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Original Research Article

Comparative Hemodynamic Response to Spinal and Epidural Anesthesia in Lower Abdominal Surgeries

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Abstract:

Background: Spinal and epidural anesthesia are commonly employed for lower abdominal surgeries; however, both techniques may cause sympathetic blockade–related hemodynamic changes, influencing perioperative safety.

Aim: To compare the hemodynamic responses and anesthesia-related complications of spinal versus epidural anesthesia in patients undergoing lower abdominal surgeries.

Methodology: This double-blind randomized clinical trial included 97 ASA I–II adult patients scheduled for elective lower abdominal surgery. Participants were allocated to spinal anesthesia (Group S, n=49) or epidural anesthesia (Group E, n=48). Systolic, diastolic, and mean arterial pressures, along with heart rate, were recorded at baseline and at regular intervals for 30 minutes after block administration. Intraoperative hypotension, vasopressor requirement, and postoperative complications were analyzed using SPSS.

Results: Baseline demographics were comparable. Epidural anesthesia produced significantly greater and sustained reductions in systolic, diastolic, and mean arterial pressures compared with spinal anesthesia ($p<0.05$), while heart rate remained similar between groups. Hypotension requiring ephedrine was significantly higher in the epidural group (60.4% vs. 8.2%, $p<0.001$). Post-dural puncture headaches were more frequent with spinal anesthesia.

Conclusion: Spinal anesthesia provided better hemodynamic stability with fewer hypotensive episodes, whereas epidural anesthesia was associated with greater blood pressure reductions and higher vasopressor use in lower abdominal surgeries.

Keywords: Spinal Anesthesia, Epidural Anesthesia, Hemodynamic Response, Hypotension, Lower Abdominal Surgery.

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Introduction

Selection of an appropriate anesthetic technique is a critical determinant of the safety of the perioperative period and the surgical outcomes, especially in patients undergoing lower abdominal surgeries. Various factors influence the choice of anesthesia, and these include the competence of the anesthesiologist, consent and expectations of the patients, age, nature and duration of the surgical procedure, intraoperative positioning, coexistent co-morbid states, and the strategy for postoperative pain management [1,2]. An ideal anesthetic technique should provide optimal conditions for the surgery with minimal adverse physiological effects, mainly those on cardiovascular stability.

Various regional anesthesia techniques, especially spinal and epidural anesthesia, are in broad application for lower abdominal surgeries because they offer adequate sensory blockade with relatively minimal systemic effects when administered appropriately [3,4]. Selective blockade of neural transmission at the spinal level in these techniques provides superior analgesia, reduced stress response, and early postoperative recovery compared to that achieved with general anesthesia. Spinal and epidural anesthesia have an advantage over general anesthesia that allows the patient to maintain spontaneous respiration and consciousness, which is greatly advantageous in patients with compromised cardiopulmonary reserve.

Despite these advantages, neuraxial anesthesia is associated with potential complications, most of which are due to sympathetic nervous system blockade. The degree of sympathetic block is determined by the level and extent of neural blockade, which affects vascular tone, venous return, and cardiac output. Hypotension remains one of the most commonly encountered adverse effects of spinal anesthesia and may be associated with serious complications if not promptly recognized and managed [5,6],. In general, hypotension is more common with spinal anesthesia than with epidural anesthesia due to the rapid onset and greater extent of sympathetic block following intrathecal drug administration. In contrast, epidural anesthesia results in a slower onset of block and allows incremental dosing that can contribute to better hemodynamic control [7].

Common lower abdominal surgeries necessitate the attainment of a sensory block up to the T6–T8 dermatome levels due to innervation of the same segments. Inevitably, the attainment of this level of block will involve sympathetic fibers and thus entail significant hemodynamic changes. In this perspective, knowledge of the cardiovascular effects of spinal and epidural anesthesia becomes fundamentally important in optimizing patient safety.

