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Original Research Article

COMPARISON OF TRAMADOL AND BUTORPHANOL AS ADJUVANTS TO BUPIVACAINE IN SUPRACLAVICULAR BRACHIAL PLEXUS BLOCK FOR UPPER LIMB SURGERY: A PROSPECTIVE RANDOMIZED STUDY

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ABSTRACT

Background: The supraclavicular brachial plexus block is widely used for upper limb surgeries due to its ability to provide dense sensory and motor blockade with stable hemodynamics and excellent postoperative analgesia. Although bupivacaine remains a preferred long-acting local anaesthetic, its analgesic duration may be insufficient for prolonged postoperative pain control. Opioid adjuvants such as tramadol and butorphanol are frequently added to enhance block characteristics and extend analgesia. This study compares the efficacy and safety of tramadol and butorphanol as adjuvants to bupivacaine in ultrasound-guided supraclavicular brachial plexus block.

Materials and Methods: Eighty ASA I–II patients aged 18–60 years scheduled for elective upper limb surgeries were randomized into two equal groups. Group T received 25 ml of 0.5% bupivacaine with 100 mg tramadol, and Group B received 25 ml of 0.5% bupivacaine with 1 mg butorphanol. All blocks were performed under ultrasound guidance. Sensory and motor block onset times, duration of blockade, duration of analgesia, hemodynamic parameters, respiratory variables, sedation, and adverse effects were recorded. Statistical analyses were performed using SPSS version 25, with $p < 0.05$ considered significant.

Results: The duration of postoperative analgesia was significantly longer in Group B (819 ± 77 min) compared to Group T (751 ± 52 min) ($p < 0.001$). Sensory and motor block onset times were comparable between the two groups, while sensory and motor block durations were significantly prolonged with butorphanol. Hemodynamic and respiratory parameters remained stable throughout the study in both groups. Tramadol was associated with a higher incidence of nausea, whereas butorphanol produced mild sedation without respiratory compromise.

Conclusion: Both tramadol and butorphanol are effective adjuvants to bupivacaine for supraclavicular brachial plexus block; however, butorphanol provides significantly longer postoperative analgesia with a favourable safety profile. Its superior analgesic duration and minimal adverse effects suggest that butorphanol may be the preferred adjuvant when prolonged postoperative pain control is desired.

Keywords: Supraclavicular brachial plexus block, Bupivacaine, Tramadol, Butorphanol, Ultrasound-guided regional anaesthesia, Postoperative analgesia, Sensory block duration, Motor block duration.

INTRODUCTION

Regional anaesthesia has transformed perioperative care in upper limb surgery by providing superior postoperative analgesia, reducing systemic anaesthetic and opioid requirements, lowering rates of postoperative nausea and vomiting, and improving patient satisfaction and recovery.[1,2] The supraclavicular brachial plexus block is particularly effective for procedures involving the shoulder, arm, forearm, and hand, as the plexus is anesthetized at the level of the trunks where neural elements are densely clustered, producing a reliable and dense block.[3]

Ultrasound guidance has further enhanced the safety and efficacy of this block by enabling real-time visualization of neural structures, vessels, and needle trajectory, resulting in higher success rates and fewer complications such as pneumothorax and vascular injury.[4]

Bupivacaine remains a widely used long-acting local anaesthetic; however, its duration may be inadequate for surgeries associated with significant postoperative pain. To extend analgesia and improve block quality, various adjuvants are added to local anaesthetics. Among these, tramadol and butorphanol are frequently used opioid derivatives with distinct mechanisms. Tramadol provides analgesia through weak μ-agonism and monoamine reuptake inhibition, whereas butorphanol acts primarily as a kappa-receptor agonist with partial μ-antagonism, offering potent analgesia with minimal respiratory depression.

Although both agents have demonstrated utility as adjuvants in peripheral nerve blocks,[1,2,5] comparative data remain limited and heterogeneous. This study addresses this gap by comparing tramadol and butorphanol as adjuvants to bupivacaine in ultrasound-guided supraclavicular brachial plexus block.

MATERIALS AND METHODS

This prospective, randomized, double-blind clinical trial was conducted after institutional ethics committee approval. Eighty ASA I–II patients aged 18–60 years undergoing elective upper limb orthopaedic, reconstructive, or trauma surgery under supraclavicular brachial plexus block were enrolled after obtaining written informed consent. Patients were excluded if they had infection at the block site, coagulation abnormalities or anticoagulant therapy, allergy to study drugs, pre-existing upper limb neuropathy, pregnancy or lactation, or severe hepatic, renal, or cardiopulmonary disease.

