

A Comparative study of Intrathecal Buprenorphine and Fentanyl as adjuvants to 0.75% Hyperbaric Ropivacaine in Lower Limb Surgeries.

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ABSTRACT

Introduction: Spinal anaesthesia is one of the most suitable modality of anaesthesia for procedures involving the lower limbs. To extend the duration of spinal anaesthesia, a variety of additives are added to spinal medication. Ropivacaine has an increased margin of safety over bupivacaine, with a decreased CNS toxicity and cardiotoxic potential.

Aims & Objectives: To compare the onset and duration of sensory and motor blocks with intrathecal buprenorphine and fentanyl as adjuvant to 0.75% hyperbaric Ropivacaine in patients undergoing elective lower limb surgeries.

To compare the hemodynamic changes with intrathecal buprenorphine and fentanyl as an adjuvant to 0.75% hyperbaric Ropivacaine in patients undergoing elective lower limb surgeries.

Methods: In this observational study, 112 patients scheduled for elective surgery of lower limb under spinal anaesthesia were randomly assigned to two groups, with 56 patients in each group. In Group 1, patients receive 3 mL volume of 0.75% hyperbaric ropivacaine and 60 mcg buprenorphine intrathecally. The onset and duration of both sensory and motor blocks, along with vital signs, are

regularly monitored at specified intervals. Postoperatively, each patient was evaluated for the duration of analgesia, pain levels, and the need for rescue analgesics at regular intervals. Hemodynamic parameters are assessed at particular intervals. Data obtained was compiled and statistically analysed with appropriate tests. A value of $p < 0.05$ is taken as significant.

Results: This study evaluates the effectiveness of buprenorphine and fentanyl as adjuncts to 0.75% hyperbaric ropivacaine in lower limb surgeries. The findings show that buprenorphine results in quicker onset times for both sensory block (1.741 minutes) and motor blocks (2.412 minutes) compared to fentanyl, which takes 2.117 minutes for onset of sensory block and 2.899 minutes for onset of motor block. Additionally, the Ropivacaine-buprenorphine group reaches the maximum level of sensory block faster at 5.8 ± 1.21 minutes compared to Ropivacaine-fentanyl group at 6.20 ± 0.79 minutes.

When it comes to the duration of analgesia, Ropivacaine with buprenorphine provides significantly longer motor block (179.11 ± 14.95 minutes) and sensory block (265.11 ± 31.45 minutes) than Ropivacaine with fentanyl, which lasts for 147.5 ± 16.32 minutes and 232.68 ± 25.97 minutes, respectively. Furthermore, the time to first rescue analgesia was longer in the buprenorphine group (338.39 ± 31.62 minutes) compared to fentanyl group (294.82 ± 27.96 minutes). Overall, the total duration of anaesthesia was also longer in the Ropivacaine-buprenorphine group (265.71 ± 31.45 minutes) compared to the Ropivacaine-fentanyl group (232.68 ± 25.97 minutes).

Both the combinations maintained stable hemodynamics. However, the Ropivacaine-Fentanyl group exhibited a slightly higher heart rate and a mild increase in diastolic blood pressure at some time points.

Conclusion: Age, gender, comorbidities, or physical characteristics did not differ significantly between the Ropivacaine-Buprenorphine and Ropivacaine-Fentanyl groups. Both combinations maintained stable heart rates and blood pressure during surgery. The Ropivacaine-Buprenorphine group demonstrated a significantly faster onset and long duration of both sensory and motor blocks. Postoperatively, patients in the Ropivacaine-Buprenorphine group reported lower Visual Analog Scale (VAS) pain scores and had a longer time before requiring rescue analgesia compared to the Ropivacaine-Fentanyl group. Overall, Ropivacaine and buprenorphine together yielded better results in providing longer-lasting analgesia and better postoperative pain control than Ropivacaine with fentanyl.

Keywords: Ropivacaine, Buprenorphine, Fentanyl, Intrathecal, Subarachnoid block, lower limb surgeries, sensory block, motor block, VAS score, rescue analgesia, hemodynamic parameters.

Introduction:

Spinal anaesthesia is one of the most suitable modalities of anaesthesia for lower limb surgeries [1]. However, postoperative pain management remains a significant challenge, as local anaesthetics alone provide a relatively limited duration of action. The addition of adjuvants can reduce the required dose of local anaesthetics, minimize adverse effects, and prolong the duration of anaesthesia. [1]

Bupivacaine, levobupivacaine, and ropivacaine are commonly used for neuraxial anaesthesia. Various adjuvants, including opioids such as morphine, fentanyl, and buprenorphine, as well as $\alpha 2$ -agonists such as clonidine, have been used to prolong spinal anaesthesia. According to the American Society of Anesthesiologists (ASA), neuraxial opioids may be used for pain relief following neuraxial anaesthesia rather than intermittent parenteral opioids [2].

