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Research Article

A Comparative Study of the Effect of Adding Dexmedetomidine, Dexamethasone and Sodium Bicarbonate to Ropivacaine in Ultrasound Guided Supraclavicular Block on the Quality of the Block in Orthopedic Surgery

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ABSTRACT

Background: Brachial plexus block, particularly the supraclavicular approach. The choice of local anesthetic and the addition of adjuvants can significantly impact the quality and duration of the block. This study aimed to compare the effects of three different additives dexmedetomidine, dexamethasone, and sodium bicarbonate when combined with ropivacaine in ultrasound-guided supraclavicular blocks.

Methods: A double-blind randomized clinical trial was conducted with 103 patients undergoing upper limb orthopedic surgery. Patients were divided into four groups, and each group received one of the following combinations: ropivacaine with dexmedetomidine, ropivacaine with dexamethasone, ropivacaine with sodium bicarbonate, or ropivacaine alone (control). The onset and duration of motor and sensory blocks, complications, patient and surgeon satisfaction, and vital signs were assessed.

Results: The study revealed that all additives, particularly dexmedetomidine, significantly influenced the onset and duration of motor and sensory blocks compared to the control group. Dexmedetomidine demonstrated the fastest onset and prolonged the block, while dexamethasone and sodium bicarbonate also had substantial effects. Importantly, the additives did not lead to an increase in complications, and patient and surgeon satisfaction remained consistent across all groups.

Conclusion: The findings of this study suggest that dexmedetomidine is a promising adjuvant for enhancing the quality and duration of supraclavicular blocks.

Introduction

Brachial plexus block, a pivotal technique in regional anesthesia, has gained widespread use for upper limb orthopedic surgeries, excluding shoulder procedures [1]. In contrast to general anesthesia, this approach effectively suppresses pain transmission and not only serves as an intraoperative anesthetic method but also extends postoperative analgesia [2-3]. Among the various approaches to brachial plexus block, the supraclavicular technique has emerged as a prevalent choice in clinical practice [4]. The integration of ultrasound guidance for needle placement has significantly enhanced the precision of drug injection, thereby reducing adverse effects [5]. This procedure typically involves injecting a local anesthetic solution of 20 to 30 ml in close proximity to the subclavian artery, just above the clavicle [6].

The selection of an appropriate local anesthetic is influenced by several factors, including the speed of block onset, the duration of the block's effect, and the quality of conduction block [7]. For instance, lidocaine and mepivacaine, at concentrations of 1% to 1.5%,

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produce anesthesia within 10 to 20 minutes but offer only 2 to 3 hours of effect. In contrast, ropivacaine at 0.5% and bupivacaine at concentrations of 0.375% to 0.5% exhibit a slower onset of action but provide extended analgesic effect, lasting at least 6 to 8 hours [8].

To further enhance the efficacy of local anesthetics in brachial plexus blocks, various adjuvant drugs are utilized, each serving distinct purposes [9]. Among these adjuncts are agents such as epinephrine, sodium bicarbonate, fentanyl, clonidine, magnesium sulfate, and dexmedetomidine [10-11]. Dexmedetomidine, a highly selective alpha-2 adrenergic agonist [12], which causes hypotension and bradycardia, and the hemodynamic stability of the patient during surgery and reduces the need for opioid [13], also due to its recognized for its capacity to improve block quality, prolong analgesic duration, and expedite the onset of local anesthesia [14-16]. A meta-analysis of 12 clinical trials conducted by Dai et al. demonstrated that the combination of dexmedetomidine with ropivacaine yielded faster onset, superior block quality, and extended block duration [17]. In a separate clinical trial by Kor et al., the utilization of dexamethasone, sodium bicarbonate, and indomethacin as adjuvants to ropivacaine in supraclavicular blocks revealed that the combination of these two adjuvants offered enhanced acceleration of block onset and prolonged pain-free periods [18]. However, no previous study has directly compared the effects of adding dexmedetomidine, sodium bicarbonate, and dexamethasone to ropivacaine in terms of block onset, block quality, and analgesic duration. As such, the present study was designed to address this gap, with the objective of comparing the effects of these additives in supraclavicular blocks using ropivacaine during upper limb orthopedic surgery.

Methods

Study Design and Participant Selection

This investigation was carried out as a double-blind, randomized clinical trial involving patients referred for upper limb surgical procedures spanning from the lower third of the arm to the distal limb. The study was carried out in Isfahan city in 2023, specifically in Isfahan hospitals. Ethical considerations were scrutinized and approved by the Isfahan University of Medical Science Committee for Ethics in Research, with approval granted under the code IR.MUI.MED.REC.1401.019. The clinical trial protocol received approval under the code IRCT20140129016415N.

