RESEARCH PAPER

Hemodynamic Stability and Postoperative Recovery Profile: A Comparative Analysis of Hyperbaric Levo-Bupivacaine and Ropivacaine in Spinal Anaesthesia

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Received: 12th Dec, 2025; Revised: 12th Feb 2026; Accepted: 13th Feb, 2026; Available Online: 10th March, 2026

ABSTRACT

Background: Spinal anaesthesia is the preferred modality for infraumbilical surgeries; however, it is frequently associated with sympathetic blockade leading to hemodynamic instability, specifically hypotension and bradycardia. Furthermore, delayed motor recovery can hinder early mobilization and discharge. The search for a local anaesthetic with an optimal safety profile has led to the use of pure S-enantiomers: Levo-bupivacaine and Ropivacaine. While Ropivacaine is purported to offer superior hemodynamic stability and faster recovery, clinical comparisons with Levo-bupivacaine using hyperbaric solutions remain debated.

Aim: This study aimed to compare the intraoperative hemodynamic stability, adverse effect profile, and postoperative recovery times between patients receiving intrathecal 0.5% Levo-bupivacaine heavy and 0.75% Ropivacaine heavy.

Methods: A prospective observational study was conducted involving 58 ASA I and II patients undergoing elective infraumbilical surgeries. Patients were divided into two groups: Group L received 0.5% Levo-bupivacaine heavy, and Group R received 0.75% Ropivacaine heavy. Intraoperative hemodynamic parameters (heart rate, systolic/diastolic blood pressure, mean arterial pressure) were monitored continuously. Postoperative recovery milestones, including time to micturition and time to mobilization, were recorded. Adverse events such as hypotension, bradycardia, nausea, and post-dural puncture headache were documented.

Results: Demographic data were comparable between groups. Intraoperative hemodynamic parameters showed no statistically significant difference at any time point ($p > 0.05$). The incidence of hypotension was 10.3% in Group L and 13.8% in Group R ($p=0.70$). Bradycardia occurred in 6.9% of Group L and 10.3% of Group R ($p=0.65$). Postoperative recovery profiles were similar: time to micturition was 250.3 ± 20.5 min (Group L) vs. 245.7 ± 21.2 min (Group R) ($p=0.35$), and time to mobilization was 310.4 ± 25.6 min (Group L) vs. 305.2 ± 24.9 min (Group R) ($p=0.40$).

Conclusion: 0.75% hyperbaric Ropivacaine demonstrates a safety and recovery profile comparable to 0.5% hyperbaric Levo-bupivacaine. Both agents maintain adequate hemodynamic stability with a low incidence of complications, making them reliable choices for infraumbilical surgeries where safety and recovery are prioritized.

Keywords: Spinal anaesthesia, Hemodynamics, Hypotension, Recovery profile, Levo-bupivacaine, Ropivacaine, Patient safety.

How to cite this article: Ravichandran P, Roshini C, Ramamurthy P. Hemodynamic Stability and Postoperative Recovery Profile: A Comparative Analysis of Hyperbaric Levo-Bupivacaine and Ropivacaine in Spinal Anaesthesia. Int J Drug Deliv Technol. 2026;16(3): 578-585. DOI: 10.25258/ijddt.16.3.65

Source of support: Nil.

Conflict of interest: None

INTRODUCTION

Regional anaesthesia, specifically central neuraxial blockade, has revolutionized the management of lower abdominal and lower limb surgeries. By interrupting neural transmission at the spinal nerve root level, spinal anaesthesia provides profound analgesia and muscle relaxation while allowing the patient to remain conscious [1]. However, the physiological consequences of spinal anaesthesia extend beyond the loss of sensation. The blockade of preganglionic sympathetic fibres leads to vasodilation, venous pooling, and a subsequent reduction in venous return and cardiac output. This physiological cascade frequently manifests as intraoperative hypotension and bradycardia, which remain the most common complications of the technique [2].

Historically, racemic bupivacaine was the agent of choice for spinal anesthesia due to its high potency and long duration of action. However, its safety profile is compromised by a narrow therapeutic index concerning cardiotoxicity. Accidental intravascular injection or excessive systemic absorption can lead to severe myocardial depression and refractory ventricular arrhythmias, primarily due to the potent blockade of cardiac sodium channels by the R-enantiomer [3]. This cardiotoxicity is often resistant to standard resuscitation measures, necessitating prolonged cardiopulmonary resuscitation and lipid emulsion therapy.

