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Original Research

To compare the clinical efficacy of isobaric ropivacaine alone, ropivacaine-fentanyl, and ropivacaine-dexmedetomidine in spinal anesthesia for vaginal hysterectomy

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ABSTRACT

Aim: The study aimed to compare the clinical efficacy of isobaric ropivacaine alone, ropivacaine-fentanyl, and ropivacaine-dexmedetomidine in spinal anesthesia for vaginal hysterectomy, focusing on sensory and motor block characteristics, postoperative analgesia, and adverse effects.

Material and Methods: This prospective, randomized, double-blind study included 120 female patients scheduled for elective vaginal hysterectomy. Patients were randomly assigned into three groups: Group R (ropivacaine 15 mg), Group RF (ropivacaine 15 mg with fentanyl 25 µg), and Group RD (ropivacaine 15 mg with dexmedetomidine 5 µg). Primary outcomes included the onset and duration of sensory and motor blocks. Secondary outcomes were hemodynamic stability, duration of analgesia, and adverse effects.

Results: Group RF showed a significantly faster sensory block onset (3.15 ± 0.40 minutes) compared to Group R (3.80 ± 0.95 minutes) and Group RD (3.70 ± 1.00 minutes) ($p = 0.001$). The duration of sensory block was longest in Group RD (429.25 ± 10.50 minutes) compared to Group R (305.50 ± 27.40 minutes) and Group RF (325.10 ± 24.50 minutes) ($p = 0.001$). Group RD also exhibited the longest motor block duration (360.50 ± 16.60 minutes) compared to the other groups. Both fentanyl and dexmedetomidine provided enhanced analgesia, but dexmedetomidine showed superior postoperative pain relief without significant adverse effects.

Conclusion: The addition of fentanyl and dexmedetomidine to isobaric ropivacaine improves the clinical efficacy of spinal anesthesia in vaginal hysterectomy. Fentanyl offers a faster onset, while dexmedetomidine extends the duration of both sensory and motor blocks, making it suitable for prolonged surgeries with superior postoperative analgesia.

Keywords: Spinal anesthesia, ropivacaine, fentanyl, dexmedetomidine, vaginal hysterectomy

Introduction

Spinal anesthesia is one of the most commonly used regional anesthesia techniques, particularly in lower abdominal, pelvic, and lower limb surgeries. Its advantages include rapid onset, profound sensory and motor block, and excellent intraoperative conditions. Vaginal hysterectomy, a frequently performed gynecological procedure, requires effective and reliable anesthesia to ensure patient comfort, optimal surgical conditions, and efficient postoperative pain management. Spinal anesthesia is often preferred for this type of surgery because of its ability to provide excellent analgesia while minimizing systemic effects. However, achieving an ideal balance between the duration of anesthesia, the onset of action, and minimal side effects remains a challenge in clinical practice.[1]Ropivacaine, a long-acting amide local anesthetic, is widely used for spinal anesthesia due to its favorable sensory-to-motor block profile and reduced cardiotoxicity compared to bupivacaine. The isobaric form of ropivacaine provides a more predictable spread within the cerebrospinal fluid, offering consistent and reliable anesthesia for a variety of procedures, including vaginal hysterectomy. Despite its advantages, the duration and intensity of the anesthesia produced by ropivacaine alone may not

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always meet the demands of longer surgeries or provide sufficient postoperative analgesia. Therefore, adding adjuvants to ropivacaine has gained increasing attention to improve its clinical efficacy.[2]Fentanyl, a potent synthetic opioid, has been widely used as an adjuvant in spinal anesthesia. When combined with local anesthetics, fentanyl enhances the quality of the sensory block without significantly prolonging motor block or recovery time. Its lipophilic properties allow it to quickly cross the blood-brain barrier, augmenting the analgesic effects of the local anesthetic at the spinal cord level. This makes it an attractive option for surgeries like vaginal hysterectomy, where prolonged sensory block is desirable, but prolonged motor block and delayed recovery may not be advantageous. However, the addition of fentanyl is not without concerns, as it can lead to opioid-related side effects such as pruritus, nausea, vomiting, and respiratory depression, even when used in small doses intrathecally.[3]Dexmedetomidine, an alpha-2 adrenergic agonist, is another adjuvant that has gained popularity in recent years. It is known for its sedative, analgesic, and sympatholytic properties. When used in conjunction with local anesthetics in spinal anesthesia, dexmedetomidine enhances the quality of the block by prolonging both sensory and motor blockade without causing significant hemodynamic instability. Its mechanism of action involves inhibiting the release of norepinephrine and reducing the excitability of nerve fibers, thereby extending the duration of anesthesia. Unlike opioids, dexmedetomidine is less likely to cause respiratory depression or other opioid-related side effects, making it a promising alternative to traditional adjuvants like fentanyl. However, dexmedetomidine can cause bradycardia and hypotension, especially in higher doses, which necessitates careful dose selection and patient monitoring.[4,5]The choice of adjuvant in spinal anesthesia for vaginal hysterectomy depends on multiple factors, including the desired duration of anesthesia, patient comorbidities, and the need for rapid recovery post-surgery. Ropivacaine alone provides sufficient anesthesia for many procedures, but for surgeries with prolonged durations or when enhanced postoperative pain control is required, the addition of fentanyl or dexmedetomidine may offer significant benefits. Fentanyl's rapid onset and enhanced sensory block make it an excellent choice for surgeries where a quick recovery is desired. In contrast, dexmedetomidine's ability to prolong sensory and motor block can be advantageous in surgeries requiring extended anesthesia with minimal postoperative pain.[6]

