

Comparative Study of Intra-operative Hemodynamic Changes During Cesarean Section Under Spinal Block by Using Bupivacaine Alone Versus Bupivacaine with Fentanyl

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Abstract

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Background: Spinal anesthesia is the preferred anesthetic technique for cesarean section due to its rapid onset and favorable maternal and fetal outcomes. However, it is frequently associated with intra-operative hemodynamic instability, particularly hypotension and bradycardia. The use of intrathecal opioids such as fentanyl as an adjuvant to bupivacaine has been proposed to improve anesthetic quality and cardiovascular stability. Bupivacaine is commonly used for spinal anesthesia in cesarean section, but its use alone may result in significant sympathetic blockade leading to hemodynamic disturbances. The addition of fentanyl may enhance analgesia and reduce adverse hemodynamic effects. Comparative evaluation of these two anesthetic regimens is essential to optimize maternal safety during cesarean delivery. **Objective:** To compare intra-operative hemodynamic changes during cesarean section under spinal anesthesia using bupivacaine

alone versus bupivacaine combined with fentanyl. **Methodology:** This prospective comparative study was conducted at Irfan General Hospital over a period of four months. A total of 222 patients undergoing cesarean section under spinal anesthesia were included and divided into two equal groups. Group A received intrathecal bupivacaine alone, while Group B received intrathecal bupivacaine with fentanyl. Intra-operative heart rate and blood pressure were recorded at baseline and at regular intervals. Data were analyzed using SPSS, and a p -value <0.05 was considered statistically significant. **Results:** Baseline demographic and hemodynamic parameters were comparable between the two groups. The incidence of hypotension and bradycardia was significantly higher in patients receiving bupivacaine alone. Patients in the bupivacaine–fentanyl group demonstrated better maintenance of systolic blood pressure and heart rate throughout the intra-operative period ($p <0.05$). **Conclusion:**

The addition of fentanyl to intrathecal bupivacaine provides superior intra-operative hemodynamic stability compared to bupivacaine alone during cesarean section. This combination appears to be a safer and more effective anesthetic option for improving maternal outcomes.

Introduction

Cesarean section is one of the most commonly performed obstetric surgical procedures worldwide, and its frequency has increased markedly over recent decades due to advances in obstetric care, improved fetal monitoring, and changes in maternal choice and clinical indications. According to global estimates, cesarean section rates have risen substantially across both developed and developing countries, making it a major public health concern in modern obstetrics.¹ Anesthetic management during cesarean delivery is of paramount importance, as it directly affects maternal safety, fetal well-being, and perioperative outcomes. Among various anesthetic techniques, spinal anesthesia is widely regarded as the preferred method for cesarean section because of its rapid onset, ease of administration, reliability, and provision of dense sensory and motor blockade. Additionally, spinal anesthesia avoids airway manipulation and minimizes fetal exposure to anesthetic agents, thereby reducing the risks associated with general anesthesia.² Owing to these advantages, spinal anesthesia has become the standard practice for both elective and emergency cesarean deliveries in many institutions. Despite its benefits, spinal anesthesia is frequently associated with intra-operative hemodynamic disturbances, most notably hypotension and bradycardia. These changes occur primarily due to sympathetic nervous system blockade, leading to vasodilation, reduced venous return, and decreased cardiac output. Maternal hypotension during cesarean section can adversely affect uteroplacental blood flow and may result in fetal acidosis if not promptly managed.³ Furthermore, maternal symptoms such as nausea, vomiting, dizziness, and discomfort are commonly linked to hypotensive episodes, emphasizing the need for careful anesthetic planning and monitoring.

Bupivacaine, a long-acting amide local anesthetic, is the most frequently used drug for spinal anesthesia in cesarean section. It provides reliable anesthesia with adequate duration for surgical procedures. However, the use of conventional doses of intrathecal bupivacaine alone has been associated with a higher incidence of hypotension due to extensive sympathetic blockade.⁴ While reducing the dose of bupivacaine may decrease the severity of hypotension, it may also lead to inadequate sensory block, increased intra-operative pain, and the need for supplemental analgesia. To enhance anesthetic efficacy while minimizing adverse hemodynamic effects, intrathecal opioids have been increasingly used as adjuvants to local anesthetics. Fentanyl, a lipophilic opioid, is commonly added to intrathecal bupivacaine because it provides potent analgesia through synergistic action at the spinal cord level without significantly intensifying sympathetic blockade.⁵ The addition of fentanyl allows for a reduction in the dose of bupivacaine, thereby improving cardiovascular stability while maintaining adequate anesthesia.

