E-ISSN 2250-0944
ISSN 2250-1150
doi: 10.31838/ijprt/16.02.94

Research Article

Comparison of Dexmedetomidine and Fentanyl as Adjuvants to Bupivacaine for Ultrasound-Guided Supraclavicular Brachial Plexus Block: A Randomized Controlled Trial

Dr. Amithkumar S. K.[1], Dr. Spoorti Pujari[2], Dr. C. S. M. Akshaya[3*]

[1]Assistant Professor, Department of Anaesthesiology, Mahadevappa Rampure Medical College, Kalaburagi, Karnataka, India.
[2]Assistant Professor, Department of Anaesthesiology, Mahadevappa Rampure Medical College, Kalaburagi, Karnataka, India.
[3*]Assistant Professor, Department of Anaesthesiology, Velammal Medical College, Madurai, Tamil Nadu, India.

Corresponding Author: Dr. C. S. M. Akshaya
Assistant Professor, Department of Anaesthesiology, Velammal Medical College, Madurai, Tamil Nadu, India.

Received: 06.05.2026, Revised: 04.06.2026, Accepted: 01.07.2026

ABSTRACT

Background: Adjuvants added to local anaesthetics in supraclavicular brachial plexus block hasten the onset and prolong the duration of sensory–motor blockade and post-operative analgesia. Dexmedetomidine, a selective α_2-adrenoceptor agonist, and fentanyl, a lipophilic μ-opioid receptor agonist, are both used perineurally, but head-to-head data under real-time ultrasound guidance remain limited.

Objectives: To compare dexmedetomidine (1 μg/kg) and fentanyl (1 μg/kg) as adjuvants to 0.5% bupivacaine in ultrasound-guided supraclavicular brachial plexus block with respect to:

1. Onset and duration of sensory and motor block.
2. Duration of post-operative analgesia and total rescue analgesic requirement.
3. Intraoperative haemodynamic parameters, sedation and adverse effects.

Methods: This prospective, randomized, double-blind, controlled trial was conducted at Mahadevappa Rampure Medical College, Kalaburagi from May 2025 to April 2026 after institutional ethics committee approval and CTRI registration. Sixty adult patients (ASA physical status I–II, aged 18–60 years) scheduled for elective upper-limb orthopaedic surgery were randomized (1:1) into two groups of 30 each. Group D received 20 mL of 0.5% bupivacaine with dexmedetomidine 1 μg/kg, and Group F received 20 mL of 0.5% bupivacaine with fentanyl 1 μg/kg. Onset and duration of sensory and motor block, duration of analgesia, visual analogue scale (VAS) scores, haemodynamic variables, Ramsay sedation score and adverse effects were recorded. Data were analysed using Student's t-test, Chi-square test and repeated-measures ANOVA; $p < 0.05$ was considered significant.

Results: The two groups were comparable in demographic characteristics. The onset of sensory block (7.0 ± 1.4 vs 9.6 ± 1.8 min; $p < 0.001$) and motor block (10.4 ± 1.9 vs 13.4 ± 2.3 min; $p < 0.001$) was significantly faster in Group D. The duration of sensory block (458 ± 50 vs 316 ± 42 min), motor block (404 ± 46 vs 282 ± 38 min) and post-operative analgesia (548 ± 58 vs 384 ± 50 min) was significantly longer in Group D (all $p < 0.001$). VAS scores from 4 h to 16 h post-block were significantly lower in Group D, and the mean rescue analgesic requirement in the first 24 h was reduced (0.8 ± 0.4 vs 1.6 ± 0.6 doses; $p < 0.001$). Sedation was greater but clinically acceptable in Group D. Bradycardia was observed in four patients in Group D ($p = 0.038$); no other clinically important adverse events occurred.

Conclusion: Dexmedetomidine (1 μg/kg) as an adjuvant to 0.5% bupivacaine in ultrasound-guided supraclavicular brachial plexus block provides significantly faster onset and longer duration of sensory–motor block and post-operative analgesia compared with fentanyl (1 μg/kg), with mild dose-

dependent bradycardia that responded to conservative measures. Dexmedetomidine appears to be the superior adjuvant for upper-limb surgery.

Keywords: Brachial Plexus Block, Bupivacaine, Dexmedetomidine, Fentanyl, Post-Operative Analgesia, Supraclavicular Block, Ultrasound Guidance.

1. INTRODUCTION

Regional anaesthesia has become an integral component of contemporary perioperative care for upper-limb surgery. The brachial plexus block, first described by Halsted in 1884 and later refined by Kulenkampff (1911) and Winnie (1970),[1] offers excellent surgical anaesthesia, reliable post-operative analgesia and avoids the physiological perturbations associated with general anaesthesia.[2] The supraclavicular approach-the so-called "spinal of the arm"-targets the plexus at the level of the divisions, where it is compact, and provides dense blockade of the entire upper limb below the shoulder.

Traditional landmark techniques carry an appreciable risk of pneumothorax, vascular puncture and inadvertent phrenic nerve blockade. The advent of ultrasound guidance has largely mitigated these concerns by permitting real-time visualization of the plexus, the pleura and adjacent vascular structures, thereby improving block success rates and safety.[3] The characteristic "bunch of grapes" sonoanatomy lateral to the subclavian artery serves as a reliable target for needle placement.[4] Nonetheless, block duration with local anaesthetics alone is often insufficient to cover the entire duration of post-operative pain, particularly following major orthopaedic procedures.

