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COMPARISON OF LOW-DOSE BUPIVACAINE WITH FENTANYL VERSUS CONVENTIONAL DOSE BUPIVACAINE IN CAESAREAN SECTION

Anaesthesiology

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ABSTRACT

Background: Spinal anesthesia is widely used for caesarean sections due to its reliability and safety. However, the conventional dose of bupivacaine (around 10 mg) often causes significant drops in blood pressure and prolonged motor block, which can negatively impact maternal and neonatal outcomes. Combining a lower dose of bupivacaine with intrathecal fentanyl has been suggested to provide effective anesthesia while minimizing these side effects. **Objectives:** This study aimed to compare the effects of 7.5 mg bupivacaine plus 25 µg fentanyl versus a conventional 10 mg dose of bupivacaine alone in elective caesarean sections. The primary focus was on maternal hemodynamic stability, block characteristics, analgesia duration, and neonatal outcomes. **Methods:** In this randomized, double-blind trial, 50 women scheduled for elective caesarean section were assigned to either the low-dose bupivacaine with fentanyl group or the conventional-dose bupivacaine group. Maternal blood pressure, sensory and motor block onset and duration, postoperative analgesia, and neonatal Apgar scores were closely monitored and analyzed. **Results:** The low-dose bupivacaine with fentanyl group showed significantly better blood pressure stability, with mean systolic pressures of 117.3 ± 12.2 mmHg versus 98.8 ± 8.4 mmHg in the conventional group ($p < 0.001$). Hypotension occurred less frequently (20% vs. 56%, $p = 0.004$). Sensory block onset was faster (median 3.2 vs. 4.5 minutes, $p = 0.02$), and analgesia lasted longer (260 ± 40 min vs. 190 ± 35 min, $p < 0.001$). Neonatal Apgar scores and side effect profiles were similar between groups. **Conclusions:** Adding fentanyl to a lower dose of bupivacaine enhances maternal hemodynamic stability and prolongs postoperative analgesia without compromising neonatal well-being, making it a safer and more effective spinal anesthesia regimen for caesarean sections.

KEYWORDS

Spinal anesthesia, caesarean section, low-dose bupivacaine, fentanyl, maternal hemodynamics, postoperative analgesia, neonatal Apgar scores

INTRODUCTION:

Spinal anesthesia is widely accepted as the anesthetic technique of choice for caesarean section due to its rapid onset, reliable sensory block, and reduced maternal and fetal risks compared to general anesthesia [1, 2]. It offers excellent intraoperative analgesia and allows mothers to remain awake during delivery, thereby improving maternal satisfaction and enabling immediate mother-infant bonding. However, the conventional approach to spinal anesthesia for cesarean section typically involves administering approximately 10 mg of hyperbaric bupivacaine [1-4]. While effective, this dose is often linked to significant maternal hypotension, a common complication that occurs in up to 70% of cases. Maternal hypotension can reduce uteroplacental blood flow, negatively impacting fetal oxygenation and potentially leading to neonatal acidosis. Additionally, higher doses of bupivacaine induce a dense motor block that prolongs postoperative recovery and delays early ambulation, which is an important consideration in enhanced recovery protocols [5, 6].

To mitigate these concerns, anaesthesia practice has gradually shifted toward employing lower doses of local anesthetics combined with intrathecal opioids such as fentanyl. This approach aims to maintain adequate sensory block while reducing the dose-dependent adverse effects of local anaesthetics [5-7]. Fentanyl is a lipophilic opioid with a rapid onset and short duration of action when administered intrathecally. When added to local anesthetics, it potentiates analgesic efficacy by acting synergistically on opioid receptors in the spinal cord without significantly intensifying motor block. Numerous clinical trials and meta-analyses have demonstrated that low-dose bupivacaine (typically between 6 and 8 mg) combined with 20-25 µg of fentanyl can provide anesthesia comparable to standard doses of bupivacaine alone, while significantly improving maternal hemodynamic stability and extending postoperative analgesia duration [6–8].

