



Original Article

Comparison of Low-Dose versus Conventional-Dose Spinal Anaesthesia in High-Risk Parturients Undergoing Caesarean Delivery

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ABSTRACT

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Background: Maternal hypotension is a common complication of conventional-dose spinal anaesthesia during caesarean delivery, particularly in high-risk parturients. Low-dose spinal anaesthesia may improve haemodynamic stability while maintaining adequate surgical anaesthesia.

Aim: To compare low-dose and conventional-dose spinal anaesthesia in high-risk parturients undergoing caesarean delivery.

Materials and Methods: This prospective randomized comparative study included 80 high-risk parturients undergoing lower segment caesarean section. Patients were randomly allocated into two groups: low-dose spinal anaesthesia (n=40) and conventional-dose spinal anaesthesia (n=40). Maternal haemodynamic parameters, incidence of hypotension, vasopressor requirement, spinal block characteristics, maternal adverse effects, and neonatal outcomes were evaluated.

Results: Baseline characteristics were comparable between the groups. The low-dose group demonstrated significantly better haemodynamic stability, with higher lowest systolic blood pressure (102.8 ± 10.6 vs. 91.5 ± 12.4 mmHg, $p < 0.001$) and mean arterial pressure (72.4 ± 7.3 vs. 65.1 ± 8.2 mmHg, $p < 0.001$). Maternal hypotension (20.0% vs. 50.0%, $p = 0.005$), ephedrine requirement (25.0% vs. 55.0%, $p = 0.006$), and nausea/vomiting (10.0% vs. 30.0%, $p = 0.026$) were significantly lower in the low-dose group. Adequate surgical anaesthesia and neonatal outcomes were comparable between the groups.

Conclusion: Low-dose spinal anaesthesia provides superior maternal haemodynamic stability with reduced hypotension and vasopressor requirement while maintaining effective surgical anaesthesia and favourable neonatal outcomes in high-risk parturients.

Keywords: Caesarean section, low-dose spinal anaesthesia, high-risk pregnancy, maternal hypotension, haemodynamic stability, bupivacaine.

INTRODUCTION

Caesarean delivery is one of the most commonly performed surgical procedures worldwide, and its incidence continues to rise due to increasing maternal age, obstetric complications, and the prevalence of medical comorbidities. High-risk parturients, including those with hypertensive disorders, cardiac disease, obesity, diabetes mellitus, and pulmonary disorders, present significant anaesthetic challenges because they are more susceptible to perioperative haemodynamic instability and adverse maternal and fetal outcomes.[1,2]

Spinal anaesthesia is the preferred anaesthetic technique for caesarean delivery because it provides rapid onset, dense sensory blockade, excellent muscle relaxation, minimal fetal drug exposure, and allows the mother to remain awake during childbirth.[3] However, conventional-dose spinal anaesthesia is frequently associated with maternal hypotension resulting from sympathetic blockade, which may reduce systemic vascular resistance, venous return, and uteroplacental blood

flow.[2,4] Maternal hypotension remains one of the most common complications of spinal anaesthesia and may adversely affect both maternal and neonatal outcomes.[5]

Various strategies have been employed to reduce spinal anaesthesia-induced hypotension, including intravenous fluid administration, vasopressor therapy, and reduction of the intrathecal local anaesthetic dose.[4,5] Low-dose spinal anaesthesia, usually achieved by reducing the dose of hyperbaric bupivacaine and combining it with intrathecal opioids, has emerged as an effective technique to maintain adequate surgical anaesthesia while minimizing haemodynamic instability.[6,3] Several randomized trials and systematic reviews have demonstrated that low-dose spinal anaesthesia significantly reduces the incidence of hypotension and vasopressor requirement while providing satisfactory anaesthetic conditions for caesarean delivery.[7]

Nevertheless, concerns remain regarding the adequacy of sensory blockade with reduced intrathecal doses, particularly in prolonged surgical procedures.[8,9] Although available evidence suggests that low-dose spinal anaesthesia offers better haemodynamic stability than conventional-dose spinal anaesthesia, studies specifically evaluating high-risk parturients remain limited.[10] Therefore, the present study was undertaken to compare low-dose and conventional-dose spinal anaesthesia in high-risk parturients undergoing caesarean delivery, with emphasis on maternal haemodynamic stability, vasopressor requirement, adequacy of anaesthesia, maternal adverse effects, and neonatal outcomes.

