RESEARCH PAPER

Comparison of efficacy of Hyperbaric ropivacaine 0.75% with dexmedetomidine vs fentanyl as adjuvant in lower limb orthopaedic surgeries undergoing spinal anaesthesia

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ABSTRACT

Introduction: Spinal anaesthesia using ropivacaine is widely employed for lower limb orthopaedic surgeries; however, its relatively shorter duration necessitates the use of adjuvants to enhance block characteristics and postoperative analgesia. Dexmedetomidine and fentanyl are commonly used intrathecal adjuvants with differing pharmacological profiles. The study aimed to compare the efficacy of intrathecal dexmedetomidine versus fentanyl as adjuvants to 0.75% hyperbaric ropivacaine in lower limb orthopaedic surgeries.

Materials and Methods: This prospective, randomized, comparative study was conducted at a tertiary care hospital from January to December 2025. Sixty patients (ASA I–II) undergoing lower limb orthopaedic surgeries were randomly allocated into two groups: Group D received dexmedetomidine (5 µg) and Group F received fentanyl (25 µg) as adjuvants to 0.75% hyperbaric ropivacaine. Sensory and motor block characteristics, duration of analgesia, hemodynamic parameters, sedation, and adverse effects were assessed.

Results: Demographic parameters were comparable between groups. Group D showed significantly faster onset of sensory (2.8 ± 0.7 vs 3.4 ± 0.8 min; p=0.002) and motor block (4.1 ± 0.9 vs 4.7 ± 1.0 min; p=0.018). The duration of sensory block (265.4 ± 35.6 vs 198.2 ± 28.4 min) and motor block (240.5 ± 30.7 vs 182.6 ± 25.3 min) was significantly prolonged in Group D (p<0.001). Duration of analgesia was longer in Group D (310.8 ± 42.5 vs 220.3 ± 35.8 min; p<0.001). Sedation was better with dexmedetomidine, while nausea/vomiting and pruritus were significantly higher in Group F. Hemodynamic parameters were lower in Group D but clinically manageable.

Conclusion: Dexmedetomidine is a superior intrathecal adjuvant to fentanyl with hyperbaric ropivacaine, providing prolonged anaesthesia, better analgesia, improved sedation, and fewer opioid-related side effects.

Keywords: Dexmedetomidine, Fentanyl, Ropivacaine, Spinal anaesthesia, Orthopaedic surgery

How to cite this article: Patel Prajwal HS, Eldo P, Soraganvi LS, Amrutha MS. Comparison of Efficacy of Hyperbaric Ropivacaine 0.75% with Dexmedetomidine vs Fentanyl as Adjuvant in Lower Limb Orthopaedic Surgeries Undergoing Spinal Anaesthesia. Int J Drug Deliv Technol. 2026;16(29s):671-676. DOI: 10.25258/ijddt.16.29s.85

Source of support: Nil

Conflict of interest: None

INTRODUCTION

Spinal anaesthesia is widely used for lower limb orthopaedic surgeries due to its rapid onset, reliable sensory and motor blockade, reduced blood loss, and avoidance of airway manipulation [1]. Among various local anaesthetic agents, ropivacaine, a long-acting amide local anaesthetic, has gained popularity because of its favourable safety profile, reduced cardiotoxicity, and differential blockade with less intense motor block compared to bupivacaine [2]. The use of hyperbaric formulations further enhances the predictability and spread of the block, making it suitable for subarachnoid administration [3].

However, the relatively shorter duration of action of ropivacaine compared to other agents may limit its utility in prolonged surgical procedures and postoperative analgesia [4]. To overcome this limitation, various intrathecal adjuvants have been explored to enhance the quality and duration of spinal anaesthesia [5]. Opioids such as fentanyl act primarily on μ-receptors in the spinal cord, providing effective analgesia with rapid onset, but are associated with side effects such as pruritus, nausea, and vomiting [6].

