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ADVANTAGES OF UNILATERAL SPINAL ANESTHESIA VERSUS CONVENTIONAL BILATERAL SPINAL ANESTHESIA IN LOWER LIMB ORTHOPEDIC SURGERY

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Spinal anesthesia is a frequently applied technique for lower limb orthopedic surgery. Hypotension is the most frequent side effect of conventional bilateral spinal anesthesia. An exclusively unilateral block only affects the sensory, motor and sympathetic functions on one side of the body without the typical adverse side effects seen with a bilateral block.

The aim of this prospective, randomized study was to compare unilateral anesthesia versus conventional bilateral spinal anesthesia in lower limb orthopedic surgery according to the quality of sensory and motor blockade, analgesia, hemodynamic stability and side effects.

Forty ASA I – II patients scheduled for lower limb orthopedic surgery were randomly allocated into two groups. Group BS patients received bilateral spinal anesthesia with 3ml isobaric 0.5% levobupivacaine (conventional dose) and group US patients received unilateral low dose spinal anesthesia with hyperbaric spinal solution (7.5mg of 0.5% levobupivacaine and 40mg of 10% glucose) over a period of 120 seconds and the patients were kept in the lateral position for 15 minutes.

In both groups, the quality of the sensory and motor block was adequate for the surgical procedure. The time to two segment regression of sensory blockade, recovery time of motor blockade, as well as the time of complete recovery was significantly shorter in US group as compared to the BS group. Seven patients in the bilateral, and one patient in the unilateral group developed hypotension that required treatment with ephedrine (Chi-square test 7.02; $p < 0.05$).

Unilateral low dose spinal anesthesia achieves stable hemodynamics. It also results in rapid recovery compared to a bilateral conventional dose spinal anesthesia.

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Introduction

Spinal anesthesia is a frequently applied technique with its ease of performance and high success rate in lower limb orthopedic surgery. It is widely used for providing a fast and effective sensory and motor blockade. This blockage reduces the stress response to a surgical trauma, decreases intraoperative blood loss, reduces the incidence of postoperative thromboembolism and decreases morbidity and mortality in comparison with general anesthesia (1).

However, side effects such as hypotension, bradycardia, nausea and vomiting, postpuncture headache and urine retention are observed (2). Hypotension is the most frequent side effect of conventional bilateral spinal anesthesia, occurring in more than 30% of patients. Ward et al. reported a decrease in mean arterial blood pressure of 21.3% of the baseline following spinal anesthesia. He also reported that a level of spinal anesthesia to T5 resulted in an increase in heart rate by 3.7%. The cardio-accelerator fibers originate from T1-T4, so the level of spinal anesthesia affecting these dermatomes may cause bradycardia (3, 4). An exclusively unilateral block only affects the sensory, motor and sympathetic functions on one side of the body and offers the advantages of a spinal block without the typical adverse side effects seen with a bilateral block (5, 6).

The advantages of unilateral spinal anesthesia include much lower incidence of clinically relevant hypotension, lower incidence of urine retention, better patient satisfaction, better mobility during recovery time and block restriction on the operative side. Several factors are required for successful unilateral spinal anesthesia: the type of spinal needle and bevel direction, the rate of injection, volume, baricity and the concentration of local anesthetics, as well as the position of patients on the operating table (7, 8). Moreover, patient posture is thought to be fundamental in determining the level of anesthesia spread, particularly when a hyperbaric anesthetic solution is used (9, 10).

The aim of our study was to compare unilateral anesthesia versus conventional bilateral spinal in lower limb orthopedic surgery according to the quality of sensory and motor blockade, analgesia, hemodynamic stability and side effects.

Materials and methods

This prospective study included forty adult patients scheduled for unilateral lower limb surgery, except patients with degenerative hip disease or hip fracture, in routine surgical theaters at the Clinic of Orthopedic Surgery and Traumatology in Clinical Center Niš. Informed consent was obtained from all patients. Inclusion criteria were American Society of Anesthesiologists (ASA) score I–II, age 18-65 years, male and female. Exclusion criteria were contraindications for spinal anesthesia: skin infection at the site of regional anesthesia, coagulopathy, taking anticoagulant drugs, allergy to local anesthetic drugs, hypovolemia, low fixed cardiac output, neurologic and psychiatric disorder, spine deformity, body mass index (BMI) > 35kg/m^2 and chronic pain treatment.

