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Comparative Evaluation of Equipotent Hyperbaric Bupivacaine, Levobupivacaine, and Ropivacaine for Spinal Anaesthesia in Caesarean Section: A Randomized Double-Blind Study

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ABSTRACT

Background: Spinal anaesthesia is the preferred technique for caesarean section. While hyperbaric bupivacaine is widely used, newer agents like levobupivacaine and ropivacaine offer potential advantages in safety and recovery. This study compared the efficacy and safety of equipotent hyperbaric formulations of these agents.

Materials and Methods: In this prospective, randomized, double-blind study, 105 ASA II parturients undergoing caesarean section were allocated into three groups (n=35 each): Group A received 10 mg hyperbaric bupivacaine (0.5%), Group B received 10 mg hyperbaric levobupivacaine (0.5%), and Group C received 15 mg hyperbaric ropivacaine (0.75%) intrathecally. Onset and duration of sensory and motor block, duration of analgesia, haemodynamic parameters, and adverse effects were evaluated. Statistical analysis was performed using ANOVA and Tukey post hoc test ($p<0.05$ significant).

Results: Baseline characteristics were comparable ($p>0.05$). The onset of sensory block was similar between Groups A and B but significantly delayed in Group C ($p<0.05$). The onset of motor block was fastest in Group A and slowest in Group C ($p<0.001$). The duration of sensory block (150.00±9.55, 140.00±10.99, 105.43±8.70 min), motor block (145.23±8.08, 140.00±8.26, 115.00±11.31 min), and analgesia (135.00±5.15, 130.00±8.06, 110.00±10.86 min) were significantly longer in Groups A and B compared to Group C ($p<0.05$). Haemodynamic parameters were largely comparable. The incidence of nausea, vomiting, and hypotension was similar among groups, with a lower incidence of hypotension in Group C.

Conclusion: All three agents provided effective spinal anaesthesia for caesarean section. Bupivacaine offered longer block duration, while ropivacaine provided shorter motor block and potential for early ambulation. Levobupivacaine showed intermediate characteristics.

Keywords: *Spinal anaesthesia, Caesarean section, Bupivacaine, Levobupivacaine, Ropivacaine, Subarachnoid block.*

INTRODUCTION

Caesarean section is one of the most frequently performed surgical procedures in modern obstetric practice, with a steadily increasing global incidence. Ensuring maternal and fetal safety during this procedure is of paramount importance, and the choice of anaesthetic technique plays a critical role in achieving this goal. Spinal anaesthesia has emerged as the preferred modality for both elective and emergency caesarean sections due to its rapid onset, reliable sensory and motor blockade, and favorable safety profile. In addition to reducing anaesthesia-related maternal mortality, it allows the mother to remain conscious during delivery, preserves airway reflexes, minimizes fetal drug exposure, and provides effective postoperative analgesia.[1-4]

Hyperbaric bupivacaine has long been considered the gold standard for intrathecal anaesthesia in caesarean section because of its consistent and dense block characteristics. However, its use is not without limitations. Adverse effects such as hypotension, prolonged motor blockade, and potential cardiotoxicity—particularly at higher doses or in cases of inadvertent intravascular administration—have prompted the exploration of safer alternatives. In this context, levobupivacaine and ropivacaine, which are pure S-enantiomers of local anaesthetics, have gained attention due to their reduced cardiotoxic and neurotoxic potential while maintaining effective anaesthetic properties.[3-7]

Previous studies have evaluated these agents individually or in pairwise comparisons. Evidence suggests that levobupivacaine provides a block profile comparable to bupivacaine, whereas ropivacaine is associated with a shorter duration of motor block, potentially facilitating earlier postoperative mobilization. While these characteristics may offer clinical advantages in specific scenarios, findings across studies have varied depending on drug concentration, baricity, and surgical context. Furthermore, many of these studies have used isobaric solutions or have not employed equipotent dosing, limiting direct comparability.[5-9]

Hyperbaric formulations are widely used in current clinical practice because they provide more predictable spread and consistent block characteristics in the subarachnoid space compared to isobaric solutions. Despite this, there is a relative paucity of literature directly comparing hyperbaric bupivacaine, levobupivacaine, and ropivacaine in equipotent doses specifically for caesarean section.

Given these considerations, a comprehensive comparison of these three agents under standardized conditions is warranted. The present study was therefore designed to evaluate and compare the efficacy, block characteristics, haemodynamic effects, and side-effect profiles of intrathecal hyperbaric bupivacaine (0.5%), levobupivacaine (0.5%), and ropivacaine (0.75%) when administered in equipotent doses for caesarean section.

MATERIALS AND METHODS

Study Design and Setting

This prospective, randomized, comparative, double-blind study was conducted in the Department of Anaesthesia at Shri Lal Bahadur Shastri Government Medical College, Nerchowk, Mandi. The study included parturients undergoing caesarean section under subarachnoid block.

Ethical Approval and Study Population

After obtaining approval from the Institutional Ethics Committee, the study was carried out on 105 ASA II parturient females scheduled for caesarean section. Written informed consent was obtained from all participants prior to inclusion in the study.

Study Duration

The study was conducted over a period of 12 months, which included patient recruitment, data collection, organization, analysis, and interpretation.