Various adjuvants-opioids, α_2-adrenoceptor agonists, dexamethasone, midazolam, magnesium sulphate and neostigmine-have been combined with local anaesthetics to enhance block characteristics.[5] Kaur and colleagues have shown that the addition of an appropriately chosen adjuvant to bupivacaine can meaningfully hasten onset and extend the analgesic window in supraclavicular block.[6] Among opioids, fentanyl, a highly lipophilic μ-agonist, has been widely used owing to its rapid onset and favourable side-effect profile. Its peripheral analgesic action is thought to be mediated by peripheral opioid receptors on primary afferents and by a local anaesthetic-like effect on nerve conduction.[7]

Dexmedetomidine, a highly selective α_2-adrenoceptor agonist (α_2: α_1 ratio ≈ 1620:1), produces analgesia through supraspinal, spinal and peripheral mechanisms. When applied perineurally, it prolongs sensory and motor block predominantly by hyperpolarising C-fibres through blockade of the hyperpolarisation-activated cation current,[8] and by local vasoconstriction that delays absorption of the co-administered local anaesthetic.[9] A randomized trial by Bharti and colleagues demonstrated that perineural dexmedetomidine produced a mean analgesic duration approximately 1.7-fold greater than that with local anaesthetic alone in supraclavicular block.[10]

Despite the growing body of literature favouring dexmedetomidine, direct comparisons with fentanyl in ultrasound-guided supraclavicular block remain relatively few, and the reported magnitude of benefit varies with the local anaesthetic, dose and injection technique used. We therefore designed the present randomized, double-blind trial to compare dexmedetomidine (1 μg/kg) and fentanyl (1 μg/kg) as adjuvants to 0.5% bupivacaine in patients undergoing elective upper-limb orthopaedic surgery under ultrasound-guided supraclavicular block.

1.1 AIMS AND OBJECTIVES

PRIMARY OBJECTIVE: To compare the duration of post-operative analgesia between the two groups.

SECONDARY OBJECTIVES: To compare

i) Onset of sensory and motor block,
ii) Duration of sensory and motor block,
iii) Intraoperative haemodynamics and Ramsay sedation score,
iv) VAS scores over 24 h,
v) Total rescue analgesic requirement,
vi) Incidence of adverse effects.

2. MATERIALS AND METHODS

2.1 STUDY DESIGN AND SETTING

This was a prospective, randomized, double-blind, parallel-group, controlled trial conducted in the Department of Anaesthesiology, Mahadevappa Rampure Medical College, Kalaburagi, over 12 months (May 2025-April

2026). Institutional Ethics Committee approval was obtained prior to enrolment (approval number and date on file with the corresponding author), and the trial was prospectively registered with the Clinical Trials Registry of India. The study was conducted in accordance with the Declaration of Helsinki (2013 revision), and the reporting conforms to the CONSORT 2010 statement.

2.2 PARTICIPANTS

Adult patients of either sex, aged 18-60 years, of American Society of Anesthesiologists (ASA) physical status I or II, scheduled for elective upper-limb orthopaedic procedures (below the mid-humerus) of anticipated duration ≤ 3 h under supraclavicular brachial plexus block were considered for inclusion. Written informed consent was obtained during the pre-anaesthetic visit.

EXCLUSION CRITERIA: patient refusal; known allergy or hypersensitivity to any study drug; local infection or skin lesion at the puncture site; coagulopathy (INR > 1.4 or platelets < 100×10^9/L); pre-existing peripheral neuropathy or brachial plexus injury; body mass index > 35 kg/m²; severe respiratory disease or contralateral phrenic nerve palsy; significant cardiac disease (heart block, sick sinus syndrome, ejection fraction < 40%); chronic opioid use; pregnancy or lactation; and inability to understand or comply with the VAS assessment.

2.3 SAMPLE SIZE CALCULATION

Sample size was estimated on the basis of the primary outcome, duration of post-operative analgesia, using data from the study by Kaur *et al.* (2015) in which the difference in mean duration of analgesia between adjuvant groups was approximately 150 min with a pooled standard deviation of 60 min. With a two-sided α of 0.05 and power of 90%, the minimum sample size worked out to 26 patients per group. Assuming a 15% attrition, 30 patients were enrolled in each arm, yielding a total sample of 60 patients.

2.4 RANDOMIZATION AND BLINDING

Eligible patients were randomly allocated in a 1:1 ratio to either Group D (dexmedetomidine) or Group F (fentanyl) using a computer-generated random number sequence. Allocation was concealed in serially numbered, opaque, sealed envelopes that were opened only after enrolment by a study nurse who was not otherwise involved in patient care. The study drugs were prepared by an anaesthesiologist not involved in patient assessment. Both the anaesthesiologist performing the block and the observer collecting outcome data were blinded to group allocation, ensuring double-blinding.

2.5 ANAESTHETIC TECHNIQUE

On arrival in the block room, standard monitoring-electrocardiography, non-invasive blood pressure and pulse oximetry-was applied and an 18-gauge intravenous cannula was secured on the non-operative side. Ringer's lactate 10 mL/kg was infused as pre-load. No sedative pre-medication was given.

With the patient in the supine position, head turned to the contralateral side and a small pillow between the scapulae, the supraclavicular fossa was prepared and draped under strict asepsis. A high-frequency linear ultrasound probe (6-13 MHz, SonoSite M-Turbo, FUJIFILM SonoSite Inc., USA) was placed in the supraclavicular fossa to identify the subclavian artery, first rib and the "bunch of grapes" appearance of the brachial plexus lateral to the artery. Using an in-plane technique, a 22-gauge, 50-mm insulated block needle (Stimuplex A, B. Braun, Germany) was advanced from lateral to medial. After negative aspiration, the study solution was deposited within the plexus sheath in 3-5 mL aliquots, with the needle repositioned to achieve circumferential spread (the "corner-pocket" technique was used to ensure ulnar coverage).

