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Original Research Article

Ropivacaine 0.5% with or without Fentanyl for Supraclavicular Brachial Plexus Block: A Comparative Study of Sensory and Motor Block Duration

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Abstract:

Background: Brachial plexus block is a widely used regional anaesthetic technique for upper limb surgeries. Adjuvants are frequently added to local anaesthetics to enhance block quality and duration. This study evaluated the effect of fentanyl (50 mcg) as an adjuvant to Ropivacaine 0.5% on the onset and duration of sensory and motor block in patients undergoing supraclavicular brachial plexus block.

Methods: This prospective, randomised, comparative study included 70 ASA I and II patients aged 20–70 years undergoing upper limb surgery under supraclavicular brachial plexus block. Patients were allocated to Group I (n=35): 0.5% ropivacaine 30 ml + 1 ml normal saline (31 ml total) or Group II (n=35): 0.5% ropivacaine 30 ml + fentanyl 50 mcg in 1 ml (31 ml total). Blocks were performed using a nerve stimulator-guided supraclavicular approach. Onset and duration of sensory and motor block were the primary outcomes. Statistical analysis was performed using the Mann-Whitney U test and Chi-square/Fisher's Exact test where appropriate; $p<0.05$ was considered significant.

Results: Demographic parameters and baseline characteristics were comparable between groups ($p>0.05$). Group II demonstrated significantly prolonged sensory block duration (Median 8.00 [7.50–8.50] hrs vs 4.00 [4.00–4.50] hrs; mean difference +3.61 hrs, 95% CI: 3.42–3.81, $p<0.001$) and motor block duration (Median 6.50 [6.50–7.00] hrs vs 3.50 [3.00–4.00] hrs; mean difference +3.13 hrs, 95% CI: 2.92–3.34, $p<0.001$) compared to Group I. Block onset was marginally but significantly delayed in Group II for both sensory ($p<0.001$) and motor block ($p<0.001$). Block success rate was higher in Group II (97.1% vs 88.6%), though this did not reach statistical significance ($p=0.356$). VAS scores at rescue analgesia were comparable between groups ($p=0.567$).

Conclusions: The addition of fentanyl 50 mcg to ropivacaine 0.5% for supraclavicular brachial plexus block significantly prolongs both sensory and motor block duration, albeit with a slight delay in block onset. Fentanyl is a safe and effective adjuvant to ropivacaine for prolonging postoperative analgesia in patients undergoing upper limb surgery.

Keywords: Brachial Plexus Block; Ropivacaine; Fentanyl; Regional Anaesthesia; Supraclavicular Block; Postoperative Analgesia.

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Introduction

Upper limb fractures constitute a significant proportion of orthopaedic injuries across all age groups, resulting from high-energy trauma in younger patients and low-energy falls in the elderly. The incidence of geriatric upper extremity injuries, particularly distal radius and humerus fractures, is rising in parallel with global population ageing. [1,2]

Regional anaesthetic techniques, particularly brachial plexus block, offer compelling advantages for upper limb surgery including superior postoperative analgesia, reduced opioid requirements, diminished thromboembolic risk, and an attenuated systemic stress response.[3] These characteristics render brachial plexus block especially suitable for elderly patients, in whom general anaesthesia carries heightened risk due to age-related physiological changes and co-existing comorbidities.

The supraclavicular approach to brachial plexus block provides rapid, reliable, and complete anaesthesia to the upper extremity distal to the shoulder, making it well suited to forearm and hand surgery.[4] Ropivacaine, a long-acting amide local anaesthetic, exerts its effect by binding to voltage-gated sodium channels, thereby inhibiting the initiation and propagation of nerve impulses, producing prolonged sensory and motor blockade.

To further enhance block quality and duration while minimising local anaesthetic dose and associated toxicity, various adjuvants have been investigated for peripheral nerve blocks. Among these, opioids such as fentanyl have been most widely studied. The mechanism of opioid enhancement at peripheral sites remains debated: proposed mechanisms include activation of peripheral opioid receptors, a direct local anaesthetic-like membrane stabilising action, and systemic absorption with central opioid receptor-mediated analgesia. [5,6,7]

Published data on the efficacy of fentanyl as a brachial plexus adjuvant are, however, conflicting. Several studies have reported significant prolongation of block duration with fentanyl addition, [8,9] while others found no additional benefit.[10] The variability in findings may relate to differences in the local anaesthetic used, fentanyl dose, block technique, and outcome measurement methodology.

The present study was therefore designed to evaluate whether the addition of fentanyl 50 mcg to ropivacaine 0.5% for nerve stimulator-guided supraclavicular brachial plexus block produces a clinically meaningful prolongation of sensory and motor block duration compared to ropivacaine alone, in patients undergoing elective upper limb surgery.

