

Comparison of Segmental versus Conventional Spinal Anaesthesia in Preeclamptic Parturient Undergoing Caesarean Section: A Randomised Controlled Study

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ABSTRACT

Introduction: Spinal anaesthesia-induced maternal hypotension is still the most frequent complication observed in preeclamptic parturient. Segmental spinal anaesthesia is another alternative where the dural puncture is done at the lower thoracic vertebral level, and segments involving the surgical interventions are blocked preferentially.

Aim: To compare haemodynamic variables and sensory and motor blockade characteristics after segmental versus conventional spinal anaesthesia in preeclamptic parturients undergoing Lower-Segment Caesarean Section (LSCS).

Materials and Methods: The present randomised controlled study was conducted at Baroda Medical College, Sir Sayajirao General Hospital, Vadodara, Gujarat, India, from July 2022 to August 2023. A total of 70 preeclamptic parturients with American Society of Anaesthesiologists (ASA) status II and III, posted for caesarean section, were randomly allocated to either Group S, which received segmental spinal anaesthesia at the T₉₋₁₀ or T₁₀₋₁₁ level, or Group C, which received conventional spinal anaesthesia at the L₂₋₃ or L₃₋₄ level. The primary parameter studied was a comparison of haemodynamic stability. Characteristics of sensory and motor blockade, ability to go to stretcher unaided, duration of postoperative analgesia,

and perioperative complications were observed secondarily. Pearson's χ^2 -test, student t-test and Mann-Whitney U test were applied as appropriate for the final statistical analysis. The significance of data analysed by p-value and p<0.05 was considered significant.

Results: The mean age and ASA status of the patients were comparable in Group S and Group C. (25.88±5.36 vs 25.36±4.89, p=0.72 and 18/17 vs 16/19, p=0.68, respectively). Reduced incidences of hypotension (14.29% vs 37.14%, p=0.03) leading to the requirement of a lesser number of doses of vasopressor in patients with Group S than in Group C (0 (0-0) vs 0 (0-1), p=0.02). The onset of sensory blockade at the T₆ dermatome was faster (69.2±72.65 vs 200.4±134.92 seconds, p<0.0001), and the duration of sensory blockade was shorter in patients belonging to Group S in comparison to Group C (123.6±55.66 vs 203.8±45.71 minutes, p<0.0001). All patients in Group C had grade three motor blockade as opposed to none in Group S (p<0.0001), which led most (90%) of patients in Group S to shift to the stretcher unaided.

Conclusion: Segmental spinal anaesthesia is a safe and alternative technique when used in a preeclamptic parturient undergoing LSCS, providing better haemodynamic stability with adequate anaesthesia and early postoperative ambulation.

Keywords: Caesarean delivery, Hypotension, Preeclampsia, Thoracic spinal, Vasopressor

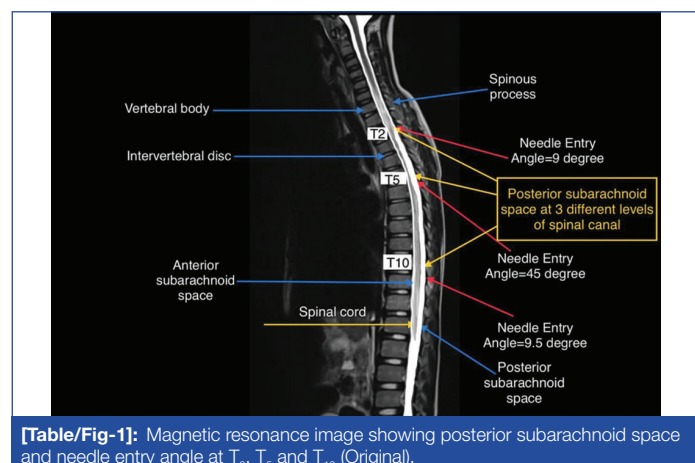
INTRODUCTION

Pregnancy-induced hypertension accounts for a leading cause of morbidity and mortality in developing countries, with a complication rate of about 5-7% of pregnancies [1]. Considering the Anaesthesiologists, severe preeclampsia presents a challenge. For elective caesarean deliveries, risk-benefit considerations strongly favour neuraxial techniques over general anaesthesia as it avoids the dangers associated with difficult intubation, the possibility of hypertensive crisis, haemorrhagic stroke and/or acid aspiration in the setting of severe preeclampsia as long as it is not contraindicated [2]. Supportive evidence favours subarachnoid block in identical conditions when the platelet counts are reported >80,000/mm³ [3]. But, it is frequently associated with hypotension, which can have both maternal and neonatal consequences. Conventional (lumbar) spinal anaesthesia using low-dose local anaesthetics in conjunction with additives has been found to provide better haemodynamic stability and fewer maternal side-effects with good neonatal outcomes to the detriment of compromised anaesthetic efficacy [4]. The segmental (thoracic) spinal anaesthesia technique limits blockade in the region to be operated on with more diluted and lower doses of local anaesthetics, which can undoubtedly avoid undesirable effects [5]. The study reported the administration of an intrathecal block at the T₁₀ level for operations on the lower

