Scientific Journal for Publishing in Health Research and Technology

Volume 2, Issue 1, 2026, Pages: 136-149

Journal homepage: https://sjphrt.com.ly/index.php/sjphrt/en/index

Effect of Preoperative Intravenous Fluid Therapy on Maternal Blood Pressure Stability During Spinal Anesthesia for Caesarean Section

Souad Fareg Mohammed Dadoush *
Department of Gynecology and Obstetrics, Faculty of Medicine, Elmergib University, Libya

أثر العلاج بالسوائل الوريدية قبل العملية على استقرار ضغط دم الأم أثناء التخدير النصفي للعملية القيصرية

سعاد فرج محمد دعدوش *
قسم أمراض النساء والتوليد، كلية الطب، جامعة المرقب، ليبيا

*Corresponding author: souadfareg77@gmail.com

Received: October 22, 2025	Accepted: December 23, 2025	Published: January 26, 2026

Abstract:
Cesarean section (CS) is the most frequently performed major surgical procedure worldwide, with rates steadily increasing and stabilizing between 18% and 22% as observed in this study at Zliten Medical Center from 2020 to 2025. Spinal anesthesia remains the preferred technique for these deliveries due to its safety and high success rate, yet it is frequently complicated by maternal hypotension. This cross-sectional study investigated the effect of preoperative intravenous fluid therapy on maternal blood pressure stability among 102 pregnant women undergoing CS under spinal anesthesia in Libya. The participants, primarily aged 30 to 40 years, were monitored for hemodynamic changes and clinical symptoms. Results indicated that while Normal Saline (NS) was the most common fluid used (67.8%), it only provided mid-term stabilization and could not completely prevent an early decline in systolic blood pressure, which dropped to 104 mmHg at 30 minutes post-induction. In contrast, Ringer's Lactate and Gelofusine showed relatively better recovery speeds. Nausea and vomiting were the most prevalent clinical signs of hypotension, affecting 33.3% of patients, followed by sleepiness and headache. Statistical regression analysis confirmed a significant relationship between both the type and quantity of preoperative fluids and blood pressure stability ($p < 0.001$). The study concludes that although preoperative fluid loading is fundamental in reducing the severity of spinal anesthesia-induced hypotension, it is insufficient as a standalone preventive measure. Consequently, the research recommends adopting standardized fluid protocols individualized to patient characteristics and combining them with vasopressors to optimize maternal and neonatal safety.

Keywords: Cesarean Section, Spinal Anesthesia, Maternal Hypotension, Intravenous Fluid Therapy, Hemodynamic Stability.

الملخص

تعد العملية القيصرية الجراحة الكبرى الأكثر شيوعاً على مستوى العالم، حيث أظهرت هذه الدراسة استقرار معدلاتها بين 18% و22% في مركز زليتن الطبي خلال الفترة من 2020 إلى 2025 .ويظل التخدير النصفي هو التقنية المفضلة لهذه العمليات نظراً لسلامته ومعدلات نجاحه العالية، ومع ذلك، فإنه غالباً ما يترافق مع مضاعفات هبوط ضغط دم الأم .بحثت هذه الدراسة المقطعية في أثر العلاج بالسوائل الوريدية قبل العملية على استقرار ضغط دم الأم لدى 102 امرأة حامل خضعن للولادة القيصرية تحت التخدير النصفي في ليبيا .تم مراقبة المشاركات، اللواتي تراوحت أعمارهن بشكل أساسي بين 30 و40 عاماً، لرصد التغيرات الهيموديناميكية والأعراض السريرية .وأشارت النتائج إلى أن المحلول الملحي العادي كان السائل الأكثر استخداماً بنسبة 67.8%، ولكنه وفر استقراراً متوسط المدى فقط ولم يتمكن من منع الانخفاض المبكر في ضغط الدم الانقباضي بشكل كامل، حيث انخفض إلى 104 ملم زئبق بعد 30 دقيقة من الحث .في المقابل، أظهر محلول رينجر لاكتات والجيلوفوسين سرعة تعافٍ أفضل نسبياً .وكانت الغثيان والقيء من أبرز العلامات السريرية لهبوط الضغط، حيث أثرت على 33.3% من المريضات، تليها النعاس والصداع .وأكد تحليل الانحدار الإحصائي وجود علاقة ذات دلالة إحصائية بين نوع وكمية السوائل قبل العملية واستقرار ضغط الدم .($p < 0.001$) تخلص الدراسة إلى أن تحميل السوائل قبل العملية يعد أمراً أساسياً في تقليل شدة هبوط الضغط الناتج عن التخدير النصفي، إلا أنه غير كافٍ كإجراء وقائي وحيد .وبناءً على ذلك، توصي الدراسة باعتماد بروتوكولات سوائل موحدة مصممة وفقاً لخصائص المريضة ودمجها مع الأدوية الرافعة للضغط لتحسين سلامة الأم والجنين.

الكلمات المفتاحية :العملية القيصرية، التخدير النصفي، هبوط ضغط دم الأم، العلاج بالسوائل الوريدية، الاستقرار الهيموديناميكي.

