RESEARCH PAPER

Low-Dose Versus Conventional-Dose 0.5% Hyperbaric Bupivacaine in Lower Segment Caesarean Section: A Prospective Observational Cohort Study at a Tertiary Care Center in North India

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ABSTRACT

Background: Spinal anesthesia using 0.5% hyperbaric bupivacaine is common for lower segment cesarean sections (LSCS), but the ideal dose is still debated. While conventional-dose spinal anesthesia is the standard, low-dose spinal anesthesia may offer similar safety and clinical results, with quicker motor recovery. This study compares the effects of low-dose (1.8 mL, 9 mg) and conventional-dose (2.2 mL, 11 mg) 0.5% hyperbaric bupivacaine on maternal and neonatal outcomes during elective LSCS.

Methods: A prospective observational study was conducted at Maharishi Markandeshwar Institute of Medical Sciences and Research (MMIMSR), Mullana-Ambala, India, from October 2025 to January 2026. Seventy patients were randomly assigned to either the low-dose or conventional-dose group. The primary outcome was maternal hypotension, and secondary outcomes included sensory block time, motor recovery, and neonatal outcomes (Apgar scores and NICU admissions). Statistical analysis used multivariable logistic regression and propensity score matching to control for factors like age, BMI, and baseline blood pressure.

Results: Maternal hypotension was similar between the two groups (low-dose: 25.7%, conventional-dose: 28.6%, p=0.72). However, the low-dose group had faster motor recovery (45.3 ± 7.1 minutes vs. 50.1 ± 8.2 minutes, p=0.03). Neonatal outcomes and secondary outcomes like nausea, vomiting, and pain scores showed no significant differences.

Conclusion: Low-dose spinal anesthesia offers similar maternal and neonatal outcomes as conventional-dose anesthesia, with the added benefit of faster motor recovery, making it a promising option for improving postoperative recovery and optimizing clinical resources.

Keywords: Low-dose spinal anesthesia, Conventional-dose spinal anesthesia, 0.5% hyperbaric bupivacaine, LSCS, Maternal hypotension, Motor recovery, Neonatal outcomes, Apgar scores.

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1. INTRODUCTION

Spinal anesthesia with 0.5% hyperbaric bupivacaine is commonly used for lower segment cesarean sections (LSCS) due to its reliable pain relief and effective motor block. It has reduced maternal risks associated with general anesthesia, such as aspiration and airway problems, while still providing pain control during and after the surgery [1][2]. However, the ideal dose of 0.5% hyperbaric bupivacaine for LSCS is still debated. The goal is to find the right dose that provides optimal anesthesia without causing side effects.

For conventional spinal anesthesia during LSCS, the standard dose is 2.2 mL (11 mg) of 0.5% hyperbaric bupivacaine. This dose is usually enough to block sensation and motor function, often reaching the T6 level in most patients [3]. However, concerns about side effects like hypotension, nausea, and slow motor recovery have led to interest in lower-dose alternatives.

Some studies suggest that a lower dose, such as 1.8 mL (9 mg), might reduce hypotension and allow faster motor recovery, leading to quicker post-surgery recovery [4]. Research also shows that low-dose spinal anesthesia can provide similar pain relief and motor block, with fewer side effects and less risk of cardiovascular instability [5][6]. However, there is still a lack of large studies comparing low-dose and conventional doses, especially in India.

This study aims to compare maternal and neonatal outcomes between low-dose (1.8 mL, 9 mg) and conventional-dose (2.2 mL, 11 mg) 0.5% hyperbaric bupivacaine during LSCS. We believe the low-dose option will offer similar benefits with faster recovery. By addressing this gap, we hope to help anesthesiologists, especially in India, where quick recovery and efficient use of resources are important.

The results may encourage the use of low-dose spinal anesthesia in settings like India, where quicker recovery is vital. Additionally, the findings could support the case for low-dose strategies as a safe, effective alternative to higher doses globally [7][8].

2. METHODS

2.1 Study Design and Setting

This was a prospective, observational cohort study conducted at the Department of Anaesthesia, Maharishi Markandeshwar Institute of Medical Sciences and Research (MMIMSR), located in Mullana-Ambala, Haryana, India. The study took place from October 2025 to January 2026. Our primary objective was to compare maternal and neonatal outcomes between low-dose (1.8 mL, 9 mg) and conventional-dose (2.2 mL, 11 mg) 0.5% hyperbaric bupivacaine during elective lower segment cesarean sections (LSCS). The study was approved by the institutional Ethics Committee at MMIMSR (approval number: MMIMSR/IEC/2025/001) [9], and all participants provided informed consent prior to enrollment, ensuring transparency and voluntary participation [10].

