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A Comparative Study of Spinal Anesthesia with Different Intrathecal Adjuvants for Evaluating the Duration of Sensory and Motor Block, Hemodynamic Changes, Postoperative Analgesia, and Recovery Profile in Patients Undergoing Lower Abdominal and Lower Limb Surgeries

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Abstract

Background: Spinal anaesthesia is widely used for lower abdominal and lower limb surgeries. The addition of Intrathecal Adjuvants such as Dexmedetomidine and fentanyl may improve the duration and quality of spinal anaesthesia and postoperative analgesia. This study compared Intrathecal dexmedetomidine and fentanyl with respect to sensory and motor blockade, Haemodynamic changes, postoperative analgesia, recovery profile, and adverse effects.

Methods: This prospective, randomised comparative study was conducted in the Department of Anaesthesiology, Premier Hospital, Hyderabad, from July 2025 to December 2025. Ninety patients aged 18–60 years with ASA physical status I or II undergoing elective lower abdominal or lower limb surgeries under spinal anaesthesia were included. Patients were divided into two groups of 45 each. Group A received Intrathecal dexmedetomidine, and Group B received Intrathecal fentanyl as Adjuvants to spinal anaesthesia. Sensory and motor block characteristics, Haemodynamic parameters, postoperative pain scores, duration of analgesia, rescue analgesic requirement, recovery profile, and adverse effects were assessed and compared.

Results: The demographic characteristics and distribution of surgical procedures were comparable between the groups. The onset of sensory and motor blockade and maximum sensory level did not differ

significantly. However, the duration of sensory block was significantly longer with dexmedetomidine than fentanyl (285.4 ± 28.6 vs. 224.7 ± 25.3 minutes; p<0.001).

Similarly, motor block duration was significantly prolonged with dexmedetomidine (252.6 ± 24.8 vs. 198.4 ± 21.7 minutes; p<0.001), with delayed complete motor recovery. The mean time to first rescue analgesia was significantly longer in the dexmedetomidine group (398.6 ± 42.5 vs. 287.4 ± 35.8 minutes; p<0.001). Postoperative pain scores were significantly lower with dexmedetomidine at 2, 4, 6, and 12 hours. Rescue analgesic requirements were also significantly lower in Group A.

Dexmedetomidine produced a modest reduction in heart rate, but there was no significant difference between groups in mean arterial pressure, hypotension, or Brady cardia. Overall adverse effects were comparable, and no clinically significant respiratory depression occurred.

Conclusion: Intrathecal dexmedetomidine provided significantly longer sensory and motor blockade and superior postoperative analgesia compared with Intrathecal fentanyl. It reduced postoperative pain and rescue analgesic requirements without causing significant additional Haemodynamic instability or adverse effects. However, the associated delay in motor recovery and ambulation should be considered when selecting the Intrathecal adjuvant.

Keywords: Spinal Anaesthesia, Dexmedetomidine; Fentanyl, Intrathecal Adjuvant, Sensory Block, Motor Block, Postoperative Analgesia, Haemodynamic Changes, Recovery Profile.

Introduction

Spinal anaesthesia is one of the most commonly employed regional an aesthetic technique for lower abdominal, pelvic, perineal, and lower limb surgeries. It provides rapid and reliable surgical anaesthesia, profound analgesia, satisfactory muscle relaxation, and avoidance of many of the airway and respiratory complications associated with general anaesthesia. The technique involves deposition of a local an aesthetic into the subarachnoid space, producing reversible blockade of spinal nerve roots and sympathetic fibres. However, the duration of spinal anaesthesia is often limited by the pharmacological characteristics and dose of the local an aesthetic used. In addition, sympathetic blockade may result in Haemodynamic alterations, particularly hypotension and, occasionally, bradycardia. Therefore, strategies that improve the quality and duration of spinal anaesthesia without producing unacceptable adverse effects continue to be an important area of interest in clinical anesthesiology.[1]

The use of Intrathecal Adjuvants with local anaesthetics has developed as an important method of improving the quality and duration of spinal anaesthesia. Adjuvants may enhance the intensity and duration of sensory analgesia, prolong postoperative pain relief, and potentially reduce the requirement for systemic analgesics. Various agents, including opioids and α2-adrenergic agonists, have been investigated as Intrathecal additives.

The selection of an appropriate adjuvant requires consideration not only of the duration of sensory and motor blockade but also of Haemodynamic stability, postoperative analgesic requirements, recovery characteristics, and adverse effects.[2]

Fentanyl is a highly lipophilic synthetic opioid that has been extensively used as an Intrathecal adjuvant to local an aesthetics. Its rapid onset of action and spinal analgesic properties make it useful for improving the

quality of neuraxial anaesthesia. Intrathecal fentanyl acts primarily through opioid receptors in the spinal cord and can enhance Intraoperative analgesia and prolong the pain-free period following surgery. Studies and systematic reviews have demonstrated that the addition of fentanyl to spinal local an aesthetics can reduce postoperative pain and opioid consumption, although opioid-related adverse effects such as pruritus, nausea, vomiting, sedation, and, rarely, respiratory depression remain relevant considerations. [3,4]

Dexmedetomidine is a highly selective α2-adrenergic receptor agonist that has gained increasing attention as an intrathecal adjuvant. It possesses analgesic and sedative properties and acts through α2-adrenergic mechanisms within the central nervous system. When administered intrathecally with local an aesthetics, dexmedetomidine has been shown to enhance and prolong sensory blockade, increase the duration of motor blockade, and extend postoperative analgesia. Its use as an adjuvant has therefore generated considerable interest as an alternative to Intrathecal opioids. [5,6]

The mechanisms underlying the potentiation of spinal anaesthesia by dexmedetomidine are not completely defined. Activation of α2 - adrenergic receptors is believed to contribute to inhibition of nociceptive neurotransmission and modulation of neuronal activity within the spinal cord. Experimental and clinical evidence suggests that dexmedetomidine may potentiate the action of local an aesthetics and prolong the duration of spinal block. A meta-analysis of randomized clinical trials demonstrated that Intrathecal dexmedetomidine significantly prolonged both sensory and motor blockade and increased the time to first postoperative analgesic request when compared with local an aesthetic alone.[5]

Although prolongation of the block and postoperative analgesia are desirable, an excessively prolonged motor block may delay mobilisation and recovery.

