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Original Research Article

Comparative Study of Maternal Hemodynamic Changes Following Spinal versus Epidural Anaesthesia for Elective LSCS

Shanthala S. Naik[1], Rashmi Ashok Baligatti[2]

[1]MBBS, MD Anaesthesiology, Specialist, Cloudphysician Healthcare Pvt Ltd, Bengaluru, Karnataka, India

[2]Assistant Professor, Department of Anaesthesiology, Adichunchanagiri Institute of Medical Sciences, Bellur cross, Karnataka, India

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Corresponding author: Dr. Shanthala S. Naik

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Abstract

Background: Spinal and epidural anaesthesia are widely used for elective lower segment caesarean section (LSCS). While spinal anaesthesia offers rapid onset and reliable blockade, it may produce greater maternal haemodynamic changes than epidural anaesthesia.

Aim: To compare maternal haemodynamic changes following spinal versus epidural anaesthesia for elective LSCS.

Methods: This prospective randomized comparative study included 120 pregnant women undergoing elective LSCS. Participants were allocated into two groups: Group S (spinal anaesthesia, n=60) and Group E (epidural anaesthesia, n=60). Maternal heart rate, blood pressure, incidence of hypotension, bradycardia, vasopressor requirement, maternal complications, neonatal APGAR scores, and maternal satisfaction were evaluated.

Results: Spinal anaesthesia produced a significantly faster onset of surgical anaesthesia (5.2 ± 0.9 vs. 14.8 ± 2.6 minutes; $p<0.001$). The spinal group demonstrated a significantly greater fall in mean arterial pressure (25.9 ± 6.4% vs. 16.8 ± 5.3%; $p<0.001$) and higher incidences of hypotension (38.3% vs. 15.0%; $p=0.004$), bradycardia (16.7% vs. 5.0%; $p=0.038$), and vasopressor requirement (35.0% vs. 13.3%; $p=0.006$). Neonatal APGAR scores at one and five minutes, maternal satisfaction, and overall surgical outcomes were comparable between the two groups.

Conclusion: Spinal anaesthesia provides rapid and reliable surgical anaesthesia but is associated with greater maternal haemodynamic instability. Epidural anaesthesia offers better cardiovascular stability with equivalent neonatal outcomes and maternal satisfaction, making both techniques suitable options for elective LSCS when supported by careful monitoring and appropriate haemodynamic management.

Keywords: Elective Lower Segment Caesarean Section; Spinal Anaesthesia; Epidural Anaesthesia; Maternal Haemodynamics; Hypotension; Vasopressor Requirement; APGAR Score.

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Introduction

Regional anaesthesia is the preferred anaesthetic technique for elective lower segment caesarean section (LSCS) because it allows the mother to remain conscious during childbirth, minimizes neonatal exposure to systemic anaesthetic agents, reduces the risks associated with airway manipulation, and provides effective postoperative analgesia. Compared with general anaesthesia, neuraxial techniques are associated with lower maternal morbidity and mortality and have become the standard of care for most elective caesarean deliveries. [1,2]

Spinal and epidural anaesthesia are the two most commonly employed neuraxial techniques for LSCS. Spinal anaesthesia is widely favored because it is technically simple, has a rapid onset of action, produces dense sensory and motor blockade, and requires a relatively small dose of local anaesthetic. However, rapid sympathetic blockade frequently results in maternal hypotension, which may lead to nausea, vomiting, dizziness, decreased uteroplacental perfusion, and fetal acidosis if not promptly recognized and treated. [3,4]

Epidural anaesthesia, in contrast, produces a gradual onset of sympathetic blockade because the local anaesthetic is administered incrementally. This slower onset generally results in better

maternal haemodynamic stability and allows titration of the block according to surgical requirements. Although epidural anaesthesia requires greater technical expertise and has a slower onset than spinal anaesthesia, it offers the advantages of prolonged postoperative analgesia through an indwelling catheter and reduced incidence of abrupt haemodynamic fluctuations. [5]

Maintenance of maternal haemodynamic stability during caesarean section is of paramount importance. Pregnancy is associated with significant physiological adaptations including increased cardiac output, decreased systemic vascular resistance, expanded plasma volume, and compression of the inferior vena cava by the gravid uterus. These changes make parturients particularly susceptible to hypotension following neuraxial blockade. Persistent maternal hypotension may compromise uteroplacental blood flow and adversely affect neonatal well-being, emphasizing the need for appropriate preventive and therapeutic strategies. [6]