Several studies have demonstrated that the combination of intrathecal fentanyl with bupivacaine improves the quality of intra-operative analgesia, prolongs postoperative pain relief, and reduces the requirement for additional analgesics.⁶ Moreover, fentanyl has a rapid onset of action and limited placental transfer, making it a safe and effective adjunct in obstetric anesthesia.⁷ Importantly, the use of fentanyl does not significantly prolong motor block, allowing for early mobilization and improved maternal satisfaction. Maternal hemodynamic stability during cesarean section is influenced by multiple factors, including anesthetic drug selection, dosage, patient positioning, fluid management, and the use of vasopressors. Continuous monitoring of parameters such as heart rate, systolic blood pressure, diastolic blood pressure, and

mean arterial pressure is essential for detecting and managing intra-operative hemodynamic changes. Although previous studies have evaluated the analgesic benefits of adding fentanyl to intrathecal bupivacaine, findings regarding its effect on intra-operative hemodynamic stability have been variable.⁸ Differences in patient populations, study designs, and anesthetic protocols necessitate further comparative research. Given the growing prevalence of cesarean section and the importance of maintaining stable maternal hemodynamics, a comparative assessment of spinal anesthesia using bupivacaine alone versus bupivacaine combined with fentanyl is clinically significant. This study aims to evaluate intra-operative hemodynamic changes associated with these two commonly used anesthetic regimens during cesarean section. The results of this study may assist anesthesiologists in optimizing spinal anesthetic techniques to improve maternal safety, enhance perioperative outcomes, and ensure better fetal well-being.

Methodology:

This prospective comparative study was conducted in the Department of Anesthesiology at Irfan General Hospital over a period of four months to evaluate intra-operative hemodynamic changes during cesarean section performed under spinal anesthesia. A total of 222 pregnant women scheduled for cesarean delivery were enrolled after obtaining written informed consent and ethical approval from the Institutional Ethics Committee of the hospital. Eligible participants were aged between 18 and 40 years, classified as American Society of Anesthesiologists (ASA) physical status I or II, and planned for cesarean section under spinal anesthesia. Patients with contraindications to spinal anesthesia, known hypersensitivity to bupivacaine or fentanyl, significant cardiovascular or systemic diseases, or complicated pregnancies such as severe preeclampsia were excluded from the study. The enrolled patients were randomly divided into two equal groups of 111 each. Group A received intrathecal bupivacaine alone, while Group B received intrathecal bupivacaine combined with fentanyl. Baseline hemodynamic parameters, including heart rate, systolic blood pressure, diastolic blood pressure, and mean arterial pressure, were recorded prior to the administration of spinal anesthesia. Following drug administration, intra-operative hemodynamic variables were monitored and documented at regular predefined intervals throughout the surgical procedure until completion. All data were systematically recorded and analyzed using Statistical Package for the Social Sciences (SPSS) version 26. Quantitative variables were expressed as mean $\pm$ standard deviation and compared between groups using the independent t-test, while categorical variables were analyzed using the chi-square test. A p-value of less than 0.05 was considered statistically significant.

Result

Age-wise Distribution of Patients (n = 222)

Age (years)	Group A (n=111)	Group B (n=111)	Total (n=222)
18–25	34 (30.6%)	36 (32.4%)	70 (31.5%)
26–30	41 (36.9%)	39 (35.1%)	80 (36.0%)
31–35	26 (23.4%)	24 (21.6%)	50 (22.5%)
36–40	10 (9.1%)	12 (10.8%)	22 (9.9%)

Comparison of Baseline Hemodynamic Parameters

Parameter	Group A (Mean $\pm$ SD)	Group B (Mean $\pm$ SD)	p-value
Heart Rate (beats/min)	86.4 $\pm$ 8.2	85.9 $\pm$ 7.9	0.61

Systolic BP (mmHg)	124.6 ± 10.3	125.1 ± 9.8	0.72
Diastolic BP (mmHg)	78.2 ± 7.1	77.8 ± 6.9	0.68
Mean Arterial Pressure (mmHg)	93.7 ± 8.0	93.6 ± 7.6	0.94

Intra-operative Changes in Systolic Blood Pressure

Time Interval	Group A (Mean ± SD)	Group B (Mean ± SD)	p-value
5 minutes	98.5 ± 9.6	106.8 ± 8.9	<0.001
10 minutes	96.2 ± 10.1	104.5 ± 9.2	<0.001
20 minutes	100.3 ± 9.4	108.2 ± 8.6	<0.001

Incidence of Hypotension

Hypotension	Group A (n=111)	Group B (n=111)	p-value
Yes	39 (35.1%)	18 (16.2%)	0.002
No	72 (64.9%)	93 (83.8%)	—