Methods

This prospective, randomised, comparative study was conducted after obtaining approval from the Institutional Ethics Committee and written informed consent from each participant. The trial was conducted in accordance with the principles of the Declaration of Helsinki.

Patient Selection: Seventy adult patients of ASA physical status grade I or II, aged 20–70 years, scheduled for elective upper limb surgery under supraclavicular brachial plexus block were enrolled. Patients were excluded if they had hypersensitivity to the study drugs, coagulopathy, active local or systemic infection, significant cardiovascular or respiratory disease, pregnancy, morbid obesity (BMI >35 kg/m²), pre-existing neuropathy of the upper limb, chronic pain on opioid therapy, or were unwilling to participate.

Randomisation and Blinding: Patients were randomly allocated using a computer-generated random number table to one of two equal groups of 35 patients. Drug preparation was performed by a resident doctor not involved in block performance or outcome assessment, ensuring allocation concealment. The anaesthesiologist assessing block parameters was blinded to group allocation.

Study Groups

Group I (Control): 0.5% Ropivacaine 30 ml + 1 ml normal saline = 31 ml total.

Group II (Study): 0.5% Ropivacaine 30 ml + fentanyl 50 mcg (in 1 ml) = 31 ml total.

Block Technique: All blocks were performed in the operation theatre under standard monitoring (pulse oximetry, non-invasive blood pressure, ECG) with intravenous access established. Using aseptic technique, a peripheral nerve stimulator-guided supraclavicular brachial plexus block was administered in the supine position with the head turned to the contralateral side. A 22G insulated needle was used, and the endpoint for injection was a motor response (wrist or finger flexion/extension) at a current of 0.3–0.5 mA. The total drug volume of 31 ml was injected incrementally after careful aspiration to exclude intravascular placement.

Outcome Measurement: Sensory and motor block parameters were assessed at 3-minute intervals up to 30 minutes after needle withdrawal. Sensory block onset was defined as loss of pin-prick sensation along the dermatomal distribution of the forearm and hand. Motor block onset was defined as complete inability to perform wrist flexion and extension, third finger flexion, thumb abduction, and little finger flexion. Block failure was defined as complaint of significant pain requiring conversion to general anaesthesia within 30 minutes of block administration. Failed blocks were excluded from onset and duration analysis.

Duration of sensory block (analgesic duration) was recorded from the time of block administration to the time at which the patient reported a VAS pain score of ≥4 (Numerical Rating Scale: 0 = no pain, 10 = worst pain imaginable). Duration of motor block was recorded from time of block administration to recovery of all motor movements. Rescue analgesia in the form of intravenous tramadol 50 mg was administered when VAS ≥4 was recorded.

Statistical Analysis: Statistical analysis was performed using SciPy (Python 3) with $\alpha=0.05$ for all tests. Normality of continuous variables was assessed by the Shapiro-Wilk test. Normally distributed continuous variables (weight, height, duration of surgery) were compared using the independent samples t-test and reported as Mean ± SD. Non-normally distributed continuous variables (age, onset and duration of sensory and motor block) were compared using the Mann-Whitney U test and reported as Median [IQR]. Categorical variables (sex, ASA grade, surgical procedure, block success/failure) were analysed using the Chi-square test or Fisher's Exact Test where any expected cell count was less than 5. VAS scores at rescue were analysed using the Mann-Whitney U test. Equality of variances for primary outcomes was confirmed using Levene's test. Mean differences with 95%

confidence intervals were calculated for primary outcome variables. A p-value of <0.05 was considered statistically significant.

Results

Demographic and Baseline Characteristics: Seventy patients were enrolled, with 35 in each group. All 70 patients completed the study; failed blocks were excluded from onset and duration analysis per protocol. The demographic and baseline characteristics of both groups are presented in Table 1. Age, sex distribution, height, duration of surgery, ASA grade, and surgical procedure type were comparable between groups (all p>0.05). Weight was significantly higher in Group II (68.63 ± 11.77 kg vs 60.66 ± 7.58 kg; p=0.001), which is acknowledged as an incidental finding discussed below.