Ropivacaine was introduced into clinical practice in 1996 and has demonstrated a favorable safety profile compared with bupivacaine, with lower risks of central nervous system and cardiovascular toxicity. It is a long-acting, pure S-enantiomer amide local anaesthetic with lower lipid solubility. Ropivacaine produces nerve blockade by reversibly inhibiting sodium ion influx, with relatively greater effects on pain-transmitting A δ and C fibres than on motor fibres. Intrathecal administration of ropivacaine was approved in the European Union in 2004. The extent of sensory and motor blockade depends on factors such as dose and patient age, with higher sensory block levels observed with increasing age. Hyperbaric ropivacaine has been evaluated against isobaric preparations for intrathecal anaesthesia and has demonstrated effective surgical anaesthesia [3,4].

Buprenorphine is a mixed agonist-antagonist opioid approximately 30 times more potent than morphine.

It is a centrally acting, lipid-soluble thebaine analogue that produces analgesia through both spinal and supraspinal mechanisms. Its antihyperalgesic properties may help prevent central sensitization, while its high lipid solubility, strong opioid receptor affinity, and prolonged duration of action make it a useful intrathecal adjuvant for postoperative pain management [5].

Fentanyl is a short-acting, lipophilic μ -opioid receptor agonist. Its action on spinal opioid receptors, particularly in the substantia gelatinosa, produces analgesia by inhibiting presynaptic release of substance P from primary sensory neurons. Fentanyl may also interact with κ -opioid receptors and is commonly used as an adjuvant to spinal anaesthesia because of its rapid onset and relatively low risk of respiratory depression. [6]

This study aims to compare the efficacy of intrathecal buprenorphine and fentanyl as adjuvants to 0.75% hyperbaric ropivacaine in patients undergoing lower limb surgery.

MATERIALS AND METHODS

Study design

This was a hospital-based observational study conducted at MES Medical College over a period of one year from the date of approval by the Institutional Ethics Committee.

Study setting

The study was conducted in the operation theatre and postoperative observation room of MES Medical College. Data were collected following administration of subarachnoid block and continued postoperatively until complete reversal of motor blockade.

Sampling

The sampling population consisted of ASA I and II patients aged 18–60 years, with a BMI of 18.5–24.9 kg/m², scheduled for elective lower limb surgeries under spinal anaesthesia. Based on a previous study by Singh AP et al., the sample size was calculated using the difference in mean duration of sensory blockade between patients receiving 0.75% ropivacaine with 60 µg buprenorphine and those receiving 0.75% ropivacaine with 25 µg fentanyl. With 1% alpha error, 90% power, and 10% beta error, the required sample size was 56 patients in each group, giving a total sample size of 112. Convenient sampling was used.

Inclusion criteria

Patients aged 18–60 years of either sex, belonging to ASA physical status I or II, with BMI 18.5–24.9 kg/m², scheduled for non-emergency unilateral lower limb surgery under spinal anaesthesia, and willing to participate were included. Procedures included lower limb orthopaedic surgery, varicose vein surgery, and wound debridement.

Exclusion criteria

Patients with contraindications to regional anaesthesia, local infection, coagulation abnormalities or thrombocytopenia (platelet count <100 × 10⁹/L), allergy to opioids or local anaesthetics, long-term opioid use, chronic pain, pregnancy or lactation, spinal deformities, or current anticoagulant therapy were excluded.

Study procedure

After obtaining written informed consent, patients were preloaded with Ringer lactate 10 mL/kg and monitored using ECG, NIBP, and pulse oximetry. Baseline heart rate, blood pressure, respiratory rate, and SpO₂ were recorded. Under strict aseptic precautions, spinal anaesthesia was administered in the lateral position using a 25G Quincke needle at the L3–L4 intervertebral space by a consultant anaesthesiologist. Group 1 received 3 mL of 0.75%

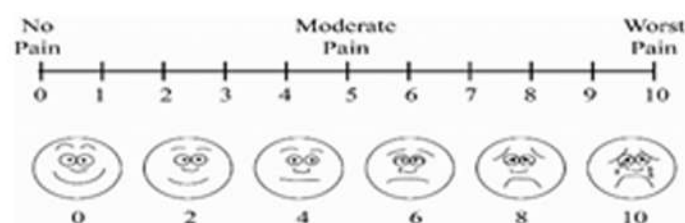
hyperbaric ropivacaine with 25 µg fentanyl.

Haemodynamic parameters were monitored at regular intervals. Hypotension was defined as a >30% reduction in systolic blood pressure from baseline or SBP <90 mmHg and was treated with intravenous mephentermine and fluids as required. Bradycardia was defined as HR <50 beats/min and treated with intravenous atropine. Adverse effects including nausea, vomiting, shivering, pruritus, respiratory depression, sedation, bradycardia, and hypotension were recorded. Sensory and motor block assessments were continued at 15-minute intervals until complete resolution.

