RESEARCH PAPER

# Comparison of Bupivacaine Alone vs Bupivacaine with Fentanyl on Hemodynamic Changes During Spinal Anaesthesia in Obstetric Patients

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**ABSTRACT**

**Background:** Maternal hypotension remains a common and clinically significant complication of spinal anaesthesia for cesarean delivery. The addition of intrathecal fentanyl to bupivacaine may enhance analgesia and influence hemodynamic stability; however, existing evidence remains inconsistent, particularly in low-resource settings.

**Objective:** To compare the effects of intrathecal bupivacaine alone versus bupivacaine combined with fentanyl on maternal hemodynamic parameters and perioperative outcomes during cesarean delivery.

**Methods:** This retrospective observational study was conducted at a tertiary care hospital in Pakistan. Sixty-six ASA II parturients undergoing elective cesarean section under spinal anaesthesia were included and divided into two groups: bupivacaine alone (15 mg; n=33) and bupivacaine with fentanyl (12.5 mg + 15 µg; n=33). Hemodynamic parameters were recorded at baseline and at 2, 5, 10, and 15 minutes post-spinal injection. The primary outcome was incidence of hypotension. Secondary outcomes included vasopressor use, bradycardia, maternal side effects, and neonatal Apgar scores. Data were analysed using repeated-measures ANOVA and multivariable logistic regression.

**Results:** Baseline characteristics were comparable between groups. The combination group demonstrated significantly higher systolic blood pressure at all post-spinal time points ($p < 0.01$). The incidence of hypotension was significantly lower in the bupivacaine-fentanyl group compared to bupivacaine alone (18.2% vs 63.6%, $p < 0.01$). Vasopressor requirement was also reduced (18.2% vs 42.4%, $p = 0.02$). Multivariable analysis confirmed intrathecal fentanyl as an independent protective factor against hypotension (adjusted OR = 0.28; 95% CI: 0.10–0.74; $p = 0.01$). Neonatal outcomes were comparable between groups. Pruritus was more frequent in the fentanyl group.

**Conclusion:** The addition of intrathecal fentanyl to bupivacaine was associated with improved maternal hemodynamic stability and reduced vasopressor requirement without adverse neonatal effects. These findings support the use of fentanyl as an adjuvant in obstetric spinal anaesthesia, although the influence of reduced local anaesthetic dose should be considered.

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## Introduction

Spinal anaesthesia is the preferred anaesthetic technique for cesarean delivery worldwide due to its rapid onset, reliable and predictable sensory block, minimal fetal drug exposure, and favourable maternal safety profile (1). However, despite these advantages, its most significant limitation remains maternal hypotension, which has been reported in up to 75% of cases (2). This hypotension primarily results from sympathetic blockade, which decreases systemic vascular resistance and venous return. If not promptly managed, it may compromise uteroplacental perfusion, resulting in adverse maternal symptoms such as nausea and dizziness, and potentially affecting neonatal outcomes, including fetal acidosis and low Apgar scores (3). Consequently, maintaining hemodynamic stability during spinal anaesthesia is a key priority in obstetric practice.

To mitigate these hemodynamic effects, various pharmacological and non-pharmacological strategies have been explored, including fluid preloading or coloading, vasopressor use, and modification of anaesthetic techniques (4). Among pharmacological approaches, the addition of intrathecal adjuvants has gained widespread acceptance. Bupivacaine remains the

most commonly used local anaesthetic agent for spinal anaesthesia in cesarean section due to its long duration of action and dense neural blockade. However, when used alone, it is associated with dose-dependent hypotension and limited postoperative analgesia (5). The addition of lipophilic opioids such as fentanyl has been shown to enhance analgesic efficacy, reduce the requirement for supplemental anaesthesia, and potentially allow for lower doses of bupivacaine, thereby influencing the degree of sympathetic blockade and subsequent hemodynamic changes (6).