The drive to improve patient safety led to the stereochemical isolation of the S-enantiomers: Levo-bupivacaine and Ropivacaine. Levo-bupivacaine, the S(-)-isomer of bupivacaine, retains the potency of the parent compound but exhibits a lower affinity for cardiac sodium channels and a faster rate of dissociation during diastole, thereby reducing the risk of cardiotoxicity [4]. Similarly, Ropivacaine, a propyl analogue of bupivacaine, was developed with the specific aim of reducing both cardiovascular and central nervous system toxicity. Studies have suggested that Ropivacaine may offer greater hemodynamic stability than bupivacaine, potentially due to a less intense sympathetic block [5].

Beyond hemodynamic stability, modern anesthetic practice emphasizes "fast-tracking" and early recovery. Prolonged motor blockade after surgery can delay mobilization, increase the risk of urinary retention, and prolong hospital stays [6]. Ropivacaine has been described as possessing a unique "differential block" property, where it preferentially blocks sensory fibers over motor fibers, theoretically allowing for adequate analgesia with a shorter duration of motor paralysis [7]. This characteristic makes it an attractive option for ambulatory surgery and enhanced recovery after surgery (ERAS) protocols.

However, the clinical realization of these benefits depends heavily on the dose and baricity of the local anesthetic used. While hypobaric and isobaric solutions are common, hyperbaric solutions (where glucose is added to increase density) are frequently preferred for their predictable spread within the subarachnoid space [8]. The literature regarding the comparative hemodynamic and recovery profiles of hyperbaric Levo-bupivacaine and hyperbaric Ropivacaine is conflicting. Some studies suggest Ropivacaine provides faster recovery and more stable hemodynamics, while others report clinical equivalence [9].

Furthermore, the issue of equipotency remains a subject of debate. Ropivacaine is less lipophilic than Levo-bupivacaine, which generally correlates with lower potency. To achieve a clinical effect comparable to the standard 0.5% bupivacaine or Levo-bupivacaine, Ropivacaine is often administered at higher concentrations, such as 0.75% [10]. It is crucial to determine whether this increase in concentration negates the theoretical safety benefits of Ropivacaine regarding hemodynamics and recovery.

This study was designed to rigorously evaluate and compare the safety profile of 0.5% hyperbaric Levo-bupivacaine and 0.75% hyperbaric Ropivacaine. By focusing specifically on hemodynamic parameters, adverse events, and recovery milestones, we aim to provide evidence to guide anesthesiologists in selecting the optimal agent for maximizing patient safety and efficiency in infraumbilical surgeries.

METHODOLOGY

Study Design and Ethical Approval

This prospective, randomized, double-blind observational study was conducted in the Department of Anaesthesiology at Sree Balaji Medical College and Hospital, Chennai, India. The study period extended from March 2023 to March 2024. Ethical clearance was granted by the Institutional Human Ethics Committee (Ref. No. 002/SBMCH/IHEC/2023/1936). The study was conducted in strict adherence to the ethical guidelines for biomedical research on human participants.

Participant Selection

A total of 58 patients scheduled for elective infraumbilical surgeries were enrolled.

Inclusion Criteria:

Age 18–60 years.

- ASA Physical Status I (healthy) or II (mild systemic disease).
- Patients undergoing procedures such as hernia repair, lower limb orthopedics, or gynecological surgeries.
- Height 150–180 cm.

- **Exclusion Criteria:**
- Refusal to participate.
- ASA III or IV.
- Coagulation abnormalities or anticoagulant therapy.
- Infection at the injection site.
- Known allergy to amide local anaesthetics.
- Pre-existing neurological deficits.
- Severe cardiac or respiratory disease.

Study Protocol and Randomization

Patients were evaluated preoperatively, and the procedure was explained. Written informed consent was obtained. Patients were assigned to one of two groups:

- Group L (n=29): Received 3 ml of 0.5% Levo-bupivacaine heavy (15 mg).
- Group R (n=29): Received 3 ml of 0.75% Ropivacaine heavy (22.5 mg).

