

Comparison of Fractionated versus Bolus Dose Injection of Drug in Spinal Anaesthesia for Lower Limb Surgeries

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Abstract: **Introduction:** Spinal anaesthesia (SA) with bupivacaine is routinely used to provide anaesthesia for lower limb surgeries. To prevent hypotension, there are various measures such as administration of fluids either colloids or crystalloids before SA and administration of a prophylactic vasopressor. **Aim and Objectives:** To compare fractionated dose with bolus dose in SA for haemodynamic stability and duration of analgesia in patients undergoing elective lower limb surgeries. **Materials & Methods:** After the Institutional Ethics Committee approval and written informed consent, the present study was carried out in 60 patients (30 in each group) of the ASA I–II, age from 15 to 80 years, height from 140 to 180 cm. After aspiration of cerebrospinal fluid, injection bupivacaine 0.5% heavy was injected according to respective groups, B(bolus) and F(fractionated). Total dose of 3ml of bupivacaine 0.5% heavy, initial two third dose was given followed by one-third dose after 90s, both doses given at a rate of 0.2 ml/s. After injection of initial two-third dose, the syringe were kept attached to the spinal needle for remaining 90 s, after which remaining one-third dose was administered. Hypotension was treated when mean arterial pressure (MAP) decreases $\leq 20\%$ of baseline with injection mephentermine 1mg given IV and will be repeated when needed. The number of hypotensive episodes and mephentermine used were recorded for each patient. Bradycardia if any (HR of < 60 beats/min) were treated with IV atropine 0.6 mg. **Results:** The patients in fractionated group showed significantly prolonged sensory and motor block and also prolonged analgesia. There were lesser episodes of bradycardia and hypotension emphasising a more stable haemodynamics in the group compared to the bolus group. **Conclusion:** Fractionated dose of spinal anaesthesia provides more haemodynamic stability and prolonged sensory and motor blockade and also longer duration of analgesia.

Keywords: Bolus, Fractionated, Bupivacaine, Hypotension

1. Introduction

Spinal anaesthesia (SA) with bupivacaine is routinely used to provide anaesthesia for lower limb surgeries. SA has a rapid onset but at the same time, precipitates hypotension. To prevent hypotension, there are various measures such as administration of fluids either colloids or crystalloids before SA and administration of a prophylactic vasopressor [1].

Multiple local anaesthetics were used over a period of time with each making way for the other, bupivacaine being the most used one in recent past due to its longer duration of action [2]. The addition of adjuvants further increased the implications of spinal each causing differential increase in onset and duration of sensory, motor and analgesia. Also with that each group of adjuvants brought their own side effects.

Sometimes bolus dose of the local anaesthetic agent in SA causes more hypotension. The fractionated dose of the local anaesthetic agent, in which two-third of the total calculated dose given initially followed by one-third dose after a time gap of 90 s, achieves adequate SA and provides a dense block with haemodynamic stability

Aim and Objectives

To compare fractionated dose with bolus dose in SA for haemodynamic stability and duration of analgesia in patients undergoing elective lower limb surgeries.

2. Material and Methods

After the Institutional Ethics Committee approval and written informed consent, the present study was carried out on sixty patients (thirty in each group) of the American Society of Anaesthesiologists physical status I–II, age from 15 to 60 years, height from 140 to 180 cm. After aspiration of csf injection bupivacaine 3ml of 0.5% heavy will be injected according to respective groups. The study was a prospective, randomised, controlled study. Patients aged 15–60 years of either sex of ASA 1 and ASA 2 grades undergoing elective lower limb surgeries were included in this study. Patients of grades ASA 3 and ASA 4, with pre-existing cardiovascular or cerebrovascular diseases, known allergy or hypersensitivity to local anaesthetic drugs, height less than 140 or more than 180 cm, weight less than 50 kgs or more than 100 kgs, deformities of spine or any other contraindication to spinal anaesthesia were excluded from this study.

