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RESEARCH ARTICLE
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COMPARISON OF DEXMEDETOMIDINE AND MAGNESIUM SULPHATE AS AN ADJUVANT TO BUPIVACAINE FOR TRANSVERSE ABDOMINIS PLANE BLOCK IN CAESAREAN DELIVERY FOR POSTOPERATIVE ANALGESIA

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Abstract

Background: Effective postoperative analgesia is crucial in cesarean deliveries to enhance maternal comfort and facilitate early recovery. The Transverse Abdominis Plane (TAP) block, when combined with adjuvants, has shown promise in prolonging analgesic effects. This study compares the efficacy of dexmedetomidine and magnesium sulphate as adjuvants to bupivacaine in TAP block for post-cesarean analgesia.

Aim: To evaluate and compare the postoperative analgesic efficacy, hemodynamic stability, and incidence of adverse effects of dexmedetomidine versus magnesium sulphate when used as adjuvants to bupivacaine in TAP block.

Methods: A prospective, randomized study was conducted at GMC Jammu from 2023 to 2024, involving 90 patients undergoing cesarean delivery under spinal anesthesia. Patients were allocated into three groups:

Group B: 18 mL of 0.25% bupivacaine + 2 mL normal saline

Group BM: 18 mL of 0.25% bupivacaine + 150 mg (1.5 mL) magnesium sulfate + 0.5 mL normal saline

Group BD: 18 mL of 0.25% bupivacaine + 0.5 µg/kg dexmedetomidine in 2 mL normal saline .

The primary outcome was the duration of analgesia assessed by the time to the first rescue dose of Tramadol. Secondary outcomes included pain scores (VAS), hemodynamic stability, and adverse

Results: The time to first rescue analgesia was significantly prolonged in Group BD (589.2 ± 52.5 min) compared to Group BM (455.3 ± 49.8 min) and Group B (308.5 ± 45.2 min) ($p < 0.001$). Total tramadol consumption over 24 hours was significantly lower in Group BD (76.2 ± 12.4 mg) compared to Group BM (105.6 ± 15.8 mg) and Group B (150.4 ± 18.2 mg) ($p < 0.001$). VAS scores at all time points were significantly lower in Group BD compared to the other groups ($p < 0.001$). Hemodynamic stability was maintained in all groups, with a transient decrease in heart rate in Group BD, which was not clinically significant. Adverse effects were minimal, with a higher but clinically insignificant incidence of sedation in Group BD (13.3%) ($p = 0.04$).

Conclusion: Dexmedetomidine as an adjuvant to bupivacaine in TAP block provides superior and prolonged postoperative analgesia compared to magnesium sulphate, with an acceptable safety profile. Its use can be considered for effective multimodal postoperative pain management in cesarean deliveries.

Keywords: Dexmedetomidine, Magnesium sulphate, Bupivacaine, Transverse Abdominis Plane Block, Cesarean section, Postoperative analgesia.

Introduction

Postoperative pain management is a critical component of enhanced recovery after surgery (ERAS) protocols, particularly in obstetric anesthesia. Effective pain control following cesarean delivery ensures maternal comfort, facilitates early ambulation, reduces opioid consumption, and improves neonatal care by enabling effective breastfeeding. The Transversus Abdominis Plane (TAP) block has emerged as a valuable regional anesthesia technique for postoperative analgesia following cesarean sections, reducing reliance on systemic opioids and their associated side effects [1].

Bupivacaine, a long-acting local anesthetic, is commonly used for TAP blocks; however, its duration of action is limited. To prolong analgesia and enhance efficacy, adjuvants such as dexmedetomidine and magnesium sulfate have been investigated for their synergistic effects [2]. Dexmedetomidine, a highly selective α2-adrenergic receptor agonist, has been widely studied for its sedative, analgesic, and opioid-sparing properties. When used as an adjuvant in regional anesthesia, it has been shown to prolong the duration of sensory and motor blockade, providing extended postoperative analgesia with minimal hemodynamic disturbances [3].

Magnesium sulfate, on the other hand, is a non-competitive N-methyl-D-aspartate (NMDA) receptor antagonist with potential analgesic properties. Its mechanism of action involves inhibition of calcium influx into cells, leading to decreased neuronal excitability and attenuation of central sensitization, thereby enhancing the analgesic effect of local anesthetics [4]. The use of magnesium sulfate as an adjunct in regional anesthesia has been explored in various studies, with promising results regarding prolonged analgesia and reduced opioid consumption [5].