abdomen and pelvis [6]. The review demonstrated a rapid onset of action, irrespective of baricity, with a reduction in the incidence of hypotension and faster recovery from the blockade, as well as a low incidence of paraesthesia and no spinal cord injuries, in 636 patients treated with thoracic spinal anaesthesia [7]. Rajeev C et al., suggested segmental (thoracic) spinal anaesthesia as a successful and efficient alternative technique when used for caesarean section in a patient with severe preeclampsia [1]. However, understanding the spinal column and experience are crucial before using such a technique. Various studies have demonstrated a significant distance between the duramater and the spinal cord at the T₂, T₅, and T₁₀ levels, with the greatest distance observed at T₅ [3,6,8].

The distance between the cord and duramater becomes an essential factor determining the threat of medullary injury caused by the needle tip. The dorsal subarachnoid space at the midthoracic level (T₅-5.8 mm) is more profound than the upper (T₂-3.9 mm) and lower (T₁₀-4.1 mm) thoracic levels. The thoracic curvature of the spine will further be accentuated if the patient is placed in a sitting head-down position, which increases the posterior separation of the spinal cord and dural sheath at thoracic levels [8,9]. With a 45° insertion angle, the distance at midthoracic levels (T₅) is increased further [Table/Fig-1]. The injury during inadvertent dural puncture while

delivering thoracic and cervical epidural anaesthesia is precluded by this space [3]. Recent literature on regional anaesthesia has explored the efficiency and safety of spinal anaesthesia through the thoracic approach, which is used for various laparoscopic, abdominal, urological, and breast surgeries. It has proven to provide intraoperative haemodynamic stability [6,10-12].



The authors reviewed the literature and found only one case report regarding thoracic spinal anaesthesia in parturients with preeclampsia, which described stable haemodynamics, effective muscle relaxation and speedy postoperative recovery [1,2,5,6]. Therefore, the authors decided to compare segmental (thoracic) versus conventional (lumbar) spinal anaesthesia in preeclamptic parturients undergoing caesarean section. It was hypothesised that segmental spinal anaesthesia would provide better haemodynamic stability than conventional spinal anaesthesia.

MATERIALS AND METHODS

The present randomised, single-blinded, controlled study was conducted at Baroda Medical College, Sir Sayajirao General Hospital, Vadodara, Gujarat, India, from July 2022 to August 2023. The Institutional Ethics Committee for Biomedical and Health Research approved the study on 29 April 2022 (vide approval letter number: IECBHR/089-2022). The study was registered at the Clinical Trial Registry of India (vide approval registration number: CTRI/2022/06/043195, registration date: June 13, 2022) before patient enrollment commenced.

Inclusion criteria: The study enlisted 18-40-year-old preeclamptic parturient with American Society of Anaesthesiologists (ASA) status II and III, having a full-term singleton pregnancy with a normal bleeding profile posted for caesarean section under spinal anaesthesia.

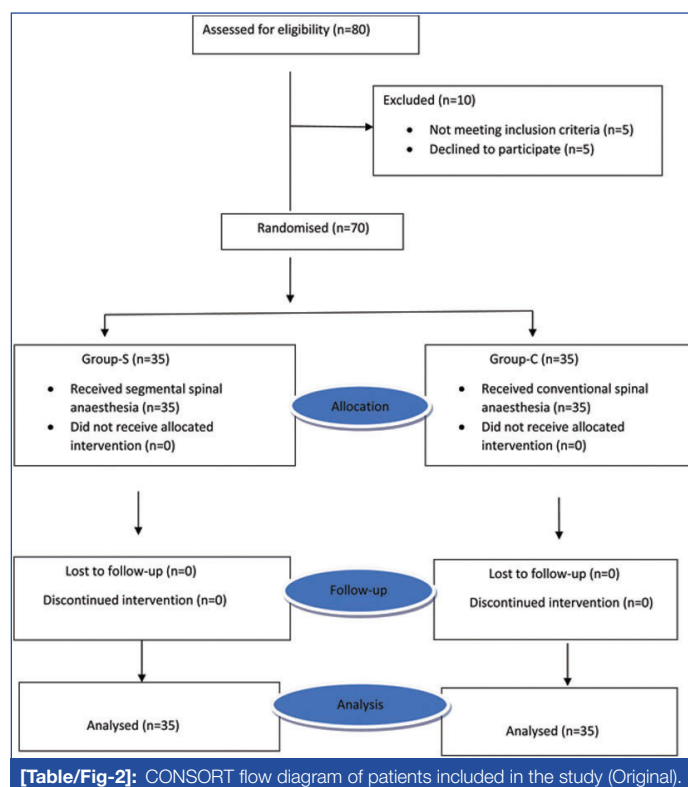
Exclusion criteria: Parturient with contraindications to spinal anaesthesia, signs of Haemolysis, Elevated Liver Enzymes and Low Platelet Count (HELLP) syndrome, foetal distress, cord prolapse, a significant history of alcohol or drug abuse, previous caesarean section, neurological or musculoskeletal diseases, thrombocytopenia (platelet count <80000/mm³), morbid obesity, placental abnormalities like placenta previa, abruption placenta and unable to understand Visual Analogue Score (VAS) as well as patients who refused to participate were excluded.

