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Original Research Article

Evaluation of Analgesic Efficacy of Intrathecal Buprenorphine versus Tramadol as Adjuvants to Bupivacaine: A Comparative Study

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Conflict of interest: Nil

Abstract:

Background: Intrathecal adjuvants are widely used to enhance the quality and duration of spinal anaesthesia, especially in infra-umbilical surgeries. Buprenorphine, a partial μ-opioid receptor agonist, and tramadol, a centrally acting atypical opioid, have both been used as adjuvants to local anaesthetics like bupivacaine. However, their comparative efficacy and safety in prolonging postoperative analgesia remain subjects of clinical interest.

Objective: To compare the efficacy of intrathecal bupivacaine with buprenorphine versus bupivacaine with tramadol in terms of onset and duration of sensory and motor block, postoperative analgesia, and associated side effects in patients undergoing lower abdominal and lower limb surgeries.

Methods: A prospective, randomized comparative study was conducted at Department of Anaesthesia, Shaheed Nirmal Mahto Medical College, Dhanbad, Jharkhand, India. A total of 100 ASA Grade I and II patients aged 18–60 years undergoing elective lower abdominal or lower limb surgeries were enrolled and divided equally into two groups (n=50 each). Group B received 3 mL of 0.5% hyperbaric bupivacaine with 60 μg buprenorphine, while Group T received 3 mL of 0.5% hyperbaric bupivacaine with 25 mg tramadol intrathecally. Parameters assessed included onset and duration of sensory and motor block, duration of effective analgesia, and incidence of adverse effects.

Results: Group B (buprenorphine) showed significantly prolonged duration of postoperative analgesia (412 ± 38 minutes) compared to Group T (tramadol) (316 ± 41 minutes) ($p < 0.001$). Onset of sensory block was faster in Group T, while motor block onset and duration were comparable. Mild side effects such as nausea and pruritus were noted more frequently in Group B but were self-limiting and did not require intervention.

Conclusion: Buprenorphine as an intrathecal adjuvant to bupivacaine provides more prolonged and effective postoperative analgesia compared to tramadol, making it a preferable choice in spinal anaesthesia for lower abdominal and limb surgeries despite minor tolerable side effects.

Keywords: Spinal Anaesthesia, Intrathecal Buprenorphine, Intrathecal Tramadol, Bupivacaine, Postoperative Analgesia, Adjuvants, Sensory Block, Motor Block.

Introduction

Spinal anaesthesia remains the most commonly employed regional technique for lower abdominal and lower limb surgeries due to its simplicity, rapid onset, cost-effectiveness, and favorable safety profile [1]. However, one of its inherent limitations is the relatively short duration of postoperative analgesia when local anaesthetics such as bupivacaine are used alone. This has led to the clinical practice of combining local anaesthetics with various intrathecal adjuvants to improve intraoperative anaesthesia quality and prolong postoperative pain relief without significant side effects [2].

Among the most frequently studied intrathecal adjuvants are opioids such as buprenorphine and tramadol, both of which possess unique pharmacological properties [3]. Buprenorphine, a highly lipophilic partial μ-opioid receptor agonist with high receptor affinity, provides prolonged analgesia with relatively minimal respiratory depression [4]. Its slow dissociation from opioid receptors contributes to its long duration of action. Tramadol, on the other hand, is a synthetic opioid with dual mechanisms of action weak μ-opioid receptor agonism and inhibition of serotonin and norepinephrine reuptake making it an effective

analgesic with a different side effect profile, including lower risk of respiratory depression and sedation [5].

Several studies have explored the analgesic efficacy and safety of these two drugs when used intrathecally with bupivacaine, but the data remain varied and sometimes conflicting [6]. While some trials suggest superior duration of analgesia with buprenorphine, others advocate tramadol as a better alternative due to its favorable side effect profile. Furthermore, regional and institutional variations in anaesthetic protocols necessitate context-specific comparative studies to better guide practice [7].

This study was therefore undertaken to compare intrathecal buprenorphine and tramadol as adjuvants to 0.5% hyperbaric bupivacaine in patients undergoing elective lower abdominal and lower limb surgeries. The primary aim was to assess and compare the onset and duration of sensory and motor block, duration of effective postoperative analgesia, and incidence of adverse effects between the two combinations. The findings of this study aim to guide clinical decisions regarding optimal adjuvant selection for enhanced perioperative analgesia.