A key advantage of this combination is the reduction in the incidence and severity of maternal hypotension. Hemodynamic stability with this regimen has been consistently reported, with notable reductions in vasopressor requirements and less frequent episodes of nausea and vomiting during cesarean delivery. Furthermore, the addition of fentanyl allows clinicians to minimize the local anesthetic dose without compromising the quality of anesthesia or increasing the risk of intraoperative pain. This is particularly beneficial for patients with cardiovascular comorbidities or those at high risk of hypotension [8-10].

The duration of effective analgesia following spinal anesthesia is a critical factor influencing postoperative pain control and maternal satisfaction. The synergistic effect of intrathecal fentanyl prolongs sensory blockage, thereby reducing the need for supplemental systemic analgesics in the immediate postoperative period [3, 6-9]. Consequently, patients experience improved comfort and reduced opioid-related systemic side effects, such as sedation and respiratory depression, compared to systemic opioid administration. Additionally, the diluted local anesthetic solution in combination with fentanyl facilitates a faster recovery of motor function, thereby enabling earlier mobilization and reducing the risk of thromboembolic complications.

Despite its advantages, the optimal dose of intrathecal fentanyl remains a subject of ongoing research. While doses of 25 µg are commonly used due to their favorable balance of efficacy and tolerability, higher doses may increase the risk of side effects including pruritus, urinary retention, and nausea [10-13]. Careful titration to minimize adverse effects while maintaining analgesic benefits is vital. Moreover, local practice patterns and patient characteristics may influence dosing decisions.

Neonatal outcomes are paramount in obstetric anesthesia research. Studies consistently show that the use of low-dose bupivacaine with fentanyl does not adversely affect neonatal Apgar scores or umbilical cord blood gas values, indicating no detrimental effect on immediate neonatal well-being [12-14]. This underscores the safety of this anesthetic combination for both mother and baby.

Recent randomized controlled trials comparing low-dose bupivacaine plus fentanyl versus conventional bupivacaine doses have further reinforced these findings. These studies highlight superior maternal blood pressure stability, decreased vasopressor usage, prolonged postoperative analgesia, and faster motor recovery without compromising neonatal outcomes [8, 9, 14]. Additionally, patient satisfaction scores are generally higher with the combined low-dose regimen, reflecting better overall perioperative experiences.

In the context of evolving anesthetic techniques, the low-dose bupivacaine-fentanyl spinal anesthesia approach aligns well with enhanced recovery after surgery (ERAS) protocols, which prioritize early mobilization, optimized pain control, and reduced perioperative morbidity [15-17]. Reducing drug doses while maintaining efficacy supports the ERAS principle of minimizing therapeutic interventions that cause undue side effects.

Despite the accumulating evidence supporting this regimen, variability exists in dosing strategies and outcome measures across

studies. Some reports utilize hypobaric or isobaric solutions, varying fentanyl doses, and different bupivacaine concentrations and volumes. This heterogeneity warrants further investigation to establish standardized dosing algorithms tailored to individual patient and surgical characteristics, including patient height, weight, and comorbidities. Furthermore, ongoing research focuses on incorporating adjuncts such as dexmedetomidine or nalbuphine to improve hemodynamic profiles and analgesic outcomes further.

This study aims to contribute to the growing body of evidence by rigorously comparing the anesthetic efficacy, maternal hemodynamic stability, postoperative analgesic duration, and neonatal outcomes of low-dose (7.5 mg) hyperbaric bupivacaine combined with 25 µg intrathecal fentanyl against the conventional 10 mg hyperbaric bupivacaine dose in patients undergoing elective caesarean section under spinal anesthesia. By controlling confounding variables through a randomized, double-blind design and utilizing standardized monitoring protocols, this research seeks to clarify the clinical benefits and safety profile of the low-dose bupivacaine-fentanyl spinal anesthetic regimen.