Sample Size Calculation

The sample size was calculated based on the mean difference in onset of motor block up to Bromage grade 3, as reported by Oraon et al. A sample size of 30 patients per group was estimated, considering a mean difference of 2.67, a study power of 90%, and a two-sided confidence interval of 99%. To account for potential dropouts and enhance study validity, an additional 10% was included, resulting in a final sample size of 35 patients in each group.

Randomization and Blinding

Patients were randomly allocated into three groups using a computer-generated randomization table. Allocation concealment was ensured using sealed opaque envelopes, which were opened only after the patient was shifted to the operating theatre. The study drug was prepared by an anaesthesiologist not involved in patient management or data collection. Both the anaesthesiologist administering the block and the observer recording intraoperative and postoperative parameters were blinded to group allocation.

Inclusion Criteria

- Singleton pregnancy
- Gestational age >34 weeks
- Age between 18 and 40 years

Exclusion Criteria

- Patient refusal or unwillingness
- Known hypersensitivity to local anaesthetics
- Local infection at the site of injection
- Hypovolemia, shock, or acid-base/electrolyte imbalance

- Bleeding disorders or anticoagulant therapy
- Neuromuscular disorders or vertebral anomalies
- Obstetric comorbidities (e.g., pregnancy-induced hypertension, gestational diabetes mellitus)
- Medical comorbidities (e.g., hypertension, cardiac, renal, or hepatic disorders)
- Polyhydramnios (AFI >25)
- Fetal weight >4 kg
- Inadequate or partial block requiring supplementary anaesthesia

Data Collection Tools
A semi-structured proforma was used to record patient demographics, onset and duration of sensory and motor block, and perioperative haemodynamic parameters.

Anaesthetic Technique
Preoperative Assessment
All eligible patients underwent a thorough pre-anaesthetic evaluation, including detailed history, general physical examination, and spine assessment. Routine investigations included complete blood count (CBC), renal function tests (RFT), liver function tests (LFT), and serum electrolytes. Baseline demographic parameters such as age, height, weight, and gestational age were recorded.

Premedication
All patients received intravenous anti-aspiration prophylaxis with metoclopramide 10 mg and ranitidine 50 mg.

Intraoperative Monitoring and Preparation
Standard ASA monitoring, including non-invasive blood pressure (NIBP), pulse oximetry (SpO_2), and 5-lead electrocardiography (ECG), was applied. Baseline heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), and SpO_2 were recorded. Intravenous access was secured with an 18G cannula, and patients were preloaded with 500 mL of crystalloid solution.

Study Groups
Patients were allocated into three groups (n = 35 each):
- **Group A:** Received 10 mg (2 mL of 0.5%) hyperbaric bupivacaine intrathecally
- **Group B:** Received 10 mg (2 mL of 0.5%) hyperbaric levobupivacaine intrathecally
- **Group C:** Received 15 mg (2 mL of 0.75%) hyperbaric ropivacaine intrathecally

The total volume of drug administered was 2 mL in all groups.

Procedure
Under strict aseptic precautions, lumbar puncture was performed in the lateral position using a midline approach at the L3–L4 or L4–L5 intervertebral space. The study drug was injected intrathecally over 10–15 seconds. Following injection, patients were positioned supine with left uterine displacement.

Assessment of Block Characteristics
Sensory Block
Sensory block was assessed using a 22G needle by loss of pinprick sensation along the midclavicular line bilaterally. Cephalad spread was evaluated until the sensation changed from dull to sharp. Adequate sensory level was defined as loss of pinprick sensation up to the T6 dermatome.
- **Onset of sensory block:** Time from drug administration to loss of pinprick sensation
- **Duration of sensory block:** Time from onset to reappearance of sensation at incision site
- **Duration of analgesia:** Time from drug administration to first requirement of analgesic

Motor Block
Motor block was assessed using the Modified Bromage Scale:
- Grade 0: Full movement
- Grade 1: Inability to raise extended leg, able to bend knee
- Grade 2: Inability to bend knee, able to move ankle
- Grade 3: No movement
- **Onset of motor block:** Time to achieve Bromage grade 2
- **Onset of complete motor block:** Time to achieve Bromage grade 3
- **Duration of motor block:** Time from complete motor block to full recovery (Grade 0)

Both sensory and motor block were assessed every minute for the first 5 minutes, then every 5 minutes until fixation, and subsequently every 15 minutes until regression.

Haemodynamic Monitoring and Management

Heart rate, SBP, DBP, MAP, and SpO_2 were recorded every 3 minutes for the first 15 minutes and then every 5 minutes until completion of surgery.

- **Hypotension** (SBP <90 mmHg or >20% fall from baseline) was treated with intravenous mephentermine 6 mg
- **Bradycardia** (HR <50 bpm) was treated with intravenous atropine 0.6 mg

Surgery was commenced after confirming adequate sensory block up to T6.

Statistical Analysis

Data were entered into Microsoft Excel (MacOS 15 Sequoia) and analysed using Epi Info version 7.2.5. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Intergroup comparisons were performed using one-way analysis of variance (ANOVA) with F-test, and post hoc pairwise comparisons were conducted using Tukey HSD test. Repeated measures ANOVA was used for haemodynamic parameters. Pearson correlation coefficient was used to assess relationships between continuous variables. A p-value <0.05 was considered statistically significant.

