

Comparatively Analysis of Adverse Events amongst 0.5% Hyperbaric Bupivacaine and 0.75% isobaric Bupivacaine at Same Dose 12mg in Patients Undergoing Caesarean Sections

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ABSTRACT

Background: Spinal anaesthesia is the preferred technique for caesarean section, with bupivacaine widely used intrathecally. The baricity and concentration of bupivacaine affect haemodynamic stability and maternal adverse events.

Objective: To compare adverse events associated with 0.5% hyperbaric bupivacaine and 0.75% isobaric bupivacaine at a fixed dose of 12 mg in elective caesarean sections.

Methods: A comparative cross-sectional study was conducted at DHQ Hospital South City Okara, including 40 ASA I–II parturients aged 20–40 years scheduled for elective caesarean section. Patients were randomly assigned to two groups: Group A received 0.5% hyperbaric bupivacaine, and Group B received 0.75% isobaric bupivacaine. Haemodynamic parameters and adverse events—including hypotension, bradycardia, nausea, vomiting, shivering, and headache—were recorded intraoperatively. Data were analyzed using SPSS, with $p \leq 0.05$ considered statistically significant.

Results: Adequate sensory block up to T4 dermatome was achieved in all patients. Incidences of hypotension, bradycardia, nausea, vomiting, and shivering were significantly higher in the 0.75% isobaric group compared to the 0.5% hyperbaric group. The 0.5% hyperbaric group showed better haemodynamic stability and fewer adverse events.

Conclusion: At an equivalent dose, 0.5% hyperbaric bupivacaine provides effective spinal anaesthesia for caesarean section with fewer adverse events and better haemodynamic stability compared to 0.75% isobaric bupivacaine. This formulation may be preferred for safer maternal outcomes.

Introduction

Caesarean section (CS) is one of the most frequently performed major surgical procedures worldwide, with global rates exceeding 21% and projected to reach 29% by 2030, influenced by rising maternal age, obesity, and obstetric indications.[1] Spinal anaesthesia has established itself as the preferred method for elective and emergency CS due to its rapid onset, reliable blockade, avoidance of general anaesthesia risks (e.g., airway complications, aspiration), and improved maternal-neonatal outcomes.[2,3]

Spinal anaesthesia involves intrathecal injection of a local anaesthetic at the L3-L4 or L4-L5 interspace using a fine-gauge pencil-point needle, targeting a T4-T6 sensory level for adequate surgical conditions.[4] Bupivacaine, a potent amide local anaesthetic, is the mainstay agent, valued for its prolonged duration (90-180 minutes), favourable sensory-motor dissociation, and low fetal transfer.[5] It is available in hyperbaric (0.5%, with 8% dextrose for specific gravity >1.020) and isobaric (typically 0.75% plain, specific gravity $\approx$ 1.006 matching CSF) formulations.[6] At a fixed dose of 12 mg—an approximate ED95 for reliable T4 blockade in parturients—the 0.5% hyperbaric requires 2.4 mL volume, while 0.75% isobaric requires 1.6 mL, resulting in differing baricity, injectate volume, and potential intrathecal spread dynamics despite equivalent drug mass.[7,8]

This title-focused comparison—0.5% hyperbaric versus 0.75% isobaric bupivacaine at 12 mg—warrants investigation because baricity fundamentally governs block predictability and haemodynamic stability in parturients susceptible to aortocaval compression.[9] Hyperbaric solutions promote gravitational cephalad spread in supine position, ensuring consistent high blocks but risking excessive sympathectomy (T1-T4) and hypotension.[10] Isobaric solutions diffuse more uniformly without gravitational bias, potentially yielding slower onset but reduced peak spread and vasopressor needs.[11] Both formulations defend clinical use: hyperbaric for rapid, dense blockade in time-sensitive CS; isobaric for haemodynamic preservation in high-risk patients (e.g., preeclampsia, cardiac comorbidity).[12,13]

Current trends emphasise minimising intrathecal doses (10-12 mg) and optimising baricity to curb hypotension—the predominant adverse event (60-95% untreated incidence)—driven by vasodilatation and reduced venous return, often manifesting as nausea, bradycardia, and fetal compromise if unmanaged.[14,15] Prophylactic phenylephrine infusions and co-loading have lowered severity, yet baric-specific variations persist, with enhanced recovery protocols favouring formulations enabling early ambulation.[16] The problem statement centres on unresolved baricity impacts at equipotent doses: hyperbaric risks profound hypotension (up to 80%), while

isobaric may prolong onset or yield inadequate cephalad levels in obese parturients.[17,18]

