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**ORIGINAL RESEARCH**

# Comparative evaluation of intrathecal dexmedetomidine and fentanyl as adjuvants to hyperbaric levobupivacaine for postoperative analgesia in lower abdominal surgeries

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## ABSTRACT

**Background**: Adequate postoperative analgesia remains an essential component of perioperative care for lower abdominal surgeries. Intrathecal hyperbaric levobupivacaine has gained popularity due to its less cardiotoxic profile compared to bupivacaine. Adjuvants such as dexmedetomidine, an α2-adrenergic agonist, and fentanyl, an opioid, may enhance the quality and duration of spinal anesthesia while minimizing side effects. **Methods**: In this prospective, randomized, comparative study, 90 adult patients of American Society of Anesthesiologists (ASA) grade I/II, aged 18–60 years, were equally assigned into three groups. Group C received 15 mg hyperbaric levobupivacaine plus 0.5 mL 0.9% saline intrathecally, Group D received 15 mg hyperbaric levobupivacaine plus 4 µg dexmedetomidine (diluted to 0.5 mL), and Group F received 15 mg hyperbaric levobupivacaine plus 25 µg fentanyl (0.5 mL). Sensory block (onset, duration), motor block (onset, duration), hemodynamic parameters, and side effects were recorded. Postoperative pain was assessed using a Visual Analogue Scale (VAS), and the time to first rescue analgesic request was noted. **Results**: Demographic profiles were comparable across the three groups. The onset of sensory and motor block was significantly faster in Group D (6.32±0.62 and 9.77±0.55 minutes) compared to Groups C and F. Group D also demonstrated a significantly prolonged duration of sensory and motor block (94.27±3.96 and 96.43±4.90 minutes, respectively). The mean time to first request for analgesia was notably longer in Group D (281.80±7.21 minutes) than in Group C (135.33±3.61 minutes) and Group F (169.33±10.00 minutes) ($p<0.001$). Although hemodynamic changes were clinically insignificant among groups, Group D showed a higher incidence of bradycardia and hypotension, which were easily managed with appropriate interventions. **Conclusion**: Dexmedetomidine as an adjuvant to hyperbaric levobupivacaine provided rapid onset, prolonged sensory and motor block, and superior postoperative analgesia compared to fentanyl. Dexmedetomidine is a promising alternative for enhanced spinal anesthesia in lower abdominal surgeries.

**Keywords**: Dexmedetomidine, Fentanyl, Levobupivacaine, Spinal Anesthesia, Postoperative Analgesia



## INTRODUCTION

Spinal anesthesia remains the mainstay of regional anesthesia techniques for lower abdominal surgeries, primarily due to its rapid onset, reliable sensory and motor blockade, and cost-effectiveness [1,2]. Levobupivacaine, the S-enantiomer of bupivacaine, exhibits a favorable pharmacokinetic and pharmacodynamic profile with reduced cardiotoxicity while maintaining a similar potency and duration of action compared to racemic bupivacaine [3]. To further optimize perioperative and postoperative analgesia, the addition of intrathecal adjuvants has gained widespread attention. These adjuvants can prolong the duration of analgesia, enhance the quality of the blockade, and reduce the requirement for systemic analgesics [4,5].

Opioids are among the most commonly used neuraxial adjuvants. Intrathecal fentanyl, in particular,

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effectively augments the analgesic effects of local anesthetics by acting on μ-opioid receptors in the dorsal horn of the spinal cord, thereby providing superior pain relief [6]. However, respiratory depression, pruritus, nausea, and vomiting remain potential side effects of neuraxial opioids.

Dexmedetomidine, an α2-adrenergic agonist, is another promising agent used as an adjuvant in spinal anesthesia. It exerts its analgesic effect by binding to presynaptic and postsynaptic α2-adrenoceptors in the dorsal horn of the spinal cord, leading to inhibition of substance P release and hyperpolarization of interneurons. This results in prolonged and more intense analgesia with a stable hemodynamic profile. Multiple studies have reported that dexmedetomidine prolongs the duration of both sensory and motor block when combined with local anesthetics, and also reduces postoperative pain scores [7]. Furthermore, sedation provided by dexmedetomidine may be advantageous in selected surgical scenarios [8].