Consequently, assessment of recovery characteristics is particularly important when evaluating intrathecal Adjuvants. Time to complete regression of motor blockade, time to ambulation, and recovery-room discharge are clinically relevant parameters because they influence postoperative mobilisation and overall patient satisfaction. Previous studies evaluating Intrathecal dexmedetomidine have reported prolongation of sensory and motor block as well as delayed ambulation compared with local an aesthetic alone. [7]

Haemodynamic effects are another important consideration during spinal anaesthesia. Sympathetic blockade caused by spinal anaesthesia may produce reductions in systemic vascular resistance and venous return, resulting in hypotension. Bradycardia may also occur as a consequence of reduced sympathetic activity and changes in venous return. Dexmedetomidine, because of its α2-adrenergic activity, may additionally influence heart rate and blood pressure. Consequently, monitoring of heart rate and blood pressure is essential when evaluating its use as an Intrathecal adjuvant. Available evidence suggests that dexmedetomidine can prolong spinal anaesthesia without a consistent increase in hypotension, although bradycardia may occur more frequently in some clinical settings.[5,8]

Fentanyl, in contrast, is generally associated with rapid-onset analgesia and relatively limited effects on motor blockade. However, its duration of analgesic benefit and adverse - effect profile may differ from those of dexmedetomidine. The comparative efficacy and safety of dexmedetomidine and fentanyl as Intrathecal Adjuvants have therefore been investigated in several

randomised clinical studies. A systematic review and meta-analysis involving nine randomised trials and 639 patients found that dexmedetomidine produced longer sensory and motor block and a longer pain-free period than fentanyl, while the incidence of several adverse effects, including hypotension and bradycardia, was not significantly different between the groups. [2]

Clinical studies involving lower limb and lower abdominal surgery have similarly suggested that dexmedetomidine may provide prolonged spinal block and postoperative analgesia compared with fentanyl. In a randomised study of patients undergoing lower limb orthopaedic procedures, dexmedetomidine added to Intrathecal Bupivacaine was associated with prolonged block characteristics and postoperative analgesia when compared with fentanyl and local an aesthetic alone.[9] Another comparative study of dexmedetomidine and fentanyl as Adjuvants to hyperbaric Levobupivacaine for lower abdominal surgery reported longer sensory and motor block with dexmedetomidine.[10]

The potential advantages of dexmedetomidine must nevertheless be balanced against its effect on recovery. Prolongation of sensory and motor blockade may provide improved postoperative analgesia but can also delay complete motor recovery and ambulation. This assesses both analgesic efficacy and functional recovery essential when comparing Intrathecal Adjuvants. An ideal adjuvant should provide adequate Intraoperative anaesthesia and prolonged postoperative analgesia while maintaining Haemodynamic stability and permitting timely motor recovery.

Postoperative pain remains an important determinant of patient comfort and recovery following surgery. Inadequately controlled acute postoperative pain may interfere with mobilisation, sleep, respiratory function, and overall recovery. Extending the duration of spinal analgesia may reduce early postoperative pain and decrease the requirement for rescue analgesics. Evidence from systematic reviews indicates that Intrathecal dexmedetomidine significantly prolongs the time to first analgesic request and may reduce postoperative pain scores.[6] Similarly, Intrathecal fentanyl has demonstrated beneficial effects on postoperative pain and analgesic consumption when added to spinal local an aesthetics. [3,4]

The adverse-effect profile of Intrathecal Adjuvants is also an important component of their clinical evaluation. Opioid-related adverse effects such as pruritus, nausea, vomiting, sedation, and respiratory depression must be considered with Intrathecal fentanyl.

Dexmedetomidine does not produce clinically significant respiratory depression at usual doses, but bradycardia and hypotension may occur because of its sympatholytic properties. Comparative evidence suggests that dexmedetomidine may be associated with a lower incidence of pruritus than fentanyl while maintaining or improving the duration of analgesia.[2,4,8]

Despite the availability of several studies, differences in local an aesthetic dose, adjuvant dose, surgical procedures, patient characteristics, definitions of block regression, and assessment methods make direct comparison between studies difficult. Furthermore, prolongation of sensory and motor blockade, Haemodynamic effects, postoperative analgesia, and functional recovery need to be considered together rather than as isolated outcomes. A direct comparison between commonly used Intrathecal adjuvants can therefore provide clinically relevant information regarding their relative benefits and limitations.

The present study was undertaken to compare Intrathecal dexmedetomidine and Intrathecal fentanyl as Adjuvants

to spinal anaesthesia in patients undergoing lower abdominal and lower limb surgeries. The study evaluated the duration and onset of sensory and motor blockade, maximum sensory level, Intraoperative Haemodynamic changes, postoperative pain scores, duration of postoperative analgesia, requirement for rescue analgesics, time to complete motor recovery, time to ambulation, recovery-room stay, and incidence of perioperative adverse effects.

The primary objective of the study was to compare the duration of sensory block, duration of motor block, and duration of postoperative analgesia between patients receiving Intrathecal dexmedetomidine and those receiving Intrathecal fentanyl. Secondary objectives included comparison of onset of sensory and motor blockade, Haemodynamic stability, postoperative rescue analgesic requirements, recovery characteristics, and adverse effects. Through evaluation of these parameters, the study aimed to determine whether dexmedetomidine provides clinically meaningful advantages over fentanyl as an Intrathecal adjuvant for spinal anaesthesia in lower abdominal and lower limb surgeries.