Sample size calculation: Based on a preliminary pilot study conducted by allocating 10 patients in each group, the authors assumed a relative reduction of 20% in episodes of hypotension in the segmental spinal group as compared to the conventional spinal group. After setting the α error 0.05 and β error 0.2, the required sample size was 59. 70 patients were enrolled keeping dropouts in mind.

Study Procedure

Written informed consent was obtained from all participants. Random assignment of all patients to two groups, either Group S

(segmental spinal group) or Group C (conventional spinal group), was done using computer-generated random numbers (www.randomizer.org) with a ratio of 1:1. The assignment was sealed in an opaque envelope which was opened after receiving the patient on the operation table by the principal investigator. The patients were blinded to the group allocation. The authors adhered to the applicable Consolidated Standards of Reporting Trials (CONSORT) guidelines [Table/Fig-2]. The group who received conventional spinal anaesthesia was taken as control group.



The nil per oral status of all patients was confirmed. The techniques of spinal anaesthesia and VAS were explained to all. A large-bore intravenous cannula was inserted after taking the patient into the operating theatre. The standard ASA monitoring, including Electrocardiogram (ECG), non-invasive blood pressure and pulse oximetry, was applied, and baseline vitals {Pulse Rate (PR), Systolic Blood Pressure (SBP), ECG and Oxygen Saturation (SpO₂)} were recorded. Parturients were premedicated with ondansetron 4 mg and pantoprazole 40 mg intravenously five minutes before induction. After placing the parturient in a left lateral position under all sterile precautions, the skin was infiltrated using 2 mL of 2% lignocaine solution. Patients in Group S received 1.2 mL of 0.5% hyperbaric bupivacaine with 25 µg of fentanyl at either T₉₋₁₀ or T₁₀₋₁₁ space, and 2.5 mL of 0.5% hyperbaric bupivacaine with 25 µg of fentanyl was delivered at either L₂₋₃ or L₃₋₄ space in Group C using a 25 G Quincke's needle. Then, the patient was turned into a supine position and a wedge was kept under the right buttock. All patients were co-loaded with 500 mL of intravenous Ringer's lactate during the procedure of spinal anaesthesia and then, after, continued as 7 ml/kg/hour. A non-rebreathing mask with oxygen at four litres per minute was continued throughout the intraoperative period.

Intraoperatively, vital parameters, including PR, SpO₂, SBP, Mean Arterial Pressure (MAP), and ECG, were monitored every two minutes for the first 15 minutes, then every 10 minutes until the end of the procedure. Characteristics of the sensory block were assessed with the tip of a hypodermic needle (i.e., pinprick method in midclavicular line bilaterally), and characteristics of the motor block were assessed as per the modified Bromage scale at 30 seconds, then every minute to five minutes, followed by at seven and 10 minutes. After adequate anaesthesia (T₆), the surgery was

started. All the neonates were assessed with Appearance, Pulse, Grimace, Activity, and Respiration (APGAR) scores at 1, 5, and 10 minutes after delivery. Surgical parameters, such as duration of surgery and blood loss, were examined. Blood loss remained up to 700-800 mL, which was replaced accordingly. Postoperatively, the patient was transferred to a recovery room and assessed at 1, 2, 3, 4, 5, and 6 hours, followed by assessments at 8, 12, and 24 hours for vital signs, VAS, and complications.

The primary outcome was to compare intraoperative haemodynamic stability, for which the incidence of hypotension and the total vasopressor requirement were recorded. Secondary outcomes included characteristics of sensory and motor block, the patient's ability to shift to a stretcher unaided, duration of postoperative analgesia, and complications. Whenever a drop in SBP to <100 mmHg or <20% of preoperative value was considered as hypotension and managed with oxygen, intravenous fluids, and ephedrine 5 mg intravenously. The total number of ephedrine doses was recorded. The time to achieve block at the T₆ dermatome (seconds) was considered as a loss of pinprick at the T₆ level. The duration of the sensory block (in hours) was calculated as the time interval from the loss of pinprick sensation to its reappearance at the T₆ dermatome. The degree of motor block was graded as per the modified Bromage scale (Bromage 0- Patient can move the hip, knee, and ankle joint; Bromage 1- Patient is unable to move the hip but can move the knee and ankle joints; Bromage 2- Patient is unable to move hip and knee but can move ankle joint; Bromage 3- Patient is unable to move hip, knee, and ankle joints). The duration of the motor block (hours) was considered as the time from grade 1 to grade 0 motor blockade. Neonatal well-being was scored according to the APGAR status. The assessment of postoperative analgesia was evaluated using a VAS, where 0 was considered to indicate no pain, and a score of 10 represented the worst pain. Duration of postoperative analgesia was considered from intrathecal injection of a drug to the requirement of the first rescue analgesic (paracetamol 1 gm intravenously when VAS ≥4). Perioperative complications like paresthesia, bradycardia (PR <20% of pre-procedure value or <60/minute, treated with atropine 0.6 mg intravenously), hypotension (as stated above), number of episodes of nausea and vomiting (treated with intravenous ondansetron, 4 mg) respiratory depression (SpO₂ <95% or respiratory rate <12/minute, managed with O₂ supplementation) and post-dural puncture headache (managed with fluids and analgesics) were looked for and managed accordingly.

