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Evaluation Of Dexmedetomidine As An Adjuvant To Epidural Bupivacaine In Vaginal Hysterectomy

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ABSTRACT

Background: Effective perioperative pain management is crucial for patient recovery and satisfaction. This study evaluates the efficacy of dexmedetomidine as an adjuvant to epidural bupivacaine in vaginal hysterectomy procedures.

Methods: Sixty patients aged 30–60 years, classified as ASA physical status I or II, scheduled for vaginal hysterectomy under epidural anesthesia were randomized into two groups. Group A received 15 mL of 0.5% bupivacaine epidurally, while Group B received the same plus dexmedetomidine 0.5 µg/kg. Onset times of sensory and motor blockade, levels of maximum sensory blockade, duration of analgesia, and recovery parameters were recorded. Hemodynamic parameters and sedation levels were monitored intraoperatively and postoperatively.

Results: Group B demonstrated a significantly faster onset of sensory blockade (10.14 ± 2.94 min) compared to Group A (17.12 ± 2.44 min; $p < 0.001$). Higher levels of maximum sensory blockade were achieved in Group B, with 76.7% reaching T4 level. The duration of analgesia was significantly longer in Group B (320.8 ± 31.5 min) versus Group A (173.4 ± 16.1 min; $p < 0.001$). Recovery times for sensory and motor blockade were also prolonged in Group B without significant adverse effects. Sedation levels were higher in the dexmedetomidine group, enhancing patient comfort.

Conclusion: Dexmedetomidine as an adjuvant to epidural bupivacaine improves anesthetic efficacy and prolongs analgesia in vaginal hysterectomy patients. Its use is associated with faster onset, higher sensory blockade levels, extended analgesia, and increased patient comfort without significant hemodynamic instability.

Keywords: *Dexmedetomidine, Epidural anesthesia, Bupivacaine, Vaginal hysterectomy, Analgesia, Alpha-2 adrenergic agonist.*

1. INTRODUCTION

Effective pain management is fundamental to perioperative care, significantly impacting patient comfort, recovery speed, and overall outcomes. Inadequate analgesia not only delays rehabilitation but is also considered ethically untenable in modern medical practice. Regional anesthesia techniques, particularly epidural anesthesia, have become integral in surgical procedures due to their ability to provide superior analgesia while minimizing systemic side effects. In vaginal hysterectomy—a prevalent major surgery among women—regional anesthesia offers distinct benefits over general anesthesia, including enhanced hemodynamic stability, reduced stress responses, and facilitation of early mobilization.[1,2,3]

Epidural anesthesia is widely favored for delivering both intraoperative anesthesia and sustained postoperative analgesia. Bupivacaine, a commonly used local anesthetic in this context, often requires higher doses to achieve optimal analgesic effects, which can elevate the risk of local anesthetic toxicity. To enhance efficacy and safety, adjuvant agents are frequently added to local anesthetics. The ideal adjuvant should prolong analgesia, provide sedation, and maintain stable hemodynamics without introducing significant adverse effects.[4,5,6]

Alpha-2 adrenergic agonists, such as dexmedetomidine, have emerged as promising adjuvants in regional anesthesia owing to their sedative and analgesic properties. Dexmedetomidine is notably more selective for alpha-2 receptors than clonidine, leading to pronounced sympatholytic effects. Its mechanism involves action on presynaptic and postsynaptic receptors in the central nervous system, resulting in decreased sympathetic outflow and norepinephrine release.[7,8] This modulation contributes to sedation, anxiolysis, and enhanced analgesia. Moreover, dexmedetomidine has been shown to augment the efficacy of local anesthetics, extending the duration of sensory and motor blockade and improving postoperative pain control.[9]

Recent systematic reviews and meta-analyses have substantiated the effectiveness of dexmedetomidine in prolonging the duration of peripheral nerve blocks and enhancing the quality of spinal anesthesia. Its utilization has been associated with extended analgesia and a reduced incidence of adverse effects. However, the potential for dose-dependent bradycardia and hypotension necessitates cautious dosing strategies. Employing lower doses, such as 0.5 µg/kg, may offer a favorable balance between maximizing therapeutic benefits and minimizing hemodynamic disturbances.[10]

This study aims to assess the efficacy of adding dexmedetomidine to epidural bupivacaine in patients undergoing vaginal hysterectomy. By comparing the onset and duration of sensory and motor blockade, measuring the duration of analgesia, and assessing the highest dermatomal level achieved between two groups—one receiving bupivacaine alone and the other receiving bupivacaine with dexmedetomidine—we seek to determine whether dexmedetomidine serves as an effective adjuvant. The goal is to enhance patient comfort and surgical outcomes without compromising hemodynamic stability, thereby potentially establishing a new standard in anesthetic practice for vaginal hysterectomy procedures.

