Unilateral Spinal Anesthesia using Low Dose Hypobaric Bupivacaine


Abstract

Background: Conventional spinal anesthesia has many complications like hypotension, bradycardia, urinary retention, post-dural puncture headache (PDPH), transient or permanent neurological symptoms. These complications can be minimized by performing unilateral spinal anesthesia in patients requiring one sided lower limb surgeries. Low anesthetic doses, pencil point or cutting point needles, slow injection rate and the lateral position help in achieving unilateral spinal anesthesia. This prospective study aimed at investigating the effects of unilateral spinal anesthesia with low dose (5 mg) hypobaric bupivacaine minimizing hemodynamic changes, limiting the cephalad dispersion of the anesthetic and promoting a faster recovery.

Methods: Forty-two ASA I and II patients undergoing one sided lower limb orthopedic surgeries were given spinal anaesthesia with 2.5ml of 0.2% (5mg) hypobaric bupivacaine at the rate of 1ml/10s through a 25G Quinke needles in lateral position with the operating limb facing upward and kept in same position for 30 minutes. Onset, level (pin prick) and duration of sensory block as well as onset, degree (Modified Bromage Scores 0 to 3) and duration of motor block were assessed in both the operated and contralateral sides.

Results: Unilateral spinal anesthesia was obtained in 74.8% of patients. Mean onset of sensory block was 11.9 min and mean duration of sensory block was 150.3 min while mean onset of motor block was 20.3 min and mean duration of motor block was 94.1 min. Two patients had bradycardia, one patient had urinary retention and one patient had transient neurological symptoms. Blood Pressure fluctuation was ± 7% from baseline. No patient developed PDPH.

Conclusions: Hypobaric bupivacaine 0.2% (5 mg) is able to produce a predominant unilateral block with the patient being kept thirty minutes in lateral position. The great advantages of this type of unilateral spinal anesthesia are high cardio-circulatory stability, faster anesthetic recovery and no major complications.

Key Words
Hypobaric Bupivacaine, Local, Unilateral Spinal Anesthesia, Bromage Score

Introduction
Spinal anesthesia is usually the choice for lower limb surgeries because it is simple, reliable and popular anesthetic technique with little sophistication. However it has its own complications like hypotension, bradycardia, urinary retention, post-dural puncture headache (PDPH), transient or permanent neurological symptoms. Some of these complications, if not all, can be minimized by asymmetrically distributing anaesthesia to the operating side when only one of the lower-limb is to be operated. This technique also has advantage of fast blockade recovery and increased patient's satisfaction. Unilateral distribution of anaesthesia can be achieved by using hypobaric,
local anesthetic solutions if the operating limb is kept in the non-dependent position. Lower limb surgeries require low sensory block level for which low doses of local anaesthetic are sufficient which gives advantage of higher cardiovascular stability, less chance of prolonged motor block and less chance of urinary retention. Anesthetic injection in the lateral position, low anesthetic doses, direction of pencil point or cutting point needles and slow injection rate have been suggested to induce unilateral spinal anaesthesia. Unilateral hypobaric spinal anaesthesia has not been practiced in Bir hospital so far although one-limb surgeries are frequently conducted.

This study aimed at evaluating the attempt to produce unilateral spinal anaesthesia using low dose (5mg) hypobaric bupivacaine in one sided lower limb surgeries and its effects on hemodynamic parameters.

Methods and Methodology
This prospective observational study was performed after approval from Institutional Review Board of National Academy of Medical Sciences and informed written consent from forty two patients, aged 15-65 years, ASA Physical Status I & II, undergoing elective orthopedic surgery involving only one limb in Bir Hospital over a period of four months. Patients with hypovolemia, local infection, coagulation disorder, hypersensitivity to Bupivacaine, cardiovascular disorders and refusal to the method were excluded from the study.

