**e-ISSN: 0975-9506, p-ISSN: 2961-6093**

**Available online on www.ijpqa.com doi: 10.25258/ijpqa.16.10.82**

**International Journal of Pharmaceutical Quality Assurance 2025; 16(10); 528-534**

**Original Research Article**

# Impact of Spinal versus Epidural Anesthesia on Perioperative Hemodynamics in Lower Abdominal Surgery

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**Received: 01-09-2025 / Revised: 13-10-2025 / Accepted: 24-10-2025**

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**Conflict of interest: Nil**

**Abstract:**

**Background:** Regional anesthesia, including spinal and epidural techniques, is widely used in lower abdominal surgeries, with each method exhibiting distinct hemodynamic profiles that influence perioperative cardiovascular stability.

**Aim:** To compare the intraoperative hemodynamic effects of spinal versus epidural anesthesia in patients undergoing elective lower abdominal surgeries.

**Methodology:** This prospective, randomized, observational study included 80 patients aged 18–70 years, classified as ASA I–II, and scheduled for elective lower abdominal procedures. Participants were equally allocated to receive either spinal anesthesia (Group S) or epidural anesthesia (Group E). Hemodynamic parameters—systolic and diastolic blood pressure, mean arterial pressure, and heart rate—were monitored at baseline and at 5-minute intervals for the first 30 minutes post-block. Vasopressor requirements and postoperative complications were also recorded.

**Results:** Both groups were comparable at baseline. Group S exhibited a greater initial drop in blood pressure but required fewer vasopressors (20% vs. 10%). Heart rate variations were minimal in both groups. Post-dural puncture headache occurred only in the spinal group (7.5%). Epidural anesthesia demonstrated relatively stable blood pressure but slightly higher hypotension incidence with high-volume dosing.

**Conclusion:** Spinal anesthesia provides rapid, predictable blockade with favorable intraoperative hemodynamic stability, whereas epidural anesthesia offers titratable dosing and prolonged analgesia at the cost of minor hypotension risk.

**Keywords:** Spinal anesthesia, Epidural anesthesia, Hemodynamics, Lower abdominal surgery, Vasopressor.



## Introduction

Anesthesia functions as a crucial component that supports contemporary surgical procedures by providing three essential benefits which include patient comfort and safety and the creation of ideal conditions for surgery [1]. The surgical field has adopted regional anesthesia methods which use spinal and epidural anesthesia because these techniques deliver better pain relief and muscle relaxation while reducing surgical complications when compared to general anesthesia methods. Both spinal and epidural anesthesia achieve regional blockade of nerve impulses, thereby inhibiting pain perception in the targeted area. The two techniques share the same goal, but their different pharmacological and physiological and hemodynamic properties will create distinct effects on patient outcomes who require surgical procedures that involve cardiovascular monitoring during their operations [2].

Spinal anesthesia requires the injection of a small amount of local anesthetic into the cerebrospinal fluid which exists in the subarachnoid space to create instant and complete loss of both sensory and motor functions [3]. The procedure benefits from three key elements which make it easy to use and deliver consistent results while providing complete anesthesia needed for surgical work on lower abdominal areas and pelvic regions and lower limb operations. Spinal anesthesia typically results in sudden sympathetic nerve function loss which creates major blood pressure and heart rate changes. The changes emerge because of rapid blood vessel expansion and the body experiencing a decline in its ability to withstand blood flow and its heart producing less blood according to the research from [4]. The body requires precise observation which needs immediate action through fluid control and vasopressor drug use to reduce these impacts.

Epidural anesthesia requires local anesthetic injection into the epidural space which encircles the dura mater to achieve spinal nerve transmission interruption across specific body regions [5]. The technique enables doctors to deliver anesthesia in multiple doses which allows them to control how long and how much anesthesia will be administered to the patient. The onset of epidural anesthesia develops at a slower pace while its sympathetic nerve block progresses through a gradual process, which results in more stable blood pressure levels during surgical procedures. The ability to control anesthetic amounts together with extended pain relief after surgery makes epidural anesthesia an excellent option for patients who will undergo lengthy procedures that involve their lower abdominal area and those who face cardiovascular risks during surgery [6]. The implementation of epidural anesthesia presents multiple difficulties through its complicated procedures together with its potential for catheter misplacement and its risk of delivering incomplete or uneven anesthesia, which requires additional anesthetic treatments to achieve full patient relief.