Comparative research exploring the efficacy and safety of fentanyl and dexmedetomidine in conjunction with levobupivacaine is still evolving. The aim of the present study was to compare the onset, duration, and quality of spinal block, along with the postoperative analgesic effect, of dexmedetomidine versus fentanyl added to hyperbaric levobupivacaine in lower abdominal surgeries. We hypothesized that dexmedetomidine would result in a faster onset and extended duration of sensory and motor block, alongside improved postoperative analgesia, compared to fentanyl, without causing significant adverse hemodynamic changes.

By elucidating the comparative benefits of dexmedetomidine and fentanyl, this study aims to guide anesthesiologists in selecting an optimal adjuvant for spinal anesthesia with levobupivacaine in lower abdominal surgical procedures. This, in turn, may have a significant impact on patients' postoperative comfort and overall recovery [2,4].

## MATERIALS AND METHODS

### Study Design and Ethical Approval

A prospective, randomized, comparative study was conducted in the Department of Anaesthesia at JNU Medical College, Jaipur, Rajasthan, India, from August 2022 through December 2023. The Institutional Ethical Committee approved the study beforehand, and all participants provided informed written consent. After obtaining ethical clearance, the trial was registered with the Clinical Trials Registry-India (CTRI/2022/11/047401, dated 17-11-2022, accessible at www.ctri.nic.in).

### Sample Size and Randomization

The sample size was calculated at a 95% confidence interval and 10% allowable error at a power of 0.80, using the formula from Murphy KR and Myors B [*reference, Appendix D*]. A minimum of 28 patients per group was required, and thus 30 patients per group were recruited to account for dropouts. Ninety patients meeting the inclusion criteria were randomly allocated into three study groups (C, D, and F) of 30 each by a sealed envelope method.

- **Group C (Control):** Hyperbaric levobupivacaine 15 mg (3 mL) + 0.5 mL of 0.9% normal saline
- **Group D (Dexmedetomidine):** Hyperbaric levobupivacaine 15 mg (3 mL) + 4 μg dexmedetomidine, diluted with 0.9% normal saline to make a total volume of 3.5 mL
- **Group F (Fentanyl):** Hyperbaric levobupivacaine 15 mg (3 mL) + 25 μg fentanyl (0.5 mL)

### Inclusion and Exclusion Criteria

**Inclusion criteria**

- ASA grade I and II patients, aged 18–60 years, of either sex
- Planned for lower abdominal surgeries under spinal anesthesia
- Provided informed consent

**Exclusion criteria**

- ASA grade III and IV
- Allergy to local anesthetics or study medications
- Lumbosacral spine pathology
- Patients on anticoagulant therapy
- Refusal to participate

### Blinding

The study drugs were prepared by an anesthesiologist who was not involved in data collection. All drug syringes were placed in identical brown envelopes. The anesthesiologist administering the spinal anesthesia was unaware of group allocation, and the investigator recording outcomes was also blinded to the group assignment. Thus, both patient and investigator were blinded.

### Study Procedure

On the day prior to surgery, a detailed pre-anesthetic evaluation was performed, including history, physical examination, systemic examination, and airway assessment. The Visual Analogue Scale (VAS) was explained to each patient to assess postoperative pain (0 = no pain; 10 = worst pain).

In the operating room, standard monitors (electrocardiogram, noninvasive blood pressure, pulse oximetry) were attached, and baseline parameters were recorded. A 20G intravenous line was secured, and patients received crystalloid preload (Ringer's lactate, 10 mL/kg over 30 minutes). Premedication included IV glycopyrrolate 0.2 mg, ondansetron 4 mg, ranitidine 150 mg, and metoclopramide 10 mg as per institutional protocol.

Under sterile conditions, a midline subarachnoid block was performed in the L3–L4 interspace using a 24–26 G Quincke spinal needle. On confirmation of free-flow cerebrospinal fluid, the assigned intrathecal drug was injected over 10–15 seconds. Patients were

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placed supine, and sensory and motor block levels were assessed.

- **Sensory block**: Assessed using pinprick method and cold sensation (spirit swab)
- **Motor block**: Assessed using the Modified Bromage scale

Hemodynamic parameters (heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure, oxygen saturation) were recorded every 5 minutes for the first 30 minutes, then every 10 minutes until the end of the surgery. Postoperative monitoring continued every 30 minutes for 2 hours, then every 3 hours for 24 hours. Rescue analgesia with intravenous diclofenac 75 mg was given when VAS ≥ 3. Time to first analgesic request from intrathecal injection was recorded as the primary endpoint.

