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MANAGEMENT STRATEGIES FOR HYPOTENSION UNDER SPINAL ANESTHESIA IN HIGH-RISK OBSTETRIC PATIENTS

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Abstract

Background: *Hypotension due to spinal anesthesia is a common complication among obstetric patients and may be worse when there is high-risk pregnancy. Several factors ensure the sufficient provision of fetal health including effective vasopressor therapy to restore maternal blood pressure and sufficient uteroplacental perfusion.*

Objective: *To determine the difference between the efficacy of phenylephrine, norepinephrine, and ephedrine in managing spinal induced hypotension in high risk obstetric patients undergoing cesarean delivery.*

Methods: *This was an observational study that involved 43 high-risk obstetric patients who acquired hypotension after administering spinal anesthesia. Regular monitoring of hemodynamic parameters was done. The hypotensive episodes and the duration of the hypotensive episode, maternal symptoms, and Apgar scores at birth of each patient were recorded. It assessed the clinical response of the selected vasopressor administered by the attending anesthetist (phenylephrine, norepinephrine or ephedrine).*

Results: *Phenylephrine showed the most positive results, and it was able to stabilize the blood pressure quickly and with only one short-lived hypotension incident in all the patients, and no complications in the mother. Norepinephrine was found to be moderately effective and a number of patients were found to have a number of, but non-prolonged hypotensive episodes. The poorest control was observed with ephedrine, recurrent episodes were frequent, the length of hypotension was greater, and the frequency of some maternal side effects like vomiting and shivering increased. The most successful results were also in the phenylephrine group, as all the neonates had normal Apgar scores, and lower scores prevailed in the norepinephrine and ephedrine groups.*

Conclusion: *Phenylephrine is the most effective and safest vasopressor to use in treatment of the spinal-induced hypotension in high-risk obstetric patients, as it provides better maternal hemodynamic stability and the best neonatal outcomes. Norepinephrine is also a sensible option in the absence of phenylephrine although ephedrine is not as effective and needs to be administered carefully.*

INTRODUCTION

Spinal anesthesia is now deemed as the most common form of anesthesia in cesarean delivery globally since it has a rapid time of onset, comparatively easy technical procedure, hemodynamic stability with a sufficiently controlled background, and has a superior maternal fetus safety profile than general

Frontier in Medical & Health Research

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anesthesia. Spinal anesthesia has strengths in comparison with the general one, namely the mother is awake under childbirth, the babies are exposed to fewer effects of anesthetic drugs, and airway-related complications are unlikely to occur with pregnant women since they are predisposed to difficult intubation due to edema of the airways and reduced functional residual capacity. Still, this has not changed the fact that the spinal anesthesia is also closely associated with acute hypotension due to sympathetic blockade and hence has continued to be a thorn in the flesh in the obstetric anesthetic practice (1).

Hypotension that is brought about by the process of spinal anesthesia is highly prevalent and ranges between 50 and 80, depending on the population, underlying heart condition, and precautionary measures. This rate is often even higher among high-risk obstetric patients (patients with preeclampsia or multiple gestations) due to the implications of the change in autonomic responsiveness and the effects of the loss of intravascular volume. As pregnancy is physiologically linked to a drop in systemic vascular resistance and an increase in blood mass, pregnant women are particularly vulnerable to such abrupt changes in vascular tone in the event of a sympathetic block and, hence, this is the reason why hypotension is not only common but also potentially fatal (04)(08).

The pathophysiology of spinal hypotension is inhibition of the sympathetic nerves, which are below the spinal puncture resulting in a severe vasodilation in the arteries and veins. The result of the dilation of the venous causes the lower extremity pooling and poor venous flow and, therefore, low preload and cardiac output. The gravid uterus also impedes the inferior vena cave of a pregnant woman in the supine position that also heightens the risk of hypotension by making the degree to which the venous pooling is increased. All these factors combined lead to the sudden and sometimes dangerous drop in blood pressure in the arteries directly after the intrathecal injection of local anesthetic (04)

The continuum of negative clinical processes of maternal hypotension of cesarean section may be observed. Even minor decreases in blood pressure may lead to nausea, vomiting, dizziness, and the sensation of losing consciousness due to the decreasing cerebral perfusion. Under severe conditions, it may progress to maternal bradycardia, unconsciousness or cardiac arrest unless treated in time. In addition, inadequate perfusion of vital organs, particularly uterus, can result in the decreased placental oxygen supply and the subsequent fetus distress. The prevention of hypotension is the main concern of obstetric anesthesia planning since the well-being of the fetus is highly dependent on the support of maternal blood pressure (12).

Maternal hypotension leads to the reduction of uteroplacental blood flow, and thus, it may result in fetal hypoxia, neonatal acidosis, and low Apgar levels under the acute postpartum period. When the uterine manipulation and positions of the mother may further decrease the perfusion, in cesarean delivery, the fetus is entirely reliant on the hemodynamics of the mother in regards to oxygenation. Also, it is proven that the low umbilical cord pH is related to extreme or chronic maternal hypotension and it is a sign of fetal metabolic acidosis that has been known to cause neonatal morbidity (13).

The at-risk obstetric patients are highly vulnerable to the hypotension resulting due to spinal anesthesia due to presence of cardiovascular, hematological, or obstetric problems. The development of endothelial dysfunction, increase in systemic vascular resistance, and contraction of intravascular volume are common to women with preeclampsia, which predetermines excessive alterations in hemodynamics after sympathetic blockage. Similarly, the size of the uterus, compression of the aorta, and cardiac output of women in multiple gestations is increased and, therefore, the response to spinal blockade is challenging. In addition, a reduction of physiological reserve may also happen in anemia or cardiac disease patients and even a slightest type of hypotension can be dangerous (19).

The changes in hemodynamics in high-risk pregnancies should be known so that the prediction and management of hypotension are possible. As one of the examples, patients with preeclamptic conditions, despite the predetermination to hypertension, may demonstrate paradoxical results of hypotensive reactions after spinal anesthesia due to the alteration of the baroreceptor sensitivity and endothelial defects. The patients with heart failure are even more vulnerable to decreased cardiac output because they have a low compensatory ability based on increasing heart rate or increasing

Frontier in Medical & Health Research

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stroke volume. All these complications raise the significance of individual anesthetic approach in the management of hypotension (17).

Other than physiological factors, there are also surgical factors which influence the risk of hypotension. The emergent cesarean birth may occasionally have limited time to prepare, ineffective fluid, and elevated stress levels to the mother, all the conditions predisposing hemodynamic instability. Intraoperative uterotonic agents can also worsen perioperative hypotension by facilitating vasodilate and cardiodepression and therefore careful monitoring under the perioperative is necessary (20).

The issue of maternal hypotension is one of the most prevalent types of complications of the spinal anesthesia that have been regularly reported in the global epidemiology. Even higher rates of hypotension were reported in South Asian studies like Pakistan due to the lack of vasopressor infusion, irregular use of monitoring, and the application of the outdated fluid-based prevention strategies rather than the evidence-based approach to prevention that is built on the vasopressor prophylaxis. Such gaps in regions justify the relevance of locally applicable studies in order to guide the best practice(29).

Hypotension prevention under spinal anesthesia is not only of clinical interest in the operating room. Poor intraoperative hemodynamic care has been linked to an increased morbidity in both the mother and the child, increased hospital stay as well as reduced maternal satisfaction of birth experience. High-risk populations have higher implications, and one of the most important aspects of safe obstetric care is the effective preventive measures (31).

It is a very delicate group of patients who are subjected to spinal anesthesia, the high-risk obstetric patients are normally patients who have low-risk cardiovascular systems. One of such circumstances is preeclampsia, associated with an exaggeration of systemic vascular resistance, endothelial dysfunction, and a change in vascular responsiveness, which predisposes this group of women to severe hypotension following sympathetic inhibition. Although the concept of traditional teaching is that, pre-existing vasoconstriction in preeclamptic patients is less likely to induce hypotension, recent studies have probably shown that abnormal vasculature in preeclampsia predisposes them to the development of sudden blood pressure changes when undergoing spinal anesthesia. This is a paradoxical physiology of the fact that it is necessary to observe closely and provide anesthetic care to this subgroup on the individual level (04)(31).

The issue will be different in the case of multiple gestation pregnancy because the chances of hypotension will rise as well. It is due to this increased size of the uterus that leads to exaggerated aortocaval compression particularly under supine position that has a more adverse impact on the venous return, and to a larger extent, on cardiac preload than singleton pregnancies. The spinal block sympathetically relaxes the preload and is more variable leading to severe hypotension that might be difficult to treat. Also, due to the early cesarean section, the twins are often complicated with fetal or maternal complications and, therefore, the hemodynamic crisis is more probable to occur (07).

Patients with underlying cardiac disorders, such as congenital heart disease, cardiomyopathy, or valvular lesions are also associated with even more complicated risks. Spinal anesthesia in their case leads to the reduction of systemic vascular resistance, and in these situations the abrupt disproportion between ventricular output and body requirements may arise. EO patients are characterized by a low physiological reserve, and acute hypotension could lead to arrhythmias, myocardial ischemia, or acute decompensation. In the management and operation of the perfusion, anesthetic, and obstetric teams, close coordination of the teams is required to stabilize the cardiac functioning (11).

The other noteworthy category is the women who are anaemic and this is a very prevalent occurrence in the South Asian groups. When there is low content of maternal hemoglobin, sufficient cardiac output and perfusion pressure becomes extremely important in the delivery of the oxygen. The abrupt drop of blood pressure after the spinal anesthesia reduces the flow of oxygen to tissues and the uteroplacental members and exposes babies to the risk of hypoxia, intraoperative hemodynamic failure, and postpartum hypoxia. Hypotension has a more severe effect on the anemic patients, and, hence, prevention should be of primary concern (15).

The choice of the method of hypotension prevention or control is likely to vary depending on the institutional decision and practice of

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

anesthetist. The intravenous fluids preloading with crystalloids is a common practice especially in the resource-limited setting because it is inexpensive and easily available. However, the crystalloids are rapidly reabsorbed within the intravascular space into the extra-vascular tissues over 1520 minutes that limits their hemodynamic effect and offers a temporary protection of hypotension. This has helped in the rise of co-loading whereby fluids are administered promptly after injecting the spine, and not administered before the injection (14).

As proved, colloids is better at intravascular volume expansion than crystalloids as well as safer than crystalloids because it is more expensive, may cause anaphylaxis, and cause renal dysfunction. Additionally, the availability of colloid solutions is not constantly high in the developing countries, and thus they cannot be used with standardized protocols. As a result of the limitations, most clinicians prefer employing a mixture of reasonable fluid administration and vasopressors to maintain stable hemodynamics (27).

Vasopressors have revolutionized the management of maternal hypotension. Ephedrine was traditionally considered superior because it did not alter the flow of uterine blood as it was a mixed 2- and 2-agonist. However, slowly-growing evidence altered this practice of pure α-agonists like phenylephrine because of the cross placentality of ephedrine and its association with fetal acidosis and the high levels of lactate in the newborn. The new standard in most countries is then in Phenylephrine infusion since it is effective in achieving maternal blood pressure without causing any harm to the fetus (30).

More recently, norepinephrine has been proposed as a more attractive substitute of phenylephrine. Its insignificant 8 -adrenergic effect can help maintain the cardiac output, preventing severe reflex bradycardia, one of the common side effects of the phenylephrine infusion. As it has been demonstrated, norepinephrine provides the same effect on blood pressure and is more likely to be better in regulating heart rate, and it can be an alternative in situations when women are not able to bear the bradycardia. This pharmacologic homeostasis may be particularly helpful in the situation with a high-risk obstetric patients with a weakened cardiac responsiveness (11).

