Original Article

Comparative Efficacy of Buprenorphine and Clonidine as Adjuvants to Bupivacaine in Supraclavicular Brachial Plexus Block for Upper-Limb Surgery: A Prospective Randomized Comparative Study

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Abstract

Background: Supraclavicular brachial plexus block provides reliable regional anaesthesia for upper-limb surgery; however, the duration and quality of a single-shot block are limited by the pharmacological profile of the local anaesthetic. Adjuvants such as buprenorphine and clonidine have been used to modify block characteristics and prolong regional anaesthesia. The o**bjective** is to compare buprenorphine and clonidine as adjuvants to bupivacaine with respect to onset and duration of sensory and motor blockade and quality of anaesthesia during supraclavicular brachial plexus block. **Material and Methods:** This hospital-based prospective randomized comparative study included 60 adults aged 20-60 years with American Society of Anesthesiologists physical status I-II undergoing unilateral upper-limb surgery below the lower end of the humerus. Participants were allocated into three groups of 20 each: Group B received 20 mL 0.5% bupivacaine plus 10 mL normal saline; Group BB received 20 mL 0.5% bupivacaine plus 100 micrograms buprenorphine and saline; and Group BC received 20 mL 0.5% bupivacaine plus 50 micrograms clonidine and saline. Total injectate volume was 30 mL. Sensory and motor blockade were assessed at five-minute intervals. Continuous variables were compared using analysis of variance, while categorical variables were assessed using the chi-square test; $p<0.05$ was considered statistically significant. **Results:** Baseline characteristics were comparable among groups. Mean sensory-block onset was 7.95+/-1.82, 8.35+/-2.56 and 13.05+/-5.46 minutes in Groups B, BB and BC, respectively ($p<0.05$). Motor-block onset was comparable (18.40+/-4.43, 17.50+/-5.15 and 17.95+/-3.69 minutes; $p>0.05$). Mean sensory-block duration was 358.30+/-71.45, 641.95+/-73.65 and 462.25+/-41.76 minutes, respectively ($p<0.05$), whereas motor-block duration did not differ significantly. Excellent anaesthesia occurred in 15%, 60% and 10% of participants, respectively, with significantly better overall quality in Group BB ($p<0.05$). **Conclusion:** Buprenorphine added to bupivacaine produced the most favourable overall block profile, principally through substantial prolongation of sensory blockade and improved quality of anaesthesia, without prolonging motor blockade. Clonidine prolonged sensory blockade but was associated with slower sensory onset.

Keywords: Brachial Plexus Block, Bupivacaine, Buprenorphine, Clonidine, Nerve Block.

Received: 01 September 2026 **Revised: 20 September 2026** **Accepted: 03 October 2026** **Published: 16 November 2026**

Introduction

Regional anaesthesia has become an important component of perioperative care for upper-limb surgery because it can provide surgical anaesthesia while reducing exposure to general anaesthesia and systemic analgesics. Supraclavicular brachial plexus block is particularly suited to procedures involving the upper extremity because the neural elements are compactly arranged at this level, allowing dense blockade of the major terminal nerve distributions.1 Regional anaesthesia for ambulatory hand surgery has demonstrated advantages in early postoperative recovery compared with general anaesthesia.[1] Continuous peripheral nerve techniques can provide prolonged analgesia, but they involve additional expertise, equipment, catheter management and potential catheter-related complications.[2] Consequently, single-shot peripheral nerve blocks remain clinically attractive.

A limitation of a single-shot brachial plexus block is that its duration depends substantially on the local anaesthetic used. Bupivacaine is a potent long-acting amide local anaesthetic and has been extensively used for peripheral nerve blockade. Nevertheless, prolonging the duration and improving the quality of regional anaesthesia without unnecessarily extending motor impairment remain important clinical objectives. Various approaches, including prolonged-release preparations and the addition of pharmacological adjuvants, have therefore been investigated.[3] Drugs including opioids, alpha2-adrenergic agonists and several other agents have been combined with

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DOI:
10.21276/amit.2026.v13.i3.1191

How to cite this article: Gajbhiye TM, Thorat SA, Subhedar RD. Comparative Efficacy of Buprenorphine and Clonidine as Adjuvants to Bupivacaine in Supraclavicular Brachial Plexus Block for Upper-Limb Surgery: A Prospective Randomized Comparative Study. Acta Med Int. 2026;13(3):1028-1035.