Intraoperative Management

Upon arrival in the operating room, standard monitoring (ECG, NIBP, SpO2) was established. Baseline vital signs were recorded. All patients received a crystalloid preload (Ringer's Lactate) of 10-15 ml/kg over 15-20 minutes to mitigate spinal-induced hypotension.

Spinal anaesthesia was performed at the L3-L4 interspace using a 25G Quincke needle under aseptic conditions in the sitting or lateral position. After drug administration, patients were immediately placed in the supine position.

Hemodynamic Monitoring

Hemodynamic parameters were recorded at baseline, immediately after the block, every 5 minutes for the first 30 minutes, and then every 15 minutes until the end of surgery.

- **Hypotension:** Defined as a decrease in systolic blood pressure (SBP) of >20% from baseline or an absolute value <90 mmHg. Managed with IV fluids and injection Ephedrine (6 mg bolus) if necessary.
- **Bradycardia:** Defined as a heart rate (HR) <50 beats per minute. Managed with injection Atropine (0.6 mg IV).

Complication Assessment

Intraoperative and immediate postoperative complications were noted:

- Nausea and Vomiting: Treated with antiemetics if required.
- Shivering.
- Respiratory depression (SpO2 <90% or Respiratory Rate <10/min).
- Post-Dural Puncture Headache (PDPH).

Postoperative Recovery

Assessment Recovery was assessed in the Post-Anaesthesia Care Unit (PACU) and the ward by a blinded observer.

- **Time to Micturition:** Time from intrathecal injection to the first spontaneous voiding of urine.
- **Time to Mobilization:** Time from intrathecal injection until the patient was able to walk unassisted (evaluated once the motor block had regressed to Bromage 0).

Statistical Analysis

Data analysis was performed using SPSS software version 21. Continuous variables (hemodynamics, recovery times) were analyzed using the independent samples t-test. Categorical variables (incidence of complications) were analyzed using the Chi-square test or Fisher's exact test. A p-value <0.05 was considered significant. Sample size calculation was based on detecting a 20% difference in the time to mobilization with a power of 80% and alpha of 0.05, resulting in 29 patients per group.

RESULTS

The study comprised 58 patients.

Age-wise distribution			
Age group (Years)	**Group L (0.5% Levo-Bupivacaine) n (%)**	**Group R (0.75% Ropivacaine) n (%)**	**p-value**
18-30	10 (34.5%)	12 (41.4%)	0.75
31-40	8 (27.6%)	7 (24.1%)	
41-50	7 (24.1%)	5 (17.2%)	
51-60	4 (13.8%)	5 (17.2%)	
Total	29	29	
Gender distribution			
Gender	**Group L (0.5% Levo-Bupivacaine) n (%)**	**Group R (0.75% Ropivacaine) n (%)**	**p-value**

Males	15 (51.7%)	16 (55.2%)	0.80
Females	14 (48.3%)	13 (44.8%)	
Total	29	29	
BMI distribution			
BMI group (kg/m²)	**Group L (0.5% Levo-Bupivacaine) n (%)**	**Group R (0.75% Ropivacaine) n (%)**	**p-value**
<18.5 (Underweight)	2 (6.9%)	3 (10.3%)	0.65
18.5 – 24.9 (Normal)	18 (62.1%)	16 (55.2%)	
25 – 25.9 (Overweight)	7 (24.1%)	8 (27.6%)	
≥ 30 (Obese)	2 (6.9%)	2 (6.9%)	
Total	29	29	
ASA distribution			
ASA Grade	**Group L (0.5% Levo-Bupivacaine) n (%)**	**Group R (0.75% Ropivacaine) n (%)**	**p-value**
ASA 1	17 (58.6%)	16 (55.2%)	0.78
ASA 2	12 (41.4%)	13 (44.8%)	
Total	29	29	

The demographic profile of the study participants is summarized in **Table 1**. The mean age of participants in Group L was comparable to that of Group R (p=0.75). The gender distribution was balanced, with males constituting 51.7% of Group L and 55.2% of Group R (p=0.80). Anthropometric data, specifically Body Mass Index (BMI), showed no significant variance between the groups (p=0.65). Similarly, the physiological status as defined by ASA grading was statistically matched (p=0.78). This homogeneity ensures that any observed differences in block characteristics can be attributed to the pharmacological agent rather than confounding patient factors.

