



Original Article

Comparison of Intrathecal Dexmedetomidine Versus Fentanyl with 0.75% Hyperbaric Ropivacaine in Elective Infraumbilical Surgeries: A Randomized Control Trial

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ABSTRACT

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Background: Ropivacaine is increasingly used for spinal anaesthesia because of its favourable safety profile and greater sensory-motor differentiation. Intrathecal adjuvants such as fentanyl and dexmedetomidine are commonly added to enhance block characteristics and prolong postoperative analgesia. However, limited evidence is available comparing these adjuvants with 0.75% hyperbaric ropivacaine in infraumbilical surgeries.

Aim and Objectives: To compare the efficacy and safety of intrathecal dexmedetomidine and fentanyl as adjuvants to 0.75% hyperbaric ropivacaine in patients undergoing elective infraumbilical surgeries.

Materials and Methods: This randomized controlled study was conducted in the Department of Anaesthesiology, Chhattisgarh Institute of Medical Sciences, among 90 patients undergoing elective infraumbilical surgeries under spinal anaesthesia. Patients were randomly allocated into three groups of 30 each. Group R received 3 ml of 0.75% hyperbaric ropivacaine with normal saline, Group RF received ropivacaine with fentanyl 25 µg, and Group RD received ropivacaine with dexmedetomidine 5 µg. Parameters assessed included onset and duration of sensory and motor block, maximum sensory block height, duration of analgesia, hemodynamic parameters, sedation score, and complications. Statistical analysis was performed using ANOVA, Chi-square test, and Fisher's exact test.

Results: The onset of sensory block was significantly faster in Group RD (2.43 ± 0.68 min) compared with Group RF (3.13 ± 0.57 min) and Group R (4.33 ± 0.96 min) ($p < 0.001$). Duration of sensory block was longest in Group RD (213.67 ± 17.42 min), followed by Group RF (165.23 ± 11.85 min) and Group R (124.37 ± 16.33 min) ($p < 0.001$). Similarly, duration of analgesia was significantly prolonged in Group RD (331.93 ± 12.07 min) compared with Group RF (262.83 ± 11.86 min) and Group R (190.80 ± 8.23 min) ($p < 0.001$). Sedation scores were significantly higher with dexmedetomidine, while complications were comparable among the groups.

Conclusion: Dexmedetomidine as an intrathecal adjuvant to 0.75% hyperbaric ropivacaine provided faster onset of block, prolonged sensory and motor blockade, longer postoperative analgesia, and better sedation compared with fentanyl and plain ropivacaine, with acceptable hemodynamic stability and minimal adverse effects.

Keywords: Spinal anaesthesia; Hyperbaric ropivacaine; Dexmedetomidine; Fentanyl; Intrathecal adjuvant; Postoperative analgesia; Infraumbilical surgery.

