Original Article

Selective Spinal Anaesthesia with Low-Dose Bupivacaine and Bupivacaine + Fentanyl in Ambulatory Arthroscopic Knee Surgery

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Abstract

Objective: To investigate the effects of selective spinal anaesthesia with low-dose bupivacaine alone and in combination with various doses of fentanyl, on blockage, haemodynamics, quality of anaesthesia, perioperative complications, and hospital release criteria.

Methods: This prospective study included 45 ASA I-II patients (age range: 20-77 years). The cases were randomised into 3 groups: Group 1 (n = 15) 0.8 ml of 4 mg 0.5% hyperbaric bupivacaine; Group 2 (n = 14) 1.3-ml solution of 4 mg 0.5% hyperbaric bupivacaine + 25 µg of fentanyl; and Group 3 (n = 14) 1.1-ml solution of 3 mg 0.5% hyperbaric bupivacaine + 25 µg of fentanyl. A double-blind design was employed and all patients were injected through L3-4 or L4-5 using a 25G point spinal needle. Sensory-motor blockage starting and ending time, maximum level of sensory-motor blockage, and grade and quality of anaesthesia were recorded. Haemodynamics, and respiration rates, and side effects were evaluated. Times for ability to pass to the stretcher without aid, walking, micturition, release from the hospital, and the first time an analgesic was needed were recorded.

Results: The time when an analgesic was first required was longer in the groups in which an opioid was added, and the shortest release time from the hospital was observed in Group 3. Other parameters remained similar across all groups.

Conclusion: Low-dose bupivacaine, with or without fentanyl, can be used safely in lower extremity surgery and can provide rapid and safe release criteria.

Keywords: Spinal anaesthesia, Ambulatory surgery, Arthroscopy, Bupivacaine, Fentanyl (JPMA 62: 313; 2012).

Introduction

In recent years, the trend towards ambulatory cases increased in order to reduce treatment expenses and hospitalisation duration for economical and social needs. The increase in ambulatory surgery has also affected the practice of anaesthesia. The conventional approach to spinal anaesthesia is to create sufficiently high blockage until the end of surgery using local anaesthetics that are effective in all cases. However, the blockade created by anaesthesia prolongs recovery in most ambulatory cases. As such, some changes have occurred in the conventional approach to spinal anaesthesia, and selective spinal anaesthesia (SSA) has increased in popularity. SSA aims at creating sufficiently effective blockade with fewer side effects by modifying the local anaesthetic dose and by using a minimal dose of intrathecal local anaesthetic. As a result, the reduction in the local anaesthetic dosage not only enables rapid recovery, but also results in fewer side effects, improved haemodynamic stability, fewer instances of undesired motor blockade, and less bladder dysfunction. This new approach enables spinal anaesthesia to also be used in ambulatory surgery.[1-5] Recently, spinal anaesthesia with low-dose bupivacaine and rapid recovery series with this method was suggested. It has been reported that low-dose intrathecal bupivacaine might be the preferred method for arthroscopic knee surgery.[6-8]

Research has shown that adding an opioid to local anaesthetic increases the success of spinal anaesthesia. It enables the use of less local anaesthetic and increases the duration and quality of anaesthesia without any effect on motor blockade. Thus, anaesthesia of higher quality appropriate for ambulatory surgery is facilitated, without any effect on the release time.[1-7]

The primary aim of this study was to evaluate the effect of low-dose bupivacaine and different doses of fentanyl added to bupivacaine on motor and sensory blockade, haemodynamic stability, quality of anaesthesia, and peri-operative complications. The secondary aim of the study was to investigate the release criteria in ambulatory patients that underwent elective arthroscopic knee surgery.

