Section: Anaesthesia

Original Research Article

COMPARATIVE STUDY TO EVALUATE THE EFFICACY OF HYPERBARIC ROPIVACAINE 0.75% VERSUS HYPERBARIC BUPIVACAINE 0.5% IN SUBARACHNOID BLOCK FOR ELECTIVE CAESAREAN SECTION

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ABSTRACT

Background: Subarachnoid block is the preferred anesthetic technique for elective caesarean section. Hyperbaric bupivacaine is widely used; however, its prolonged motor blockade and potential hemodynamic effects have encouraged the search for safer alternatives. Ropivacaine, with its favorable pharmacological profile, may offer advantages in obstetric spinal anesthesia. The aim is to compare the efficacy of hyperbaric ropivacaine 0.75% and hyperbaric bupivacaine 0.5% for subarachnoid block in elective caesarean section. **Materials and Methods:** This prospective randomized comparative study included 90 parturients scheduled for elective caesarean section, divided into two groups of 45 each. Group R received hyperbaric ropivacaine 0.75% and Group B received hyperbaric bupivacaine 0.5% intrathecally. Sensory and motor block characteristics, intraoperative hemodynamic parameters, and perioperative complications were recorded and analyzed using appropriate statistical tests. **Result:** The onset of sensory and motor blockade was faster with hyperbaric bupivacaine, whereas hyperbaric ropivacaine demonstrated significantly faster regression of motor block and shorter duration of motor blockade ($p < 0.05$). Hemodynamic parameters were comparable between groups, with better maintenance of systolic blood pressure observed in the ropivacaine group during later intraoperative periods. The incidence of adverse effects such as hypotension and bradycardia was low and similar in both groups. No serious complications were reported. **Conclusion:** Hyperbaric ropivacaine 0.75% provides effective spinal anesthesia for elective caesarean section with favorable recovery characteristics and comparable hemodynamic stability when compared to hyperbaric bupivacaine 0.5%. It represents a safe and effective alternative for obstetric spinal anesthesia.

INTRODUCTION

Subarachnoid block (SAB), commonly referred to as spinal anesthesia, is the most frequently employed regional anesthetic technique for elective caesarean section owing to its rapid onset, reliable sensory and motor blockade, ease of administration, cost-effectiveness, and favorable maternal and neonatal outcomes. Compared to general anesthesia, spinal anesthesia provides better airway safety, reduced risk of aspiration, minimal drug transfer to the fetus, early maternal bonding, and superior postoperative analgesia. These advantages have made SAB the preferred technique for obstetric anesthesia worldwide.[1]

Hyperbaric bupivacaine 0.5% has traditionally been considered the gold standard local anesthetic for spinal anesthesia in caesarean section. It provides

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dense sensory blockade, adequate muscle relaxation, and prolonged duration of anesthesia. However, its use is associated with certain limitations, including prolonged motor blockade, delayed ambulation, hypotension due to sympathetic blockade, and a higher potential for cardiotoxicity and central nervous system toxicity at higher plasma concentrations. These concerns have prompted the search for alternative local anesthetics that offer comparable anesthetic efficacy with an improved safety profile.[2]

Ropivacaine, a long-acting amide local anesthetic and pure S-enantiomer, has emerged as a promising alternative to bupivacaine. Structurally similar to bupivacaine but less lipophilic, ropivacaine demonstrates greater sensory-motor separation, resulting in adequate sensory anesthesia with relatively less intense and shorter duration of motor blockade. This pharmacological characteristic is particularly beneficial in obstetric anesthesia, where early mobilization, reduced motor impairment, and enhanced maternal comfort are desirable. Additionally, ropivacaine exhibits lower cardiotoxic and neurotoxic potential compared to bupivacaine, making it a safer option in parturients who may be vulnerable to hemodynamic fluctuations.[3]

The baricity of intrathecal local anesthetic solutions plays a crucial role in determining the spread, predictability, and extent of spinal block. Hyperbaric solutions, achieved by adding glucose to the anesthetic agent, allow controlled and gravity-dependent distribution of the drug within the cerebrospinal fluid, leading to more consistent block characteristics. Hyperbaric bupivacaine has been extensively studied and widely used in caesarean section, whereas hyperbaric ropivacaine has been explored relatively less, despite encouraging results from available clinical trials.[4]

Aim: To compare the efficacy of hyperbaric ropivacaine 0.75% and hyperbaric bupivacaine 0.5% in subarachnoid block for elective caesarean section.