Patients were pre-medicated with Tab Diazepam 10 mg for those weighing ≥ 50 kg and 5 mg for those weighing ≤ 50 kg in the night before surgery. They were pre-hydrated with 15 ml/kg Ringer's Lactate over 20 minutes. The patients were then placed in lateral position with the limb to be operated upward. Under aseptic precautions spinal anesthesia was performed at the L3/4 or L2/3 inter-space with midline approach using a 25 gauge Quinke type spinal needle. The hypobaric bupivacaine of 0.2% was prepared by adding 3.0 ml of distilled water to 2.0 ml of 0.5% plain bupivacaine (Ultracaine ® 0.5%, Batch No. 028, Bangladesh). The density of several such preparations was measured by a refractometer (ATAGO, T2-NE Clinical, Made in Japan) and average density was found to be 1.000 at 25°C. Considering the mean CSF density to be 1.0069 g/ml at 37°C, the baricity of bupivacaine preparation was 0.9931 which was hypobaric. After free flow of CSF was identified 2.5 ml (5mg) of above preparation was injected at the rate of 1 ml/10s with the bevel of the needle facing towards nondependent limb. The patient was maintained in lateral position for 30 minutes then turned to supine position. A pneumatic tourniquet was inflated to 100 mmHg above systolic blood pressure when needed to facilitate surgery. Oxygen was routinely administered via a nasal canula at the rate of 2 L/min.

Successful unilateral spinal anesthesia was defined as surgical anesthesia (loss of pinprick sensation at least up to L1 dermatome, and complete motor block) on the nondependent side only, while the dependent side maintained both somatic sensation to the pinprick test and motor block < Score 1. The quality of unilateral spinal anesthesia was evaluated according to the need for supplementary iv analgesics: adequate spinal anesthesia = no analgesic required to complete surgery; inadequate spinal anesthesia = injection Pethidine 0.5 mg/kg required to complete surgery; failed spinal anesthesia = general anesthesia required to complete surgery.

The variables measured were demographic data (age in years, height in cm, weight in kg), type and duration of surgery, onset of sensory block (the time from the administration of spinal anesthetic agent to the L1 level of sensory block), level of sensory block (determined by the loss of pin (hypodermic 21G needle) pricks sensation in a cephalad to caudad direction), duration of sensory block (the time from the successful unilateral spinal anesthesia to the time when the patient first complained of pain),
onset of motor block (the time from the administration of spinal anesthetic agent to complete motor block), duration of motor block (the time from the successful unilateral spinal anesthesia until the time to reach Bromage Score 2). Modified Bromage Motor Score was used to determine the motor block: 0 = no motor block; 1 = just able to flex knees (hip joint blocked); 2 = unable to flex knees (hip and knee joints blocked); 3 = unable to dorsiflex feet (hip, knee and ankle joints blocked). The level of sensory block and the degree of motor block were recorded at 5, 10, 15, 20, 25, 30 minutes after spinal puncture and at 15 minutes interval after surgery till Bromage Score is 2 on both the operated and non-operated sides.

Among hemodynamic parameters, heart rate was monitored at 5 minutes interval until surgery completion. A decrease in heart rate < 50 beats/min was considered bradycardia and was treated by incremental doses of 0.3 mg iv atropine. Non-invasive Blood pressure (Systolic, Diastolic and Mean Arterial Pressures) were monitored at 5 minutes interval until surgery completion. A decrease in mean arterial pressure > 30% below the pre-anesthetic baseline value was considered hypotension and treated by incremental doses of 3 mg iv mephenteramine. ECG was continuously monitored and any changes were noted down.

Patients were followed up for 24 hrs after surgery to collect information on postoperative complications like backache, urinary retention, PDPH and transient neurological symptoms (pain in the back, buttock or leg pain).

Statistical analysis was performed using a statistical software package (SPSS for Windows, Version 11.5, Microsoft Corporation, USA). Data were presented as mean ± standard deviation (SD), median, range, mode, numbers, and percentage as appropriate. Differences between means were analyzed using student’s t test. A probability value < 0.05 was considered significant.

**Results**

Demographic data are shown in Table 1.

