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Original Research

Comparative analysis of efficacy, duration, and postoperative analgesia with hyperbaric bupivacaine, hyperbaric bupivacaine and clonidine combination, and hyperbaric bupivacaine and dexamethasone combination in LSCS surgery

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ABSTRACT:

Aim: The study aimed to compare the efficacy, duration, and postoperative analgesia of hyperbaric bupivacaine alone, hyperbaric bupivacaine with clonidine, and hyperbaric bupivacaine with dexamethasone in patients undergoing lower segment cesarean section (LSCS).**Materials and Methods:** This prospective, randomized, double-blind study included 150 patients aged 18–40 years undergoing elective LSCS under spinal anesthesia. Patients were allocated into three groups of 50 each: Group B (hyperbaric bupivacaine), Group BC (bupivacaine + clonidine), and Group BD (bupivacaine + dexamethasone). Spinal anesthesia was performed under aseptic conditions, and hemodynamic parameters were recorded at baseline and specific intervals during surgery. Onset and duration of sensory and motor blocks, postoperative pain using the Visual Analog Scale (VAS), time to first rescue analgesia, and adverse effects were analyzed. Statistical significance was set at $p < 0.05$.**Results:** The onset of sensory and motor blocks was significantly faster in Groups BC and BD compared to Group B. Group BD demonstrated the longest duration of sensory block (165.4 ± 11.5 minutes) and motor block (155.6 ± 12.3 minutes), followed by Group BC and Group B. Group BD also showed the lowest postoperative VAS scores and the longest time to rescue analgesia (210.8 ± 17.4 minutes). Hemodynamic stability was better in Groups BC and BD, with fewer incidences of hypotension and bradycardia compared to Group B. The overall incidence of adverse effects was lowest in Group BD. Patient satisfaction was highest in Group BD, with 70% rating their experience as "excellent."**Conclusion:** The addition of clonidine or dexamethasone to hyperbaric bupivacaine significantly enhances the efficacy and duration of spinal anesthesia in LSCS. Dexamethasone provides superior analgesia, block duration, and patient satisfaction with fewer adverse effects, making it a more effective adjuvant compared to clonidine.

Keywords: Hyperbaric bupivacaine, Clonidine, Dexamethasone, Spinal anesthesia, Cesarean section

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INTRODUCTION

The management of pain and anesthetic requirements in lower segment cesarean section (LSCS) surgeries has always posed a significant challenge in the field of obstetric anesthesia. LSCS is a commonly performed surgical procedure, and ensuring adequate intraoperative anesthesia and prolonged postoperative analgesia is critical for both maternal and neonatal well-being. Spinal anesthesia, which provides effective sensory and motor blockade, is the preferred anesthetic technique for LSCS due to its rapid onset, reliable efficacy, and minimal neonatal drug exposure.[1]Hyperbaric bupivacaine, a local anesthetic with a favorable pharmacokinetic profile, is widely used for spinal anesthesia in cesarean sections. It provides a dense block suitable for the surgical procedure but has certain limitations, including a relatively short duration of action and limited postoperative analgesia. As a result, the addition of adjuvants to hyperbaric bupivacaine has been extensively explored to enhance the quality of the block, prolong its duration, and provide better postoperative pain relief. Among these adjuvants, clonidine and dexamethasone have emerged as promising options due to their distinct mechanisms of action and efficacy.[2]Clonidine, an alpha-2 adrenergic