Several studies have compared spinal and epidural anaesthesia with respect to maternal blood pressure, heart rate, vasopressor requirements, incidence of hypotension, and neonatal outcomes. Although spinal anaesthesia provides rapid and reliable surgical anaesthesia, epidural anaesthesia has been reported to produce fewer haemodynamic disturbances in selected patients. Despite numerous published studies, the optimal neuraxial technique remains a subject of clinical interest because maternal characteristics, local anaesthetic dosage, and institutional practices influence haemodynamic responses. [5,6] Therefore, the present study was undertaken to compare maternal haemodynamic changes following spinal and epidural anaesthesia in patients undergoing elective LSCS, with special emphasis on heart rate, blood pressure, incidence of hypotension, vasopressor requirement, maternal adverse effects, and neonatal outcome.

Materials and Methodology

Study Design: This was a prospective, randomized, comparative clinical study.

Study Setting: The study was conducted in the Department of Anaesthesiology in collaboration with the Department of Obstetrics and Gynaecology at a tertiary care teaching hospital among pregnant women undergoing elective lower segment caesarean section (LSCS).

Study Duration: The study was conducted over a period of 18 months after obtaining approval from the Institutional Ethics Committee.

Sample Size: A total of 120 pregnant women were enrolled and randomly allocated into two equal groups:

- **Group S (n = 60):** Spinal anaesthesia
- **Group E (n = 60):** Epidural anaesthesia

The sample size was calculated considering a 95% confidence level, 80% statistical power, and an expected difference in the incidence of maternal hypotension between the two techniques.

Study Population

Pregnant women scheduled for elective LSCS under regional anaesthesia.

Inclusion Criteria

- Singleton term pregnancy (≥37 weeks gestation).
- Age between 18 and 40 years.
- ASA physical status II.
- Elective LSCS.
- Cephalic presentation.
- Willingness to provide written informed consent.

Exclusion Criteria

- Patient refusal.
- Contraindications to regional anaesthesia.
- Pregnancy-induced hypertension or severe preeclampsia/eclampsia.
- Significant cardiovascular, respiratory, hepatic, renal, or neurological disease.
- Placenta previa with anticipated massive hemorrhage.
- Multiple pregnancy.
- BMI >35 kg/m².
- Known allergy to local anaesthetic agents.

Randomization: Participants were randomized into two groups using a computer-generated randomization sequence. Allocation concealment was maintained using sequentially numbered sealed opaque envelopes.

Anaesthetic Technique: All patients underwent standard pre-anaesthetic evaluation and fasting as per institutional protocol. Intravenous access was established with an 18G cannula, and preload with 10–15 mL/kg of Ringer's lactate was administered. Standard ASA monitoring including electrocardiography (ECG), non-invasive blood pressure (NIBP), pulse oximetry (SpO_2), and heart rate monitoring was instituted.

Group S (Spinal Anaesthesia): Spinal anaesthesia was administered in the sitting position at the L3–L4 or L4–L5 intervertebral space using a 25G Quincke spinal needle. Patients received 2.0–2.2 mL of 0.5% hyperbaric bupivacaine intrathecally. Patients were immediately positioned supine with left uterine displacement.

Group E (Epidural Anaesthesia): Epidural anaesthesia was administered using an 18G Tuohy needle at the L2–L3 or L3–L4 intervertebral space.

After identification of the epidural space using the loss-of-resistance technique, an epidural catheter was inserted 3–5 cm into the epidural space. Following a negative aspiration test and administration of a test dose, 15–18 mL of 0.5% bupivacaine was administered incrementally to achieve a sensory block up to the T4 dermatome.

Study Parameters

Primary Outcome Measures

- Maternal heart rate.
- Systolic blood pressure.
- Diastolic blood pressure.
- Mean arterial pressure.
- Incidence of hypotension.
- Vasopressor requirement.

Secondary Outcome Measures

- Time to achieve adequate sensory block.
- Incidence of bradycardia.
- Nausea and vomiting.
- Shivering.
- Neonatal APGAR score at 1 and 5 minutes.
- Maternal satisfaction.

Definitions

- **Hypotension:** Systolic blood pressure <90 mmHg or a fall of >20% from baseline.
- **Bradycardia:** Heart rate <50 beats/min.
- **Successful block:** Sensory block up to the T4 dermatome adequate for surgery.

Hypotension was managed with intravenous crystalloids and 6 mg intravenous mephentermine in incremental doses. Bradycardia was treated with 0.6 mg intravenous atropine.