Objectives

1. To evaluate sensory and motor block characteristics following intrathecal administration of hyperbaric ropivacaine 0.75% and hyperbaric bupivacaine 0.5%.
2. To compare intraoperative hemodynamic stability between the two study groups.
3. To assess the incidence of perioperative adverse effects and complications associated with both drugs.

MATERIALS AND METHODS

Source of Data: Data were collected from parturients posted for elective caesarean section in the Department of Anaesthesiology at the study institution. All patients fulfilling the inclusion criteria and providing written informed consent were enrolled in the study.

Study Design: The study was conducted as a prospective, randomized, comparative clinical study. Participants were randomly allocated into two equal groups using a computer-generated randomization table.

Study Location: The study was carried out in the operation theatres of the Department of Obstetrics and Gynecology at a tertiary care teaching hospital.

Study Duration: The study was conducted over a period of 18 months from the date of institutional ethical committee approval.

Sample Size

A total of 90 parturients were included in the study.

- Group R (n = 45): Received hyperbaric ropivacaine 0.75% intrathecally.
- Group B (n = 45): Received hyperbaric bupivacaine 0.5% intrathecally.

Inclusion Criteria

- ASA physical status I and II parturients
- Age between 18 and 35 years
- Term singleton pregnancy
- Scheduled for elective caesarean section
- Willingness to participate and provide informed consent

Exclusion Criteria

- Patient refusal
- Contraindications to spinal anesthesia (coagulopathy, infection at injection site, raised intracranial pressure)
- Pregnancy-induced hypertension, preeclampsia, or severe cardiac disease
- Allergy to local anesthetic agents
- Emergency caesarean sections

Procedure and Methodology: All patients were preoperatively evaluated and kept nil per oral as per standard guidelines. Baseline vital parameters including heart rate, blood pressure, respiratory rate, and oxygen saturation were recorded. After securing intravenous access, patients were preloaded with crystalloid solution.

Under strict aseptic precautions, subarachnoid block was performed in the sitting position at the L3 -L4 or L4 -L5 intervertebral space using a 25G Quincke spinal needle. Group R received the predetermined dose of hyperbaric ropivacaine 0.75%, while Group B received hyperbaric bupivacaine 0.5%. After injection, patients were positioned supine with left uterine displacement.

Sensory block onset, maximum sensory level, time to achieve T6 dermatome, motor block onset and grade (Modified Bromage scale), duration of sensory and motor blockade, and two-segment regression time were recorded. Hemodynamic parameters were monitored at regular intervals intraoperatively. Hypotension and bradycardia were treated according to standard institutional protocols.

Sample Processing: All collected data were entered into a predesigned case record form. Data were checked for completeness and consistency before statistical analysis.

Statistical Methods: Data were analyzed using statistical software. Quantitative variables were

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expressed as mean ± standard deviation and compared using Student's t-test. Qualitative variables were expressed as frequencies and percentages and analyzed using Chi-square test or Fisher's exact test. A p-value <0.05 was considered statistically significant.

Data Collection: Demographic details, intraoperative block characteristics, hemodynamic parameters, and adverse events were systematically recorded by an independent observer who was blinded to group allocation.

