

Comparison of Hyperbaric Bupivacaine Alone versus Bupivacaine with Fentanyl for Spinal Anesthesia in Lower Abdominal and Lower Limb Surgery

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ABSTRACT

Background: The addition of fentanyl to hyperbaric bupivacaine for spinal anesthesia may enhance block characteristics and postoperative analgesia. However, comparative data on the clinical benefits of this combination in lower abdominal and lower limb surgery remain limited. **Objective:** To compare the block characteristics and postoperative analgesic outcomes of hyperbaric bupivacaine alone versus bupivacaine with fentanyl for spinal anesthesia. **Methods & Materials:** This prospective comparative study was conducted at the Department of Anaesthesiology & ICU, National Institute of Traumatology & Orthopedic Rehabilitation (NITOR), Dhaka, Bangladesh, from January to December 2025. A total of 60 adult patients undergoing lower abdominal or lower limb surgery under spinal anesthesia were equally allocated to two groups: Group B (hyperbaric bupivacaine 0.5% 3 mL) and Group BF (hyperbaric bupivacaine 0.5% 3 mL with 25 µg fentanyl). Onset and duration of sensory and motor block, time to first analgesic request, and postoperative pain scores were recorded. **Results:** The mean duration of sensory block was significantly longer in Group BF (187.4 ± 22.6 minutes vs. 132.8 ± 18.4 minutes, $p < 0.001$). Time to first analgesic request was also prolonged in Group BF (248.6 ± 34.2 minutes vs. 158.4 ± 28.6 minutes, $p < 0.001$). Postoperative pain scores were consistently lower in the fentanyl group at all time points. **Conclusion:** The addition of fentanyl to hyperbaric bupivacaine significantly prolongs sensory block duration and postoperative analgesia without increasing complications. This combination is a safe and effective alternative for spinal anesthesia in lower abdominal and lower limb surgery.

Keywords: Bupivacaine, Fentanyl, Lower limb surgery, Regional anesthesia, Spinal anesthesia, Surgery.

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INTRODUCTION

Spinal anesthesia remains one of the most widely practiced regional anesthetic techniques globally, valued for its reliability, rapid onset, and excellent surgical conditions for procedures involving the lower abdomen, pelvis, perineum, and lower extremities [1]. The technique involves the deposition of a local anesthetic into the cerebrospinal fluid, producing reversible blockade of spinal nerve roots and providing profound sensory and motor anesthesia [2]. Among the various local anesthetics available, hyperbaric bupivacaine has emerged as the gold standard for spinal anesthesia due to its predictable spread, dose-dependent duration of action, and favorable safety profile [3]. Despite its widespread acceptance, the use of bupivacaine alone for spinal anesthesia is associated with certain limitations, including a relatively short duration of sensory block and limited postoperative analgesia [4]. To overcome these shortcomings, various adjuvants have been added to intrathecal bupivacaine, with the goal of enhancing block characteristics, prolonging postoperative analgesia, and improving overall patient satisfaction [5]. Among these adjuvants, fentanyl a highly lipophilic synthetic opioid has gained

considerable popularity due to its synergistic interaction with local anesthetics at the spinal cord level [6]. The addition of fentanyl to intrathecal bupivacaine produces several clinically desirable effects. The synergistic action of fentanyl at the mu-opioid receptors in the substantia gelatinosa of the spinal cord enhances sensory blockade, reduces visceral pain, and extends the duration of postoperative analgesia without significantly prolonging motor block [7]. A systematic review and meta-analysis of randomized controlled trials comparing midazolam and fentanyl as adjuvants to hyperbaric bupivacaine found that fentanyl combined with bupivacaine may be more suitable for non-obstetric procedures requiring prolonged analgesia with a shorter motor block, as well as for surgeries where early mobilization is preferred [8]. Numerous clinical studies have compared the efficacy of bupivacaine with and without fentanyl for spinal anesthesia. A prospective randomized controlled trial of 72 parturients undergoing cesarean delivery demonstrated that the addition of intrathecal fentanyl to hyperbaric bupivacaine was effective in reducing intraoperative visceral pain with stable maternal hemodynamics and without

