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Comparative Analysis of Intrathecal Bupivacaine Alone and in Combination with Intravenous Dexmedetomidine or Butorphanol for Lower Abdominal Surgeries

Authors
Vandna Bharti1, Archana Gautam2,Abhishek Kumar Baranwal3, Arun Ahirwar4,Deepti Sharma5

Affiliations
1. *Assistant Professor, Department of Anesthesiology, Kalyan Singh Superspeciality Cancer Institute, Lucknow, Uttar Pradesh*
2. *Assistant Professor, Department of Anesthesiology, Kalyan Singh Superspeciality Cancer Institute, Lucknow, Uttar Pradesh*
3. *Associate Professor, Department of Anesthesiology, Maharshi Vashistha Autonomous State Medical College, Basti, Uttar Pradesh*
4. *Associate Professor, Department of Anesthesiology, Rajkiya Medical College, Jalaun, Uttar Pradesh*
5. *Senior Resident, Department of Anesthesiology, Kalyan Singh Superspeciality Cancer Institute, Lucknow, Uttar Pradesh*

Corresponding Author- Dr. Vandna Bharti, Assistant Professor, Department of Anesthesiology, Kalyan Singh Superspeciality Cancer Institute, Lucknow, Uttar Pradesh
Mail id – doc.mevanna@gmail.com,Mob no – 6397391105

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Spinal anesthesia, dexmedetomidine, butorphanol, sensory blockade, motor blockade, hemodynamic stability, pain management

ABSTRACT
Background: Subarachnoid block (SAB) is commonly preferred over general anesthesia (GA) for lower abdominal surgeries due to its superior efficacy and safety.
Aim and Objective: This study aims to evaluate the impact of intravenous (IV) adjuvants—dexmedetomidine (DEX) and butorphanol (BUT)—on intrathecal (IT) Bupivacaine (BUP) during lower abdominal surgeries.
Materials and Methods: A randomized, double-blind, prospective study was conducted on 60 patients scheduled for lower abdominal surgery. Participants were randomly divided into three groups: Group B received IT BUP alone, Group B+DEX received IT BUP with IV DEX, and Group B+BUT received IT BUP with IV BUT. Primary outcomes measured included sensory and motor block duration, postoperative pain, sedation, and adverse effects (AEs).
Results: Both DEX and BUT as IV adjuvants significantly prolonged the duration of sensory and motor blocks compared to IT BUP alone. Patients in the adjuvant groups showed faster motor block onset and longer sensory block duration. Lower pain scores were observed in these groups, indicating better analgesia. Sedation scores were higher in the adjuvant groups, while AEs were similar across all groups. DEX also notably reduced the incidence of shivering.
Conclusion: DEX and BUT are effective IV adjuvants to IT BUP, improving the anesthetic quality and postoperative analgesia without increasing the risk of AEs.

1. Introduction:

The subarachnoid block is a well-established and effective alternative to general anesthesia, particularly for lower abdominal surgeries. Recent research highlights the benefits of combining small doses of dexmedetomidine with Bupivacaine in spinal anesthesia, demonstrating a faster onset of motor block, prolonged motor and sensory block durations, and stable hemodynamics without significant sedation[1]. The incorporation of opioids, such as fentanyl, into intrathecal local anesthetics has also been shown to enhance analgesia, allowing for reduced drug doses and minimizing side effects, a particular advantage for elderly patients[2,3].

Dexmedetomidine, due to its synergistic effects, has been noted for extending the duration of sensory block and providing superior analgesia without significant respiratory depression, as supported by multiple studies[4]. Another agent, butorphanol, with its mixed agonist-antagonist profile, offers potent analgesia with minimal side effects, making it a promising candidate for postoperative pain management[5].