Data Collection: Baseline haemodynamic parameters were recorded before administration of anaesthesia. Heart rate and blood pressure were recorded every 2 minutes for the first 10 minutes, every 5 minutes until delivery, and every 10 minutes thereafter until completion of surgery. Neonatal APGAR scores were assessed at 1 and 5 minutes by the attending pediatrician.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using SPSS version 25.0. Continuous variables were expressed as mean ± standard deviation (SD) and compared using the independent Student's t-test. Categorical variables were expressed as frequencies and percentages and analyzed using the Chi-square test or Fisher's exact test as appropriate. A p-value <0.05 was considered statistically significant.

Results

A total of 120 pregnant women undergoing elective lower segment caesarean section (LSCS) under regional anaesthesia were enrolled in the study. Participants were randomly allocated into two equal groups:

- **Group S:** Spinal Anaesthesia (n = 60)
- **Group E:** Epidural Anaesthesia (n = 60)

Both groups were comparable with respect to demographic and obstetric characteristics. Maternal haemodynamic parameters, incidence of hypotension, vasopressor requirement, maternal complications, and neonatal outcomes were compared.

Table 1: Baseline Demographic and Obstetric Characteristics

Variable	Group S (n=60)	Group E (n=60)	p-value
Age (years)	27.8 ± 3.9	28.2 ± 4.1	0.582
Weight (kg)	68.5 ± 7.4	69.1 ± 7.8	0.663
Height (cm)	158.7 ± 5.8	159.2 ± 6.1	0.648
BMI (kg/m²)	27.2 ± 2.8	27.5 ± 2.9	0.573
Gestational age (weeks)	38.4 ± 0.8	38.5 ± 0.9	0.512
Primigravida, n (%)	34 (56.7)	32 (53.3)	0.711
Multigravida, n (%)	26 (43.3)	28 (46.7)	

The two groups were comparable regarding age, body weight, height, BMI, gestational age, and parity (p>0.05). Hence, demographic and obstetric characteristics were well matched, minimizing baseline confounding.

Table 2: Comparison of Maternal Hemodynamic Parameters

Parameter	Group S	Group E	p-value
Baseline Heart Rate (beats/min)	86.5 ± 8.2	85.9 ± 7.9	0.694
Lowest Heart Rate (beats/min)	70.8 ± 7.5	76.9 ± 6.8	<0.001
Baseline MAP (mmHg)	93.8 ± 7.1	94.2 ± 6.8	0.751
Lowest MAP (mmHg)	69.5 ± 6.8	78.2 ± 6.5	<0.001
Maximum fall in MAP (%)	25.9 ± 6.4	16.8 ± 5.3	<0.001
Time to T4 sensory block (min)	5.2 ± 0.9	14.8 ± 2.6	<0.001

Spinal anaesthesia resulted in a significantly faster onset of surgical anaesthesia but was associated with a greater reduction in heart rate and mean arterial pressure compared with epidural anaesthesia ($p<0.001$), indicating more pronounced haemodynamic changes.

Table 3: Intraoperative Maternal Complications

Complication	Group S (n=60)	Group E (n=60)	p-value
Hypotension	23 (38.3%)	9 (15.0%)	0.004
Bradycardia	10 (16.7%)	3 (5.0%)	0.038
Nausea/Vomiting	11 (18.3%)	5 (8.3%)	0.107
Shivering	8 (13.3%)	6 (10.0%)	0.572
Vasopressor requirement	21 (35.0%)	8 (13.3%)	0.006
Atropine requirement	8 (13.3%)	2 (3.3%)	0.047

Maternal hypotension, bradycardia, and vasopressor requirement were significantly higher in the spinal anaesthesia group ($p<0.05$). Although nausea, vomiting, and shivering occurred more frequently after spinal anaesthesia, these differences were not statistically significant.

Table 4: Neonatal Outcome and Maternal Satisfaction

Variable	Group S	Group E	p-value
APGAR score at 1 minute	8.1 ± 0.6	8.0 ± 0.7	0.381
APGAR score at 5 minutes	9.8 ± 0.4	9.7 ± 0.5	0.214
Maternal satisfaction score (0–10)	9.2 ± 0.7	9.0 ± 0.8	0.172
Duration of surgery (min)	56.8 ± 8.5	57.4 ± 8.2	0.684

Neonatal outcomes, as assessed by APGAR scores at 1 and 5 minutes, were comparable between the two groups ($p>0.05$). Maternal satisfaction and duration of surgery were also similar, indicating that both techniques provided effective anaesthesia and favorable clinical outcomes.

