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SCIENTIFIC ARTICLE

Comparison of the effects and complications of unilateral spinal anesthesia versus standard spinal anesthesia in lower-limb orthopedic surgery

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Abstract
Introduction: A restricted sympathetic block during spinal anesthesia may minimize hemodynamic changes. This prospective randomized study compared unilateral and bilateral spinal anesthesia with respect to the intra- and postoperative advantages and complications of each technique.
Material and methods: Spinal anesthesia was induced with 0.5% hyperbaric bupivacaine and a 25-G Quincke needle (Dr. J) in two groups of patients with physical status ASA I–II who had been admitted for orthopedic surgeries. In group A, dural puncture was performed with the patient in a seated position using 2.5 cm^3 of hyperbaric bupivacaine. Each patient was then placed in the supine position.

In group B, dural puncture was performed with the patient in the lateral decubitus position with 1.5 cm^3 of hyperbaric bupivacaine. The lower limb was the target limb. The speed of injection was 1 mL/30 s, and the duration of time spent in the lateral decubitus position was 20 min.
Results: The demographic data were similar in both groups. The time to the onset of the sensory and motor block was significantly shorter in group A ($p = 0.00$). The duration of motor and sensory block was shorter in group B ($p < 0.05$).

The success rate for unilateral spinal anesthesia in group B was 94.45%. In two patients, the spinal block spread to the non-dependent side. The incidence of complications (nausea, headache, and hypotension) was lower in group B ($p = 0.02$).
Conclusion: When unilateral spinal anesthesia was performed using a low-dose, low-volume and low-flow injection technique, it provides adequate sensory-motor block and helps to achieve stable hemodynamic parameters during orthopedic surgery on a lower limb. Patients were more satisfied with this technique as opposed to the conventional approach. Furthermore, this technique avoids unnecessary paralysis on the non-operated side.

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Introduction

The patients who undergo orthopedic surgery on the lower limb differ in terms of age as well as the type of surgery performed. Regional anesthesia, especially spinal anesthesia, is beneficial for most of these patients. Over the past few years, bupivacaine has been used routinely for epidural and spinal anesthesia.[1,2] Unilateral and bilateral spinal anesthesia require different volumes and doses of bupivacaine.[3]

Unilateral spinal anesthesia is used during most surgical procedures performed on the lower limbs.[4] There are many benefits to this technique including fewer hemodynamic changes,[5] less urinary retention, more satisfied patients, better motility during recovery and the restriction of selective nerve block to the relevant limb.[6]

Several factors are required for successful unilateral spinal anesthesia, including: the type of needle and its bevel direction, the speed of injection,[7] volume, baricity, the concentration of local anesthesia as well as the position of the patient on the operating table.[8]

To comprehensively investigate the benefits of unilateral as compared with bilateral spinal anesthesia, we evaluated the effects on sufficient sensory and motor block, optimum analgesia, hemodynamic changes, nausea, vomiting and headache.

Materials and methods

The patients were divided in two randomized groups of 36 patients: A and B.

In group A, standard spinal anesthesia was used on even days. In group B, unilateral spinal anesthesia was used on odd days. Patient age ranged from 18 to 50 years. The patients were in ASA class I or II. The duration of Nil per os (NPO) time and the sedation regimen were the same in both groups. Any patient who had a history of cardiovascular disease, hypertension, neuropathy, addiction, or smocking was excluded from the study. Patients who could not be placed in a lateral position (e.g., due to a pelvis fracture) were also excluded from the study, as were patients who required general anesthesia during surgery or a surgery requiring over 2 h.

Ethical approval for this study (protocol number: 891001) was provided by the Mashhad University ethics committee, Mashhad, Iran (Chairperson Dr. Tavakkol Afshar) on 18 June 2011. Informed consent was obtained from each patient to ensure that he or she understood that the technique used for spinal anesthesia would be modified.

An IV cannula was inserted, then a 10 mL/kg intravenous infusion of lactated Ringer's solution was administered over 20 min. All patients underwent standard monitoring, including electrocardiography, non-invasive blood-pressure measurements and pulsoximetry.

In group A, spinal anesthesia was performed with the patient in the sitting position at the L3–L4 interspace using a 25-G Quincke spinal needle (Dr. J) in sterile condition. Once intrathecal placement had been confirmed, 2.5 mL of hyperbaric bupivacaine 0.5% was injected. The patient was then placed in the supine position.