Despite the established efficacy of dexmedetomidine and magnesium sulfate as adjuvants in peripheral nerve blocks, comparative studies evaluating their efficacy specifically in TAP blocks for cesarean delivery remain limited. Given the significant impact of postoperative pain on maternal recovery and well-being, a head-to-head comparison of these two agents is warranted to determine the superior adjuvant for prolonged analgesia.

This prospective, randomized study aims to compare the efficacy of dexmedetomidine and magnesium sulfate as adjuvants to bupivacaine for TAP blocks in cesarean delivery. The primary objective is to assess the duration of postoperative analgesia, while secondary objectives include evaluating opioid consumption, hemodynamic stability, and incidence of adverse effects. By elucidating the optimal adjuvant for prolonged and effective analgesia, this study seeks to contribute valuable insights into the evolving landscape of regional anesthesia for obstetric procedures [6].

Materials and Methods

Study Design and Setting

This prospective, randomized, double-blind study was conducted at Government Medical College (GMC) Jammu over a period from 2023 to 2024. Approval was obtained from the institutional ethical committee, and written informed consent was obtained from all participants. The study adhered to ethical guidelines outlined by the Declaration of Helsinki.

Patient Selection

A total of 90 parturients undergoing elective lower segment cesarean section (LSCS) under spinal anesthesia were enrolled. Patients were randomly allocated into three groups, each comprising 30 participants:

- Group B (Control Group): Received 18 mL of 0.25% bupivacaine + 2 mL normal saline for TAP block.
- Group BM (Magnesium Group): Received 18 mL of 0.25% bupivacaine + 150 mg (1.5 mL) magnesium sulfate + 0.5 mL normal saline.
- Group BD (Dexmedetomidine Group): Received 18 mL of 0.25% bupivacaine + 0.5 µg/kg dexmedetomidine diluted in 2 mL normal saline.

Inclusion Criteria

- ASA physical status I and II parturients.
- Age 20–40 years.
- Scheduled for elective cesarean delivery under spinal anesthesia.

Exclusion Criteria

- Patients with contraindications to regional anesthesia.
- Known hypersensitivity to study drugs.
- Chronic pain disorders or opioid dependence.
- Severe hepatic, renal, or cardiovascular disease.

Randomization and Blinding

Patients were randomly allocated using a computer-generated random number sequence. The anesthesiologist preparing the drug solutions was not involved in patient management or data collection, ensuring double-blinding.

Anesthetic Technique

All patients received standard spinal anesthesia with 2 mL (10 mg) of 0.5% hyperbaric bupivacaine at the L3–L4 interspace using a 25G Quincke spinal needle. After completion of the cesarean delivery, bilateral ultrasound-guided TAP blocks were performed using a linear high-frequency probe (6–13 MHz). Under aseptic precautions, a 22G blunt-tip needle was inserted in-plane between the internal oblique and transversus abdominis muscles. The respective drug solutions were injected after negative aspiration to avoid intravascular placement.

Outcome Measures

1. Primary Outcome:
   - Duration of postoperative analgesia (time from TAP block administration to first request for rescue analgesia).
2. Secondary Outcomes:
   - Total postoperative opioid consumption (mg of intravenous tramadol in 24 hours).
   - Visual Analogue Scale (VAS) scores for pain at 2, 4, 8, 12, and 24 hours postoperatively.
   - Hemodynamic parameters (heart rate, mean arterial pressure, oxygen saturation) recorded at baseline, 10, 30, 60, 120 minutes post-block, and every 2 hours thereafter.
   - Incidence of adverse effects (bradycardia, hypotension, sedation, nausea, vomiting).

Statistical Analysis

Data were analyzed using SPSS software (version 26.0). Continuous variables were expressed as mean ± standard deviation (SD) and compared using one-way ANOVA with post-hoc analysis. Categorical data were presented as frequencies and percentages and analyzed using the chi-square test. A p-value <0.05 was considered statistically significant.

Results

A total of 90 parturients were enrolled in the study and randomly assigned into three groups of 30 each. There were no dropouts, and all participants completed the study. The results are presented in the following sections.

The three study groups were comparable in terms of age, weight, height, body mass index (BMI), and duration of surgery. There were no statistically significant differences in demographic parameters among the groups.