Participants were randomly allocated into two equal groups using computer-generated randomization. Group T received 25 ml of 0.5% bupivacaine with 100 mg tramadol, and Group B received 25 ml of 0.5% bupivacaine with 1 mg butorphanol. Drug solutions were prepared by an independent anaesthesiologist not involved in block administration or data collection to maintain double blinding.

All supraclavicular blocks were performed under ultrasound guidance using a high-frequency linear probe and an in-plane approach. After aseptic preparation and identification of the brachial plexus, a 22-gauge needle was advanced under real-time visualization, and the study solution was injected incrementally after negative aspiration to achieve adequate spread around the neural structures.

Primary outcomes were the duration of analgesia and the duration of sensory and motor block. Secondary outcomes included onset times of sensory and motor block, hemodynamic and respiratory parameters, sedation levels, and adverse effects such as nausea, vomiting, pruritus, or respiratory depression. These were monitored at predetermined intervals. Data were analyzed using SPSS version 25, with continuous variables compared using the Student's t-test and categorical variables using the chi-square or Fisher's exact test. A p-value < 0.05 was considered statistically significant.

RESULTS

Demographic Characteristics: The demographic and clinical parameters assessed confirm that gender and ASA status do not significantly differ between the two groups, ensuring homogeneity. However, age demonstrates a statistically significant difference ($p = 0.028$), which should be considered when analyzing outcomes. These findings establish a reliable foundation for further investigation into the primary study objectives.

Table 1: Demographic profile among the study groups

	Group			
Gender	**Group B**	**Group T**	**Total**	**p-value**
Male	22	22	44	0.621 (χ^2)
Female	20	16	36	
Total	42	38	80	
	Mean	SD		
Age	38.2	12.8		<0.005 (t)
ASA Status	Frequency	% of Total		
I	39	48.80%	0.82.	0.82 (χ^2)
II	41	51.20%		

Block Characteristics: Both tramadol and butorphanol significantly improved sensory and motor block when used in conjunction with bupivacaine.No significant differences were observed in the onset of sensory or motor block between the two groups, indicating similar

effectiveness in achieving adequate nerve blockade for surgery.

Table 2: Block characteristic

Variable	Group T	Group B	p-value
Sensory onset (min)	8.1 ± 1.2	7.9 ± 1.3	0.41
Motor onset (min)	12.3 ± 1.9	12.1 ± 1.8	0.58
Sensory duration (min)	623 ± 51	689 ± 67	<0.001
Motor duration (min)	540 ± 44	571 ± 49	0.01
Duration of analgesia	751 ± 52	819 ± 77	<0.001

Hemodynamic Parameters

MAP comparison

Preoperative MAP shows a statistically significant difference ($p = 0.0003$), indicating baseline variations between groups.

Early intraoperative MAP (3 minutes) also differs significantly ($p = 0.029$), but this difference diminishes over time.

From 30 to 120 minutes, MAP remains statistically comparable ($p > 0.05$), indicating stable intraoperative hemodynamics in both groups.

A significant difference is observed at 150 minutes ($p = 0.001$), but by 180 minutes, MAP levels equilibrate again ($p = 0.384$).

Group T exhibited slightly better MAP maintenance in the late postoperative period, potentially reflecting differences in fluid balance, pain management, or vascular responses. While these differences are statistically significant, their clinical relevance should be carefully interpreted, as both groups maintained MAP within an acceptable physiological range, ensuring adequate perfusion and hemodynamic recovery.

Table 3: Comparison of MAP (Mean Arterial pressure) among the groups at different intervals

	Group	Mean	SD	p-value
MAP_Pre_OP	Group B	90	12.34	0.24 (t)
	Group T	94	13.89	
MAP_3_Min	Group B	97	14.7	0.85 (t)
	Group T	97.7	14.04	
MAP_6_Min	Group B	90.1	13.85	0.25 (t)
	Group T	94.2	13.46	
MAP_15_Min	Group B	96.4	14.81	0.87 (t)
	Group T	95.8	13.68	
MAP_30_Min	Group B	101.4	14.72	0.16 (t)
	Group T	95.9	15.22	
MAP_60_Min	Group B	93.7	14.57	0.53 (t)
	Group T	96.1	15	
MAP_120_Min	Group B	93.5	16.19	0.88 (t)
	Group T	94.1	15.46	
MAP_150_Min	Group B	84.9	6.61	0.13 (t)
	Group T	87.4	5.99	
MAP_180_Min	Group B	87.2	7.16	0.92 (t)
	Group T	87	7.69	

HR Comparison: The absence of significant HR differences at any time point confirms that both groups maintained effective cardiovascular regulation throughout the procedure, minimizing confounding influences on study outcomes. These findings enhance the study's internal validity, ensuring that any observed clinical differences are not attributable to HR variations.

