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# Comparative evaluation of spinal versus combined spinal-epidural anesthesia for elective caesarean section

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**Abstract**
**Background:** Neuraxial anaesthesia is the preferred technique for elective caesarean section. Single-shot spinal anaesthesia is widely used due to its rapid onset but is associated with hypotension and limited duration of analgesia. Combined spinal-epidural anaesthesia offers the advantage of an epidural catheter, which may improve haemodynamic stability and postoperative pain control. Evidence comparing these techniques under contemporary practice remains inconclusive.
**Materials and Methods:** In this prospective comparative study, 50 ASA I-II parturients scheduled for elective caesarean section were allocated to receive either spinal anaesthesia (Group S, N=25) or combined spinal-epidural anaesthesia (Group C, N=25). Primary outcomes included incidence and severity of hypotension and vasopressor requirement. Secondary outcomes were time to achieve $T_4$ sensory block, need for intraoperative supplementation, maternal side effects, duration of effective postoperative analgesia, postoperative pain scores using the Visual Analogue Scale (VAS), and maternal satisfaction.
**Results:** Baseline demographic and haemodynamic parameters were comparable between groups. Time to achieve $T_4$ sensory block was shorter in Group S (4.2±0.8 min) than Group C (5.1±1.0 min). Hypotension occurred more frequently in Group S (56%) compared with Group C (36%), with higher vasopressor requirement (420±180 µg vs 280±140 µg; $p<0.05$). Intraoperative supplementation was required more often in Group S (20%) than Group C (8%). Duration of postoperative analgesia was significantly longer in Group C (6.8±1.4 h vs 3.4±0.9 h; $p<0.001$). Postoperative VAS scores were significantly lower and maternal satisfaction higher in Group C ($p<0.05$).
**Conclusion:** Combined spinal epidural anaesthesia provides better haemodynamic stability, superior postoperative analgesia, and higher maternal satisfaction than spinal anaesthesia for elective caesarean section, despite a slightly slower onset of surgical block.

**Keywords:** Caesarean section, spinal anaesthesia, combined spinal epidural anaesthesia, hypotension, vasopressor requirement

## Introduction
Caesarean section (CS) is one of the most commonly performed obstetric surgical procedures worldwide, with steadily rising rates in both developed and developing countries. Neuraxial anaesthesia is considered the technique of choice for elective caesarean delivery due to its superior maternal safety profile, avoidance of airway manipulation, reduced risk of aspiration, decreased maternal morbidity, and improved neonatal outcomes compared to general anaesthesia [1, 2]. In addition, neuraxial techniques allow the mother to remain awake during delivery, facilitating early maternal-neonatal bonding and breastfeeding initiation [3].
Single-shot spinal anaesthesia (SSA) is the most widely used neuraxial technique for elective CS because of its rapid onset, technical simplicity, dense sensory and motor blockade, and high success rate [4]. However, spinal anaesthesia is associated with significant sympathetic blockade, leading to maternal hypotension in up to 70-80% of cases if prophylactic measures are not instituted [5]. Maternal hypotension can result in nausea, vomiting, dizziness, and, more importantly, reduced uteroplacental perfusion with potential adverse fetal effects [6]. Although modern strategies such as left uterine displacement, judicious fluid therapy, and prophylactic vasopressor infusions particularly phenylephrine have improved haemodynamic control, hypotension remains a clinically relevant concern during spinal anaesthesia for CS [7].
Combined spinal-epidural anaesthesia (CSE) was introduced to combine the rapid onset and reliability of spinal anaesthesia with the flexibility of an epidural catheter [8]. The presence of an epidural catheter allows supplementation of anaesthesia in cases of inadequate or patchy block, extension of block duration during prolonged surgery, and provision of effective postoperative

analgesia [9]. These theoretical advantages make CSE an attractive alternative to SSA, particularly in elective cases where prolonged surgical duration or enhanced postoperative pain control is anticipated.