STUDY DRUG PREPARATION: Group D received 20 mL of 0.5% bupivacaine to which dexmedetomidine 1 µg/kg was added. Group F received 20 mL of 0.5% bupivacaine to which fentanyl 1 µg/kg was added. The total bupivacaine dose was 100 mg, well within the maximum safe dose (2 mg/kg for a 70-kg adult) and consistent with contemporary recommendations for ultrasound-guided supraclavicular block, in which real-time visualisation allows reliable circumferential spread with lower volumes than were traditionally used with landmark techniques. Both solutions were prepared by a blinded anaesthesiologist in identical 20-mL syringes; they were clear, colourless and indistinguishable in appearance.

2.6 ASSESSMENT OF BLOCK

Sensory block was assessed every 2 min after drug administration in the dermatomes of the median, ulnar, radial and musculocutaneous nerves using a pin-prick test, and graded on a 3-point scale (0 = normal sensation; 1 = analgesia, blunted sensation; 2 = anaesthesia, no sensation). Motor block was assessed by asking the patient to perform flexion of the elbow (musculocutaneous), thumb abduction (radial), thumb adduction (ulnar) and opposition of thumb and little finger (median) and graded on a modified Bromage scale (0 = normal motor function; 1 = decreased motor strength but able to move fingers; 2 = complete motor block).

Onset of sensory block was defined as the time from completion of injection to loss of pin-prick sensation (grade 2) in all four nerve distributions. **Onset of motor block** was defined as the time to complete inability to perform the movements above (grade 2). **Duration of sensory block** was defined as the time from onset to return of pin-prick sensation. **Duration of motor block** was defined as the time from onset to complete recovery of motor power. **Duration of analgesia** was defined as the time from injection to first request for rescue analgesic (VAS ≥ 4).

A block was considered successful if surgical anaesthesia was achieved within 30 min; otherwise it was deemed a failed block and the patient was converted to general anaesthesia and excluded from further analysis. No failed blocks were encountered in the present study.

2.7 INTRAOPERATIVE AND POST-OPERATIVE MONITORING

Heart rate, non-invasive blood pressure, mean arterial pressure and peripheral oxygen saturation were recorded at baseline, at 5, 10, 15, 30, 45, 60, 90 and 120 min after drug administration and every 30 min thereafter till the end of surgery. Bradycardia was defined as a heart rate < 60 beats/min or a fall > 20% from baseline and treated with atropine 0.6 mg intravenously. Hypotension was defined as systolic pressure < 90 mmHg or a fall > 20% from baseline and treated with intravenous fluids and incremental doses of mephentermine 3 mg. Sedation was graded using the Ramsay sedation scale.[11]

Post-operatively, patients were shifted to the recovery area and pain scores were recorded on a 10-point visual analogue scale (0 = no pain; 10 = worst imaginable pain) at 0, 2, 4, 6, 8, 12, 16, 20 and 24 h. Rescue analgesia in the form of intravenous paracetamol 1 g was administered when the VAS score reached ≥ 4. If pain was not relieved within 30 min, intramuscular diclofenac 75 mg was given as a second-line rescue. Total rescue analgesic requirements in the first 24 h were recorded.

2.8 STATISTICAL ANALYSIS

Data were entered in Microsoft Excel and analysed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY). Continuous variables are expressed as mean ± standard deviation and compared using Student's independent t-test if normally distributed (as verified by the Shapiro-Wilk test) or Mann-Whitney U-test if not. Repeated haemodynamic and VAS measurements were analysed by repeated-measures ANOVA with post-hoc Bonferroni correction. Categorical variables are expressed as frequency (percentage) and compared using the Chi-square or Fisher's exact test as appropriate. A two-sided p-value < 0.05 was considered statistically significant.

3. RESULTS

Between May 2025 and April 2026, 74 patients were screened, of whom 14 were excluded (nine did not meet the inclusion criteria, three declined participation and two were excluded for other reasons). Sixty patients were randomized and completed the study with no losses to follow-up; the CONSORT flow diagram is shown in Figure 1.