Motor block will be assessed by modified Bromage score

- 0- No motor paralysis, able to flex hips/knees/ankles
- 1- Inability to flex the hip, able to move knees
- 2- Inability to flex the knee, able to flex ankles
- 3- Inability to flex the ankle/ unable to move any part of the lower limb

Visual analogue scale- pain score is recorded between 0 and 10 (0= no pain 10 =worst pain)



STATISTICAL DATA ANALYSIS AND RESULTS

Data were entered in Microsoft Excel and analysed using SPSS version 26. Normality was assessed using the Kolmogorov–Smirnov test. Appropriate parametric or non-parametric tests were used, with the chi-square/Fisher's exact test for categorical variables and independent t-test/Mann–Whitney U

test for quantitative variables.

The mean age of participants was 40.73 ± 12.17 years, with no significant difference between Group 1 (40.27 ± 12.67 years) and Group 2 (41.20 ± 11.76 years; $p = 0.68$). Overall, 67% were males and 33% females, while 58.9% were ASA I and 41.1% ASA II, with no significant difference between groups. Implant removal was the most common procedure (41.1%), followed by closed reduction with K-wire fixation (14.3%) and meniscal balancing (13.4%). The distribution of surgical procedures differed significantly between the two groups ($p = 0.005$).

The mean height, weight, and BMI of the participants were 159.12 ± 11.15 cm, 65.64 ± 5.60 kg, and 27.29 ± 16.80 kg/m², respectively. There were no statistically significant differences in height, weight, or BMI between the two groups ($p > 0.05$), indicating that the groups were comparable with respect to these parameters.

Preoperative hemodynamic parameters were within normal ranges, with mean HR 79.96 ± 12.43 bpm, SBP 128.31 ± 14.49 mmHg, DBP 82.11 ± 6.98 mmHg, SpO₂ $99.02 \pm 0.64\%$, and RR 13.91 ± 1.06 /min. During spinal anaesthesia, these parameters remained largely stable. The Ropivacaine–fentanyl group showed significantly higher heart rates at 2, 8, 15, 20, 25, 30, and 35 minutes postoperatively ($p < 0.05$). (figure 1)

Systolic blood pressure showed no statistically significant difference between the groups during the intraoperative and postoperative periods ($p > 0.05$). Diastolic blood pressure was slightly higher in the ropivacaine–fentanyl group, with statistically significant differences at several intraoperative time points and during the immediate postoperative period and at 120 minutes ($p \leq 0.05$). (figure 2 & 3) SpO₂ remained comparable between the groups throughout the intraoperative and postoperative periods, with no statistically significant differences ($p > 0.05$).

Respiratory rate was mildly lower in the ropivacaine–fentanyl group at several time points. Although statistically significant ($p \leq 0.05$), this difference was clinically insignificant.

Postoperatively, heart rate was significantly higher in the ropivacaine–fentanyl group throughout the observation period ($p \leq 0.05$). Postoperative systolic BP and SpO₂ remained comparable between groups, while diastolic BP showed a modest increase with fentanyl at selected time points. Overall, the observed respiratory changes were statistically significant but not clinically relevant.

The onset of sensory blockade was significantly faster in the ropivacaine–buprenorphine group compared with the ropivacaine–fentanyl group. The mean onset time was 104.46 ± 34.17 seconds (1.74 ± 0.56 minutes) in the buprenorphine group, compared with 127.07 ± 25.80 seconds (2.12 ± 0.43 minutes) in the fentanyl group. This difference was statistically significant ($p = 0.001$), indicating a more rapid establishment of sensory blockade with buprenorphine as an adjuvant (figure 4).

Similarly, the onset of motor blockade was significantly earlier in the ropivacaine–buprenorphine group. The mean onset time was 144.73 ± 38.96 seconds (2.41 ± 0.64 minutes), compared with 173.95 ± 27.50 seconds (2.90 ± 0.45 minutes) in the ropivacaine–fentanyl group. The difference was highly statistically significant ($p = 0.0001$), demonstrating a faster onset of motor blockade with buprenorphine (figure 5).

Regarding the maximum level of sensory blockade, the majority of participants in both groups achieved a sensory block at the T8 level, while T9 was the lowest level observed. There was no statistically significant difference between the groups in the

maximum sensory block level ($p = 0.7$), suggesting that both adjuvants produced a comparable cephalad spread of sensory blockade.