RESULTS

Table 1: Baseline profile (Efficacy comparison)

Variable	Group R (n=45) n(%)	Group B (n=45) n(%)	Test of significance	Effect / 95% CI	p-value
Age 20 -29 years	25 (55.56)	28 (62.22)	Chi-square test	Risk difference = −6.67% (−26.95% to 13.62%)	0.52
Age 30 -39 years	20 (44.44)	17 (37.78)	Chi-square test	Risk difference = +6.67% (−13.62% to 26.95%)	0.52

The baseline age distribution was comparable between the two study groups. In Group R, 55.56% of parturients belonged to the 20 -29 years age group and 44.44% were in the 30 -39 years age group, while in Group B, 62.22% were aged 20 -29 years and 37.78% were aged 30 -39 years. The difference in age distribution between the two groups was not statistically significant (p = 0.52). The risk difference for the 20 -29 years age group was −6.67% (95% CI: −26.95% to 13.62%), indicating comparable baseline demographic characteristics and ensuring appropriate group matching for further efficacy comparison.

Table 2: Sensory and motor block characteristics

Parameter	Group R (Mean±SD)	Group B (Mean±SD)	Test of significance	Mean difference (R−B) with 95% CI	p-value
Onset of sensory block up to T6 (min)	3.98±0.97	3.48±0.73	Unpaired t-test	+0.50 (0.14 to 0.86)	0.0006*
Onset of sensory block up to T10 (min)	2.62±0.53	2.42±0.39	Unpaired t-test	+0.20 (0.01 to 0.39)	0.45
Time to maximum sensory block (min)	5.25±1.07	4.59±0.78	Unpaired t-test	+0.66 (0.27 to 1.05)	0.001*
Two-segment regression from maximum sensory block (min)	16.08±16.56	29.22±14.40	Unpaired t-test	−13.14 (−19.57 to −6.71)	0.06
Onset of motor block (min)	5.08±0.84	4.18±0.74	Unpaired t-test	+0.90 (0.57 to 1.23)	0.01*
Complete regression of motor block (min)	102.02±15.18	143.73±14.46	Unpaired t-test	−41.71 (−47.95 to −35.47)	0.001*

*Statistically significant as per reported p-value.

The onset of sensory block up to the T6 dermatome was significantly longer in Group R (3.98 ± 0.97 minutes) compared to Group B (3.48 ± 0.73 minutes), with a mean difference of 0.50 minutes (95% CI: 0.14 to 0.86; p = 0.0006). Similarly, the time required to achieve maximum sensory block was significantly higher in Group R (5.25 ± 1.07 minutes) than in Group B (4.59 ± 0.78 minutes) (mean difference: 0.66 minutes; 95% CI: 0.27 to 1.05; p = 0.001). Although the onset of sensory block up to the T10 dermatome was slightly longer in Group R (2.62 ± 0.53 minutes) compared to Group B (2.42 ± 0.39 minutes), this difference was not statistically significant (p = 0.45).

The two-segment regression time from the maximum sensory block was shorter in Group R (16.08 ± 16.56 minutes) compared to Group B (29.22 ± 14.40 minutes), suggesting faster regression of sensory block with ropivacaine; however, this difference did not reach statistical significance (p = 0.06). The onset of motor block was significantly delayed in Group R (5.08 ± 0.84 minutes) compared to Group B (4.18 ± 0.74 minutes), with a mean difference of 0.90 minutes (95% CI: 0.57 to 1.23; p = 0.01). Furthermore, the complete regression of motor block was significantly faster in Group R (102.02 ± 15.18 minutes) compared to Group B (143.73 ± 14.46 minutes), with a mean difference of −41.71 minutes (95% CI: −47.95 to −35.47; p = 0.001).

Table 3: Intraoperative hemodynamic stability

A) Heart rate (bpm)

Time	Group R (Mean±SD)	Group B (Mean±SD)	Test	Mean difference (R−B) with 95% CI	p-value
0 min	110.93±10.27	110.93±10.27	Unpaired t-test	0.00 (−4.31 to 4.31)	NS / not provided
4 min	85.71±3.60	85.71±3.60	Unpaired t-test	0.00 (−1.51 to 1.51)	NS / not provided
60 min	77.11±4.47	77.11±4.47	Unpaired t-test	0.00 (−1.87 to 1.87)	NS / not provided

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B) Systolic blood pressure (mmHg)

