RESEARCH PAPER

Haemodynamic Effects of Spinal Anaesthesia in Severe Pre-Eclamptic and Normotensive Parturients

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ABSTRACT

Spinal anaesthesia is increasingly preferred for caesarean delivery in severe pre-eclampsia, yet its haemodynamic behaviour compared with normotensive parturients remains incompletely defined, especially in resource-limited settings. This prospective hospital-based cohort study compared blood pressure, heart rate, vasopressor requirement, intravenous fluid administration and neonatal APGAR scores in 26 severely pre-eclamptic and 26 normotensive women undergoing elective caesarean section under spinal anaesthesia with 10 mg hyperbaric bupivacaine, recorded at five-minute intervals for 40 minutes. Pre-eclamptic women were significantly older and had higher body mass index, and their systolic, diastolic and mean arterial pressures stayed significantly higher at every interval ($p < 0.001$).

Ephedrine was needed by 15.4% of normotensive and no pre-eclamptic women, and normotensive women received significantly more intravenous fluid. Heart rate differed only transiently at five minutes, and APGAR scores were comparable. Spinal anaesthesia was safe in both groups with close monitoring, judicious fluids and vasopressor readiness.

Keywords: Pre-eclampsia, spinal anaesthesia, caesarean section, haemodynamic changes, ephedrine.

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INTRODUCTION

Hypertensive disorders of pregnancy remain a major cause of maternal and perinatal morbidity worldwide. Pre-eclampsia, defined as new-onset hypertension after 20 weeks of gestation with proteinuria or end-organ dysfunction, complicates 5–8% of pregnancies, particularly in developing countries where antenatal care coverage remains suboptimal.[1,2] In India, hypertensive disorders affect 7–10% of pregnancies and contribute substantially to maternal deaths.[3] Pre-eclampsia occupies a central place because of its unpredictable course and multisystem involvement, and severe disease brings raised systemic vascular resistance, contracted intravascular volume, endothelial dysfunction and heightened vasopressor sensitivity, all of which complicate anaesthetic management during labour and caesarean delivery.

The choice of anaesthesia in pre-eclampsia has been debated for years. General anaesthesia in these women carries exaggerated pressor responses to laryngoscopy, difficult intubation from airway oedema, aspiration, intracranial haemorrhage and pulmonary oedema, while neonates may show lower Apgar scores and respiratory depression from transplacental drug transfer.[4,5] Spinal anaesthesia has therefore emerged as the preferred technique. It is technically simple, produces rapid dense blockade, avoids airway manipulation and exposes the fetus to minimal drug. Historically, sudden profound hypotension was feared because it could compromise uteroplacental perfusion, yet repeated studies show that women with severe pre-eclampsia experience less frequent, less severe and more easily treated hypotension than normotensive women, attributed to high baseline vascular tone, reduced vasodilatory capacity and raised circulating catecholamines.[6,7]

Spinal anaesthesia nevertheless demands caution. Altered sensorium, visual disturbance, thrombocytopenia or coagulopathy may preclude its use, fluid preloading or co-loading risks pulmonary oedema, and vasopressor requirements may differ

between pre-eclamptic and normotensive women, making close monitoring and individualised management essential.[8] In the absence of such contraindications, spinal anaesthesia is increasingly viewed as safer than general anaesthesia because it avoids the severe sympathetic stimulation of airway manipulation and gives more stable perioperative haemodynamics. Understanding blood pressure responses, heart rate changes, hypotension, vasopressor use and maternal and neonatal outcomes is crucial for defining optimal practice, particularly where resources are limited, and such evidence is essential for developing standardised guidelines that protect both maternal safety and fetal wellbeing.

Caesarean delivery rates continue to rise in India, and safe anaesthesia must be ensured for this high-risk group. Despite its clinical importance, regional data comparing haemodynamic responses between severe pre-eclampsia and normotensive parturients undergoing caesarean section under spinal anaesthesia remain limited. Addressing this gap will guide anaesthesiologists working in tertiary, district and primary care settings. This study therefore aimed to compare the haemodynamic effects and incidence of hypotension induced by spinal anaesthesia in severely pre-eclamptic and normotensive parturients undergoing caesarean section, and to evaluate vasopressor and fluid requirements and neonatal APGAR scores. Vasopressor use, fluid strategy and fetal outcome under spinal anaesthesia may differ between these populations and deserve direct comparison in local practice, with findings that may improve clinical decision-making.

