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Original Research Article

COMPARATIVE EVALUATION OF INTRATHECAL FENTANYL AND BUPRENORPHINE AS ADJUVANTS TO HYPERBARIC BUPIVACAINE IN SPINAL ANAESTHESIA

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ABSTRACT

Background: Intrathecal addition of adjuvats to long acting local anesthetics like bupivacaine are frequetly used for prolonging the duration of anaesthesia and analgesia. This trial compared fentanyl and buprenorphine as additives to hyperbaric bupivacaine regarding block features and postoperative pain relief.

Materials and Methods: Eighty ASA I-II patients (18–60 years) undergoing elective lower limb surgeries were randomly divided into two groups of 40. Group F received 17 mg hyperbaric bupivacaine 0.5% + 25 µg fentanyl intrathecally. Group B received 17 mg hyperbaric bupivacaine 0.5% + 90 µg buprenorphine. Onset and duration of sensory/motor blocks, analgesia duration, hemodynamics, and complications were assessed.

Results: Sensory and motor block onset was significantly faster in Group F. Duration of sensory block and postoperative analgesia were markedly prolonged in Group B. Motor block recovery was similar. Hemodynamic profiles were comparable. Pruritus was more frequent with fentanyl; nausea slightly higher with buprenorphine.

Conclusion: Fentanyl offers quicker block initiation, while buprenorphine provides extended pain relief. Both are safe and effective adjuvants.

Keywords: Spinal anaesthesia, Intrathecal fentanyl, Intrathecal buprenorphine, Adjuvants, Bupivacaine.

INTRODUCTION

Spinal anaesthesia is one of the most commonly preferred regional anaesthetic techniques for lower abdominal, pelvic, and lower limb orthopaedic surgeries. It is preferred because of its rapid onset, reliable sensory and motor blockade, reduced risk associated with airway manipulation during general anaesthesia, and cost-effectiveness. However, when local anaesthetics such as hyperbaric bupivacaine or ropivacaine are used alone, the duration of anaesthesia and postoperative analgesia is often limited.[1-5] Furthermore, increasing the dose of bupivacaine to prolong analgesia may lead to undesirable effects, including cardiovascular toxicity.

To address these shortcomings, various intrathecal adjuvants have been investigated to enhance the quality and duration of spinal anaesthesia. Among these, neuraxial opioids have gained considerable acceptance because they potentiate analgesia without significantly affecting sympathetic or motor function. Several agents, including midazolam, clonidine, dexmedetomidine, fentanyl, butorphanol, magnesium sulphate, neostigmine, midazolam, and dexamethasone, and buprenorphine, have been used as adjuncts to local anaesthetics to improve the characteristics of the spinal block and provide prolonged postoperative pain relief while maintaining an acceptable safety profile.[2,3,4-18]

Fentanyl and buprenorphine are commonly studied opioids to enhance the quality of spinal anaesthesia through different pharmacodynamic mechanisms.

Fentanyl is a highly lipophilic, pure µ-opioid receptor agonist that rapidly penetrates neural tissues and binds to spinal opioid receptors. Owing to its high lipid solubility, it produces a quick onset of analgesia. However, its rapid clearance from the cerebrospinal fluid limits the duration of its analgesic effect.

Buprenorphine is a highly lipophilic opioid with a relatively large molecular weight and acts as a partial μ-opioid receptor agonist and κ-receptor antagonist. Its physicochemical characteristics reduce cephalad spread within the cerebrospinal fluid, thereby lowering the likelihood of delayed respiratory depression.[4,5] In addition, its strong receptor affinity and slow dissociation from μ-receptors result in prolonged receptor occupancy and sustained postoperative analgesia, reducing the requirement for rescue analgesics.

The present study was designed to compare the clinical efficacy of intrathecal fentanyl and buprenorphine when used as adjuvants to hyperbaric bupivacaine during spinal anaesthesia. Particular emphasis was placed on evaluating the onset and duration of sensory and motor blockade, postoperative analgesia, haemodynamic changes, and adverse effects associated with these two opioids.

MATERIALS AND METHODS

This randomized controlled study was conducted from April 2025 to March 2026 in Parbhani Medical College, after Institutional Ethical Committee approval and written informed consent. Eighty patients aged 18–65 years, American Society of Anesthesiologists (ASA) grade I or II, scheduled for lower limb surgery, were included in this prospective, randomised trial.

All patients underwent routine pre-anaesthetic evaluation. The participants were randomly allocated into two equal groups comprising 40 patients each. The anaesthesiologist responsible for data collection and assessment of outcomes was blinded to the study drug administered. Standard monitoring, including electrocardiography (ECG), non-invasive blood pressure (NIBP), and pulse oximetry (SpO_2), was instituted in all patients.