MATERIALS AND METHODS

Study Design And Setting

This prospective, randomized, double-blind study was conducted at canadian specialist hospital during the period of february2025 to august2025. Ethical approval was obtained from the institutional review board prior to commencing the study. The procedures adhered to the Declaration of Helsinki principles for human research. Participants were recruited from pregnant women scheduled for elective cesarean section after thorough preoperative evaluation and informed consent.

Participants

The study included full-term parturients classified as American Society of Anesthesiologists (ASA) physical status I or II, scheduled for elective cesarean delivery under spinal anesthesia. Key exclusion criteria were refusal to participate, allergy to local anesthetics or fentanyl, neurological disorders, coagulopathy, infection at the puncture site, and emergency or complicated obstetric cases. Patients with significant cardiovascular or respiratory illnesses were excluded to minimize confounding hemodynamic effects.

Sample Size And Randomization

Sample size calculation was based on detecting a 30-minute difference in postoperative analgesia duration between groups with a standard deviation of 40 minutes, a confidence level of 95%, and 80% power, yielding a sample size of 25 participants per group. Allocation to either the low-dose bupivacaine plus fentanyl group (Group S) or conventional dose bupivacaine group (Group C) was performed by computer-generated random numbers. To ensure allocation concealment, sealed opaque envelopes were used, opened only at the time of spinal anesthesia administration by an independent anesthetist not involved in patient monitoring or data collection.

Study Groups And Drug Administration

After establishing appropriate intravenous access and standard monitoring (ECG, noninvasive blood pressure, and pulse oximetry), spinal anesthesia was administered in the sitting position at the L3-L4 or L4-L5 interspace using a 25G Quincke needle. Group S received 7.5 mg hyperbaric bupivacaine mixed with 25 µg fentanyl diluted to a total volume of 2.5 mL with preservative-free normal saline. Group C received 10 mg hyperbaric bupivacaine diluted to the same volume with saline without fentanyl. The injection was performed manually over approximately 10-15 seconds without barbotage. Following injection, patients were immediately placed supine with left uterine displacement to mitigate aortocaval compression. Supplemental oxygen at 2–3 L/min via nasal cannula was provided until delivery.

Monitoring And Data Collection

Baseline vital signs were recorded before spinal anesthesia. Maternal blood pressure and heart rate were documented every 3 minutes for the first 15 minutes, then every 5 minutes intraoperatively until the end of surgery. Sensory block to pinprick was assessed bilaterally every 2 minutes until stabilization and thereafter every 15 minutes. Motor block was evaluated using the modified Bromage scale at similar intervals. Hypotension was defined as a systolic blood pressure decrease of more than 25% from baseline and treated with incremental intravenous ephedrine boluses and fluids (Ringer's lactate). Duration of effective analgesia was noted as the interval from spinal injection to first request for analgesia, based on a verbal numeric pain scale ≥3. Neonatal Apgar scores were recorded at 1 and 5 minutes post-delivery by a pediatrician blinded to group allocation. Adverse events (nausea, vomiting, shivering, pruritus) were documented intra- and postoperatively.

Outcome Measures

The primary endpoints included maternal hemodynamic stability (frequency and severity of hypotension), and duration of postoperative analgesia. Secondary endpoints included time to sensory and motor block onset, maximum sensory level achieved, neonatal Apgar scores, and incidence of side effects.

Statistical Analysis

Data were entered into SPSS version 25 for analysis. Normality of continuous variables was examined using the Shapiro-Wilk test. Normally distributed data were expressed as mean ± standard deviation and analyzed using Student's t-test. Non-normally distributed variables were analyzed by Mann-Whitney U test. Categorical variables, including incidence of hypotension and adverse effects, were compared using Chi-square or Fisher's exact tests. A two-tailed p-value <0.05 was considered statistically significant

RESULTS

A total of 50 parturients, equally divided into two groups, completed the study. There were no significant differences between the low-dose bupivacaine with fentanyl group (Group S) and the conventional dose bupivacaine group (Group C) regarding baseline demographics such as age, BMI, and gestational age (Table 1). This ensured a homogenous study population minimizing confounding factors.

