Original Article

# A Prospective, Randomized, Comparative Study between Dexmedetomidine and Buprenorphine as an Adjuvant to Ropivacaine in Ultrasound-guided Supraclavicular Brachial Plexus Block for Upper Limb Orthopaedic Surgeries

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## Abstract

**Introduction:** Supraclavicular approaches serve as a common method for administering regional anesthesia in upper limb procedures. In improving the impact with a length of pain relief, medical professionals frequently include additional substances such as dexmedetomidine, buprenorphine, dexamethasone, clonidine, sodium bicarbonate, and tramadol alongside local anesthetics. The intent of this study was to evaluate its impact of incorporating buprenorphine and dexmedetomidine into ropivacaine 0.5%. **Materials and Methods:** The trial of 90 patients between the ages of 18 and 60, who were identified as American Society of Anesthesiologists Grade 1 and 2, and scheduled upper limb surgery using the supraclavicular approach, were included. They were assigned into distinct groups, each of the groups consisting of thirty individuals. Group R was administered anesthesia consisting of 25 ml of ropivacaine 0.5% along with 1 ml of saline. Group B was administered anesthetics containing ropivacaine 0.5% and buprenorphine, which was diluted in saline. Group D was administered a solution containing ropivacaine 0.5% and dexmedetomidine, which was diluted in saline. **Results:** Group D had an earlier sensory blockade onset (8.25 min) compared to Group B (9.64 min) and Group R (12.89 min). Group D demonstrated a notably quicker motor blockade onset (9.21 min) in contrast to Group B (12.07 min) and Group R (15.03 min). In contrast with the other groups, Group D exhibited a more longer time frame of both sensory and motor blockades and also an extended period of anesthesia after the surgery. **Conclusion:** Dexmedetomidine was a more effective adjuvant over buprenorphine in the brachial plexus blocks. This resulted in significantly lower postoperative pain scores at 407.67 min and 612.32 min for the plain ropivacaine and buprenorphine groups, respectively.

**Keywords:** Buprenorphine, dexmedetomidine, ropivacaine, supraclavicular brachial plexus block, ultrasound guidance

## Introduction

The supraclavicular methods for brachial plexus blockage have become a widely accepted technique in regional anesthesia for upper limb treatments, backed by a plethora of studies.[1-3] To increase the effectiveness and prolongation of the block and reduce the total amount of local anesthetics needed, adjuncts such as dexmedetomidine, buprenorphine, dexamethasone, clonidine, sodium bicarbonate, and tramadol are combined with local anesthetics. This reduces the possibility of systemic side effects.[4,5]

Ropivacaine, like bupivacaine, has characteristics such as low lipid solubility, an acute elimination half-time, more extensive plasma clearance, a longer term of action, lower affinity to cardiac tissues compared to the parent drug bupivacaine, and a wider safety margin.[6,7]

Buprenorphine is an opioid that is lipophilic and has a high molecular weight. It has a strong affinity for μ-receptors and a longer duration. Unlike other opioids, it has fewer significant side effects such as respiratory depression and sedation.[7-9] It is

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readily accessible and affordable, which is why it was chosen for this study.[9-11] Dexmedetomidine works as a powerful α2 adrenoceptor agonist that is frequently employed in regional anesthesia since it offers its sedation, analgesia, sympatholytic, and hemodynamic stability properties. If implemented in appropriate doses, it does not lead to respiratory depression, making it a reliable part of local anesthetics and a helpful peripheral block adjuvant.[12-14]

Despite this, the comparative efficacy of buprenorphine and dexmedetomidine as adjuncts with local anesthetics remains uncertain, as individual studies have not reached a consensus on which provides a superior enhancement of block quality. Historical research has predominantly explored their roles alongside bupivacaine. This gap in knowledge led us to conduct our study, in which we seek to identify the variations between 0.5% ropivacaine plus buprenorphine or dexmedetomidine compared to ropivacaine alone when the setting of a supraclavicular brachial plexus block. Our primary objective delves into the duration period of analgesia; at the same time, our secondary aims encompass the assessment of onset times, the persistence of sensory and motor blockades, and the documentation of any adverse reactions.