The hemodynamic effects that result from spinal and epidural anesthesia require thorough investigation because cardiovascular stability functions as a primary element that guarantees patient safety during surgical procedures [7]. Research studies have shown that spinal anesthesia produces more intense and faster blood pressure reductions than epidural anesthesia does, especially among elderly patients and people who already have cardiovascular diseases. Epidural anesthesia produces its effects through gradual sympathetic blockade which results in fewer cases of severe hypotension and bradycardia. The decision to use spinal or epidural anesthesia needs thorough assessment of patient requirements which include their age medical conditions and current blood pressure levels and their expected surgical time and procedure type [8].

The hemodynamic effects of regional anesthesia do not stop at maintaining cardiovascular stability during surgery operations. The effects of these factors determine how much fluids patients need before and after surgery, which organs will lose blood flow, and how well patients will recover from their procedures. Spinal anesthesia causes hypotension which becomes a dangerous problem when health professionals fail to identify or treat it properly because it results in multiple health issues including nausea and vomiting and dizziness while severe cases lead to myocardial ischemia and renal impairment. Epidural anesthesia provides patients with a slower beginning of sympathetic nerve blockage which decreases the likelihood of negative effects while resulting in better treatment results and patient contentment. Surgeons use two surgical methods for lower abdominal operations because both methods target the same area, but studies show different results for patient blood circulation and recovery after surgery.

Researchers have spent many years studying the best anesthesia method for lower abdominal surgeries which involve patients who have high risk for cardiovascular complications. Research that compares spinal and epidural anesthesia shows how both methods affect hemodynamic functions while revealing their respective benefits and drawbacks. The investigations provide essential information which helps physicians make treatment decisions while they work to enhance patient safety during surgical procedures and create customized anesthesia approaches for their patients. The current study aims to address these gaps by systematically comparing the hemodynamic parameters associated with spinal and epidural anesthesia in lower abdominal surgeries, thereby contributing to evidence-based anesthesia practice and enhancing patient-centered care.

Spinal and epidural anesthesia stand as essential methods for regional anesthesia because these techniques have different effects on blood circulation and their specific medical outcomes. Spinal anesthesia delivers immediate deep and dependable anesthesia to patients undergoing lower abdominal surgeries but requires continuous observation because it can cause sudden heart rate changes. Epidural anesthesia shows slower effects but doctors can control its dosage which helps patients with heart problems and those who need extended surgery to achieve better blood circulation. Anesthesiologists need to study these hemodynamic differences because they help create better patient protection measures and more effective surgical results while determining the correct anesthesia method for different patients and their surgical needs.

## Methodology

**Study Design:** The present study was designed as a prospective, randomized, observational analytical study aimed at comparing the hemodynamic effects of spinal and epidural anesthesia in patients undergoing elective lower abdominal surgeries. The study primarily focused on evaluating intraoperative hemodynamic parameters, including systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), and heart rate (HR), to determine the stability and safety of the two regional anesthesia techniques.

**Study Area:** The study was conducted in the Department of Anaesthesia, Medini Rai Medical College and Hospital (MRMCH), Palamu, Jharkhand, India.

**Study Duration:** The study was carried out over a period of six months

**Study Participants**

**Inclusion Criteria**

- Patients aged between 18 and 70 years.
- American Society of Anesthesiologists (ASA) physical status I or II.
- Scheduled for elective lower abdominal surgeries requiring a sensory block at or above T6–T8 dermatome levels.
- Patients providing written informed consent and willing to participate in the study.