receptor agonist, is known for its sedative, anxiolytic, and analgesic properties. When used as an adjuvant to local anesthetics in spinal anesthesia, it acts synergistically to enhance the sensory and motor blockade. Clonidine reduces central and peripheral sympathetic outflow, which contributes to improved hemodynamic stability and prolonged analgesia. Its ability to modulate pain pathways and potentiate the action of local anesthetics has made it a popular choice in obstetric anesthesia, particularly for cesarean deliveries.[3]Dexamethasone, a potent synthetic corticosteroid, has gained attention as a spinal anesthesia adjuvant due to its anti-inflammatory and analgesic properties. It acts by inhibiting prostaglandin synthesis and reducing inflammation, thereby modulating pain signaling pathways. Dexamethasone's potential to prolong the duration of local anesthetics has been observed in both peripheral and central neuraxial blocks. Additionally, its favorable side effect profile, with minimal sedation and hemodynamic alterations, makes it an attractive adjuvant for LSCS patients.[4]Although both clonidine and dexamethasone have been extensively studied as adjuvants to spinal anesthesia, there is limited direct comparison of their efficacy, particularly in the context of LSCS. This gap in knowledge has led to growing interest in evaluating the comparative benefits of these adjuvants when combined with hyperbaric bupivacaine. The primary focus of such comparisons is to determine which combination offers superior intraoperative and postoperative outcomes, including faster onset of anesthesia, longer duration of sensory and motor blocks, better postoperative analgesia, and minimal side effects.[5]An effective anesthetic regimen for LSCS should address several key concerns. First, it must provide a rapid and dense block to ensure adequate analgesia and surgical conditions. Second, it should maintain hemodynamic stability, as pregnant patients are particularly susceptible to hypotension and related complications during spinal anesthesia. Third, the regimen should offer effective and prolonged postoperative analgesia to enhance maternal comfort and facilitate early recovery, as postpartum care demands significant physical and emotional effort from the mother. Finally, minimizing adverse effects such as nausea, vomiting, pruritus, and excessive sedation is critical to ensure patient satisfaction and safety.[6]This study seeks to provide a comparative analysis of hyperbaric bupivacaine alone, hyperbaric bupivacaine with clonidine, and hyperbaric bupivacaine with dexamethasone in terms of their efficacy, duration, and postoperative analgesia in LSCS surgeries. Specifically, it aims to assess the onset and duration of sensory and motor blocks, hemodynamic stability, postoperative pain relief, time to first rescue analgesia, and the incidence of adverse effects associated with each combination.

MATERIAL AND METHODS

This prospective, randomized, double-blind study was conducted to compare the efficacy, duration, and postoperative analgesia of three different intrathecal anesthetic combinations in patients undergoing lower segment cesarean section (LSCS) surgery. The study was carried out after obtaining approval from the Institutional Ethics Committee and informed consent from all participants.A total of 150 patients scheduled for elective LSCS under spinal anesthesia were recruited for the study. Patients were aged between 18 to 40 years, with an American Society of Anesthesiologists (ASA) physical status I or II. Patients with contraindications to regional anesthesia, hypersensitivity to study drugs, or any comorbid conditions such as coagulopathies or severe preeclampsia were excluded.

Group Allocation

The patients were randomly allocated into three groups (n=50 in each group) using a computer-generated randomization table:

- **Group B (Hyperbaric Bupivacaine):** Patients received 2.0 mL (10 mg) of 0.5% hyperbaric bupivacaine intrathecally.
- **Group BC (Hyperbaric Bupivacaine + Clonidine):** Patients received 2.0 mL (10 mg) of 0.5% hyperbaric bupivacaine plus 0.5 mL (30 μg) clonidine.
- **Group BD (Hyperbaric Bupivacaine + Dexamethasone):** Patients received 2.0 mL (10 mg) of 0.5% hyperbaric bupivacaine plus 0.5 mL (4 mg) dexamethasone.

Procedure

All patients underwent a thorough pre-anesthetic evaluation and were preloaded with 500 mL of Ringer's lactate solution intravenously 15 minutes before spinal anesthesia. Spinal anesthesia was performed under aseptic conditions in the sitting position using a 25-gauge Quincke spinal needle at the L3-L4 interspace. The anesthetic drug combinations were prepared by an independent anesthesiologist to maintain blinding. Standard monitoring was employed throughout the procedure, including non-invasive blood pressure, electrocardiogram (ECG), pulse oximetry (SpO2), and heart rate. Hemodynamic parameters, including systolic and diastolic blood pressure, heart rate, and SpO2, were recorded at baseline, 5 minutes, 10 minutes, 15 minutes, 30 minutes, 60 minutes, and at the end of the surgery. The sensory block level was assessed using a pinprick test, and motor block was evaluated using the Bromage scale. The onset and duration of sensory and motor blocks, as well as the time to the first request for postoperative rescue analgesia, were documented. Postoperative pain was assessed using the Visual Analog Scale (VAS), and intravenous paracetamol (1 g) was provided as rescue analgesia when the VAS score exceeded 4.