The time required to reach the highest sensory block level was also shorter with buprenorphine. The mean time was 5.80 ± 1.21 minutes in the ropivacaine-buprenorphine group compared with 6.20 ± 0.79 minutes in the ropivacaine-fentanyl group. This difference was statistically significant ($p = 0.04$), indicating a more rapid achievement of peak sensory blockade with buprenorphine.

The duration of motor blockade was significantly longer with buprenorphine (179.11 ± 14.95 minutes) than with fentanyl (147.50 ± 16.32 minutes; $p = 0.0001$). Similarly, the duration of sensory blockade was significantly prolonged in the buprenorphine group (265.11 ± 31.45 minutes) compared with the fentanyl group (232.68 ± 25.97 minutes; $p = 0.0001$). Overall, buprenorphine provided a faster onset and significantly prolonged sensory and motor blockade compared with fentanyl when used as an adjuvant to intrathecal ropivacaine.

The VAS scores were assessed at multiple postoperative time intervals from 15 to 240 minutes. At 240 minutes, the data were analysed using the Mann-Whitney U test because the scores were not normally distributed. The mean VAS rank was lower in the ropivacaine-buprenorphine group (53.31) compared with the ropivacaine-fentanyl group (60.61). This difference was statistically significant ($p < 0.05$), indicating significantly lower postoperative pain scores with buprenorphine at 240 minutes.

The mean time to first rescue analgesia was significantly longer in the ropivacaine-buprenorphine group (338.39 ± 31.62 minutes) compared with the ropivacaine-fentanyl group (294.82 ± 27.96

minutes). This difference was highly statistically significant ($p = 0.0001$), indicating a longer duration of effective postoperative analgesia with buprenorphine.

The modified Bromage scores remained at 3 in both groups up to 75 minutes. From 90 minutes onward, the scores decreased more rapidly in the ropivacaine-fentanyl group, with a significant difference observed at 105 and 120 minutes ($p = 0.0001$). The ropivacaine-buprenorphine group maintained a higher motor block score for longer, indicating a prolonged duration of motor blockade. The total duration of anaesthesia was significantly longer in the ropivacaine-buprenorphine group (265.71 ± 31.45 minutes) compared with the ropivacaine-fentanyl group (232.68 ± 25.97 minutes; $p = 0.0001$), demonstrating a significantly prolonged anaesthetic effect with buprenorphine.

The modified Bromage scores remained at 3 in both groups up to 75 minutes. At 90 minutes, a slight reduction was observed in the ropivacaine-fentanyl group, followed by a significant decline at 105 and 120 minutes (2.71 ± 0.53 vs. 3 ± 0 in the ropivacaine-buprenorphine group; $P < 0.05$). Overall, the ropivacaine-buprenorphine group maintained a longer duration of motor blockade, with a slower recovery from Bromage score 3 to 0, indicating more prolonged motor block compared with the fentanyl group. The total duration of anaesthesia was significantly longer in the ropivacaine-buprenorphine group compared with the ropivacaine-fentanyl group (265.71 ± 31.45 vs. 232.68 ± 25.97 minutes; $P = 0.0001$), indicating a significantly prolonged anaesthetic effect with buprenorphine as an intrathecal adjuvant.

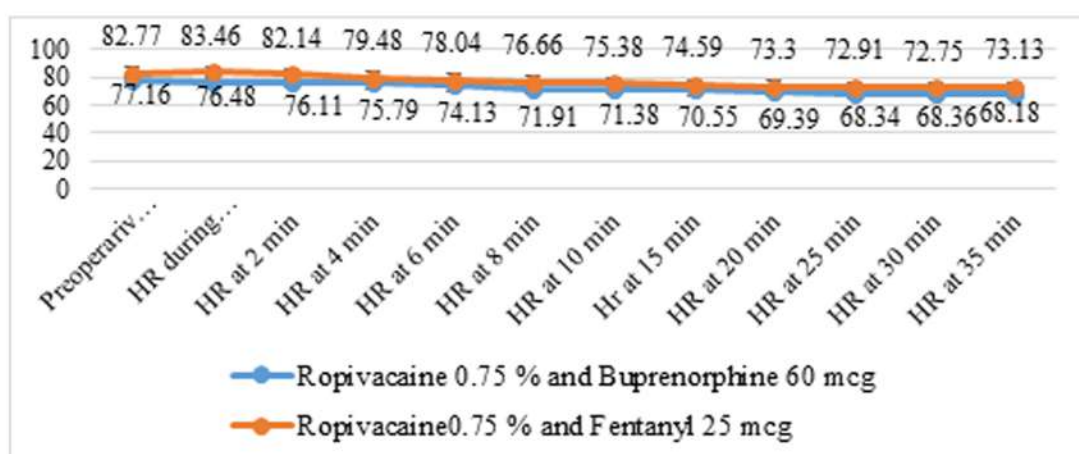


Figure 1: COMPARISON OF STUDY GROUPS BY HEART RATE (PER MINUTE)