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INTRODUCTION

Spinal anaesthesia, also known as subarachnoid block, is one of the most commonly practiced neuraxial anaesthetic techniques for infraumbilical surgeries because of its rapid onset, reliable sensory and motor blockade, minimal systemic drug exposure, and favourable postoperative recovery profile [1]. The technique involves injection of a local anaesthetic solution into the subarachnoid space, producing reversible inhibition of nerve impulse transmission through direct action on spinal nerve roots. Due to its simplicity, cost-effectiveness, and excellent operating conditions, spinal anaesthesia remains the preferred anaesthetic technique for lower abdominal, perineal, and lower limb procedures [2]. The selection of an appropriate intrathecal local anaesthetic significantly influences the onset, duration, and safety of spinal blockade. Although bupivacaine has long been regarded as the standard agent for spinal anaesthesia because of its potent and prolonged block characteristics, concerns regarding cardiotoxicity and neurotoxicity have encouraged the search for safer alternatives [3]. Ropivacaine, a pure S-enantiomer amino-amide local anaesthetic, has emerged as an effective alternative because of its lower lipid solubility, reduced affinity for cardiac sodium channels, and improved safety profile [3]. In addition, ropivacaine produces greater sensory-motor differentiation, allowing adequate surgical anaesthesia with less intense motor blockade and facilitating earlier postoperative mobilization [4]. The concentration and baricity of ropivacaine play important roles in determining block characteristics. Hyperbaric 0.75% ropivacaine, developed by adding dextrose to the solution, provides more predictable intrathecal spread, faster onset, improved cephalad control, and reliable sensory and motor blockade compared to isobaric preparations [5]. Its favourable hemodynamic stability and satisfactory anaesthetic profile have contributed to its increasing use in infraumbilical surgeries. Despite its effectiveness, intrathecal ropivacaine alone may provide limited postoperative analgesia. To enhance block quality and prolong postoperative pain relief, various intrathecal adjuvants have been combined with local anaesthetics. Fentanyl, a lipophilic μ -opioid receptor agonist, enhances sensory blockade and prolongs analgesia by inhibiting nociceptive transmission through A δ and C fibres, with minimal effect on motor blockade and hemodynamics [5]. Dexmedetomidine, a highly selective alpha-2 adrenergic agonist, produces analgesia by inhibiting neurotransmitter release and hyperpolarizing spinal neurons, thereby prolonging both sensory and motor blockade while maintaining stable hemodynamics [6]. Several investigators have evaluated the efficacy of ropivacaine and its adjuvants in spinal anaesthesia. Olapour et al. [3] demonstrated favourable safety and recovery characteristics of intrathecal ropivacaine compared with bupivacaine in cesarean section. Harish et al. [4] reported effective block characteristics with 0.75% ropivacaine in lower limb and perineal surgeries, while Yennawar et al. [7] observed satisfactory anaesthesia and stable hemodynamics with ropivacaine in TURP procedures. Ravipati et al. [6] found that dexmedetomidine produced prolonged sensory blockade and postoperative analgesia compared with fentanyl when used with isobaric ropivacaine. Similar findings using hyperbaric bupivacaine were reported by Rai et al. [8] and Rahimzadeh et al. [9]. However, limited prospective evidence exists comparing dexmedetomidine and fentanyl specifically as adjuvants to 0.75% hyperbaric ropivacaine in elective infraumbilical surgeries, particularly with inclusion of a plain hyperbaric ropivacaine control group. Therefore, the present study was designed to evaluate and compare the effects of intrathecal dexmedetomidine and fentanyl as adjuvants to 0.75% hyperbaric ropivacaine on sensory and motor block characteristics, duration of postoperative analgesia, hemodynamic stability, and perioperative safety.

MATERIALS AND METHODS

Study Design and Setting

This randomized controlled trial was conducted in the Department of Anaesthesiology at the Major Operation Theatre Complex of Chhattisgarh Institute of Medical Sciences. The study was undertaken after obtaining approval from the Institutional Ethics Committee and Scientific Research Review Committee. The study was conducted over the designated study period until the required sample size was achieved. The study included patients scheduled for elective infraumbilical surgeries under subarachnoid block who fulfilled the inclusion and exclusion criteria. Written informed consent was obtained from all participants prior to enrolment.

Inclusion Criteria

Patients fulfilling the following criteria were included in the study:

- Age between 18 and 60 years
- Either sex
- American Society of Anesthesiologists (ASA) physical status Grade I and II
- Body mass index (BMI) between 18.5 and 24.9 kg/m²

Exclusion Criteria

Patients with the following conditions were excluded from the study:

- Contraindications to spinal anaesthesia such as spinal deformity or local sepsis
- Refusal to participate in the study
- Known allergy to study drugs
- Chronic opioid therapy
- Neurological or psychiatric illness on concurrent medication
- Cardiopulmonary disease, hepatorenal disease, or coagulation disorders

Randomization and Group Allocation

A total of 90 eligible patients were randomized using a computer-generated randomization technique into three equal groups of 30 patients each:

- Group RD: received 3 ml of 0.75% hyperbaric ropivacaine (22.5 mg) with dexmedetomidine 5 µg (0.5 ml)
- Group RF: received 3 ml of 0.75% hyperbaric ropivacaine (22.5 mg) with fentanyl 25 µg (0.5 ml)
- Group RC: received 3 ml of 0.75% hyperbaric ropivacaine (22.5 mg) with 0.5 ml normal saline

Selection bias was minimized through randomization, while observational bias was reduced by blinding during data collection and assessment.