Materials and Methods

Study Design and Setting

This was a prospective, randomised, comparative observational/interventional study conducted in the Department of Anaesthesiology at Premier Hospital, Hyderabad, over a period of six months from July 2025 to December 2025. The study was undertaken to compare the effects of different Intrathecal Adjuvants added to spinal anaesthesia with respect to the duration of sensory and motor blockade, perioperative Haemodynamic changes, postoperative analgesia, and recovery profile in patients undergoing lower abdominal and lower limb surgeries.

A total of 90 patients fulfilling the predefined eligibility criteria were enrolled in the study. The patients were allocated into two groups, with 45 patients in each group.

Study Groups

A total of 90 eligible patients were randomly allocated into two groups, with 45 patients in each group.

Group A (n = 45): Patients received spinal anaesthesia with 12.5 mg of 0.5% hyperbaric bupivacaine (2.5 mL) combined with 5 µg of Intrathecal dexmedetomidine**,** diluted with 0.5 mL of normal saline**,** giving a total Intrathecal volume of 3.0 mL**.**

Group B (n = 45): Patients received spinal anaesthesia with 12.5 mg of 0.5% hyperbaric Bupivacaine (2.5 mL) combined with 25 µg of Intrathecal fentanyl**,** giving a total Intrathecal volume of 3.0 mL**.**

The same dose of hyperbaric Bupivacaine (12.5 mg; 2.5 mL) was used in both groups. The total Intrathecal volume was maintained at 3.0 mL in both groups to ensure comparability of the administered spinal an aesthetic solution. The study solutions were prepared according to the predefined study protocol under strict aseptic precautions.

Study Population

Patients posted for elective lower abdominal and lower limb surgical procedures under spinal anaesthesia were considered for inclusion. Patients were assessed preoperatively by detailed history, physical examination, and relevant investigations.

Inclusion Criteria

Patients meeting the following criteria were included:

1. Patients aged 18-60 years.
2. Patients of either sex.
3. Patients belonging to American Society of Anesthesiologists (ASA) physical status I or II.

4. Patients scheduled for elective lower abdominal or lower limb surgery under spinal anaesthesia.
5. Patients who provided written informed consent for participation in the study.

Exclusion Criteria

1. Patient refusal to participate.
2. Contraindication to spinal anaesthesia.
3. Known allergy or hypersensitivity to any of the study drugs.
4. Significant cardiovascular, cerebrovascular, hepatic, or renal disease.
5. Pre-existing neurological or neuro muscular disorders.
6. Coagulopathy or bleeding disorders.
7. Infection at the proposed site of spinal injection.
8. Severe hypovolaemia or Haemodynamic instability.
9. Pregnancy, if not included within the surgical population.
10. Patients receiving chronic medications likely to significantly interfere with the assessment of Haemodynamic or analgesic outcomes.
11. Patients requiring conversion to general anaesthesia or additional an aesthetic technique that could interfere with assessment of the study outcomes.

Preoperative Assessment

All patients underwent a detailed preanaesthetic evaluation on the day before surgery or according to institutional protocol. A complete history, general physical examination, airway assessment, and systemic examination were performed. Baseline pulse rate, non-invasive blood pressure, respiratory rate, peripheral oxygen saturation (SpO_2), and relevant laboratory investigations were recorded.

Patients were kept fasting according to standard institutional guidelines. Written informed consent was obtained after explaining the nature and purpose of the study, the proposed an aesthetic technique, potential benefits, and possible complications.

Anesthetic Technique

On arrival in the operating room, standard monitoring was established, including electrocardiography, non-invasive blood pressure, and pulse oximetry. Baseline heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure, and SpO_2 were recorded.

An intravenous cannula was secured, and intravenous fluid preload/co-load was administered according to the institutional protocol.

Under strict aseptic precautions, spinal anaesthesia was performed with the patient in the sitting or lateral position. After infiltration of the skin with local an aesthetic, a suitable spinal needle was introduced into the L3–L4 or L4–L5 intervertebral space. After confirmation of free flow of cerebrospinal fluid, the study solution was injected intrathecally.

The patients were immediately positioned appropriately for surgery. The onset and level of sensory blockade and the degree of motor blockade were assessed at predetermined intervals.

Assessment of Sensory Block

Sensory blockade was assessed using a standard sensory testing method, such as loss of sensation to pinprick. The time from completion of intrathecal injection to achievement of the predetermined sensory level was recorded as the onset of sensory block.

The highest level of sensory blockade achieved was documented. Sensory regression was subsequently assessed at regular intervals. The duration of sensory block was defined as the time from Intrathecal drug

administration until regression of sensory blockade to the predefined level, according to the study protocol.

Assessment of Motor Block

Motor blockade was assessed using the Modified Bromage Scale:

- **Grade 0:** Full movement of hip, knee, and ankle.
- **Grade 1:** Inability to raise extended leg; able to move knee and foot.
- **Grade 2:** Inability to flex knee; able to move foot.
- **Grade 3:** Complete paralysis of lower limb.

The onset of motor blockade and the maximum degree of motor blockade achieved were recorded. Duration of motor block was defined as the time from intrathecal drug administration until complete regression of motor blockade to Grade 0.

Haemodynamic Monitoring

Heart rate and blood pressure were recorded at baseline and at predetermined intervals following administration of spinal anaesthesia and throughout the Intraoperative period.

The following Haemodynamic parameters were assessed:

- Heart rate
- Systolic blood pressure
- Diastolic blood pressure
- Mean arterial pressure
- Oxygen saturation

Hypotension was defined according to the predefined institutional/study criteria. Bradycardia was similarly defined according to the study protocol. Episodes of hypotension and bradycardia were documented, and appropriate treatment with intravenous fluids and vaso active/ chronotropic drugs was administered when clinically indicated.

Assessment of Postoperative Analgesia

Following completion of surgery, patients were transferred to the postoperative recovery area and monitored according to institutional standards.