RESULTS

Table 1. Distribution of study participants according to intervention groups

Group	Intervention (Intrathecal drug)	Dose and concentration	Number of patients (n)	Percentage (%)
Group A	Hyperbaric bupivacaine	10 mg (2 mL of 0.5%)	35	33.3
Group B	Hyperbaric levobupivacaine	10 mg (2 mL of 0.5%)	35	33.3
Group C	Hyperbaric ropivacaine	15 mg (2 mL of 0.75%)	35	33.3
Total	—	—	**105**	**100.0**

A total of 105 ASA II parturient females undergoing caesarean section under subarachnoid block were enrolled in the study. The participants were randomly allocated into three equal groups, with 35 patients in each group. Group A received 10 mg (2 mL of 0.5%) hyperbaric bupivacaine, Group B received 10 mg (2 mL of 0.5%) hyperbaric levobupivacaine, and Group C received 15 mg (2 mL of 0.75%) hyperbaric ropivacaine intrathecally. The distribution of patients was uniform across all three groups, with each group comprising 33.3% of the total study population, thereby ensuring comparability and eliminating allocation bias at baseline.

Table 2. Baseline demographic, anthropometric, obstetric, operative, and haemodynamic characteristics of the study population

Variable	Group A (n=35) Mean ± SD / n (%)	Group B (n=35) Mean ± SD / n (%)	Group C (n=35) Mean ± SD / n (%)	Test statistic	P value
Age (years)	27.54 ± 3.64	26.60 ± 3.76	27.00 ± 3.86	F = 0.556	0.575
Weight (kg)	62.54 ± 8.16	61.89 ± 7.54	60.00 ± 7.03	F = 1.058	0.351
Height (cm)	158.71 ± 5.93	157.66 ± 4.75	157.54 ± 4.77	F = 0.544	0.582
BMI (kg/m²)	24.86 ± 3.11	24.91 ± 2.99	24.83 ± 3.00	F = 0.007	0.993
Gestational age (weeks)	38.50 ± 1.12	38.15 ± 1.48	38.53 ± 1.44	F = 0.836	0.436
Baseline pulse rate (per min)	93.94 ± 11.37	93.66 ± 13.03	91.54 ± 12.04	F = 0.406	0.667
Baseline SBP (mmHg)	120.97 ± 10.31	121.37 ± 7.90	118.11 ± 8.69	F = 1.357	0.262
Baseline DBP (mmHg)	76.29 ± 7.41	78.63 ± 6.54	75.83 ± 6.30	F = 1.724	0.184
Elective LSCS	6 (17.1%)	10 (28.6%)	13 (37.1%)	$\chi^2 = 3.525$	0.172
Emergency LSCS	29 (82.9%)	25 (71.4%)	22 (62.9%)	—	—
Total patients	35 (100%)	35 (100%)	35 (100%)	—	—

The three study groups were comparable with respect to baseline demographic, anthropometric, and obstetric characteristics. There were no statistically significant differences among the groups in terms of age, weight, height, body mass index, or gestational age ($p > 0.05$ for all). Baseline haemodynamic parameters, including pulse rate, systolic blood pressure, and diastolic blood pressure, were also similar across all groups, indicating homogeneity prior to intervention. The distribution of operative procedures (elective versus emergency caesarean section) did not differ significantly among the groups ($\chi^2 = 3.525$, $p = 0.172$). Additionally, pairwise comparison of gestational age using Tukey HSD analysis revealed no significant differences between any of the groups, further confirming baseline comparability.

Table 3. Comparison of heart rate (beats per minute) among the study groups at different time intervals

Time Interval	Group A (n=35) Mean ± SD	Group B (n=35) Mean ± SD	Group C (n=35) Mean ± SD	F value	P value
0 min	90.86 ± 12.70	92.89 ± 14.49	91.29 ± 12.31	0.23	0.795

3 min	92.11 ± 11.76	92.06 ± 13.58	91.17 ± 12.20	0.06	0.940
6 min	93.71 ± 24.10	96.77 ± 19.24	93.89 ± 18.07	0.242	0.785
9 min	93.29 ± 18.64	92.31 ± 12.96	91.29 ± 11.92	0.160	0.853
12 min	89.14 ± 14.07	93.89 ± 13.88	91.43 ± 12.26	1.092	0.339
15 min	89.31 ± 14.88	93.69 ± 14.64	91.69 ± 12.24	0.858	0.427
20 min	87.60 ± 15.49	92.66 ± 13.19	91.23 ± 11.72	1.295	0.278
25 min	90.54 ± 16.19	92.29 ± 12.67	91.31 ± 12.20	0.140	0.869
30 min	87.46 ± 16.48	93.51 ± 15.44	91.51 ± 12.06	1.526	0.222
35 min	88.17 ± 17.13	93.11 ± 14.81	91.31 ± 12.25	0.991	0.375
40 min	87.63 ± 17.54	93.54 ± 13.12	91.63 ± 12.46	1.506	0.227
45 min	87.63 ± 17.76	94.94 ± 14.14	91.51 ± 11.46	2.174	0.119
End of surgery	87.74 ± 18.96	92.43 ± 13.57	91.26 ± 12.18	0.902	0.409

Heart rate remained comparable among all three groups throughout the intraoperative period. There were no statistically significant differences in mean heart rate at any recorded time interval, including baseline, intraoperative measurements, and at the end of surgery ($p > 0.05$ for all comparisons). Although minor fluctuations in heart rate were observed within each group over time, these variations were not clinically or statistically significant. Overall, all three study drugs demonstrated similar haemodynamic stability with respect to heart rate.

