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Prevention and Management of Hypotension During Spinal Anesthesia: A Narrative Review

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ABSTRACT

Background: Spinal anesthesia is widely used in lower limb, lower abdominal, and obstetric surgery due to its rapid onset, extensive sensory and motor blockade, and good analgesic effect. The most frequent complication associated with this method is intraoperative hypotension, which occurs due to sympathetic vasomotor blockade, venous pooling, decreased venous return, and compromised cardiac compensatory response. Obstetric patients may experience decreased organ perfusion during hypotensive episodes.

Objective: The purpose of this narrative review is to present the causes, risk factors, manifestations, and interventions that have been shown to prevent and treat hypotension following spinal anesthesia.

Methods: Articles were identified through a literature search of PubMed, Scopus, and Google Scholar for the years 2015 to 2026. Keywords used were spinal anesthesia, hypotension, prevention, and management. A total of 87 articles were screened, of which 45 articles were selected for inclusion in the review.

Results: Factors associated with hypotension following spinal anesthesia can be grouped into patient-, procedure-, and drug-related factors. Patient factors include pregnancy, age, intravascular volume, and cardiac disease. Procedural factors include block height, local anesthetic dose, speed of injection, and positioning. Drug-related factors include the type of local anesthetic, vasoconstrictors, and adjuncts. Controlled crystalloid (electrolyte) fluid co-loading and early use of vasopressors, particularly phenylephrine or norepinephrine, are effective strategies for prevention. Continuous non-invasive hemodynamic monitoring can facilitate early identification of hemodynamic disturbances and support an appropriate response. The effects of spinal anesthesia-induced hypotension may be greatly reduced through appropriate management.

Conclusion: Spinal anesthesia may cause hypotension primarily due to sympathetic blockade. Recognition of relevant patient-, procedural-, and drug-related factors, together with appropriate fluid management, early vasopressor use, and hemodynamic monitoring, can support its prevention and management.

Keywords: *Anesthesia, Spinal; Hypotension; Blood Pressure; Perioperative Care; Bradycardia; Hemodynamics; Patient Positioning; Fluid Therapy*

INTRODUCTION

Overview of spinal anesthesia

The major advantage of spinal anesthesia (SA) is that it provides an adequate sensory, motor, and sympathetic nerve block, which has led to its widespread adoption as a regional anesthesia technique. (J.-K. Lee, Park, Hyun, Hodel, & Hausmann, 2021). Spinal anesthesia has a rapid onset of action, predictable block properties, and avoids airway manipulation, making it an appealing option for surgeries performed on the lower abdomen, pelvis, perianal, and lower extremity areas. Furthermore, spinal anesthesia has several benefits over general anesthesia, such as a reduction in postoperative pain, blood loss, and the incidence of thromboembolic complications (Schubert, Wiesmann, Wulf, & Dinges, 2023).

NICE guidelines recommend that neuraxial anesthetic be offered for cesarean section. Local anesthetics like bupivacaine, ropivacaine, or lidocaine are given into the subarachnoid space. Analgesics with a longer duration of action, like opioids (e.g., fentanyl or morphine), might be used to extend the duration of the action. The sensory blockade level needed is around T10 for vaginal delivery and T4 for cesarean delivery (Watson, Richardson, & Lucas, 2022).

Significant hemodynamic changes occur with spinal anesthesia, such as sympathetic blockade, hypotension, and bradycardia. Regional anesthesia has been found to have certain benefits over general anesthesia, such as maintenance of consciousness and spontaneous respiration during delivery, which results in fewer pulmonary complications and faster recovery after delivery (Finsterwald et al., 2018). Patients also go through the perioperative pathway quicker and discharge from the hospital earlier (Watters, Scott, Sammour, Harris, & Ludbrook, 2024).

Hypotension is most commonly defined as a decrease in systolic blood pressure (SBP) to <80% of baseline or an absolute SBP <100 mmHg (Chaithra, 2018). However, definitions vary across studies; a survey of UK obstetric anesthetists found that most consider hypotension to be an SBP <100 mmHg or <90 mmHg (Ferré et al., 2020). For the purposes of this review, we adopt the definition of SBP <80% of baseline or <100 mmHg, acknowledging the variation in definitions reported in the literature. Acute hypotension may lead to brainstem ischemia and stimulate the vomiting centers (Ferré et al., 2020).
The most common and clinically significant side effect of spinal anesthesia is hypotension. When left untreated, it may result in inadequate tissue perfusion, organ hypoxia, and ischemia. In risk groups, such as pregnant women, older people, and patients with pre-existing cardiovascular disease (CVD), even small changes in blood pressure are significant (Ferré et al., 2020). The use of obstetric anesthesia, which results in poor maternal blood pressure, can lead to poor uterine and placental blood flow, fetal distress, and acidosis. Other complications of intraoperative hypotension include cardiac ischemic events, acute kidney injury, and postsurgical cognitive impairment. So prevention and management are crucial (Pirenne, Dewinter, & Van de Velde, 2023).

