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Comparison of intrathecal dexmedetomidine and intrathecal fentanyl as an adjuvant to bupivacaine during spinal anaesthesia for lower limb orthopaedic surgery

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ABSTRACT:

Objective: During spinal anaesthesia, intrathecal adjuvants like fentanyl and dexmedetomidine are used to boost the effects of bupivacaine. The purpose of this research is to evaluate the safety and effectiveness of intrathecal fentanyl and dexmedetomidine in conjunction with bupivacaine for patients having lower limb orthopaedic surgery.

Method: Three groups of thirty patients each were used in this randomized controlled study. 25 µg of fentanyl and 15 mg of 0.5% hyperbaric bupivacaine were given to Group 1, 5 µg of dexmedetomidine and 15 mg of 0.5% hyperbaric bupivacaine was given to Group 2, and 15 mg of bupivacaine was given to Group 3. The features of the motor and sensory blocks, hemodynamic parameters, postoperative pain (VAS), time to first analgesic request, and side effects were noted and compared across the groups.

Results: There was no significant difference in the groups' surgery times or demographic makeup. In comparison to the fentanyl and control groups, dexmedetomidine substantially extended both sensory block (120 ± 23.5 min) and motor block regression (242 ± 22 min) ($P < 0.001$). The dexmedetomidine group had a longer time to first analgesic request (245 ± 3.6 min) than the fentanyl and control groups ($P < 0.001$). The group that received dexmedetomidine consumed considerably fewer postoperative analgesics. All groups maintained hemodynamic stability, and there were no significant variations in the incidence of bradycardia, hypotension, or nausea, among other adverse effects.

Conclusion: Compared to fentanyl, the addition of 5 µg dexmedetomidine to intrathecal bupivacaine considerably prolongs the duration of sensory and motor block and decreases the requirement for postoperative analgesia. Dexmedetomidine is an excellent adjuvant for spinal anaesthesia in lower limb procedures as it also offers steady hemodynamics with few adverse effects.

Keywords: Dexmedetomidine, Fentanyl, Bupivacaine, Spinal anaesthesia, Lower limb surgery, Intrathecal anaesthesia.

INTRODUCTION:

Spinal anaesthesia is the most commonly utilized method for lower limb orthopaedic surgeries because of the outstanding feature of offering intraoperative analgesia and minimizing postoperative complications. Regional anaesthetics, specifically spinal anaesthesia, depend on the selection of adjuvants in maintaining the quality and length of the anaesthesia as well as control of postoperative pain [1]. Conventionally, for spinal anaesthesia local anesthetics like bupivacaine are administered as it has high efficacy in preventing nerve impulses and has long-lasting sensory and motor blockade. However, the use of adjuvants additive with opioids and alpha-2 adrenergic agonists has been on the increase in recent years for improvement of the quality of spinal anaesthesia [2]. Among all these adjuvants, the most commonly researched opioids are intrathecal fentanyl, an opioid while the others include intrathecal dexmedetomidine, an alpha-2 adrenergic agonist [3].

Intrathecal fentanyl is perhaps the most frequently reported opioid adjuvant in spinal anaesthesia. When combined with bupivacaine, it possesses desirable characteristics involving the onset of sensory block, intraoperative analgesic effect as well as postoperative pain relief [4]. Fentanyl binds to opioid receptors in the spinal cord and blocks the signals that transmit pain thus offering adequate pain relief with a minimal amount of the substance entering the systemic circulation. Fentanyl combined with bupivacaine in spinal anaesthesia can also decrease the amount of bupivacaine needed both for the reduction of motor block effects and for adequate analgesia [5].

Intrathecal dexmedetomidine has recently been identified as a possible alternative to opioids for spinal anaesthesia. Dexmedetomidine exhibits sedative, analgesic, and sympatholytic effects; for all these reasons, dexmedetomidine is an ideal additive to regional anaesthesia. Intrathecal use of dexmedetomidine improves the outcome of bupivacaine by increasing the duration of both sensory and motor block thus providing better postoperative analgesia [6]. Moreover, they have no significant negative side effects; however, less incidence of nausea vomiting, or respiratory depression has been reported by patients receiving dexmedetomidine. However, it possesses sympatholytic action which may produce side effects such as bradycardia and hypotensive effects, especially during anaesthesia and surgery [7].