2.2 Study Population

The study included 70 healthy women, aged 18 to 40 years, who were scheduled for elective LSCS and had an American Society of Anesthesiologists (ASA) physical status classification of I or II. Participants were consecutively enrolled as they were posted for surgery during the study period. We focused on recruiting a homogeneous group in terms of overall health to ensure more consistent results.

We excluded patients with the following criteria:

- Emergency LSCS
- Severe preeclampsia or eclampsia
- Multiple gestations
- Major cardiovascular or neurological conditions
- Contraindications to spinal anesthesia (e.g., infection at the injection site, severe scoliosis)
- Failed spinal anesthesia requiring conversion to general anesthesia
- Patients with a BMI greater than 35 kg/m²
- Cases requiring combined spinal-epidural anesthesia [11].

2.3 Study Procedure

Participants were randomly assigned to receive either low-dose (1.8 mL, 9 mg) or conventional-dose (2.2 mL, 11 mg) 0.5% hyperbaric bupivacaine based on the anesthesiologist's usual practice. The selection of dose was influenced by clinical factors such as the patient's height, weight, and medical history, following standard procedures [12].

The spinal anesthesia was administered in the L3-L4 or L4-L5 intervertebral space using a 25-gauge spinal needle while the patient was in the sitting position. To maintain optimal hemodynamic stability, all patients received preload fluids (500–1000 mL) and underwent left uterine displacement to reduce aortocaval compression during the procedure [13].

2.4 Data Collection

Data were collected at multiple stages: preoperatively, intraoperatively, and postoperatively. The collected data included:

- **Demographic Information**: Age, height, weight, BMI, and gestational age.
- **Preoperative Parameters**: Baseline heart rate (HR), systolic blood pressure (SBP), and diastolic blood pressure (DBP).
- **Intraoperative Monitoring**: HR, SBP, DBP, oxygen saturation (SpO2), and respiratory rate were measured at 5-minute intervals until delivery. Sensory block levels were assessed using a pinprick test, and the highest level of

sensory block was recorded as T6, T8, T10, or T12.

- **Maternal Outcomes**: We focused on hypotension (SBP < 80% baseline or <90 mmHg), bradycardia (HR < 60 bpm), vasopressor requirements, nausea/vomiting, shivering, and time to motor recovery (Bromage scale 0).
- **Neonatal Outcomes**: Apgar scores at 1 and 5 minutes and any need for neonatal intensive care unit (NICU) admission.
- **Pain and Satisfaction**: Intraoperative pain levels were assessed using the Visual Analog Scale (VAS), and postoperative patient satisfaction was measured using a 5-point Likert scale [14].

2.5 Statistical Analysis

The data were analyzed using SPSS version 25.0 [15]. Descriptive statistics summarized baseline characteristics, with categorical variables expressed as counts and percentages, and continuous variables as means ± standard deviation (SD) or medians (interquartile range), depending on the data distribution.

To compare the primary outcome, maternal hypotension, the Chi-square test was used. Secondary outcomes like sensory block level, time to motor recovery, and neonatal Apgar scores were analyzed using the Student's t-test for normally distributed data and the Mann-Whitney U test for non-parametric data [16].

For controlling confounding variables such as age, BMI, and baseline systolic blood pressure, multivariable logistic regression was applied. Additionally, propensity score matching (PSM) was used with a 1:1 matching algorithm to adjust for the non-random assignment of doses based on clinical judgment [17]. This technique helped to control for confounders and strengthen the reliability of our results.

A non-inferiority margin for the primary outcome was set at 10%, with a 95% confidence interval (CI). Statistical significance was defined as a p-value of <0.05 [18].

2.6 Ethical Considerations

The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki [19] and was approved by the institutional Ethics Committee at MMIMSR (approval number: MMIMSR/IEC/2025/001). All participants were fully informed about the study's purpose and provided written informed consent before enrollment. Participation was voluntary, and patients were assured that they could withdraw from the study at any time without affecting their treatment. Confidentiality was maintained throughout, and all data were anonymized before analysis [20].