Patients were randomly allocated into two groups of 20 patients (N = 20). The BS group patients received bilateral spinal anesthesia with 15mg isobaric 0.5% levobupivacaine (conventional doses). The US group patients received unilateral spinal anesthesia with 7.5mg hyperbaric 0.5% levobupivacaine (low doses). Hyperbaric solution was prepared by combining 7.5mg of isobaric 0.5% levobupivacaine (1.5ml) with 40mg 10% glucosae (0.4ml). All patients were given 2mg midazolam intravenously as premedication, as well as an intravenous infusion of 7mL/kg of lactated Ringer solution. Standard monitoring was used, including noninvasive blood pressure, electrocardiogram, peripheral pulse oximetry, and respiratory rate measurements. Baseline arterial blood pressure and heart rate were recorded at the end of volume expansion, before inducing spinal block.

All patients were placed in a lateral position on the operative side down, while the vertebral column was positioned as horizontally as possible. Under complete aseptic technique, dural puncture was performed using a midline approach at the L3-L4 interspace with a 27 gauge spinal pencil point needle. BS group received an intrathecal injection of 15mg plane (isobaric) levobupivacane 0.5% over a period of 10 seconds. The direction of the needle aperture was cranial during the injection. After injection of spinal solution the patients immediately were turned in supine position (conventional bilateral spinal anesthesia). US group received of 7.5mg plane levobupivacaine 0.5% with 40mg glucose (hyperbaric solution) over a period of 120 seconds (injection speed: 1ml/min) without further aspiration maneuvers. The bevel of the needle pointed down to operative site during the injection. The patients were kept in the lateral position for 15 min and then placed in the supine position for surgery (unilateral low dose spinal anesthesia).

Hemodynamic changes were recorded every 5 min after spinal anesthesia, and then until the end of surgery. Hypotension (SAP < 90 or 30% decrease from the baseline) was treated with additional intravenous bolus of 250ml crystalloid. However, if supplementation of fluids failed to reverse hypotension, intravenous ephedrine 5-10mg bolus was administrated. Bradycardia (HR < 50) was treated with 0.5 mg of atropine intravenously.

The sensory anesthesia level was evaluated by pinprick method with 22 gauge hypodermic needle along the anterior middle clavicular line of both sides. The time to onset of analgesia was defined as the time to the onset of sensory block to maximum cephalad spread. The onset and degree of motor block were evaluated using a modified Bromage scale (0 = no motor block; 1 = hip blocked; 2 = hip and knee blocked; 3 = complete motor block). Pain was assessed from the beginning of surgery using a 10cm visual analog scale (VAS). We also recorded side effects such as nausea, vomiting and headache. The urinary retention was not recorded due to a significant number of patients with preoperatively placed urinary catheter.

Statistical analysis was performed using standard data processing programs - MS EXCEL and software package R. Tests were performed with Chi-square, Fisher's exact test and t-test for independent samples. A value of $p < 0.05$ was considered as significant. Continuous variables were presented as mean ± stdev or as median (range); categorical data were presented as number (%).

Results

There were no significant differences between two groups with respect to age, gender, weight, ASA status, duration of surgery and intraoperative crystalloids (Table 1).

In both groups, anesthesia was adequate for the surgical procedure and none of the patient needed general anesthesia or intraoperative analgesics. The quality of the sensory and motor block, as well as intraoperative analgesia are shown in Table 2. T10-T12 anesthesia was achieved in both groups. The maximum level of sensory blockade was higher in the bilateral spinal group T7 (T4-T8) than in the unilateral spinal group T8 (T11-T7) thoracic dermatome, but there was no significant difference ($p > 0.05$).

Table 1. Patient's characteristics, duration of surgery and intraoperative crystalloids

	BS group (N = 20)	US group (N = 20)
Age (years)	45.4 ± 12.84	44.2 ± 12.79
Sex (Male/Female)	12/8	14/6
Weight (kg)	76.5 ± 13.2	75.2 ± 12.62
ASA classification	ASA I 4 (20%) ASA II 16 (80%)	ASA I 5 (25%) ASA II 15 (75%)
Duration of surgery (min)	64.3 ± 18.46	61.0 ± 17.22
Intraoperative crystalloids (ml)	1109 ± 522.4	1038 ± 456.86

Data are means ± sd or numbers. ASA – American Society of Anesthesiologists.
There were no significant differences between groups ($p > 0.05$).
BS group – bilateral spinal anesthesia; US group – unilateral spinal anesthesia