Table 4. Comparison of systolic blood pressure (SBP, mmHg) among the study groups at different time intervals with pairwise analysis

Time Interval	Group A (n=35) Mean ± SD	Group B (n=35) Mean ± SD	Group C (n=35) Mean ± SD	F value	Overall P value	A vs B	A vs C	B vs C
0 min	115.37 ± 9.84	116.23 ± 9.54	112.86 ± 8.82	1.21	0.30	0.92	0.50	0.30
3 min	118.86 ± 12.81	121.57 ± 11.22	108.89 ± 8.17	13.13	0.00*	0.55	0.00*	0.00*
6 min	108.29 ± 21.28	112.51 ± 17.64	106.51 ± 14.85	1.01	0.37	0.59	0.91	0.35
9 min	110.83 ± 19.80	117.51 ± 11.64	109.14 ± 10.18	3.26	0.04*	0.14	0.88	0.04*
12 min	111.74 ± 14.60	121.26 ± 10.96	111.31 ± 8.23	8.27	0.00*	0.00*	0.99	0.00*
15 min	114.40 ± 19.12	120.74 ± 11.95	112.31 ± 8.10	3.52	0.03*	0.14	0.80	0.03*
20 min	112.86 ± 19.09	123.40 ± 12.10	108.23 ± 8.21	10.98	0.00*	0.00*	0.35	0.00*
25 min	116.11 ± 19.49	119.54 ± 8.24	108.31 ± 8.36	6.72	0.002*	0.52	0.04*	0.00*
30 min	113.20 ± 19.01	123.97 ± 10.05	108.23 ± 8.12	12.87	0.00*	0.00*	0.26	0.00*
35 min	113.34 ± 18.39	121.23 ± 10.66	108.11 ± 8.20	8.82	0.00*	0.04*	0.22	0.00*
40 min	112.69 ± 18.07	121.00 ± 12.16	116.37 ± 8.47	3.34	0.04*	0.03*	0.49	0.33
45 min	114.03 ± 17.93	121.49 ± 10.88	117.11 ± 8.69	2.86	0.06	0.05	0.59	0.35
End of surgery	113.43 ± 17.11	122.66 ± 12.10	115.74 ± 8.48	4.74	0.01*	0.01*	0.74	0.07

*Statistically significant ($p < 0.05$)

Systolic blood pressure (SBP) was comparable among the three groups at baseline (0 min) ($p = 0.30$). However, statistically significant differences were observed at several intraoperative time intervals, specifically at 3, 9, 12, 15, 20, 25, 30, 35, and 40 minutes, as well as at the end of surgery ($p < 0.05$). Pairwise analysis demonstrated that Group B and Group C differed significantly at most intraoperative time points, including 3, 9, 12, 15, 20, 25, 30, and 35 minutes. Significant differences between Group A and Group B were observed at 12, 20, 30, and 35 minutes, and at the end of surgery. In contrast, Group A and Group C showed significant differences only at 3 and 25 minutes. No statistically significant differences were noted among the groups at 6 minutes and 45 minutes. Overall, variations in SBP were more pronounced in Group B compared to Groups A and C; however, these changes remained within clinically acceptable limits.

Table 5. Comparison of diastolic blood pressure (DBP, mmHg) among the study groups at different time intervals with pairwise analysis

Time Interval	Group A (n=35) Mean ± SD	Group B (n=35) Mean ± SD	Group C (n=35) Mean ± SD	F value	Overall P value	A vs B	A vs C	B vs C
0 min	72.51 ± 7.00	73.49 ± 5.45	71.94 ± 5.64	5.78	0.563	0.78	0.92	0.54
3 min	76.74 ± 9.60	83.34 ± 6.89	69.89 ± 5.79	27.42	0.00*	0.00*	0.00*	0.00*
6 min	70.29 ± 14.86	78.03 ± 11.60	69.23 ± 7.99	5.78	0.004*	0.02*	0.93	0.01*
9 min	74.09 ± 11.57	80.31 ± 6.84	70.63 ± 6.30	11.48	0.00*	0.01*	0.21	0.00*
12 min	73.80 ± 11.31	83.40 ± 6.83	71.34 ± 5.98	20.28	0.00*	0.00*	0.44	0.00*
15 min	76.66 ± 12.11	83.26 ± 7.11	72.11 ± 6.02	14.13	0.00*	0.01*	0.08	0.00*