STATISTICAL ANALYSIS

All data were compiled, and the master chart was prepared in Microsoft Excel. The continuous data were presented as mean±SD and the categorical data as numbers or percentages. The statistical analysis of the data was done using MedCalc for Windows, version 22.030 (MedCalc Software Ltd., Ostend, Belgium). The continuous variables, such as age, characteristics of sensory blockade and motor blockade, and duration of postoperative analgesia, were analysed using Student's t-test. Pearson's χ^2 -test or Fisher's-exact test was applied to analyse categorical data like gender, ASA grading, and incidences of hypotension, Bromage grading for the degree of motor blockade as appropriate. The normality for data distribution was checked using the Shapiro-Wilk test. Then the Mann-Whitney U test was applied for the non-normally distributed data, such as the total number of doses of vasopressor needed. The significance of data analysed by p-value and p<0.05 was considered significant.

RESULTS

Overall, 80 patients were assessed for eligibility. Ten patients were excluded due to their inability to meet the eligibility criteria or refusal to participate, which ultimately resulted in the enrollment of 70 patients and the randomisation of 35 patients in each group. After

randomisation, the participants either received segmental spinal or conventional spinal anaesthesia as per group allocation for a caesarean section. All patients completed the study [Table/Fig-2]. The two groups were comparable demographically, as shown in [Table/Fig-3]. The operative procedure and surgical duration remained similar between the two groups.

Parameters	Group S (n=35)	Group C (n=35)	p-value
Age (years)	25.88±5.36	25.36±4.89	0.72
Weight (kg)	54.7±7.44	56.4±6.22	0.45
ASA grading II/III	18/17	16/19	0.68
Duration of surgery (minutes)	76.40±11.86	76±10.40	0.90

[Table/Fig-3]: Demographic profile.

(Values are presented as mean±SD or numbers. Statistical analysis: Student t-test, except ASA grading by Pearson's χ^2 -test, Abbreviations: kg-kilogram, ASA: American Society of Anesthesiologists)

As per [Table/Fig-4], lesser incidences of hypotension were observed in Group S (14.29%) when compared to Group C in which it was 37.14% (p=0.03, difference: 22.85%, 95% Confidence Interval (CI) 2.28% to 41.22%, degree of freedom (df) 1, χ^2 - 4.72). The total intraoperative requirement for vasopressor doses was significantly lower in Group S than in Group C. (0 (0-0) vs 0 (0-1), p=0.02, Z=-2.30, standardised effect size=0.28 [Table/Fig-4]. Four patients in Group C required two doses of ephedrine; otherwise, all patients in both groups needed a single dose. Both groups' mean HR, SBP, MAP and SpO₂ remained comparable throughout the perioperative period [Tables/Fig-5-8].

Parameter	Group S (n=35)	Group C (n=35)	p-value
Incidences of hypotension (percentage)	5 (14.29%)	13 (37.14%)	0.03
Total number of doses of vasopressor required (Median (IQR))	0 (0-0)	0 (0-1)	0.02

[Table/Fig-4]: Intraoperative characteristics of haemodynamics - comparison of incidences of hypotension intraoperatively and total consumption of vasopressor. IQR: Interquartile range; (Values are presented as numbers/percentages or median with Interquartile Range (IQR) Statistical analysis: Incidences of hypotension- Pearson's χ^2 -test, Total number of doses of vasopressor required- Mann-Whitney U test)

Mean Heart Rate	Group S (n=35)	Group C (n=35)	p-value
Preop	93.52±9.50	95.36±10.71	0.52
Intraop 1 min	95.76±9.63	98.08±10.74	0.43
3 min	94.64±8.82	99.04±10.44	0.11
5 min	95.44±7.69	99.76±9.02	0.07
7 min	95.2±7.89	99.84±9.72	0.07
10 min	95.4±7.59	98.8±7.78	0.13
15 min	94.36±7.30	97.44±6.91	0.13
20 min	94.8±6.50	97.6±7.16	0.15
30 min	94±6.16	96.88±7.63	0.15
40 min	94.56±6.57	95.52±9.31	0.68
50 min	93.04±6.61	95.68±8.99	0.24
60 min	92.2±6.17	96.56±8.26	0.11
70 min	93.28±6.63	96.25±6.81	0.12
80 min	92.72±5.71	95.68±6.87	0.10
90 min	92.72±5.59	95.56±7.07	0.12
100 min	92.88±5.57	95.48±7.07	0.16
110 min	92.96±5.60	95.48±7.07	0.17
Immediate postop	93.92±6.91	97.04±7.74	0.14
1 hr	94.32±6.49	95.04±8.16	0.73
2 hr	95.36±6.10	98.08±8.17	0.12