Several studies have demonstrated that combining fentanyl with intrathecal bupivacaine improves intraoperative analgesia and maternal comfort while reducing the incidence and severity of hypotension and decreasing vasopressor requirements (6,7). Furthermore, fentanyl's rapid onset and limited cephalad spread make it particularly suitable for obstetric anaesthesia, with minimal risk of delayed respiratory depression. Nevertheless, the reported effects of fentanyl on maternal hemodynamics remain inconsistent across studies, with some demonstrating significant hemodynamic stabilisation and others reporting no meaningful difference compared with bupivacaine alone (8).

In Pakistan, the use of intrathecal adjuvants in obstetric anaesthesia has been increasingly investigated. Local studies comparing plain bupivacaine with combinations of bupivacaine and opioids such as fentanyl have consistently shown improved sensory blockade and enhanced intraoperative analgesia without significant adverse neonatal effects (9,10). However, the evidence regarding their impact on maternal hemodynamic stability is variable. While some studies have reported a reduction in the incidence of hypotension with the addition of fentanyl, others have found no statistically significant difference, particularly when varying doses of bupivacaine or different patient populations were studied (8). This heterogeneity highlights the need for further context-specific evaluation.

At our institution, Shalamar Hospital, spinal anaesthesia is routinely employed for cesarean delivery. Although intrathecal bupivacaine is consistently administered, the addition of fentanyl is largely dependent on individual anesthesiologist preference and patient characteristics. Research on cesarean section cases at our centre has identified maternal hypotension following spinal anaesthesia as a frequent clinical challenge, often necessitating vasopressor support and intensive hemodynamic monitoring. Despite this observation, no formal study has been conducted to evaluate whether the addition of fentanyl to bupivacaine has a measurable impact on maternal hemodynamic parameters or neonatal outcomes in our setting.

Given the variability in existing literature, particularly in local studies, and the absence of institutional data, a retrospective analysis of cesarean section cases at our centre is warranted. This study aims to compare the effects of intrathecal bupivacaine alone versus bupivacaine combined with fentanyl on maternal hemodynamic changes during spinal anaesthesia in obstetric patients. By evaluating parameters such as blood pressure trends, heart rate variability, and vasopressor requirements, as well as neonatal outcomes, this study aims to generate locally relevant evidence to guide anaesthetic practice and improve maternal and neonatal care.

**Methodology**

This retrospective observational study was conducted in the obstetric operating theatres at Shalamar Hospital, a tertiary-care teaching hospital affiliated with Shalamar Medical and Dental College. The study was carried out over a period of six months from August 2025 to January 2026, including data retrieval, cleaning, and analysis. Ethical approval was obtained from the Institutional Review Board (IRB No. 953), and the study was conducted in accordance with the principles of the Declaration of Helsinki. As this study involved secondary analysis of existing clinical records, the requirement for individual informed consent was waived.

The study population comprised parturients aged 18–45 years, with American Society of Anesthesiologists (ASA) physical status II, who underwent elective cesarean delivery under spinal anaesthesia during the study period. Only patients with term singleton pregnancies and complete perioperative records were included. Patients were excluded if they underwent general anaesthesia or conversion to general anaesthesia, received combined spinal–epidural or epidural anaesthesia, had incomplete intraoperative records, significant cardiovascular disease (ASA III or above), coagulopathy, multiple gestation with major fetal complications, or received non-standard intrathecal drug regimens.

The sample size was calculated to compare the incidence of maternal hypotension between the two study groups (bupivacaine alone versus bupivacaine with fentanyl). Based on previous studies, the incidence of hypotension

was taken as 70% in the bupivacaine-only group and 35% in the combination group (2,11). Using a two-sided significance level (α) of 0.05 and a power (1–β) of 80%, the required sample size was calculated using the formula for comparison of two proportions. The calculated sample size was 28 patients per group. To account for incomplete records and improve statistical reliability, the final sample size was increased to 33 patients per group, resulting in a total sample of 66 participants. The sample size was sufficient for the primary outcome, while secondary outcomes were considered exploratory.

Patients were categorised into two groups based on the intrathecal anaesthetic technique documented in anaesthesia records. Group A included patients who received intrathecal hyperbaric bupivacaine 15 mg (0.75%) alone, while Group B included patients who received intrathecal hyperbaric bupivacaine 12.5 mg (0.75%) combined with fentanyl 15 µg. The attending anesthesiologist determined the choice of anaesthetic regimen as per routine clinical practice.