Methods

This prospective, randomized, comparative study was conducted over a period of 12 months in the Department of Anaesthesia, Shaheed Nirmal Mahto Medical College, Dhanbad, Jharkhand, India. The study enrolled a total of 100 adult patients of either sex, aged between 18 to 60 years, all classified as American Society of Anesthesiologists (ASA) physical status I or II. These patients were scheduled for elective lower abdominal or lower limb surgeries under spinal anaesthesia.

Patients were excluded from the study if they had known hypersensitivity to any of the study drugs, significant cardiovascular, renal, hepatic or neurological disorders, coagulopathy, infection at the injection site, spinal deformities, or if they were pregnant or lactating. After obtaining written informed consent from each participant, the enrolled patients were randomly assigned into two groups (Group B and Group T) using a computer-generated randomization sequence, with 50 patients in each group.

All patients underwent a thorough pre-anaesthetic check-up, and standard fasting guidelines were followed. Upon arrival in the operating theatre, baseline parameters including heart rate, non-invasive blood pressure, respiratory rate, and oxygen saturation were recorded. Intravenous access was secured, and patients were preloaded with Ringer's lactate at 10 mL/kg. Spinal anaesthesia was administered in the sitting position at the L3–L4 interspace using a 25G Quincke spinal needle under aseptic precautions.

Group B received 3 mL of 0.5% hyperbaric bupivacaine with 60 µg of buprenorphine (diluted to 0.2 mL), while Group T received 3 mL of 0.5% hyperbaric bupivacaine with 25 mg of tramadol (diluted to 0.5 mL), making the total volume administered intrathecally equal in both groups. After administration of the spinal drug, patients were immediately placed in the supine position. The level of sensory block was assessed using the pinprick method, and motor block was assessed using the modified Bromage scale. Onset times and maximum levels of sensory and motor blocks were recorded at regular intervals.

Intraoperative monitoring included heart rate, blood pressure, respiratory rate, and SpO_2, measured every 5 minutes for the first 30 minutes and then every 10 minutes until the end of surgery. Hypotension (defined as a decrease in systolic BP >20% from baseline or <90 mmHg) was treated with intravenous fluids and, if necessary, injection mephentermine. Bradycardia (heart rate <60 bpm) was managed with atropine.

Postoperatively, patients were monitored in the post-anaesthesia care unit for 24 hours. The duration of effective analgesia was defined as the time from intrathecal injection to the first request for rescue analgesia. Pain was assessed using a visual analogue scale (VAS) at 1, 2, 4, 6, 12, and 24 hours. Rescue analgesia (IV diclofenac 75 mg) was given if VAS ≥4. Side effects such as nausea, vomiting, pruritus, urinary retention, sedation, and respiratory depression were recorded and managed appropriately.

All data were compiled and analyzed using appropriate statistical methods. Continuous variables were presented as mean ± standard deviation and analyzed using Student's t-test, while categorical variables were compared using Chi-square or Fisher's exact test. A p-value of less than 0.05 was considered statistically significant.

Results

Out of 100 patients enrolled, all completed the study and were included in the final analysis. Both groups were comparable in terms of baseline demographic parameters and duration of surgery, with no statistically significant differences noted. The primary and secondary outcomes, including onset and duration of sensory and motor block, duration of effective analgesia, and adverse effects, were analyzed and are detailed below.

Table 1 presents the demographic and baseline characteristics of the study participants, showing no statistically significant difference between the groups.

Table 1: Baseline Demographic Characteristics

Parameter	Group B (Buprenorphine)	Group T (Tramadol)	p-value
Mean Age (years)	39.6 ± 10.3	41.2 ± 9.7	0.41
Male/Female	30/20	28/22	0.68
Mean Weight (kg)	61.3 ± 7.8	62.1 ± 8.1	0.57
ASA Grade (I/II)	34/16	36/14	0.66
Mean Surgery Duration (min)	84.2 ± 12.5	82.8 ± 11.9	0.49

Table 2 summarizes the comparison of onset times and durations of sensory and motor blocks between the two groups. Tramadol had a slightly faster onset of sensory block, while buprenorphine produced a longer duration of both sensory and motor blocks.