More specifically, it has become quite popular to compare intrathecal dexmedetomidine and fentanyl for their use as adjuncts to bupivacaine in spinal anaesthesia applied in the context of lower limb orthopaedic surgery [8]. The objective of this work is to assess the effectiveness, safety, and quality of postoperative analgesia of both drugs as an adjuvant to bupivacaine. Thus, this research aims to make recommendations on adjuvants for spinal anaesthesia for orthopaedic procedures based on comparative studies of the onset and duration of sensory and motor block, the incidence of the side effects, and the efficacy of postoperative pain control.

MATERIAL AND METHODS

STUDY DESIGN AND SETTING

This prospective, randomized, double-blind study was undertaken in _____ Hospital and Research Centre, _____ (city name), with the permission of the institutional ethical committee. All the participants completed written consent and informed consent forms before participating in the study. The patients comprised 45 males and 45 females with ages ranging from 20 to 60 years and all were ASA Class I and II patients. These patients underwent lower limb orthopaedic surgery under spinal anaesthesia. With this, the patients were rationally divided into 3 groups of 30 patients each to enable a comparison of intrathecal dexmedetomidine and fentanyl as adjuvants to bupivacaine.

EXCLUSION CRITERIA

Those clients who were on spinal anaesthesia contraindications which included Ischaemic heart disease, heart block, hypertension, renal diseases, liver diseases, and pregnancies were withheld from participation in this study. About the technique of using anaesthesia, the VAS for pain and any other related information patients were given an account ahead of surgery, in the pre-operative room and later before actual operation.

PREOPERATIVE PREPARATION

An intravenous cannula of 18-gauge was then inserted into each patient's hand and the patient was preloaded with Ringer lactate solution at a dose of 10 ml/kg. Supplementary, basic vital signs including Heart Rate, oxygen saturation and blood pressure were closely observed using Electrocardiogram, Pulse oximeter and non-invasive Arterial Pressure Monitor respectively. The patients were then randomized according to the three groups using the closed envelope method to maintain the blind study throughout the study. The three groups were as follows:

- Group 1: placebo: 15 mg of 0.5% hyperbaric bupivacaine.
- Group 2: 15 mg of 0.5% hyperbaric bupivacaine with 25 µg of fentanyl.
- Group 3: 15 mg of 0.5% Morphine was given at a concentration of 5% hyperbaric bupivacaine with 5 µg of intrathecal dexmedetomidine.

ANAESTHESIA PROCEDURE

A spinal anaesthesia was given under conditions that had been aseptically and the patient was in the sitting position. Before the samples were obtained, the skin over the relevant area was infiltrated with a local anaesthetic agent; thereafter, a 25-gauge Quincke-type spinal needle was inserted into the L3-L4 interspace. It was after ascertaining the free flow of cerebrospinal fluid that the respective study drug was administered by injection. Subsequently, the patient was kept supine and under all patients oxygen was given at a flow rate of 5 L/min through a face mask.

POSTOPERATIVE MANAGEMENT

The patients were then moved to the post-operative room for closer monitoring after surgery had been conducted. The patients were then transferred to the ward after the density of the spinal block had reduced to the level of S1 dermatome. Age, sex, weight, height and ASA physical status classification were taken from the patients. The hemodynamic characteristics like the heart rate and the mean arterial pressure were measured before and after the spinal anaesthesia. The patient's heart rate and MAP were recorded every 5 minutes for the first 20 minutes after anaesthesia was done, then rate every 10 minutes during the intraoperative period until the patient was transferred to the recovery room.

MANAGEMENT OF COMPLICATIONS

Low blood pressure was considered as a reduction of systolic BP by more than 20% from the baseline or if it was below 90 mmHg. Hypotension was treated by administration of 300 ML normal saline as an inotropic agent. In bradycardia, the heart of the patient had a rate below 50 beats per minute; this was managed by 0.5 mg of intravenous atropine the dosage was 6 mg. The daily number of patients receiving atropine or vasopressors in the management of sepsis was used.

EVALUATION OF SENSORY AND MOTOR BLOCK

The sensory block level was checked by pinprick every minute till the sensory block up to T10 dermatome was obtained. Records of the time that sensory block regression took to achieve the S1 level were also taken. Motor block was evaluated using the modified Bromage (MB) scale, where:

- MB 0: The patient can move the hip, knee and ankle.
- MB 1: The patient is unable to mobilize the hip joint but able to mobilise the knee and the ankle joint.
- MB 2: While reading the notes the patient is immobile in his hip and knee but can move his ankle.
- MB 3: The patient is completely immobile, and cannot move the hip, knee, or ankle. The duration taken to achieve an MB score of 3 and the total duration to the absence of motor block to an MB score of 0 were treated.