2. MATERIALS AND METHODS

Study Design

This prospective, randomized, controlled study was conducted over an 18-month period from January 2021 to August 2022.

Study Setting

The research took place in the Department of Anaesthesiology and Critical Care at Gandhi Medical College, Secunderabad.

Sample Size

A total of 60 patients were enrolled in the study.

Inclusion Criteria

Participants were eligible if they met the following criteria:

1. Classified as American Society of Anesthesiologists (ASA) physical status I or II.
2. Aged between 30 and 60 years.
3. Scheduled for vaginal hysterectomy procedures not exceeding 120 minutes in duration.

Exclusion Criteria

Patients were excluded based on the following:

1. Age less than 30 years or more than 60 years.
2. Known allergy to amide group local anesthetics.
3. Presence of comorbidities such as diabetes mellitus, ischemic heart disease, hypertension, cardiac rhythm disturbances, chronic obstructive pulmonary disease, coagulation abnormalities, or spinal deformities.

Randomization and Group Allocation

Eligible patients scheduled for elective vaginal hysterectomy under epidural anesthesia were randomly assigned to one of two groups using a computer-generated randomization sequence:

- **Group A (Control Group):** Received 15 mL of 0.5% bupivacaine epidurally.
- **Group B (Study Group):** Received 15 mL of 0.5% bupivacaine combined with dexmedetomidine at a dose of 0.5 µg/kg epidurally.

Preoperative Preparation

In the preoperative area, an 18-gauge intravenous cannula was inserted into each patient. All patients were preloaded with 500 mL of lactated Ringer's solution to mitigate potential hypotension following epidural administration. Upon arrival in the operating room, standard monitoring devices were attached, including non-invasive blood pressure (NIBP), electrocardiography (ECG), pulse oximetry (SpO_2), and respiratory rate monitors. Baseline vital signs were recorded prior to the initiation of anesthesia.

Epidural Anesthesia Technique

Under strict aseptic conditions and with the patient in the sitting position, a lumbar epidural block was performed at the L2–L3 interspace using an 18-gauge Tuohy needle. After local infiltration with 2% lignocaine, the epidural space was identified using the loss-of-resistance-to-air technique. An epidural catheter was advanced 4 cm into the epidural space and secured in place. A test dose of 3 mL of 2% lignocaine with adrenaline was administered to exclude intrathecal or intravascular placement of the catheter.

Administration of Study Drugs

Following confirmation of correct catheter placement, the study drug was administered epidurally according to group allocation. The medications were prepared by an anesthesia technician who was blinded to the group assignments to ensure the integrity of the randomization.

Assessment of Sensory and Motor Blockade

Sensory blockade was evaluated bilaterally using the pin-prick method at 5-minute intervals for 30 minutes following drug administration. The onset time to achieve a sensory level up to the T10 dermatome and the highest sensory level attained were documented. Motor blockade was assessed using the Modified Bromage Scale:

- **Grade 0:** No motor block; full movement of legs and feet.
- **Grade 1:** Inability to raise extended leg; able to move knees and feet.
- **Grade 2:** Inability to flex knees; able to move feet.
- **Grade 3:** Complete motor block of lower limbs; inability to move legs or feet.

The time to reach complete motor blockade (Grade 3) was recorded.

Intraoperative Monitoring

Hemodynamic parameters, including heart rate, NIBP, SpO_2, and ECG, were continuously monitored throughout the surgical procedure. Recordings were made every 5 minutes intraoperatively and every 15 minutes postoperatively in the recovery unit. Hypotension was defined as a decrease in systolic blood pressure greater than 30% from baseline and was treated with intravenous mephentermine in 3–6 mg increments. Bradycardia was defined as a heart rate less than 50 beats per minute and was managed with intravenous atropine 0.6 mg.

Sedation Assessment

Sedation levels were assessed using the Ramsay Sedation Scale at baseline and every 20 minutes during surgery:

1. **Score 1:** Patient is anxious and agitated or restless.
2. **Score 2:** Patient is cooperative, oriented, and tranquil.
3. **Score 3:** Patient responds to commands only.
4. **Score 4:** Patient exhibits a brisk response to light glabellar tap or loud auditory stimulus.
5. **Score 5:** Patient exhibits a sluggish response to light glabellar tap or loud auditory stimulus.
6. **Score 6:** Patient exhibits no response to stimulation.

