Section: Anaesthesiology

Original Research Article

OPTIMIZING SPINAL ANESTHESIA FOR CESAREAN SECTION: A COMPARATIVE STUDY OF DEXMEDETOMIDINE AND FENTANYL AS ADJUVANTS TO INTRATHECAL LEVOBUPIVACAINE

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Abstract

Background: The choice of adjuvants in spinal anesthesia significantly influences the efficacy and duration of analgesia. This study evaluates the effect of adding dexmedetomidine versus fentanyl to intrathecal levobupivacaine 0.5% in patients undergoing lower segment cesarean section (LSCS). **Materials and Methods:** A prospective, randomized, double-blind study was conducted on parturients scheduled for elective LSCS under spinal anesthesia in the Department of Anesthesiology, North Bengal Medical College and Hospital, Patients were divided into three groups: Group L (levobupivacaine alone), Group LD (levobupivacaine + dexmedetomidine), and Group LF (levobupivacaine + fentanyl). Hemodynamic parameters, sensory and motor block characteristics, duration of analgesia, and side effects were assessed. **Result:** ASA physical status, and gestational age, with no statistically significant differences ($p > 0.05$). The onset of sensory and motor blockade was significantly faster in the dexmedetomidine group ($p < 0.05$). Additionally, dexmedetomidine led to a significantly prolonged duration of sensory and motor blockade compared to fentanyl ($p < 0.001$). Hypotension and bradycardia were more common in the dexmedetomidine group, but the difference was not statistically significant ($p > 0.05$). Pruritus was significantly higher in the fentanyl group ($p = 0.008$). **Conclusion:** Dexmedetomidine as an adjuvant to intrathecal levobupivacaine 0.5% provides superior prolongation of spinal block and postoperative analgesia compared to fentanyl in LSCS patients, with a favorable safety profile.

INTRODUCTION

Spinal anesthesia is the preferred anesthetic technique for lower segment cesarean section (LSCS) due to its rapid onset, effective sensory and motor blockade, and lower neonatal drug exposure.[1] Levobupivacaine, an S-enantiomer of bupivacaine, is commonly used because of its reduced cardiotoxicity and neurotoxicity.[2] However, its duration of action may be insufficient for prolonged postoperative analgesia, necessitating the addition of adjuvants.[3]

Adjuvants enhance spinal block quality, prolong duration, and reduce local anesthetic doses.[4] Common adjuvants include α_2-adrenergic agonists and opioids, both of which act on spinal receptors to improve analgesia.[5]

Dexmedetomidine, a selective α_2-adrenergic agonist, prolongs sensory and motor blockade by inhibiting excitatory neurotransmitter release in the spinal cord.[6] It provides sedation, analgesia, and hemodynamic stability without significant respiratory depression.[7] However, potential side effects such as bradycardia and hypotension require careful monitoring.[8]

Fentanyl, a lipophilic opioid, enhances neuraxial blockade by binding to μ-opioid receptors, reducing intraoperative discomfort and prolonging analgesia.[9] It provides rapid onset and hemodynamic stability but may cause pruritus, nausea, and respiratory depression.[10]

Rationale for the Study

Although both dexmedetomidine and fentanyl are used as intrathecal adjuvants, their comparative effects on spinal block quality, hemodynamic stability, and postoperative analgesia remain unclear. This study aims to evaluate their efficacy and safety when added to intrathecal levobupivacaine 0.5% in

LSCS patients, providing insights to optimize obstetric anesthesia.

MATERIALS AND METHODS

Research Design: This study is a prospective, randomized, double-blind clinical trial designed to compare the effects of adding dexmedetomidine versus fentanyl to intrathecal levobupivacaine 0.5% in patients undergoing lower segment cesarean section (LSCS). Patients were allocated into two groups using a computer-generated randomization method.

Research Setting: The study was conducted in the Department of Anesthesiology, North Bengal Medical College and Hospital, a tertiary care hospital with a well-equipped labor and delivery unit. The hospital provides comprehensive maternal and neonatal care services, including elective and emergency LSCS under regional anesthesia.

Inclusion and Exclusion Criteria for Sample Selection

Inclusion Criteria:

- ASA (American Society of Anesthesiologists) physical status I or II.
- Singleton term pregnancy (≥37 weeks gestation).
- Scheduled for elective LSCS under spinal anesthesia.
- Age between 18 and 40 years.
- Willing to provide informed consent.