1. INTRODUCTION

Cesarean section (CS) is the most frequently performed major surgical procedure worldwide. By 2020, it was estimated that approximately one in five births would occur via cesarean delivery, reflecting a substantial increase in its global utilization. In 1990, the worldwide average rate of cesarean section was reported to be 6.7% (Ropert, 2019).

Spinal anesthesia is currently the preferred anesthetic technique for cesarean deliveries globally due to its high success rate and favorable safety profile. It is estimated that nearly 72% of hospital-based cesarean deliveries are conducted under spinal anesthesia (Yu, et. al., 2019). Despite its widespread use, spinal anesthesia is commonly associated with maternal hypotension, which remains the most frequent and clinically significant adverse effect during cesarean section (Ebraham, 2018).

Maternal hypotension during cesarean delivery can compromise uteroplacental perfusion and pose serious risks to both the mother and the fetus. Therefore, maintaining hemodynamic stability throughout the procedure is essential, and preventive as well as therapeutic interventions are required to minimize blood pressure fluctuations (Oh, et.al., 2014). Although spinal anesthesia is considered the anesthetic technique of choice for cesarean sections, its hemodynamic consequences—particularly hypotension—continue to represent a major anesthetic challenge.

Several studies have also compared cesarean delivery trends in the United States with those in other countries, revealing notable variations in practice patterns. While similar rates of cesarean sections for breech presentation and fetal distress have been reported in the United States and northern European countries such as Norway, Scotland, and Sweden, higher rates of cesarean delivery in the United States have been attributed to previous cesarean sections and labor dystocia. In light of these considerations, the present study aims to evaluate the effect of

preoperative intravenous fluid administration on maternal blood pressure during spinal anesthesia in cesarean section.

2. MATERIALS AND METHODS

2.1 Research Design

This study adopted a cross-sectional research design to investigate the effect of preoperative intravenous fluid administration on maternal blood pressure during spinal anesthesia for cesarean section in Libya in 2023. The assessment was based on measuring maternal blood pressure at predefined time points before and after the induction of spinal anesthesia during the cesarean procedure.

In addition, a structured questionnaire was administered to pregnant women undergoing cesarean delivery to collect supplementary data related to preoperative intravenous fluid administration and its perceived impact on blood pressure stability during spinal anesthesia. This combined approach enabled a comprehensive evaluation of the relationship between preoperative fluid therapy and hemodynamic changes associated with spinal anesthesia in cesarean sections.

2.2 Study Sample

The present study included a sample of 102 pregnant women scheduled for cesarean section at the Zliten Medical Center as well as selected private clinics operating in Zliten city. The participants were randomly selected and represented a wide age range, extending from under 20 years to over 40 years.

Ethical approval for the study protocol was obtained from the Faculty of Health Sciences at Al-Asmarya Islamic University, Libya. All participants were informed about the purpose of the study prior to data collection.

A structured questionnaire was randomly administered to each participant to assess the presence of symptoms associated with hypotension following spinal anesthesia. These symptoms included headache, nausea or vomiting, drowsiness, dizziness, general weakness, or the absence of any symptoms.

2.3 Scope and Limitations of the Study

This study focused on evaluating the effect of preoperative intravenous fluid administration on maternal blood pressure during spinal anesthesia for cesarean section. The research was conducted exclusively at Zliten Medical Center, Al-Juma Domestic Hospital, and selected private clinics where cesarean deliveries are routinely performed.

Accordingly, the findings of this study are limited to the population and clinical settings within Zliten city and may not be fully generalizable to other regions or healthcare facilities. The data were collected over a defined period extending from January 2025 to April 2026.

2.4 Procedure

A structured questionnaire was developed to collect comprehensive data from the study participants. The questionnaire included demographic characteristics such as maternal age, categorized into four groups (< 20 years, 20–<30 years, 30–<40 years, and ≥ 40 years). In addition, medical history variables were recorded, including the presence of chronic diseases such as hypertension (HTN), diabetes mellitus (DM), asthma, and anemia.

Clinical data collection also encompassed blood pressure measurements taken before and after the induction of spinal anesthesia, along with relevant parameters such as body weight and timing of measurements. Information regarding preoperative intravenous fluid therapy was documented, including the type and volume of fluids administered prior to spinal anesthesia. Furthermore, signs and symptoms associated with hypotension—such as headache, nausea, vomiting, dizziness, weakness, or absence of symptoms—were systematically assessed.

The study was conducted at Zliten Medical Center, Al-Juma Domestic Hospital, and selected private clinics where cesarean sections are routinely performed. Maternal blood pressure was

continuously monitored and documented both before and after the induction of spinal anesthesia to identify the occurrence of hypotension and related clinical manifestations.

2.5Statistical Analysis of Data

Data analysis was performed using the Statistical Package for the Social Sciences (SPSS), version 18. Prior to statistical testing, all quantitative variables were assessed for normality using the Kolmogorov–Smirnov test. Continuous variables were summarized and presented as means and standard deviations.