Pre-Anaesthetic Evaluation and Preparation

All patients underwent detailed pre-anaesthetic evaluation 24 hours prior to surgery. Patients were kept nil per oral for 8 hours before surgery. Tablet ranitidine 150 mg was administered orally on the night before surgery. Lignocaine sensitivity testing was performed and confirmed to be negative in all patients. After shifting to the operation theatre, intravenous access was secured using an 18-gauge cannula in the non-dominant hand, and preloading was done with Ringer's lactate solution 10 ml/kg. Standard monitoring including electrocardiography, non-invasive blood pressure, heart rate, respiratory rate, and peripheral oxygen saturation (SpO₂) was instituted and baseline parameters were recorded.

Anaesthetic Technique

Under strict aseptic precautions, subarachnoid block was administered in the sitting position at the L3–L4 intervertebral space using a 25-gauge Quincke spinal needle. After confirmation of free flow of cerebrospinal fluid, the allocated study drug was injected intrathecally. Patients were then immediately positioned supine. The completion of intrathecal injection was considered as time zero.

Assessment of Block Characteristics

Sensory block was assessed using pinprick sensation with a blunt-tipped 22-gauge needle at the T10 dermatome level every minute for the first 5 minutes and every 2 minutes thereafter until the maximum sensory level was achieved. The onset of sensory block was defined as the time interval from intrathecal injection to attainment of sensory block at the T10 dermatome. The highest sensory level was considered when two consecutive readings at the same dermatome level were identical. Duration of sensory block was defined as the time taken for regression of sensory level from T10 to S1 dermatome.

Motor blockade was assessed using the Modified Bromage Scale:

- Grade 0: No motor paralysis
- Grade 1: Inability to raise extended leg
- Grade 2: Inability to flex knee
- Grade 3: Inability to flex ankle

The onset of motor block was defined as the time from intrathecal injection to achievement of Bromage Grade 1 block. Duration of motor block was defined as the time from onset of complete motor block to regression to Bromage Grade 0. Sedation was assessed using the Modified Ramsay Sedation Score. Postoperative pain assessment was performed using the Visual Analogue Scale (VAS), and rescue analgesia was administered when the VAS score exceeded 4.

Hemodynamic Monitoring and Management

Hemodynamic parameters including systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), heart rate (HR), respiratory rate (RR), and SpO₂ were recorded at baseline, every minute for the first 5 minutes, every 5 minutes for the next 25 minutes, and thereafter every 15 minutes until completion of surgery. Postoperatively, vital parameters were monitored hourly for the first 3 hours and then every 3 hours for 24 hours. Hypotension, defined as a decrease in systolic blood pressure greater than 30% from baseline, was managed with intravenous Ringer's lactate bolus of 5 ml/kg followed by incremental doses of intravenous mephentermine if required. Bradycardia, defined as heart rate less than 60 beats per minute, was treated with incremental doses of intravenous atropine.

Dropout Criteria

Patients with partial or failed spinal anaesthesia, requirement of supplemental analgesia, conversion to general anaesthesia, or surgical duration exceeding 3 hours were excluded from the final analysis.

Outcome Measures

The primary outcome measures included onset and duration of sensory block, onset and duration of motor block, and duration of postoperative analgesia. Secondary outcome measures included highest sensory level achieved, hemodynamic parameters, sedation score, and adverse effects.

Statistical Analysis

All data were entered into Microsoft Excel and analyzed using IBM SPSS Statistics software 26. Continuous variables were expressed as mean ± standard deviation, while categorical variables were expressed as frequencies and percentages.