Advantages of epidural anesthesia include titration of dose and prolonged postoperative analgesia using catheters. This has enabled the anesthesiologist to achieve segmental anesthesia with relative preservation of sympathetic tone in comparison with spinal anesthesia [8]. Relative to spinal anesthesia, epidural anesthesia requires more technical expertise, has a more gradual onset, and occasionally produces an incomplete block. Spinal anesthesia is easier to perform, offers rapid onset of dense sensory and motor block, and is highly predictable. However, the rapid sympathetic block may be associated with abrupt hypotension, particularly in the elderly or those patients with limited cardiovascular reserve.

Although both techniques are in common use for lower abdominal surgery, direct comparative data on the cardiovascular impact of these two techniques remain limited. Most available studies are either technique-isolated or explore their use in other clinical settings, such as obstetric or orthopedic surgeries. Thus, few studies have systematically compared the incidence of hypotension and complications associated with it when using either technique for lower abdominal surgeries that require a block at or above the T6–T8 level. Given the increasing emphasis on patient safety and individualized anesthetic care, such comparisons are clinically relevant [9].

Multiple factors influence hemodynamic stability during anesthesia, including patient age, baseline cardiovascular status, intravascular volume, and the extent of sympathetic blockade. Severe or prolonged hypotension could impair organ perfusion, leading to adverse outcomes such as myocardial ischemia, renal dysfunction, or delayed recovery [10,11],. Identifying the technique that provides optimal surgical conditions with minimal hemodynamic fluctuations is thus of paramount importance, especially in high-risk patients.

The current study was conducted to compare the hemodynamic changes and anesthesia-related complications associated with spinal and epidural anesthesia in patients undergoing lower abdominal surgeries. By analyzing the blood pressure, heart rate variations, and incidence of hypotension, this study will add to the present body of literature and aid the anesthesiologists in choosing the most appropriate regional anesthesia technique for lower abdominal surgical procedures. This study will further lead to modifications in the clinical guidelines and improvement in the perioperative safety and patient outcomes in this surgical population.

Materials And Methods

Study Design: This study was designed as a double-blind randomized clinical trial to compare the hemodynamic responses of spinal anesthesia and epidural anesthesia in patients undergoing lower abdominal surgeries.

Study Area: The study was conducted in the Department of Anesthesiology, Bhagwan Mahavir Institute of Medical Sciences (BMIMS), Pawapuri, Nalanda, Bihar, India.

Study Duration: The study was carried out over a period of six months from March 2025 to August 2025

Sample Size: A total of 97 patients were included in the study.

Study Population: The study population comprised adult patients scheduled for elective lower abdominal surgeries under regional anesthesia at BMIMS, Pawapuri. Eligible patients were randomly allocated into two groups:

- Group S (Spinal Anesthesia Group)
- Group E (Epidural Anesthesia Group)

Inclusion Criteria

Patients fulfilling the following criteria were included:

- Age between 18 and 70 years
- ASA physical status I or II
- Scheduled for elective lower abdominal surgery requiring sensory block at or above T6–T8 level
- Patients willing to participate and providing written informed consent

Exclusion Criteria

Patients were excluded if they had:

- Patient refusal
- Contraindications to spinal or epidural anesthesia
- Inability to maintain required positioning
- Raised intracranial pressure
- Coagulopathy or bleeding disorders
- Sepsis or local infection at the injection site
- Hypovolemia
- Known allergy to local anesthetic drugs
- Peripheral neuropathy or neurological disorders
- Severe hypotension (MAP < 50 mmHg)
- Significant cardiovascular disease (ejection fraction < 30%)
- Liver dysfunction (enzymes > 1.5 times normal)
- Renal impairment (serum creatinine > 1.5 mg/dl)

Data Collection: Data were collected using a structured and predesigned proforma. Baseline demographic details such as age, gender, weight, ASA physical status, and clinical parameters were recorded preoperatively. Hemodynamic variables including systolic blood pressure, diastolic blood pressure, mean arterial pressure, and heart rate were monitored using a multiparameter monitor. These parameters were recorded at baseline, immediately after administration of anesthesia, and subsequently at 5-minute intervals for the first 30 minutes following the block. In addition to intraoperative hemodynamic measurements, secondary outcomes such as the requirement for vasopressor support (ephedrine), occurrence of respiratory arrest during surgery, and postoperative complications including nausea, vomiting, post-dural puncture headache, and back pain within the first 24 hours were documented.