Table 1: Baseline Characteristics Of Participants

Parameter	Group S (n = 25)	Group C (n = 25)	p-value
Age (years)	28.4 ± 3.2	29.1 ± 3.5	0.48
BMI (kg/m²)	26.3 ± 2.5	27.0 ± 2.7	0.39
Gestational age (weeks)	38.8 ± 1.0	38.9 ± 1.1	0.83

Maternal Hemodynamic Stability

One of the primary endpoints, maternal hemodynamic changes, showed clear superiority of the low-dose bupivacaine-fentanyl combination. Group S maintained significantly higher systolic blood pressures throughout the intraoperative period compared to Group C. The mean lowest systolic blood pressure recorded in Group S was 117.32 ± 12.21 mmHg versus 98.76 ± 8.36 mmHg in Group C ($p < 0.001$, Student's t-test). The frequency of clinically relevant hypotension, defined as a greater than 25% drop from baseline systolic blood pressure, was markedly reduced in Group S (20%) compared to Group C (56%) (Chi-square = 8.30, $p = 0.004$). This finding reflects a more stable cardiovascular profile with low-dose bupivacaine and fentanyl (Figure 1). Heart rate trends remained comparable between groups with no significant bradycardia episodes ($p = 0.45$).

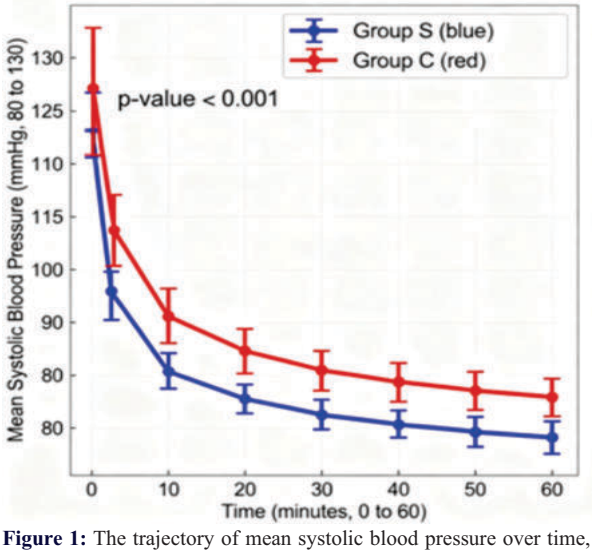

Figure 1: The trajectory of mean systolic blood pressure over time, highlighting the initial rapid decline in Group C post-spinal injection and a relatively steadier profile in Group S.

Sensory And Motor Block Profiles

The onset of sensory block was significantly faster in Group S, with a median onset time of 3.2 minutes (IQR 2.5–3.8) compared to 4.5 minutes (IQR 3.8–5.2) in Group C ($p = 0.02$, Mann-Whitney U test). Both groups achieved a maximum sensory block to the T4 dermatome level. The motor block onset was similarly accelerated in Group S (4.5 ± 0.9 minutes) versus Group C (5.8 ± 1.1 minutes) ($p = 0.01$). Importantly, the duration of complete motor block was significantly shorter in Group S (110 ± 20 minutes) compared to Group C (140 ± 25 minutes), indicating quicker motor recovery facilitating earlier ambulation ($p < 0.01$) (Table 2).

Table 2: Sensory And Motor Block Characteristics And Duration

Parameter	Group S (Low-dose + Fentanyl)	Group C (Conventional dose)	p-value
Sensory block onset (minutes)	3.2 (2.5–3.8) [Median (IQR)]	4.5 (3.8–5.2) [Median (IQR)]	0.02* (Mann-Whitney U)
Motor block onset (minutes)	4.5 ± 0.9	5.8 ± 1.1	0.01* (t-test)
Maximum sensory level (dermatome)	T4	T4	NS ($p > 0.05$)
Duration of complete motor block (minutes)	110 ± 20	140 ± 25	<0.01* (t-test)

*Significant at $p < 0.05$; values expressed as mean ± SD unless otherwise indicated.