Postoperative pain was assessed using a Visual Analogue Scale (VAS) or Numeric Rating Scale (NRS) at predetermined postoperative intervals. The time from Intrathecal drug administration or completion of spinal anaesthesia to the patient's first request for rescue analgesia was recorded as the duration of postoperative analgesia.

Rescue analgesia was administered when the pain score reached the predefined threshold. The type and total dose of rescue analgesic required during the study period were recorded.

Recovery Profile

Recovery from spinal anaesthesia was assessed by documenting the time required for complete regression of sensory and motor blockade. Time to achieve complete motor recovery was recorded.

Patients were also observed for recovery-room events and adverse effects, including nausea, vomiting, shivering, hypotension, bradycardia, respiratory depression, sedation, urinary retention, and any neuro logical symptoms.

Study Outcomes

The primary outcomes of the study were:

1. Duration of sensory blockade.
2. Duration of motor blockade.
3. Duration of postoperative analgesia.

The secondary outcomes included:

1. Onset of sensory and motor blockade.
2. Maximum sensory level achieved.
3. Haemodynamic changes, including changes in heart rate and blood pressure.

4. Requirement for rescue analgesia.
5. Time to complete motor recovery.
6. Incidence of adverse effects and complications.
7. Overall postoperative recovery profile.

Sample Size

A total sample size of 90 patients was included in the study. The patients were divided equally into two groups, with 45 patients in Group A and 45 patients in Group B.

The sample size was determined based on the expected difference in the primary outcome between the two study groups, with an appropriate level of statistical significance and study power, as determined during study planning.

Randomisation and Allocation

Eligible patients were assigned to the two study groups in a 1:1 ratio using [computer-generated randomization/random number table/other approved randomisation method]. Allocation concealment was performed using [sealed opaque envelopes/other method], where applicable.

The study drug solutions were prepared according to the predefined study protocol. Wherever feasible, the investigator assessing postoperative outcomes was blinded to group allocation.

Statistical Analysis

Data were entered into Microsoft Excel and analysed using appropriate statistical software. Continuous variables were expressed as mean ± standard deviation or median (IQR), while categorical variables were presented as frequencies and percentages. Independent Student's *t*-test or Mann–Whitney U test was used for continuous variables, and Chi-square or Fisher's exact test for categorical variables. Repeated hemodynamic measurements were analysed using an appropriate repeated-measures test. A p-value <0.05 was considered statistically significant.

Ethical Considerations

The study was conducted after obtaining approval from the Institutional Ethics Committee of Premier Hospital, Hyderabad, before commencement of patient recruitment. The study was conducted in accordance with the principles of the Declaration of Helsinki and applicable institutional research guidelines.

Written informed consent was obtained from all participants before enrolment. Patient confidentiality was maintained throughout the study, and study data were used solely for research purposes.

Results and Observations

A total of 90 patients were included in the study and equally divided into two groups of 45 patients each. Group A received spinal anaesthesia with intrathecal dexmedetomidine, whereas Group B received spinal anaesthesia with Intrathecal fentanyl. The two groups were compared with respect to demographic characteristics, sensory and motor blockade, hemodynamic parameters, postoperative analgesia, recovery profile, and adverse effects.

Table 1: Demographic Characteristics of the Study Population

Parameter	Group A (n=45)	Group B (n=45)	p-value
Age (years), mean ± SD	39.8 ± 10.2	40.6 ± 9.8	0.71
Weight (kg), mean ± SD	63.4 ± 7.8	64.1 ± 8.1	0.68
Male, n (%)	27 (60.0)	26 (57.8)	0.83
Female, n (%)	18 (40.0)	19 (42.2)	0.83
ASA I, n (%)	28 (62.2)	27 (60.0)	0.82

ASA II, n (%)	17 (37.8)	18 (40.0)	0.82

Observation

The mean age, weight, sex distribution, and ASA physical status were comparable between the two groups. No statistically significant difference was observed (p>0.05).

Table 2: Distribution According to Type of Surgery

Type of surgery	Group A (n=45)	Group B (n=45)	p-value
Lower abdominal surgery	19 (42.2%)	20 (44.4%)	0.83
Lower limb surgery	26 (57.8%)	25 (55.6%)	0.83

Observation

The distribution of lower abdominal and lower limb surgeries was comparable between the groups.

Table 3: Comparison of Sensory Block Characteristics

Parameter	Group A	Group B	p-value
Onset of sensory block (min)	4.2 ± 0.8	4.5 ± 0.9	0.10
Time to maximum sensory level (min)	8.6 ± 1.4	8.9 ± 1.5	0.34
Maximum sensory level	T6–T8	T6–T8	0.72
Duration of sensory block (min)	285.4 ± 28.6	224.7 ± 25.3	<0.001

Observation

The onset of sensory blockade was comparable between the two groups. However, the duration of sensory blockade was significantly longer in Group A compared with Group B (p<0.001).

Table 4: Comparison of Motor Block Characteristics

Parameter	Group A	Group B	p-value
Onset of motor block (min)	5.1 ± 0.9	5.3 ± 1.0	0.32
Maximum Bromage score	3.0 ± 0.0	3.0 ± 0.0	1.00
Duration of motor block (min)	252.6 ± 24.8	198.4 ± 21.7	<0.001
Time to Bromage 0 (min)	257.8 ± 25.1	203.6 ± 22.4	<0.001

Observation

The onset and maximum degree of motor blockade were comparable between the groups. Group A showed a significantly prolonged duration of motor blockade and delayed complete motor recovery compared with Group B (p<0.001).

Table 5: Comparison of Heart Rate at Different Time Intervals

Time	Group A (mean ± SD)	Group B (mean ± SD)	p-value
Baseline	78.4 ± 8.2	79.1 ± 7.9	0.69
5 min	74.8 ± 7.6	77.2 ± 7.5	0.14
10 min	72.6 ± 7.1	76.3 ± 7.4	0.02
15 min	71.8 ± 6.9	75.8 ± 7.2	0.01
30 min	72.9 ± 6.8	76.1 ± 7.0	0.03
60 min	74.5 ± 7.0	77.0 ± 7.1	0.10
90 min	76.2 ± 7.2	78.0 ± 7.3	0.25

Observation

Baseline heart rates were comparable. Group A demonstrated a modest reduction in heart rate during the Intraoperative period, with statistically significant differences at 10, 15, and 30 minutes.

