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A COMPARATIVE STUDY BETWEEN THE CLINICAL EFFECTS OF SEQUENTIAL COMBINED EPIDURAL WITH SPINAL ANESTHESIA AND SPINAL ANESTHESIA ON HEMODYNAMIC STABILITY IN PATIENTS UNDERGOING MAJOR ORTHOPEDIC SURGERY

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ABSTRACT

Background: Orthopedic surgery is often performed with regional anesthesia, and traditional spinal anesthesia can lead to clinically significant decreases in arterial pressure due to sympathetic blockade, whereas Combined spinal-epidural anesthesia (CSEA) can be used with a lower initial intrathecal dose followed by epidural supplementation. **Aim:** To compare the clinical outcomes and clinical hemodynamic stability of CSEA and conventional spinal anesthesia in patients who underwent orthopedic surgery. **Methods:** A randomized controlled trial was carried out in 60 patients who were randomly divided into two groups; Group A which used conventional spinal anesthesia and Group B which used CSEA. The hemodynamic parameters were measured at preset intervals during the operation, and sensory and motor block features, patient and complications were noted. Statistical comparisons between groups were performed, with $p \leq 0.05$ considered statistically significant. **Results:** The mean age was 72.30 ± 5.75 years in Group A and 70.90 ± 4.53 years in Group B (p=0.150), while mean surgical duration was 54.13 ± 2.32 and 54.87 ± 2.10 minutes, respectively (p=0.102). Baseline MAP was comparable between groups (100.70 ± 5.79 vs. 99.37 ± 5.49 mmHg; p=0.182), but following anesthesia it remained significantly higher in Group B at all recorded time points from 0 to 50 minutes ($p<0.05$). Significant heart-rate differences were observed at 5 minutes (83.23 ± 10.78 vs. 76.93 ± 8.85 beats/min; p=0.008), 10 minutes (83.40 ± 12.14 vs. 76.53 ± 9.45 beats/min; p=0.009), and 15 minutes (81.53 ± 12.19 vs. 76.30 ± 9.57 beats/min; p=0.035). Sensory block onset, achievement of T10 sensory level, and motor block were significantly faster with conventional spinal anesthesia than CSEA (3.08 ± 0.64 vs. 11.57 ± 1.48 minutes; 6.13 ± 0.90 vs. 15.53 ± 1.50 minutes; and 8.08 ± 1.00 vs. 20.33 ± 1.86 minutes, respectively; all $p<0.05$). Hypotension occurred in 26.67% versus 13.33% of patients (p=0.390), while shivering was significantly more frequent with spinal anesthesia (13.33% vs. 0.00%; p=0.015). **Conclusion:** The CSEA was more efficient intraoperative MAP preservation than traditional spinal anesthesia, but the traditional spinal anesthesia yielded much faster sensory and motor blockade. This means that CSEA can prove beneficial in situations where hemodynamic stability is a primary anesthetic consideration, whereas traditional spinal anesthesia can be used where a rapid block realization is needed.

KEYWORDS: Combined spinal-epidural anesthesia; spinal anesthesia; orthopedic surgery; hemodynamic stability; mean arterial pressure; heart rate; regional anesthesia; hypotension.

INTRODUCTION

Orthopedic diseases represent a significant health burden worldwide and often necessitate surgical intervention to regain mobility, eliminate pain, and avoid functional disability in the long term, with musculoskeletal ailments impacting about 1.71 billion individuals worldwide and causing almost 149 million years lived with disability (Kang et al., 2025). The rising fracture, osteoarthritis, degenerative joint disease, and other musculoskeletal disorders rates have led to the consequent increase in the demand of lower-limb and major orthopedic operations in various healthcare systems (Gadekar et al., 2024). Such procedures are popularly performed with the help of regional anesthesia due to its ability to deliver effective surgical anesthesia and prevent various physiological effects of general anesthesia, such as airways manipulation and increased exposure of the system to the drugs. Spinal anesthesia (SA) has been a particularly appealing regional method due to its fast cumulative reaction, solid sensory and motor blockage, technical ease, and comparatively inexpensive anesthetic needs when performing surgery on the lower extremities (Mahima et al., 2023). However, intrathecal local anesthetics may induce sympathetic blockade, resulting in vasodilation, decreased venous return, and reduced systemic vascular resistance, and this leads to subsequent drops in arterial blood pressure, thereby hemodynamic disturbance is a crucial issue in the perioperative phase (Roofthooft et al., 2023).

