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Assessment of low-dose slow-injection unilateral spinal Anaesthesia with 6 mg 0.5% hyperbaric bupivacaine and 90 µg buprenorphine

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Abstract: *Background:* Spinal anaesthesia is a simple, reliable, and widely practiced technique offering excellent postoperative analgesia but may cause hypotension, urinary retention, and delayed recovery. Unilateral spinal anaesthesia minimizes these complications by restricting the block to the operative side, providing better haemodynamic stability, reduced motor block on the non-operative side, and faster ambulation. Its effectiveness depends on low-dose, slow-injection administration while maintaining the lateral position. Adding intrathecal opioids enhances analgesia without prolonging motor block. *Aim and Objectives:* To evaluate the success rate of unilateral spinal anaesthesia using 1.2 ml (6 mg) of 0.5% hyperbaric bupivacaine with 0.3 ml (90 µg) buprenorphine, injected slowly at 0.5 ml/min. *Materials and Methods:* This prospective study included 85 patients undergoing unilateral lower limb surgeries. Anaesthesia was administered in the lateral position and patients were turned supine after 20 minutes. Sensory and motor block levels, limb temperature difference, haemodynamic parameters, and use of atropine or vasopressors were recorded. Postoperative parameters included nausea, vomiting, motor block duration, and time to first micturition. *Results:* A successful unilateral block was achieved in 73.8% of patients. Unilateral sympathetic, motor, and sensory blocks occurred in 82.5%, 77.5%, and 76.3% of patients, respectively. Most achieved a T12–L1 sensory level. Mean systolic pressure fell by 13 mmHg, with vasopressor use in only 2.5%. No patient required atropine or developed urinary retention. Motor recovery occurred within 2.5–5.5 hours. Nausea occurred in 2.5%, with no vomiting. *Conclusions:* This technique provided effective unilateral spinal anaesthesia with minimal haemodynamic changes and side effects.

Keywords: Unilateral Spinal Anaesthesia, Low-Dose Slow-Injection Technique, Hyperbaric Bupivacaine, Buprenorphine, Lower Limb Surgery.

Introduction

Spinal anaesthesia is a simple, rapid, and reliable regional anaesthetic technique, widely practiced worldwide [1]. It provides superior postoperative analgesia compared to general anaesthesia but may cause hypotension, bradycardia, postoperative nausea and vomiting, urinary retention, and shivering [2]. Unilateral spinal anaesthesia offers advantages for unilateral lower limb surgeries by minimizing cardiovascular effects, reducing motor blockade on the non-operative side, and enabling early ambulation and discharge [3-4]. It is preferred when anaesthetic blockade is required only on the operative side while preserving function on the contralateral limb [5].

Success depends on limiting drug spread to the operative side using a low dose, slow injection, and maintaining the lateral position [3]. Several factors influence success, including needle characteristics, injection site, volume, baricity, patient position, and table tilt [4]. Among these, patient position is the

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most critical determinant of anaesthetic spread, especially with hyperbaric solutions [4]. High doses of bupivacaine may lead to haemodynamic instability, urinary retention, and delayed motor recovery [6]. The optimal dose and volume also differ between bilateral and unilateral spinal anaesthesia [7].

Enk et al. described the "low-dose, low-volume, low-flow" technique with lateral decubitus maintenance for 5–30 minutes as most effective for achieving a unilateral block [8]. Using a low anaesthetic dose provides selective blockade on the operative side, faster postoperative recovery, less urinary retention, and higher patient satisfaction. 4 Combining intrathecal opioids with local anaesthetics produces synergistic analgesia, allowing effective anaesthesia with subtherapeutic local doses [9]. Hyperbaric solutions further ensure localized and controlled drug spread [10]. Hence, the present study was conducted to evaluate the success rate of unilateral spinal anaesthesia using a very low dose of 1.2 ml (6 mg) of 0.5% hyperbaric bupivacaine with 0.3 ml (90 µg) buprenorphine, administered by a low-dose, slow-injection (0.5 ml/min) technique.