3 hr	97.36±6.12	100.4±7.38	0.07
4 hr	98.17±5.99	97.44±19.11	0.86
5 hr	99.68±6.67	102.88±5.71	0.07
6 hr	99.84±6.73	103.04±5.60	0.07

[Table/Fig-5]: Perioperative mean heart rate variation at different time intervals. (Values are presented as mean±SD; Statistical analysis: Student t-test; Min- Minutes, hr- Hours)

Mean SBP (mmHg)	Group S (n=35)	Group C (n=35)	p-value
Preop	148.88±18.48	149.76±18.43	0.87
Intraop 1 min	145.68±19.54	146.24±15.07	0.91
3 min	137.20±17.19	138.96±15.35	0.70
5 min	129.80±15.89	130.12±18.99	0.94
7 min	123.52±16.63	120.48±21.31	0.58
10 min	121.08±15.84	119.92±20.40	0.82
15 min	121.72±14.09	121.91±18.88	0.97
20 min	122.8±11.69	122.96±17.90	0.97
30 min	123.28±11.91	125.68±19.18	0.60
40 min	125.52±11.36	127.36±17.28	0.66
50 min	126.72±11.29	127.28±15.96	0.89
60 min	128.72±11.68	128.72±14.92	1.00
70 min	131.12±10.53	130.80±14.60	0.93
80 min	132.32±10.81	133.04±13.64	0.84
90 min	133.12±11.16	133.20±13.86	0.98
100 min	133.20±11.22	133.28±13.86	0.98
110 min	133.20±11.22	133.28±13.86	0.98
Immediate postop	134.16±12.23	135.52±13.05	0.70
1 hr	135.04±10.41	136.56±13.86	0.88
2 hr	136.88±10.47	138.80±12.81	0.56
3 hr	137.84±11.47	141.76±13.23	0.27
4 hr	139.20±10.03	143.36±11.38	0.18
5 hr	140.40±10.26	143.68±10.99	0.28
6 hr	140.56±10.60	143.92±10.70	0.27

[Table/Fig-6]: Perioperative Mean Systolic Blood Pressure (SBP) (mmHg) variation at different time intervals.

(Values are presented as mean±SD; Statistical analysis: Student t-test; Abbreviation: SBP: Systolic blood pressure, MIN: Minutes, HR: Hours)

MAP (mmHg)	Group S (n=35)	Group C (n=35)	p-value
Preop	112.61±13.70	114.03±12.89	0.71
Intraop 1 min	111.01±14.26	111.84±10.89	0.82
3 min	105.09±13.63	106.85±11.20	0.62
5 min	99.32±12.89	99.64±14.07	0.93
7 min	95.52±11.59	92.32±15.93	0.42
10 min	92.2±13.05	91.81±15.32	0.40
15 min	92.65±11.29	93.81±13.41	0.74
20 min	93.78±9.36	94.90±13.53	0.74
30 min	94.05±8.39	95.65±14.62	0.64
40 min	96.08±8.02	97.81±12.36	0.56
50 min	96.32±8.24	97.73±14.17	0.67
60 min	97.78±8.41	103.81±23.52	0.23
70 min	99.92±7.83	102.54±11.58	0.35
80 min	100.75±8.04	103.73±11.23	0.29
90 min	101.49±8.22	104.36±11.47	0.31
100 min	101.57±8.30	104.45±11.58	0.32
110 min	101.65±8.39	104.53±11.71	0.32
Immediate postop	98.07±21.55	103.31±9.49	0.27
1 hr	103.2±7.49	104.19±9.21	0.68
2 hr	104.19±8.28	104.61±8.15	0.88

3 hr	104.51±8.0	107.47±8.48	0.21
4 hr	105.55±7.06	108.37±7.89	0.19
5 hr	106.59±7.31	108.91±7.13	0.26
6 hr	106.75±7.50	109.31±6.79	0.21

[Table/Fig-7]: Perioperative mean of Mean Arterial Pressure (mmHg) variation at different time intervals.