Dexmedetomidine, a highly selective α2-adrenergic agonist, has emerged as a promising adjuvant in neuraxial anaesthesia [7]. It prolongs both sensory and motor blockade by inhibiting the release of norepinephrine and hyperpolarizing neuronal membranes in the dorsal horn of the spinal cord [8]. Additionally, it provides sedation and analgesia without significant respiratory depression [9]. Several studies have demonstrated that intrathecal dexmedetomidine enhances the duration of analgesia and improves block characteristics when combined with local anaesthetics [10].

Despite the growing evidence supporting the use of dexmedetomidine, limited data exist comparing its efficacy directly with fentanyl when used as an adjuvant to hyperbaric ropivacaine in lower limb orthopaedic surgeries [11]. Therefore, the present study aimed to compare the efficacy of intrathecal dexmedetomidine versus fentanyl as adjuvants to 0.75% hyperbaric ropivacaine in terms of onset and duration of sensory and motor blockade, duration of analgesia, hemodynamic stability, sedation, and associated adverse effects in patients undergoing lower limb orthopaedic surgeries under spinal anaesthesia.

MATERIALS AND METHODS

This prospective, randomized, comparative study was conducted at a tertiary care hospital over a period of one year from January 2025 to December 2025. After obtaining approval from the Institutional Ethics Committee and written informed consent from all participants, a total of 60 patients aged between 18–65 years, belonging to American Society of Anaesthesiologists (ASA) physical status I and II, and scheduled for elective lower limb orthopaedic surgeries under spinal anaesthesia were enrolled in the study. Patients with contraindications to spinal anaesthesia, known allergy to study drugs, significant cardiovascular or neurological disorders, coagulopathy, or infection at the injection site were excluded.

The patients were randomly allocated into two groups of 30 each using a computer-generated randomization method. Group D received 3 ml of 0.75% hyperbaric ropivacaine with dexmedetomidine (5 μg), while Group F received 3 ml of 0.75% hyperbaric ropivacaine with fentanyl (25 μg). All patients were preloaded with intravenous crystalloid solution prior to the procedure. Under strict aseptic precautions, spinal anaesthesia was administered in the sitting position at the L3–L4 or L4–L5 interspace using a 25G Quincke spinal needle, and the study drug was injected intrathecally.

Following drug administration, patients were immediately positioned supine, and standard monitoring including heart rate, non-invasive blood pressure, and oxygen saturation was continuously recorded. Sensory block was assessed using pinprick method, and the time of onset, highest sensory level, duration, and regression were noted. Motor block was evaluated using the Modified Bromage Scale. Duration of analgesia was defined as the time from drug administration to the first request for rescue analgesia, and pain was assessed using the Visual Analog Scale (VAS). Sedation was assessed using the Ramsay Sedation Scale. Hemodynamic parameters and any adverse effects such as hypotension, bradycardia, nausea, vomiting, pruritus, or respiratory depression were recorded throughout the intraoperative and postoperative periods.

Data were entered into Microsoft Excel and analyzed using IBM SPSS Statistics for Windows, Version 26.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. The independent t-test was used for comparison of continuous variables, and the chi-square test or Fisher's exact test was applied for categorical data. A p-value of less than 0.05 was considered statistically significant.

RESULTS

The baseline demographic characteristics were comparable between both groups. The mean age was 42.8 ± 11.6 years in Group D and 44.1 ± 10.9 years in Group F. Gender distribution (18/12 vs 17/13), mean weight (68.5 ± 9.8 kg vs 70.2 ± 10.4 kg), ASA I/II status (20/10 vs 19/11), and duration of surgery (92.3 ± 18.4 min vs 95.1 ± 20.2 min) were similar, with no statistically significant differences ($p>0.05$). (Table 1)

Table 1: Baseline Demographic Characteristics

Variable	Group D (Dexmedetomidine) (n=30)	Group F (Fentanyl) (n=30)	p-value
Age (years)	42.8 ± 11.6	44.1 ± 10.9	0.642

