth Pain Med* 2010; 35:422-426.
4. Sadowski M, Tułaza B, Łysenko L. Renaissance of supraclavicular brachial plexus block. *Anaesthesiol Intensive Ther* 2014; 46:37-41.
5. Williams SR, Chouinard P, Arcand G, et al. Ultrasound guidance speeds execution and improves the quality of supraclavicular block. *Anesth Analg* 2003; 97:1518-1523.
6. Aliste J, Bravo D, Fernández D, et al. A randomized comparison between interscalene and small-volume supraclavicular blocks for arthroscopic shoulder surgery. *Reg Anesth Pain Med* 2018; 43:590-595.
7. Brummett CM, Williams BA. Additives to local anesthetics for peripheral nerve blockade. *Int Anesthesiol Clin* 2011; 49:104-116.
8. Laiq N, Khan MN, Arif M, et al. Midazolam with bupivacaine for improving analgesia quality in brachial plexus block for upper limb surgeries. *J Coll Physicians Surg Pak* 2008; 18:674-678.
9. McCartney CJ, Duggan E, Apatu E. Should we add clonidine to local anesthetic for peripheral nerve blockade? A qualitative systematic review of the literature. *Reg Anesth Pain Med* 2007; 32:330-338.
10. Robaux S, Blunt C, Viel E, et al. Tramadol added to 1.5% mepivacaine for axillary brachial plexus block improves postoperative analgesia dose-dependently. *Anesth Analg* 2004; 98:1172-1177.
11. Marashi S, Sharifnia H, Azimaraghi O, et al. Naloxone added to bupivacaine or bupivacaine–fentanyl prolongs motor and sensory block during supraclavicular brachial plexus blockade: a randomized clinical trial. *Acta Anaesthesiol Scand* 2015; 59:921-927.
12. Fulling PD, Peterfreund RA. Alkalinization and precipitation characteristics of 0.2% ropivacaine. *Reg Anesth Pain Med* 2000; 25:518-521.
13. Contreras-Dominguez V, Carbonell-Bellolio P, Sanzana ES, et al. Addition of sodium bicarbonate and/or clonidine to mepivacaine: Influence on axillary brachial plexus block characteristics. *Rev Esp Anestesiol Reanim* 2006; 53:532-537.
14. Liu F-C, Liou J-T, Li AH, et al. The effect of warmed ropivacaine to body temperature on epidural sensory block characteristics. *J Clin Anesth* 2010; 22:110-114.
15. Heath P, Brownlie G, Herrick M. Latency of brachial plexus block the effect on onset time of warming local anaesthetic solutions. *Anaesthesia* 1990; 45:297-301.
16. Trabelsi W, Gabsia AB, Lebbi A, et al. Effect of warming bupivacaine 0.5% on ultrasound-guided axillary plexus block. Randomized prospective double-blind study. *Orthop Traumatol Surg Res* 2017; 103:71-75.
17. Kohli S, Kaur M, Sahoo S, et al. Brachial plexus block: Comparison of two different doses of clonidine added to bupivacaine. *J Anaesthesiol Clin Pharmacol* 2013; 29:491-495.
18. Bijker JB, van Klei WA, Vergouwe Y, et al. Intraoperative hypotension and 1-year mortality after noncardiac surgery. *Anesthesiology* 2009; 111:1217-1226.
19. Lesser JB, Sanborn KV, Valskys R, et al. Severe bradycardia during spinal and epidural anesthesia recorded by an anesthesia information management system. *Anesthesiology* 2003; 99:859-866.
20. Deitch K, Chudnofsky CR, Dominici P. The utility of supplemental oxygen during emergency department procedural sedation and analgesia with midazolam and fentanyl: A randomized, controlled trial. *Ann Emerg Med* 2007; 49:1-8.
21. Venkatesh RR, Kumar P, Trissur RR, et al. A randomized controlled study of 0.5% bupivacaine, 0.5% ropivacaine and 0.75% ropivacaine for supraclavicular brachial plexus block. *J Clin Diagn Res* 2016; 10:UC09-UC12.
22. Morgan GE, Mikhail MS, Murray MJ. Local anesthetics. *J Clin Anesth* 2002;

3:193-201.

23. Kamaya H, Hayes JJ Jr, Ueda I. Dissociation constants of local anesthetics and their temperature dependence. *Anesth Analg* 1983; 62:1025-1030.
24. Berde CB, Strichartz GR. Local anesthetics. In: Miller RD, Eriksson LI, Fleisher LA, et al. (eds). *Miller's Anesthesia*. 7th ed. Philadelphia, Elsevier, Churchill Livingstone, 2009; 30:1031-1056.
25. Becker DE, Reed KL. Local anesthetics: Review of pharmacological considerations. *Anesth Prog* 2012; 59:90-102.
26. Lee R, Kim YM, Choi EM, et al. Effect of warmed ropivacaine solution on onset and duration of axillary block. *Korean J Anesthesiol* 2012; 62:52-56.
27. Dawson P, Bjorksten A, Duncan I, et al. Stability of fentanyl, bupivacaine and adrenaline solutions for extradural infusion. *Br J Anaesth* 1992; 68:414-417.
28. Arai Y-CP, Ueda W, Takimoto E, et al. The influence of hyperbaric bupivacaine temperature on the spread of spinal anesthesia. *Anesth Analg* 2006; 102:272-275.
29. Gölboyu BE, Aksun M, Ekinci M, et al. Effects of using 37°C bupivacaine on spinal block characteristics and shivering. *J Clin Anal Med* 2016; 7:89-93.
30. Tripathi D, Shah K, Shah C, et al. Supraclavicalar brachial plexus block for upper limb orthopedic surgery: A randomized, double blinded comparison between ropivacaine and bupivacaine. *Internet J Anesthesiol* 2012; 30:1-7.