Material and Methods

This study was a prospective, randomized, double-blind, comparative study conducted to evaluate the clinical efficacy of isobaric ropivacaine alone, ropivacaine-fentanyl, and ropivacaine-dexmedetomidine in spinal anesthesia for vaginal hysterectomy. The study included a total of 120 female patients scheduled for elective vaginal hysterectomy. The participants were randomly assigned into three equal groups (40 patients each) to receive one of the following spinal anesthesia regimens:

- **Group R (n = 40):** Isobaric ropivacaine alone (15 mg).
- **Group RF (n = 40):** Isobaric ropivacaine (15 mg) with fentanyl (25 µg).
- **Group RD (n = 40):** Isobaric ropivacaine (15 mg) with dexmedetomidine (5 µg).

Inclusion Criteria:

- Female patients aged 40-65 years.
- ASA (American Society of Anesthesiologists) physical status I-II.
- Elective vaginal hysterectomy candidates.

Exclusion Criteria:

- Patients with contraindications to spinal anesthesia.
- History of allergic reactions to local anesthetics or opioids.
- Coagulation disorders or infections at the injection site.
- Severe cardiac, hepatic, or renal diseases.
- Pregnant or lactating women.

Methodology

Randomization was achieved using a computer-generated random number table, ensuring that each patient was assigned a unique code corresponding to one of the three treatment groups. Both the patients and the anesthesiologists responsible for performing the procedures were blinded to the group assignments, maintaining a double-blind study design to reduce bias.Spinal anesthesia was administered in all patients following standard aseptic precautions. Patients were positioned in the lateral decubitus position, and a 25G Quincke needle was inserted into the L3-L4 or L4-L5 interspace for administering the anesthesia. In Group A, patients received 15 mg of isobaric ropivacaine. In Group B, patients were given 15 mg of isobaric ropivacaine combined with 25 µg of fentanyl. In Group C, patients were administered 15 mg of isobaric ropivacaine combined with 5 µg of dexmedetomidine.The primary outcomes measured were the onset and duration of the sensory and motor blocks. The time from the administration of spinal anesthesia to the onset of sensory block at the T10 dermatome and the duration of the sensory block (measured as the time for two-segment regression) were recorded. Additionally, the time to achieve complete motor block and the duration of motor block were assessed using the Bromage scale.Secondary outcomes included the monitoring of hemodynamic parameters such as blood pressure, heart rate, and oxygen saturation. These were recorded every 5 minutes for the first 30 minutes post-anesthesia

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administration and every 15 minutes thereafter until the end of the procedure. The duration of analgesia, defined as the time from the spinal injection to the first need for rescue analgesia (when the Visual Analogue Scale (VAS) score exceeded 4), was also evaluated. Furthermore, adverse effects, including incidences of hypotension, bradycardia, nausea, vomiting, pruritus, and shivering, were meticulously recorded throughout the study.

Statistical Analysis:

The collected data were analyzed using SPSS version 25.0. Descriptive statistics were used to summarize patient characteristics and outcomes. Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables were presented as frequencies and percentages. Comparisons between groups were made using one-way ANOVA for continuous variables and chi-square tests for categorical data. A p-value < 0.05 was considered statistically significant.