Table 2: Intraoperative Hemodynamic Parameters

Parameter	Group L (0.5% Levo-Bupivacaine)	Group R (0.75% Ropivacaine)	p-value
Baseline Pulse Rate (bpm)	75.2 ± 8.3	74.8 ± 8.1	0.85
Pulse Rate after 5 min	76.1 ± 7.9	75.3 ± 8.0	0.70
Pulse Rate after 10 min	75.8 ± 8.0	75.0 ± 7.8	0.75
Pulse Rate after 15 min	76.3 ± 7.8	75.5 ± 7.9	0.65
Baseline Blood Pressure (mm Hg)	120/80 ± 10/6	119/79 ± 9/5	0.80
BP after 5 min	118/78 ± 9/5	117/77 ± 8/6	0.70
BP after 10 min	117/77 ± 8/6	116/76 ± 9/5	0.65
BP after 15 min	118/78 ± 9/5	117/77 ± 8/6	0.70
Mean Arterial Pressure (mm Hg)	90.5 ± 5.4	90.2 ± 5.2	0.85
SpO_2 (%)	98.5 ± 0.8	98.6 ± 0.7	0.75

The hemodynamic parameters are summarized in **Table 2.**

Pulse Rate (HR): The baseline pulse rate was 75.2 ± 8.3 bpm in Group L and 74.8 ± 8.1 bpm in Group R (p=0.85). Throughout the intraoperative period (at 5, 10, and 15 minutes), there were no significant differences in heart rate variations between the two groups. Both groups maintained stable sinus rhythm without severe tachycardia or bradycardia trends

Blood Pressure (BP):

Baseline BP: 120/80 mmHg (Group L) vs. 119/79 mmHg (Group R) (p=0.80).

Systolic BP (SBP): At 5 minutes, SBP was 118 ± 9 mmHg (Group L) vs. 117 ± 8 mmHg (Group R) (p=0.70). This trend continued at 10 and 15 minutes with no significant statistical difference ($p > 0.05$).

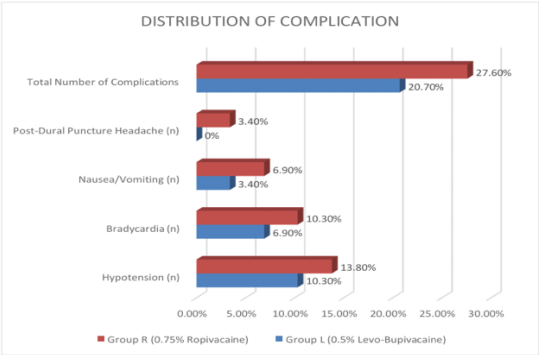
Diastolic BP (DBP): Similarly, DBP measurements showed no significant variance between the groups throughout the monitoring period ($p > 0.05$).

- **Mean Arterial Pressure (MAP):** The intraoperative MAP was 90.5 ± 5.4 mmHg in Group L and 90.2 ± 5.2 mmHg in Group R (p=0.85).
- **Oxygen Saturation (SpO2):** Both groups maintained excellent oxygenation with mean SpO2 values >98% throughout the procedure (p=0.75).

Table 3: Complications and Side Effects

Complications/ Side Effects	Group L (0.5% Levo-Bupivacaine)	Group R (0.75% Ropivacaine)	p-value
Hypotension (n)	3 (10.3%)	4 (13.8%)	0.70
Bradycardia (n)	2 (6.9%)	3 (10.3%)	0.65
Nausea/ Vomiting (n)	1 (3.4%)	2 (6.9%)	0.60
Post- Dural Puncture Headache (n)	0 (0%)	1 (3.4%)	0.50
Total Number of Complications	6 (20.7%)	8 (27.6%)	0.55

Figure 1: Complications and Side Effects



The overall incidence of adverse events was low in both groups, as shown in **Table 3**.

- **Hypotension:** Observed in 3 patients (10.3%) in Group L and 4 patients (13.8%) in Group R (p=0.70). These episodes were transient and responded well to fluid boluses or a single dose of ephedrine.
- **Bradycardia:** Occurred in 2 patients (6.9%) in Group L and 3 patients (10.3%) in Group R (p=0.65). All cases were managed successfully with atropine.
- **Nausea/Vomiting:** Recorded in 1 patient (3.4%) in Group L and 2 patients (6.9%) in Group R (p=0.60).
- **Post-Dural Puncture Headache (PDPH):** Only 1 patient in Group R (3.4%) experienced PDPH, compared to none in Group L (p=0.50).
- **Total Complications:** The total complication rate was 20.7% in Group L and 27.6% in Group R (p=0.55), indicating a statistically comparable safety profile.