Material and Methods

Study was conducted in M.S. Ramaiah Medical College, after obtaining approval from the Institutional Ethics Committee, a prospective observational study was conducted. Adult patients aged 18–65 years, classified as American Society of Anaesthesiologists (ASA) grade I or II, scheduled for unilateral lower limb surgeries under spinal anaesthesia were included.

Inclusion Criteria:

- Age 18–65 years
- ASA physical status I and II
- Patients undergoing unilateral lower limb surgery

Exclusion Criteria: Patients with autonomic neuropathy, urinary catheter in situ, vascular pathology, scoliosis, history of spinal surgery, pregnancy, obesity (BMI >35 kg/m²), or those on anticoagulant therapy were excluded.

Procedure: After obtaining written informed consent, standard monitoring including non-invasive blood pressure, electrocardiography, heart rate, and pulse oximetry was established. The operating room temperature was maintained at 23 ± 0.5°C. An intravenous line was secured, and crystalloid infusion was started at 20 ml/kg/hr.

Patients were positioned in the lateral decubitus position with the operative limb dependent. Under strict aseptic precautions, lumbar puncture was performed at the L3–L4 or L4–L5 interspace using a 25G Quincke needle. After confirming free cerebrospinal fluid flow, the needle bevel was directed toward the dependent side. A total of 1.5 ml of drug solution containing 1.2 ml (6 mg) of 0.5% hyperbaric bupivacaine and 0.3 ml (90 µg) of buprenorphine was injected intrathecally at a rate of 0.5 ml/min. The lateral position was maintained for 20 minutes to allow fixation of the anaesthetic solution, after which patients were turned supine.

Assessment: Sensory block was assessed bilaterally 20 minutes after injection by loss of pinprick sensation, with the highest dermatome recorded. Motor block was graded using the Modified Bromage Scale. Temperature was measured at the medial aspect of both knees before and 20 minutes after the block to assess sympathetic blockade. Successful unilateral spinal anaesthesia was defined as the presence of sensory, motor, and sympathetic block on the dependent side, with no corresponding effect on the non-dependent side.

Heart rate, blood pressure, and oxygen saturation were recorded at baseline and 20 minutes after the block. Hypotension (≥30% fall in systolic pressure or MAP <60 mmHg) was treated with intravenous fluids and ephedrine (6 mg), while bradycardia (HR <50/min) was treated with atropine (0.6 mg). The duration of motor block and time to first micturition were recorded postoperatively. Intraoperative use of ephedrine or atropine and episodes of nausea or vomiting were also documented.

Results

A total of 85 patients were enrolled in the study. Five patients were excluded due to

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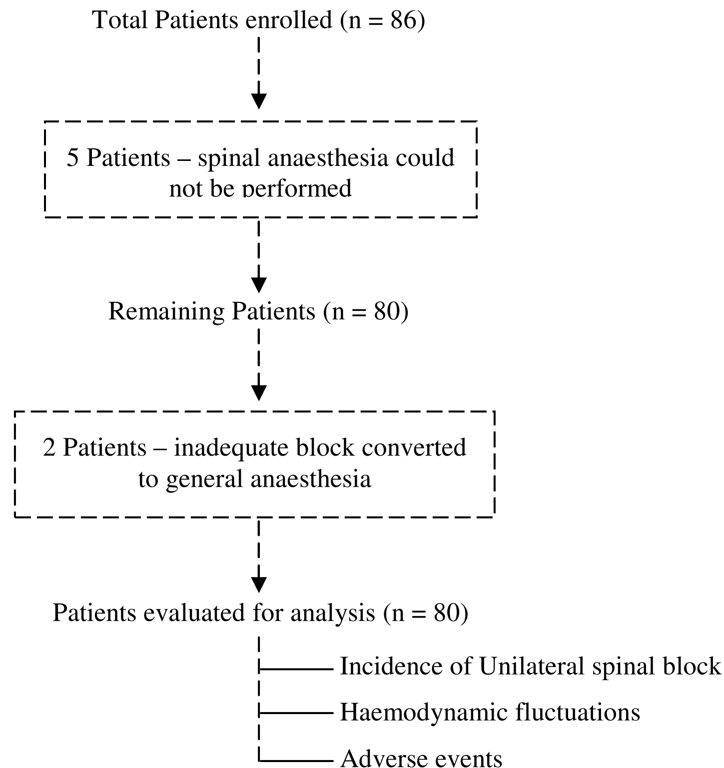
failed spinal anaesthesia, and two required conversion to general anaesthesia because of inadequate block. The remaining 80 patients were evaluated for the incidence of unilateral spinal anaesthesia, haemodynamic changes, and adverse events (Flowchart- 1).