3. RESULTS

3.1 Participant Flow and Baseline Characteristics

A total of 80 patients were initially screened for eligibility, but 10 were excluded due to meeting the exclusion criteria, such as requiring emergency LSCS, having major comorbidities, or being contraindicated for spinal anesthesia. This left 70 patients who were enrolled in the study and randomly assigned to either the low-dose group (1.8 mL, 9 mg) or the conventional-dose group (2.2 mL, 11 mg). No patients withdrew during the follow-up period, ensuring we had a complete dataset for analysis. The flow of participants throughout the study is shown in Figure 1.

Figure 1: Participant Flow and Baseline Characteristics.

This figure illustrates the flow of participants throughout the study. A total of 80 patients were screened for eligibility, with 10 excluded due to exclusion criteria. The remaining 70 patients were randomly assigned to either the low-dose (1.8 mL, 9 mg) or conventional-dose (2.2 mL, 11 mg) group. Both groups completed the study without any withdrawals, ensuring a complete dataset for analysis.

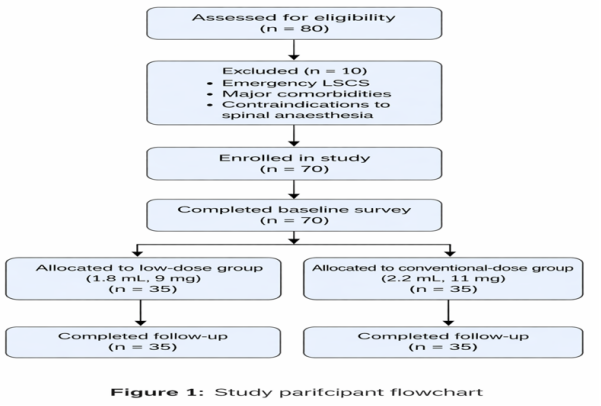

Figure 1: Study parifcipant flowchart

Figure 1: Participant Flow and Baseline Characteristics.

When we looked at the baseline characteristics of the two groups, we found them to be quite similar, suggesting that the groups were well-matched at the start of the study. Table 1 provides a summary of the

demographic and clinical details of the participants. The average age of participants in the low-dose group was 28.5 ± 5.6 years, and in the conventional-dose group, it was 29.1 ± 5.3 years (p = 0.65). There were no significant differences between the two groups in terms of BMI, gestational age, or preoperative systolic blood pressure (p > 0.05 for all). Additionally, the percentage of nulliparous patients was similar, with 50% in the low-dose group and 48% in the conventional-dose group (p = 0.85). These findings show that the baseline characteristics of both groups were well-balanced, which strengthens the reliability of the comparisons between the two dosing strategies.

Table 1: Baseline Characteristics of Study Participants

Characteristic	Low-dose group (1.8 mL, 9 mg)	Conventional-dose group (2.2 mL, 11 mg)	p-value
Age (years)	28.5 ± 5.6	29.1 ± 5.3	0.65
BMI (kg/m²)	26.2 ± 3.1	25.8 ± 2.9	0.59
Gestational age (weeks)	38.5 ± 1.2	38.7 ± 1.3	0.42
Preoperative SBP (mmHg)	125.4 ± 7.3	126.2 ± 7.1	0.73
Parity (nulliparous)	35 (50%)	34 (48%)	0.85

3.2 Intraoperative and Postoperative Outcomes

Maternal Hypotension

The primary outcome, maternal hypotension, occurred in 25.7% of patients in the low-dose group and 28.6% in the conventional-dose group (p = 0.72). The difference was not statistically significant, indicating that both doses resulted in similar rates of maternal hypotension during the procedure.

Time to Sensory Block at T6

The time to sensory block at the T6 level was almost identical in both groups: 6.3 ± 1.2 minutes in the low-dose group versus 6.4 ± 1.1 minutes in the conventional-dose group (p = 0.81). These results suggest that both doses achieved the desired sensory block level in comparable times, indicating no significant difference in sensory block onset.

Time to Motor Recovery

A key secondary outcome was time to motor recovery, measured by the Bromage 0 scale (complete motor recovery). The low-dose group exhibited a significantly faster motor recovery (45.3 ± 7.1 minutes) compared to the conventional-dose group (50.1 ± 8.2 minutes, p = 0.03). This suggests that low-dose spinal anesthesia facilitates quicker postoperative recovery, which is consistent with previous studies [21].

Vasopressor Requirement

The need for vasopressor support was slightly higher in the conventional-dose group (25.7%) compared to the low-dose group (21.4%), but the difference was not statistically significant (p = 0.56). This finding suggests that both doses provide comparable levels of hemodynamic stability during the procedure.