local anaesthetics with variable effects on sensory blockade, motor blockade and postoperative analgesia.[4]

Buprenorphine is a highly lipophilic partial mu-opioid receptor agonist with prolonged receptor binding and a comparatively long duration of analgesic activity. When administered as an adjuvant to local anaesthetic solutions for peripheral nerve block, buprenorphine has been reported to prolong regional analgesia. Jain et al. demonstrated favourable effects when buprenorphine was added to ropivacaine for supraclavicular brachial plexus block.[5] Candido et al. similarly reported prolonged postoperative analgesia when buprenorphine was incorporated into the local anaesthetic solution for axillary brachial plexus blockade.[6] Opioid adjuvants, however, may be accompanied by adverse effects including nausea, vomiting, sedation and pruritus. Bazin et al. documented differential effects of opioid additives, including buprenorphine, during brachial plexus blockade.[7]

Clonidine, an alpha2-adrenergic agonist, is another established regional anaesthetic adjuvant. Its peripheral effects have been attributed to interactions with neural ion channels and alpha2-mediated mechanisms that may modify nerve conduction and prolong local-anaesthetic action. Clinical studies have demonstrated that clonidine may alter block onset and prolong sensory and motor blockade, although the magnitude of these effects has varied according to dose, local anaesthetic, nerve-block technique and route of administration. Paliwal and Karnawat directly compared buprenorphine and clonidine as adjuvants to bupivacaine and found meaningful differences in block and analgesic characteristics.[8] Chakraborty et al. demonstrated prolongation of bupivacaine-induced supraclavicular block with clonidine.[9] while Bedi et al. provided evidence supporting a predominantly perineural effect of clonidine when combined with bupivacaine.[10]

Despite these observations, direct comparison of an opioid adjuvant with an alpha2-adrenergic adjuvant remains clinically relevant because a desirable agent should not merely prolong analgesia but should produce a favourable balance among block onset, sensory duration, motor recovery and quality of surgical anaesthesia. Therefore, the present study compared buprenorphine and clonidine as adjuvants to bupivacaine in supraclavicular brachial plexus block. The principal objectives were to compare the onset of sensory and motor blockade, duration of sensory and motor blockade, and quality of anaesthesia among bupivacaine alone, bupivacaine-buprenorphine and bupivacaine-clonidine regimens.

Materials and Methods

Study design: A hospital-based prospective randomized comparative study was conducted to compare the block characteristics obtained with buprenorphine and clonidine when used as adjuvants to bupivacaine for supraclavicular brachial plexus block.

Study setting and duration: The study was conducted in the Department of Anaesthesiology at a tertiary-care centre among patients attending the outpatient and inpatient services and scheduled for eligible upper-limb procedures. The study duration was 18 months.

Study population: The study population consisted of adult male and female patients with American Society of Anesthesiologists (ASA) physical status I or II who were scheduled to undergo unilateral upper-limb surgery below the lower end of the humerus.

Eligibility criteria:

Inclusion criteria:

- Age 20-60 years.
- ASA physical status I or II.
- Either sex.
- Unilateral upper-limb surgery below the lower end of the humerus.

Exclusion criteria:

- Suspected coagulopathy or infection at the proposed block site.
- Age below 20 years or above 60 years.
- Hypertension, diabetes mellitus, seizure disorder, liver disease, renal disease or coronary artery disease.
- Refusal to participate.
- Known allergy to local anaesthetics or study drugs.
- Pregnancy.
- ASA physical status III or IV.
- Bilateral upper-limb procedure.
- Pneumothorax.
- Contraindications to regional blockade, significant systemic illness, treatment with medications having psychotropic or adrenergic activity, or chronic analgesic treatment beyond simple analgesics.

Sample size and sampling: A total sample size of 60 participants, with 20 participants per study group, was used. The thesis calculated sample size using n = Z^2 p(1-p)/d^2, where Z=1.96, p=0.80 and precision (d)=0.18. The calculated value was 18.9 participants, which was rounded to 20 participants per group, resulting in a total sample size of 60.

Participant recruitment and enrolment: Patients attending the tertiary-care hospital who fulfilled the eligibility criteria were evaluated preoperatively. Written informed consent was obtained after approval of the study by the Institutional Ethics Committee and Review Board. Each participant underwent a detailed clinical history, physical examination and relevant investigations according to the study proforma. The visual analogue scale was explained before the procedure, with 0 representing no pain and 10 representing the worst pain.