On the other hand, Butorphanol acts as a mixed agonist-antagonist, selectively targeting κ-opioid receptors while demonstrating partial agonist activity at μ-opioid receptors[4]. This unique receptor profile allows it to deliver effective analgesia with reduced risk of respiratory depression and minimal sedation, making it particularly advantageous in postoperative settings[5.] Additionally, we have included details on butorphanol's pharmacokinetics, encompassing its absorption, metabolism, and elimination processes, to offer a more comprehensive view of its role and efficacy as an adjuvant in spinal anesthesia[5].

Study Rationale and Justification

Effective postoperative pain control in lower abdominal surgeries is essential to ensure patient comfort, facilitate recovery, and minimize complications. However, while intrathecal bupivacaine alone can provide effective anesthesia, its duration and intensity may be insufficient for extended analgesia in certain patient populations. Additionally, the use of high doses may lead to hemodynamic instability and other side effects, particularly in elderly or comorbid patients. Therefore, this study investigated the addition of intravenous (IV) dexmedetomidine and butorphanol as adjuvants to intrathecal bupivacaine, seeking to improve pain management outcomes by prolonging analgesia duration and minimizing adverse effects.

Recent studies have shown that dexmedetomidine, a selective α2-adrenergic agonist, and butorphanol, a mixed agonist-antagonist with a high affinity for κ-opioid receptors, can be effective adjuvants in spinal anesthesia due to their synergistic effects in prolonging sensory and motor blocks. Dexmedetomidine has demonstrated benefits in prolonging sensory block without significant respiratory depression, while butorphanol offers potent analgesia with a lower risk of sedation and respiratory compromise in postoperative settings[4]study sought to address specific clinical gaps in pain management for lower abdominal surgeries, where prolonged analgesia and stable hemodynamics are critical. By providing a comparative analysis of intrathecal bupivacaine alone and in combination with either IV dexmedetomidine or butorphanol, this research aimed to identify an optimized approach to anesthesia that minimizes patient discomfort and enhances recovery, particularly for high-risk patients. Furthermore, these findings offer guidance for anesthetic practice in lower abdominal surgeries, potentially shaping a more effective and safe postoperative pain management protocol. Additionally, the hemodynamic profiles and recovery times of patients in each group are analyzed to provide further insights into the overall clinical efficacy and safety of these combinations.

2. Materials and Methods:

This randomized, double-blind, prospective trial was conducted at King George's Medical University (KGMU), Lucknow, UP, India, from February 2012 to January 2014, following approval from the institutional ethics committee (KGMU/IMS/IEC/IRB/2012-13/78-/09/034) dated 03.03.2012. Sixty patients, aged 18 to 55 years, classified as ASA I/II, and scheduled for lower abdominal surgery under spinal anesthesia were recruited. Informed consent was obtained from all participants.

In this study, we selected intravenous (IV) adjuvants over intrathecal adjuvants to mitigate the risk of complications associated with intrathecal drug administration, such as prolonged motor blockade, hypotension, and potential neurotoxicity. IV administration also allowed us to maintain greater control over the timing and pharmacological effects of the drugs, ensuring a more predictable and manageable anesthetic course for the patients.

The sample size calculation for this study, conducted at King George's Medical University (KGMU), Lucknow, UP, India, focused on the primary outcome of postoperative analgesia duration. Based on findings from previous studies by Kanazi et al. (2006) and Bansal and Garg (2013) on the effects of adjuvant agents in spinal anesthesia, we aimed to detect a 20% difference in analgesia duration between the study groups. To ensure a statistical power of 80% to observe this effect with a significance level (α) of 0.05, a sample size of 20 participants per group was determined to be sufficient to detect clinically meaningful differences in postoperative analgesia duration.

Given that this is a three-limb study, we applied Bonferroni correction to maintain statistical rigor across multiple comparisons. The correction helped to control for Type I error in the presence of three groups and further validated the adequacy of a 20-participant sample per group for reliable results.

To account for potential dropouts or deviations from the study protocol, we increased our recruitment target and enrolled a total of 60 patients, who were randomly allocated into three groups (20 patients per group). This allocation strategy helped ensure balanced group sizes, allowing for a robust comparison of the interventions and minimizing the risk of sample-related bias in evaluating the duration of postoperative analgesia.