Theoretically, baricity exerts a profound influence on intrathecal local anaesthetic pharmacokinetics and pharmacodynamics. Hyperbaric solutions, with higher specific gravity, exploit gravitational forces in the supine parturient (with 15–20° left tilt), facilitating predictable cephalad migration along the lumbar lordosis and thoracic kyphosis, thereby achieving rapid T4 onset but increasing the risk of high or total spinal block if spread exceeds T1.[19,20] In contrast, isobaric solutions remain neutrally buoyant, distributing isotropically within CSF independent of posture, theoretically minimising excessive rostral spread and sympathetic blockade while potentially delaying peak block height due to slower diffusion.[21,22] Theoretical models of CSF flow (bulk flow ~0.5 mL/min, oscillatory pulsations) predict that hyperbaric agents concentrate in dependent regions, enhancing block density but amplifying haemodynamic perturbation via broader dermatomal sympathectomy.[23] Isobaric agents, by avoiding density gradients, may preserve cardiac output and systemic vascular resistance better, aligning with Poiseuille's law and Fick's principles of diffusion in a low-Reynolds-number CSF environment.[24] Furthermore, injectate volume differences at fixed dose (2.4 vs 1.6 mL) alter initial dilution and osmotic effects, theoretically favouring smaller-volume isobaric for reduced turbulence and more uniform mixing.[25] These theoretical considerations extend to adverse events: hyperbaric's gravitational bias may exacerbate hypotension in the presence of aortocaval compression (reducing venous return by 30–40%), while isobaric's posture-independence could mitigate this in prolonged surgery or varying patient positions.[26,27] Existing evidence, though limited to indirect comparisons, supports these principles, with meta-analyses indicating trends toward faster onset but higher vasopressor requirements with hyperbaric formulations.[28,29] However, theoretical gaps remain regarding fixed-dose (12 mg) baricity effects in modern prophylactic regimens.[30]

Therefore, this study aims to conduct a comparative analysis of adverse events between 0.5% hyperbaric bupivacaine and 0.75% isobaric bupivacaine at a fixed 12 mg dose in patients undergoing elective caesarean section under spinal anaesthesia, seeking to determine the formulation with superior haemodynamic profile and fewer complications.

Materials and Methods

This comparative cross-sectional study was conducted at the District Headquarters (DHQ) Hospital South City Okara to evaluate and compare adverse events associated with 0.5% and 0.75% hyperbaric bupivacaine administered at equivalent doses in patients undergoing caesarean section under spinal anaesthesia.

A total of 40 adult female patients scheduled for elective caesarean section under spinal anaesthesia were enrolled using a non-probability consecutive sampling technique. Participants were equally divided into two groups: Group A received 0.5%

hyperbaric bupivacaine, while Group B received 0.75% hyperbaric bupivacaine at the same milligram dose. All eligible patients presenting during the study period were included until the required sample size was achieved.

Inclusion criteria comprised women aged 20–40 years, classified as American Society of Anesthesiologists (ASA) physical status I or II, with a single-term pregnancy of ≥ 37 weeks' gestation, scheduled for elective caesarean section, and who provided informed consent. Patients undergoing emergency caesarean sections, those with ASA physical status III or higher, known hypersensitivity to local anaesthetics, pre-existing cardiovascular, neurological, hepatic, or renal disorders, use of medications affecting cardiovascular stability, multiple gestations, or obstetric complications such as pre-eclampsia or eclampsia were excluded.

Intraoperative and postoperative adverse events—including hypotension, bradycardia, nausea, vomiting, shivering, and headache—were recorded using a structured proforma. Hypotension was defined as a decrease in systolic blood pressure greater than 20% from baseline and was managed with intravenous vasopressors according to institutional protocol. The frequency and severity of adverse events were compared between the two groups.

Ethical approval was obtained from the Institutional Review Board of DHQ Hospital South City Okara prior to commencement of the study.

Statistical analysis was performed using IBM SPSS Statistics software. Continuous variables were expressed as mean $\pm$ standard deviation and compared using the Student's *t*-test, while categorical variables were analyzed using the chi-square test. A *p*-value of ≤ 0.05 was considered statistically significant.

RESULTS

A total of 40 parturients undergoing caesarean section under spinal anesthesia were included in the study and were allocated into two groups based on the concentration of bupivacaine administered. Baseline demographic characteristics and ASA physical status were comparable between the two groups, with the majority of patients belonging to ASA class I and II. Adequate sensory block suitable for surgery was achieved in all patients, most commonly reaching the T4 dermatome level, which is consistent with the standard sensory level required for caesarean delivery under spinal anesthesia [31]. The onset of spinal anesthesia was rapid in both groups; however, patients receiving 0.75% bupivacaine demonstrated a tendency toward a more intense and prolonged sensory and motor blockade compared to those receiving 0.5% hyperbaric bupivacaine.