Hypotension in association with spinal anesthesia is caused by sympathetic blockade, which causes venous and arterial dilation (Ferré et al., 2020). Sympathetic blockade leads to venous pooling in the lower extremities and splanchnic circulation, which decreases venous return, thus decreasing cardiac output. Loss of vasomotor tone also occurs in the arteries and decreases systemic vascular resistance. A sympathetic block can progress to cardiac accelerator fibers (T1-T4), causing bradycardia (Padberg, 2024) (Figure 1).

Spinal anesthesia also weakens the baroreceptor reflex, and therefore the responses to hypotension will be decreased. Hypotension depends on the level of the block, local anesthetic dose, type of local anesthetic, and patient factors such as age, baseline autonomic tone, and intravascular volume status (Dong et al., 2024).

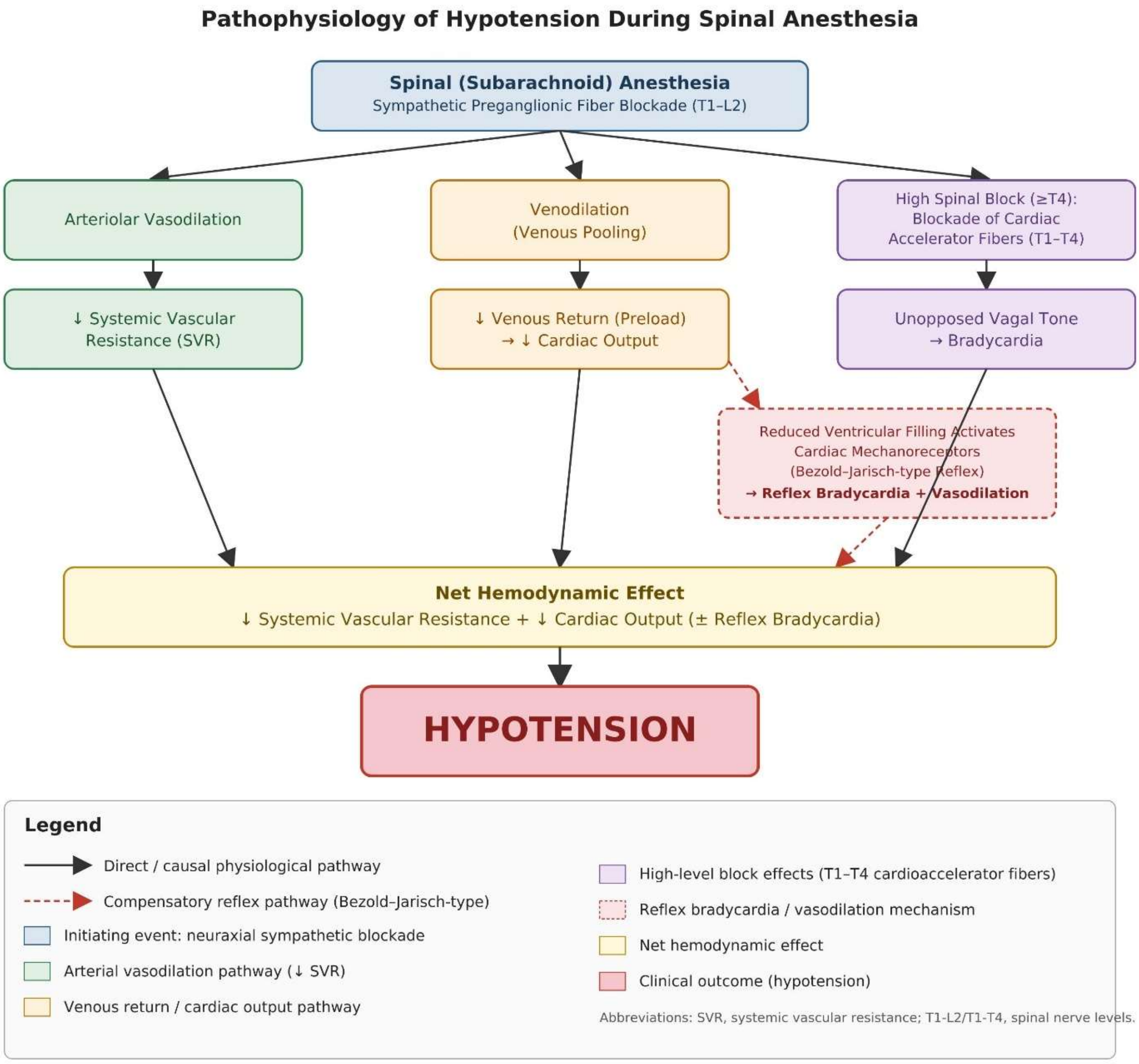

Figure 1. Mechanism of hypotension that occurs during spinal anesthesia
(Spinal anesthesia will block sympathetic nerve fibers (T1-L2), which will lead to vasodilation of the arteries and veins. This causes a decrease in systemic vascular resistance, increased venous pooling, decreased venous return (preload), and decreased stroke volume and cardiac output, leading to hypotension).
Source: Authors' original creation