METHODOLOGY

This hospital-based prospective cohort study ran for one year and six months in the Department of Anaesthesiology of a tertiary care hospital. Severely pre-eclamptic and normotensive parturients scheduled for elective caesarean section received an identical spinal anaesthesia protocol.

Participant Selection

Sample size was calculated using OpenEpi (95% confidence, 80% power, 1:1 ratio, 53% outcome in unexposed, odds ratio 1.6), giving 26 per group; 52 women were enrolled. Women aged 20–35 years, ASA grade I–III, posted for elective caesarean section were included. Refusal of consent, coagulopathy, local anaesthetic hypersensitivity, ischaemic heart disease, diabetes, local-site infection or sepsis led to exclusion.

Data Collection

After pre-anaesthetic evaluation and written informed consent, baseline pulse, blood pressure, respiratory rate and SpO_2 were recorded. Intra-operative variables, vasopressor use and neonatal outcomes were entered into a pre-structured sheet, checked and later transferred to a master chart.

Anaesthetic Technique

After 6–8 hours of fasting, Ringer lactate 10 ml/kg was co-loaded, and metoclopramide 10 mg with ondansetron 4 mg was given. Spinal anaesthesia was performed using a 25G needle at L3–L4 with 2 ml (10 mg) of 0.5% hyperbaric bupivacaine, targeting a T4 sensory level.

Outcome Measures

Variables were recorded five-minutely for 40 minutes. Primary outcomes: haemodynamic changes and ephedrine requirement (systolic below 100 mmHg or mean pressure fall above 30%). Secondary outcomes: fluid volume and APGAR scores.

Statistical Analysis

Data were analysed using Jamovi version 2.3.28. Continuous variables are expressed as mean and standard deviation and were compared by the independent t-test or Mann–Whitney U test; categorical variables were compared by the Chi-square or Fisher's exact test. A p-value below 0.05 was considered significant.

RESULT

Fifty-two parturients, 26 per group, were analysed. Severely pre-eclamptic women were older (28.8 ± 3.5 versus 24.2 ± 2.1 years), heavier, shorter and had higher body mass index (22.6 versus 19.6 kg/m^2). Baseline systolic, diastolic and mean pressures were 165.5, 101.7 and 122.9 mmHg in the pre-eclamptic group and 115.5, 73.8 and 87.7 mmHg in the normotensive group, whereas pulse and SpO_2 were comparable.

After spinal anaesthesia, pre-eclamptic women remained 20.7–23.5 mmHg higher in systolic pressure at every interval. Ephedrine was required by four normotensive women (15.4%) and none of the pre-eclamptic women. Cumulative fluid at 40 minutes was 1215 versus 896 mL. Heart rate differed only at five minutes (95 versus 86.5 beats/min), and APGAR scores were similar.

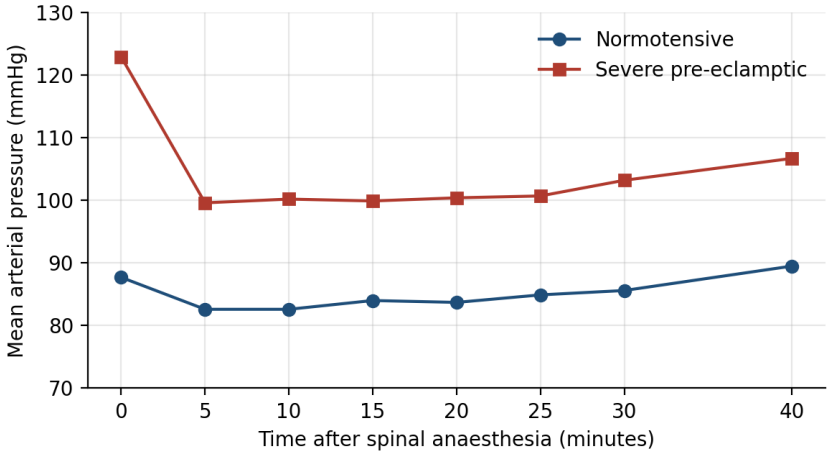


Fig 1: Mean arterial pressure (mmHg) before and after spinal anaesthesia in the two groups.