Several studies have compared spinal and combined spinal-epidural anaesthesia for caesarean section, with mixed results. Early randomized studies demonstrated that while both techniques provide effective surgical anaesthesia, spinal anaesthesia was associated with a more rapid onset of hypotension, whereas CSE showed a slower onset but similar overall incidence of hypotension [10]. Other studies evaluating patient positioning and fluid strategies during CSE have shown that haemodynamic outcomes are significantly influenced by perioperative management rather than the neuraxial technique itself [11].

Low-dose spinal anaesthesia administered as part of a CSE technique has been investigated as a method to reduce sympathetic blockade and hypotension. Some trials have reported reduced incidence of hypotension, nausea, and vomiting with low-dose CSE compared to conventional-dose spinal anaesthesia; however, these benefits were often offset by an increased need for epidural supplementation and variability in block adequacy [12]. Differences in intrathecal drug doses, definitions of hypotension, and vasopressor use across studies limit the generalisability of these findings.

There is insufficient high-quality evidence comparing spinal and combined spinal-epidural anaesthesia for elective caesarean section under contemporary anaesthetic practice, particularly with standardised vasopressor use. Additionally, limited data exist on patient-centred outcomes such as block adequacy, need for rescue analgesia, postoperative pain control, and maternal satisfaction. This gap necessitates further comparative evaluation to determine whether CSE offers meaningful clinical advantages over spinal anaesthesia in elective caesarean delivery.

The aim of this study is to comparatively evaluate spinal anaesthesia and combined spinal-epidural anaesthesia in patients undergoing elective caesarean section with respect to haemodynamic stability, adequacy and reliability of surgical anaesthesia, incidence of maternal side effects, requirement for intraoperative supplementation, and quality of postoperative analgesia, thereby addressing existing gaps in the literature under current anaesthetic practice standards.

## Materials and Methods

### Study Design and Setting

This prospective, comparative, observational study was conducted in the Departments of Anaesthesiology and Obstetrics & Gynaecology of a Mamata Medical College and General hospital, Khammam after obtaining approval from the Institutional Ethics Committee. The study was carried out over a defined study period on parturients scheduled for elective caesarean section. Written informed consent was obtained from all participants prior to enrolment.

### Sample Size and Study Population

A total of 50 pregnant women posted for elective caesarean section were included in the study. Participants were allocated into two equal groups of 25 each based on the neuraxial anaesthesia technique administered.

**Group S:** Received single-shot spinal anaesthesia,

**Group C:** Received combined spinal-epidural anaesthesia.

Allocation was done as per institutional practice and anaesthesiologist discretion.

### Anaesthetic Technique

All patients were preoperatively evaluated and fasted according to standard guidelines. On arrival in the operating theatre, baseline heart rate, non-invasive blood pressure, oxygen saturation, and electrocardiography were recorded. Intravenous access was secured and patients were preloaded with crystalloid solution.

In Group S, spinal anaesthesia was administered at the L3-L4 or L4-L5 interspace using a 25G Quincke spinal needle, and a standard dose of hyperbaric bupivacaine with or without opioid adjuvant was injected intrathecally.

In Group C, combined spinal-epidural anaesthesia was performed at the same intervertebral space using the needle-through-needle technique. After confirmation of cerebrospinal fluid flow, a reduced dose of intrathecal hyperbaric bupivacaine was administered, followed by placement of an epidural catheter for intraoperative supplementation or postoperative analgesia if required.

All patients were positioned supine with left uterine displacement. Oxygen was administered by face mask. Hypotension was defined as a decrease in systolic blood pressure greater than 20% from baseline or systolic blood pressure < 90 mmHg and was treated with intravenous fluids and vasopressors as per institutional protocol.