3. Procedure

Standard monitors including non-invasive blood pressure (NIBP), electrocardiogram (ECG) and pulse oximeter (SpO₂) were attached to the patient, and baseline blood pressure and heart rate (HR) were recorded. Intravenous line was taken with 18 or 20 gauge IV cannula. Standard monitors like non-invasive blood pressure (NIBP), electrocardiogram (ECG) and pulse oximeter (SpO₂) were connected to patient, and baseline blood pressure and heart rate were recorded. SA was given in sitting position with 23-gauge Quincke spinal needle in L3–L4 or L4–L5 interspace.

After aspiration of cerebrospinal fluid, injection bupivacaine 0.5% heavy was injected according to respective groups, B and F. Total dose of SA was 3ml in both groups. Group B patients received a single bolus of bupivacaine over 10 seconds. Group F patients received fractionated dose of bupivacaine with two-third of the total calculated dose given initially followed by one-third dose after 90 seconds, both doses given at a rate of 0.2 ml/s. After injection of initial two-third dose, the syringe was kept attached to the spinal needle for next 90 seconds, after which the remaining one-third was given.

To prevent observer's bias, patients were kept sitting for 90 s after completion of the spinal in Group B. Patients were then turned into the supine position. We supplemented oxygen with the face mask at 5 L/min.

The patients were randomly divided into two groups using computer-generated sequential number placed in envelopes and opened only before the starting of the study. The study designed in double-blind fashion such that the patient and the assessor were unaware of the group. The assessor was kept blinded during the administration of the drug. Only the attending anaesthesiologist administering the spinal anaesthesia knew the group division.

We noted time of onset, level and regression of motor and sensory block. Confirmation of sensory block was assessed by loss of pinprick sensation. Motor block was assessed by a modified Bromage scale. These tests were performed every 5 min until the achievement of maximum sensory and motor block (Bromage scale 3) and every 30 min after surgery until the sensory and motor variables were back to normal. The onset time of sensory or motor blockade was defined as the interval between intrathecal injection and time to achieve maximum block height or a modified Bromage score of 3, respectively.

Surgical incision was allowed when loss of pinprick sensation reached the T6 dermatome level bilaterally and when Bromage scale of three was achieved. Patients with inadequate sensory block and requiring conversion to general anaesthesia were excluded from the study. Intraoperatively, patients were monitored with continuous ECG, HR, NIBP and SpO₂. Hypotension was treated when mean arterial pressure (MAP) decreased $\leq 20\%$ of baseline with injection mephentermine 6 mg given IV and repeated when needed. The number of hypotensive episodes and mephentermine used were recorded for each patient. We treated bradycardia if any (HR of < 50 beats/min) with IV atropine 0.6 mg.

The duration of sensory blockade was defined as the interval from administration of spinal anaesthesia to S2 segment regression. The duration of motor block was defined as the time interval from the onset of motor block to the time of achievement of modified Bromage scale zero (0). Pain was assessed with the visual analogue scale (VAS) every 30 min post-operatively for the first 2 h then hourly up to 6 h. The duration of analgesia was defined as the time from intrathecal injection till the first demand for rescue analgesic when VAS was ≥ 4 . The patient was given diclofenac sodium 75 mg intramuscular as rescue analgesic.

Statistical analysis

All the observations were recorded, and all the results were statistically analysed using Microsoft Excel 2010. Quantitative data were presented as mean \pm standard deviation (SD) and analysed using the unpaired *t*-test. $P < 0.05$ was considered statistically significant.

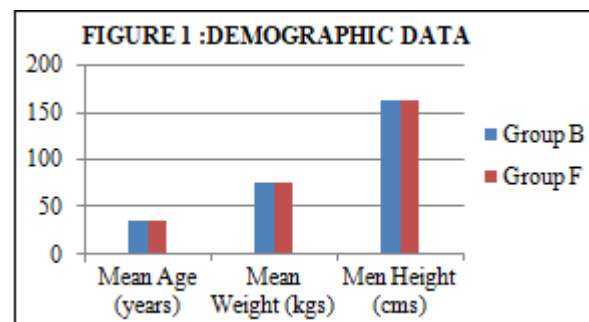
4. Observation and Results

The study was done in 60 patients divided into two groups of 30 between ages of 15 to 60 years and of ASA 1 and ASA 2 status posted under spinal anaesthesia. Patients from both groups were given a total dose of 3ml 0.5% bupivacaine heavy, as a bolus in one group and in two divided doses of 2ml and 1ml in another group with a time duration of 90 seconds.