METHODOLOGY

A narrative review was performed to consolidate the existing evidence for preventing and treating hypotension during spinal anesthesia. A systematic literature search was performed to identify articles published in the last five years (2015–2026) on PubMed, Scopus, and Google Scholar. The search terms utilized included combinations of the following: "spinal anesthesia", "hypotension", "prevention", "management", "vasopressors", "fluid therapy", and "hemodynamic monitoring" with the use of "Boolean" operators (AND, OR) as appropriate. A total of 87 records were retrieved from the database. The titles and abstracts were assessed for specific inclusion criteria. The full text of articles that may have been eligible were evaluated. In addition, by hand searching the reference lists of included articles, additional relevant articles were identified that were not included in the database search. This process provided an all-encompassing search strategy that was both comprehensive and repeatable for a narrative review.

A total of 87 articles were retrieved after searching the databases. Following title and abstract screening, 62 papers were discarded for failure to meet the criteria for inclusion (such as non-English articles, conference abstracts, opinion papers, etc., or articles not directly related to spinal anesthesia induced hypotension). The other 25 articles were assessed for full text review. Of these, 7 were omitted due to inadequate data, or due to duplication, or they did not seem to be relevant. The number of articles retrieved from the database was 18. Another 27 articles were found by hand searching the reference lists of the included articles. There were 45 articles included in this narrative review.

LITERATURE REVIEW

Co-loading is shown to be effective in preventing spinal anesthesia-induced hypotension. A 2020 randomised controlled trial (RCT) showed that the incidence of hypotension was higher in crystalloid preloading than co-loading group. Pre-loading compared with co-loading for preventing post-spinal hypotension during cesarean section in 2024 showed a reduction in the prevalence of hypotension in co-loaded group. Saeed and colleagues found that co-loading was associated with the increased mean SBP 10 minutes ($p < 0.01$) and 15 minutes ($p < 0.01$) post induction (Saeed et al., 2024). The use of vasopressors has undergone a considerable change in the last 20 years. Burns et al. (2001) polled consultant obstetric anesthetists in the UK and discovered that 87.1% gave fluids prior to spinal anesthesia and 95.2% only used ephedrine. In 2021, however, a review was conducted, and it was found that women undergoing cesarean section should receive prophylactic vasopressors; phenylephrine is suggested as the first-line drug (Heesen et al., 2021). In a 2019 systematic review, phenylephrine has been shown to improve maternal nausea and vomiting and to achieve better neonatal acid-base status than ephedrine (Xu, Shen, Liu, Yang, & Wang, 2019).

Ondansetron has been found to be a helpful prophylactic agent. A 2020 study titled "Intravenous ondansetron to prevent hypotension during cesarean delivery under spinal anesthesia" showed that the incidence of hypotension and the use of vasopressors were decreased after taking ondansetron as a prophylactic. A meta-analysis of 2018 confirmed ondansetron's efficacy and reported that ondansetron decreased the ED50 of phenylephrine by 26% (Xiao et al., 2020).

Mechanical interventions also help to prevent spinal anesthesia-induced hypotension. In a study published in 2024, "Effect of pneumatic leg compression on phenylephrine dose for preventing spinal-induced hypotension at cesarean delivery," pneumatically compressed legs resulted in fewer episodes of hypotension and reduced phenylephrine requirements. A 2014 RCT in elderly patients showed that prophylactic use of glycopyrrolate significantly decreased hypotension from 70% to 27% ($p=0.001$). However, a recent meta-analysis from 2018 revealed that preemptive glycopyrrolate failed to overall decrease the incidence of hypotension during cesarean delivery but did reduce the requirement for vasopressors (Xiao et al., 2020).

Evidence has been synthesized through comprehensive reviews. The literature gaps were identified in a 2017 review published in "Post-spinal anesthesia hypotension during cesarean delivery, a comprehensive review." In a 2020 review, the authors "Preventing and treating hypotension during caesarean section under spinal anesthetic: What is current evidence-based practice?" reviewed the evidence-based techniques (Hasanin, Mokhtar, Badawy, & Fouad, 2017).

MECHANISM OF HYPOTENSION IN SPINAL ANESTHESIA

Sympathetic blockade & vasodilation

Sympathetic blockade is the main cause of hypotension with spinal anesthesia. When efferent sympathetic fibers between T1 and L2 are blocked, there is a lack of vasomotor response in arterial and venous systems (Lee et al., 2017). Arteriolar dilation reduces systemic vascular resistance (SVR), which results in a fall in mean arterial pressure (MAP). Capacitance is increased, which results in blood pooling and reduced preload, in lower limb veins and splanchnic veins. Hypotension severity increases with higher spinal block levels; sympathetic blockade typically extends two to six dermatomes above the sensory block level (Taş, Kelleci, Umuroğlu, & Abdullayev, 2026).

