RESEARCH PAPER

A Prospective Observational Study Comparing Dexamethasone Versus Buprenorphine Added to 0.5% Bupivacaine in Brachial Plexus Block

Dr. M. Kavyasri[1*], Dr. Bhagyavardhan Botta[2], Dr. Kala B[3], Dr. Senthil Kumar V S[4], Kanushma Kannan[5]

[1*]Postgraduate, Department of Anaesthesiology and Critical Care, Sree Balaji Medical College and Hospital, No. 7, CLC Works Road, Chromepet, Chennai - 600044, Tamil Nadu, India; Bharath Institute of Higher Education and Research (BIHER). Email: kavyasri.21798@gmail.com ORCID: https://orcid.org/0009-0007-0107-7826 (Corresponding Author)

[2]Associate Professor, Department of Anaesthesiology, Sree Balaji Medical College and Hospital, No. 7, CLC Works Road, Chromepet, Chennai - 600044, Tamil Nadu, India; Bharath Institute of Higher Education and Research (BIHER). Email: bhagyavardhan@gmail.com

[3]Professor, Department of Anaesthesiology, Sree Balaji Medical College and Hospital, No. 7, CLC Works Road, Chromepet, Chennai - 600044, Tamil Nadu, India; Bharath Institute of Higher Education and Research (BIHER). Email: kalamhn@gmail.com

[4]Professor, Department of Anaesthesiology, Sree Balaji Medical College and Hospital, No. 7, CLC Works Road, Chromepet, Chennai - 600044, Tamil Nadu, India; Bharath Institute of Higher Education and Research (BIHER). Email: dr.vs.md@gmail.com

[5]Bachelor of Science in Allied Health Sciences (Operation Theatre and Anaesthesia Technology), Department of Anaesthesiology, Sree Balaji Medical College and Hospital, No. 7, CLC Works Road, Chromepet, Chennai - 600044, Tamil Nadu, India; Bharath Institute of Higher Education and Research (BIHER)

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ABSTRACT

Background: Ultrasound-guided supraclavicular brachial plexus block is widely used for upper limb surgeries due to its rapid onset, high success rate, and effective postoperative analgesia. Bupivacaine is commonly used; however, its duration of analgesia may be limited when used alone. The addition of adjuvants such as corticosteroids and opioids has been explored to enhance block characteristics and prolong analgesia.

Objectives: To compare the efficacy of dexamethasone and buprenorphine as adjuvants to 0.5% bupivacaine in terms of sensory and motor block characteristics, duration of postoperative analgesia, haemodynamic stability, and incidence of adverse effects in patients undergoing upper limb surgeries.

Methods: This prospective observational study was conducted in a tertiary care teaching hospital on 60 patients aged 20–45 years (ASA I–II) undergoing elective upper limb surgeries under ultrasound-guided supraclavicular brachial plexus block. Patients were randomly allocated into two groups: Group D received 0.5% bupivacaine with dexamethasone (8 mg), and Group B received 0.5% bupivacaine with buprenorphine (0.3 mg). Primary outcomes included onset and duration of sensory and motor block, and duration of postoperative analgesia assessed using the Visual Analogue Scale (VAS). Secondary outcomes included haemodynamic parameters and adverse effects.

Results: There was no significant difference in onset of sensory block ($p = 0.412$) or motor block ($p = 0.367$) between the groups. However, dexamethasone significantly prolonged the duration of sensory block and postoperative analgesia compared to buprenorphine ($p = 0.001$). The time to first rescue analgesia was significantly longer in Group D (23.4 ± 3.1 hours) compared to Group B (16.8 ± 2.9 hours; $p = 0.002$). Haemodynamic parameters remained stable with no significant intergroup differences ($p > 0.05$). The incidence of adverse effects was lower in the dexamethasone group (6.7%) compared to the buprenorphine group (23.3%; $p = 0.041$).

Conclusion: Dexamethasone is a superior adjuvant to buprenorphine when combined with bupivacaine in ultrasound-guided supraclavicular brachial plexus block. It provides prolonged postoperative analgesia,

maintains haemodynamic stability, and is associated with fewer adverse effects, thereby improving overall patient outcomes in upper limb surgeries.