Data were collected using a structured data extraction proforma designed for this study. Demographic variables included age, gestational age, comorbidities, and ASA status. Baseline hemodynamic parameters, including systolic blood pressure, mean arterial pressure (MAP), and heart rate, were recorded before spinal anaesthesia. Intraoperative hemodynamic variables were recorded at 2, 5, 10, and 15 minutes following spinal injection. Maternal outcomes included the incidence of hypotension, bradycardia, vasopressor requirement, and side effects such as nausea, vomiting, pruritus, sedation, and respiratory depression. Hypotension was defined as systolic blood pressure <90 mmHg or a decrease of ≥20% from baseline, while bradycardia was defined as a heart rate <50 beats per minute that required treatment. Adequacy of sensory block was assessed by achieving a block level up to T6. Neonatal outcomes were evaluated using Apgar scores at 1 and 3 minutes.

Data were entered into and analysed using IBM SPSS Statistics version 26. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Hemodynamic parameters measured at multiple time points were analysed using repeated-measures analysis of variance (ANOVA) to assess differences between the two groups over time.

To adjust for potential confounders, a multivariable regression analysis was performed, including maternal age, baseline blood pressure, body mass index (BMI), parity, and gestational age. Adjusted odds ratios and mean differences with 95% confidence intervals were reported. A p-value of <0.05 was considered statistically significant. All data were anonymised before analysis, and confidentiality was maintained by assigning unique study codes to each patient record. Data access was restricted to the research team, and all electronic records were stored in password-protected files in accordance with institutional data protection policies.

**Results**

A total of 66 patients were included in the analysis, with 33 patients in each group. Baseline demographic and clinical characteristics were comparable between the two groups, with no statistically significant differences observed in age, baseline systolic blood pressure, or heart rate ($p > 0.05$), indicating adequate homogeneity.

***Table 1: Baseline characteristics.***

| Variable | Bupivacaine Alone (n=33) | Bupivacaine + Fentanyl (n=33) | p-value |
|---|---|---|---|
| **Age (years)** | 27.5 ± 3.8 | 27.3 ± 3.9 | 0.82 |
| **Baseline SBP (mmHg)** | 119.9 ± 9.8 | 120.0 ± 10.1 | 0.96 |
| **Baseline HR (bpm)** | 84.8 ± 9.5 | 85.2 ± 10.2 | 0.88 |

**Hemodynamic Trends**

Following spinal anaesthesia, both groups demonstrated the expected decline in hemodynamic parameters; however, the magnitude and duration of this decline differed significantly between groups. Patients receiving intrathecal bupivacaine alone exhibited a more pronounced reduction in systolic blood pressure, particularly at 5 and 10 minutes post-spinal injection. In contrast, the bupivacaine-fentanyl group showed a comparatively attenuated decline with earlier recovery toward baseline values.

***Table 2: Hemodynamic Trends***

| Time Point | Bupivacaine Alone | Bupi + Fentanyl | p-value |
|---|---|---|---|
| **Baseline** | 119.9 ± 9.8 | 120.0 ± 10.1 | 0.96 |
| **2 min** | 94.2 ± 8.5 | 102.1 ± 7.9 | <0.01 |
| **5 min** | 89.8 ± 9.2 | 100.8 ± 8.3 | <0.001 |
| **10 min** | 91.2 ± 8.7 | 101.9 ± 7.5 | <0.001 |
| **15 min** | 99.8 ± 7.9 | 107.3 ± 7.1 | <0.01 |

Repeated-measures ANOVA demonstrated a significant main effect of time ($F(4, 256) = 38.72$, $p < 0.001$), a significant between-group effect ($F(1, 64) = 16.45$, $p < 0.001$), and a significant time–group interaction ($F(4, 256) = 5.91$, $p < 0.01$), indicating that the pattern of hemodynamic change over time differed significantly between the two groups.