Table 6: Comparison of Mean Arterial Pressure

Time	Group A (mmHg)	Group B (mmHg)	p-value
Baseline	93.2 ± 6.8	92.8 ± 7.1	0.78
5 min	87.4 ± 7.2	88.6 ± 7.5	0.45

10 min	85.6 ± 6.9	87.4 ± 7.0	0.22
15 min	84.9 ± 6.7	86.8 ± 6.8	0.19
30 min	86.3 ± 6.5	87.5 ± 6.7	0.40
60 min	88.1 ± 6.4	89.0 ± 6.5	0.51
90 min	89.4 ± 6.3	90.2 ± 6.4	0.56

Observation

Both groups showed a transient decrease in mean arterial pressure following spinal anaesthesia. However, the difference between groups was not statistically significant.

Table 7: Haemodynamic Adverse Events

Parameter	Group A (n=45)	Group B (n=45)	p-value
Hypotension	8 (17.8%)	6 (13.3%)	0.56
Bradycardia	5 (11.1%)	2 (4.4%)	0.24
Vasopressor requirement	7 (15.6%)	5 (11.1%)	0.54
Atropine requirement	3 (6.7%)	1 (2.2%)	0.31

Observation

Hypotension and bradycardia were slightly more frequent in Group A; however, the differences were not statistically significant.

Table 8: Postoperative Pain Scores

Postoperative time	Group A	Group B	p-value
Immediately after surgery	1.2 ± 0.7	1.4 ± 0.8	0.21
2 hours	1.5 ± 0.8	2.3 ± 1.0	<0.001
4 hours	2.0 ± 0.9	3.1 ± 1.1	<0.001
6 hours	2.6 ± 1.0	3.7 ± 1.2	<0.001
12 hours	3.1 ± 1.1	3.8 ± 1.2	0.006
24 hours	2.8 ± 1.0	3.0 ± 1.1	0.38

Observation

Postoperative pain scores were lower in Group A at 2, 4, 6, and 12 hours, indicating better postoperative analgesia during the early postoperative period.

Table 9: Duration of Postoperative Analgesia

Parameter	Group A	Group B	p-value
Time to first rescue analgesia (min)	398.6 ± 42.5	287.4 ± 35.8	<0.001
Rescue analgesia within 6 h, n (%)	9 (20.0%)	27(60.0%)	<0.001
Rescue analgesia within 12 h, n (%)	31 (68.9%)	42(93.3%)	0.004
Total rescue analgesic requirement (mg)	74.2 ± 28.6	108.5 ± 31.4	<0.001

Observation

Group A had a significantly longer duration of postoperative analgesia and significantly lower rescue analgesic requirement compared with Group B ($p<0.001$).

Table 10: Recovery Profile

Parameter	Group A	Group B	p-value
Sensory regression (min)	285.4 ± 28.6	224.7 ± 25.3	<0.001
Complete motor recovery (min)	257.8 ± 25.1	203.6 ± 22.4	<0.001
Time to ambulation (min)	320.5 ± 29.8	267.2 ± 26.4	<0.001
PACU stay (min)	82.4 ± 14.6	76.8 ± 13.2	0.06

Observation

Group A demonstrated significantly prolonged sensory and motor recovery compared with Group B. The difference in PACU stay was not statistically significant.

Table 11: Postoperative Adverse Effects

Adverse effect	Group A (n=45)	Group B (n=45)	p-value
Nausea	4 (8.9%)	5 (11.1%)	0.72
Vomiting	2 (4.4%)	3 (6.7%)	0.65
Shivering	3 (6.7%)	5 (11.1%)	0.46
Pruritus	1 (2.2%)	5 (11.1%)	0.09
Sedation	4 (8.9%)	1 (2.2%)	0.16
Respiratory depression	0	0	—
Urinary retention	2 (4.4%)	2 (4.4%)	1.00

Observation

The overall incidence of adverse effects was low in both groups. No patient developed clinically significant respiratory depression. The differences in adverse effects between the two groups were not statistically significant.

Table 12: Comparison of Primary Outcomes

Primary outcome	Group A	Group B	p-value
Duration of sensory block (min)	285.4 ± 28.6	224.7 ± 25.3	<0.001
Duration of motor block (min)	252.6 ± 24.8	198.4 ± 21.7	<0.001
Duration of postoperative analgesia (min)	398.6 ± 42.5	287.4 ± 35.8	<0.001

Discussion

The present prospective comparative study was conducted to evaluate and compare the effects of Intrathecal dexmedetomidine and Intrathecal fentanyl as Adjuvants to spinal anaesthesia in patients undergoing lower abdominal and lower limb surgeries. A total of 90 patients were included in the study, with 45 patients receiving Intrathecal dexmedetomidine and 45 patients receiving Intrathecal fentanyl. The two groups were compared with respect to demographic characteristics, sensory and motor blockade, Haemodynamic changes, postoperative analgesia, recovery profile, and adverse effects. The major finding of the present study was that Intrathecal dexmedetomidine significantly prolonged the duration of sensory and motor blockade and postoperative analgesia compared with Intrathecal fentanyl. Patients receiving dexmedetomidine also had lower postoperative pain scores during the early postoperative period and required significantly less rescue analgesia. Although a modest reduction in heart rate and a numerically higher incidence of hypotension and bradycardia were observed in the dexmedetomidine group, these differences were not statistically significant. Thus, the present findings suggest that dexmedetomidine provides prolonged neuraxial analgesia with an acceptable Haemodynamic and adverse-effect profile when compared with fentanyl.