Time	Group R (Mean±SD)	Group B (Mean±SD)	Test	Mean difference (R−B) with 95% CI	p-value
0 min	119.48±7.03	116.22±8.39	Unpaired t-test	+3.26 (0.02 to 6.50)	0.48
4 min	98.77±5.96	101.51±5.91	Unpaired t-test	−2.74 (−5.23 to −0.25)	0.03*
20 min	99.97±3.49	97.73±1.87	Unpaired t-test	+2.24 (1.07 to 3.41)	0.0002*
50 min	98.31±3.27	96.88±1.17	Unpaired t-test	+1.43 (0.40 to 2.46)	0.006*
60 min	99.97±3.49	97.07±1.62	Unpaired t-test	+2.90 (1.76 to 4.04)	0.000002*

C) Diastolic blood pressure (mmHg)

Time	Group R (Mean±SD)	Group B (Mean±SD)	Test	Mean difference (R−B) with 95% CI	p-value
2 min	66.80±6.99	65.77±7.15	Unpaired t-test	+1.03 (−1.93 to 3.99)	0.49
4 min	61.60±5.03	61.24±4.82	Unpaired t-test	+0.36 (−1.70 to 2.42)	0.72
50 min	59.60±1.09	59.68±1.04	Unpaired t-test	−0.08 (−0.53 to 0.37)	0.25

*Statistically significant as per reported p-value.

Heart rate measurements at baseline (0 minutes), 4 minutes, and 60 minutes were identical between both groups, with no statistically significant differences observed, indicating comparable chronotropic stability during the intraoperative period. With respect to systolic blood pressure (SBP), baseline values were comparable between Group R (119.48 ± 7.03 mmHg) and Group B (116.22 ± 8.39 mmHg) ($p = 0.48$). At 4 minutes, Group R demonstrated significantly lower SBP compared to Group B ($p = 0.03$). However, at subsequent time points (20, 50, and 60 minutes), Group R showed significantly higher SBP values than Group B ($p < 0.01$), suggesting relatively better maintenance of systolic blood pressure with hyperbaric ropivacaine during the later intraoperative period. Diastolic blood pressure (DBP) values at 2, 4, and 50 minutes were comparable between the two groups, with no statistically significant differences ($p > 0.05$), indicating similar diastolic pressure stability with both anesthetic agents.

Table 4: Perioperative adverse effects and complications

Complication	Group R n(%)	Group B n(%)	Test of significance	Risk difference (R−B) with 95% CI	p-value
Bradycardia	1 (2.22)	1 (2.22)	Chi-square test	0.00% (−6.09% to 6.09%)	1.00
Hypotension	9 (20.00)	7 (15.50)	Chi-square test	+4.44% (−11.33% to 20.22%)	0.25
Respiratory depression	0 (0.00)	0 (0.00)			

The incidence of perioperative complications was low and comparable between the two groups. Bradycardia was observed in one patient (2.22%) in each group, with no statistically significant difference ($p = 1.00$). Hypotension occurred in 20.00% of patients in Group R and 15.50% of patients in Group B; however, this difference was not statistically significant ($p = 0.25$). No cases of respiratory depression were observed in either group. Overall, both hyperbaric ropivacaine and hyperbaric bupivacaine demonstrated a similar and acceptable safety profile in terms of perioperative adverse events.

DISCUSSION

Baseline Profile [Table 1] In the present study, the age distribution between Group R and Group B was comparable, with the majority of parturients belonging to the 20 -29 years age group followed by the 30 -39 years age group. No statistically significant difference was observed between the two groups ($p = 0.52$), indicating adequate baseline matching. Similar demographic comparability has been reported by Naithani U et al. (2025),[5] where age and other baseline characteristics were evenly distributed between ropivacaine and bupivacaine groups. This uniformity in baseline variables is crucial for minimizing confounding factors and ensures that differences in outcomes can be attributed primarily to the pharmacological properties of the study drugs rather than patient-related variables.

Sensory and Motor Block Characteristics [Table 2] The present study demonstrated a significantly slower onset of sensory block up to T6 and delayed achievement of maximum sensory block in the ropivacaine group compared to the bupivacaine group. These findings are consistent with the observations of Oraon P et al. (2022),[6] who reported a slower onset of sensory blockade with hyperbaric ropivacaine due to its lower lipid solubility and reduced penetration into nerve fibers.

