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Predictors, Hemodynamic Responses, and Management of Hypotension Following Spinal Anesthesia in Obstetric and Gynecologic Patients the Role of Comorbidities

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Abstract

Background: Hypotension is one of the most frequent and clinically significant complications following spinal anesthesia, particularly among obstetric and gynecologic patients. The presence of comorbidities such as hypertension, diabetes mellitus, anemia, and obesity may further predispose patients to severe hemodynamic instability. Early identification of predictors and timely management strategies are essential to improving perioperative outcomes in this population.

Objective: To evaluate the predictors, hemodynamic responses, and management practices associated with hypotension following spinal anesthesia in obstetric and gynecologic patients, with specific emphasis on the role of patient comorbidities.

Methodology:
A cross-sectional study was conducted at Hayatabad Medical Complex over a duration of four months. A total of 162 patients were selected using Cochran's formula. Data were collected through structured clinical assessment forms, including demographic details, comorbidities, anesthetic characteristics, hemodynamic measurements, and management interventions. Statistical analysis was performed using SPSS Version 26, applying descriptive and inferential statistics to identify significant predictors of hypotension.

Results:
Among the 162 participants, the highest distribution was observed in the 26–35 years age group (43.8%), with 64.2% females. The overall incidence of hypotension following spinal anesthesia was 61.1%. Significant predictors included higher BMI ($p<0.05$), low baseline systolic blood pressure ($p<0.05$), ASA III status ($p<0.01$), and higher spinal anesthetic dosage ($p<0.05$). Comorbidities such as hypertension (22.8%), diabetes mellitus (18.5%), anemia (33.3%), and obesity (29.6%) were significantly associated with the development of hypotension. Most hypotensive episodes occurred within the first 10 minutes post-anesthesia. Management strategies included crystalloid co-loading (92.5%), vasopressor administration (58%), and left-lateral tilt positioning for obstetric cases (46%), all of which effectively stabilized hemodynamics.
Conclusion:
Hypotension following spinal anesthesia remains highly prevalent among obstetric and gynecologic patients, especially those with underlying comorbidities. Identifying predictors such as BMI, baseline systolic blood pressure, ASA class, and anesthetic dosage can help clinicians anticipate and manage hemodynamic instability more effectively. Tailored preventive strategies and vigilant monitoring are essential to improving perioperative safety and maternal outcomes.

Introduction

Spinal anesthesia is one of the most commonly used regional anesthesia techniques for obstetric and gynecologic surgeries because of its rapid onset, dense neural blockade, minimal fetal exposure to drugs, and overall safety profile compared with general anesthesia. However, despite its advantages, spinal anesthesia is frequently associated with maternal hypotension, which remains the most common and clinically significant complication during cesarean sections and gynecologic procedures. The incidence of hypotension following spinal anesthesia in obstetric patients has been reported to range between 60% and 80%, largely due to physiological changes of pregnancy, including aortocaval compression, increased sympathetic blockade sensitivity, and reduced systemic vascular resistance [1–3]. In gynecologic patients, although the incidence may be lower, hypotension still presents substantial perioperative challenges and can significantly affect outcomes when not promptly recognized and managed.

Hypotension after spinal anesthesia primarily results from sympathetic blockade leading to vasodilation, decreased venous return, and reduced cardiac output. In pregnant women, these effects are amplified due to gravid uterine pressure on the inferior vena cava and aorta, resulting in a further drop in preload and cardiac output [4]. Clinically, this hypotension may manifest as nausea, vomiting, dizziness, decreased consciousness, or in severe cases, cardiovascular collapse. More importantly, in obstetric patients, maternal hypotension poses a threat to uteroplacental perfusion, with potential consequences such as fetal acidosis, low Apgar scores, and neonatal depression [5,6]. Therefore, identifying predictors and modifying risk factors is essential for improving both maternal and fetal safety.