Left uterine displacement (LUD) is an aspect of the maternal positioning measure that will still be essential in the prevention of hypotension. The uterus with a great deal of mass may press on the inferior vena cava when the mother lies flat leading to decreased venous fill-up and enhanced the effect of sympathetic blockage. LUD also reduces this compression that causes the uterus to push aside the major vessels and thereby increases the preload and normalizes the hemodynamics. Even though it is effective, LUD cannot be a satisfactory intervention, particularly in high-risk patients, and will have to be applied in combination with other interventions, such as vasopressors or fluid co-loading (06).

These approaches are applied differently in other countries. In high-income countries, continuous vasopressor is the standard treatment, and it is being supported with advanced monitoring devices, such as cardiac output monitors, invasive blood pressure lines, and real-time hemodynamic screens. On the other hand, most of the low- and middle-income countries rely on crystalloid preloading of the body or intermittent infusion of vasopressors due to the lack of infusion pumps and the quantity of trained anesthesia specialists. This gap shows that comparative studies must conduct research in a local setting, which in this case is Pakistani tertiary hospitals, where the resources and patients do not seem to be equivalent to the western populations (15).

Local data is significant because the effectiveness of interventions may be different among the population due to the rise in the rates of anemia, preeclampsia, or unavailability of advanced monitoring. The social security hospital and the Gulab Devi Hospital in Lahore are constrained by staffing, surveillance gadgets, and conventional protocols, and as such, the approaches that offer the most efficient, cost-effective, and viable solutions in the circumstances of these hospital environments must be discussed. Without region-specific evidence, clinicians are either prone to obsolete practice or inconsistent with each other, which exposes high-risk obstetric patients to the threat of hypotension and associated consequences (16).

Maternal hypotension prevention under spinal anesthesia is a potentially multimodal problem, and not all groups of patients have been included in the research on the identification of each of the potential mechanisms. Various clinicians combine a combination of fluid loading and vasopressor with maternity positioning and close hemodynamic monitoring in an effort to reduce

Frontier in Medical & Health Research

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the severity and duration of hypotensive episodes. Such a comorbid strategy is especially applicable with high-risk obstetric patients because physiological reserves will be low, and the consequences of hypotension can be disastrous to the mother and the fetus (26).

Fluid use remains popular though its effectiveness remains a matter of discussion. The majority of the available evidence suggests that co-loading, an infusion of fluids immediately after the spinal injection, is more hemodynamically effective than the traditional preloading because the former is more associated with the timing of sympathetic blockade. However, since the redistribution of the crystalloids out of the intravascular compartment is rapid, and the issues triggered by the colloids are the development of anaphylaxis and renal dysfunction, the application of fluid therapy is not sufficient to prevent the emergence of hypotension, which is why the usage of adjunctive vasopressor support is warranted (31).

Continuous infusion with vasopressors, particularly phenylephrine, is now the new standard of care in the obstetric anesthesia of most modern regions. Phenylephrine alpha-stimulation causes vasoconstriction of the arteries, which counteracts the effect of vasodilation of the spinal and quickly raises the systolic blood pressure. Its use has been associated with improved maternal hemodynamic stability, reduced incidences of nausea and vomiting and improved outcomes among neonatal patients compared to older agents such as ephedrine. However, reflex bradycardia is one of the weaknesses especially to patients whose hearts have already been damaged (33).

Norepinephrine infusion implementation is a significant finding in the prevention of spinal-induced hypotension. Mild-effect beta-agonist action contributes to the cardiac output maintenance and provides an adequate vasoconstriction to normalize the blood pressure. Multiple randomized trials have proven that norepinephrine low-dose infusion has the same or even better hemodynamic control in which incidences of reflex bradycardia are reduced compared to phenylephrine cases. This predetermines the suitability of the norepinephrine since there is a high risk of obstetric patients unable to tolerate the drop in heart rate because of low cardiovascular reserves (06).

Another very important component of hypotension deterrents is maternal positioning (and especially left uterine displacement (LUD)). Decongestion of the vena cava can also be achieved by tilting the patient 15 degrees to the left or by inserting a wedge under the right hip that aids in increasing the cardiac output and venous return when performing spinal anesthesia. LUD is the first preventive intervention applicable in the environment where there are no vasopressor infusion pumps or advanced hemodynamic monitoring, and it is weaker when applied alone to address high-risk groups. As it is stated, position does not fully counteract the tremendous vasodilation brought about by spinal anesthesia, yet it is a necessary supplementary measure (12).

The new trends of avoiding the onset of hypotension under cesarean section are guidelines at the international consensus which prescribe standardized regimens of vasopressor infusion, aggressive monitoring and fluid co-loading. However, the recommendations are largely based on the studies carried in the high-resource contexts, where infusion pumps, real-time cardiac output monitors, trained staff, etc. are readily available. On the other hand, not every healthcare system, including the developing ones, can afford to fully implement such standardized practices, which is why the anesthetic practice varies to a great extent (18).

Various hospitals in Pakistan have some disparities in anesthetic management strategies because not all hospitals have access to vasopressors, and they have inadequate monitoring facilities and disparities in training clinicians. Crystalloid preloading is the most commonly employed preventive strategy despite the substantial evidence of using vasopressor prophylaxis. Moreover, continuous administration of vasopressors is not a widespread practice, not even in the tertiary care units because of the excessive number of patients and insufficient number of pumps. As a result, the patients at risk in obstetric care are exposed to uncontrolled hypotension, and the necessity to finalize the research based on the region is understandable to implement best practices (20).

Lack of standardized, evidence-based protocols in Pakistan shows a great clinical practice gap. As much as global literature highly agrees with the use of the phenylephrine or norepinephrine infusion as the primary preventive measure, it is not clear what strategies offer the best outcomes in resource-

Frontier in Medical & Health Research

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constrained hospitals where advanced monitoring tools and trained anesthesia personnel are not necessarily available. Also, obstetric patients with high risk in Pakistan tend to display comorbid conditions such as severe anemia, uncontrolled hypertension, malnutrition, and late hospital presentations, and that is qualitatively different as compared to populations that were investigated in high resource settings (18).

Considering such differences, comparative research on the effectiveness of various management strategies on the ground under local conditions is required. The comparison of phenylephrine infusion, norepinephrine infusion, crystalloid co-loading, and left uterine displacement will have a valuable implication of which intervention or a combination of interventions has the safest and most effective results of high-risk obstetric patients in the tertiary hospitals of Lahore. With the help of such a comparative approach, clinicians can determine more practical, cost-effective, and feasible ways of preventing hypotension, particularly in the environments where an advanced vasopressor infusion pump or invasive monitoring is not always at hand (02).

The fact that the obstetric complications in Pakistan are very high also strengthens the importance of assessing various anesthetic management. Anesthetic complications that are preventable also continue to be strongly related to maternal mortality, and anesthetic perioperative hypotension caused by spinal anesthesia is a significant factor in intraoperative morbidity. Evidence-based measures to enhance intraoperative hemodynamic control have a direct impact on improving maternal outcomes, lessening neonatal morbidity and mortality, and meeting relevant population health objectives in relation to maternal and child health (09).

The given research consequently tends to fill a knowledge gap that is already critical by comparing the effectiveness of four major strategies of hypotension management that are commonly applied under the spinal anesthesia procedure in high-risk obstetric patients when it comes to cesarean delivery. This research can be done in Social Security Hospital and Gulab Devi Hospital, Lahore, which will give a chance to produce evidence pertinent to the setting, which is reflective of real-world practices and resource limitation. The results can be used to help shape the local guidelines, enhance clinical decision-making, and increase maternal and neonatal safety in an environment where the streamlined management guidelines are highly in demand (16).

Incorporating both the global and local data, the study is aimed at developing pragmatic advice to be applied to Pakistani clinical settings. Finally, better management of hypotension caused by spinal anesthesia in high-risk obstetric patients is not merely the issue of anesthetic practice, but the cornerstone of safe childbirth and prevention of morbidity and mortality (07).

Rationale of the Study

The Maternal hypotension is the most frequent and possibly dangerous complication of the cesarean section spinal anesthesia that is often manifested in high-risk obstetric patients with preeclampsia, multiple gestation, anemia, obesity, and cardiac disease. Severe hypotension can lead to maternal nausea and vomiting, dizziness, loss of consciousness and loss of uteroplacental blood flow. It may cause fetal acidosis, low Apgar and fetal neonatal resuscitation. A majority of the government and semi-government hospitals in Pakistan like Social Security Hospital and Gulab Devi Hospital do not have any standardized practice of prevention of spinal-induced hypotension and management approach is largely on anesthetist, availability of drugs, as well as, clinical judgment.

A number of measures are usually used to prevent hypotension which include proactive vasopressor infusions (phenylephrine and norepinephrine), immediate co-loading with crystalloid, and left uterine relocation. However, the lack of local comparative data on the best strategy to provide the high-risk obstetric patients with improved hemodynamic stability exists. This study is therefore valid to come up with context-specific results on the relative efficacy of these three managerial styles. The findings will be helpful in educating the standard practice in the area, avoiding maternal and fetal morbidity, and enabling safe practice in anesthesia in resource constrained Lahore obstetric units.

1.1 Aims and Objectives of the Study

Aim:

To compare the efficacy of various management measures in prevention and management of maternal hypotension in spinal anesthesia in high-

Frontier in Medical & Health Research

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risk obstetric patients who underwent a cesarean section.

Objective:

To compare the effectiveness of different vasopressors in managing spinal-induced hypotension in high-risk obstetric patients, and to assess the associated maternal and neonatal outcomes.

2 LITERATURE REVIEW

Banerjee et al. (2020) stated that Spinal anesthesia has been considered as the gold standard used in cesarean section since it provides dense sensory and motor block, quick onset, maternal awareness of the delivery process and low exposure of the systemic anesthetic agents to the neonate. It is regarded by different other international guidelines as a safer method compared to general anesthesia because airways manipulation is not performed on pregnant patients who are known to be at risk of having failed intubation and aspiration due to physiological airway edema, reduced functional residual capacity, and slow gastric emptying. However, no matter how popular it is, spinal anesthesia is commonly associated with the maternal hypotension continuing to be among the major topics of clinical research that strive to improve the conditions of the mother and fetus even further (01).

Kinsella et al. (2018) The mechanisms that facilitate the hypotension induced by the spinal anesthesia have some deep-rooted causes in the changes in the cardiovascular of pregnancy. Pregnancy is a hyper dynamic state, which is observed to be followed by an elevated blood volume, augmented cardiac output, reduced systemic vascular resistance and augmented sympathetic tone to create stability in the circulatory condition. One of the effects of the spinal anesthesia is sympathetic blockade that leads to immediate venous and arterial vasodilation, pooling of the veins, and reduced blood flow to the heart, the compensatory mechanism that the pregnant women rely on. They are particularly meaningful in the patients with obstetrics, and even the small dose of the local anesthetics may lead to significant hemodynamic changes in a few minutes (04).

MacDonald et al. (2020) The decrease in blood pressure following spinal anesthesia is the mixture of a decreased preload, decreased systemic vascular resistance, as well as a damaged baroreceptor reflexes. The gravid uterus is another significant factor as it obstructs the inferior vena cava under the supine posture and additionally reduces the flow of the venous further deteriorating the cardiac output. The phenomenon is also known as aortocaval compression syndrome and since this compression occurs in addition to the hemodynamic instability commonly seen in the case of cesarean section under the influence of spinal anesthesia, it is argued that the idea of early detection and preventive treatment of hypotension should be supported (08).