Table 4: Postoperative Recovery

Parameter	Group L (0.5% Levo-Bupivacaine)	Group R (0.75% Ropivacaine)	p-value
Time to Micturition (min)	250. 3 ± 20.5	245. 7 ± 21.2	0.35
Time to Mobilization (min)	310. 4 ± 25.6	305. 2 ± 24.9	0.40

- **Time to Micturition:** The time required to void urine was 250.3 ± 20.5 minutes for Levo-bupivacaine and 245.7 ± 21.2 minutes for Ropivacaine. The difference was not significant (p=0.35).
- **Time to Mobilization:** Patients in Group L were able to ambulate at 310.4 ± 25.6 minutes, while those in Group R ambulated at 305.2 ± 24.9 minutes (p=0.40).

DISCUSSION

The pursuit of the ideal anaesthetic agent involves balancing efficacy with safety and efficiency. This study provides a comprehensive comparison of the hemodynamic and recovery profiles of 0.5% hyperbaric Levo-bupivacaine and 0.75% hyperbaric Ropivacaine. Our findings suggest that despite differences in chemical structure and lipophilicity, both agents exhibit remarkably similar clinical behaviour when used in these specific hyperbaric concentrations for infraumbilical surgeries.

Physiological Impact and Hemodynamic Stability Spinal anaesthesia induces a sympathectomy that typically spans two to six dermatomes higher than the sensory block [11]. This blockade results in arteriolar vasodilation (reducing afterload) and venodilation (reducing preload). The clinical manifestation is hypotension, which, if severe, can compromise organ perfusion.

In our study, we observed remarkable stability in hemodynamic parameters for both groups. The incidence of hypotension was low (10.3% vs 13.8%) and statistically equivalent. This finding challenges the prevalent notion that Ropivacaine provides superior hemodynamic stability compared to bupivacaine derivatives. Theoretical models suggest that

Ropivacaine causes less potent sympathetic blockade due to its lower lipid solubility and faster clearance from nerve fibres [12]. However, our results align with Whiteside et al. [13], who also found no significant difference in the incidence of hypotension between Ropivacaine and Levo-bupivacaine.

The Role of Baricity in Hemodynamic Control

A critical factor influencing our hemodynamic outcomes is the baricity of the solutions used. Hyperbaric solutions, being denser than cerebrospinal fluid (CSF), follow gravity. When patients are placed supine immediately after injection, the solution settles in the thoracic kyphosis (typically T6-T8). This gravitational restriction theoretically limits the cephalad spread of the block, thereby sparing the high thoracic sympathetic fibers (T1-T4) responsible for maintaining cardiac chronotropy [20]. This likely explains the low incidence of bradycardia observed in our study (6.9% vs 10.3%). Had isobaric solutions been used, the spread might have been more variable and unpredictable, potentially leading to higher incidences of hemodynamic volatility.

Dosing Strategy and Sympathetic Blockade

The lack of difference in hypotension rates between the groups may be attributed to the dosing strategy. We utilized 22.5 mg of Ropivacaine (3 ml of 0.75%) compared to 15 mg of Levo-bupivacaine (3 ml of 0.5%). Capogna et al. suggested that the minimum local analgesic concentration (MLAC) of Ropivacaine is approximately 60% that of bupivacaine [21]. By increasing the concentration of Ropivacaine to 0.75%, we likely produced a sympathetic blockade of comparable intensity to that of 0.5% Levo-bupivacaine, neutralizing the potential "sparing" benefit of Ropivacaine seen at lower doses. This suggests that for surgeons requiring dense blocks (necessitating higher doses), the hemodynamic "advantage" of Ropivacaine may be less pronounced than in low-dose labour analgesia settings.