The Chi-square test or Fisher's exact test was used for qualitative data analysis. Quantitative variables between groups were compared using Analysis of Variance (ANOVA). A p value of less than 0.05 was considered statistically significant.

RESULTS

A total of 90 patients undergoing elective infraumbilical surgeries were included and randomized equally into three groups: Group R, Group RF, and Group RD, with 30 patients in each group. The baseline demographic variables, including gender, height, weight, and ASA physical status, were comparable among the three groups, except age, which showed a statistically significant difference, with Group RD having a higher mean age ($p = 0.0094$) (Table 1).

Table 1. Baseline demographic characteristics of study participants

Variable	Group R (n=30)	Group RF (n=30)	Group RD (n=30)	Statistical value	p-value
Age, years	32.73 ± 9.68	31.83 ± 9.29	39.67 ± 12.46	F = 4.92	0.0094
Male, n (%)	16 (53.33)	15 (50.00)	21 (70.00)	$\chi^2 = 2.82$	0.246
Female, n (%)	14 (46.67)	15 (50.00)	9 (30.00)		
Height, cm	166.3 ± 6.89	163.9 ± 6.86	163.2 ± 6.74	F = 1.64	0.198
Weight, kg	63.56 ± 11.06	61.33 ± 10.73	60.83 ± 6.93	F = 0.667	0.516
ASA Grade I, n (%)	25 (83.33)	24 (80.00)	24 (80.00)	$\chi^2 = 0.14$	0.930
ASA Grade II, n (%)	5 (16.67)	6 (20.00)	6 (20.00)		