Maternal symptoms of severe hypoperfusion include nausea, vomiting, dyspnea, and decreased cooperation. Fetal complications include low Apgar scores and umbilical cord acidosis. If the hypotension is severe, it can lead to permanent neurological damage in the child (Patel & Ninave, 2024).

Left ventricle afterload reduction leads to decreased venous return & cardiac output
Vasodilation and blood pooling reduce venous return to the right atrium. Through the Frank-Starling mechanism, decreased venous return reduces end-diastolic volume and stroke volume, proportionally decreasing cardiac output. If higher thoracic levels (T1-T4) are blocked, cardiac accelerator fibers are inhibited, causing bradycardia and further reducing cardiac output (Patel & Ninave, 2024). If untreated, this can result in cardiovascular collapse (Yu, Gu, Liao, & Feng, 2021).

Role of the baroreceptor reflex
If blood pressure drops, the baroreceptor reflex is activated, leading to an increase in HR and vasoconstriction of the peripheral circulation. However, sympathetic efferent pathways involved in this compensation are suppressed during spinal anesthesia, diminishing the body's compensatory response to hypotension (Khan & Paliwal, 2026).

In healthy parturients under spinal anesthetic, systemic vascular resistance decreases because of dilation of smaller arteries(Lertkovit & Nivatpumin, 2022).Normally, baroreceptor activation increases heart rate and stroke volume; however, if the block reaches the cervical region, reflex tachycardia is inhibited, further contributing to hypotension (Kondo, Hirose, Maeda, Yoshino, & Suzuki, 2019).

FACTORS THAT INCREASE THE RISK OF HYPOTENSION

Patient-Related Factors
Multiple patient parameters affect the probability and severity of hypotension (Masha, Lorato, Amsalu, & Markos, 2025). Compensatory ability is reduced in elderly patients due to their lower baseline sympathetic tone, decreased baroreceptor sensitivity, and limited cardiovascular reserve. The risk of hypotension is increased during pregnancy due to physiological vasodilation, redistribution of blood volume, and aortocaval compression from the enlarged uterus.
Comorbidities such as diabetes, hypertension, and cardiovascular disease affect autonomic nervous system response and vascular compliance, which can raise the risk for hypotension.
Hypovolemia or Dehydration: In hypovolemic patients, even minimal sympathetic blockade causes dramatic blood pressure changes due to reduced preload. Bradycardia and hypotension may be exacerbated in patients on beta-blockers or antihypertensives.

Procedure-Related Factors
The hemodynamic outcomes are significantly affected by technical aspects of spinal anesthesia (Finsterwald et al., 2018). Higher block levels induce more vasodilation and hypotension.
Local Anesthetic Dose: Higher volumes and doses increase sympathetic inhibition and cephalic spread (Lee et al., 2017).
Injection Speed: The speed of intrathecal injection may influence the spread and uniformity of the block, although evidence remains limited (Lee et al., 2017).
Block distribution is influenced by patient positioning such as supine or Trendelenburg position. The positioning, seated or head up, may improve venous pooling. Left uterine displacement is important to prevent aortocaval compression during pregnancy (Lee et al., 2017).

Drug-Related Factors

Local Anesthetic Type: Bupivacaine and tetracaine have a longer duration of hypotension than lidocaine because of the longer half-life and greater lipid solubility (Whizar-Lugo, Íñiguez-López, Cárdenas-Maytorena, & Ramírez-Puerta, 2020). Increased Risk of Hypotension with Use of Adjuncts: Opioids and clonidine may enhance sympathetic and sensory block, which may lead to an increased risk of hypotension. Preoperative vasodilators or sedatives also require careful monitoring.

CLINICAL MANIFESTATIONS & DIAGNOSIS

Signs & Symptoms

Clinical presentation is characterized by nausea, vomiting, dizziness, blurring of vision, lightheadedness, or fainting. Cutaneous symptoms are cold, pale, clammy skin or delayed capillary refill. Hypotension can be accompanied by bradycardia due to the inhibitory action of cardiac accelerator fibers (T1-T4). Severe forms can lead to changes in mental state, restlessness, confusion, or even loss of consciousness. In obstetric patients, maternal hypotension can cause decreased placental blood flow, with decreased baseline fetal heart rate variability as a sign of fetal distress (Ferré et al., 2020).

Hemodynamic Monitoring

Non-invasive blood pressure (NIBP) should be checked every 2-3 minutes after spinal anesthesia. Continuous Arterial Blood Pressure (ABP) monitoring using an arterial line gives beat-to-beat information for high-risk patients. ECG is used to detect bradycardia or arrhythmia. During labor and delivery, fetal heart rate monitoring is standard (Pinsky et al., 2022).