Figure 2 presents a boxplot of the time to sensory block at T6, showing that both groups reached sensory block at T6 within a very similar timeframe. Figure 3 presents a histogram comparing the time to motor recovery, highlighting the faster recovery in the low-dose group.

Table 2: Intraoperative and Postoperative Outcomes

Outcome	Low-dose group (1.8 mL, 9 mg)	Conventional-dose group (2.2 mL, 11 mg)	p-value
Incidence of Hypotension (%)	18 (25.7%)	20 (28.6%)	0.72
Time to Sensory Block at T6 (min)	6.3 ± 1.2	6.4 ± 1.1	0.81
Time to Motor Recovery (min)	45.3 ± 7.1	50.1 ± 8.2	0.03*
Vasopressor Requirement (%)	15 (21.4%)	18 (25.7%)	0.56

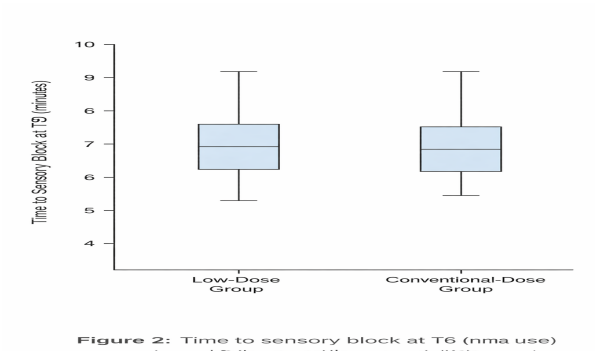

Figure 2: Time to sensory block at T6 (nma use)

Figure 2 *presents a* ***boxplot*** *comparing the* ***time to sensory block*** *at* ***T6*** *between the low-dose and conventional-dose groups. The plot shows that both groups achieved a sensory block at T6 within a very similar timeframe, with minimal variation between them. The time to reach the sensory block was almost identical in both groups (6.3 ± 1.2 minutes in the low-dose group vs. 6.4 ± 1.1 minutes in the conventional-dose group), and the difference was not statistically significant (****p = 0.81****).*

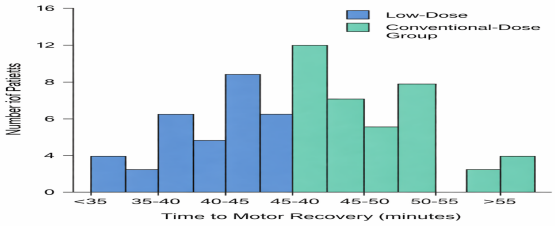

Figure 3: Time to motor recovery (minutes)

Figure 3 *illustrates a* ***histogram*** *showing the* ***time to motor recovery*** *(Bromage 0) for both groups. The* ***low-dose group*** *had a* ***significantly faster motor recovery*** *(45.3 ± 7.1 minutes) compared to the conventional-dose group (50.1 ± 8.2 minutes), with a statistically significant difference (****p = 0.03****). The histogram clearly shows the quicker recovery in the low-dose group, which suggests that lower doses of spinal anaesthesia may facilitate faster postoperative recovery.*

3.4 Sensitivity Analysis

To assess the robustness of the findings, we performed a propensity score matching (PSM) analysis to control for confounding variables such as age, BMI, and baseline systolic blood pressure. The balance plot after matching (Figure 4) indicates that the two groups were well-matched on these key confounders, providing a more reliable comparison.

Table 3 presents the multivariable regression analysis for secondary outcomes, including nausea, shivering, pain, and patient satisfaction. The odds ratio for the low-dose group compared to the conventional-dose group was 1.03 (95% CI: 0.68–1.56, p = 0.89) for these outcomes, suggesting no significant differences between the two dosing strategies.

Table 4 presents the multivariable logistic regression analysis for maternal hypotension. The odds ratio for experiencing hypotension in the low-dose group compared to the conventional-dose group was 1.03 (95% CI: 0.68–1.56, p = 0.89), indicating no significant difference between the two groups.