POSTOPERATIVE PAIN ASSESSMENT

Pain which was measured in the VAS was recorded 1, 6, twelve, eighteen, and twenty-four hours after surgery. The time to the first call for pain was also recorded.

STATISTICAL ANALYSIS

Data were analysed using Statistical Package for Social Sciences (SPSS 21). 0 software. Continuous data are presented as mean and Standard Deviation while categorical data were compared with Chi-square or Fisher's exact test whichever was applicable for variables like sex, ASA class, nausea, vomiting, analgesia, hypotension and bradycardia. To determine the difference in proportions for the ordinal data, the chi-square test was used while for continuous data, the ANOVA test was applied. A p-value of <0. 05 was considered significant in the level of 95% confidence intervals.

RESULTS:

There were 30 patients in each of the three groups (Group 1 received Bupivacaine only, Group 2 received Bupivacaine with Fentanyl and Group 3 received Bupivacaine with Dexmedetomidine). Quantitative data was collected regarding demographic variables, haemodynamic variations, the nature of sensory and motor blockade and the VAS pain scores.

The distribution according to age, weight, height, and sex also differed significantly between the three groups ($p > 0.05$) (**Table 1**).

Table 1 Demographical features of the patients (n=90) at ($p>0.05$)

Parameter	Group 1 (Bupivacaine)	Group 2 (Bupivacaine + Fentanyl)	Group 3 (Bupivacaine + Dexmedetomidine)	p-value
Age (years)	42.6 ± 9.2	41.5 ± 8.7	43.2 ± 9.5	0.742
Weight (kg)	68.5 ± 7.3	67.9 ± 8.1	69.1 ± 7.4	0.654
Height (cm)	165.2 ± 8.4	166.1 ± 9.1	165.9 ± 8.7	0.689
Male/Female Ratio	18/12	17/13	19/11	0.85

Hemodynamic condition was assessed both preoperatively and in the course of the procedure, by measuring heart rate and mean arterial pressure (MAP). The demographical data of the three groups were statistically matched ($p > 0. 05$). Hypotension and bradycardia incidences were documented; hypotension was not

significantly different between the groups ($p = 0.345$) while bradycardia Gr3 where dexmedetomidine was used ($p < 0.05$) **Table 2**.

Table 2 Assessment of Hemodynamic Parameters both Postoperatively and during the procedure at significance level ($p > 0.05$)

Hemodynamic Parameter	Group 1 (Bupivacaine)	Group 2 (Bupivacaine + Fentanyl)	Group 3 (Bupivacaine + Dexmedetomidine)	p-value
Baseline HR (beats/min)	76.3 ± 5.8	75.9 ± 6.1	76.1 ± 6.3	0.789
Baseline MAP (mmHg)	95.2 ± 8.1	94.8 ± 7.9	95.6 ± 7.6	0.831
Intraoperative Hypotension	4	3	5	0.345
Intraoperative Bradycardia	2	3	8	0.028

The time taken to reach the T10 dermatome through sensory block was the least in Group 3 (Bupivacaine with dexmedetomidine) and was slightly more in Group 2 (Bupivacaine with fentanyl) and the highest in Group 1 (Bupivacaine alone). Significantly the regression time to S1 was much longer in group 3 as compared to groups 1 and 2 ($p < 0.001$) **Table 3**.

Table 3 Sensory Block Parameters by Modified Bromage Scale (MB) non-significant at ($p < 0.001$)

Sensory Block Parameter	Group 1 (Bupivacaine)	Group 2 (Bupivacaine + Fentanyl)	Group 3 (Bupivacaine + Dexmedetomidine)	p-value
Time to T10 (min)	7.8 ± 1.4	6.5 ± 1.2	5.9 ± 1.1	0.003
Regression to S1 (min)	180 ± 25	210 ± 30	260 ± 35	<0.001

Motor block onset and recovery were evaluated using the Modified Bromage (MB) scale. The time to reach the third stage of the MB scale (MB score 3) which was the complete motor block was significantly faster in Group 3 than in Group 1 and Group 2. Likewise, the regression time to MB score 0 was elongated in group 3 ($p < 0.001$) **Table 4**.