In group B, the patients were placed in the lateral decubitus position with the target limb in the lower position.

Table 1 Bromage score.

Grade	Criteria	Degree of block
I	Free movement of legs and feet	Nil (0%)
II	Just able to flex knees with free movement of the feet	Partial (33%)
III	Unable to flex knees, but with free movement of the feet	Almost complete (66%)
IV	Unable to move the legs or feet	Complete (100%)

Similar to the technique used for group A, the L3–L4 intervertebral space was detected, then spinal anesthesia was performed with a 25-G Quincke spinal needle. After the confirmation of intrathecal needle placement, 1.5 mL of hyperbaric bupivacaine 0.5% was injected at a speed of 1 cm^3 every 30 s. The bevel of the needle pointed downward during the injection. The patients were kept in the lateral position for 20 min and then placed in the supine position for surgery.

To reduce patient anxiety, 2 mg of midazolam was injected I.V.

Hemodynamic variables such as blood pressure and heart rate were checked before spinal anesthesia and then every 5 min in both groups. If blood pressure decreased by more than 25% of baseline and heart rate dropped to less than 50 beats/min, the patient was considered to suffer from hypotension or bradycardia, respectively.

The hypotension was managed by rapid IV infusion of 250 mL of lactated Ringer's solution. Bradycardia was managed using 0.5–1 mg of intravenously administered atropine. If the hypotensive patient did not respond to treatment, ephedrine 5 mg was injected. A visual analog scale ranging from 0 to 10 was used for evaluation of nausea and the number of vomiting episodes were used to evaluate the extent of patient vomiting.

To check the level of sensory block, a cold object was held in contact with the skin. The Bromage scale was used to check the accuracy of the motor block (see Table 1).[9]

The clinical data including the onset of sensory and motor block, hemodynamic changes, the duration of sensory and motor block and the complications of spinal anesthesia were evaluated using SPSS version 19.6.

In this statistical analysis, a p value of <0.05 was considered as significant.

For statistical analysis of the hemodynamic changes, the paired t-test was used.

The independent t-test was used to compare the efficacy of the sensory and motor blocks. The Mann–Whitney U-test was used to evaluate the level of patient satisfaction.

Results

The demographics of both groups were similar (Table 2).

T10–T12 anesthesia was achieved in both groups. The average time to anesthetic onset in the unilateral group

Table 2 Demographic data.

Specification	Bilateral group $n = 36$	Unilateral group $n = 36$	p-Value
Age	31.5 ± 5.37	26.7 ± 7.55	>5%
Sex			
Male	25	27	>5%
Female	11	9	>5%
Weight	74.7 ± 11.60	75.71 ± 9.30	>5%
Duration of surgery (min)	95.15 ± 10.07	94.20 ± 9.67	–

Table 3 Duration of motor and sensory block.

	Bilateral group (A) $n = 36$	Unilateral group (B) $n = 36$	p-Value
Duration of motor block (min)	174.11 ± 17.42	136.65 ± 32.38	0.02
Duration of sensory block (min)	189.40 ± 21.15	157.12 ± 17.07	0.00
Bromage scale			
IV	8 cases	13 cases	0.059
III	28 cases	23 cases	

was 4.47 ± 1.3 min. In the bilateral group, this value was 2.44 ± 0.41 min (p value = 0.00).

The average time to the onset of immobility in the unilateral group was 6.17 ± 1.5 min. In the bilateral group, this rate was 4.35 ± 1.25 min (p value = 0.00). Sensory and motor block lasted longer in the bilateral group as compared to the unilateral group (Table 3). An average Bromage score of 4 was achieved for the motor block in both groups ($p = 0.59$).

None of the patients in the unilateral group experienced nausea or vomiting. In the bilateral group, eight patients had nausea and one of them experienced episodes of vomiting ($p = 0.02$). Two patients in the unilateral group and eight patients in the bilateral group had headaches ($p = 0.03$). The average time to voiding after spinal anesthesia was 4.9 h in the unilateral group and 5.3 h in the bilateral group ($p > 0.05$). The level of patient satisfaction was 91.2% in the unilateral group and 85.3% in the bilateral group ($p > 0.05$).

The rates of complications are presented in Table 4.

Table 4 Complications.

Complications	Unilateral (number)	Bilateral (number)	p-Value
Nausea and vomiting	0	8	0.02
Headache	2	8	0.03
Hypotension	0	6	0.02
Bradycardia	0	5	0.02

The success rate for unilateral spinal anesthesia in our study was 94.45%, but in two cases, the anesthetic drug spread to the other side of the canal, resulting in bilateral anesthesia.