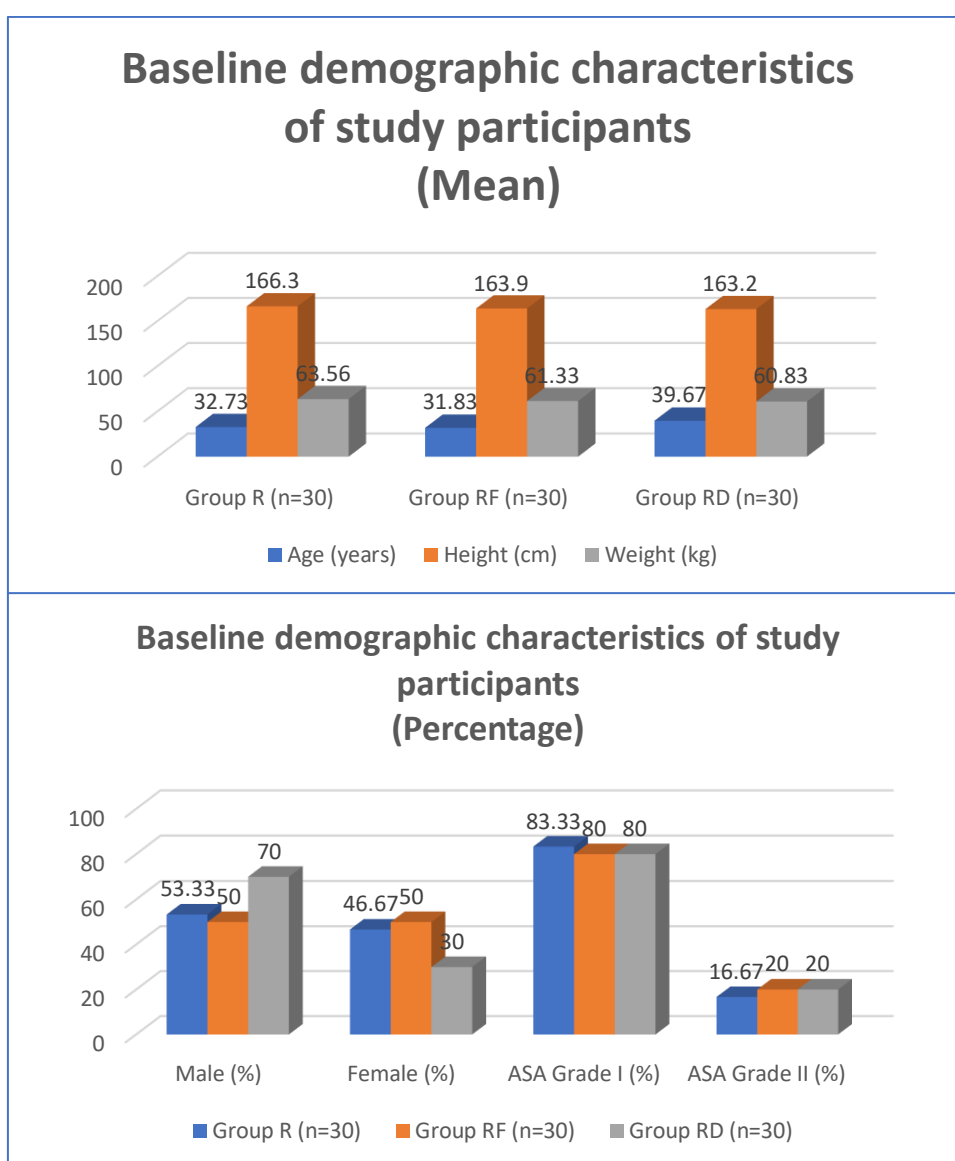


Figure 1 Baseline demographic characteristics of study participants

The onset of sensory block was significantly fastest in Group RD, followed by Group RF and Group R. Similarly, onset of motor block was earliest in Group RD. The duration of sensory block, motor block, and analgesia was significantly prolonged in Group RD compared with Group RF and Group R. Post hoc Tukey analysis showed statistically significant

differences in all pairwise comparisons for sensory onset, motor onset, duration of sensory block, and duration of analgesia. Duration of motor block also differed significantly between all groups (Table 2).

Table 2. Comparison of block characteristics among the study groups

Variable	Group R	Group RF	Group RD	F value	p-value
Time of onset of sensory block, min	4.33 ± 0.96	3.13 ± 0.57	2.43 ± 0.68	48.685	<0.001
Time of onset of motor block, min	2.47 ± 0.82	1.93 ± 0.58	1.40 ± 0.50	20.321	<0.001
Duration of sensory block, min	124.37 ± 16.33	165.23 ± 11.85	213.67 ± 17.42	253.256	<0.001
Duration of motor block, min	97.20 ± 13.83	113.43 ± 15.03	126.07 ± 16.69	27.094	<0.001
Time to maximum sensory height, min	6.97 ± 1.67	5.00 ± 1.29	2.87 ± 0.90	71.996	<0.001
Duration of analgesia, min	190.80 ± 8.23	262.83 ± 11.86	331.93 ± 12.07	1265.600	<0.001