Comparisons of mean values between groups were conducted using the independent samples t-test, while one-way analysis of variance (ANOVA) was applied to examine differences among more than two groups. These analyses were used to evaluate variations in blood pressure levels and the occurrence of hypotension among pregnant women undergoing cesarean section under spinal anesthesia, in relation to preoperative intravenous fluid administration.

Categorical variables were expressed as frequencies and percentages and analyzed using cross-tabulation. Pearson's chi-square test was employed to assess the association between the dependent variable (maternal hypotension) and independent variables related to preoperative intravenous fluid therapy during spinal anesthesia for cesarean section. All statistical tests were two-tailed, and results were considered statistically significant at a confidence level of 95% ($p < 0.05$).

3. ETHICS APPROVAL

Formal permission to conduct the study was obtained from the relevant authorities at Zliten Medical Center, including approval from the Head of the Cesarean Section Department. Informed consent was obtained from all participants prior to their inclusion in the study, and they were assured of their right to withdraw from the research at any stage without any consequences. All collected data were handled with strict confidentiality, and participants' privacy was fully respected throughout the research process.

4. RESULTS

4.1 Cesarean Section Statics

Table 1. The Caesarean Sections Comparison from (2020 – 2024)

Year	Caesarean Cases	
	Total	**%**
2020	1249	21%
2021	1091	18%
2022	1230	21%
2023	1319	22%
2024	1058	18%
	Total	%
	5947	**100%**

Table (1) presents the annual distribution of cesarean section (CS) cases recorded between 2020 and 2025, with a total of 5,947 cesarean deliveries. The findings indicate a relatively stable pattern of cesarean section rates over the study period, with annual proportions ranging from 18% to 22%. The highest proportion was observed in 2023 (22%), while the lowest rates were recorded in 2021 and 2024 (18%).

These results are consistent with global epidemiological evidence demonstrating a sustained increase and stabilization of cesarean section rates worldwide over the past three decades. Globally, the mean cesarean section rate increased from approximately 6.7% in 1990 to more than 21% by 2018, with projections suggesting a further rise to nearly 28.5% by 2030 if current

trends continue (Betrán et al., 2021). The rates observed in the present study fall within this global range, indicating that the local pattern of cesarean delivery aligns with international trends.

Several studies have emphasized that the growing reliance on cesarean delivery is influenced by a combination of medical, organizational, and socio-demographic factors, including changes in obstetric practice, increased use of fetal monitoring, medico-legal concerns, and maternal preferences (Boerma et al., 2018; Soto-Vega et al., 2015). The relatively modest year-to-year variation observed in this study suggests a consistent clinical reliance on cesarean section as a mode of delivery, rather than abrupt shifts in obstetric policy.

From an anesthetic and perioperative perspective, the high and sustained volume of cesarean sections highlights the clinical importance of optimizing anesthetic management during these procedures. Spinal anesthesia remains the most commonly used technique for cesarean delivery worldwide; however, maternal hypotension remains one of its most frequent and clinically significant complications (Kinsella et al., 2018). Consequently, the large number of cesarean cases documented during the study period provides a strong clinical rationale for investigating strategies aimed at improving maternal hemodynamic stability, such as the administration of preoperative intravenous fluids.

In this context, the current study's focus on the effect of preoperative intravenous fluid therapy on maternal blood pressure stability during spinal anesthesia is well justified. The findings of Table (1) underscore that even modest improvements in perioperative management may have a substantial impact on maternal outcomes, given the high volume of cesarean deliveries performed annually. This interpretation is consistent with previous research emphasizing that optimizing fluid management protocols is a key component in reducing anesthesia-related hypotension and improving both maternal and neonatal safety during cesarean section (Bishop et al., 2020; Kinsella et al., 2018).

4.2 Age of the participants

A total of 102 pregnant women undergoing cesarean section at Zliten Medical Hospital were included in the study. Figure (1) illustrates the distribution of the surveyed participants who received preoperative intravenous fluid therapy during spinal anesthesia, categorized according to their age groups.

Table 2. Age of the participants

Age	**Total**	**%**
Less than 20 yrs.	21	21%
20 to less than 30 yrs.	29	28%
30 to less than 40 yrs.	47	46%
over 40 yrs.	5	5%
Sum	**102**	**100%**

The age distribution of the study participants indicates that the majority of pregnant women undergoing cesarean section were within the age group of 30 to less than 40 years, accounting for 46% (n = 47) of the total sample. This finding suggests that cesarean delivery is more prevalent among women in advanced reproductive age, which is often associated with increased obstetric risks and medical indications for surgical delivery.

The second largest age group was 20 to less than 30 years, representing 28% (n = 29) of the participants, followed by women aged less than 20 years at 21% (n = 21). In contrast, women aged over 40 years constituted of the sample, accounting for only 5% (n = 5).

Overall, the age distribution reflects a concentration of cesarean sections among women in the middle reproductive age range, which is consistent with clinical practice, as this group is more likely to experience pregnancy-related complications requiring cesarean delivery. This

demographic pattern provides an appropriate context for assessing the effect of preoperative intravenous fluid therapy on maternal blood pressure stability during spinal anesthesia.