MATERIALS AND METHODS

Study Design and Setting

This prospective, randomized, comparative interventional study was conducted in the Department of Anaesthesiology at a tertiary care teaching hospital. The study was done at Gandhi medical College ,Bhopal, Madhya Pradesh for 7 month duration

Study Population

A total of 80 high-risk parturients scheduled for elective or emergency lower segment caesarean section under spinal anaesthesia were enrolled and randomly allocated into two groups:

- Group L (Low-dose spinal anaesthesia): 40 patients
- Group C (Conventional-dose spinal anaesthesia): 40 patients

Inclusion Criteria

- Pregnant women aged 18–40 years.
- Singleton pregnancy with gestational age ≥ 37 weeks.
- High-risk pregnancy (hypertensive disorders, diabetes mellitus, obesity, stable cardiac or respiratory disease).
- ASA physical status II–III.
- Patients undergoing elective or emergency caesarean section under spinal anaesthesia.

Exclusion Criteria

- Refusal to participate.
- Contraindications to spinal anaesthesia.
- Allergy to study drugs.
- Multiple pregnancy.
- Severe cardiac disease (NYHA III–IV).
- Major obstetric haemorrhage or failed spinal anaesthesia requiring general anaesthesia.

Study Procedure

After standard preoperative evaluation, routine monitoring (ECG, non-invasive blood pressure, pulse oximetry, and heart rate) was instituted. Spinal anaesthesia was administered at the L3–L4 or L4–L5 interspace using a 25G Quincke spinal needle under aseptic precautions.

- **Group L:** 7.5 mg of 0.5% hyperbaric bupivacaine with fentanyl 25 μ g.
- **Group C:** 10 mg of 0.5% hyperbaric bupivacaine with fentanyl 25 μ g.

Patients were positioned supine with left uterine displacement following the block. Haemodynamic parameters were recorded at regular intervals throughout surgery. Hypotension (systolic blood pressure <90 mmHg or $>20\%$ fall from baseline) was treated with intravenous ephedrine, while bradycardia (heart rate <60 beats/min) was managed with atropine.

Outcome Measures

Primary Outcome

- Incidence of maternal hypotension.

Secondary Outcomes

- Changes in heart rate and blood pressure.

- Vasopressor requirement.
- Sensory and motor block characteristics.
- Intraoperative adverse events (nausea, vomiting, shivering, bradycardia).
- Neonatal APGAR scores at 1 and 5 minutes.

Statistical Analysis

Data were analysed using SPSS version 26.0. Continuous variables were expressed as mean $\pm$ SD and categorical variables as frequency and percentage. Comparisons between groups were performed using the independent t-test or Mann–Whitney U test for continuous variables and the Chi-square test or Fisher's exact test for categorical variables. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 80 high-risk parturients undergoing lower segment caesarean section under spinal anaesthesia were randomized equally into the low-dose spinal anaesthesia group (n=40) and the conventional-dose spinal anaesthesia group (n=40). All participants completed the study and were included in the final analysis.

The baseline demographic and clinical characteristics were comparable between the two groups (Table 1). There were no significant differences in maternal age (29.8 ± 4.7 vs. 30.5 ± 5.1 years, $p=0.521$), BMI (30.4 ± 2.9 vs. 30.9 ± 3.2 kg/m², $p=0.468$), gestational age (38.2 ± 1.1 vs. 38.4 ± 1.0 weeks, $p=0.389$), mode of caesarean section, or associated high-risk conditions (all $p>0.05$).