The mean age in the Bolus group was 36 ± 10.35 years as compared to 35.37 ± 8.48 years in the control group and the difference was statistically not significant (P value-0.796). Both groups had 60% of male patients that is 18 in 30 and 40% of female patients that in 12 in 30. No statistical variation among both groups based on gender. Below pie diagram depicts the distribution of gender in both groups. Mean weight of patients in Bolus group was 75.97 ± 7.08 and in fractionated group was 76.10 ± 6.09 . The P value was calculated to be 0.937 showing no significant difference. Mean height of patients in Bolus group was 162.67 ± 7.47 and in fractionated group was 162.47 ± 6.09 . The P value was calculated to be 0.834. The procedure of spinal anaesthesia in both groups was performed in 5 surgeries namely Varicose veins stripping (VVS), Meniscectomy of knee for meniscal tears (MN), Proximal fibular osteotomy for osteoarthritis knee (PFO), Split skin grafting unhealed ulcers or post burns (SSG) and Implant removals (IR) of tibia. They were comparable in both groups.

Table 1: Demographic Data

	Group B	Group F	P value
AGE (years)	36 ± 10.35	35.37 ± 8.48	0.796
WEIGHT (kgs)	75.97 ± 7.08	76.10 ± 6.09	0.93
HEIGHT (cms)	162.67 ± 7.47	162.47 ± 6.09	0.834



Properties of Blockade

The mean onset time of sensory blockade in the Bolus group was 4.90 ± 0.80 and in Fractionated group was 4.90 ± 0.76 with a P value of 1, drawing the conclusion that there is no significant time difference in onset of block. However the duration of sensory blockade in Bolus group was 125.77 ± 15.54 and in Fractionated group was 147.77 ± 14.38 with a P value of 0.0001 that is very significant statistically, meaning

a prolonged duration of sensory block in the Fractionated group.

Table 2: Properties of Blockade

	Group B	Group F	P value
Onset of sensory block (min)	4.90 +0.80	4.90 +0.76	1.00
Duration of sensory block (min)	125.77+ 15.54	147.77+ 14.38	0.0001
Onset of motor block (min)	7.17+0.95	6.93 +0.87	0.324
Duration of motor block(min)	107.5+ 13.24	118.5+ 13.11	0.0019
Duration of analgesia (min)	154.07+15.78	180.80 +17.16	0.0001

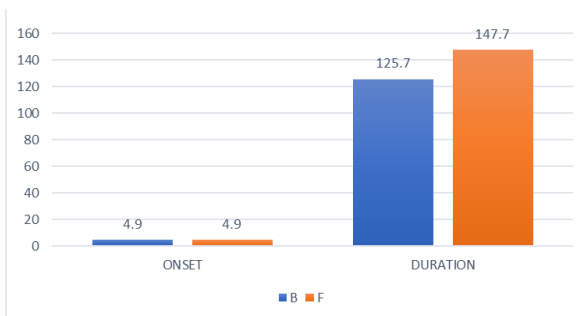


Figure 2: Sensory Blockade

The mean onset time of motor blockade in the Bolus group was 7.17 ± 0.95 and in Fractionated group was 6.93 ± 0.87 with a P value of 0.324, drawing the conclusion that there is no significant time difference in onset of block. However the duration of motor blockade in Bolus group was 107.5 ± 13.24 and in Fractionated group was 118.5 ± 13.11 with a P value of 0.0019, that is very significant statistically, meaning a prolonged duration of motor block in the Fractionated group.

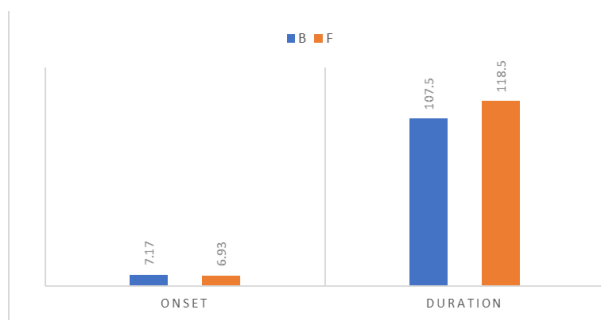


Figure 3: Motor Blockade

The mean duration of analgesia in the Bolus group was 154.07 ± 15.78 and in Fractionated group was 180.80 ± 17.16 with a P value of 0.0001, that is very significant statistically, meaning a prolonged duration of analgesia in the Fractionated group.

