Effects of Ultrasound-Guided Supraclavicular Block Using Bupivacaine-Dexmedetomidine or Bupivacaine Alone in Hemodynamics of Patients Undergoing Upper Limb Orthopedic Surgery

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Abstract- The aim of this study was to evaluate the effect of bupivacaine with dexmedetomidine in comparison with bupivacaine during supraclavicular block with ultrasound guide on the hemodynamics of patients undergoing upper limb orthopedic surgery. Eighty patients (40 patients in each group) who were candidates for upper limb orthopedic surgery randomly received 30 ml of bupivacaine alone (group 1) or 30 ml of bupivacaine with 20 µg of dexmedetomidine (group 2). The supraclavicular nerve block was performed using an ultrasound guide. Patients' hemodynamic data (including mean arterial blood pressure, heart rate per minute, respiration rate per minute, and peripheral blood oxygen saturation), the onset of action, and duration of sensory-motor block were compared between the two groups. The mean arterial blood pressure during surgery in group 2 was lower than in group 1, but the differences were not statistically significant. The onset of sensory and motor block in group 2 was significantly shorter than in group 1 (P=0.0001). The duration of sensory and motor block in group 2 was significantly longer than in group 1 (P=0.0001). During this study, none of the patients had hemodynamic disturbance or surgical complications. The addition of dexmedetomidine to bupivacaine during the supraclavicular block, in addition to hemodynamic stability of the patient during surgery, increases the duration of sensory and motor block.

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Keywords: Regional anesthesia; Dexmedetomidine; Bupivacaine; Supraclavicular nerve block

Introduction

As a group of major surgeries, orthopedic surgeries have remarkable therapeutic effectiveness, along with some specific complications (1), including pain, nausea, vomiting, and postoperative infections (2). In addition to patient discomfort, these complications can lead to immobility and decreased desire for physical activity in the affected patients, resulting in additional complications, including atelectasis, Deep Vein Thrombosis (DVT), and constipation (3). There are several techniques for reducing the post-surgical complications and duration of recovery ward hospitalization, including regional anesthetic techniques and systemic analgesic methods (4). Among several methods for pain alleviation and comfort improvement of patients undergoing orthopedic surgeries, the brachial plexus block is highly effective. The perineural nerve block is a commonly used technique applied as an adjunct anesthetic method combined with general anesthesia or as an alternative for that (4). It is especially preferred because it results in efficient post-surgical analgesia (5). In general, brachial plexus blockade is performed using the axillary, supraclavicular, or interscalene approaches

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(6). Another alternative approach for brachial plexus block, introduced in the early twentieth century, is the infraclavicular approach (7). The ultrasound guide in peripheral anesthesia allows the anesthesiologist to precisely inject the local anesthetic into the connective tissue sheath surrounding the nerve (8). Advances in ultrasound technology, especially in high-definition ultrasound imaging, allowed us to detect the connective tissue sheath surrounding the nerve (9).

The brachial plexus nerves, surrounded by the brachial plexus sheath, are located in the supraclavicular cavity (10). Ultrasound-guided injection of local anesthetic into the covering sheath of this plexus, known as the targeted intracluster injection, leads to faster anesthesia of this nerve plexus (11). An increased dose of local anesthetic can increase the anesthesia duration, along with the risk of related systemic and neurological complications (12). According to animal and human studies, high-dose intravenous injection of bupivacaine leads to a dose-dependent and negative inotropic effect (13). The adjunct analgesic strategy is an alternative method that can increase the anesthesia duration and reduce the related side effects with lower doses of local anesthetic (12). Dexmedetomidine is a highly selective agonist for α2-adrenergic receptors that has sedative and analgesic effects (14). As an adjuvant anesthetic, this drug can reduce the need for higher doses of other local anesthetics and the sympathetic response caused by the injection-induced stress. In addition, it has cardioprotective effects against myocardial ischemia (15). Up to now, the studies on the effect of dexmedetomidine-bupivacaine co-injection on the Heart Rate (HR) and Mean Arterial Pressure (MAP) of patients have yielded controversial results. Therefore, the present study aimed to compare the effects of bupivacaine injection and dexmedetomidine-bupivacaine co-injection, which are used in ultrasound-guided brachial plexus block through the supraclavicular approach, on the hemodynamics of the patients undergoing upper limb orthopedic surgery.