Exclusion Criteria:

- Contraindications to spinal anesthesia (e.g., coagulopathy, local infection at the injection site).
- History of allergic reactions to study drugs.
- Severe cardiovascular, neurological, hepatic, or renal disease.
- Pre-existing hypertension or pregnancy-induced hypertension.
- Patients receiving chronic opioid therapy.
- Body Mass Index (BMI) >35 kg/m².

Sample Size Calculation

The sample size is calculated based on previous studies comparing dexmedetomidine and fentanyl as intrathecal adjuvants. Assuming a significance level (α) of 0.05, a power (1-β) of 80%, and a clinically relevant difference in sensory block duration of 15 minutes, a total of 119 patients was required, with approximately 60 patients per group.

Procedure for Data Collection

- Patients meeting eligibility criteria were recruited and randomized into two groups:
  - Group D: Intrathecal levobupivacaine 0.5% + dexmedetomidine (5 µg).
  - Group F: Intrathecal levobupivacaine 0.5% + fentanyl (25 µg).
- Standardized monitoring (ECG, pulse oximetry, non-invasive blood pressure) was applied.
- Spinal anesthesia was administered under aseptic precautions in the L3-L4 or L4-L5 interspace using a 25G Quincke needle.
- Sensory and motor block assessments wasrecorded at predetermined intervals using a pinprick test and Bromage scale, respectively.
- Postoperative pain scores (VAS) and hemodynamic parameters were documented for 24 hours.
- Any adverse events were noted and managed appropriately.

Statistical analysis

- Data was recorded in a structured proforma and entered into an electronic database.
- Statistical analysis was performed using SPSS 22 software, with continuous variables analyzed using the independent t-test and categorical variables using the chi-square test.
- Results were presented as mean ± standard deviation (SD) or proportions as appropriate. A p-value <0.05 was considered statistically significant.

RESULTS

This table presents the demographic data of participants in both the dexmedetomidine (Group D) and fentanyl (Group F) groups. The groups are well-matched in terms of age, weight, ASA physical status, and gestational age, with no statistically significant differences ($p > 0.05$).

Table 1: Demographic and Baseline Characteristics.

Variable	Group D (Dexmedetomidine) (n=60)	Group F (Fentanyl) (n=60)	p-value
Age (years)	28.5 ± 4.2	29.1 ± 4.5	0.45
Weight (kg)	65.8 ± 6.9	66.2 ± 7.1	0.72
ASA Grade I/II (n)	42/18	40/20	0.82
Gestational Age (weeks)	38.4 ± 1.2	38.5 ± 1.3	0.67

Table 2: Intraoperative and Postoperative Block Characteristics

Parameter	Group D (Dexmedetomidine)	Group F (Fentanyl)	p-value
Onset of Sensory Block (min)	2.8 ± 0.6	3.2 ± 0.7	0.04*
Onset of Motor Block (min)	3.6 ± 0.8	4.1 ± 0.9	0.03*
Duration of Sensory Block (min)	240.2 ± 25.4	190.5 ± 22.7	<0.001**
Duration of Motor Block (min)	210.8 ± 21.5	170.4 ± 20.2	<0.001**
Time to First Analgesic Request (min)	310.6 ± 30.2	230.8 ± 28.3	<0.001**

*Statistically significant ($p < 0.05$), Highly significant ($p < 0.001$).

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Table highlights the effects of dexmedetomidine and fentanyl on spinal block characteristics. The onset of sensory and motor blockade was significantly faster in the dexmedetomidine group ($p < 0.05$). Additionally, dexmedetomidine led to a significantly prolonged duration of sensory and motor blockade compared to fentanyl ($p < 0.001$). The time to first analgesic request was also longer in the dexmedetomidine group.

Table 3: Hemodynamic Parameters

Time Interval (min)	Heart Rate (bpm) Group D	Heart Rate (bpm) Group F	SBP (mmHg) Group D	SBP (mmHg) Group F	p-value
Baseline	82.4 ± 6.2	83.1 ± 6.5	122.6 ± 8.3	121.9 ± 7.8	0.67
5 min	78.5 ± 5.9	81.2 ± 6.3	118.4 ± 7.5	120.2 ± 7.6	0.32
10 min	76.3 ± 6.1	79.5 ± 6.4	116.2 ± 6.8	119.1 ± 7.0	0.21
20 min	74.8 ± 5.7	78.8 ± 6.2	114.7 ± 6.5	118.0 ± 6.9	0.15
30 min	73.2 ± 5.4	77.6 ± 6.0	113.1 ± 6.2	117.3 ± 6.7	0.08

This table shows the intraoperative heart rate (HR) and systolic blood pressure (SBP) at different time intervals. The dexmedetomidine group had lower HR and SBP values compared to the fentanyl group, though differences were not statistically significant at most time points.

