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Original Research Article

Comparison of Nalbuphine and Dexamethasone as Adjuvants to Ropivacaine for Ultrasound-Guided Supraclavicular Brachial Plexus Block in Upper Limb Orthopedic Surgery

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Abstract

Introduction: Ultrasound-guided supraclavicular brachial plexus block is widely used for upper limb orthopedic surgeries because it provides effective intraoperative anesthesia and prolonged postoperative analgesia. Various adjuvants have been combined with ropivacaine to improve block characteristics and extend analgesic duration. Nalbuphine and dexamethasone are among the most commonly investigated adjuvants; however, evidence comparing their relative efficacy remains limited. This study compared nalbuphine and dexamethasone as adjuvants to ropivacaine for ultrasound-guided supraclavicular brachial plexus block.

Materials and Methods: This prospective, randomized comparative study included 100 ASA physical status I–II patients aged 18–65 years undergoing elective upper limb orthopedic surgery. Patients were randomly allocated into two equal groups (n=50 each). Group N received 30 mL of 0.5% ropivacaine with nalbuphine, while Group D received 30 mL of 0.5% ropivacaine with dexamethasone. Primary outcomes included onset and duration of sensory and motor blockade and duration of postoperative analgesia. Secondary outcomes comprised postoperative Visual Analog Scale (VAS) scores, rescue analgesic requirement, hemodynamic parameters, Ramsay sedation scores, and adverse effects. Statistical analysis was performed using SPSS version 26.0, with $p<0.05$ considered statistically significant.

Results: Baseline demographic and surgical characteristics were comparable between the groups ($p>0.05$). Nalbuphine produced a significantly faster onset of sensory and motor blockade ($p<0.05$). Dexamethasone significantly prolonged sensory block (760.48±82.37 vs. 598.64±74.91 minutes), motor block (650.12±74.65 vs. 505.38±66.82 minutes), and postoperative analgesia (912.68±96.24 vs. 683.54±81.36 minutes) (all $p<0.001$). Patients receiving dexamethasone demonstrated significantly lower postoperative VAS scores after four hours, delayed first rescue analgesia, reduced 24-hour analgesic consumption, and fewer rescue analgesic requirements (all $p<0.01$). Hemodynamic parameters remained stable, and adverse effects were infrequent and comparable in both groups.

Conclusion: Both nalbuphine and dexamethasone were safe and effective adjuvants to ropivacaine for ultrasound-guided supraclavicular brachial plexus block. Nalbuphine provided a faster onset of blockade, whereas dexamethasone offered significantly prolonged block duration, superior postoperative analgesia, reduced analgesic consumption, and an excellent safety profile, making it the preferred adjuvant for prolonged postoperative pain control.

Keywords: Ultrasound-Guided Supraclavicular Brachial Plexus Block; Ropivacaine; Nalbuphine; Dexamethasone; Postoperative Analgesia.

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Introduction

Upper limb orthopedic surgeries are commonly performed under brachial plexus block because it provides excellent intraoperative anesthesia, prolonged postoperative analgesia, reduced opioid consumption, early mobilization, and fewer systemic adverse effects compared with general anesthesia [1]. Among the various approaches, the ultrasound-guided supraclavicular brachial plexus block has gained widespread acceptance due to its high success rate, rapid onset, improved visualization of neural structures, reduced volume of local anesthetic required, and lower incidence of complications [2]. The use of ultrasound guidance has further enhanced the safety and efficacy of

regional anesthesia by allowing precise needle placement and real-time visualization of local anesthetic spread [3]. Ropivacaine is a long-acting amide local anesthetic widely used for peripheral nerve blocks because of its favorable safety profile, lower cardiotoxicity and neurotoxicity compared with bupivacaine, and its ability to provide effective sensory blockade with relatively less motor blockade [4]. Despite these advantages, the duration of postoperative analgesia produced by ropivacaine alone may not be sufficient for prolonged pain relief following orthopedic procedures [5]. Consequently, several adjuvants have been investigated to enhance block characteristics, prolong analgesia, decrease postoperative analgesic requirements, and improve patient comfort [6].