Procedure: After preoperative assessment and confirmation of eligibility, patients were randomly allocated into two groups using a computer-generated randomization sequence: Group S (Spinal Anesthesia) and Group E (Epidural Anesthesia). Blinding was maintained for patients and outcome assessors, while the anesthesiologist performing the block was not blinded due to the nature of the intervention. All patients were preloaded with crystalloid solution at a dose of 7 ml/kg and received intravenous fentanyl 50 µg as premedication. In Group S, spinal anesthesia was performed in the sitting position at the L2–L3 or L3–L4 interspace using a 25G Quincke needle, and 3 ml of 0.5% hyperbaric bupivacaine was injected intrathecally. Patients were then positioned supine. In Group E, an epidural catheter was inserted at the L2–L3 or L3–L4 interspace using a 17G Tuohy needle, with identification of the epidural space by the loss of resistance technique. A test dose of 3 ml of 2% lidocaine with epinephrine (5 µg/ml) was administered to confirm catheter placement, followed by 15 ml of 0.5% bupivacaine in incremental doses. Standard monitoring was applied throughout the procedure, and all interventions were performed by experienced anesthesiologists.

Statistical Analysis: Statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) software. The normality of data distribution was assessed using the Shapiro–Wilk test. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Comparisons between the two groups for continuous variables were carried out using the independent t-test or Mann–Whitney U test as appropriate, and categorical variables were compared using the chi-square test or Fisher's exact test. Changes in hemodynamic parameters over time between the two groups were analyzed using repeated-measures analysis of variance, with time as the within-subject factor and type of anesthesia as the between-subject factor. A p-value of less than 0.05 was considered statistically significant."

Result

Table 1 summarizes the demographic and clinical characteristics of patients receiving spinal anesthesia (Group S, n = 49) and epidural anesthesia (Group E, n = 48). The mean age was comparable between Group S (46.8 ± 15.9 years) and Group E (49.6 ± 16.4 years, p = 0.38). Sex distribution was similar in both groups (Group S: 27 males/22 females; Group E: 26 males/22 females, p = 0.94). Mean body weight also did not differ significantly (64.2 ± 9.8 kg vs 65.7 ± 10.1 kg, p = 0.46). The distribution of ASA physical status I/II was comparable between the two groups (31/18 in Group S vs 29/19 in Group E, p = 0.77). Overall, there were no statistically significant differences in baseline demographic or clinical characteristics, indicating that both groups were well matched prior to intervention.

Table 1: Demographic and Clinical Characteristics of Patients in the Two Groups

Variables	Spinal Anesthesia (Group S, n = 49)	Epidural Anesthesia (Group E, n = 48)	P-value
Age (years)	46.8 ± 15.9	49.6 ± 16.4	0.38
Sex (Male/Female)	27 / 22	26 / 22	0.94
Weight (kg)	64.2 ± 9.8	65.7 ± 10.1	0.46
ASA physical status (I / II)	31 / 18	29 / 19	0.77

Table 2 compares systolic blood pressure (SBP) changes over time between the spinal anesthesia group (Group S, n = 49) and the epidural anesthesia group (Group E, n = 48). Baseline SBP was comparable between the two groups (126.4 ± 11.8 mmHg in Group S vs 125.1 ± 12.2 mmHg in Group E, p = 0.58). Immediately after the block, SBP decreased in both groups but was significantly lower in Group E (115.3 ± 13.6 mmHg) compared with Group S (121.6 ± 12.4 mmHg, p = 0.01). This difference persisted at subsequent time points, with Group E showing consistently lower SBP at 5, 10, 15, 20, 25, and 30 minutes (all $p < 0.05$). Overall, epidural anesthesia was associated with a more pronounced and sustained reduction in SBP compared to spinal anesthesia during the first 30 minutes after block administration.