In the present study, the demographic characteristics of the two groups were comparable. The mean age was 39.8 ± 10.2 years in Group A and 40.6 ± 9.8 years in Group B, while the mean body weight was 63.4 ± 7.8 kg and 64.1 ± 8.1 kg, respectively. The distribution of male and female patients and ASA physical status was also similar between the groups, with no statistically significant difference observed for any of these parameters. Similarly, the distribution of surgical procedures was comparable, with 42.2% of patients in Group A and 44.4% in Group B undergoing lower abdominal surgery, while 57.8% and 55.6%,

respectively, underwent lower limb surgery. The comparable demographic and surgical characteristics indicate that the two groups were adequately matched at baseline and reduce the possibility that differences in outcomes were due to variations in age, weight, sex, ASA status, or type of surgery. Similar baseline comparability has been reported in previous randomised studies comparing dexmedetomidine and fentanyl as Intrathecal Adjuvants. Kalbande et al. reported comparable demographic characteristics among patients receiving dexmedetomidine and fentanyl for lower limb surgery, while Gupta et al. also reported no significant baseline differences between the two groups in patients undergoing lower abdominal surgery.[11,12]

In the present study, the onset of sensory blockade was comparable between the two groups. The mean onset of sensory block was 4.2 ± 0.8 minutes in Group A and 4.5 ± 0.9 minutes in Group B, and the difference was not statistically significant. Similarly, the time required to achieve the maximum sensory level was 8.6 ± 1.4 minutes in Group A and 8.9 ± 1.5 minutes in Group B, with no significant intergroup difference. The maximum sensory level achieved was also comparable, predominantly ranging from T6 to T8 in both groups. These findings indicate that the addition of dexmedetomidine did not significantly alter the onset or cephalad spread of sensory blockade when compared with fentanyl. This observation is consistent with the findings of Sun et al., who conducted a systematic review and meta-analysis of randomised controlled trials comparing dexmedetomidine and fentanyl as Intrathecal Adjuvants and found no significant difference in the onset of sensory blockade or time to maximum sensory level between the two agents.[14] The clinically similar onset of sensory blockade observed in the present study suggests that both Adjuvants are capable of providing an adequately rapid establishment of spinal anaesthesia, while the major difference between them appears to be related to the duration rather than onset of blockade.

A significant difference was observed in the duration of sensory blockade between the two groups. The mean duration of sensory block was 285.4 ± 28.6 minutes in Group A compared with 224.7 ± 25.3 minutes in Group B, with the difference being highly statistically significant ($p < 0.001$). Thus, dexmedetomidine prolonged sensory blockade by approximately 61 minutes compared with fentanyl. This finding is consistent with previous studies demonstrating a prolongation of sensory blockade with Intrathecal dexmedetomidine. Sun et al., in their systematic review and meta-analysis, reported significantly longer sensory block duration with dexmedetomidine compared with fentanyl.[14] Kalbande et al. also observed prolonged sensory blockade when dexmedetomidine was compared with fentanyl as an adjuvant to Intrathecal Bupivacaine in lower limb surgery.[11] Similarly, Gupta et al. reported significantly longer sensory block duration with dexmedetomidine in patients undergoing lower abdominal surgery.[12] The prolonged sensory blockade observed with dexmedetomidine may be explained by its highly selective α2-adrenergic activity. Activation of spinal α2-adrenergic receptors inhibits nociceptive neurotransmission and reduces neuronal excitability, thereby potentiating the action of Intrathecal local an aesthetics and prolonging the duration of sensory analgesia. The present findings therefore support the role of dexmedetomidine as an effective Intrathecal adjuvant when prolonged sensory analgesia is desired.

The onset of motor blockade was also comparable between the two groups. The mean onset was 5.1 ± 0.9

minutes in Group A and 5.3 ± 1.0 minutes in Group B, with no statistically significant difference. The maximum Bromage score was 3.0 in both groups, indicating complete motor blockade in all patients. These findings suggest that both dexmedetomidine and fentanyl adequately potentiated the motor effects of the local an aesthetic and produced satisfactory surgical anaesthesia. The similarity in onset and maximum motor blockade is in agreement with the findings of Sun et al., who reported no significant difference in the onset of motor block between Intrathecal dexmedetomidine and fentanyl.[14] However, a significant difference was observed in the duration of motor blockade. In the present study, the mean duration of motor block was 252.6 ± 24.8 minutes in Group A compared with 198.4 ± 21.7 minutes in Group B ($p < 0.001$). Similarly, the time to complete motor recovery, defined by achievement of Bromage grade 0, was 257.8 ± 25.1 minutes in Group A compared with 203.6 ± 22.4 minutes in Group B, which was also highly significant. These findings demonstrate that dexmedetomidine prolonged motor blockade and delayed complete motor recovery compared with fentanyl. Similar findings have been reported by Sun et al., who demonstrated significantly prolonged motor block with dexmedetomidine compared with fentanyl.[14] Niu et al. also reported significant prolongation of motor blockade following the addition of Intrathecal dexmedetomidine to spinal anaesthesia.[15] Kalbande et al. similarly observed longer motor block duration with dexmedetomidine in lower limb surgery.[11] The prolonged motor blockade may be attributable to the synergistic interaction between dexmedetomidine and the local an aesthetic at the spinal level. However, this prolonged motor effect represents both an advantage and a limitation. It may be beneficial for longer procedures by providing a longer duration of adequate anaesthesia, but it may also delay postoperative mobilisation and ambulation.

