Volume 4, Issue 1, 2026

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

EFFECTIVENESS AND HEMODYNAMICS IMPACTS OF HYPERBARIC BUPIVACAINE 0.5% AND 0.75% GIVEN INTRATHECALLY IN ELECTIVE CESAREAN SECTION

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DOI: https://doi.org/10.5281/zenodo.18372350

Keywords
Spinal anesthesia; Hyperbaric bupivacaine; Cesarean section; Hemodynamic stability; Sensory block; Vasopressor requirement

Article History
Received: 01 December 2025
Accepted: 11 January 2026
Published: 26 January 2026

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Abstract

Background

Spinal anesthesia using hyperbaric bupivacaine is the technique of choice for elective cesarean sections; however, the optimal concentration that ensures adequate anesthesia with minimal hemodynamic disturbance remains controversial. Higher concentrations may increase adverse effects without providing additional clinical benefit.

Objective

To compare the effectiveness, hemodynamic stability, and adverse effects of intrathecal hyperbaric bupivacaine 0.5% and 0.75% in patients undergoing elective cesarean section.

Methods

A retrospective observational comparative study was conducted on 80 parturients (ASA II, aged 20–40 years) undergoing elective cesarean section. Patients were equally divided into two groups: Group A received 12 mg of 0.5% hyperbaric bupivacaine, while Group B received 12 mg of 0.75% hyperbaric bupivacaine intrathecally. Hemodynamic parameters including systolic blood pressure and heart rate were recorded at baseline and at 15, 30, 45, and 60 minutes after spinal anesthesia. Sensory block level, onset of motor block, incidence of nausea and vomiting, patient satisfaction, and requirement for rescue vasopressors were also evaluated. Statistical analysis was performed using SPSS version 30.

Results

Both groups demonstrated comparable baseline demographic characteristics. No statistically significant difference was observed in systolic blood pressure or heart rate between the two groups throughout the observation period ($p > 0.05$). A higher proportion of patients in Group A achieved a T4 sensory block level compared to Group B (85% vs. 65%, $p < 0.05$). The incidence of nausea and vomiting was

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

significantly lower in Group A (12.5%) than in Group B (40%, $p < 0.01$). Patient satisfaction was higher in the 0.5% group, and fewer patients required rescue vasopressor therapy compared to the 0.75% group.

Conclusion

Intrathecally hyperbaric bupivacaine 0.5% provides comparable hemodynamic stability with superior sensory block characteristics, fewer adverse effects, and greater patient satisfaction compared to 0.75% hyperbaric bupivacaine. The lower concentration appears to be a safer and more effective option for spinal anesthesia in elective cesarean sections.

INTRODUCTION

Spinal anesthesia is the preferred anesthetic technique for elective cesarean section due to its rapid onset, dense neural blockade, minimal drug transfer to the fetus, and reduced maternal morbidity when compared with general anesthesia [1, 2]. Among local anesthetic agents, hyperbaric bupivacaine is widely used because of its prolonged duration of action, predictable sensory block, and reliable surgical conditions [3].Adequate spinal anesthesia for cesarean delivery requires achieving a sensory block up to the T4–T6 dermatome level while maintaining hemodynamic stability [4]. However, sympathetic blockade resulting from spinal anesthesia frequently leads to hypotension and bradycardia, particularly in pregnant patients due to physiological changes such as aortocaval compression and reduced venous return [5]. These hemodynamic disturbances can compromise uteroplacental perfusion and increase the risk of maternal nausea, vomiting, and fetal acidosis if not appropriately managed [6].The concentration and dose of intrathecal hyperbaric bupivacaine play a crucial role in determining the extent of sensory and motor block as well as the incidence of adverse effects [7]. Higher concentrations may produce a denser and higher block but are also associated with an increased incidence of hypotension, nausea, vomiting, and greater vasopressor requirements [8]. Conversely, lower concentrations may provide sufficient anesthesia with improved hemodynamic stability and faster recovery profiles [9].Hyperbaric bupivacaine is commonly available in concentrations of 0.5% and 0.75%, both of which are used in clinical practice for cesarean sections. Previous studies have reported conflicting results regarding the comparative effectiveness and safety of these two concentrations, particularly in terms of hemodynamic stability and patient comfort [10–12].

Table#1 Determinant Influencing the Local Anesthetic Solution Distribution in Cerebrospinal Fluid (11).

