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ORIGINAL ARTICLE

Low-dose ropivacaine or levobupivacaine walking spinal anesthesia in ambulatory inguinal herniorrhaphy

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Abstract
Purpose The purpose of our study was to compare the equipotent doses of ropivacaine and levobupivacaine for walk-out criteria and the characteristics of spinal anesthesia in inguinal herniorrhaphy surgery.
Methods Combined spinal–epidural anesthesia was performed. Adult patients were randomly allocated to receive 5 mg 0.5% ropivacaine plus 25 μg fentanyl (group RF, $n = 25$) or 3.75 mg 0.75% levobupivacaine plus 25 μg fentanyl (group LF, $n = 25$). Each solution was hypobaric, and the same volume, 3 ml, was administered. Sensory and motor block characteristics, hemodynamic changes, side effects, number of patients having ability to stand and walk at the end of the operation, time to first analgesic requirement, time to urination, time to getting out of bed (ambulation), and time to home discharge were determined.
Results Sensory block onset time and time to reach the T6 dermatome were significantly shorter in group LF, whereas time to the two-segment regression and time to first analgesic requirement were significantly shorter in group RF. All patients in group LF were Bromage 0. Time to home discharge was shorter in group LF, but this difference was not statistically significant.
Conclusion We suggest that both local anesthetics can be used in walking spinal technique. Levobupivacaine may be an alternative local anesthetic for walking spinal anesthesia as it provides minimum motor block and a long duration of postoperative analgesia, even if its use is not associated with a shorter home discharge time.

Keywords Walking spinal · Ropivacaine · Levobupivacaine

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Introduction

"Walking spinal" is a new regional anesthesia technique that became popular after the selective spinal anesthesia (SSA) methods were developed. Ganapathy [1] improved SSA so that the patients could stand up and walk after the operation, the recovery room could be bypassed, and patients could be discharged earlier; they called this "walking spinal." The main aim of this technique is to provide spinal anesthesia with greater precision and selectivity so that functional return occurs rapidly. A number of investigators have made modifications such as using smaller doses of local anesthetics. New techniques

focus on lower doses of local anesthetics with or without intrathecal or systemic adjuvants, such as fentanyl and sufentanil. This technique results in a less intense motor block of shorter duration and faster sensorial recovery, which has the advantages of earlier mobilization and discharge from hospital and may be particularly useful in ambulatory surgery [2, 3].

Inguinal herniorrhaphy is one of the most common procedures in general surgery. Early mobilization and early discharge are most desirable characteristics in inguinal hernia repair, as in all day-case surgery. Spinal anesthesia that enables effective sensorial and motor block is frequently used for inguinal hernia repair [4]. The advantages of an awake patient, minimal drug costs, and rapid patient turnover has made this the method of choice for many surgical procedures. However, spinal anesthesia for hernia repair is more complicated; a higher level of sensory block is required, but increasing the dose of long-acting local anesthetics may produce extensive sensory and motor block as well as arterial hypotension, resulting in delayed discharge from hospital [5]. Ropivacaine and levobupivacaine are quite new among local anesthetics. Some clinical evidence also suggests that at equivalent doses, ropivacaine and levobupivacaine have less motor block and less toxicity [6]. In this study, we compared equipotent doses of hypobaric ropivacaine and levobupivacaine addition of fentanyl for the characteristics of walking spinal (or SSA) anesthesia for inguinal hernia repair [7].

Materials and methods

After institutional ethical committee approval, each patient's written informed consent was obtained. Fifty patients of American Society of Anesthesiologists (ASA) physical status I–III who were undergoing inguinal herniorrhaphy were recruited to participate in this double-blind, prospective, single-center, randomized trial. Patients were between 18 and 65 years of age. ASA physical status IV or V, presence of neurological or neuromuscular disease, infection at the injection site, bleeding disorders, and history of hypersensitivity to local or other anesthetics were determined as exclusion criteria.

