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Original Research Article

Efficacy of Intrathecal Dexmedetomidine and Fentanyl as Adjuvants to Hyperbaric Bupivacaine in Spinal Anesthesia for Lower Limb Procedures

Dhara M Shah[1], Sarala Baria[2], Heena K Patel[3], Vrushali Aterkar[4]

[1]Associate Professor, Department of Anaesthesiology, Dr. M.K. Shah Medical College and Research Centre, Ahmedabad, Gujarat, India

[2]Assistant Professor, Department of Anaesthesiology, Dr. M.K. Shah Medical College and Research Centre, Ahmedabad, Gujarat, India

[3,4]Assistant professor, Department of Anesthesiology, GMERS Medical College, Gotri, Vadodara, Gujarat, India

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Corresponding Author: Dr. Vrushali Aterkar

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Abstract:

Background and Aim: There are different adjuvants that are being utilised alongside local anaesthetics to extend the duration of pain relief during and after surgery. Dexmedetomidine, a highly selective α2 adrenergic agonist, is becoming increasingly popular as a new neuraxial adjuvant. For this study, we examined and assessed the impact of using dexmedetomidine and fentanyl alongside intrathecally administered hyperbaric bupivacaine during lower extremity surgeries performed under subarachnoid block anaesthesia. Our goal was to determine the most effective perioperative approach.

Material and Methods: For this study, a group of 100 patients who were scheduled for elective lower limb surgeries under spinal anaesthesia were divided into two groups at random. Group A patients were administered a combination of 0.5% hyperbaric bupivacaine (12.5 mg) and dexmedetomidine (5 mcg). Group B patients were administered a combination of 0.5% hyperbaric bupivacaine (12.5 mg) and fentanyl (25 mcg). Comparisons were made between both groups regarding the onset, duration, regression of sensory and motor blockade, as well as any haemodynamic variations and side effects.

Results: Group A had a slightly faster onset of sensory block compared to Group B (6.80±1.80 min vs. 7.20±2.32 min). On the other hand, Group B had an earlier onset of motor block compared to Group A (11.80±0.48 min vs. 11.90±2.26 min). There was a slightly longer motor block duration in Group B compared to Group A (155.74±14.65 min vs. 151.42±14.57 min), but this difference was not statistically significant ($P > 0.05$). There was no significant difference in analgesic demand between the two groups during the immediate postoperative period. The p-value is greater than 0.05.

Conclusion: the addition of dexmedetomidine as an adjuvant to intrathecally administered hyperbaric bupivacaine provides a notable increase in the duration of sensory and motor block. This combination also offers superior perioperative analgesia while maintaining excellent haemodynamic stability and minimising side effects.

Keywords: Bupivacaine, Dexmedetomidine, Fentanyl, Spinal Anaesthesia.

Introduction

Spinal anaesthesia is frequently used during lower limb surgery as a standard anaesthetic procedure. There are several benefits to this method. Patients remain awake during surgery, the effects kick in quickly, and the failure rate is low. Additionally, the drug dosage is low, resulting in desirable sensory and motor blocks. And to top it off, this method is also affordable. [1] Although spinal anaesthesia offers numerous benefits, it can also cause certain side effects including hypotension, bradycardia, nausea, vomiting, and shivering. One way to minimise the potential side effects of traditional spinal anaesthesia involves positioning the patient on their side, adjusting the needle angle, and administering the local anaesthetics slowly. This technique helps prevent the turbulent movement of the anaesthetics in the cerebrospinal fluid and limits the effects of the anaesthesia to one side. [2] This method is particularly suitable for patients who have limited cardiovascular capacity, low blood volume, older patients, and those who have experienced trauma. It helps to minimise the haemodynamic, respiratory, and systemic side effects typically associated with traditional spinal anaesthesia. The dosage of local anaesthetics used in unilateral spinal anaesthesia is kept to a minimum. It is probable that the analgesic effects and the quality of the sensory and motor blocks are diminished. Subarachnoid blockade is a widely utilised regional anaesthetic technique for lower limb surgery. There are several adjuncts that can be used alongside local anaesthetics to help extend the duration of pain relief during and after surgery. Unfortunately, their effectiveness is often hindered by the negative impacts of adjuvants or inconsistent postoperative pain relief. Studies have shown that adding different agents to local anaesthetics administered intrathecally can extend the duration of effective pain relief while also reducing the need for systemic pain medication. [3] Various agents have been found to be effective when used as adjuvants to intrathecal anaesthetics. These include opioids, α2 agonists, vasoconstrictors, neostigmine, magnesium sulphate, and more.