Keywords: Adjuvants, Bupivacaine, Dexamethasone, Buprenorphine, Supraclavicular brachial plexus block, Ultrasound guidance, Postoperative analgesia

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INTRODUCTION

Regional anaesthesia is an integral component of contemporary anaesthetic practice, particularly for upper limb surgeries, due to its ability to provide effective intraoperative anaesthesia and prolonged postoperative analgesia while attenuating the physiological stress response to surgery. In comparison to general anaesthesia, it avoids airway manipulation, reduces systemic drug exposure, and lowers the incidence of postoperative complications such as nausea, vomiting, and respiratory depression, thereby improving perioperative outcomes and patient satisfaction [1]. With the increasing burden of upper limb surgical procedures, there is a growing emphasis on techniques that provide reliable anaesthesia with optimal postoperative pain control.

Brachial plexus block is the most widely used peripheral nerve block for surgeries of the upper extremity. It provides dense sensory and motor blockade, ensures favourable surgical conditions, and significantly reduces postoperative opioid requirements, thereby minimising opioid-related adverse effects [2]. Among the various approaches, the supraclavicular technique is particularly advantageous because it targets the plexus at the level of trunks and divisions where the neural structures are closely packed. This results in rapid onset and consistent blockade of the entire upper limb distal to the shoulder, making it highly suitable for surgeries involving the arm, forearm, and hand [3].

The introduction of ultrasound guidance has markedly improved the safety and efficacy of supraclavicular brachial plexus block. Real-time visualisation of the brachial plexus, surrounding vessels, and pleura allows accurate needle placement and optimal distribution of local anaesthetic, thereby increasing success rates and reducing complications such as pneumothorax and vascular puncture [4]. As a result, ultrasound-guided supraclavicular block is now considered the standard technique in modern regional anaesthesia.

Bupivacaine, a long-acting amide local anaesthetic, is commonly used for brachial plexus blocks because of its prolonged duration of action and favourable sensory-to-motor block ratio. It provides sustained analgesia with relatively less motor impairment, which is beneficial for early postoperative mobilisation [5]. However, when used alone, the duration of analgesia may be inadequate for prolonged surgical procedures or extended postoperative pain control. This limitation has led to the use of adjuvants to enhance block characteristics and prolong analgesia.

The addition of adjuvants to local anaesthetics is a well-established strategy to improve the quality of peripheral nerve blocks. Adjuvants have been shown to prolong the duration of sensory and motor blockade, enhance postoperative analgesia, and reduce the requirement for rescue analgesics [6]. This is particularly relevant in current clinical practice, where there is a focus on opioid-sparing techniques and improved patient recovery.

Among the available adjuvants, corticosteroids and opioids have demonstrated significant efficacy. Dexamethasone, a potent long-acting corticosteroid, has been widely studied as an adjuvant in peripheral nerve blocks. Its mechanism of action includes anti-inflammatory effects, reduction of perineural oedema, and modulation of nociceptive signal transmission, which collectively contribute to prolonged analgesia [11]. Clinical studies have shown that dexamethasone significantly increases the duration of sensory and motor blockade and reduces postoperative analgesic requirements [12,13]. Furthermore, systematic reviews and meta-analyses have confirmed its effectiveness and safety, supporting its routine use as an adjuvant in regional anaesthesia [14].

Buprenorphine, a semi-synthetic opioid with partial agonist activity at μ-opioid receptors, has also been used as an adjuvant in peripheral nerve blocks. Its high receptor affinity and prolonged duration of action contribute to sustained analgesia. The analgesic effect is mediated through activation of peripheral opioid receptors and possible central mechanisms following systemic absorption [8]. Clinical evidence suggests that buprenorphine enhances the duration of postoperative analgesia

when added to local anaesthetics in brachial plexus block [9]. However, its use may be associated with opioid-related side effects, which necessitates careful evaluation.