Intraoperative haemodynamic parameters demonstrated significantly better cardiovascular stability in the low-dose group (Table 2, Figure 1). Baseline systolic blood pressure, mean arterial pressure, heart rate, and SpO₂ were comparable (all $p>0.05$). However, the lowest systolic blood pressure (102.8 ± 10.6 vs. 91.5 ± 12.4 mmHg, $p<0.001$) and mean arterial pressure (72.4 ± 7.3 vs. 65.1 ± 8.2 mmHg, $p<0.001$) were significantly higher, while the maximum heart rate was significantly lower (92.1 ± 11.5 vs. 99.6 ± 12.8 beats/min, $p=0.008$) in the low-dose group.

Maternal intraoperative outcomes favored the low-dose group (Table 3, Figure 2). Maternal hypotension (20.0% vs. 50.0%, $p=0.005$), ephedrine requirement (25.0% vs. 55.0%, $p=0.006$), total ephedrine dose (5.6 ± 3.1 vs. 10.8 ± 4.5 mg, $p<0.001$), and nausea/vomiting (10.0% vs. 30.0%, $p=0.026$) were significantly lower. Although bradycardia and shivering occurred less frequently in the low-dose group, these differences were not statistically significant.

The characteristics of spinal block are shown in Table 4. Time to achieve T6 sensory block was slightly longer in the low-dose group (4.8 ± 1.2 vs. 4.2 ± 1.0 minutes, $p=0.024$), whereas the duration of sensory block (114.6 ± 18.7 vs. 127.8 ± 20.4 minutes, $p=0.003$) and motor block (138.2 ± 22.6 vs. 160.4 ± 24.8 minutes, $p<0.001$) were significantly shorter. Maximum sensory level and adequacy of surgical anaesthesia were comparable between the groups.

Neonatal outcomes did not differ significantly between the groups (Table 5). APGAR scores at 1 and 5 minutes and NICU admission rates were comparable (all $p>0.05$), indicating that low-dose spinal anaesthesia did not adversely affect neonatal outcome.

Analysis of variables associated with maternal hypotension showed significantly lower rates of maternal hypotension (20.0% vs. 50.0%, $p=0.005$) and ephedrine requirement (25.0% vs. 55.0%, $p=0.006$) in the low-dose group, while maternal age, BMI, gestational age, and PIH/preeclampsia were similar between groups (Table 6).

Multivariate logistic regression identified conventional-dose spinal anaesthesia as the only independent predictor of maternal hypotension (adjusted OR 3.84, 95% CI 1.42–10.36; $p=0.008$), whereas BMI, maternal age, gestational age, and PIH/preeclampsia were not significant predictors (Table 7, Figure 3).

Table 1. Baseline Demographic and Clinical Characteristics of the Study Population