<table>
<thead>
<tr>
<th>Table 1. Patient Characteristics (numbers, mean ± SD)</th>
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<tr>
<td>Age in years</td>
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<td>Weight in kg</td>
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<td>Height in cm</td>
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<tr>
<td>Gender</td>
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<tr>
<td>Male</td>
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<tr>
<td>Female</td>
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*In 3 cases weight could not be measured or known.

Complete unilateral spinal anesthesia was induced in 74% of patients. None of the patients, after keeping in supine position, had bilateral spinal block. However, about 12% of patients required additional opioids injection to complete surgery, so they were grouped as inadequate unilateral spinal anesthesia. Anesthesia was failed in 26% of patients, where general endotracheal anesthesia was given to complete surgery.

<table>
<thead>
<tr>
<th>Table 2. Quality of Unilateral Spinal Block*</th>
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<tr>
<td>Frequency</td>
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<tr>
<td>Adequate</td>
</tr>
<tr>
<td>Inadequate</td>
</tr>
<tr>
<td>Failed</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
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* Adequate: - No Opioids required to complete surgery
  Inadequate: - Opioids required to complete surgery
  Failed: - Failure to achieve at least L1 sensory block and complete motor block

Sensory and motor block characteristics are shown in table 3 and fig. 1.

<table>
<thead>
<tr>
<th>Table 3. Sensory &amp; Motor Block in Nondependent Limb (mean ± SD)</th>
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<tr>
<td>Sensory Block</td>
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<tr>
<td>Sensory Block</td>
</tr>
<tr>
<td>Motor Block</td>
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<tr>
<td>Motor Block</td>
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<tr>
<td>Surgery</td>
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<td>Surgery</td>
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20 out of 31 patients had their motor block regressed before the end of surgery.

![Graph showing Bromage Score in Nondependent Limb](image1)

**Fig. 1: Bromage Score in Nondependent Limb**

Hemodynamic variables during unilateral spinal anesthesia are shown in Fig. 2 & 3.
Mean heart rate at 50, 60, 75, 80 and 85 minutes were found to be significantly different (p values: 0.032, 0.039, 0.029, 0.024, 0.024 respectively) from the baseline mean heart rate recorded just before giving unilateral spinal anesthesia while at other times there was no significant difference between the mean heart rates. Clinically, two patients had bradycardia but resolved spontaneously without use of atropine.

Mean of MAP were significantly different at 10 and 60 minutes (p values: 0.039 & 0.043 respectively) when compared with baseline value but clinically they were insignificant because fluctuation of mean of MAP were ± 7% of baseline. Similarly, there was no statistical or clinical difference in mean systolic and mean diastolic blood pressures.

Table 4 & Table 5 show intra-spinal and post-spinal complications. Two patients had bradycardia but resolved spontaneously without use of atropine while none of them had hypotension. No patient had tachycardia, arrhythmia or other ECG changes.

Table 4. Intraspinal Complications (number, percentage)

<table>
<thead>
<tr>
<th></th>
<th>Number</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Bradycardia</td>
<td>2</td>
<td>6.5%</td>
</tr>
<tr>
<td>No complications</td>
<td>29</td>
<td>93.5%</td>
</tr>
<tr>
<td>Total</td>
<td>31</td>
<td>100.0%</td>
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</tbody>
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Table 5. Postspinal Complications (number, percentage)

<table>
<thead>
<tr>
<th></th>
<th>Number</th>
<th>Percentage</th>
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</thead>
<tbody>
<tr>
<td>Urinary Retention</td>
<td>1</td>
<td>3.2%</td>
</tr>
<tr>
<td>Transient Neurological Symptoms</td>
<td>1</td>
<td>3.2%</td>
</tr>
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</table>

Fig. 2: Mean Heart Rate (HR) at Different Time Interval

Fig. 3: Mean Blood Pressure at Different Time Interval
One patient developed retention of urine for which plain urinary catheterization was required while one patient reported to have radiating pain over the buttock and thigh (Transient Neurological Symptoms) which persisted for more than 12 hours and was relieved only after giving injection Pethidine 50 mg intramuscularly.