Under strict aseptic precautions, lumbar puncture was done at the L3-L4 interspace using a 25G spinal needle. Study drugs were administered intrathecally according to group allocation.

Patients were monitored intraoperatively and postoperatively for block characteristics, haemodynamic changes, and adverse reactions.

Inclusion: ASA I-II, age 18–60 years, elective lower limb surgeries.All the patients selected in the study were of height >150cm.

Exclusion: Patients unwilling for spinal aaesthesia, other exclusion criterias of spinal anaesthesia like coagulopathy, or patients on anricoagulants, infection at the site of injection, opioid or bupivacaine allergy, chronic opioid use.

The primary outcome measures included onset and duration of sensory and motor blockade and duration of postoperative analgesia. Secondary outcome measures included haemodynamic parameters and incidence of adverse effects.

Parameters Evaluated: The onset of sensory block was defined as the interval between intrathecal drug administration and loss of pinprick sensation at the T10 dermatome.

Onset of motor blockade was defined as the time required to achieve complete motor block, corresponding to a Modified Bromage Score of.[3].

The duration of sensory block was defined as the time taken for regression of sensory blockade to the L1 dermatome.

Duration of analgesia was defined as the interval between intrathecal injection and the patient's first request for rescue analgesia. Pain intensity was assessed using the Visual Analogue Scale (VAS), ranging from 0 (no pain) to 10 (worst imaginable pain), and was recorded every 30 minutes. Rescue analgesia was administered when the VAS score was ≥.[4].

Heart rate, blood pressure, and oxygen saturation were monitored throughout the study period. Hypotension was defined as a reduction of more than 20% from baseline blood pressure and was managed with intravenous boluses of ephedrine (6 mg). Bradycardia was defined as a heart rate below 60 beats per minute and was treated with intravenous atropine (0.6 mg) or glycopyrrolate (0.2 mg). All patients received preloading with Ringer's lactate solution before administration of spinal anaesthesia.

The level of sensory (pin prick method) and motor block (Modified Bromage Scale) is to be evaluated at every 2 minutes interval using hypodermic needle till 10 minutes and then at 15 and thereafter every 30 minutes intervals for 6 hours. The pain was assessed by a visual analog scale (VAS) score. All the patients were instructed about the VAS and to point out the intensity of pain on a scale of 0-no pain, and 10-worst pain. Duration of effective analgesia was defined as the time from the intrathecal injection to VAS <5 and duration of rescue analgesia as the time from the intrathecal injection to VAS >5 with the time taken for the first pain medication. Analgesics were avoided until demanded by the patients.

Complications such as bradycardia, hypotension, respiratory depression nausea & vomiting, pruritus, and shivering, if any are noted.

Both groups were comparable regarding age, gender distribution, and body weight, indicating adequate randomization.

RESULTS

Table 1: Baseline Demographic and Clinical Characteristics of Participants

Variable	Group F	Group B	p-value
Age (years)	50.2 ± 8.4	48.6 ± 7.9	>0.05
Weight (kg)	60.5 ± 7.2	62.3 ± 8.1	>0.05
Male/Female	22/18	24/14	>0.05

Block Characteristics: Patients in the fentanyl group exhibited earlier onset of sensory block compared to the buprenorphine group. However, duration of sensory blockade and postoperative analgesia was markedly prolonged in patients receiving buprenorphine.

Table 2: Block characteristics.

Parameter	Group F	Group B	p-value
Onset of sensory block (min)	2.82 ± 0.82	3.62 ± 0.62	<0.001
Motor Block Onset (min)	3.45±0.45	4.52±0.30	<0.001
Duration of sensory block (min)(Regression to L1)	200 ± 22	266 ± 26	<0.001
Duration of analgesia (min)	252 ± 31	401 ± 40	<0.001

Adverse Effects: Minor complications were observed in both groups, though no serious respiratory depression occurred.

Table 3: Complications

Complication	Group F	Group B
Nausea/Vomiting	1	3
Pruritus	3	1
Hypotension	1	2
Bradycardia	1	1

[Table 1] shows the findings of the two groups with respect to age, the sex distribution and types of surgeries, both the groups were similarly matched with respect to these factors.