neonatal side effects [9]. A randomized double-blind clinical trial investigating different doses of intrathecal fentanyl combined with bupivacaine for cesarean section found that the combination of 25 µg fentanyl with 7.5 mg bupivacaine was associated with a favorable balance of sensory blockade and analgesia, with a reduced need for rescue analgesia [10]. A comparative analysis of intrathecal bupivacaine with fentanyl versus bupivacaine with midazolam in lower abdominal and lower limb surgeries reported that the fentanyl group exhibited a substantially longer duration for both sensory (211.5 vs. 154.4 minutes) and motor blockade (269.8 vs. 214.6 minutes), as well as a significantly longer duration of effective analgesia (266 ± 15.9 vs. 197.6 ± 13.7 minutes) [11]. The hemodynamic profile of the bupivacaine-fentanyl combination has also been favorable. A study comparing the efficacy of intrathecal bupivacaine heavy with fentanyl and intrathecal levobupivacaine heavy with fentanyl for lower limb and lower abdominal surgeries found no significant differences in hemodynamic parameters or side effects between the groups, but noted that hyperbaric bupivacaine provided a longer duration of spinal anesthesia [12].

Similarly, low-dose bupivacaine with fentanyl has been associated with less hypotension, reduced vasopressor requirements, and lower incidence of nausea compared to standard-dose bupivacaine alone [13]. Despite these encouraging findings, there remains considerable heterogeneity in the literature regarding the optimal dose of fentanyl, the degree of clinical benefit, and the balance between improved analgesia and opioid-related side effects such as pruritus, nausea, and respiratory depression [8]. Furthermore, many studies have focused on obstetric populations, with limited data from non-obstetric surgeries in the Bangladeshi context. This prospective comparative study was therefore undertaken to compare the block characteristics and postoperative analgesic outcomes of hyperbaric bupivacaine alone versus hyperbaric bupivacaine with fentanyl for spinal anesthesia in patients undergoing lower abdominal and lower limb surgery at a tertiary care hospital in Dhaka, Bangladesh. By generating locally relevant evidence, we aim to inform anesthetic practice and contribute to the optimization of spinal anesthesia protocols in this setting.

METHODS & MATERIALS

Study population: This prospective comparative study was conducted at the Department of Anaesthesiology & ICU, National Institute of Traumatology & Orthopedic Rehabilitation (NITOR), Dhaka, Bangladesh, from January to

December 2025. A total of 60 adult patients undergoing lower abdominal or lower limb surgery under spinal anesthesia were equally allocated to two groups: Group B (hyperbaric bupivacaine 0.5% 3 mL) and Group BF (hyperbaric bupivacaine 0.5% 3 mL with 25 µg fentanyl).

Inclusion criteria: Patients aged 18 to 65 years, of either sex, with American Society of Anesthesiologists (ASA) physical status I or II, undergoing elective lower abdominal or lower limb surgery under spinal anesthesia, and providing written informed consent were eligible for inclusion.

Exclusion criteria: Patients with known allergy to local anesthetics or fentanyl, pre-existing neurological disorders, spinal deformities, coagulopathies, infection at the puncture site, chronic opioid use, or those requiring emergency surgery were excluded.

Study procedure: After obtaining written informed consent, demographic and baseline clinical data were recorded. Patients were randomly allocated to two groups: Group B received hyperbaric bupivacaine 0.5% 3 mL (15 mg) intrathecally, and Group BF received hyperbaric bupivacaine 0.5% 3 mL (15 mg) with 25 µg fentanyl. Spinal anesthesia was performed using a standard midline approach with a 25-gauge Quincke needle.

Onset and duration of sensory block were assessed using the pinprick method, and motor block was assessed using the modified Bromage scale [14,15]. Postoperative pain was evaluated using the Numeric Rating Scale (NRS) at 2, 4, 6, and 12 hours. Time to first analgesic request and total analgesic consumption were recorded.