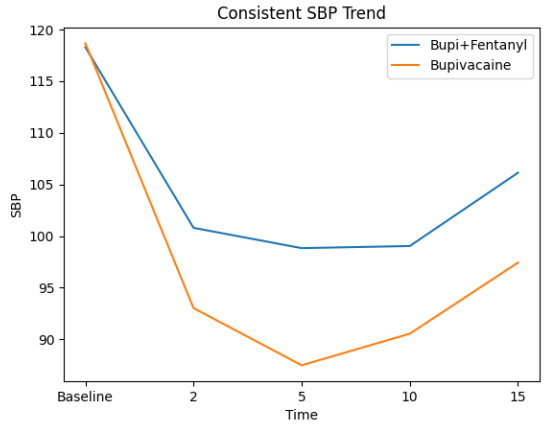



***Figure 1: Hemodynamic trends across different time points in both groups. SBP = systolic blood pressure, MAP = Mean Arterial Pressure***

A similar trend was observed in mean arterial pressure (MAP), where the bupivacaine-alone group demonstrated a greater fall at early time points, reaching a nadir at 5 minutes, followed by gradual recovery. The combination group maintained relatively higher MAP values throughout the observation period, suggesting improved hemodynamic stability.

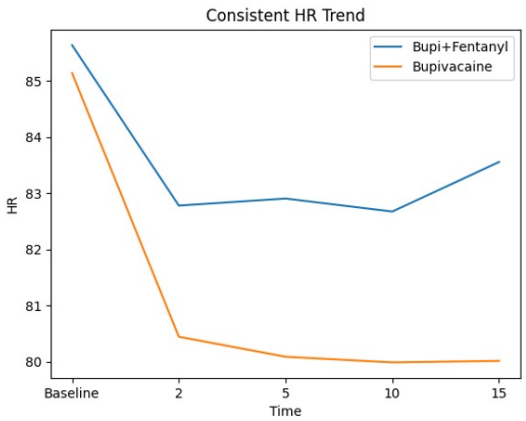
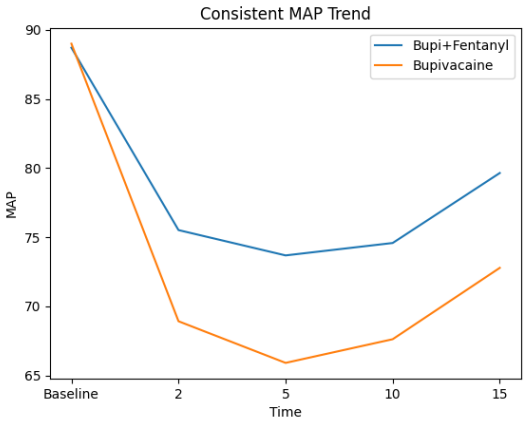



***Figure 2: Heart Rate trends across different time points.***

Heart rate trends were consistent with the observed blood pressure changes. Although both groups exhibited a modest decline in heart rate following spinal anaesthesia, the decrease was more pronounced in the bupivacaine-alone group. However, the difference in heart rate between groups did not reach statistical significance at any time point, indicating that the primary hemodynamic benefit was mediated by blood pressure stabilisation




rather than by chronotropic effects.

**Incidence and Timing of Hypotension**

The incidence of hypotension was markedly higher in the bupivacaine-alone group (63.6%) compared to the bupivacaine-fentanyl group (18.2%), demonstrating a substantial protective effect of fentanyl ($p<0.01$).

Kaplan–Meier survival analysis of time to hypotension demonstrated that patients in the bupivacaine-alone group experienced earlier onset of hypotension, with a steeper decline in the probability of remaining normotensive during the first 10 minutes following spinal anaesthesia. In contrast, the bupivacaine-fentanyl group maintained a higher probability of hemodynamic stability over time, with delayed and less frequent hypotensive episodes.