**Statistical Analysis**

Data were entered in Microsoft Excel and analyzed using appropriate statistical tests. Continuous variables were expressed as mean ± standard deviation. Categorical variables were summarized as frequencies or percentages. For intergroup comparisons, a p value <0.05 was considered significant.

**RESULTS**

A total of 90 patients were analyzed (30 in each group). Demographic profiles were comparable in terms of age, gender distribution, body weight, height, and ASA status, with no statistically significant differences among the three groups (p>0.05).

1. **Hemodynamic Parameters**:

- Systolic and diastolic blood pressure, mean arterial pressure, and heart rate showed a mild decline from the baseline in all groups, but these changes were not clinically concerning. Group D had a slightly higher incidence of hypotension and bradycardia, which responded well to standard management.

2. **Sensory and Motor Block**:

- The onset of sensory block was fastest in Group D (6.32±0.62 min) followed by Group F (10.50±0.67 min), and slowest in Group C (13.61±0.67 min) (p<0.001).
- Duration of sensory block was significantly prolonged in Group D (94.27±3.96 min), followed by Group F (83.87±3.53 min), and least in Group C (61.67±7.11 min).
- Similarly, the motor block onset was quickest in Group D (9.77±0.55 min), whereas Group F (12.88±0.68 min) and Group C (16.51±0.50 min) had delayed onsets.
- The duration of motor block was greatest in Group D (96.43±4.90 min), followed by Group F (95.37±3.08 min), and least in Group C (79.77±3.94 min).

3. **Postoperative Analgesia**:

- Time to first rescue analgesic request was substantially longer in Group D (281.80±7.21 min) compared to Group F (169.33±10.00 min) and Group C (135.33±3.61 min) (p<0.001).
- VAS scores remained lower in Group D for a significantly longer duration. At 2 and 4 hours postoperatively, the pain scores were significantly higher in Group C and Group F than in Group D.

4. **Adverse Effects**:

- Hypotension and bradycardia were more frequent in Group D (6 cases) than in Group F (2 cases) and Group C (0 cases). Other adverse effects, such as nausea, vomiting, pruritus, and shivering, were comparable across groups and easily managed.

Below are selected tables and figures summarizing the key results.

**Table 1. Demographic Characteristics**

| Parameter | Group C (n=30) | Group D (n=30) | Group F (n=30) | p Value |
|---|---|---|---|---|
| Age (years) (mean ± SD) | 48.93 ± 6.48 | 37.50 ± 10.78 | 42.53 ± 16.48 | 0.61 |
| Weight (kg) (mean ± SD) | 66.23 ± 7.08 | 66.90 ± 6.11 | 66.23 ± 5.50 | 0.93 |
| Height (cm) (mean ± SD) | 162.77 ± 6.91 | 161.50 ± 7.30 | 162.43 ± 6.92 | 0.84 |
| ASA I/II (n) | 21/9 | 21/9 | 22/8 | 0.95 |

**Table 2. Sensory and Motor Blockade Characteristics**

| Variable | Group C | Group D | Group F | p Value |
|---|---|---|---|---|
| Onset of Sensory Block (min) | 13.61 ± 0.67 | 6.32 ± 0.62 | 10.50 ± 0.67 | <0.001 |
| Duration of Sensory Block (min) | 61.67 ± 7.11 | 94.27 ± 3.96 | 83.87 ± 3.53 | <0.001 |
| Onset of Motor Block (min) | 16.51 ± 0.50 | 9.77 ± 0.55 | 12.88 ± 0.68 | <0.001 |
| Duration of Motor Block (min) | 79.77 ± 3.94 | 96.43 ± 4.90 | 95.37 ± 3.08 | <0.001 |

**Table 3. Time to First Analgesic Request and VAS at 2h, 4h**

| Parameter | Group C | Group D | Group F | p Value |
|---|---|---|---|---|
| Time to first rescue analgesia (min) | 135.33 ± 3.61 | 281.80 ± 7.21 | 169.33 ± 10.00 | <0.001 |
| VAS at 2 hours (mean ± SD) | 1.60 ± 0.63 | 0.20 ± 0.40 | 1.30 ± 0.46 | <0.01 |
| VAS at 4 hours (mean ± SD) | 3.50 ± 0.50 | 1.10 ± 0.30 | 3.50 ± 0.76 | <0.01 |