Materials and Methods

The present study was a case-control study. The patients presented to the Shariati Hospital from February 2021 to July 2021 who were candidates for elective orthopedic surgery on the distal upper limb were included in the study. The patients and their families and friends fully explained the study design and objectives. Then, those willing to participate gave informed written consent. The inclusion criteria were the patients aged 20-60 years with a Body Mass Index (BMI) of less than 35 who were included in class 1 or 2 of the American Society of Anesthesiologists physical status (ASA Class). The exclusion criteria included brachial plexus block failure, the operation duration of longer than 180 minutes, the need for general anesthesia, a previous history of drug hypersensitivity, and severe cardiac, pulmonary, or renal disease. The participants were randomly divided into two groups: the case group and the control group. The case group underwent ultrasound-guided brachial plexus block through the supraclavicular approach using 30 ml of 0.5% bupivacaine and 20 µg dexmedetomidine solution, while the control group received 30 ml of 0.5% bupivacaine and 0.2 ml normal saline.

MAP, HR, peripheral blood oxygen saturation ($SatO_2$), and Respiratory Rate (RR) of the patients were recorded at the following times: at the beginning of the surgery, 5 and 15 minutes after operation initiation, then every 15 minutes until the end of the surgery, in the recovery ward, and when leaving the recovery ward. Also, the time of sensory and motor block onset, sensory and motor block duration, the first time the patient asked for opioid analgesics, and opioid dose used within 24 hours post-surgery were recorded in both groups. Upon the patient's arrival in the operating room, they underwent standard monitoring with pulse oximetry, electrocardiography, and non-invasive automatic blood pressure monitoring. Moreover, nasal oxygen with an oxygen flow of 3 liters per minute and venous access using a catheter size 20 on the contralateral upper limb were provided for the patients. During the supraclavicular blockade, the patient was supine with his/her head slightly turned to the opposite side and the affected upper limb extended along the body. The patients underwent injections with the pre-prepared solutions based on their groups and were assessed for sensory and motor block 5-, 10-, 15-, and 30-minutes post-injection and then every 10 minutes after the operation initiation. The sensory block was evaluated using the pinprick test, and the sense of the affected limb was compared with the contralateral limb. Moreover, a verbal scoring system was used to evaluate the patient's sensory perception of the dermatomes innervated by the ulnar, median, radial, and musculocutaneous nerves. In this system, the patient reported a score of 10 for normal sense and 0 for complete anesthesia against painful stimulations based on the Visual Analogue Scale (VAS) (16).

The motor block was evaluated and scored in the muscle groups innervated by the musculocutaneous, radial, ulnar, and median nerves through the movements of elbow flexion, thumb abduction, thumb adduction, and

thumb opposition, respectively, based on the Lovett Rating Scale as follows:

No contraction or movement=0, visible contraction without movement=1, movement on a flat surface without overcoming the gravity=2, the limb can be lifted by overcoming the gravity but cannot be kept elevated=3, the limb can be lifted and kept elevated, but it is weak=4, normal contraction and movement=5.

The sensory block duration was defined as the duration between the onset of complete sensory block (score 0 in the VAS) and the first postoperative pain in any dermatomes innervated by the ulnar, median, radial, or musculocutaneous nerves. Moreover, the motor block duration was defined as the duration between the onset of complete motor block (score 0 on the Lovett Rating Scale) and regaining the normal motor ability in the muscles innervated by the ulnar, median, and radial, or musculocutaneous nerves. The data were recorded in researcher-made forms. Data analysis was performed by the SPSS software. The sample size was calculated as 40 for each group considering the following assumptions: The change rate of 20% as a clinically significant change, the assumed mean change rates of 17% in the control groups and 20% in the case group, a Standard Deviation (SD) of 8%, α=0.05, the statistical power of 95%, and a margin of error of 3%. The normal distribution of the quantitative variables was evaluated, and their comparisons were performed using the Mann-Whitney U test or independent t-test, while the chi-squared test was used for qualitative variables. Moreover, the comparisons for the quantitative variables with repeated measures were performed using ANOVA. The significance level was considered as 0.05 for all tests.

The study protocol was approved by the ethics committee of Tehran University of Medical Sciences under the code name IR.TUMS.MEDICINE.REC.1395.1566 1395/11/10 and IRCT Number: IRCT2016112631108N1.

Results

The mean duration between the anesthetic injection and the onset of sensory block was significantly shorter in Group 2 (6.07±0.57 min) than in Group 1 (12.33±1.09 min) (*P*=0.0001). This fact was also true for the mean duration between the anesthetic injection and the onset of motor block, which was significantly shorter in Group 2 (10.92±1.22 min) compared to Group 1 (20±1.06 min) (*P*=0.0001). Moreover, the mean duration of sensory block was significantly longer in Group 2 (644.63±29.62 min) compared to Group 1 (504.13±65.57 min) (*P*=0.0001). The same was true for the mean duration of motor block (Group 1: 601.7±30.20 min, Group 2: 451.88±61.93 min, *P*=0.0001).