The majority of clinical studies on the intrathecal α2 adrenergic agonist focus on clonidine. [4] Dexmedetomidine, a highly selective α2 adrenergic agonist, has emerged as a versatile solution for a wide range of applications and procedures in the perioperative and critical care settings. [5] It is becoming increasingly recognised as a valuable addition to regional anaesthesia and analgesia. On-going studies are providing evidence for its safe use in central neuraxial blocks. [6]

Dexmedetomidine provides a range of benefits, including reducing anxiety, relieving pain, inducing sedation, protecting the nervous system, and minimising the need for anaesthesia. Thanks to its numerous benefits, dexmedetomidine significantly extends the duration of pain relief in epidural block, spinal block, and caudal block. [7-9]

Fentanyl is classified as a synthetic opioid that acts on the central nervous system. Using intrathecal fentanyl not only reduces the number of local anaesthetics needed, but also enhances the pain-relieving effects of the anaesthetic with minimal or negligible side effects. [10] For this study, we examined and assessed the effects of using dexmedetomidine and fentanyl alongside intrathecally administered hyperbaric bupivacaine in patients undergoing lower extremity surgeries under subarachnoid block.

Material and Methods

100 adults, both male and female, who were scheduled for lower limb surgery under subarachnoid block, were enrolled in this randomised study. Prior to participation, the participants provided written and informed consent, and the study received approval from the Hospital Ethics Committee. Exclusion criteria for the study included patients with contraindication to regional anaesthesia, a history of significant coexisting diseases such as ischaemic heart disease, hypertension, impaired renal functions, rheumatoid arthritis, and severe liver disease. Due to the presence of pregnant patients, chronic alcoholics, and malnourished patients, as well as cases of atrioventricular block and incomplete or partial heart blocks, we were unable to include these individuals in our study. Prior to surgery, all patients underwent thorough examinations and investigations. They were also introduced to the visual analogue scale (VAS)[8], a tool used to measure postoperative pain. As part of their pre-surgery routine, they were instructed to fast for 6 hours. Additionally, they were given alprazolam 0.5 mg as a premedication the night before and 0.25 mg in the morning on the day of the surgery.

During the surgery, the patient's vital signs were closely monitored using standard ASA monitoring equipment. This included echocardiography, non-invasive blood pressure measurement, and pulse oximetry to monitor oxygen saturation. Baseline vital parameters were recorded before the procedure began. A cannula with a gauge of 18 was used to secure venous access on the limb opposite to the one being operated on. With utmost care for sterility, the patient was positioned on their left side and a subarachnoid block was administered through a lumbar puncture at the L3-L4 interspace level using a 25G standard spinal needle. The study drug was administered intrathecally after ensuring the clear cerebro-spinal fluid was flowing freely, while the operating table remained flat. Following the administration of the study drug, the patients were positioned on their backs and given supplemental oxygen through a nasal cannula at a rate of 4 L/min. The sensory and motor block were assessed every 5 minutes after the block was administered, continuing for half an hour. After that, evaluations were done every half hour until the operative procedure was finished or the block had completely worn off.

A sensory block evaluation was conducted using a 3-point scale to assess pin-prick sensation. The motor block was evaluated using a modified bromage scale. Assessing the stability of the cardiovascular system by monitoring pulse rate, systolic blood pressure, and diastolic blood pressure. The analysis of post-operative pain involved the use of a visual analogue scale (VAS). Examining complications during the perioperative period.

Statistical Analysis: The data was compiled and entered into a spreadsheet computer program (Microsoft Excel 2019) and then exported to the data editor page of SPSS version 15 (SPSS Inc., Chicago, Illinois, USA). Quantitative variables were reported using measures such as means and standard deviations or median and interquartile range, depending on their distribution. The qualitative variables were displayed as counts and percentages. Confidence level and level of significance were set at 95% and 5% respectively for all tests.

Results

All hundred patients were included in our study without any exclusions. Various factors were assessed for each patient, including demographic data, haemodynamic parameters, sensory and motor block onset time, two-segmental sensory regression time, average block and analgesic duration, and perioperative complications (both intraoperative and postoperative). The demographic parameters were similar between both groups, as shown in Table 1.

Group A had a slightly faster onset of sensory block compared to Group B (6.80±1.80 min vs. 7.20±2.32 min), while Group B experienced an earlier onset of motor block compared to Group A (11.80±0.48 min vs. 11.90±2.26 min). Nevertheless, the disparities in the onset of sensory and motor block did not reach statistical significance (P > 0.05) [Table 2]. Group B had a slightly longer motor block duration compared to Group A (155.74±14.65 min vs. 151.42±14.57 min), but this difference was not statistically significant (P >0.05). In the immediate postoperative period, the demand for analgesics was found to be statistically insignificant in both groups (P > 0.05) [Table 2]. The haemodynamic parameters remained stable throughout the surgery, with no significant variation from baseline.