Table 1: Demographic and Baseline Characteristics

Variable	Group I (n=35) Ropivacaine 0.5%	Group II (n=35) Ropivacaine 0.5% + Fentanyl	Test Statistic	p-value
Age (years)*	45.0 [34.5–59.0]	48.0 [40.0–60.5]	U=500.5	0.190
Weight (kg)	60.66 ± 7.58	68.63 ± 11.77	t = −3.369	0.001†
Height (cm)	161.86 ± 8.61	165.29 ± 8.83	t = −1.645	0.105
Duration of Surgery (min)	62.09 ± 16.74	66.97 ± 16.98	t = −1.212	0.230
Sex (Male : Female)	19 : 16	20 : 15	χ^2=0.058	0.810
ASA Grade (I : II)	22 : 13	20 : 15	χ^2=0.238	0.626
Surgical Procedure			χ^2=1.708	0.426
ORIF	17 (48.6%)	22 (62.9%)		
Closed Reduction	8 (22.9%)	7 (20.0%)		
Implant Removal	10 (28.6%)	6 (17.1%)		

Data are Mean ± SD unless stated otherwise. Age reported as Median [IQR] (non-normal distribution by Shapiro-Wilk). †Weight difference was statistically significant (p=0.001) and is discussed as a potential confounder. Independent t-test for normally distributed variables; Mann-Whitney U for age; Chi-square for categorical variables. ORIF = open reduction and internal fixation.

Onset of Sensory and Motor Block: The onset of both sensory and motor block was significantly delayed in Group II compared to Group I (Table 2). Sensory block onset was 7.50 [7.00–8.00] minutes in Group I versus 8.40 [8.00–9.00] minutes in Group II (mean difference +0.98 min, 95% CI: 0.73–1.23, p<0.001). Motor block onset was 12.00 [11.00–12.00] minutes in Group I versus 13.10 [12.45–13.50] minutes in Group II (mean difference +1.35 min, 95% CI: 1.04–1.66, p<0.001). Although statistically significant, these differences were modest and clinically of limited consequence.

Table 2: Onset of Sensory and Motor Block

Parameter	Group I Median [IQR]	Group II Median [IQR]	Mean Diff (G2−G1)	p-value
Onset of Sensory Block (min)	7.50 [7.00–8.00]	8.40 [8.00–9.00]	+0.98 [0.73, 1.23]	<0.001
Onset of Motor Block (min)	12.00 [11.00–12.00]	13.10 [12.45–13.50]	+1.35 [1.04, 1.66]	<0.001

Data are Median [IQR]. Mann-Whitney U test used (non-normal distribution confirmed by Shapiro-Wilk test). A positive mean difference indicates Group II had longer onset time than Group I. 95% CI calculated using large-sample approximation for mean difference.

Duration of Sensory and Motor Block (Primary Outcomes): Group II demonstrated significantly prolonged sensory and motor block duration compared to Group I (Table 3). The median duration of sensory block was 8.00 [7.50–8.50] hours in Group II compared to 4.00 [4.00–4.50] hours in Group I (mean difference +3.61 hours, 95% CI: 3.42–3.81, p<0.001). The median duration of motor block was 6.50 [6.50–7.00] hours in Group II versus 3.50 [3.00–4.00] hours in Group I (mean difference +3.13 hours, 95% CI: 2.92–3.34, p<0.001). Mann-Whitney U values of 0.0 for both primary outcomes indicate complete non-overlap of block duration values between groups. Levene's test confirmed equality of variances for sensory (F=0.835, p=0.364) and motor duration (F=0.944, p=0.335).

Table 3: Duration of Sensory and Motor Block (Primary Outcomes)

Parameter	Group I Median [IQR]	Group II Median [IQR]	Mean Diff (G2−G1), 95% CI	p-value
Duration of Sensory Block (hrs)	4.00 [4.00–4.50]	8.00 [7.50–8.50]	+3.61 [3.42, 3.81]	<0.001
Duration of Motor Block (hrs)	3.50 [3.00–4.00]	6.50 [6.50–7.00]	+3.13 [2.92, 3.34]	<0.001

Data are Median [IQR]. Mann-Whitney U test (non-normal distribution). Failed blocks excluded from duration analysis. U=0.0 for both primary outcomes indicates complete separation of values between groups. Levene's test confirmed equal variances (sensory: F=0.835, p=0.364; motor: F=0.944, p=0.335).

VAS Score at Rescue Analgesia and Block Success: VAS scores at the time of rescue analgesia were comparable between groups, with a median of 4.00 (IQR: 4.0–5.0) in both groups (U=565.0, p=0.567), confirming that the sensory block endpoint (VAS ≥4) was equivalent in both groups. Block success rates were 88.6% (31/35) in Group I and 97.1% (34/35) in Group II; this difference was not statistically significant (Fisher's Exact, p=0.356), though the trend favoured the fentanyl group (Table 4).

Table 4: VAS Score at Rescue Analgesia and Block Success/Failure

Parameter	Group I (n=35)	Group II (n=35)	Test Statistic	p-value
VAS Score at Rescue Analgesia* [Median (IQR)]	4.00 (4.0–5.0) n=31	4.00 (4.0–5.0) n=34	U=565.0	0.567
Block Success [n (%)]	31 (88.6%)	34 (97.1%)	Fisher's Exact	0.356
Block Failure [n (%)]	4 (11.4%)	1 (2.9%)		

*VAS scores recorded only at time of rescue analgesia (VAS ≥4) for successful blocks. Block failure defined as conversion to general anaesthesia within 30 minutes of block administration. Fisher's Exact Test used for block success/failure (expected cell count <5).