Category	Factors
Injected solution characteristics	Baricity (hypobaric, isobaric, hyperbaric); volume, dose, and concentration; temperature; viscosity; additives (enhancers)
Injection technique	Patient position; level of injection; needle type and alignment; intrathecal catheter; direction of needle and injection
Patient-related factors	Age and sex; weight and height; intra-abdominal pressure; pregnancy; spinal anatomy

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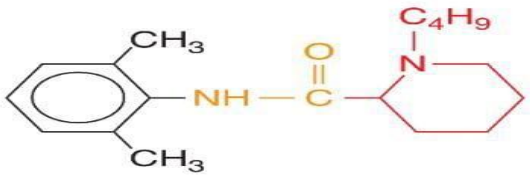
ISSN: (e) 3007-1607 (p) 3007-1593

Figure#1 chemical structure of bupivacaine



While some investigations suggest no significant difference between the two, others indicate that lower concentrations may be associated with fewer adverse effects without compromising anesthetic adequacy [13, 14].Despite the widespread use of hyperbaric bupivacaine, there remains limited region-specific evidence directly comparing intrathecally 0.5% and 0.75% concentrations using an equivalent dose in elective cesarean sections. Additionally, variations in patient demographics, anesthetic techniques, and monitoring protocols contribute to inconsistent findings across studies [15].

Therefore, the present study was designed to compare the effectiveness, hemodynamic effects, and incidence of side effects of intrathecally hyperbaric bupivacaine 0.5% and 0.75% administered in equal doses for elective cesarean section. By evaluating sensory block characteristics, hemodynamic stability, patient satisfaction, and vasopressor requirements, this study aims to identify the concentration that offers optimal anesthetic efficacy with minimal maternal risk.

MATERIALS AND METHODS

Study Design and Setting

This retrospective observational comparative study was conducted at Gulab Devi Teaching Hospital Lahore over a period of six months [16].

Study Population

Eighty parturient aged 20–40 years, classified as ASA physical status II, undergoing elective cesarean section under spinal anesthesia were included. Patients were enrolled using a non-probability consecutive sampling technique [17].

Eligibility Criteria

Inclusion criteria comprised term singleton pregnancies (37–42 weeks) scheduled for elective cesarean section. Patients with contraindications to spinal anesthesia, significant cardiovascular or systemic disease, spinal deformities, known bupivacaine allergy, or obstetric complications were excluded.

Anesthetic Technique

All patients were preloaded with Ringer's lactate (10 mL/kg). Spinal anesthesia was administered at the L3–L4 interspace using a 25-gauge Quincke needle with the patient in a sitting position. Patients were divided into two groups:

- **Group A:** 12 mg (2.4 mL) of 0.5% hyperbaric bupivacaine
- **Group B:** 12 mg (1.6 mL) of 0.75% hyperbaric bupivacaine

After injection, patients were positioned supine with left uterine displacement.

Data Collection

Demographic data were recorded from anesthesia records. Systolic blood pressure and heart rate were documented at baseline and at 15, 30, 45, and 60 minutes following spinal anesthesia [19]. Sensory block level was assessed by pin-prick method, and motor block was evaluated using the modified Bromage scale. Incidence of hypotension, bradycardia, nausea, vomiting, and vasopressor requirement were also noted. Hypotension was defined as a >20% decrease in systolic blood pressure from baseline [20].

Statistical Analysis

Data were analyzed using SPSS version 30. Continuous variables were expressed as mean ± standard deviation and compared using the independent sample t-test. Repeated-measures ANOVA assessed hemodynamic changes over time, while categorical variables were analyzed using the chi-square test. A p-value <0.05 was considered statistically significant.