(Values are presented as mean±SD; Statistical analysis: Student t-test; Abbreviation: MAP: Mean arterial pressure; MIN: Minutes; HR: Hours)

SpO ₂ (%)	Group S (n=35)	Group C (n=35)	p-value
Preop	98.24±0.92	98.4±0.70	0.43
Intraop 1 min	98.36±0.81	98.48±0.77	0.59
3 min	98.68±0.55	98.84±0.37	0.23
5 min	98.92±0.27	98.92±0.27	1.00
7 min	98.92±0.27	98.96±0.2	0.55
10 min	98.92±0.27	98.96±0.2	0.55
15 min	98.96±0.2	98.88±0.33	0.31
20 min	98.96±0.2	98.96±0.2	1.00
30 min	98.92±0.27	98.92±0.27	1.00
40 min	98.96±0.2	98.96±0.2	1.00
50 min	98.92±0.27	98.96±0.2	0.55
60 min	98.88±0.33	98.92±0.27	0.64
70 min	98.96±0.2	98.96±0.2	1.00
80 min	98.92±0.27	98.96±0.2	0.55
90 min	98.92±0.27	98.96±0.2	0.55
100 min	98.96±0.2	98.96±0.2	1.00
110 min	98.96±0.2	98.92±0.27	0.55
Immediate postop	98.96±0.2	98.92±0.27	0.55
1 hr	98.92±0.27	98.96±0.2	0.55
2 hr	98.92±0.27	98.96±0.2	0.55
3 hr	98.96±0.2	98.96±0.2	1.00
4 hr	98.96±0.2	98.96±0.2	1.00
5 hr	98.96±0.2	98.96±0.2	1.00
6 hr	98.96±0.2	98.96±0.2	1.00

[Table/Fig-8]: Perioperative mean SpO₂ (%) variation at different time intervals.

(Values are presented as mean±SD; Statistical analysis: Student t-test)

[Table/Fig-9] summarises the characteristics of spinal blockade achieved in both groups. The achievement of T₆ sensory blockade was significantly faster in Group S within 69.2±72.65 seconds, while it took 200.4±134.92 seconds in Group C to achieve the same (p<0.0001, 95% CI 79.52 to 182.88, df 68, SE 25.90). Sensory blockade was significantly prolonged in Group C, lasting up to 203.8±45.71 minutes, compared to Group S, which lasted for 123.6±55.66 minutes (p<0.0001, 95% CI 55.91 to 104.49, df 68, SE 12.17). All patients in Group C had a grade 3 degree of motor blockade, while in Group S, the grades were 0, 1, 2, and 3, with 18, 10, 7, and 0 patients, respectively. The motor blockade was delayed up to 171.2±51.64 minutes in Group C in comparison to Group S, which lasted for 101.6±48.53 minutes (95% CI 45.70 to 93.50, p<0.0001, DF 68, SE 11.98). Ninety-one percent of patients in Group S had been able to move to the stretcher unaided. At the same time, no one could do so in Group C, which was statistically highly significant (p<0.0001, 95% CI 73.92 to 96.82, df 1, χ^2 57.61).

All the neonates had APGAR scores of seven or higher at 1, 5, and 10 minutes after delivery [Table/Fig-10]. The postoperative VAS score remained comparable between both groups [Table/Fig-11]. No significant difference was observed in the total duration of postoperative analgesia between the two groups (p=0.437, 95% CI -34.10 to 14.90, df 68, SE 12.28) [Table/Fig-9]. Two patients from Group S and three patients from Group C had nausea postoperatively without associated hypotension. None of the

Parameters	Group S (n=35)	Group C (n=35)	95% CI	p-value
Sensory blockade				
Onset (secs)	69.2±72.65	200.4±134.9	79.52 to 182.88	<0.0001
Duration (min)	123.6±55.66	203.8±45.71	55.91 to 104.49	<0.0001
Motor blockade				
Modified Bromage scale (0/1/2/3)	18/10/7/0	0/0/0/35	44.55 to 94.64	<0.0001
Duration of motor blockade (mins)	101.6±48.53	171.2±51.64	45.70 to 93.50	<0.0001
Move to stretcher unaided (yes/no) (percentage)	32/3 (91%)	0/35 (0%)	73.92 to 96.82	<0.0001
Total duration of postoperative analgesia	280.8±48.12	271.2±54.41	-34.10 to 14.90	0.437

[Table/Fig-9]: Characteristics of spinal anaesthesia: comparison of sensory and motor blockade, ability to move to stretcher unaided and total duration of postoperative analgesia.

(Values are presented as mean±SD or numbers/percentages, Statistical analysis: Onset, duration of sensory and motor blockade and duration of postoperative analgesia - Student t-test, Modified Bromage grading and percentage of patients moved to stretcher unaided- Pearson's χ^2 -test, Abbreviations: SD: standard deviation; CI: Confidence interval; sec: seconds; min: minutes)

Time	Group S (n=35)	Group C (n=35)	p-value
1 minute	7.16±0.68	6.91±0.65	0.19
5 minutes	8.2±0.64	7.91±0.65	0.11
10 minutes	8.24±0.59	7.95±0.62	0.09

[Table/Fig-10]: Neonatal APGAR scores at various time intervals.

(Values are presented as mean±SD; Statistical analysis: Student t-test)

VAS	Group S (n=35)	Group C (n=35)	p-value
Immediate postop	0	0	
1 hr	0.24±0.83	0.6±1.22	0.23
2 hr	1.36±1.77	2.24±2.00	0.11
3 hr	3.64±1.68	4.28±1.88	0.21
4 hr	5.64±1.11	5.8±1.52	0.67
5 hr	6.84±0.55	6.68±0.74	0.39
6 hr	7±0.2	7±0.1	1.0

[Table/Fig-11]: Postoperative Visual Analogue Scale (VAS) Score at various time intervals.