4.3 Patient history (Chronic disease)

Table (4.1) illustrates the prevalence of chronic medical conditions among the patients, with particular emphasis on hypertension, diabetes mellitus, asthma, anemia, and other comorbidities that may influence maternal hemodynamic stability during spinal anesthesia.

Table 3. Patient history (Chronic disease)

No.	**Chronic diseases**	**Total**	**%**
1.	HTN	5	4.9%
2.	D.M	14	13.7%
3.	ASTHMA	19	18.6%
4.	ANEMIA	27	26.5%
5	NON	37	36.3%
Sum		**102**	**100%**

The results presented in Table (3) demonstrate a noticeable variation in the prevalence of chronic medical conditions among pregnant women undergoing cesarean section. Anemia was the most common condition, affecting 26.5% of the participants, highlighting its widespread occurrence among pregnant women and its potential impact on maternal hemodynamic stability during spinal anesthesia.

Asthma ranked second with a prevalence of 18.6%, followed by diabetes mellitus at 13.7%, while hypertension showed the lowest prevalence at 4.9%. Although hypertension is traditionally considered a major risk factor for blood pressure instability, the presence of anemia and other chronic conditions may also significantly influence the incidence and severity of hypotension during spinal anesthesia.

Notably, 36.3% of the participants reported no chronic medical conditions, providing a useful reference group for comparing blood pressure responses and evaluating the effect of preoperative intravenous fluid therapy. Overall, these findings emphasize the clinical importance of thorough preoperative medical assessment, as chronic comorbidities play a critical role in maternal cardiovascular responses and should be carefully considered when managing spinal anesthesia for cesarean delivery.

4.4 Blood Pressure before and after spinal anesthesia

Table 4. The findings of (BP) before spinal anesthesia according to Age

Age	**Blood Pressure (BP)**	Total	%
< 20yrs	130/80	36	38%
20yrs - <30yrs	140/70	28	27%
30yrs - <40yrs	110/60	23	20%
> 40yrs	150/90	15	15%
Sum		**102**	**100%**

The distribution of baseline blood pressure (BP) before spinal anesthesia in the present study revealed notable variations across age groups. Younger women (<20 years) exhibited predominantly normal-to-high baseline BP, whereas the 30–<40 years group showed. relatively lower baseline readings, and the >40 years group demonstrated higher BP values, indicating potential age-related cardiovascular differences.

These findings are consistent with evidence from current literature indicating that baseline blood pressure is a significant predictor of spinal anesthesia-induced hypotension (SAIH) in cesarean section. For example, Shitemaw et al. (2020) reported that baseline systolic BP <120

mmHg was strongly associated with increased risk of intraoperative hypotension following spinal anesthesia during cesarean delivery (AOR = 6.293, $p < 0.05$) in an Ethiopian cohort, underscoring that lower pre-anesthesia BP predisposes to greater hemodynamic instability under regional block conditions (Shitemaw et al., 2020).

Similarly, Betrán et al. (2021) highlighted those physiological changes in pregnancy, including vascular responsiveness and autonomic balance, influence maternal BP responses under spinal anesthesia, especially across different age groups and baseline hemodynamic states (Betrán et al., 2021).

Moreover, age-related vascular changes have been discussed in studies showing that elderly parturients may exhibit more pronounced hypotensive responses to sympathetic blockade, due to reduced baroreceptor sensitivity and altered cardiac output dynamics (Hofhuizen, 2019), which may explain the relatively higher pre-anesthesia BP in older women (>40 years) in our sample.

Overall, the age-dependent variations in pre-spinal BP observed in this study align with prior evidence that baseline hemodynamic status, often influenced by age and cardiovascular adaptations in pregnancy, is a key factor in predicting maternal BP behavior during spinal anesthesia for cesarean section.

4.5 The effect of normal saline (SN) fluid on blood pressure level during spinal anesthesia

Table 5. Temporal Changes in Blood Pressure after Spinal Anesthesia According to the Type and Volume of Preoperative Intravenous Fluids

Category	**Type of Fluids**	**Injected Amount**	**Total of Cases**	%	**BP**	**Blood Pressure (BP) and Time measured**				
						30min later	**1hr Later**	**1:30hts later**	**2:00hrs later**	**2:30 hr later**
Group1	NS	2500CC	69	67.8	Systolic (BP)	104	110	118	104	125
					Diastolic BP	70	68	82	83	81
Group2	RL	2500CC	24	23.5	Systolic (BP)	102	106	118	105	139
					Diastolic BP	74	70	79	82	74
Group3	Gelofusine	1000CC	9	8.8	Systolic (BP)	95	105	112	119	110
					Diastolic BP	62	66	67	74	72
Sum			**102**	**100 %**						

Table (5) illustrates the temporal changes in systolic and diastolic blood pressure following spinal anesthesia according to the type and volume of preoperative intravenous fluids administered. The results indicate that Normal Saline (NS) was the most frequently used fluid, administered to 69 patients (67.8%), reflecting its widespread use in routine obstetric anesthesia practice due to its availability and familiarity.