Data analysis: Data were entered into a predesigned proforma and analyzed using SPSS version 23.0. Continuous variables were expressed as mean ± standard deviation, and categorical variables as frequencies and percentages. An independent t-test was used to compare continuous variables between groups, and a chi-square test was used for categorical variables. A p-value <0.05 was considered statistically significant.

RESULT

A total of 60 patients (30 in each group) completed the study. The baseline demographic and clinical characteristics of the study population are summarized in Table I. The mean age was 42.4 ± 14.6 years in Group B and 43.1 ± 15.2 years in Group BF (p=0.856). Both groups were comparable with respect to sex distribution, ASA physical status, and type of surgical procedure (p>0.05 for all comparisons), indicating successful randomization.

Table I
Demographic and clinical characteristics of the study population (n=60).

Variable	Category	Group B	Group BF	p-value
		(n=30)	(n=30)	
Age (years), mean ± SD	—	42.4 ± 14.6	43.1 ± 15.2	0.856
Sex	Male	17 (56.7)	16 (53.3)	0.793
	Female	13 (43.3)	14 (46.7)	
ASA status	I	20 (66.7)	21 (70.0)	0.781
	II	10 (33.3)	9 (30.0)	
Type of surgery	Lower abdominal	18 (60.0)	17 (56.7)	0.793
	Lower limb	12 (40.0)	13 (43.3)	

Independent t-test for continuous variables; Chi-square test for categorical variables. SD = standard deviation; ASA = American Society of Anesthesiologists.

The block characteristics of both groups are presented in Table II and visually represented in Figure 1. The mean duration of sensory block was significantly longer in Group BF compared to Group B (187.4 ±

22.6 minutes vs. 132.8 ± 18.4 minutes, p<0.001). Similarly, the mean duration of motor block was prolonged in Group BF (157.6 ± 20.8 minutes vs. 118.4 ± 16.2 minutes, p<0.001). The time to achieve

maximum sensory level was comparable between groups (p=0.342), while the maximum sensory level achieved was similar in both groups (T6-T8).

Table II
Block characteristics of spinal anesthesia.

Parameter	Group B	Group BF	p-value
	(n=30)	(n=30)	
Onset of sensory block (minutes), mean ± SD	4.2 ± 1.2	4.0 ± 1.1	0.506
Onset of motor block (minutes), mean ± SD	5.4 ± 1.6	5.1 ± 1.4	0.445
Duration of sensory block (minutes), mean ± SD	132.8 ± 18.4	187.4 ± 22.6	<0.001
Duration of motor block (minutes), mean ± SD	118.4 ± 16.2	157.6 ± 20.8	<0.001
Maximum sensory level achieved (median, range)	T7 (T6-T8)	T7 (T6-T8)	0.876

Independent t-test for continuous variables; Mann-Whitney U test for ordinal variables. SD = standard deviation.

The postoperative outcomes are presented in *Table III* and visually represented in *Figure 2*. The time to first analgesic request was significantly prolonged in Group BF compared to Group B (248.6 ± 34.2 minutes vs. 158.4 ± 28.6 minutes,

$p<0.001$). Total analgesic consumption in the first 24 hours was significantly lower in Group BF (52.4 ± 18.6 mg vs. 78.6 ± 22.4 mg of tramadol equivalents, $p<0.001$). Postoperative pain scores measured using the Numeric Rating Scale (NRS) were

consistently lower in Group BF at all time points (2, 4, 6, and 12 hours), with statistically significant differences observed at 4 hours ($p=0.003$), 6 hours ($p<0.001$), and 12 hours ($p<0.001$).

Table III
Postoperative outcomes.