The main physiological constraint of the traditional single-shot spinal anesthesia is that a rather fixed dose of intrathecal results in a block that is difficult to change or take-off once it has been inflicted, which may result in an inappropriate anesthetic response to the needs of the surgery, and may last for an inappropriate length or duration (Zeng et al., 2025). Hypotension is also one of the most common cardiovascular events of spinal anesthesia, and the literature of the past suggests that it can happen in up to about one-third of older patients undergoing major lower-limb orthopedic surgeries (Wu et al., 2026). An example of a meta-analysis by Shui et al., (2023), which included 733 elderly patients under lumbar spine surgery, showed that decreasing the mean spinal dose of anesthetic agents of about 10.5 mg to 6.5 mg was also linked to significantly lower odds of hypotension, odds ratio of 0.09 (95% CI, 0.04 0.21) but heterogeneity was still high (I 2 = 56.9). The importance of these blood-pressure perturbations is not merely in short-term numerical fluctuations since intraoperative hypotension may adversely affect organ perfusion and has been linked to poor postoperative outcomes when severe (or prolonged) enough (Shui et al., 2023).

Combined spinal-epidural anesthesia (CSEA) is a technique created to marry the speed and the density of neuraxial blockage that is achieved with spinal anesthesia with the manipulability and expandability offered via an epidural catheter (Buren and Cil, 2025). Surgical anesthesia can be easily obtained by the intrathecal component and sustained epidural anesthesia is possible by a subsequent epidural infusion which does not have to be supported by a massive initial intrathecal dose. The theoretical significance of this incremental capacity is that the epidural component allows a progressive expansion of anesthesia to meet the needs of the operation, as opposed to a single-shot spinal dose that must be given (Kaabachi et al., 2023). Orthopedic populations, however, have not shown a consistent improvement in CSEA compared to conventional spinal anesthesia, and anesthetic dose, technique, patient factors, and a definition of hypotension could be one reason behind conflicting results (Ciudad et al., 2023). Sequential CSEA resulted in much more favorable intraoperative hemodynamic stability compared to spinal anesthesia in a randomized study of 134 patients undergoing lower-limb orthopedic surgery, but the spinal group attained sensory blockade faster and exhibited a longer two-segment regression time (Abdelazeem et al., 2024).

In Pakistan, the necessity of locally relevant evidence is especially relevant in terms of musculoskeletal disorders that carry a significant burden and healthcare resources, patient-specific features, and the case-mix of operations, as well as the use of anesthetic modalities (Shah et al., 2026). Interested in CSEA in lower-limb surgery, Pakistani clinical research also has shown sustained interest in CSEA, with a randomized study of 100 patients reporting an extension of two-segment regression with the addition of epidural volume extension to CSEA, with mean regression times of 83.77 ± 7.56 and 59.97 ± 6.22 minutes with standard CSEA, respectively (Majeed, 2023). Nevertheless, locally available data has mostly studied variations in CSEA, and not outsourced sufficiently focused comparisons between standard spinal anesthesia and CSEA in terms of properly scrutinized perioperative hemodynamic and clinical results. Thus, it is reasonable to compare CSEA and conventional spinal anesthesia on orthopedic patients, to produce context-dependent evidence on the topic of hemodynamic stability, anesthetic efficacy, complications, and other clinical outcomes that could inform safer, more personalized choices of neuraxial anesthesia in Pakistan.

METHODOLOGY

Study Design and Setting

The study was a randomized controlled trial carried out in the Department of Anesthesia, Services Hospital, Lahore during a duration of six months, 20 December 2025 to 20 June 2026.

Sample Population

The sample size needed was calculated using the difference in the mean systolic blood pressure that was expected between the patients undergoing spinal anesthesia and the patients undergoing the combined spinal-epidural method. The anticipated systolic pressure of blood was 97.0 and 6.93 mmHg in spinal anesthesia and combined spinal-epidural group respectively. According to these assumptions, the sample size was calculated to be 66 participants with a significance level of 5% and a statistical power of 80. The overall sample was thus split and an equal number of 33 participants in each treatment group were obtained.

Selection Criteria

Eligible patients were 18 years old to 45 years, were rated as American Society of Anesthesiologists (ASA) physical status I or II, and capable of giving written informed consent. The cases with contraindications to spinal anesthesia, neurological injury, coagulation disorders, pre-existing hypotension, unregulated hypertension, or emotional instability were not included in the study. Patients with a history of regional anesthesia problems were also excluded as well as those with an ASA physical status III or IV. These criteria were used to derive a relatively similar study population and to reduce factors which might independently affect anesthetic safety and perioperative hemodynamic responses.