Sharp et al. (2019) Clinical outcomes of maternal hypotension are hardly limited to the temporary pain. Even brief episodes can compromise the cerebral perfusion of the mother, which causes dizziness, nausea, vomiting, pallor and in a few cases syncope or bradycardia due to the reduction in coronary perfusion. Persistent and intense hypotension can trigger cardiovascular collapse particularly in those women who already have a weak cardiovascular. The implications of this to maternal are concerning, but what is more important are the effects on the fetus because the uteroplacental perfusion is highly pressure-dependent and is susceptible to any reductions in maternal blood flow (13).

Mohta et al. (2020) Situation with maternal hemodynamics has a tremendous impact on the welfare of the fetus in the case of cesarean delivery. The decrease in blood pressure in the mother directly cuts blood flow in the placenta, which results in the fetus being experiencing hypoxia and acidosis and having low Apgar of the first minutes of the life. Various studies have shown that the umbilical cord blood test has uncovered that infants of mothers with severe spinal hypotension had reduced PH and higher lactate levels as compared to infants who were born to mothers with no hemodynamic disturbances. Particularly risky obstetric groups are exposed to the dangers of the latter fetal effects, and the prevention of maternal hypotension is also a significant aspect of a safe obstetric anesthesia practice (19).

Ueyama and Goto (2020) Maternal, fetal and procedural determinants of the severity of spinal induced hypotension are few. The deeper hypotension is associated with an increased level of sensory block, especially greater than T4, due to the increased sympathetic block. Factors that relate to the patient such as high body mass index, old age

Frontier in Medical & Health Research

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of the mother, multiple pregnancies and poor autonomic capacity contribute to the increase of hemodynamic variations. Intrathecal opioids might also induce the development of hemodynamic instability, and it has also been found to contribute to augmenting postoperative analgesia (26).

Hall and Ngan Kee (2018) Even high-risk obstetric patients are more likely to experience hypotension. The vascularity compliance of the preeclamptic women is irregular, and endothelial dysfunction and abnormalities of intravascular volume abnormality are present that predisposes them to changes in blood pressure unpredictably despite their predisposition to exhibit hypertension. Although preclamptic patients are hypothesized to be less severely hypotensive due to their being in the vasoconstricted state of the baseline, the recent evidence has demonstrated that they have highly unpredictable hemodynamic responses, and their fetal trade-off can be even more intensive ones, which is attributed to the fact that they have a long-term inadequacy of the placenta (33).

Lim et al. (2021) Multiple gestation pregnancies have unique physiological needs that place them at risk of being affected by hypotension due to spinal anesthesia provided. The larger the size of the uterus, the greater the compression on the aorta reducing the venous return, even more so. More exposed to the crises in obstetrics such as fetal distress or malposition, which can be immediately resolved through surgery, but with insufficient time to organize the hemodynamic stabilization of patients are these patients. This results in a much reduced operating room safety margin and simple changes on hemodynamics can have a disproportionate impact on the fetal and maternal stability (38).

Jamil et al. (2018) The other population of patients presenting challenges is that of patients with underlying cardiac disease. In both the causes of the impairment in cardiac reserve be it congenital lesion, valvular disease, or cardiomyopathy, it is resounding that the impairment in cardiac reserve adds to the risk of spinal induced hypotension. Reduction in systemic vascular resistance after spinal anesthesia could cause afterload mismatch that leads to abrupt falls in forward cardiac output, myocardial ischemia, and arrhythmias. These patients are to be properly titrated to spinal anesthesia and actively provided with their hemodynamics (03).

Langesæter et al. (2020) The other risk factor is anemia which is very prevalent among the obstetric population of the South Asians. The reduced hemoglobin has a significant impact on oxygen delivery capacity and thus fetal oxygenation is once again pegged on maternal blood pressure and heart rate that is maintained. The premature fetal distress in such patients can be caused by hypotension, which is induced by the low level of oxygen and decreased capacity to tolerate placental perfusion pauses. This means that early prevention of hypotension is a requirement in order to maintain the optimal supply of oxygen to the mother and the fetus (07).

Sharp et al. (2019) The first-line mechanism of prevention of spinal anesthesia-induced hypotension was previously the fluid therapy. Crystalloid preloading had been much employed because it is cheap and convenient. However, crystalloids are rapidly wasted out of the intravascular space and bring about temporary rise in the volume of flow. Hydroxyethyl starch and gelatin solutions were also more effective at keeping intravascular volume, yet coagulation disruption risks, anaphylaxis, and renal damage were also a limitation to their use, especially in underdeveloped countries (13).

Terkawi et al. (2016) The strategy of fluid administration evolution led to the concept of co-loading that is, the intervention of crystalloids immediately after the spinal anesthesia is given to coordinate the sympathetic blockage. Several randomized studies have demonstrated that co-loading is superior to preloading in the rate of hypotension but fluid therapy by itself is still not effective to assist a majority of the high-risk population, which highlights the significance of adjunctive vasopressor therapy (15).

Corke et al. (2017) The fact that the fluid therapy could not overcome the effects of the spinal anesthesia that results in hypotension and this prompted the management focus to be in the case of vasopressors which reverse directly the effects of the sympathetic blockage that leads to deep vasodilation. The mixed 2- and 2-adrenergic effect of ephedrine, which was believed to keep uterine perfusion and fetal toxicity to a minimum, was used as the vasopressor in obstetric anesthesia over decades. Subsequent research however established that ephedrine readily passes through placenta and can cause infant acidosis and low scores on Apgar hence, limiting its use as a prophylaxis medication.

Frontier in Medical & Health Research

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This new perception resulted in the implementation of direct α-agonists such as phenylephrine that stabilize maternal blood pressure more quickly and reliably without causing any metabolic alterations in the fetus (20).

Puthenveettil et al. (2019) The application of phenylephrine infusion as the first line vasopressor of obstetric hypotension has been confirmed by a large number of randomized controlled trials. These works never cease to indicate that phenylephrine is a superior hemodynamic agent to ephedrine, in the majority of cases when administered as a chronic infusion and not via intermittent boluses. Permanent IV will be able to guarantee no changes in systemic vascular resistance and minimal hypotension or hypertension due to consistent plasma level. Moreover, the issue of maternal outcomes, such as nausea, vomiting, and intraoperative discomfort, is also reduced in the case of maintaining the blood pressure in a tight range, which again adds to the necessity to select prophylactic measures of infusion (23).

Ayorinde et al. (2019) Despite all these advantages, phenylephrine is associated with reflex bradycardia due to its being a powerful vasoconstrictive effector but lacking the 3-adrenergic effect. This reduction in the heart rate may result in the reduction of cardiac output despite the adequate blood pressure in any of the patients, and it happens in patients with dysfunctional heart performance. The restriction gave rise to the designing of other vasopressors that have an efficient vasoconstriction effect without any cardiac rate or cardiac output alteration. As a result, the use of norepinephrine has been gaining further popularity in the past few years (27).

Singh et al. (2020) It is both α-adrenergic vasoconstrictive and slightly β-adrenergic, and thus, it helps the heart pump blood along with maintaining the blood pressure. Numerous studies have been conducted under the last decade, which have demonstrated the effectiveness of norepinephrine in the prevention of hypotension under cesarean section with no worse fetal outcome and improved hemodynamic consequences on the mothers . It is worth mentioning that norepinephrine exhibits less instances of reflex bradycardia and heart rate to systemic vascular resistance ratio, hence it can be regarded as a promising alternative to high-risk obstetric patients with a low cardiovascular reserve (30).

Khaw and Wang (2021) The comparative analyses of the phenylephrine and norepinephrine have remained to underline the benefits of norepinephrine as a way of providing a more physiologic hemodynamic profile. Compared to phenylephrine, norepinephrine infusion was found to work better in terms of heart rate and cardiac output, without fetal oxygenation or Apgar deterioration. Furthermore, the pharmacodynamic model allows norepinephrine to be approximately one-tenth as potent as phenylephrine, and this provides the clinician with a convenient model to spike the dose. This data has contributed to its use to increase the application of norepinephrine in the obstetric anesthesia protocol especially in regions with focus on maintaining the heart rate (34).

Bhardwaj and Grover (2018) Even though vasopressor infusion can no longer be considered as a treatment option on its own in the prevention of the low blood pressure caused by the spine, the supplementary efforts are important particularly in the non advanced monitors or infusion facilities. Maternal positioning interventions such as the left uterine displacement (LUD) are implemented to reduce aortocaval compressions and maximize the venous return of the patient by tilting them by 15 degrees left or lifting the right hip with a wedge. This procedure has been found capable of maintaining preload and improving cardiac output especially in late pregnancy when the uterus is very large. Although LUD is not an entirely sufficient strategy itself, it is one of the components of multimodal preventive strategies, especially in the environments that lack resources (21).

Allen and Fernando (2018) The unstable patients such as those with preeclampsia, cardiac or anemia may require special combination of vasopressors, liquid therapy, and maternal positioning to limit the risk of excessive hypotension. With preeclamptic painters, in the example, lower doses of local anesthetics and more active maintenance of vasopressors can be useful to counter their various reactivity to analgesics are involved. Conversely, cardiac patients may require a minimized dosage of vasopressors to avoid afterload increase, which can worsen cardiac functioning, which highlights the necessity of individualizing anesthetic preparation (24).

Frontier in Medical & Health Research

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Ayorinde et al. (2019) The emergence of new hemodynamic monitoring technologies has increased the possibilities of clinicians to detect and intervene in the problem of hypotension. Blood pressure is also constantly checked non-invasively, and it is based on it that alterations in blood pressure are observed in real-time and exclusion of hypotensive events is eliminated. Similarly, cardiac output monitors, pulse contour analysis, or bioimpedance devices may help anesthesiologists understand the variables of stroke volume, cardiac output, and systemic vascular resistance under spinal anesthesia in a better manner to optimize their vasopressors. It is probable that these more common technologies in more situations of resourcefulness will have a positive impact on maternal anesthesia care in the country, despite the fact that their growing use in the country is already encouraging (27).

Singh et al. (2020) The other technology that has been employed in the treatment of obstetric hypotension is the deployment of closed-loop vasopressor systems where the system automatically adjusts the infusion rates of the system based on the continuous blood pressure feedback. They assist in reducing the mental load of anesthesiologists and in rapid regulation of the deviation of the blood pressure, which decreases the incidence of severe or long-term instances of hypotension. A comparison of closed loop system and trials with manual titration has shown superiority in blood pressure control in closed-loop groups, where cost and availability are the primary factors against complete implementation in low and middle-income nations (30).

Hall and Ngan Kee (2018) The newest global recommendations suggest that, under spinal anesthesia, fluid co-loading, prophylactic vasopressor infusion, maternal positioning, and continuous monitoring are all the most effective methods of preventing maternal hypotension (Kinsella et al., 2018). However, such recommendations need to be localized in order to become possible. In the majority of developing nations like Pakistan, the unavailability of infusion pumps, inconsistent human resource training, and the unavailability of drugs discourage the use of standard protocols of infusion of vasopressor. Therefore, crystalloid loading and reactive bolus dosing continue to be used by many anesthesia providers, rather than proactive infusion (33).

Tao et al. (2020) The local data that have been released by Pakistani hospitals show that high cases of spinal induced hypotension were maintained due to application of outdated methods, reduced monitoring, and poor use of vasopressor infusion. Studies on Lahore and Karachi reveal that the most popular mode of prevention up to date is still crystalloid preloading, despite it being shown to be inferior to the use of vasopressor-based interventions in terms of stable maternal hemodynamics. This gap between the evidence in the international community and practice in the country shows the enormous need of comparative studies that would help to evaluate different hypotension management interventions in realistic circumstances in Pakistan (37).