Discussion

The principal finding of this study is that the addition of fentanyl 50 mcg to ropivacaine 0.5% for supraclavicular brachial plexus block produces a clinically and statistically significant prolongation of both sensory and motor block duration, with a modest but significant delay in block onset.

The median duration of sensory block in the fentanyl group (8.00 hours) was approximately double that of the ropivacaine-alone group (4.00 hours), representing a mean increase of 3.61 hours (95% CI: 3.42–3.81, p<0.001). Similarly, median motor block duration increased from 3.50 hours to 6.50 hours with fentanyl addition (mean difference +3.13 hours, 95% CI: 2.92–3.34, p<0.001). The U statistic of 0.0 for both primary outcomes — indicating complete non-overlap of individual data between groups — underscores the magnitude and consistency of this effect.

These findings are consistent with those of Rajkhowa et al., who reported a similarly marked prolongation of sensory and motor block duration when fentanyl 50 mcg was added to ropivacaine 0.5% for supraclavicular brachial plexus block (sensory block 7.75 ± 0.47 vs 4.5 ± 0.39 hours; motor block 6.56 ± 0.43 vs 3.66 ± 0.46 hours; p=0.0001 for both).[11] Madhusudhana et al. similarly demonstrated significant prolongation of sensory (9 hours) and motor block (8 hours) duration with fentanyl 50 mcg added to ropivacaine 0.75%, compared to ropivacaine alone (6 hours sensory, 5 hours motor), supporting a class effect of opioid adjuvants on brachial plexus blocks.[12]

The mechanism by which fentanyl prolongs peripheral nerve block remains incompletely understood. Proposed mechanisms include: (1) activation of peripheral opioid receptors at sites of inflammation; (2) a direct local anaesthetic-like membrane-stabilising effect on mammalian peripheral nerves; and (3) systemic absorption with subsequent central opioid receptor-mediated analgesia. [5,6,13] The relative contribution of each mechanism may vary depending on clinical context.

Block onset was marginally delayed in the fentanyl group — by approximately one minute for sensory block and 1.35 minutes for motor block — consistent with prior reports.[11] This has been attributed to a reduction in the pH of the local anaesthetic solution on addition of fentanyl (which is mildly acidic), resulting in a higher proportion of the ionised, membrane-impermeant form of the local anaesthetic. While statistically significant, this delay is of negligible clinical relevance in routine practice.

Block success rates were numerically higher in the fentanyl group (97.1% vs 88.6%), consistent with the findings of Rajkhowa et al. (one failure in the fentanyl group vs five in the plain ropivacaine group). Although this difference did not reach statistical significance in our study (p=0.356, likely reflecting limited power for this secondary

outcome), the trend suggests that fentanyl addition may enhance block reliability.

A statistically significant difference in body weight between groups (p=0.001) was noted as an incidental finding. Given that the total drug volume and drug concentration were identical and fixed (not weight-adjusted) in both groups, and that the primary outcomes were measured as temporal parameters (hours, minutes) rather than pharmacokinetic indices, this weight difference is unlikely to have materially confounded the observed block duration results. However, future studies with larger samples and formal stratification by weight would be valuable.

The comparable VAS scores at rescue analgesia between groups (median 4.0 in both; p=0.567) confirm that both groups used the same sensory endpoint for defining block duration, validating the internal consistency of our measurement methodology.

Contrary evidence exists: Fletcher et al. found no additional analgesic benefit from fentanyl added to lidocaine with epinephrine for axillary brachial plexus block, though they noted faster onset along the musculocutaneous nerve.[10] These discrepancies may reflect differences in the local anaesthetic vehicle (lidocaine vs bupivacaine/ropivacaine), block approach (axillary vs supraclavicular), or fentanyl dose.

Limitations of this study include the single-centre design, nerve stimulator guidance (versus the now-preferred ultrasound guidance), absence of haemodynamic monitoring data, and the incidental weight imbalance between groups. Future studies employing ultrasound-guided technique, formal blinding of outcome assessors, and larger samples would further strengthen these findings.

Conclusion

The addition of fentanyl 50 mcg to ropivacaine 0.5% for nerve stimulator-guided supraclavicular brachial plexus block significantly prolongs both sensory block duration (median increase approximately 4 hours) and motor block duration (median increase approximately 3 hours) compared to ropivacaine alone. Block onset is marginally delayed but this is not clinically significant. Fentanyl is a safe, readily available, and effective adjuvant to ropivacaine for prolonging postoperative analgesia in patients undergoing elective upper limb surgery.

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