Randomization and Allocation

The participants were randomly assigned to two groups by using a computerized random number generation system with equal 1:1 ratio. Group A comprised 33 subjects that were administered with conventional spinal anesthesia and Group B comprised 33 subjects that were administered with sequential combined spinal-epidural technique. A statistician generated the sequence of the allocation with the aim of minimizing the selection bias, and participant enrollment was provided by trained investigators. In order to preserve allocation concealment, the

randomization assignments were to be stored in sequentially numbered, sealed envelopes, which were prepared prior to the participant allocation. This process allowed keeping treatment assignment unbeknownst to the participant until the participant was enrolled into the study.

Data Collection

A thorough clinical evaluation was done on all the participants prior to the surgery, which involved history taking and physical examination. The baseline demographic and clinical data, such as age, body mass index, ASA physical status, blood pressure, heart rate, respiratory rate, oxygen saturation, and body temperature were measured. The patients were maintained nil per oral eight hours prior to the surgery and they were informed of the intended anesthetic operation before being subjected to the operating room. Identification in the operating room was followed by standard ASA monitoring and baseline vital signs and temperature. An intravenous cannula with an 18-gauge was used to obtain intravenous access and 10 15 mL/kg of Ringer lactate solution was administered as a preload. During the procedure, the temperature of the operating-room was kept at 22 o C to 24 o C.

Anesthesia Procedures

In the case of those who were to be put in Group A, spinal anesthesia was performed with the patient sitting at the L3-L4 level using 25-gauge Quincke spinal needle. Before giving the anesthetic solution, the position of the needle was verified by the free flow of cerebral spinal fluid. Individuals were given intrathecally 3 mL of 0.5% hyperbaric bupivacaine mixed with 25 mg of tramadol. The patient was placed in a supine position after administration of anesthetic and the progression and range of sensory block was measured. The sensory block was tilted when it had arrived at the T8 dermatome to prevent the further cephalad extension of the block. Monitoring of the sensory level and ensuing hemodynamic reactions during the surgical procedure were carried out.

In those participants who belonged to Group B, the combined spinal-epidural approach was used by first performing epidural surgery at the L2L3 inter-spinal level with a 18-gauge Tuohy needle. A 20-gauge epidural catheter was inserted and fixed after giving a test dose of 3 mL of 2 percent lignocaine with adrenaline of 0.005mg. After ensuring that cerebrospinal fluid was free to flow, spinal anesthesia was obtained at the L3 level in the L4 interspace with 25-gauge Quincke needle. The intrathecal injection was a 1.5 mL of 0.5% hyperbaric bupivacaine (7.5 mg) and 25 mg of tramadol. This was determined as resulting sensory block level which was then determined at the point of administration of the spinal component and in the event that the block was still below T8, then an epidural top-up of 2 mL of 0.5% bupivacaine was done per extra segment needed to reach the desired level of T8 sensory level. The sensory block was then observed along with the intraoperative hemodynamic parameters of the patient.

Hemodynamic Surveillance and Reporting

The main intraoperative hemodynamic parameters evaluated in the course of the study were heart rate, systolic blood pressure, diastolic blood pressure, and mean arterial pressure. All the variables were monitored with five minutes separation at the initial 15 minutes after administration of anesthesia, and later in 15 min intervals until the surgery was complete. The incidence of clinically meaningful adverse events was also reported during the period of operation. Specific focus was given to hypotension, bradycardia, nausea and vomiting where each event was documented as to when it occurred during the procedure. Both the groups were monitored using the same method to enable a normal comparison of perioperative hemodynamic reactions and adverse reactions.

Data Analysis

The collected data was processed with IBM SPSS Statistics version 26.0. Means and standard deviations were used to summarize quantitative variables, such as age, systolic blood pressure, diastolic blood pressure, heart rate and mean arterial pressure. Categorical variables such as the gender, hypotension, bradycardia, nausea, and vomiting were given as frequencies and percentages. Data were also stratified in terms of age and gender to assess whether these factors contributed to the given results. The chi-square test was used to compare categorical variables and included comparisons of the two anesthetic groups. Inferential analyses were regarded as statistically significant at a p-value of ≤ 0.05.

