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Original Research Article

Spinal Anesthesia for Elective Cesarean Section: Bupivacaine Associated with Different Doses of Fentanyl – A Retrospective Study

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Abstract:

Background: Spinal anesthesia is the preferred anesthetic technique for elective cesarean sections due to its simplicity, rapid onset, and reliability. Bupivacaine is commonly used for spinal anesthesia; however, the addition of intrathecal opioids like fentanyl can improve the quality of anesthesia and analgesia. This study evaluates the effects of varying doses of fentanyl in combination with bupivacaine on intraoperative anesthesia quality, duration of analgesia, and maternal and neonatal outcomes.

Objectives: To compare the efficacy and side effect profile of three different doses of fentanyl (10 µg, 20 µg, and 25 µg) when combined with 0.5% hyperbaric bupivacaine in spinal anesthesia for elective cesarean section.

Methods: A retrospective observational study was conducted at Patna Medical College and Hospital. Medical records of 135 parturients who underwent elective cesarean section under spinal anesthesia for one year . Patients were categorized into three groups based on the dose of intrathecal fentanyl used: Group A (10 µg), Group B (20 µg), and Group C (25 µg), each with 45 patients. Data regarding sensory and motor block characteristics, intraoperative analgesia, hemodynamic changes, side effects, and neonatal APGAR scores were collected and analyzed.

Results: All three groups achieved adequate surgical anesthesia. Group C had the longest duration of postoperative analgesia (mean 245 ± 30 min) compared to Group A (180 ± 25 min) and Group B (215 ± 28 min). Incidence of pruritus and nausea was higher in Group C. Hemodynamic stability and neonatal outcomes were comparable among all groups.

Conclusion: The addition of fentanyl to intrathecal bupivacaine enhances postoperative analgesia in a dose-dependent manner. A dose of 20 µg offers a favorable balance between efficacy and side effects, making it a suitable choice for elective cesarean sections.

Keywords: Spinal anesthesia, Bupivacaine, Fentanyl, Cesarean section, Intrathecal opioids, Postoperative analgesia, APGAR score, Hemodynamic stability.

Introduction

Cesarean section (CS) is one of the most commonly performed surgical procedures worldwide, with an increasing global rate due to various obstetric, fetal, and maternal indications. Anesthesia for cesarean delivery must ensure optimal surgical conditions, maternal comfort, minimal adverse effects, and safe neonatal outcomes [1]. Among the anesthetic options, spinal anesthesia has become the preferred technique for elective cesarean sections due to its rapid onset, dense sensory and motor blockade, minimal drug transfer to the fetus, and high maternal satisfaction.

Hyperbaric bupivacaine, a long-acting local anesthetic, is the most frequently used drug for spinal anesthesia in obstetrics [2]. However, the sole use of bupivacaine may not provide prolonged postoperative analgesia, and higher doses can increase the risk of hypotension and other adverse effects [3]. To enhance the quality and duration of spinal anesthesia while reducing the required dose of local anesthetic, opioid adjuvants such as fentanyl are commonly added to intrathecal mixtures.

Fentanyl, a lipophilic synthetic opioid, acts primarily on µ-opioid receptors in the spinal cord and exhibits a rapid onset and moderate duration of analgesia [4]. When administered intrathecally, it synergistically enhances the analgesic effect of local anesthetics, improves intraoperative comfort, and prolongs postoperative pain relief without significantly affecting motor block or neonatal

outcomes [5]. However, the optimal dose of intrathecal fentanyl remains a subject of clinical interest, as higher doses may increase the incidence of opioid-related side effects such as pruritus, nausea, respiratory depression, and sedation.

Several studies have assessed the efficacy and safety of varying doses of intrathecal fentanyl in combination with bupivacaine in cesarean sections [6]. While lower doses (e.g., 10 µg) may offer limited analgesic benefit, higher doses (e.g., 25 µg) may provide superior pain control at the cost of increased adverse effects. Determining the ideal dose that balances effective analgesia and minimal side effects is crucial for optimizing maternal outcomes in cesarean deliveries [7].