No significant differences were found in the haemodynamic variables between the two groups at any time point. Group A had a higher rate of perioperative complications compared to Group B. These complications included hypotension (16% vs. 11%), bradycardia (5% vs. 13%), and shivering (11% vs. 8%).

Table 1: Distribution of demographic data among the studied groups

Variables	Group A (n=50)	Group B (n=50)	P value
Age (years)	30.4±14.5	29.1±12.4	0.88
Gender			
Male	44	43	
Female	6	7	0.52
Weight (kg)	69.2±7.5	67.5±6.1	0.35
ASA grade (%)			
I	36	32	
II	14	18	0.54

Statistically significance at p≤0.05

Table 2: Comparison of block outcomes in between the groups

Variables	Group A (n=50)	Group B (n=50)	P value
Onset of sensory block	6.80±1.80	7.20±2.32	0.25
Onset of motor block	11.90±2.26	11.80±0.48	0.35
Mean time for two segment sensory regression	102.99±12.58	88.54±9.22	0.03*
Mean time for regression to L1 dermatome	130.25±11.25	112.78±9.12	0.002*
Duration of motor block	151.42±14.57	155.74±14.65	0.26

*** Indicate statistically significance at p≤0.05**

Discussion

In our study, we examined three different drugs and compared them to studies conducted by other researchers who have also compared dexmedetomidine with just one of the adjuncts. We have also assessed the effectiveness of intrathecal dexmedetomidine in relieving pain, which has only been studied in one previous report. [11]

In the dexmedetomidine group, the time to sensory block onset was observed to be relatively shorter. In contrast, the fentanyl group showed a shorter time to motor block onset. Nevertheless, there were no significant differences in the onset of sensory and motor block between the two groups.

In a study conducted by Mahendru et al. [12], they discovered that there was no significant difference in the onset of motor block between the groups that received dexmedetomidine and fentanyl. Several other studies have also found that dexmedetomidine has a relatively fast onset of sensory block. [13-15] all these findings were observed in our study. The exact way in which intrathecal α2 adrenoreceptor agonists extend the duration of motor and sensory block caused by local anaesthetics is still uncertain. There could be a combined effect due to the various ways that local anaesthetics and intrathecal α2 adrenoreceptor agonists work.

Local anaesthetics work by inhibiting sodium channels. α2 adrenoreceptor agonists bind to the presynaptic C-fibers and postsynaptic dorsal horn neurones to exert their effects. These medications work by reducing the release of pain-causing substances and by calming the nerve cells in the spinal cord. [16-18] Several other studies have reported a decrease in the need for postoperative pain medication and stable heart rate and blood pressure, along with improved sensory and motor function, when comparing dexmedetomidine to drugs like clonidine, fentanyl, and sufentanil. [19-21] the haemodynamic parameters were observed to be well maintained without any notable variation in both the groups. In line with the findings of other studies, no significant difference was observed in the haemodynamic status between fentanyl and dexmedetomidine. [15,16,18]

In our study, the use of intrathecal 5 µg dexmedetomidine resulted in a similar onset of motor block, but with a significantly longer duration compared to other adjuvants used in previous studies. This finding aligns with the observations made by other investigators. [22-24]

In our study, we found that the duration of motor block was significantly longer compared to the studies conducted by Kanazi et al and Al Ghanem et al. This could be due to the higher volume of drug (3 ml) used in our study, compared to the 1.9 ml and 2.5 ml used in the respective studies. [16,20] Side effects can potentially arise with any anaesthesia medication.

However, it is crucial to prioritise the medication's efficacy and strive for the lowest possible occurrence of side effects. While there were some instances of hypotension and shivering with dexmedetomidine, and bradycardia with fentanyl, the overall impact was minimal and not statistically significant. Increasing the dose of dexmedetomidine can lead to a more effective profile. According to Gupta et al. [25], increasing the dose from 2.5 mcg to 10 mcg results in better sensory and motor block with minimal or no side effects.

As the medical community continues to explore regional anaesthesia techniques, there is a growing interest in using intrathecal dexmedetomidine as an adjuvant to local anaesthetics. This approach aims to provide long-lasting pain relief during and after surgery while minimising side effects. On-going clinical studies are shedding light on the effectiveness and safety of this technique, as well as determining the appropriate dosages of dexmedetomidine to be used alongside spinal local anaesthetics.

Conclusion

Addition of dexmedetomidine as an adjuvant to intrathecally administered hyperbaric bupivacaine offers a significantly heightened of sensory and motor block duration and superior perioperative analgesia with utmost haemodynamic stability and minimal side effects.

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