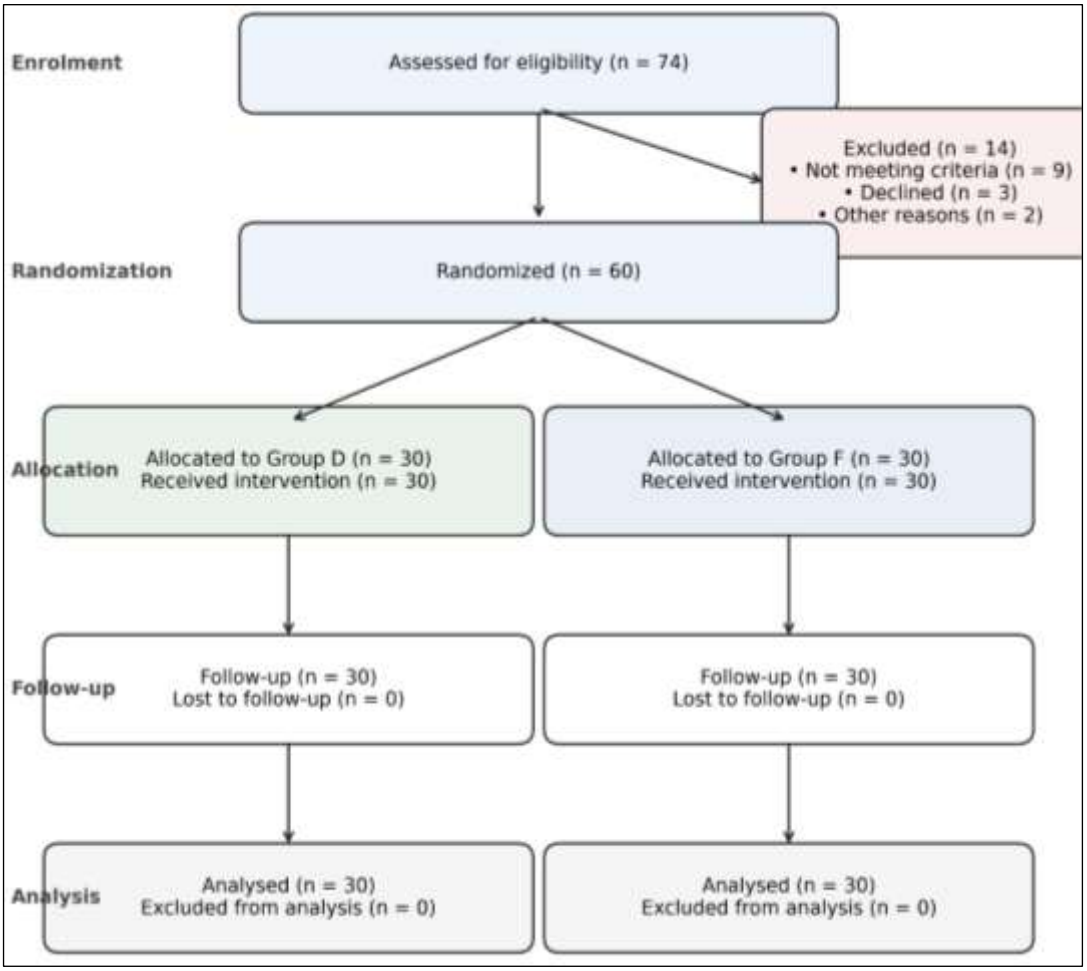

Figure No. 1: CONSORT flow diagram of participant enrolment, allocation, follow-up and analysis

3.1 DEMOGRAPHIC AND BASELINE CHARACTERISTICS

The two groups were comparable with respect to age, sex distribution, weight, height, body mass index, ASA physical status and duration of surgery (Table 1). None of the differences reached statistical significance, indicating successful randomization.

Table No. 1: Demographic and baseline characteristics of the study population

Parameter	Group D (n = 30)	Group F (n = 30)	p-value
Age (years)	36.4 ± 10.2	37.8 ± 11.1	0.612
Sex (Male/Female)	22/8	20/10	0.559
Weight (kg)	62.5 ± 8.4	64.1 ± 9.2	0.483
Height (cm)	164.6 ± 7.8	166.1 ± 8.2	0.472
BMI (kg/m²)	23.1 ± 2.6	23.2 ± 2.8	0.884
ASA I/II	24/6	22/8	0.542
Duration of surgery (min)	92 ± 24	88 ± 27	0.545

Values are mean ± SD or n. BMI, body mass index; ASA, American Society of Anesthesiologists.

3.2 BLOCK CHARACTERISTICS

The onset of both sensory and motor block was significantly faster in Group D than in Group F. Similarly, the durations of sensory block, motor block and post-operative analgesia were significantly prolonged in Group D (Table 2, Figure 2).

Table No. 2: Onset and duration of sensory and motor block, and duration of analgesia

Parameter (minutes)	Group D (n = 30)	Group F (n = 30)	p-value
Onset of sensory block	7.0 ± 1.4	9.6 ± 1.8	< 0.001*
Onset of motor block	10.4 ± 1.9	13.4 ± 2.3	< 0.001*
Duration of sensory block	458 ± 50	316 ± 42	< 0.001*
Duration of motor block	404 ± 46	282 ± 38	< 0.001*
Duration of analgesia	548 ± 58	384 ± 50	< 0.001*

Values are mean ± SD. *Statistically significant (p<0.05).

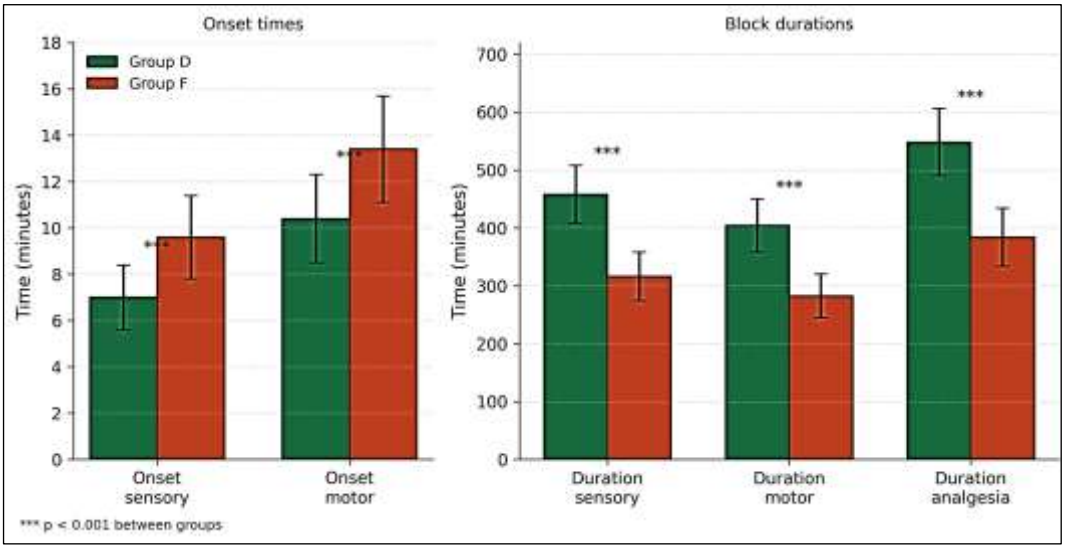

Figure No. 2. Comparison of onset times and durations of sensory block, motor block and post-operative analgesia between Group D (dexmedetomidine) and Group F (fentanyl). Error bars represent standard deviation. ***p < 0.001

3.3 POST-OPERATIVE VAS SCORES AND RESCUE ANALGESIA

Post-operative VAS scores were comparable between the groups at 0 and 2 h. From the fourth hour onwards, VAS scores were significantly lower in Group D up to 16 h, after which they became comparable (Table 3, Figure 3). The total number of rescue analgesic doses in the first 24 h was significantly lower in Group D (0.8 ± 0.4) compared with Group F (1.6 ± 0.6; p < 0.001).