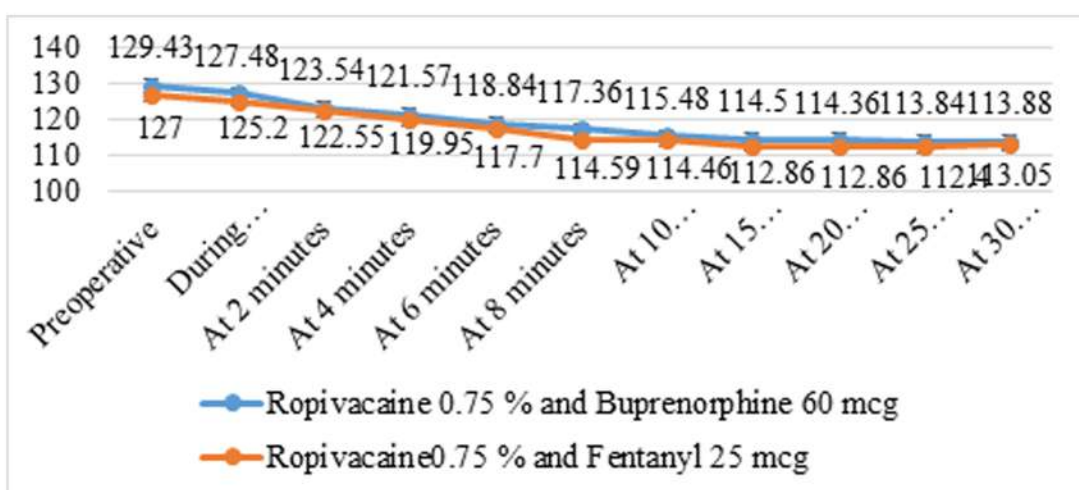


Figure 2: COMPARISON OF STUDY GROUPS BY SYSTOLIC BP (mmHg)

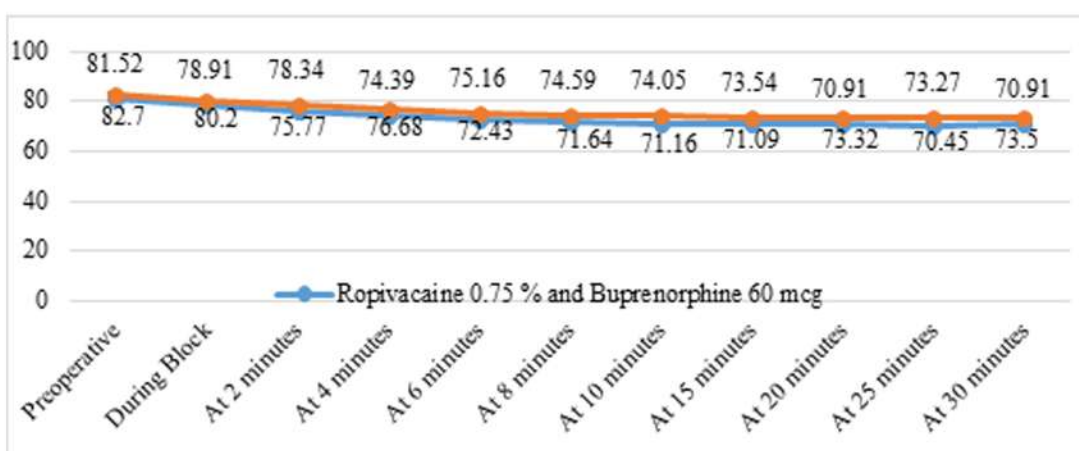


Figure 3: COMPARISON OF STUDY GROUPS, BY DIASTOLIC BLOOD PRESSURE(mmHg)