Postoperative Analgesia and Recovery Parameters

The following parameters were recorded:

- Time to two-segment regression of sensory blockade.
- Time to regression of sensory blockade to the S1 dermatome.
- Duration of analgesia, defined as the time from epidural drug administration to the first request for rescue analgesia.
- Total number of top-up doses required during the study period.
- Patient satisfaction scores were evaluated at the end of the procedure using a standardized scale.

Patient Positioning

Approximately 25–30 minutes after epidural injection, patients were positioned in the lithotomy position with a Trendelenburg tilt as required for the surgical procedure.

Management of Adverse Events

All patients were closely monitored for any adverse events or side effects throughout the study period. Any untoward

incidents were documented and managed promptly according to standard medical protocols.

Statistical Analysis

Data were compiled and analyzed using STATA statistical software version 13.0. Continuous variables were expressed as mean ± standard deviation (SD). Comparisons between the two groups were made using the independent samples t-test for continuous variables and the chi-square test for categorical variables. A p-value less than 0.05 was considered statistically significant.

3. RESULTS

The study compared the baseline characteristics and various anesthesia-related outcomes between two groups, A and B, each comprising 30 participants. Baseline measurements of weight and height showed no significant differences between the groups (Table 1). Specifically, the average weight was 66.4 ± 9.3 kg in Group A and 62.5 ± 10.2 kg in Group B, with a p-value of 0.12. Similarly, height measurements were 160.5 ± 6.8 cm in Group A and 160.8 ± 5.0 cm in Group B, with a p-value of 0.87.

Significant differences were observed in the onset times of sensory and motor blockades (Table 2). The onset of sensory blockade was notably faster in Group B (10.14 ± 2.94 minutes) compared to Group A (17.12 ± 2.44 minutes), with a statistically significant p-value of <0.001. Likewise, the onset of motor blockade was quicker in Group B (22.98 ± 4.78 minutes) than in Group A (27.16 ± 4.52 minutes), also with a p-value of <0.001.

Regarding the maximum level of sensory blockade achieved, Group B had a higher percentage of participants reaching the T4 sensory level (76.7% vs. 16.7% in Group A), while the majority of Group A achieved a T6 level (60.0% vs. 10.0% in Group B), as shown in Table 3.

Recovery parameters further differentiated the two groups significantly (Table 4). Group A had a markedly shorter two-segment regression time (110.32 ± 10.21 minutes) compared to Group B (240.32 ± 9.48 minutes), with a p-value of <0.001. Sensory and motor recovery times were also significantly shorter in Group A, where sensory recovery occurred in 190.4 ± 13.0 minutes, and motor recovery in 167.5 ± 15.6 minutes, compared to 347.5 ± 31.6 minutes and 301.2 ± 35.3 minutes in Group B, respectively.

The duration of analgesia showed a similar trend (Table 5). Group A experienced analgesia for 173.4 ± 16.1 minutes, substantially less than the 320.8 ± 31.5 minutes observed in Group B, with the difference being statistically significant ($p < 0.001$).

These results indicate that the anesthetic technique used in Group B resulted in faster onset and a longer duration of both sensory and motor blockades, as well as extended analgesic effects, albeit with a prolonged recovery period. Conversely, Group A participants experienced a slower onset of anesthesia but benefited from a quicker recovery process. This suggests a potential trade-off between the rapid onset and duration of anesthesia versus recovery times, which might influence the choice of anesthetic technique based on clinical needs.

Table 1: Baseline Characteristics of Study Participants

Parameters	Group A (n=30)	Group B (n=30)	p-value
Weight (kg)	66.4 ± 9.3	62.5 ± 10.2	0.12
Height (cm)	160.5 ± 6.8	160.8 ± 5.0	0.87

Table 2: Onset Time of Sensory and Motor Blockade (in minutes)

Parameters	Group A (n=30)	Group B (n=30)	p-value
Sensory Block Onset	17.12 ± 2.44	10.14 ± 2.94	<0.001
Motor Block Onset	27.16 ± 4.52	22.98 ± 4.78	<0.001

Table 3: Levels of Maximum Sensory Blockade Achieved

Maximum Sensory Level	Group A (n=30)	Group B (n=30)	Total (N=60)
T4	5 (16.7%)	23 (76.7%)	28 (46.7%)
T5	2 (6.7%)	4 (13.3%)	6 (10.0%)
T6	18 (60.0%)	3 (10.0%)	21 (35.0%)
T7	3 (10.0%)	0 (0.0%)	3 (5.0%)
T8	2 (6.7%)	0 (0.0%)	2 (3.3%)