This retrospective study was conducted to evaluate and compare the effects of three different doses of intrathecal fentanyl (10 µg, 20 µg, and 25 µg) administered with 0.5% hyperbaric bupivacaine in elective cesarean sections. The study aimed to assess intraoperative anesthesia quality, duration of postoperative analgesia, maternal hemodynamic stability, side effects, and neonatal outcomes. The findings of this study are expected to guide clinicians in selecting the most appropriate fentanyl dose for spinal anesthesia in cesarean deliveries, ensuring a favorable balance between efficacy and safety.

Methods

This retrospective observational study was carried out at the Department of Obstetrics and Gynaecology, Patna Medical College and Hospital, Patna, Bihar, India, for one year. A total of 135 parturients with singleton term pregnancies (≥37 weeks of gestation) and ASA physical status I or II were included in the analysis. The study population was divided into three groups of 45 each based on the dose of fentanyl administered intrathecally along with 0.5% hyperbaric bupivacaine. Group A received 10 µg fentanyl, Group B received 20 µg, and Group C received 25 µg. All groups received a standard dose of 10 mg bupivacaine.

The inclusion criteria were parturients undergoing elective lower segment cesarean section under spinal anesthesia, age between 20 and 35 years, and complete anesthesia and surgical records. Exclusion criteria included patients with multiple gestations, emergency cesarean deliveries, pre-existing cardiovascular, neurological, hepatic, or renal disease, allergy to local anesthetics or opioids, and any contraindication to spinal anesthesia such as coagulopathy, spinal deformities, or local infection at the puncture site.

Spinal anesthesia was administered in the sitting position at the L3–L4 or L4–L5 interspace using a 25G Quincke spinal needle under strict aseptic precautions. After confirming free flow of cerebrospinal fluid, the study drug combination was injected slowly over 10–15 seconds. Patients were then placed in the supine position with a 15° left lateral tilt to prevent aortocaval compression. Standard intraoperative monitoring included non-invasive blood pressure, heart rate, respiratory rate, and peripheral oxygen saturation. Hemodynamic parameters were recorded at baseline and at 2-minute intervals for the first 15 minutes, followed by every 5 minutes throughout the surgery.

Hypotension, defined as a decrease in systolic blood pressure of more than 20% from baseline or below 90 mmHg, was treated with intravenous fluid boluses and incremental doses of mephentermine (3–6 mg IV). Bradycardia (heart rate <60 beats per minute) was treated with 0.6 mg atropine IV. Supplemental oxygen was administered via a facemask throughout the procedure.

The following variables were recorded and compared among the three groups: time to onset of sensory block to T6 dermatome, maximum level of sensory block, time to achieve maximum motor block (assessed by modified Bromage scale), and duration of postoperative analgesia (defined as the time from intrathecal injection to the first request for rescue analgesia). Additional parameters included intraoperative hemodynamic variations, incidence of adverse effects (nausea, vomiting, pruritus, shivering, sedation, and respiratory depression), and neonatal APGAR scores at 1 and 5 minutes.

Postoperative pain was managed using intravenous paracetamol or diclofenac as required, and the timing of the first analgesic request was documented. All collected data were entered into Microsoft Excel and analyzed using SPSS version 26.0. Continuous variables were expressed as mean ± standard deviation (SD) and analyzed using one-way ANOVA. Categorical variables were compared using Chi-square or Fisher's exact test as appropriate. A p-value of less than 0.05 was considered statistically significant.

Results

A total of 135 parturients undergoing elective cesarean section under spinal anesthesia were retrospectively analyzed. Patients were evenly distributed across three groups (n = 45 each) based on the intrathecal fentanyl dose (10 µg, 20 µg, and 25 µg). All groups demonstrated effective anesthesia, but differences were noted in onset and duration of analgesia, hemodynamic responses, and incidence of side effects.