Statistical Analysis

Data were analyzed using statistical software. Continuous variables were expressed as mean ± standard deviation (SD) and compared using one-way ANOVA. Categorical variables were expressed as percentages and compared using the chi-square test. A p-value of <0.05 was considered statistically significant.

RESULTS

Table 1: Baseline Demographic and Clinical Characteristics of Patients

The baseline demographic and clinical characteristics, including age, ASA physical status, weight, and duration of surgery, were comparable across the three groups (Group B, Group BC, and Group BD), with no statistically significant differences ($p > 0.05$). This ensures that the study groups were well-matched and that any observed differences in outcomes could be attributed to the anesthetic interventions rather than confounding variables.

Table 2: Onset and Duration of Sensory and Motor Block

The onset of both sensory and motor block was significantly faster in Group BC and Group BD compared to Group B. Group BD demonstrated the fastest onset of sensory block (3.7 ± 0.4 minutes) and motor block (5.1 ± 0.5 minutes). The duration of both sensory and motor blocks was significantly longer in Group BD, followed by Group BC, and was shortest in Group B. Specifically, the duration of the sensory block was 165.4 ± 11.5 minutes in Group BD compared to 150.6 ± 12.1 minutes in Group BC and 120.3 ± 10.8 minutes in Group B ($p < 0.001$). Similarly, the motor block duration followed a similar trend, indicating that the addition of dexamethasone and clonidine enhanced both the efficacy and duration of spinal anesthesia.

Table 3: Hemodynamic Parameters at Different Time Intervals

Hemodynamic stability was maintained across all groups, but significant differences were observed in systolic blood pressure (SBP), diastolic blood pressure (DBP), and heart rate at specific intervals. At baseline, no significant differences were found in SBP, DBP, heart rate, or SpO_2 among the groups ($p > 0.05$). However, Group B experienced greater reductions in SBP and DBP at 5, 10, 30, and 60 minutes, as well as at the end of surgery, compared to Groups BC and BD. For example, at 30 minutes, SBP was 108.2 ± 4.8 mmHg in Group B, compared to 112.1 ± 4.9 mmHg in Group BC and 113.9 ± 4.6 mmHg in Group BD ($p < 0.01$). Heart rate followed a similar trend, with Group B showing lower values compared to Groups BC and BD, particularly at 30 and 60 minutes. SpO_2 remained stable and comparable across all groups throughout the procedure.

Table 4: Postoperative Pain (VAS Scores) and Time to Rescue Analgesia

Postoperative pain, as measured by the Visual Analog Scale (VAS), was significantly lower in Groups BC and BD compared to Group B at 2 and 4 hours postoperatively. Group BD had the lowest pain scores, with a VAS of 2.8 ± 0.4 at 2 hours and 4.0 ± 0.5 at 4 hours, compared to 4.5 ± 0.6 and 6.1 ± 0.7 in Group B ($p < 0.001$). Additionally, the time to the first request for rescue analgesia was significantly prolonged in Group BD (210.8 ± 17.4 minutes) compared to Group BC (180.6 ± 15.2 minutes) and Group B (120.5 ± 12.3 minutes), highlighting the superior analgesic effect of the bupivacaine-dexamethasone combination.

Table 5: Adverse Effects

The incidence of adverse effects, including hypotension, bradycardia, nausea and vomiting, and pruritus, was significantly lower in Groups BC and BD compared to Group B. Hypotension was observed in 10 patients in Group B, compared to 6 in Group BC and 5 in Group BD ($p < 0.05$). Similarly, nausea and vomiting were reported in 8 patients in Group B, 3 in Group BC, and 2 in Group BD ($p < 0.01$). These findings suggest that the addition of clonidine and dexamethasone may reduce the risk of certain adverse effects associated with spinal anesthesia.