20 min	75.89 ± 15.14	83.26 ± 6.93	69.40 ± 5.73	16.27	0.00*	0.01*	0.02*	0.00*
25 min	77.54 ± 16.03	83.37 ± 6.90	69.34 ± 5.68	15.48	0.00*	0.06	0.01*	0.00*
30 min	76.34 ± 16.16	83.37 ± 6.99	69.43 ± 5.70	14.90	0.00*	0.02*	0.02*	0.00*
35 min	77.17 ± 16.50	83.46 ± 6.94	69.40 ± 5.76	14.73	0.00*	0.04*	0.01*	0.00*
40 min	77.60 ± 15.70	83.26 ± 6.95	74.83 ± 6.30	5.79	0.00*	0.07	0.52	0.003*
45 min	75.63 ± 15.62	83.26 ± 6.92	75.29 ± 6.16	6.47	0.00*	0.01*	0.99	0.01*
End of surgery	75.69 ± 15.78	83.40 ± 7.02	74.29 ± 6.16	7.53	0.00*	0.01*	0.84	0.00*

*Statistically significant ($p < 0.05$)

Diastolic blood pressure (DBP) was comparable among the three groups at baseline (0 min) ($p = 0.563$). However, statistically significant differences were observed at nearly all intraoperative time intervals from 3 minutes onward until the end of surgery ($p < 0.05$). Pairwise comparison revealed that Group B and Group C differed significantly at almost all time points, including 3, 6, 9, 12, 15, 20, 25, 30, 35, 40, and 45 minutes, as well as at the end of surgery. Significant differences between Group A and Group B were observed at 3, 6, 9, 12, 15, 20, 30, 35, and 45 minutes, and at the end of surgery. In contrast, Group A and Group C showed significant differences at 3, 20, 25, 30, and 35 minutes. No statistically significant differences were noted among the groups at baseline. Overall, DBP variations were more pronounced in Group B compared to Groups A and C during the intraoperative period.

Table 6. Comparison of mean arterial pressure (MAP, mmHg) among the study groups at different time intervals with pairwise analysis

Time Interval	Group A (n=35) Mean ± SD	Group B (n=35) Mean ± SD	Group C (n=35) Mean ± SD	F value	Overall P value	A vs B	A vs C	B vs C
0 min	84.94 ± 6.16	84.66 ± 7.13	83.23 ± 5.42	0.75	0.47	0.98	0.49	0.61
3 min	90.80 ± 9.00	96.00 ± 7.14	82.86 ± 5.74	27.89	0.00*	0.01*	0.00*	0.00*
6 min	83.26 ± 15.40	89.49 ± 13.17	81.63 ± 9.52	3.60	0.03*	0.11	0.86	0.03*
9 min	86.09 ± 13.16	92.69 ± 7.18	83.51 ± 6.65	8.74	0.00*	0.01*	0.49	0.00*
12 min	86.23 ± 10.48	96.00 ± 6.58	84.69 ± 5.76	21.23	0.00*	0.00*	0.69	0.00*
15 min	89.23 ± 11.14	95.71 ± 7.22	85.51 ± 5.73	13.38	0.00*	0.00*	0.15	0.00*
20 min	88.23 ± 12.58	96.63 ± 7.10	82.31 ± 5.65	22.59	0.00*	0.00*	0.01*	0.00*
25 min	90.40 ± 12.95	95.43 ± 5.85	82.37 ± 5.67	19.46	0.00*	0.05	0.00*	0.00*
30 min	88.66 ± 12.88	96.83 ± 6.59	82.29 ± 5.59	23.20	0.00*	0.00*	0.01*	0.00*
35 min	89.17 ± 13.59	96.11 ± 6.23	82.37 ± 5.64	19.42	0.00*	0.00*	0.00*	0.00*
40 min	89.31 ± 13.24	95.80 ± 7.19	88.63 ± 6.10	6.22	0.00*	0.01*	0.95	0.005*
45 min	88.43 ± 13.09	96.06 ± 6.59	89.26 ± 6.10	7.30	0.00*	0.00*	0.92	0.01*
End of surgery	88.23 ± 13.43	96.49 ± 6.61	88.06 ± 6.07	9.34	0.00*	0.00*	0.99	0.00*

*Statistically significant ($p < 0.05$)

Mean arterial pressure (MAP) was comparable among the three groups at baseline (0 min) ($p = 0.47$). However, statistically significant differences were observed at almost all intraoperative time intervals from 3 minutes onwards until the end of surgery ($p < 0.05$). Pairwise analysis revealed that Group B and Group C differed significantly at nearly all time points, including 3, 6, 9, 12, 15, 20, 25, 30, 35, 40, and 45 minutes, as well as at the end of surgery. Significant differences between Group A and Group B were observed at 3, 9, 12, 15, 20, 30, 35, 40, and 45 minutes, and at the end of surgery. In contrast, Group A and Group C showed significant differences at 3, 20, 25, 30, and 35 minutes. No statistically significant difference was noted among the groups at baseline. Overall, MAP fluctuations were more pronounced in Group B compared to Groups A and C during the intraoperative period.