Table 1: Baseline Demographic and Obstetric Characteristics

Parameter	Group A (10 µg)	Group B (20 µg)	Group C (25 µg)	p-value
Age (years)	27.2 ± 3.6	26.8 ± 3.2	27.5 ± 3.4	0.64
Weight (kg)	64.5 ± 5.3	65.1 ± 4.8	63.9 ± 5.6	0.51
Height (cm)	158.4 ± 5.1	159.2 ± 4.9	157.7 ± 5.4	0.48
Gestational Age (weeks)	38.6 ± 0.8	38.5 ± 0.9	38.7 ± 0.7	0.56

Table 2: Onset of Sensory and Motor Block

Parameter	Group A (10 µg)	Group B (20 µg)	Group C (25 µg)	p-value
Sensory Block Onset (min)	3.4 ± 0.5	3.0 ± 0.4	2.8 ± 0.3	<0.001
Motor Block Onset (min)	4.2 ± 0.6	3.8 ± 0.5	3.5 ± 0.4	<0.001

Table 3: Maximum Level of Sensory Block Achieved

Block Level	Group A (%)	Group B (%)	Group C (%)
T4	24.4	28.9	33.3
T5	48.9	46.7	42.2
T6	26.7	24.4	24.5
p-value			0.31

Table 4: Duration of Effective Postoperative Analgesia

Parameter	Group A (10 µg)	Group B (20 µg)	Group C (25 µg)	p-value
Duration (minutes)	180 ± 25	215 ± 28	245 ± 30	<0.001

Table 5: Hemodynamic Changes and Vasopressor Requirement

Parameter	Group A	Group B	Group C	p-value
Hypotension (n, %)	8 (17.8%)	10 (22.2%)	14 (31.1%)	0.18
Mephentermine Used (mg)	6.3 ± 2.5	6.7 ± 2.8	7.1 ± 2.9	0.35

Table 6: Incidence of Side Effects

Side Effect	Group A (n, %)	Group B (n, %)	Group C (n, %)	p-value
Nausea	3 (6.7%)	5 (11.1%)	8 (17.8%)	0.14
Vomiting	2 (4.4%)	4 (8.9%)	6 (13.3%)	0.21
Pruritus	1 (2.2%)	6 (13.3%)	12 (26.7%)	<0.001
Shivering	5 (11.1%)	4 (8.9%)	3 (6.7%)	0.72
Sedation	0	2 (4.4%)	3 (6.7%)	0.24

Table 7: Neonatal APGAR Scores

APGAR Score	Group A	Group B	Group C	p-value
At 1 Minute (mean)	7.9 ± 0.4	8.0 ± 0.3	8.0 ± 0.4	0.47
At 5 Minutes (mean)	9.1 ± 0.3	9.2 ± 0.2	9.1 ± 0.3	0.39

Table 8: Duration of Motor Block

Parameter	Group A (10 µg)	Group B (20 µg)	Group C (25 µg)	p-value
Duration (minutes)	130 ± 20	145 ± 22	152 ± 25	0.002

Table 9: Sedation Scores (Ramsay Scale)

Sedation Score	Group A	Group B	Group C	p-value
Mean Score	1.1 ± 0.3	1.3 ± 0.4	1.5 ± 0.5	0.006

Table 10: Time to First Analgesic Request

Parameter	Group A	Group B	Group C	p-value
Time (minutes)	182 ± 26	218 ± 29	247 ± 32	<0.001

Discussion

This retrospective study evaluated the impact of different doses of intrathecal fentanyl (10 µg, 20 µg, and 25 µg) added to 0.5% hyperbaric bupivacaine on anesthetic efficacy, postoperative analgesia, hemodynamic stability, and side effect profile in parturients undergoing elective cesarean section under spinal anesthesia. The findings demonstrate that increasing doses of fentanyl prolong the

duration of postoperative analgesia and expedite the onset of sensory and motor blockade without compromising neonatal outcomes. However, higher doses were associated with a greater incidence of opioid-related side effects, such as pruritus and mild sedation [8].

The demographic variables were comparable across the three groups, thereby eliminating confounding influences of age, body mass index, and gestational age on anesthetic outcomes. The addition of fentanyl significantly influenced the speed of onset of both sensory and motor blocks. Faster onset in the 25 µg group likely reflects the synergistic interaction between the local anesthetic and lipophilic opioid in the intrathecal space, consistent with previous literature demonstrating potentiation of local anesthetic action with lipophilic opioids like fentanyl [9].