Patients and Method

The study included 45 ASA I-II cases that underwent elective arthroscopic interventions. The patients were randomised into 3 equal groups. The study protocol was approved by our institution's ethics committee and informed consent was obtained from all the participants. Cases with contraindications for spinal anaesthesia, those with scoliosis, diabetes, peripheral neuropathy or neuromuscular disease, and those that did not provide informed consent were excluded from the study. Patients were randomly assigned to three groups using sealed envelopes. Peripheral venous access was made with an 18G catheter before the procedure and the patients were given saline solution (NaCl 0.9%) 10 ml kg^{-1} h^{-1} for 30 min. During the operation, the saline solution was administered at 7 ml kg^{-1} h^{-1}. Baseline systolic blood pressure (SBP), diastolic blood pressure (DBP), average blood pressure (ABP), heart rate (HR) and peripheral oxygen saturation (SpO2) were recorded, and then the subarachnoid space was accessed via a 25G Quincke spinal needle (Pencan® B. Braun, Melsungen, Germany) through L3-4 or L4-5 in the midline. The study solutions were prepared in a separate area by a person not involved in the patients' care, and the patients and anaesthesiologists were blinded to the study solutions. The solutions were administered as follows: 8 ml of 4 mg 0.5% hyperbaric bupivacaine for Group 1 (n = 15); 1.3 ml of 4 mg 0.5% hyperbaric bupivacaine + 25 µg fentanyl for Group 2 (n = 14), and 1.1 ml of 3 mg 0.5% hyperbaric bupivacaine + 25 µg fentanyl for Group 3 (n = 14). The solutions were prepared and administered intrathecally within 2 minutes. Following the injection of the solutions, all the patients waited for 15 minutes while lying in the lateral position. The level of sensory and motor blockade was measured every 5 minutes. Patients were made to lie flat on their backs at the 15th minute and surgery was performed if sensory blockade was above the T12 level. Sensory and motor blockades were evaluated at the end of the operation and then every 20 minutes until the blockade completely disappeared. Sensory blockade was evaluated by the pinprick test and a 4-point scale (0: normal sense; 1: reduced sense; 2: hypoesthesia; 3: no sense). Motor blockade was evaluated by the modified Bromage test and a 4-point scale (0: normal motor function in hip, knee, ankle, and toes; 1: motor blockade only in the hip; 2: motor blockade in the hip and knee; 3: motor blockade in the hip, knee, and ankle). Sensory blockade start time was considered as the moment of sensory loss up to the knee, and the end time as the moment at which normal sense returned to the L1 dermatome. Motor blockade start time was considered as the moment when motor blockade in the hip began to be 1 point, and the end time as the moment at which the patient could lift the leg from the hip. Sensory and motor blockades start and end time, and maximum sensory and motor blockade level and grade were recorded.

After evaluating the sensory blockade as 2, according to the scale, a tourniquet was applied with 350 mmHg pressure to the extremity before starting the surgery. SBP, DBP, ABP, HR, and SpO2 values were recorded every 5 minute for the first 15 minutes after applying spinal blockade, and then every 15 minutes until the end of the surgery and 1 h post surgery. A 20% decrease in ABP from baseline was considered as hypotension and was treated with a 500-ml

infusion of crystalloid liquid. HR below 45 pulses min^{-1} was considered as bradycardia and was treated with 0.5 mg of atropine, and oxygen was provided via a mask for cases with SpO_2 below 95%. The cases were monitored for pruritus, nausea and vomiting, allergic reactions, and respiration depression. The quality of anaesthesia was evaluated as follows: 'very good' — the patient was satisfied; 'good' — the analgesia was complete though the patient was not comfortable due to the position of the leg and required IV medication; 'insufficient' — the analgesia was not complete and the patient required additional nerve blockage and analgesic; 'failure' — analgesia was insufficient and general anaesthesia was administered.

During the surgery, 2 segment-regression (2SRT) was recorded, and times for ability to pass to the stretcher without aid (full, a little, hardly, with aid), walking, micturition, criteria for release from the hospital and the first time an analgesic was needed (FANT) were recorded. Criteria for release from the hospital were normal orientation to time, place and person, stable vital signs for at least one hour, urination, no nausea or vomiting, no haemorrhage or any other surgical complication, and very mild or no pain. Post-spinal headache and temporary neurologic symptoms on post-operative day 2 and after 1 week were evaluated via telephone. The telephone numbers to reach us if they would have any complaints in the next days were arranged.

The calculation of the required sample size was based on mean and standard deviation of complete regression of spinal block after spinal anaesthesia for outpatient knee arthroscopy. Fifteen patients per group were required to detect a 30-minutes difference in time for complete regression of spinal anaesthesia with an expected effect size to standard deviation ratio of 0.9, and accepting a two-tailed α error of 5% and a β error of 20%.