Importance of Early Recognition

Hypotension progresses rapidly. Early detection reduces maternal and fetal morbidity and end-organ hypoperfusion by enabling timely fluid administration, vasopressor therapy, and repositioning (Ferré et al., 2020).

PREVENTION & MANAGEMENT STRATEGIES

Pre-loading & co-loading with fluids

The risk of hypotension can be decreased by administering intravenous fluids before (preloading) or during (co-loading) spinal anesthesia. Intravenous crystalloids (Ringer's Lactate, Hartmann's Solution, and Normal Saline) and colloids (Hydroxyethyl Starch and Gelatins) help to expand blood volume and increase venous return, which compensates for vasodilation caused by sympathetic blockade (Saeed et al., 2024).

Crystalloids vs Colloids

Crystalloids (Lactated Ringer's, Normal Saline) are readily available and inexpensive but are rapidly absorbed. After 20-30 minutes, only 20-25% of the crystalloid is still in the intravascular compartment. A colloid will also stay in the blood longer because it has a higher oncotic pressure, such as hydroxyethyl starch and gelatins (Shang et al., 2021). Colloids are, however, associated with a risk of anaphylaxis, coagulation problems, and renal dysfunction, so they are not used in obstetric anesthesia. The most common fluid type used is still “crystalloids.”

Preloading with crystalloids is no longer recommended as it is ineffective. Colloid preloading or rapid colloid co-loading helps to significantly reduce maternal hypotension and vasopressor requirements. Crystalloid co-loading is more effective, safer, and less expensive than the use of colloid co-loading. In pre-eclampsia, fluid loading should be optimized to avoid overload(Shang et al., 2021).

Pre-load vs. Co-load

Crystalloid preloading (500-1500 mL) is of no benefit, as crystalloids rapidly redistribute. Evidence indicates that 20 mL/kg Ringer’s lactate administered during spinal injection (co-load) provides greater benefit than the same volume given as a preload over 20 minutes (Hunie et al., 2022).

Generally, hemodynamic stability is maintained with crystalloid (500-1000 mL) or colloid fluids. Whether as pre-load or co-load, colloids offer versatility at any point in time. Different strategies should be used to address individual fluid requirement (Uzun Saritaş & Yelken, 2023).

Optimal Volume

The initial number of crystalloids in non-obstetric patients is usually 10-15 mL/kg with consideration of the patient's baseline hydration status and cardiovascular condition. Elderly patients and those with reduced cardiac reserve require more judicious fluid management to avoid pulmonary edema. Fluid therapy alone or in combination with pharmacologic therapy results in an optimal outcome (Salimi & Fardelmann, 2025).

Pharmacological Management

The main class of drugs used to maintain cardiac output and re-establish systemic vascular resistance (SVR) include vasopressors (O'Neill & Helwig, 2016).

Vasopressors

Ephedrine is a mixed α- and β-adrenergic agonist that causes an increase in heart rate, myocardial contractility, and peripheral vascular tone. It is given as a 5-10 mg IV bolus. Phenylephrine provides better fetal acid-base outcomes (Xu et al., 2019) and has historically been preferred in obstetric anesthesia.

Phenylephrine is a pure alpha-1 vasoconstricting agent. Typical doses include 50-100 mcg bolus intravenously or 25-50 mcg/min infusion. It may cause reflex bradycardia, especially with high block levels. Norepinephrine is increasingly used in obstetric anesthesia. It has a less bradycardic effect than phenylephrine due to its α1-mediated vasoconstriction and mild β1 agonism. Infusion rates of 2-6 µg/min are commonly used. Recent randomized trials have demonstrated an association of norepinephrine with better maintenance of maternal cardiac output (Mohta, 2023).

Currently, phenylephrine is recommended as the vasoconstrictor of choice during hypotension induced by spinal anesthesia. Ephedrine might still be suitable in some patient groups (Mets, 2016).

Phenylephrine administered immediately after intrathecal injection is more effective in preventing hypotension than waiting until SBP drops. Variable-rate infusion provides better hemodynamic stability than fixed-rate or intermittent boluses (Meena & Sathyanarayana, 2021). Closed-loop computer-controlled infusions achieve tighter control of blood pressure than manual infusions. Norepinephrine 0.07-0.08 µg/kg/min appears adequate to prevent spinal anesthesia-induced hypotension (Kee, Tam, Khaw, Ng, & Lee, 2017).Additional studies are required before norepinephrine can be considered superior to phenylephrine.

Anticholinergic Agents

For acute symptomatic bradycardia due to severe sympathetic blockade, atropine (0.5 mg IV) is used. Glycopyrrolate (0.2 mg IV) is the preferred drug in obstetric patients due to minimal placental transfer. These agents do not affect the level of arterial blood pressure directly(Patel, Habib, Phillips, Carvalho, & Sultan, 2018). Routine atropine prophylaxis is not advised. Atropine, at low doses (around 5 µg/kg), can have a beneficial effect on certain patients with low baseline heart rate (Pramadika et al., 2025).