Discussion

The patient's position during and immediately after spinal anesthesia influences the spinal distribution of drugs. If an anesthetic drug solution is hypo- or hyperbaric with respect to the cerebrospinal fluid, it is possible to create a unilateral block. Moreover, the distance between the left and right nerve roots in the lumbar and thoracic regions is about 10–15 cm, which makes it possible to achieve unilateral spinal anesthesia.[10]

Kuusniemi et al. reported that hyperbaric bupivacaine is more effective in achieving unilateral spinal anesthesia than plain bupivacaine.[11] However, determining the optimal time for lateral positioning is difficult when a high dose of hyperbaric bupivacaine (12–20 mg) is used.[12,13] The anesthetic drug may migrate even when the patient is placed in the lateral position for 30–60 min. Conversely, if a low dose (5–8 mg) of anesthetic solution is used, putting the patient in the lateral position for 10–15 min may prevent migration of the anesthetic drug.

In this study, we injected 1.5 cm^3 of hyperbaric bupivacaine 0.5% to achieve unilateral spinal anesthesia. The patient was kept in the lateral position for 20 min, which led to unilateral spinal anesthesia in 94.45% of cases. In two cases, the anesthetic drug spread to the other side, resulting in bilateral spinal anesthesia. In a study performed by Esmaoglu, the patient was in the lateral position for 10 min. This approach yielded an 85.7% success rate. This discrepancy in terms of the success rate seems to be dependent on the duration of time spent in the lateral position.[4]

Notably, none of the patients in the unilateral spinal anesthesia group experienced hypotension, but six patients in the bilateral group had hypotension ($p < 0.05$). Chohan and Afshan administered unilateral spinal anesthesia prior to lower-limb surgery in elderly patients with ASA classification of III or IV (average age, 60). The authors found no significant hemodynamic changes. They used hyperbaric bupivacaine 0.5% (1.1–1.8 mL).[14]

In our study, there was no bradycardia in the unilateral group, but in the bilateral group, 5 patients had bradycardia ($p = 0.04$). On average, the time to the onset of anesthesia and immobility was faster in the bilateral as compared to the unilateral spinal anesthesia group ($p = 0.00$). The sensory and motor block lasted for less time in the unilateral as compared to the bilateral group. Unilateral spinal anesthesia is therefore suitable for out-patient surgery.

Valanne used 4 or 6 mg of bupivacaine to induce unilateral spinal anesthesia in 106 patients scheduled to undergo knee arthroscopy. While both doses were sufficient for sensory and motor block, 4 mg of bupivacaine achieves a more rapid regression of motor function.[15]

Headache after spinal anesthesia was reported in two and eight patients in the unilateral and bilateral groups, respectively. In contrast, Smaoglue used 1.5 cm^3 and 3 cm^3 of hyperbaric bupivacaine 0.5% for unilateral and bilateral anesthesia, respectively: six and nine patients, respectively,

experienced headache. This discrepancy may be related to the type of needle used (Quincke) or the relatively young age of the patient population.[16]

Notably, spinal anesthesia can disturb bladder function by disabling the micturition reflex. Kamphuis and colleagues reported that voiding disturbance continues until the nerve block has regressed to the third sacral root.[17]

In our investigation, the average time to voiding after spinal anesthesia was 4.9 and 5.3 h in the unilateral and bilateral groups, respectively. This difference was not significant. Atef et al. reported no urinary retention after unilateral spinal anesthesia with 5 mg of hyperbaric bupivacaine, while in their study, after induction with 12.5 mg dosage, this complication observed in five percent of the subjects. So, it appears that a reduction in the bupivacaine dosage decreases the likelihood of urinary retention, as well.[18]

Conclusion

Unilateral spinal anesthesia with a low dose (7.5 mg), limited volume (1.5 cm^3) and low-flow injection (1 cm^3/30 s) technique induces sufficient sensory and motor block with an appropriate level of analgesia. The technique is therefore suitable for lower-limb surgery. This technique achieves stable hemodynamics, particularly in elderly and ASA class III/IV patients. It also results in rapid recovery and greater satisfaction among outpatients, in addition to preventing unnecessary nerve block in the contra lateral limb.

Conflicts of interest

The authors declare no conflicts of interest.

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