Flowchart- 1: Number of patients enrolled in the study



The mean age of the patients was 48.66 ± 16.84 years, with a mean height of 170.19 ± 7.88 cm, mean weight of 69.11 ± 14.41 kg, and an average BMI of 23.82 ± 3.09 kg/m². The study group comprised 65 males and 15 females. According to the ASA physical status classification, 32 patients were ASA grade I and 48 were ASA grade II (Table 1).

Table-1: Demographic Data of patients studied	
variables	**Mean ± SD**
Height (cm)	170.19±7.88
Weight (kg)	69.11±14.41
BMI (kg/m^2)	23.82±3.09
Age in years	48.66±16.84
Gender M/F	65/15
ASA score I/II	32/48

The incidence of unilateral sympathetic block, indicated by a temperature difference between limbs, was 82.5%. Unilateral motor block was achieved in 77.5% of patients, while unilateral sensory block occurred in 76.3%. A complete unilateral block involving all three modalities sympathetic, motor, and sensory was successfully obtained in 73.8% of cases (Table 2).

Table-2: Incidence of Unilateral Block	
Incidence of unilateral block	**%**
Sympathetic (Diff. in temp.)	82.5
Motor	77.5
Sensory	76.3
Unilateral (All three modalities)	73.8

Average fall in SBP before and after block is 13 mm of Hg while average fall in DBP before and after subarachnoid block is 10.50 mm of Hg. While difference in heart rate before and after block is 10 bpm only (Fig-1).

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Fig-1: Duration of onset of motor recovery in dependent limb

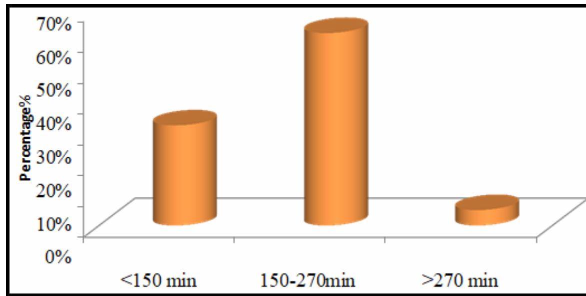


Table-3: Motor block on dependent side		
Motor block dependent side (Modified Bromage Scale)	**No. of patients (n=80)**	**%**
0	2	2.5
1	2	2.5
2	28	35.0
3	48	60.0

Average of motor recovery time in dependent limb seen is between 2.5 hours to maximum 4.5 hours (table-3). Table 4 depicts incidence of motor blockade on non dependent side after unilateral anaesthesia.

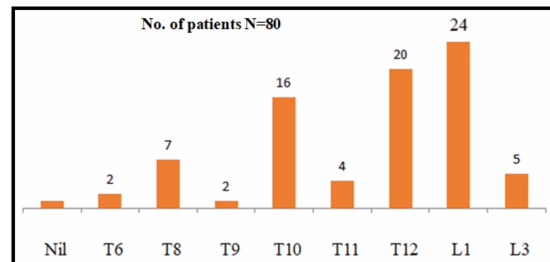
Table-4: Motor Block on non-dependent side		
Motor block Non-dependent side	**No. of patients (n=80)**	**%**
0	64	80.0
1	2	2.5
2	9	11.3
3	5	6.3

Onset of 1ST Micturition Post Operatively: The onset of micturition after surgery occurred within 3 hours 30 minutes in 37.5% of patients, between 3 hours 30 minutes and 5 hours 30 minutes in 60%, and after 5 hours 30 minutes in only 2.5% of patients (table-5).