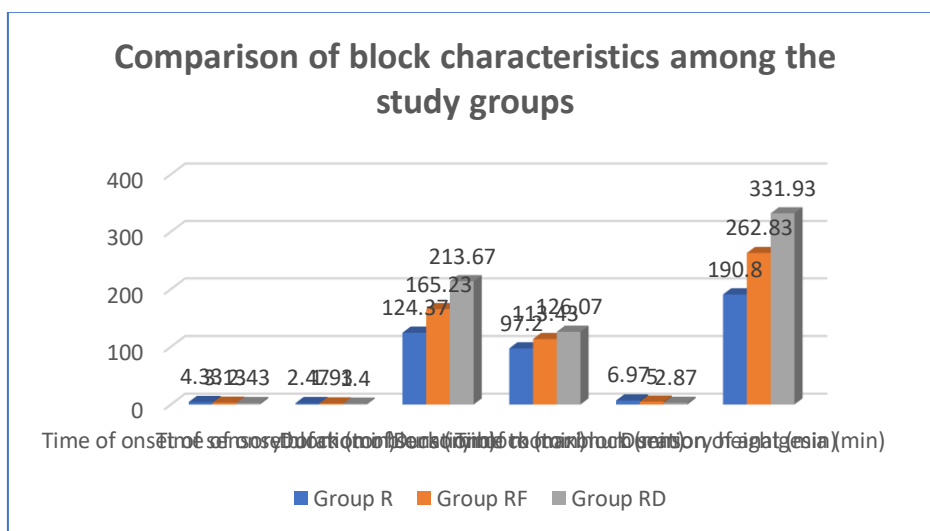


Figure 2 Comparison of block characteristics among the study groups

The maximum height of sensory block differed significantly among the groups ($\chi^2 = 19.472$, $p = 0.0125$). In Group R, the most common sensory levels achieved were T10 and T12, whereas Group RF most frequently achieved T6. In Group RD, T8 was the most common sensory level, followed by T6 and T10 (Table 3).

Table 3. Maximum height of sensory block among study groups

Maximum sensory level	Group R n (%)	Group RF n (%)	Group RD n (%)
T5	0 (0.0)	3 (10.0)	1 (3.3)
T6	4 (13.3)	14 (46.7)	7 (23.3)
T8	6 (20.0)	7 (23.3)	12 (40.0)
T10	10 (33.0)	3 (10.0)	7 (23.3)
T12	10 (33.3)	3 (10.0)	3 (10.0)
Total	30 (100.0)	30 (100.0)	30 (100.0)

$\chi^2 = 19.472$; $p = 0.0125$

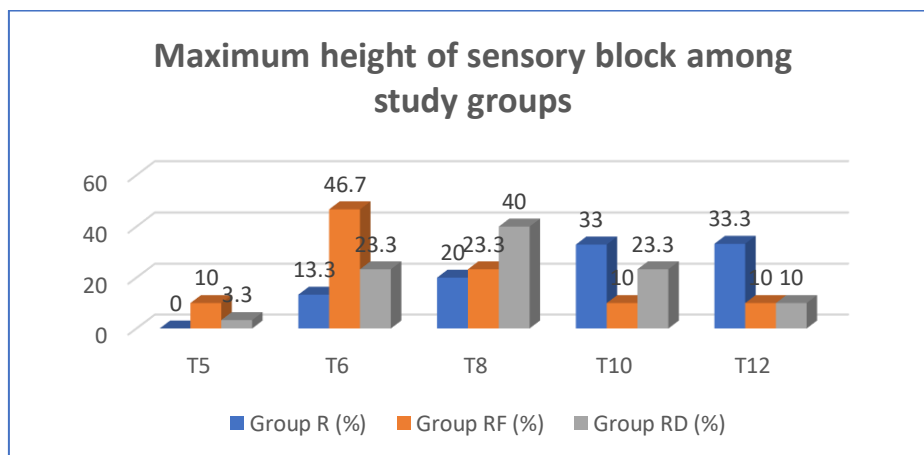


Figure 3 Maximum height of sensory block among study groups

Hemodynamic parameters were comparable at baseline. During the intraoperative period, Group RD showed lower mean arterial pressure and heart rate compared with Groups R and RF, with significant differences at multiple intraoperative time points. However, postoperative MAP and heart rate stabilized and became comparable across groups. SpO₂ and respiratory rate remained within normal physiological limits throughout the perioperative period, and the observed statistical differences at some time points were clinically insignificant. Sedation scores were significantly higher in Group RD, followed by Group RF and Group R.

Complications were infrequent in all groups. Hypotension was more common in Group R, while bradycardia was more frequent in Group RD. However, the differences in vomiting, hypotension, bradycardia, nausea, and shivering were not statistically significant among the groups (Table 4).

Table 4. Distribution of complications among study groups

Complication	Group R n (%)	Group RF n (%)	Group RD n (%)	p-value
Vomiting	2 (6.67)	0 (0.00)	2 (6.67)	0.809
Hypotension	6 (20.00)	3 (10.00)	2 (6.67)	0.260
Bradycardia	2 (6.67)	3 (10.00)	8 (26.67)	0.061
Nausea	5 (16.67)	0 (0.00)	4 (12.33)	0.231
Shivering	2 (6.67)	1 (3.33)	2 (6.67)	0.809

Overall, dexmedetomidine as an adjuvant to 0.75% hyperbaric ropivacaine produced the fastest onset of sensory and motor block, shortest time to maximum sensory level, longest duration of sensory and motor blockade, and maximum duration of postoperative analgesia. Fentanyl also improved block characteristics compared with plain ropivacaine, but the effect was less pronounced than dexmedetomidine.