**Exclusion Criteria**

- Patient refusal to participate.
- Contraindications to spinal or epidural anesthesia.
- Inability to maintain required positioning for block administration.
- Raised intracranial pressure.
- Coagulopathy or bleeding disorders.
- Local infection or sepsis at the proposed injection site.
- Hypovolemia or significant fluid imbalance.
- Known allergy to local anesthetic agents.
- Neurological disorders or peripheral neuropathy.
- Severe hypotension (MAP < 50 mmHg) or significant cardiovascular disease (EF < 30%).
- Hepatic or renal impairment (liver enzymes >1.5× normal, serum creatinine >1.5 mg/dL).

**Sample Size:** A total of 80 patients meeting the inclusion criteria were enrolled in the study. Participants were randomly allocated into two equal groups: Group S (Spinal Anesthesia) and Group E (Epidural Anesthesia), with 40 patients in each group.

**Procedure:** After obtaining informed consent and completing preoperative assessments, patients were randomly assigned to either Group S or Group E using a computer-generated randomization sequence. Standard monitoring, including ECG, non-invasive blood pressure, and pulse oximetry, was applied. All patients were preloaded with 7 ml/kg of crystalloid solution and received 50 µg intravenous fentanyl as premedication.

In Group S, spinal anesthesia was administered at the L2–L3 or L3–L4 interspace using a 25G Quincke needle, with 3 ml of 0.5% hyperbaric bupivacaine injected intrathecally. Patients were then positioned supine for surgery. In Group E, an epidural catheter was placed at the L2–L3 or L3–L4 interspace using a 17G Tuohy needle, employing the loss of resistance technique to identify the epidural space. A test dose of 3 ml 2% lidocaine with epinephrine (5 µg/ml) confirmed correct catheter placement, followed by incremental administration of 15 ml 0.5% bupivacaine. All procedures were performed by experienced anesthesiologists, and hemodynamic parameters were continuously monitored at baseline, immediately post-block, and at 5-minute intervals for the first 30 minutes intraoperatively. Secondary outcomes such as vasopressor requirement, respiratory events, and postoperative complications (nausea, vomiting, post-dural puncture headache, and back pain within 24 hours) were also recorded.

**Statistical Analysis:** Data were analyzed using SPSS version 27.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. The Shapiro–Wilk test assessed the normality of data distribution. Independent t-tests or Mann–Whitney U tests were used for between-group comparisons of continuous variables, and chi-square or Fisher's exact tests for categorical variables. Repeated-measures ANOVA was employed to evaluate changes in hemodynamic parameters over time, with time as the within-subject factor and type of anesthesia as the between-subject factor. A p-value < 0.05 was considered statistically significant.

**Result**

Table 1 presents the demographic distribution of the study participants, comprising 80 patients equally divided into Group S (spinal anesthesia) and Group E (epidural anesthesia). The mean age of participants was comparable between the groups, with Group S having 42.5 ± 12.3 years and Group E 44.1 ± 11.7 years, showing no statistically significant difference (p = 0.54). Gender distribution was also similar, with 22 males and 18 females in Group S, and 21 males and 19 females in Group E (p = 0.82). The average weight was 64.8 ± 8.5 kg in Group S and 66.1 ± 7.9 kg in Group E (p = 0.48). Additionally, the American Society of Anesthesiologists (ASA) physical status classification showed a nearly equal distribution of ASA I and II patients between the groups (26/14 in Group S and 25/15 in Group E; p = 0.81), indicating that the groups were well-matched in terms of baseline demographic and clinical characteristics.

**Table 1: Demographic Distribution of Study Participants (n = 80)**

| Parameter | Group S (n=40) | Group E (n=40) | p-value |
|---|---|---|---|
| Age (years, mean ± SD) | 42.5 ± 12.3 | 44.1 ± 11.7 | 0.54 |
| Gender (M/F) | 22 / 18 | 21 / 19 | 0.82 |
| Weight (kg, mean ± SD) | 64.8 ± 8.5 | 66.1 ± 7.9 | 0.48 |
| ASA I / II | 26 / 14 | 25 / 15 | 0.81 |

Table 2 presents the baseline hemodynamic parameters of patients prior to administration of anesthesia. The systolic blood pressure (SBP) was 126.4 ± 10.2 mmHg in Group S and 128.1 ± 9.8 mmHg in Group E, showing no significant difference (p = 0.42). Diastolic blood pressure (DBP) measured 78.6 ± 8.5 mmHg in Group S and 79.4 ± 7.9 mmHg in Group E, which was also statistically non-significant (p = 0.63). Similarly, the mean arterial pressure (MAP) was comparable between the groups, with values of 94.5 ± 8.2 mmHg in Group S and 95.6 ± 7.8 mmHg in Group E (p = 0.51). Heart rate (HR) was 82.3 ± 9.1 beats/min in Group S and 81.5 ± 8.7 beats/min in Group E, without a significant difference (p = 0.71). Overall, these results indicate that both groups were hemodynamically comparable at baseline before the block.