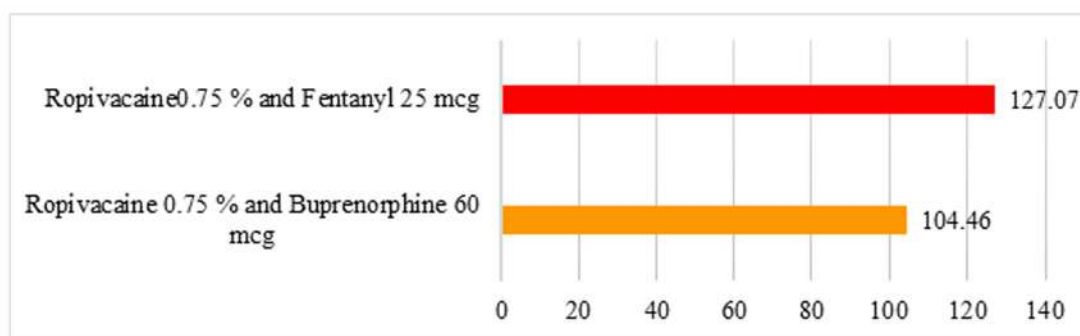


Figure 4: COMPARISON OF STUDY GROUPS BASED ON THE ONSET OF SENSORY BLOCK

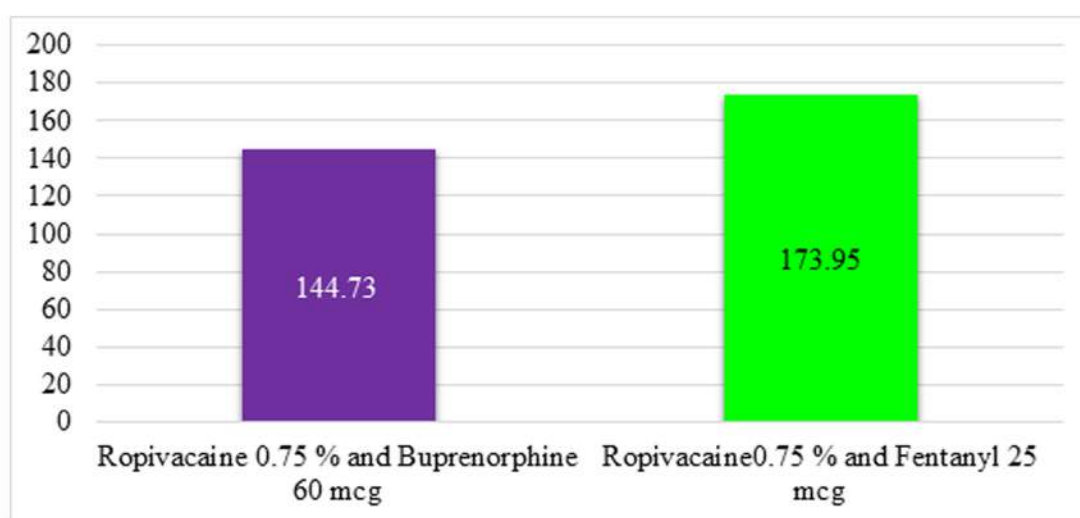


FIGURE 5: COMPARISON OF STUDY GROUPS BASED ON ONSET OF MOTOR BLOCK (seconds)

DISCUSSION

This hospital-based observational study compared the efficacy of buprenorphine and fentanyl as adjuvants to 0.75% hyperbaric ropivacaine for spinal anaesthesia. The findings demonstrated that ropivacaine combined with buprenorphine provided a more effective and longer-lasting anaesthetic effect than ropivacaine with fentanyl. Buprenorphine was associated with a faster onset of sensory and motor blockade, prolonged duration of sensory and motor block, delayed requirement for rescue analgesia, and improved postoperative VAS scores, suggesting greater overall efficacy as an intrathecal adjuvant.

The two groups were comparable with respect to age, ASA status, height, weight, BMI, and baseline physiological characteristics, with no statistically significant differences. The mean age was 40.73 years, with 40.27 ± 12.67 years in the buprenorphine group and 41.20 ± 11.76 years in the fentanyl group ($p = 0.68$). Most participants were ASA grade I, consistent with observations from Sharma A et al. 26 and other previous studies [27,41,42].

Haemodynamic parameters were largely comparable. Although the fentanyl group demonstrated higher heart rates at certain postoperative time points and slightly higher diastolic blood pressure at some intervals, systolic blood pressure showed no

significant intergroup difference. Previous studies have generally reported minimal haemodynamic disturbances with these adjuvants [18,19,27,34,36, 39,40,42].

The onset of sensory blockade was significantly faster in the buprenorphine group (104.46 ± 34.17 vs. 127.07 ± 25.8 minutes; $p = 0.001$). Similar findings were reported by Ravindran et al., Sharma A et al., Singh AP et al., and Layek et al., who observed a shorter onset with ropivacaine-buprenorphine, although Das et al. reported contrary findings [25-27,22]. Motor block onset was also significantly faster with buprenorphine (144.73 ± 38.96 vs. 173.95 ± 27.5 minutes; $p = 0.0001$). This finding was consistent with studies by Aravind Pal Singh et al. and other investigators, supporting the more rapid onset of motor blockade with buprenorphine [27,5,6,34-38].