Table No. 3: Visual analogue scale (VAS) scores at various time points post-block.

Time (h)	Group D (VAS)	Group F (VAS)	p-value
0	0.1 ± 0.2	0.1 ± 0.2	0.892
2	0.4 ± 0.3	0.6 ± 0.4	0.096
4	0.6 ± 0.4	1.2 ± 0.5	< 0.001*
6	0.9 ± 0.5	2.1 ± 0.6	< 0.001*
8	1.4 ± 0.6	3.4 ± 0.7	< 0.001*
12	2.2 ± 0.7	4.1 ± 0.8	< 0.001*
16	3.1 ± 0.8	3.6 ± 0.8	0.017*
20	2.6 ± 0.7	3.0 ± 0.7	0.052
24	2.4 ± 0.7	2.7 ± 0.7	0.114

Values are mean ± SD. *Statistically significant (p<0.05).

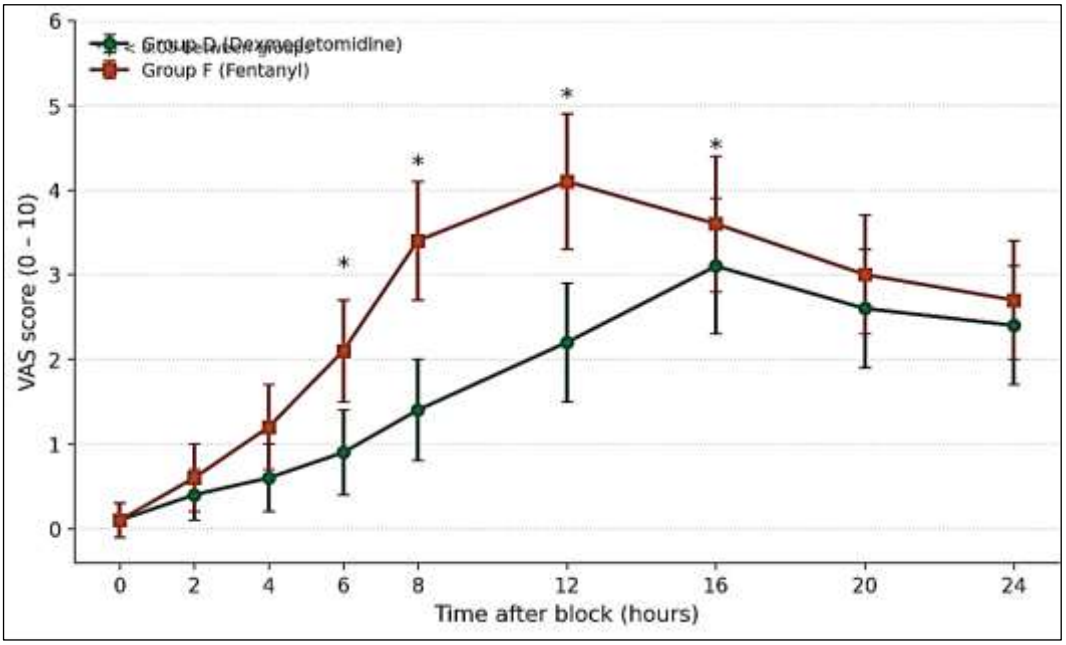

Figure No. 3: Mean visual analogue scale (VAS) scores over 24 h in the two groups. Error bars represent standard deviation. Asterisks indicate time points at which the between-group difference was statistically significant (p<0.05)

3.4 HAEMODYNAMIC PARAMETERS

Baseline heart rate and mean arterial pressure were comparable between groups. In Group D, both parameters showed a gradual decline reaching a nadir at 30-45 min, with a maximum mean reduction of approximately 13% in heart rate and 8% in mean arterial pressure compared with baseline. In Group F the parameters remained relatively stable throughout the observation period. The between-group differences at 30, 45 and 60 min were statistically significant but did not require pharmacological intervention beyond the four cases of bradycardia described below (Table 4, Figures 4 and 5).

Table No. 4: Selected intraoperative haemodynamic parameters (representative time points).

Time	HR-D	HR-F	MAP-D	MAP-F	p (HR/MAP)
Baseline	82.4 ± 7.2	83.1 ± 7.4	94.6 ± 8.1	95.2 ± 8.3	0.71/0.78
5 min	79.6 ± 6.8	82.4 ± 7.0	92.8 ± 7.8	94.4 ± 8.0	0.12/0.44
15 min	74.2 ± 6.1	80.8 ± 6.6	88.6 ± 7.2	92.8 ± 7.6	< 0.001*/0.032*
30 min	71.9 ± 5.9	80.2 ± 6.5	86.9 ± 7.0	92.1 ± 7.5	< 0.001*/0.007*
45 min	70.8 ± 5.8	79.8 ± 6.4	86.2 ± 6.9	91.8 ± 7.4	< 0.001*/0.003*
60 min	71.4 ± 5.9	80.1 ± 6.5	86.8 ± 7.1	92.4 ± 7.5	< 0.001*/0.005*
120 min	73.8 ± 6.2	81.2 ± 6.7	89.1 ± 7.4	93.6 ± 7.7	< 0.001*/0.021*

Values are mean ± SD. HR, heart rate (beats/min); MAP, mean arterial pressure (mmHg). *Statistically significant.