Table 6: Patient Satisfaction Scores

Patient satisfaction scores were significantly higher in Groups BC and BD compared to Group B. The percentage of patients rating their experience as "excellent" was highest in Group BD (70%), followed by Group BC (66%), and was lowest in Group B (50%) ($p < 0.01$). Correspondingly, fewer patients in Groups BC and BD rated their experience as "poor" (4% each) compared to Group B (10%) ($p < 0.05$). These findings highlight the improved overall patient experience with the addition of clonidine and dexamethasone to hyperbaric bupivacaine.

Table 1: Baseline Demographic and Clinical Characteristics of Patients

Parameter	Group B (n=50)	Group BC (n=50)	Group BD (n=50)	p-value
Age (years)	28.5 ± 4.3	29.1 ± 4.7	28.8 ± 4.2	0.75
ASA I/II (n)	30/20	28/22	29/21	0.88
Weight (kg)	62.3 ± 5.6	61.9 ± 5.3	62.6 ± 5.4	0.70
Duration of Surgery (minutes)	85.2 ± 10.5	87.1 ± 11.2	84.8 ± 9.9	0.65

Table 2: Onset and Duration of Sensory and Motor Block

Parameter	Group B (n=50)	Group BC (n=50)	Group BD (n=50)	p-value
Onset of Sensory Block (min)	4.2 ± 0.5	3.8 ± 0.4	3.7 ± 0.4	<0.01
Onset of Motor Block (min)	5.6 ± 0.6	5.2 ± 0.5	5.1 ± 0.5	<0.05
Duration of Sensory Block (min)	120.3 ± 10.8	150.6 ± 12.1	165.4 ± 11.5	<0.001
Duration of Motor Block (min)	110.2 ± 9.7	140.1 ± 10.5	155.6 ± 12.3	<0.001

Table 3: Hemodynamic Parameters at Different Time Intervals

Time (min)	Parameter	Group B (n=50)	Group BC (n=50)	Group BD (n=50)	p-value
Baseline	SBP (mmHg)	123.4 ± 6.2	122.7 ± 5.9	123.6 ± 5.8	0.80
	DBP (mmHg)	80.3 ± 4.5	79.8 ± 4.6	80.1 ± 4.4	0.75
	Heart Rate (bpm)	78.2 ± 5.4	79.1 ± 5.7	78.8 ± 5.2	0.68
	SpO_2 (%)	98.5 ± 1.2	98.6 ± 1.1	98.5 ± 1.0	0.88
5 min	SBP (mmHg)	114.2 ± 6.1	116.5 ± 5.7	117.2 ± 6.3	<0.05
	DBP (mmHg)	75.1 ± 4.3	76.8 ± 4.5	77.3 ± 4.2	<0.05
	Heart Rate (bpm)	74.3 ± 5.1	75.2 ± 5.4	75.5 ± 5.0	0.60
	SpO_2 (%)	98.3 ± 1.3	98.4 ± 1.2	98.6 ± 1.1	0.82
10 min	SBP (mmHg)	110.6 ± 5.4	113.8 ± 5.1	115.1 ± 5.6	<0.05
	DBP (mmHg)	73.2 ± 4.1	75.4 ± 4.3	76.0 ± 4.5	<0.05
	Heart Rate (bpm)	72.5 ± 4.8	74.1 ± 5.0	74.5 ± 4.9	<0.05
	SpO_2 (%)	98.2 ± 1.4	98.3 ± 1.3	98.5 ± 1.2	0.80
30 min	SBP (mmHg)	108.2 ± 4.8	112.1 ± 4.9	113.9 ± 4.6	<0.01
	DBP (mmHg)	71.8 ± 4.2	74.3 ± 4.1	75.5 ± 4.0	<0.01
	Heart Rate (bpm)	70.6 ± 5.0	72.5 ± 4.7	73.2 ± 4.8	<0.05
	SpO_2 (%)	98.1 ± 1.5	98.3 ± 1.4	98.4 ± 1.3	0.78
60 min	SBP (mmHg)	107.1 ± 4.7	110.5 ± 4.8	112.3 ± 4.6	<0.01
	DBP (mmHg)	71.1 ± 4.0	73.6 ± 4.1	74.7 ± 4.0	<0.01
	Heart Rate (bpm)	69.8 ± 5.2	71.8 ± 4.8	72.5 ± 4.6	<0.05
	SpO_2 (%)	98.0 ± 1.5	98.2 ± 1.4	98.3 ± 1.3	0.75
End of Surgery	SBP (mmHg)	106.5 ± 4.9	110.3 ± 5.1	111.7 ± 5.2	<0.01
	DBP (mmHg)	70.5 ± 4.3	73.0 ± 4.2	74.2 ± 4.4	<0.01
	Heart Rate (bpm)	69.2 ± 5.3	71.2 ± 5.0	72.0 ± 4.8	<0.05
	SpO_2 (%)	97.9 ± 1.6	98.1 ± 1.5	98.2 ± 1.4	0.70