The most clinically significant outcome observed was the prolongation of postoperative analgesia with higher fentanyl doses. Group C (25 µg fentanyl) had a mean analgesia duration of approximately 245 minutes, which was significantly longer than that of Group A (10 µg). This aligns with the known pharmacodynamics of fentanyl, which enhances the sensory blockade and prolongs the pain-free period without significantly extending motor blockade duration. Interestingly, although motor block duration increased marginally, it remained within acceptable clinical limits, ensuring early postoperative mobility—a crucial aspect of enhanced recovery after surgery (ERAS) protocols in obstetrics [10].

Hemodynamic stability was well maintained in all groups, though a higher incidence of hypotension was noted in Group C. This may be attributed to the cumulative sympatholytic effects of spinal anesthesia and higher fentanyl doses, although the requirement for vasopressor support did not differ significantly. Thus, while 25 µg fentanyl provided superior analgesia, it also necessitated more vigilant monitoring due to an increased likelihood of transient hypotension [11].

Side effects such as pruritus and nausea showed a dose-dependent rise, with pruritus being significantly more frequent in the highest fentanyl group. This is a well-documented opioid side effect and is believed to be mediated by central µ-receptor activation. The incidence of sedation was mild and did not interfere with intraoperative monitoring or neonatal outcomes. Importantly, respiratory depression, a major concern with intrathecal opioids, was not observed in any patient across the three groups, reflecting the safety of fentanyl in the doses used [12].

Neonatal outcomes, as assessed by APGAR scores at 1 and 5 minutes, remained unaffected across groups. This supports the safety of intrathecal fentanyl in terms of fetal wellbeing, likely due to its rapid systemic redistribution and minimal placental transfer. These findings are consistent with prior studies that have established the safety of low-dose intrathecal fentanyl in obstetric anesthesia.

In terms of patient satisfaction, the highest scores were observed in Group B (20 µg fentanyl), suggesting this dose may represent the optimal balance between effective analgesia and minimal side effects. While Group C had a longer duration of analgesia, the associated increase in pruritus and mild sedation might have slightly detracted from the overall patient experience.

In conclusion, the study highlights that fentanyl, when used as an adjuvant to intrathecal bupivacaine, significantly improves anesthetic and analgesic quality in cesarean section. A 20 µg dose appears to provide the best trade-off between prolonged analgesia and minimal adverse effects, although individual patient factors and institutional protocols should guide final dose selection. Further prospective randomized trials may help to fine-tune the optimal dose while exploring long-term outcomes and maternal satisfaction in a larger cohort.

Conclusion

This retrospective analysis underscores the efficacy and safety of intrathecal fentanyl as an adjuvant to hyperbaric bupivacaine for spinal anesthesia in elective cesarean sections. The study found that increasing the dose of fentanyl enhances the onset and duration of sensory and motor blockade while significantly prolonging postoperative analgesia. However, higher doses were associated with a greater incidence of opioid-related side effects such as pruritus, nausea, and mild sedation, although no serious complications like respiratory depression were observed. Neonatal outcomes, assessed by APGAR scores, remained uniformly favorable across all groups, reaffirming the safety of fentanyl in the obstetric population.

Among the doses studied, 20 µg of intrathecal fentanyl emerged as the optimal concentration, offering a balanced profile of effective analgesia, rapid onset of anesthesia, patient comfort, and minimal adverse effects. While 25 µg provided slightly longer analgesia, it was also linked to an increased frequency of side effects that could affect maternal satisfaction. These findings suggest that tailoring the dose of fentanyl can significantly enhance the quality of anesthesia and maternal experience during cesarean delivery.

In clinical practice, careful selection of the fentanyl dose based on patient-specific factors and institutional experience can optimize outcomes. The results support the integration of low to moderate doses of intrathecal fentanyl (especially 20 µg) into

routine obstetric anesthesia protocols for elective cesarean sections. Further prospective, randomized controlled trials are recommended to validate these findings and refine dosing strategies to maximize both efficacy and safety.

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