### Inclusion Criteria

- Pregnant women aged 18-40 years
- ASA physical status I or II
- Singleton term pregnancy (≥ 37 weeks gestation)
- Scheduled for elective caesarean section
- Willingness to participate and provide informed consent

### Exclusion Criteria

- Refusal to participate
- Emergency caesarean section
- Contraindications to neuraxial anaesthesia (coagulopathy, local infection, spinal deformity)
- Pregnancy-induced hypertension, pre-eclampsia, or eclampsia
- Significant cardiac, respiratory, or neurological disease
- Multiple gestation or fetal anomalies

### Study Tools

- Pre-designed and pre-validated case record proforma
- Standard multiparameter monitor (heart rate, NIBP, $SpO_2$, ECG)
- Visual Analogue Scale (VAS) for postoperative pain assessment
- Bromage scale for assessment of motor blockade

### Data Collection

- Demographic data (age, weight, height, ASA status)
- Baseline haemodynamic parameters
- Time to achieve $T_4$ sensory block
- Incidence and severity of hypotension
- Total vasopressor requirement
- Need for intraoperative supplementation or conversion of anaesthesia
- Maternal side effects (nausea, vomiting, shivering, pruritus)

- Duration of effective postoperative analgesia
- Postoperative pain scores using VAS
- Maternal satisfaction score

**Statistical Analysis**

Data were entered into Microsoft Excel and analyzed using SPSS software. Continuous variables were expressed as mean±standard deviation and categorical variables as percentages. Student's *t*-test and Chi-square test were used for comparison between groups, with a *p*-value <0.05 considered statistically significant.

**Results**

**Table 1:** Demographic Characteristics of Study Participants

| Variable | Group S-Spinal Anaesthesia (N=25) | Group C-Combined Spinal-Epidural Anaesthesia (N=25) |
|---|---|---|
| Age (years) | 26.8±3.9 | 27.4±4.2 |
| Weight (kg) | 64.2±6.8 | 65.1±7.2 |
| Height (cm) | 158.6±4.9 | 159.2±5.1 |
| ASA Physical Status I | 18 (72%) | 17 (68%) |
| ASA Physical Status II | 7 (28%) | 8 (32%) |

As shown in Table 1, the demographic characteristics of the study participants were comparable between the two groups. The mean age of patients in Group S was 26.8±3.9 years, while in Group C it was 27.4±4.2 years. Mean body weight and height were also similar between the groups, with no clinically relevant differences observed. The distribution of ASA physical status was comparable, with the majority of patients belonging to ASA Physical Status I in both groups (72% in Group S and 68% in Group C), and the remainder classified as ASA Physical Status II.