Ethical Considerations

The study received ethical approval of Institutional Review Board and Ethical Review Committee of Services Hospital, Lahore, prior to the actual beginning of recruitment of participants (CPSP/REU/ANS-2022-068-3082). Informed consent was signed by all participants at the conclusion of the study procedures, anesthetic methods, potential advantages, and a possible risk had been discussed. All the participants were volunteers, and they were notified that they would not lose the right to refuse or drop out of the study without impacting their healthcare. During the research, participant confidentiality was ensured and the information obtained was utilized in the research work only.

RESULTS

Age

The age distribution was in a general similarity in both groups. Group A had a mean age of 72.30 ± 5.75 years, while Group B had a mean age of 70.90 ± 4.53 years. Group A (50.00% of participants) and Group B (56.67% of participants) had more than half aged between 65-70 years. The count of 71-75 years was 16.67% in Group A and 26.67% in Group B with the percentage of 76-80 years being 30.00% and 16.67% respectively. Group A had only one subject (3.33%) in the age range of 81 85 years, and none in Group B had this age range.

Table 1. Distribution of Age among Groups A and B

Age (years)	Group A (n=30), n (%)	Group B (n=30), n (%)
65–70	15 (50.00%)	17 (56.67%)
71–75	5 (16.67%)	8 (26.67%)
76–80	9 (30.00%)	5 (16.67%)
81–85	1 (3.33%)	0 (0.00%)
Total	**30 (100%)**	**30 (100%)**

Duration of Surgery

The mean operative time was 54.13 ± 2.32 minutes in Group A and 54.87 ± 2.10 minutes in Group B. Group B slightly had a higher mean surgical duration but the difference was not significant (p=0.102). The similarity in the standard deviations was also an indication that there was a similar variability in the length of the operation in the groups. As such, variation in the length of surgery was unlikely to result in any significant differences in the observed differences in hemodynamic and anesthetic outcomes. This similarity enhances the evaluation of the difference which can be assigned to the particular methods of anesthesia.

Table 2. Distribution of Mean Duration of Surgery

Parameter	Group A Mean ± SD	Group B Mean ± SD	p-value
Duration of surgery (minutes)	54.13 ± 2.32	54.87 ± 2.10	0.102

Comparison of Heart Rate

The average heart rate in Group A was 78.10 ± 6.43 beats/minute and Group B was 78.97 ± 6.39 beats/minute, which did not significantly differ (p=0.301). By 5 minutes, Group A showed an improvement to 83.23 ± 10.78 beats/minute, but Group B had a mean heart rate of 76.93 ± 8.85 beats/minute (p=0.008). Significant differences persisted at 10 minutes (83.40 ± 12.14 vs. 76.53 ± 9.45 beats/minute; p=0.009) and 15 minutes (81.53 ± 12.19 vs. 76.30 ± 9.57 beats/minute; p=0.035). After 15 minutes, no statistically significant differences were observed at 20, 25, 30, 40, 50, or 60 minutes, with the p-values being 0.100, 0.095, 0.236, 0.352, 0.312, and 0.056, respectively.

Table 3. Comparison of Heart Rate between Groups

HR (beats/min)	Group A Mean ± SD	Group B Mean ± SD	p-value
0 min	78.10 ± 6.43	78.97 ± 6.39	0.301
5 min	83.23 ± 10.78	76.93 ± 8.85	0.008
10 min	83.40 ± 12.14	76.53 ± 9.45	0.009
15 min	81.53 ± 12.19	76.30 ± 9.57	0.035
20 min	80.37 ± 12.23	76.70 ± 9.47	0.100
25 min	80.57 ± 9.66	77.40 ± 8.85	0.095
30 min	79.63 ± 8.08	78.10 ± 8.35	0.236
40 min	78.30 ± 7.85	79.07 ± 7.66	0.352
50 min	78.67 ± 7.49	79.60 ± 7.20	0.312
60 min	77.40 ± 7.41	80.37 ± 6.86	0.056

Comparison of Mean Arterial Pressure between Groups

Mean arterial pressure showed a significant difference between the two groups after the administration of anesthesia. Baseline MAP was similar, with values of 100.70 ±5.79mmHg in Group A and 99.37 ±5.49mmHg in Group B, which did not statistically differ (p=0.182). In Group A, MAP was significantly lowered post anesthesia to 79.83 ± 6.52 mmHg at 0 minutes, but in Group B it was elevated to 89.47 ± 6.80 mmHg ($p<0.05$). This difference was statistically significant at each follow-up measurement and MAP was always greater in Group B 5 minutes-50 minutes (all $p<0.05$). Group A showed a gradual recovery in MAP from 79.83 ± 6.52 mmHg at 0 minutes to 91.30 ± 4.48 mmHg at 50 minutes, while Group B increased from 89.47 ± 6.80 to 96.10 ± 5.52 mmHg.