The duration of both motor and sensory blockade was significantly longer with buprenorphine. Motor blockade lasted 179.11 ± 14.95 minutes in the buprenorphine group compared with 147.5 ± 16.32 minutes in the fentanyl group. Similarly, sensory block duration was 265.11 ± 31.45 minutes with buprenorphine versus 232.68 ± 25.97 minutes with fentanyl. These findings are consistent with Rashmi Pal and other previous studies demonstrating prolonged sensory and motor blockade and greater potency with buprenorphine compared with fentanyl. [46,33,34,37,39]. Arvinder Pal Singh et al. also reported that both adjuvants prolonged sensory blockade compared with ropivacaine alone, with buprenorphine providing better prolongation and postoperative pain relief when directly compared with fentanyl [29]. Postoperative analgesia was superior in the buprenorphine group. At 240 minutes, VAS scores were significantly lower than in the fentanyl group ($p < 0.05$), indicating better sustained postoperative analgesia. Previous evidence

similarly demonstrated higher postoperative VAS scores with fentanyl and greater persistence of analgesic effect with ropivacaine-buprenorphine.5 The time to first rescue analgesic requirement was also significantly longer with buprenorphine (338.39 ± 31.62 vs. 294.82 ± 27.96 minutes; $p = 0.0001$), consistent with findings reported by Nithyasree et al [42].

Modified Bromage scores further demonstrated a more prolonged motor block with buprenorphine, particularly at 105 and 120 minutes, when scores were significantly higher than in the fentanyl group. Similar observations regarding the time required to achieve complete motor blockade have been reported by Omprakash et al. and other investigators [47,40-42]. Overall, the findings indicate that buprenorphine is a more effective intrathecal adjuvant to 0.75% hyperbaric ropivacaine than fentanyl, providing faster onset of sensory and motor blockade, longer duration of blockade, prolonged postoperative analgesia, delayed rescue analgesic requirement, and improved pain control.

CONCLUSION

The present study provides valuable insights into the comparative efficacy of buprenorphine and fentanyl as adjuvants to 0.75% hyperbaric ropivacaine in patients undergoing various surgical procedures. The results demonstrate that the onset of sensory block and motor block was considerably faster in the buprenorphine group (104.46 ± 34.17 seconds for sensory block and 144.73 ± 38.96 seconds for motor block) compared to the fentanyl group (127.07 ± 25.8 seconds for sensory block and 173.95 ± 27.5 seconds for motor block). This rapid onset is clinically advantageous, particularly in settings where timely analgesia is critical.

The duration of both sensory as well as motor block was significantly longer in the buprenorphine group,

minutes and motor block lasting for 179.11 ± 14.95 minutes, compared to 232.68 ± 25.97 minutes and 147.5 ± 16.32 minutes in the fentanyl group, respectively. This extended duration of analgesia can lead to reduced postoperative pain and decreased reliance on rescue analgesics, enhancing patient satisfaction and recovery. The lower VAS scores at 240 minutes in the buprenorphine group in comparison with the fentanyl group highlight the superior analgesic effect of buprenorphine. Additionally, the longer time for first rescue analgesia in the buprenorphine group (338.39 ± 31.62 minutes) compared to the fentanyl group (294.82 ± 27.96 minutes) underscores its effectiveness in prolonging analgesia, which is crucial for improving postoperative recovery and minimizing opioid consumption. The observations of this research support the usage of buprenorphine as a preferred adjuvant with ropivacaine in SAB. Given its advantages in relation to the onset time, analgesic duration, and hemodynamic stability, buprenorphine may be particularly beneficial in surgical settings where rapid and prolonged analgesia is desired.

REFERENCES

1. Capdevila X, Aveline C, Delaunay L, Bouaziz H, Zetlaoui P, Choquet O, Jouffroy L, Herman-Demars H, Bonnet F. Factors determining the choice of spinal versus general anesthesia in patients undergoing ambulatory surgery: results of a multicenter observational study. *Advances in Therapy*. 2020 Jan;37(1):527-40.
2. Das N, et al. Analgesic efficacy in caesarean section: A comparison between fentanyl and buprenorphine as adjuvants to bupivacaine under subarachnoid block. *J Clin Anaesth*. 2023;74:110-115.
3. Dar FA, Mushtaq MB, Khan UM. Hyperbaric spinal ropivacaine in lower limb and hip surgery: A comparison with hyperbaric bupivacaine. *Journal of Anaesthesiology, Clinical Pharmacology*. 2015 Oct; 31(4):466.
4. Simpson D, Curran MP, Oldfield V, Keating GM. Ropivacaine. *Drugs*. 2005 Dec;65(18):2675-717.
5. Ravindran R, Sajid B, Ramadas KT, Susheela I. Intrathecal hyperbaric bupivacaine with varying doses of buprenorphine for postoperative analgesia after cesarean section: A comparative study. *Anesthesia, Essays and Researches*. 2017 Oct; 11(4):952.
6. Sharma A, Kumari A, Gupta R, Kaur S, Arora D, Kaur K. Comparison of intrathecal bupivacaine-fentanyl and bupivacaine-butorphanol combinations for joint replacement surgeries. *Journal of Anaesthesiology Clinical Pharmacology*. 2022 Jan 1;38(1):79-83.
7. McClellan KJ, Faulds D. Ropivacaine. *Drugs*. 2000 Nov;60(5):1065-93. Kuthiala G, Chaudhary G. Ropivacaine: A review of its pharmacology and clinical use. *Indian journal of anaesthesia*. 2011 Mar 1;55(2):104-10.
8. Selander D, Sjoval J, Waldenlind L. Accidental i.v injections of ropivacaine: Clinical experience of six cases [abstract]. *Reg Anaesth* 1997;22:70.
9. 17. Ramos-Matos CF, Bistas KG, Lopez-Ojeda W. Fentanyl. [Updated 2023 May 29]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 Jan
10. Lim IH, Lee SG, Ban JS, Min BW. Spinal Anesthesia 0.75% Isobaric Ropivacaine with Fentanyl for a Lower Extremity Operation. *Korean*