Mechanisms of Bradycardia

Bradycardia in spinal anaesthesia is often mediated by the Bezold-Jarisch reflex (BJR). This paradoxical reflex is triggered when cardiac mechanoreceptors in the ventricular wall are stimulated by a low end-diastolic volume (due to venous pooling), leading to increased vagal tone and bradycardia [22]. The fact that our study showed minimal bradycardia suggests tha**1.** the preload was well-maintained, likely due to the effective crystalloid coloading protocol (10-15 ml/kg) and the restricted block height achieved by the hyperbaric solutions.

Safety Profile and Adverse Effects

Both Levo-bupivacaine and Ropivacaine were developed to address the cardiotoxicity risks of racemic bupivacaine. The R-enantiomer of bupivacaine avidly binds to the open state of the cardiac sodium channel and dissociates very slowly during diastole, leading to cumulative block and arrhythmias [15]. In contrast, Levo-bupivacaine and Ropivacaine dissociate rapidly.

In our study, no major cardiovascular or neurological adverse events occurred. The minor side effects observed (nausea, vomiting) are often secondary to hypotension (causing cerebral hypoperfusion or gut ischemia, releasing emetogenic serotonin) rather than a direct drug effect [16]. Since hypotension rates were similar, it follows that nausea rates were also comparable.

Postoperative Recovery and the "Fast-Track" Debate

Rapid recovery is a cornerstone of modern ambulatory anaesthesia. Delayed return of bladder function (micturition) and motor strength (mobilization) are the primary rate-limiting steps for discharge. Ropivacaine is often marketed as having a shorter duration of action, facilitating earlier discharge [18].

However, our data showed no statistically significant difference in recovery times. Time to micturition was approximately 4 hours, and time to mobilization was approximately 5 hours for both groups. This contradicts findings by Fanelli et al., who reported significantly faster discharge times with hyperbaric Ropivacaine compared to bupivacaine in outpatient arthroscopy [23]. The discrepancy likely lies in the total milligram dose. Fanelli's group utilized lower doses (e.g., 10-12 mg), whereas our study utilized 22.5 mg. This reinforces the pharmacological principle that recovery is dose-dependent. While 0.75% Ropivacaine ensures excellent surgical conditions, it does not offer the "fast-track" recovery seen with lower concentrations (0.2% or 0.5%). Clinicians aiming for rapid turnover might need to sacrifice some block density by using lower doses or adding adjuvants like fentanyl.

Clinical Implications

The choice of anesthetic agent must factor in the surgical duration, patient comorbidities, and discharge planning.

For Inpatient Surgery: Where early discharge is not the priority, both 0.5% Levo-bupivacaine and 0.75% Ropivacaine are excellent choices. They provide stable hemodynamics and reliable safety margins.

2. **For High-Risk Cardiac Patients:** While our study showed equivalence in healthy patients, the theoretical safety margin of Ropivacaine and Levo-bupivacaine over racemic bupivacaine makes them the preferred agents.
3. **Geriatric Considerations:** Although our study was limited to patients under 60, pertinent literature suggests that in elderly patients, the clearance of local anesthetics is reduced, and hemodynamic sensitivity is increased. Veering et al. demonstrated that age significantly affects the spread and duration of spinal anesthesia [24]. While our study suggests safety in younger adults, caution and potential dose reduction should be exercised when extrapolating these high-concentration hyperbaric protocols to geriatric populations.

Limitations

Our study had a sample size of 58, which is adequate for common hemodynamic parameters but insufficient to detect rare complications like transient neurological symptoms (TNS) or severe cardiac events. The study was limited to ASA I and II patients; results might differ in elderly or ASA III/IV patients with limited physiological reserve who might manifest hemodynamic instability more readily. Additionally, we did not measure patient satisfaction or quantifying pain scores in the post-anaesthesia care unit, which are important patient-centered outcomes.