In Group 1 (NS, 2500 ml), an initial reduction in systolic blood pressure was observed at 30 minutes post-spinal anesthesia (104 mmHg). This finding is consistent with the well-established physiological effects of spinal anesthesia, which include sympathetic blockade,

peripheral vasodilation, and a consequent reduction in systemic vascular resistance (Fitzgerald et al., 2020). Despite this early decline, systolic blood pressure showed a gradual recovery within the first hour and at 1.5 hours, reaching 118 mmHg, followed by relative stabilization at subsequent measurement points.

Diastolic blood pressure exhibited only minor fluctuations and remained within clinically acceptable limits throughout the observation period. This pattern suggests that normal saline provides a moderate degree of hemodynamic support, although it does not fully eliminate the risk of early hypotension immediately following spinal anesthesia.

These findings are in agreement with previous studies reporting that crystalloid preloading alone is often insufficient to completely prevent spinal anesthesia–induced hypotension, but can attenuate its severity and duration (Oh et al., 2014; Munyanziza et al., 2022). Fitzgerald et al. (2020) similarly noted that while crystalloid fluids contribute to blood pressure maintenance, their effectiveness is limited by rapid redistribution from the intravascular space, particularly during the early post-spinal period.

When compared with Ringer's Lactate and Gelofusine groups, differences were observed in both the magnitude and speed of blood pressure recovery. Although NS demonstrated acceptable mid-term blood pressure stabilization, colloid solutions such as Gelofusine showed a tendency toward more sustained intravascular volume expansion, as reported in earlier randomized trials (Gunusen et al., 2010; De Jong & Den Hartog, 2010). Nevertheless, the predominant use of NS in the present study reflects real-world clinical practice in many low- and middle-income settings, where colloids may be less accessible.

Overall, the results of this study suggest that preoperative administration of normal saline in adequate volumes contributes to improved hemodynamic stability following spinal anesthesia during cesarean section. However, the early decline in systolic blood pressure observed indicates that normal saline alone may be insufficient to fully prevent early hypotension, especially in high-risk patients. This supports current evidence recommending multimodal preventive strategies, including optimized fluid management combined with vasopressor therapy, to achieve optimal maternal blood pressure stability during cesarean delivery under spinal anesthesia (Fitzgerald et al., 2020; Munyanziza et al., 2022).

4.6 Signs and symptoms of hypotension

After induction of spinal anesthesia, arterial blood pressure was systematically monitored and recorded for each participant. Clinical manifestations suggestive of hypotension were carefully observed and documented throughout the perioperative period. The collected findings regarding blood pressure changes and associated signs and symptoms of hypotension are summarized in Table (6).

Table 6. Clinical Signs and Symptoms Associated with Hypotension Following Spinal Anesthesia

No.	Signs and symptoms	Total	%
1.	Headache	14	13.7%
2.	Nausea or vomiting	34	33.3%
3.	sleepiness	29	28.4%
4.	dizziness	11	10.8%
5.	weakness	8	7.8%
6.	others	6	5.9%
Sum		**102**	**100%**

spinal anesthesia among the study participants. The findings indicate that nausea and vomiting were the most frequently reported symptoms, occurring in 34 patients (33.3%), followed by sleepiness in 29 patients (28.4%) and headache in 14 patients (13.7%). Less common

manifestations included dizziness (10.8%) and general weakness (7.8%), while other symptoms were reported in a small proportion of cases (5.9%).

This pattern of clinical manifestations is consistent with the well-documented physiological effects of spinal anesthesia–induced hypotension, which results primarily from sympathetic blockade leading to peripheral vasodilation, reduced venous return, and transient decreases in cerebral and gastrointestinal perfusion. Several studies have identified nausea and vomiting as the most common early clinical indicators of maternal hypotension during spinal anesthesia for cesarean section (Fitzgerald et al., 2020; Kinsella et al., 2018).

The relatively high prevalence of sleepiness observed in the present study may reflect mild cerebral hypoperfusion secondary to transient reductions in systolic blood pressure. Similar findings were reported by Oh et al. (2014), who noted that neurological symptoms such as drowsiness and headache often accompany early hypotensive episodes, even before marked declines in blood pressure are detected on monitoring devices.

Headache, reported by 13.7% of participants, may be attributed to fluctuations in cerebral blood flow or early post-dural puncture effects, although its incidence in this study remained lower than that of gastrointestinal symptoms. This observation aligns with previous reports indicating that headache is less frequent than nausea and vomiting in spinal anesthesia–related hypotension (Munyanziza et al., 2022).

The comparatively low incidence of dizziness and generalized weakness suggests that most hypotensive episodes were mild to moderate in severity, without progression to severe hemodynamic instability. This may be explained by the early identification of symptoms and timely interventions, including preoperative fluid administration and continuous hemodynamic monitoring. De Jong and Den Hartog (2010) emphasized that prompt recognition of subjective symptoms is crucial, as clinical manifestations often precede significant numerical declines in blood pressure.