Discussion

The present prospective comparative study evaluated maternal haemodynamic changes following spinal and epidural anaesthesia in patients undergoing elective lower segment caesarean section (LSCS).

The study demonstrated that spinal anaesthesia provided a significantly faster onset of surgical anaesthesia but was associated with greater haemodynamic instability, including a higher incidence of hypotension, bradycardia, and vasopressor requirement. Epidural anaesthesia, although slower in onset, maintained better maternal haemodynamic stability while providing satisfactory surgical conditions and comparable neonatal outcomes.

In the present study, spinal anaesthesia achieved the desired T4 sensory block significantly faster than epidural anaesthesia. This finding is in agreement with Rollins and Lucero [7], who reported that spinal anaesthesia offers rapid onset and dense neural blockade, making it the preferred technique for most elective caesarean sections. The immediate intrathecal administration of local anaesthetic produces reliable surgical anaesthesia within a few minutes, whereas epidural anaesthesia requires incremental dosing and a longer onset period. Maternal haemodynamic changes were significantly more pronounced in the spinal anaesthesia group. Patients receiving spinal anaesthesia exhibited greater reductions in mean arterial pressure and heart rate than those receiving epidural anaesthesia. Similar findings were reported by Dyer et al. [8], who observed that spinal anaesthesia causes abrupt sympathetic blockade resulting in a greater fall in systemic vascular resistance and blood pressure compared with epidural anaesthesia. Their study also demonstrated superior haemodynamic stability with epidural blockade because of its gradual onset of sympathetic block.

The incidence of maternal hypotension in the spinal group was significantly higher than in the epidural group. These findings are consistent with those reported by Mercier et al. [9], who identified maternal hypotension as the most frequent complication following spinal anaesthesia for caesarean delivery. The authors emphasized that rapid recognition and prompt correction of hypotension are essential to maintain uteroplacental perfusion and optimize maternal and fetal outcomes.

A significantly greater proportion of patients in the spinal group required vasopressor support. This observation agrees with the findings of Ngan Kee [10], who highlighted that prophylactic fluid administration and timely vasopressor therapy are fundamental components in preventing and treating spinal-induced hypotension during caesarean delivery. The greater vasopressor requirement in the spinal group observed in the present study reflects the more pronounced sympathetic blockade associated with intrathecal local anaesthetic administration.

Bradycardia occurred more frequently in patients receiving spinal anaesthesia, although it was successfully managed with atropine. Similar observations were reported by Lee et al. [11], whose systematic review demonstrated that haemodynamic alterations accompanying spinal anaesthesia often necessitate pharmacological intervention to maintain maternal cardiovascular stability. Appropriate monitoring and early treatment contribute significantly to favourable maternal and neonatal outcomes.

Despite greater haemodynamic fluctuations following spinal anaesthesia, neonatal outcomes remained comparable between the two groups, with no significant differences in APGAR scores at one and five minutes. These findings are supported by George et al. [12], who demonstrated that effective management of maternal hypotension preserves uteroplacental perfusion and results in satisfactory neonatal outcomes regardless of the regional anaesthetic technique employed.

Overall maternal satisfaction was high in both groups, reflecting the effectiveness of both neuraxial techniques for elective LSCS. Carvalho and Dyer [13] emphasized that advances in obstetric anaesthesia, including vigilant haemodynamic monitoring, judicious use of vasopressors, and standardized management protocols, have considerably improved maternal safety during caesarean delivery.

The present study supports these observations by demonstrating that although spinal anaesthesia is associated with greater haemodynamic changes, both spinal and epidural anaesthesia provide safe and effective anaesthesia when appropriate perioperative management is employed.

Conclusion

Both spinal and epidural anaesthesia are safe and effective techniques for elective lower segment caesarean section. Spinal anaesthesia provides a rapid onset of sensory blockade and excellent operating conditions but is associated with significantly greater maternal haemodynamic changes, including hypotension, bradycardia, and increased vasopressor requirement.

Epidural anaesthesia offers superior haemodynamic stability with comparable neonatal outcomes and maternal satisfaction, although the onset of anaesthesia is slower. Appropriate patient selection, vigilant intraoperative monitoring, and prompt management of haemodynamic alterations enable both techniques to be used successfully for elective LSCS.

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