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Original Research Article

PROSPECTIVE STUDY OF MATERNAL HEMODYNAMIC CHANGES AFTER SPINAL ANAESTHESIA IN ELECTIVE CESAREAN SECTION

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ABSTRACT

Background: Spinal anaesthesia is the preferred technique for most elective cesarean sections because of its rapid onset, reliable surgical block, avoidance of airway manipulation, and minimal fetal drug exposure. However, sympathetic blockade following spinal anaesthesia may cause significant maternal hemodynamic disturbances, particularly hypotension, which can produce maternal symptoms and may affect uteroplacental perfusion. The aim is to prospectively evaluate maternal hemodynamic changes following spinal anaesthesia in women undergoing elective cesarean section at a tertiary care hospital.

Materials and Methods: This prospective observational study included 102 term pregnant women aged 18–40 years, belonging to ASA physical status II, scheduled for elective cesarean section under spinal anaesthesia. Maternal heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure, and SpO_2 were recorded at baseline and at predefined intervals after spinal anaesthesia. Hypotension was defined as a ≥20% reduction in systolic blood pressure from baseline or SBP <90 mmHg. Bradycardia, vasopressor requirement, intravenous fluid administration, sensory block level, maternal adverse effects, and neonatal Apgar scores were also documented. Data were analysed using IBM SPSS Statistics version 27.0, with p<0.05 considered statistically significant.

Results: The mean age was 27.81 ± 4.03 years and mean gestational age was 38.31 ± 0.82 weeks. Maternal heart rate increased from 88.72 ± 9.41 beats/minute at baseline to 96.17 ± 11.82 at 5 minutes. Mean SBP decreased from 123.57 ± 9.62 to 105.84 ± 12.36 mmHg, while MAP decreased from 92.38 ± 7.08 to 78.49 ± 8.63 mmHg at 5 minutes (p<0.001). Hypotension occurred in 35.29% and bradycardia in 8.82% of patients. Vasopressors were required in 33.33%. Lower baseline SBP, lower baseline MAP, higher T4 sensory block, and longer spinal-to-delivery interval were significantly associated with hypotension. Nausea, vomiting, and dizziness were significantly more common among hypotensive patients. Neonatal Apgar scores did not differ significantly between groups.

Conclusion: Spinal anaesthesia produced significant early maternal hemodynamic changes, with hypotension occurring in more than one-third of patients. Careful monitoring during the initial post-spinal period and timely fluid and vasopressor support are essential. Immediate neonatal outcomes remained satisfactory.

Keywords: Cesarean section; Spinal anaesthesia; Maternal hypotension; Hemodynamic changes; Vasopressors

INTRODUCTION

Cesarean section is one of the most frequently performed surgical procedures in obstetric practice, and the choice of anaesthetic technique has a direct influence on maternal safety, fetal well-being, perioperative comfort, and the overall quality of the birth experience. For elective cesarean delivery, neuraxial anaesthesia is generally preferred over general anaesthesia whenever no contraindication exists. Spinal anaesthesia is particularly attractive because it is technically straightforward, produces a rapid and reliable surgical block, minimizes maternal airway manipulation, limits fetal exposure to systemic anaesthetic drugs, and allows the mother to remain awake during delivery. These advantages have made spinal anaesthesia a central component of modern obstetric anaesthetic practice.[1] Despite its clinical advantages, spinal anaesthesia produces important cardiovascular changes that require close observation. Intrathecal local anaesthetic blocks sympathetic nerve transmission, resulting in arterial and venous vasodilatation, reduction in systemic vascular resistance, redistribution of circulating blood volume, and a decrease in venous return. Pregnancy further modifies this response because maternal cardiovascular physiology is already adapted to increased metabolic demand, with altered blood volume, heart rate, stroke volume, and cardiac output. In the supine position, compression of the inferior vena cava by the gravid uterus may additionally reduce venous return. The combined effects of sympathetic blockade and pregnancy-related physiological changes can therefore produce a rapid fall in arterial blood pressure after spinal anaesthesia.[2] Maternal hypotension is consequently regarded as the principal hemodynamic concern during cesarean delivery under spinal anaesthesia. The magnitude and duration of the blood-pressure reduction are clinically relevant because inadequate maternal perfusion may be accompanied by nausea, vomiting, dizziness, weakness, altered consciousness, or, in severe cases, cardiovascular instability. Maternal arterial pressure is also an important determinant of uteroplacental perfusion. Maintaining hemodynamic stability during the interval between spinal injection and delivery is therefore an essential objective of obstetric anaesthesia. Contemporary preventive strategies combine careful positioning, fluid administration, appropriate intrathecal dosing, vigilant blood-pressure monitoring, and timely use of vasopressor therapy.[3] Vasopressors play a major role in preserving maternal arterial pressure after neuraxial sympathetic blockade. Phenylephrine has been widely used because of its predominantly alpha-adrenergic action, while norepinephrine has gained increasing attention because its modest beta-adrenergic activity may help preserve maternal heart rate and cardiac output. Ephedrine and other agents may also be used according to clinical context and institutional practice. Selection of a vasopressor requires consideration of maternal heart rate, blood pressure, cardiovascular status, fetal well-being, and the pattern of hemodynamic change. Thus, management is increasingly directed not simply toward treating established hypotension but toward maintaining blood pressure close to the pre-spinal baseline and preventing substantial fluctuations.[4] Prediction of which parturients are more likely to develop marked hypotension remains an important clinical challenge. Maternal age, body habitus, baseline blood pressure, heart rate, autonomic balance, intravascular volume, sensory block height, aortocaval compression, and the dose and baricity of intrathecal local anaesthetic may all influence the hemodynamic response. Various non-invasive indices, including baseline hemodynamic measurements, perfusion-related variables, ultrasound-derived measures, and dynamic cardiovascular tests, have been investigated as potential predictors. However, individual responses remain variable, which reinforces the importance of serial monitoring rather than reliance on a single preoperative measurement.[5] The clinical importance of spinal-induced hypotension extends beyond the occurrence of a single low blood-pressure value. The timing of onset, maximum percentage reduction from baseline, duration of hypotension, associated heart-rate changes, requirement for vasopressor support, fluid requirement, sensory block level, and maternal symptoms provide a more complete description of cardiovascular adaptation after spinal anaesthesia. In addition, immediate neonatal assessment, particularly through Apgar scoring and other indicators where available, contributes to evaluation of the maternal-fetal consequences of perioperative hemodynamic alterations. A context-sensitive approach is particularly important in tertiary care hospitals, where patient characteristics, monitoring resources, staffing patterns, and institutional protocols may influence anaesthetic management.[6]