(Values are presented as mean±SD; Statistical analysis: Student t-test, p>0.05; HR: Hours; VAS: Visual Analogue Scale)

patients in any group had bradycardia, pruritus, post-dural puncture headache or neurological sequelae.

DISCUSSION

The present study resulted in fewer incidences of intraoperative hypotension, lower vasopressor requirements, a faster onset with a shorter duration of sensory block, and early motor power recovery in patients who received segmental compared to conventional spinal anaesthesia as hypothesised before the study.

Compared to Group C, a 22% reduction in intraoperative incidences of hypotensive episodes and a significant reduction in demand for the vasopressor (ephedrine) were observed in Group S. A high degree of haemodynamic stability was documented in the case study, which utilised a low-dose thoracic segmental spinal technique in a patient with severe preeclampsia, resulting in high patient satisfaction, as reported by Rajeev C et al., [1]. A similar result was obtained by Imbelloni LE et al., who found a significant 52.2% decrease in the incidence of hypotension when comparing 15 mg of hyperbaric bupivacaine with 7.5 mg at the lumbar and thoracic levels, respectively [13,14]. Similarly, Mahmoud A et al., found minimal haemodynamic derangement requiring single-dose ephedrine in 16% of patients using midthoracic injection for breast

surgery [15]. As judged by the sensory block, most of the spinal cord segments responsible for sympathetic outflow are blocked by the local anaesthetics; preferential blockade of the sensory and motor fibres with reduced drug volume would play a vital role in preserving stable haemodynamics [7]. As stated by Henke Vanessa G et al., the incidence of spinal anaesthesia-induced hypotension depends on the dose of the local anaesthetics [2].

The patients in Group S achieved significantly faster sensory blockade at the T₆ dermatome compared to those in Group C. Most patients were pain-free as they turned supine, which immediately made them calm and comfortable. The smaller amount of cerebrospinal fluid in the thoracic segment compared to the lumbar and cervical segments and the thinner thoracic radicular compared to other segments led to lesser dilution of the local anaesthetic drug. The easily blocked rootlets are due to their smaller diameter, which justifies a faster onset of sensory blockade in patients belonging to Group S [15,16]. Prior studies have also reported a reduction in time (2.22 vs 7.17 minutes and 2.7 vs 7.2 minutes) to reach the hyperbaric bupivacaine to T₃ level using thoracic injection, with a dose half that of conventional doses (15 mg vs 7.5 mg), compared to lumbar injection [13,14]. This supports the use of a 1.2 mL drug volume for thoracic injection in this study. According to the available data, the average Indian parturient requires a 2.6 mL volume and a dose of 8.8 mg to 15 mg of 0.5% bupivacaine with an opioid at the lumbar spinal level for effective spinal blockade [17,18]. Low-dose bupivacaine as a lumbar spinal injection was studied by many authors, with the advantage of fewer incidences of hypotension at the cost of inadequate anaesthesia [4,18]. The beginning of the block is always faster, regardless of the baricity of local anaesthetic at a thoracic level, as stated by Imbelloni LE et al., [19]. The thoracic injection would ensure the mixture of opioids, and the local anaesthetic produces a dense effect at surgically relevant segmental levels [10]. The duration of sensory block remained longer in patients who belonged to the conventional spinal group than the thoracic spinal group, which aligns with the study by Imbelloni LE et al., [13].

The present study revealed a shorter duration and less motor blockade in Group S compared to Group C. Most patients in Group S (90%) were able to shift to a stretcher unaided, whereas none from Group C could do so. However, differences in sensory and motor block duration between thoracic and lumbar injections remained lower (18% vs 16%, which opposed the study by Imbelloni LE et al., (56% vs 46%), possibly due to ultra-low dose bupivacaine (3.5 mg) used in thoracic spinal and as well as difference in the site of the surgery in our study [13]. Recently, it was proposed that understanding the physiology of spinal anaesthesia involves explaining the placement of a hyperbaric solution in the supine position, which predominantly blocks the sensory roots (posterior) at the expense of the motor roots, which lie anteriorly [13,14]. The provision of a longer duration of sensory than motor blockade was demonstrated earlier using hyperbaric over isobaric bupivacaine, which makes it a better choice for thoracic spinal anaesthesia [19]. This would lead to the prolongation of sensory blockade compared to the lower degree and short-term lower limb motor block. A 50% reduction in the drug dose resulted in a 40.60% reduction in motor blockade in patients who received thoracic spinal anaesthesia in our study. This resulted in rapid motor recovery, allowing them to be transferred to the stretcher after surgery. This can also help achieve early ambulation and has been proven to be significantly advantageous in high-risk cases, such as preeclampsia, resulting in an early postoperative recovery with a reduced rate of complications, including deep vein thrombosis, pulmonary embolism, and renal failure, as stated by Ellakany M et al., [20]. Furthermore, both groups showed similar total durations of postoperative analgesia. However, Imbelloni LE et al., reported a significantly increased duration of analgesia with a higher dose of local anaesthetics at the lumbar level [13].