Table 7. Comparison of sensory block, motor block, and duration of analgesia among the study groups

Parameter	Group A (n=35) Mean ± SD	Group B (n=35) Mean ± SD	Group C (n=35) Mean ± SD	F value	Overall P value	A vs B	A vs C	B vs C
Onset of sensory block (min)	3.03 ± 0.62	3.11 ± 0.83	3.91 ± 0.51	18.824	<0.05*	0.853	0.000*	0.000*
Onset of motor block (min)	6.86 ± 1.03	8.03 ± 0.89	10.40 ± 0.98	121.590	<0.05*	0.000*	0.000*	0.000*
Duration of sensory block (min)	150.00 ± 9.55	140.00 ± 10.99	105.43 ± 8.70	199.566	<0.05*	0.000*	0.000*	0.000*

Duration of motor block (min)	145.23 ± 8.08	140.00 ± 8.26	115.00 ± 11.31	104.792	<0.05*	0.055	0.000*	0.000*
Duration of analgesia (min)	135.00 ± 5.15	130.00 ± 8.06	110.00 ± 10.86	87.77	<0.05*	0.037*	0.000*	0.000*

Significant differences were observed among the three groups with respect to block characteristics and duration of analgesia. The onset of sensory block was comparable between Groups A and B ($p = 0.853$), but was significantly delayed in Group C compared to both Groups A and B ($p < 0.001$). The onset of motor block differed significantly among all three groups ($p < 0.001$), with the fastest onset observed in Group A, followed by Group B, and the slowest onset in Group C. The duration of sensory block was longest in Group A, followed by Group B, and shortest in Group C, with statistically significant differences between all groups ($p < 0.001$). Similarly, the duration of motor block was longest in Group A and shortest in Group C. No statistically significant difference was observed between Groups A and B ($p = 0.055$), whereas both Groups A and B showed significantly longer durations compared to Group C ($p < 0.001$). The duration of analgesia was also significantly different among the groups ($p < 0.001$), being longest in Group A, followed by Group B, and shortest in Group C. Pairwise comparisons revealed statistically significant differences between all groups. Overall, hyperbaric bupivacaine demonstrated the most prolonged sensory and motor blockade and analgesia, while ropivacaine showed a shorter duration of action with delayed onset, and levobupivacaine exhibited intermediate characteristics.

Table 8. Comparison of adverse effects among the study groups

Complication	Group A (n=35) n (%)	Group B (n=35) n (%)	Group C (n=35) n (%)	Total n (%)	χ^2 value	Overall P value	A vs B	B vs C	A vs C
Nausea	3 (8.6)	3 (8.6)	3 (8.6)	9 (8.6)	0.00	1.00	1.00	1.00	1.00
Vomiting	4 (11.4)	2 (5.7)	3 (8.6)	9 (8.6)	0.73	0.69	0.393	0.642	0.690
Hypotension	7 (20.0)	6 (17.1)	3 (8.6)	16 (15.2)	1.92	0.38	0.758	0.284	0.172

The incidence of adverse effects, including nausea, vomiting, and hypotension, was comparable among the three groups. Nausea was observed in 8.6% of patients in each group, with no statistically significant difference ($\chi^2 = 0.00$, $p = 1.00$). Vomiting occurred in 11.4% of patients in Group A, 5.7% in Group B, and 8.6% in Group C, with no statistically significant difference ($\chi^2 = 0.73$, $p = 0.69$). Hypotension was observed more frequently in Group A (20.0%) and Group B (17.1%) compared to Group C (8.6%); however, this difference did not reach statistical significance ($\chi^2 = 1.92$, $p = 0.38$). Pairwise comparisons between the groups also did not reveal any statistically significant differences for any of the adverse effects.

DISCUSSION

Hyperbaric bupivacaine has long been the most commonly used local anaesthetic for spinal anaesthesia. It is available as a racemic mixture containing dextrobupivacaine and levobupivacaine enantiomers. In recent years, the pure S(−)-enantiomers, namely levobupivacaine and ropivacaine, have been increasingly adopted in clinical practice due to their improved safety profile, particularly with respect to cardiovascular and central nervous system toxicity. Although the physicochemical properties of these enantiomers are similar, their pharmacodynamic behavior differs significantly. The S(−)-enantiomers exhibit lower affinity for sodium, potassium, and calcium ion channels involved in systemic toxicity, thereby reducing adverse effects compared to racemic bupivacaine.

In the present study, 105 parturient females undergoing caesarean section were equally divided into three groups receiving hyperbaric bupivacaine (Group A), hyperbaric levobupivacaine (Group B), and hyperbaric ropivacaine (Group C). The groups were comparable with respect to baseline characteristics including age, weight, height, body mass index, gestational age, and baseline pulse rate, thereby ensuring homogeneity and minimizing confounding factors.

The onset of sensory block was comparable between the bupivacaine and levobupivacaine groups but was significantly delayed in the ropivacaine group. These findings are consistent with those reported by Oraon P et al[9], who also observed a delayed onset with ropivacaine. Similarly, Choubey et al[10] and Alley et al[11] reported no significant difference between bupivacaine and levobupivacaine in terms of sensory onset. The delayed onset observed with ropivacaine may be attributed to its lower lipid solubility and reduced potency compared to bupivacaine.