Patients were randomly allocated to two groups according to a computer-generated list of random numbers that were placed in opaque sealed envelopes. Following preoperative evaluation of the patient, the method of anesthesia was explained and patient questions were answered on the day before the surgery. Oral premedication consisted of diazepam 10 mg. A fluid load consisting of crystalloid solution in a dose of 10 ml/kg was intravenously administered 1 h before initiation of the regional block. Routine monitors applied in the operating room included electrocardiograph, noninvasive blood pressure, and pulse oximeter (KMA275; Petas, Ankara, Turkey). The patient was placed in the sitting position, the insertion area was prepared using antiseptic solutions, and 2–3 ml lidocaine 2% was injected into the skin and subcutaneous tissue for local anesthesia. Combined spinal–epidural anesthesia (CSEA) was instituted in the sitting position with a midline approach at the L2–L3 level in all subjects by a second author. The epidural space was located by a 18-gauge Tuohy needle using the loss of resistance to air technique, and the dura was punctured by a 27 G Quincke point spinal needle (Portex, Hythe, Kent; UK) that passed through the epidural needle.

Group RF ($n = 25$)

Ropivacaine 0.5%, 5 mg (Naropin; AstraZeneca, USA), was mixed with 25 μg fentanyl and sterile water. The specific gravity of this mixture was 1.002; as the specific gravity of cerebrospinal fluid is 1.003–1.008 at 37°C, this mixture would be hypobaric in this fluid. Specific gravity was determined with a refractometer (American Optical Company, Chicago, IL, USA), measured at 37°C.

Group LF ($n = 25$)

Levobupivacaine 0.75%, 3.75 mg (Chirocaine; Abbott Laboratories, North Chicago, IL, USA), was mixed with 25 μg fentanyl and sterile water; the specific gravity of this mixture was 1.001.

Each of the solutions was diluted to a total volume of 3 ml with distilled water. The solution was injected over 150–180 s after free cerebrospinal fluid leakage was obtained through the needle, and the tip of the needle was pointed in the cephalad direction during this process. The epidural catheter was inserted 4 cm into the epidural space. The patients were placed in a 30° semi-sitting position after achievement of the subarachnoid block, and the operation was then performed. Bradycardia (heart rate <50 beats/min) was treated with atropine (0.01 mg/kg), and hypotension (decrease in systolic arterial blood pressure >20% of baseline) was treated with intravenous ephedrine (5–10 mg) or boluses of fluid (250 ml crystalloid solution).

The patient-controlled epidural analgesia device was started immediately after the first request for additional pain relief with a standard protocol (levobupivacaine 0.125%: baseline infusion rate 0.2 mg/kg/h, bolus dose 2 mg, lockout time 20 min).

An observer blinded to the grouping procedure evaluated the patients. The quality of spinal anesthesia was assessed by testing for sensory and motor blockade. Sensory block was assessed by complete loss of pinprick sensation, and the extent of motor block was determined according to the modified Bromage scale (0, no impairment; 1, unable to

raise extended legs but able to move knees and ankles; 2, unable to raise extended legs as well as unable to flex knees, able to move feet; 3, not able to flex ankle, feet, or knees) [8]. Sensory and motor blockade were measured at 1-min intervals for the first 5 min, then every 5 min until the end of surgery. Further testing was then performed at 10-min intervals in the postanesthesia care unit (PACU) until recovery of S2 sensation.

Data regarding sensory block onset time, time to reach T6 dermatome, time to peak level, time to the two-segment regression, time to S2 regression, number of patients having ability to stand and walk at the end of the operation (ASW), time to first analgesic requirement, time to urination, time to getting out of bed (ambulation), time to home discharge, and hemodynamic changes were determined. Home discharge criteria were absence of nausea, vomiting, or bleeding; minimal or no pain; ability to walk and void. Complications such as hypotension, bradycardia, respiratory depression, nausea, vomiting, and pruritus were also noted.

After surgery, surgeon and patient were questioned about the quality of their anesthesia using a four-point scale (1, perfect; 2, some feelings but no discomfort; 3, some discomfort but rescue analgesia unnecessary; 4, major discomfort and rescue analgesia mandatory).

The data obtained at the end of the study were analyzed using SPSS for Windows, version 10.0.1. The sample size was calculated, based on 90% power, to be able to detect a 30-min difference in mean time to complete sensory recovery. Prestudy power analysis using our patient population mean and standard deviation suggested that 20 patients in each group (power of 90%) would be sufficient. Demographic data were analyzed using the Student's *t* test. Comparisons of sensory block and modified Bromage motor blockade scale results were made using appropriately sized contingency table analysis. Analysis of the sensory block onset time, highest dermatomal level of sensory blockade, modified Bromage scale of motor blockade, time to reach T6 dermatome, time to peak level, time to the two-segment regression, time to S2 regression, time to first analgesic requirement, time to urination, time to getting out of bed (ambulation), and time to discharge from hospital was performed using a two-sample Student's *t* test. The level of significance was set as $P < 0.05$.