Volume 4, Issue 1, 2026

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

RESULTS

Baseline Characteristics

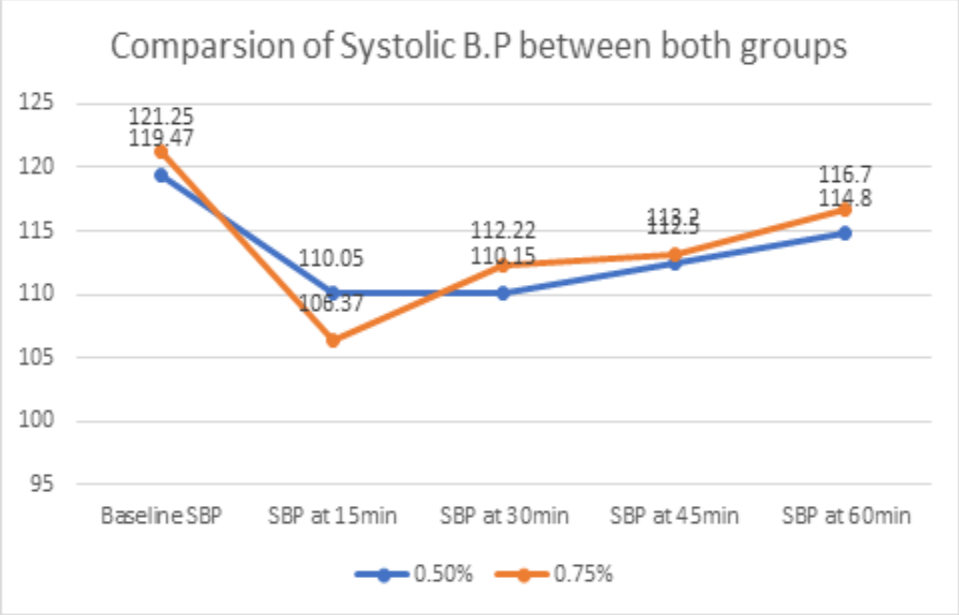
A total of 80 parturient were included in the analysis, with 40 patients in each group. There were no statistically significant differences between Group A (0.5% hyperbaric bupivacaine) and Group B (0.75% hyperbaric bupivacaine) with respect to age, weight, or height ($p > 0.05$), indicating comparable baseline demographic characteristics between the two groups.

Hemodynamic Parameters

Baseline systolic blood pressure (SBP) and heart rate (HR) were comparable between the two groups. Throughout the intraoperative period (15, 30, 45, and 60 minutes after spinal anesthesia), no statistically significant differences were observed in SBP or HR between Group A and Group B ($p > 0.05$).

At 60 minutes, mean SBP was 114.8 ± 7.45 mmHg in Group A and 116.7 ± 11.69 mmHg in Group B ($p = 0.389$). Similarly, mean HR at 60 minutes was 83.42 ± 7.47 bpm in Group A and 83.65 ± 7.76 bpm in Group B, showing no significant intergroup variation.

Variable	Group A (0.5%) Mean±S.D	Group B (0.75%) Mean±SD	P.Value
Baseline SBP	119.47±11.02	121.25±15.65	0.559
SBP at 15 min	110.05±9.37	106.37±19.14	0.279
SBP at 30 min	110.15±9.42	112.22±12.85	0.413
SBP at 45 min	112.50±8.52	113.20±13.60	0.783
SBP at 60 min	114.80±7.45	116.70±11.69	0.389



Sensory and Motor Block Characteristics

Both groups achieved adequate sensory and motor block for surgical anesthesia. A significantly higher proportion of patients in Group A attained a T4 sensory block level compared to Group B (85% vs. 65%, $p = 0.039$). Motor block progression was comparable between groups, and by 60 minutes, complete motor block involving hip, knee, and ankle joints was achieved in all patients, with no statistically significant difference in onset or intensity of motor block.

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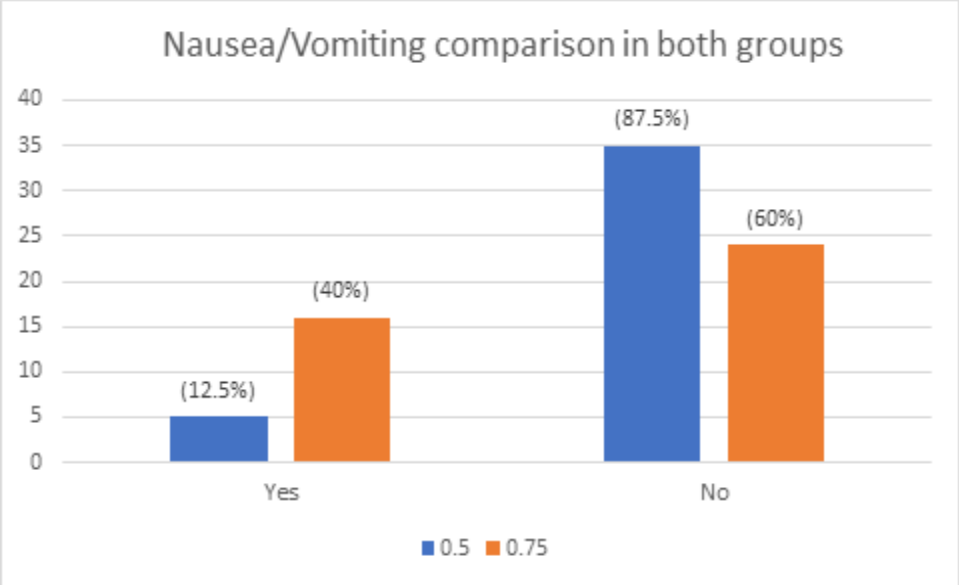
ISSN: (e) 3007-1607 (p) 3007-1593

Adverse Effects and Vasopressor Requirement

The incidence of nausea and vomiting was significantly lower in Group A compared to Group B (12.5% vs. 40%, p = 0.005). Patient satisfaction was significantly higher in the 0.5% group (90%) than in the 0.75% group (65%, p = 0.007). Additionally, the requirement for rescue vasopressor therapy was lower in Group A, with 92.5% of patients not requiring vasopressors compared to 75% in Group B (p = 0.034). The incidence of bradycardia and clinically significant hypotension did not differ significantly between the two groups.