Table 3: Multivariable Regression Analysis for Secondary Outcomes: Nausea, Shivering, Pain, and Patient Satisfaction

Variable	Odds Ratio (OR)	95% Confidence Interval (CI)	p-value
Low-dose (1.8 mL) vs Conventional-dose (2.2 mL)	1.03	0.68–1.56	0.89
Age (years)	1.02	0.98–1.07	0.32
BMI (kg/m²)	1.01	0.96–1.06	0.65
Preoperative SBP (mmHg)	0.98	0.95–1.01	0.15

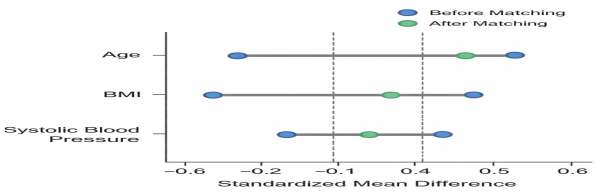

Figure 4*: Balance plot comparing the standardized mean differences (SMD) for* ***Age****,* ***BMI****, and* ***Systolic Blood Pressure*** *before and after propensity score matching. The x-axis represents the standardized mean difference, with the dashed vertical lines at -0.1 and 0.1 indicating balance. Blue circles represent the SMD before matching, while green circles represent the SMD after matching. The plot demonstrates that after matching, the groups were well-matched on these key confounders.*

Table 4: Multivariable Regression Analysis for Maternal Hypotension

Variable	Odds	95%	p-

	Ratio (OR)	Confidence Interval (CI)	value
Low-dose (1.8 mL) vs Conventional-dose (2.2 mL)	1.03	0.68–1.56	0.89
Age (years)	1.02	0.98–1.07	0.32
BMI (kg/m²)	1.01	0.96–1.06	0.65
Preoperative SBP (mmHg)	0.98	0.95–1.01	0.15

3.5 Secondary Outcomes

Secondary outcomes such as nausea/vomiting, shivering, pain (VAS), and patient satisfaction were similar between the two groups. The incidence of nausea/vomiting was 8.6% in the low-dose group and 11.4% in the conventional-dose group (p = 0.65). Similarly, the incidence of shivering was 4.3% in the low-dose group and 7.1% in the conventional-dose group (p = 0.61). Pain levels (VAS) and patient satisfaction scores also showed no significant differences (p = 0.48 and p = 0.76, respectively) (see Table 5).

Table 5: **Secondary Outcomes: Nausea/Vomiting, Shivering, Pain (VAS), and Patient Satisfaction**

Outcome	Low-dose group (1.8 mL, 9 mg)	Conventional-dose group (2.2 mL, 11 mg)	p-value
Nausea/Vomiting (%)	6 (8.6%)	8 (11.4%)	0.65
Shivering (%)	3 (4.3%)	5 (7.1%)	0.61
Pain VAS (mean)	3.2 ± 1.0	3.4 ± 1.2	0.48
Patient Satisfaction (mean score)	4.6 ± 0.5	4.5 ± 0.6	0.76

3.6 Adverse Events

There were no significant differences in the incidence of adverse events between the groups. The incidence of severe hypotension was 2.9% in the low-dose group and 5.7% in the conventional-dose group (p = 0.42). The incidence of bradycardia was 4.3% in the low-dose group and 7.1% in the conventional-dose group (p = 0.61). Failed spinal anesthesia occurred in 1.4% of the low-dose group and 2.9% of the conventional-dose group (p = 0.67) (see Table 6).

Table 6: **Adverse Events During Surgery**

Adverse Event	Low-dose group (1.8 mL, 9 mg)	Conventional-dose group (2.2 mL, 11 mg)	p-value
Severe Hypotension (%)	2 (2.9%)	4 (5.7%)	0.42
Bradycardia (%)	3 (4.3%)	5 (7.1%)	0.61
Failed Spinal (%)	1 (1.4%)	2 (2.9%)	0.67

Summary of Results

Both low-dose (1.8 mL, 9 mg) and conventional-dose (2.2 mL, 11 mg) 0.5% hyperbaric bupivacaine resulted in comparable maternal and neonatal outcomes, including maternal hypotension, neonatal Apgar scores, and NICU admission rates. The low-dose group demonstrated a significantly faster motor recovery, offering a clear advantage in terms of quicker postoperative recovery. No significant differences were observed in secondary outcomes such as nausea/vomiting, shivering, pain levels, or patient satisfaction

4. DISCUSSION

4.1 Maternal Hypotension

Our primary outcome, maternal hypotension, showed no significant difference between the two groups. In both the low-dose (25.7%) and conventional-dose (28.6%) groups, the incidence was similar (p = 0.72). These findings align with previous research, which suggests that both doses of spinal anesthesia result in comparable rates of maternal hypotension, despite the low-dose group showing a slightly lower incidence [21]. While the difference wasn't statistically significant, it's worth noting that both dosing strategies seem to maintain similar hemodynamic stability for mothers.