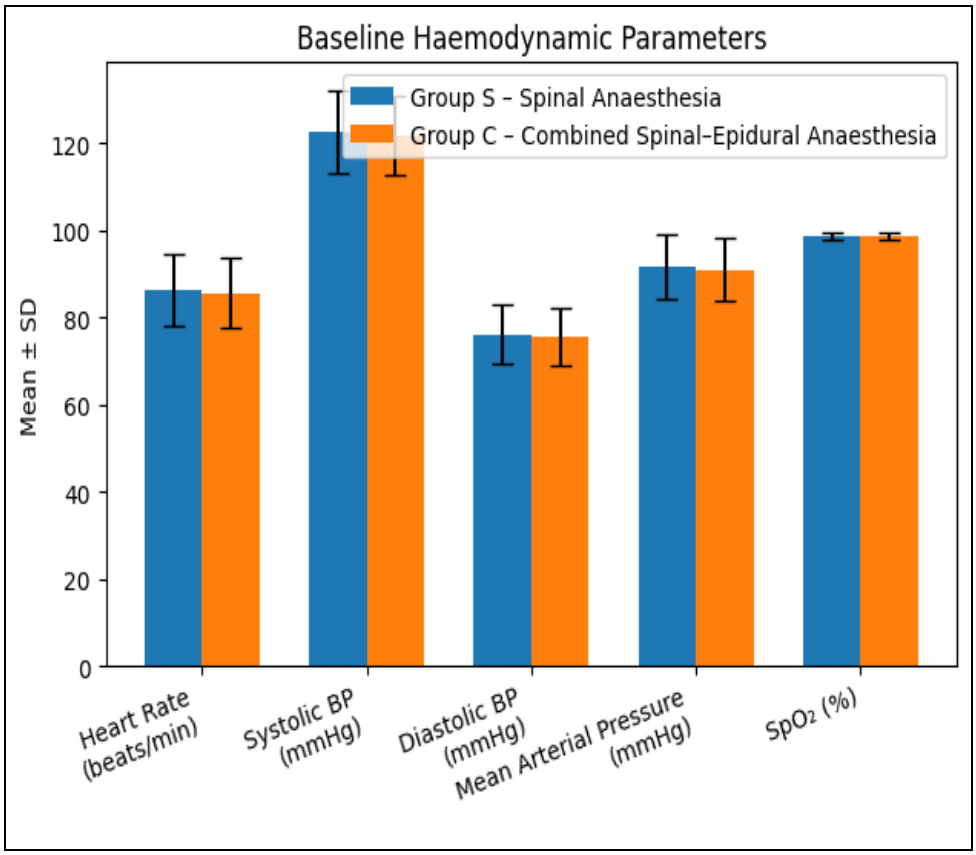


**Fig 1:** Baseline haemodynamic parameters of study participants

Baseline haemodynamic parameters were comparable between the two study groups, as summarized in Figure 1. The mean heart rate was similar in Group S (86.4±8.2 beats/min) and Group C (85.7±7.9 beats/min). Systolic and diastolic blood pressures did not differ appreciably between the groups, with mean arterial pressure also being comparable. Baseline oxygen saturation values were within normal limits and nearly identical in both groups.

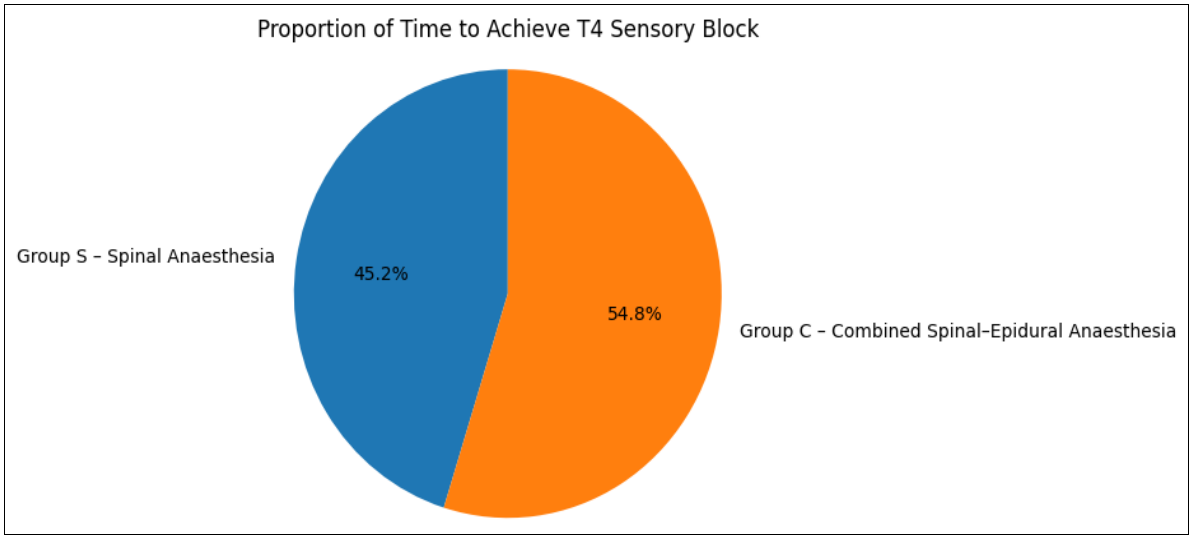


**Fig 2:** Comparison of Time to Achieve $T_4$ Sensory block between spinal and combined spinal-epidural anaesthesia

The time required to achieve a $T_4$ sensory block is presented in Figure 2. Patients in Group S attained the $T_4$ sensory level more rapidly, with a mean time of 4.2±0.8 minutes, compared to 5.1±1.0 minutes in Group C. This demonstrates a faster onset of surgical anaesthesia with spinal anaesthesia when compared with combined spinal-epidural anaesthesia. However, the observed difference was modest and unlikely to be of major clinical significance in elective caesarean section settings.