Inclusion criteria comprised individuals aged 18 years and older, weighing between 50 and 90 kg (lean body mass), with American Society of Anesthesiologists (ASA) physical status classification of 1 or 2. Exclusion criteria included a known allergy to any of the drugs used in the study, presence of infectious lesions at the block site, coagulation disorders, or use of anticoagulant medications. Any change in the surgical plan prompted patient withdrawal from the study.

Sample size calculation considered an alpha level of 5%, beta of 20%, and an effect size of 0.7. This calculation yielded a total of 120 patients, who were subsequently randomly allocated into one of four equally sized groups using random allocation software.

Preoperative Procedures

Upon obtaining informed consent, patients received detailed information on how to evaluate sensory and motor block effects following the procedure. Subsequently, patients were transferred to the procedure room, where baseline vital signs, including heart rate (HR), blood pressure (BP), and hemoglobin oxygen saturation (SpO2), were measured and documented.

Block Procedure

To perform the supraclavicular block, patients were positioned semi-sitting at a 30-degree angle under ultrasound guidance. The head and neck were appropriately oriented, and the patients were connected to monitoring equipment for continuous evaluation of blood pressure, electrocardiogram (EKG), and SpO2. Oxygen was administered at a rate of 2-4 liters per minute through a nasal cannula. Intravenous midazolam was incrementally administered (1 mg at 3-minute intervals) until the desired level of sedation was attained, characterized by spontaneous eye closure.

The supraclavicular block was then performed under ultrasound guidance by a trained operator, with the local anesthetic (ropivacaine 0.5% at 30 ml) being injected in two aliquots: one at the pocket corner and the other in the center of the brachial plexus. All injections were performed using a 22-gauge spinal needle connected to an extension tube.

Drug Combinations

The additives studied in conjunction with the local anesthetic (ropivacaine) were prepared in the following manner and delivered to the operator in identically coded syringes:

Group 1 received 30 micrograms of dexmedetomidine added to the drug in 1 ml of normal saline.

Group 2 received 0.6 ml of 7.5% sodium bicarbonate added to the medication, brought up to 1 ml with normal saline.

Group 3 was administered 4 mg (1 ml) of dexamethasone added to the medication.

The control group received 1 ml of normal saline added to the medication.

The codes remained sealed until the conclusion of sample collection and subsequent statistical analysis.

Assessment of Block Efficacy

Following the completion of the block procedure, movement and sensory block effects were assessed at 3-minute intervals. Motor block evaluation involved two examinations:

Asking patients to bring the tips of their index finger and thumb together while keeping the other fingers extended.

Observing the maintenance of the forearm in a 90-degree position, with the arm held perpendicular to the patient's body by the operator.

Sensory block assessment was conducted by applying a blunt needle to three specific points: the dorsal hand, forearm, and arm.

Upon achieving appropriate anesthetic conditions for the surgical intervention, patients were transferred to the operating room, where the surgical procedure was carried out under continuous monitoring. Sedation during the procedure was provided using 1 to 3 mg of midazolam and 50 to 100 micrograms of fentanyl. In cases of patient restlessness or intolerance, propofol infusion was initiated (0.05-0.2 mg/kg/h). The patient's level of relaxation and pain relief was recorded at 15-minute intervals during the procedure.

Postoperative Evaluation

Following the completion of the surgical procedure, patients' postoperative pain and immobility were assessed at 5-minute intervals. Measurements included heart rate, respiratory rate, arterial blood oxygen saturation, and blood pressure before drug administration, at 15-minute intervals until discharge from the recovery room. Additional measurements included the amount of sedation and narcotic drugs administered during the operation and recovery. The level of sedation was measured by Richmond agitation score [19], the time intervals between drug administration and the onset of numbness in three different regions, and the return of sensation and movement in the limb. Patient agitation and immobility levels, assessed every 15 minutes during the procedure, as well as the degree of satisfaction reported by the surgeon and the patient regarding anesthesia and limb immobility, were measured and documented using the Visual Analog Scale (VAS).

Additionally, the incidence of complications, such as hypotension, hypertension, bradycardia, tachycardia, desaturation, or apnea, was evaluated and recorded.

Statistical Analysis

The collected data were entered into SPSS 25 statistical software. Quantitative variables were analyzed using ANOVA, while repeated continuous quantitative variables were analyzed using repeated measures ANOVA. Qualitative variables were assessed using the chi-squared statistical test at a significance level of 0.05. Grading of patient movement intensity ranged from complete immobility (0) to high movement (3) affecting the surgery.