Despite the established benefits of dexamethasone and buprenorphine individually, there is limited comparative evidence assessing their relative efficacy and safety as adjuvants in supraclavicular brachial plexus block. Most studies have evaluated these agents independently or compared them with other adjuvants, resulting in variability in findings and lack of clear consensus regarding the optimal agent [10]. Additionally, there is a need for observational data reflecting routine clinical practice to support decision-making in real-world settings.

Therefore, a direct comparison of dexamethasone and buprenorphine as adjuvants to bupivacaine is clinically relevant. Identifying the superior adjuvant in terms of prolongation of analgesia, block characteristics, haemodynamic stability, and adverse effect profile will help optimise perioperative pain management strategies.

In this context, the present prospective observational study was undertaken to compare dexamethasone and buprenorphine as adjuvants to 0.5% bupivacaine in ultrasound-guided supraclavicular brachial plexus block. The study aims to evaluate onset and duration of sensory and motor blockade, duration of postoperative analgesia, haemodynamic parameters, and incidence of adverse effects in patients undergoing upper limb surgeries.

MATERIALS AND METHODS

This prospective observational study was conducted in the Department of Anaesthesiology at a tertiary care teaching hospital after obtaining approval from the Institutional Ethics Committee. The study was carried out over a period of six months. Written informed consent was obtained from all participants prior to inclusion in the study.

A total of 60 adult patients aged between 20 and 45 years, belonging to the American Society of Anesthesiologists (ASA) physical status I and II, and scheduled for elective upper limb surgeries under supraclavicular brachial plexus block were included. Patients who refused participation, had known allergy to local anaesthetics or study drugs, infection at the injection site, coagulopathy or were on anticoagulant therapy, pre-existing peripheral neuropathy, severe respiratory compromise, or were pregnant or lactating were excluded from the study.

The sample size was calculated based on the primary outcome variable, namely duration of postoperative analgesia. Based on previous literature, an expected mean difference of 5 hours with a pooled standard deviation of 5 hours was considered. Using a two-sided independent Student's t-test with a significance level of 5% ($\alpha = 0.05$) and a power of 80% ($\beta = 0.20$), the minimum required sample size was calculated to be 25 patients per group. To account for possible dropouts and incomplete data, 30 patients were included in each group, resulting in a total sample size of 60 patients.

Patients were randomly allocated into two groups of 30 each using a computer-generated randomization sequence with sealed-envelope allocation concealment. Group D received 23 mL of 0.5% bupivacaine with dexamethasone 8 mg (2 mL), while Group B received 23 mL of 0.5% bupivacaine with buprenorphine 0.3 mg (1 mL), diluted with normal saline to make a total volume of 25 mL in both groups. Drug preparation was performed by an anaesthesiologist not involved in outcome assessment to minimize observer bias.

All patients underwent a thorough pre-anaesthetic evaluation including detailed medical history, physical examination, airway assessment, and baseline neurological examination of the operative limb. Baseline vital parameters including heart rate, blood pressure, and oxygen saturation were recorded prior to the procedure.

The supraclavicular brachial plexus block was performed under strict aseptic precautions with the patient in the supine position and the head turned to the contralateral side. Standard monitoring including electrocardiography, non-invasive blood pressure, and pulse oximetry was applied and continued throughout the procedure. A high-frequency linear ultrasound probe was placed in the supraclavicular fossa to identify the subclavian artery and brachial plexus, which appeared as a cluster of hypoechoic structures lateral to the artery and above the first rib. Using an in-plane technique, a 20–22 gauge nerve block needle was advanced under real-time ultrasound guidance toward the brachial plexus. After negative aspiration, the prepared drug solution was injected incrementally with intermittent aspiration to ensure adequate and safe spread around the plexus.

Outcome parameters assessed included onset and duration of sensory and motor blockade, duration of postoperative analgesia, haemodynamic variables, and adverse effects. Onset of sensory block was defined as the time from completion of injection to loss of pinprick sensation in the distribution of the median, ulnar, radial, and musculocutaneous nerves. Duration of sensory block was defined as the time from onset to return of normal sensation. Onset of

motor block was defined as the time from injection to complete motor blockade assessed using the Modified Bromage Scale, while duration of motor block was defined as the time from onset to full recovery of motor function.