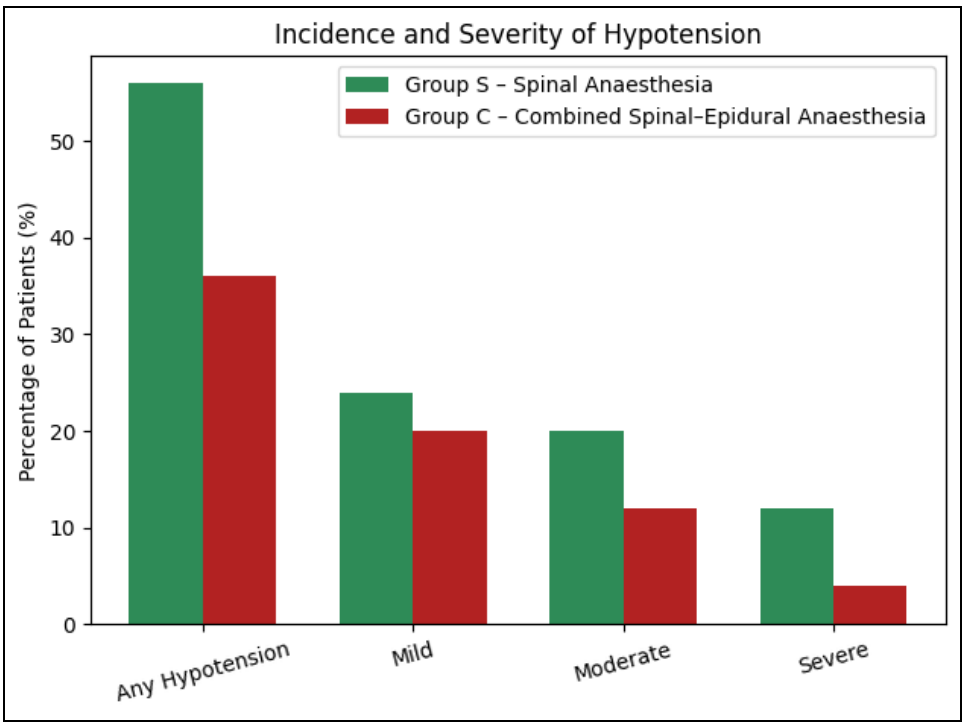


**Fig 3:** Incidence and Severity of Hypotension in the Study Groups

Figure 3 shows the incidence and severity of hypotension observed in the two study groups are shown in Table 4. Hypotension occurred more frequently in Group S, with 14 patients (56%) affected, compared to 9 patients (36%) in Group C. Furthermore, moderate and severe hypotension were more commonly observed in the spinal anaesthesia group, whereas the majority of hypotensive episodes in the combined spinal-epidural group were mild in nature. These findings indicate that combined spinal-epidural anaesthesia was associated with better haemodynamic stability compared to spinal anaesthesia during elective caesarean section.

**Table 2:** Total Vasopressor Requirement

| Parameter | Group S-Spinal Anaesthesia (N=25) | Group C-Combined Spinal-Epidural Anaesthesia (N=25) |
|---|---|---|
| Patients requiring vasopressor | 14 (56%) | 9 (36%) |
| Total vasopressor dose (Phenylephrine equivalent, µg) | 420±180 | 280±140 |
| Number of vasopressor boluses (n) | 2.6±1.3 | 1.7±1.1 |

Table 2 summarises the vasopressor requirements in the two study groups. A greater proportion of patients in Group S required vasopressor support, with 14 patients (56%) receiving vasopressors compared to 9 patients (36%) in Group C. The mean total vasopressor dose, expressed as phenylephrine equivalent, was higher in the spinal anaesthesia group (420±180 µg) than in the combined spinal-epidural group (280±140 µg). Additionally, the number of vasopressor boluses administered was greater in Group S.