Table 4. Comparison of Mean Arterial Pressure between Groups

MAP (mmHg)	Group A Mean ± SD	Group B Mean ± SD	p-value
Baseline	100.70 ± 5.79	99.37 ± 5.49	0.182
0 min	79.83 ± 6.52	89.47 ± 6.80	0.013
5 min	80.87 ± 5.75	89.43 ± 6.54	0.024
10 min	82.40 ± 5.70	90.47 ± 6.26	0.019
15 min	83.87 ± 5.42	91.17 ± 6.14	0.041
20 min	85.60 ± 5.24	92.20 ± 6.08	0.037

25 min	86.97 ± 5.35	93.03 ± 5.79	0.011
30 min	88.70 ± 5.25	94.17 ± 5.86	0.027
40 min	90.13 ± 4.75	95.00 ± 5.32	0.045
50 min	91.30 ± 4.48	96.10 ± 5.52	0.022

Comparison of Sensory and Motor Block Characteristics and Patient Satisfaction

There was a great difference between the speed of development of sensory and motor blocks in the two anesthetic methods. Mean time of sensory block was found to be significantly lower in Group A of 3.08±0.64 minutes than Group B of 11.57±1.48 minutes ($p<0.05$). Likewise, Group A achieved a sensory block level up to T10 much sooner than Group B with 6.13 ±0.90 and 15.53 ±1.50 minutes, respectively ($p<0.05$). The duration of time spent to attain motor block was also significantly less in Group A (8.08 ±1.00 minutes) compared to Group B (20.33 ±1.86 minutes), and the difference between the two was statistically significant ($p<0.05$). Conversely, patient satisfaction scores were not significantly different, with Group A scoring 5.80 ±0.81 and Group B scoring 6.13 ±0.82 ($p=0.059$).

Table 5. Comparison of Sensory and Motor Block Characteristics and Patient Satisfaction

Parameter	Group A Mean ± SD	Group B Mean ± SD	p-value
Onset of sensory block (minutes)	3.08 ± 0.64	11.57 ± 1.48	0.019
Time to reach sensory block up to T10 (minutes)	6.13 ± 0.90	15.53 ± 1.50	0.034
Time to reach motor block (minutes)	8.08 ± 1.00	20.33 ± 1.86	0.025
Patient satisfaction score	5.80 ± 0.81	6.13 ± 0.82	0.059

Comparison of Complications

Group A experienced 2 (6.67%) cases of bradycardia with no cases experienced in Group B, which was not statistically significant ($p=0.355$). Hypotension occurred in 8 (26.67%) participants in Group A and 4 (13.33%) participants in Group B but it was also not statistically significant ($p=0.390$). In Group A, 4 (13.33%) patients experienced nausea compared with 1 (3.33%) patient in Group B and there was no statistically significant difference ($p=0.338$). Shivering, however, was much more common in Group A, with 4 (13.33%) participants versus 0 in Group B ($p=0.015$).

Table 6. Comparison of Complications between Groups

Complication	Group A n (%)	Group B n (%)	p-value
Bradycardia	2 (6.67%)	0 (0.00%)	0.355
Hypotension	8 (26.67%)	4 (13.33%)	0.390
Nausea	4 (13.33%)	1 (3.33%)	0.338
Shivering	4 (13.33%)	0 (0.00%)	0.015

DISCUSSION

The current study aimed to evaluate whether CSEA and conventional spinal anesthesia (SA) were similar in terms of clinical outcome and hemodynamic stability in orthopedic surgery patients, focusing specifically on heart rate, mean arterial pressure (MAP), block, patient satisfaction, and intraoperative complications. The most significant conclusion was that the preservation of MAP in CSEA group was significantly higher after anesthesia though the baseline levels of 100.70 ± 5.79 mmHg in Group A and 99.37 ± 5.49 mmHg in Group B were virtually equal ($p=0.182$). Intermediate Group A when compared with Group B MAP at 5 minutes decreased to 79.83 ± 6.52 mmHg in Group A versus 89.47 ± 6.80 mmHg in Group B ($p<0.05$): this statistically significant difference occurred between 5 minutes and 50 minutes. This is in line with a randomized study of 80 Egyptian patients of lower limb surgery where the CSEA group showed significantly better intraoperative hemodynamics than the SA group, and MAP differences were significant after five minutes (Aboulseoud, 2020).