REFERENCES

1. Carpenter RL, Caplan RA, Brown DL, Stephenson C, Wu R. Incidence and risk factors for side effects of spinal anesthesia. Anesthesiology. 1992;76(6):906-16.
2. Hartmann B, Junger A, Klasen J, et al. The incidence and risk factors for hypotension after spinal anesthesia induction: an analysis with automated data collection. Anesth Analg. 2002;94(6):1521-9.
3. Albright GA. Cardiac arrest following regional anesthesia with etidocaine or bupivacaine. Anesthesiology. 1979;51(4):285-7.
4. Burlacu CL, Buggy DJ. Update on local anesthetics: focus on levobupivacaine. Ther Clin Risk Manag. 2008;4(2):381-92.
5. Knudsen K, Beckman Suurkula M, Blomberg S, Sjovall J, Edvardsson N. Central nervous and cardiovascular effects of i.v. infusions of ropivacaine, bupivacaine and placebo in volunteers. Br J Anaesth. 1997;78(5):507-14.
6. Mulroy MF, Salinas FV, Larkin KL, Polissar NL. Ambulatory spinal anesthesia: a comparison of plain ropivacaine and bupivacaine. Reg Anesth Pain Med. 2004;29(5):371-5.
7. Wille M. Intrathecal use of ropivacaine: a review. Acta Anaesthesiol Belg. 2004;55(3):251-9.
8. Hocking G, Wildsmith JA. Intrathecal drug spread. Br J Anaesth. 2004;93(4):568-78.
9. Luck JF, Fettes PD, Wildsmith JA. Spinal anaesthesia for elective surgery: a comparison of hyperbaric solutions of racemic bupivacaine, levobupivacaine, and ropivacaine. Br J Anaesth. 2008;101(5):705-10.
10. Gautier P, De Kock M, Van Steenberge A, Miclotte M. Intrathecal ropivacaine for ambulatory surgery. Anesthesiology. 1999;91(5):1239-45.
11. Greene NM. Physiology of spinal anesthesia. 3rd ed. Baltimore: Williams & Wilkins; 1981.
12. Heavner JE. Local anesthetics. Curr Opin Anaesthesiol. 2007;20(4):336-42.
13. Whiteside JB, Burke D, Wildsmith JA. Spinal anaesthesia with ropivacaine 5 mg ml-1 in glucose 10 mg ml-1 or 50 mg ml-1. Br J Anaesth. 2003;90(3):304-8.
14. Mackey DC, Carpenter RL, Thompson GE, Brown DL, Bodily MN. Bradycardia and asystole during spinal anesthesia: a report of three cases without morbidity. Anesthesiology. 1989;70(6):866-8.
15. Clarkson CW, Hondeghem LM. Mechanism for bupivacaine depression of cardiac conduction: fast block of sodium channels during the action potential with slow recovery from block during diastole. Anesthesiology. 1985;62(4):396-405.
16. Carpenter RL. Gastrointestinal effects of regional anesthesia. In: Brown DL, editor. Regional Anesthesia and Analgesia. Philadelphia: Saunders; 1996. p. 116-24.
17. Turnbull DK, Shepherd DB. Post-dural puncture headache: pathogenesis, prevention and treatment. Br J Anaesth. 2003;91(5):718-29.
18. Casati A, Fanelli G, Danelli G, et al. Spinal anesthesia with lidocaine or preservative-free ropivacaine for outpatient knee arthroscopy: a prospective, randomized, double-blind comparison. Anesth Analg. 2004;99(5):1499-504.
19. Kallio H, Snall EV, Kero MP, Rosenberg PH. Comparison of hyperbaric ropivacaine 10 mg and hyperbaric bupivacaine 10 mg in spinal anaesthesia for day case knee arthroscopy. Br J Anaesth. 2004;92(4):632-5.
20. Sheskey MC, Rocco AG, Bizzarri-Schmid M, Francis DM, Edstrom H, Covino BG. A dose-response study of bupivacaine for spinal anesthesia. Anesth Analg. 1983;62(10):931-5.

21. Capogna G, Celleno D, Fusco P, Lyons G, Columb M. Relative potencies of bupivacaine and ropivacaine for analgesia in labour. Br J Anaesth. 1999;82(3):371-3.
22. Critchley LA, Conway F. Hypotension during subarachnoid anaesthesia: haemodynamic effects of colloid and metaraminol. Br J Anaesth. 1996;76(5):734-6.
23. Fanelli G, Casati A, Aldegheri G, et al. Cardiovascular effects of two different regional anaesthetic techniques for unilateral leg surgery. Acta Anaesthesiol Scand. 1998;42(1):80-4.
24. Veering BT, Burm AG, Vletter AA, van den Hoeven RA, Spferdijk J. The effect of age on systemic absorption and systemic disposition of bupivacaine after subarachnoid administration. Anesthesiology. 1991;74(2):250-7.