**Table 3:** Need for Intraoperative Supplementation or Conversion of Anaesthesia

| Parameter | Group S-Spinal Anaesthesia (N=25) | Group C-Combined Spinal-Epidural Anaesthesia (N=25) |
|---|---|---|
| Adequate block without supplementation | 20 (80%) | 23 (92%) |
| Intraoperative supplementation required | 5 (20%) | 2 (8%) |
| Epidural top-up required | — | 2 (8%) |
| Intravenous analgesic supplementation | 5 (20%) | 0 (0%) |
| Conversion to general anaesthesia | 0 (0%) | 0 (0%) |

The requirement for intraoperative supplementation or conversion of anaesthesia is presented in Table 3. An adequate surgical block without the need for supplementation was achieved in a higher proportion of patients in Group C (92%) compared to Group S (80%). Intraoperative supplementation was more frequently required in the spinal anaesthesia group, with 5 patients (20%) needing additional intravenous analgesics. In contrast, only 2 patients (8%) in the combined spinal-epidural group required supplementation, which was effectively managed with epidural top-up through the indwelling catheter. No patient in either group required conversion to general anaesthesia. These findings highlight the advantage of combined spinal-epidural anaesthesia in providing flexibility for intraoperative supplementation and maintaining adequate surgical anaesthesia.

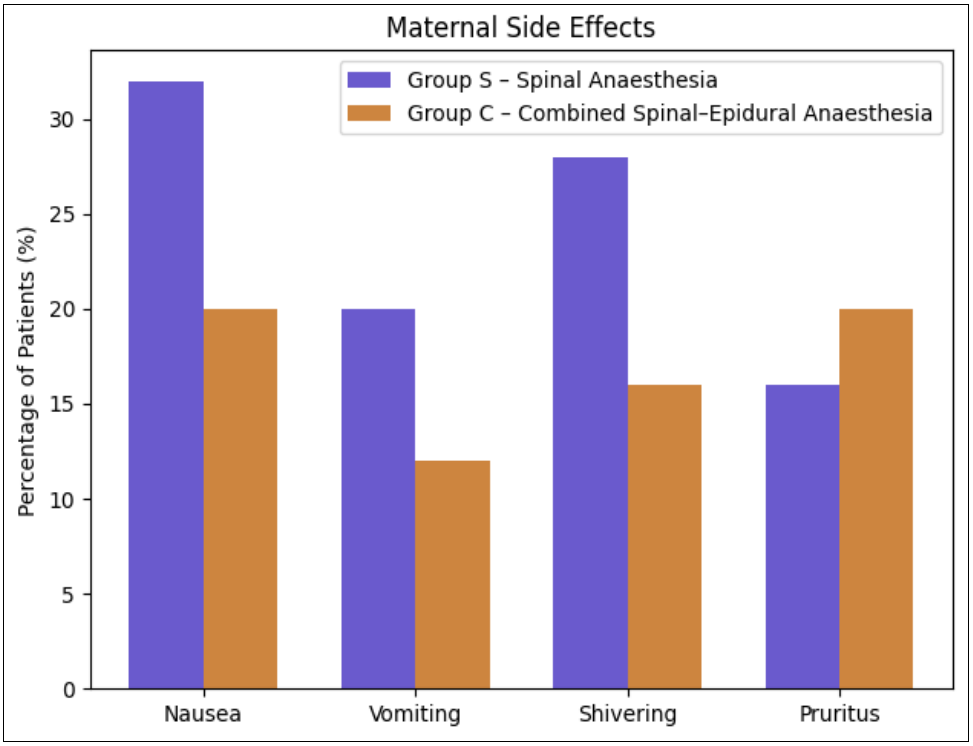


**Fig 4:** Maternal Side Effects in the Study Groups

Maternal side effects observed during the intraoperative period are summarised in Figure 4. Nausea and vomiting were more frequently reported in the spinal anaesthesia group, with 8 patients (32%) experiencing nausea and 5 patients (20%) experiencing vomiting, compared to 5 patients (20%) and 3 patients (12%), respectively, in the combined spinal-epidural group. Shivering was also more common in Group S (28%) than in Group C (16%). The incidence of pruritus was comparable between the two groups. Overall, these findings suggest that combined spinal-epidural anaesthesia was associated with a lower incidence of hypotension-related maternal side effects when compared with spinal anaesthesia.