Data obtained during the study were evaluated using SPSS V.12.0. Average and standard deviation values were obtained for proportionally measured variables, while frequency and percentage values were obtained for the categorical data. For comparisons between the 3 groups, Bonferoni modification of the Kruskal Wallis H test was used. In all tests, $p = 0.005$ was considered significant, $p < 0.05$ was considered as an availability of a significant difference, and $p > 0.05$ was considered a non-significant difference.

Results

Initially, 45 patients were included in the study, but 2 of them were given general anaesthesia (propofol 2 mg kg^{-1}, fentanyl 2 $\mu g\ kg^{-1}$, laryngeal mask 33% O_2 + 1%-2% izoforan in a 67% N_2O mixture) after the surgeon was informed that the patient was not comfortable because of insufficient muscular relaxation. As such, those 2 patients were not included in the evaluation. One of those patients was in Group 1, and the other was in Group 3.

The demographic characteristics of Groups 1, 2, and 3 were similar; no statistically significant difference was observed between the groups (Table-1).

There was no statistically significant difference between ABP values ($p > 0.05$) (Table-2). In addition, a reduction was observed in all three groups in comparison to the pre-operative values. However, these reductions were not > 30% in any patient and were not clinically significant.

No statistically significant difference was observed in HR between the groups ($P > 0.05$). A clinically non-significant decrease was observed in comparison to the pre-operative values in all 3 groups (Table-3).

No statistically significant difference was observed in SpO_2 values between the 3 groups ($P > 0.05$). A clinically non-significant decrease was observed in comparison to the

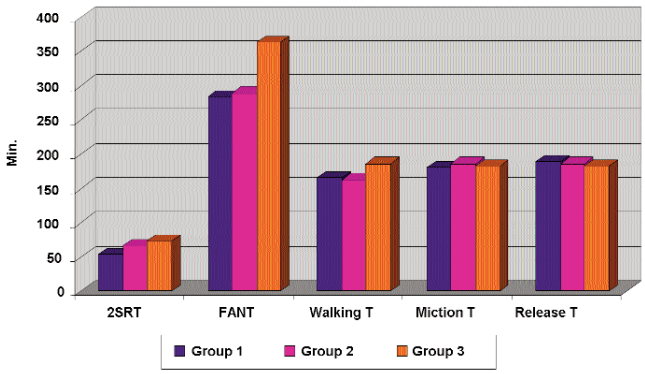

Figure: 2SRT, FANT, walking, miction, and release times (min).

Table-1: Demographic characteristics of the patients.

	Age (years)	Weight (kg)	Height (cm)	BMI	Gender		Surgical duration
					M (n/%)	F (n/%)	
Group 1 n = 15	39.1 ± 6.9	73.6 ± 10.8	167.5 ± 7.2	26.2 ± 3.2	6/40.0	9/60.0	43.7 ± 18.0
Group 2 n = 14	35.0 ± 12.4	77.4 ± 10.9	171.9 ± 10.3	26.1 ± 2.3	3/21.4	11/78.6	48.6 ± 17.5
Group 3 n = 14	39.4 ± 15.6	70.9 ± 10.1	169.8 ± 6.4	24.6 ± 2.6	9/64.3	5/35.7	37.1 ± 15.0
P	0.568	0.277	0.353	0.245	0.07		0.209

Values are given as mean ± SD.
BMI: Body Mass Index.

Tabe-2: ABP measurements.

	Group I	Group II	Group III	P
Pre-surgery	104,9±11,2	95,4±13,1	96,3±9,4	0,061
5th min.	94,9±13,0	86,9±10,4	93,1±15,6	0,239
10th min.	93,1±12,8	88,6±12,9	88,8±14,4	0,591
15th min.	96,9±14,8	94,9±13,6	92,6±13,6	0,714
30th min.	95,2±10,4	91,1±13,1	91,4±12,2	0,594
45th min.	95,8±9,5	91,4±12,2	90,9±10,4	0,404
60th min.	95,5±13,1	87,7±10,1	92,6±11,9	0,210
Tourniquet time	95,7±14,4	93,1±11,9	94,0±8,0	0,836
Incision time	94,2±10,9	91,8±12,4	89,6±11,9	0,583
1.h Post-surgery	93,9±12,9	91,5±7,8	89,3±8,7	0,474

Values are given as mean ± SD.
ABP: Average Blood Pressure.

Table-3: HR measurements in the 3 groups.