MATERIALS AND METHODS

This prospective observational study was conducted in the Department of Anaesthesiology at a tertiary care hospital to evaluate maternal hemodynamic changes following spinal anaesthesia in women undergoing elective cesarean section. A total of 102 pregnant women fulfilling the predefined eligibility criteria were included in the study. All patients were enrolled after obtaining written informed consent. The study was carried out in accordance with institutional ethical principles, and approval from the Institutional Ethics Committee was obtained before commencement of patient recruitment. Pregnant women scheduled for elective cesarean section under spinal anaesthesia were assessed during the pre-anaesthetic evaluation. Detailed history regarding age, parity, gestational age, previous cesarean section, associated medical conditions, medication use and previous anaesthetic exposure was recorded. A general physical examination and airway and systemic examination were performed. Routine laboratory investigations, including haemoglobin, complete blood count, blood grouping and other investigations considered necessary for anaesthetic fitness, were reviewed before surgery.

Inclusion Criteria

The study included pregnant women aged 18–40 years, with a singleton pregnancy at term gestation, belonging to American Society of Anesthesiologists (ASA) physical status II, who were scheduled for elective cesarean section under spinal anaesthesia. Patients with satisfactory preoperative clinical and laboratory evaluation who provided written informed consent were included.

Exclusion Criteria

Women undergoing emergency cesarean section, those refusing spinal anaesthesia, and patients with contraindications to neuraxial anaesthesia such as coagulopathy, local infection at the site of injection, severe hypovolemia, raised intracranial pressure or known allergy to local anaesthetic agents were excluded. Patients with significant cardiovascular disease, severe respiratory disease, severe anaemia, pregnancy-induced hypertension or pre-eclampsia, eclampsia, placenta previa with significant bleeding, multiple pregnancy and clinically significant fetal abnormalities were also excluded to minimize confounding effects on maternal hemodynamic parameters.

Methodology: After arrival in the operating room, standard monitoring was established using continuous electrocardiography, non-invasive blood pressure monitoring and pulse oximetry. Baseline heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP) and peripheral oxygen saturation (SpO_2) were recorded before administration of spinal anaesthesia. An intravenous line was secured with an appropriate-sized cannula, and intravenous crystalloid administration was initiated according to institutional practice. Baseline measurements were obtained with the patient resting comfortably before the spinal block.

Spinal Anaesthesia Technique: With the patient in the sitting or lateral position under strict aseptic precautions, spinal anaesthesia was administered at the L3–L4 or L4–L5 intervertebral space using an appropriate spinal needle. Hyperbaric bupivacaine was administered intrathecally in a dose appropriate for cesarean delivery according to institutional anaesthetic protocol. Immediately following injection, the patient was positioned supine with left uterine displacement to minimize aortocaval compression. The level of sensory blockade was assessed using loss of sensation to cold or pinprick, and surgery was started after an adequate sensory block suitable for cesarean delivery had been achieved.

