International Journal of Public Health Science (IJPHS)
Vol. 15, No. 3, September 2026, pp. 786~793
ISSN: 2252-8806, DOI: 10.11591/ijphs.v15i3.27038

Impact of lower limb elevation on blood pressure in cesarean patients: a quasi-experimental study

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Article Info

Article history:

Received Feb 27, 2026
Revised Jun 2, 2026
Accepted Jul 21, 2026

Keywords:

Cesarean section
Hypotension
Lower-limb elevation
Maternal hemodynamics
Spinal anesthesia

ABSTRACT

Among the available anesthetic techniques, spinal anesthesia remains the preferred method for cesarean section procedures, because of its rapid onset and safety profile; however, it is frequently associated with hypotension that may compromise maternal and fetal stability. This study was conducted to assess the influence of lower limb elevation as a non-pharmacological intervention on blood pressure following spinal anesthesia. A one-group pretest-posttest quasi-experimental design was implemented to evaluate 90 cesarean section patients who met the inclusion criteria. Blood pressure values, including systolic and diastolic parameters, were obtained at baseline and at the 5th, 10th, and 15th minutes after spinal anesthesia, and the data analysis using paired t-tests indicated significant increases in systolic and diastolic blood pressure over time, with mean systolic pressure rising from 87.59 mmHg to 97.89 mmHg and mean diastolic pressure increasing from 59.56 mmHg to 67.21 mmHg at minute 15 ($p < 0.001$). This study provides context-specific clinical evidence on the hemodynamic effects of lower limb elevation among post-spinal anesthesia cesarean section patients in a clinical setting. However, the non-inclusion of a control group and randomization reduce the strength of causal interpretation. These findings provide support for the notion that lower limb elevation may enhance potential benefits as a supportive intervention for post-spinal hypotension and warrant further controlled studies to confirm its efficacy.

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1. INTRODUCTION

Cesarean delivery is a surgical approach performed through incisions in the abdominal wall and uterus to deliver the fetus [1]-[4]. Globally, cesarean delivery rates have increased substantially and are recognized as a growing public health concern, particularly in middle- and high-income countries [5]-[8]. This rising trend underscores the need to optimize perioperative management strategies to ensure maternal and fetal safety.

In Indonesia, the 2018 Basic Health Research (Riskesdas) reported a national cesarean section rate of 17.6%, with considerable regional variation [9]-[12]. This indicates a substantial and heterogeneous burden of cesarean delivery across healthcare settings, requiring context-appropriate clinical management, particularly in perioperative care. Such variation also reflects differences in access to obstetric services and clinical practices, which may influence the management of perioperative complications, including hypotension following spinal anesthesia.

Due to its ability to produce anesthesia quickly and its established safety advantages, spinal anesthesia is extensively utilized during cesarean section procedures [13]-[15]. Although spinal anesthesia is widely utilized, hypotension remains a frequently observed complication, occurring when systolic blood pressure falls by over 20% relative to baseline or drops below 90 mmHg [16]-[18]. This condition may be associated with detrimental maternal outcomes and compromised fetal perfusion if not promptly managed [19], [20]. Therefore, effective strategies to prevent or manage this complication are essential in obstetric anesthesia practice.

Lower limb elevation is a simple non-pharmacological intervention that enhances venous return and cardiac preload through gravitational mechanisms [21]-[23]. Previous studies have demonstrated that leg elevation techniques, including the Trendelenburg position, can increase cardiac output by 6–9% within one minute in patients with acute hypotension [24], [25]. However, existing evidence predominantly focuses on general hemodynamic responses or critically ill populations, with limited studies specifically examining its effect on spinal anesthesia-induced hypotension during cesarean delivery in patients, particularly in resource-limited hospital settings. This highlights the need for context-specific evidence to evaluate its applicability in routine obstetric care.