Results

A total of 204 patients were initially assessed for inclusion in the study. However, 53 patients did not meet the inclusion criteria, and 26 patients declined to undergo surgery under regional anesthesia. Ultimately, 125 patients were enrolled in the study and were randomly assigned to one of four groups. During the block procedure, nine patients were excluded due to technical issues encountered prior to drug administration, and an additional 13 patients were excluded post-drug administration due to extended surgery duration (eight patients) or changes in the surgical plan (five patients). Statistical analysis was conducted based on data collected from the remaining 103 patients (Figure 1).

Of the 103 patients included in the study, 26 were female, and the remaining 87 were male (Table 1). There were no significant gender-based differences among the four groups (P-value=0.600).

The age of the participants ranged from 18 to 65 years, with no statistically significant differences in age distribution among the four groups (P-value=0.12).

Vital Signs and Intraoperative Monitoring

During the study, vital signs, such as heart rate, blood pressure, and hemoglobin oxygen saturation, were regularly monitored. In (Table 2) there were no significant differences observed among the four groups for intraoperative systolic pressure (P=0.592), heart rate (P=0.716), hemoglobin oxygen saturation (P=0.757), and Richmond Agitation Score relaxation level (P=0.751).

Onset and Duration of Block

The primary outcomes of this study included the onset and duration of motor and sensory blocks. All additives, namely dexmedetomidine, dexamethasone, and sodium bicarbonate, showed statistically significant differences in these parameters compared to the control group.

Dexmedetomidine demonstrated the shortest onset time for motor and sensory blocks (motor block: 1.25±9.96, sensory block: 1.36±15.00).

The combination of ropivacaine and sodium bicarbonate exhibited the second shortest onset time for motor and sensory blocks (motor block: 1.90±13.62).

The combination of dexamethasone and ropivacaine showed intermediate results in terms of onset (motor block: 1.49±18.00) (Table 3).

Duration of the blocks was also significantly different among the groups, indicating that the additives influenced the duration of the block's effect.

Complications

Complications, including decreased hemoglobin oxygen saturation, hypotension, hypertension, tachycardia, and bradycardia, were observed during the study. However, the four study groups did not show statistically significant differences concerning these complications.

Patient and Surgeon Satisfaction

Both patient and surgeon satisfaction with anesthesia and limb immobility were assessed. The study found no statistically significant differences between the four study

groups regarding these satisfaction measures (patient satisfaction: P=0.923, surgeon satisfaction: P=0.741).