**Table 4:** Duration of Effective Postoperative Analgesia

| Parameter | Group S-Spinal Anaesthesia (N=25) | Group C-Combined Spinal-Epidural Anaesthesia (N=25) | P-Value |
|---|---|---|---|
| Duration of effective analgesia (hours) | 3.4±0.9 | 6.8±1.4 | <0.001 |

The duration of effective postoperative analgesia in the two study groups is presented in Table 4. Patients in Group C experienced a significantly longer duration of effective analgesia (6.8±1.4 hours) compared to those in Group S (3.4±0.9 hours). This difference was statistically significant ($p<0.001$), indicating superior postoperative pain control in the combined spinal-epidural anaesthesia group.

**Table 5:** Postoperative pain scores using visual analogue scale (VAS)

| Time Interval | Group S-Spinal Anaesthesia (N=25) | Group C-Combined Spinal-Epidural Anaesthesia (N=25) | P-Value |
|---|---|---|---|
| VAS at 2 hours | 2.3±0.8 | 1.4±0.6 | 0.002 |
| VAS at 6 hours | 4.8±1.2 | 2.6±1.0 | < 0.001 |
| VAS at 12 hours | 6.2±1.1 | 3.9±1.2 | < 0.001 |

Postoperative pain scores assessed using the Visual Analogue Scale are shown in Table 5. At 2 hours postoperatively, the mean VAS score was significantly lower in Group C (1.4±0.6) compared to Group S (2.3±0.8) (P=0.002). This difference became more pronounced at 6 and 12 hours, with Group C consistently demonstrating lower pain scores (2.6±1.0 and 3.9±1.2, respectively) than Group S (4.8±1.2 and 6.2±1.1, respectively). The differences at 6 and 12 hours were highly statistically significant ($p$<0.001). These findings indicate that combined spinal-epidural anaesthesia provided superior and sustained postoperative analgesia compared to spinal anaesthesia.

**Table 6:** Maternal Satisfaction Score

| Satisfaction Level | Group S-Spinal Anaesthesia (N=25) | Group C-Combined Spinal-Epidural Anaesthesia (N=25) | P-Value |
|---|---|---|---|
| Excellent | 10 (40%) | 16 (64%) | 0.03 |
| Good | 11 (44%) | 7 (28%) | |
| Fair | 4 (16%) | 2 (8%) | |
| Poor | 0 (0%) | 0 (0%) | |

Maternal satisfaction scores are summarised in Table 6. A higher proportion of patients in the combined spinal-epidural anaesthesia group reported excellent satisfaction (64%) compared to the spinal anaesthesia group (40%). Conversely, fair satisfaction was more commonly reported in Group S (16%) than in Group C (8%). Overall maternal satisfaction was significantly higher in the combined spinal-epidural group, with the difference between groups reaching statistical significance (P=0.03). These results suggest that combined spinal-epidural anaesthesia was associated with improved overall maternal experience, likely due to better intraoperative comfort and superior postoperative pain control.

## Discussion

This prospective comparative study evaluated spinal anaesthesia (Group S) and combined spinal epidural anaesthesia (Group C) in 50 parturients undergoing elective caesarean section. The primary outcomes included onset of surgical anaesthesia, incidence and severity of hypotension, and vasopressor requirement. Secondary outcomes were intraoperative supplementation, maternal side effects, postoperative analgesia, postoperative pain scores, and maternal satisfaction. The findings indicate that although spinal anaesthesia produced a faster onset of $T_4$ sensory blockade, combined spinal epidural anaesthesia offered superior overall perioperative and postoperative outcomes.