Table 2. Comparison of the spinal blockades

	BS group (N = 20)	US group (N = 20)
Maximum cephalad spread (dermatome)	T7 (T4 – T8)	T8 (T11 – T7)
Onset time of sensory blockade (min)	6.7 ± 0.9	8.05 ± 1.07*
Time to two segment regression (min)	91.55 ± 9.55	57.75 ± 7.32*
Intraoperative analgesia (VAS = 0 – 10)	0 (100%)	0 (100%)
Degree of motor block - operative side	Bromage III 20 (100%)	Bromage III 20 (100%)
Degree of motor block - nonoperative side	Bromage III 20 (100%)	Bromage I/II 3 (15%)*
Duration of motor block (min)	179 ± 13.74	105.25 ± 12.59*
Full recovery (min)	232 ± 17.49	167.25 ± 10.42*

Data are means±sd or numbers. VAS – visual analog scale.
*Statistical significance was set at the $p < 0.05$ level.
BS group – bilateral spinal anesthesia; US group – unilateral spinal anesthesia.

The average time to sensory onset in the unilateral group was 8.05 ± 1.07 min. In the bilateral group, this value was 6.7 ± 0.9 min (t value -4.21; $p < 0.05$). The time to two segment regression of sensory blockade was significantly shorter in the unilateral spinal group 57.75 ± 7.32 min versus 91.55 ± 9.55 min in the bilateral spinal group (t value -12.24; $p < 0.05$). Recovery time of motor blockade in unilateral spinal group (105.25 ± 12.59 min) was significantly shorter (t value 17.24; $p < 0.05$), as well as the time of complete recovery (167.25 ± 10.42 min) in the unilateral spinal group (t value -13.86; $p < 0.05$). An average Bromage score of III was achieved for the motor block in both groups. A strictly the unilateral spinal anesthesia in the US group was achieved in seventeen patients, while in three patients spinal block spread to the nonoperative side (Bromage I or II).

Table 3. Hemodynamic changes and side-effects of spinal anesthesia

	BS group (N = 20)	US group (N = 20)
Hypotension (SP<90mmHg)	7 (35%)	1 (5%)*
Bradycardia (SF < 50 / min)	4 (20%)	1(5%)
Nausea, vomiting	4 (25%)	1 (5%)
Headache	1	0

Data are numbers.
*Statistical significance was set at the $p < 0.05$ level.
BS group – bilateral spinal anesthesia; US group – unilateral spinal anesthesia.

Hemodynamic changes and side effects of spinal anesthesia in both groups are shown in Table 3. Seven patients in the bilateral, and one patient in the unilateral group developed hypotension that required treatment with ephedrine. There were significant differences in the incidence of hypotension between study groups (Chi-square test 7.02; $p < 0.05$). Bradycardia, nausea and vomiting occurred in four

patients in the bilateral group and in one patient in the unilateral group. One patient in the bilateral group and no one in the unilateral group needed treatment for headache. There were no significant differences in the incidence of bradycardia, nausea and vomiting and headache between BS versus US group ($p > 0.05$).

Discussion

The conventional bilateral spinal anesthesia is widely used in adults for lower limb orthopedic surgery. Although considered safe, it has got many complications. The most common side effects are hypotension and bradycardia due to sympathetic blockade (2, 11). Unilateral spinal anesthesia only affects the sensory, motor and sympathetic functions on one side of the body and offers the advantages of a spinal block without the typical adverse side effects seen with a bilateral block. The cardiovascular stability following unilateral spinal anesthesia is certainly one of the most important benefits. Hypotension may develop in 30% of patients with bilateral spinal anesthesia, even with intermediate doses (2, 12) compared to 0–6% with unilateral spinal anesthesia (13).

The research showed that the patient's position immediately after spinal anesthesia affects the distribution of anesthetics into the spinal cord. The baricity of local anesthetics (hypo or hyper-baricity) in relation to the specific gravity of the cerebrospinal fluid enables the achievement of a unilateral block. It is also important that the distance between the left and right nerve roots and the lumbar region is about 10-15cm, which makes it possible to achieve unilateral spinal anesthesia too (14). Kuusniemi and colleagues reported that hyperbaric bupivacaine is more effective in achieving unilateral spinal anesthesia than plain bupivacaine (15). However, determining the optimal time for lateral positioning is difficult when a high dose of hyperbaric bupivacaine (12-20mg) is used. The anesthetic drug may migrate during 30 - 60 min. Conversely, if a low dose (5-8mg) of anesthetic solution is used, putting the patient in the lateral position for 10-15 min may prevent migration of the anesthetic drug (9, 16).

In our study, we injected 7.5 mg of hyperbaric levobupivacaine slowly through pencil-point directional needles. The patient was kept in the lateral position for 15 min, which led to unilateral spinal anesthesia in 85% of cases. In three cases, the anesthetic drug spread to the other side, resulting in bilateral spinal anesthesia with Bromage scale I/II on the nonoperative side. In a study performed by Esmaoglu, the unilaterality of the block was achieved in 85.7% of patients after 10 minutes in a lateral decubitus with small doses of hyperbaric solution (17).