Other Adjunct Agents

Ondansetron (4-8 mg IV) is a 5-HT3 receptor blocker that antagonizes the Bezold-Jarisch reflex and therefore is useful for reducing spinal anesthesia-induced bradycardia and hypotension. This is particularly helpful when it comes to cesarean section. Intermittent bolus doses are not recommended, and continuous infusion of vasopressors is encouraged (Stampfl & DeBlieux, 2024).

Non-Pharmacological Management

Patient positioning, leg elevation, and the compression of the lower extremity improve venous return. These interventions help to decrease the severity of hypotension when combined with fluid and vasopressor therapy(Noffsinger, 2022).Combined leg elevation >30° and elastic compression are associated with a significant decrease in the incidence of post-spinal hypotension (18% vs. 53%, P=0.004). Leg wrapping alone effectively reduces hypotension and vasopressor requirements.

Mild Trendelenburg positioning (10-15 degrees) may increase central venous pressure but risks upward block dispersion. In pregnant women, left uterine displacement helps reduce aortocaval compression and mitigate hypotension (Lee et al., 2017). Non-pharmacological measures alone cannot fully prevent hypotension (Noffsinger, 2022):

1. Fluid co-loading
2. Prophylactic vasopressor infusion
3. Optimal patient positioning

DISCUSSION

Comparison of preventative & management strategies

Prevention and treatment for spinal anesthesia-induced hypotension require a multimodal approach. Generally, single-modality treatment is ineffective. Fluid preloading is not effective because of rapid crystalloid redistribution. Co-loading with fluids, in combination with intrathecal administration, provides intravascular expansion. Prophylactic continuous vasopressor infusion prophylaxis provides greater hemodynamic stability than reactive bolus administration. Non-pharmacological methods such as leg elevation and left uterine tilt provide supportive benefits (Noffsinger, 2022).

Most effective evidence-based approaches

Evidence is consistent with the use of combined crystalloid co-loading and IV phenylephrine infusion as standard of care in preventing hypotension during obstetric procedures under spinal anesthesia (Heesen et al., 2021). Given its favorable balance of maintaining maternal cardiac output and comparatively less reflex bradycardia, norepinephrine IV infusion is a potential first-line agent in obstetric anesthesia. The recommendation for vasopressors in non-obstetric patients (such as those with orthopedic, urologic or general surgery) depends on the underlying physiology, comorbidities, and hemodynamic goals. Results from obstetric studies might not be directly transferable to these populations and additional studies are required. However, fluid management needs to be more careful for elderly patients and for those with lower cardiac reserve to prevent pulmonary edema (Lee et al., 2017).

LIMITATIONS AND GAPS IN THE CURRENT EVIDENCE

Significant gaps remain. There is a considerable variation and trials uncertainty in optimal dosing, especially norepinephrine infusions. There are relatively few high-quality trials of elderly or high-risk cardiovascular patients. The majority of the data available are from cesarean delivery studies. The results of this review have been derived from obstetric evidence and therefore may not be directly applicable to other populations, including orthopedic, urologic, and general surgery patients and elderly and high-risk cardiac patients. Further research in these populations is needed. Long-term cognitive outcomes of intraoperative hypotension also require further research. The risk-benefit ratio of colloids remains to be determined. Individualized hemodynamic plans and real-time monitoring of cardiac output should be a topic of future research.

CONCLUSION

Spinal anesthesia is a very common regional anesthesia method because of its rapid onset, effective analgesia and avoidance of any manipulation of the airways. Hypotension (caused by sympathetic blockade, venous pooling, decreased cardiac output, and lack of compensatory mechanisms) is the most common and clinically relevant side effect (Lee et al., 2017). Understanding of procedure- and patient-related factors, adequate hydration, prompt application of vasopressors, and non-pharmacologic supportive measures are important for prevention and treatment.

Importance of prevention & individualized management

The multimodal approach of crystalloid co-loading, the use of appropriate patient positioning, and the use of vasopressors for early treatment of hypotension provides more benefit than single interventions. The unique characteristics of each patient's physiology, comorbidities, block height, and surgery type need to be taken into consideration. Older people and pregnant women should be treated as a priority, as they have less physiological reserve and are at increased risk of adverse effects associated with hypotension.

FUTURE DIRECTIONS AND CLINICAL IMPLICATIONS

The increasing number of studies on cardiac output preservation and safety could make norepinephrine a preferred first-line vasopressor. Precision medicine techniques, dynamic hemodynamic monitoring systems, and evidence outside of obstetrics are areas of research that should be explored in the future. Increased patient safety, reduced morbidity from hypotension, and improved perioperative outcomes will result from improved preventive measures.