DISCUSSION

The present study compared the effectiveness, hemodynamic stability, and adverse effects of intrathecal hyperbaric bupivacaine 0.5% and 0.75% administered in equal doses for elective cesarean section. The findings demonstrate that while both concentrations provided adequate anesthesia and comparable hemodynamic profiles, the 0.5% concentration was associated with superior sensory block characteristics, fewer adverse effects, and reduced vasopressor requirements.

In this study, systolic blood pressure and heart rate remained comparable between the two groups throughout the intraoperative period, indicating that both concentrations maintained overall hemodynamic stability. These findings are consistent with previous reports showing no significant difference in major hemodynamic parameters between 0.5% and 0.75% hyperbaric bupivacaine when administered intrathecally for cesarean delivery [26,27]. The absence of significant bradycardia or severe hypotension in either group suggests that careful dosing and standardized anesthetic techniques play a crucial role in maintaining cardiovascular stability.

Despite similar hemodynamic trends, patients receiving 0.5% hyperbaric bupivacaine achieved a higher frequency of T4 sensory block compared to those receiving 0.75%. This finding may be attributed to differences in solution spread within the cerebrospinal fluid, influenced by baricity, volume, and concentration [28]. Adequate sensory block up to T4 is essential for cesarean section, and achieving this level without excessive sympathetic blockade is clinically advantageous [29].

The incidence of nausea and vomiting was significantly higher in the 0.75% group. This observation aligns with earlier studies reporting a greater frequency of emetogenic symptoms with higher concentrations of intrathecal local anesthetics, likely secondary to more pronounced sympathetic blockade and associated hypotension [30,31]. Reduced gastrointestinal perfusion and activation of

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ISSN: (e) 3007-1607 (p) 3007-1593

central vomiting centers may further contribute to this effect [32].

Patient satisfaction was notably higher in the 0.5% group, which may be explained by a balance between effective sensory anesthesia and fewer unpleasant side effects. Moreover, the reduced requirement for rescue vasopressors in the lower concentration group suggests improved hemodynamic tolerance, supporting the use of 0.5% hyperbaric bupivacaine as a safer alternative [33].

These findings are in agreement with several regional and international studies demonstrating that lower concentrations or doses of intrathecally bupivacaine provide sufficient anesthesia with improved safety profiles and faster postoperative recovery [34–36]. Collectively, the evidence supports the concept that increasing concentration does not necessarily enhance anesthetic efficacy but may increase the risk of adverse outcomes.

Conclusion

The findings of this study indicate that intrathecally hyperbaric bupivacaine 0.5% provides anesthetic efficacy comparable to 0.75% concentration in elective cesarean sections, while offering superior sensory block characteristics, fewer adverse effects, and reduced vasopressor requirements. Both concentrations maintained stable hemodynamic parameters; however, the lower concentration was associated with higher patient satisfaction and a lower incidence of nausea and vomiting. These results suggest that increasing the concentration of hyperbaric bupivacaine does not confer additional clinical benefit and may increase the risk of undesirable side effects. Therefore, 0.5% hyperbaric bupivacaine appears to be a safer and more effective choice for spinal anesthesia in elective cesarean delivery.

Limitations

This study has certain limitations. Its retrospective design may introduce selection and documentation bias. The sample size was relatively small and confined to which may limit the generalizability of the findings. Additionally, neonatal outcomes and long-term maternal recovery parameters were not assessed. Future prospective, randomized controlled trials with larger sample sizes are recommended to further validate these findings.

Clinical Implications

The results of this study have important clinical implications for anesthetic practice in obstetrics. The use of 0.5% hyperbaric bupivacaine can optimize anesthetic outcomes by ensuring adequate sensory blockade while minimizing hemodynamic disturbances and adverse effects. Adopting lower concentrations may reduce the need for rescue vasopressors, enhance patient comfort, and improve overall perioperative safety during elective cesarean sections.

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