Participant Grouping and Interventions

Participants were randomly assigned using a computer-generated sequence into three groups, each receiving 15 mg hyperbaric bupivacaine (3 ml of 0.5%) for spinal anesthesia. Group B (control) received an IV infusion of 100 ml normal saline, Group B+D received dexmedetomidine at 1 µg/kg in 100 ml saline, and Group B+B received butorphanol at 20 µg/kg in 100 ml saline. Doses were based on prior research to ensure optimal analgesia and safety.

Premedication included oral ranitidine (150 mg) and alprazolam (0.25 mg) the night before surgery. On the day of surgery, patients were preloaded with Ringer's lactate (10 ml/kg). Spinal anesthesia was administered at the L4-L5 interspace with a 25-gauge Quincke needle, followed by IV adjuvants over 20 minutes. Bradycardia was redefined for patients with a baseline heart rate of 60-65 beats per minute as a reduction >20% from baseline rather than <60 bpm, to minimize unnecessary atropine use.

Vital parameters were continuously monitored. Hypotension (systolic BP <90 mmHg or >20% drop) was managed with IV fluids and mephentermine (6 mg). Bradycardia was treated with IV atropine (0.6 mg) based on revised criteria. Sensory and motor blocks were assessed using a pin-prick test and the Bromage scale, respectively. Postoperative pain was evaluated hourly using the Visual Analog Scale (VAS) for 24 hours, with IV paracetamol for rescue analgesia,dose 15 mg/kg over 20 min. Sedation was documented as needed.

Continuous variables were reported as mean ± SD, and categorical variables as percentages. Primary outcomes (heart rate, blood pressure, oxygen saturation, sedation, and VAS scores) were analyzed using repeated measures ANOVA with group-time interactions. Group comparisons used one-way ANOVA with Tukey's post hoc test, and categorical variables were analyzed with the chi-square test. A p-value <0.05 was considered significant, and SPSS version 20.0 was used for analysis.

3. **Results**

The baseline characteristics, including age, gender, weight, height, and ASA grade, were comparable across the three study groups—Category-(B), Category-(B+D), and Category-(B+B)—ensuring that no baseline factors influenced the study outcomes. Age was consistent across groups, with a mean of 38.4 ± 10.2 years in Category-(B), 37.9 ± 9.8 years in Category-(B+D), and 38.1 ± 10.0 years in Category-(B+B), showing no statistically significant difference (p = 0.892). Gender distribution was equal, with 10 males and 10 females in each group, making gender-based comparisons unnecessary. The average weight was also similar, with Category-(B) at 65.3 ± 8.5 kg, Category-(B+D) at 66.1 ± 7.9 kg, and Category-(B+B) at 64.8 ± 8.2 kg, with no significant difference (p = 0.703). Likewise, the average height was consistent, recorded as 165.4 ± 7.0 cm for Category-(B), 164.8 ± 6.8 cm for Category-(B+D), and 165.2 ± 7.2 cm for Category-(B+B) (p = 0.850). Additionally, the ASA grade distribution was balanced across all groups. Overall, these baseline characteristics were evenly matched, minimizing potential bias in the study.

Table 1:Presenting baseline characteristics (Age, Gender, Weight, Height, ASA grade) across the three categories.

Characteristic	Category-(B)	Category-(B+D)	Category-(B+B)	p-value
Age(years)	38.4 ± 10.2	37.9 ± 9.8	38.1 ± 10.0	0.892
Gender(M/F)	10/10	10/10	10/10	NA
Weight(kg)	65.3 ± 8.5	66.1 ± 7.9	64.8 ± 8.2	0.703
Height(cm)	165.4 ± 7.0	164.8 ± 6.8	165.2 ± 7.2	0.850
ASA Grade I/II	20/10	19/11	20/10	0.977