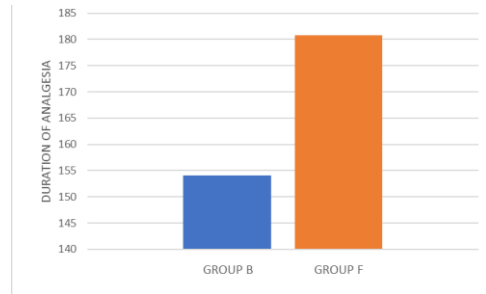


Figure 4: Duration of Analgesia

Haemodynamic Characteristics

The mean heart rate was comparable between both the groups from baseline to 60 minutes though there were more episodes of bradycardia in bolus group compared to fractionated group at the time of 10 mins. However statistically there was no significant difference. Three patients in group B had bradycardia and one patient in group F had bradycardia and were promptly treated with atropine 0.6mg .

Table 3: Hemodynamic Characteristics

Time	Mean HR			Mean Arterial Pressure		
	Group B	Group F	P Value	Group B	Group F	P Value
Baseline	83.30± 7.03	86.00± 9.54	0.2173	95.04 ±10.40	97.83 ± 7.80	0.392
5 MINS	94.17± 11.67	89.80 ±10.60	0.1347	102.73 ±9.18	103.53 ±7.86	0.718
10 MINS	96.40 ±18.01	92.20± 12.37	0.2969	96.90± 10.60	98.93± 7.82	0.401
15 MINS	93.77± 9.46	88.40 ±11.48	0.0527	101.43± 9.04	99.13 ±±8.66	0.318
30 MINS	88.00± 7.74	87.43 ±8.93	0.7937	102.67 ±18.39	101.83 ± 6.76	0.816
45 MINS	83.80± 6.22	84.27 ±7.85	0.7995	89.67± 6.24	103.03 ± 5.36	0.0001
60 MINS	81.23 ± 6.32	83.73± 7.42	0.1656	106.60 ±4.97	104.37 ± 5.42	0.101

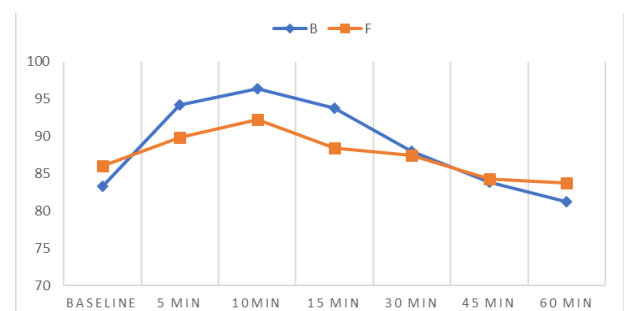


Figure 5: Mean Heart Rate

Mean arterial pressure at various points of time were noted from baseline to 60 minutes, which showed significant difference at 45 minutes of time. There were episodes of hypotension in 10 patients in group bolus and 4 patients in fractionated group. They were treated with i.v mephentaramine 6mg.

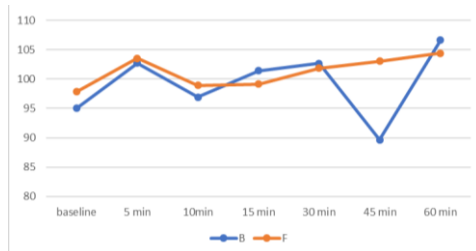


Figure 6: Mean Arterial Pressure

There was no significant difference in spo2 in both of the groups. No desaturation episodes were present

5. Discussion

Hypotension and cardiovascular instability are still the two major concerns post spinal anaesthesia^[3]. In view of prolonging a surgery increased dosage of the local anaesthetic further increases the chance of these complications. The addition of adjuvants dates back long and has undergone a wide range of research and metamorphosis. Trail and testing was done on a number of groups including opioids, NMDA blockers, Alpha 2 agonists, benzodiazepine like midazolam, neostigmine etc [4],[5],[6],[7]. Research on each group showed varying results on onset of sensory and motor blockade, duration of block and analgesia. Also each group of them had their own complications[8]. Opioids were associated with rash, nausea, vomiting, rarely respiratory depression too[9]. Alpha 2 agonists are notorious for profound bradycardia and hypotension. Intrathecal neostigmine caused severe headache, vomiting and bradycardia[10].