Nalbuphine, a mixed κ-opioid receptor agonist and μ-opioid receptor antagonist, has emerged as an effective adjuvant for peripheral nerve blocks due to its analgesic properties, rapid onset of action, and relatively low incidence of opioid-related adverse effects [7]. Dexamethasone, a potent synthetic corticosteroid, is another widely studied adjuvant that has consistently demonstrated the ability to prolong the duration of sensory and motor blockade and extend postoperative analgesia, possibly through its anti-inflammatory effects and modulation of nociceptive transmission [8]. Although both nalbuphine and dexamethasone have shown promising results as adjuvants to local anesthetics, evidence comparing their relative efficacy when combined with ropivacaine for ultrasound-guided supraclavicular brachial plexus block remains limited and inconclusive [9,10].

Identifying the optimal adjuvant for peripheral nerve blocks is essential to maximize block quality, prolong postoperative analgesia, reduce rescue analgesic requirements, and minimize adverse effects. The present study aimed to compare the efficacy and safety of nalbuphine and dexamethasone as adjuvants to ropivacaine in ultrasound-guided supraclavicular brachial plexus block for patients undergoing upper limb orthopedic surgery, with respect to onset and duration of sensory and motor blockade, duration of postoperative analgesia, postoperative pain scores, rescue analgesic requirement, hemodynamic parameters, sedation, and adverse effects.

Materials and Methods

This prospective, randomized, comparative study was conducted in the Department of Anaesthesiology at a tertiary care teaching hospital after obtaining approval from the Institutional Ethics Committee and written informed consent from all participants. The study included 100 adult patients of either sex, aged 18–65 years, belonging to the American Society of Anesthesiologists (ASA) physical status I or II, who were scheduled to undergo elective upper limb orthopedic surgeries under ultrasound-guided supraclavicular brachial plexus block. Patients with known hypersensitivity to local anesthetics or study drugs, coagulopathy, local infection at the injection site, pre-existing peripheral neuropathy, severe hepatic or renal dysfunction, pregnancy, lactation, chronic opioid use, psychiatric illness, or refusal to participate were excluded from the study.

Eligible patients were randomly allocated into two equal groups (n=50 each) using a computer-generated randomization sequence with allocation concealment by sealed opaque envelopes. Group N received ultrasound-guided supraclavicular brachial plexus block with 30 mL of 0.5% ropivacaine combined with nalbuphine as the adjuvant, while Group D received 30 mL of 0.5% ropivacaine combined with dexamethasone as the adjuvant. All blocks were performed under strict aseptic precautions using a high-frequency linear ultrasound transducer.

After identification of the brachial plexus at the supraclavicular level, the study drug was injected using an in-plane needle approach following negative aspiration, ensuring adequate spread of the local anesthetic around the neural structures. Standard intraoperative monitoring, including electrocardiography, non-invasive blood pressure, heart rate, and peripheral oxygen saturation (SpO_2), was maintained throughout the procedure.

The primary outcome measures included onset time of sensory and motor blockade, duration of sensory and motor blockade, and duration of postoperative analgesia. Sensory blockade was assessed using pinprick sensation over the distributions of the median, radial, ulnar, and musculocutaneous nerves, while motor blockade was evaluated using the Modified Bromage Scale for the upper limb. Duration of analgesia was defined as the interval from completion of drug administration to the patient's first request for rescue analgesia. Secondary outcome measures included postoperative pain assessed using the Visual Analog Scale (VAS), time to first rescue analgesic, total analgesic consumption during the first 24 postoperative hours, Ramsay Sedation Score, intraoperative hemodynamic parameters, and the incidence of adverse events such as nausea, vomiting, bradycardia, hypotension, pruritus, respiratory depression, local anesthetic systemic toxicity, and block failure.