Overall, the findings of this study reinforce the importance of systematic monitoring of clinical symptoms in conjunction with blood pressure measurements during spinal anesthesia for cesarean delivery. Reliance solely on numerical blood pressure values may underestimate early hypotensive events, whereas symptom-based assessment provides an additional layer of clinical safety. These results support current anesthetic guidelines advocating for early preventive and corrective strategies to minimize maternal discomfort and optimize hemodynamic stability during cesarean section under spinal anesthesia (Kinsella et al., 2018; Fitzgerald et al., 2020).

Table 7. Statistical Analysis of the Impact of Intravenous Fluid Characteristics on Maternal Hypotension Following Spinal Anesthesia

variable	**Correlation Coefficient (r)**	**Determination Coefficient (R^2)**	**F Calculated Value**	**F Tabular Value**	**P-Value**	**t-test**	**Regression Coefficient β**	**Decision**
Fluid Type	0.876	0.749	241.657	3.94	0.000	18.15	0.876	There is an effect
Quantity of Fluid	0.924	0.817	315.943		0.000	24..15	0.924	There is an effect

Table 7 presents a regression analysis examining the influence of both type and quantity of preoperative intravenous fluids on maternal hypotension induced by spinal anesthesia. The

correlation coefficients (r = 0.876 for fluid type and r = 0.924 for fluid quantity) indicate strong positive relationships between these predictors and maternal blood pressure outcomes. The high determination coefficients (R^2 = 0.749 and 0.817, respectively) suggest that a substantial portion of the variance in hypotension outcomes is explained by these variables. Furthermore, the calculated F values far exceed the tabular critical values (3.94), and the t-tests (t = 18.15 and t = 24.18) are highly significant ($p < 0.001$), confirming that both fluid characteristics have a statistically significant effect on maternal hypotension following spinal anesthesia.

These findings are consistent with the broader literature demonstrating that fluid management plays a key role in mitigating spinal anesthesia–induced hypotension (SAIH) in cesarean delivery. For instance, a systematic review and meta-analysis highlighted that intravenous fluid loading—whether crystalloid or colloid—is a recognized strategy for reducing the incidence and severity of hypotension after spinal anesthesia in obstetric patients, though it may be most effective when combined with vasopressors and other hemodynamic support measures (Rijs et al., 2020).

Similarly, epidemiological and clinical studies have identified preload status and volume of intravenous fluids as critical factors associated with the risk of developing hypotension. In a large cohort from Ethiopia, lack of preoperative fluid preload was associated with a significantly higher likelihood of hypotension after spinal anesthesia in cesarean patients (Barud et al., 2025). Such associations reinforce the current study's demonstration that the quantity of fluid delivered prior to anesthesia is a powerful predictor of blood pressure stability.

Other research suggests that while fluid therapy alone may not completely prevent hypotension, it remains an essential component of multimodal protocols aimed at stabilizing maternal hemodynamics during spinal anesthesia (Shitemaw et al., 2020; Fletcher, 2022). These studies collectively corroborate the present findings, indicating that optimized preload and appropriate fluid choice significantly influence maternal blood pressure outcomes following spinal anesthesia.

In sum, the results of Table 7 align with a body of evidence supporting targeted fluid management to mitigate spinal anesthesia–induced hypotension in cesarean deliveries. Given the well-documented physiologic mechanisms underlying hypotension in this context—primarily due to sympathetic blockade and decreased venous return—the significant predictive effect of fluid characteristics observed in this study is both biologically plausible and consistent with current clinical evidence.

5. DISCUSSION

The present study provides a comprehensive analysis of maternal hemodynamic behavior during cesarean section under spinal anesthesia, with particular emphasis on the role of preoperative intravenous fluid therapy. The findings demonstrate a relatively stable cesarean section rate between 2020 and 2025, ranging from 18% to 22%, which is consistent with global trends indicating stabilization of cesarean delivery rates at relatively high levels worldwide (Boerma et al., 2018; Betrán et al., 2021). This sustained volume of cesarean sections underscores the clinical importance of optimizing anesthetic and perioperative management strategies to minimize maternal complications, particularly hypotension.

The demographic profile revealed that most cesarean deliveries occurred among women aged 30–<40 years, an age group often associated with increased obstetric risk and medical indications for surgical delivery. This distribution aligns with previous studies suggesting that advanced maternal age is frequently linked to higher cesarean section rates and greater susceptibility to hemodynamic instability during spinal anesthesia (Hofhuizen, 2019). Additionally, the high prevalence of anemia among participants represents a clinically relevant factor that may exacerbate hypotensive resonses by reducing oxygen delivery and cardiovascular reserve, as supported by earlier reports (Shitemaw et al., 2020).

Baseline blood pressure varied across age groups, with lower pre-spinal values observed in women aged 30–<40 years, a finding that is clinically significant given that low baseline systolic blood pressure has been identified as a strong predictor of spinal anesthesia–induced hypotension (SAIH). This observation is consistent with previous evidence indicating that baseline hemodynamic status plays a critical role in determining maternal blood pressure responses following spinal anesthesia (Kinsella et al., 2018; Shitemaw et al., 2020).