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AUTHORS' CONTRIBUTIONS

- Anas Jahangir - Conceptualisation; Literature Search; Manuscript Drafting; Review and Editing; Project Administration; Manuscript Revision.
- Muhammad Hashim - Methodology; Literature Search; Data/Article Screening; Analysis and Interpretation; Review and Editing.
- Hira Khan - Literature Search; Data/Article Screening; Manuscript Drafting; Review and Editing; Manuscript Revision.
- Atia Ur Rehman - Literature Search; Methodology; Data/Article Screening; Analysis and Interpretation; Supervision.
- Fatima Ashraf - Conceptualisation; Methodology; Analysis and Interpretation; Review and Editing.

REFERENCES

Buren, M. A., & Cil, H. (2025). Anesthetic considerations and management of spine surgery performed under neuraxial anesthesia. Current Anesthesiology Reports, 15(1), 28.

Dong, S., Wang, Q., Wang, S., Zhou, C., & Wang, H. (2024). Hypotension prediction index for the prevention of hypotension during surgery and critical care: A narrative review. Computers in Biology and Medicine, 170, 107995.

Ferré, F., Martin, C., Bosch, L., Kurrek, M., Lairez, O., & Minville, V. (2020). Control of spinal anesthesia-induced hypotension in adults. Local and regional anesthesia, 39-46.

Finsterwald, M., Muster, M., Farshad, M., Saporito, A., Brada, M., & Aguirre, J. A. (2018). Spinal versus general anesthesia for lumbar spine surgery in high risk patients: perioperative hemodynamic stability, complications and costs. Journal of clinical anesthesia, 46, 3-7.

Hasanin, A., Mokhtar, A. M., Badawy, A. A., & Fouad, R. (2017). Post-spinal anesthesia hypotension during cesarean delivery, a review article. Egyptian Journal of Anaesthesia, 33(2), 189-193.

Heesen, M., Hilber, N., Rijs, K., Rossaint, R., Girard, T., Mercier, F., & Klimek, M. (2021). A Systematic Review of Phenylephrine Versus Noradrenaline for the Management of Hypotension Associated With Neuraxial Anesthesia in Women Undergoing Cesarean Section. Obstetric Anesthesia Digest, 41(1), 1-2.

Hunie, M., Wubishet, T., Fenta, E., Teshome, D., Kibret, S., Desse, T., . . . Zewdu, D. (2022). The Effect of Preloading and Co-Loading in the Prevention of Hypotension among Mothers Who Underwent Cesarean Delivery under Spinal Anesthesia: A Prospective Cohort Study. Systematic Reviews in Pharmacy, 13(2).

Kee, W. D. N., Tam, Y.-H., Khaw, K. S., Ng, F. F., & Lee, S. W. (2017). Closed- loop feedback computer-controlled phenylephrine for maintenance of blood pressure during spinal anesthesia for cesarean delivery: a randomized trial comparing automated boluses versus infusion. Anesthesia & Analgesia, 125(1), 117-123.

Khan, I. A., & Paliwal, N. W. (2026). Bradycardia during thoracic segmental spinal anesthesia: Beyond cardio-accelerator (T1-T4) Fiber blockade. JCA Advances, 100248.

Kondo, Y., Hirose, N., Maeda, T., Yoshino, A., & Suzuki, T. (2019). Relationship between changes in regional cerebral blood volume and oxygenation and changes in cardiac output and systemic vascular resistance during spinal anesthesia in women undergoing cesarean section. Journal of Anesthesia, 33(5), 579-586.

Lertkovit, S., & Nivatpumin, P. (2022). Anesthetic management of cesarean delivery of parturient with systemic lupus erythematosus associated with pulmonary arterial hypertension-A case report. Anesthesia and Pain Medicine, 17(3), 291-297.

Lee, J.-K., Park, J. H., Hyun, S.-J., Hodel, D., & Hausmann, O. N. (2021). Regional anesthesia for lumbar spine surgery: can it be a standard in the future? Neurospine, 18(4), 733.

Lee, J. E., George, R. B., & Habib, A. S. (2017). Spinal-induced hypotension: Incidence, mechanisms, prophylaxis, and management: Summarizing 20 years of research. Best practice & research Clinical anaesthesiology, 31(1), 57-68.

Masha, T. M., Lorato, S. S., Amsalu, H., & Markos, Z. (2025). The incidence and associated factors of hypotension during spinal anesthesia at tertiary hospital: a prospective cross-sectional study. Annals of Medicine and Surgery, 87(12), 8136-8142.

Mets, B. (2016). Should norepinephrine, rather than phenylephrine, be considered the primary vasopressor in anesthetic practice? Anesthesia & Analgesia, 122(5), 1707-1714.

Meena, K. R., & Sathyanarayana, V. (2021). A study of phenylephrine administration for the prevention and treatment of hypotension in cesarean section during spinal anaesthesia: A randomised clinical trial.

Mohta, M. (2023). Norepinephrine–Can it Replace Phenylephrine as the Vasopressor of Choice in Obstetric Anesthesia? (Vol. 2, pp. 1-4): Medknow.