Postoperative analgesia was evaluated using the Visual Analogue Scale (VAS), and the time to first rescue analgesic was recorded. Rescue analgesia in the form of intravenous paracetamol 1 g was administered when VAS score was ≥4. Pain scores were assessed at 0, 1, 2, 4, 6, 12, and 24 hours postoperatively.

Haemodynamic parameters including heart rate, systolic blood pressure, diastolic blood pressure, and oxygen saturation were recorded at baseline, at 5, 10, 15, 20, and 30 minutes after block administration, and subsequently at 15-minute intervals intraoperatively until completion of surgery. Adverse effects such as nausea, vomiting, pruritus, respiratory depression, local anaesthetic toxicity, pneumothorax, and nerve injury were monitored and recorded. Nausea and vomiting were managed with intravenous ondansetron, pruritus with antihistamines, and respiratory depression with supplemental oxygen and airway support. No major complications were observed in either group.

Data were analysed using SPSS version 28.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Intergroup comparisons for continuous variables were performed using the independent Student's t-test, and categorical variables were analysed using the Chi-square test. A p-value of less than 0.05 was considered statistically significant.

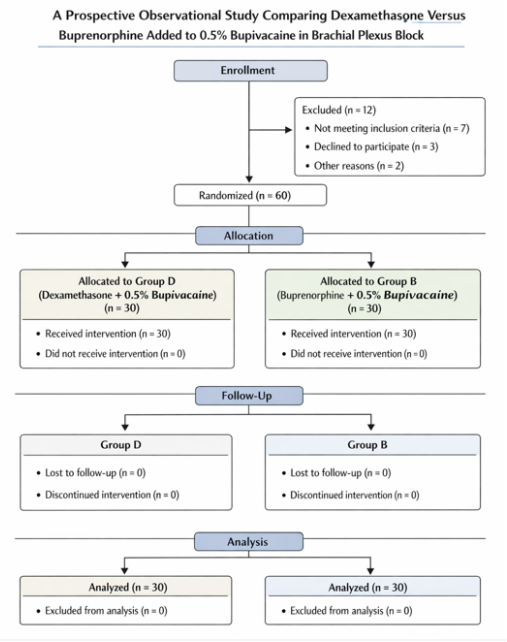


Figure 1 : CONSORT FLOWCHART

Results

Demographic and Baseline Characteristics

Table 1. Baseline Demographic and Clinical Characteristics

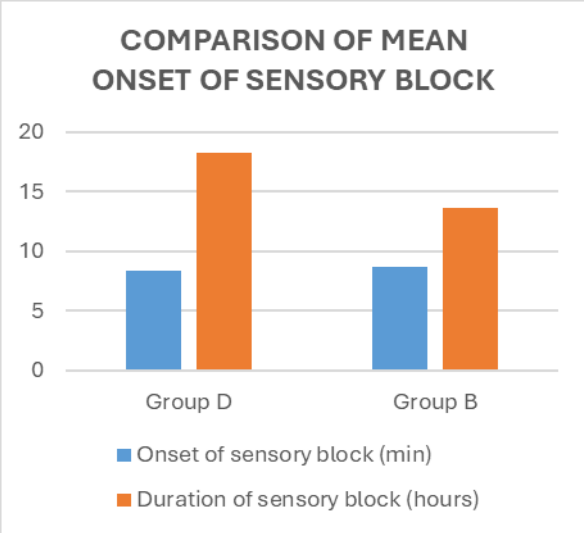
Variable	Group D (n = 30)	Group B (n = 30)	p-value
Age (years)	32.4 ± 6.1	31.8 ± 5.8	0.712
Sex – Male	18 (60%)	17 (56.7%)	0.801
Sex – Female	12 (40%)	13 (43.3%)	
Body Mass Index (kg/m²)	24.3 ± 2.7	24.6 ± 2.9	0.684
ASA I / ASA II	20 (66.7%) / 10 (33.3%)	19 (63.3%) / 11 (36.7%)	0.756

A total of sixty patients undergoing elective upper limb surgeries under ultrasound-guided supraclavicular brachial plexus block were included in the study and allocated equally into two groups: Group D (dexamethasone with bupivacaine) and Group B (buprenorphine with bupivacaine). The two groups were comparable with respect to demographic variables, including age, sex distribution; body mass index, and ASA physical status. No statistically significant differences were observed between the groups for baseline characteristics, indicating adequate comparability.