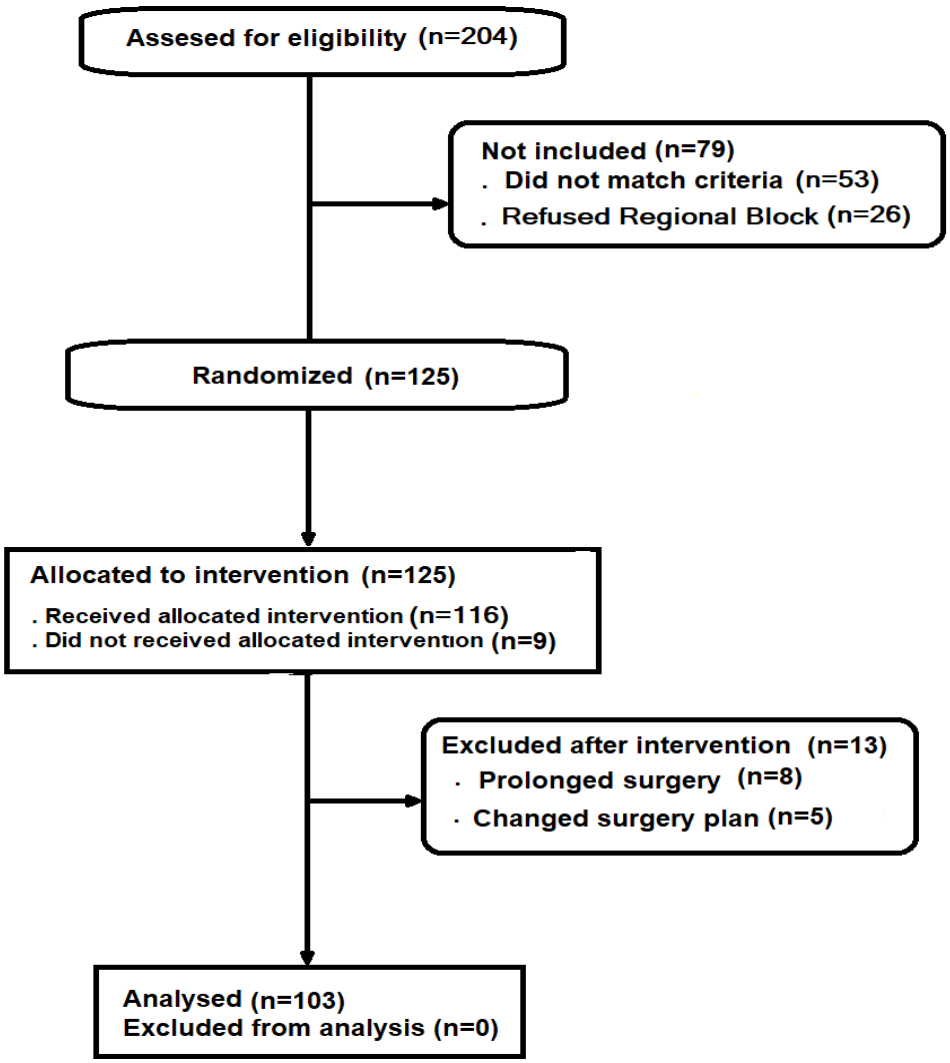

Figure 1- Flowchart of the study

Table 1- Comparison of variables and demographic characteristics of patients in the groups

Variables	Dexmedetomidine (N=26)	Sodium Bicarbonate (N=26)	Dexamethasone (N=26)	Control (N=25)	P value
Age (yrs.)	33.31± 12.53	41.58± 14.02	41.92± 13.48	39.68 ±15.84	0.13
Weight (kg)	75.27 ± 1.73	71.05 ± 1.73	73 ± 1.43	72.15 ± 1.53	0.12
Height (cm)	169.05 ± 1.33	168.91 ± 1.11	170.41 ± 1.02	168.41 ± 1.02	0.54
Gender(%)n	F (42.5%) 4	F (60%) 2	F (37%) 5	F (37%) 5	0.60
	M (55%) 22	M(40%) 24	M(62.5%)21	M(62.5%) 20	

Table 2- distribution of complications in study groups

Variables	Tachycardia	Bradycardia	Hypotension	Hypertension	Desaturation
dexmedetomidine	5	1	3	3	3
sodium bicarbonate	8	1	2	6	1
dexamethasone	3	2	5	4	4
Control	4	0	1	1	1
P value	0.33	0.56	0.33	0.24	0.36

Table 3- Time to initiation and duration of motor and sensory block in study groups

Variables	Initiation	Initiation	Duration	Duration
Group	Sensory block	Motor block	Sensory block	Motor block
dexmedetomidine	309.42±24.89	173.27±16.18	15.00±1.36	9.96±1.25
sodium bicarbonate	240.15±37.00	154.69±17.36	19.73±1.71	13.62±1.90
dexamethasone	231.92±34.15	150.38±20.40	18.00±1.49	14.23±1.28
Control	237.80±34.61	145.80±19.07	26.04±1.24	17.52±1.16
P value	0.000	0.000	0.000	0.000

Discussion

The brachial plexus block, particularly the supraclavicular approach, plays a vital role in providing effective anesthesia for upper limb orthopedic surgery. This comparative study aimed to assess the impact of adding dexmedetomidine, dexamethasone, and sodium bicarbonate to ropivacaine in ultrasound-guided supraclavicular blocks and evaluate their effects on the speed, duration, and quality of the block.

Local Anesthetic Selection

The choice of local anesthetic is crucial in brachial plexus blocks. Ropivacaine and bupivacaine are preferred for their longer-lasting effects compared to lidocaine and mepivacaine. This study used ropivacaine 0.5% as the baseline local anesthetic for all groups.

Additives

The addition of drugs to local anesthetics is a common practice to improve the quality and duration of regional blocks [20]. This study focused on three different additives: dexmedetomidine, dexamethasone, and sodium bicarbonate.

Dexmedetomidine: Dexmedetomidine, a selective alpha-2 agonist, has been shown to enhance block quality, prolong analgesia, and expedite the onset of the local anesthetic. A meta-analysis by Dai et al. [17] supported its use, citing faster onset, better block quality, and longer duration when combined with ropivacaine.

Dexamethasone: The study by Kour et al. [18] examined dexamethasone as an adjuvant for ropivacaine in supraclavicular block and found that this combination accelerated block onset and prolonged its duration. However, this study aimed to compare dexamethasone with other additives to assess its relative effectiveness.