Gender (M/F)	18/12	17/13	0.793
Weight (kg)	68.5 ± 9.8	70.2 ± 10.4	0.512
ASA I/II	20/10	19/11	0.781
Duration of surgery (min)	92.3 ± 18.4	95.1 ± 20.2	0.566

The onset of sensory block was significantly faster in Group D (2.8 ± 0.7 min) compared to Group F (3.4 ± 0.8 min, p=0.002). Time to reach T10 was also shorter in Group D (4.6 ± 1.1 min vs 5.3 ± 1.3 min, p=0.021). The duration of sensory block (265.4 ± 35.6 min vs 198.2 ± 28.4 min) and time to regression to S1 (301.6 ± 40.2 min vs 228.7 ± 32.1 min) were significantly prolonged in Group D (p<0.001). (Table 2)

Table 2: Characteristics of Sensory Block

Parameter	Group D	Group F	p-value
Onset of sensory block (min)	2.8 ± 0.7	3.4 ± 0.8	**0.002**
Time to reach T10 (min)	4.6 ± 1.1	5.3 ± 1.3	**0.021**
Duration of sensory block (min)	265.4 ± 35.6	198.2 ± 28.4	**<0.001**
Time to regression to S1 (min)	301.6 ± 40.2	228.7 ± 32.1	**<0.001**

The onset of motor block was faster in Group D (4.1 ± 0.9 min) than Group F (4.7 ± 1.0 min, p=0.018). Additionally, the duration of motor block was significantly longer in Group D (240.5 ± 30.7 min) compared to Group F (182.6 ± 25.3 min, p<0.001). (Table 3)

Table 3: Characteristics of Motor Block (Modified Bromage Scale)

Parameter	Group D	Group F	p-value
Onset of motor block (min)	4.1 ± 0.9	4.7 ± 1.0	**0.018**
Duration of motor block (min)	240.5 ± 30.7	182.6 ± 25.3	**<0.001**

The time to first rescue analgesia was significantly prolonged in Group D (310.8 ± 42.5 min) compared to Group F (220.3 ± 35.8 min, p<0.001). However, VAS scores at first analgesic request were comparable between Group D (5.8 ± 0.9) and Group F (6.1 ± 1.0, p=0.214). (Table 4)

Table 4: Duration of Analgesia

Parameter	Group D	Group F	p-value
Time to first rescue analgesia (min)	310.8 ± 42.5	220.3 ± 35.8	**<0.001**
VAS score at first analgesia	5.8 ± 0.9	6.1 ± 1.0	0.214

Mean heart rate was significantly lower in Group D (68.2 ± 7.5 beats/min) compared to Group F (74.6 ± 8.2 beats/min, p=0.003). Similarly, mean systolic blood pressure was lower in Group D (112.4 ± 10.6 mmHg vs 118.7 ± 11.2 mmHg, p=0.028), while diastolic blood pressure was comparable (72.3 ± 8.4 mmHg vs 76.5 ± 7.9 mmHg, p=0.061). (Table 5)

Table 5: Hemodynamic Parameters

Parameter	Group D	Group F	p-value
Mean HR (beats/min)	68.2 ± 7.5	74.6 ± 8.2	**0.003**
Mean SBP (mmHg)	112.4 ± 10.6	118.7 ± 11.2	**0.028**
Mean DBP (mmHg)	72.3 ± 8.4	76.5 ± 7.9	0.061

Sedation scores differed significantly between groups (p=0.014), with most patients in Group D having a Ramsay score of 3 (66.7%) compared to 36.7% in Group F. In contrast, a higher proportion of patients in Group F had a score of 2 (60.0% vs 26.7% in Group D). (Table 6)

Table 6: Sedation Score (Ramsay Sedation Scale)

Sedation Score	Group D (n, %)	Group F (n, %)	p-value
2	8 (26.7%)	18 (60.0%)	**0.014**
3	20 (66.7%)	11 (36.7%)	
4	2 (6.6%)	1 (3.3%)	