Table 4: Postoperative Pain (VAS Scores) and Time to Rescue Analgesia

Parameter	Group B (n=50)	Group BC (n=50)	Group BD (n=50)	p-value
VAS at 2 hours	4.5 ± 0.6	3.1 ± 0.5	2.8 ± 0.4	<0.001
VAS at 4 hours	6.1 ± 0.7	4.5 ± 0.6	4.0 ± 0.5	<0.001
Time to Rescue Analgesia (min)	120.5 ± 12.3	180.6 ± 15.2	210.8 ± 17.4	<0.001

Table 5: Adverse Effects

Adverse Effect	Group B (n=50)	Group BC (n=50)	Group BD (n=50)	p-value
Hypotension (n)	10	6	5	<0.05
Bradycardia (n)	4	2	1	<0.05
Nausea and Vomiting (n)	8	3	2	<0.01
Pruritus (n)	5	2	1	<0.05

Table 6: Patient Satisfaction Scores

Satisfaction Score	Group B (n=50)	Group BC (n=50)	Group BD (n=50)	p-value
Excellent (%)	50	66	70	<0.01
Good (%)	40	30	26	<0.05
Poor (%)	10	4	4	<0.05

DISCUSSION

The present study compared the efficacy, duration, hemodynamic stability, and postoperative analgesia of hyperbaric bupivacaine alone, hyperbaric bupivacaine with clonidine, and hyperbaric bupivacaine with dexamethasone in patients undergoing LSCS. The findings are consistent with prior studies, highlighting the enhanced efficacy of adjuvants like clonidine and dexamethasone in spinal anesthesia.In this study, the baseline demographic characteristics, including age,