Sodium Bicarbonate: Sodium bicarbonate is known for its ability to increase the pH of local anesthetic solutions, potentially hastening the onset of action. It was included in the study as an additive [21].

Patient Characteristics

The study included 103 patients who underwent upper limb orthopedic surgery, and the groups were well-balanced in terms of gender and age.

Vital Signs and Intraoperative Monitoring:

During the study, vital signs and intraoperative monitoring were similar across the groups, indicating that the baseline conditions were maintained consistently.

Onset and Duration of Block

The primary outcomes of the study included the onset and duration of motor and sensory blocks. All additives, including dexmedetomidine, dexamethasone, and sodium bicarbonate, showed statistically significant differences in these parameters compared to the control group.

Dexmedetomidine demonstrated the fastest onset of motor and sensory blocks.

Ropivacaine combined with sodium bicarbonate had the second-fastest onset.

Dexamethasone and ropivacaine combination showed intermediate results in terms of onset.

The duration of blocks was also significantly different among the groups, suggesting that additives influenced the duration of block effect.

Complications

The study assessed the occurrence of complications during the procedure, including decreased hemoglobin oxygen saturation, hypotension, hypertension, tachycardia, and bradycardia. Importantly, no significant differences were observed between the groups for these complications, indicating that the additives did not lead to increased adverse events.

Patient and Surgeon Satisfaction

Patient and surgeon satisfaction with anesthesia and limb immobility are crucial measures of the success of regional anesthesia. In this study, there were no significant differences between the groups regarding patient and surgeon satisfaction.

Just as it has been mentioned a great amount of effort is currently being made to increase the quality of local blocks in the extremities. One of such measures is the addition of dexamethasone to local anesthetics which has shown promising results in improving the quality of blocks and reducing post-operative pain.

Moreover, two more drugs were used in this study, in order to increase the quality of axillary block, which included sodium bicarbonate and dexamethasone, with a difference that bicarbonate was used in all the patients

and only under such circumstances there can be something stated about the effects of dexamethasone.

Previous studies showed that adding corticosteroids to local anesthetics resulted in the lengthening of the duration of peripheral nerve blocks [22-24].

In a study, McCormack used a combination of 20 cc mepivacaine, 20 cc bupivacaine and 0.2 cc epinephrine to perform sensory and motor block in clinical wards. In one pf these groups 40 mg methylprednisolone was added to the combination. The increase in sensory block in the group with a corticosteroid was significantly higher than the control group. This was also witnessed in the present study such that adding dexamethasone increased the duration of block. Furthermore, in the above study adding methylprednisolone increased the duration of motor block [25].

Although corticosteroids have been used successfully to treat post-operative pain, there is still some controversy about this topic and there have been varying results from different studies [26-27].

In the present study, the severity of post-operative pain during the initial stages after surgery was significantly lower in the dexamethasone group compared to the bicarbonate group, but with the passage of time, the two groups were similar in this regard.

The use of corticosteroids as an adjuvant in aiding local anesthetics in peripheral nerve blocks has rarely been demonstrated and its mechanism of action is not well known.

It appears that corticosteroids cause vasoconstriction upon local use. The vasoconstrictive effects of local corticosteroid use are generated by the classic corticosteroid receives [28-29].

On the other hand, dexmedetomidine has a high affinity to alpha-2 receptors and its optimal dosage depends on these receptors which include sedative, analgesic and hemodynamic effects. Previous studies have shown that dexmedetomidine has been used at a dosage of 30-100 micrograms in brachial plexus blocks (BPBs) [30-31].

In a study by Yoshitomi which used dexmedetomidine, the initiating time of sensory and motor blocks were reduced (K) which was compatible with the current study in which the rapid initiation of the block and lengthening of the sensory and motor block occurred.

In a study by Sahu in which dexmedetomidine and dexamethasone were studied, it was demonstrated that in the dexmedetomidine group the start of the block was more rapid and duration of the block was longer [32].

Conclusion

In conclusion, this comparative study explored the effects of dexmedetomidine, dexamethasone, and sodium bicarbonate as additives to ropivacaine in ultrasound-guided supraclavicular blocks for upper limb orthopedic surgery. The findings suggest that dexmedetomidine exhibited the fastest onset of motor and sensory blocks and influenced block duration, making it a promising adjuvant. While dexamethasone and sodium bicarbonate also had significant effects, their relative advantages need further consideration. Importantly, these additives did not result in increased complications or reduced patient and surgeon satisfaction. This study contributes valuable insights into optimizing supraclavicular blocks for upper limb orthopedic surgery and sets the stage for further research into the relative advantages of these additives in regional anesthesia.

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