Study groups and interventions:

•Group B: 20 mL of 0.5% isobaric bupivacaine plus 10 mL normal saline; total volume 30 mL.

•Group BB: 20 mL of 0.5% bupivacaine plus 100 micrograms buprenorphine (1 mL) and 9 mL normal saline; total volume 30 mL.

•Group BC: 20 mL of 0.5% bupivacaine plus 50 micrograms clonidine (1 mL) and 9 mL normal saline; total volume 30 mL.

Standard monitoring comprising electrocardiography, non-invasive blood pressure measurement and pulse oximetry was instituted in the operating room. Baseline heart rate, systolic and diastolic blood pressure, peripheral oxygen saturation and respiratory rate were recorded, and an 18-G intravenous cannula

was secured. No analgesic or sedative medication was administered as premedication before assessment of the block. The study solution was supplied for administration, while the researcher performing the block was blinded to the medication being administered.

Supraclavicular block technique: A peripheral nerve stimulator-guided supraclavicular approach was used. Patients were positioned supine, semi-sitting or slightly oblique, with the head directed away from the side to be blocked. The interscalene groove and subclavian artery were identified as anatomical landmarks. Under aseptic precautions, a 22-25 G, 5-cm Stimuplex needle was inserted in the parasagittal plane. Flexion or extension of the fingers at a stimulating current of approximately 0.3-0.5 mA was considered the target motor response. The assigned 30-mL study solution was then administered. Surgery was allowed to proceed after satisfactory blockade had been established.

Assessment of sensory block: Sensory blockade was assessed every five minutes after administration of the study solution until complete blockade occurred or 30 minutes had elapsed. Pin-prick sensation was tested using a hypodermic needle in the distributions of the ulnar, median, musculocutaneous and radial nerves. A three-point assessment was used: 0, normal sensation; 1, loss/reduction of pin-prick sensation; and 2, loss of touch sensation. The onset of sensory blockade was defined as the interval between injection of the study solution and development of the specified reduction in pain sensation at the surgical site. Sensory regression was subsequently assessed at 15-minute intervals until recovery. Duration of sensory block was defined as the interval from completion of study-drug infiltration until return of sensation in the hand and forearm.

Assessment of motor block: Motor function was evaluated in the distributions of the radial, musculocutaneous, median and ulnar nerves by assessing forearm movement against resistance, thumb opposition and thumb adduction. Motor function was graded on a three-point scale: 0, normal motor function; 1, decreased motor strength; and 2, complete motor block. A comparable three-level upper-extremity motor scale has been used for assessment of motor blockade in regional anaesthesia.11 Onset of motor block was defined as the interval from administration of the test solution to development of motor weakness. Duration of motor block was defined as the period from completion of study-drug infiltration until complete recovery of motor power of the hand and forearm.

Quality of anaesthesia: Quality of surgical anaesthesia was assessed at the end of surgery and categorized as follows: Excellent, no complaints from the participant; Good, few vague complaints without need for supplemental medication; Moderate, complaints necessitating supplemental analgesia; and Unsuccessful, requirement for general anaesthesia.

Study variables

Exposure/independent variable: The principal independent variable was study-group assignment: bupivacaine alone, bupivacaine plus buprenorphine, or bupivacaine plus clonidine.

Outcome/dependent variables

- Onset time of sensory block.
- Onset time of motor block.
- Duration of sensory block.
- Duration of motor block.
- Quality of anaesthesia.

Other recorded variables: Age, sex, ASA physical status, body mass index, heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure and peripheral oxygen saturation were recorded.

Data quality assurance: Eligibility was assessed using predefined inclusion and exclusion criteria. All patients underwent standardized preoperative evaluation, and the visual analogue scale and block-assessment methods were explained before the procedure. Standard monitoring was used for all groups. The injectate volume was fixed at 30 mL, and sensory and motor outcomes were evaluated at predefined intervals using the same assessment procedure in all three groups.

Statistical analysis: Data were analysed using SPSS version 20 and Microsoft Excel. Continuous variables were summarized as mean and standard deviation, whereas categorical variables were summarized using frequency and percentage. The thesis specified assessment of distributional assumptions before comparison of quantitative variables. Analysis of variance (ANOVA) was used for comparison of continuous outcomes among the three groups. Pairwise comparisons were reported for selected outcomes. Categorical variables were compared using Pearson's chi-square test. A two-sided p-value <0.05 was considered statistically significant. Graphical presentations were prepared using Microsoft Excel.