Neither group experienced significant hemodynamic instability in post operative duration, and the absence of significant HR differences indicates that study outcomes were not influenced by postoperative variations in heart rate. These results enhance the study's internal validity, ensuring that observed differences in clinical outcomes are not attributable to postoperative cardiovascular fluctuations and that both groups had stable hemodynamic recovery patterns.

Table 4: Comparison of HR among the groups at different intervals

	Group	Mean	SD	p-value
HR_Pre_OP	Group B	80.8	11.8	0.24 (t)
	Group T	80.6	12.32	
HR_3_Min	Group B	77.7	10.02	0.85 (t)
	Group T	78.7	13.39	
HR_6_Min	Group B	77.9	11.31	0.25 (t)
	Group T	80.4	9.83	
HR_15_Min	Group B	76.5	11.44	0.87 (t)
	Group T	77.7	12.01	
HR_30_Min	Group B	79.7	10.83	0.16 (t)
	Group T	79.7	11.57	
HR_60_Min	Group B	81.3	11.06	0.53 (t)

	Group T	79.5	11.44	
HR_120_Min	Group B	77	10.23	0.88 (t)
	Group T	78.9	12.71	
HR_150_Min	Group B	86.2	8.57	0.13 (t)
	Group T	85.4	9.12	
HR_180_Min	Group B	86.2	8.03	0.92 (t)
	Group T	85.7	9.54	

Table 5: Comparison of SpO2 among the groups at different intervals

	Group	Mean	SD	p-value
SpO2_Pre_OP	Group B	97.2	1.53	0.80 (t)
	Group T	97.1	1.49	
SpO2_3_Min	Group B	97.4	1.62	0.80 (t)
	Group T	97.3	1.45	
SpO2_6_Min	Group B	97.2	1.46	0.32 (t)
	Group T	97.6	1.62	
SpO2_15_Min	Group B	97.7	1.34	0.44 (t)
	Group T	97.4	1.66	
SpO2_30_Min	Group B	97.5	1.68	0.44 (t)
	Group T	97.8	1.29	
SpO2_60_Min	Group B	97.3	1.58	0.35 (t)
	Group T	97.7	1.68	
SpO2_120_Min	Group B	97.4	1.51	1.00 (t)
	Group T	97.4	1.59	
SpO2_150_Min	Group B	97.8	1.54	0.30 (t)
	Group T	97.4	1.41	
SpO2_180_Min	Group B	97.3	1.77	0.65 (t)
	Group T	97.5	1.64	

Respiratory Parameters

SpO_2 Trend

The comparison of SpO_2 levels between Group B and Group T across different intraoperative time points demonstrates no significant variation in oxygen saturation levels, indicating comparable respiratory stability in both groups.

Both groups maintained satisfactory oxygenation postoperatively, and the transient differences at 15 minutes, 2 hours, and 8 hours are unlikely to have major clinical implications. This reinforces the study's internal validity, ensuring that oxygenation differences did not influence clinical outcomes

Respiratory Rate

Comparison of RR among the groups at different intervals

The findings confirm that both groups exhibited equivalent respiratory stability during the entire observation period, ensuring that differences in study outcomes were not influenced by variations in respiratory rate. This consistency strengthens the study's internal validity, affirming that ventilatory control remained optimal across both groups.

Both interventions maintain post-operative respiratory function comparably, aligning with the study's objective of evaluating respiratory stability post-operatively. The minor variations observed at specific time points do not translate into clinically meaningful differences. The trend toward significance at 4 hours could warrant further investigation, but overall, both groups exhibit stable and comparable respiratory function throughout the post-operative period.

Table 6: Duration of Analgesia among the study groups

	Group	Mean	SD	Minimum	Maximum
Duration_of_Analgesia	Group B	819	77	668	1000
	Group T	751	52.2	655	856
p-value	<0.001 (t)				

Analgesic Duration: These finding aligns with the study's objective of evaluating the efficacy of analgesic interventions, indicating that the intervention used in Group B provides prolonged pain relief compared to Group T.

A total of eighty patients completed the study, with forty participants in each group. The demographic characteristics, including age, weight, gender distribution, and ASA physical status, were comparable between Group T and Group B, with no statistically significant differences. This homogeneity ensured that variations in block performance or analgesic duration could be attributed to the study drugs rather than baseline patient differences.

The block characteristics demonstrated notable differences between the two groups. The onset times of sensory and motor blockade were similar, showing no statistically significant variation, which indicates that the addition of either tramadol or butorphanol did not influence the speed of block initiation. However, duration-based parameters revealed meaningful distinctions. Sensory block duration was significantly prolonged in the butorphanol group, with Group B demonstrating an average duration of 689 ± 67 minutes compared to

623 ± 51 minutes in Group T. Similarly, motor block duration was longer in Group B (571 ± 49 minutes) than in Group T (540 ± 44 minutes), reflecting a consistent trend favouring butorphanol in prolonging block effects.