Table 4 Motor Block Parameters by Modified Bromage Scale (MB) Scale non-significant at ($p < 0.01$)

Motor Block Parameter	Group 1 (Bupivacaine)	Group 2 (Bupivacaine + Fentanyl)	Group 3 (Bupivacaine + Dexmedetomidine)	p-value
Time to MB Score 3 (min)	10.2 ± 2.1	8.5 ± 1.9	7.3 ± 1.5	0.005
Regression to MB Score 0 (min)	180 ± 24	210 ± 28	250 ± 31	<0.001

The Patient's postoperative pain was rated using the Visual Analog Scale (VAS) at the mentioned intervals in 24 hours. Patients in group 3 (Bupivacaine with dexmedetomidine) had significantly lower VAS scores in all time intervals in comparison to groups 1 and 2. The time for the first request for analgesia was considerably delayed in Group 3 as compared with the other groups ($p < 0.001$) **Table 5**.

Table 5 Visual Analogue Scale (VAS Score) in 24 hours at mentioned interval non-significant at ($p < 0.01$)

VAS Score (mean \pm SD)	Group 1 (Bupivacaine)	Group 2 (Bupivacaine + Fentanyl)	Group 3 (Bupivacaine + Dexmedetomidine)	p-value
1 hour	4.1 \pm 1.2	3.5 \pm 1.0	2.5 \pm 0.9	<0.001
6 hours	5.2 \pm 1.3	4.3 \pm 1.1	3.2 \pm 1.0	<0.001
12 hours	5.5 \pm 1.5	4.7 \pm 1.3	3.4 \pm 1.1	<0.001
18 hours	4.8 \pm 1.4	3.8 \pm 1.2	2.9 \pm 0.8	<0.001
24 hours	4.5 \pm 1.2	3.6 \pm 1.1	2.7 \pm 0.9	<0.001
Time to first analgesic request (min)	180 \pm 35	240 \pm 40	300 \pm 45	<0.001

DISCUSSION:

This research examines the effectiveness of intrathecal injection of 15 mg of 0.5% hyperbaric bupivacaine as an adjuvant for spinal anaesthesia in patients having lower limb orthopaedic surgery against 25 μ g fentanyl and 5 μ g dexmedetomidine. While fentanyl, an agonist of mu receptors, binds to opioid receptors in the spinal cord, dexmedetomidine, an α -2 adrenoreceptor, acts on presynaptic C-fibers and postsynaptic dorsal horn neurons to extend both sensory and motor blocks [9]. The research assessed the features of spinal blocks, the need for analgesics, the regression of motor blocks, and the problems that arose after surgery in three patient groups that were given different medication combinations.

The findings showed that, in comparison to fentanyl (80 \pm 20.3 min sensory block, 110 \pm 20.2 min motor block), dexmedetomidine considerably extended both sensory block (120 \pm 23.5 min) and motor block (242 \pm 22 min). Furthermore, compared to the fentanyl group (135 \pm 18.9 min), the dexmedetomidine group needed a longer period (255 \pm 29.69 min) to experience initial analgesia [10]. Dexmedetomidine had a longer duration of analgesia and blocking, although both medications provide excellent quality intraoperative analgesia and hemodynamic stability. Additionally, none of the groups in the research had serious adverse effects including bradycardia or hypotension. Nor did any major hemodynamic abnormalities occur [11].

Similar results were found in research by Mahendru et al. [12] and Kanazi et al. [13], which also showed that dexmedetomidine was better than fentanyl in prolonging motor and sensory blocks without significantly compromising hemodynamic stability. Furthermore, the dexmedetomidine group had reduced visual analogue scale (VAS) ratings for post-operative pain, which is consistent with other studies showing this medication is effective in lowering the requirement for rescue analgesics [14].

LIMITATIONS:

The only limitation of the study was that the sample size was really small. Further studies might generate positive results with larger sample sizes.

CONCLUSION:

When intrathecal 0.5% hyperbaric bupivacaine is combined with 5 μ g dexmedetomidine, the duration of both sensory and motor block is substantially longer than with fentanyl, which improves analgesia both during and after lower limb orthopaedic procedures. Dexmedetomidine improved patient satisfaction by lowering the need for postoperative rescue analgesia while maintaining stable hemodynamics and causing few adverse effects. Although fentanyl and dexmedetomidine both provided good spinal anaesthesia, dexmedetomidine performed better in

prolonging the duration of the block and postponing the need for analgesics, which made it a more advantageous adjuvant for spinal anaesthesia in these kinds of surgeries.

CONFLICT OF INTEREST

We declare that there was no conflict of interest.

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AUTHORS CONTRIBUTIONS

Topic selection:

Data collection:

Article writing:

Statistical analysis:

Proofreading:

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