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**Table 4. Adverse Effects**

| Adverse Effect | Group C (n=30) | Group D (n=30) | Group F (n=30) | p Value |
|---|---|---|---|---|
| Hypotension/Bradycardia | 0 | 6 | 2 | 0.009 |
| Nausea | 1 | 2 | 2 | 0.70 |
| Pruritus | 1 | 1 | 1 | 0.63 |
| Shivering | 2 | 3 | 2 | 0.54 |
| Vomiting | 1 | 1 | 0 | 0.57 |

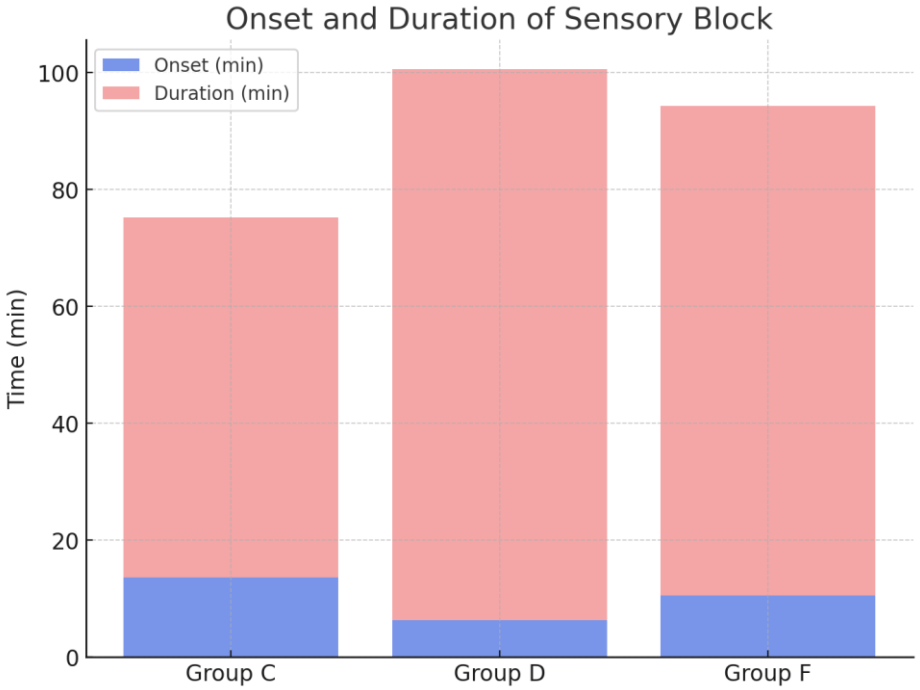


**Figure 1. Onset and Duration of Sensory Block**

*(Bar chart illustrating significantly faster onset and longer duration in Group D compared to Groups C and F.)*