Bhardwaj and Grover (2018) Having in mind that the high-risk obstetric populations are likely to experience hypotension, which arises as a result of spinal anesthesia, it is urgent to devise contextual solutions to guarantee a decrease in maternal and neonatal morbidity. The predisposing factors or factors that put Pakistani obstetric patients in a dire situation include the quality of prenatal health care, anemia, the lack of access to subspecialty care, and the high tendency to arrive at the hospital late, and it is vital to consider what of the offered strategies is the most effective, cost-effective, and feasible. Studies conducted in affluent environments may not be relevant to the local, which is the reason why research-based context is essential (21).

Zhang et al. (2021) Another issue is the timing and dosage of preventive therapies which influences the management of hypotension which occurs as a consequence of the application of the spinal anesthesia. Intravenous prophylaxis has been shown to be superior to intrathecal reactive treatment because hypotension is more likely to develop abruptly under the initial 2-5 minutes of intrathecal injection and can become excessively rapid to permit the correctional active to eliminate the effects of the mother and fetus. Clinicians may obtain more balanced hemodynamic profile by starting vasopressor infusion when sympathetic block is not yet fully developed to prevent incidence and severity of hypotension and reduce the use of rescue boluses, which may provoke abrupt changes in the blood pressure (29).

Langesæter et al. (2020) The proactive and not reactive treatment principle has transformed the practice of obstetric anesthesia radically. The

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comparison of prophylaxis administration of boluses with reactive administration of boluses has always been conducted, and in such studies, the control of the maternal blood pressure is improved, the incidence of nausea and vomiting are decreased, and the maternal outcome of the neonate is better in the prophylaxis group. Even though bolus-only regimens are better relevant in a low-resource environment due to the lack of syringe pumps, it is associated with a significant variability of hemodynamic ranges, therefore, they cannot be applied to high-risk obstetric patients requiring closer physiological control. Hence, the modality of continuous infusion has been the one used when the infusion pumps are available(07).

Langesæter et al. (2020) Fluid therapy is also an important adjunct, although not the most important intervention. As of late, it has been suggested that moderate fluid management coupled with low-dose vasopressor infusion is more effective than either of the two approaches, which suggests that the two interventions can be used in tandem. Combination of crystalloids 500-1000 mL and prophyla is practiced today by most clinicians(07).

Terkawi et al. (2016) The literature also shows that emergency cesarean surgeries are linked with the development of maternal hypotension than the elective ones. The cases in emergency also include the shortage of time to optimize the fluids, increased maternal stress, and the lesser predictability of the anesthetic conditions. Maternal positioning, as well as prompt initiation of vasopressor therapy and effective coordination between anesthesia and obstetric teams are even more essential in such cases. It has been also demonstrated that the institutions in which there is an established protocol regarding obstetric emergencies have significantly lower rates of severe hypotension and fetal compromise. This shows the need to ensure the elaboration of structured perioperative pathways of elective and acute cesarean sections(15).

Terkawi et al. (2016) The study of fetal outcomes remains to show the significance of hemodynamic stability when conducting maternal anesthesia. Newborns with maternal hypotension usually have worse Apgar scores, higher resuscitation rates, and, in the worst case scenario, are taken to neonatal intensive care units. The measurements of Umbilical cord pH and base excess always depict a poorer state of acid-base balance in infants born by mothers with prolonged hypotension, and it is determinant to highlight the effects of maternal blood pressure as a factor affecting fetal oxygenation. These results confirm the importance of proactive and not reactive hemodynamic management in case of spinal anesthesia (30).

Lim et al. (2021) When considering the literature on the topic, one can conclude that the use of vasopressors, including phenylephrine and norepinephrine, is still considered the core of the management of spinal anesthesia, but the optimal approach can be different depending on the capabilities of a particular institution, the specifics of a patient, and the resources available. The settings of high income are progressing towards the employment of precision-guided infusion algorithms and sophisticated monitoring technologies, and the low-income countries are resting on the inexpensive, simple strategies that focus on maternal positioning, selective fluid therapy, and bolus dosing guidelines. This disparity explains the significance of comparison research which could evaluate different interventions within the real-life context that Pakistani hospitals must address (38).

Dyer et al. (2019) Local studies may be important since the maternal statistics, common comorbidities and health system constraints are highly heterogeneous in comparison with the western population. This country is unique in its predisposing factors as the levels of anemia, malnutrition, preeclampsia, and lack of prenatal care coverage resulting in the necessity of special measures of hypotension prevention. Also, the professionalism of the staff and access to the infusion of vasopressors may affect the results, and it is an acute question which practices were proved to be effective and might be used in the local practice. The absence of such evidence still does not deny clinicians a chance to follow an outdated or inconsistent practice, which may negatively affect the well-being of a mother and a fetus (02).

Habib and George (2019) Further development of multimodal strategies is crucial in facilitating the ideal hemodynamic control in the process of carrying out spinal anesthesia. The combination of vasopressor infusion and close attention to fluids, maternal position, and continuous observational measures are the most effective measures to prevent hypotension and its negative outcomes. The literature continually highlights that there is no single intervention that can prevent the

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occurrence of hypotension in all patients, but rather physiologically informed therapy combinations would provide the most consistent results. This combination method is particularly useful in high-risk obstetric populations a situation in which the stakes of hemodynamic instability are much greater(18).

3 METHODOLOGY

Materials and Methods

3.1 Study Design

This paper was of a descriptive observational design. Risky obstructed women who were subject to cesarean section under the spinal anesthetic condition were monitored. Patients who were developed hypotension following spinal anesthesia were only included and their reaction to various vasopressors (phenylephrine, norepinephrine, and ephedrine) compared as a normal clinical practice. Randomization/Investigator intervention No randomization/investigator imposed intervention was conducted.

3.2 Clinical Settings

The study was carried out in two teaching hospitals, Lahore Social Security Hospital and Gulab Devi Hospital of which each performs high number of obstetric surgeries in a year. These institutions were chosen because they have high-risk obstetric cases and also they have experienced anesthesia teams. The sample was comprised of the participants who were hospitalized on the basis of cesarean section under spinal anesthesia in the obstetrics and gynecology operating theatres of the said hospitals. All the elective and emergency cases that met the inclusion criteria were included to make the findings generalizable.

3.3 Study Duration

The study will last four months, between September 2025 and December 2025.

3.4 Sample Selection

Inclusion Criteria:

- High-risk obstetric patients (e.g., preeclampsia, multiple pregnancy, anemia, or mild cardiac disease).
- Age 20–40 years undergoing cesarean section under spinal anesthesia.
- Classified as ASA II–III according to the American Society of Anesthesiologists' physical status classification.
- Developed hypotension after spinal anesthesia, defined as a fall in systolic blood pressure >20% from baseline or SBP <90 mmHg.
- Provided written informed consent to participate.

Exclusion Criteria:

- The patients who have contraindications to spinal anesthesia (e.g., coagulopathy, puncture site infection).
- Phenylephrine or norepinephrine known allergy or intolerance.
- Patients that need general anesthesia or conversion to general under operation.
- The decision not to take part in the research.

3.5 Sampling Technique

The methods were a non-probability consecutive sampling. All high-risk obstetric patients that met the inclusion criteria throughout the study were recruited consecutively after giving an informed consent.

3.6 Sample Size

Cochran formula of observational studies was used to estimate the sample size by assuming 95 percent level of confidence (Z = 1.96), the maximum variability was to be 0.5, therefore the expected proportion of 0.5 and the margin of error of 0.15. The determined sample size was about 43 respondents. The 43 high-risk obstetric patients who had developed hypotension in the post-operative period following spinal anesthesia and were eligible to take part in the study were enrolled consecutively.

The sample size was determined using Cochran's formula for comparative cross-sectional studies:

$$n = \frac{Z^2 \times p(1-p)}{d^2}$$

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Where:

- **n** = required sample size
- **Z** = 1.96 (for 95% confidence level)
- **p** = estimated proportion of occurrence (0.5 assumed for maximum variability)
- **d** = margin of error (0.15)

Substituting these values:

$$n = \frac{(1.96)^2 \times 0.5(1-0.5)}{(0.15)^2}$$

$$n = \frac{3.8416 \times 0.25}{0.0225} = 42.68$$

Therefore, 43 participants were incorporated. This population was enough to give the required power to identify meaningful differences between the four management groups (phenylephrine, norepinephrine, crystalloid co-loading, and positioning).

3.7 Informed Consent

All participants were enrolled after giving informed consent in writing. In order to have the consent procedure, the study purpose, possible risks, and possible benefits were explained in both English and Urdu to make the study understandable. The subjects would be guaranteed voluntary participation and the ability to leave at any time and not to influence the clinical care.

3.8 Study Parameters

Obstetric patients aged between 20 and 40 years that were undergoing cesarean section were the source of data. Demographic, baseline hemodynamics (Systolic, diastolic and mean arterial pressure, heart rate), type of management strategy followed, and intraoperative complications were the parameters. Apgar scores at 1 and 5 minutes and the need to resuscitate the fetus or admit the baby to the NICU were also recorded.

3.9 Outcome Measures

Primary Outcome Measure:

Effectiveness of the vasopressor used (phenylephrine, norepinephrine, or ephedrine) in controlling spinal-induced hypotension, assessed by:

- Incidences of hypotension per patient.
- Duration of hypotension before achieving blood pressure stabilization

Secondary Outcome Measures:

- Maternal events: nausea, vomiting, bradycardia (HR less than 50 bpm), shivering, and loss of consciousness.
- Neonatal outcomes: Apgar score <7 at 1 and 5 minutes, and the requirement to provide neonatal resuscitation or NICU care.
- Perceptions of the patients on how hypotension is dealt with (satisfaction and comfort).

3.10 Data Collection Tool

A structured data collection form (questionnaire) was developed by the investigators after reviewing prior studies. It consisted of three parts:

- Demographics/risks of patients.
- Baseline, 2, 5, 10 and 15 minutes hemodynamic monitoring after the spinal anesthesia.
- Recording of outcome section incidence of hypotension, vasopressor, maternal symptoms, and status of the newborn.

The form was also tested on 5 patients to make it clear and adjusted where it was required. Blood pressure was taken by means of an automated non invasive monitor, and heart rate by continuous ECG monitor.

3.11 Data Collection Procedure

Four months of data collection was carried out at the obstetric operating theatre namely Social Security Hospital and Gulab Devi Hospital, Lahore. The structured questionnaire and data collection form were used. Informed consent had been taken and baseline vital parameters were recorded before spinal anesthesia after which blood pressure was recorded at 2, 5, 10, and 15 minutes.

Only the high-risk obstetric patients who developed hypotension were included. As soon as

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hypotension was registered, the anesthetist who was on duty at the time noted the particular vasopressor (phenylephrine, norepinephrine, or ephedrine) and the amount and the length of hypotensive episodes. Maternal symptoms that occurred under the operation were monitored and neonatal delivery Apgar scores were obtained. The proforma was arranged and all the data typed and tabulated to be analysed statistically.

3.12 Data / Statistical Analysis

All collected data were entered and cleaned using the Statistical Package (SPSS) version 25. Descriptive statistics, including frequencies, percentages, and cross-tabulations, were used to summarize demographic characteristics and study variables. Tables and graphs were prepared to display the distribution of hypotensive episodes, duration of hypotension, maternal outcomes, neonatal Apgar scores, and vasopressor effectiveness.

Since the primary design of the study was descriptive, the main analysis focused on clinical trends rather than hypothesis testing. However, non-parametric inferential statistics (Kruskal–Wallis test) were applied to explore differences between vasopressor groups for maternal and neonatal outcomes, given the ordinal nature of the data. A p-value < 0.05 was considered statistically significant.

