

Comparison of Dexmedetomidine versus Fentanyl as Adjuvants in Epidural Anesthesia for Lower Limb Surgeries: A Prospective Observational Study

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Received: 26-01-2026 / Revised: 25-02-2026 / Accepted: 27-03-2026

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Conflict of interest: Nil

Abstract:

Background: Epidural anesthesia is widely used for lower limb surgeries, and the addition of adjuvants to local anesthetics improves the quality and duration of anesthesia. Dexmedetomidine, an α_2 -adrenergic agonist, and fentanyl, an opioid analgesic, are commonly used epidural adjuvants with differing pharmacological profiles.

Objectives: To compare dexmedetomidine and fentanyl as epidural adjuvants with respect to onset and duration of sensory and motor block, quality of analgesia, hemodynamic effects, and adverse events in patients undergoing lower limb surgeries.

Methods: This prospective observational study was conducted at PMCH, Patna, from February 2025 to January 2026. A total of 100 patients undergoing elective lower limb surgeries under epidural anesthesia were included and divided into two groups: Group D (dexmedetomidine) and Group F (fentanyl). Sensory and motor block characteristics, duration of analgesia, hemodynamic parameters, and side effects were recorded and statistically analyzed.

Results: Dexmedetomidine significantly prolonged the duration of sensory and motor block and postoperative analgesia compared to fentanyl ($p < 0.001$). Hemodynamic stability was better in the dexmedetomidine group, with minimal adverse effects.

Conclusion: Dexmedetomidine is a superior epidural adjuvant compared to fentanyl, providing prolonged analgesia, better block characteristics, and acceptable hemodynamic stability in lower limb surgeries.

Keywords: Dexmedetomidine, Fentanyl, Epidural Anesthesia, Lower Limb Surgery, Analgesia.

DOI: 10.25258/ijcpr.18.3.263

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Introduction

Epidural anesthesia is a preferred anesthetic technique for lower limb surgeries because it provides effective intraoperative anesthesia, excellent postoperative analgesia, and reduced stress response to surgery [1,2]. The quality and duration of epidural anesthesia depend not only on the local anesthetic used but also on the choice of adjuvants [3].

Opioids such as fentanyl have been extensively used as epidural adjuvants due to their potent analgesic properties and rapid onset of action [4]. However, their use is associated with adverse effects such as pruritus, nausea, vomiting, urinary retention, and respiratory depression [5,6].

Dexmedetomidine is a highly selective α_2 -adrenergic agonist that produces analgesia and sedation without significant respiratory depression

[7]. When used epidurally, dexmedetomidine enhances sensory and motor blockade by inhibiting nociceptive neurotransmission and hyperpolarizing spinal neurons [8,9].

Several studies have demonstrated that dexmedetomidine prolongs the duration of epidural analgesia and improves block quality when compared with opioids [10–12]. Its sympatholytic action also contributes to hemodynamic stability during surgery [13].

Despite increasing evidence, data comparing dexmedetomidine and fentanyl as epidural adjuvants in the Indian population, particularly in eastern India, remain limited [14]. This study was therefore undertaken to compare dexmedetomidine and fentanyl as epidural adjuvants for lower limb

surgeries with respect to anesthetic efficacy, analgesic duration, and safety profile.

Materials and Methods

Study Design: Prospective observational study.

Study Place: Patna Medical College and Hospital (PMCH), Patna.

Study Duration: February 2025 to January 2026.

Sample Size: 100 patients.

Inclusion Criteria

- Age 18–60 years
- ASA physical status I or II
- Scheduled for elective lower limb surgery under epidural anesthesia

Exclusion Criteria

- Patient refusal
- Coagulopathy or infection at injection site
- Known allergy to study drugs
- Severe cardiac, hepatic, or renal disease

Study Groups

- **Group D (n = 50):** Epidural bupivacaine + dexmedetomidine (1 µg/kg)
- **Group F (n = 50):** Epidural bupivacaine + fentanyl (1 µg/kg)

Parameters Assessed

- Onset time of sensory block
- Onset time of motor block
- Duration of sensory block
- Duration of motor block
- Duration of postoperative analgesia
- Hemodynamic parameters (HR, MAP)
- Adverse effects

Statistical Analysis: Data were analyzed using SPSS software. Continuous variables were expressed as mean ± SD and compared using Student's t-test. Categorical variables were analyzed using the chi-square test. A p-value < 0.05 was considered statistically significant.