Table-5: Onset of 1st micturition post operatively		
Onset of time of micturition post surgery (in hours)	**No. of patients (n=80)**	**%**
< 3:30	30	37.5
3:30-5:30	48	60.0
> 5:30	2	2.5

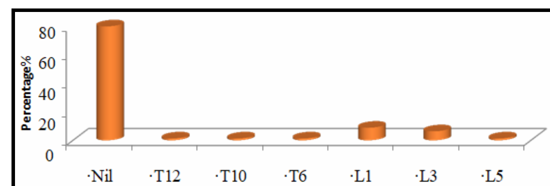
Level of sensory block on dependent side (Figure-2): Highest level of sensory block on dependent side seen is T6 in only 2 patients. While maximum no of patients achieved T_{12}-L_1 block (44 patients).

Fig-2: Level of sensory block on dependent side



Upper level of sensory block Non- dependent side (Figure-3): Highest level of sensory block on dependent side seen is T6 in only 2 patients. While maximum no of patients achieved T_{12}-L_1 block (44 patients).

Fig-3: Upper level of sensory block Non-dependent side



On the dependent side, a temperature difference of ≥ 0.5°C after the block was observed in 66 patients (82.5%), while 14 patients (17.5%) showed a difference of < 0.5°C. On the non-dependent side, a temperature difference of ≥ 0.5°C was noted in only 11 patients (13.75%), whereas 69 patients (86.25%) had a temperature difference of <0.5°C. Regarding postoperative nausea and vomiting (PONV), 2 patients (2.5%) experienced nausea, while no cases of vomiting (0%) were reported. Intraoperatively, none of the patients required atropine, and vasopressors were used in only 2 patients (2.5%), while 78 patients (97.5%) did not require any vasopressor support.

Discussion

Unilateral spinal anaesthesia (USA) is preferred for surgeries confined to one lower limb because it produces selective neural blockade with improved haemodynamic

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stability, faster motor recovery, and earlier ambulation when compared with conventional bilateral spinal anaesthesia. By restricting sympathetic blockade predominantly to the operative side, USA reduces the incidence of hypotension and facilitates early discharge, making it particularly suitable for ambulatory and elderly patients.

The “low-dose, low-volume, low-flow” technique described by Enk et al. emphasizes the importance of controlled intrathecal spread, especially when patients are maintained in the lateral decubitus position for 5–30 minutes. Careful manipulation of baricity, dose, injection rate, and patient positioning helps achieve selective anaesthesia while minimizing contralateral spread, thereby fulfilling the essential goals of ambulatory anaesthesia—safety, effectiveness, minimal adverse effects, and rapid recovery [8,11-12].

The success rate of USA reported in literature varies widely from 31% to 94.45%, largely due to differences in methodology, drug dose, baricity, injection speed, needle type, and criteria used to define “strict” unilateral block. In the present study, the success rate was 73.8%, which lies within the reported range. Bergmann et al. documented higher rates of unilateral sympathetic, sensory, and motor block (86%, 94%, and 98%, respectively), possibly because their criteria included a reduction of at least one MRC grade rather than complete absence of block on the non-dependent side.

Seyyed and Mohammad achieved a 94.45% success rate using 7.5 mg hyperbaric bupivacaine with a controlled low-flow injection, while Enk et al. demonstrated that slower injection rates (0.5 ml/min) significantly improved unilateral block frequency compared to faster rates (7.5 ml/min). Conversely, Meyer et al. reported only 31% strict unilateral success despite low-flow injection, highlighting that injection rate alone does not guarantee unilateral spread and that positioning and patient-related anatomical factors also contribute significantly. Thus, heterogeneity in technical approach and assessment criteria explains much of the variability across studies [2,7-8,13-14].

The incidence of strict unilateral sympathetic block in our study was 82.5%, assessed by a ≥0.5°C temperature rise in the dependent limb. Differences in reported sympathetic block rates among authors may be attributed to variations in monitoring techniques. Bergmann et al. incorporated both electrical dermal resistance and temperature monitoring, which likely provided a more sensitive real-time assessment of sympathetic tone. In contrast, several investigators have questioned the reliability of skin temperature alone due to its slower and indirect response to sympathetic blockade. Although dermal resistance monitoring may offer greater precision, it is not routinely available in many clinical settings; therefore, temperature monitoring remains a practical and feasible alternative. Differences in monitoring methodology likely contributed to discrepancies in sympathetic block incidence between studies [2,8,13-14].