The onset of motor block differed significantly among all three groups, with bupivacaine producing the fastest onset, followed by levobupivacaine and then ropivacaine. These findings are in agreement with Anand et al[12], who demonstrated earlier motor blockade with bupivacaine. Choubey et al[10] and Saring et al[13] also reported similar observations, attributing this difference to the higher potency and lipid solubility of bupivacaine, as well as the reduced affinity of levobupivacaine for motor fibers due to its S(−)-enantiomeric structure.

The duration of sensory block was longest in the bupivacaine group, followed by levobupivacaine, and shortest in the ropivacaine group. This difference was statistically significant among all groups. Similar findings have been reported by

Lunia et al[14], who observed a longer duration of analgesia with bupivacaine compared to ropivacaine. The prolonged duration of action of bupivacaine can be explained by its higher lipid solubility, stronger protein binding, and greater affinity for sodium channels, particularly due to the presence of the R(+) isomer.

The duration of motor block was also longest in the bupivacaine group and shortest in the ropivacaine group. No statistically significant difference was observed between bupivacaine and levobupivacaine, whereas both demonstrated significantly longer motor block compared to ropivacaine. These findings are consistent with those reported by Gautier P et al[7] and Luck JF et al[15]. The shorter duration of motor block observed with levobupivacaine compared to bupivacaine may be attributed to its lower affinity for Aα motor fibers and higher clearance rate due to hepatic metabolism.[16]

The duration of analgesia followed a similar pattern, being longest in the bupivacaine group, followed by levobupivacaine and ropivacaine, with statistically significant differences among all groups. While Luck JF et al[15] and Oraon P et al[9] reported no significant difference between bupivacaine and levobupivacaine, our study demonstrated a modest but statistically significant difference between these two agents. However, consistent with previous literature, ropivacaine provided significantly shorter analgesia compared to the other two drugs.

Haemodynamic parameters remained largely stable across all groups. Heart rate did not show any statistically significant difference at any time interval. Although minor fluctuations were observed, these were not clinically significant. A transient decrease in systolic blood pressure was noted at certain time points, particularly around 6 minutes, but was not consistently significant across all groups. Mean arterial pressure showed a decrease following spinal anaesthesia, particularly in the early intraoperative period, which is expected due to sympathetic blockade. Although some variations were noted, especially in the levobupivacaine group, these differences were not clinically significant. These findings are comparable with those reported by Kaur K et al.[17]

In contrast, diastolic blood pressure demonstrated statistically significant differences among the groups during the intraoperative period. A more pronounced decrease was observed particularly between levobupivacaine and ropivacaine groups at certain time intervals, suggesting subtle differences in haemodynamic response among the agents.

The incidence of hypotension was higher in the bupivacaine group and lowest in the ropivacaine group, although this difference did not reach statistical significance. Similar findings were reported by Whiteside et al[18], who observed a lower incidence of hypotension with ropivacaine compared to bupivacaine. Kaur K et al[17] also reported greater haemodynamic instability with bupivacaine compared to levobupivacaine. This is clinically relevant, as hypotension during caesarean section can adversely affect both maternal well-being and uteroplacental perfusion.

The incidence of nausea and vomiting was comparable among all three groups and did not differ significantly. Although vomiting was slightly more frequent in the bupivacaine group, this difference was not statistically significant. These findings are consistent with those reported by Oraon P et al[9]. The occurrence of nausea and vomiting is often related to hypotension and reduced cerebral perfusion following spinal anaesthesia.

Overall, the findings of the present study suggest that while hyperbaric bupivacaine provides faster onset and longer duration of sensory and motor block, ropivacaine offers advantages in terms of shorter duration of motor block and potentially improved haemodynamic stability. Levobupivacaine demonstrates an intermediate profile between the two, combining effective anaesthesia with a favorable safety margin.

CONCLUSION

The present study demonstrates that intrathecal administration of equipotent doses of hyperbaric bupivacaine, levobupivacaine, and ropivacaine provides effective and reliable spinal anaesthesia for caesarean section. Hyperbaric bupivacaine was associated with a faster onset and longer duration of sensory and motor blockade, as well as prolonged analgesia, while levobupivacaine exhibited a comparable but slightly shorter duration profile. Ropivacaine, although associated with a delayed onset and shorter duration of block, offered the advantage of significantly reduced duration of motor blockade, facilitating earlier postoperative mobilization. Additionally, ropivacaine demonstrated a trend toward improved haemodynamic stability with a lower incidence of hypotension, although not statistically significant. Therefore, while bupivacaine remains the most effective agent for prolonged surgical anaesthesia, ropivacaine may be considered a suitable alternative in situations where early ambulation and enhanced recovery are desirable, with levobupivacaine serving as an intermediate option balancing efficacy and safety.

Limitations

This study has certain limitations that should be considered while interpreting the findings. Being a single-centre study, the generalizability of the results to other clinical settings and populations may be limited. Additionally, the study included only ASA II parturients without significant obstetric or medical comorbidities, thereby restricting the applicability of the findings to a broader and higher-risk population. The sample size, although adequately powered for primary outcomes, may not have been sufficient to detect smaller differences in haemodynamic variables and adverse effects. Furthermore, long-term outcomes such as neonatal parameters and extended postoperative recovery profiles were not assessed. Future

multicentric studies with larger sample sizes and inclusion of patients with diverse clinical conditions are warranted to validate and extend the applicability of these findings.