The sample size was fixed at 100 patients, with 50 participants in each study group. Data were entered into Microsoft Excel and analyzed using Statistical Package for the Social Sciences (SPSS) version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD) and compared using the independent Student's t-test, whereas categorical

variables were presented as frequency and percentage and analyzed using the Chi-square test or Fisher's exact test, wherever appropriate. A two-tailed p value of <0.05 was considered statistically significant.

Results

A total of 100 patients were enrolled and equally allocated to Group N (ropivacaine with nalbuphine) and Group D (ropivacaine with dexamethasone), with 50 patients in each group. The demographic characteristics were comparable between the groups.

The mean age was 39.82 ± 11.74 years in Group N and 40.64 ± 12.18 years in Group D (p=0.731). There were no significant differences in gender distribution, weight, height, BMI, or ASA physical status between the two groups (p>0.05), indicating that both groups were well matched at baseline. (Table 1)

Table 1: Baseline Demographic Characteristics of the Study Participants

Variable	Group N (n=50)	Group D (n=50)	P value
Age (years)	39.82 ± 11.74	40.64 ± 12.18	0.731
Male, n (%)	34 (68.0)	33 (66.0)	0.832
Female, n (%)	16 (32.0)	17 (34.0)	
Weight (kg)	66.84 ± 8.21	67.58 ± 8.69	0.664
Height (cm)	165.42 ± 7.38	166.10 ± 7.65	0.653
BMI (kg/m²)	24.46 ± 2.98	24.59 ± 3.14	0.829
ASA I, n (%)	32 (64.0)	30 (60.0)	0.680
ASA II, n (%)	18 (36.0)	20 (40.0)	

The distribution of surgical procedures was similar in both groups. Distal radius fixation was the most frequently performed procedure (27.0%), followed by forearm fracture fixation (23.0%), hand surgery (19.0%), humerus surgery (17.0%), and elbow surgery (14.0%). No statistically significant difference was observed in the type of surgery performed between Group N and Group D (p=0.991), demonstrating comparable surgical characteristics. (Table 2)

Table 2: Distribution of Type of Upper Limb Surgery

Type of Surgery	Group N (n=50)	Group D (n=50)	Total (n=100)	P value
Distal radius fixation	14 (28.0)	13 (26.0)	27 (27.0)	0.991
Forearm fracture fixation	12 (24.0)	11 (22.0)	23 (23.0)	
Hand surgery	9 (18.0)	10 (20.0)	19 (19.0)	
Humerus surgery	8 (16.0)	9 (18.0)	17 (17.0)	
Elbow surgery	7 (14.0)	7 (14.0)	14 (14.0)	

Patients receiving nalbuphine exhibited a significantly faster onset of both sensory and motor blockade compared with those receiving dexamethasone (p<0.05). However, dexamethasone significantly prolonged the duration of sensory block (760.48 ± 82.37 vs. 598.64 ± 74.91 minutes), motor block (650.12 ± 74.65 vs. 505.38 ± 66.82 minutes), and postoperative analgesia (912.68 ± 96.24 vs. 683.54 ± 81.36 minutes) compared to nalbuphine (all p<0.001). (Table 3)

Table 3: Block Characteristics

Variable	Group N (n=50)	Group D (n=50)	P value
Sensory onset (min)	8.16 ± 1.47	9.01 ± 1.63	0.007
Motor onset (min)	11.08 ± 1.79	11.91 ± 1.94	0.028
Sensory block duration (min)	598.64 ± 74.91	760.48 ± 82.37	<0.001
Motor block duration (min)	505.38 ± 66.82	650.12 ± 74.65	<0.001
Duration of analgesia (min)	683.54 ± 81.36	912.68 ± 96.24	<0.001

Intraoperative hemodynamic parameters remained stable and comparable in both groups throughout the surgical procedure. The mean heart rate, mean arterial pressure, and oxygen saturation showed no statistically significant differences between Group N and Group D (p>0.05), indicating that both adjuvants maintained satisfactory cardiovascular and respiratory stability during surgery. (Table 4)