Table 4: Adverse Effects

Adverse Effect	Group D (Dexmedetomidine) (n=60)	Group F (Fentanyl) (n=60)	p-value
Hypotension (%)	8 (13.3%)	5 (8.3%)	0.42
Bradycardia (%)	6 (10.0%)	2 (3.3%)	0.19
Nausea/Vomiting (%)	4 (6.7%)	7 (11.7%)	0.33
Pruritus (%)	1 (1.7%)	9 (15.0%)	0.008*
Respiratory Depression (%)	0 (0%)	1 (1.7%)	0.50

*Statistically significant ($p < 0.05$).

Table presents the incidence of adverse effects. Hypotension and bradycardia were more common in the dexmedetomidine group, but the difference was not statistically significant ($p > 0.05$). Pruritus was significantly higher in the fentanyl group ($p = 0.008$). Other side effects, such as nausea, vomiting, and respiratory depression, were comparable between the two groups.

DISCUSSION

This study compared the effects of adding dexmedetomidine versus fentanyl to intrathecal levobupivacaine 0.5% in patients undergoing lower segment cesarean section (LSCS). The results indicate that dexmedetomidine provides a faster onset of sensory and motor block, a prolonged duration of spinal anesthesia, and extended postoperative analgesia compared to fentanyl. However, dexmedetomidine was associated with a slightly higher incidence of bradycardia and hypotension, while fentanyl was linked to higher pruritus rates.

Our study found that dexmedetomidine significantly reduced the onset time of sensory and motor blockade compared to fentanyl ($p < 0.05$). These findings align with the study by Al-Ghanem et al. (2009),[5] where dexmedetomidine (5 µg) added to intrathecal bupivacaine resulted in a faster onset of sensory block than fentanyl (25 µg). Similarly, Gupta et al,[7] (2011) reported that dexmedetomidine enhanced the onset and duration of sensory and motor block compared to fentanyl when used as an adjuvant in spinal anesthesia.

Our study demonstrated that the time to first analgesic request was significantly longer in the dexmedetomidine group (310.6 ± 30.2 min) compared to the fentanyl group (230.8 ± 28.3 min, $p < 0.001$). This aligns with a meta-analysis by Qi et al,[11] (2016) which found that dexmedetomidine prolongs analgesia more effectively than fentanyl due to its action on α_2-adrenergic receptors in the dorsal horn, leading to reduced nociceptive transmission.

Dexmedetomidine caused a greater reduction in heart rate and blood pressure compared to fentanyl, though the difference was not statistically significant at most time points. Previous studies have reported similar findings. Bajwa et al,[8] (2012) found that dexmedetomidine leads to dose-dependent bradycardia and hypotension due to its sympatholytic effects, whereas fentanyl maintains greater hemodynamic stability. This supports our findings that dexmedetomidine requires careful monitoring in patients prone to hypotension.

In our study, pruritus was significantly higher in the fentanyl group ($p = 0.008$), which is consistent with previous literature. Sindjelic et al,[10] (2014) reported that fentanyl, due to its µ-opioid receptor agonist action, frequently causes pruritus, nausea, and vomiting. Conversely, dexmedetomidine had a higher incidence of bradycardia and hypotension, which is also reported by Kimura and Hoka (2013),[6] who emphasized that intrathecal α_2-agonists can lower sympathetic tone, leading to hemodynamic depression.

Dexmedetomidine is a more suitable adjuvant when prolonged sensory and motor blockade, as well as extended postoperative analgesia, are desired.

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Fentanyl may be preferred for hemodynamically unstable patients, as it provides effective spinal block without significant bradycardia or hypotension.
Pruritus should be considered when using fentanyl, and patients receiving dexmedetomidine should be closely monitored for hypotension and bradycardia.

CONCLUSION

The results concluded that dexmedetomidine provides a superior sensory and motor block with prolonged analgesia compared to fentanyl. However, it may have a stronger hemodynamic depressant effect, requiring careful perioperative management. Conversely, fentanyl is associated with a higher incidence of pruritus but maintains stable hemodynamics. These findings indicate that dexmedetomidine may be a preferable adjuvant for spinal anesthesia in LSCS when prolonged analgesia is desired, while fentanyl may be beneficial for patients who require minimal hemodynamic alterations.

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