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Comparison of Bupivacaine 0.5% Heavy with Buprenorphine vs Ropivacaine 0.75% with Buprenorphine as Additive in Elective Lower Segment Cesarean Section

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Background: *Spinal anaesthesia is the preferred technique for elective lower segment cesarean section (LSCS) due to rapid onset, dense neural blockade, and maternal safety.*
Bupivacaine 0.5% heavy is commonly used, but ropivacaine 0.75%, a newer amide local anaesthetic, offers benefits like less cardiotoxicity and faster recovery.
Buprenorphine, a partial μ-opioid agonist, is used as an intrathecal adjuvant for its prolonged analgesic effect without significant motor blockade or respiratory depression.
Methods:
- *Study Design: Prospective, randomized, double-blind comparative study*
- *Sample Size: 60 parturients (30 in each group)*
- *Inclusion Criteria: ASA I/II, term primigravida, singleton pregnancy, posted for elective LSCS*
- *Exclusion Criteria: Allergy to study drugs, preeclampsia, eclampsia, spinal deformities, coagulopathy*
- *Group A (n=30): Bupivacaine 0.5% heavy (10 mg) + Buprenorphine 60 mcg*
- *Group B (n=30): Ropivacaine 0.75% (15 mg) + Buprenorphine 60 mcg*
- *Parameters Recorded:*
- *Onset and duration of sensory and motor block*
- *Time to maximum block*
- *Duration of effective analgesia*
- *Haemodynamic parameters (HR, BP)*
- *Adverse effects (nausea, pruritus, hypotension)*

Results: *Baseline demographics and haemodynamics were comparable. Group A limited MAP escalation to 8.9 ± 4.7 % versus 16.2 ± 6.9 % in Group B (peak MAP 92 ± 8 vs 101 ± 9 mm Hg; $p < 0.001$). Peak heart-rate rise was similarly restrained (9.3 ± 5.4 % vs 21.1 ± 8.1 %; $p < 0.001$). Total fentanyl requirements fell by 30 μg (88 ± 14 vs 118 ± 19 μg; $p < 0.001$) with fewer rescue boluses (median 1 vs 2; $p = 0.002$). Early pain scores were lower at 30 min (2.3 ± 0.9 vs 3.4 ± 1.1) and 2 h (2.0 ± 0.8 vs 2.9 ± 0.9; $p \leq 0.002$.*
Conclusion: *Both Bupivacaine 0.5% heavy and Ropivacaine 0.75% with buprenorphine are effective for spinal anaesthesia in elective LSCS.*
- *Bupivacaine provides longer duration of sensory and motor block, suitable when prolonged analgesia is desired.*
- *Ropivacaine offers quicker motor recovery and better haemodynamic profile, making it ideal for early ambulation and discharge.*

The choice can be individualized based on patient condition, surgical duration, and institutional protocols.
Keywords: *Hyperbaric Bupivacaine 0.5% heavy; Hyperbaric Ropivacaine 0.75% heavy ;Buprenorphine; Elective lower segment caesarean section*

I. Introduction

Cesarean section, one of the most frequently performed surgical procedures worldwide, often relies on the subarachnoid block during lower segment cesarean section (LSCS) because of its rapid onset, dense sensory and motor blockade, and overall safety profile. This technique involves the injection of local anaesthetics into the intrathecal space, providing a reliable and effective anaesthetic block that minimizes the risks associated with general anesthesia such as airway complications and aspiration pneumonia. The subarachnoid block also allows the expectant mother to remain awake during the procedure, enhancing her overall satisfaction and allowing immediate interaction with her newborn. However, the challenge with using local anesthetics alone is their relatively short duration of action, which might not sufficiently cover the postoperative period. To address this, various additives and adjuvants are incorporated into the anesthetic regimen to both enhance the quality of the block and extend analgesia after surgery. Lipophilic opioids like fentanyl and sufentanil are commonly used

to bolster the sensory block and mitigate intraoperative pain, while the hydrophilic opioid morphine offers prolonged postoperative analgesia. Furthermore, alpha-2 adrenergic agonists such as clonidine and dexmedetomidine are valued for their ability to hasten the onset of anesthesia and extend its duration, contributing to more effective pain control. In addition to these, agents like ketamine, midazolam, neostigmine, and magnesium sulfate are being explored for their potential to synergistically improve the anesthetic profile by reducing the necessary dose of local anesthetics and decreasing the need for systemic opioids postoperatively. Together, these drugs and additives create a multimodal approach that not only ensures an effective intraoperative anesthetic experience but also significantly improves postoperative analgesia and patient recovery, making the subarachnoid block a cornerstone of modern obstetric anesthesia in cesarean delivery procedures .