Table 2: Comparison of Systolic Blood Pressure (SBP) Changes Over Time (mmHg)

Time interval	Group S (n = 49)	Group E (n = 48)	P-value
Baseline	126.4 ± 11.8	125.1 ± 12.2	0.58
Immediately after block	121.6 ± 12.4	115.3 ± 13.6	0.01
5 minutes	118.9 ± 13.1	109.8 ± 14.2	<0.001
10 minutes	117.2 ± 12.6	108.5 ± 13.9	<0.001
15 minutes	118.1 ± 12.3	110.2 ± 14.1	0.002
20 minutes	119.4 ± 11.9	112.7 ± 13.8	0.01
25 minutes	120.6 ± 11.7	114.1 ± 13.4	0.02
30 minutes	122.3 ± 11.5	116.9 ± 13.1	0.03

Table 3 shows the comparison of diastolic blood pressure (DBP) changes over time between the spinal anesthesia group (Group S, n = 49) and the epidural anesthesia group (Group E, n = 48). Baseline DBP was comparable in both groups (78.6 ± 8.9 mmHg in Group S vs 77.9 ± 9.4 mmHg in Group E, p = 0.71). Immediately after block administration, DBP decreased in both groups but was significantly lower in Group E (69.8 ± 10.1 mmHg) compared to Group S (74.2 ± 9.3 mmHg, p = 0.02). This significant difference persisted at all subsequent time points, with Group E demonstrating consistently lower DBP at 5, 10, 15, 20, 25, and 30 minutes (all $p \leq 0.02$). Overall, epidural anesthesia resulted in a greater and more sustained reduction in DBP compared with spinal anesthesia during the first 30 minutes following block placement.

Table 3: Comparison of Diastolic Blood Pressure (DBP) Changes Over Time (mmHg)

Time interval	Group S (n = 49)	Group E (n = 48)	P-value
Baseline	78.6 ± 8.9	77.9 ± 9.4	0.71
Immediately after block	74.2 ± 9.3	69.8 ± 10.1	0.02
5 minutes	72.5 ± 9.6	66.3 ± 10.4	0.001
10 minutes	71.9 ± 9.2	65.7 ± 10.2	0.001
15 minutes	72.4 ± 9.1	66.8 ± 10.3	0.003
20 minutes	73.6 ± 8.8	68.1 ± 10.0	0.006
25 minutes	74.8 ± 8.6	69.5 ± 9.7	0.01
30 minutes	75.9 ± 8.4	71.2 ± 9.5	0.02

Table 4 compares mean arterial pressure (MAP) changes over time between the spinal anesthesia group (Group S, n = 49) and the epidural anesthesia group (Group E, n = 48). Baseline MAP was similar in both groups (94.5 ± 9.7 mmHg in Group S vs 93.6 ± 10.1 mmHg in Group E, p = 0.67). Immediately after block, MAP decreased in both groups, with a significantly greater reduction observed in Group E (84.1 ± 11.0 mmHg) compared to Group S (89.9 ± 10.2 mmHg, p = 0.01). This difference remained significant at all subsequent time points, including 5 minutes (80.8 ± 11.5 vs 88.0 ± 10.6 mmHg, $p < 0.001$), 10 minutes (79.9 ± 11.2 vs 87.3 ± 10.1 mmHg, $p < 0.001$), and up to 30 minutes (86.3 ± 10.4 vs 92.1 ± 9.2 mmHg, p = 0.02). Overall, epidural anesthesia was associated with a more pronounced and sustained decrease in MAP compared to spinal anesthesia during the first 30 minutes following block administration.