Parameter (mean $\pm$ SD)	Group B (n=30)	Group BF (n=30)	p-value
Time to first analgesic request (minutes)	158.4 $\pm$ 28.6	248.6 $\pm$ 34.2	<0.001
Total analgesic consumption (mg tramadol eq.)	78.6 $\pm$ 22.4	52.4 $\pm$ 18.6	<0.001
NRS pain score at 2 hours	3.2 $\pm$ 1.4	2.6 $\pm$ 1.2	0.082
NRS pain score at 4 hours	4.6 $\pm$ 1.6	3.4 $\pm$ 1.4	0.003
NRS pain score at 6 hours	5.2 $\pm$ 1.8	3.8 $\pm$ 1.5	<0.001
NRS pain score at 12 hours	4.8 $\pm$ 1.7	3.2 $\pm$ 1.4	<0.001

Independent t-test. SD = standard deviation; NRS = Numeric Rating Scale (0 = no pain, 10 = worst possible pain); eq. = equivalents.

The incidence of complications and side effects is presented in *Table IV*. Hypotension occurred in 26.7% of patients in Group B and 23.3% in Group BF ($p=0.766$). Bradycardia was observed in 16.7% of Group B and 13.3% of Group BF

($p=0.718$). Nausea was reported in 13.3% of Group B and 16.7% of Group BF ($p=0.718$). Pruritus occurred exclusively in Group BF (10.0% vs. 0%, $p=0.078$), though the difference did not reach statistical significance. No cases of

respiratory depression or neurological complications were observed in either group.

Table IV
Complications and side effects.

Complication/Side effect	Group B (n=30)	Group BF (n=30)	p-value
Hypotension, n (%)	8 (26.7)	7 (23.3)	0.766
Bradycardia, n (%)	5 (16.7)	4 (13.3)	0.718
Nausea, n (%)	4 (13.3)	5 (16.7)	0.718
Vomiting, n (%)	2 (6.7)	3 (10.0)	0.64
Pruritus, n (%)	0 (0)	3 (10.0)	0.078
Respiratory depression, n (%)	0 (0)	0 (0)	—

*Chi-square tests were used to compare proportions between groups.

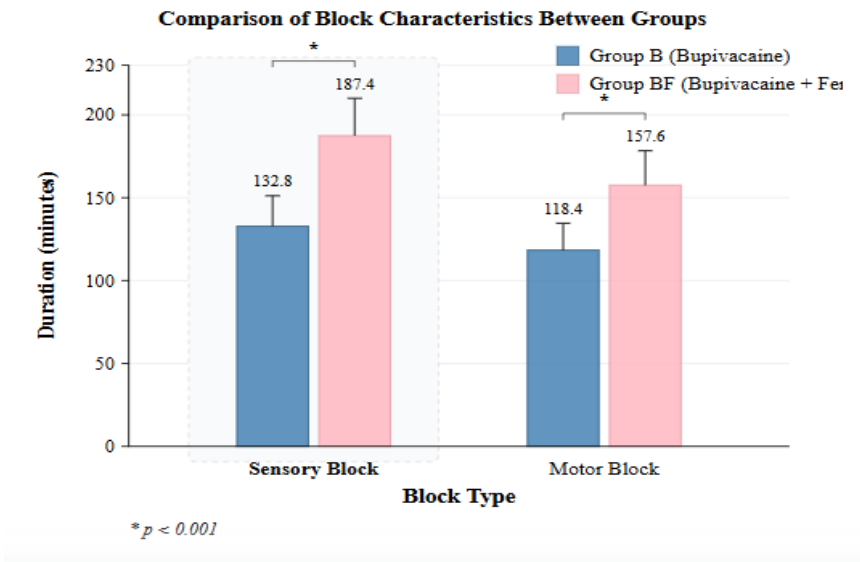


Figure 1 Comparison of block characteristics between groups.

The bar chart compares the duration of sensory and motor block between Group B (bupivacaine alone) and Group BF

(bupivacaine with fentanyl). Patients in Group BF demonstrated a significantly longer duration of both sensory and motor

blockade. * $p < 0.001$. Error bars represent standard deviation (*Figure 1*).