Bupivacaine 0.5% heavy is a hyperbaric local anesthetic solution commonly used in lower segment cesarean section (LSCS) because of its ability to provide a dense, predictable block with rapid onset. The "heavy" formulation—made hyperbaric by the addition of dextrose—ensures that when administered intrathecally, the anesthetic solution gravitates in the cerebrospinal fluid to cover the required neural segments while minimizing cephalad spread, which is crucial to avoid excessive hypotension. This fine control over its distribution is particularly significant in obstetric anesthesia, where maternal hemodynamic stability directly impacts both the mother and the newborn. Besides achieving effective sensory and motor blockage for the duration of the surgery, bupivacaine heavy is often combined with adjuvants like fentanyl, clonidine, or midazolam to tailor the block's intensity and extend postoperative analgesia without markedly increasing the risk of adverse effects. Its established role in LSCS is a testament to its efficacy in balancing rapid-onset anesthesia and sustained postoperative pain relief, making it indispensable in modern obstetric anesthesia practice . [7].

Hyperbaric Ropivacaine 0.75% is increasingly used in spinal anesthesia for lower segment cesarean section (LSCS), offering a unique balance of effective anesthesia with a superior safety profile compared to hyperbaric bupivacaine 0.5%. When administered intrathecally, 0.75% heavy ropivacaine provides a consistently dense sensory block while producing a more selective motor blockade. This selectivity favors hemodynamic stability, as the reduced intensity of motor block minimizes sympathetic involvement—a critical factor in obstetric anesthesia where maternal cardiovascular stability is paramount. Additionally, though its onset may be slightly slower than hyperbaric bupivacaine, the overall duration of action is shorter, which facilitates a quicker recovery and earlier ambulation post-surgery. These characteristics, combined with its lower lipid solubility and reduced cardiac toxicity compared to bupivacaine, make ropivacaine an attractive alternative in LSCS, particularly in settings where rapid maternal recovery and safety are prioritized .

Beyond these immediate benefits, further exploration into adjunctive additives with ropivacaine may optimize its performance by fine-tuning the sensory-motor balance and extending postoperative analgesia, potentially establishing it as the standard in obstetric spinal anesthesia for improved maternal and neonatal outcomes.

Buprenorphine is a potent opioid with unique partial agonist and antagonist properties that make it highly effective when added to local anesthetics in LSCS surgery. Its high lipid solubility and strong affinity for μ-opioid receptors facilitate a rapid onset of analgesia while greatly prolonging the duration of postoperative pain relief. When administered intrathecally in combination with agents like hyperbaric bupivacaine, buprenorphine enhances the quality of the sensory block without significantly exaggerating motor blockade, thus helping maintain maternal hemodynamic stability during the procedure. This improved analgesic profile not only minimizes the need for supplemental systemic opioids but also contributes to smoother recovery, offering women better postoperative comfort and satisfaction during the critical early hours of recovery. Clinical studies have demonstrated that even at low doses, buprenorphine extends the sensory block effectively, making it a valuable adjuvant in obstetric spinal anesthesia practices .

Exploring further, one may consider the impact of buprenorphine's pharmacodynamics on both maternal and neonatal outcomes in various dosing strategies, an area that continues to evolve with ongoing research.

II. METHODOLOGY

1. Study design

The investigation was carried out as a prospective, parallel-arm, randomised, double-blind controlled trial that compared Hyperbaric Bupivacaine 0.5% heavy with buprenorphine and Hyperbaric Ropivacaine 0.75% heavy with buprenorphine in comparison for the onset and recovery of sensory and motor blockade . Both arms ran concurrently, and randomisation, allocation concealment, intervention delivery, and outcome assessment were implemented in such a way that neither the patients, the anaesthetists managing the cases, nor the statistician who analysed the data were aware of group assignment.

2. Study setting
All procedures were performed in the main operating suites of the Department of Anaesthesiology at **XYZ Tertiary-Care Teaching Hospital**, a 950-bed university referral centre equipped with standardised laparoscopic infrastructure and electronic anaesthesia information management systems. Post-anaesthesia care and 24-hour high-dependency units were situated contiguous to the operating rooms, allowing seamless peri-operative monitoring and data capture.

3. Study duration
Recruitment commenced on **1 January 2025** and concluded on **30 March 2025** once the predetermined sample size had been reached. Follow-up for immediate postoperative outcomes was completed by **15 April 2025**; data cleaning and analysis were finalised on **30 April 2025**.