Table 4: Comparison of Mean Arterial Pressure (MAP) Changes Over Time (mmHg)

Time interval	Group S (n = 49)	Group E (n = 48)	P-value
Baseline	94.5 ± 9.7	93.6 ± 10.1	0.67
Immediately after block	89.9 ± 10.2	84.1 ± 11.0	0.01
5 minutes	88.0 ± 10.6	80.8 ± 11.5	<0.001
10 minutes	87.3 ± 10.1	79.9 ± 11.2	<0.001
15 minutes	88.2 ± 9.9	81.3 ± 11.4	0.002
20 minutes	89.6 ± 9.6	83.0 ± 11.1	0.004
25 minutes	90.7 ± 9.4	84.6 ± 10.8	0.01
30 minutes	92.1 ± 9.2	86.3 ± 10.4	0.02

Table 5 compares heart rate (HR) changes over time between the spinal anesthesia group (Group S, n = 49) and the epidural anesthesia group (Group E, n = 48). Baseline HR was comparable between the two groups (78.2 ± 10.6 beats/min in Group S vs 79.5 ± 11.1 beats/min in Group E, p = 0.55). Following block administration, HR showed minimal fluctuations in both groups, with no statistically significant differences at any time point, including immediately after the block and at 5, 10, 15, 20, 25, and 30 minutes (all p > 0.05). Overall, heart rate remained stable and comparable between spinal and epidural anesthesia groups throughout the 30-minute observation period.

Table 5: Comparison of Heart Rate Changes Over Time (beats/min)

Time interval	Group S (n = 49)	Group E (n = 48)	P-value
Baseline	78.2 ± 10.6	79.5 ± 11.1	0.55
Immediately after block	76.9 ± 10.9	78.6 ± 11.4	0.43
5 minutes	76.1 ± 11.2	79.8 ± 12.0	0.09
10 minutes	75.8 ± 11.0	80.3 ± 12.3	0.06
15 minutes	76.4 ± 10.7	80.1 ± 12.1	0.1
20 minutes	77.2 ± 10.4	79.6 ± 11.8	0.28
25 minutes	77.8 ± 10.2	79.1 ± 11.6	0.53
30 minutes	78.5 ± 10.0	79.0 ± 11.3	0.81

Table 6 summarizes the intraoperative and postoperative complications observed in the spinal anesthesia group (Group S, n = 49) and the epidural anesthesia group (Group E, n = 48). Hypotension requiring ephedrine occurred significantly more frequently in Group E (29 patients; 60.4%) compared with Group S (4 patients; 8.2%), and this difference was highly significant (p < 0.001). No cases of respiratory arrest were reported in either group. The incidence of nausea and vomiting was comparable between groups (*12.2% in Group S vs 8.3% in Group E; p = 0.52). Post-dural puncture headache was significantly more common in the spinal anesthesia group (14.3%) than in the epidural group (2.1%, p = 0.03). Back pain was reported more frequently in Group E (29.2%) compared with Group S (16.3%), although this difference did not reach statistical significance (p = 0.12). Overall, epidural anesthesia was associated with a higher incidence of hypotension, while spinal anesthesia showed a higher rate of post-dural puncture headache.

Table 6: Intraoperative and Postoperative Complications

Complications	Group S (n = 49)	Group E (n = 48)	P-value
Hypotension requiring ephedrine	4 (8.2%)	29 (60.4%)	<0.001
Respiratory arrest	0	0	—
Nausea and vomiting	6 (12.2%)	4 (8.3%)	0.52
Post-dural puncture headache	7 (14.3%)	1 (2.1%)	0.03
Back pain	8 (16.3%)	14 (29.2%)	0.12

Discussion

In this randomized clinical trial, spinal anesthesia was compared with epidural anesthesia for lower abdominal surgeries. Both types of anesthesia were effective, but their hemodynamic profiles differed significantly. The demographical and clinical features - age, sex, weight, ASA class - were similar in the groups, allowing the internal validity to be high in attributing any hemodynamic difference to the type of anesthesia rather than patient variation. (Mehrabi & Shirazi, 2010; Agarwal & Kishore, 2009) [12,13]."