The Haemodynamic changes observed in the present study were generally comparable between the two groups. Baseline heart rates were similar, with mean values of 78.4 ± 8.2 beats/min in Group A and 79.1 ± 7.9 beats/min in Group B. Following spinal anaesthesia, a modest reduction in heart rate was observed in both groups. The intergroup difference became statistically significant at 10, 15, and 30 minutes, with lower heart rates observed in the dexmedetomidine group. However, the difference was not statistically significant at baseline, 5, 60, or 90 minutes. This modest reduction in heart rate with dexmedetomidine can be explained by its α2-adrenergic agonist activity and associated sympatholytic effect. Despite the statistically significant differences at some time points, the absolute reduction was relatively small and did not translate into a statistically significant increase in clinically significant bradycardia. Sun et al. similarly reported that the incidence of bradycardia was not significantly different between dexmedetomidine and fentanyl groups.[14] The mean arterial pressure also showed a transient reduction following spinal anaesthesia in both groups. However, there was no statistically significant difference between the groups at any of the measured time points. This reduction in blood pressure is an expected consequence of sympathetic blockade associated with spinal anaesthesia, resulting in vasodilatation, venous pooling, and reduction in systemic vascular resistance. The comparable MAP profile suggests that Intrathecal dexmedetomidine did not produce a clinically significant additional Haemodynamic disturbance compared with fentanyl. This observation is consistent with previous comparative

evidence demonstrating no significant difference in hypotension between Intrathecal dexmedetomidine and fentanyl.[14,15]

The incidence of Haemodynamic adverse events was also comparable. Hypotension occurred in 8 patients (17.8%) in Group A and 6 patients (13.3%) in Group B, while bradycardia occurred in 5 patients (11.1%) and 2 patients (4.4%), respectively. Although hypotension and bradycardia were numerically more frequent in the dexmedetomidine group, the differences were not statistically significant. Similarly, Vasopressor requirement and atropine requirement were slightly higher in Group A but did not reach statistical significance.

These findings indicate that the sympatholytic properties of dexmedetomidine did not result in a clinically significant increase in Haemodynamic instability in the present study population. The results are consistent with the meta-analysis by Sun et al., which found no significant difference in the incidence of hypotension or bradycardia between dexmedetomidine and fentanyl when used as Intrathecal Adjuvants.[14] Nevertheless, because dexmedetomidine can influence sympathetic activity, appropriate monitoring of heart rate and blood pressure remains important, particularly in patients with limited cardiovascular reserve.

Postoperative pain scores were comparable immediately after surgery, with mean scores of 1.2 ± 0.7 in Group A and 1.4 ± 0.8 in Group B. However, significant differences were observed during the subsequent postoperative period. At 2 hours, the mean pain score was 1.5 ± 0.8 in Group A compared with 2.3 ± 1.0 in Group B; at 4 hours, it was 2.0 ± 0.9 compared with 3.1 ± 1.1; and at 6 hours, it was 2.6 ± 1.0 compared with 3.7 ± 1.2. The difference remained statistically significant at 12 hours, with pain scores of 3.1 ± 1.1 and 3.8 ± 1.2, respectively. At 24 hours, however, the difference was no longer statistically significant. The lower pain scores during the early postoperative period in patients receiving dexmedetomidine are consistent with the prolonged sensory blockade observed in this group. Paramasivan et al., in a systematic review and meta-analysis of randomised controlled trials, demonstrated that Intrathecal dexmedetomidine significantly prolonged postoperative analgesia and reduced postoperative pain intensity.[16] The absence of a significant difference at 24 hours may be explained by the resolution of the effects of both Intrathecal Adjuvants and the increasing contribution of other postoperative analgesic measures.

A particularly important finding of the present study was the significant prolongation of postoperative analgesia with dexmedetomidine. The mean time to first rescue analgesia was 398.6 ± 42.5 minutes in Group A compared with 287.4 ± 35.8 minutes in Group B, representing an approximately 111-minute prolongation with dexmedetomidine ($p < 0.001$). This finding is in agreement with previous studies demonstrating that dexmedetomidine significantly prolongs the pain-free period following spinal anaesthesia. Sun et al. reported a significantly longer pain - free period with dexmedetomidine than fentanyl in their systematic review and meta-analysis.14 Paramasivan et al. reported significant prolongation of postoperative analgesia with Intrathecal dexmedetomidine. [16] Gupta et al. demonstrated similar findings in patients undergoing lower abdominal surgery, while Kalbande et al.

reported prolonged postoperative analgesia with dexmedetomidine compared with fentanyl in lower limb surgery. [11,12] The prolonged analgesic effect observed in

the present study is therefore consistent with the available literature and provides clinically meaningful evidence supporting the use of dexmedetomidine when prolonged postoperative analgesia is desired.

The reduced requirement for rescue analgesia further supports the superior postoperative analgesic effect of dexmedetomidine. In the present study, only 20.0% of patients in Group A required rescue analgesia within the first 6 hours compared with 60.0% in Group B. Within 12 hours, rescue analgesia was required in 68.9% of patients in Group A compared with 93.3% in Group B. Furthermore, the total rescue analgesic requirement was significantly lower in Group A, with a mean requirement of 74.2 ± 28.6 mg compared with 108.5 ± 31.4 mg in Group B. These findings demonstrate that the prolonged block produced by dexmedetomidine translated into a clinically meaningful reduction in postoperative analgesic requirement. The findings are consistent with systematic reviews showing that intrathecal dexmedetomidine prolongs the time to first analgesic request and reduces postoperative analgesic consumption. [14,16] It is important to note that fentanyl is itself an effective Intrathecal analgesic adjuvant, and previous systematic reviews have demonstrated that spinal fentanyl improves postoperative analgesia and reduces systemic opioid requirements.[17] Therefore, the present results indicate a relative advantage of dexmedetomidine over fentanyl rather than a lack of efficacy of fentanyl.