REFERENCES

1. Ozden MGN, Koruk S, Collak Z, Panik N. Comparison of the effects of general and spinal anesthesia for cesarean delivery on maternal and fetal outcomes: A retrospective analysis of data. North Clin Istanb. 2023 Sep 11;10(5):575-582
2. Pınar Karaca Baysal, Birzat Emre Gölboyu, Mürsel Ekinci, Mahmut Güden, Ali Ahiskalioğlu, Erkan Cem Çelik. Effects of Anthropometric Measurements on Spinal Anaesthesia Block Characteristics and Hemodynamics. Medeniyet Med J. 2016; 31(1): 23-31
3. Sng BL, Siddiqui FJ, Leong WL, Assam PN, Chan ES, Tan KH, Sia AT. Hyperbaric versus isobaric bupivacaine for spinal anaesthesia for caesarean section. Cochrane Database Syst Rev. 2016 Sep 15;9(9):CD005143.
4. Foster RH, Markham A. Levobupivacaine: A review of its pharmacology and use as a local anaesthetic. Drugs 2000;59:551-79.
5. Shamill Eanga Helill, Sahile WA, Ritbano Ahmed Abdo, Getahun Dendir Wolde, Hassen Mosa Halil. The effects of isobaric and hyperbaric bupivacaine on maternal hemodynamic changes post spinal anesthesia for elective cesarean delivery: A prospective cohort study. 2019;14(12):e0226030.
6. Athar M, Ahmed SM, Ali S, Doley K, Varshney A, Siddiqi MMH. Levobupivacaína o ropivacaína: un ensayo aleatorio doble ciego controlado con dosis equipotentes en la anestesia espinal. Rev Colomb Anestesiol. 2016; 44:97-104
7. Gautier P, De Kock M, Huberty L, Demir T, Izydorczic M, Vanderick B. Comparison of the effects of intrathecal ropivacaine, levobupivacaine, and bupivacaine for Caesarean section. Br J Anaesth. 2003 Nov;91(5):684-9.
8. Sethi D. Randomised Control Trial Comparing Plain Levobupivacaine and Ropivacaine with Hyperbaric Bupivacaine in Caesarean Deliveries. Turk J Anaesthesiol Reanim. 2019; 47(6): 471-9.
9. Oraon P, Hembrom B, Kumar M, Ram B, Lakra L. Comparative study between intrathecal 0.5% isobaric levobupivacaine, 0.5% isobaric ropivacaine, and 0.5% hyperbaric bupivacaine in elective lower segment cesarean section: A randomized clinical study. Anesth Essays Res. 2022;16:238-43.
10. Choubey P, Choubey P, Achari S, Pandey AK. Comparative Evaluation of Hyperbaric Levobupivacaine and Hyperbaric Bupivacaine for Categories 3 And 4 Cesarean Section under Spinal Anesthesia. Int J Sci Stud 2024;11(12):36-41
11. Alley EA, Kopacz DJ, McDonald SB, Liu SS. Hyperbaric Spinal Levobupivacaine: A Comparison to Racemic Bupivacaine in Volunteers. Anesth & Analg. 2002;94(1):188–93
12. Anand R, Nag DS, Patel R, Sharma P, Uppalapati VK, Singh UK. Comparative efficacy of hyperbaric bupivacaine vs hyperbaric ropivacaine in spinal anesthesia for cesarean section: A meta-analysis. World J Methodol 2025; 15(2): 99300
13. Saring N, Namdeo A, Apo M, Sanyal R.Comparison of Equivalent Doses of Intrathecal Hyperbaric Levo-bupivacaine and Hyperbaric Bupivacaine for Caesarean Section: A Prospective Randomised Double-blind StudyJ Clin of Diagn Res.2024; 18(3):UC06-UC09.
14. Lunia A, Kumar M, Kumar D, Sharda ML. Comparison of hyperbaric 0.75% ropivacaine with 0.5% bupivacaine for elective caesarean section under spinal anaesthesia: a double blind randomised controlled study. *Int J Acad Med Pharm.* 2023;5(2):58–61.
15. Luck JF, Fettes PD, Wildsmith JA. Spinal anaesthesia for elective surgery: a comparison of hyperbaric solutions of racemic bupivacaine, levobupivacaine, and ropivacaine. Br J Anaesth. 2008 Nov;101(5):705-10.
16. Debbarma B, Yumnam AS, Laithangbam P, Singh TH, Singh TR, Singh NR. A comparative study of hyperbaric bupivacaine (0.5%) with hyperbaric levobupivacaine for spinal anesthesia in cesarean section: A randomized, controlled trial. J Med Soc. 2017 Jan 1;31(1):32-6.
17. Kaur K, Johar S, Kumar A, Jain M, Kumar P, Singh A.A comparative study of intrathecal bupivacaine and levobupivacaine for patients undergoing caesarean section. Int J Adv Med 2019;6:1792-7.
18. Whiteside JB, Burke D, Wildsmith JA. Comparison of ropivacaine 0.5% (in glucose 5%) with bupivacaine 0.5% (in glucose 8%) for spinal anaesthesia for elective surgery. Br J Anaesth. 2003 Mar;90(3):304-8.