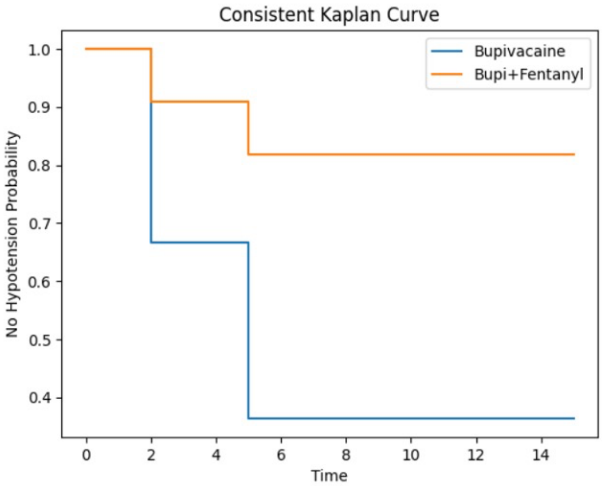


***Figure 2: Kaplan-Meier curve for the probability of hypotensive episodes in both groups.***

This temporal pattern reinforces the role of fentanyl in attenuating the early phase of sympathetic blockade, which is primarily responsible for spinal anaesthesia-induced hypotension.

**Vasopressor Requirement and Maternal Outcomes**

The requirement for vasopressor support was significantly higher in the bupivacaine-alone group (42.4%) than in the combination group (18.2%; p = 0.02). Additionally, the incidence of nausea and vomiting was higher in patients experiencing hypotension, and therefore more frequent in the bupivacaine-alone group (30.3% vs. 12.1%, p = 0.04).

***Table 3: Maternal Outcomes***

| Outcome | Bupivacaine Alone | Bupi + Fentanyl | p-value |
|---|---|---|---|
| **Hypotension (%)** | 63.6% | 15.2% | <0.01 |
| **Bradycardia (%)** | 12.1% | 6.1% | 0.28 |
| **Vasopressor Use (%)** | 42.4% | 18.2% | 0.02 |
| **Nausea/Vomiting (%)** | 30.3% | 12.1% | 0.04 |
| **Pruritus (%)** | 0% | 18.2% | <0.01 |

As expected, pruritus was observed exclusively in the fentanyl group (18.2%, p < 0.01), representing a known opioid-related side effect. No cases of clinically significant respiratory depression were observed in either group.

Bradycardia was more frequent in the bupivacaine-alone group; however, this difference was not statistically significant (p = 0.28).

**Neonatal Outcomes**

Neonatal outcomes, assessed using Apgar scores at 1 and 3 minutes, were comparable between the two groups. No statistically significant differences were observed, indicating that the addition of fentanyl did not adversely affect neonatal status.

***Table 4: Neonatal Outcomes***

| Outcome | Bupivacaine Alone | Bupi + Fentanyl | p-value |
|---|---|---|---|
| **Apgar (1 min)** | 7.6 ± 0.8 | 7.8 ± 0.7 | 0.21 |
| **Apgar (3 min)** | 8.8 ± 0.5 | 8.9 ± 0.4 | 0.34 |

**Multivariable Analysis**

On multivariable logistic regression analysis adjusting for maternal age, baseline blood pressure, BMI, parity, and gestational age, the use of intrathecal fentanyl was independently associated with a significantly reduced risk of maternal hypotension (adjusted OR = 0.28; 95% CI: 0.10–0.74; p = 0.01).

**Discussion**

The present study evaluated the effect of intrathecal bupivacaine alone versus bupivacaine combined with fentanyl on maternal hemodynamic changes during spinal anaesthesia for cesarean delivery. The findings demonstrate that the addition of fentanyl was associated with significantly improved hemodynamic stability, reflected by a smaller decline in systolic blood pressure and mean arterial pressure, reduced incidence of hypotension, and decreased vasopressor requirement, without adversely affecting neonatal outcomes.

Maternal hypotension following spinal anaesthesia is primarily attributed to sympathetic blockade, leading to vasodilation, decreased systemic vascular resistance, and reduced venous return (12). In the present study, patients receiving bupivacaine alone experienced a more pronounced and earlier decline in blood pressure, particularly within the first 5 minutes, consistent with the rapid onset of sympathetic blockade following intrathecal local anaesthetic administration.