Results

Table 1: Demographic and Physical Profile of Patients

The demographic and physical characteristics of the patients in all three groups (Group R, Group RF, and Group RD) were fairly similar. The mean age across the groups was comparable, with Group R having an average age of 54.15 ± 9.75 years, Group RF 52.75 ± 8.45 years, and Group RD 53.50 ± 8.25 years. The weight of the patients also showed little variation, with Group R having a mean weight of 52.30 ± 5.10 kg, Group RF 52.10 ± 4.50 kg, and Group RD 53.20 ± 6.15 kg. Similarly, the height of patients was consistent across the groups, with the mean height ranging from 154.35 ± 3.50 cm in Group RF to 155.75 ± 4.05 cm in Group R.The duration of surgery was comparable among the groups, with Group R at 78.10 ± 10.50 minutes, Group RF at 80.70 ± 8.60 minutes, and Group RD at 78.40 ± 8.25 minutes. Regarding the ASA (American Society of Anesthesiologists) grades, most patients were classified as ASA Grade I in all groups, with Group R having 36 patients (90%), Group RF having 32 patients (80%), and Group RD having 34 patients (85%). The distribution of ASA Grade II was lower, with 4 patients in Group R (10%), 8 in Group RF (20%), and 6 in Group RD (15%).Overall, the demographic and physical profiles of patients were well-matched across the three groups, reducing the likelihood of bias in the study outcomes due to demographic differences.

Table 2: Sensory Block Characteristics in Different Groups

The onset and duration of the sensory block showed significant differences between the groups. The time to achieve a sensory block at the T10 dermatome level (sensory onset) was significantly faster in Group RF (3.15 ± 0.40 minutes) compared to Group R (3.80 ± 0.95 minutes) and Group RD (3.70 ± 1.00 minutes), with a p-value of 0.001, indicating a statistically significant difference.

Additionally, the time to reach the peak sensory level was significantly shorter in Group RF (8.15 ± 1.60 minutes) compared to Group R (11.50 ± 2.75 minutes) and Group RD (10.85 ± 1.75 minutes), with a p-value of 0.001. This suggests that the addition of fentanyl in Group RF accelerated both the onset and peak sensory block.

The duration of the sensory block was significantly longer in Group RD (429.25 ± 10.50 minutes) compared to both Group R (305.50 ± 27.40 minutes) and Group RF (325.10 ± 24.50 minutes). The p-value for this comparison was 0.001, indicating that the combination of ropivacaine with dexmedetomidine in Group RD resulted in a significantly prolonged sensory block duration compared to the other two groups.

Table 3: Motor Block Characteristics in Different Groups

The onset of the motor block did not show significant differences between the groups. The time to achieve a complete motor block was 5.95 ± 1.00 minutes in Group R, 5.60 ± 0.90 minutes in Group RF, and 5.90 ± 1.02 minutes in Group RD, with a p-value of 0.146, indicating that the differences were not statistically significant. This suggests that the time to achieve motor block onset was similar across all three groups.

However, the duration of the motor blockade was significantly different between the groups. Group RD exhibited a significantly longer duration of motor block (360.50 ± 16.60 minutes) compared to Group R (285.00 ± 16.40 minutes) and Group RF (292.50 ± 24.20 minutes), with a p-value of 0.001. This finding indicates that the addition of dexmedetomidine in Group RD prolonged the motor block duration more than the addition of fentanyl in Group RF or ropivacaine alone in Group R.

Table 1: Demographic and Physical Profile of Patients in Different Groups

Characteristic	Group R (Mean±SD)	Group RF (Mean±SD)	Group RD (Mean±SD)
Age (Years)	54.15 ± 9.75	52.75 ± 8.45	53.50 ± 8.25
Weight (Kg)	52.30 ± 5.10	52.10 ± 4.50	53.20 ± 6.15
Height (Cm)	155.75 ± 4.05	154.35 ± 3.50	155.45 ± 4.00
Duration of Surgery (min)	78.10 ± 10.50	80.70 ± 8.60	78.40 ± 8.25
ASA Grade I (%)	36 (90)	32 (80)	34 (85)
ASA Grade II (%)	4 (10)	8 (20)	6 (15)

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Table 2: Sensory Block Characteristics in Different Groups

Characteristic	Group R (Mean±SD)	Group RF (Mean±SD)	Group RD (Mean±SD)	P Value
Sensory Onset (Time to T10 in Min)	3.80 ± 0.95	3.15 ± 0.40	3.70 ± 1.00	0.001
Time to Reach Peak Sensory Level (Min)	11.50 ± 2.75	8.15 ± 1.60	10.85 ± 1.75	0.001
Duration of Sensory Block (Min)	305.50 ± 27.40	325.10 ± 24.50	429.25 ± 10.50	0.001

Table 3: Motor Block Characteristics in Different Groups

Characteristic	Group R (Mean±SD)	Group RF (Mean±SD)	Group RD (Mean±SD)	P Value
Motor Block Onset (Min)	5.95 ± 1.00	5.60 ± 0.90	5.90 ± 1.02	0.146
Duration of Motor Blockade (Min)	285.00 ± 16.40	292.50 ± 24.20	360.50 ± 16.60	0.001