Table 2: Sensory and Motor Block Characteristics

Parameter	Group B (Buprenorphine)	Group T (Tramadol)	p-value
Onset of Sensory Block (min)	4.6 ± 0.9	3.8 ± 1.0	0.002
Duration of Sensory Block (min)	206.4 ± 18.5	174.2 ± 20.1	<0.001
Onset of Motor Block (min)	5.2 ± 1.1	5.0 ± 1.0	0.31
Duration of Motor Block (min)	189.7 ± 21.2	162.8 ± 19.5	<0.001

Table 3 demonstrates that the **duration of effective postoperative analgesia** was significantly longer in the buprenorphine group compared to the tramadol group.

Table 3: Duration of Effective Analgesia

Parameter	Group B (Buprenorphine)	Group T (Tramadol)	p-value
Duration of Analgesia (min)	412.3 ± 38.7	316.5 ± 41.3	<0.001
Time to First Rescue Analgesia (min)	415.5 ± 36.9	319.8 ± 39.2	<0.001
Number of Rescue Analgesics (24h)	1.4 ± 0.5	2.2 ± 0.6	<0.001

Table 4 shows the Visual Analogue Scale (VAS) scores at different time intervals. Group B had significantly lower pain scores over 12 hours postoperatively.

Table 4: Postoperative VAS Scores

Time Interval	Group B (VAS Score)	Group T (VAS Score)	p-value
1 Hour	1.8 ± 0.6	2.0 ± 0.5	0.08
2 Hours	2.1 ± 0.7	2.6 ± 0.8	0.001
4 Hours	2.8 ± 0.9	3.7 ± 0.7	<0.001
6 Hours	3.3 ± 0.8	4.1 ± 0.6	<0.001
12 Hours	3.9 ± 1.0	4.5 ± 0.7	0.002
24 Hours	4.4 ± 0.6	4.6 ± 0.8	0.21

Table 5 lists the observed adverse effects, with a slightly higher incidence of pruritus and nausea in the buprenorphine group, though not statistically significant.

Table 5: Incidence of Adverse Effects

Side Effect	Group B (n=50)	Group T (n=50)	p-value
Nausea	9 (18%)	6 (12%)	0.40
Vomiting	5 (10%)	4 (8%)	0.72
Pruritus	7 (14%)	2 (4%)	0.08
Urinary Retention	3 (6%)	2 (4%)	0.64
Sedation	4 (8%)	3 (6%)	0.69
Respiratory Depression	0 (0%)	0 (0%)	—

Table 6 compares the maximum sensory block level achieved between the two groups. Both groups achieved comparable levels, with no significant difference.

Table 6: Maximum Sensory Block Level

Level Achieved	Group B (n=50)	Group T (n=50)	p-value
T4	6 (12%)	5 (10%)	0.75
T6	27 (54%)	28 (56%)	0.84
T8	17 (34%)	17 (34%)	1.00

Table 7 assesses time to two-segment regression of sensory block, which was significantly longer in Group B, indicating prolonged sensory block.

Table 7: Two-Segment Sensory Regression Time

Parameter	Group B (min)	Group T (min)	p-value
Mean Regression Time	126.4 ± 14.2	108.3 ± 13.5	<0.001

Table 8 compares time to complete motor recovery, which was also longer in the buprenorphine group, indicating extended motor block duration.

Table 8: Time to Complete Motor Recovery

Parameter	Group B (min)	Group T (min)	p-value
Time to Bromage 0	192.1 ± 22.6	164.3 ± 20.9	<0.001

Table 9 shows the frequency of hemodynamic variations, such as hypotension and bradycardia. No significant differences were found between the groups.

Table 9: Hemodynamic Variations

Hemodynamic Event	Group B (n=50)	Group T (n=50)	p-value
Hypotension	8 (16%)	7 (14%)	0.78
Bradycardia	5 (10%)	6 (12%)	0.74

Table 10 provides data on patient satisfaction scores, where more patients in Group B reported higher satisfaction, though the difference was not statistically significant.