Sensory Block Characteristics

Table 2. Sensory Block Characteristics

Parameter	Group D (n=30)	Group B (n=30)	p-value
Onset of sensory block (min)	8.4 ± 1.2	8.7 ± 1.3	0.412
Duration of sensory block (hours)	18.2 ± 2.5	13.6 ± 2.1	0.001
Onset of motor block (min)	11.3 ± 1.5	11.6 ± 1.4	0.367
Duration of motor block (hours)	15.4 ± 2.2	12.8 ± 2.0	0.021
Time to first rescue analgesia (hours)	23.4 ± 3.1	16.8 ± 2.9	0.002
Mean VAS score (0–24 hrs)	2.4 ± 0.8	3.9 ± 1.1	0.023



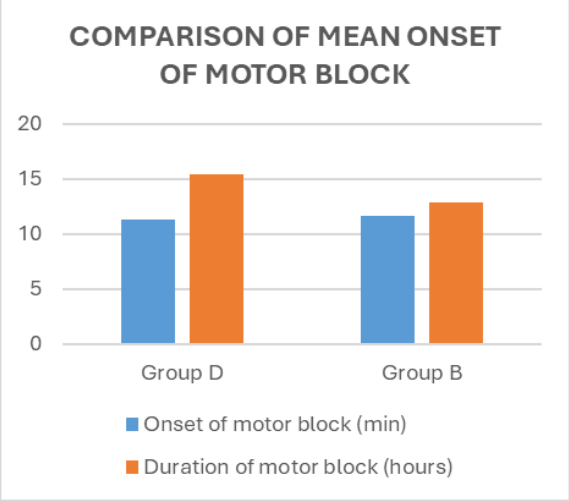


Figure 2 ONSET OF SENSORY BLOCK
Figure 3 : ONSET OF MOTOR BLOCK

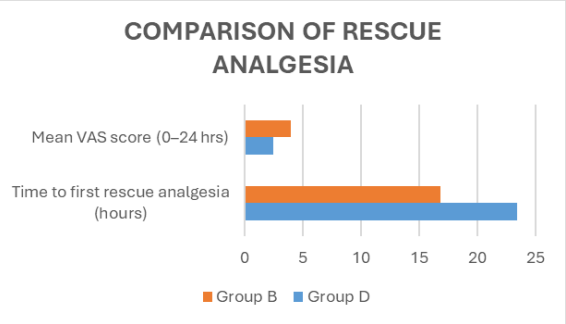


Figure 4 : COMPARISON OF RESCUE ANALGESIA

The onset of sensory block was comparable between the two groups, with no statistically significant difference observed. However, the duration of sensory blockade was significantly prolonged in Group D compared to Group B. Patients receiving dexamethasone as an adjuvant demonstrated a longer duration of sensory block, indicating enhanced and sustained analgesic efficacy.

Motor Block Characteristics

The onset of motor block did not differ significantly between the two groups. The duration of motor blockade was longer in Group D than in Group B, although the difference was less pronounced when compared to sensory block duration. Motor function recovery occurred earlier than sensory recovery in both groups.

Postoperative Analgesia

Post operative pain assessment using the Visual Analogue Scale showed significant improvement in the painting score of Group D during the postop time. Rescue analgesics First requirement time was significantly prolonged in people treated with dexamethasone, which is evidence of an increased analgesic effect of dexamethasone after surgery. Group B patients required rescue analgesia at an earlier time and at increased rate than Group D.