Journal of Anesthesiology. 2002 Nov 1;43(5):600-5.

11. Luck JF, Fettes PD, Wildsmith JA. Spinal anaesthesia for elective surgery: a comparison of hyperbaric solutions of racemic bupivacaine, levobupivacaine, and ropivacaine. *Br J Anaesth*. 2008 Nov;101(5):705-10. doi: 10.1093/bja/aen250. Epub 2008 Sep 2. PMID: 18765643.

12. Kulkarni KR, Deshpande S, Namazi I, Singh SK, Kondilya K. A comparative evaluation of hyperbaric ropivacaine versus hyperbaric bupivacaine for elective surgery under spinal anesthesia. *Journal of anaesthesiology, clinical pharmacology*. 2014 Apr; 30(2):238.

13. Layek A, Maitra S, Gozi NK, Bhattacharjee S, Pal S, Sen S, Hazra A. Comparison between intrathecal isobaric ropivacaine-fentanyl and bupivacaine-fentanyl in elective infraumbilical orthopedic surgery: A randomized controlled study. *J Anaesthesiol Clin Pharmacol*. 2015 Oct-Dec;31(4): 542-6.

14. Nithyashree N, Vijay V Katti/A Comparative Study of Intrathecal Hyperbaric Bupivacaine 0.5% with Fentanyl versus Hyperbaric Bupivacaine 0.5% with Buprenorphine in Lower Limb and Lower Abdominal Surgeries/Indian J Anesth Analg. 2021; 8(2): 181-185.

15. Khan FA, Hamdani GA. Comparison of intrathecal fentanyl and buprenorphine in urological surgery [published correction appears in *J Pak Med Assoc*. 2006 Oct;56(10):482

16. Pate RV, Vasava NG, Kachchhi MB. Comparative effects of intravenous diclofenac versus intramuscular diclofenac on post-operative surgical pain management. *MIJOANS*. 2020;14(2): 60-4.

17. Rashmi Pal, K. K. Arora, N. S. Doneria. Intrathecal Buprenorphine, Clonidine and Fentanyl as Adjuvants to 0.5% Hyperbaric Bupivacaine in Lower Abdominal and Lower Limb Surgeries: A Prospective, Randomized and Comparative Study. *Journal of Evolution of Medical and Dental Sciences*. 2015; 4(46): 8009-8017.

18. Moore F, et al. Neurotoxic effects of local anesthetics: Comparison of bupivacaine and ropivacaine in animal models. *Eur J Anaesthesiol*. 2001; 18(7):433-439.

19. Mahima Gupta, S. Shailaja, K. Sudhir Hegde; Comparison of Intrathecal Dexmedetomidine with Buprenorphine as Adjuvant to Bupivacaine in Spinal Anaesthesia. *Journal of Clinical and Diagnostic Research*. 2014 Feb, Vol-8(2):114-117.

20. Fauzia khan et al comparison of intrathecal fentanyl and buprenorphine in urological surgery volume 56,no 6, June 2006

21. Rahimzadeh P, Hamid Reza S, Imami F, Derakhshan P, Amniati Comparative addition of dexmedetomidine and fentanyl to intrathecal bupivacaine in orthopedic procedure in lower limbs; *BMC Anesthesiology* (2018) 10.1186/s12871-018-0531-7

22. Boztuğ N, Bigat ZE, Ertok ER, Erman MÜ. Intrathecal ropivacaine versus ropivacaine plus fentanyl for out-patient arthroscopic knee surgery. *Journal of international medical research*. 2005 Jul; 33(4):365-71.

23. Kuthiala G, Chaudhary G. Ropivacaine: A review of its pharmacology and clinical use. *Indian journal of anaesthesia*. 2011 Mar;55(2):104.

24. Finucane BT. Ropivacaine—a worthy replacement for bupivacaine?. *Canadian journal of anaesthesia*. 1990 Oct;37(7):722-5.