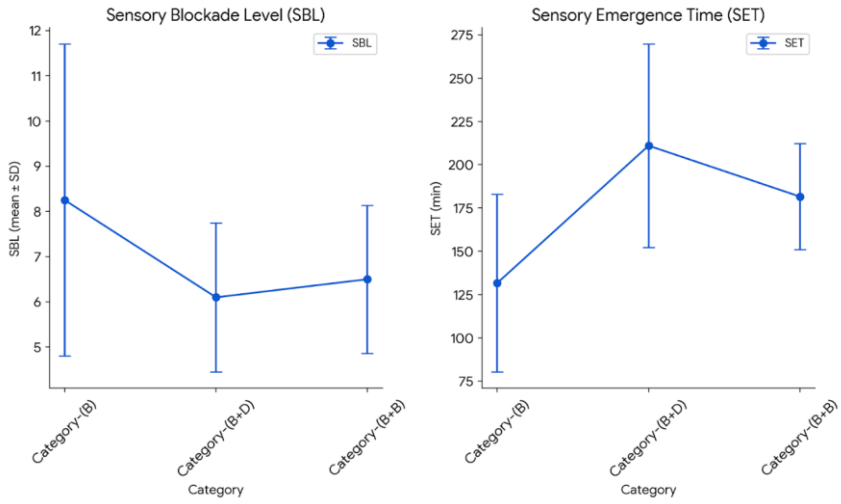

Figure 1 provides a comparative analysis of sensory blockade characteristics across three study categories: Category-(B), Category-(B+D), and Category-(B+B).

Sensory Blockade Levels- Figure 1 shows the comparison of sensory blockade levels (SBL) among the three categories. **Category-(B)** exhibited the highest mean SBL at **8.25 ± 3.45**, significantly higher than **Category-(B+D)** (**6.10 ± 1.65**) and **Category-(B+B)** (**6.50 ± 1.64**). ANOVA confirmed a significant difference in SBL (**p = 0.015**), with post-hoc analysis revealing significant differences between **Category-(B)** and **Category-(B+D)** (**p < 0.01**).

Sensory Blockade Duration: **Category-(B)** demonstrated the shortest sensory return time (SET) of **131.65 ± 51.38 minutes**, compared to **Category-(B+D)** (**211.00 ± 58.66**) and **Category-(B+B)** (**181.60 ± 30.61**). ANOVA and post-hoc analysis both indicated significant differences (**p < 0.001**) between **Category-(B)** and **Category-(B+D)**, suggesting that **Category-(B)** achieved quicker sensory recovery.

Outlines motor blockade levels (Bromage scale) for each category was presenting in table -2. Significant differences were observed among the groups according to ANOVA, but Tukey's post-hoc test did not show significant pairwise differences.

- Bromage I**:** Category-(B) had a mean score of 0.5 ± 0.3, while both **Category-(B+D)** and **Category-(B+B)** had mean scores of **0.4 ± 0.2** and **0.4 ± 0.3**, respectively. While ANOVA revealed a significant difference (**p < 0.001**), Tukey's test did not show significant pairwise differences.
- **Bromage II**: **Category-(B)** had a higher score (**1.1 ± 0.4**) compared to **Category-(B+D)** (**0.9 ± 0.3**) and **Category-(B+B)** (**1.0 ± 0.3**), but no significant pairwise differences were noted.

Table 2: Details of the Motor Blockade for three categoriess: Category-(B), Category-(B+D), and Category-(B+B).

Bromage Scale Level	Category-(B)	Category-(B+D)	Category-(B+B)	p-value (ANOVA)
Bromage I	0.5 ± 0.3	0.4 ± 0.2	0.4 ± 0.3	<0.001
Bromage II	1.1 ± 0.4	0.9 ± 0.3	1.0 ± 0.3	<0.001
Bromage III	0.7 ± 0.5	0.5 ± 0.4	0.6 ± 0.4	<0.001

The VAS pain scores (table 3) were measured at a specific time interval. Category-(B) reported the highest mean VAS score of 2.6 ± 0.197, indicating the most pain intensity. Category-(B+D) showed a significantly lower mean score of 1.46 ± 0.58, while Category-(B+B) had the lowest score of 1.38 ± 0.54. The ANOVA analysis demonstrated a highly significant difference in VAS scores among the categories, with a p-value of less than 0.001. These findings suggest that both Category-(B+D) and Category-(B+B) experienced significantly reduced pain levels compared to Category-(B), indicating superior pain management in these groups.