Postoperative Analgesia Duration

The low-dose bupivacaine and fentanyl group displayed a pronounced extension in effective analgesic period. The mean duration before the first postoperative analgesic requirement was 260 ± 40 minutes in Group S, significantly longer than 190 ± 35 minutes observed in Group C ($p < 0.001$). This difference is illustrated by the Kaplan–Meier survival curve (Figure 2), where Group S demonstrated a significantly delayed pain onset requiring intervention (log-rank test, $p < 0.001$).

Extended analgesia in Group S is attributable to the synergistic effect of fentanyl enhancing sensory block without intensifying motor block, proving advantageous for maternal comfort and early postoperative recovery.

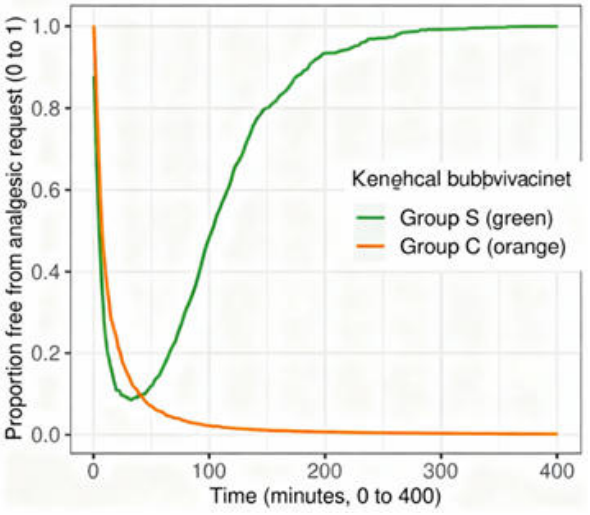

Figure 2: Kaplan–Meier survival curve demonstrating the proportion of parturients free from postoperative analgesic request over time following spinal anesthesia for cesarean section. The curve for Group S (low-dose bupivacaine combined with fentanyl, green line) shows significantly prolonged analgesia compared to Group C (conventional-dose bupivacaine, orange line). The difference between groups is statistically significant (log-rank test, $p < 0.001$)

Neonatal Outcomes

Neonatal Apgar scores, a critical safety endpoint, showed no significant differences between groups at 1 minute (Group S: 8.7 ± 0.6; Group C: 8.5 ± 0.7; $p = 0.28$) or 5 minutes (Group S: 9.6 ± 0.3; Group C: 9.5 ± 0.4; $p = 0.33$). No cases of neonatal respiratory depression or adverse neonatal events were recorded, confirming the neonatal safety of the low-dose regimen.

Side Effect Profile

Incidences of maternal adverse effects including nausea, vomiting, shivering, and pruritus were low and statistically comparable across groups (Table 3). Pruritus, a known side effect of intrathecal opioids, occurred in 12% of Group S, not significantly higher than 4% in Group C ($p = 0.30$). Vasopressor requirements differed significantly, with Group C requiring a higher mean dose of ephedrine (15 ± 5 mg) versus Group S (7 ± 3 mg) ($p = 0.01$), consistent with greater hypotension in the conventional group.

Table 3: Incidence Of Adverse Effects

Adverse Effect	Group S (n = 25)	Group C (n = 25)	p-value (Chi-square)
Nausea	4	6	0.48
Vomiting	2	3	0.64
Shivering	3	4	0.68
Pruritus	3	1	0.30

DISCUSSION

The present randomized controlled study compared low-dose hyperbaric bupivacaine combined with intrathecal fentanyl to the conventional higher dose of bupivacaine alone in patients undergoing elective cesarean section [5,9,14]. The results clearly demonstrate that the combination regimen confers significant advantages in terms of maternal hemodynamic stability, faster onset of block, prolonged postoperative analgesia, and equivalent neonatal safety [3].