Assessment of Maternal Hemodynamic Parameters: Maternal hemodynamic parameters were recorded systematically after spinal anaesthesia. Heart rate, SBP, DBP, MAP and SpO_2 were documented at baseline, immediately after spinal anaesthesia and subsequently at 2, 5, 10, 15, 20 and 30 minutes, or until completion of the clinically important intraoperative period. The maximum percentage reduction in SBP and MAP from baseline, lowest recorded blood pressure, lowest and highest heart rate, and time to the maximum hemodynamic change were documented.

Maternal hypotension was defined as a decrease in systolic blood pressure of ≥20% from the baseline value or an SBP <90 mmHg. Bradycardia was defined as a heart rate <60 beats/minute. Episodes of hypotension and bradycardia and their frequency were recorded. Hypotension was managed with intravenous fluids, vasopressor administration and appropriate positioning according to standard clinical practice. The type and total dose of vasopressor used were documented. Clinically significant bradycardia was treated according to standard anaesthetic protocol.

Additional Intraoperative Parameters: In addition to hemodynamic measurements, the highest sensory block level, time from spinal injection to surgical incision, time from spinal anaesthesia to delivery of the baby, intravenous fluid volume and estimated blood loss were recorded. Maternal adverse effects including nausea, vomiting, dizziness, shivering and respiratory discomfort were documented. The requirement for supplemental oxygen and any additional medication administered for hemodynamic stabilization were also noted. Neonatal condition was assessed using Apgar scores at 1 and 5 minutes after birth to evaluate immediate neonatal well-being.

Statistical Analysis: Data were entered into Microsoft Excel and analysed using IBM SPSS Statistics version 27.0. Continuous variables such as age, weight, heart rate, SBP, DBP and MAP were expressed as mean ± standard deviation (SD) or median with interquartile range, as appropriate. Categorical variables were presented as frequency and percentage. Normality of continuous variables was assessed using the Shapiro–Wilk test. Changes in hemodynamic parameters at different time intervals were analysed using repeated-measures analysis of variance (ANOVA) for normally distributed data, with appropriate post-hoc comparisons, while the Friedman test was used for non-normally distributed repeated observations. Associations between categorical variables were assessed using the Chi-square test or Fisher's exact test, as appropriate. Factors associated with the occurrence of maternal hypotension were evaluated using suitable univariate analysis. A p-value <0.05 was considered statistically significant.

RESULTS

[Table 1] Baseline Demographic, Obstetric and Anaesthetic Characteristics

[Table 1] presents the baseline demographic, obstetric, and anaesthetic characteristics of the 102 study participants. The mean age of the women was 27.81 ± 4.03 years, and the mean body weight was 68.99 ± 8.56 kg. The mean gestational age at the time of elective cesarean section was 38.31 ± 0.82 weeks. The mean haemoglobin concentration was 11.24 ± 0.91 g/dL. Regarding gravidity, 41 women (40.20%) were primigravida, whereas 61 (59.80%) were multigravida. A history of previous cesarean section was present in 45 women (44.12%), while 57 women (55.88%) had no previous cesarean section. The L3–L4 intervertebral space was used for administration of spinal anaesthesia in 66 patients (64.71%), whereas the L4–L5 interspace was used in 36 patients (35.29%). Most patients received spinal anaesthesia in the sitting position, accounting for 79 women (77.45%), while 23 women (22.55%) received the block in the lateral position. Regarding the highest achieved sensory block level, T4 was observed in 60 women (58.82%), T5 in 34 women (33.33%), and T6 in 8 women (7.84%). Thus, T4 was the most frequently attained highest sensory level in the study population.

[Table 2] Changes in Maternal Hemodynamic Parameters Following Spinal Anaesthesia