Hemodynamic changes following spinal anesthesia were observed in both groups. Episodes of hypotension and bradycardia occurred more frequently in patients who received 0.75% bupivacaine. This observation aligns with previously reported

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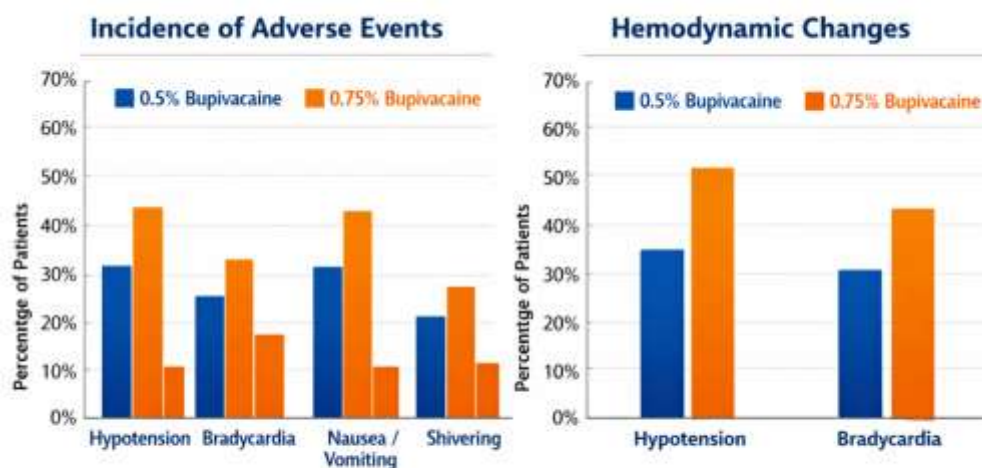
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findings that higher concentrations of intrathecal local anesthetics are associated with greater sympathetic blockade [32]. Although oxygen saturation remained within normal limits in most cases, the higher concentration group exhibited greater hemodynamic variability, necessitating closer monitoring and management.

Adverse effects such as nausea, vomiting, shivering, and headache were recorded in both groups. The incidence of nausea, vomiting, and shivering was higher in the 0.75% bupivacaine group, whereas patients in the 0.5% hyperbaric bupivacaine group experienced fewer adverse events overall. No serious or life-threatening complications were observed during the study period.



DISCUSSION

Spinal anesthesia is widely accepted as the anesthetic technique of choice for caesarean section due to its rapid onset, dense sensory block, and reduced maternal morbidity compared with general anesthesia [31]. Bupivacaine remains the most commonly used intrathecal local anesthetic; however, the selection of optimal concentration is crucial to balance effective anesthesia with maternal safety.

In the present study, both 0.5% hyperbaric bupivacaine and 0.75% bupivacaine provided satisfactory surgical anesthesia. However, the higher incidence of hypotension and bradycardia observed in patients receiving 0.75% bupivacaine suggests a more pronounced sympathetic blockade. Previous studies have demonstrated that higher concentrations of intrathecal bupivacaine increase the degree of sympathetic nervous system inhibition, leading to significant reductions in systemic vascular resistance and venous return [33].

The increased frequency of nausea, vomiting, and shivering in the 0.75% bupivacaine group can be explained by spinal-induced hypotension and enhanced sympathetic blockade. These adverse effects are well-documented sequelae of maternal hypotension during spinal anesthesia for caesarean section [34]. In contrast, patients receiving 0.5% hyperbaric bupivacaine experienced better hemodynamic stability and fewer adverse effects while maintaining adequate sensory anesthesia.

These findings are consistent with existing literature suggesting that increasing the concentration of intrathecal bupivacaine does not proportionally improve anesthetic efficacy but does increase the risk of cardiovascular adverse effects [35]. Therefore, the use of lower concentrations at an appropriate dose may provide a safer anesthetic profile without compromising surgical conditions.

CONCLUSION

Both 0.5% hyperbaric bupivacaine and 0.75% bupivacaine were effective in providing spinal anesthesia for caesarean section when administered at the same fixed dose. However, the use of 0.75% bupivacaine was associated with a higher incidence of adverse events, particularly hypotension, bradycardia, nausea, vomiting, and shivering, which can be attributed to excessive sympathetic blockade [33,34].

In contrast, 0.5% hyperbaric bupivacaine achieved adequate sensory and motor block with improved hemodynamic stability and fewer adverse effects. From a clinical standpoint, minimizing maternal complications while maintaining effective anesthesia is essential during caesarean delivery. Based on the findings of this study and supported by existing literature [31,35], 0.5% hyperbaric bupivacaine appears to be a safer and more balanced option for spinal anesthesia in patients undergoing caesarean section. Further large-scale, multicenter studies are recommended to confirm these findings and guide standardized anesthetic practice.

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