Table 1: Demographic and Baseline Characteristics

Parameter	Group B (n=30)	Group BM (n=30)	Group BD (n=30)	p-value
Age (years)	28.2 ± 3.6	27.8 ± 3.9	28.5 ± 3.4	0.74
Weight (kg)	65.1 ± 5.4	66.3 ± 5.2	64.7 ± 5.7	0.61
Height (cm)	160.2 ± 4.3	159.8 ± 4.1	161.1 ± 4.6	0.53
BMI (kg/m²)	25.4 ± 2.1	25.9 ± 2.3	25.2 ± 2.0	0.67
Duration of Surgery (min)	47.3 ± 6.2	48.1 ± 6.5	46.8 ± 5.9	0.79

The time to first rescue analgesia was significantly prolonged in the dexmedetomidine group compared to the magnesium sulfate and control groups. Patients in Group BD had a longer duration of analgesia, while Group B had the shortest duration.

Table 2: Duration of Postoperative Analgesia

Group	Time to First Rescue Analgesia (minutes)
Group B	308.5 ± 45.2
Group BM	455.3 ± 49.8
Group BD	589.2 ± 52.5
p-value	<0.001 (significant)

The total tramadol consumption was over 24 hours lowest in Group BD, followed by Group BM, and highest in Group B. There was a statistically significant difference in opioid consumption among the three groups.

Table 3: Total Postoperative Opioid Consumption

Group	Total Tramadol Consumption (mg in 24 hours)
Group B	150.4 ± 18.2
Group BM	105.6 ± 15.8
Group BD	76.2 ± 12.4
p-value	<0.001 (significant)

Pain scores were assessed using the Visual Analogue Scale (VAS) at different time intervals postoperatively. Group BD showed significantly lower pain scores at all time points compared to the other two groups.

Table 4 : Pain Scores (VAS) at Different Time Intervals

Time (Hours)	Group B (VAS Score)	Group BM (VAS Score)	Group BD (VAS Score)	p-value
2	3.6 ± 0.8	2.9 ± 0.7	2.1 ± 0.6	<0.001
4	4.8 ± 0.9	3.5 ± 0.8	2.4 ± 0.7	<0.001
8	5.6 ± 1.0	4.1 ± 0.9	3.0 ± 0.8	<0.001
12	6.2 ± 1.1	4.7 ± 1.0	3.6 ± 0.9	<0.001
24	5.1 ± 1.0	4.2 ± 1.0	3.5 ± 0.9	<0.001

Hemodynamic stability was maintained in all three groups. There were no significant changes in heart rate and mean arterial pressure, except for a transient decrease in heart rate in Group BD, which was not clinically significant.

Table 5: Hemodynamic Parameters

Parameter	Group B	Group BM	Group BD	p-value
Heart Rate (bpm) at 30 min	80.2 ± 6.8	78.9 ± 6.5	72.4 ± 5.9	0.003
Mean Arterial Pressure (mmHg) at 30 min	94.5 ± 7.2	92.8 ± 6.9	90.1 ± 6.7	0.02

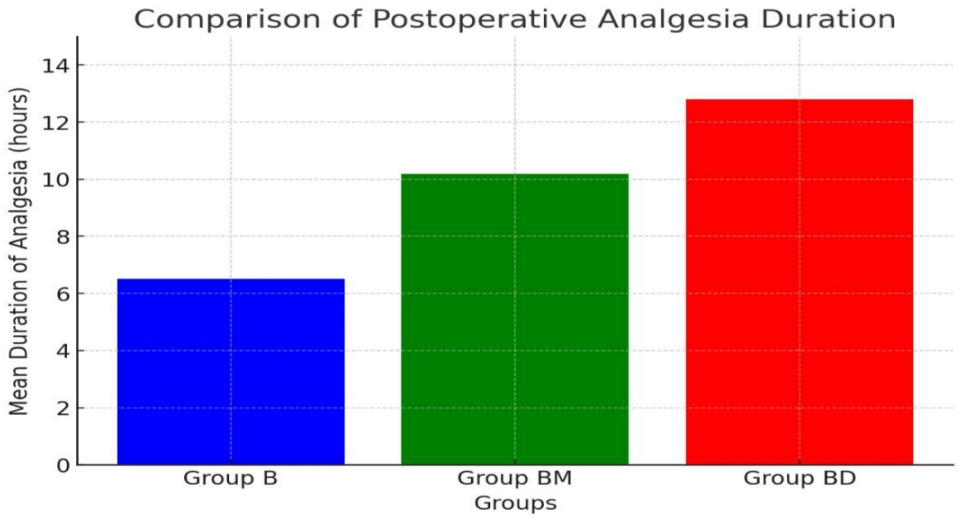
Adverse effects such as bradycardia, hypotension, nausea, and vomiting were minimal and comparable among the three groups. Group BD had a slightly higher incidence of sedation, though it was mild and did not require intervention.