Table 4: Intraoperative Hemodynamic Parameters

Variable	Group N	Group D	P value
Heart rate (beats/min)	74.62 ± 6.18	73.95 ± 5.91	0.581
Mean arterial pressure (mmHg)	87.42 ± 6.84	86.76 ± 6.53	0.624
SpO_2 (%)	99.10 ± 0.72	99.18 ± 0.69	0.572

Postoperative pain scores were comparable during the initial two hours after surgery. Thereafter, patients in the dexamethasone group demonstrated significantly lower VAS scores at 4, 6, 8, 12, and 24 hours compared with the nalbuphine group (all $p<0.01$), reflecting superior and more sustained postoperative analgesia with dexamethasone. (Table 5)

Table 5: Postoperative Pain Scores (VAS)

Time	Group N	Group D	P value
1 hour	0.18 ± 0.39	0.14 ± 0.35	0.594
2 hours	0.54 ± 0.61	0.36 ± 0.49	0.104
4 hours	1.26 ± 0.72	0.82 ± 0.65	0.002
6 hours	2.34 ± 0.81	1.48 ± 0.70	<0.001
8 hours	3.84 ± 0.96	2.28 ± 0.81	<0.001
12 hours	4.92 ± 0.84	3.34 ± 0.92	<0.001
24 hours	2.84 ± 0.77	2.18 ± 0.71	<0.001

The mean time to first rescue analgesia was significantly longer in Group D than in Group N (914.84 ± 94.73 vs. 684.16 ± 82.51 minutes, $p<0.001$).

Additionally, patients receiving dexamethasone required significantly lower total diclofenac consumption during the first 24 postoperative hours (76.80 ± 21.43 vs. 112.40 ± 26.75 mg, $p<0.001$).

A significantly smaller proportion of patients in Group D required a second rescue analgesic compared with Group N (14.0% vs. 38.0%, $p=0.006$). (Table 6)

Table 6: Time to First Rescue Analgesia and Total Analgesic Requirement

Variable	Group N	Group D	P value
Time to first rescue analgesia (min)	684.16 ± 82.51	914.84 ± 94.73	<0.001
Total diclofenac consumption (mg/24 h)	112.40 ± 26.75	76.80 ± 21.43	<0.001
Patients requiring second rescue analgesic, n (%)	19 (38.0)	7 (14.0)	0.006

Ramsay sedation scores were marginally higher in the nalbuphine group during the first postoperative hour (2.28 ± 0.45 vs. 2.10 ± 0.36, $p=0.029$). However, sedation scores became comparable between the two groups from the second postoperative hour onward, with no statistically significant differences observed thereafter, indicating minimal and clinically acceptable sedation with both adjuvants. (Table 7)

Table 7: Ramsay Sedation Score

Time	Group N	Group D	P value
1 hour	2.28 ± 0.45	2.10 ± 0.36	0.029
2 hours	2.12 ± 0.39	2.04 ± 0.28	0.247
4 hours	2.00 ± 0.20	2.00 ± 0.00	1.000
6 hours	2.00 ± 0.00	2.00 ± 0.00	1.000

Both study groups exhibited a low incidence of adverse effects. The frequencies of nausea/vomiting, bradycardia, hypotension, and pruritus were low and did not differ significantly between the groups ($p>0.05$). No patient developed respiratory depression or local anesthetic systemic toxicity, and block failure occurred in only one patient in each group, confirming the favorable safety profile of both nalbuphine and dexamethasone as adjuvants to ropivacaine. (Table 8)

Table 8: Adverse Effects

Adverse Effect	Group N (n=50)	Group D (n=50)	P value
Nausea/Vomiting	3 (6.0)	2 (4.0)	0.646
Bradycardia	2 (4.0)	1 (2.0)	0.558
Hypotension	2 (4.0)	1 (2.0)	0.558
Pruritus	2 (4.0)	0 (0.0)	0.153
Block failure	1 (2.0)	1 (2.0)	1.000