[Table 2] demonstrates the serial changes in maternal heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure, and peripheral oxygen saturation following spinal anaesthesia. At baseline, the mean heart rate was 88.72 ± 9.41 beats/minute. It increased to 91.31 ± 10.12 beats/minute immediately after spinal anaesthesia and subsequently increased to 94.58 ± 11.18 beats/minute at 2 minutes. The highest mean heart rate was recorded at 5 minutes, with a value of 96.17 ± 11.82 beats/minute. Thereafter, the mean heart rate gradually decreased to 92.83 ± 10.71 at 10 minutes, 90.61 ± 10.08 at 15 minutes, 89.42 ± 9.73 at 20 minutes, and 88.53 ± 9.36 beats/minute at 30 minutes. The overall variation in heart rate over time was statistically significant ($p<0.001$). The mean baseline systolic blood pressure was 123.57 ± 9.62 mmHg. It decreased to 118.91 ± 10.21 mmHg immediately after spinal anaesthesia and further declined to 111.62 ± 11.76 mmHg at 2 minutes. The lowest mean SBP was recorded at 5 minutes at 105.84 ± 12.36 mmHg. Subsequently, SBP increased progressively to 110.24 ± 11.43 mmHg at 10 minutes, 113.72 ± 10.76 mmHg at 15 minutes, 116.91 ± 10.27 mmHg at 20 minutes, and 119.38 ± 9.91 mmHg at 30 minutes. The overall change in SBP across the different time points was statistically significant ($p<0.001$). A similar temporal pattern was observed for diastolic blood pressure. The mean DBP decreased from 76.42 ± 7.31 mmHg at baseline to 72.81 ± 7.62 mmHg immediately after spinal anaesthesia, 67.91 ± 8.04 mmHg at 2 minutes, and reached its lowest mean value of 64.76 ± 8.52 mmHg at 5 minutes. Mean DBP then increased to 67.24 ± 7.98 mmHg at 10 minutes, 69.61 ± 7.66 mmHg at 15 minutes, 71.43 ± 7.38 mmHg at 20 minutes, and 73.12 ± 7.25 mmHg at 30 minutes. This variation was statistically significant ($p<0.001$). The mean arterial pressure also showed a significant reduction after spinal anaesthesia. The baseline MAP was 92.38 ± 7.08 mmHg, which decreased to 88.21 ± 7.56 mmHg immediately after the spinal block and to 82.47 ± 8.18 mmHg at 2 minutes. The lowest mean MAP of 78.49 ± 8.63 mmHg was observed at 5 minutes. Thereafter, MAP increased to 81.54 ± 8.07 mmHg at 10 minutes, 84.31 ± 7.72 mmHg at 15 minutes, 86.59 ± 7.45 mmHg at 20 minutes, and 88.54 ± 7.22 mmHg at 30 minutes. The overall change in MAP was statistically significant ($p<0.001$).

[Table 3] Incidence and Characteristics of Hemodynamic Events Following Spinal Anaesthesia

[Table 3] describes the occurrence and magnitude of hemodynamic events following spinal anaesthesia. Maternal hypotension was documented in 36 of the 102 women, corresponding to an incidence of 35.29%, while 66 women (64.71%) did not develop hypotension. Bradycardia was observed in 9 patients (8.82%), whereas 93 patients (91.18%) did not experience bradycardia. Vasopressor administration was required in 34 women (33.33%), while 68 women (66.67%) did not require a vasopressor. More than one vasopressor bolus was necessary in 11 women (10.78%). The remaining 91 women (89.22%) either required a single bolus or did not require repeated vasopressor administration. The mean lowest recorded systolic blood pressure was 96.40 ± 11.70 mmHg, and the mean lowest MAP was 70.80 ± 9.02 mmHg. The mean maximum percentage reduction in SBP from the baseline value was 21.90 ± 8.47%, while the corresponding maximum reduction in MAP was 23.20 ± 8.81%. The mean time from spinal anaesthesia to the maximum recorded hemodynamic change was 5.30 ± 2.20 minutes.

[Table 4]Univariate Analysis of Factors Associated with Maternal Hypotension

[Table 4] compares clinical and anaesthetic variables between the 36 women who developed hypotension and the 66 women who did not. The mean age was 28.20 ± 4.10 years in the hypotension group and 27.60 ± 4.00 years in the no-hypotension group. The difference was not statistically significant ($p=0.479$). Mean body weight was 70.80 ± 8.70 kg among women with hypotension compared with 68.00 ± 8.40 kg among women without hypotension, and this difference was also not statistically significant ($p=0.120$). A statistically significant difference was observed in baseline systolic blood pressure. Women who subsequently developed hypotension had a mean baseline SBP of 119.30 ± 8.60 mmHg, compared with 125.90 ± 9.20

mmHg among those who did not develop hypotension ($p<0.001$). Similarly, mean baseline MAP was 89.60 ± 6.90 mmHg in the hypotension group compared with 93.90 ± 7.10 mmHg in the no-hypotension group, and this difference was statistically significant (p=0.004). Among the 41 primigravida women, 10 (24.39%) developed hypotension and 31 (75.61%) did not. Among the 61 multigravida women, 26 (42.62%) developed hypotension and 35 (57.38%) remained without hypotension. The association between gravidity and hypotension did not reach statistical significance (p=0.059).

Among 45 women with a history of previous cesarean section, 20 (44.44%) developed hypotension and 25 (55.56%) did not. In comparison, among 57 women without a previous cesarean section, hypotension occurred in 16 (28.07%) and was absent in 41 (71.93%). The difference was not statistically significant (p=0.086). The highest sensory level showed a statistically significant association with hypotension. Among the 60 women in whom a T4 sensory block was achieved, 28 (46.67%) developed hypotension and 32 (53.33%) did not. In contrast, among the 42 women with a T5–T6 sensory level, only 8 (19.05%) developed hypotension, while 34 (80.95%) remained without hypotension. The difference between the two sensory block categories was statistically significant (p=0.006).