## Materials and Methods

Patients within the ages of 18–60, who were admitted to elective upper limb orthopedic surgeries, specifically distal humerus and forearm surgeries, were selected for the study. An extensive study was conducted with the necessary approvals from the institutional ethical committee and CTRI registration No-CTRI/2021/10/037274. The study followed a prospectively, randomly assigned, double-blind, comparative approach. The study duration was conducted for 18 months with 90 trauma patients.

### Selection criteria

Individuals with a prior medical history of neurological, psychiatric, neuromuscular, coagulation disorders, alcoholism, or drug abuse, as well as those currently taking anticoagulants, adrenoceptor agonists, or antagonists, were not considered for the research.

According to Patil *et al*., with an alpha error level of 0.05, 90% power, and 95% confidence limit, 25 patients per group were required to identify clinically significant differences in postoperative analgesia and block onset and duration. Based on a 5% dropout rate, 90 patients were kept for improved results validation.[11]

### Study design and study settings

The IEC-approved study involved 90 participants who had given informed, written consent after a preanesthetic evaluation. This research was designed as a controlled, randomized trial, dividing participants into three groups of 30 using a computerized random allocation method [Figure 1].

### Allocation

- Group R: Participants were administered 25 ml of 0.5% ropivacaine with an additional 1 ml of saline
- Group B: Participants received 25 ml of 0.5% ropivacaine combined with 3 μg/kg of buprenorphine, further diluted to 1 ml with saline
- Group D: This group received a 25 ml solution containing 0.5% ropivacaine and dexmedetomidine (1 μg/kg), also diluted to 1 ml in saline.

### Procedural details

Participants were positioned in a supine position, with their arms resting comfortably by their sides. A linear ultrasound probe with high frequency was utilized for precisely identifying the brachial plexus and subclavian artery. The probe was carefully placed over the supraclavicular fossa and aligned with the clavicle, while ensuring a sterile environment. The needle was inserted with precision, tracing its path from the side to the middle, to accurately target the primary cluster of brachial plexus nerves. Once it was determined that no blood was extracted (negative aspiration), smaller doses of the anesthetic were carefully administered near other nerve structures.

### Sensory and motor-assessment

The emergence of the sensory block (S.Bk) was closely monitored every 3 min for the first half hour, then every 30 min for 12 hourly, and finally hourly until the effects of the anesthesia completely wore off. The beginning of the S.Bk was marked from the time the anesthetic was injected until the patient no longer felt a pinprick sensation. The length of the S.Bk was recorded from when it first began until anesthesia fully wore off.

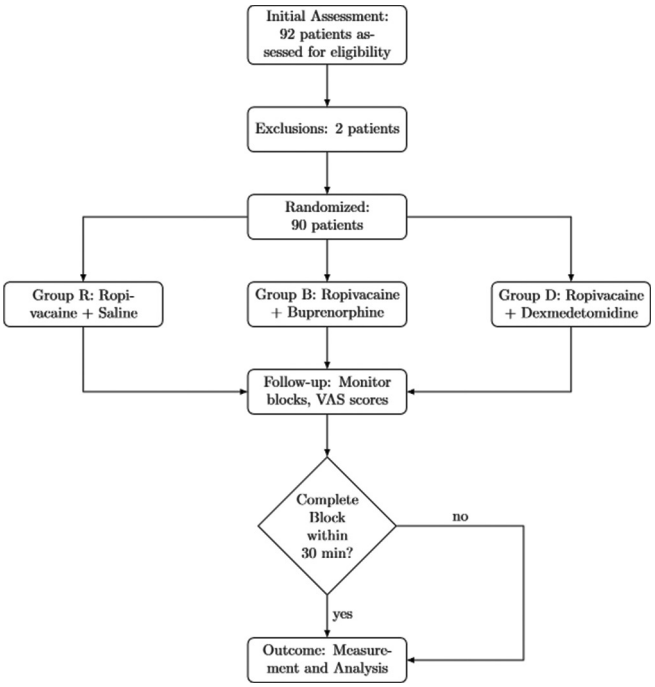


**Figure 1:** CONSORT flow chart on dexmedetomidine and buprenorphine as additions to ropivacaine in upper limb surgeries. VAS: Visual Analog Scale