Local observational data collected between April and May 2023 at a Type C hospital in Medan showed that approximately 60% of cesarean section patients experienced hypotension following spinal anesthesia. Despite this high incidence, lower limb elevation has not been standardized as part of routine postoperative care in this setting, indicating a gap between available evidence and clinical practice. This gap underscores the need to evaluate simple and feasible interventions that can be implemented in real-world clinical settings. Therefore, this investigation aims to determine the extent to which lower limb elevation influences systolic and diastolic blood pressure measurements among cesarean section patients following spinal anesthesia. This study provides context-specific clinical evidence from a regional hospital setting to address the limited application of non-pharmacological interventions in routine obstetric anesthesia care.

From a public health perspective, improving the management of perioperative complications during cesarean delivery is an important component of maternal health service quality. As cesarean section rates continue to increase globally and nationally [5]-[7], [9]-[11], a growing number of women are exposed to potential complications associated with spinal anesthesia, including hypotension. Effective management of these complications is therefore relevant not only to individual patient outcomes but also to broader efforts aimed at strengthening maternal safety and the quality of obstetric care. Interventions that are simple, feasible, and low-cost may be particularly valuable in supporting standardized clinical practice across healthcare facilities with varying resource capacities. By evaluating the hemodynamic effects of lower limb elevation, this study contributes evidence that may inform supportive strategies for maintaining maternal hemodynamic stability and optimizing the quality of perioperative maternal care.

2. METHOD

Cesarean section patients who received spinal anesthesia at a Type C hospital in Medan were enrolled in a quasi-experimental study based on a one-group pretest-posttest design. Baseline blood pressure (pretest) was measured prior to the intervention, followed by the application of lower limb elevation at a 20° angle for 15 minutes. Blood pressure measurements were subsequently recorded at the 5th, 10th, and 15th minutes after spinal anesthesia. The study population consisted of spinal anesthesia patients scheduled for cesarean section at the study site, with an average monthly volume of approximately 90 patients. The final study sample consisted of 90 participants who met the predetermined inclusion criteria using a total sampling approach during the data collection period. Accordingly, the final sample size reflected the number of eligible patients available for inclusion during the period of study.

To minimize the influence of potential confounding factors, several controls were implemented through study design and procedural standardization. Participant characteristics were restricted using predefined inclusion criteria, including age between 20–45 years and ASA physical status II, to ensure relative homogeneity in baseline physiological conditions. Anesthetic-related variables were controlled by administering a uniform dose of 10 mg bupivacaine and standardizing the spinal injection site at the L3–L4 level, along with a consistent injection rate of approximately 0.2 ml/second. In addition, the intervention protocol was applied uniformly across all participants, with lower limb elevation maintained at a 20° angle for 15 minutes, to reduce variability related to positioning effects. Blood pressure (systolic and diastolic) was measured using non-invasive monitoring at baseline and at predetermined intervals following the administered intervention. Changes in blood pressure associated with the intervention were assessed by comparing pre- and post-intervention measurements using paired t-tests, with statistical significance defined as $p < 0.05$.

3. RESULTS

A total of 90 cesarean section patients undergoing spinal anesthesia were included in this study. The demographic and clinical characteristics of the participants are presented in Table 1. As shown in Table 1, most participants were aged 20–35 years represented the majority of participants (61.2%), whereas 34.4% were over 35 years of age and 4.4% were below 20 years. The majority of participants had no previous history of cesarean section (70.0%). Based on body mass index classification, 80.0% of participants were categorized as overweight, while 20.0% had normal BMI, indicating a relatively homogeneous distribution of clinical characteristics.