Fahmy et al compared the circulatory and anaesthetic effects of bolus versus fractionated administration of bupivacaine. They found that fractionated dose of bupivacaine prolonged the duration of action and was associated with more circulatory stability.

Favarel *et al.* studied sixty elderly patients undergoing surgery for hip fracture for haemodynamic tolerance of titrated doses of bupivacaine versus single dose SA and concluded that titrated doses of bupivacaine was safe, efficient and provided better haemodynamic stability than single dose SA.

Badheka et al., compared fractionated dose versus bolus dose injection in spinal anaesthesia for patients undergoing elective caesarean section, for haemodynamic stability and duration of analgesia. They concluded the fractionated group had more haemodynamic stability and also a prolonged motor and sensory blockade.

All the the above and others were conducted in view of using fractionated dose of spinal as a safe alternative for cases requiring prolonged blockade and thus more dose or an adjuvant without causing more haemodynamic variations or the side effects due to adjuvants.

The present study was done to compare the anaesthetic and haemodynamic parameters in fractionated spinal anaesthesia technique with the routine bolus technique in lower limb surgeries. We have done a controlled, randomised

prospective study in 60 patients posted for lower limb surgeries.

They were divided into two groups randomly and one spinal anaesthesia in one group was given as a bolus of 3ml fixed dose which is a routine practice. The other group were given spinal in two fractionated doses 90 seconds apart with patient in sitting position, a first dose of 2/3rd that is 2ml and the second dose of 1/3rd that is 1ml.

Parameters regarding neuraxial blockade such as the onset and duration of sensory block, onset and duration of motor block and also the duration of analgesia were measured between the study groups.

To measure the haemodynamic stability heart rate and systolic, diastolic and mean arterial blood pressure at various points were noted after taking baseline readings. Also the spo2 at various points of time were noted.

All the patients were between 15-60 years of either sex with demographic comparable between both the groups for age, weight and height.

This study differs from other studies conducted by Badheka et al, and Monika et al, in that they were done in pregnant women and this study was done in study group having both male and female patients posted for lower limb surgeries.

The aforementioned studies calculated the dose of spinal anaesthesia in patients depending on the height, that is 0.07mg/cm height of the patient [11]. However in our current study we took a fixed dose of 3ml in patients from both groups as the dose taken in those studies was not adequate in non-pregnant population. The mean height in both groups was comparable and showed an insignificant P value.

The salient findings of this study were the prolongation of both sensory (147.77 mins) and motor blockade (118.5 mins) in the group receiving fractionated dose in comparison to the sensory (125.77) and motor (107.5) blockade in bolus group. Also analgesia in the fractionated group (180.80) was significantly more than the bolus group (154.07). These findings were in support of the studies done by Badheka et al, and Manjula et al, and others. However none of the studies had a possible explanation for prolonging of sensory and motor blockades and also analgesia which were statistically significant with the same amount of drug and with all other demographic parameters being comparable.

6. Limitations of Our Study

Fixed dose of drug was given in all patients without calculating dose according to weight or height. No possible explanation for better blockade and haemodynamic stability in the fractionated group despite giving same volume of drug. Done is ASA 1 and ASA 2 patients only, so haemodynamic stability in cardiovascular unstable cases or patients with other comorbidities could not be evaluated.

7. Conclusion

In conclusion the fractionated group patients were more haemodynamically stable compared to bolus group in view of episodes of hypotension and bradycardia. There was no significant difference in onset of either sensory or motor blockade, however the duration of sensory and motor blockade was significantly more in fractionated group compared to bolus group. The duration of analgesia was also significantly more in fractionated group compared to bolus group.

8. Declaration of Patient Consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest: There are no conflicts of interest.

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