Statistical Outcome

Independent t-tests showed higher systolic (t = –8.06 to –10.55), diastolic (t = –5.57 to –7.86) and mean arterial pressures (t = –7.52 to –10.66) in pre-eclampsia at all intervals ($p < 0.001$). Heart rate differed at five minutes ($p = 0.033$). Fluid volumes were lower in pre-eclampsia ($p < 0.001$); ephedrine need and APGAR scores did not differ significantly.

DISCUSSION

This prospective cohort study compared the haemodynamic response to spinal anaesthesia in 26 severely pre-eclamptic and 26 normotensive parturients undergoing elective caesarean section; equal group sizes facilitated an unbiased comparison. The principal finding was that pre-eclamptic women maintained significantly higher systolic, diastolic and mean arterial pressures than normotensive women at every interval, required no vasopressor and received less intravenous fluid, while neonatal APGAR scores were comparable. These observations agree with the evidence that spinal anaesthesia is acceptable in severe pre-eclampsia, replacing the earlier fear of sudden profound hypotension.[6,7,9] Similar comparisons have been undertaken in cohorts from Iran and Ethiopia, and spinal anaesthesia has also been compared with epidural anaesthesia in severe pre-eclampsia.[10,11,12,13,14]

Baseline characteristics differed between the groups. Pre-eclamptic women were significantly older, heavier and had higher body mass index, whereas normotensive women were taller. Comparable studies have generally reported well-matched groups with no significant differences in age, weight, height or body mass index,[15,16,17] and another study found similar age but higher body weight in the pre-eclamptic group without consistent statistical significance.[18] Our findings therefore suggest a stronger association between advanced maternal age, higher body mass index and severe pre-eclampsia, although the imbalance may reflect the small sample and the selection of elective cases, and it limits direct comparison of haemodynamic responses.

As expected, baseline blood pressure was markedly higher in severe pre-eclampsia, with systolic 165.5 versus 115.5 mmHg, diastolic 101.7 versus 73.8 mmHg and mean 122.9 versus 87.7 mmHg, while oxygen saturation and heart rate (84.9 versus 79.7 beats/min) were similar. Significantly elevated baseline pressures in pre-eclamptic parturients have been documented across several comparable cohorts, confirming a uniform pathophysiological pattern.[18,15,16,17]

After spinal anaesthesia, pre-eclamptic women remained 20.7–23.5 mmHg higher in systolic, 13.3–15.8 mmHg higher in diastolic and 15.8–17.6 mmHg higher in mean arterial pressure throughout the observation period (all $p < 0.001$). Sustained higher mean arterial pressure in pre-eclamptic women at every time point has been described,[15] as has a greater percentage fall in diastolic and mean pressures among normotensive women (26.8% versus 20.1% and 24.9% versus 20.1% respectively).[16] Greater hypotension incidence (74% versus 47%) and higher vasopressor use in normotensive women have also been reported.[17]

Our own data, however, require careful interpretation. Using group means, systolic pressure at five minutes fell by roughly 20% from baseline in pre-eclamptic women (165.5 to 132 mmHg) compared with about 6% in normotensive women (115.5 to 109 mmHg), and mean arterial pressure fell by approximately 19% and 6% respectively. The pre-eclamptic group therefore experienced a larger relative decline, yet its pressures stayed well above conventional hypotension thresholds, which explains why no ephedrine was needed. Because treatment was triggered by a systolic pressure below 100 mmHg or a mean pressure fall above 30%, higher starting pressures conferred a built-in margin. Stability in pre-eclampsia is thus better described as preserved pressure levels than as a smaller fall, and the incidence of hypotension was not tabulated separately in this study.

Several physiological factors may explain why spinal anaesthesia is tolerated despite this decline. Severe pre-eclampsia involves endothelial dysfunction, raised

systemic vascular resistance, heightened sympathetic activity and increased circulating catecholamines and endothelin-1, which raise resting vascular tone and blunt vasodilatation after sympathetic blockade. Reduced plasma volume and haemoconcentration may further limit the extent of sympathetic blockade, and a low-dose single-shot technique with 10 mg bupivacaine and a controlled block height may add to this effect. In normotensive parturients, venous pooling, aortocaval compression and a marked fall in vascular resistance after T4 blockade make hypotension more likely, consistent with the four women who needed ephedrine.