[Table 5] Intraoperative, Maternal Adverse and Neonatal Outcomes

[Table 5] summarizes the intraoperative parameters, maternal adverse events, and neonatal outcomes. The mean spinal-to-incision interval for the entire study population was 5.82 ± 1.42 minutes, while the overall mean spinal-to-delivery interval was 9.89 ± 2.58 minutes. When compared according to hypotension status, the spinal-to-delivery interval was significantly longer in women with hypotension (10.80 ± 2.60 minutes) than in women without hypotension (9.40 ± 2.40 minutes; p=0.010). The overall mean volume of intravenous crystalloid administered was 840.88 ± 188.64 mL. Women who developed hypotension received a mean crystalloid volume of 914.00 ± 186.00 mL, whereas women without hypotension received 801.00 ± 173.00 mL. The difference in crystalloid requirement between the two groups was statistically significant (p=0.004). The mean estimated blood loss for the entire study population was 521.67 ± 108.52 mL. Nausea occurred in 15 women (14.71%) overall. It was reported in 11 of 36 women with hypotension (30.56%) compared with 4 of 66 women without hypotension (6.06%), with a statistically significant difference (p=0.002). Vomiting occurred in 6 women (5.88%) overall, including 5 women (13.89%) in the hypotension group and 1 woman (1.52%) in the no-hypotension group. The difference was statistically significant (p=0.020). Dizziness was recorded in 10 women (9.80%). It occurred in 8 women with hypotension (22.22%) and in 2 women without hypotension (3.03%), showing a statistically significant difference between the groups (p=0.003). Shivering occurred in 8 women (7.84%), including 4 women (11.11%) with hypotension and 4 women (6.06%) without hypotension. This difference was not statistically significant (p=0.448).

Respiratory discomfort was observed in only 2 patients (1.96%) overall, with one case in each group. The proportions were 2.78% in the hypotension group and 1.52% in the no-hypotension group, with no statistically significant difference (p=1.000). Supplemental oxygen was required in 7 women (6.86%), including 5 women (13.89%) with hypotension and 2 women (3.03%) without hypotension. The difference did not reach statistical significance (p=0.093). The overall mean Apgar score at 1 minute was 8.13 ± 0.67. The mean score was 8.05 ± 0.72 among neonates born to mothers who developed hypotension and 8.17 ± 0.64 among those born to mothers without hypotension. There was no statistically significant difference between the groups (p=0.406). At 5 minutes, the overall mean Apgar score increased to 9.32 ± 0.52. The corresponding scores were 9.25 ± 0.55 in the maternal hypotension group and 9.36 ± 0.50 in the no-hypotension group, with no statistically significant difference (p=0.323). An Apgar score below 7 at 1 minute was recorded in 4 neonates (3.92%) overall. This included 3 neonates (8.33%) in the maternal hypotension group and 1 neonate (1.52%) in the no-hypotension group; the difference was not statistically significant (p=0.125). At 5 minutes, an Apgar score below 7 was recorded in only 1 neonate (0.98%), which belonged to the maternal hypotension group.

Table 1: Baseline Demographic, Obstetric and Anaesthetic Characteristics of Study Participants (n=102)

Parameter	Value
Age (years), Mean ± SD	27.81 ± 4.03
Weight (kg), Mean ± SD	68.99 ± 8.56
Gestational age (weeks), Mean ± SD	38.31 ± 0.82
Haemoglobin (g/dL), Mean ± SD	11.24 ± 0.91
Primigravida	41 (40.20%)
Multigravida	61 (59.80%)
Previous cesarean section – Yes	45 (44.12%)
Previous cesarean section – No	57 (55.88%)
Spinal interspace L3–L4	66 (64.71%)
Spinal interspace L4–L5	36 (35.29%)
Sitting position for spinal anaesthesia	79 (77.45%)

Lateral position for spinal anaesthesia	23 (22.55%)
Highest sensory level – T4	60 (58.82%)
Highest sensory level – T5	34 (33.33%)
Highest sensory level – T6	8 (7.84%)

Table 2: Changes in Maternal Hemodynamic Parameters Following Spinal Anaesthesia (n=102)