In both groups, systolic, diastolic, and mean arterial pressures (MAP) were reduced after anesthesia, but hypotension was deeper and longer lasting in the epidural group. Immediately post-block, systolic

pressure fell to 115.3 ± 13.6 mmHg in the epidural group versus 121.6 ± 12.4 mmHg in the spinal group, and values further declined at 30 minutes, respectively, to 108.5 ± 13.9 mmHg vs. 117.2 ± 12.6 mmHg. Diastolic pressures followed a similar trend (e.g., 66.3 ± 10.4 vs. 72.5 ± 9.6 mmHg at 5 minutes). The deeper hypotension in the epidural group was accompanied by substantially greater vasopressor requirements, 60.4% vs. 8.2%. Indeed, most literature attributes hypotension that is more abrupt to spinal anesthesia Scott, 1982 [5]; instead, our results reflect the influence of epidural dosing—namely, 15 mL of 0.5% bupivacaine, which is expected to produce extensive sympathetic blockade Reiz, 1982; Kang et al., 2014. High-volume epidurals indeed have been shown to cause systemic vasodilation and require vasopressor support Scott, 1982; Zandstra et al., 2014 [5,14].

MAP reflected these trends for the most part, with the epidural group reaching 79.9 ± 11.2 mmHg versus 87.3 ± 10.1 mmHg in the spinal group at 10 minutes. Greater ephedrine requirement corroborates previous thought that, although an advantage of epidural anesthesia is the ability for incremental dosing, large-volume or high-level blocks certainly can compromise hemodynamic stability (Reiz, 1982; Zandstra et al., 2014) [6,14].

No significant differences were detected in heart rate across the two groups. This is consistent with accepted physiology: neuraxial blocks decrease peripheral vascular resistance; however, without cardiac sympathetic fibers being blocked (T1–T4), bradycardia may result—heart rate is typically unchanged (Scott, 1982) [5].

Among procedural complications, PDPH occurred in 14.3% of spinal patients vs. 2.1% in the epidural group. This is consistent with known risks: intentional dural puncture using larger-gauge Quincke needles predisposes to PDPH through cerebrospinal fluid leakage (Uppal et al., 2023) [15]. In contrast, epidural-related PDPH is rare unless caused by inadvertent dural puncture (Uppal et al., 2023) [15].

This is presumably due to the epidural catheter placement, which may cause a localized paraspinal tissue irritation (Zandstra et al., 2014) [14]; it was reported more frequently in the epidural group, 29.2% vs. 16.3%, but did not reach statistical significance.

Overall, spinal anesthesia was associated with greater intraoperative hemodynamic stability, lower vasopressor use, and an overall favorable side-effect profile for surgery of the lower abdomen, challenging the assumption that epidural anesthesia universally carries fewer hemodynamic risks. These findings instead emphasize the relation of dose and spread control in epidural anesthesia. While spinal anesthesia has a greater inherent risk of PDPH, the hemodynamic profile and surgical suitability make it an attractive option, particularly in patients with cardiovascular vulnerabilities.

When choosing epidural anesthesia, practitioners should also consider dose reduction, segmental targeting, and prophylactic vasopressors in patients at risk for hypotension. Spinal anesthesia may capitalize on evidence-based hypotension prevention strategies such as phenylephrine infusion or leg compression to further enhance cardiovascular stability (Licker et al., 2019) [16]. The limitations of this study include assessment of only early intraoperative hemodynamics (first 30 minutes), no monitoring of block height, and use of ephedrine rescue instead of continuous vasopressor infusion. Future studies should involve longer monitoring, precise dermatomal level assessment, and comparison of vasopressor strategies to establish whether the demonstrated epidural-induced hypotension is technique-related or patient-related.

Conclusion

The current study therefore established that despite the similar patient populations undergoing surgeries of the lower abdomen receiving spinal and epidural anesthesia, the hemodynamic effects were significantly different. Epidural anesthesia resulted in a more profound and longer-lasting decrease in systolic, diastolic, and mean arterial pressures intraoperatively compared to spinal anesthesia, translating to increased hemodynamic instability. Changes in heart rate for both techniques were similar and clinically insignificant. Further, the incidence of hypotension requiring pharmacological intervention was higher with epidural anesthesia, while spinal anesthesia was associated more frequently with post-dural puncture headaches. Overall, spinal anesthesia offered better hemodynamic stability with fewer hypotensive episodes, suggesting it may be the more favorable option in patients where maintenance of stable blood pressure is a priority.

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