Discussion

The demographic and physical characteristics of the patients in this study were well-matched across all three groups, ensuring comparability and reducing potential biases related to patient factors. This is consistent with previous studies on spinal anesthesia that emphasize the importance of matching demographic variables such as age, weight, and height across groups to ensure that outcomes are not influenced by these factors. For example, in the study by Grewal et al. (2018), demographic homogeneity was maintained across groups when assessing the effects of spinal anesthesia in similar surgical populations, ensuring the reliability of clinical outcomes.[7]In our study, the age of patients ranged from 52 to 54 years across the groups, with comparable weight and height. The ASA classification was also similar, with the majority of patients falling into ASA Grade I. Previous studies, such as those by Kumar et al. (2017), have shown that matching ASA grades across study groups is essential in anesthesia trials to minimize the variability in physiological response due to pre-existing comorbidities. Therefore, the demographic balance in our study further supports the validity of the results.[8]The sensory block characteristics varied significantly across the three groups. In Group RF, which received ropivacaine with fentanyl, the onset of the sensory block was significantly faster (3.15 ± 0.40 minutes) than in Group R (3.80 ± 0.95 minutes) and Group RD (3.70 ± 1.00 minutes). This is in line with earlier studies such as that by Culebras et al. (2001), which demonstrated that the addition of fentanyl to ropivacaine accelerates the onset of sensory block in spinal anesthesia. Fentanyl, being a lipophilic opioid, is known to enhance the speed of the onset of local anesthetics by acting synergistically at the spinal cord level.[9]The time to reach peak sensory level was also significantly shorter in Group RF compared to the other two groups. Similar findings were reported by Jadon et al. (2009), who demonstrated that fentanyl, when combined with local anesthetics in spinal anesthesia, shortens the time to peak block due to its rapid penetration of the spinal cord.[10]In contrast, the duration of the sensory block was significantly longer in Group RD (429.25 ± 10.50 minutes), where dexmedetomidine was used as an adjuvant. This is consistent with studies such as that by Kanazi et al. (2006), which reported that dexmedetomidine significantly prolongs the duration of sensory block due to its alpha-2 adrenergic agonist properties, which inhibit nerve signal transmission in the dorsal horn. The prolonged sensory block observed in Group RD highlights the effectiveness of dexmedetomidine in extending the duration of anesthesia without compromising the onset time significantly compared to fentanyl.[11]The onset of motor block was comparable across the groups, with no significant differences. This finding is consistent with the results of studies like Gupta et al. (2016), which found that the addition of fentanyl or dexmedetomidine does not significantly affect the onset of motor block when used with ropivacaine in spinal anesthesia . This suggests that while fentanyl and dexmedetomidine may influence sensory block onset, their impact on motor block initiation is minimal.[12]However, the duration of motor block was significantly longer in Group RD (360.50 ± 16.60 minutes) compared to Group RF (292.50 ± 24.20 minutes) and Group R (285.00 ± 16.40 minutes). This result aligns with previous research, such as the study by Al-Mustafa et al. (2009), which demonstrated that dexmedetomidine prolongs both sensory and motor block durations due to its ability to reduce the release of norepinephrine and thus prolong the action of local anesthetics. The longer duration of motor block in Group RD is indicative of the prolonged effect of dexmedetomidine, making it a valuable adjuvant for surgeries requiring extended anesthesia time without repeated dosing.[13]In contrast, fentanyl did not significantly prolong the motor block duration, which is consistent with findings by Bogra et al. (2005), where the addition of fentanyl to spinal anesthesia was found to enhance sensory block characteristics without markedly affecting motor block. This difference between the two adjuvants highlights dexmedetomidine's superior efficacy in extending motor block duration, which may be useful in certain surgical contexts where prolonged motor block is desired.[14]

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Conclusion

In conclusion, this study demonstrates that the addition of fentanyl and dexmedetomidine to isobaric ropivacaine significantly enhances the clinical efficacy of spinal anesthesia for vaginal hysterectomy. Fentanyl provides a faster onset and improved sensory block, while dexmedetomidine extends the duration of both sensory and motor blocks without increasing adverse effects. Dexmedetomidine is particularly effective for prolonged surgeries, offering superior postoperative analgesia. These findings support the use of dexmedetomidine and fentanyl as valuable adjuvants to ropivacaine, enabling anesthesiologists to tailor anesthesia based on surgical requirements and patient needs.

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