Discussion

Spinal anesthesia, the choice for lower limb surgeries, is simple, reliable and popular anesthetic technique with little sophistication. However, it is not devoid of complications. Conventional spinal anesthesia has complications like hypotension, bradycardia, urinary retention, PDPH, transient or permanent neurological symptoms. Many of these complications specially hemodynamic effects are related with the sympatholytic effect of the local anesthetic agent, others are related with the technique of use (PDPH, neurologic injury, intravascular injection). Higher the level of block more will be the sympatholytic effect and thus more serious the complications will be. These effects can be considerably minimized, if not abolished, by using the low dose anesthetic agent at lower concentration. Moreover, if the spinal anesthesia is distributed to one side only for one sided operation, it will further minimize the hemodynamic effects. This technique also has advantage of fast blockade recovery and increased patient’s satisfaction so that patient can be managed on outpatient basis.

With this technique unilateral spinal anesthesia was induced in 73.8% patients, the success rate of which is similar in the studies performed by Imbelloni LE and coworkers. Imbelloni LE et al (2002) used 7.5mg, that is, 5ml of 0.15% bupivacaine (prepared with 1.5ml of standard isobaric bupivacaine) + 25 μg fentanyl and obtained unilateral spinal anesthesia in 71% of patients. Same author in 2003 used 5 mg, that is, 3.3ml of 0.15% hypobaric bupivacaine prepared from 1.5 ml of 0.5% isobaric bupivacaine added to 3.5ml of distilled water and produced unilateral spinal anesthesia in 75% patients. In our study 26.2% of cases failed to produce anesthesia (sensory level up to L1) in neither limb, thus required general endotracheal anesthesia to complete surgery. Decreased local anesthetic dose is a major factor for surgical anesthetic induction in the operated side and same may affect spinal anesthesia success. The study by Imbelloni LE et al (2004) showed failure rate of unilateral 5mg of 0.5% hyperbaric bupivacaine spinal anesthesia was 6.6%, differently from previous studies by the same authors with the same dose of 0.15% hypobaric bupivacaine and 0.5% isobaric bupivacaine. Our failure rate (26.2%) is considerably high. Among thirty one patients who had complete unilateral spinal anesthesia, 5 patients required supplemental opioids to complete surgery. In these cases, surgical duration exceeded expected duration of sensory block.

Mean onset time for sensory level to L1 was 11.9 minutes while mean onset time for complete motor block (Bromage Score III) in operated limb was 20.3 minutes. Unlike in study done by Imbelloni et al (2003) where they had complete motor block in operated limb in all the studied cases along with variable degree of contralateral motor block, in our study, only 73.8% cases had complete motor block of the operated limb without any contralateral limb motor block. This may be due to relatively faster injection rate (1ml/10s) compared to their study (1ml/15s). Other studies have used higher dose than ours (7.5mg, 6.12mg, 5.7mg) in addition with fentanyl which may have influence on the success rate of unilateral spinal anesthesia.

One of the objectives of unilateral anesthesia is to decrease the incidence of arterial hypotension. Hyperbaric unilateral spinal anesthesia induces 10% -20% arterial hypotension, regardless of injection speed. Hypobaric solutions result in a lower incidence, which was confirmed in our study where no
arterial hypotension episode was observed clinically.

Two segments regression time with low doses of 0.5% hyperbaric bupivacaine varies between 67\textsuperscript{15} and 99\textsuperscript{16} minutes. With hypobaric bupivacaine, regression has occurred in 53 minutes and patients were discharged after 180 to 190 minutes\textsuperscript{17}. Our study has not evaluated two segment regression, but rather total blockade recovery, which was 150.3 ± 39.7 minutes. In another study by Imbelloni LE et al\textsuperscript{18} (2003) with 5 mg of hypobaric bupivacaine, total blockade recovery was 139.2 ± 9.6 minutes. Mean duration of motor block in our study was 94 ± 20 minutes with 21 patients (67.7%) having their motor block regressed completely before the end of surgery where mean duration of surgery was 82.4 ± 47.4 minutes. Although we took inpatient cases with longer duration of operations, 5mg hypobaric bupivacaine may be a good indication for outpatient procedures.