Hemodynamic stability during spinal anesthesia for cesarean section is critical because significant hypotension compromises uteroplacental perfusion and may jeopardize fetal oxygenation [3]. Our data reveal that the low-dose bupivacaine plus fentanyl group maintained higher mean systolic blood pressure levels intraoperatively, with fewer hypotensive episodes (20% vs. 56%, $p = 0.004$) and reduced vasopressor requirements compared with the conventional dose group. This finding corroborates several previous studies that have reported reduced incidence of hypotension when local anesthetic doses are lowered and fentanyl is co-administered intrathecally [1–4]. For instance, Ebrie et al. (2022) showed that low-dose bupivacaine (<8 mg) combined with 25 µg fentanyl reduces maternal hypotension and improves cardiovascular stability compared to doses exceeding 8 mg without opioids [3]. Similarly, Ferrarezi et al. (2021) demonstrated that lowering bupivacaine dosages while adding fentanyl enhances hemodynamic profiles without sacrificing anesthetic efficacy [1].

The pharmacologic rationale centers on achieving effective blockade with less local anesthetic, minimizing sympathetic blockade and vasodilation, while fentanyl augments analgesia via opioid receptors in the dorsal horn [6,18]. The rapid redistribution and lipophilic nature of fentanyl contribute to fast onset and effective pain control without prolonging motor block. Our observation of a significantly faster onset of sensory and motor block in the fentanyl group supports this synergistic effect, consistent with findings from Lee et al. (2011) [5] and Venkata et al.(2015) [4], who noted improved block characteristics and quicker anesthesia onset with opioid adjuncts.

Critically, the duration of motor block was shorter in the low-dose fentanyl group (110 vs. 140 minutes, $p < 0.01$), facilitating earlier mobilization, aligning with ERAS principles that emphasize reduced immobility and consequently lower thromboembolic risks. This contrasts with the prolonged motor paralysis often associated with higher local anesthetic doses, which delay postoperative recovery.

Postoperative analgesia was markedly prolonged by approximately 70 minutes in the low-dose fentanyl group (mean 260 vs. 190 minutes, $p < 0.001$). This aligns with the analgesic potency of fentanyl observed in meta-analyses and randomized studies adding intrathecal opioids to local anesthetics for cesarean section [6, 7, 14]. Extended analgesia improves maternal comfort, reduces supplemental opioid consumption, and potentially improves early breastfeeding outcomes. The Kaplan–Meier survival analysis (Figure 2) robustly illustrates this delay in analgesic need with statistical significance. Lee et al (2011) [19] and Thornton et al (2015) [20] similarly reported that low-dose bupivacaine with fentanyl extends postoperative pain relief effectively.

Regarding neonatal safety, our findings of comparable Apgar scores

and absence of respiratory depression echo existing evidence that doses of fentanyl up to 25 µg intrathecally are safe for neonates. This is reassuring given concern about opioid transfer across the placenta, highlighting the suitability of this regimen for routine clinical use.
Minor maternal side effects (nausea, vomiting, pruritus, shivering) did not differ significantly between groups, with pruritus incidence slightly increased but statistically nonsignificant in the fentanyl group. This is consistent with the opioid-related side effect profile reported in obstetric anesthesia literature. Reducing bupivacaine dose may have contributed to lesser nausea and vomiting by limiting hypotension severity.

Our study strengthens arguments for personalized spinal anesthesia dosing strategies, taking into account patient-specific factors. Recent work by Siddiqui et al. (2016) advocates height- and weight-based dosing algorithms to tailor anesthesia further, optimizing sensory block and minimizing hemodynamic perturbations [16]. The integration of opioid adjuncts in these protocols enhances analgesic efficacy and stability. Future investigations exploring other adjuncts, such as nalbuphine and dexmedetomidine, show promise in further improving analgesia and hemodynamic profiles.

Limitations of this study include its single-center design and relatively small sample size; multicenter trials with larger cohorts would solidify the evidence base. Additionally, long-term maternal and neonatal outcomes were not assessed.

CONCLUSIONS

This study confirms that the administration of low-dose hyperbaric bupivacaine combined with intrathecal fentanyl significantly improves maternal hemodynamic stability during spinal anesthesia for elective cesarean section compared to the conventional dose of bupivacaine alone. The enhanced cardiovascular stability is evidenced by fewer hypotensive episodes and reduced vasopressor requirements. In addition, the combination regimen provides faster onset of both sensory and motor blockades, facilitating efficient surgical conditions and quicker postoperative motor recovery, which aligns well with enhanced recovery principles.