In both groups, the quality of the sensory and motor block was adequate for the surgical procedure. The time to two segment regression of sensory blockade, recovery time of motor blockade, as well as the time of complete recovery was significantly shorter in the unilateral spinal group as compared to the bilateral group. Unilateral spinal anesthesia is therefore suitable for outpatient surgery. This findings is also in agreement with the studies by Fanelli et al. (18) and Borghi et al. (19).

In our study, seven patients in the bilateral group had hypotension and only one patient in the unilateral group ($p < 0.05$). Chohan and Afshan administered unilateral spinal anesthesia prior to lower-limb surgery in elderly patients with ASA classification of III or IV. They used hyperbaric bupivacaine (1.1 – 1.8ml). The authors found no significant hemodynamic changes (20). The cardiovascular stability following unilateral spinal anesthesia is certainly one of the most important benefits, especially in high risk patients.

There was no significant difference in bradycardia, nausea and vomiting, as well as postdural puncture headache (PDPH). Headache after spinal anesthesia was reported in one patient in the bilateral group. We used a small gauge (G27) pencil-point (Whitacre) spinal needle. The low incidence of PDPH may be related to the type of the needle used (21).

Conclusion

We observed that both bilateral and unilateral spinal anesthesia provide adequate intraoperative conditions. Unilateral sensory and motor block, a faster recovery profile, and a stable hemodynamic state can be achieved with low doses of hyperbaric levobupivacaine (7.5ml) injected slowly through pencil-point directional needles in patients who are maintained in the lateral decubitus position for 15 min. This technique of unilateral spinal anesthesia achieves stable hemodynamics, particularly in elderly. It also results in rapid recovery compared to a bilateral conventional spinal anesthesia.

Unilateral low dose spinal anesthesia is suitable for high-risk patients, as well as for ambulatory surgery.

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PREDNOSTI UNILATERALNE SPINALNE ANESTEZIJE U ODNOSU NA KONVENCIONALNU BILATERALNU SPINALNU ANESTEZIJU U ORTOPEDSKOJ HIRURGIJI DONJEG EKSTREMITETA

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Spinalna anestezija je često primenjivana tehnika u ortopedskoj hirurgiji donjeg ekstremiteta. Hipotenzija je najčešći sporedni efekat konvencionalne bilateralne spinalne anestezije. Poseban unilateralni blok utiče na senzornu, motornu i simpatičku funkciju samo jedne strane tela bez tipičnih neželjenih sporednih efekata viđenih bilateralnim blokom.

Cilj ove prospektivne, randomizovane studije je da uporedi unilateralnu anesteziju sa konvencionalnom bilateralnom spinalnom anestezijom u ortopedskoj hirurgiji donjeg ekstremiteta, u odnosu na kvalitet senzorne i motorne blokade, analgezije, hemodinamske stabilnosti i sporednih efekata.

Četrdeset ASA I – II bolesnika, planiranih za ortopedsku hirurgiju donjeg ekstremiteta, podeljeno je randomizacijom u dve grupe. Bolesnici BS grupe dobili su bilateralnu spinalnu anesteziju sa 3 ml izobarnog 0,5% levobupivakaina (konvencionalna doza), a bolesnici US grupe dobili su unilateralnu spinalnu anesteziju malom dozom sa hiperbarnim spinalnim rastvorom (7,5 mg 0,5% levobupivakaina i 40 mg 10% glukoze) tokom 120 sekundi i bolesnici su držani u lateralnom položaju 15 minuta.

U obe grupe, kvalitet senzornog i motornog bloka bio je adekvatan za hiruršku proceduru. Vreme regresije senzornog bloka za dva segmenta, vreme oporavka od motorne blokade, kao i vreme do potpunog oporavka bilo je značajno kraće u US grupi u poređenju sa BS grupom. Sedam bolesnika u bilateralnoj i jedan bolesnik u unilateralnoj grupi razvili su hipotenziju koja je zahtevala lečenje efedrinom (chi square test 7,02; $p < 0,05$).

Unilateralna spinalna anestezija malom dozom postiže stabilnu hemodinamiku. Takođe, rezultira brzim oporavkom u poređenju sa bilateralnom spinalnom anestezijom konvencionalnom dozom.

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Ključne reči: *spinalna anestezija, hemodinamika, unilateralna, levobupivakain, mala doza*