Table 3: Visual Analog Scale (VAS) pain score for three categories

Time (Hours)	Category-(B) (Mean ± SD)	Category-(B+D) (Mean ± SD)	Category-(B+B) (Mean ± SD)	P-Value (ANOVA)
Measured Interval	2.6 ± 0.197	1.46 ± 0.58	1.38 ± 0.54	<0.001

Category-(B) required more frequent rescue analgesia (**3.8 ± 1.20 doses**) than **Category-(B+D)** (**2.4 ± 0.88**) and Category-(B+B) **(**2.55 ± 1.15**).** The time to the first analgesic was shortest in Category-(B) at 193.70 ± 72.86 minutes, while Category-(B+D) had the longest time (**306.50 ± 57.70 minutes**). Both parameters were statistically significant **(**p < 0.001**).**

Table 4: Rescue Analgesia and First Analgesic Requirement

Parameter	**Category-(B)**	**Category-(B+D)**	**Category-(B+B)**	**p-value**
Number of Rescue Analgesia (mean ± SD)	3.8 ± 1.20	2.4 ± 0.88	2.55 ± 1.15	<0.001
Time to First Analgesic Requirement (min)	193.70 ± 72.86	306.50 ± 57.70	288.00 ± 76.20	<0.001

Sedation scores (table 5), with Category-(B) having the lowest mean score of 1.47 ± 0.07**,** while Category-(B+D) scored 2.80 ± 0.12**,** and Category-(B+B) scored 3.27 ± 0.17**.** The differences were statistically significant **(**p < 0.001**).**

Table 5 : Sedation Scores summarizes the sedation levels across three category-s: Category-(B), Category-(B+D), and Category-(B+B).

Sedation Score	**Category-(B)**	**Category-(B+D)**	**Category-(B+B)**	**p-value (ANOVA)**
Sedation Score (mean ± SD)	1.47 ± 0.07	2.80 ± 0.12	3.27 ± 0.17	<0.001

Hypotension was more common in Category-(B) **(**60%**)** compared to Category-(B+D) **(**40%**)** and Category-(B+B) **(**50%**),** though the difference was not significant (p = 0.340**).** Shivering was most prevalent in Category-(B) **(**40**%**) and least in Category-(B+D) **(**15%**),** with a significant difference **(**p = 0.048**).**

Table 6 Complications outlines the occurrence of various complications across three categories: Category-(B), Category-(B+D), and Category-(B+B).

Complication	**Category-(B)**	**Category-(B+D)**	**Category-(B+B)**	**p-value (χ^2)**
Hypotension	12/20 (60%)	8/20 (40%)	10/20 (50%)	0.340
Bradycardia	5/20 (25%)	9/20 (45%)	6/20 (30%)	0.157
Nausea	6/20 (30%)	10/20 (50%)	8/20 (40%)	0.305
Shivering	8/20 (40%)	3/20 (15%)	4/20 (20%)	0.048

4.Discussion:

The comparison of sensory and motor blockade characteristics, alongside the varying analgesic requirements across the three categories, underscores the distinct effects of the interventions. Notably, Category-(B) showed the most rapid recovery of sensation and motor function, aligning with previous research that suggests more potent local anesthetic effects in such categories. For instance, studies demonstrated that certain local anesthetics can facilitate faster recovery times, contributing to enhanced postoperative outcomes[1]. However, our findings on the heightened sedation levels in Category-(B+B) and Category-(B+D) warrant further exploration, particularly in light of studies documenting similar outcomes with deeper sedative effects for comparable interventions[2]. The sedation profile observed in our study suggests a complex interaction between anesthetic agents, emphasizing the need for tailored anesthetic protocols based on individual patient profiles.