Motor function (Modified Bromage Scale) which categorized motor capabilities as follows:

- Grade 0: The patient could raise their straight arm 90° for 2 s
- Grade 1: The patient could bend their elbow and move their fingers but couldn't raise their arm
- Grade 2: Finger movement was possible, but bending the elbow was not
- Grade 3: There was a complete loss of movement in the arm, elbow, and fingers.

The point at which a patient reached Grade 2 was noted as the start of the motor blockade, and how long the motor blockade lasted was tracked until full motor function was restored.

### Effectiveness and complications monitoring

The analgesic effectiveness was monitored from when the full sensory blockade was achieved until patients reported a pain level of 3 or higher on the Visual Analog Scale or requested additional painkillers. Various complications, such as injury to blood vessels, accumulation of blood under the skin (hematoma), nausea, vomiting, difficulty breathing, changes in breathing rate or oxygen levels, local anesthetic reactions, changes in heart rhythm, and drowsiness were all documented.

The level of pain was graded from 0 to 10, with 0 – no pain and 10 – severe pain. The assessments were conducted at regular intervals, starting with every 5 min for the first half hour, then every half hourly for 8 h, and finally, 1 h until a moderate pain level (score of 3) was reported. If there was no complete S.Bk or motor block (M.Bk) within half hourly, the participant was given general anesthesia and taken out of the study.

### Vital sign monitoring and pain management

Throughout the procedure, vital signs such as heart rate, blood pressure, and oxygen levels were continuously monitored. Pain management interventions were administered upon request, specifically through a slow infusion of 75 mg of diclofenac sodium diluted in 100 mL of saline.

## Results

All three groups had similar patient demographics, including age, weight, and sex distribution. The groups did not show significant differences in age and weight. The age's mean of the participants in Group's R, B, and D was 45.67 ± 7.40, 46.32 ± 7.62, and 47.29 ± 7.41, respectively ($P = 0.7$). Similarly, the average weight in Groups R, B, and D is 74.22 ± 11.44, 76.16 ± 8.57, and 77.38 ± 9.30, respectively ($P = 0.4$). The distribution of sexes was also consistent across all groups, with 16 males and 14 females.

The statistical analysis revealed significant results in the median time to onset among the different groups. In Group B, the median time to onset for an S.Bk was 9.64 ± 0.78 min, whereas in Group D, it was 8.25 ± 0.58 min, and in Group R, it was 12.89 ± 0.73 min. The M.Bk's median onset times were significantly different between the groups, with Group B having a median onset time of 12.07 ± 0.81 min, Group D having a median onset time of 9.21 ± 0.62 min, and Group R having a median starting time of 15.03 ± 0.83 min. The difference in onset times was statistically significant, with a significance threshold of <0.001. The M.Bk's mean duration was significantly different between the groups. In Group B, the mean duration was 481.07 ± 12.27 min; in Group D, it was 562.14 ± 17.50 min, and in Group R, it was 294.28 ± 13.72 min. Interestingly, a significant difference in the mean length of the S.Bk among the different groups. Specifically, Group B had an average length of 566.07 ± 16.40 min, Group D had an average length of 684.28 ± 12.88 min, and Group R had an average length of 360.71 ± 12.74 min. A significant difference in the time frame of analgesia among the groups. Group R had an average length of analgesia of 407.67 ± 14.87 min, Group B had 612.32 ± 14.93 min, and Group D had the longest duration at 728.57 ± 16.54 min. Only 3 out of 30 patients in the buprenorphine group experienced postoperative vomiting, and no other severe complications were reported.