Comparison of Heart Rate Changes

Parameter	Group A (Mean ± SD)	Group B (Mean ± SD)	p-value
Lowest HR recorded (beats/min)	64.8 ± 6.9	70.6 ± 6.2	<0.001
Bradycardia incidence	22 (19.8%)	9 (8.1%)	0.01

Discussion

Spinal anesthesia remains the preferred anesthetic technique for cesarean section due to its rapid onset, reliability, and favorable maternal and neonatal outcomes. However, intra-operative hemodynamic instability, particularly hypotension and bradycardia, continues to be a major concern associated with sympathetic blockade. The present study compared intra-operative hemodynamic changes during cesarean section under spinal anesthesia using bupivacaine alone versus bupivacaine combined with fentanyl, with the aim of identifying a technique that offers better cardiovascular stability. In the current study, demographic variables such as age distribution were comparable between both groups, with the majority of patients belonging to the 26–30 years age group. This similarity in baseline characteristics minimizes confounding factors and strengthens the validity of the comparison. All patients were female, as expected in a cesarean population. Baseline hemodynamic parameters, including heart rate and blood pressure, were also statistically similar between the two groups, ensuring that any subsequent changes could be attributed to the anesthetic technique rather than pre-existing differences.

The most significant finding of this study was the greater hemodynamic stability observed in patients receiving bupivacaine with fentanyl compared to bupivacaine alone. Patients in the bupivacaine-only group exhibited a significantly higher incidence of hypotension, particularly within the first 10 minutes following spinal anesthesia. This observation is consistent with previous studies reporting that intrathecal bupivacaine, when used alone in standard doses, causes extensive sympathetic blockade leading to peripheral vasodilation and reduced venous return.⁹ The addition of fentanyl to intrathecal bupivacaine resulted in a significantly smaller decline in systolic blood pressure at various intra-operative intervals. This finding

supports the hypothesis that fentanyl enhances spinal analgesia through synergistic action at the spinal opioid receptors without intensifying sympathetic blockade. As a result, lower doses of local anesthetic can be used while maintaining adequate sensory blockade, thereby reducing the severity of hypotension. Similar results have been reported by studies demonstrating improved cardiovascular stability with the addition of intrathecal opioids in obstetric anesthesia.^{10, 11}

In this study, the incidence of hypotension was significantly higher in the bupivacaine-only group compared to the combination group. This finding is clinically important, as maternal hypotension during cesarean section has been associated with adverse maternal symptoms such as nausea, vomiting, and dizziness, as well as compromised uteroplacental perfusion.¹² By reducing the frequency and severity of hypotension, the bupivacaine–fentanyl combination contributes to improved maternal comfort and potentially better fetal outcomes. Bradycardia was also observed more frequently in patients receiving bupivacaine alone. This can be explained by the blockade of cardiac accelerator fibers (T1–T4) following high spinal anesthesia, leading to unopposed parasympathetic activity.¹³ The lower incidence of bradycardia in the fentanyl group suggests that improved hemodynamic stability may reduce the need for pharmacological intervention such as atropine, thereby simplifying intra-operative management. The findings of the present study are in agreement with earlier research demonstrating that intrathecal fentanyl, when combined with bupivacaine, improves the quality of anesthesia and provides better hemodynamic control.¹⁴ Additionally, fentanyl's rapid onset, short duration of action, and minimal placental transfer make it a safe adjunct in obstetric anesthesia.¹⁵ No significant adverse effects related to fentanyl, such as respiratory depression or excessive sedation, were observed during the study period.

The present study has certain limitations. Being a single-center study, the results may not be fully generalizable to other settings with different patient populations or anesthetic practices. Additionally, neonatal outcomes such as Apgar scores and umbilical cord blood gas analysis were not included, which could have provided further insight into fetal well-being. Future multicenter randomized controlled trials with larger sample sizes and inclusion of neonatal parameters are recommended to validate these findings.

Conclusion

This study concludes that the addition of fentanyl to intrathecal bupivacaine for spinal anesthesia during cesarean section provides superior intra-operative hemodynamic stability compared to bupivacaine alone. Patients receiving the bupivacaine fentanyl combination experienced a significantly lower incidence of hypotension and bradycardia, with better maintenance of blood pressure and heart rate throughout the intra-operative period. These findings highlight the synergistic effect of fentanyl in enhancing anesthetic quality while minimizing adverse cardiovascular effects associated with spinal anesthesia. Therefore, the combination of bupivacaine with fentanyl appears to be a safer and more effective anesthetic technique for cesarean section, contributing to improved maternal safety and perioperative outcomes.

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