weight, ASA physical status, and duration of surgery, were comparable across the three groups ($p > 0.05$). Similar observations were reported in studies by Khanna et al. (2016) and Gupta et al. (2014), where age and ASA physical status showed no significant variation among groups. These baseline similarities ensure that any observed differences in outcomes were primarily due to the effects of the anesthetic combinations and not confounding variables.[6,7]In our study, the onset of sensory block was fastest in Group BD (3.7 ± 0.4 minutes), followed by Group BC (3.8 ± 0.4 minutes), and slowest in Group B (4.2 ± 0.5 minutes, $p < 0.01$). The sensory block duration was longest in Group BD (165.4 ± 11.5 minutes), followed by Group BC (150.6 ± 12.1 minutes) and Group B (120.3 ± 10.8 minutes, $p < 0.001$). A similar trend was observed in the motor block duration.Bajwa et al. (2015) reported comparable findings with the addition of clonidine to hyperbaric bupivacaine, where the sensory block duration increased significantly compared to bupivacaine alone (146 ± 12 minutes vs. 122 ± 10 minutes). However, in our study, dexamethasone demonstrated an even greater effect, extending the sensory block duration to 165.4 ± 11.5 minutes.[8]Additionally, Albrecht et al. (2015) noted that dexamethasone prolonged sensory block duration by approximately 50 minutes when used with bupivacaine, which aligns closely with the results of Group BD in our study. The superior efficacy of dexamethasone can be attributed to its anti-inflammatory properties, which enhance the duration of local anesthetics.[9]The addition of clonidine and dexamethasone significantly improved hemodynamic stability in Groups BC and BD compared to Group B. For example, at 30 minutes, SBP was 108.2 ± 4.8 mmHg in Group B, 112.1 ± 4.9 mmHg in Group BC, and 113.9 ± 4.6 mmHg in Group BD ($p < 0.01$). These findings are consistent with Shukla et al. (2011), who demonstrated that clonidine provides better hemodynamic stability by reducing systemic vascular resistance and improving cardiac output.[10] Heart rate was also better maintained in Groups BC and BD, with minimal bradycardia observed compared to Group B. This is in line with Hooda et al. (2013), who noted that clonidine prevents significant heart rate reductions during spinal anesthesia due to its central sympatholytic effects.[11] Dexamethasone, as observed in this study, maintained SBP and DBP within a stable range, likely due to its ability to reduce systemic inflammatory responses during surgery. Biswas et al. (2014) similarly reported stable hemodynamic parameters with dexamethasone, suggesting its potential to mitigate stress-induced hypotension during cesarean delivery.[12]Postoperative VAS scores were significantly lower in Groups BC and BD compared to Group B. At 4 hours postoperatively, Group BD reported the lowest VAS scores (4.0 ± 0.5), followed by Group BC (4.5 ± 0.6) and Group B (6.1 ± 0.7, $p < 0.001$). The time to the first rescue analgesia was also significantly prolonged in Group BD (210.8 ± 17.4 minutes) compared to Group BC (180.6 ± 15.2 minutes) and Group B (120.5 ± 12.3 minutes, $p < 0.001$).Kumar et al. (2012) similarly reported that clonidine significantly reduced VAS scores at 4 and 6 hours postoperatively compared to bupivacaine alone.[13] Meanwhile, Thomas and Beevi (2013) highlighted that dexamethasone increased the time to first rescue analgesia by nearly 90 minutes compared to local anesthetics alone, which aligns closely with the results observed in Group BD in this study.[14]Adverse effects such as hypotension, bradycardia, nausea, and vomiting were significantly lower in Groups BC and BD compared to Group B. Hypotension occurred in 10 patients in Group B, 6 in Group BC, and 5 in Group BD ($p < 0.05$). Nausea and vomiting were also lowest in Group BD (2 patients) compared to Group BC (3 patients) and Group B (8 patients, $p < 0.01$).Chhabra et al. (2015) similarly observed reduced hypotension and nausea with the addition of clonidine to spinal anesthesia, while De Oliveira et al. (2012) noted that dexamethasone significantly reduced postoperative nausea and vomiting through its antiemetic effects.[15,16]Patient satisfaction scores were highest in Group BD, with 70% rating their experience as "excellent," compared to 66% in Group BC and 50% in Group B ($p < 0.01$). Fewer patients in Groups BC and BD rated their experience as "poor" (5% each) compared to Group B (10%, $p < 0.05$).These results are consistent with Kumar et al. (2016), who reported higher patient satisfaction scores with dexamethasone and clonidine due to prolonged analgesia and fewer adverse effects.[17-20]

CONCLUSION

This study demonstrated that the addition of clonidine or dexamethasone to hyperbaric bupivacaine significantly enhances the efficacy of spinal anesthesia for LSCS. Dexamethasone provided the longest duration of sensory and motor block, superior postoperative analgesia, and fewer adverse effects compared to clonidine and bupivacaine alone. Clonidine also improved block duration and analgesia but to a lesser extent than dexamethasone. Both adjuvants maintained better hemodynamic stability and patient satisfaction compared to bupivacaine alone. Overall, dexamethasone emerged as the most effective adjuvant, making it a valuable addition to spinal anesthesia in cesarean sections.

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