The mean time of the first request for opioid analgesic after the operation was significantly delayed in Group 2 (20.60±3.19 hours) compared to Group 1 (17.75±4.04 hours) (*P*=0.001). Moreover, the mean dose of opioids received by the patients within the first 24 hours post-surgery was significantly lower in Group 2 (5.37±3.07 mg) compared to Group 1 (9.87±5.12 mg) (*P*=0.0001). Also, the patient postoperative satisfaction was significantly higher in Group 2 than in Group 1 (*P*=0.025). The VAS score of all the patients was 0 following 6 hours from the surgery (*P*=0.561), while the mean VAS scores of 12, 18, and 24 hours post-surgery were lower in Group 2 compared to Group 1 (*P*=0.347, *P*=0.128, and *P*=0.344, respectively); however, these differences were not significant.

The MAP measured at the times of 5, 15, 30, 45, 60, 75, 90, 105, 120, 135, 150, and 165 minutes following operation initiation was lower in Group 2 than in Group 1; however, these differences were not significant. Moreover, upon arrival in the recovery ward and when leaving this ward, the mean MAP was insignificantly lower in Group 2 than in Group 1 (*P*=0.899 and *P*=0.967, respectively). Also, The HR measured 5, 15, 30, 45, 60, 75, 90, 105, 120, 135, and 150 minutes following operation initiation was lower in Group 2 than in Group 1, with insignificant differences. The HR changes upon arrival to recovery were higher in Group 2 than in Group 1 (*P*=0.793), while the same variable was lower when leaving the recovery in Group 2 than in Group 1 (*P*=0.415). The mean RR measured 5, 15, 30, 45, 60, 75, 90, 105, 120, and 135 minutes following operation initiation was significantly lower in Group 2 compared to Group 1 (*P*=0.001). Finally, the mean peripheral blood oxygen saturation at the times of 5, 15, 30, 45, 60, 75, 90, 105, 120, and 135 minutes following operation initiation was significantly lower in Group 2 compared to Group 1 (*P*=0.0001).

Discussion

Up to now, the studies on the effect of dexmedetomidine-bupivacaine co-injection on HR and MAP have yielded controversial results. Therefore, the present study aimed to investigate the effect of dexmedetomidine addition on the hemodynamics of patients undergoing upper limb orthopedic surgery using bupivacaine for the brachial plexus block. The hemodynamic variables investigated in the present study

included HR, MAP, $SatO_2$, and RR. Our results showed higher hemodynamic stability in the group receiving dexmedetomidine, observed in all the times investigated. However, no complication was found in either of the groups.

According to our findings, the mean duration of sensory and motor blocks was significantly higher in the group receiving dexmedetomidine. A study by Marhofer et al. investigated 36 participants undergoing ulnar nerve block who were divided into 3 groups: the first group only received 3 ml of ropivacaine (0.75%), the second group received 3 ml of ropivacaine (0.75%), and 20 µg of local dexmedetomidine and the third group received 3 ml of ropivacaine (0.75%) and 20 µg of systemic dexmedetomidine. No case of bradycardia (more than 20% reduction in HR compared to pre-intervention) or hypotension (more than 20% reduction in blood pressure compared to pre-intervention) was observed during the study, which was compatible with our findings (17).

In a study by Fritsch *et al*., 62 patients underwent ultrasound-guided interscalene block combined with general anesthesia for elective shoulder surgery. The patients were divided into 2 groups. The first group underwent local anesthesia with 12 ml of ropivacaine 0.5%, while the second group received 12 ml of ropivacaine 0.5% with 150 µg of dexmedetomidine. The authors reported that the second group had reduced HR compared to the first group. However, the blood pressure remained stable (18). In our study, all the hemodynamic indicators were stable, and no intergroup difference was found.

Moreover, another study by Esmaoglu *et al.*, Included 60 patients undergoing hand and forearm surgery who were randomly divided into two groups with equal numbers. The first group received 40 ml of levobupivacaine 0.5% and 1 ml of normal saline, while the second group received 40 ml of levobupivacaine 0.5% and 1 ml of dexmedetomidine. The authors indicated a higher rate of bradycardia in the second group, showing that the optimal dose of dexmedetomidine should be more investigated (19). However, according to our results, the fixed dosage used in our study led to good effectiveness and hemodynamic stability in the patients.