Table 1. Respondent demographic and clinical characteristics (n = 90)

Variable	Classification	Frequency	Percentage (%)
Age	<20	4	4.4
	20-35	55	61.2
	>35	31	34.4
Cesarean history	Ever	27	30.0
	Never	63	70.0
BMI (kg/m2)	Normal (18.5-24.9)	18	20.0
	Overweight (25-29.9)	72	80.0
	Thin/obese	0	0.0

Blood pressure trends, including systolic and diastolic values assessed at 0, 5, 10, and 15 minutes after spinal anesthesia, are detailed in Table 2. As shown in Table 2, the average systolic and diastolic blood pressure measurements increased progressively over time following the intervention. At baseline (0 minutes), mean systolic and diastolic blood pressures were 87.59 ± 2.70 mmHg and 59.56 ± 3.04 mmHg, respectively. These values increased to 91.24 ± 2.77 mmHg and 61.47 ± 3.13 mmHg at 5 minutes, and further to 93.49 ± 2.94 mmHg and 63.67 ± 3.45 mmHg at 10 minutes. The highest mean values were observed at 15 minutes, reaching 97.89 ± 5.20 mmHg for systolic and 67.21 ± 4.94 mmHg for diastolic blood pressure, indicating a consistent upward trend during the observation period. One participant demonstrated a minimum systolic value of 59 mmHg at the 10-minute measurement. This pattern may indicate a time-dependent hemodynamic response, with gradual improvement in blood pressure occurring within the first 15 minutes following the intervention.

Table 2. Systolic and diastolic values trends after spinal anesthesia (n = 90)

Time after spinal anesthesia	Parameter	Mean ± SD	Min-max
0 min	Systolic	87.59 ± 2.70	84-93
	Diastolic	59.56 ± 3.04	56-70
5 min	Systolic	91.24 ± 2.77	85-96
	Diastolic	61.47 ± 3.13	58-72
10 min	Systolic	93.49 ± 2.94	59-100
	Diastolic	63.67 ± 3.45	60-76
15 min	Systolic	97.89 ± 5.20	91-112
	Diastolic	67.21 ± 4.94	62-82

SD: Standard deviation

Table 3 summarizes the differences in blood pressure between the pretest and posttest evaluations. Analysis using paired t-tests demonstrated that the intervention produced significant alterations in systolic and diastolic blood pressure, as reported in Table 3 ($p < 0.001$). Mean systolic blood pressure increased from 87.59 mmHg to 97.89 mmHg, with mean diastolic blood pressure rising from 59.56 mmHg to 67.21 mmHg over the observation period. Comparison of the pretest and posttest measurements demonstrated a significant alteration in blood pressure.

Table 3. Summarizes the differences in blood pressure between the pretest and posttest evaluations (n = 90)

Parameter	Pretest mean	Posttest mean	p-value	t-value	t-table
Systolic (mmHg)	87.59	97.89	0.000	-23.141	1.662
Diastolic (mmHg)	59.56	67.21	0.000	-20.507	1.662

No major adverse events were reported during the observation period. Apart from isolated individual blood pressure fluctuations observed during serial measurements, no clinical complications

requiring pharmacological intervention were documented. These observations indicate that the intervention was applied without any clinically significant events being recorded during the study period, although adverse outcomes were not systematically evaluated as a predefined study endpoint.

4. DISCUSSION

Significant elevations in systolic and diastolic blood pressure were observed among cesarean section patients after a 15-minute period of lower-limb elevation following spinal anesthesia. This pattern of hemodynamic improvement is consistent with previous research exploring non-pharmacological methods to mitigate spinal anesthesia–induced hypotension. These results indicate that simple positional interventions may contribute to early hemodynamic stabilization in this patient population.

Several clinical studies have reported similar effects of leg elevation on maternal hemodynamics. Among 39 women undergoing cesarean delivery under spinal anesthesia, Karlisa *et al.* [26] found that positioning the lower limbs at a 30° elevation significantly lowered the incidence of hypotension. The reported mean difference was 11.35 ± 5.43 mmHg ($p = 0.001$), indicating improved blood pressure stability following the intervention. Another pre-experimental study at RSU Mitra Sejati Medan likewise found significant increases in systolic and diastolic blood pressure associated with leg elevation post–spinal anesthesia in cesarean patients ($p < 0.001$ for both parameters) [27].