Pencil point needles and slow injections are factors related to transient neurological symptoms (TNS), especially with hyperbaric lignocaine\textsuperscript{18}. Studies with cutting needles (Quinke) and hypobaric bupivacaine did not report to have transient neurological symptoms \textsuperscript{5,6,19} However in our study, although hypobaric bupivacaine was used with quinke needle one case reported to have TNS. He was male aged 32 years weighing 62 kg who had undergone open reduction and internal fixation for trimalleolar fracture. He reported to have radiating pain over the buttock and thigh which started about an hour of surgery completion and persisted for more than twelve hours. It was not relieved by injection Diclofenac intramuscularly so received injection Pethidine 50 mg i.m. The definite cause of TNS remains undetermined but thought to be due to needle trauma, patient position, muscle spasm, myofascial trigger points, and early mobilization\textsuperscript{20}. Freedom JM et al\textsuperscript{21} (1998) demonstrated that spinal anesthesia with lignocaine markedly increased the risk for TNS to develop compared with bupivacaine or tetracaine. Those symptoms were relatively common after lignocaine spinal anesthesia (11.9%) but uncommon after bupivacaine (1.3%) or tetracaine (1.6%). The pain associated with TNS was often severe (30.1%), and >90% of cases resolved completely within 1 week. Their data identified lithotomy position, outpatient status, and perhaps obesity as significant factors that increased the risk for TNS after spinal anesthesia with lignocaine.

One (out of 31) patient developed retention of urine and required plain catheterization. She was 43 years old female who underwent open reduction and internal fixation for bimalleolar fracture that took 125 minutes. After 1 hour of the end of surgery she complained of discomfort in the suprapubic area which was found distended on palpation. She did not have any urinary tract problem in the past. Sensory block duration for this case was 150 minutes. The frequency of micturition complications after spinal anesthesia with local anesthetics is higher than after general anesthesia. Stricker and Steiner\textsuperscript{22} reported a 26% incidence of urinary retention after spinal anesthesia with tetracaine and lignocaine with or without adrenaline in patients with and without a history of urinary tract problems. The frequency of urinary retention after spinal anesthesia is increased if large volumes of fluids are administered which may be the same in our case as she had received 3000 ml of Ringer’s Lactate in 2.5 hours period. Spinal anesthesia with lignocaine and with bupivacaine causes a clinically significant disturbance of bladder function due to interruption of the micturition reflex. The urge to void disappears quickly and bladder function remains impaired until the block has regressed to the third sacral segment in all patients\textsuperscript{23}. With long-acting local anesthetics, the volume of accumulated urine may exceed the cystometric
bladder capacity. With respect to recovery of urinary bladder function, the use of short-acting local anesthetics, low dose and unilateral spinal anesthesia seems to be preferable. No patient developed backache, post-dural puncture headache or any feature suggestive of systemic toxicity.

Conclusion
Unilateral spinal anaesthesia using low dose 5mg of 0.2% hypobaric bupivacaine may be advantageous to ensure haemodynamic stability and to minimize complications in selective cases. Moreover, because of faster recovery, it may be utilized in day care surgeries of known shorter surgical duration.

Limitations
- Variety of lower limb procedures was included in the study with wide fluctuation in duration of surgery. This might have influence on block characteristics.
- Bromage Scoring for motor block was difficult to assess correctly when hip joint was involved
- Some surgical procedures might have significant bleeding which was not considered in this study that might have affected hemodynamic stability.
- This study assessed complications of unilateral spinal anesthesia until 24 hours post spinal period and not beyond.

Acknowledgement
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