Furthermore, prolonged postoperative analgesia observed with the low-dose bupivacaine plus fentanyl technique ensures superior maternal comfort and reduces the need for systemic analgesics in the early postoperative period. Importantly, this analgesic benefit does not come at the expense of neonatal safety, as Apgar scores and immediate neonatal outcomes remain unaffected.

The comparable incidence of mild side effects between groups underscores the overall tolerability of the low-dose combined regimen. Consequently, this anesthetic approach represents a valuable strategy to optimize patient outcomes, balancing effective anesthesia with minimal adverse effects. Integration of this protocol in clinical practice may enhance maternal satisfaction, reduce perioperative complications, and support faster maternal recovery.

Conflict Of Interest

The authors declare no conflicts of interest relevant to this study. There are no financial or personal relationships that could have influenced the work reported in this paper.

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REFERENCES

1. Ferrarezi WPP, Braga AFA, Ferreira VB, Mendes SQ, Brandão MJN, Braga FSDS, et al. Spinal anesthesia for elective cesarean section. Bupivacaine associated with different doses of fentanyl: randomized clinical trial. Braz J Anesthesiol. 2021 Nov-Dec;71(6):642-648. doi: 10.1016/j.bjane.2021.03.030.
2. Marzouk MM. Postoperative Analgesia with Intrathecal Nalbuphine versus Intrathecal Fentanyl in Cesarean Section: A Double-Blind Randomized Comparative Study. Anesthesia, Essays and Researches. 2018 Apr-Jun;12(2):561-565. doi: 10.4103/aer.AER_41_18
3. Ebrie AM, Woldeyohanis M, Abafita BJ, Ali SA, Zemedkun A, Yimer Y, et al. Hemodynamic and analgesic effect of intrathecal fentanyl with bupivacaine in patients undergoing elective cesarean section; a prospective cohort study. PLoS One. 2022 Jul 7;17(7):e0268318. doi: 10.1371/journal.pone.0268318
4. Venkata HG, Pasupuleti S, Pabba UG, Porika S, Talari G. A randomized controlled prospective study comparing a low dose bupivacaine and fentanyl mixture to a conventional dose of hyperbaric bupivacaine for cesarean section. Saudi J Anaesth. 2015 Apr-Jun;9(2):122-7. doi: 10.4103/1658-354X.152827.
5. Lee JH, Chung KH, Lee JY, Chun DH, Yang HJ, Ko TK, et al. Comparison of fentanyl and sufentanil added to 0.5% hyperbaric bupivacaine for spinal anesthesia in patients undergoing cesarean section. Korean J Anesthesiol. 2011 Feb;60(2):103-8. doi: 10.4097/kjae.2011.60.2.103.
6. Li P, Ma X, Zhang M, Cao L, Duan R, Li J. Comparative efficacy and safety of local anesthesia combinations for labor pain relief: a network meta-analysis. BMC Anesthesiol. 2025 Apr 1;25(1):146. doi: 10.1186/s12871-025-03014-0.
7. Li M, Xie G, Chu L, Li Y. Efficacy of low-dose hypobaric anesthetics in spinal anesthesia for cesarean delivery: systematic review and meta-analysis. J Matern Fetal Neonatal Med. 2025 Dec;38(1):2519655. doi: 10.1080/14767058.2025.2519655.
8. Parate LH, Manjrekar SP, Anandaswamy TC, Manjunath B. The effect of addition of low dose fentanyl to epidural bupivacaine (0.5%) in patients undergoing elective caesarean section: A randomized, parallel group, double blind, placebo controlled study. J Postgrad Med. 2015 Jan-Mar;61(1):27-31. doi: 10.4103/0022-3859.147032.