[Table 2] shows the onset of sensory block, the onset of motor blockade, time for L1 regression and duration of analgesia. There was a statistically significant difference in the groups with respect to all the other variables as described ($P < 0.05$). The onset of sensory block was earlier in the F group 2.82 ± 0.82 compared to B group (3.62 min) $P < 0.05$. The onset of motor blockade was earlier in the F group (3.45 min), as compared to B group (4.5 min), $P < 0.05$. The mean time for regression to L1was more in the B group (266 min) than F group (200 min), $P < 0.05$. Maximum duration of analgesia after spinal drug administration was the significantly more in the B group (401 ± 40 min) than F group (252 ± 31 min), $P < 0.05$.

DISCUSSION

Spinal anaesthesia offers several advantages over general anaesthesia, particularly for surgical procedures involving the lower abdomen, perineum, and lower extremities. These benefits include rapid onset of action, excellent muscle relaxation, avoidance of airway manipulation, reduced postoperative morbidity, and cost-effectiveness. The use of intrathecal opioids as adjuvants to local anaesthetics was introduced in the late 1970s, with morphine being the first opioid employed for this purpose.[6] Since then, numerous studies have demonstrated that the addition of opioids to local anaesthetics enhances the quality of spinal blockade and prolongs the duration of postoperative analgesia.[6]

Many previous studies have shown that addition of intrathecal opioids as adjuvant to local anaesthetics gives synergistic action and thus prolongs the duration of analgesia and potentiate the effects of local anesthetics.[7-11]

The rapid onset observed with fentanyl may be explained by its high lipid solubility, which facilitates faster diffusion into spinal tissues. Buprenorphine, due to stronger receptor affinity and prolonged receptor occupancy, produced longer-lasting postoperative analgesia. Buprenorphine, a μ receptor partial agonist can be safely used in subarachnoid blocks. It has high molecular weight and is lipophilic which may prevent its rostral spread and thus respiratory depression,[5] Sittaramane S et al in their study they compared the effect of fentanyl 25mcg with bupivacaine 0.5% and buprenorphine 60 mcg with bupivacaine 0.5% in spinal anaesthesia for elective caesarean section and concluded that the mean duration of effective analgesia was significant statistically between the two groups. The addition of intrathecal Fentanyl as an adjuvant to spinal anesthesia produces a faster onset time and excellent quality peri-operative analgesia, So our results are similar to these studies.

The present study included 80 patients undergoing elective lower limb surgeries and was designed to compare the onset and characteristics of sensory and motor blockade, duration of postoperative analgesia, and haemodynamic effects of intrathecal fentanyl and buprenorphine used as adjuvants to hyperbaric bupivacaine. Our findings demonstrated a statistically significant difference between the two groups. The addition of fentanyl (25 μg) to 17 mg of hyperbaric bupivacaine resulted in a significantly faster onset of sensory blockade compared with the addition of buprenorphine.

Many studies shows that addition of fentanyl gives fast onset of sensory block. Khanna et al., in studies using different intrathecal doses of fentanyl, reported no significant difference in the onset of sensory blockade.[9]. In contrast, Techanivate et al. observed that the addition of 25 μg fentanyl to 3 mL of 0.5% hyperbaric bupivacaine produced a more rapid onset of sensory blockade and reduced the time required to achieve the maximum sensory level compared with

bupivacaine alone10.Similarly, Singh et al. found that adding 25 µg fentanyl to 13.5 mg of 0.75% hyperbaric bupivacaine did not significantly alter the onset of sensory or motor block and did not prolong the duration of motor blockade induced by bupivacaine.[4]

In the present study, sensory blockade developed significantly earlier in the fentanyl group than in the buprenorphine group. These observations are supported by the findings of Khan et al., who evaluated low-dose fentanyl and buprenorphine as intrathecal adjuvants in patients undergoing transurethral resection of the prostate.[12] Their study demonstrated that the combination of fentanyl with bupivacaine resulted in earlier onset of both sensory and motor blockade compared with buprenorphine, findings that closely correspond with those observed in our study.

The present study demonstrated that the mean onset time of motor blockade was significantly shorter in the fentanyl group than in the buprenorphine group. The earlier onset of motor block observed with fentanyl may be attributed to its rapid penetration into spinal tissues owing to its high lipid solubility. In contrast, Singh et al. reported that intrathecal fentanyl did not significantly influence the onset or duration of motor blockade. The discrepancy between their findings and ours may be related to differences in the concentration and dose of bupivacaine used, as their study employed 0.75% hyperbaric bupivacaine.

In the present study, regression of sensory blockade to the L1 dermatome occurred significantly later in the buprenorphine group than in the fentanyl group, indicating a longer duration of sensory blockade with intrathecal buprenorphine. This prolonged effect may be attributed to the high lipophilicity and strong µ-opioid receptor affinity of buprenorphine, which result in sustained receptor occupancy and extended analgesic action.