The synergistic effect of fentanyl when added to intrathecal local anaesthetic has already been proven [4]. Prior studies have demonstrated the abolishment of visceral pain, reduction in incidences of nausea, increased haemodynamic stability and duration of postoperative analgesia, and reduction in the dose of bupivacaine without affecting bradycardia, nausea, vomiting, shivering, or maternal or neonatal respiration when fentanyl was added to intrathecal bupivacaine for caesarean section [4,21].

Being afraid of potential damage to the spinal cord and haemodynamic disturbances due to the blockade of thoracic cardioaccelerator fibres (T_2 - T_9), with the addition of thoracic and abdominal muscle weakness contributing to respiratory difficulties, has made the thoracic spinal a controversial technique [20,22]. A higher level of blockade with segmental spinal anaesthesia using a smaller drug volume minimally affects ventilation, as the patient's coughing ability is preserved and the diaphragm remains intact, since it is innervated from the cervical level (C_3 - C_9) [12,23]. However, an adequate dose of local anaesthetics can prevent the effect of forceful expiration and cough due to the innervation of anterior abdominal muscles by the thoracic nerves, which are primarily important [20]. None of our patients in the segmental spinal group reported respiratory discomfort throughout the study. Additionally, a significant difference in lumbar spine curvature was observed in pregnant patients compared to non-pregnant patients during the third trimester, characterised by a remarkable increase in the angle, with no corresponding changes in the thoracic spine [24]. This favours choosing the technique of thoracic spinal in this group of patients. Increased distance between the duramater and spinal cord at the thoracic level due to the insertion of the needle at the angle of 45° , the head down sitting position and pushing forward the duramater forming the tent along the needle collectively provide safety and decrease the chances of neurological complications and while going for thoracic spinal puncture [6]. The LSCS under the thoracic spine was reported using the T_8 - T_9 space with a 1.4 mL local anaesthetic volume, achieving a sensory block from the T_4 to L_2 level [1,6].

Paresthesia was observed in one patient during the delivery of thoracic spinal anaesthesia without any untoward neurological effects. Previous data available shows 4-10% vs 13.6% incidences of paresthesia with thoracic and lumbar injection without any neurological sequelae and being reported as transitory [6,25]. Except for two patients from Group S and three patients from Group C who developed nausea postoperatively without associated hypotension, no other complications were observed. Ellakany M et al., also observed a reduced incidence of nausea and vomiting [12]. A decreased incidence of postoperative pneumonia and atelectasis was reported after segmental spinal anaesthesia when used in patients with respiratory co-morbidity [11,26]. Bradycardia was not observed in both groups in our study, as reported by Mahmoud A et al., [15].

This is the first-ever study using a segmental spinal technique in preeclamptic patients categorised as high-risk obstetrics in whom haemodynamic stability and early ambulation matter a lot to decrease perioperative complications.

Limitation(s)

However, the study is limited to a single centre and Indian participants, so the results can't be generalised to other populations. The second limitation included using only hyperbaric local anaesthetic in segmental spinal anaesthesia. Therefore, the results can't be extrapolated to isobaric or a mixture of local anaesthetics. The third limitation was the inability to perform double blinding due to the different levels of puncture sites. To minimise bias, a single anaesthesiologist performed all thoracic and lumbar punctures. In future, a multicentric study using local anaesthetic with different baricity in segmental spinal in patients with high-risk pregnancies is required to add further knowledge.

CONCLUSION(S)

In conclusion, segmental spinal anaesthesia is a safe and alternative anaesthetic technique to conventional spinal anaesthesia when used for high-risk obstetric populations like preeclamptic parturients. It provides better haemodynamic stability than conventional spinal anaesthesia. The faster onset and dense segmental sensory block make patients comfortable as early as they turn supine. The speedy recovery of motor function leads to early postoperative ambulation, which can help to decrease the incidence of postoperative complications in preeclamptic parturients. The duration of postoperative analgesia remains similar whether the patient received segmental or conventional spinal anaesthesia. No complications other than nausea were seen. Although a helpful technique in high-risk obstetrics, it must be used cautiously under expert guidance and with proper vigilance.

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AUTHOR DECLARATION:

- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. NA

PLAGIARISM CHECKING METHODS: [\[Jain H et al.\]](#)

- Plagiarism X-checker: Jan 02, 2025
- Manual Googling: May 27, 2025
- iThenticate Software: May 29, 2025 (10%)

ETYMOLOGY: Author Origin
EMENDATIONS: 6

Date of Submission: [Dec 27, 2024](#)
Date of Peer Review: [Apr 04, 2025](#)
Date of Acceptance: [May 31, 2025](#)
Date of Publishing: [Oct 01, 2025](#)