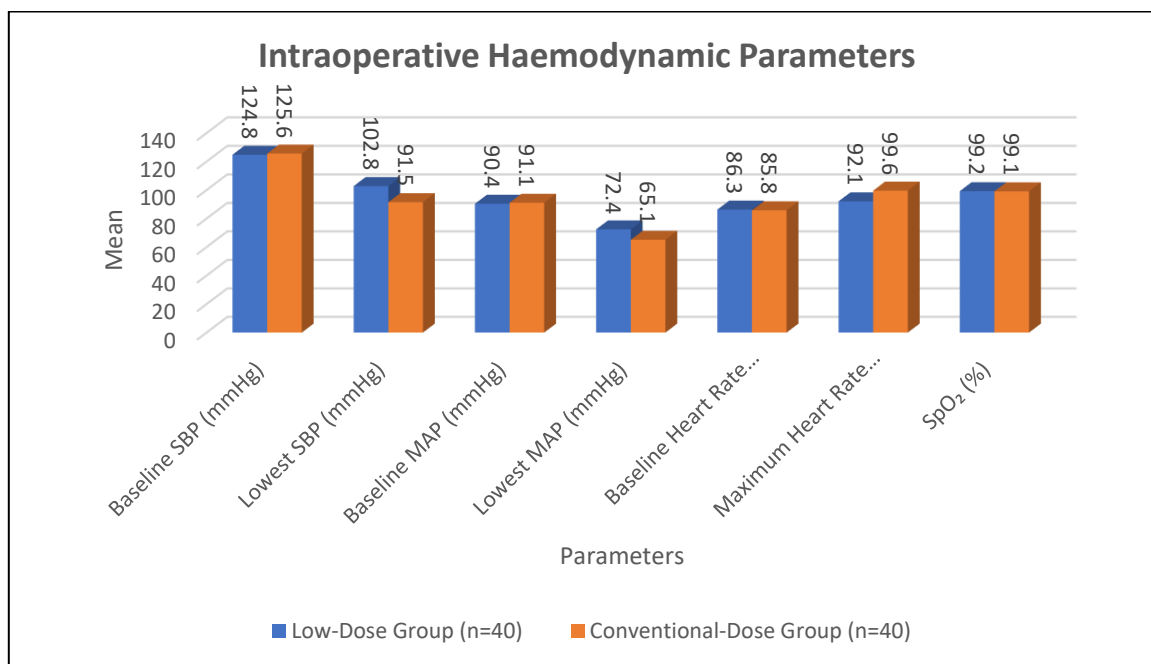
Variable	Low-Dose Group (n=40)	Conventional-Dose Group (n=40)	P value
Age (years), Mean $\pm$ SD	29.8 ± 4.7	30.5 ± 5.1	0.521
BMI (kg/m ²), Mean $\pm$ SD	30.4 ± 2.9	30.9 ± 3.2	0.468
Gestational age (weeks), Mean $\pm$ SD	38.2 ± 1.1	38.4 ± 1.0	0.389
Elective LSCS	24 (60.0%)	22 (55.0%)	0.651
Emergency LSCS	16 (40.0%)	18 (45.0%)	
PIH/Preeclampsia	18 (45.0%)	19 (47.5%)	0.823
Diabetes mellitus	8 (20.0%)	7 (17.5%)	0.775
Cardiac disease	6 (15.0%)	5 (12.5%)	0.744
Obesity	8 (20.0%)	9 (22.5%)	0.786

Statistical test: Independent Student's *t*-test (continuous variables) and Chi-square test (categorical variables)

Table 2. Comparison of Intraoperative Haemodynamic Parameters

Parameter	Low-Dose Group (n=40)	Conventional-Dose Group (n=40)	P value
Baseline SBP (mmHg)	124.8 ± 9.4	125.6 ± 10.2	0.716
Lowest SBP (mmHg)	102.8 ± 10.6	91.5 ± 12.4	<0.001
Baseline MAP (mmHg)	90.4 ± 6.2	91.1 ± 6.8	0.639
Lowest MAP (mmHg)	72.4 ± 7.3	65.1 ± 8.2	<0.001
Baseline Heart Rate (beats/min)	86.3 ± 9.6	85.8 ± 8.9	0.812
Maximum Heart Rate (beats/min)	92.1 ± 11.5	99.6 ± 12.8	0.008
SpO ₂ (%)	99.2 ± 0.8	99.1 ± 0.9	0.671

Statistical test: Independent Student's *t*-test.

**Figure 1. Comparison of Intraoperative Haemodynamic Parameters****Table 3. Comparison of Maternal Intraoperative Outcomes**

Variable	Low-Dose Group (n=40)	Conventional-Dose Group (n=40)	P value
Maternal hypotension	8 (20.0%)	20 (50.0%)	0.005
Ephedrine required	10 (25.0%)	22 (55.0%)	0.006
Total ephedrine dose (mg), Mean ± SD	5.6 ± 3.1	10.8 ± 4.5	<0.001
Bradycardia	2 (5.0%)	6 (15.0%)	0.136
Nausea/Vomiting	4 (10.0%)	12 (30.0%)	0.026
Shivering	3 (7.5%)	8 (20.0%)	0.106

Statistical test: Chi-square test (categorical variables) and Independent Student's *t*-test (continuous variables).