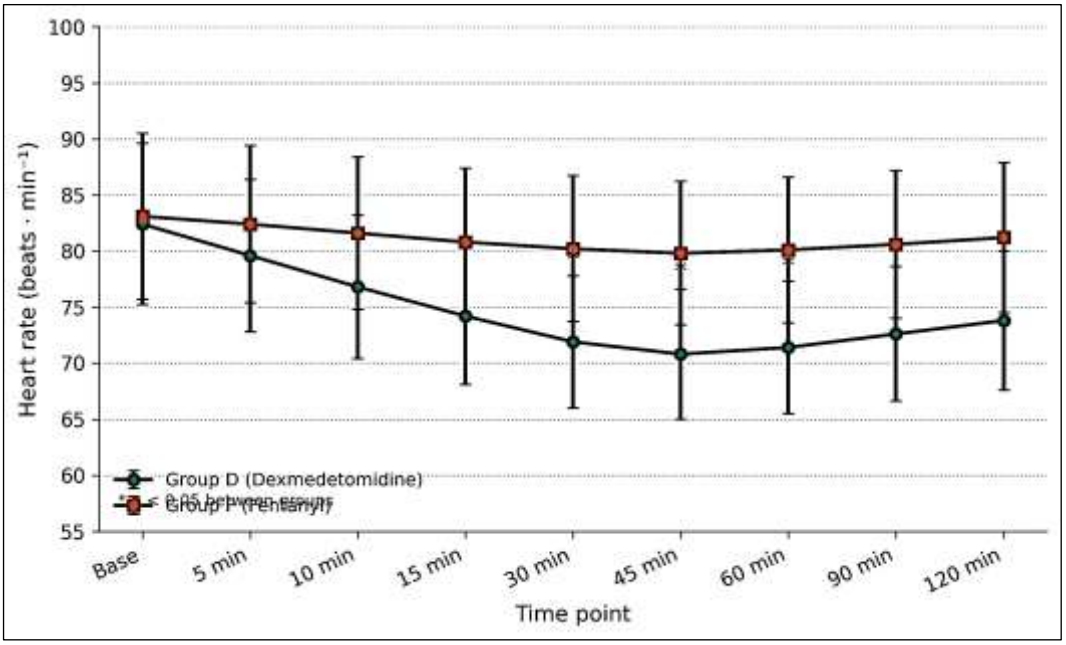

Figure No. 4: Intraoperative heart rate profile in the two groups

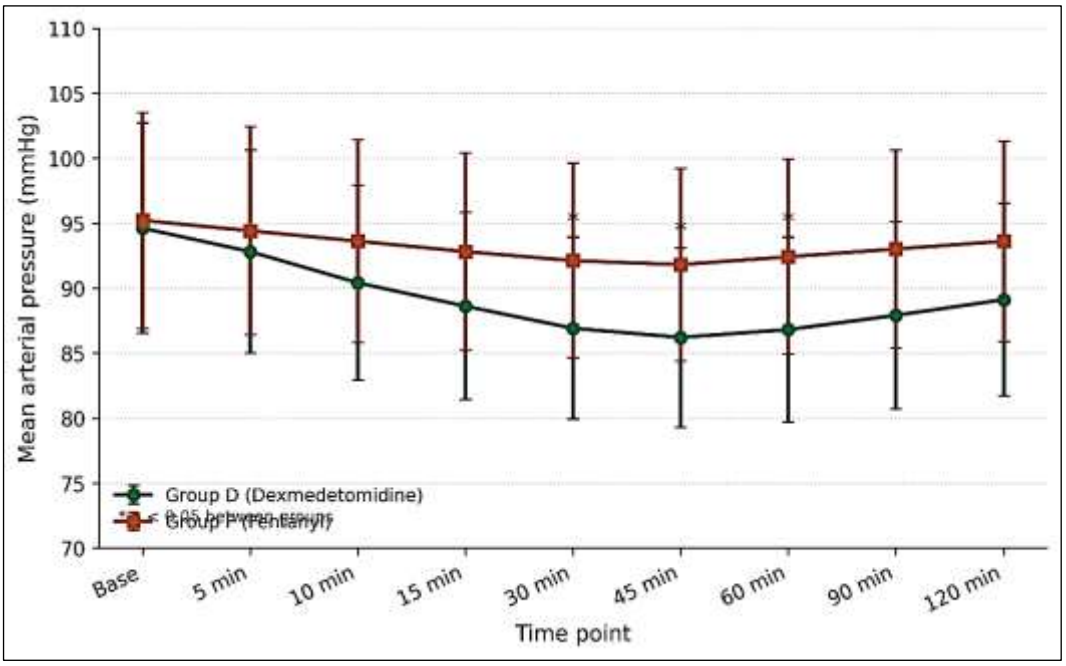

Figure No. 5: Intraoperative mean arterial pressure profile in the two groups

3.5 SEDATION, RESCUE ANALGESIA AND ADVERSE EFFECTS

The mean intraoperative Ramsay sedation score in Group D was 2.6 ± 0.5 compared with 1.4 ± 0.4 in Group F ($p < 0.001$). No patient reached a score of ≥ 5, and none required airway intervention. Bradycardia occurred in four patients (13.3%) in Group D and none in Group F ($p = 0.038$); all responded to a single dose of intravenous atropine. Transient hypotension was observed in three patients (10%) in Group D and one (3.3%) in Group F ($p = 0.301$) and was managed with fluid boluses. Post-operative nausea was more frequent in Group F (4 patients) than in Group D (1 patient) but did not reach statistical significance. No patient developed pneumothorax, local anaesthetic systemic toxicity, Horner's syndrome, respiratory depression or neurological sequelae (Table 5).