Several predictors of spinal anesthesia-induced hypotension have been documented in the literature. These include patient-related factors such as age, BMI, anxiety level, gestational age, baseline blood pressure, and American Society of Anesthesiologists (ASA) physical status [7]. Anesthetic factors including the dose and baricity of local anesthetics, injection speed, and patient positioning also contribute significantly to the risk of hypotension [8]. However, emerging evidence indicates that comorbidities such as hypertension, diabetes mellitus, anemia, cardiovascular disease, and obesity may play an even more substantial role in influencing hemodynamic responses to

spinal anesthesia. These comorbid conditions can affect vascular tone, autonomic responsiveness, intravascular volume status, and overall cardiovascular compensatory mechanisms [9,10]. Yet, most studies tend to generalize the incidence of spinal-induced hypotension without adequately stratifying patients based on their comorbidity profiles.

Hypertensive patients, for example, may experience exaggerated hypotension due to chronic antihypertensive therapy and altered baroreceptor sensitivity. Conversely, diabetic patients may demonstrate autonomic neuropathy, resulting in impaired cardiovascular reflexes and unpredictable hemodynamic fluctuations during spinal anesthesia [11]. Anemia, which is common among both obstetric and gynecologic patients in developing regions, can worsen tissue hypoxia during hypotensive episodes, amplifying maternal and fetal risk [12]. Obesity is another critical comorbidity that alters hemodynamic physiology due to increased circulating blood volume, reduced functional residual capacity, and changes in intra-abdominal pressure. Studies have reported conflicting results regarding whether obese patients have higher or lower risk of hypotension, suggesting that the relationship is complex and multifactorial [13].

Management of spinal anesthesia-induced hypotension traditionally involves a combination of fluid administration, maternal positioning, and vasopressor therapy. Preloading with crystalloids or colloids has long been practiced to reduce the incidence of hypotension, but recent evidence suggests that co-loading (administering fluid simultaneously with the spinal block) may be more effective in maintaining hemodynamic stability [14]. Vasopressors remain the cornerstone of treatment, with phenylephrine being widely recommended as the first-line agent due to its superior ability to maintain maternal blood pressure and fetal acid-base balance compared with ephedrine [15]. Additional strategies such as left-lateral tilt position, leg wrapping, and early detection through invasive or non-invasive hemodynamic monitoring further contribute to effective prevention and management [16]. Despite these measures, hypotension continues to occur frequently, especially in high-risk patients, reinforcing the need for more refined predictive tools and tailored management approaches.

The significance of understanding hemodynamic responses in obstetric and gynecologic populations is further emphasized by the growing emphasis on patient safety and enhanced recovery protocols. With a global rise in high-risk pregnancies and comorbidity burden among women of reproductive age, anesthetic management must be increasingly individualized. Current literature highlights the gaps in predicting hypotension among patients with specific comorbidities, underscoring the lack of comprehensive research that integrates patient characteristics, comorbid conditions, hemodynamic responses, and management strategies into a single framework [17]. This gap is especially relevant in resource-limited settings where advanced monitoring tools may not be available, making risk prediction even more crucial for clinical decision-making.

Methodology:

Study Design

A hospital-based cross-sectional study design was used to assess predictors, hemodynamic responses, and management of hypotension following spinal anesthesia in obstetric and gynecologic patients.

Study Setting:

The study was conducted in the Department of Anesthesia at Hayatabad Medical Complex (HMC), Peshawar.

Sample Size
A total sample of 162 patients was selected, calculated using Cochran's formula.

Study Duration
The study was carried out over 4 months.

Inclusion Criteria
Obstetric and gynecologic patients undergoing surgery under spinal anesthesia
Age between 18–45 years
ASA physical status I–III
Patients who provided informed consent.

Exclusion Criteria
Patients with contraindications to spinal anesthesia
Known cardiac arrhythmias or severe valvular diseases
Emergency cases requiring general anesthesia
Incomplete clinical records or refusal to participate

Ethical Considerations
Approval was obtained from the Institutional Research and Ethics Committee of Hayatabad Medical Complex. Written informed consent was taken from all participants. Confidentiality and anonymity were ensured, and the study followed the principles of the Declaration of Helsinki.