Regarding fluid management, normal saline was the most frequently administered preoperative fluid. Although its use was associated with partial recovery and mid-term stabilization of blood pressure, an early decline in systolic blood pressure was consistently observed following spinal anesthesia. This pattern reflects the well-established physiological effects of sympathetic blockade and rapid redistribution of crystalloids, and is in agreement with prior studies demonstrating that crystalloid loading alone may attenuate but not fully prevent hypotension (Oh et al., 2014; Fitzgerald et al., 2020). Comparisons with Ringer's Lactate and Gelofusine suggest that colloid solutions may offer more sustained intravascular volume expansion, although their routine use may be limited by availability and cost in low-resource settings.

Clinical manifestations of hypotension, particularly nausea, vomiting, and sleepiness, were common and aligned with classical descriptions of SAIH. These symptoms often precede marked numerical declines in blood pressure and therefore represent valuable early indicators of hemodynamic compromise (De Jong & Den Hartog, 2010; Kinsella et al., 2018). The predominance of mild-to-moderate symptoms in this study likely reflects timely monitoring and intervention.

Finally, regression analysis confirmed that both the type and quantity of preoperative intravenous fluids exert a statistically significant effect on maternal hypotension, explaining a substantial proportion of the variance in blood pressure outcomes. These findings are strongly supported by contemporary literature emphasizing that adequate fluid preload is a key determinant of maternal hemodynamic stability, particularly when integrated into multimodal preventive strategies that include vasopressor support (Rijs et al., 2020; Fletcher, 2022).

Overall, the results of this study reinforce current evidence that while preoperative intravenous fluids play a crucial role in mitigating spinal anesthesia–induced hypotension, fluid therapy alone is insufficient for complete prevention. Optimized, individualized fluid management combined with vigilant monitoring and adjunctive measures remains essential to ensure maternal safety during cesarean delivery under spinal anesthesia.

6. CONCLUSIONS AND RECOMENDATION

6.1 CONCLISIONS

1. The study revealed that cesarean section rates during the period (2020–2025) were relatively high and stable, reflecting an increasing reliance on this mode of delivery within the healthcare institutions included in the study.
2. It was found that the age group (30 to less than 40 years) represented the highest proportion of women undergoing cesarean section, which is associated with increased pregnancy-related risks with advancing reproductive age.
3. The results indicated a notable prevalence of certain chronic diseases among pregnant women, particularly anemia, which may adversely affect hemodynamic stability during spinal anesthesia.
4. Differences in baseline blood pressure prior to spinal anesthesia were observed according to age, with lower pre-anesthetic blood pressure being associated with a higher likelihood of post-anesthetic hypotension.
5. The findings demonstrated that spinal anesthesia leads to a significant decrease in arterial blood pressure during the first minutes following its administration, primarily due to sympathetic blockade and peripheral vasodilation.

6. Normal saline was the most frequently used intravenous fluid prior to spinal anesthesia and contributed to improving mid-term hemodynamic stability, although it did not completely prevent early hypotension.
7. Other fluids, such as Ringer's Lactate and Gelofusine, showed a relative improvement in the speed of blood pressure recovery compared to normal saline alone.
8. Nausea and vomiting were identified as the most common symptoms associated with hypotension, followed by drowsiness and headache, highlighting the importance of clinical assessment in addition to numerical blood pressure measurements.
9. Statistical analysis confirmed a strong and statistically significant relationship between both the type and quantity of intravenous fluids and blood pressure stability following spinal anesthesia.
10. The results demonstrated that preoperative fluid therapy is a fundamental factor in reducing the severity of hypotension; however, it is insufficient on its own to completely prevent its occurrence.

6.2 RECOMMENDATIONS

1. The adoption of clear and standardized protocols for preoperative intravenous fluid management in cesarean section procedures is strongly recommended.
2. The general health status of the pregnant woman, particularly the presence of anemia or chronic diseases, should be carefully considered when planning anesthesia.
3. Exclusive reliance on crystalloid solutions should be avoided, and they should be combined with other strategies, such as the use of vasopressors when indicated.
4. Continuous and precise blood pressure monitoring should be ensured during the early postoperative period following spinal anesthesia.
5. Medical staff should be trained to recognize early clinical signs of hypotension and not rely solely on numerical blood pressure readings.
6. Intravenous fluid volumes should be individualized according to the patient's age and baseline blood pressure prior to anesthesia.
7. The implementation of safe anesthesia protocols in obstetric units should be strengthened, particularly in resource-limited settings.
8. Future comparative studies between different types of intravenous fluids are encouraged.
9. The findings of this study should be incorporated into training programs for anesthesiologists and midwifery staff.
10. Clinical documentation and follow-up systems should be improved to ensure quality of care and maternal safety.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that they have no conflict of interest.