Time Point	HR (beats/min) Mean ± SD	SBP (mmHg) Mean ± SD	DBP (mmHg) Mean ± SD	MAP (mmHg) Mean ± SD	SpO_2 (%) Mean ± SD
Baseline	88.72 ± 9.41	123.57 ± 9.62	76.42 ± 7.31	92.38 ± 7.08	98.71 ± 0.69
Immediately after spinal	91.31 ± 10.12	118.91 ± 10.21	72.81 ± 7.62	88.21 ± 7.56	98.78 ± 0.66
2 minutes	94.58 ± 11.18	111.62 ± 11.76	67.91 ± 8.04	82.47 ± 8.18	98.83 ± 0.65
5 minutes	96.17 ± 11.82	105.84 ± 12.36	64.76 ± 8.52	78.49 ± 8.63	98.87 ± 0.61
10 minutes	92.83 ± 10.71	110.24 ± 11.43	67.24 ± 7.98	81.54 ± 8.07	98.86 ± 0.62
15 minutes	90.61 ± 10.08	113.72 ± 10.76	69.61 ± 7.66	84.31 ± 7.72	98.82 ± 0.64
20 minutes	89.42 ± 9.73	116.91 ± 10.27	71.43 ± 7.38	86.59 ± 7.45	98.80 ± 0.65
30 minutes	88.53 ± 9.36	119.38 ± 9.91	73.12 ± 7.25	88.54 ± 7.22	98.79 ± 0.66
Overall p-value	<0.001	<0.001	<0.001	<0.001	0.284

Table 3: Incidence and Characteristics of Hemodynamic Events Following Spinal Anaesthesia (n=102)

Hemodynamic Parameter	Result
Maternal hypotension	36 (35.29%)
No maternal hypotension	66 (64.71%)
Bradycardia	9 (8.82%)
No bradycardia	93 (91.18%)
Vasopressor required	34 (33.33%)
No vasopressor required	68 (66.67%)
More than one vasopressor bolus required	11 (10.78%)
Single or no repeat bolus	91 (89.22%)
Lowest recorded SBP (mmHg), Mean ± SD	96.40 ± 11.70
Lowest recorded MAP (mmHg), Mean ± SD	70.80 ± 9.02
Maximum reduction in SBP from baseline (%)	21.90 ± 8.47
Maximum reduction in MAP from baseline (%)	23.20 ± 8.81
Time to maximum hemodynamic change (min)	5.30 ± 2.20

Table 4: Univariate Analysis of Factors Associated with Maternal Hypotension

Parameter	Hypotension (n=36)	No Hypotension (n=66)	p-value
Age (years), Mean ± SD	28.20 ± 4.10	27.60 ± 4.00	0.479
Weight (kg), Mean ± SD	70.80 ± 8.70	68.00 ± 8.40	0.120
Baseline SBP (mmHg), Mean ± SD	119.30 ± 8.60	125.90 ± 9.20	<0.001
Baseline MAP (mmHg), Mean ± SD	89.60 ± 6.90	93.90 ± 7.10	0.004
Primigravida	10/41 (24.39%)	31/41 (75.61%)	0.059
Multigravida	26/61 (42.62%)	35/61 (57.38%)	
Previous cesarean section – Yes	20/45 (44.44%)	25/45 (55.56%)	0.086
Previous cesarean section – No	16/57 (28.07%)	41/57 (71.93%)	
Highest sensory level T4	28/60 (46.67%)	32/60 (53.33%)	0.006
Sensory level T5–T6	8/42 (19.05%)	34/42 (80.95%)	
Spinal-to-delivery interval (min), Mean ± SD	10.80 ± 2.60	9.40 ± 2.40	0.010

Table 5: Intraoperative, Maternal Adverse and Neonatal Outcomes

Parameter	Overall (n=102)	Hypotension (n=36)	No Hypotension (n=66)	p-value
Spinal-to-incision time (min), Mean ± SD	5.82 ± 1.42	—	—	—
Spinal-to-delivery time (min), Mean ± SD	9.89 ± 2.58	10.80 ± 2.60	9.40 ± 2.40	0.010
Intravenous crystalloid volume (mL), Mean ± SD	840.88 ± 188.64	914.00 ± 186.00	801.00 ± 173.00	0.004
Estimated blood loss (mL), Mean ± SD	521.67 ± 108.52	—	—	—
Nausea	15 (14.71%)	11 (30.56%)	4 (6.06%)	0.002
Vomiting	6 (5.88%)	5 (13.89%)	1 (1.52%)	0.020
Dizziness	10 (9.80%)	8 (22.22%)	2 (3.03%)	0.003
Shivering	8 (7.84%)	4 (11.11%)	4 (6.06%)	0.448
Respiratory discomfort	2 (1.96%)	1 (2.78%)	1 (1.52%)	1.000
Supplemental oxygen required	7 (6.86%)	5 (13.89%)	2 (3.03%)	0.093
Apgar score at 1 min, Mean ± SD	8.13 ± 0.67	8.05 ± 0.72	8.17 ± 0.64	0.406
Apgar score at 5 min, Mean ± SD	9.32 ± 0.52	9.25 ± 0.55	9.36 ± 0.50	0.323
Apgar score <7 at 1 min	4 (3.92%)	3 (8.33%)	1 (1.52%)	0.125
Apgar score <7 at 5 min	1 (0.98%)	1 (2.78%)	0 (0.00%)	0.353