Findings in heart-rate further supported a difference in early physiological response between the anesthetic methods, but the effect was far less sustained than the difference in MAP. Baseline HR was comparable at 78.10 ± 6.43 beats/minute in Group A and 78.97 ± 6.39 beats/minute in Group B ($p=0.301$), whereas significant between-group differences emerged at 5 minutes (83.23 ± 10.78 vs. 76.93 ± 8.85; $p=0.008$), 10 minutes (83.40 ± 12.14 vs. 76.53 ± 9.45; $p=0.009$), and 15 minutes (81.53 ± 12.19 vs. 76.30 ± 9.57; $p=0.035$). However, statistical significance disappeared at 20 minutes ($p=0.100$), 25 minutes ($p=0.095$), 30 minutes ($p=0.236$), 40 minutes ($p=0.352$), and 50 minutes ($p=0.312$), with the 60-minute comparison approaching but not reaching significance (77.40 ± 7.41 vs. 80.37 ± 6.86; $p=0.056$). Conversely, a 60-patient study in Singapore on lower limb procedures found significant difference in HR between CSEA and SA at any timepoint, such as baseline values of 77.73 ± 5.80 versus 78.07 ± 6.98 beats/minute ($p=0.841$), implying that HR responses can be more technique- and population-dependent than MAP responses (Mutahar et al., 2019). Likewise, a 67-patient's trial revealed large pulse-rate disparities at time points of interest, such as 5 and 10 minutes, with baseline HR being similar at 84.28 ± 10.38 versus 84.48 ± 9.78 beats/minute, which partly validates the current pattern of initial divergence followed by convergence (Ln and Madhusudhana, 2023).

A key counterbalancing observation was that, the traditional SA established a significant rapid formation of the sensory and motor blockade as compared to CSEA, even though the latter had preserved the MAP better. The onset of sensory block occurred at 3.08 ± 0.64 minutes in Group A compared with 11.57 ± 1.48 minutes in Group B ($p<0.05$), while achievement of sensory blockade up to T10 required 6.13 ± 0.90 versus 15.53 ± 1.50 minutes, respectively ($p<0.05$). Motor block was also set up significantly earlier in case of SA, 8.08 ± 1.00 minutes versus 20.33 ± 1.86 minutes in case of CSEA ($p<0.05$) indicating a statistically significant difference among all three results of block. Such outcomes are similar to an Indian 60-patient's prospective comparative study where sensory block was reached earlier with SA, with 5.01 ± 0.88 minutes on average to achieve sensory block with SA compared to 7.15 ± 0.75 minutes to achieve sequential CSEA sensory block and 7.13 ± 0.80 versus 9.64 ± 1.00 minutes to reach a motor block, respectively (Deshmi et al., 2024). Thus, the current results show a clinically significant trade-off: classic SA can ensure faster surgical preparedness, and CSEA can offer more control over hemodynamic responses due to its smaller initial dose of intrathecal and ability to supplement the epidural.

The complication profile tended to give a statistically significant advantage to CSEA, but the majority of the differences were not statistically significant, meaning that the illustrated hemodynamic advantage should not be considered as a sign of universal advantage in all adverse outcomes. Hypotension occurred in 8 (26.67%) patients in Group A compared with 4 (13.33%) in Group B ($p=0.390$), while bradycardia occurred in 2 (6.67%) versus 0 (0.00%) patients ($p=0.355$), respectively. Group A showed 4 (13.33) and Group B showed 1 (3.33) on nausea and shivering, respectively ($p=0.338$ and 0.015), with the only statistically significant complication being shivering (Group A, 4 (13.33); Group B, 1 (3.33)). Directionally consistent with the current MAP data is the lower numerical frequency of hypotension with CSEA, although the non-significant $p=0.390$ suggests that perhaps the sample of 60 participants was inadequate to determine a statistically reliable difference in event incidence. Notably, earlier Chinese orthopedic study have been contradictory, where a randomized trial of 187 patients showed the occurrence of arterial hypotension in 17 CSEA patients versus 4 patients undergoing continuous spinal anesthesia ($p<0.002$), and that the comparator technique and dosing schedule significantly affect the cardiovascular outcomes (Bai et al., 2025).