Unilateral motor block was achieved in 73.8% of patients in our study using strict modified Bromage criteria requiring complete absence of motor block on the non-dependent side. This may explain why our motor block rates were slightly lower than those reported by Bergmann et al., who considered even partial reduction in muscle strength as successful unilateral block. Furthermore, dose selection influences motor spread: higher doses increase the likelihood of bilateral motor involvement, whereas very low doses may increase failure rates. Recovery of motor function within 270 minutes in 95% of our patients supports the suitability of low-dose techniques for ambulatory practice. Variations in drug concentration, opioid adjuvant use, and assessment criteria account for inter-study differences in motor block outcomes [2-3, 5].

Haemodynamic stability was well maintained in the present study, with hypotension occurring in only 2.5% of patients and easily managed with a single 6 mg dose of ephedrine. Reduced sympathetic spread in unilateral techniques explains the lower incidence of hypotension compared to bilateral spinal anaesthesia. Esmaoglu et al. similarly reported minimal haemodynamic disturbances with low-dose hyperbaric

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bupivacaine, supporting the concept that dose reduction and lateral positioning help preserve cardiovascular stability. Differences in patient demographics, baseline comorbidities, fluid management strategies, and block height may further account for variations in haemodynamic outcomes reported in literature [15].

The selection of 6 mg of 0.5% hyperbaric bupivacaine combined with 90 µg buprenorphine was intended to balance adequate sensory blockade with rapid motor recovery. Kristiina et al. demonstrated improved unilateral block characteristics with hyperbaric solutions compared to plain bupivacaine at similar doses. The addition of buprenorphine likely enhanced analgesia without significantly prolonging motor blockade due to its high lipid solubility and prolonged receptor binding. Differences in opioid type (fentanyl, clonidine, or buprenorphine), dose, and pharmacodynamic profile may explain variations in sensory duration and recovery patterns across studies [5].

Technical factors such as needle type and patient positioning also influence block distribution. Quincke 25G needles were used in our study to allow free cerebrospinal fluid flow and controlled injection. Maintenance of lateral positioning for 20 minutes was adopted based on recommendations suggesting that gravitational influence during the early phase after injection limits contralateral migration of hyperbaric solution. Some studies propose that fixation of bupivacaine occurs within minutes, while others recommend 15–20 minutes to maximize selectivity; these differences in positioning protocols may partially explain variability in reported success rates [16-17].

Urinary retention, a known complication of bilateral spinal anaesthesia due to parasympathetic blockade, was not observed in our study. Early return of bladder function in most patients suggests preservation of contralateral sacral parasympathetic fibres. Reduced local anaesthetic dose and unilateral sympathetic spread likely contributed to this favorable outcome. Minor adverse effects were minimal, with only 2.5% experiencing nausea and no vomiting, further supporting the safety profile of the technique.

Overall, differences between our findings and those of other authors can be attributed to variations in local anaesthetic dose, baricity, opioid adjuvant selection, injection speed, needle design, duration of lateral positioning, definitions of strict unilaterality, and methods used to assess sympathetic block. Lack of standardized criteria remains the principal reason for heterogeneity in reported success rates. Nevertheless, our results demonstrate that low-dose hyperbaric bupivacaine combined with buprenorphine provides effective unilateral spinal anaesthesia with satisfactory success rates, stable haemodynamics, minimal complications, and favourable recovery characteristics suitable for lower limb surgery [2,7-8,14].

Conclusion

Unilateral spinal anaesthesia using low-dose hyperbaric bupivacaine with buprenorphine provides effective anaesthesia confined to the operative limb, superior hemodynamic stability, early recovery, and minimal complications making it a safe and practical option for lower limb surgeries, especially in elderly and ambulatory patients.

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Conflicts of interest: There are no conflicts of interest.

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