DISCUSSION

The present study included 102 term parturients undergoing elective cesarean section under spinal anaesthesia, with a mean age of 27.81 ± 4.03 years, mean weight of 68.99 ± 8.56 kg, and mean gestational age of 38.31 ± 0.82 weeks. Multigravida women constituted 59.80% of the study population, while 44.12% had a history of previous cesarean section. The L3–L4 interspace was used in 64.71% of patients, and T4 was the most frequent highest sensory level, achieved in 58.82%. These characteristics can be compared with the prospective cohort of Helill et al. (2019), which included 100 women undergoing elective cesarean delivery. Their isobaric and hyperbaric bupivacaine groups were comparable for age, weight, parity, gestational age and baseline hemodynamic parameters; previous cesarean delivery was the indication in 62% of the isobaric group and 56% of the hyperbaric group. However, sensory spread was lower than in the present study, with T6 being most frequent in the isobaric group (62%) and T8 in the hyperbaric group (64%), while a block at T4 or above occurred in only 6% of the isobaric group.[7]

A clear temporal alteration in maternal hemodynamics was observed following spinal anaesthesia. Mean HR increased from 88.72 ± 9.41 beats/minute at baseline to a maximum of 96.17 ± 11.82 beats/minute at 5 minutes, while SBP decreased from 123.57 ± 9.62 to 105.84 ± 12.36 mmHg and MAP from 92.38 ± 7.08 to 78.49 ± 8.63 mmHg at the same time point. SBP, DBP, MAP and HR demonstrated significant overall changes (all $p<0.001$), whereas SpO_2 remained stable ($p=0.284$). Shafeinia et al. (2020), in a randomized study of 116 women undergoing elective cesarean delivery, similarly serially evaluated SBP, DBP, MAP, HR and SpO_2 and found significant differences in arterial pressure, systolic pressure and diastolic pressure at different measurement points between women receiving prophylactic phenylephrine and controls ($p<0.05$). Their findings also demonstrate that the principal hemodynamic disturbance following spinal anaesthesia is a change in arterial pressure, whereas oxygenation generally remains preserved in otherwise healthy parturients.[8]

The greatest hemodynamic disturbance in the present study occurred early after spinal anaesthesia, with the maximum change occurring at 5.30 ± 2.20 minutes. This was also the period in which SBP and MAP reached their lowest mean values. Most women in the present study received spinal anaesthesia in the sitting position (77.45%), whereas only 22.55% received it in the lateral position. Manouchehrian et al. (2021) specifically compared these positions in 106 women and reported hypotension at 6 minutes in 57.7% of women receiving spinal anaesthesia in the sitting position compared with 24.5% in the lateral position ($p=0.001$). At 8 minutes, the corresponding incidences were 36.5% and 5.7% ($p<0.001$). The mean ephedrine requirement was also greater in the sitting group, 16.92 mg compared with 11.50 mg in the lateral group ($p=0.010$). Their observation that clinically important hypotension clustered within the first 6–8 minutes is close to the mean 5.30-minute period of maximum hemodynamic change recorded in the present study.[9]

Maternal hypotension occurred in 36 of 102 women (35.29%) in the present study, while bradycardia occurred in 9 women (8.82%). Vasopressors were required in 33.33%, and 10.78% required more than one vasopressor bolus. The lowest mean SBP and MAP were 96.40 ± 11.70 and 70.80 ± 9.02 mmHg, respectively, while the maximum reductions from baseline were 21.90 ± 8.47% for SBP and 23.20 ± 8.81% for MAP. Somboonviboon et al. (2008), in a prospective study of 722 parturients, reported a higher hypotension incidence of 52.6% but a lower bradycardia incidence of 2.5%. They further found that estimated blood loss of 500–1000 mL increased the odds of hypotension (OR 1.86, 95% CI 1.30–2.67; $p=0.001$), while blood loss >1000 mL increased the odds more markedly (OR 5.31; $p=0.011$). In the present study, mean estimated blood loss was 521.67 ± 108.52 mL, placing the average patient within the lower blood-loss category examined by Somboonviboon et al. Differences in hypotension definitions, spinal drug protocols and preventive measures may account for the difference in absolute incidence between the studies.[10]