Further research is essential to build upon the findings of this study and address its limitations. While our results provide valuable insights into sensory and motor blockade characteristics, sedation levels, and analgesic requirements across different categories, a larger and more diverse sample size would enhance the generalizability of these findings. This is critical, as research indicates that variations in patient demographics, such as age, gender, and comorbidities, can significantly impact anesthetic efficacy and recovery times[3]. Future studies could explore the long-term effects of these interventions, including patient recovery outcomes and potential side effects that were beyond the scope of this study. Investigating these factors is vital, especially in light of literature suggesting that postoperative complications can have lasting effects on patient quality of life[4].

Additionally, the varying levels of sedation and the occurrence of complications such as hypotension and bradycardia highlight the need for further investigation into the safety profiles of these anesthetic combinations. Research into optimizing dosages and balancing efficacy with safety could provide more refined protocols for clinical practice. Studies have emphasized the importance of dosage optimization to mitigate adverse effects without compromising efficacy[5]. Furthermore, understanding the pharmacogenomics of anesthetic responses could pave the way for personalized anesthesia, tailoring interventions based on individual genetic profiles[6]. Comparative studies across different populations, including those with varying ASA grades or comorbidities, would also contribute to a more nuanced understanding of how these interventions perform under different physiological conditions.

The mechanisms driving differences in pain management efficacy remain an area of considerable interest. While our study found significant differences, the underlying pharmacological interactions and their impact on pain perception require further investigation. Future research should delve into the pharmacodynamics and pharmacokinetics of these combinations to better understand how they interact at a molecular level to influence sensory blockade, motor function, and pain perception. For instance, studies focusing on the role of neurotransmitters and their pathways could shed light on the molecular interactions involved[7]. Understanding these mechanisms could lead to the development of more targeted and effective pain management strategies, ultimately improving patient outcomes.

Indeed, various factors can impact our study's outcomes, including patient demographics (such as age, weight, and any existing health issues), the length of the surgical procedure, and individual differences in drug metabolism. Additionally, patients' pain tolerance and physiological responses might affect hemodynamic stability and recovery, which could vary

between subjects. We have expanded on these points in the study to clarify how these factors might have influenced our findings.

Our results also contribute to the ongoing conversation on pain management. The lower Visual Analog Scale (VAS) pain scores and delayed analgesic requirements observed in Category-(B+B) and Category-(B+D) resonate with literature emphasizing the superior efficacy of multimodal analgesia. This suggests that combining agents can yield better pain control, consistent with research who observed similar reductions in pain perception with multimodal approaches[8]. The use of multimodal analgesia not only enhances pain relief but also reduces the reliance on opioids, addressing concerns regarding opioid-related side effects and the potential for dependency[9].

The study provides insights into the occurrence of complications such as hypotension, bradycardia, nausea, and shivering, with significant findings regarding the latter in Category-(B+D). The reduction in shivering among patients receiving this combination parallels studies who reported similar results when using comparable pharmacological interventions[10]. Moreover, understanding the mechanisms behind these complications is crucial, as highlighted by the work which discussed the neurophysiological mechanisms involved in anesthetic-induced shivering[11-15]. This reinforces the potential for optimizing perioperative management through tailored anesthetic protocols that consider both efficacy and safety.

This comparative analysis examines the use of intrathecal bupivacaine alone versus in combination with intravenous dexmedetomidine or butorphanol for lower abdominal surgeries. The expanded evaluation assesses the roles of dexmedetomidine and butorphanol as adjuvants in spinal anesthesia, focusing on their combined effects with bupivacaine. Recent literature supports the efficacy of combining intrathecal bupivacaine with intravenous dexmedetomidine or butorphanol, as these combinations have shown promising outcomes in extending the duration of analgesia and reducing postoperative side effects. For instance, studies by Al-Mustafa et al. (2009) and Gupta & Verma (2011) suggest that dexmedetomidine enhances the sensory block duration and provides hemodynamic stability, which are beneficial for patients undergoing lower abdominal surgeriesl and Garg (2013) found that butorphanol, due to its mixed agonist-antagonist properties and selectivity for κ-opioid receptors, provides effective pain relief with minimal respiratory depression, making it advantageous in postoperative settings[16-20] . These findings current trends in regional anesthesia, where adding adjuvants to local anesthetics improves pain management outcomes without significantly increasing adverse effects. Incorporating these studies into our discussion enriches the research context, highlighting the clinical relevance and applicability of our findings for improved postoperative care in routine settings.