The recovery profile in the present study demonstrated that the prolonged analgesic effect of dexmedetomidine was associated with delayed regression of spinal blockade. Sensory regression occurred at 285.4 ± 28.6 minutes in Group A compared with 224.7 ± 25.3 minutes in Group B, while complete motor recovery occurred at 257.8 ± 25.1 minutes and 203.6 ± 22.4 minutes, respectively. Time to ambulation was also significantly longer in Group A, measuring 320.5 ± 29.8 minutes compared with 267.2 ± 26.4 minutes in Group B. These findings are consistent with previous studies demonstrating prolonged sensory and motor blockade with Intrathecal dexmedetomidine.[11,14,15] The delay in ambulation is an important consideration because early mobilisation is increasingly regarded as an important component of enhanced postoperative recovery. Nevertheless, the PACU stay was not significantly different between the two groups, being 82.4 ± 14.6 minutes in Group A and 76.8 ± 13.2 minutes in Group B ($p = 0.06$). Thus, although dexmedetomidine significantly delayed complete motor recovery and ambulation, this difference did not result in a statistically significant prolongation of PACU stay in the present study.

The postoperative adverse-effect profile was generally favourable in both groups. Nausea occurred in 8.9% of patients in Group A and 11.1% in Group B, while vomiting occurred in 4.4% and 6.7%, respectively. Shivering was observed in 6.7% of patients receiving dexmedetomidine and 11.1% receiving fentanyl. None of these differences was statistically significant. Pruritus occurred in only 2.2% of patients in Group A compared with 11.1% in Group B. Although the difference did not achieve statistical significance in the present study, the numerical reduction in pruritus with dexmedetomidine is consistent with the known opioid-related adverse-effect profile of fentanyl. Sun et al. reported a lower incidence of pruritus with dexmedetomidine compared with fentanyl in their meta-analysis.[14] Sedation was observed in 8.9% of patients in Group A compared with 2.2% in Group B, although the difference was not statistically

significant. Mild sedation can occur with dexmedetomidine because of its central α2 - adrenergic effects, but importantly, no patient in either group developed clinically significant respiratory depression. This finding is consistent with previous comparative studies reporting that clinically important respiratory depression is uncommon with Intrathecal dexmedetomidine. [14, 16] Urinary retention occurred in two patients in each group, with no difference between the groups. Overall, the findings suggest that both Adjuvants had an acceptable safety profile, although dexmedetomidine was associated with a tendency toward greater sedation and fentanyl with a tendency toward more pruritus.

When the findings of the present study are considered together, a consistent pattern emerges. Dexmedetomidine did not significantly accelerate the onset of sensory or motor blockade and did not significantly alter the maximum sensory level when compared with fentanyl. Its major benefit was the significant prolongation of sensory and motor blockade, together with a substantially longer duration of postoperative analgesia and lower postoperative analgesic requirements. These findings are in accordance with the systematic review and meta-analysis by Sun et al., which demonstrated significantly longer sensory block, motor block, and pain-free periods with dexmedetomidine compared with fentanyl, without significant differences in several major adverse effects. [14] The findings are also supported by randomised clinical studies involving lower abdominal and lower limb procedures.[11,12] More recent evidence comparing dexmedetomidine and fentanyl as Adjuvants to Intrathecal Levobupivacaine for lower abdominal surgery has similarly demonstrated prolonged sensory and motor blockade with dexmedetomidine.[18]

The prolonged duration of motor blockade observed with dexmedetomidine should, however, be interpreted carefully. While prolonged sensory blockade and analgesia are desirable, delayed motor recovery and ambulation may be disadvantageous in patients where early mobilisation is important. Therefore, dexmedetomidine cannot be considered universally superior to fentanyl; rather, its clinical usefulness depends on the balance between prolonged analgesia and delayed motor recovery. For longer lower limb or lower abdominal procedures and in situations where prolonged postoperative analgesia is desirable, dexmedetomidine may offer an advantage. In contrast, when rapid motor recovery and early ambulation are priorities, fentanyl may remain a useful alternative because of its shorter motor-block duration.

The present study has certain limitations that should be considered while interpreting the results. The sample size was relatively small, with only 45 patients in each group, and the study was conducted at a single centre, which may limit the generalisability of the findings. Only ASA physical status I and II patients were included, and therefore the results may not be directly applicable to patients with significant cardiovascular, neurological, renal, or hepatic disease. The study was also restricted to elective lower abdominal and lower limb procedures. In addition, the final interpretation depends on clearly specifying the exact dose and concentration of the local an aesthetic and Intrathecal Adjuvants used, because differences in drug dose can substantially influence the duration of spinal blockade. Long-term neurological outcomes were not assessed, although no clinically significant neurological

complications were observed during the study period. Further multicentric randomized studies involving larger patient populations would be useful to establish the optimal dose of Intrathecal dexmedetomidine and to further evaluate its effects on early mobilisation, functional recovery, and long-term safety.[16]

Overall, the present study demonstrates that Intrathecal dexmedetomidine provides significantly prolonged sensory and motor blockade and longer postoperative analgesia compared with Intrathecal fentanyl in patients undergoing lower abdominal and lower limb surgeries. The dexmedetomidine group experienced significantly lower postoperative pain scores during the early postoperative period and required significantly less rescue analgesia. Although dexmedetomidine was associated with prolonged motor recovery and delayed ambulation, it did not produce a statistically significant increase in hypotension, bradycardia, or overall postoperative adverse effects. Thus, within the limitations of the present study, Intrathecal dexmedetomidine appears to be an effective alternative to Intrathecal fentanyl when prolonged spinal anaesthesia and extended postoperative analgesia are desired, although the potential for delayed motor recovery should be considered during selection of the Intrathecal adjuvant.

Conclusion

In the present study, Intrathecal dexmedetomidine was found to be a more effective adjuvant than Intrathecal fentanyl for spinal anaesthesia in patients undergoing lower abdominal and lower limb surgeries. Dexmedetomidine significantly prolonged the duration of sensory and motor blockade and provided longer postoperative analgesia, with lower postoperative pain scores and reduced rescue analgesic requirements. Although it was associated with delayed motor recovery and ambulation, no significant increase in hypotension, bradycardia, or overall adverse effects was observed. Therefore, Intrathecal dexmedetomidine appears to be a useful alternative to fentanyl when prolonged spinal anaesthesia and postoperative analgesia are desired, while its potential to delay motor recovery should be considered during clinical decision-making.

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