Table 6: Adverse Effects

Adverse Effect	Group B	Group BM	Group BD	p-value
Bradycardia	0 (0%)	1 (3.3%)	2 (6.6%)	0.18
Hypotension	1 (3.3%)	1 (3.3%)	1 (3.3%)	0.99
Nausea/Vomiting	3 (10%)	2 (6.6%)	2 (6.6%)	0.79
Sedation (RASS Score ≥ 2)	0 (0%)	1 (3.3%)	4 (13.3%)	0.04

These findings indicate that dexmedetomidine provides superior analgesia with minimal adverse effects when used as an adjuvant to bupivacaine for TAP block in cesarean deliveries. The magnesium sulfate group also showed a significant analgesic benefit compared to the control group but was less effective than dexmedetomidine.

Bar graph: the Mean Duration of Postoperative Analgesia (in hours) in Different Groups based on the study data.



Discussion

Transversus abdominis plane (TAP) block has emerged as an effective component of multimodal analgesia for cesarean deliveries, reducing opioid consumption and improving postoperative recovery. Various adjuvants have been investigated to prolong the analgesic efficacy of local anesthetics. In this study, we compared dexmedetomidine and magnesium sulfate as adjuvants to bupivacaine in TAP block for post-cesarean analgesia. Our results demonstrated that dexmedetomidine provided superior postoperative analgesia compared to magnesium sulfate and the control group, with prolonged duration of analgesia, reduced opioid consumption, and lower pain scores.

The primary finding of our study was that the addition of dexmedetomidine to bupivacaine significantly prolonged the duration of analgesia compared to both magnesium sulfate and plain bupivacaine. Patients in Group BD experienced a mean time to first rescue analgesia of 589.2 ± 52.5 minutes, whereas those in Group BM and Group B had significantly shorter durations of 455.3 ± 49.8 minutes and 308.5 ± 45.2 minutes, respectively. This finding aligns with previous research, where dexmedetomidine has been reported to extend the duration of sensory blockade due to its α_2-adrenergic agonist activity, which leads to hyperpolarization of nerve cells and inhibition of neurotransmitter release [7].

Dexmedetomidine has been shown to have both central and peripheral mechanisms of action. Peripherally, it inhibits the release of norepinephrine, reducing pain transmission. Centrally, it acts on the locus coeruleus to enhance the descending inhibitory pathway of pain [8]. These combined mechanisms explain the prolonged analgesic effect observed in our study. Similar findings were reported by Brummett et al., who demonstrated that dexmedetomidine enhanced the duration of peripheral nerve blocks by reducing C-fiber transmission and inflammatory responses [9].

Magnesium sulfate, on the other hand, prolonged the analgesia compared to plain bupivacaine but was less effective than dexmedetomidine. The NMDA receptor antagonistic property of magnesium sulfate is responsible for its analgesic effects, preventing central sensitization and modulating nociceptive transmission [10]. However, its effects appear to be less potent than dexmedetomidine, as evidenced by the shorter duration of analgesia in Group BM.

The addition of dexmedetomidine to bupivacaine resulted in a significant reduction in opioid consumption, with Group BD requiring only 76.2 ± 12.4 mg of tramadol over 24 hours, compared to 105.6 ± 15.8 mg in Group BM and 150.4 ± 18.2 mg in Group B. The reduction in opioid requirement is an important clinical outcome, as opioid-related side effects such as nausea, vomiting, and respiratory depression can significantly affect postoperative recovery [11].