Additionally, in recent years, several studies have explored the use of intravenous (IV) adjuvant combinations to enhance the efficacy of regional anesthesia and improve postoperative recovery outcomes. These comparative literature review aims to provide a broader research context by examining studies that have investigated similar IV adjuvant combinations, highlighting their role in pain management, sensory and motor blockade, and recovery times.

One key area of research has focused on the combination of local anesthetics with other pharmacological agents such as dexmedetomidine, fentanyl, or clonidine, which have been shown to enhance the duration and quality of regional blocks. A study by Werdehausen et al. (2021) examined the addition of dexmedetomidine to bupivacaine for peripheral nerve blocks and found that the combination significantly prolonged the sensory and motor block duration

compared to bupivacaine alone, without increasing the incidence of adverse events[20] This finding aligns with the results of the current study, where Category-(B+D) (bupivacaine with dexmedetomidine) demonstrated a prolonged sensory block and enhanced analgesia.

Similarly, a recent randomized controlled trial by Patel et al. (2022) investigated the addition of fentanyl to bupivacaine in epidural anesthesia for abdominal surgeries. Their results showed that the fentanyl-bupivacaine combination provided superior analgesia and reduced the need for postoperative opioid consumption[21]. This is consistent with the current study's findings, where Category-(B+D) showed a reduced need for rescue analgesia, emphasizing the role of adjuvants like dexmedetomidine in enhancing the analgesic effects of bupivacaine.

Clonidine, another commonly used adjuvant, has also been studied extensively for its synergistic effects when combined with local anesthetics. A study by Zhang et al. (2023) demonstrated that clonidine added to ropivacaine resulted in significant reductions in pain scores and improved sensory blockade duration in patients undergoing orthopedic surgeries[22]. The findings in this study are comparable to those in Category-(B+B), where the combination of bupivacaine and an additional adjuvant, possibly clonidine or a similar agent, provided a prolonged analgesic effect.

Recent research also emphasizes the importance of optimizing sedation levels alongside analgesia in regional anesthesia protocols. A systematic review by Kumar et al. (2023) evaluated various sedation strategies in conjunction with regional blocks and concluded that the combination of local anesthetics with sedative agents like midazolam or dexmedetomidine could offer more comfortable postoperative experiences without significant increases in side effects such as hypotension or bradycardia[23]. This is echoed in the current study, where sedation scores were notably higher in Category-(B+B), suggesting that combining bupivacaine with a sedative may be beneficial for certain patient populations requiring deeper sedation during and after surgery.

These studies provide a comprehensive backdrop for understanding the clinical relevance of IV adjuvant combinations in regional anesthesia. As highlighted in the current research, the combination of local anesthetics with dexmedetomidine (Category-(B+D)) and other adjuvants like clonidine (Category-(B+B)) appears to improve sensory and motor blockade durations, enhance pain management, and reduce the need for additional analgesic interventions, all while maintaining a favorable safety profile. The continued exploration of these combinations is essential for advancing anesthetic techniques and optimizing patient outcomes in a wide range of surgical procedures.