Ethical considerations: The study was undertaken after approval from the Institutional Ethics Committee and Review Board. Written informed consent was obtained before enrolment. Standard monitoring and resuscitation equipment were available during the regional anaesthetic procedure.

Results

Participant flow: A total of 60 participants were included and analysed, with 20 participants in each study arm. Group B received bupivacaine alone, Group BB received bupivacaine with 100 micrograms buprenorphine, and Group BC received bupivacaine with 50 micrograms clonidine. All three groups were represented in the final efficacy analysis.

Baseline demographic and clinical characteristics: The three groups were comparable with respect to age, sex distribution, ASA physical status and body mass index. Mean age was 39.25+/-11.20 years in Group B, 39.75+/-11.01 years in Group BB and 38.85+/-11.69 years in Group BC ($p>0.05$). Men constituted 60%, 55% and 65% of the three groups, respectively. ASA physical status I was present in 65%, 80% and 70%, respectively, with no statistically significant between-group difference. Mean BMI was 25.53+/-3.61 kg/m2 in Group B, 26.31+/-4.18 kg/m2 in Group BB and 25.34+/-3.59 kg/m2 in Group BC ($p>0.05$).

Onset of sensory blockade: Mean sensory-block onset differed significantly among the groups. It was 7.95+/-1.82 minutes in Group B, 8.35+/-2.56 minutes in Group BB and 13.05+/-5.46 minutes in Group BC (overall $p<0.05$). Pairwise comparisons showed no significant difference between Groups B and BB

(p>0.05), whereas sensory onset was significantly longer in Group BC than in both Group B and Group BB (p<0.05 for each comparison).

Onset of motor blockade: Mean motor-block onset was 18.40+/-4.43 minutes in Group B, 17.50+/-5.15 minutes in Group BB and 17.95+/-3.69 minutes in Group BC. The difference among groups was not statistically significant (p>0.05).

Duration of sensory blockade: A statistically significant difference was observed in sensory-block duration. Mean duration was shortest with bupivacaine alone at 358.30+/-71.45 minutes, increased to 462.25+/-41.76 minutes with clonidine, and was longest with buprenorphine at 641.95+/-73.65 minutes (p<0.05). Thus, compared with bupivacaine alone, addition of buprenorphine increased the observed mean sensory-block duration by approximately 284 minutes, while clonidine increased it by approximately 104 minutes.

Duration of motor blockade: Unlike sensory blockade, motor-block duration did not differ significantly among the three regimens. Mean durations were 341.25+/-75.19 minutes in Group B, 328.30+/-90.96 minutes in Group BB and 345.05+/-78.44 minutes in Group BC (p>0.05).

Quality of anaesthesia: Quality of anaesthesia differed significantly between study groups. Excellent anaesthesia occurred in 3/20 (15%) participants in Group B, 12/20 (60%) in Group BB and 2/20 (10%) in Group BC. Good anaesthesia was observed in 60%, 30% and 55%, respectively, whereas moderate anaesthesia was observed in 25%, 10% and 35%, respectively. No participant in any of the three groups was categorized as having unsuccessful anaesthesia requiring conversion on the basis of the reported quality assessment. Pairwise analysis demonstrated a significant difference between Group B and Group BB and between Group BB and Group BC (p<0.05), whereas Group B and Group BC did not differ significantly.

Haemodynamic observations: Heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure and peripheral oxygen saturation remained comparable across the three study groups during the observation period (p>0.05). Baseline mean heart rates were 74.17+/-6.80, 75.25+/-6.72 and 74.40+/-7.95 beats/min in Groups B, BB and BC, respectively. Baseline SpO2 was 98.04+/-1.43%, 98.27+/-1.14% and 98.74+/-1.23% in Groups B, BB and BC, respectively, with no significant differences throughout observation.