Table No. 5: Sedation score, rescue analgesic requirement and adverse effects

Parameter	Group D (n = 30)	Group F (n = 30)	p-value
Ramsay sedation score (intraop)	2.6 ± 0.5	1.4 ± 0.4	< 0.001*
Number of rescue doses/24 h	0.8 ± 0.4	1.6 ± 0.6	< 0.001*
Bradycardia, n (%)	4 (13.3)	0 (0)	0.038*
Hypotension, n (%)	3 (10.0)	1 (3.3)	0.301
Nausea/vomiting, n (%)	1 (3.3)	4 (13.3)	0.161
Pruritus, n (%)	0 (0)	2 (6.7)	0.492
Respiratory depression, n	0	0	—
Pneumothorax, n	0	0	—
LAST, n	0	0	—

Values are mean ± SD or n (%). LAST, local anaesthetic systemic toxicity. *Statistically significant.

4. DISCUSSION

The principal findings of this randomized, double-blind trial are that, in ultrasound-guided supraclavicular brachial plexus block for elective upper-limb surgery, the addition of dexmedetomidine (1 µg/kg) to 0.5% bupivacaine produces a significantly faster onset and a markedly longer duration of sensory and motor block, as well as prolonged post-operative analgesia and lower total rescue analgesic consumption, when compared with fentanyl (1 µg/kg). These benefits were achieved with modest, self-limiting bradycardia in a minority of patients and a level of sedation that was clinically acceptable and did not compromise the airway.

Our observations are consistent with several previous investigations. Esmaoglu and colleagues, working with levobupivacaine in axillary block, reported a doubling of block duration when 100 µg of dexmedetomidine was added, without any serious adverse events.[9] Swami *et al*. compared dexmedetomidine and clonidine as adjuvants in supraclavicular block and found significantly longer durations of both sensory and motor block, as well as analgesia, in the dexmedetomidine group.[5] Bharti *et al*. demonstrated in a similarly designed trial that dexmedetomidine produced a mean analgesic duration approximately 1.7-fold greater than that with local anaesthetic alone.[10] The magnitude of prolongation seen in our study-approximately 164 min of additional analgesia relative to fentanyl-closely mirrors the differences reported in the Indian population by Kumar *et al*. [12] and Nallam *et al*. [13].

The mechanism underlying dexmedetomidine's peripheral action is now reasonably well characterised. Brummett and colleagues, in an elegant series of experiments on isolated rat sciatic nerve, showed that perineural dexmedetomidine blocks the hyperpolarisation-activated cation current (I_h), thereby preventing the rebound depolarisation that normally follows local anaesthetic action, and thus prolongs block duration without producing histopathological evidence of neurotoxicity.[8] A vasoconstrictive effect at the site of injection, mediated by post-junctional α_2-adrenoceptors on vascular smooth muscle, is thought to further prolong local anaesthetic contact with the plexus.[9] In addition, dexmedetomidine may exert a mild systemic analgesic effect through locus coeruleus α_2-agonism, although the doses used perineurally produce only low plasma concentrations.[14,15]

Fentanyl's peripheral analgesic action, in contrast, is more controversial. While early studies by Nishikawa *et al*. [7] and Karakaya *et al*. [16] reported modest prolongation of axillary block with 100 µg of fentanyl, others have found little or no benefit and have raised the possibility of systemic rather than local mechanisms. In our study, fentanyl-supplemented blocks produced clinically effective anaesthesia and analgesia lasting approximately 6.4 h, which is consistent with expectations for plain bupivacaine and confirms that at the 1 µg/kg dose fentanyl offers only marginal additional benefit over the local anaesthetic itself.

The haemodynamic profile observed in the dexmedetomidine group deserves comment. A biphasic response is well recognised: an initial transient hypertensive phase from peripheral α_2B-mediated vasoconstriction, followed by bradycardia and hypotension consequent to central sympatholysis. In our patients the initial hypertensive phase was not evident, probably because of the low perineural dose (mean 60-70 µg total) and slow systemic absorption. The subsequent decline in heart rate and mean arterial pressure was gradual, reached a nadir

at approximately 45 min, and was clinically inconsequential in the majority. Only four patients required a single dose of atropine, and none required vasopressor infusion. This safety profile compares favourably with that reported by Song *et al*. [17] and Rashmi *et al*. [18] using similar dose regimens. The greater incidence of nausea in the fentanyl group is likewise expected given the emetogenic potential of μ-opioid agonists.

Ultrasound guidance appears to have contributed to the excellent safety record of the present series. The ability to visualise the plexus in real time permitted circumferential deposition of the drug within the sheath while avoiding the subclavian artery, dome of the pleura and the sympathetic chain. No patient developed pneumothorax, vascular puncture, Horner's syndrome or hemidiaphragmatic paresis of clinical relevance. These findings are in agreement with the outcome data of Perlas *et al*. from 510 consecutive ultrasound-guided supraclavicular blocks [3].

Taken together, our results support the choice of dexmedetomidine 1 μg/kg over fentanyl 1 μg/kg as an adjuvant to bupivacaine for ultrasound-guided supraclavicular brachial plexus block. The clinically relevant benefits-earlier onset, close to 3 h of additional analgesia, halving of rescue analgesic doses, and improved patient comfort-are achieved at a small and manageable cost of transient bradycardia and mild sedation. These benefits translate into potential advantages for early mobilisation, patient satisfaction and post-operative resource utilisation.

4.1 STRENGTHS AND LIMITATIONS

The strengths of the present trial include its prospective, randomized, double-blind design, adequate power, standardized ultrasound-guided technique performed by a single group of experienced anaesthesiologists, and use of a rigorously validated assessment protocol. A CONSORT-compliant flow of participants was maintained with no losses to follow-up.