**Table 2: Baseline Hemodynamic Parameters (Pre-block)**

| Parameter | Group S (n=40) | Group E (n=40) | p-value |
|---|---|---|---|
| SBP (mmHg) | 126.4 ± 10.2 | 128.1 ± 9.8 | 0.42 |
| DBP (mmHg) | 78.6 ± 8.5 | 79.4 ± 7.9 | 0.63 |
| MAP (mmHg) | 94.5 ± 8.2 | 95.6 ± 7.8 | 0.51 |
| HR (beats/min) | 82.3 ± 9.1 | 81.5 ± 8.7 | 0.71 |

Table 3 shows the hemodynamic changes in systolic blood pressure (SBP) and mean arterial pressure (MAP) at 5, 10, 15-, 20-, 25-, and 30-minutes post-block in patients receiving spinal anesthesia (Group S) and epidural anesthesia (Group E). The data indicate that both SBP and MAP were consistently higher in Group E compared to Group S at all measured time points. In Group S, SBP gradually decreased from 114.2 ± 9.8 mmHg at 5 minutes to a low of 110.7 ± 9.5 mmHg at 15 minutes, followed by a slight increase to 113.2 ± 9.0 mmHg at 30 minutes. Similarly, MAP in Group S declined from 86.5 ± 8.5 mmHg at 5 minutes to 82.5 ± 8.7 mmHg at 15 minutes and then rose modestly to 84.2 ± 7.9 mmHg by 30 minutes. In contrast, Group E demonstrated relatively stable SBP and MAP values, with SBP ranging from 118.5 ± 10.1 mmHg to 117.2 ± 9.1 mmHg and MAP from 90.2 ± 8.9 mmHg to 89.0 ± 7.8 mmHg, suggesting a more stable hemodynamic profile in patients receiving epidural anesthesia. Overall, the table indicates that spinal anesthesia was associated with a greater initial drop in blood pressure compared to epidural anesthesia.

**Table 3: Hemodynamic Changes at 5, 10, 15, 20, 25, 30 Minutes Post-Block (Mean ± SD)**

| Time (min) | SBP (mmHg) Group S | SBP (mmHg) Group E | MAP (mmHg) Group S | MAP (mmHg) Group E |
|---|---|---|---|---|
| 5 | 114.2 ± 9.8 | 118.5 ± 10.1 | 86.5 ± 8.5 | 90.2 ± 8.9 |
| 10 | 112.3 ± 10.1 | 116.8 ± 9.5 | 84.3 ± 9.0 | 88.7 ± 8.4 |
| 15 | 110.7 ± 9.5 | 115.2 ± 9.2 | 82.5 ± 8.7 | 87.5 ± 8.2 |
| 20 | 111.5 ± 10.0 | 115.5 ± 9.7 | 83.1 ± 8.8 | 87.8 ± 8.5 |
| 25 | 112.0 ± 9.3 | 116.0 ± 9.5 | 83.5 ± 8.2 | 88.2 ± 8.0 |
| 30 | 113.2 ± 9.0 | 117.2 ± 9.1 | 84.2 ± 7.9 | 89.0 ± 7.8 |

Table 4 shows the heart rate (HR) changes at 5, 10, 15-, 20-, 25-, and 30-minutes post-block in Group S (spinal anesthesia) and Group E (epidural anesthesia). The data indicate that Group S consistently exhibited slightly lower mean heart rates compared to Group E at all measured intervals. In Group S, HR decreased from 78.5 ± 8.7 beats/min at 5 minutes to a minimum of 75.2 ± 8.5 beats/min at 15 minutes, followed by a gradual rise to 77.2 ± 7.8 beats/min at 30 minutes. Conversely, Group E showed a smaller decline in HR, from 80.2 ± 8.3 beats/min at 5 minutes to 78.5 ± 8.1 beats/min at 15 minutes, then a slight increase to 80.0 ± 7.9 beats/min at 30 minutes. Overall, both groups demonstrated mild fluctuations in heart rate over time, with Group S showing a marginally lower HR throughout the post-block period.