Table 1: Baseline demographic and clinical characteristics of the study groups

Characteristic	Group B (n=20)	Group BB (n=20)	Group BC (n=20)	p-value
Age, years, mean+/-SD	39.25+/-11.20	39.75+/-11.01	38.85+/-11.69	>0.05
Male, n (%)	12 (60)	11 (55)	13 (65)	>0.05
Female, n (%)	8 (40)	9 (45)	7 (35)	
ASA I, n (%)	13 (65)	16 (80)	14 (70)	>0.05
ASA II, n (%)	7 (35)	4 (20)	6 (30)	
BMI, kg/m2, mean+/-SD	25.53+/-3.61	26.31+/-4.18	25.34+/-3.59	>0.05
Normal BMI, n (%)	8 (40)	7 (35)	9 (45)	
Overweight, n (%)	11 (55)	11 (55)	9 (45)	
Obese, n (%)	1 (5)	2 (10)	2 (10)	

Group B, bupivacaine; Group BB, bupivacaine+buprenorphine; Group BC, bupivacaine+clonidine; ASA, American Society of Anesthesiologists physical status; BMI, body mass index. ANOVA was used for continuous variables and chi-square test for categorical variables.

Table 2: Comparison of sensory and motor block characteristics among the three groups

Block characteristic	Group B	Group BB	Group BC	Overall p-value
Sensory-block onset, min	7.95+/-1.82	8.35+/-2.56	13.05+/-5.46	<0.05
Motor-block onset, min	18.40+/-4.43	17.50+/-5.15	17.95+/-3.69	>0.05
Sensory-block duration, min	358.30+/-71.45	641.95+/-73.65	462.25+/-41.76	<0.05
Motor-block duration, min	341.25+/-75.19	328.30+/-90.96	345.05+/-78.44	>0.05

Values are mean+/-SD. Between-group comparisons were performed using ANOVA. Group B, bupivacaine; Group BB, bupivacaine+buprenorphine; Group BC, bupivacaine+clonidine.

Pairwise comparison for sensory-block onset

Comparison	p-value
Group B vs Group BB	>0.05
Group B vs Group BC	<0.05
Group BB vs Group BC	<0.05

Table 3: Comparison of quality of surgical anaesthesia among study groups

Quality of anaesthesia	Group B n (%)	Group BB n (%)	Group BC n (%)
Excellent	3 (15)	12 (60)	2 (10)
Good	12 (60)	6 (30)	11 (55)
Moderate	5 (25)	2 (10)	7 (35)
Unsuccessful	0	0	0
Total	20 (100)	20 (100)	20 (100)

Pairwise comparisons: Group B vs Group BB, p<0.05; Group B vs Group BC, p>0.05; Group BB vs Group BC, p<0.05. Chi-square test.

Table 4: Haemodynamic and oxygen-saturation profile during supraclavicular block

Parameter	Principal finding	Between-group comparison
Heart rate	Comparable throughout observation	p>0.05
Systolic blood pressure	Comparable throughout observation	p>0.05
Diastolic blood pressure	Comparable throughout observation	p>0.05
Mean arterial pressure	Comparable throughout observation	p>0.05
SpO2	Comparable throughout observation	p>0.05

ANOVA was used for between-group comparison at assessed time points. SpO2, peripheral oxygen saturation.

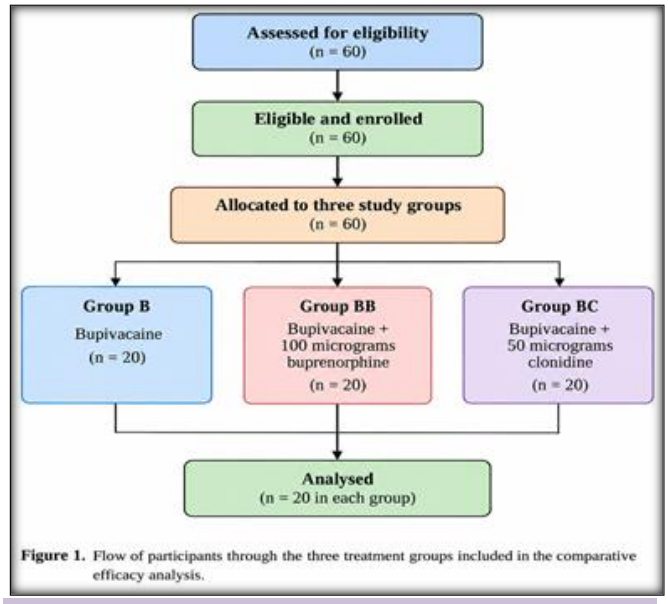


Figure 1. Flow of participants through the three treatment groups included in the comparative efficacy analysis.