Noffsinger, S. R. (2022). Evidence-Based Prevention Strategies for the Management of Spinal Anesthesia-Induced Hypotension in Healthy Parturients Undergoing Elective Cesarean Delivery. AANA journal, 90(4).

O'Neill, J., & Helwig, E. (2016). Postoperative management of the physiological effects of spinal anesthesia. Journal of Perianesthesia Nursing, 31(4), 330-339.

Padberg, T. (2024). Cardiovascular effects of neuraxial anesthesia. In: Anesthesia & Analgesia, 138(4), 789-801.

Pramadika, T., Nurcahyo, W. I., Wicaksono, S. A., Saputra, T., Manapa, C. H., & Ksatriaputra, A. (2025). Intrathecal atropine as an adjuvant in spinal anesthesia: a systematic review of efficacy and safety. Anaesthesia, Pain & Intensive Care, 29(7), 796.

Patel, S., & Ninave, S. (2024). Postspinal anesthesia hypotension in caesarean delivery: a narrative review. Cureus, 16(4), e59232.

Patel, S. D., Habib, A. S., Phillips, S., Carvalho, B., & Sultan, P. (2018). The effect of glycopyrrolate on the incidence of hypotension and vasopressor requirement during spinal anesthesia for cesarean delivery: a meta-analysis. Anesthesia & Analgesia, 126(2), 552-558.

Pirenne, V., Dewinter, G., & Van de Velde, M. (2023). Spinal anaesthesia in obstetrics. Best practice & research Clinical anaesthesiology, 37(2), 101-108.

Pinsky, M. R., Cecconi, M., Chew, M. S., De Backer, D., Douglas, I., Edwards, M., . . . Monnet, X. (2022). Effective hemodynamic monitoring. Critical Care, 26(1), 294.

Saeed, M. T., Rao, A., Saeed, M. N., Alam, T., Riaz, A., & Ahmad, H. (2024). Co-Loading Versus Pre-Loading for Preventing Post-Spinal Hypotension in Caesarean Section. Pakistan Armed Forces Medical Journal, 74(2), 401.

Salimi, N. K., & Fardelmann, K. L. (2025). PREGNANT PATIENT FOR NON-OBSTETRIC SURGERY. Perioperative Medicine: A Problem-Based Learning Approach, 345.

Schubert, A.-K., Wiesmann, T., Wulf, H., & Dinges, H.-C. (2023). Spinal anesthesia in ambulatory surgery. Best practice & research Clinical anaesthesiology, 37(2), 109-121.

Shang, Y., Li, H., Ma, J., Tan, L., Li, S., Li, P., . . . Wang, R. (2021). Colloid preloading versus crystalloid preloading to prevent hypotension after spinal anesthesia for cesarean delivery: A protocol for systematic review and meta-analysis. Medicine, 100(7), e24607.

Taş, D., Kelleci, Y., Umuroğlu, T., & Abdullayev, R. (2026). Spinal Anesthesia and Regional Hemodynamic Parameters. Journal of Ultrasound in Medicine, 45(3), 557-568.

UZUN SARITAŞ, P., & YELKEN, B. (2023). Comparison of the Effect of Prophylactic Ephedrin, Ringer's Lactate, and Colloid Applied During Spinal Anaesthesia on Hemodynamic Parameters in Geriatric Patients. İzmir Tepecik Eğitim Hastanesi Dergisi, 33(1).

Watson, S. E., Richardson, A. L., & Lucas, D. N. (2022). Neuraxial and general anaesthesia for caesarean section. Best practice & research Clinical anaesthesiology, 36(1), 53-68.

Watters, D. A., Scott, D. A., Sammour, T., Harris, B., & Ludbrook, G. L. (2024). If the peri-operative patient pathway was right, what would it look like? ANZ Journal of Surgery, 94(9), 1462-1470.

Whizar-Lugo, V. M., Íñiguez-López, K. L., Cárdenas-Maytorena, A. C., & Ramírez-Puerta, C. D. (2020). Local anesthetics Topics in Local Anesthetics: IntechOpen.

Xiao, F., Wei, C., Chang, X., Zhang, Y., Xue, L., Shen, H., . . . Chen, X. (2020). A prospective, randomized, double-blinded study of the effect of intravenous ondansetron on the effective dose in 50% of subjects of prophylactic phenylephrine infusions for preventing spinal anesthesia–induced hypotension during cesarean delivery. Anesthesia & Analgesia, 131(2), 564-569.

Xu, S., Shen, X., Liu, S., Yang, J., & Wang, X. (2019). Efficacy and safety of norepinephrine versus phenylephrine for the management of maternal hypotension during cesarean delivery with spinal anesthesia: A systematic review and meta-analysis. Medicine, 98(5), e14331.

Yu, C., Gu, J., Liao, Z., & Feng, S. (2021). Prediction of spinal anesthesia-induced hypotension during elective cesarean section: a systematic review of prospective observational studies. International Journal of Obstetric Anesthesia, 47, 103175.

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