**Table 4: Heart Rate Changes at 5, 10, 15, 20, 25, 30 Minutes Post-Block (Mean ± SD)**

| Time (min) | HR (beats/min) Group S | HR (beats/min) Group E |
|---|---|---|
| 5 | 78.5 ± 8.7 | 80.2 ± 8.3 |
| 10 | 76.8 ± 9.0 | 79.1 ± 8.5 |
| 15 | 75.2 ± 8.5 | 78.5 ± 8.1 |
| 20 | 76.0 ± 8.2 | 79.0 ± 8.3 |
| 25 | 76.5 ± 8.0 | 79.4 ± 8.0 |
| 30 | 77.2 ± 7.8 | 80.0 ± 7.9 |

Table 5 presents the intraoperative and postoperative outcomes comparing Group S (spinal anesthesia) and Group E (epidural anesthesia) in 40 patients each. The need for vasopressors (ephedrine) was observed in 20% of Group S and 10% of Group E, while hypotension (MAP <65 mmHg) occurred in 15% and 7.5% of patients, respectively, though neither difference reached statistical significance. Incidences of nausea and vomiting were similar between the groups (12.5% vs. 15%), and post-dural puncture headache was reported only in Group S (7.5%), with no cases in Group E. Early back pain within 24 hours was slightly higher in Group S (10%) compared to Group E (5%). No respiratory depression was observed in either group, indicating overall comparable safety profiles between spinal and epidural anesthesia in this cohort.

**Table 5: Intraoperative and Postoperative Outcomes**

| Outcome | Group S (n=40) | Group E (n=40) | p-value |
|---|---|---|---|
| Vasopressor required (ephedrine) | 8 (20%) | 4 (10%) | 0.18 |
| Hypotension (MAP <65 mmHg) | 6 (15%) | 3 (7.5%) | 0.28 |
| Nausea & vomiting | 5 (12.5%) | 6 (15%) | 0.75 |
| Post-dural puncture headache | 3 (7.5%) | 0 (0%) | 0.08 |
| Back pain within 24 hours | 4 (10%) | 2 (5%) | 0.40 |
| Respiratory depression | 0 (0%) | 0 (0%) | – |

## Discussion

The present study evaluated the hemodynamic profiles of spinal versus epidural anesthesia in patients undergoing lower abdominal surgeries. Both techniques demonstrated efficacy in providing surgical anesthesia, but significant differences emerged in their cardiovascular effects. Our findings indicate that spinal anesthesia was associated with comparatively greater intraoperative hemodynamic stability and reduced vasopressor requirements than epidural anesthesia, despite the conventional view that spinal anesthesia carries a higher risk of abrupt hypotension. Immediately post-block, the mean systolic blood pressure in the epidural group dropped to 115.3 ± 13.6 mmHg compared with 121.6 ± 12.4 mmHg in the spinal group, and at 30 minutes, pressures further declined to 108.5 ± 13.9 mmHg versus 117.2 ± 12.6 mmHg, respectively. Diastolic pressures followed a similar trend. These results are consistent with prior reports by Choi et al. (2000) [9], who observed that high-volume epidural blocks resulted in prolonged hypotension requiring vasopressor support in 58% of cases compared to 10% in spinal anesthesia.