Figure 1: Participant flow through the study

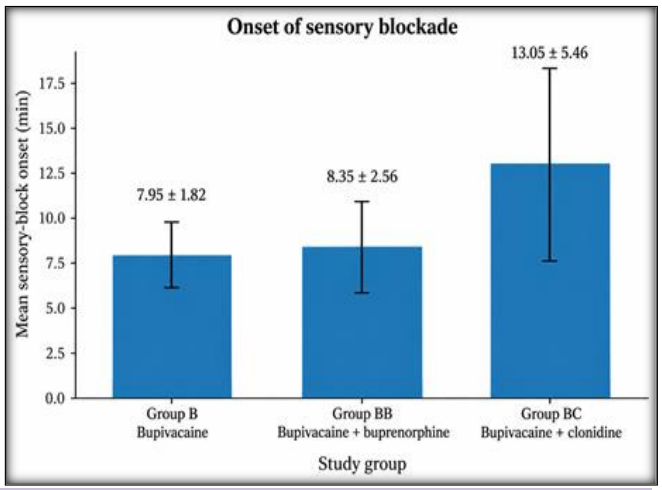


Figure 2: Mean onset time of sensory block among the three study groups

Mean+/-SD onset time of sensory blockade. Sensory onset was significantly delayed in the bupivacaine-clonidine group compared with bupivacaine alone and bupivacaine-buprenorphine (p<0.05).

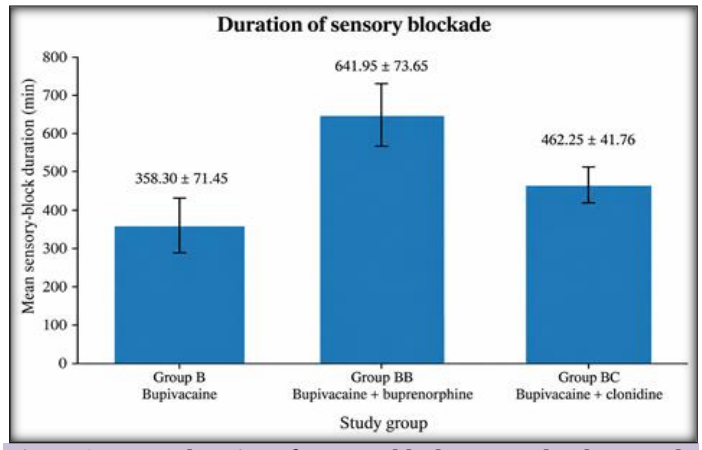


Figure 3: Mean duration of sensory block among the three study groups

Mean+/-SD duration of sensory blockade. Sensory-block duration differed significantly among groups (p<0.05), with the longest observed duration in the buprenorphine group.

Discussion

The present prospective randomized comparative study evaluated two pharmacologically distinct adjuvants-buprenorphine and clonidine-when added to bupivacaine for supraclavicular brachial plexus block. The principal finding was that the effects of the two adjuvants on block characteristics were not equivalent. Addition of buprenorphine produced a marked prolongation of sensory blockade and was associated with a substantially greater proportion of patients experiencing excellent surgical anaesthesia, without prolonging motor blockade. Clonidine also increased the duration of sensory blockade compared with bupivacaine alone, but sensory-block onset was slower. Motor-block onset and duration were comparable across all three groups. These observations indicate that assessment of an adjuvant should consider the overall sensory-motor block profile rather than duration alone.

The groups were comparable in age, sex, ASA physical status and BMI, thereby reducing the likelihood that major differences in these baseline characteristics explained the observed differences in block outcomes. This comparability is consistent with the randomized comparative study of Paliwal and Karnawat, in which the demographic profile and ASA physical status were also comparable among treatment groups.8 Baseline balance is particularly relevant in peripheral nerve-block studies because age, body habitus, associated systemic conditions and procedural factors can influence block performance and recovery.