3.13 Ethical Consideration

The research upheld high levels of ethical behavior. The institutional review board (IRB) of Superior University, Lahore gave ethical consent prior to the start. The patient information was kept in a confidential place with anonymous identifiers and the research team was restricted to only access the information about the patients. All subjects were fully informed about the purpose and interventions of the study. No extra invasive procedure or imposition of a financial burden over-and-above the normal practice of anesthetics.

4 RESULTS

The chapter reflects the findings of the research in terms of the data analysis of the 43 high-risk obstetrics patients who were subjected to spinal anesthesia through cesarean section. Findings have been provided in a frequency table, charts and inferential statistics.

The demographic variables (age, parity, BMI, ASA status) were evaluated as baseline variables to learn about the nature of the patients to determine the management of hypotension.

TABLE 4.1

Age of Patients * Parity (No of previous deliveries) Crosstabulation

		Parity (No of previous deliveries)				Total
		0	1	2-3	>4	
Age of Patients	18-22	9	4	0	0	13
	23-27	3	8	3	0	14
	28-32	0	4	4	0	8
	>32	0	2	3	3	8
Total		12	18	10	3	43

Most patients aged 18–22 had no previous deliveries, showing a predominance of young primigravida women. Patients aged 23–27 mostly had one previous delivery. Higher parity (≥2) was mainly seen in older age groups. This indicates that parity increases with maternal age.

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FIGURE 4.1

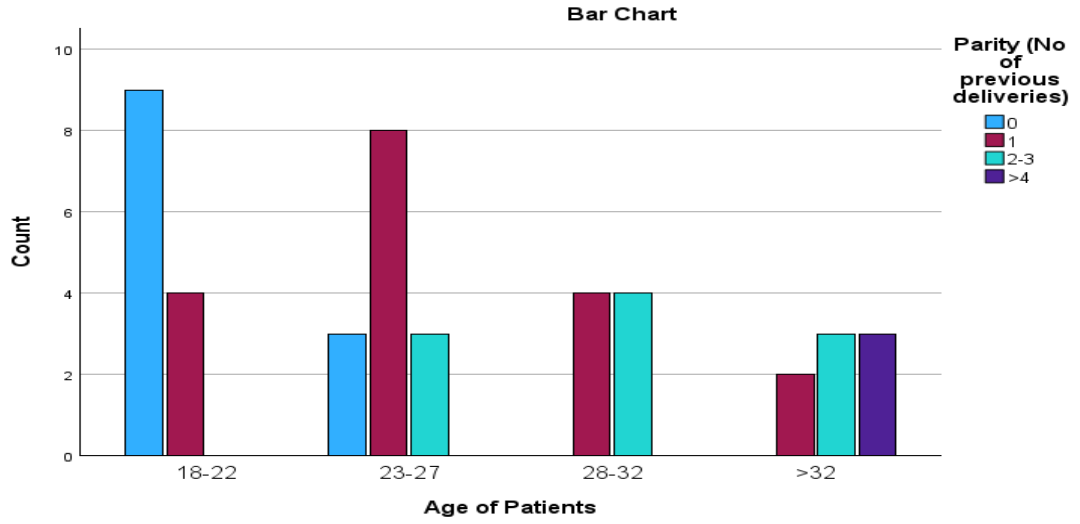

TABLE 4.2

Age of Patients * Body Mass Index Crosstabulation					
		Body Mass Index			
		<25	25-29.9	>30	Total
Age of Patients	18-22	13	0	0	13
	23-27	9	4	1	14
	28-32	2	5	1	8
	>32	0	2	6	8
Total		24	11	8	43

Most of the patients between 18 and 22 and 23 and 27 were found to be of normal weight with a BMI of less than 25. A BMI above 30 (obesity) was majorly recorded among patients aged above 32 years. This demonstrates that older mothers were more obese.

FIGURE 4.2

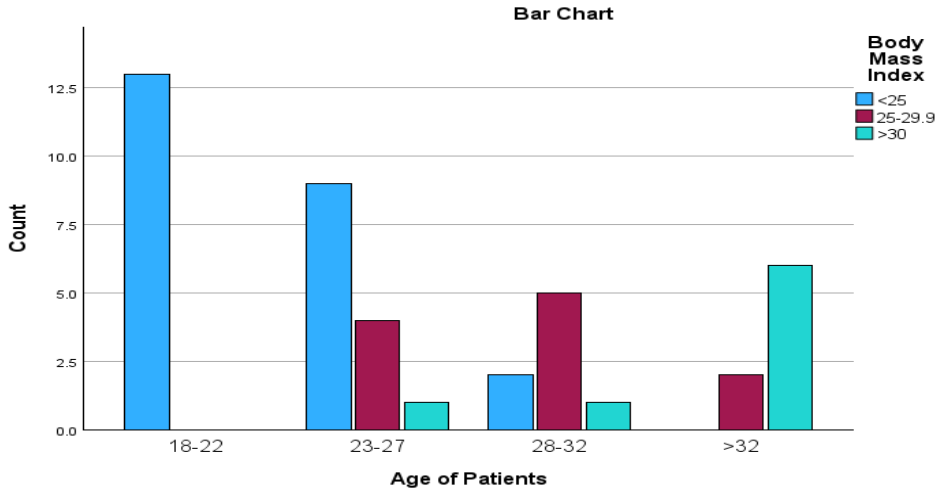

TABLE 4.3

Age of Patients * ASA physical status Crosstabulation

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		ASA physical status			
		I	II	III	Total
Age of Patients	18-22	13	0	0	13
	23-27	12	2	0	14
	28-32	4	4	0	8
	>32	2	3	3	8
Total		31	9	3	43

The majority of patients regardless of their age were of ASA I, which referred to healthy patients. Older patients (≥28 years) experienced more comorbidities with age ASA II and III were more common in older patients (GE: 28 years and older).

FIGURE 4.3

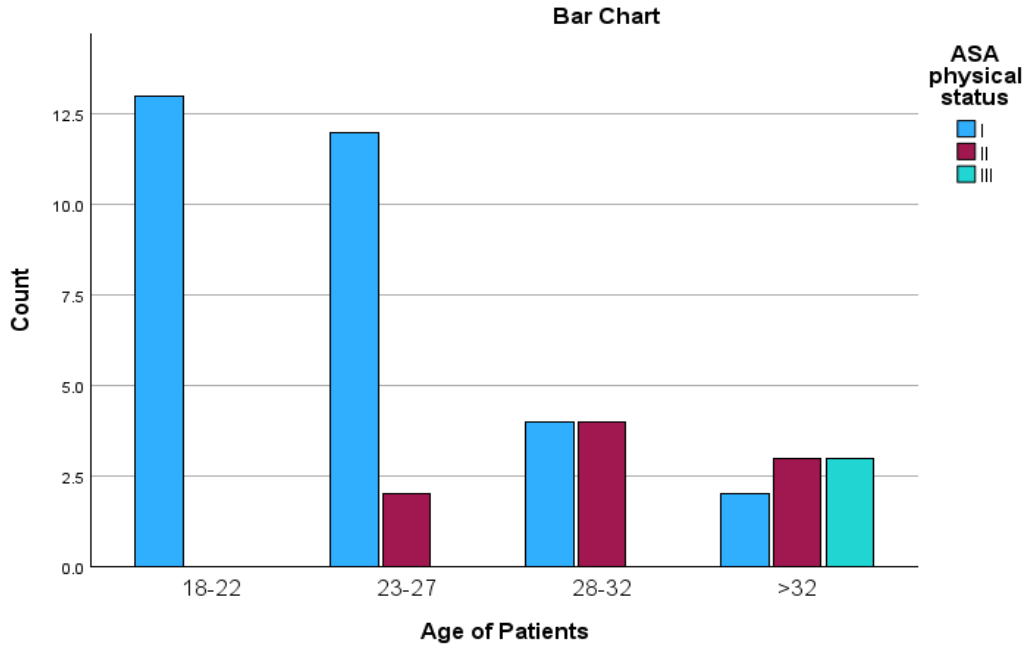

TABLE 4.4

Type of Surgery * Fluid mangement used Crosstabulation				
		Fluid mangement used		
		Crystalloid	Colloid	Total
Type of Surgery	Elective Cesarean Section	38	5	43
Total		38	5	43

The use of crystalloids was overwhelming in elective cesarean section (38 cases) and least colloid use (5 cases). This is indicative of the common practice of prophylaxis of spinal-induced hypotension by use of crystalloids.

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FIGURE 4.4

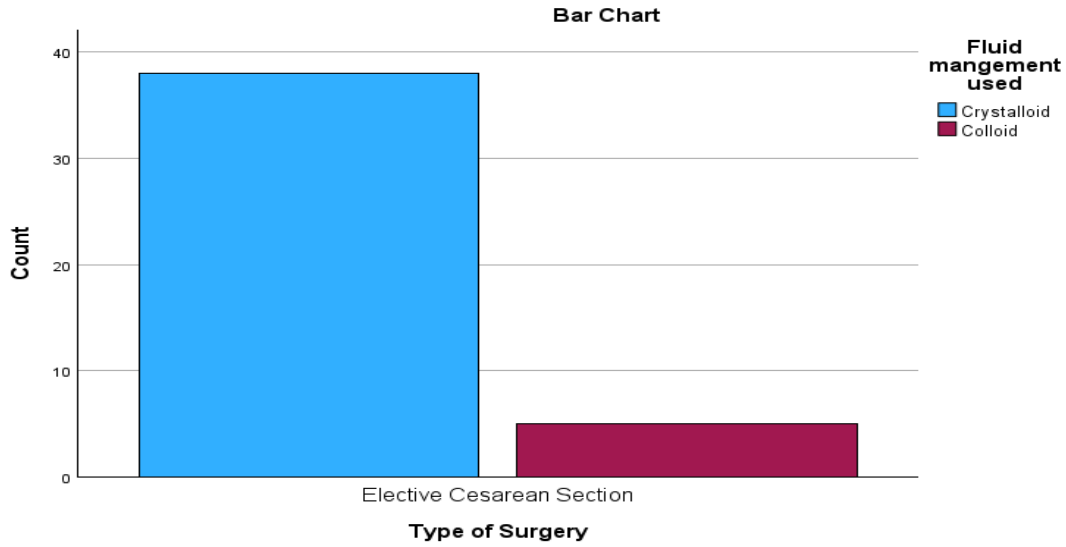

TABLE 4.5

Type of Surgery * Other strategy used Crosstabulation

		Other strategy used		
		Head down tilt	Combination therapy	Total
Type of Surgery	Elective Cesarean Section	24	19	43
Total		24	19	43

Head-down tilt was the most common management intervention imposed on the majority of patients whereas combination therapy (fluids + vasopressor + positioning) was applied less frequently. This implies that non-pharmacological approaches were first widely used.