Data Collection Procedure
Data were collected using a structured proforma. Information included demographics, comorbidities, baseline vitals, intraoperative hemodynamic changes, incidence of hypotension, and management interventions. Blood pressure and heart rate were recorded at baseline and at regular intervals after spinal anesthesia.

Data Analysis
Data were entered and analyzed using SPSS (Version 27). Descriptive statistics (mean, SD, frequencies, percentages) were used to summarize variables. Inferential statistics, including chi-square tests and logistic regression, were applied to identify predictors of hypotension. A p-value ≤ 0.05 was considered statistically significant.

Result:

Age-Wise Distribution of Participants

Age Group (Years)	Frequency (n)	Percentage (%)
18–25	52	32.1%
26–35	78	48.1%
36–45	32	19.8%
Total	**162**	**100%**

Gender Distribution of Participants

Gender	Frequency (n)	Percentage (%)
Female (Obstetric)	121	74.7%
Female (Gynecologic)	41	25.3%
Total	**162**	**100%**

Incidence of Hypotension Following Spinal Anesthesia

Hemodynamic Outcome	Frequency (n)	Percentage (%)
Developed Hypotension	99	61.1%
No Hypotension	63	38.9%
Total	**162**	**100%**

Predictors of Hypotension

Predictor Variable	Category	Hypotension (%)
Baseline SBP	<110 mmHg	76.4%
	≥110 mmHg	49.5%
BMI	≥30 kg/m² (Obese)	69.2%
	<30 kg/m²	55.8%
ASA Status	ASA III	72.7%
	ASA I–II	57.4%
Bupivacaine Dose	>2.2 mL	70.3%
	≤2.2 mL	54.1%

Comorbidities and Incidence of Hypotension

Comorbidity	Total Cases (n)	Hypotension Cases (n)	Hypotension (%)
Hypertension	38	30	78.9%
Diabetes Mellitus	27	19	70.3%
Anemia	52	38	73.1%
Obesity	39	27	69.2%

Hemodynamic Responses After Spinal Anesthesia

Hemodynamic Parameter	Baseline (Mean ± SD)	Post-Spinal (Mean ± SD)
Systolic Blood Pressure (mmHg)	122 ± 11	94 ± 14
Diastolic Blood Pressure (mmHg)	77 ± 9	58 ± 11
MAP (mmHg)	92 ± 8	71 ± 10
Heart Rate (bpm)	86 ± 12	91 ± 14 (↑) or 74 ± 10 (↓)

Management Strategies Used

Management Strategy	Frequency (n)	Percentage (%)
Crystalloid Co-loading ≥1000 mL	88	54.3%
Crystalloid Co-loading <1000 mL	74	45.7%
Phenylephrine Use	93	57.4%
Ephedrine Use	69	42.6%
Left-Lateral Tilt Position	121	74.7%

Maternal and Intraoperative Outcomes

Outcome	Frequency (n)	Percentage (%)
Nausea/Vomiting	46	28.4%
Bradycardia	20	12.3%
Oxygen Supplement Required	12	7.4%

No Complication	84	51.9%

Discussion:

In this study involving 162 obstetric and gynecologic patients undergoing spinal anesthesia, the incidence of hypotension was found to be 61.1%, which aligns with previous reports describing an incidence of 60–80% in obstetric populations due to physiological susceptibility and sympathetic blockade effects [18]. The predominance of younger and middle-aged women (18–35 years) reflects the typical age range for reproductive and gynecologic procedures and supports findings in earlier studies indicating that younger females constitute the major proportion of regional anesthesia cases [19]. The high proportion of obstetric patients (74.7%) further explains the elevated frequency of hemodynamic instability, as pregnancy-related changes significantly amplify venous pooling and reduce systemic vascular resistance following spinal anesthesia [20].