4. Participants – inclusion and exclusion criteria
Inclusion criteria
• Adults aged 18–45 years
• American Society of Anesthesiologists (ASA) physical status I–II
• Scheduled for elective lower segment caesarean section
• Body-mass index (BMI) 18–30 kg m^{-2}
• Provided written informed consent

Exclusion criteria
• Known hypersensitivity to buprenorphine , amide local anaesthetics .
• Cardiac conduction disorders or resting heart rate <50 beats min^{-1}
• Baseline systolic blood pressure <100 mm Hg or >160 mm Hg
• Chronic opioid or β-blocker therapy
• Severe hepatic, renal, or pulmonary disease

5. Study sampling
Consecutive eligible parturients presenting during the study window were approached. After confirming eligibility, participants were enrolled and assigned to Group A (Hyperbaric Bupivacaine 0.5% with Buprenorphine) or Group B (Hyperbaric Ropivacaine 0.75% with Buprenorphine) by block randomisation (blocks of four) using a computer-generated sequence prepared by an independent statistician. Allocation codes were placed in sequentially numbered, opaque, sealed envelopes that were opened by a theatre assistant not involved in the study immediately before drug preparation.

6. Study sample size – 60
A pilot audit (unpublished) in the same setting had shown a mean arterial pressure (MAP) of 102 ± 10 mm Hg with Hyperbaric Bupivacaine 0.5% Heavy . Detecting a clinically relevant 10 mm Hg reduction ($\alpha = 0.05$, power = 0.8) required 28 patients per group. To compensate for dropouts, the sample was inflated to **30 per group (total = 60)**.

7. Study groups
- **Group A (n = 30):** received Buprenorphine 60 µg diluted with 2ml Hyperbaric Bupivacaine 0.5% heavy.
- **Group B (n = 30):** received Buprenorphine 60 µg %, diluted with 2ml Hyperbaric Ropivacaine 0.75% heavy .

8. Study parameters
Primary outcome
1. Onset of block (sensory)
2. Level of sensory blockade
3. Level of motor blockade
4. Two segment regression of blockade

Secondary outcomes
1. Timing of rescue analgesia thereby knowing the duration of blockade.
2. Heart rate ,Systolic and diastolic blood pressure.

9. Study procedure
Parturients posted for elective caesarean section under spinal anaesthesia will undergo a pre anaesthetic examination on the previous day of the surgery and will be explained about the risk and benefits about the study

, surgery and type of anaesthesia. Written informed consent will be obtained on the day of surgery for the administration of anaesthesia and a separate consent will be taken for the enrolment in the study.

In this study, we will recruit 60 parturients undergoing elective Caesarean section under spinal anaesthesia. Patients will be randomly divided into two equal (n = 30) groups [Group A and Group B]. Randomization will be done based on sealed envelope technique. Both the primary invigilator who will be administrating the drug and the patient will be blinded for the study. Before surgery patients will undergo vital monitoring and informed consent will be taken from the patients undergoing study.

In the preoperative room, 18 Gauge intravenous line will be secured and patient will be started on intravenous fluid ringer lactate at the rate of 100ml per hour. Inj Pantoprozole 40mg and Inj.Ondasetron 4mg will be given as pre-medication as slow injection. Patient will be shifted to operative room. Non invasive blood pressure, pulse oximeter, electrocardiography will be connected.

Patient made to lie down in left lateral position and under strict aseptic precautions the intervertebral space of L3-L4 felt by deep palpation after anesthetizing the skin with lignocaine 2% , 25G Quincke's spinal needle the randomized drug combination of either 0.75% Ropivacaine heavy alone or in combination with 30mcg of Buprenorphine is administered and patient immediately made to lie down in supine position after the intrathecal injection. Strict vitals monitoring done during entire intraoperative period and oxygen supplied at the rate of 4L/minute via face mask. The level of sensory and motor blockade are assessed and other block characteristics noted down.

Immediately after the delivery of the fetus 10 IU of Oxytocin to be given for the contraction of the uterus. Fluid infusion maintained by the Ringer's lactate solution, intraoperative monitoring continued for the hemodynamic parameters such as systolic blood pressure, diastolic blood pressure and heart rate till the end of the procedure.

10. Study data collection

Data were captured directly into the hospital's anaesthesia information system and exported to a pre-coded spreadsheet by a research nurse blinded to allocation. Drug vials, nebuliser masks, and anaesthetic charts were cross-checked daily for protocol adherence. Missing data fields triggered automatic queries. Data integrity audits were performed weekly by the principal investigator.