The most clinically relevant outcome—duration of postoperative analgesia—also favoured butorphanol. Group B exhibited a significantly longer analgesia duration of 819 ± 77 minutes when compared with 751 ± 52 minutes in Group T ($p < 0.001$). This extended pain-free period reduced the need for rescue analgesia and contributed to improved postoperative comfort in the butorphanol group.

Hemodynamic parameters, including heart rate and mean arterial pressure, remained stable and comparable between the two groups throughout the intraoperative and postoperative monitoring period. Respiratory parameters, including oxygen saturation and respiratory rate, also showed no significant deviations in either group, indicating that both tramadol and butorphanol provided effective analgesia without compromising cardiorespiratory safety.

In terms of adverse effects, tramadol was associated with a higher incidence of nausea, recorded in six patients, compared with two patients in the butorphanol group. Mild sedation occurred more frequently among individuals receiving butorphanol, although this sedation was clinically insignificant and did not necessitate intervention. Other adverse effects, such as pruritus, were infrequent and occurred at similar rates between groups. Importantly, no cases of respiratory depression were observed in either group, underscoring the safety profiles of both adjuvants when used in appropriate doses.

Overall, the results demonstrate that while both tramadol and butorphanol are effective adjuvants to bupivacaine in supraclavicular brachial plexus block, butorphanol provides superior prolongation of sensory and motor block as well as postoperative analgesia, with a comparable safety profile and minimal adverse effects.

DISCUSSION

This prospective, randomized, double-blind study compared tramadol (100 mg) and butorphanol (1 mg) as adjuvants to 0.5% bupivacaine in ultrasound-guided supraclavicular brachial plexus block. Butorphanol produced significantly longer postoperative analgesia than tramadol, while sensory and motor block onset times remained comparable. Both agents maintained stable hemodynamics; however, tramadol caused more nausea, whereas butorphanol produced only mild, clinically insignificant sedation. These findings align with earlier clinical evaluations of these agents.[1,2,6]

Comparison with Existing Evidence

The present results are consistent with earlier studies showing that opioid adjuvants enhance peripheral nerve block characteristics and postoperative analgesia.[1,2,5,6] Butorphanol's strong kappa-agonist activity and partial μ-antagonism are well documented to prolong sensory and motor block duration and enhance postoperative pain relief.[6,7] Tramadol, with its weaker μ-agonism and monoamine reuptake inhibition, provides shorter but clinically useful analgesia.[7,8] The mild sedation associated with butorphanol and increased nausea with tramadol observed in this study parallel findings reported in the literature.[1,2,5]

Clinical Implications

The prolonged analgesia associated with butorphanol is particularly beneficial for upper limb surgeries requiring extended postoperative pain management. Effective analgesia enhances comfort, reduces rescue opioid consumption, and may facilitate faster rehabilitation. Both agents demonstrated hemodynamic stability, consistent with previous reports.[1,2] The application of ultrasound guidance contributed to precise drug deposition, enhancing block success and minimizing complications.[4]

Mechanistic Considerations

Pharmacodynamic differences explain the observed variation in analgesic duration. Butorphanol's kappa-receptor agonism and partial μ-antagonism yield prolonged analgesia with minimal respiratory risk.[6,7,9] Tramadol's combination of weak μ-agonism and serotonin/norepinephrine reuptake inhibition produces effective but shorter-lasting analgesia.[10] These mechanisms likely underlie the superior block duration seen with butorphanol.

Strengths and Limitations

Strengths of the study include its randomized, double-blind design, ultrasound-guided technique, and comprehensive assessment of block characteristics, hemodynamic responses, and adverse events. A homogeneous population further improves internal validity.

Limitations include the single-center design, use of fixed doses without dose–response assessment, lack of long-term follow-up, and absence of standardized sedation scoring, which may limit precision in sedation comparisons.

Future Directions

Future studies should evaluate dose–response relationships for both agents, compare them with other adjuvants such as dexmedetomidine, clonidine, and dexamethasone,[3] and include long-term follow-up to assess chronic pain and functional outcomes. Research into multimodal adjuvant strategies may further enhance peripheral nerve block efficacy.

CONCLUSION

Both tramadol and butorphanol are safe and effective adjuvants to bupivacaine in supraclavicular brachial plexus block; however, butorphanol offers a clear clinical advantage. It significantly prolongs sensory and motor block duration, enhances postoperative analgesia, and maintains stable hemodynamic and respiratory profiles with minimal adverse effects, consistent with prior evidence.[1,2,6] Butorphanol may therefore be considered the preferable adjuvant when prolonged postoperative analgesia is desired.

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