## Discussion

In Tables 1 and 2, dexmedetomidine (Group D) and buprenorphine (Group B) with ropivacaine significantly improved upper limb surgery block efficacy over plain ropivacaine (Group R). The dexmedetomidine group had the fastest onset of S.Bk and M.Bks (8.25 ± 0.58 and 9.21 ± 0.62 min) and the longest durations of analgesia (728.57 ± 16.54 min), motor (562.14 ± 17.50 min), and sensory (684.28 ± 12.88 buprenorphine group showed intermediate results, with sensory and motor onsets at 9.64 ± 0.78 and 12.07 ± 0.81 min and analgesia duration at 612.32 ± 14.93 min [Figures 2 and 3]. Dexmedetomidine or buprenorphine improved the efficacy of plain ropivacaine, which had the slowest onset and shortest duration. In our study design, buprenorphine at a concentration of 3 μg/kg, diluted to a volume of 1 ml with normal saline, was mixed with 25 ml of 0.5% ropivacaine for Group-B. Similarly, dexmedetomidine at 1 μg/kg, also diluted to 1 ml with normal saline, was combined with 25 ml of 0.5% ropivacaine for Group D, whereas Group R received a solution of 1 ml of normal saline and 25 ml of 0.5% ropivacaine.

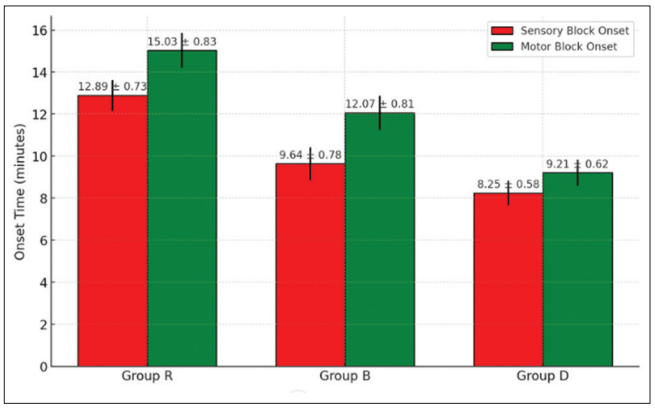


**Figure 2:** Comparison of sensory block and motor block onset times across treatment groups

**Table 1: Comparison of participant characteristics in dexmedetomidine versus buprenorphine with ropivacaine for upper limb surgery**

| | Group-R (average±SD) | Group-B (average±SD) | Group-D (average±SD) | *P* |
|---|---|---|---|---|
| Age (years) | 45.67±7.40 | 46.32±7.622 | 47.29±7.41 | 0.7 |
| Weight (kg) | 74.22±11.44 | 76.16±8.57 | 77.38±9.30 | 0.4 |
| Sex | Male (16) | Female (14) | Male (16) | Female (14) |

SD: Standard deviation

**Table 2: Clinical outcomes and complications of brachial plexus block**

| Measurement | Group-R (average±SD) | Group-B (average±SD) | Group-D (average±SD) | Significance | Complications |
|---|---|---|---|---|---|
| Time to S.Bk onset | 12.89±0.73 | 9.64±0.78 | 8.25±0.58 | <0.001 | 0, 3, 0 |
| Time to M.Bk onset | 15.03±0.83 | 12.07±0.81 | 9.21±0.62 | <0.001 | 0, 3, 0 |
| M.Bk duration | 294.28±13.72 | 481.07±12.27 | 562.14±17.50 | <0.001 | 0, 3, 0 |
| S.Bk duration | 360.71±12.74 | 566.07±16.40 | 684.28±12.88 | <0.001 | 0, 3, 0 |
| Analgesia duration | 407.67±14.87 | 612.32±14.93 | 728.57±16.54 | <0.001 | 0, 3, 0 |