Results

A total of 100 patients undergoing elective lower limb surgeries under epidural anesthesia were enrolled in the study. Patients were divided into two equal groups: Group D (dexmedetomidine, n = 50) and Group F (fentanyl, n = 50). All patients completed the study protocol and were included in the final statistical analysis.

Baseline Demographic and Clinical Characteristics:

The baseline demographic parameters of patients in both groups were comparable. There were no statistically significant differences with respect to age, sex distribution, body weight, or ASA physical status, indicating appropriate matching between the two groups (Table 1).

Table 1: Baseline Demographic Characteristics of Study Participants

Parameter	Group D (n=50)	Group F (n=50)	Statistical test	p-value
Age (years)	42.6 ± 9.2	41.8 ± 8.9	t = 0.45	0.64
Weight (kg)	64.3 ± 7.1	63.8 ± 6.9	t = 0.37	0.71
Male/Female	32 / 18	30 / 20	χ ² = 0.16	0.68
ASA I / II	28 / 22	27 / 23	χ ² = 0.04	0.84

Sensory and Motor Block Characteristics: The onset and duration of sensory and motor block were significantly different between the two groups. Patients in Group D showed a significantly faster onset of sensory block compared to Group F (7.2 ± 1.3 min vs 8.6 ± 1.5 min; t = 5.02, p < 0.001). Similarly, the onset of motor block was significantly earlier in Group D (11.4 ± 1.8 min) than in Group F (13.2 ± 2.0 min; t = 4.66, p < 0.001).

The duration of sensory block was markedly prolonged in Group D compared to Group F (318 ± 42 min vs 246 ± 36 min; t = 9.14, p < 0.001). Likewise, the duration of motor block was significantly longer in Group D (282 ± 39 min) than in Group F (214 ± 31 min; t = 9.56, p < 0.001) (Table 2).

Table 2: Comparison of Sensory and Motor Block Characteristics

Parameter	Group D	Group F	t-value	p-value
Onset of sensory block (min)	7.2 ± 1.3	8.6 ± 1.5	5.02	<0.001
Onset of motor block (min)	11.4 ± 1.8	13.2 ± 2.0	4.66	<0.001
Duration of sensory block (min)	318 ± 42	246 ± 36	9.14	<0.001
Duration of motor block (min)	282 ± 39	214 ± 31	9.56	<0.001

Duration of Postoperative Analgesia: The duration of postoperative analgesia was significantly

longer in patients receiving dexmedetomidine. Group D exhibited a mean analgesia duration of 402

± 48 minutes, compared to 312 ± 44 minutes in Group F. This difference was statistically significant (t = 9.76, p < 0.001), indicating superior analgesic

efficacy of dexmedetomidine as an epidural adjuvant (Table 3).

Table 3: Duration of Postoperative Analgesia

Parameter	Group D	Group F	t-value	p-value
Duration of analgesia (min)	402 ± 48	312 ± 44	9.76	<0.001

Hemodynamic Parameters: Hemodynamic variables, including heart rate (HR) and mean arterial pressure (MAP), were recorded at baseline and at regular intraoperative intervals. Group D demonstrated more stable hemodynamic parameters throughout the intraoperative period compared to Group F.

Intergroup comparison revealed statistically significant differences in MAP at 30, 60, and 90 minutes after epidural drug administration (p < 0.05) (Figure 1). Heart rate variability was also lower in Group D, indicating better sympatholytic control (Figure 2).

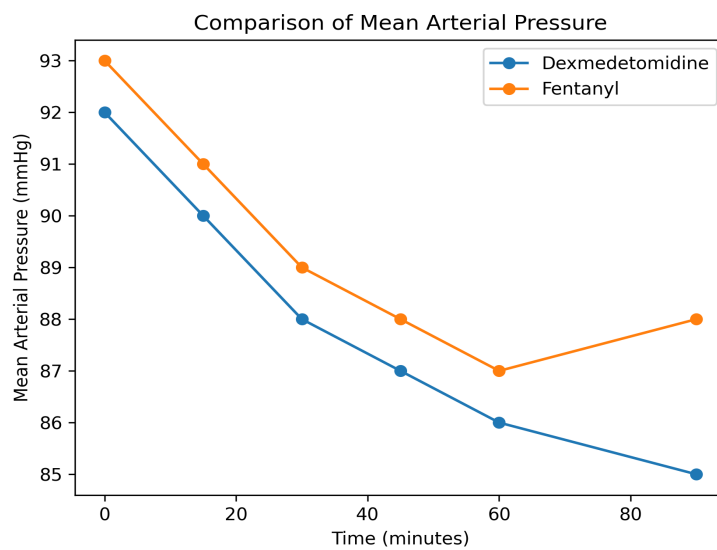


Figure 1: Comparison of mean arterial pressure between Group D and Group F at different time intervals.