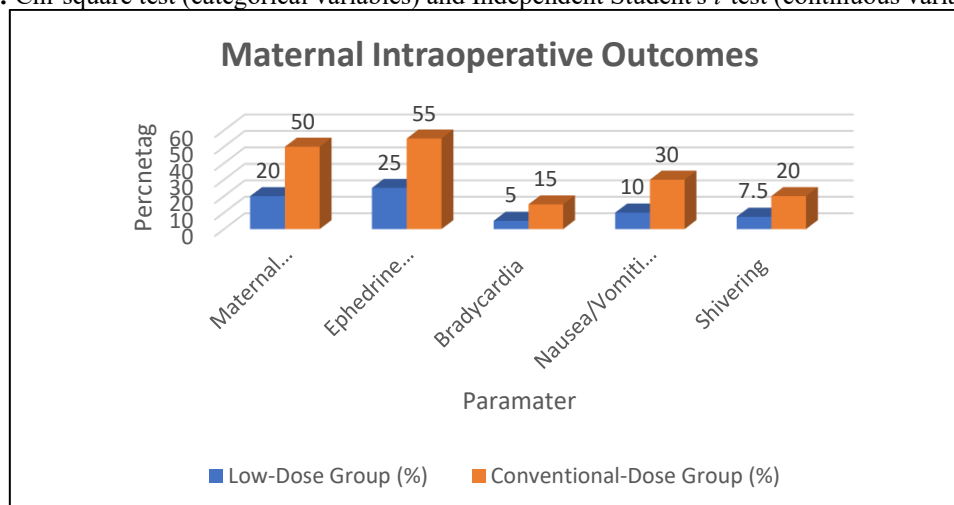
**Figure 2. Comparison of Maternal Intraoperative Outcomes**

Table 4. Comparison of Characteristics of Spinal Block

Variable	Low-Dose Group (n=40)	Conventional-Dose Group (n=40)	P value
Time to T6 sensory block (minutes)	4.8 ± 1.2	4.2 ± 1.0	0.024
Maximum sensory level ≥T4	30 (75.0%)	34 (85.0%)	0.262
Duration of sensory block (minutes)	114.6 ± 18.7	127.8 ± 20.4	0.003
Duration of motor block (minutes)	138.2 ± 22.6	160.4 ± 24.8	<0.001
Adequate surgical anaesthesia	38 (95.0%)	39 (97.5%)	0.556

Statistical test: Independent Student's *t*-test (continuous variables) and Chi-square test (categorical variables).

Table 5. Comparison of Neonatal Outcomes

Variable	Low-Dose Group (n=40)	Conventional-Dose Group (n=40)	P value
APGAR score at 1 minute	8.1 ± 0.7	7.9 ± 0.8	0.214
APGAR score at 5 minutes	9.2 ± 0.5	9.1 ± 0.4	0.371
NICU admission	2 (5.0%)	3 (7.5%)	0.643

Statistical test: Independent Student's *t*-test (APGAR scores) and Fisher's Exact test (NICU admission).