Results

Sixty-two patients were recruited between June and December 2006. Twelve of these patients refused CSEA, and 50 patients met the inclusion criteria and were enrolled in the study. The groups were similar with respect to age, weight, height, gender, ASA physical status, and duration of the surgery (Table 1). Readiness for surgery was achieved in all patients studied, and no spinal block failure was reported, with a 100% success rate in each group.

Table 1 Demographic characteristics in the two groups

Characteristic	Group RF ($n = 25$)	Group LF ($n = 25$)
Age (years)	50.1 ± 16.3	45.2 ± 13.2
Weight (kg)	69.2 ± 8.2	70.1 ± 10.3
Height (cm)	169.1 ± 6.9	172.8 ± 7.4
ASA I/II/III	4/17/4	5/18/2
Gender (F/M)	3/22	5/20
Duration of surgery (min)	55.8 ± 14.7	50.1 ± 18.4

Values are means ± SD or numbers of patients (*n*)ASA, American Society of Anesthesiologists; group RF, 5 mg 0.5% ropivacaine plus 25 μg fentanyl; group LF, 3.75 mg 0.75% levobupivacaine plus 25 μg fentanyl

No significant differences were found between the two groups

Sensory block onset time was longer in group RF. Time to reach the T6 dermatome was longer in group RF. When evaluated from the maximum sensory block level, in group RF 2 patients reached T3 and 23 patients reached T4 dermatomes; in group LF, 1 patient reached T2, 16 patients reached T4, and 8 patients reached T6 dermatomes. There was no statistically significant difference between the two groups regarding the highest dermatomal level of sensory blockade. The mean motor block onset time in our study was 10.5 ± 7 min in group RF; we did not observe any motor block in group LF. Five patients in group RF were Bromage 0, 18 patients in group RF were Bromage 1, 1 patient in group RF was Bromage 2, and another (1) patient in group RF was Bromage 3 motor block. All patients in group LF were Bromage 0. Time to two-segment regression was shorter in group RF. Time to S2 regression was shorter in group LF. Time to first analgesic requirement was significantly shorter in group RF (group RF, 251.1 ± 33.8 min; group LF, 286.6 ± 30.7 min) ($P = 0.001$). The number of ASW patients was similar between the groups. Twenty-three patients in group RF and all patients in group LF could walk out of the recovery room 120 min after the injection of the anesthetic agent. Voiding time was not different between the two groups (group RF, 230.1 ± 28.2; group LF, 212.1 ± 44.6 min) (Tables 2, 3).

The two groups were similar regarding comfort of the surgery and surgeon and patient satisfaction, and those parameters were graded as very good. PACU and home discharge time were shorter in group LF, but this difference was not statistically significant.

Hemodynamic parameters were similar between the groups at times of evaluation. SpO_2 alteration was not significant between the two groups. Ephedrine and atropine consumption was also similar in the two groups. Two patients in group RF and three patients in group LF were treated by 0.01 mg/kg intravenous atropine, respectively, and three patients in group

Table 2 Intraoperative block characteristics in the two groups

Characteristic	Group RF ($n = 25$)	Group LF ($n = 25$)
Sensory block onset time (s)	212.2 ± 37.4	160.7 ± 37.6*
Time to reach T6 dermatome (s)	410.3 ± 149.9	312.8 ± 145.0*
Highest level of sensory block	4 (3–4)	4 (2–6)
Maximum motor blockade score	1 (0–3)	0*
Patients converted to general anaesthesia (n)	0	0

Values are median (range), number of patients (n), or means ± SD

*$P < 0.01$ between groups

Table 3 Postoperative block characteristics in the two groups

Characteristic	Group RF ($n = 25$)	Group LF ($n = 25$)
Ability to stand and walk at the end of operation (n)	23	25
Time to two-segment regression (min)	66.2 ± 15.1	80.1 ± 12.8**
Time to S2 regression (min)	75.5 ± 15.4	65.8 ± 10.3*
Time to ambulation (min)	210 ± 23.1	200 ± 20.4
Time to urination (min)	230.1 ± 28.2	212.1 ± 44.6
Time to first analgesic requirement (min)	251.1 ± 33.8	286.6 ± 30.7**
Time to home discharge (min)	282 ± 25	270 ± 21.2

Values are means ± SD or number of patients (n)