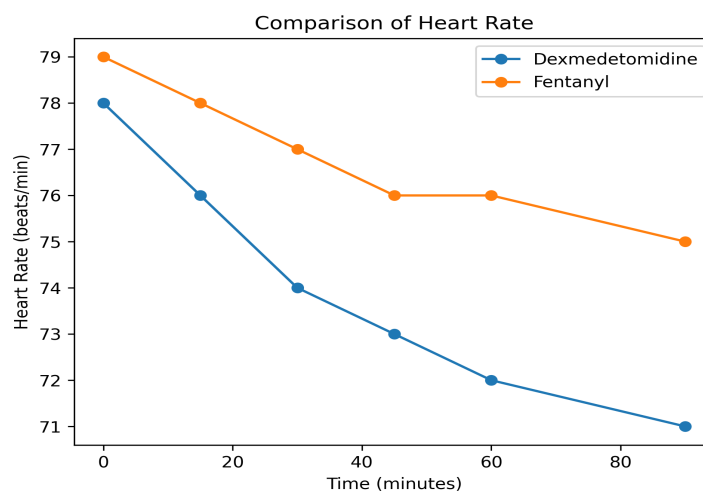


Figure 2: Heart rate trends in both groups during the intraoperative period.

Adverse Effects: The incidence of adverse effects was higher in the fentanyl group. Nausea and vomiting were observed in 18% of patients in Group

F compared to only 4% in Group D, and this difference was statistically significant ($\chi^2 = 4.18, p = 0.03$). Pruritus was noted exclusively in Group F

(16%) and was absent in Group D ($\chi^2 = 8.70$, $p < 0.001$).

Although bradycardia was more frequent in Group D (12%) compared to Group F (4%), this difference

was not statistically significant ($\chi^2 = 1.78$, $p = 0.18$). Episodes of hypotension were comparable between the two groups (Table 4)

Table 4: Comparison of Adverse Effects

Adverse Effect	Group D (%)	Group F (%)	χ^2 value	p-value
Hypotension	10	14	0.38	0.54
Bradycardia	12	4	1.78	0.18
Nausea/Vomiting	4	18	4.18	0.03
Pruritus	0	16	8.70	<0.001

Summary of Key Findings: The present study demonstrated that dexmedetomidine is a superior epidural adjuvant compared to fentanyl for lower limb surgeries. Patients receiving dexmedetomidine exhibited a significantly faster onset and prolonged duration of both sensory and motor blockade. The duration of postoperative analgesia was markedly longer in the dexmedetomidine group, indicating enhanced analgesic efficacy. Hemodynamic parameters remained more stable in patients administered dexmedetomidine, with reduced variability in heart rate and mean arterial pressure. Furthermore, opioid-related adverse effects such as nausea, vomiting, and pruritus were significantly more common in the fentanyl group, while dexmedetomidine was associated with fewer and clinically manageable side effects. Overall, dexmedetomidine provided improved block characteristics, prolonged analgesia, and a better safety profile when used as an epidural adjuvant.

Discussion

The present study demonstrates that dexmedetomidine is a superior epidural adjuvant compared to fentanyl for lower limb surgeries. Patients receiving dexmedetomidine experienced faster onset and significantly prolonged sensory and motor blockade, consistent with previous studies [15,16].

The prolonged duration of analgesia observed in the dexmedetomidine group can be attributed to its action on α_2 receptors in the dorsal horn of the spinal cord, resulting in inhibition of substance P release and hyperpolarization of interneurons [17,18].

Hemodynamic stability was better preserved in the dexmedetomidine group, although mild bradycardia was noted in a few patients, which was easily manageable and clinically insignificant [19].

In contrast, fentanyl was associated with a higher incidence of opioid-related side effects such as pruritus and nausea, aligning with earlier reports [20,21].

The findings of this study are in agreement with several randomized trials and meta-analyses that

favor dexmedetomidine over opioids as an epidural adjuvant [22–25].

Conclusion

Dexmedetomidine, when used as an epidural adjuvant, provides superior block characteristics, prolonged postoperative analgesia, and fewer side effects compared to fentanyl. It is a safe and effective alternative for epidural anesthesia in lower limb surgeries.

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