Table 4: Recovery Parameters (in minutes)

Parameters	Group A (n=30)	Group B (n=30)	p-value
Two-Segment Regression	110.32 ± 10.21	240.32 ± 9.48	<0.001
Sensory Recovery Time	190.4 ± 13.0	347.5 ± 31.6	<0.001
Motor Recovery Time	167.5 ± 15.6	301.2 ± 35.3	<0.001

Table 5: Duration of Analgesia (in minutes)

Parameter	Group A (n=30)	Group B (n=30)	p-value
Duration of Analgesia	173.4 ± 16.1	320.8 ± 31.5	<0.001

4. DISCUSSION

The present study evaluated the efficacy of dexmedetomidine as an adjuvant to epidural bupivacaine in patients undergoing vaginal hysterectomy. The addition of dexmedetomidine significantly enhanced the anesthetic and analgesic profile compared to bupivacaine alone. Specifically, the onset of sensory blockade was faster in the dexmedetomidine group (Group B) with a mean onset time of 10.14 ± 2.94 minutes compared to 17.12 ± 2.44 minutes in the control group (Group A). This rapid onset may be attributed to the synergistic effect of dexmedetomidine on nerve conduction, facilitating quicker sensory blockade.[11,12]

Furthermore, the study demonstrated that patients in Group B achieved a higher maximum sensory blockade level, with 76.7% reaching the T4 dermatome, compared to only 16.7% in Group A. This suggests that dexmedetomidine enhances the spread and efficacy of local anesthetics in the epidural space. The mechanism may involve vasoconstriction at the injection site due to alpha-2 receptor agonism, reducing local anesthetic clearance and prolonging its action.[13]

The duration of both sensory and motor blockade was significantly prolonged in Group B. The time to two-segment regression was more than doubled in the dexmedetomidine group (240.32 ± 9.48 minutes) compared to the control group (110.32 ± 10.21 minutes). Similarly, the duration of analgesia was markedly extended in Group B (320.8 ± 31.5 minutes) versus Group A (173.4 ± 16.1 minutes). These findings are consistent with previous studies that have reported prolonged analgesia with the use of dexmedetomidine as an adjuvant in regional anesthesia.[14]

The enhanced analgesic effect can be explained by dexmedetomidine's action on alpha-2 adrenergic receptors in the dorsal horn of the spinal cord, inhibiting the release of substance P and glutamate, which are key neurotransmitters in pain pathways. Additionally, dexmedetomidine induces hyperpolarization of nerve fibers, further contributing to prolonged analgesia.

Hemodynamic stability is a crucial consideration in regional anesthesia. In this study, the addition of dexmedetomidine did not result in significant adverse hemodynamic events. Although alpha-2 agonists can cause bradycardia and hypotension due to decreased sympathetic outflow, careful dosing at 0.5 µg/kg appeared to mitigate these risks. Only minimal occurrences of intraoperative nausea and vomiting were observed, with no significant difference between the groups.[15]

Sedation levels were higher in the dexmedetomidine group, with 43.3% of patients exhibiting a sedation score of 1 compared to 10% in the control group. This mild sedation is advantageous in surgical settings, as it enhances patient comfort without

the need for additional sedative agents.

The findings of this study align with those of Bharti et al. and Bajwa et al., who also reported improved analgesic profiles with dexmedetomidine as an adjuvant in epidural anesthesia. The consistency across studies reinforces the potential of dexmedetomidine to enhance regional anesthetic techniques.

However, some limitations should be acknowledged. The study had a relatively small sample size of 60 patients, which may affect the generalizability of the results. Additionally, the study was limited to ASA I and II patients aged 30 to 60 years undergoing vaginal hysterectomy, and findings may not be applicable to other populations or surgical procedures.

Future research with larger, more diverse populations and varying surgical contexts would be beneficial to further validate these findings. Moreover, exploring different dosing regimens of dexmedetomidine could optimize its use while minimizing potential side effects.

5. CONCLUSION

The addition of dexmedetomidine at a dose of 0.5 µg/kg to epidural bupivacaine significantly improves the anesthetic and analgesic outcomes in patients undergoing vaginal hysterectomy. It accelerates the onset of sensory and motor blockade, achieves higher levels of sensory blockade, and prolongs the duration of analgesia without significant adverse effects. Dexmedetomidine proves to be an effective and safe adjuvant, enhancing patient comfort and potentially improving surgical outcomes.

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