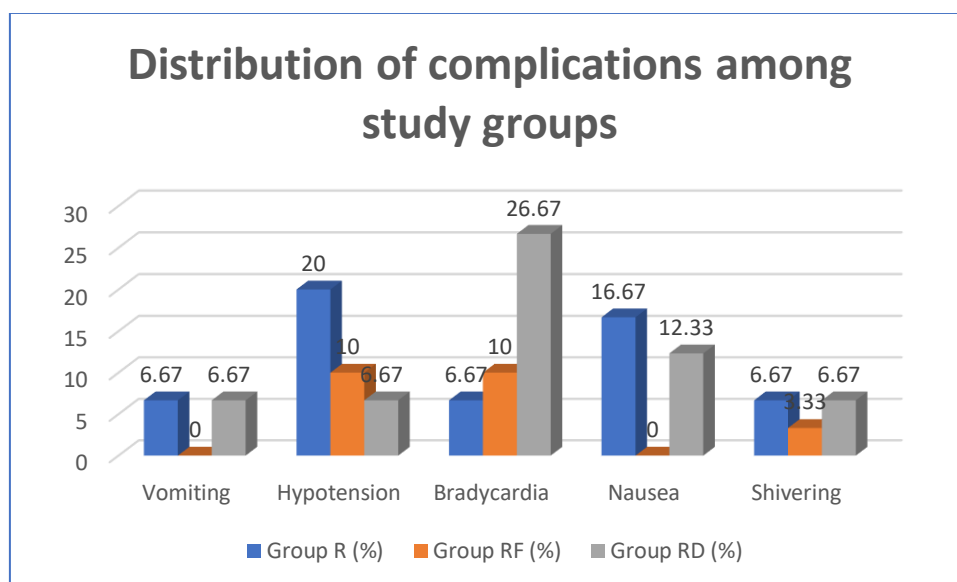


Figure 4 Distribution of complications among study groups

DISCUSSION

The present randomized controlled study compared plain 0.75% hyperbaric ropivacaine with fentanyl and dexmedetomidine as intrathecal adjuvants in patients undergoing elective infraumbilical surgeries. Baseline demographic parameters including gender, height, weight, and ASA status were comparable among the groups, although the mean age was significantly higher in Group RD (39.67 ± 12.46 years) compared with Group R (32.73 ± 9.68 years) and Group RF (31.83 ± 9.29 years) ($p = 0.0094$). Similar demographic comparability was reported by Kulkarni et al. [10], Layek et al. [11], and Jagtap et al. [12]. In the present study, the onset of sensory block was significantly faster in Group RD (2.43 ± 0.68 min) compared with Group RF (3.13 ± 0.57 min) and Group R (4.33 ± 0.96 min) ($p < 0.001$). Similarly, onset of motor block was earliest in Group RD (1.40 ± 0.50 min), followed by Group RF (1.93 ± 0.58 min) and Group R (2.47 ± 0.82 min) ($p < 0.001$). Ravipati et al. [6] also reported faster onset of sensory block with dexmedetomidine compared with fentanyl when combined with intrathecal ropivacaine (156.5 ± 33.8 sec vs 185.2 ± 35.2 sec; $p = 0.002$). Bi et al. [13] similarly observed significantly faster sensory and motor block onset with dexmedetomidine added to hyperbaric ropivacaine. The duration of sensory block in our study was longest in Group RD (213.67 ± 17.42 min), followed by Group RF (165.23 ± 11.85 min) and Group R (124.37 ± 16.33 min) ($p < 0.001$). Likewise, duration of motor block was significantly prolonged in Group RD (126.07 ± 16.69 min) compared with Group RF (113.43 ± 15.03 min) and Group R (97.20 ± 13.83 min) ($p < 0.001$). Ravipati et al. [6] also demonstrated prolonged sensory and motor blockade with dexmedetomidine compared with fentanyl, while Rahimzadeh et al. [9] reported significantly delayed sensory regression with dexmedetomidine compared