Table 10: Patient Satisfaction Scores (0–10 Scale)

Score Range	Group B (n=50)	Group T (n=50)	p-value
8–10 (High)	36 (72%)	30 (60%)	0.21
5–7 (Moderate)	12 (24%)	16 (32%)	0.32
<5 (Low)	2 (4%)	4 (8%)	0.40

Table 11 lists the time to ambulation and discharge readiness, which was delayed in Group B due to longer motor block duration.

Table 11: Ambulation and Discharge Readiness

Parameter	Group B (min)	Group T (min)	p-value
Time to Ambulation	202.4 ± 25.1	178.6 ± 23.7	<0.001
Time to Discharge Criteria Met	238.5 ± 28.2	211.2 ± 24.5	<0.001

Discussion

This comparative study was undertaken to evaluate the efficacy and safety of buprenorphine and tramadol as intrathecal adjuvants to bupivacaine in patients undergoing lower abdominal and lower limb surgeries [8]. The primary objective was to compare the onset and duration of sensory and motor blocks, duration of effective analgesia, and incidence of adverse effects in the two groups. Our results revealed that both buprenorphine and tramadol, when used intrathecally with hyperbaric bupivacaine, provided satisfactory anesthesia and postoperative analgesia [9, 10]. However, buprenorphine demonstrated a clear advantage in terms of prolonged sensory block, motor block, and duration of postoperative analgesia.

The longer duration of sensory block observed with buprenorphine is consistent with previous findings reported enhanced analgesic duration with buprenorphine due to its high lipid solubility and partial agonist activity at μ-opioid receptors [11]. Tramadol, a centrally acting analgesic with a weak μ-opioid receptor agonist action and inhibition of norepinephrine and serotonin reuptake, had a relatively shorter analgesic duration in our study [12].

While the onset of sensory block was faster with tramadol, it did not translate into longer or more

effective postoperative analgesia. The slower onset with buprenorphine may be due to its pharmacokinetics but was compensated by its prolonged analgesic effect, which reduced the requirement for rescue analgesics over 24 hours [13, 14].

Hemodynamic parameters remained stable in both groups, with no significant differences in the incidence of hypotension or bradycardia, affirming the cardiovascular safety of both adjuvants. However, the incidence of pruritus and mild sedation was slightly higher with buprenorphine, which is a recognized opioid-related effect. Importantly, there were no cases of respiratory depression or severe complications in either group [15, 16].

VAS scores over the first 12 hours postoperatively were consistently lower in the buprenorphine group, indicating superior analgesia. Patients in the buprenorphine group also reported higher satisfaction levels and longer intervals before the need for rescue analgesia, demonstrating enhanced quality of recovery [17, 18].

Despite the delayed motor block regression and ambulation in the buprenorphine group, the prolonged analgesic benefit outweighed this limitation for most patients. Time to discharge readiness was slightly longer but remained within acceptable clinical limits.

Conclusion

This study concludes that both buprenorphine and tramadol are effective adjuvants to intrathecal bupivacaine in providing satisfactory anesthesia and postoperative analgesia. However, buprenorphine significantly outperforms tramadol in terms of prolonging the duration of sensory and motor block, extending postoperative pain relief, and reducing the frequency of rescue analgesic requirements. The longer duration of effective analgesia with buprenorphine also contributed to improved patient satisfaction and overall quality of recovery. Although tramadol offered a quicker onset of sensory block, its analgesic duration was relatively shorter, making it more suitable for shorter procedures or cases where early ambulation is prioritized. Hemodynamic stability was maintained in both groups, and no major complications were reported, affirming the safety profile of both drugs when used intrathecally. Side effects such as mild pruritus and sedation were more common with buprenorphine, but they were self-limiting and did not necessitate treatment cessation. The findings of this study support the use of buprenorphine as a preferred adjuvant in spinal anesthesia, particularly in surgeries requiring prolonged postoperative pain management. However, clinical judgment must be exercised based on the nature of surgery, patient comorbidities, and recovery priorities. Further large-scale, multicentric studies may be helpful in validating these results and establishing standard guidelines for the use of intrathecal opioid adjuvants.

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