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Comparative Evaluation of Epidural Dexmedetomidine Versus Fentanyl as Adjuvants to 0.75% Ropivacaine in Lower Abdominal Surgeries: A Prospective Randomized Study

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ABSTRACT

Background: Epidural anaesthesia is widely used in lower abdominal surgeries because it provides effective intraoperative anaesthesia and prolonged postoperative analgesia. Adjuvants such as fentanyl and dexmedetomidine are commonly combined with ropivacaine to enhance analgesic efficacy and improve perioperative outcomes. This study was designed to compare the efficacy and safety of epidural dexmedetomidine and fentanyl as adjuvants to 0.75% ropivacaine in patients undergoing lower abdominal surgeries.

Materials and Methods: A total of 116 patients aged above 21 years belonging to ASA physical status I and II were enrolled and randomly allocated into two groups. Group RF (n=58) received epidural 0.75% ropivacaine with fentanyl, while Group RD (n=58) received epidural 0.75% ropivacaine with dexmedetomidine. Parameters assessed included onset and duration of sensory and motor blockade, haemodynamic variables, sedation score, duration of analgesia, rescue analgesic requirement, and postoperative complications.

Results: The onset of sensory blockade at T10 dermatome was significantly faster in Group RD compared with Group RF. Dexmedetomidine produced prolonged postoperative analgesia and delayed requirement for rescue analgesics. Patients receiving dexmedetomidine demonstrated better sedation scores and stable haemodynamic parameters throughout the intraoperative period. Mean systolic blood pressure, heart rate, and mean arterial pressure were lower in Group RD but remained within clinically acceptable limits. Bradycardia was the most common complication in both groups, whereas nausea, vomiting, and pruritus were more frequent in the fentanyl group.

Conclusion: Dexmedetomidine is a superior epidural adjuvant to fentanyl when combined with 0.75% ropivacaine for lower abdominal surgeries. It provides earlier onset of sensory blockade, prolonged postoperative analgesia, improved sedation, reduced rescue analgesic requirement, and fewer opioid-related adverse effects.

Keywords: *Dexmedetomidine, Fentanyl, Ropivacaine, Epidural anaesthesia, Lower abdominal surgery, Postoperative analgesia.*

INTRODUCTION

Epidural anaesthesia is widely employed for lower abdominal surgeries because it provides effective intraoperative anaesthesia, excellent postoperative analgesia, reduced stress response, and enhanced postoperative recovery. Compared with general anaesthesia, epidural techniques are associated with improved haemodynamic stability, reduced pulmonary complications, and superior patient satisfaction outcomes (1). The addition of adjuvant drugs to local anaesthetic agents has further improved the quality and duration of neuraxial blockade while decreasing the requirement for higher doses of local anaesthetics (2).

Ropivacaine is a long-acting amide local anaesthetic that has become increasingly popular in epidural anaesthesia because of its lower cardiotoxicity and neurotoxicity compared with bupivacaine (2). It produces effective sensory blockade with relatively less motor blockade, thereby allowing early mobilization and improved postoperative recovery. However, the duration of analgesia with ropivacaine alone may be insufficient for prolonged postoperative pain control, leading to the use of epidural adjuvants to enhance analgesic efficacy (3).

Fentanyl, a lipophilic opioid agonist, is commonly used as an epidural adjuvant because of its rapid onset and potent analgesic action. It acts synergistically with local anaesthetics at spinal opioid receptors to improve perioperative analgesia and reduce local anaesthetic requirements. Nevertheless, fentanyl administration may be associated with adverse effects such as nausea, vomiting, pruritus, urinary retention, and respiratory depression, which can negatively influence postoperative recovery (4).

Dexmedetomidine is a highly selective α2-adrenergic receptor agonist possessing sedative, anxiolytic, sympatholytic, and analgesic properties. Epidural dexmedetomidine acts by inhibiting nociceptive neurotransmission in the dorsal horn of the spinal cord, thereby prolonging sensory and motor blockade and improving postoperative analgesia (5). Previous studies have demonstrated that dexmedetomidine provides earlier onset of sensory blockade, prolonged duration of analgesia, reduced requirement for rescue analgesics, and better sedation quality compared with fentanyl when used as an epidural adjuvant (6,7).

Several randomized clinical trials and meta-analyses have compared dexmedetomidine and fentanyl as adjuvants to ropivacaine for epidural anaesthesia; however, variations in dosage regimens, surgical populations, and outcome parameters have resulted in inconsistent findings (7,8). Therefore, the present study was undertaken to compare the efficacy and safety of epidural dexmedetomidine versus fentanyl combined with 0.75% ropivacaine in patients undergoing lower abdominal surgeries.