Table 6. Predictors of Maternal Hypotension According to Study Group

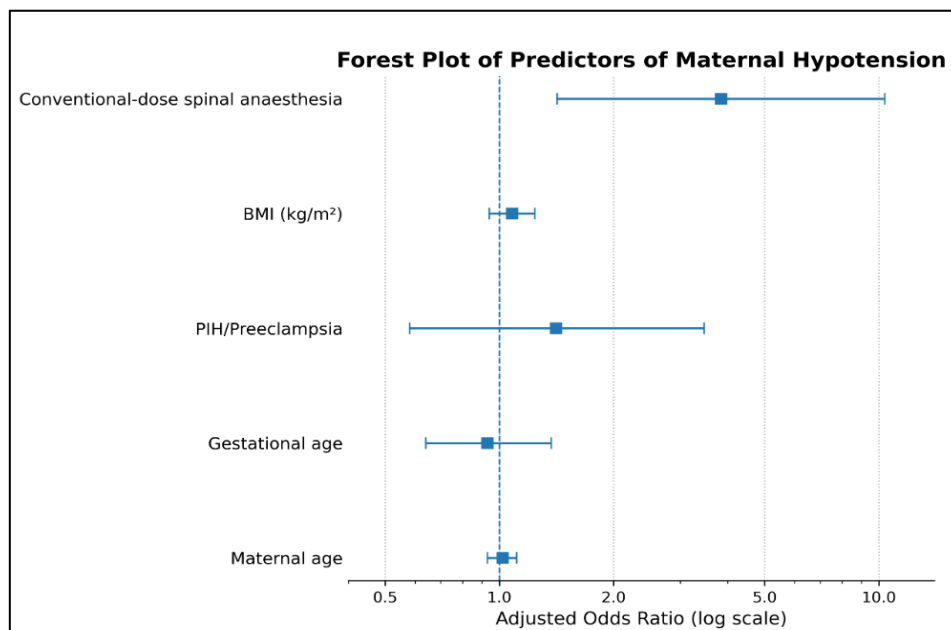
Variable	Low-Dose Group (n=40)	Conventional-Dose Group (n=40)	P value
Maternal hypotension	8 (20.0%)	20 (50.0%)	0.005
Mean BMI (kg/m ²)	30.4 ± 2.9	30.9 ± 3.2	0.468
PIH/Preeclampsia	18 (45.0%)	19 (47.5%)	0.823
Gestational age (weeks)	38.2 ± 1.1	38.4 ± 1.0	0.389
Maternal age (years)	29.8 ± 4.7	30.5 ± 5.1	0.521
Ephedrine requirement	10 (25.0%)	22 (55.0%)	0.006

Statistical test: Independent Student's *t*-test (continuous variables) and Chi-square test (categorical variables).

Table 7. Multivariate Logistic Regression Analysis for Predictors of Maternal Hypotension

Variable	Adjusted Odds Ratio (95% CI)	P value
Conventional-dose spinal anaesthesia	3.84 (1.42–10.36)	0.008
BMI (kg/m ²)	1.08 (0.94–1.24)	0.261
PIH/Preeclampsia	1.41 (0.58–3.46)	0.448
Gestational age	0.93 (0.64–1.37)	0.719
Maternal age	1.02 (0.93–1.11)	0.674

Statistical test: Multivariate binary logistic regression.

**Figure 3. Multivariate Logistic Regression Analysis for Predictors of Maternal Hypotension**

DISCUSSION

The present study demonstrated comparable baseline characteristics between the low-dose and conventional-dose spinal anaesthesia groups. Maternal age (29.8 ± 4.7 vs. 30.5 ± 5.1 years), BMI (30.4 ± 2.9 vs. 30.9 ± 3.2 kg/m²), gestational age

(38.2 ± 1.1 vs. 38.4 ± 1.0 weeks), and the prevalence of pregnancy-induced hypertension/preeclampsia (45.0% vs. 47.5%) were similar (all $p > 0.05$), indicating successful randomization. Likewise, Langesaeter et al. [11] reported comparable baseline characteristics among the four randomized study groups, ensuring that subsequent differences in haemodynamic parameters were attributable to the spinal anaesthetic regimen rather than patient characteristics.

Maintaining maternal haemodynamic stability is essential during spinal anaesthesia, particularly in high-risk pregnancies. In the present study, the low-dose group showed significantly better haemodynamic stability, with higher lowest systolic blood pressure (102.8 ± 10.6 vs. 91.5 ± 12.4 mmHg, $p < 0.001$), higher mean arterial pressure (72.4 ± 7.3 vs. 65.1 ± 8.2 mmHg, $p < 0.001$), and lower maximum heart rate (92.1 ± 11.5 vs. 99.6 ± 12.8 beats/min, $p = 0.008$). Similar findings were reported by Langesaeter et al. [11], who found that patients receiving 7 mg intrathecal bupivacaine with phenylephrine infusion had significantly better preservation of cardiac output ($P = 0.005$), systemic vascular resistance ($P < 0.0001$), and systolic blood pressure ($P = 0.012$) than those receiving 10 mg bupivacaine.

The physiological explanation for these findings is supported by Higuchi et al. [12], who demonstrated by MRI that 30° and 45° left lateral tilt significantly increased inferior vena cava volume, whereas 15° tilt produced little improvement, indicating that greater relief of aortocaval compression improves venous return and maternal haemodynamics.