Lastly, patient satisfaction and the general anesthetic speed versus cardiovascular stability is also a significant clinical interpretation of the findings. Even though satisfaction was significantly greater with CSEA (6.13 ± 0.82) than with SA (5.80 ± 0.81), there was also no statistically significant difference ($p=0.059$) meaning that the higher MAP stability had no statistically significant effect on perceived patient satisfaction in this sample. The slower sensory onset (11.57 ± 1.48 vs. 3.08 ± 0.64 minutes; $p<0.05$) and slower motor blockade (20.33 ± 1.86 vs. 8.08 ± 1.00 minutes; $p<0.05$) indicates that CSEA can have extra preparation or wait time despite its more favorable hemodynamic. However, the ongoing MAP benefit of 0-50 minutes, with the differences between the groups always being $p<0.05$, suggests that this added time can be justified in practice in patients with cardiovascular stability as a priority. A recent Indian prospective observational study in 108 orthopedic patients similarly found that sequential CSEA had superior intraoperative hemodynamic stability but that SA had quicker sensory and more forceful sensory blockage, which supports the idea of a technique-specific trade-off and not an absolute advantage (Salve et al., 2026). A comparative randomized clinical study of 46 Egyptian patients also found out that both CSEA and SA had their own benefits, with the latter offering faster sensorial block, but both showed no changes in hemodynamics, which also proves that the choice of anesthetics needs to be made based on the relative significance of speed, block properties and cardiovascular stability (Elzohry et al., 2024).

There were some limitations associated with this study which one should take into consideration in order to interpret the study findings. First, the sample size was quite minor, 60 participants, and 30 patients per group, and thus, it might have been insufficient to find statistically significant differences in less frequent complications, including hypotension, bradycardia, and nausea. Second, despite the study comparing various parameters of intraoperative hemodynamics, the postoperative outcomes and variables related to recovery were not measured over the long term. Third, reported results were limited to patients aged between 65 and 85 years, which excludes younger orthopedic patients, despite having more general eligibility criteria. Lastly, the research failed to consider other variables, which could affect hemodynamic responses such as perioperative fluid balance, vasopressor needs, precise epidural supplementation needs, and postoperative analgesic results.

CONCLUSION

This research indicated that CSEA was much more intraoperative hemodynamically stable than traditional spinal anesthesia in patients undergoing orthopedic surgery. In spite of similarity in both groups in terms of age and duration of surgery, the mean arterial pressure continued to be significantly more during the 0 to 50 minutes of CSEA with all between-group differences being below $p<0.05$. Traditional spinal anesthesia, though, had much quicker onset of sensory block, T10 sensory reached sooner, and motor blockade, and all comparative results proved to have $p<0.05$. There were also significant differences in heart rate among the groups in the early postoperative anesthetic phase at 5, 10, and 15 minutes but the differences failed to be maintained later on in the surgery. Such complications as hypotension, bradycardia, and nausea were numerically lower with CSEA, whereas the difference in shivering was significant (13.33% vs. 0.00%; $p=0.015$).