	Group 1	Group 2	Group 3	P
Pre-surgery	78.1 ± 9.3	79.1 ± 10.2	77.1 ± 11.8	0.880
5th min	79.9 ± 8.8	80.5 ± 9.3	77.6 ± 9.6	0.678
10th min	77.2 ± 8.1	78.6 ± 11.6	75.6 ± 10.2	0.742
15th min	77.1 ± 8.9	76.9 ± 12.3	73.6 ± 12.3	0.641
30th min	69.9 ± 8.5	71.1 ± 8.8	68.4 ± 7.4	0.684
45th min	70.1 ± 6.8	66.9 ± 8.8	63.1 ± 6.4	0.053
60th min	68.7 ± 7.4	68.3 ± 10.5	69.1 ± 5.1	0.966
Tourniquet Time	72.1 ± 9.2	74.3 ± 11.2	72.9 ± 13.0	0.874
Incision Time	68.8 ± 8.0	70.7 ± 9.4	69.2 ± 11.2	0.854
1 h post-surgery	70.0 ± 6.2	74.3 ± 11.2	68.5 ± 6.3	0.379

Values are given as mean ± SD.
HR: Heart Rate.

Table-4: Distribution of sensory blockage on the operation side.

	Group 1	Group 2	Group 3
Median (range)	T10 (T12-T9)	T10 (T12-T9)	T10 (T11-T9)

pre-operative values in all the groups. There wasn't a statistically significant difference in the respiratory rate among the 3 groups ($p > 0.05$).

Motor blockade grade at the 15th minute on the operation side (OperS) was lowest in Group 3. No motor blockade was observed on the opposite side (OppS). Motor blockade grade on the operation side at the post-operative first time was always null. The distribution of sensory blockade on the operation side at the 15th minute was also noted (Table-4). On the opposite side, higher patched sensory blockade involvement was observed in the L1-2-3 dermatome in Groups 2 and 3. No statistical difference was observed in 2-segment regression time, first time of analgesic need, micturition time, walking time, or release criteria among the 3 groups ($P > 0.05$) (Figure).

The distribution of quality of anaesthesia was similar. In comparison of ability of the patients to pass to the stretcher without aid, passing patients to the stretcher in Group 3 was found to be better . The need for additional sedation in each group was similar. Patients in Groups 2 and 3 had more side effects than those in Group 1.

Discussion

Equal surgical levels, anaesthetic comfort and safety were obtained in all the groups. Failure of anaesthesia was not observed in any of the patients. Average sensory blockade level was T10 in all the groups. Sensory blockade involvement on the side opposite the surgery was observed in Groups 2 and 3. No difference was noted between the groups in terms of haemodynamic values. Blockade on the operation side at the 15th minute, as evaluated with the modified Bromage scale, was higher in Groups 1 and 2 than in Group 3.

In the present study, anaesthesia failure was not observed. Five patients in Group1, 4 in Group 2, and 3 in Group 3 required IV sedation. However, none of them required deep sedation. This result is similar to those of other studies that have reported no difference concerning the quality and success of anaesthesia, and the need for additional sedation despite a reduction in local anaesthetic dosage when an opioid is added.[4,8,9]

In the present study, one patient each in Groups 1 and 3 were given general anaesthesia and excluded from the study even though they had a sufficiently high level of anaesthesia (sensory blockade T10, motor blockade 1, according to Bromage). These 2 patients had no complaints, but insufficient muscular relaxation can be taken as a failure of the study.

In the present study, average sensory blockade level on the operation side was T10 in all 3 groups. The result is in agreement with previously reported results.[8,9]

Sensory blockade involvement was observed in Groups 2 and 3. This involvement was patched and was observed in several dermatomes. These results are consistent with those of Korhonen et al.[9] The fact that the unilateral blockade ratio was low in the groups given fentanyl (Groups 2 and 3) may have been due to the density decrease. The density of local anaesthetic is an important factor in obtaining unilateral spinal blockade. The density of the hyperbaric bupivacaine we used was 1.0210 g ml^{-1}.[10] In our calculations we used these mathematical formulas; the density of the solution used in Group 2 was calculated as 1.0104 g ml^{-1} and in Group 3, it was calculated as 1.0085 g ml^{-1}. Taking these data into consideration, all 3 solutions that we used were hyperbaric in comparison to the cerebrospinal fluid, and therefore, we suggest that the mixture we used was appropriate for unilateral spinal anaesthesia.