Maternal hypotension occurred significantly less frequently in the low-dose group than in the conventional-dose group (20.0% vs. 50.0%, $p = 0.005$). Ephedrine was required in only 25.0% of patients receiving low-dose spinal anaesthesia compared with 55.0% in the conventional-dose group ($p = 0.006$), and the mean ephedrine dose was significantly lower (5.6 ± 3.1 mg vs. 10.8 ± 4.5 mg, $p < 0.001$). Nausea and vomiting were also significantly reduced (10.0% vs. 30.0%, $p = 0.026$). These findings are comparable to those of Langesaeter et al. [11], who reported the lowest incidence of hypotension and the best preservation of cardiac output in patients receiving low-dose spinal anaesthesia with phenylephrine infusion. Funk et al. [12] further explained that preservation of venous return is essential for maintaining cardiac output during sympathetic blockade, thereby reducing hypotension and vasopressor requirements. Together, these observations support the improved haemodynamic profile observed in the present study.

Both techniques provided satisfactory surgical anaesthesia. Adequate surgical anaesthesia was achieved in 95.0% of patients in the low-dose group and 97.5% in the conventional-dose group ($p = 0.556$). Although sensory block onset was slightly slower (4.8 ± 1.2 vs. 4.2 ± 1.0 minutes, $p = 0.024$), the duration of sensory block (114.6 ± 18.7 vs. 127.8 ± 20.4 minutes, $p = 0.003$) and motor block (138.2 ± 22.6 vs. 160.4 ± 24.8 minutes, $p < 0.001$) was significantly shorter in the low-dose group.

These observations are consistent with Langesaeter et al. [11], who demonstrated that reducing intrathecal bupivacaine maintained satisfactory surgical conditions while minimizing haemodynamic disturbances and facilitating earlier postoperative recovery.

Neonatal outcomes were comparable in both groups. The mean APGAR score at 1 minute was 8.1 ± 0.7 in the low-dose group and 7.9 ± 0.8 in the conventional-dose group ($p = 0.214$), while the 5-minute APGAR scores were 9.2 ± 0.5 and 9.1 ± 0.4 , respectively ($p = 0.371$). NICU admission rates were also similar (5.0% vs. 7.5%, $p = 0.643$).

Comparable neonatal outcomes were also reported by Langesaeter et al. [11], who found that improved maternal haemodynamic stability with low-dose spinal anaesthesia did not adversely affect neonatal wellbeing or fetal outcomes.

Although advanced cardiac output monitoring was not used in the present study, routine haemodynamic monitoring demonstrated clear differences between the two spinal anaesthetic techniques. Chin et al. [15] reported that the third-generation FloTrac/Vigileo system showed poor ability to track stroke volume changes in patients with high systemic vascular resistance. Desebbe et al. [15] similarly demonstrated only moderate agreement between FloTrac-derived cardiac output and reference techniques, while Critchley [16] concluded that pulse contour analysis may not reliably detect rapid cardiac output changes in haemodynamically unstable patients. These studies highlight the limitations of advanced monitoring devices and emphasize that clinically meaningful haemodynamic improvements with low-dose spinal anaesthesia can still be effectively identified using standard blood pressure and heart rate monitoring in routine obstetric practice.

CONCLUSION

Low-dose spinal anaesthesia provided superior maternal haemodynamic stability compared with conventional-dose spinal anaesthesia in high-risk parturients undergoing caesarean delivery. It significantly reduced the incidence of maternal hypotension, vasopressor requirement, and intraoperative adverse effects while maintaining adequate surgical anaesthesia and comparable neonatal outcomes. Therefore, low-dose spinal anaesthesia appears to be a safe and effective anaesthetic technique for caesarean delivery in high-risk obstetric patients.

Limitations

The study was conducted at a single tertiary care centre with a relatively small sample size, which may limit the generalizability of the findings. In addition, advanced haemodynamic monitoring such as continuous cardiac output measurement was not performed, and long-term maternal and neonatal outcomes were not evaluated.

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