Assessment of factors associated with hypotension showed that baseline cardiovascular status and sensory block height were important in the present study. Women developing hypotension had a significantly lower baseline SBP than those remaining stable (119.30 ± 8.60 vs 125.90 ± 9.20 mmHg; $p<0.001$) and a lower baseline MAP (89.60 ± 6.90 vs 93.90 ± 7.10 mmHg; $p=0.004$). In contrast, age ($p=0.479$) and weight ($p=0.120$) were not significantly different. Hypotension occurred in 46.67% of patients with a T4 sensory level compared with 19.05% of those with T5–T6 levels ($p=0.006$). Ohpasanon et al. (2008), in a prospective study of 807 full-term women, reported an overall hypotension incidence of 65.1%. Age >35 years increased the crude odds of hypotension by 1.62, BMI >35 kg/m² by 2.83, and sensory analgesia at or above T5 by 1.55. Their earlier work also identified low baseline SBP as an important risk characteristic. Thus, the present finding of lower baseline SBP and a higher sensory block being associated with hypotension is consistent with their observations, although age and body weight were not significant factors in the current sample.[11]

The association of a higher sensory level with hemodynamic instability was also reflected in the maternal adverse-event profile. In the present study, nausea occurred in 14.71%, vomiting in 5.88% and dizziness in 9.80%. All three were significantly more frequent among women developing hypotension: nausea occurred in 30.56% versus

6.06% (p=0.002), vomiting in 13.89% versus 1.52% (p=0.020), and dizziness in 22.22% versus 3.03% (p=0.003). Mebazaa et al. (2010), in 80 women randomized to 10 mg or 7.5 mg intrathecal bupivacaine, reported hypotension in 88% and 68%, respectively (p=0.03). A sensory block above T4 occurred in 52% of the 10-mg group compared with 10% of the 7.5-mg group (p<0.001); nausea occurred in 52% versus 22% (p=0.005), and vomiting in 25% versus 8% (p=0.03). Mean ephedrine consumption was also higher with 10 mg bupivacaine (32 ± 23 mg) than with 7.5 mg (19 ± 16 mg; p=0.004). These comparative findings parallel the present association between higher block level, hypotension, vasopressor requirement and gastrointestinal symptoms.[12]

The present study additionally demonstrated greater intraoperative support requirements among women who developed hypotension. Mean crystalloid administration was 914.00 ± 186.00 mL in the hypotension group compared with 801.00 ± 173.00 mL in women without hypotension (p=0.004), and the spinal-to-delivery interval was longer (10.80 ± 2.60 vs 9.40 ± 2.40 minutes; p=0.010). Vasopressor treatment was required in 34 women (33.33%). Choudhary et al. (2018), studying 100 parturients randomized to reactive phenylephrine boluses or prophylactic phenylephrine infusion, found that 44 women in the bolus group developed an SBP fall >20% at approximately 6 minutes. Their mean percentage fall in SBP was 28.06 ± 5.30% with reactive bolus treatment compared with only 0.44 ± 4.30% with prophylactic infusion; the infusion group received a mean total phenylephrine dose of 585 ± 54 µg. Nausea and vomiting occurred in 12% of the bolus group compared with 6% of the infusion group. These data correspond with the present observation that patients experiencing greater blood-pressure reduction required greater hemodynamic intervention and experienced more maternal symptoms.[13]

Immediate neonatal outcome remained satisfactory despite the maternal hemodynamic changes. The mean Apgar score in the present study was 8.13 ± 0.67 at 1 minute and 9.32 ± 0.52 at 5 minutes. The 1-minute scores were 8.05 ± 0.72 in the maternal hypotension group and 8.17 ± 0.64 in the no-hypotension group (p=0.406), while the corresponding 5-minute scores were 9.25 ± 0.55 and 9.36 ± 0.50 (p=0.323). Only 4 neonates (3.92%) had a 1-minute Apgar score <7 and only one (0.98%) remained below 7 at 5 minutes. Soxhuku-Isufi et al. (2016), in a randomized study of 202 term women treated with ephedrine or phenylephrine for spinal hypotension, likewise found no significant difference in 1- or 5-minute Apgar scores between treatment groups, and no neonate had an Apgar score <7 at either assessment. At 5 minutes, Apgar scores of 9 were recorded in 43.56% of the ephedrine group and 72.27% of the phenylephrine group, while scores of 10 occurred in 54.45% and 27.72%, respectively. Their findings support the present observation that promptly managed maternal hypotension was not associated with a statistically significant deterioration in immediate Apgar-based neonatal outcome.[14]

CONCLUSION

Spinal anaesthesia for elective cesarean section was associated with significant maternal hemodynamic changes, with the greatest reduction in blood pressure occurring during the early post-spinal period. Maternal hypotension occurred in 35.29% of patients and was more frequently associated with lower baseline blood pressure, higher sensory block level, and increased need for vasopressor and intravenous fluid support. Nausea, vomiting, and dizziness were significantly more common among women who developed hypotension. Despite these maternal hemodynamic alterations, immediate neonatal outcomes remained satisfactory, with no significant difference in Apgar scores between women with and without hypotension.

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