FIGURE 4.5

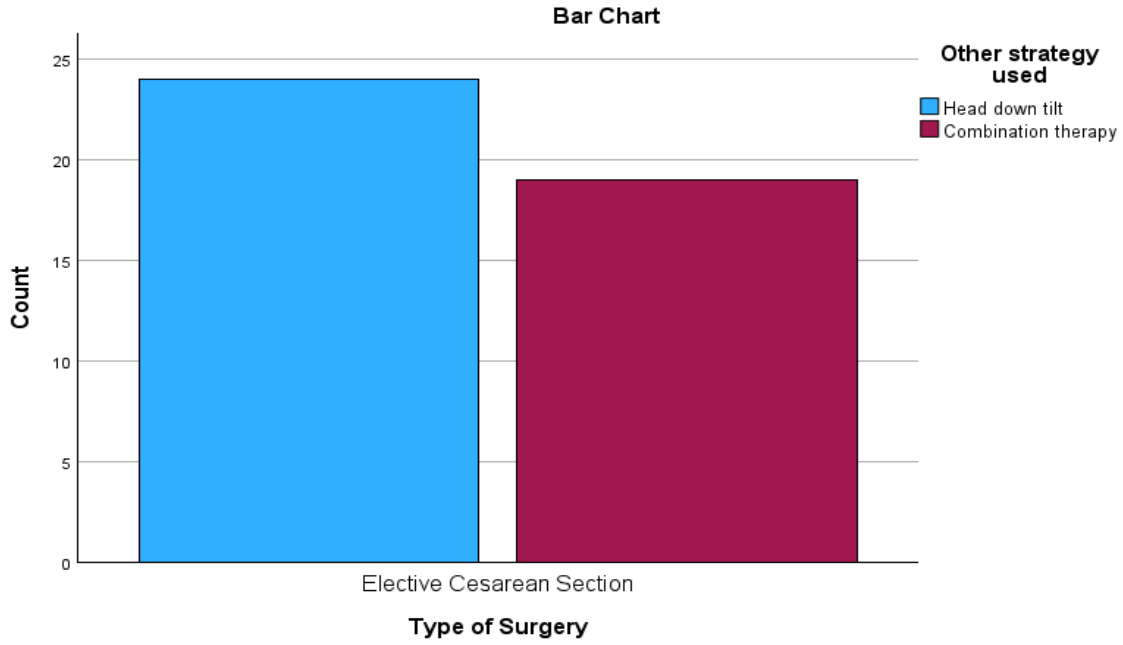

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TABLE 4.6

Did Hypotension occur after Spinal * Number of Hypotensive Episodes Crosstabulation					
		Number of Hypotensive Episodes			
		1	2-3	>3	Total
Did Hypotension occur after Spinal	Yes	22	15	6	43
Total		22	15	6	43

Hypotension was witnessed in all patients. The majority experienced singleton episodes, and a small proportion of patients experienced more than three episodes, which implies that high-risk obstetric patients vary in the severity of hypotension.

FIGURE 4.6

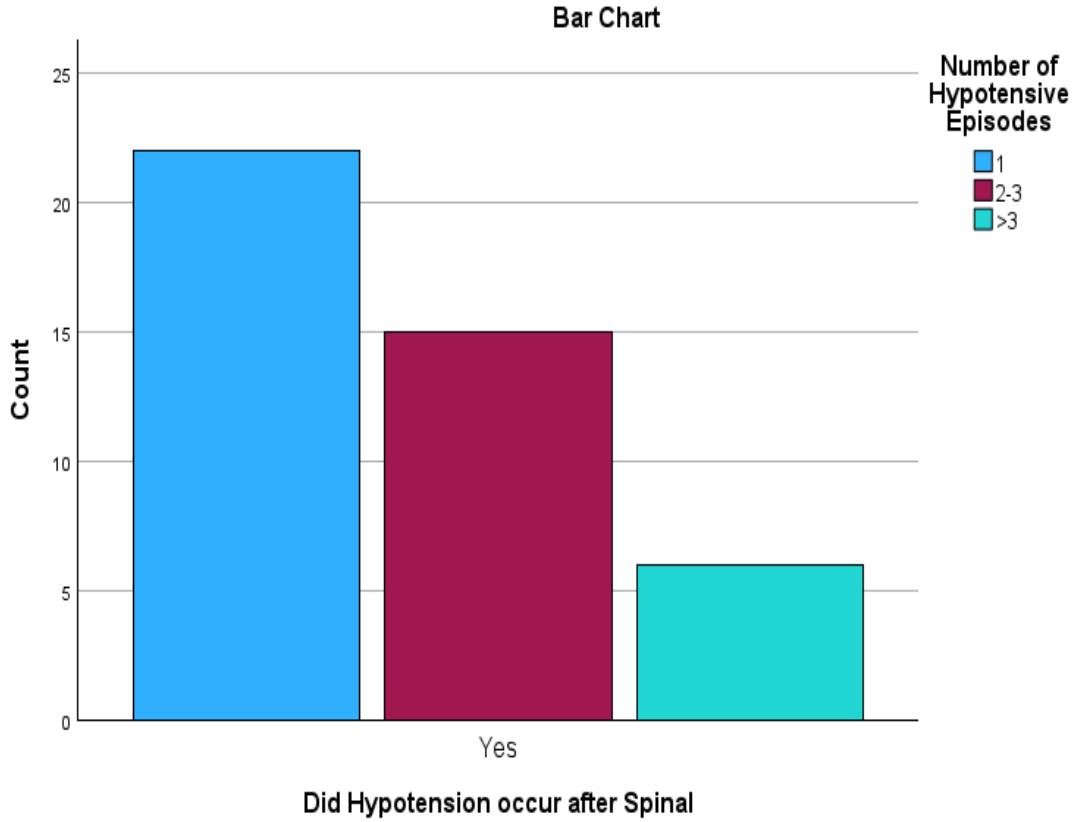

TABLE 4.7

Did Hypotension occur after Spinal * Duration of Hypotension in minutes Crosstabulation					
		Duration of Hypotension in minutes			
		<5 minutes	5-10 minutes	>10 minutes	Total
Did Hypotension occur after Spinal	Yes	23	14	6	43
Total		23	14	6	43

Most patients (less than 5 minutes of hypotension) showed that they responded effectively to management. Very few of them had a prolonged hypotension (>10 minutes).

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FIGURE 4.7

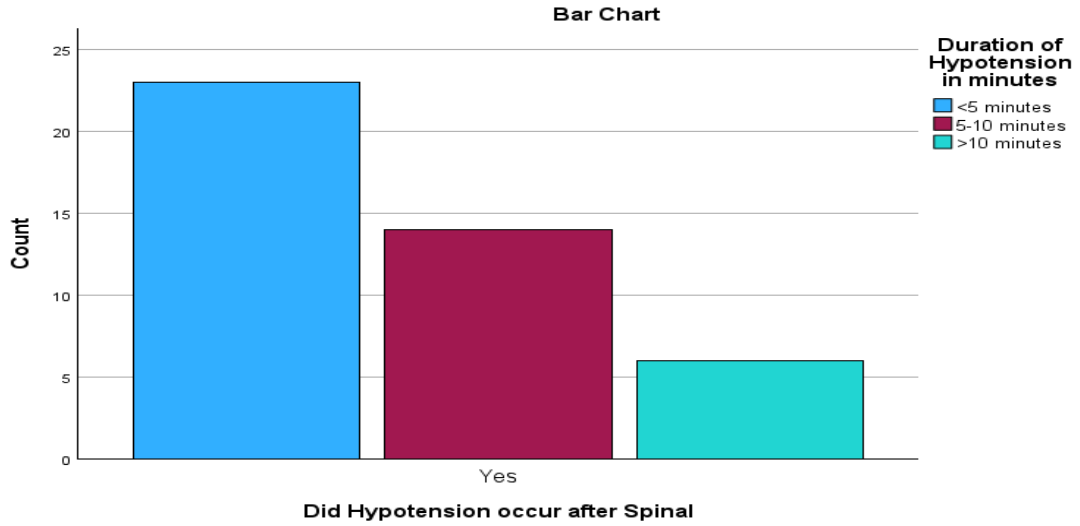

TABLE 4.8

Vasopressor given * Number of Hypotensive Episodes Crosstabulation					
		Number of Hypotensive Episodes			
		1	2-3	>3	Total
Vasopressor given	Phenylepherine	16	0	0	16
	Ephedrine	2	5	6	13
	Norepinephrine	4	10	0	14
Total		22	15	6	43

The users of phenylephrine were predominantly having only a single episode, with high effect. The users of ephedrine tended to have repeated doses (2-3 occasions), and norepinephrine tended to have moderate control. Phenylephrine had the greatest stability.

FIGURE 4.8

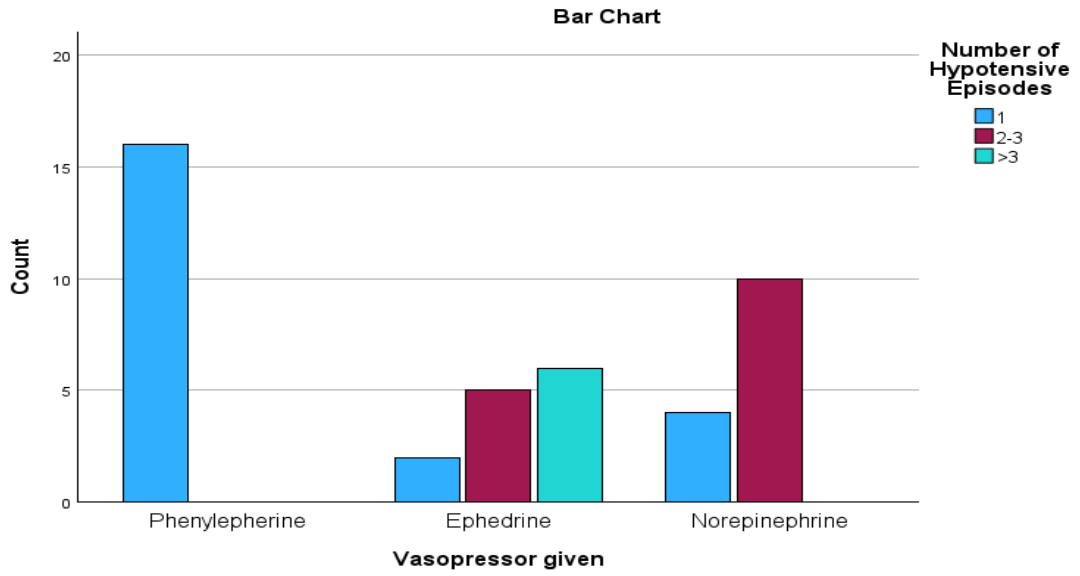

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TABLE 4.9

Vasopressor given * Duration of Hypotension in minutes Crosstabulation					
		Duration of Hypotension in minutes			
		<5 minutes	5-10 minutes	>10 minutes	Total
Vasopressor given	Phenylepherine	16	0	0	16
	Ephedrine	3	4	6	13
	Norepinephrine	4	10	0	14
Total		23	14	6	43

Phenylephrine produced quick recovery (less than 5 min) in every patient. Ephedrine and norepinephrine were linked to the longer periods. This is also an additional indication that phenylephrine is better acting.