Blockade that occurred in the operation field, which was evaluated using the modified Bromage scale, was deeper in Groups 1 and 2 at the 15th minute than in Group

3. Motor recovery was faster in Group 3 and was complete in all the patients of this group at the end of the operation. This result, though clinically significant, was not statistically significant. While all the patients in Group 3 could pass to the stretcher without any aid at the end of the operation, 4 patients in Group 1 and 2 patients in Group 2 passed to the stretcher with a little difficulty. In the present study, no difference in ABP, DBP, SBP or HR was noted among the 3 groups. Intrathecally administered opioids do not have side effects, such as haemodynamic changes.[11] The haemodynamic stability observed in the present study was probably due to using a low dose and to the fact that the anaesthesia level did not increase much.

No significant difference in SpO_2, which is the most important parameter for respiratory depression, was observed among the groups. Intrathecal fentanyl has a minimal risk of respiratory depression in the early phase. However, it has been reported that it does not affect respiratory response curves at a dose of ≤ 25 µg.[12]

Though a statistical difference was not observed in 2SRT in the 3 groups in the present study. Longer 2SRT was observed in Groups 2 and 3. A comparison of our study groups based on FANT, showed that prolongation occurred in Groups 2 and 3, but the prolongation was not statistically significant. Intrathecal opioid administration delays the time to first analgesic need in the post-operative phase.[13] While fentanyl 0.25 µg kg^{-1} provides short-term post-operative analgesia, it is reported that with doses of 0.5 and 0.75 µg kg^{-1}, the duration of post-operative analgesia was longer and was associated with more frequent side effects.[14] In the present study, FANT was not long so much and this may have been due to the fact that we used doses < 0.25 µg kg^{-1}.

Patients in Groups 1, 2, and 3 could walk at the 166th, 162.5th, and 151st minute, respectively, and were released at the 189th, 186th and 183rd minute, respectively. Though there was no statistical difference between the groups, patients in Group 3 were able to walk earlier. Many studies report that as the intrathecal anaesthetic dose increases, walking and release times increase.[4,7,15] Our times were shorter, and this was due to the fact that we used lower doses.

Hydrophilic opioids can cause urinary retention, whereas lipophilic opioids cause this less frequently.[4] In the present study, micturition occurred approximately before 3 hours in all the groups. One patient in each of Groups 2 and 3 had some difficulty. However, micturition occurred within 6 hours and catheterisation was not required. Both patients were male and aged 66 and 77 years respectively. Their difficulty with micturition could have been due to prostatic complaints related to their advanced ages. The need for micturition delayed the release by 15 minutes in Group 1, by 23.5 minutes in Group 2, and by 31.5 minutes in Group 3. Our study also supports the opinion that micturition before release in low-risk patients can be disregarded in ambulatory surgical procedures performed with SSA.

The incidence rate of transient neurological symptoms (TNS) with bupivacaine use varies between 0% and 3%.[16,17] We did not observe TNS in any of the 3 groups and we think that bupivacaine is a suitable agent for intrathecal administration. In addition, animal studies and intensive clinical experience show that fentanyl can be used safely in limited doses.[18] Additionally, in the present study no clinical signs of neurotoxicity were observed. Another factor limiting spinal anaesthesia in ambulatory patients is postdural puncture headache (PDPH). According to several researchers, its incidence varies from 0.2% to 24%.[12] With the use of 25G and thinner pencil point needles this incidence is < 1%. It occurs at similar rates with the use of Quincke needles.[19] We did not observe PDPH in our groups.

The incidence of pruritus associated with intrathecal fentanyl administration varies between 0% and 100%.[4,9] In the present study, the frequency of pruritus in Groups 2 and 3 was 42.6% and 50%, respectively. Only 1 patient in each group required treatment; mild itching occurring in the other patients did not require treatment. In the light of all these results, we suggest that pruritus might occur as a result of intrathecal fentanyl administration. However, it is usually mild.

Conclusion

Equal levels of surgery, comfortable anaesthesia and safety were obtained in all the groups of the study. Low-dose local anaesthetic and fentanyl combined can provide rapid and safe release criteria, together with safe and sufficient anaesthesia conditions for arthroscopic knee surgery in ambulatory patients, who are increasing in number. We did not observe statistically significant differences among the 3 groups. However, clinical and statistically significant differences are likely to be obtained with larger patient groups.

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