Several limitations should be acknowledged. First, the study was conducted in a single tertiary-care institution, which may limit external validity. Second, plasma levels of the adjuvants were not measured, so the relative contributions of local and systemic mechanisms cannot be dissected. Third, only one dose of each adjuvant was tested; dose-response relationships, particularly for dexmedetomidine, remain to be explored in this population. Fourth, follow-up was limited to 24 h and thus late outcomes such as chronic post-surgical pain and any subtle neurological effects were not captured. Finally, the study was not powered to detect rare adverse events; larger multicentre trials or registry data will be required for a definitive safety appraisal.

5. CONCLUSION

In patients undergoing elective upper-limb orthopaedic surgery under ultrasound-guided supraclavicular brachial plexus block, dexmedetomidine 1 μg/kg added to 20 mL of 0.5% bupivacaine produced a significantly faster onset of sensory and motor block, a substantially longer duration of block and post-operative analgesia, and lower rescue analgesic requirements than fentanyl 1 μg/kg used in the same volume of local anaesthetic. The dexmedetomidine group showed mild, dose-related bradycardia and clinically acceptable sedation but no serious adverse events. Dexmedetomidine is therefore recommended as the adjuvant of choice for ultrasound-guided supraclavicular brachial plexus block in this setting, with vigilant intraoperative haemodynamic monitoring.

5. REFERENCES

1. Winnie AP. Interscalene brachial plexus block. Anesth Analg. 1970;49(3):455-66.
2. Neal JM, Gerancher JC, Hebl JR, Ilfeld BM, McCartney CJL, Franco CD, *et al*. Upper extremity regional anesthesia: essentials of our current understanding, 2008. Reg Anesth Pain Med. 2009;34(2):134-70.
3. Perlas A, Lobo G, Lo N, Brull R, Chan VWS, Karkhanis R. Ultrasound-guided supraclavicular block: outcome of 510 consecutive cases. Reg Anesth Pain Med. 2009;34(2):171-6.
4. Chan VWS, Perlas A, Rawson R, Odukoya O. Ultrasound-guided supraclavicular brachial plexus block. Anesth Analg. 2003;97(5):1514-7.
5. Swami SS, Keniya VM, Ladi SD, Rao R. Comparison of dexmedetomidine and clonidine (α_2-agonist drugs) as an adjuvant to local anaesthesia in supraclavicular brachial plexus block: a randomised double-blind prospective study. Indian J Anaesth. 2012;56(3):243-9.
6. Kaur H, Singh G, Rani S, Gupta KK, Kumar M, Rajpal A, *et al*. Effect of dexmedetomidine as an adjuvant to bupivacaine in supraclavicular brachial plexus block: a randomized double-blind prospective study. J Anaesthesiol Clin

Pharmacol. 2015;31(3):333-8.
7. Nishikawa K, Kanaya N, Nakayama M, Igarashi M, Tsunoda K, Namiki A. Fentanyl improves analgesia but prolongs the onset of axillary brachial plexus block by peripheral mechanism. Anesth Analg. 2000;91(2):384-7.
8. Brummett CM, Norat MA, Palmisano JM, Lydic R. Perineural administration of dexmedetomidine in combination with bupivacaine enhances sensory and motor blockade in sciatic nerve block without inducing neurotoxicity in the rat. Anesthesiology. 2008;109(3):502-11.
9. Esmaoglu A, Yegenoglu F, Akin A, Turk CY. Dexmedetomidine added to levobupivacaine prolongs axillary brachial plexus block. Anesth Analg. 2010;111(6):1548-51.
10. Bharti N, Sardana DK, Bala I. The analgesic efficacy of dexmedetomidine as an adjunct to local anesthetics in supraclavicular brachial plexus block: a randomized controlled trial. Anesth Analg. 2015;121(6):1655-60.
11. Ramsay MA, Savege TM, Simpson BR, Goodwin R. Controlled sedation with alphaxalone-alphadolone. Br Med J. 1974;2(5920):656-9.
12. Kumar A, Sharma D, Sibi ME, Datta B, Gogoi B. Comparison of fentanyl and dexmedetomidine as an adjuvant to bupivacaine for supraclavicular brachial plexus block. J Sci Soc. 2015;42(2):85-90.
13. Nallam SR, Chiruvella S, Karanam S. Supraclavicular brachial plexus block: comparison of varying doses of dexmedetomidine combined with levobupivacaine-a double-blind randomised trial. Indian J Anaesth. 2017;61(3):256-61.
14. Marhofer D, Kettner SC, Marhofer P, Pils S, Weber M, Zeitlinger M. Dexmedetomidine as an adjuvant to ropivacaine prolongs peripheral nerve block: a volunteer study. Br J Anaesth. 2013;110(3):438-42.
15. Vieira PA, Pulai I, Tsao GC, Manikantan P, Keller B, Connelly NR. Dexmedetomidine and dexamethasone as adjuvants to ropivacaine reduce onset time and prolong duration of interscalene block. Eur J Anaesthesiol. 2010;27(3):285-8.
16. Karakaya D, Buyukgoz F, Baris S, Guldogus F, Tur A. Addition of fentanyl to bupivacaine prolongs anesthesia and analgesia in axillary brachial plexus block. Reg Anesth Pain Med. 2001;26(5):434-8.
17. Song JH, Shim HY, Lee TJ, Jung JK, Cha YD, Lee DI, *et al.* Comparison of dexmedetomidine and epinephrine as an adjuvant to 1% mepivacaine in brachial plexus block. Korean J Anesthesiol. 2014;66(4):283-9.
18. Rashmi HD, Komala HK. Effect of dexmedetomidine as an adjuvant to 0.75% ropivacaine in interscalene brachial plexus block using nerve stimulator: a prospective, randomized double-blind study. Anesth Essays Res. 2017;11(1):134-9.