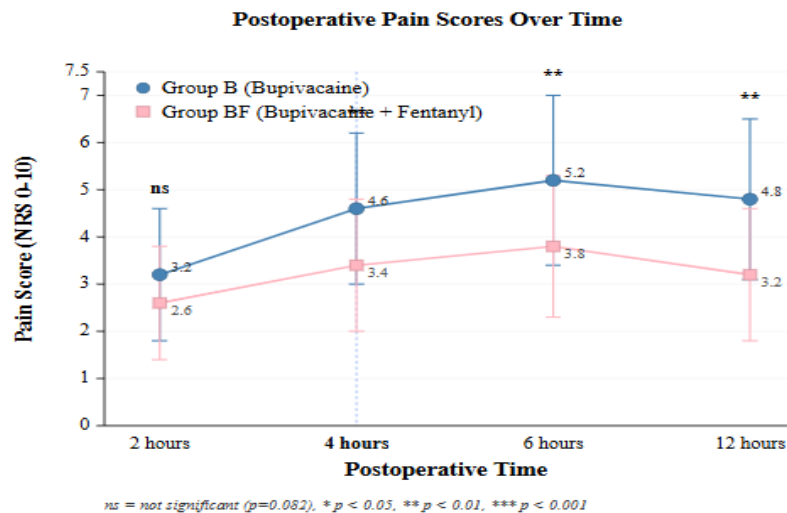


Figure 2 Postoperative pain scores over time.

The line graph illustrates postoperative pain scores (NRS) at 2, 4, 6, and 12 hours in both groups. Patients in Group BF consistently reported lower pain scores at all time points, with statistically significant differences observed at 4, 6, and 12 hours. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. NRS = Numeric Rating Scale (0 = no pain, 10 = worst possible pain) (Figure 2).

DISCUSSION

This prospective comparative study of 60 patients undergoing lower abdominal and lower limb surgery demonstrates that the addition of 25 µg fentanyl to hyperbaric bupivacaine for spinal anesthesia significantly prolongs sensory block duration (187.4 ± 22.6 minutes vs. 132.8 ± 18.4 minutes, $p < 0.001$) and motor block duration (157.6 ± 20.8 minutes vs. 118.4 ± 16.2 minutes, $p < 0.001$) compared to bupivacaine alone. Furthermore, the fentanyl combination extended the time to first analgesic request (248.6 ± 34.2 minutes vs. 158.4 ± 28.6 minutes, $p < 0.001$), reduced total analgesic consumption, and provided consistently lower postoperative pain scores without significantly increasing hemodynamic complications. These findings support the clinical utility of fentanyl as an adjuvant to bupivacaine for improving spinal anesthesia outcomes in non-obstetric surgical populations.

The prolongation of sensory block duration observed in the fentanyl group aligns with findings from a recent comparative analysis of intrathecal bupivacaine with fentanyl versus bupivacaine with midazolam in lower abdominal and lower limb surgeries, which reported that the fentanyl group exhibited a substantially longer duration for both sensory (211.5 vs. 154.4 minutes) and motor blockade (269.8 vs. 214.6 minutes) [16]. The same study demonstrated that the fentanyl group had a

significantly longer duration of effective analgesia compared to the midazolam group (266 ± 15.9 vs. 197.6 ± 13.7 minutes) [16]. These consistent findings across different comparator groups reinforce the superiority of fentanyl as an adjuvant for prolonging spinal anesthesia. The extended time to first analgesic request (248.6 ± 34.2 minutes) and reduced total analgesic consumption in the fentanyl group are clinically significant outcomes. A randomized double-blind clinical trial evaluating different doses of intrathecal fentanyl combined with bupivacaine for cesarean section found that patients receiving 25 µg fentanyl had significantly longer duration of analgesia and less need for rescue analgesia compared to those receiving bupivacaine alone or lower fentanyl doses [17]. The optimal analgesia was obtained when a 25-µg dose of fentanyl was combined with bupivacaine compared to bupivacaine alone or combined with lower doses of fentanyl [17]. The present study's findings extend these observations to non-obstetric lower abdominal and lower limb surgeries, demonstrating that the analgesic benefits of fentanyl are reproducible across diverse surgical populations. The consistently lower postoperative pain scores observed in the fentanyl group at 4, 6, and 12 hours are consistent with the synergistic interaction between fentanyl and bupivacaine at the spinal cord level. Fentanyl acts at mu-opioid receptors in the substantia gelatinosa of the spinal cord, enhancing sensory blockade and reducing visceral pain without significantly prolonging motor block [18]. A double-blinded randomized controlled trial comparing opioid-free and opioid-based thoracic continuous spinal anesthesia in patients undergoing major abdominal surgery reported that the opioid-based group performed significantly better