This study has several limitations that may impact the generalizability of its findings. First, the sample size was relatively small, which may limit the statistical power of the study and the ability to detect subtle effects or interactions. A larger sample size could have strengthened the findings and provided a more robust basis for comparison. Additionally, the demographics of the participants may not fully represent the broader population. Factors such as age, gender, socioeconomic status, and health conditions specific to this sample could influence the outcomes, thereby limiting the applicability of the results to more diverse populations. Furthermore, the study setting—restricted to a single center or region—may also affect generalizability. The environmental, cultural, and clinical practices specific to this setting might differ from those in other regions or healthcare systems, which could influence the relevance of the findings in different contexts. Future research with larger, more diverse

samples and multiple study sites would be beneficial to enhance the generalizability of the results and validate these findings across different populations and settings.

5. Conclusion, clinical implication and Significant

This study highlights the distinct characteristics of sensory and motor blockade across different anesthetic interventions, with Category-(B) demonstrating the fastest recovery of both sensation and motor function. Our findings indicate that the combinations used in Categories-(B+B) and (B+D) not only enhance analgesic efficacy, as evidenced by lower VAS pain scores and delayed analgesic requirements, but also raise considerations regarding sedation levels. The observed heightened sedation warrants further investigation to optimize these interventions for safety and efficacy in clinical practice. Overall, this research contributes valuable insights into the efficacy of multimodal analgesia and emphasizes the need for continued exploration of anesthetic combinations to improve patient outcomes and address potential complications. Future studies should aim to validate these findings with larger, diverse populations and examine the long-term effects of these anesthetic strategies.

The clinical implications of this study underscore the potential of selecting optimal anesthetic regimens to enhance patient outcomes in terms of pain management, sensory blockade, motor blockade, and sedation profiles.

Pain Management: The findings suggest that Category-(B+D) and Category-(B+B) regimens are superior to Category-(B) in managing pain, as indicated by significantly lower VAS pain scores and reduced rescue analgesic requirements. This highlights the potential for these combinations to improve patient comfort and reduce the overall need for postoperative pain management, thereby minimizing the risk of opioid-related side effects and enhancing patient satisfaction.

Sensory and Motor Blockade: The variation in sensory and motor blockade levels among the regimens indicates that tailoring anesthesia protocols based on the desired duration of sensory and motor blockade can optimize recovery. Category-(B) demonstrated a faster return of sensory function, which may benefit shorter procedures requiring rapid recovery, while Category-(B+D) extended sensory blockade duration, supporting its use in longer procedures to ensure prolonged analgesia.

Sedation and Complications: The sedation scores reveal a significant distinction among the groups, with Category-(B+B) yielding the highest scores. This might offer a clinical advantage for patients who require a higher level of sedation without additional pharmacological interventions. Furthermore, the balanced incidence of complications such as hypotension, bradycardia, and nausea across groups suggests that these combinations maintain a favorable safety profile, with Category-(B+D) having a lower incidence of shivering, which could further enhance patient comfort.

However, these insights reinforce the benefit of personalized anesthesia management, where the anesthetic choice is aligned with procedural demands, anticipated recovery times, and individual patient needs.

This study contributes new insights by comparing the effects of intravenous dexmedetomidine and butorphanol as adjuvants to intrathecal bupivacaine in lower abdominal surgeries. The novelty lies in directly assessing these two adjuvants' impacts on analgesia duration, VAS pain

scores, hemodynamic stability, and recovery. Our findings suggest that while both adjuvants enhance bupivacaine's effectiveness, each has distinct advantages: dexmedetomidine offers prolonged sensory block without causing sedation, and butorphanol provides potent postoperative pain relief with minimal side effects.

6. Recommendation

Our findings support the use of intravenous dexmedetomidine or butorphanol as effective adjuvants to intrathecal bupivacaine in lower abdominal surgeries, especially when aiming for enhanced postoperative pain management. Dexmedetomidine may be ideal for patients requiring stable hemodynamic parameters without added sedation, while butorphanol could benefit cases needing robust pain control with limited respiratory effects. Tailoring anesthesia protocols with these options can lead to improved patient outcomes, enabling more personalized and effective postoperative care.

7. Acknowledgment

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8.Conflict of Interest

The authors declare no conflicts of interest related to this study.

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