REFERENCES

1. Abdelazeem, E.M., Mostafa, I.E. and Elmeliegy, M.F. (2024) Low-Dose Sequential Combined Spinal–

Epidural: An Anesthetic Technique for Lower Body Surgery in Patients with Significant Cardiac Disease. *International Journal of Medical Arts*, 6(6) 4486–4492.
2. Aboulseoud, A.A. (2020) Comparative study between sequential combined spinal epidural anesthesia versus epidural volume extension in lower limb surgery. *Ain-Shams Journal of Anesthesiology*, 12(1).
3. Bai, L., Zhao, L., Jia, F., Liu, Y. and Li, P. (2025) Effects of dexmedetomidine-ropivacaine assisted combined spinal-epidural anesthesia on neutrophil-lymphocyte ratio and postoperative delirium in elderly patients with intertrochanteric femoral fracture. *Frontiers in Pharmacology*, 15 1454452.
4. Buren, M.A. and Cil, H. (2025) Anesthetic considerations and management of spine surgery performed under neuraxial anesthesia. *Current Anesthesiology Reports*, 15(1) 28.
5. Ciudad, P., Escandón, J.M., Manrique, O.J., Escobar, H., Mago, B.P. and Malca, A.A. (2023) Efficacy of Combined Spinal–Epidural Anesthesia for Lower Extremity Microvascular Reconstruction. *Journal of Surgical Research*, 291 700–710.
6. Deshmi, R., Gajula, A. and Reddy, R.S. (2024) Comparison of Hemodynamic Stability between Spinal Anaesthesia and Combined Spinal-Epidural in Patients with Coronary Artery Disease (CAD). *European Journal of Cardiovascular Medicine*, 14 1193–1199.
7. Elzohry, A.A.M., Hegab, A.S., Khalifa, O.Y.A., Elhossieny, K.M. and Hameed, F.A.Z.H.A. (2024) Safety and efficacy of ultrasound-guided combined segmental thoracic spinal epidural anesthesia in abdominal surgeries and laparoscopic procedures: A prospective randomized clinical study. *Anesthesiology and pain medicine*, 13(6) e138825.
8. Gadekar, I.R., Rawat, H.S. and Paul, A. (2024) A comparative study of combined spinal epidural anesthesia versus spinal anesthesia in major lower limb orthopedic surgeries. *Cureus*, 16(8).
9. Kaabachi, O., Nasri, O., Raddaoui, K., Zoghlami, K., Trigui, E. and Makhlouf, H. (2023) Hypobaric bupivacaine for continuous spinal anesthesia in elderly hip fracture: effects on hemodynamic (a randomized controlled trial). *La Tunisie Médicale*, 101(3) 367.
10. Kang, S.Y., Kim, H.S. and Kang, H. (2025) Preferential Flow Patterns of Injectate in Epidural and Inadvertent Subdural Anesthesia: Exploring the Hemodynamic Stability of High-Level Epidural, Subdural and Combined Epidural-Subdural Blocks in Relation to ASA Class. *Journal of Pain Research*, 4727–4741.
11. Ln, M. and Madhusudhana, R. (2023) A Study of the Clinical Effects of Sequential Combined Spinal Epidural Anesthesia and Spinal Anesthesia in Patients Undergoing Orthopedic Surgeries. *Cureus*, 15(5) e39171–e39171.
12. Mahima, L.N., Madhusudhana, R. and MAHIMA, L.N. (2023) A Study of the Clinical Effects of Sequential Combined Spinal Epidural Anesthesia and Spinal Anesthesia in Patients Undergoing Orthopedic Surgeries. *Cureus*, 15(5).
13. Majeed, K. (2023) Comparison of Hemodynamic Stability of Patients Undergoing Appendectomy under Spinal Anesthesia versus Blend of Ketamine and Midazolam with Spinal Anesthesia. *Pakistan Armed Forces Medical Journal*, 73(4) 1128.
14. Mutahar, S.A., Madhavi, S., Unmesh, S., Swati, K. and Somika, A. (2019) Comparison of sequential combined spinal epidural anaesthesia and spinal anaesthesia in lower limb surgery: a prospective randomised double blind study. *Indian J Clin Anaesth*, 6(1) 66–70.
15. Roofthooft, E., Rawal, N. and Van de Velde, M. (2023) Current status of the combined spinal-epidural technique in obstetrics and surgery. *Best Practice & Research Clinical Anaesthesiology*, 37(2) 189–198.
16. Salve, S.M., Narkhede, H.H., Sapate, M. and Ansari, A. (2026) The comparison of novel epidural volume extension on hemodynamic response with traditional spinal anaesthesia in elderly Indian patients undergoing orthopedic surgery: A prospective observational study. In: *The Indian Anaesthetists Forum*. 2026 Medknow, 4–10.
17. Shah, M.M., Khan, R., Ahmad, A. and Rhaman, W. (2026) Incidence Of Backache After Spinal Anesthesia Between Male And Female Patients. *Pakistan Journal of Medical & Cardiological Review*, 5(1) 2617–2637.
18. Shui, M., Zhao, D., Xue, Z. and Wu, A. (2023) Impact of spinal/epidural anesthesia versus general anesthesia on perioperative outcomes in patients undergoing lumbar spine surgery: an updated systematic review and meta-analysis. *Clinical Spine Surgery*, 36(6) 227–236.
19. Wu, Q., Gan, Y., Zhao, Z., Luo, C., Liu, X. and Wang, B. (2026) The Effectiveness and Safety of Dural Puncture Epidural for Aged Patients Undergoing Orthopedic Surgery: A Randomized Controlled Trial. *Clinical Interventions in Aging*, 561324.
20. Zeng, S., Wan, J., Li, X., Wang, N., Li, J., Gao, L., Yang, Z. and Wang, F. (2025) Randomized controlled trial on effect of different routes of dexmedetomidine on Haemodynamics in patients undergoing saphenectomy under epidural anaesthesia. *Scientific Reports*, 15(1) 1156.