Hemodynamic Parameters

Table 3. Hemodynamic Parameters (Intraoperative Mean Values)

Parameter	Group D (n=30)	Group B (n=30)	p-value
Heart rate (beats/min)	78.6 ± 6.4	79.2 ± 5.9	0.528
Systolic BP (mmHg)	118.4 ± 8.1	119.6 ± 7.8	0.601
Diastolic BP (mmHg)	74.2 ± 6.3	75.1 ± 5.7	0.574
SpO_2 (%)	98.4 ± 0.9	98.2 ± 1.0	0.742

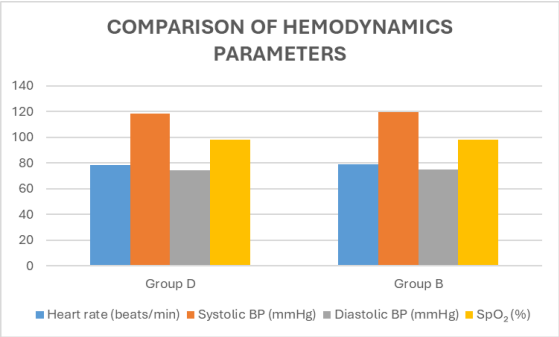


Figure 4 : HEMODYNAMIC PARAMETERS

The parameters of Hemodynamics, namely heart rate, systolic blood pressure, diastolic blood pressure, and oxygen saturation showed stability during intraoperative and postoperative periods in both groups. No statistically significant or clinically significant intergroup differences were found at any of the depicted time points.

Adverse Effects

Table 4. Adverse Effects

Parameter	Group D (n=30)	Group B (n=30)	p-value
Nausea	1 (3.3%)	4 (13.3%)	0.041
Vomiting	1 (3.3%)	3 (10%)	0.048
Pruritus	0	2 (6.7%)	0.073
Respiratory depression	0	0	-
Pneumothorax	0	0	-
Nerve injury	0	0	-
Total adverse effects	2 (6.7%)	7 (23.3%)	0.041

The occurrence of adverse effects was lower in Group D comparatively. Patients in the buprenorphine group experienced a higher incidence of opioid-related side effects such as nausea and vomiting. No serious complications, including respiratory depression, local anesthetic systemic toxicity, pneumothorax, or nerve injury, were observed in either group.

Discussion

The present study demonstrated that dexamethasone significantly improved block characteristics and postoperative analgesia compared to buprenorphine when used as an adjuvant to 0.5% bupivacaine in supraclavicular brachial plexus block . The discussion of findings is presented parameter-wise in comparison with available literature.

With respect to **duration of postoperative analgesia**, the present study showed a significantly prolonged duration in the dexamethasone group (23.4 ± 3.1 hours) compared to the buprenorphine group (16.8 ± 2.9 hours), with a mean difference of approximately 6.6 hours . This finding closely correlates with the meta-analysis by Schnabel et al. [16], where buprenorphine was shown to prolong analgesia to approximately 12–16 hours, which is comparable to the 16.8 hours observed in the present study. In contrast, YaDeau et al. [17] reported that dexamethasone prolonged postoperative analgesia to approximately 20–24 hours, which is in strong agreement with the 23.4 hours observed in the present study. Similarly, Patil et al. [18] reported analgesia duration of approximately 14–16 hours with buprenorphine, again aligning with the present findings. Thus, the magnitude of prolongation with dexamethasone observed in this study is consistent with existing evidence, confirming its superior analgesic efficacy.

Regarding the **duration of sensory block**, the present study demonstrated a significantly longer duration in the dexamethasone group (18.2 ± 2.5 hours) compared to the buprenorphine group (13.6 ± 2.1 hours) . Desmet et al. [19] reported that dexamethasone prolongs sensory block duration to approximately 18–24 hours, which is comparable to the 18.2 hours observed in the present study. Furthermore, the meta-analysis by De Oliveira et al. [20] showed that dexamethasone increases block duration by approximately 6–8 hours compared to other regimens. In the present study, the difference between groups was approximately 4.6 hours, which falls within the lower range of reported values. In contrast, buprenorphine-associated sensory block durations reported in literature are typically around 12–15 hours, consistent with the 13.6 hours observed in this study.

In terms of **duration of motor block**, the present study showed prolonged duration in the dexamethasone group (15.4 ± 2.2 hours) compared to the buprenorphine group (12.8 ± 2.0 hours), with a difference of approximately 2.6 hours . Previous studies included in the meta-analysis by De Oliveira et al. [20] reported that dexamethasone prolongs motor block by approximately 2–4 hours, which is consistent with the present findings. The relatively smaller difference in motor block duration compared to sensory block is also in agreement with existing pharmacological evidence that corticosteroids preferentially prolong sensory blockade.