The incidence of hypotension (20% vs 13.3%, p=0.488) and bradycardia (16.7% vs 6.7%, p=0.228) was comparable between Group D and Group F. However, nausea/vomiting (6.7% vs 23.3%, p=0.038) and pruritus (0% vs 20%, p=0.010) were significantly higher in Group F. No cases of respiratory depression were observed in either group. (Table 7)

Table 7: Adverse Effects

Complication	Group D (n, %)	Group F (n, %)	p-value
Hypotension	6 (20%)	4 (13.3%)	0.488
Bradycardia	5 (16.7%)	2 (6.7%)	0.228
Nausea/Vomiting	2 (6.7%)	7 (23.3%)	**0.038**
Pruritus	0 (0%)	6 (20%)	**0.010**
Respiratory depression	0	0	—

DISCUSSION

The present study demonstrated that intrathecal dexmedetomidine, when used as an adjuvant to 0.75% hyperbaric ropivacaine, provides superior block characteristics compared to fentanyl. A significantly faster onset of sensory and motor block was observed in the dexmedetomidine group, along with prolonged duration of both sensory (265.4 ± 35.6 min) and motor block (240.5 ± 30.7 min). These findings are consistent with the study by Gupta et al., which reported that dexmedetomidine significantly prolongs sensory and motor blockade compared to fentanyl [12].

In the present study, the duration of analgesia was markedly prolonged in the dexmedetomidine group (310.8 ± 42.5 min vs 220.3 ± 35.8 min), indicating enhanced postoperative pain relief. Similar findings have been reported in multiple studies and meta-analyses, where dexmedetomidine significantly increased the pain-free period and reduced the requirement for rescue analgesics compared to fentanyl [13]. Additionally, a recent study using hyperbaric ropivacaine also demonstrated significantly longer sensory and motor block duration and prolonged analgesia with dexmedetomidine, supporting the findings of the present study [14].

Hemodynamic parameters in the current study revealed lower heart rate and systolic blood pressure in the dexmedetomidine group, although these changes were clinically manageable. This is in agreement with previous studies that reported a tendency toward bradycardia and hypotension with dexmedetomidine due to its sympatholytic action, but without significant clinical compromise [15]. Sedation was also significantly better in the dexmedetomidine group, with a higher proportion of patients achieving Ramsay sedation score of 3, which correlates with earlier findings that dexmedetomidine provides better intraoperative sedation without respiratory depression [15,16].

Regarding adverse effects, the present study observed a higher incidence of nausea/vomiting and pruritus in the fentanyl group, whereas dexmedetomidine showed a relatively better side-effect profile. This is consistent with previous literature, which highlights opioid-related side effects such as pruritus, nausea, and vomiting with fentanyl, while dexmedetomidine is associated with fewer such complications [13]. Furthermore, studies have consistently demonstrated that dexmedetomidine reduces opioid-related adverse effects while improving analgesic efficacy [13,17].

The present study has certain limitations that should be considered while interpreting the results. The sample size

was relatively small (n=60), which may limit the generalizability of the findings. Being a single-center study external validity may be restricted. The study did not include long-term follow-up to assess prolonged analgesic outcomes or delayed adverse effects. Additionally, only a single fixed dose of dexmedetomidine and fentanyl was evaluated, without exploring dose–response relationships. Advanced monitoring of sedation and analgesia using objective tools was not performed, and interobserver variability in block assessment could not be completely eliminated.

CONCLUSION

Intrathecal dexmedetomidine as an adjuvant to 0.75% hyperbaric ropivacaine provides superior anaesthetic and analgesic efficacy compared to fentanyl in lower limb orthopaedic surgeries. It is associated with faster onset and significantly prolonged duration of sensory and motor blockade, extended postoperative analgesia, and better sedation, with a lower incidence of opioid-related side effects such as pruritus and nausea. Although it may be associated with mild hemodynamic changes, these are clinically manageable. Therefore, dexmedetomidine appears to be a more effective and safer alternative to fentanyl as an intrathecal adjuvant in spinal anaesthesia.

Funding: none

Conflict of interest: None

Acknowledgment: None

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