Ephedrine was required by 15.4% of normotensive and none of the pre-eclamptic women, although this difference was not statistically significant in a sample of this size. Other investigators found significantly higher ephedrine consumption in normotensive women (13.4 versus 6.6 mg)[18] and higher vasopressor doses (100 versus 28.6 mcg).[17] Vasopressors should nevertheless be readily available for every parturient, since requirements vary with the level of block and baseline status.[8]

Cumulative intravenous fluid was significantly greater in normotensive women at all intervals (1215 versus 896 mL at 40 minutes; $p < 0.001$). This reflects a deliberately restrictive strategy in pre-eclampsia to avoid pulmonary oedema and, possibly, greater susceptibility to spinal-induced hypotension among normotensive women. Restricting volume matters because fluid overload can precipitate pulmonary oedema, a recognised complication of severe pre-eclampsia. Both groups received a standardised 10 ml/kg Ringer lactate co-load. Earlier studies likewise found higher fluid requirements in normotensive parturients, significantly so in one[17] and non-significantly in another.[18]

Heart rate was significantly higher in pre-eclamptic women only at five minutes (95 versus 86.5 beats/min; $p = 0.033$), possibly reflecting early sympathetic activity, and the groups converged thereafter. Oxygen saturation and intra-operative temperature did not differ at any time, in agreement with reports showing no significant difference in heart rate or oxygenation.[18,16]

Neonatal outcomes were reassuring. APGAR scores at one minute (7.54 versus 7.27) and five minutes (10 versus 9.88) were statistically similar ($p = 0.146$ and 0.077 respectively), and puncture-to-delivery time was about four minutes in both groups. Comparable APGAR scores between pre-eclamptic and normotensive mothers under spinal anaesthesia have been repeatedly reported,[18,16,17,19] supporting neonatal safety with a technique that avoids the transplacental drug exposure associated with general anaesthesia.

Practical implications follow. Pre-eclamptic women should not be denied spinal anaesthesia merely for fear of hypotension, yet frequent monitoring is essential because the largest changes occurred early, within the first five to ten minutes. Individualised fluid co-loading, early recognition of a falling pressure relative to baseline and prompt vasopressor use should guide practice. In normotensive women, a greater tendency towards hypotension argues for adequate co-loading and vasopressor readiness.

The study has limitations. It was conducted at a single centre with only 52 participants, restricting generalisability and statistical power. Baseline age and body mass index differed between groups, severity grading, prior antihypertensive therapy and fluid status were not controlled in detail, and variation in technique may have introduced performance bias. Neonatal assessment was limited to APGAR scores, without umbilical artery pH or NICU admission data, and long-term maternal outcomes were not evaluated.

Despite these limitations, the results support spinal anaesthesia in severe pre-eclampsia without contraindications, with continuous monitoring, restrained fluid administration and readily available vasopressors. Larger multicentre studies that report hypotension incidence against standardised definitions are needed to establish uniform guidelines, which are particularly relevant in resource-limited settings where regional anaesthesia is often preferred.

CONCLUSION

This prospective comparison demonstrates clear differences in baseline and intra-operative cardiovascular status between the groups. Spinal anaesthesia produced predictable and well-tolerated haemodynamic changes in both severely pre-eclamptic and normotensive parturients undergoing elective caesarean section. Pre-eclamptic women, who were older and had higher body mass index, maintained significantly higher systolic, diastolic and mean arterial pressures throughout, required no ephedrine and received less intravenous fluid, whereas four normotensive women needed vasopressor support. Heart rate differed only transiently at five minutes, and oxygen saturation and temperature remained stable and comparable. Neonatal APGAR scores and puncture-to-delivery time were comparable, indicating no adverse effect on immediate neonatal wellbeing. Because diabetes and ischaemic heart disease were excluded, these findings apply to otherwise healthy women aged 20–35 years.

Spinal anaesthesia can therefore be considered safe and effective in severe pre-eclampsia in the absence of contraindications, provided that blood pressure and heart rate are monitored closely, fluids are given judiciously and vasopressors are readily available. Anaesthetic protocols should be individualised to maternal risk, with careful dose titration and early recognition of hypotension. Larger multicentre studies are recommended to confirm these findings and support standardised guidelines. Careful individualised management remains essential to optimise maternal

safety while maintaining favourable neonatal outcomes.

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