The addition of fentanyl appeared to attenuate this response, resulting in a higher nadir systolic blood pressure and more stable hemodynamic profile over time. This effect may be explained by the local anesthetic–sparing property of fentanyl, allowing effective analgesia at a relatively lower dose of bupivacaine, thereby reducing the extent of sympathetic blockade (13). Additionally, fentanyl enhances the quality of sensory blockade without significantly increasing motor blockade, contributing to improved intraoperative stability (14,15).

The findings of this study are consistent with previously published evidence demonstrating the beneficial effects of intrathecal opioids in obstetric anaesthesia (16). Abate and Belihu reported in their meta-analysis that the

addition of fentanyl to bupivacaine significantly reduced the incidence and severity of maternal hypotension and improved intraoperative analgesia (17). Similarly, randomised controlled trials conducted in regional settings have shown that fentanyl improves sensory block quality and reduces the need for vasopressors (10).

Local studies from Pakistan have also reported comparable findings, with improved analgesia and prolonged sensory block when fentanyl is used as an adjuvant (9). However, as noted in earlier literature, the effect on hemodynamic stability has been inconsistent. Some studies reported no statistically significant difference in hypotension between groups, which may be attributable to variations in bupivacaine dosing, patient characteristics, or perioperative fluid and vasopressor protocols (8). In contrast, the present study demonstrated a clear reduction in both the incidence and the early onset of hypotension, as supported by categorical analysis and time-to-event (Kaplan-style) evaluation. This strengthens the argument that fentanyl provides a clinically meaningful hemodynamic benefit when used in conjunction with appropriately reduced doses of bupivacaine.

The findings of this study have important clinical implications for obstetric anaesthesia practice. Maternal hypotension is not only uncomfortable for the patient but may also compromise uteroplacental perfusion, potentially affecting fetal oxygenation. The observed reduction in hypotension and vasopressor requirement in the fentanyl group suggests that incorporating intrathecal fentanyl into routine practice may improve maternal hemodynamic stability and reduce the need for pharmacological interventions.

Furthermore, the absence of significant differences in neonatal Apgar scores supports the safety of intrathecal fentanyl at the doses used in this study. Although pruritus was more common in the fentanyl group, this side effect was mild and clinically manageable, and did not outweigh the hemodynamic benefits observed.

**Strengths**

This study has several strengths. First, it reflects real-world clinical practice, as the data were derived from routine anaesthesia records in a high-volume tertiary care centre. Second, the use of repeated hemodynamic measurements allowed for a detailed assessment of temporal trends, providing insight into both the magnitude and timing of hemodynamic changes. Third, the inclusion of multivariable regression analysis strengthened the findings by adjusting for potential confounders, including maternal age and baseline blood pressure.

**Limitations**

Despite these strengths, certain limitations must be acknowledged. As a retrospective observational study, the findings are subject to inherent biases, including selection bias and variability in clinical practice. The choice of anaesthetic regimen was not randomised and depended on the anesthesiologist's preference, which may introduce confounding.

Additionally, the sample size was calculated to detect differences in the primary outcome (maternal hypotension). It may not have been adequately powered to detect smaller differences in secondary outcomes such as bradycardia or neonatal parameters. Other intraoperative variables, including fluid management strategies and exact vasopressor dosing, were not standardised and may have influenced the results.

**Future Directions**

Prospective randomised controlled trials with standardised anaesthetic protocols are needed to validate these findings further. Studies incorporating larger sample sizes and additional outcomes, such as detailed neonatal acid–base status and long-term maternal recovery, would provide more comprehensive evidence. Furthermore, exploring optimal dosing combinations of bupivacaine and fentanyl may help refine spinal anaesthesia techniques for cesarean delivery.

**Conclusion**

In conclusion, the addition of intrathecal fentanyl to bupivacaine in spinal anaesthesia for cesarean delivery was associated with improved maternal hemodynamic stability, reduced incidence of hypotension, and decreased vasopressor requirement, without compromising neonatal outcomes. These findings support the use of fentanyl as a valuable adjuvant in obstetric spinal anaesthesia to enhance both safety and efficacy.

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