Also, Obayah *et al*., investigated 30 pediatric patients undergoing complete cleft palate repair surgery who were randomly divided into two groups with equal numbers. The first group only received 0.25% bupivacaine, while the second group received 0.25% bupivacaine and 1 µg/kg dexmedetomidine. The authors reported no intergroup difference in hemodynamic variables of MAP and HR, which is compatible with our results (20).

A double-blinded study by Rancourt *et al*., investigated 14 patients who were randomly divided into 2 groups. All the participants underwent an ultrasound-guided tibial nerve block at a site 4-5 cm proximal to the internal malleolus. The first group only received 10 ml of ropivacaine 0.5%, while the second group received 1 µg/kg of dexmedetomidine in addition to 10 ml of ropivacaine 0.5%. All the participants underwent monitoring for bradycardia and hypotension. According to the findings, the mean values of systolic and diastolic blood pressure were decreased between minutes 60 and 480. Moreover, two patients had a 30% reduction in systolic blood pressure compared to the pre-injection blood pressure. Also, the HR was not significantly different between the groups (21). These findings were relatively compatible with our findings. However, we reported no case of hypotension.

A double-blinded study by Das *et al*., investigated 90 patients aged between 20 and 40 years old who were undergoing elective hand surgery under brachial plexus block. The participants were randomly divided into two groups of 45. The first group received 30 ml of ropivacaine 0.5% and 75 µg of clonidine, while the second group received 30 ml of ropivacaine 0.5% and 100 µg of dexmedetomidine. The authors reported significantly lower levels of intraoperative hemodynamic variables in the second group; however, no significant side effect was observed. 4 patients in the second group developed bradycardia, which was resolved with atropine, while no bradycardia was observed in the first group. Also, both groups had no case of significant hypotension (22). These findings are compatible with our results; however, we observed no side effects requiring additional treatment in either of the groups.

In a double-blinded study by Kathuria *et al*., 60 patients with ASA type 1 and 2 underwent brachial plexus block using the supraclavicular approach for elective surgery on the upper limb. The patients were randomly divided into 3 groups. The first group received 30 cc of ropivacaine 0.5%, while the second group received 30 cc of ropivacaine 0.5% and 50 µg of dexmedetomidine. Moreover, the third group received 30 cc of ropivacaine 0.5% and a concurrent IV infusion of 50 µg dexmedetomidine in normal saline. No respiratory distress, hypoxia, nausea, vomiting, or other complication was observed (23). These results, which are compatible with our results, indicate the safety of this intervention.

Memiçs *et al*., investigated 30 patients admitted for elective hand surgery who were randomly divided into two groups. The first group received 40 ml of lidocaine 0.5% and 1 ml of normal saline, while the second group

received 40 ml of lidocaine 0.5% and 0.5 µg/kg of dexmedetomidine. The authors reported no need for bradycardia or hypotension treatment, the oxygen saturation within the normal range for all the patients, and no significant intergroup difference in intraoperative and postoperative MAP, HR, and oxygen saturation (24), which was compatible with our findings.

According to a study by Kalappa *et al*., on 60 patients undergoing surgery, dexmedetomidine addition with a dose of 1 µg/kg led to a significantly longer analgesia duration than the ropivacaine alone. However, the hemodynamic side effects were not significantly different between the groups. These findings are compatible with our results (25). Another study by Kamal *et al*., on 60 pediatric patients aged 2-10 years old who underwent surgery showed that dexmedetomidine addition with a dose of 2 µg/kg caused a significantly longer duration of analgesia compared to ropivacaine alone. Moreover, those receiving dexmedetomidine were more sedated and had a better sleep. However, hemodynamic side effects were not significantly different between the groups, which was compatible with our results (26).

In general, it can be concluded that effective postoperative pain management involves a multimodal approach using different drugs with different mechanisms and administration methods (27-29). Nowadays, various treatments are available for postoperative pain reduction, and each of these alternatives has its own effectiveness (30). In addition to analgesic effects, these methods can stabilize the intraoperative and postoperative hemodynamics of the patients. Considering our results and by comparing these results with those of the previous studies, we concluded that the hemodynamic changes due to administration of 20 µg dexmedetomidine combined with bupivacaine for supraclavicular block used for upper limb orthopedic surgery are not significant or worrying. Therefore, this drug combination can be recommended due to higher patient satisfaction and longer sensory and motor block duration. However, it is recommended to perform multicenter studies with larger sample sizes to achieve more valid results and compare the obtained findings with those of the present study.

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