Complementary evidence was also reported in a 2025 clinical trial by Helmy *et al.* [28], which evaluated leg elevation in combination with vasopressor management. In this randomized study, passive leg elevation was associated with both decreased noradrenaline requirements and a reduced occurrence of hypotension compared with control conditions, suggesting that leg elevation contributes to hemodynamic support and can complement pharmacologic strategies. These findings align with the progressive improvement trend identified in the present study across the 0–15 minute intervals.

Although the direction of effect reported in the current study supports observations documented in earlier investigations [26]-[28], several differences should be considered when interpreting the findings. Earlier studies primarily focused on the incidence of hypotension, prevention strategies, or vasopressor requirements, whereas the present study specifically evaluated serial changes in systolic and diastolic blood pressure over multiple observation points following spinal anesthesia. This repeated assessment provides additional insight into the temporal pattern of hemodynamic recovery associated with lower limb elevation. Furthermore, the consistency of the observed blood pressure increase across the 5-, 10-, and 15-minute measurements strengthens the plausibility of a sustained physiological response rather than an isolated measurement effect. Nevertheless, because this study did not include a control group, spontaneous recovery following spinal anesthesia cannot be completely excluded as an alternative explanation.

The observed hemodynamic improvement may be explained by physiological mechanisms related to venous return. Through the action of gravity, elevating the legs facilitates the movement of blood from the lower extremities into the central circulatory system, thereby increasing venous return and ventricular preload. This increase in preload may subsequently enhance cardiac output, contributing to the observed rise in systolic and diastolic blood pressure. This mechanism is consistent with established hemodynamic principles underlying positional interventions in acute hypotension.

Beyond statistical significance, the magnitude and consistency of the observed blood pressure increase may have clinical relevance in the context of post-spinal hypotension management. In the present study, mean systolic blood pressure increased by more than 10 mmHg over the 15-minute observation period, while mean diastolic blood pressure increased by approximately 8 mmHg. Although the study was not designed to evaluate clinical outcomes such as symptom reduction, vasopressor requirements, or maternal-fetal complications, the observed hemodynamic trend suggests that lower limb elevation may contribute to supporting circulatory stability during the period in which spinal anesthesia–induced sympathetic blockade is most likely to affect blood pressure. Therefore, the findings should be interpreted not merely as statistically significant changes, but as evidence of a potentially meaningful physiological response that warrants further investigation in controlled studies.

Previous research has generally supported the feasibility of non-pharmacological maneuvers as adjuncts to standard management of spinal-induced hypotension. While systematic reviews and meta-analyses focusing on pharmacologic prophylaxis have emphasized the efficacy of agents including the use of phenylephrine and norepinephrine as prophylactic measures against hypotension during cesarean delivery, they also highlight the high incidence of hypotension following spinal anesthesia and the ongoing need for complementary approaches [29]. This reinforces the relevance of exploring simple adjunctive strategies such as positional interventions.

Although direct comparisons across studies are limited by differences in design, patient populations, and intervention parameters, the direction of the effect observed in this study is compatible with the broader literature. Additionally, a 2025 quality improvement report focusing on spinal hypotension management

underscores the combined effects of multiple factors on hemodynamic control and the potential role of simple intraoperative adjustments alongside pharmacologic protocols, although it does not evaluate leg elevation specifically [30]. In addition to statistical significance, the extent of the blood pressure increase obtained in the present study may have clinical relevance. Even modest improvements in blood pressure can contribute to maintaining maternal hemodynamic stability and may help reduce the risk of symptomatic hemodynamic instability related to spinal anesthesia.

Given the observed hemodynamic improvements and their potential clinical relevance, the findings may have practical implications for healthcare service delivery. Lower limb elevation is a simple intervention that can be performed immediately after spinal anesthesia without requiring additional equipment, specialized training, or substantial resource allocation. As such, it may be feasible to incorporate this maneuver into existing perioperative monitoring and patient-positioning protocols used in cesarean section services. Its potential value may be particularly relevant in healthcare facilities where access to advanced monitoring technologies or extensive pharmacological resources is limited. However, lower limb elevation should not be viewed as a substitute for established pharmacological management of spinal anesthesia–induced hypotension. Rather, it may be considered as a supportive component within a broader hemodynamic management strategy that includes routine monitoring, early detection of hypotension, and appropriate pharmacological intervention when clinically indicated. Further controlled studies are required before recommending formal integration into clinical guidelines or standardized care pathways.