Sensory-block onset demonstrated an interesting and clinically relevant pattern. The bupivacaine and bupivacaine-buprenorphine groups had almost identical onset times-7.95 and 8.35 minutes, respectively-whereas addition of clonidine was associated with an onset of 13.05 minutes. Thus, buprenorphine did not appear to compromise the rapid onset characteristic of the underlying bupivacaine block, whereas the clonidine regimen produced slower sensory onset in this study. Paliwal and Karnawat similarly reported delayed sensory onset in their clonidine group.8 However, published evidence concerning clonidine has not been uniform. Chakraborty et al. reported shorter onset of surgical block when clonidine was added to bupivacaine,9 and Bedi et al. observed faster sensory blockade with perineural clonidine.[10] Differences between studies may reflect clonidine dose, local-anaesthetic concentration, total injectate volume, anatomical approach and details of nerve localization.

Abhishek et al. also demonstrated that apparently small changes in the local-anaesthetic/adjuvant combination can alter sensory- and motor-block characteristics during supraclavicular blockade.[12] These findings emphasize that the effect of an adjuvant cannot necessarily be extrapolated across different local anaesthetics, concentrations and techniques. The present study used identical total injectate volumes of 30 mL, which reduced one potential source of between-group variability.

Motor-block onset, in contrast, was not significantly affected by either adjuvant. Mean onset varied only from 17.50 to 18.40 minutes across the three groups. Paliwal and Karnawat likewise reported no important between-group difference in motor onset.[8] Singh and Aggarwal, in their double-blind comparison of clonidine-added bupivacaine with bupivacaine alone, also evaluated the effect of clonidine on supraclavicular block characteristics.[13] Collectively, these observations suggest that the effects of adjuvants on sensory and motor fibres may not evolve in parallel.

The most prominent efficacy finding was the difference in sensory-block duration. Bupivacaine alone provided a mean sensory block lasting approximately 358 minutes. Addition of clonidine increased this to approximately 462 minutes, representing an observed extension of about 104 minutes. Addition of buprenorphine produced a mean sensory duration of approximately 642 minutes-nearly 284 minutes longer than bupivacaine alone and approximately 180 minutes longer than clonidine. The magnitude of this difference supports a pharmacologically meaningful effect of buprenorphine on sensory-block persistence.

Buprenorphine has several properties that may account for this observation. It is highly lipophilic, possesses strong affinity for mu-opioid receptors and dissociates slowly from these receptors, properties compatible with prolonged analgesic activity. Peripheral opioid mechanisms may additionally contribute when opioid drugs are deposited close to neural tissue. Candido et al. demonstrated prolonged postoperative analgesia following addition of buprenorphine to local anaesthetic during axillary brachial plexus block.6 Bazin et al., comparing opioid additives in brachial plexus blockade, also demonstrated that opioid selection can materially affect the duration and characteristics of regional analgesia.[7] Jain et al. subsequently reported favourable results with buprenorphine added to ropivacaine during supraclavicular blockade.[5]

The clonidine-associated increase in sensory duration is also biologically plausible. alpha2-Adrenergic agonists can modify nerve conduction, and clonidine may act through mechanisms involving hyperpolarization and interaction with axonal ion channels. Eisenach et al. reviewed the use of alpha2-adrenergic agonists in regional anaesthesia and highlighted both neuraxial and peripheral mechanisms.[14] Chakraborty et al. demonstrated a significant prolongation of bupivacaine-induced supraclavicular blockade when clonidine was used as an adjuvant.[9] Singelyn et al. similarly showed that relatively low-dose clonidine added to mepivacaine could prolong anaesthesia and analgesia following axillary brachial plexus block.[15]

Importantly, the prolonged sensory block observed with buprenorphine was not accompanied by a corresponding prolongation of motor block. Motor-block durations were approximately 341, 328 and 345 minutes in the bupivacaine, buprenorphine and clonidine groups, respectively. From a clinical perspective, this separation between prolonged sensory effect and motor recovery is potentially desirable. An adjuvant that extends useful sensory anaesthesia without proportionately extending motor impairment may facilitate postoperative neurological assessment and functional recovery while retaining the analgesic advantages of a longer block. Nevertheless, this interpretation should be considered in the context of the modest sample size and requires validation in larger studies specifically designed to examine differential sensory-motor recovery.

Quality of anaesthesia provided an additional clinically meaningful measure. Excellent anaesthesia was achieved in 60% of participants receiving buprenorphine compared with 15% receiving bupivacaine alone and 10% receiving clonidine. Furthermore, only 10% of the buprenorphine group was categorized as having moderate anaesthesia, compared with 25% and 35% in the other two groups. No participant was classified as having an unsuccessful block in any group. These findings suggest that the greater duration of sensory blockade with buprenorphine was accompanied by an improvement in the practical quality of intraoperative regional anaesthesia rather than representing an isolated numerical difference in block duration.