Although the onset of sensory block up to T10 was marginally delayed in Group R, this difference was not statistically significant, suggesting comparable early block establishment for surgical readiness. Similar results were reported by Anshumali A. (2025),[7] who found no clinically relevant delay in achieving adequate sensory levels with ropivacaine when used in equipotent doses.

The two-segment regression time was shorter in the ropivacaine group, indicating faster sensory regression. This trend is supported by studies by George M et al. (2022),[8] which demonstrated shorter sensory block duration with ropivacaine compared to bupivacaine. Although the difference in the present

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study did not reach statistical significance, the observed trend reinforces the concept of faster recovery associated with ropivacaine.

The onset of motor block was significantly delayed in the ropivacaine group, and the complete regression of motor block was significantly faster compared to bupivacaine. These findings are in strong agreement with Tarkase AS. (2020),[9] who reported reduced intensity and shorter duration of motor blockade with ropivacaine. This characteristic is clinically advantageous in obstetric anesthesia as it facilitates early mobilization and reduces postoperative discomfort while maintaining adequate intraoperative anesthesia.

Intraoperative Hemodynamic Stability [Table 3] Heart rate values were comparable between both groups throughout the intraoperative period, indicating similar chronotropic stability. With respect to systolic blood pressure, although an initial transient decrease was noted in Group R at 4 minutes, the ropivacaine group demonstrated significantly better maintenance of systolic blood pressure at later time points. These findings are comparable to those reported by Chatterjee A et al. (2025),[10] who observed comparable or improved hemodynamic stability with ropivacaine.

Diastolic blood pressure remained comparable between the two groups at all measured time points, suggesting that both drugs produced similar degrees of sympathetic blockade. The relatively stable hemodynamic profile observed with ropivacaine may be attributed to its lower potency and reduced sympathetic blockade compared to bupivacaine, as highlighted by Naithani U et al. (2025).[5]

Perioperative Adverse Effects and Complications [Table 4] The incidence of perioperative complications such as bradycardia and hypotension was low and comparable between the two groups. No cases of respiratory depression were observed. These findings are consistent with those reported by Parashi VH et al. (2025),[11] who found no significant difference in the incidence of adverse effects between hyperbaric ropivacaine and hyperbaric bupivacaine.

CONCLUSION

The present comparative study demonstrated that both hyperbaric ropivacaine 0.75% and hyperbaric bupivacaine 0.5% provide effective and reliable spinal anesthesia for elective caesarean section with satisfactory surgical conditions. Although hyperbaric bupivacaine produced a relatively faster onset of sensory and motor blockade, hyperbaric ropivacaine was associated with significantly faster regression of motor blockade and shorter duration of motor block, facilitating earlier postoperative mobilization and recovery.

Hemodynamic parameters remained largely comparable between the two groups, with hyperbaric ropivacaine showing better maintenance of systolic blood pressure at later intraoperative time points, indicating favorable hemodynamic stability. The incidence of perioperative adverse effects such as hypotension and bradycardia was low and comparable in both groups, and no serious complications were observed.

Overall, hyperbaric ropivacaine 0.75% emerges as a safe and effective alternative to hyperbaric bupivacaine 0.5% for subarachnoid block in elective caesarean section, offering the added advantage of faster motor recovery while maintaining adequate anesthetic efficacy and maternal safety.

Limitations of the Study

1. The study was conducted at a single tertiary care center, which may limit the generalizability of the findings.
2. The sample size, although adequate for primary outcomes, was relatively small for detecting rare adverse events.
3. Neonatal outcomes such as umbilical cord blood gas analysis were not assessed in detail.
4. Long-term maternal outcomes including time to ambulation, duration of hospital stay, and patient satisfaction scores were not evaluated.
5. Only fixed drug doses were used and dose-response relationships were not explored.
6. The study focused on elective caesarean sections and the results may not be applicable to emergency procedures.

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