From a healthcare quality perspective, the findings support ongoing efforts to strengthen maternal safety during cesarean delivery. Consistent management of post-spinal hypotension is an important aspect of perioperative obstetric care because hemodynamic instability requires prompt recognition and intervention. By providing evidence on a low-complexity supportive maneuver that can be applied within routine clinical workflows, this study contributes to the broader objective of improving the reliability and consistency of maternal care processes. While the present study does not directly evaluate quality indicators or patient-centered outcomes, the findings provide preliminary evidence that may inform future quality-improvement initiatives in obstetric anesthesia services.

Beyond its clinical implications, the findings may also be relevant to ongoing efforts to improve the quality of maternal healthcare services. Maintaining hemodynamic stability during and after cesarean delivery is an important aspect of safe obstetric care, particularly in patients receiving spinal anesthesia. Because lower limb elevation is a simple intervention that can be performed without additional equipment, its incorporation into routine perioperative monitoring and positioning practices may support consistent patient management across different healthcare settings. While further controlled studies are needed to establish effectiveness and inform guideline development, the present findings provide preliminary evidence that may contribute to quality-improvement initiatives focused on maternal safety and perioperative care.

The present study's findings add to the existing evidence base by quantifying hemodynamic responses over discrete time intervals after spinal anesthesia and by demonstrating statistically significant effects in a real-world clinical setting. However, the absence of subgroup analyses means that differential effects by demographic or clinical characteristics cannot be confirmed, limiting detailed comparison with studies that stratify outcomes by variables such as body mass index or baseline hemodynamic status. In addition, although safety outcomes were not systematically recorded in this study, the absence of major adverse events during observation is consistent with the generally favorable safety profile of positional interventions reported in the literature.

5. CONCLUSION

In this study, lower-limb elevation at an angle of approximately 20° for 15 minutes was linked to gradual increases in both systolic and diastolic blood pressure among cesarean section patients following spinal anesthesia. Significant differences were observed between baseline and post-intervention measurements, with blood pressure values showing a consistent upward trend during the 15-minute observation period. These findings suggest that lower-limb elevation may contribute to hemodynamic support during the early period following spinal anesthesia. Given the study's quasi-experimental one-group design, the findings should be interpreted with caution and cannot establish a causal relationship between the intervention and the observed blood pressure changes. Nevertheless, the study provides context-specific evidence regarding the hemodynamic response associated with lower-limb elevation in a routine clinical setting. Further controlled studies are needed to confirm these findings and clarify their potential role within perioperative maternal care.

This study has several limitations. The research utilized a single-group pretest–posttest design in the absence of both randomization and a comparison group, which limits causal inference, as spontaneous hemodynamic recovery cannot be fully excluded. The single-center setting and inclusion of only ASA II

patients undergoing elective cesarean section may limit generalizability. Blood pressure was measured at fixed intervals using a digital device, which may not capture transient fluctuations. In addition, minor adverse effects and concurrent intraoperative interventions were not systematically documented, and effect size estimates were not reported.

ACKNOWLEDGMENTS

The authors acknowledge with gratitude the support provided by the hospital management, clinical staff, and all participating patients for their cooperation and support throughout this study. Their contribution facilitated the implementation of data collection procedures and completion of the conduct of the study. The authors additionally recognize the support provided by healthcare personnel involved in patient monitoring and study coordination during the data collection period.

FUNDING INFORMATION

Authors state no funding involved.

AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

DATA AVAILABILITY

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request, in accordance with institutional policies and ethical considerations.

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