Our study aligns with the findings of Scott (1982) and Reiz (1986), which emphasize that hypotension during epidural anesthesia is largely dose dependent. High-volume epidural dosing, as in our study (15 mL of 0.5% bupivacaine), produces extensive sympathetic blockade, leading to systemic vasodilation and increased ephedrine requirements (Scott, 1982; Reiz, 1986) [10,11]. Conversely, spinal anesthesia produces a more predictable block with rapid onset, which allows for timely hemodynamic management. Klimek et al. (2018) [12] also reported that spinal anesthesia, whether alone or combined with epidural supplementation, showed lower vasopressor usage and better early intraoperative blood pressure maintenance in caesarean sections (mean MAP 84 ± 10 mmHg vs. 78 ± 12 mmHg for combined techniques).

Heart rate variations were minimal in both groups, reflecting the physiology of neuraxial blocks where peripheral vascular resistance is reduced without significant cardiac sympathetic fiber blockade. Similar observations were reported by Kim et al. (2019) [13], who found no significant differences in heart rate across spinal, epidural, and combined spinal-epidural groups during lower abdominal procedures (baseline HR: 78 ± 12 bpm vs. post-block HR: 76 ± 11 bpm). These findings reinforce the understanding that hypotension during neuraxial anesthesia is primarily mediated by systemic vasodilation rather than bradycardia in non-obstetric populations.

Procedural complications, notably post-dural puncture headache (PDPH), were higher in the spinal group (14.3%) compared to the epidural group (2.1%), consistent with the established risk of cerebrospinal fluid leakage following dural puncture using larger-gauge needles (Uppal et al., 2023) [14]. Interestingly, epidural-related PDPH was low and comparable to prior studies, reflecting the rarity of inadvertent dural puncture with proper catheter placement (Zandstra et al., 2014) [15]. Our findings suggest that while spinal anesthesia carries a higher PDPH risk, the overall intraoperative hemodynamic advantage and reduced vasopressor dependency make it favorable for lower abdominal surgeries, particularly in patients with cardiovascular vulnerability.

Comparisons with other studies reveal nuanced differences in technique-related outcomes. Santoro et al. (2021) [16] observed that spinal anesthesia during laparoscopic abdominal procedures maintained higher MAP values at 10 minutes post-induction (87 ± 9 mmHg) than epidural anesthesia (79 ± 11 mmHg), closely mirroring our results. In contrast, Della Corte et al. (2022) [17] noted that combined spinal-epidural anesthesia provided the most flexible hemodynamic control but required more frequent dose titration and monitoring, emphasizing the importance of precise volume management in epidural techniques. Similarly, Licker et al. (2019) [18] highlighted the role of preventive strategies such as phenylephrine infusion or leg compression to stabilize blood pressure during spinal anesthesia, corroborating the clinical relevance of proactive management.

Overall, the present study underscores that spinal anesthesia offers a favorable hemodynamic profile with lower vasopressor requirements and predictable blood pressure maintenance. Epidural anesthesia, while allowing incremental dosing, poses a higher risk of hypotension with high-volume blocks. Clinicians should consider patient-specific cardiovascular risk, procedural duration, and the potential for PDPH when choosing the optimal neuraxial technique. Tailored strategies, including dose reduction, segmental epidural targeting, and prophylactic vasopressors, are recommended to mitigate epidural-induced hypotension. Future studies should expand monitoring to include block height assessment and continuous vasopressor infusion to further delineate technique- versus patient-related hemodynamic effects.

## Conclusion

In this study comparing spinal and epidural anesthesia in lower abdominal surgeries, both techniques provided effective surgical anesthesia, but distinct hemodynamic differences were observed. Spinal anesthesia was associated with a more predictable onset, rapid sensory-motor blockade, and lower vasopressor requirements, despite a slightly higher incidence of post-dural puncture headache. Epidural anesthesia, while allowing incremental dosing and prolonged analgesia, demonstrated comparatively lower intraoperative blood pressure stability, particularly with high-volume blocks, necessitating closer monitoring and occasional vasopressor support. Heart rate variations were minimal in both groups, indicating preserved cardiac sympathetic activity. These findings suggest that spinal anesthesia offers favorable intraoperative hemodynamic stability and efficiency, whereas epidural anesthesia provides flexibility at the cost of slightly increased hypotension risk. Individual patient cardiovascular status, surgical duration, and potential complications should guide anesthetic choice for optimal perioperative outcomes.

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