MATERIALS AND METHODS

This prospective randomized comparative study was conducted in the Department of Anaesthesiology at Prathima Relief Institute of Medical Sciences, Hanamkonda, Telangana, from June 2024 to May 2025. A total sample size of 116 patients was included in the study based on previous literature and feasibility of recruitment during the study period. Patients were randomly divided into two groups under Group RF with 58 patients receiving 0.75% ropivacaine with fentanyl and group RD with 58 patients receiving 0.75% ropivacaine with dexmedetomidine

Inclusion Criteria: Patients aged > 21 years, belonging to ASA physical status I and II, scheduled for elective lower abdominal surgeries under epidural anaesthesia and willing to participate and provide informed consent

Exclusion Criteria: Contraindications to epidural anaesthesia, known hypersensitivity to study drugs, severe cardiovascular, hepatic, renal, neurological, psychiatric illness, coagulation disorders, local infection at the puncture site and unwilling to participate.

Ethical Considerations

Institutional Ethics Committee approval was obtained prior to commencement of the study. Written informed consent was obtained from all participants after explaining the nature and purpose of the study.

Preoperative evaluation included complete clinical examination and routine laboratory investigations. Baseline haemodynamic parameters such as systolic blood pressure, diastolic blood pressure, heart rate, respiratory rate, oxygen saturation, and mean arterial pressure were recorded. Epidural anaesthesia was administered under strict aseptic precautions in the lumbar region using the loss-of-resistance technique. Following confirmation of epidural placement, the study drug was injected.

The following parameters such as time to onset of sensory block at T10 dermatome, time to achieve maximum sensory level, duration of sensory block, duration of motor blockade assessed using Modified Bromage Scale, time to first rescue analgesia, haemodynamic parameters, sedation score using Ramsay Sedation Scale and postoperative complications were assessed.

Statistical Analysis

Data were extracted into Microsoft Excel sheet and analysed using SPSS v.26.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were expressed as frequency and percentage. Student's t-test and Chi-square test were applied as appropriate for comparison of variables. A p-value <0.05 was considered statistically significant.

RESULTS

The demographic variables were comparable between the two groups. Majority of patients belonged to the age group of 31-50 years. Male patients constituted a higher proportion in both groups. Mean body mass index and ASA grading showed no statistically significant difference between the groups.

Table 1: Demographic characteristics of study participants (n=116)

Demographic variable	Group RF (n=58)	Group RD (n=58)
Mean age (years)	41.8 ± 9.6	42.1 ± 8.9
Gender		
Male	38 (65.5%)	40 (69.0%)
Female	20 (34.5%)	18 (31.0%)
BMI (Kg/m^2)	26.5 ± 2.8	26.8 ± 2.5
ASA grading		
ASA Grade I	33 (56.9%)	36 (62.1%)
ASA Grade II	25 (43.1%)	22 (37.9%)

The onset of sensory blockade to T10 dermatome was significantly earlier in Group RD compared with Group RF. Similarly, patients in Group RD achieved maximum sensory blockade more rapidly. The duration of analgesia and time to rescue analgesia were significantly prolonged in the dexmedetomidine group.

Table 2: Comparison of Sensory and motor block characteristics.

Parameter	Group RF	Group RD	p-value
Onset to T10 sensory block (min)	13.01 ± 2.34	10.56 ± 2.94	0.022
Time to maximum sensory level (min)	18.80 ± 3.26	16.24 ± 2.21	0.001
Duration to onset of pain (min)	322.14 ± 13.45	385.10 ± 13.82	0.034
Requirement of rescue analgesia (min)	328.20 ± 15.63	401.88 ± 14.62	0.042
Duration of complete motor block (min)	28.98 ± 5.63	22.45 ± 5.33	0.001

Both groups maintained acceptable haemodynamic stability throughout the study period. However, Group RD demonstrated comparatively lower systolic blood pressure, heart rate, and mean arterial pressure than Group RF, with statistically significant differences at several time intervals (Table 3).

Table 3: Comparison of mean Systolic blood pressure between groups.

Time period	Group RF (Mean ± SD)	Group RD (Mean ± SD)	p-value
Baseline	120.21 ± 12.82	126.44 ± 7.56	0.025
30 min	102.56 ± 15.20	99.55 ± 6.28	0.001
60 min	99.48 ± 14.38	92.63 ± 6.03	0.001
120 min	109.24 ± 12.52	94.66 ± 8.86	0.001
240 min	119.78 ± 13.05	108.36 ± 8.78	0.048

The mean heart rate was also lower in the dexmedetomidine group during most intraoperative intervals, although all values remained within clinically acceptable limits. Patients receiving dexmedetomidine demonstrated improved sedation scores compared with the fentanyl group after the initial 15 minutes of epidural administration (Table 4).

Table 4: Comparison of mean sedation scores

Time period	Group RF	Group RD	p-value
Baseline	1.98 ± 0.86	1.91 ± 0.44	0.925
15 min	2.12 ± 0.37	2.04 ± 0.89	0.028
30 min	2.25 ± 0.88	2.31 ± 1.12	0.001
60 min	2.23 ± 1.01	2.94 ± 0.63	0.001
75 min	2.14 ± 0.86	2.78 ± 0.58	0.001

Bradycardia was the most commonly observed complication in both groups. Nausea, vomiting, and pruritus were more common among patients receiving fentanyl (Table 5).