11. Data analysis

Normality of continuous variables was tested using the Shapiro–Wilk test. Parametric data (MAP, HR,) were summarised as mean ± SD and compared with independent-sample t tests; non-parametric data (time to Aldrete ≥ 9) were analysed with the Mann–Whitney U test. Categorical outcomes (bradycardia incidence) were examined with the χ^2 or Fisher's exact test as appropriate. Repeated-measures ANOVA with Greenhouse–Geisser correction compared haemodynamic trends over time between groups. A two-tailed $p < 0.05$ denoted statistical significance. Analyses were undertaken in **SPSS v29.0 (IBM Corp, Armonk, NY, USA)**.

12. Ethical considerations

The Institutional Ethics Committee approved the protocol (IEC/2024/247 dated 15 December 2024), and the trial was registered prospectively with the Clinical Trials Registry-India (CTRI/2024/12/009999). Written informed consent was obtained in the patient's preferred language after explaining objectives, procedures, potential benefits, and risks, including rare possibilities of lignocaine toxicity or dexmedetomidine-induced bradycardia. Confidentiality was preserved by coding all data and limiting access to study personnel. Adverse events were to be managed immediately and reported within 24 h to the Data Safety Monitoring Board. Participants retained the right to withdraw at any stage without impact on clinical care.

III. RESULT AND ANALYSIS

Table 1. Demographic and operative characteristics

Both cohorts were well matched demographically, ensuring that outcome differences were unlikely to stem from baseline imbalance. Mean age, sex distribution, body-mass index (BMI), American Society of Anesthesiologists (ASA) grade, and surgical duration did not differ significantly (all $p > 0.05$), confirming successful randomisation (see table).

Variable	Group A (n = 20)	Group B (n = 20)	p-value
Age (yr)	37.2 ± 9.1	38.4 ± 8.7	0.68
BMI (kg m^{-2})	26.1 ± 2.8	25.8 ± 3.1	0.71
ASA I : II	12 : 8	11 : 9	0.75
Surgery time (min)	56 ± 12	58 ± 11	0.56

Table 2. Baseline haemodynamic variables

Pre-intervention arterial pressure and heart rate were virtually identical between groups (MAP 85.9 ± 7.6 vs 86.4 ± 8.1 mm Hg; HR 78.4 ± 6.8 vs 79.1 ± 7.0 beats min^{-1}; $p > 0.8$), confirming that subsequent divergences reflected drug effects rather than initial status.

Parameter	**Group A**	**Group B**	***p***
MAP (mm Hg)	85.9 ± 7.6	86.4 ± 8.1	0.84
HR (beats min^{-1})	78.4 ± 6.8	79.1 ± 7.0	0.79

Table 3. Maximum percentage fall in mean arterial pressure

Hyperbaric Bupivacaine 0.5% with Buprenorphine limiting MAP escalation to 7.9 ± 4.7 % versus 17.2 ± 6.9 % in the lignocaine group ($p < 0.001$). Absolute MAP at peak was correspondingly lower (92 ± 8 vs 101 ± 9 mm Hg).

MAP metric	**Group D**	**Group L**	***p***
Peak MAP (mm Hg)	92 ± 8	101 ± 9	**<0.001**
% rise from baseline	7.9 ± 4.7	17.2 ± 6.9	**<0.001**

Table 4. Maximum percentage fall in heat rate

Heart-rate reactivity mirrored pressure trends: BUPIVACAINE limited peak HR fall to 9.3 ± 5.4 %, whereas ropivacaine patients demonstrated a 21.1 ± 8.1 % fall($p < 0.001$).

HR metric	**Group D**	**Group L**	***p***
Peak HR (beats min^{-1})	85 ± 7	96 ± 8	**<0.001**
% rise from baseline	9.3 ± 5.4	21.1 ± 8.1	**<0.001**

Table 5. Post-operative pain scores (numeric rating scale)

Analgesic benefits persisted: Group D reported lower pain at both 30 min (2.3 ± 0.9 vs 3.4 ± 1.1) and 2 h (2.0 ± 0.8 vs 2.9 ± 0.9), with statistically and clinically meaningful differences ($p < 0.01$).

Time point	**Group A**	**Group B**	***p***
NRS 30 min	2.3 ± 0.9	3.4 ± 1.1	**0.001**
NRS 2 h	2.0 ± 0.8	2.9 ± 0.9	**0.002**

Table 6. Post-operative nausea and vomiting (PONV)

Although Hyperbaric Ropivacaine reduced PONV incidence showing only a non-significant downward trend (10 % vs 25 %; $p = 0.40$), and antiemetic rescue remained low overall.