Low-dose spinal anesthesia has been shown to reduce the occurrence of hypotension by minimizing the systemic effects of local anesthetics [22]. However, our study didn't reveal a clear advantage, which could be due to differences in patient populations, anesthesia techniques, or variations in dosing protocols. Future studies with larger sample sizes might offer further

insights into whether low-dose spinal anesthesia could significantly reduce hypotension.

4.2 Sensory and Motor Block

When it comes to time to sensory block, there was no significant difference between the two groups. Both groups achieved the target sensory block level (T6) in about 6.3 to 6.4 minutes, suggesting that the low-dose approach works just as effectively in providing sensory block as the conventional dose [23].

However, time to motor recovery was notably faster in the low-dose group. Patients in this group recovered motor function in 45.3 ± 7.1 minutes, while those in the conventional-dose group took 50.1 ± 8.2 minutes ($p = 0.03$). This faster motor recovery in the low-dose group is in line with studies that suggest lower doses of spinal anesthesia facilitate quicker recovery from motor block. This is significant for post-operative care, as it may allow patients to ambulate earlier and shorten their hospital stay [24].

4.3 Neonatal Outcomes

In terms of neonatal outcomes, there were no significant differences between the two groups. Both groups had Apgar scores within the clinically acceptable range, and no significant differences were observed at 1 minute ($p = 0.34$) and 5 minutes ($p = 0.42$). Additionally, the rate of NICU admission was comparable: 5.7% in the low-dose group versus 8.6% in the conventional-dose group ($p = 0.54$). These results suggest that both doses of bupivacaine are equally safe for the neonates, with no significant differences in the need for resuscitation or intensive care.

Our findings are consistent with the established safety profile of spinal anesthesia in LSCS, where 0.5% hyperbaric bupivacaine has minimal impact on neonatal health [25]. The similar rates of NICU admission further support that both dosing regimens maintain neonatal safety.

4.4 Secondary Outcomes and Adverse Events

Looking at the secondary outcomes, there were no significant differences in the incidence of nausea/vomiting, shivering, pain (VAS scores), or patient satisfaction between the two groups. Nausea/vomiting occurred in 8.6% of the low-dose group and 11.4% of the conventional-dose group ($p = 0.65$), while shivering was seen in 4.3% of the low-dose group and 7.1% in the conventional-dose group ($p = 0.61$). Pain scores (VAS) and patient satisfaction scores also showed no significant differences ($p = 0.48$ and $p = 0.76$, respectively). These findings suggest that low-dose spinal anesthesia does not compromise post-operative comfort or patient satisfaction, aligning with earlier studies that report fewer postoperative side effects with lower doses [26].

Regarding adverse events, the incidence of severe hypotension and bradycardia was similar between both groups, with 2.9% of patients in the low-dose group experiencing severe hypotension and 4.3% experiencing bradycardia. This suggests that low-dose spinal anesthesia does not increase the risk of adverse events compared to the conventional dose, which is reassuring for clinicians and patients alike [27].

4.5 Strengths and Limitations

One of the key strengths of this study is its prospective observational design, which allowed for real-time data collection and helped reduce the biases that often come with retrospective studies. Additionally, the use of propensity score matching to control for key confounders such as age, BMI, and baseline blood pressure strengthened the reliability of our findings.

However, as an observational study, the non-random assignment of patients to either the low-dose or conventional-dose group introduces the possibility of selection bias. Although propensity score matching adjusted for known confounders, there may still be residual confounding. The study's relatively small sample size also limits the generalizability of the results. Larger, multicenter studies are needed to confirm our findings and explore the benefits and risks of low-dose spinal anesthesia more thoroughly in the context of LSCS.

4.6 Conclusion

In conclusion, this study suggests that low-dose 0.5% hyperbaric bupivacaine offers comparable maternal and neonatal outcomes to the conventional dose in elective LSCS, with the added benefit of faster motor recovery. Both doses were associated with similar rates of maternal hypotension, nausea/vomiting, and neonatal outcomes, indicating that low-dose spinal anesthesia is a safe and effective alternative. These findings support considering low-dose spinal anesthesia in clinical practice, particularly for its potential to facilitate faster postoperative recovery and improve patient outcomes in LSCS procedures.

Declaration on the Use of AI

AI tools were used to assist with language polishing, improving sentence structure, and enhancing clarity throughout the manuscript. These tools were also employed to generate the figures. However, all content

and figures were thoroughly reviewed and revised by the authors to ensure accuracy, integrity, and alignment with the study's objectives. The final manuscript and figures reflect the authors' research, analysis, and clinical expertise.

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