with fentanyl and control groups (560.5 ± 81.9 min vs 329.8 ± 44.1 min vs 241.8 ± 22.3 min; $p < 0.001$). Shashikala et al. [5] similarly found maximum prolongation of motor block with dexmedetomidine added to hyperbaric ropivacaine. The maximum sensory block level and cephalad spread differed significantly among groups in the present study ($\chi^2 = 19.472$, $p = 0.0125$). Most patients in Group R achieved T10–T12 block, while higher levels were observed with fentanyl and dexmedetomidine. Time to achieve maximum sensory height was shortest in Group RD (2.87 ± 0.90 min), followed by Group RF (5.00 ± 1.29 min) and Group R (6.97 ± 1.67 min) ($p < 0.001$). Fettes et al. [14] and Whiteside et al. [15] also reported more predictable cephalad spread with hyperbaric ropivacaine preparations. Rahimzadeh et al. [9] similarly observed faster attainment of peak sensory block with dexmedetomidine compared with fentanyl. The duration of postoperative analgesia was significantly prolonged in Group RD (331.93 ± 12.07 min) compared with Group RF (262.83 ± 11.86 min) and Group R (190.80 ± 8.23 min) ($p < 0.001$). Rai et al. [8] reported significantly longer rescue analgesia time with dexmedetomidine than lower-dose groups, while Shashikala et al. [5] observed longer analgesia with dexmedetomidine than fentanyl (356.67 ± 63.02 min vs 255.10 ± 35.63 min). Rahimzadeh et al. [9] also demonstrated markedly prolonged analgesia with dexmedetomidine compared with fentanyl (496.6 ± 70.2 min vs 296.3 ± 44.8 min; $p < 0.001$). Intraoperatively, Group RD showed greater reduction in mean arterial pressure and heart rate compared with the other groups, reflecting the sympatholytic action of dexmedetomidine. However, postoperative hemodynamic parameters remained comparable. Similar findings were reported by Zhang et al. [16] and Gautam et al. [17], who observed increased hypotension and bradycardia tendency with dexmedetomidine without major adverse events. Sedation scores were significantly higher in Group RD at all intraoperative intervals ($p < 0.001$), indicating better patient comfort and sedation quality. Shashikala et al. [5] and Gautam et al. [17] also reported higher Ramsay sedation scores with dexmedetomidine compared with fentanyl. Complications such as hypotension, bradycardia, nausea, vomiting, and shivering were comparable among the groups and were not statistically significant. Similar safety profiles were reported by Bi et al. [13], Nahakpam et al. [18], Jagtap et al. [12], and McNamee et al. [19], supporting the safety of intrathecal ropivacaine with dexmedetomidine or fentanyl.

CONCLUSION

Intrathecal dexmedetomidine as an adjuvant to 0.75% hyperbaric ropivacaine provided significantly faster onset of sensory and motor blockade, prolonged duration of spinal anaesthesia, and longer postoperative analgesia compared with fentanyl and plain ropivacaine. Dexmedetomidine also produced better intraoperative sedation with acceptable hemodynamic stability and no significant increase in adverse effects. Although fentanyl improved block characteristics compared with ropivacaine alone, its effects were less pronounced than dexmedetomidine. Therefore, dexmedetomidine may be considered a more effective intrathecal adjuvant for elective infraumbilical surgeries requiring prolonged and reliable spinal anaesthesia.

LIMITATIONS

The present study was conducted at a single tertiary care center with a relatively small sample size, which may limit the generalizability of the findings. Long-term postoperative outcomes and patient satisfaction were not assessed. Additionally, only a single dose of dexmedetomidine and fentanyl was evaluated, and dose-response comparisons were not performed.

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