*$P < 0.05$ between groups, **$P < 0.01$ between groups

Table 4 Side effects in the two groups

Side effect	Group RF ($n = 25$)	Group LF ($n = 25$)
Bradycardia (requiring atropine) (n)	2 (8)	3 (12)
Hypotension (requiring ephedrine) (n)	3 (12)	4 (16)
Nausea/vomiting (n)	0/0	0/0
Pruritus (n)	0	0
Respiratory depression (n)	0	0

Values are number of patients (n) and percentage (%)

No statistically significant differences occurred between the groups

RF and four patients in group LF received 10 mg intravenous ephedrine, respectively. There was no difference between the groups with regard to amount of medications used and side effect ratios. None of the patients experienced nausea or vomiting during the follow-up period (Table 4).

Discussion

The results of the present study indicated that, for inguinal hernia repair, both anesthetics can be used in the walking spinal technique. In our study, sensory block onset time, time to reach T6 dermatome, and time to S2 regression time were shorter in group LF, and two-segment regression and first analgesic requirement times were longer in group LF. Furthermore, all patients in group LF were Bromage 0. Hemodynamic parameters, side effects, PACU, and home discharge time were similar in the two groups.

SSA has been becoming more popular and has been used in more areas recently. Investigators have assessed various doses, baricity, and concentration. The minimum local analgesic doses of ropivacaine, levobupivacaine, and bupivacaine as well as their intrathecal potency ratios were first determined by Camorcia et al. [9]. The authors ranged the potencies as spinal bupivacaine > levobupivacaine > ropivacaine; the minimum intrathecal motor block potency ratio was 0.83 for ropivacaine:levobupivacaine [10]. In our study we estimated the local analgesic dose to be 3.75 mg for levobupivacaine and 5 mg for ropivacaine, with a potency ratio of 0.75 for ropivacaine:levobupivacaine. The physicochemical properties of levobupivacaine (93.4% protein binding) suggest that its duration of action (protein binding) should be slightly less that of ropivacaine (94% protein binding). The anesthetic potency of a local anesthetic depends, at least in part, on its physicochemical properties, which include the drug's lipid solubility expressed in terms of a lipid–water (n-octanol:water) partition coefficient. As the partition coefficient increases, there is greater lipid solubility and higher local anesthetic potency [11, 12]. The physicochemical properties of ropivacaine (partition coefficient = distribution ratio = 115) suggest that its partition coefficient should be less than that of levobupivacaine (partition coefficient = distribution ratio = 346) [13]. The physicochemical properties of these two local anesthetics are slightly different according to protein binding and partition coefficient. However, current data are not sufficient to explain the differences in motor and sensorial block characteristics of these two local anesthetics. Further studies are needed to determine the intrathecal motor block potency.

Dosage is more important than concentration or volume with respect to intrathecal spread, particularly when solutions have the same baricity. Lower doses of intrathecal agents with or without intrathecal or systemic adjuvants may be used. Adjuvants such as fentanyl and sufentanil facilitate reductions in the dose of local anesthetics and prolong sensory block without delaying time to void [3, 14]. With the use of low doses and adequate baricity, and appropriate patient positioning, only the dermatomes of the surgical space are blocked, allowing the procedure to proceed. In addition, tolerance to visceral sensations such as bladder distension and peritoneal stretch are improved. Experience with new techniques has opened up the possibility of providing SSA with a real possibility of fast-tracking

outpatients through the recovery process [3]. Only small doses of intrathecal agents are used in SSA to have an effect on only the nerve roots supplying a specific area. Long-acting local anesthetics such as ropivacaine and levobupivacaine have recently been introduced for clinical use [15].

In one study including 90 pregnant women undergoing cesarean section, the patients were divided into three groups: 8 mg bupivacaine, 8 mg levobupivacaine, or 12 mg ropivacaine. Sufentanil 2.5 μg was added to all groups, and the total volume was made up to 3 ml by adding normal saline. The solution was administered intrathecally in 60 s by the CSEA approach. Motor recovery was significantly faster after levobupivacaine and ropivacaine, and the time to first analgesic requirement was shorter in the levobupivacaine and ropivacaine groups [15].