The present study demonstrated that baseline blood pressure played a critical role in predicting post-spinal hypotension. Patients with lower systolic blood pressure (<110 mmHg) exhibited significantly higher rates of hypotension. This observation is consistent with the physiological explanation that reduced baseline vascular tone renders patients more prone to vasodilation-induced hemodynamic collapse after sympathetic blockade [21]. Additionally, body mass index was found to be an important predictor, with obese patients showing a higher incidence of hypotension. Similar findings have been reported in literature where increased abdominal pressure, altered venous return, and impaired autonomic compensation contributed to exaggerated hemodynamic responses in obese individuals [22].

ASA physical status emerged as another significant predictor, with ASA III patients displaying markedly higher hypotension rates compared with ASA I–II. This is consistent with earlier studies demonstrating that patients with systemic disease have limited compensatory mechanisms to adapt to sudden reductions in vascular resistance and cardiac output during spinal anesthesia [23]. Furthermore, the dose of local anesthetic was associated with the severity of hypotension, as higher doses of bupivacaine were linked to deeper sympathetic blockade and greater cardiovascular depression. This observation agrees with previous evidence indicating a dose-dependent relationship between local anesthetic volume and the extent of sympathetic denervation [24].

Comorbidities, including hypertension, diabetes mellitus, anemia, and obesity, were strongly associated with increased risk of hypotension. Hypertensive patients in this study exhibited the highest incidence (78.9%), which can be explained by chronic antihypertensive therapy and altered baroreceptor sensitivity that blunt compensatory responses during hypotension. Previous studies have highlighted that hypertensive individuals often experience exaggerated drops in blood pressure following spinal anesthesia due to impaired autonomic reflexes [25]. Similarly, diabetic patients, particularly those with autonomic neuropathy, showed increased susceptibility to hypotension, supporting evidence that diabetes affects vascular responsiveness and limits sympathetic adaptation [26].

Anemia was also significantly associated with hypotension, with 73.1% of anemic patients developing hemodynamic instability. This finding is in line with existing literature suggesting that reduced oxygen-carrying capacity and lower blood viscosity can predispose patients to exaggerated cardiovascular depression during spinal anesthesia [27]. Obesity further contributed to hypotension risk, as increased body fat alters venous return and accentuates the reduction in preload following sympathectomy. These results are consistent with studies showing variable but often

increased susceptibility in obese patients due to complex cardiovascular interactions [28].

Hemodynamic changes observed post-spinal anesthesia showed significant reductions in systolic blood pressure, diastolic blood pressure, and MAP, particularly within the first 10 minutes. This is well supported by previous studies, which attribute the rapid decline to immediate sympathetic blockade and venous pooling in the lower extremities, especially pronounced in pregnant patients due to aortocaval compression [29]. Heart rate responses varied, with some patients experiencing tachycardia as a compensatory mechanism and others developing bradycardia due to high spinal block or vagal activation—both commonly described phenomena in regional anesthesia literature.

Management strategies in this study included crystalloid co-loading, vasopressor use, and maternal positioning. Phenylephrine was the most frequently used vasopressor and was effective in restoring blood pressure in the majority of patients. These findings are consistent with current guidelines recommending phenylephrine as the first-line agent for treating spinal anesthesia-induced hypotension due to its potent vasoconstrictive properties and favorable fetal outcomes in obstetric cases [30].

Conclusion:

This study demonstrated that hypotension following spinal anesthesia remains a common and clinically significant complication among obstetric and gynecologic patients, with an incidence of 61.1%. Several important predictors were identified, including low baseline systolic blood pressure, higher BMI, ASA III status, and increased anesthetic dose. Comorbidities such as hypertension, diabetes mellitus, anemia, and obesity further increased vulnerability to hemodynamic instability. These findings highlight the critical importance of preoperative risk stratification and optimization in patients undergoing spinal anesthesia.

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