Both groups were comparable with respect to age, weight, height, and ASA physical status, ensuring minimal baseline confounding and allowing valid comparison of study outcomes. Similar baseline equivalence has been reported in previous randomised trials and systematic reviews comparing spinal and combined spinal epidural anaesthesia for caesarean delivery [9, 13].

The time to achieve $T_4$ sensory block was shorter in the spinal anaesthesia group. This finding is consistent with the pharmacological profile of single-shot spinal anaesthesia, which delivers the full intrathecal dose in one step, resulting in rapid onset. However, the difference of approximately one minute is unlikely to be clinically significant in elective settings. Previous systematic reviews, including the Cochrane review by Simmons *et al*., have similarly reported only marginal differences in onset time between the two techniques [9].

Maternal hypotension was more frequent and severe in the spinal anaesthesia group, with a corresponding increase in vasopressor requirement. This is attributable to the abrupt sympathetic blockade associated with spinal anaesthesia. Thorén *et al*. demonstrated that hypotension occurs with both techniques, although spinal anaesthesia may result in earlier and more pronounced hypotension [10].

In contrast, studies using identical intrathecal doses in both techniques have shown no haemodynamic advantage of combined spinal-epidural anaesthesia [14]. A meta-analysis by Klimek *et al*. also concluded that existing evidence does not demonstrate a clear haemodynamic superiority of either technique, largely due to heterogeneity and low certainty of evidence [13]. The reduced hypotension and vasopressor use observed with combined spinal-epidural anaesthesia in the present study may reflect the benefits of dose flexibility and epidural titration.

The need for intraoperative supplementation was higher in the spinal anaesthesia group. The presence of an epidural catheter in the combined spinal-epidural group allowed effective neuraxial supplementation without conversion to general anaesthesia. This supports the widely acknowledged advantage of combined spinal-epidural anaesthesia in providing a reliable rescue route for inadequate or prolonged blocks [9, 13]. While low-dose spinal strategies may reduce hypotension, they are associated with increased supplementation requirements, as shown by Arzola and Wieczorek [15].

Nausea, vomiting, and shivering were more common in the spinal anaesthesia group, consistent with the higher incidence of hypotension. Modern haemodynamic management strategies aim to reduce these symptoms by maintaining blood pressure close to baseline [13]. Pruritus incidence was comparable between groups, likely reflecting intrathecal opioid use rather than the anaesthetic technique itself [9].

Combined spinal-epidural anaesthesia provided significantly longer postoperative analgesia and lower VAS pain scores at all measured intervals. These findings highlight the advantage of utilising the epidural catheter for postoperative pain control. Improved analgesia translated into higher maternal satisfaction, an outcome influenced by intraoperative comfort, reduced side effects, and effective postoperative pain management. Although previous studies have reported variable satisfaction outcomes, enhanced analgesia consistently correlates with improved patient satisfaction [15].

## Limitations

The primary limitation of the present study is the relatively small sample size, which may limit the detection of rare adverse events. Additionally, variations in vasopressor administration protocols and postoperative epidural analgesia regimens may influence haemodynamic and pain-related outcomes.

## Conclusion

Both spinal anaesthesia and combined spinal-epidural anaesthesia are effective neuraxial techniques for elective caesarean section. Spinal anaesthesia offers a faster onset of surgical blockade, whereas combined spinal-epidural anaesthesia provides superior haemodynamic stability, reduced vasopressor requirement, greater flexibility for intraoperative supplementation, prolonged postoperative analgesia, lower postoperative pain scores, and higher maternal satisfaction. Combined spinal-epidural anaesthesia may therefore be preferred when enhanced postoperative analgesia and intraoperative adaptability are desired, while spinal anaesthesia remains a reliable option for routine elective cases with robust haemodynamic management.

## Conflict of Interest

Not available

## Financial Support

Not available

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