In one study, the unilateral technique with a low dose of 8 mg hyperbaric bupivacaine, 8 mg hyperbaric levobupivacaine, or 12 mg hyperbaric ropivacaine resulted in a reliable block for hernia repair. Motor recovery was significantly faster after levobupivacaine and ropivacaine, whereas the time to home-readiness was similar for all agents [4]. In another study, the unilateral technique with 7.5 mg hyperbaric ropivacaine 0.5%, 7.5 mg hyperbaric levobupivacaine 0.5%, or 5 mg hyperbaric levobupivacaine 0.5% was studied; 7.5 mg hyperbaric ropivacaine 0.5% and 5 mg hyperbaric levobupivacaine 0.5% provided adequate spinal block for outpatient knee arthroscopy, with a faster home discharge as compared with 7.5 mg hyperbaric levobupivacaine 0.5% [16].

McNamee et al. [17] used 7.5 or 10 mg intrathecal ropivacaine in arthroscopy and reported the time to the onset of the sensory block as 2 min (range, 2–21 min) and the sensorial block regression time as 180 min (range, 30–244 min. Those values are not similar to those in the foregoing study, which may be the result of difference of baricity of the solutions and the total amount of local anesthetics used. Vaghadia et al. injected 3-ml solutions at a speed of 0.5 ml/s from L2–L3 or L4–L5 interspinal spaces by 27-G Whitacre spinal needles with the patient in sitting position, and when the sensory block level reached the T6 dermatome, patients were placed in the Trendelenburg position. The Trendelenburg position may have directed the local anesthetic molecules caudally and increased block depth [18]. The semi-sitting position and slower speed of injection in this study might have caused cephalic movement of those molecules, resulting in reduction of density of the local anesthetic and a shallower block in the distal regions; this factor might have caused the difference between the two studies [18]. In the latter study of Vaghadia et al., they suggest that SSA has the advantage of requiring minimal doses of conventional intrathecal anesthetic to obtain anesthesia of specific nerve roots and selective modalities; it provides selective pinprick anesthesia without affecting the motor functions and maintains the integrity of the dorsal columns. For these reasons, SSA attains selective short-duration spinal anesthesia and facilitates ambulation at the completion of the surgical procedure [19].

McNamee et al. have reported that all patients had at least a motor block of 1 according to the modified Bromage scale, and the degree or the duration of the block was not significantly different [17]. In our study, 5 of 25 patients in group RF and all the patients in group LF had motor blockade as Bromage score 0. The short duration in the ropivacaine group may be caused by the hypobaricity of our opioid-mixed solution. We believe that the plausible explanation of absence of the motor block in our study may be the small amount of local anesthetics and additional low-dose opioid used intrathecally. Those differences may be caused by differences in baricity and concentration of the solutions or the positioning of the patients [17, 20, 21].

Sell et al. used continuous spinal anesthesia technique in total hip replacement surgery, determining minimum effective doses for levobupivacaine and ropivacaine to be 11.7 and 12.8 mg, respectively. Nine of the 21 patients in the levobupivacaine group and 11 of the 20 patients in the ropivacaine group required ephedrine for hypotension [22]. We have added opioids to the local anesthetic mixtures and applied them in 180 s while the patient was in 30° semi-sitting position to minimize the hemodynamic effects, and in this way we could administer a smaller dose of local anesthetic with minimum hemodynamic side effects.

McNamee et al. have found the time to first analgesic requirement in 10-mg and 7.5-mg ropivacaine groups to be 230 and 210 min, respectively, which times were quite similar [17]. In our study time, to first analgesic requirement was longer than in the McNamee study, which may be the effect of additional fentanyl [17]. The effect of additional fentanyl is thought to be important for achieving anesthesia with less motor blockade using a smaller amount of local anesthetic and providing early postoperative ambulation.

Urinary retention after spinal anesthesia may delay home discharge. Breebaart et al. evaluated bladder function with urinary bladder scanning after day-case (same-day) spinal anesthesia with 60 mg lidocaine, 15 mg ropivacaine, or 10 mg levobupivacaine, and reported that the quality of anesthesia and motor block were not different for each drug but that voiding and home discharge occurred significantly earlier with lidocaine [23].

In conclusion, we compared equipotent doses of ropivacaine and levobupivacaine in the walking spinal technique for inguinal herniorrhaphy. The small dose of fentanyl was added to the intrathecal local anesthetics because intrathecal fentanyl plays an important role in "walking spinal anesthesia." As the foregoing data show,

we suggest that both anesthetics can be used in the walking spinal technique; however, levobupivacaine is preferred because of its blocking characteristics and longer time to first analgesic requirement, even if its use is not associated with a shorter home discharge time.

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Conflict of interest The authors had no conflict of interest to declare in relationship to this article.

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