FIGURE 4.9

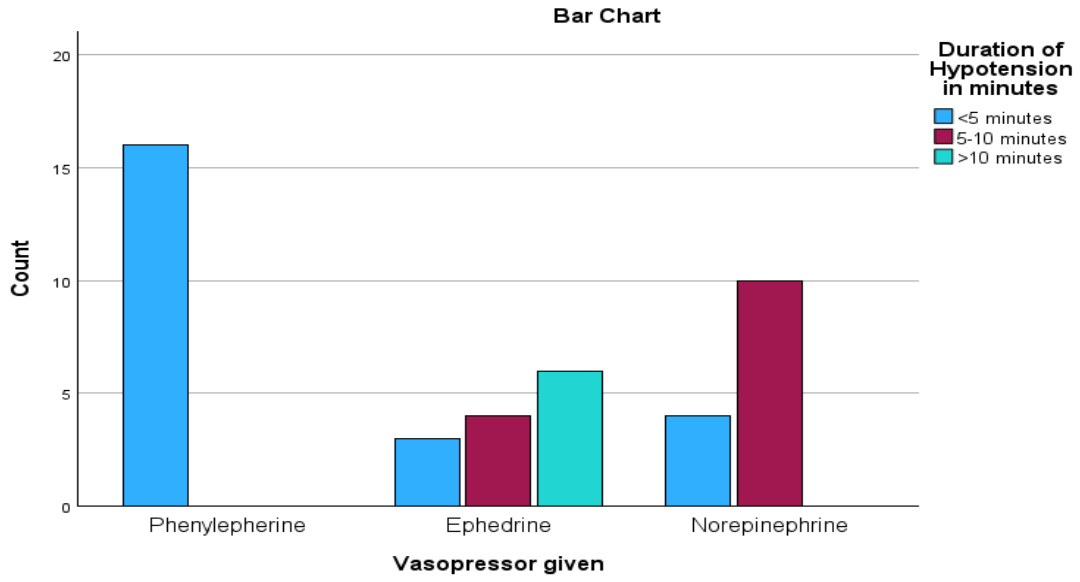

TABLE 4.10

Parity * (No of previous deliveries) Did Hypotension occur after Spinal Crosstabulation			
		Did Hypotension occur after Spinal	
		Yes	Total
Parity (No of previous deliveries)	0	12	12
	1	18	18
	2-3	10	10
	>4	3	3
Total		43	43

The hypotension of all parity groups proved the absence of parity-based protection. Nonetheless, parity 0 and 1 (younger, smaller uterus) groups were observed to have the majority of the cases of hypotension, which is correlated with a physiological expectation.

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FIGURE 4.10

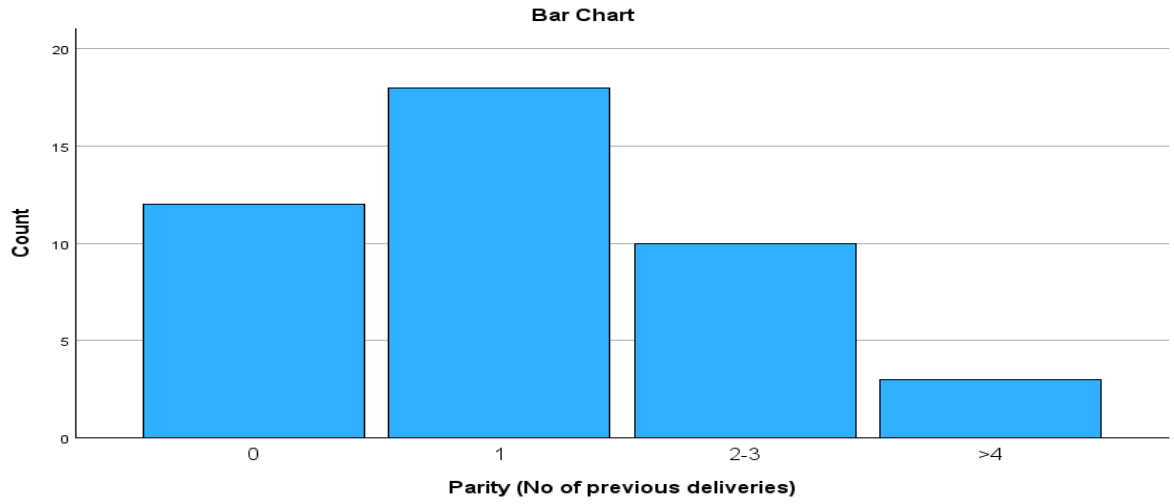

TABLE 4.11

Fluid mangement used * Did Hypotension occur after Spinal Crosstabulation			
		Did Hypotension occur after Spinal	
		Yes	Total
Fluid mangement used	Crystalloid	38	38
	Colloid	5	5
Total		43	43

Most cases that had experienced hypotension were treated with crystalloids. This is common practice, as well as it underlines the fact that crystalloids alone might not be sufficient in preventing hypotension.

FIGURE 4.11

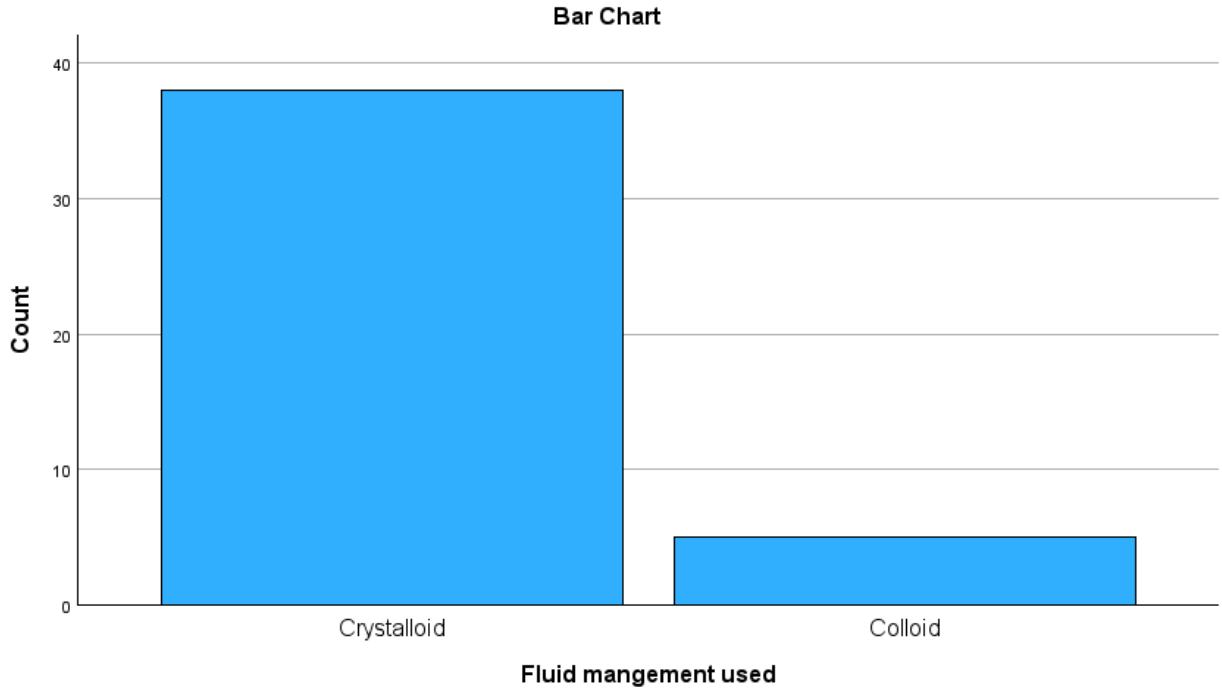

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TABLE 4.12

Type of Surgery * Vasopressor given Crosstabulation					
		Vasopressor given			
		Phenylepherine	Ephedrine	Norepinephrine	Total
Type of Surgery	Elective Cesarean Section	16	13	14	43
Total		16	13	14	43

The most common vasopressor in elective cesarean delivery was phenylephrine. Less frequent use was made of norepinephrine and ephedrine. This shows preference of phenylephrine by the clinicians.

FIGURE 4.12

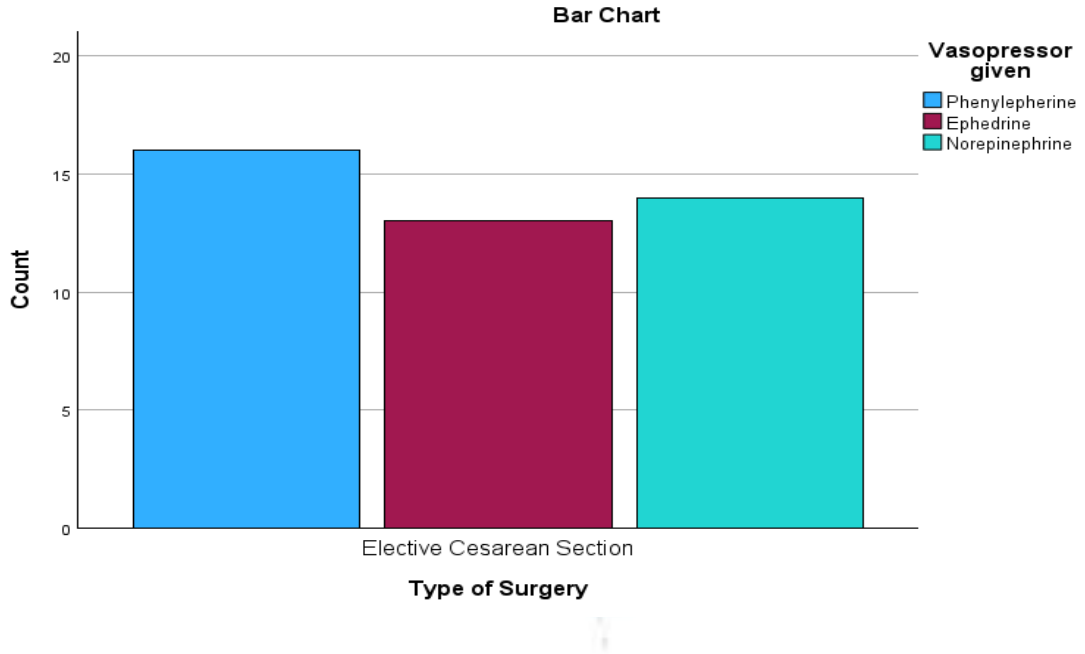

TABLE 4.13

Vasopressor given * Maternal Outcomes Crosstabulation							
		Maternal Outcomes					
		Normal Outcome	Vomitting	Bradycardia	Shivering	Loss of Consiousness	Total
Vasopressor given	Phenylepherine	16	0	0	0	0	16
	Ephedrine	2	4	1	2	4	13
	Norepinephrine	4	0	1	8	1	14
Total		22	4	2	10	5	43

The greatest number of normal maternal outcomes was achieved with phenylephrine. The ephedrine was linked with vomiting, and shivering, but norepinephrine had more adverse events such as shivering and mild bradycardia.