Discussion

Ultrasound-guided supraclavicular brachial plexus block is widely accepted for upper limb orthopedic surgery because it provides reliable surgical anesthesia, excellent postoperative analgesia, and facilitates early recovery. The use of adjuvants with long-acting local anesthetics has further improved block quality and prolonged analgesia. In the present study, baseline demographic characteristics, ASA physical status, and distribution of surgical procedures were comparable between the two groups, confirming adequate randomization. Patients receiving nalbuphine demonstrated a significantly faster onset of sensory and motor

blockade, whereas dexamethasone produced significantly longer sensory block, motor block, and postoperative analgesia. These findings indicate that although nalbuphine hastens block onset, dexamethasone provides more prolonged postoperative analgesia, making it a superior adjuvant for sustained pain control.

The prolonged duration of sensory block, motor block, and postoperative analgesia observed with dexamethasone in the present study is consistent with previous studies. Kumar et al. demonstrated that adding dexamethasone to ropivacaine in supraclavicular brachial plexus block significantly prolonged sensory and motor blockade while markedly increasing the duration of postoperative analgesia compared with ropivacaine alone [11].

Similarly, Bindal et al. reported significantly prolonged block characteristics with dexamethasone added to either ropivacaine or bupivacaine, without increasing adverse effects [12]. Krishna et al. also observed significantly prolonged analgesia, lower postoperative pain scores, and reduced rescue analgesic requirements when dexamethasone was used as an adjuvant to ropivacaine during supraclavicular brachial plexus block [13]. These observations are attributed to the anti-inflammatory effects of dexamethasone, reduction in perineural edema, and direct modulation of nociceptive C-fiber transmission, thereby prolonging the action of local anesthetics.

In contrast, nalbuphine was associated with a significantly faster onset of sensory and motor blockade in the present study, although the overall duration of analgesia was shorter than that achieved with dexamethasone.

Opioid receptors identified on peripheral nerves and the kappa-agonistic action of nalbuphine may explain its ability to hasten block onset while enhancing postoperative analgesia. Similar findings have been reported by Venkatraman R et al., who demonstrated that nalbuphine significantly accelerated block onset and prolonged postoperative analgesia when used as an adjuvant in supraclavicular brachial plexus block.

Comparative studies evaluating dexamethasone against other adjuvants have consistently shown that although opioid adjuvants improve block quality, dexamethasone remains superior in prolonging analgesia and reducing postoperative analgesic consumption [14,15]. Patients in the dexamethasone group experienced significantly lower postoperative VAS scores, delayed first rescue analgesic requirement, reduced 24-hour analgesic consumption, and fewer patients requiring additional rescue analgesia compared with the nalbuphine group. Hemodynamic variables remained stable throughout the perioperative period, sedation scores were clinically acceptable, and the incidence of adverse events was low and comparable in both groups.

No patient developed respiratory depression or local anesthetic systemic toxicity, indicating that both adjuvants possess favorable safety profiles. Similar safety outcomes have been reported in previous randomized controlled trials evaluating dexamethasone and nalbuphine as adjuvants in peripheral nerve blocks, supporting their safe clinical application. However, considering the significantly prolonged postoperative analgesia and reduced analgesic requirements observed both in the present study and previous literature, dexamethasone appears to provide a greater overall analgesic benefit than nalbuphine when combined with ropivacaine for ultrasound-guided supraclavicular brachial plexus block [11-15].

Conclusion

The addition of both nalbuphine and dexamethasone to ropivacaine provided effective and safe ultrasound-guided supraclavicular brachial plexus block for upper limb orthopedic surgery. Nalbuphine was associated with a faster onset of sensory and motor blockade, whereas dexamethasone significantly prolonged the duration of sensory and motor blockade, extended postoperative analgesia, reduced postoperative pain scores, delayed the need for rescue analgesia, and decreased overall analgesic consumption without increasing adverse effects. Based on these findings, dexamethasone appears to be a more effective adjuvant to ropivacaine for achieving prolonged postoperative analgesia and improved pain management while maintaining a favorable safety profile.

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