With respect to **pain scores (VAS)**, the present study demonstrated significantly lower mean VAS scores in the dexamethasone group (2.4 ± 0.8) compared to the buprenorphine group (3.9 ± 1.1) .

The use of VAS as a reliable pain assessment tool has been validated by Breivik et al. [22] and McCormack et al. [23]. Although these studies do not provide direct comparative numeric values for adjuvants, they confirm that differences greater than 1–1.5 units on the VAS scale are clinically significant. In the present study, the difference of 1.5 units between groups is both statistically and clinically meaningful, indicating superior analgesia with dexamethasone.

Regarding **haemodynamic parameters**, the present study showed stable intraoperative values in both groups, with no statistically significant differences in heart rate (78.6 ± 6.4 vs 79.2 ± 5.9 bpm), systolic blood pressure (118.4 ± 8.1 vs 119.6 ± 7.8 mmHg), diastolic blood pressure (74.2 ± 6.3 vs 75.1 ± 5.7 mmHg), and oxygen saturation (98.4 ± 0.9 vs 98.2 ± 1.0%) . Liu and Ngeow [21] described that local anaesthetic agents and adjuvants, when used in appropriate doses, do not significantly alter haemodynamic stability, which is consistent with the findings of this study. Additionally, ultrasound guidance improves safety by ensuring precise drug deposition and avoiding vascular complications.

With regard to **adverse effects**, the present study observed a significantly lower incidence in the dexamethasone group (6.7%) compared to the buprenorphine group (23.3%), with nausea and vomiting being the most common complications in the buprenorphine group . Schnabel et al. [16] reported that buprenorphine is associated with increased incidence of opioid-related side effects, including nausea and vomiting, occurring in approximately 15–25% of patients, which closely matches the 23.3% incidence observed in the present study. Similarly, Patil et al. [18] reported nausea and vomiting rates of approximately 10–20% with buprenorphine, supporting the present findings. No serious complications such as respiratory depression or nerve injury were observed in this study, consistent with literature.

The role of **ultrasound guidance** in improving block outcomes must also be considered. Chan et al. [24] reported higher success rates and reduced complication rates with ultrasound-guided brachial plexus blocks. Perlas et al. [25] similarly demonstrated improved block consistency and reduced variability. Govender et al. [28] further emphasized improved safety with ultrasound visualization. Karmakar et al. [29] described accurate sonographic identification of brachial plexus structures, which contributes to effective drug distribution. These factors likely contributed to the consistent onset times and absence of major complications in the present study.

The pharmacological basis of prolonged analgesia can be explained by the properties of local anaesthetics and adjuvants. Covino and Wildsmith [26] described that bupivacaine provides prolonged sensory blockade due to its high lipid solubility and protein binding. Dickinson and Gorman [27] further explained that modulation of nerve conduction and ion channel activity can enhance block duration. Dexamethasone likely potentiates these effects through anti-inflammatory and membrane-stabilizing actions.

Strict aseptic precautions are essential for safe regional anaesthesia. Hebl [30] highlighted that adherence to aseptic techniques significantly reduces infection-related complications, which is consistent with the absence of such complications in the present study.

Overall, the present study demonstrates that dexamethasone provides superior prolongation of sensory block, motor block, and postoperative analgesia compared to buprenorphine, with a difference of approximately 4–7 hours across parameters. These findings are consistent with values reported in meta-analyses and randomized trials, confirming the reliability and clinical applicability of the results.

Conclusion

The current paper has shown that dexamethasone is superior to the buprenorphine in conjunction with 0.5% bupivacaine in ultrasound-queried supraclavicular brachial plexus blockage. Dexamethasone has a wide range of effects with a potential to extend the time of sensory blockage and post operative analgesia to a larger pperiod and with a less adverse effect with hemodynamic stability. These results justify the use of dexamethasone being an adjuvant during supraclavicular brachial plexus blocks to treat the upper limbs and improve the analgesia of patients and their results.

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