References

[1] Barud, A. A., et al. (2025). Incidence and risk factors of hypotension in cesarean section patients under spinal anesthesia at a referral hospital. BMC Pregnancy and Childbirth. https://doi.org/xxxxx

[2] Betrán, A. P., Ye, J., Moller, A. B., Souza, J. P., & Zhang, J. (2021). Trends and projections of caesarean section rates: Global and regional estimates. BMJ Global Health, 6(6), e005671. https://doi.org/10.1136/bmjgh-2021-005671

[3] Bishop, D. G., Rodseth, R. N., & Dyer, R. A. (2020). Strategies for the prevention of spinal hypotension during caesarean section. Southern African Journal of Anaesthesia and Analgesia, 26(1), 10–15.

[4] Boerma, T., Ronsmans, C., Melesse, D. Y., Barros, A. J. D., Barros, F. C., Juan, L., … Temmerman, M. (2018). Global epidemiology of use of and disparities in caesarean sections. The Lancet, 392(10155), 1341–1348. https://doi.org/10.1016/S0140-6736(18)31928-7

[5] De Jong, A., & Den Hartog, E. (2010). Hemodynamic effects of spinal anesthesia in obstetric patients. Current Opinion in Anaesthesiology, 23(3), 304–309. https://doi.org/10.1097/ACO.0b013e328339c1a6

[6] Ebraham, A., & Lenny, S. (2018). Cesarean section under spinal anesthesia: An empirical study. Periodicum Biologorum, 122(4), 245–251.

[7] Fitzgerald, J. P., Fedoruk, L. M., Jansen, N., & Carvalho, B. (2020). Prevention of hypotension during spinal anesthesia for elective cesarean delivery: A systematic review. Anaesthesia, 75(1), 84–92. https://doi.org/10.1111/anae.14845

[8] Fletcher, J. (2022). Spinal-induced hypotension at caesarean section. ScienceDirect. https://doi.org/xxxxx

[9] Gunusen, I., Karaman, S., Ertugrul, V., Firat, V., & Kirdemir, P. (2010). Colloid preload versus crystalloid preload for prevention of hypotension during spinal anesthesia for cesarean section. International Journal of Obstetric Anesthesia, 19(2), 150–155. https://doi.org/10.1016/j.ijoa.2009.11.007

[10] Hofhuizen, C. (2019). Spinal anesthesia–induced hypotension: Decrease in systemic vascular resistance and/or cardiac output. Journal of Clinical Monitoring and Computing.

[11] International consensus statement on the management of hypotension with vasopressors during caesarean section under spinal anaesthesia. Anaesthesia, 73(1), 71–92. https://doi.org/10.1111/anae.14080.

[12] Kinsella, S. M., Carvalho, B., Dyer, R. A., Fernando, R., McDonnell, N., Mercier, F. J., & Palanisamy, A. (2018). International consensus statement on the management of hypotension with vasopressors during cesarean section under spinal anesthesia. Anaesthesia, 73(1), 71–92. https://doi.org/10.1111/anae.14080

[13] Munyanziza, T., Rulisa, S., & Habimana, R. (2022). Incidence and clinical manifestations of spinal anesthesia–induced hypotension during cesarean section. Rwanda Journal of Medicine and Health Sciences, 5(1), 45–52.

[14] N., Mercier, F. J., & Palanisamy, A. (2018). International consensus statement on the management of hypotension with vasopressors during cesarean section under spinal anesthesia. Anaesthesia, 73(1), 71–92. https://doi.org/10.1111/anae.14080.

[15] Oh, C. S., Kim, S. H., Kim, Y. J., & Choi, S. S. (2014). Effects of crystalloid preload versus coload on maternal hypotension during spinal anesthesia for cesarean delivery. Journal of Anesthesia, 28(4), 540–546. https://doi.org/10.1007/s00540-013-1742-9

[16] Rijs, K. (2020). Fluid loading therapy to prevent spinal hypotension in cesarean section. European Journal of Anaesthesiology, 37(6), 459–468.

[17] Ropert, S. Hellen, (2019), Study: Early Repeat C-Sections Puts Babies At Risk, PLoS ONE., Medical Report, Part3.

[18] Shitemaw, T., Jemal, B., Mamo, T., & Akalu, L. (2020). Incidence and associated factors for hypotension after spinal anesthesia during cesarean section. PLOS ONE, 15(8), e0236755. https://doi.org/10.1371/journal.pone.0236755

[19] Soto-Vega, E., Herrera-Gómez, A., & Muñoz-Rodríguez, J. (2015). Rising trends of cesarean section worldwide: A systematic review. Journal of Obstetrics and Gynaecology Research, 41(9), 1359–1368.

[20] Soto-Vega, E., Herrera-Gómez, A., & Muñoz-Rodríguez, J. (2015). Rising trends of cesarean section worldwide: A systematic review. Journal of Obstetrics and Gynaecology Research, 41(9), 1359–1368.

[21] Yu, Y., Lin, F., Dong, W., Li, H., Zhang, X., & Chen, C. (2019). The effectiveness of financial intervention strategies for reducing caesarean section rates: A systematic review. BMC Public Health, 19(1), 1–10. https://doi.org/10.1186/s12889-019-6579-8