Singh et al. reported that the addition of 25 µg fentanyl to intrathecal bupivacaine prolonged both two-segment sensory regression time and regression to the L1 dermatome11. Similarly, Khan and Hamdani demonstrated that intrathecal buprenorphine significantly prolonged sensory blockade, with approximately 35% of patients exhibiting regression to the L1 dermatome only after three hours of subarachnoid injection.[12]

Comparable findings were reported by Nithyashre N et al., who compared intrathecal hyperbaric bupivacaine combined with fentanyl and buprenorphine in patients undergoing lower abdominal and lower limb surgeries.[14] They observed that two-segment sensory regression was significantly slower in the buprenorphine group than in the fentanyl group. The findings of our study are consistent with these observations and further support the superiority of buprenorphine in prolonging the duration of sensory blockade and postoperative analgesia.

In the present study, the duration of postoperative analgesia was significantly longer in the buprenorphine group (401 ± 40 minutes) than in the fentanyl group (252 ± 31 minutes). The prolonged analgesic effect associated with buprenorphine may be explained by its strong affinity for µ-opioid receptors and prolonged receptor binding. Comparable findings have been reported in previous studies evaluating intrathecal adjuvants. Nelamangala et al. compared the intrathecal use of buprenorphine (100 mcg) and fentanyl (50 mcg) as adjuvants to 17.5 mg of 0.5% hyperbaric bupivacaine in patients undergoing lower limb orthopedic surgeryand concluded that patients in the buprenorphine group required significantly fewer rescue analgesics during the first 24 hours after surgery. In addition, postoperative pain scores assessed using the Visual Analog Scale (VAS) were favorable, and both groups experienced only minimal adverse effects.[21] Deepak V. Dhummansure et al. observed a significantly longer duration of sensory blockade in patients receiving clonidine compared with those receiving fentanyl.[17] Likewise, Negi AS and Gupta M et al. demonstrated a significant prolongation of sensory blockade in patients administered intrathecal clonidine compared with those receiving intrathecal buprenorphine.[18]. Collectively, these findings indicate that the choice of intrathecal adjuvant substantially influences the duration of postoperative analgesia and sensory blockade, with buprenorphine providing a distinct advantage over fentanyl in prolonging postoperative pain relief.

With regard to haemodynamic parameters, a slightly greater reduction in systolic blood pressure was observed in the buprenorphine group compared with the fentanyl group. Although a decrease in heart rate occurred in both groups, the difference was not statistically significant. These findings suggest that both intrathecal fentanyl and buprenorphine maintain acceptable haemodynamic stability when used as adjuvants to spinal anaesthesia. Randall et al. reported that the incidence of hypotension was not significantly altered by the addition of fentanyl to intrathecal local anaesthetics.[15] However, other investigators have suggested that neuraxial fentanyl may increase the occurrence of hypotension when combined with spinal local anaesthetics. Similarly, Hoda et al., in a study evaluating different doses of spinal bupivacaine with and without fentanyl in patients undergoing hip fracture surgery, found that intraoperative heart rate remained comparable among groups, whereas the reduction in systolic blood pressure was significantly greater in patients receiving fentanyl.[16] None of the patients in the present study developed any serious cardiovascular, respiratory, or central nervous system complications. The low incidence of adverse effects observed in both groups indicates that intrathecal fentanyl and buprenorphine are safe and well-tolerated adjuvants to hyperbaric bupivacaine. However, because of its prolonged duration of action and superior postoperative analgesic profile, buprenorphine may

be preferred in situations where extended pain relief is desirable.

The findings of this study are consistent with those reported in previous investigations, which have demonstrated a more rapid onset of sensory blockade with fentanyl and a longer duration of postoperative analgesia with buprenorphine. Furthermore, both drugs maintained satisfactory haemodynamic stability and were associated with only minor adverse effects, reinforcing their usefulness and safety in routine spinal anaesthesia practice.

CONCLUSION

The addition of either buprenorphine (90 µg) or fentanyl (25 µg) to 17 mg of 0.5% hyperbaric bupivacaine improves the quality of spinal anaesthesia and enhances postoperative analgesia. Intrathecal fentanyl is associated with a faster onset of sensory and motor blockade, making it suitable when rapid establishment of anaesthesia is required. In contrast, intrathecal buprenorphine provides significantly prolonged sensory blockade and postoperative analgesia, thereby reducing the need for rescue analgesics. Both adjuvants demonstrated acceptable haemodynamic stability and a low incidence of adverse effects. Nevertheless, larger prospective, randomized, double-blinded studies involving patients undergoing similar surgical procedures are warranted to further validate these findings and establish optimal intrathecal opioid regimens.

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