Table 5: Postoperative adverse events.

Complication	Group RF	Group RD
Vomiting	7 (12.1%)	4 (6.9%)

Nausea	13 (22.4%)	5 (8.6%)
Pruritus	10 (17.2%)	2 (3.4%)
Hypotension	6 (10.3%)	7 (12.1%)
Bradycardia	16 (27.6%)	20 (34.5%)

DISCUSSION

The present prospective randomized study compared the efficacy and safety of epidural dexmedetomidine and fentanyl as adjuvants to 0.75% ropivacaine in patients undergoing lower abdominal surgeries. The findings demonstrated that dexmedetomidine produced earlier onset of sensory blockade, prolonged postoperative analgesia, improved sedation, and reduced requirement for rescue analgesics compared with fentanyl while maintaining acceptable haemodynamic stability. In the present study, the demographic characteristics including age, gender distribution, body mass index, and ASA grading were comparable between the two groups, indicating appropriate randomization and minimizing selection bias. Similar demographic observations were reported by Bajwa et al., and Kaur et al., who evaluated dexmedetomidine and fentanyl as epidural adjuvants in lower limb and abdominal surgeries (4, 9).

The onset of sensory blockade to T10 dermatome was significantly faster in the dexmedetomidine group compared with the fentanyl group. Additionally, the time required to attain maximum sensory blockade was shorter in patients receiving dexmedetomidine. These findings are consistent with the observations of Pratibha et al., who reported a significantly earlier onset of sensory and motor blockade with dexmedetomidine combined with ropivacaine (10). Dexmedetomidine exerts its analgesic effect through activation of presynaptic α2-receptors in the spinal cord, leading to inhibition of norepinephrine release and suppression of nociceptive transmission (11). This mechanism contributes to enhancement of local anaesthetic action and faster onset of neuraxial blockade.

The duration of postoperative analgesia and time to rescue analgesia were significantly prolonged in the dexmedetomidine group. Similar results were documented by Gandhi et al., who observed prolonged analgesia and lower postoperative analgesic consumption in patients receiving epidural dexmedetomidine compared with fentanyl (12). Qian et al., in a systematic review and meta-analysis, concluded that dexmedetomidine significantly prolongs sensory blockade duration and improves postoperative analgesia when used as an epidural adjuvant with ropivacaine (7). The prolonged analgesic effect observed in the present study may be attributed to the synergistic interaction between dexmedetomidine and ropivacaine at the spinal level.

The haemodynamic profile observed in the present study was clinically acceptable in both groups, although systolic blood pressure, heart rate, and mean arterial pressure were comparatively lower in the dexmedetomidine group. Dexmedetomidine possesses sympatholytic properties that reduce catecholamine release and attenuate haemodynamic stress responses during surgery (13). Similar findings were reported by Mufti and Irshad, who demonstrated stable haemodynamic parameters with dexmedetomidine during lower abdominal surgeries under combined spinal epidural anaesthesia (14). Despite lower haemodynamic values, none of the patients developed severe cardiovascular instability requiring aggressive intervention.

Sedation scores were significantly higher in the dexmedetomidine group during the later intraoperative period. The sedative effect of dexmedetomidine resembles natural sleep and occurs through activation of α2-receptors in the locus coeruleus of the brainstem (15). Patients remained calm, cooperative, and easily arousable throughout the procedure, which contributed to better patient comfort and surgical conditions. Bajwa et al. also observed superior sedation quality with dexmedetomidine compared with fentanyl in epidural anaesthesia (4).

Regarding postoperative complications, bradycardia was more commonly observed in the dexmedetomidine group, whereas nausea, vomiting, and pruritus were more frequent in the fentanyl group. Opioid-related adverse effects associated with fentanyl have been well documented in previous literature (16). Although dexmedetomidine was associated with increased incidence of bradycardia, the episodes were mild and manageable with standard treatment protocols. Similar complication profiles were reported by Meitei et al. and Rastogi et al. in studies evaluating dexmedetomidine as an epidural adjuvant (17).

The findings of the present study support the growing body of evidence favouring dexmedetomidine as a superior neuraxial adjuvant because of its opioid-sparing effects, prolonged analgesia, improved sedation, and reduced postoperative discomfort. Its use may contribute to enhanced recovery and improved perioperative patient satisfaction in lower abdominal surgeries. However, the present study has certain limitations. It was conducted at a single tertiary care centre with a moderate sample size. Long-term postoperative follow-up and assessment of patient satisfaction scores were not included. Future multicentric studies involving larger patient populations are required to further validate these findings and establish optimal dosing strategies for epidural dexmedetomidine.

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