regarding pain scores at rest at 0 hours ($p=0.023$), 18 hours ($p=0.023$), and 24 hours ($p=0.016$) postoperatively, with decreased intrathecal bupivacaine requirement and postoperative rescue fentanyl requirement [19]. These findings corroborate the present study's observation that fentanyl addition provides meaningful analgesic benefits extending into the early postoperative period. The comparable incidence of hypotension between groups (26.7% vs. 23.3%, $p=0.766$) and bradycardia (16.7% vs. 13.3%, $p=0.718$) is noteworthy. A study comparing hemodynamic changes following intrathecal fentanyl with low-dose bupivacaine and bupivacaine alone found that the decrease in systolic blood pressure was slight in patients who received fentanyl combined with low-dose bupivacaine compared to those receiving bupivacaine alone [20]. The absence of significant hemodynamic differences in the present study may reflect the relatively low dose of fentanyl used (25 µg) and the comparable local anesthetic doses between groups, suggesting that the addition of fentanyl does not exacerbate the hemodynamic consequences of spinal anesthesia. The incidence of pruritus in the fentanyl group (10.0% vs. 0%, $p=0.078$) is consistent with the well-documented opioid-related side effect of intrathecal fentanyl. A randomized double-blind clinical trial reported that more episodes of pruritus were observed when bupivacaine was combined with fentanyl compared to bupivacaine alone ($p < 0.01$) [17]. Although the difference did not reach statistical significance in the present study, the trend toward increased pruritus in the fentanyl group aligns with the broader literature and should be considered when selecting this combination for clinical practice. Notably, no cases of respiratory depression or neurological complications were observed

in either group, supporting the safety profile of the fentanyl-bupivacaine combination at the doses used. The strengths of this study include its prospective, comparative design with standardized anesthetic and assessment protocols, which minimizes bias and enhances the reliability of the findings. The use of validated assessment tools, including the Bromage scale for motor block and the Numeric Rating Scale for pain, strengthens the validity of the outcome measurements. The inclusion of both sensory and motor block characteristics, along with comprehensive postoperative outcomes, provides a holistic evaluation of the two techniques.

LIMITATIONS

The single-center design, purposive sampling, and modest sample size (n=60) limit generalizability. Lack of blinding and absence of long-term follow-up data are additional constraints. Unmeasured confounding variables, including patient expectations and surgical factors, may have influenced the observed outcomes.

CONCLUSION

The addition of 25 µg fentanyl to hyperbaric bupivacaine significantly prolongs sensory and motor block duration, extends time to first analgesic request, reduces postoperative pain scores, and decreases analgesic consumption without increasing hemodynamic complications. This combination is a safe and effective alternative for spinal anesthesia in lower abdominal and lower limb surgery.

RECOMMENDATION

We recommend the addition of 25 µg fentanyl to hyperbaric bupivacaine for spinal anesthesia in lower abdominal and lower limb surgeries where prolonged intraoperative anesthesia and extended postoperative analgesia are desired. Larger multicenter randomized controlled trials are warranted to validate these findings.

CONFLICT OF INTEREST

The authors declare no conflicts of interest. No funding was received for this study. The corresponding author had full access to all data and final responsibility for the decision to submit for publication.

AI DECLARATION

Artificial intelligence tools contributed marginally to manuscript preparation and development. All core scientific content was human-verified.

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