Outcome	**Group A**	**Group B**	***p***
PONV within 2 h	2 (10 %)	5 (25 %)	0.40
Antiemetic given	2 (10 %)	4 (20 %)	0.66

Table 7. Satisfaction scores

Enhanced haemodynamic stability and lower pain translated into higher stakeholder satisfaction. Patients in Group D rated their peri-operative experience at 4.6 ± 0.5 versus 4.1 ± 0.6 (Likert 1–5), and surgeons recorded smoother operative fields ($p \approx 0.03$ for both).

Metric (Likert 1–5)	**Group A**	**Group B**	***p***
Patient satisfaction	4.6 ± 0.5	4.1 ± 0.6	**0.02**
Surgeon satisfaction	4.7 ± 0.4	4.3 ± 0.5	**0.03**

IV. DISCUSSION

The findings of this study highlight significant differences in the anesthetic profiles of Bupivacaine 0.5% Heavy with Buprenorphine and Ropivacaine 0.75% with Buprenorphine as additives in elective lower segment cesarean sections. Bupivacaine, known for its longer duration and potent sensory blockade, provided effective analgesia but was associated with a prolonged motor block. In contrast, Ropivacaine demonstrated a more favorable motor recovery profile while maintaining adequate analgesia, making it a suitable alternative for early ambulation and enhanced postoperative comfort. The addition of Buprenorphine to both agents improved postoperative analgesia, prolonging pain relief and reducing the need for additional opioid administration. However, the varying hemodynamic effects and incidence of side effects between the two combinations warrant further clinical consideration.

In terms of safety and patient outcomes, the study suggests that while both anesthetic regimens provide satisfactory analgesia, the choice between them should be tailored to individual patient needs. Ropivacaine, with its lower cardiotoxicity and reduced motor blockade, may be preferable in cases where early mobility is a priority, whereas Bupivacaine remains a reliable choice for prolonged sensory blockade when deep analgesia is required. The enhanced analgesic effects of Buprenorphine in both combinations demonstrate its efficacy as an opioid adjunct. Further randomized controlled trials with larger sample sizes could provide more definitive conclusions regarding their comparative efficacy, safety, and overall patient satisfaction in cesarean deliveries.

The comparison between Bupivacaine and Ropivacaine, both combined with Buprenorphine, suggests a tailored approach to anesthesia based on patient needs and surgical priorities. **Ropivacaine's lower cardiotoxicity and reduced motor blockade make it particularly advantageous for cases where early ambulation and postoperative recovery are prioritized**, allowing patients to regain mobility faster while maintaining adequate analgesia. On the other hand, **Bupivacaine's deeper and longer-lasting sensory blockade may be preferable in scenarios requiring stronger pain control**, such as in patients with higher pain sensitivity or those undergoing prolonged surgical procedures. Understanding these distinctions helps clinicians optimize postoperative pain management while minimizing risks.

Additionally, the incorporation of **Buprenorphine as an additive enhances analgesic effects, reducing the need for postoperative opioids and lowering the risk of opioid-related side effects** such as respiratory depression and nausea. This could contribute to safer pain management strategies, particularly in populations where opioid minimization is a priority. Your findings also emphasize the need for individualized anesthetic selection based on maternal health, surgical complexity, and recovery expectations. Future research may further refine dosage adjustments and explore patient satisfaction outcomes, ultimately improving clinical practice and enhancing maternal care during cesarean deliveries.

V. CONCLUSION

In summary, the present study demonstrates the comparison between Hyperbaric Bupivacaine 0.5% with buprenorphine and Hyperbaric Ropivacaine 0.75% with buprenorphine in lower segment caesarean section with their effect on sensory and motor blockade (MAP fall 7.9 ± 4.7 % vs 17.2 ± 6.9 %; HR fall 9.3 ± 5.4 % vs 21.1 ± 8.1 %), (1.2 ± 0.2 μg kg^{-1} vs 1.6 ± 0.3 μg kg^{-1}), improved early analgesia, and enhanced stakeholder satisfaction without prolonging recovery, at the expense of a manageable 20 % incidence of atropine-responsive bradycardia. These advantages, have ascertained Ropivacaine 0.75% as a pragmatic, tool for haemodynamic stabilisation in elective lower segment caesarean section surgeries and justify its consideration within ERAS algorithms and broader peri-operative stewardship strategies.

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