S.Bk: Sensory block, M.Bk: Motor block, SD: Standard deviation

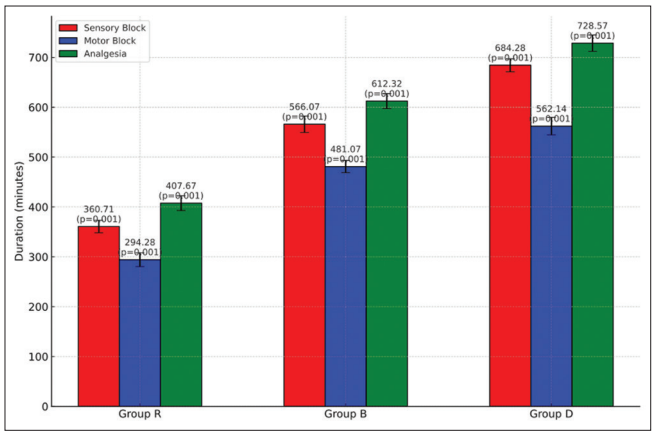


**Figure 3:** Duration of sensory and motor block and analgesia across groups

When conducting upper limb procedures, peripheral nerve blocks can serve as an alternative to general anesthesia. They offer optimal surgical conditions, ensuring muscle relaxation and stable intraoperative hemodynamic. In addition, they provide excellent pain management, postoperative analgesia, and minimize the financial burden. Patients can expect early recovery and reduced side effects. The ultrasonography-guided technique offers the advantage of providing real-time imaging guidance, leading to improved success rates and reduced complications by minimizing the need for local anesthetic.[15-17] For this investigation, we selected the supraclavicular brachial plexus block, utilizing an ultrasound-guided approach, given its relevance and applicability. Nonetheless, the benefits of this technique might be transient, constrained by the relatively brief effective duration of currently available local anesthetics, which could result in the cessation of the block before the onset of peak postoperative pain.[16] To mitigate this limitation and extend both intraoperative anesthesia and postoperative analgesia, adjuvants have been incorporated alongside local anesthetics.[16,18] Both opioids and α2 adrenergic agonists have demonstrated efficacy in prolonging anesthetic effects.

Ropivacaine, classified under the amino-amide family of local anesthetics, stands out due to its S (−) enantiomeric purity, which substantially minimizes the risks associated with central nervous system and cardiac adverse effects. Research has consistently shown that ropivacaine's effectiveness in peripheral nerve blocks is on par with bupivacaine, yet it boasts a lower side effect profile.[19,20] Studies by Kuthiala and Chaudhary have illustrated that the performance and impact of ropivacaine closely match those of bupivacaine and its analog levobupivacaine in such applications.[6] Furthermore, findings by Klein *et al*. indicate that elevating ropivacaine's concentration beyond 0.5%–0.75% does not significantly enhance the initiation or extension of S.Bk and M.Bks. Based on this evidence, our investigation adopts 0.5% ropivacaine as the anesthetic of choice.[7] Modak and Basantwani and his group further support the suitability of ropivacaine at this concentration as a preferable option to bupivacaine 0.5% for supraclavicular blocks, reinforcing our selection for this study.[8]

Buprenorphine is an opioid that is attracted to fat and has a strong attraction to μ receptors. It has a longer-lasting impact and is also cost-effective. In addition, it has a lower incidence of adverse effects that include respiratory depression and drowsiness. Multiple studies have been conducted and have established that buprenorphine has a substantial impact when used as an adjunct to local anesthesia in the supraclavicular block.[9,11,21,22]

The study conducted by Jain *et al*. found that the introduction of buprenorphine had a mean S.Bk onset of approximately 8.60 ± 2.82 min and a mean M.Bk onset of about 11.13 ± 1.89 min. This indicates a significantly faster onset compared to the group that received only bupivacaine.[23] In a study conducted by Chinnappa *et al*., the use of dexmedetomidine as an additional treatment showed that S.Bk's took an average of 9.5 ± 5.8 min to take effect, whereas M.Bk' took an average of 15.6 ± 6.3 min. This

highlights that both S.Bk and M.Bk were achieved more quickly compared to using plain bupivacaine alone.[24] Our investigation [Table 2 and Figure 2] found that the median S.Bk onset occurred at 9.64 ± 0.78 min in the ropivacaine with buprenorphine group (Group B) and at 8.25 ± 0.58 min in the ropivacaine with dexmedetomidine group (Group D), compared to 12.89 ± 0.73 min in the control group (Group R). The median onset for M.Bk's was noted at 12.07 ± 0.81 min in Group B and 9.21 ± 0.62 min in Group D, compared to 15.03 ± 0.83 min in the control group (Group R), with $P < 0.00$. The results indicate a considerable increase in the time it takes for motor and S.Bk's to take effect in the group that received dexmedetomidine. This supports prior research that has shown the effectiveness of these agents in boosting the onset of blocks.[25-27]