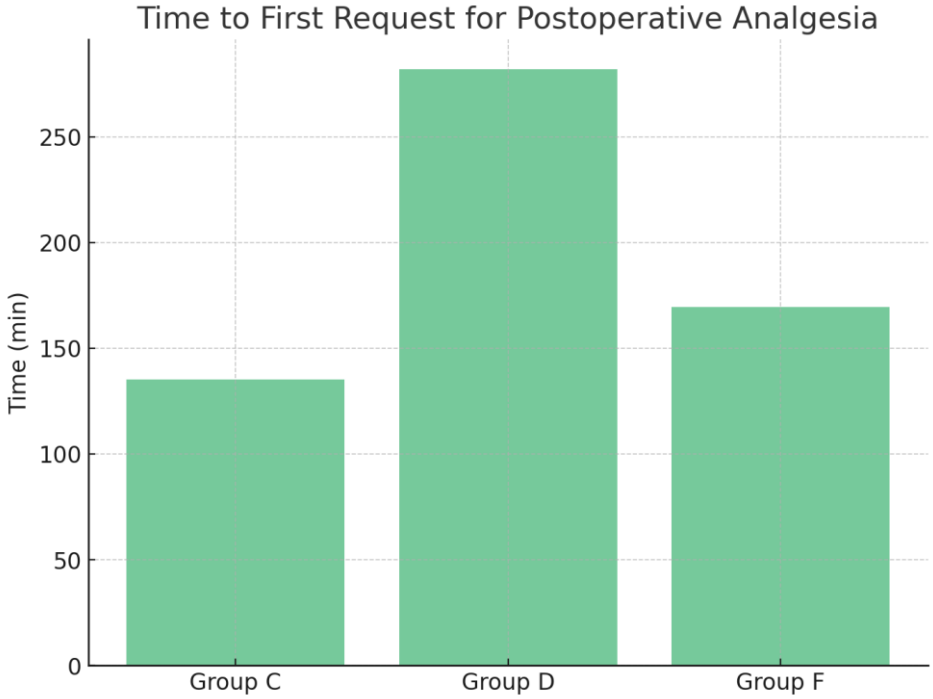


**Figure 2. Time to First Rescue Analgesia**

*(Line graph showing Group D had significantly prolonged analgesia relative to Groups C and F.)*

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## DISCUSSION

Spinal anesthesia with hyperbaric levobupivacaine offers effective anesthesia and analgesia for lower abdominal surgeries with decreased cardiotoxicity relative to racemic bupivacaine [1,4]. The search for an ideal adjuvant to further prolong the duration of intrathecal anesthesia and improve postoperative pain control has been continuous [2]. In this context, both fentanyl, a potent opioid, and dexmedetomidine, a selective α2-adrenergic agonist, have shown synergistic effects with local anesthetics [6,7].

In our study, dexmedetomidine (Group D) demonstrated a significantly faster onset of both sensory and motor block compared to fentanyl (Group F) and the control group (Group C). The intrinsic mechanism of dexmedetomidine involves binding to α2-adrenoceptors in the locus coeruleus and spinal dorsal horn, decreasing noradrenergic outflow and substance P release. This leads to hyperpolarization of interneurons and intensification of analgesic effects [7]. Fentanyl, while effective, primarily acts through μ-opioid receptor agonism [6]. These distinct molecular actions can explain the notable differences in onset and overall blockade quality.

Our findings align with previous literature suggesting that dexmedetomidine prolongs the duration of spinal anesthesia more effectively than fentanyl [7,9]. We observed that the duration of sensory block was significantly higher in Group D (94.27±3.96 min) in comparison to Group F (83.87±3.53 min). This translated into a longer analgesic window, as Group D required rescue analgesia at a mean of approximately 282 minutes, contrasting with 169 minutes in Group F. These observations further highlight the superiority of α2-agonists in ensuring extended postoperative analgesia [8,9].

Hemodynamic stability is a critical consideration when selecting an intrathecal adjuvant. Although dexmedetomidine was associated with a slightly higher incidence of hypotension and bradycardia ($p=0.009$), these events were effectively managed with intravenous fluids and vasopressors. Fentanyl also carries risks, such as bradycardia, pruritus, and respiratory depression, though no significant respiratory compromise was observed in this study [5]. Overall, neither adjuvant resulted in serious adverse events in the present investigation.

Postoperative analgesia is crucial for enhanced recovery protocols, as inadequate pain relief can delay mobilization and prolong hospital stay [2]. The significantly lower VAS scores in Group D at 2 and 4 hours postoperatively underscore dexmedetomidine's potential to offer prolonged comfort, thereby reducing the need for repeated administration of systemic analgesics. This is consistent with the results of previous studies that have demonstrated the analgesic and sedative properties of dexmedetomidine when used intrathecally [7,10].

In summary, our study corroborates that dexmedetomidine is a more effective adjuvant to hyperbaric levobupivacaine compared to fentanyl for spinal anesthesia in lower abdominal surgeries. The benefits include a rapid onset of action, extended duration of sensory and motor blockade, and superior analgesic effect postoperatively, with manageable side effects. Future studies could further explore different doses of dexmedetomidine and the role of patient comorbidities in shaping clinical outcomes.

## CONCLUSION

Dexmedetomidine as an adjuvant to hyperbaric levobupivacaine in spinal anesthesia offers faster onset and longer duration of sensory and motor blockade, as well as more prolonged postoperative analgesia, compared to fentanyl. While dexmedetomidine is associated with a slightly higher risk of hypotension and bradycardia, these are readily managed with standard intraoperative interventions. Overall, dexmedetomidine appears to be a superior alternative to fentanyl for enhancing the efficacy of spinal anesthesia in lower abdominal surgeries, thereby improving patient comfort and potentially expediting postoperative recovery.

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