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FIGURE 4.13

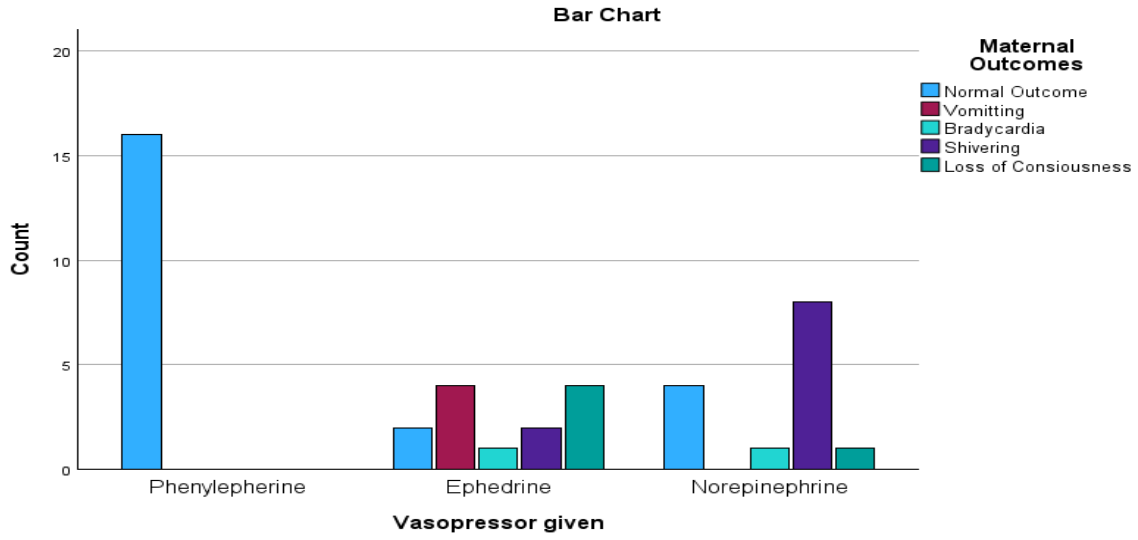


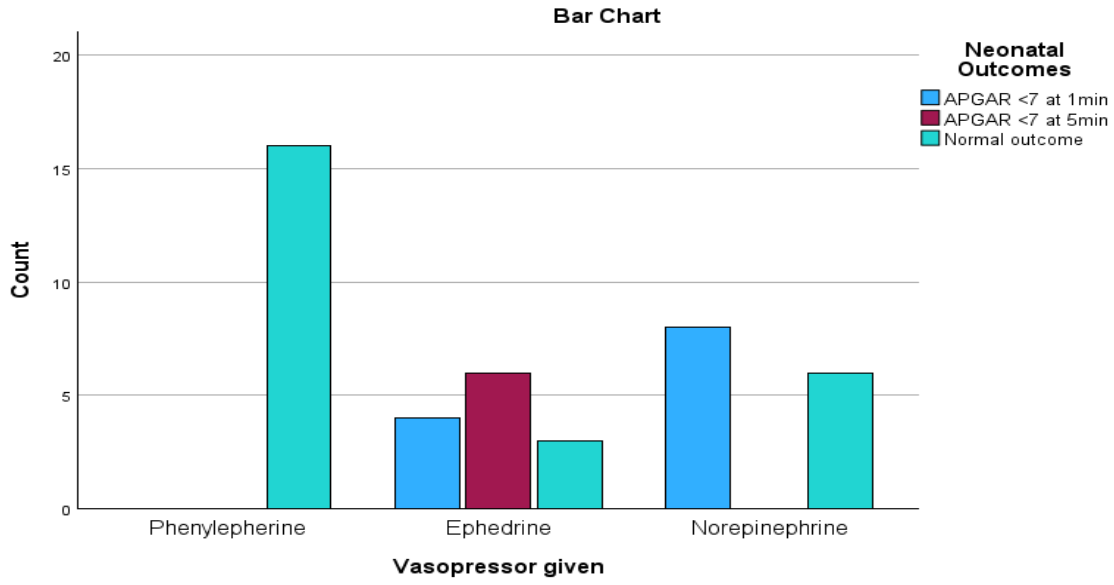
TABLE 4.14

Vasopressor given * Neonatal Outcomes Crosstabulation

		Neonatal Outcomes			
		APGAR <7 at 1min	APGAR <7 at 5min	Normal outcome	Total
Vasopressor given	Phenylepherine	0	0	16	16
	Ephedrine	4	6	3	13
	Norepinephrine	8	0	6	14
Total		12	6	25	43

Phenylephrine had the best neonatal outcomes as all the infants reported normal Apgar scores. Compromise between ephedrine and norepinephrine was observed as more babies with low Apgar at 1 minute. This strengthens phenylephrine as the most safe.

FIGURE 4.14



Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

Kruskal-Wallis Test
Vasopressor Given * Duration of Hypotension

Table 4.15

Ranks			
	Vasopressor given	N	Mean Rank
Number of Hypotensive Episodes	Phenylepherine	16	11.50
	Ephedrine	13	32.00
	Norepinephrine	14	24.71
	Total	43	

Test Statistics[a,b]

	Number of Hypotensive Episodes
Kruskal-Wallis H	24.457
df	2
Asymp. Sig.	<.001

a. Kruskal Wallis Test
b. Grouping Variable: Vasopressor given

The number of hypotensive episodes was significantly different between vasopressor groups ($p < 0.001$). Phenylephrine performed the best with the fewest episodes, Norepinephrine showed moderate performance, while ephedrine resulted in the highest number of hypotensive episodes.

Kruskal-Wallis Test
Vasopressor Given * Maternal Outcomes

Table 4.16

Ranks

	Vasopressor given	N	Mean Rank
Maternal Outcomes	Phenylepherine	16	11.50
	Ephedrine	13	29.19
	Norepinephrine	14	27.32
	Total	43	

Test Statistics[a,b]

	Maternal Outcomes
Kruskal-Wallis H	21.102
df	2
Asymp. Sig.	<.001

a. Kruskal Wallis Test
b. Grouping Variable: Vasopressor given

There is a statistically significant difference between vasopressors in terms of maternal outcomes. Phenylephrine produced the best maternal stability, while ephedrine resulted in the highest complication rates

Frontier in Medical & Health Research

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Kruskal-Wallis Test
Vasopressor Given * Neonatal Outcomes

Tabl3 4.17

Ranks

	Vasopressor given	N	Mean Rank
Neonatal Outcomes	Phenylepherine	16	31.00
	Ephedrine	13	16.31
	Norepinephrine	14	17.00
	Total	43	

Test Statistics[a,b]

	Neonatal Outcomes
Kruskal-Wallis H	16.821
df	2
Asymp. Sig.	<.001

a. Kruskal Wallis Test
b. Grouping Variable: Vasopressor given

Neonatal outcomes significantly varied across vasopressor groups. Phenylephrine resulted in the best Apgar scores, while ephedrine showed the poorest neonatal response.

Conclusion

This study had established that of all the high-risk obstetric patients who underwent spinal anesthesia, 43 patients developed hypotension which subsided in five minutes with most having a single episode. Phenylephrine was the most effective of the vasopressors and it offered the most rapid stabilization that involved a low number of maternal complications and the overall neonatal APGAR results. Norepinephrine was moderately controlling and ephedrine led to more frequent and longer lasting hypotensive events and higher maternal adverse effects and low neonatal outcome. However, the findings in general show that phenylephrine is the safest and the most effective vasopressor in the management of spinal-induced hypotension in high-risk obstetric patients.

4.1 To evaluate the perception

In the vast majority of cases, patients mentioned that they experienced sudden dizziness and weakness upon the decrease of their blood pressure after spinal anesthesia. Nevertheless, they were satisfied with the fact that the anesthesia team responded to them in a timely manner. According to many patients, the vasopressor treatment made them feel better in a short period of time and alleviated their suffering. Most of them were comforted by the frequent surveillance and feedback by the staff members. Altogether, the patients felt that the treatment of hypotension was effective, safe, and reassuring, and they liked the attention paid to them by the clinical team to their episode.

5 Discussion

The results of the current research can shed some valuable light on the efficacy of various vasopressors with the aim of treating hypotension induced by spinal conditions in high-risk obstetric patients. In the present study, every respondent (n=43) had hypotension following spinal anesthesia, which made it possible to directly compare treatment responses. The findings made it clear that phenylephrine was the most successful agent whereby a single short episode of the hypotensive effect was experienced by all the patients after 7-10 minutes of blood pressure stabilization. No maternal issues and no negative birth outcomes were mentioned in this cohort, which outlined the safety of the drug and its dependability. These findings are in line with the international evidence, which demonstrates that the gold-standard of the vasopressor in obstetric

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anesthesia is phenylephrine because of its high α-adrenergic efficacy and low side effects in fetuses (01).

Compared to it, norepinephrine was moderate in its performance. Although it helped to avoid prolonged hypotension, a high number of patients had repeated outbursts before they became stable. The trend is consistent with other studies indicating that norepinephrine can stabilize cardiac output compared to phenylephrine but it might necessitate more frequent changes in the case of spinal anesthesia. Although there were several incidents, the neonatal outcomes were satisfactory, which contributes to the reason why neonatal care would accept the use of norepinephrine as a viable alternative in case of shortage in phenylephrine (04).

Ephedrine however gave the least results. A number of patients had over three hypotensive incidences and time length was more predominant in this group. Ephedrine reported more maternal complications (vomiting, shivering and temporary loss of consciousness) because the effect was slower and mixed adrenergic. The results obtained are consistent with the world literature, which has increasingly abandoned ephedrine because of its fetal acidosis and delayed pediatric adaptation. In this research also, the tendency to have low Apgar scores was more prevalent in the babies that were born to mothers who took ephedrine (08).

There is also a support regarding the significance of promptly identifying and managing maternal hypotension. The care was perceived to be effective, timely, and reassuring by patients, which is why round-the-clock monitoring and effective communication can be important in cesarean delivery. This is in line with other research findings which stated that patient comfort and confidence levels will raise substantially whereby the management of hypotension is done in a proactive and efficient manner (13).

All in all, the results affirm the validity that phenylephrine is safest and most effective as a first-line vasopressor in the management of spinal induced hypotension among high-risk obstetric patients, especially in low resource settings such as in Pakistan. Since it has better maternal and neonatal outcomes, broader implementation of phenylephrine protocols in publicly operated hospitals in Lahore is necessary because ephedrine is still common in Lahore because of its affordability and availability concerns. Enhancement of training, provision of better supply of drugs and normalization of protocols used in obstetric anesthesia can greatly boost the safety of obstetric anesthesia in such facilities (19).

6 CONCLUSION

This paper has determined that the occurrence of hypotension which is induced by the spine is a clinical complication which is prevalent and common in all high-risk obstetric patients who have gone through cesarean surgeries. There was an analysis of the vasopressors and it was found that phenylephrine is the most appropriate, and the safest one, to stabilise the maternal blood pressure, reduce the rate, as well as, the duration of hypotensive episodes, and ensure the most favourable maternal and neonatal outcomes. Moderate hemodynamic control was provided to norepinephrine and ephedrine had the worse results, such as the long-term hypotension, rising side effects in the mothers, and lower neonatal Apgar scores. The results suggest that the early recognition, close monitoring, and the evidence-based selection of vasopressor in anesthesia under obstetrics is crucial. The availability of phenylephrine, its consistent application, particularly in low-resource hospitals, would be among the primary considerations in helping the high-risk pregnant women, to increase their safety and the quality of care. Overall, the study revolves around the concept that early intervention and adequate selection of medications and continuous communication between the participants of the anesthesia team are the most important aspects of preserving maternal physiology and ensuring good neonatal outcome in the case of spinal-induced hypotension.

6.1 RECOMMENDATIONS

- Phenylephrine must be introduced as the initial vasopressor to be used in the management of the spinal induced hypotension in high risk obstetric patients.
- Phenylephrine should be regularly available in the operation theatres of the hospitals particularly in governments and teaching hospitals.
- The anesthesia staff needs to be trained and refreshed on the new guidelines and protocols on the use of vasopressor infusion.

Frontier in Medical & Health Research

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- All cesarean deliveries with the spinal anesthesia should be performed with continuous non-invasive blood pressure monitoring.
- There should be a standardized version of management protocols on the management of hypotension that should be developed and carried out in the labor rooms and OTs.
- Maternal and neonatal complications associated with the use of ephedrines should be avoided by reducing its use especially in high-risk groups.
- In cases where phenylephrine is not available, norepinephrine can be utilized, and it should be monitored.
- Psychological intervention through patient education and preoperative counseling should be considered to enhance satisfaction and lower the level of anxiety.
- Future researches need to involve increased sample sizes and multi-centric data to enhance generalizability of results.

6.2 STUDY LIMITATIONS

- The sample used was only 43 patients therefore limiting applicability of findings to the general population.
- It was also done in two hospitals, which are not necessarily representative of the clinical setting.
- Patients only who developed hypotension were involved, thus preventing measures could not be assessed.
- There was also no fixed protocol as to the manner in which vasopressor dosage and method of administration was done; instead, it was done at the discretion of the clinician.
- No advanced hemodynamics monitoring (e.g., cardiac output) was provided, which made it difficult to assess it in detail.
- Only Apgar scores were used to evaluate neonatal outcomes and no cord blood gas.
- The study was an observational research design; randomized controlled trials would be more convincing.
- Self-reported perceptions on patient part might be affected by recall bias or emotional stress.

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