In Jain *et al*.'s drug study of the length of blocks in buprenorphine, Group B was significantly longer (451.8 min) compared to Group C (320.5 min). Similarly, in Group B, the length of blocks was also higher (525.8 min) compared to Group C (373 min).[23] In a study conducted by researchers, dexmedetomidine was used as an additional treatment. The results showed that the group receiving dexmedetomidine experienced significantly longer blocks compared to the control group. Specifically, the S.Bk lasted approximately 630.6 ± 208.2 min, whereas the M.Bk lasted around 545.9 ± 224.0 min.[24]

The statistical analysis revealed significance among the three groups, with a $P < 0.001$. The duration of M.Bk was found to be 566.07 ± 16.40 (min) in Group B, 684.28 ± 12.88 (min) in Group D, and 360.71 ± 12.74 in Group R. $P < 0.001$ indicates a difference among the groups. This is consistent with research that demonstrates how adjuvants such as dexmedetomidine can extend the length of a block. The study discovered that dexmedetomidine considerably increased the amount of time of both S.Bk and M.Bk with respect to using ropivacaine alone.[27,28]

Jain *et al*. work, the average duration of pain relief was found to be 868.2 ± 77.78 min.[23] The work by Chinnappa *et al*., the total period of pain relief was reported to be 805.7 ± 205.9 min.[24,25] In the group that received ropivacaine plus buprenorphine, the average length of the pain relief turned out 612.32 ± 14.93 min. For the group that received ropivacaine plus dexmedetomidine, the average duration was 728.57 ± 16.54 min. In comparison, the control group (Group R) had an average duration of 407.67 ± 14.87 min. $P < 0.001$ suggests a substantial difference among the three groups ($P < 0.05$). The findings align with previous meta-analyses that showed how incorporating dexmedetomidine in the form of an adjuvant toward ropivacaine dramatically extended the time frame of postoperative pain relief compared to using ropivacaine alone.[29] In addition, studies support buprenorphine's analgesic properties, although the specific use of buprenorphine as an adjuvant with ropivacaine requires further exploration from other researchers.[29,30]

Ultrasound-guided techniques for all blocks in our study contributed to the low adverse effects in our cohort. In previous research, ultrasound guidance in block administration improved precision and significantly reduced vascular puncture and hemi-diaphragmatic paresis risks.[16,23,31] Only 3 out of 30 buprenorphine patients vomited during surgery and the 24-h postoperative monitoring period. No side effects were reported in dexmedetomidine and control groups like other studies. Our study is limited by the lack of dexmedetomidine serum levels during surgery, this omission limits our ability to evaluate the drug's systemic effects after local absorption, short follow-up, and a single-center study. Future research and analysis with an intravenous dexmedetomidine cohort will fill this gap and improve our knowledge of the drug's systemic effects.

## Conclusion

Dexmedetomidine with ropivacaine for the supraclavicular brachial plexus blocks significantly expedites the initiation of blocks, both sensory and motor, relative to buprenorphine and solely ropivacaine. Dexmedetomidine contributes to a longer duration of S.Bk and M.Bk's, along with a longer postoperative analgesia, offering a notable advantage over buprenorphine. This enhancement in block efficacy and analgesia duration by dexmedetomidine is achieved by not introducing significant adverse effects or complications, marking it as a preferable choice in clinical settings for achieving comprehensive anesthesia and analgesia.

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### Conflicts of interest

There are no conflicts of interest.

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