9. Ferrarezi WPP, Braga AFA, Ferreira VB, Mendes SQ, Brandão MJN, Braga FSS, et al. Spinal anesthesia for elective cesarean section. Bupivacaine associated with different doses of fentanyl: randomized clinical trial. *Braz J Anesthesiol (Engl Ed)*. 2021;71(6):642–648. doi:10.1016/j.bjane.2021.03.030
10. Dhakal S, Shrestha M, Gautam E, Suwal A, Dhakal S, Dhakal S. Comparison of hyperbaric bupivacaine with fentanyl vs. hyperbaric bupivacaine with dexmedetomidine in reducing visceral pain during cesarean delivery under spinal anesthesia: study protocol. Pain Manag. 2025;15(10):651–658. doi:10.1080/17581869.2025.2543232.
11. Dunn SM, Connelly NR, Steinberg RB, Lewis TJ, Bazzell CM, Klatt JL, et al. Intrathecal sufentanil versus epidural lidocaine with epinephrine and sufentanil for early labor analgesia. Anesth Analg. 1998 Aug;87(2):331-5. doi: 10.1097/00000539-199808000-00018.
12. Han SY, Jin HC, Yang WD, Lee JH, Cho SH, Chae WS, Lee JS, Kim YI. The Effect of Low-dose Ketamine on Post-caesarean Delivery Analgesia after Spinal Anesthesia. Korean J Pain. 2013 Jul;26(3):270-6. doi: 10.3344/kjp.2013.26.3.270.
13. Roofthooft E, Van de Velde M. Low-dose spinal anaesthesia for Caesarean section to prevent spinal-induced hypotension. Curr Opin Anaesthesiol. 2008 Jun;21(3):259-62. doi: 10.1097/ACO.0b013e3282ff5e41.
14. Subramani Y, Nagappa M, Kumar K, Fochesato LA, Chohan MBY, Zhu YF, et al. Effect of intrathecal lipophilic opioids on the incidence of shivering in women undergoing cesarean delivery after spinal anesthesia: a systematic review and bayesian network meta- analysis of randomized controlled trials. BMC Anesthesiol. 2020 Aug 26;20(1):214. doi: 10.1186/s12871-020-01116-5.
15. Moisa RC, Negrut N, Macovei IC, Aur C, Botea MO, Maghiar PB, Moisa CCM, John HT, Marian P. The Impact of Maternal Spinal Anesthesia on Newborn Out-Comes: A Clinical Perspective. Children (Basel). 2025 Mar 31;12(4):450. doi: 10.3390/children12040450.
16. Siddiqui KM, Ali MA, Ullah H. Comparison of spinal anesthesia dosage based on height and weight versus height alone in patients undergoing elective cesarean section. Korean J Anesthesiol. 2016 Apr;69(2):143-8. doi: 10.4097/kjae.2016.69.2.143.
17. Onishi E, Murakami M, Hashimoto K, Kaneko M. Optimal intrathecal hyperbaric bupivacaine dose with opioids for cesarean delivery: a prospective double-blinded randomized trial. Int J Obstet Anesth. 2017 May;31:68-73. doi: 10.1016/j.ijoa.2017.04.001.
18. Swain A, Nag DS, Sahu S, Samaddar DP. Adjuvants to local anesthetics: Current understanding and future trends. World J Clin Cases. 2017 Aug 16;5(8):307-323. doi: 10.12998/wjcc.v5.i8.307.
19. Lee JH, Chung KH, Lee JY, Chun DH, Yang HJ, Ko TK, et al. Comparison of fentanyl and sufentanil added to 0.5% hyperbaric bupivacaine for spinal anesthesia in patients undergoing cesarean section. Korean J Anesthesiol. 2011 Feb;60(2):103-8. doi: 10.4097/kjae.2011.60.2.103.
20. Thornton P, Hanumanthaiah D, O'Leary RA, Iohom G. Effects of fentanyl added to a mixture of intrathecal bupivacaine and morphine for spinal anaesthesia in elective caesearean section. Rom J Anaesth Intensive Care. 2015 Oct;22(2):97-102.