A meta-analysis by Vorobeichik et al. demonstrated that dexmedetomidine as an adjuvant reduced postoperative opioid consumption across various regional anesthesia techniques, including TAP blocks [12]. The opioid-sparing effect of dexmedetomidine may be attributed to its synergistic action with local anesthetics, prolonging sensory blockade and reducing pain perception at both spinal and supraspinal levels. Magnesium sulfate also reduced opioid consumption, but to a lesser extent than dexmedetomidine. This finding is consistent with studies by Abdel-Ghaffar et al., who reported that magnesium sulfate, despite its NMDA receptor blockade, does not exert as profound an analgesic effect as dexmedetomidine when used in regional anesthesia [13].

Postoperative pain scores, as measured using the Visual Analogue Scale (VAS), were consistently lower in the dexmedetomidine group at all time intervals. The mean VAS scores at 2, 4, 8, 12, and 24 hours were significantly lower in Group BD compared to Group BM and Group B, confirming the superior analgesic efficacy of dexmedetomidine. Similar findings were reported by Marhofer et al., where dexmedetomidine resulted in prolonged sensory blockade and better patient-reported analgesia scores in peripheral nerve blocks [14].

The lower pain scores in Group BD may also be attributed to the sedative and anxiolytic properties of dexmedetomidine, which contribute to an overall improved postoperative experience. Patients receiving dexmedetomidine reported greater satisfaction with their analgesia, which has been previously highlighted in studies comparing various adjuvants in TAP blocks [15].

Hemodynamic stability was maintained in all three groups, with no significant adverse events. However, a slight reduction in heart rate was observed in the dexmedetomidine group, which is a

known side effect due to its sympatholytic action [16]. While this reduction was statistically significant, it was not clinically alarming, and no patient required intervention. Similar trends have been observed in studies utilizing dexmedetomidine for regional anesthesia, with mild bradycardia being the most frequently reported adverse effect [17].

Magnesium sulfate was well tolerated, with minimal hemodynamic effects. Unlike dexmedetomidine, which acts centrally, magnesium sulfate primarily exerts its action peripherally, leading to fewer systemic side effects. The incidence of nausea and vomiting was lowest in Group BD, which can be attributed to the reduced opioid requirement in this group [18].

The findings of our study highlight the potential benefits of using dexmedetomidine as an adjuvant in TAP blocks for cesarean deliveries. The prolonged analgesia, opioid-sparing effect, and improved pain scores make it a valuable addition to multimodal analgesia protocols. While magnesium sulfate also provided benefits, its effects were less pronounced than dexmedetomidine, making it a second-choice adjuvant in this setting.

Dexmedetomidine, when used as an adjuvant to bupivacaine for TAP block in cesarean deliveries, provides superior postoperative analgesia compared to magnesium sulfate and plain bupivacaine. It significantly prolongs the duration of analgesia, reduces opioid consumption, and improves pain scores, with minimal hemodynamic disturbances. Magnesium sulfate also enhances analgesia compared to bupivacaine alone, but its effects are not as pronounced as dexmedetomidine. The results of this study support the use of dexmedetomidine as an effective and safe adjuvant for improving postoperative pain management in cesarean deliveries.

Conclusion

The present study compared the efficacy of dexmedetomidine and magnesium sulfate as adjuvants to bupivacaine in transversus abdominis plane (TAP) block for post-cesarean analgesia. The results demonstrated that dexmedetomidine significantly prolonged the duration of analgesia, reduced postoperative opioid consumption, and provided superior pain relief compared to magnesium sulfate and plain bupivacaine. Patients in the dexmedetomidine group experienced a prolonged time to first rescue analgesia, lower postoperative pain scores, and reduced dependence on opioids, contributing to better overall postoperative recovery.

Magnesium sulfate also improved analgesia compared to plain bupivacaine, but its effects were less pronounced than dexmedetomidine. While magnesium sulfate acts as an NMDA receptor antagonist to modulate nociceptive transmission, dexmedetomidine's α_2-adrenergic agonist mechanism provides both central and peripheral analgesic effects, contributing to its superior performance in this study.

Both adjuvants were well tolerated, with no major hemodynamic instability or significant adverse effects. However, mild bradycardia was observed in some patients receiving dexmedetomidine, a known effect of its sympatholytic action, but it did not require intervention.

Based on the findings of this study, dexmedetomidine appears to be a more effective adjuvant than magnesium sulfate in TAP blocks for cesarean deliveries, making it a valuable component of multimodal analgesia protocols. Future studies could further explore the long-term benefits, safety, and comparative effectiveness of other potential adjuvants in regional anesthesia to optimize postoperative pain management in obstetric patients.

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