The clonidine findings differ to some extent from studies reporting improved overall block quality. Bernard and Macaire demonstrated dose-related changes in brachial plexus anaesthesia after addition of clonidine to lidocaine.[16] However, the local anaesthetic, clonidine dose and axillary rather than supraclavicular technique differed from those of the present study. Such methodological differences are important because peripheral adjuvant effects are likely to depend on both local drug concentration and the anatomical characteristics of deposition around the nerve.

Haemodynamic variables remained comparable throughout the study. Heart rate, systolic and diastolic blood pressure, mean arterial pressure and SpO2 did not differ significantly among groups. This is relevant particularly for clonidine, because systemic alpha2-adrenergic effects can produce bradycardia and

hypotension. Bedi et al. similarly observed clinically acceptable haemodynamic findings during evaluation of perineural and intravenous clonidine.10 Chakraborty et al. reported no significant differences in heart rate, blood pressure or oxygen saturation between study groups.[9] These findings support the haemodynamic tolerability of the doses evaluated in the present investigation within the selected ASA I-II population.

Several strengths of the study deserve consideration. First, it directly compared two different classes of adjuvant with an active local-anaesthetic control under a common study protocol. Second, the total injectate volume was identical in all three groups, improving comparability. Third, clinically meaningful sensory and motor outcomes were evaluated separately rather than relying solely on time to rescue analgesia. Fourth, the participants were similar with respect to important baseline variables. Fifth, haemodynamic monitoring was performed throughout the procedural observation period. Finally, the inclusion of a structured assessment of anaesthetic quality supplemented the numerical measures of block onset and duration.

The study also had limitations. The sample size was relatively small, with 20 participants per group, limiting precision and the ability to evaluate uncommon adverse outcomes. It was conducted at a single tertiary-care centre and included only ASA I-II adults aged 20-60 years, which limits generalizability to older patients, those with major systemic disease and other surgical populations. The nerve blocks were performed using peripheral nerve stimulation and anatomical landmarks; therefore, the results should not automatically be extrapolated to contemporary ultrasound-guided techniques. Block outcomes were based on clinical sensory and motor assessments, and pharmacokinetic measurements were not performed. Furthermore, the analyses largely relied on separate comparisons of endpoints rather than a prespecified hierarchical or multivariable efficacy framework.

Future studies should therefore evaluate these agents in adequately powered, multicentre randomized controlled trials using standardized ultrasound-guided techniques. Prespecified primary outcomes, confidence intervals for between-group effect estimates and multiplicity-adjusted pairwise comparisons would improve statistical interpretability. Studies should also determine whether the apparent sensory-motor differential observed with buprenorphine is reproducible and whether it translates into improved recovery quality, functional outcomes and patient satisfaction.

Overall, the findings suggest that the two adjuvants produced distinct block profiles rather than simply extending the effect of bupivacaine to a similar degree. Buprenorphine yielded the most favourable efficacy pattern in this study by substantially prolonging sensory blockade and improving anaesthetic quality without significantly prolonging motor blockade.

Conclusion

In adults undergoing unilateral upper-limb surgery under supraclavicular brachial plexus block, the addition of buprenorphine or clonidine to 0.5% bupivacaine produced different effects on block characteristics. Buprenorphine did not significantly alter sensory-block onset compared with bupivacaine alone but produced the longest sensory blockade and was associated with a substantially greater proportion of patients achieving excellent surgical anaesthesia. Importantly, this prolongation of sensory blockade was not accompanied by a significant increase in motor-block duration. Clonidine also prolonged sensory blockade compared with bupivacaine alone; however, sensory-block onset was significantly slower than that observed with either bupivacaine alone or bupivacaine-buprenorphine. Motor-block onset and duration remained comparable among all three groups. Haemodynamic parameters and oxygen saturation were also comparable during the study period. Within the population, doses and nerve-stimulator-guided technique evaluated in this study, buprenorphine demonstrated the more favourable overall anaesthetic block profile, principally because of prolonged sensory blockade and superior quality of anaesthesia without concomitant prolongation of motor blockade. Larger controlled studies using contemporary ultrasound-guided techniques are warranted to confirm these findings and define their clinical applicability.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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