Original Article

# Hyperbaric spinal ropivacaine in lower limb and hip surgery: A comparison with hyperbaric bupivacaine

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## Abstract

**Background and Aims:** Bupivacaine is more cardiotoxic than ropivacaine. Ropivacaine provides effective spinal anesthesia for lower limb and hip surgeries. This prospective study was designed to compare the efficacy and safety of intrathecal hyperbaric ropivacaine with hyperbaric bupivacaine for patients undergoing limb and hip surgeries.

**Material and Methods:** Two hundred patients aged 40-75 years, with American Society of Anesthesiologists I and II of either gender were randomly divided into Group R (Ropivacaine) and Group B (Bupivacaine) to receive an intrathecal injection of 3 ml of hyperbaric ropivacaine 0.5% or 3 ml of hyperbaric bupivacaine 0.5%, respectively. Onset and duration of sensory blockade were determined using the pinprick method by a three-point scale at T-10 dermatome. Onset and duration of motor block were assessed by modified Bromage scale. Duration of postoperative analgesia, hemodynamic changes, central nervous system and cardiovascular system toxicity or any adverse effects were observed.

**Results:** The mean onset of sensory block (6 ± 1.3 min vs. 3 ± 1.1 min; $P < 0.001$) and motor block (13 ± 1.6 min vs. 9 ± 1.3 min; $P < 0.05$) was significantly slower in ropivacaine group as compared to bupivacaine group. The total duration of sensory block was significantly shorter in the ropivacaine group (160 ± 12.9 min) than in the bupivacaine group (260 ± 16.1 min; $P < 0.05$). The mean duration of motor block was also shorter in the ropivacaine group compared to bupivacaine group (126 ± 9.2 min vs. 174 ± 12.6 min; $P < 0.05$). Quality of anesthesia was comparable in two groups ($P = 0.04$).

**Conclusion:** We conclude that hyperbaric bupivacaine used intrathecally has a faster onset of sensory block and prolonged duration of analgesia compared to hyperbaric ropivacaine.

**Key words:** Bupivacaine, hyperbaric, ropivacaine, spinal anesthesia

## Introduction

Bupivacaine, an amino-amide compound, was synthesized and introduced into the clinical practice in 1963 and proved to be a very effective long-acting local anesthetic agent. In 1979, Albright[1] drew attention to the dangers of the longer acting local anesthetic agents, bupivacaine and etidocaine, in case they gained accidental intravascular access, resulting in re-entrant arrhythmias and cardiac depression, sometimes culminating in cardiac arrest.[2] These shortcomings, of this otherwise novel local anesthetic, resulted in the development of a newer anesthetic agent "ropivacaine."

Ropivacaine, a new amino-amide local anesthetic agent, is similar in chemical structure to bupivacaine.[3,4] Extensive clinical data has shown that ropivacaine is effective and safe for regional anesthetic techniques such as epidural and brachial plexus block.[5] However, hyperbaric ropivacaine has been little studied in intrathecal anesthesia. The purpose of this study was to evaluate the efficiency and safety of hyperbaric ropivacaine in spinal anesthesia and to compare it with hyperbaric bupivacaine in lower limb and hip surgeries.

## Material and Methods

With the approval of Ethics Committee of the institution, 200 patients of American Society of Anesthesiologists (ASA)

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grade I-II of either sex in the age range of 40-75 years, scheduled to undergo lower limb and hip surgery under spinal anesthesia were selected for the study and were randomly divided using computer generated numbers into two groups with 100 patients in each group:

Group R (ropivacaine group)
This group consisted of 100 patients who received 3 ml intrathecal injection of 0.5% hyperbaric ropivacaine.

Group B (bupivacaine group)
This group consisted of 100 patients who received 3 ml intrathecal injection of 0.5% hyperbaric bupivacaine.

Exclusion criteria included bleeding disorders, neurlogical disease, local skin infections, severe back deformities, raised intracranial pressure, moderate to severe valvular lesions and morbid obesity.

Pre-anesthetic evaluation was done at least 24 h prior to the surgery. Tablet alprazolam 0.25 mg to 0.5 mg night before surgery was prescribed to the patients. Patients were kept nil per oral from midnight before surgery. On the day of surgery, an intravenous line was established on the nondominant hand using 16G size intravenous cannula and preloading was done in every patient (using 20 ml of crystalloid/kg of body weight). The multi-channel monitor (Mindrays-BeneVeiw T8, Instromedix India) was attached and baseline parameters of pulse rate, blood pressure (systolic, diastolic, and mean) electrocardiography (lead II, V) and $SpO_2$ were recorded. The hyperbaric solution of 0.5% ropivacaine was prepared aseptically by mixing 5 ml of 0.75% isobaric ropivacaine (Ropin®, Neon, India) with 2 ml of 25% dextrose and 0.5 ml sterile water at room temperature. This gave a total volume of 7.5 ml resulting in a final glucose concentration of 6.6% in hyperbaric ropivacaine solution with specific gravity of 1.02450 at room temperature.[6]

Under all aseptic precautions, the subarachnoid blocks were performed using 25G Quincke spinal needle with patient in the sitting position at L3-L4 intervertebral space. The patients were made supine immediately afterward. After the block, vitals were monitored every 2 min up to 15 min and thereafter, every 5 min interval till completion of surgery. Oxygen 5 L/min was administered through Hudson facemask throughout the procedure. The onset of sensory block at T-10 level was taken as the time from injection of anesthetic solution to the loss of sensation to pinprick. The sensory block was tested at every 2 min intervals till the establishment of the block and every 5 min during surgery. After the completion of the surgery, the sensory block was tested at 15 min intervals till its complete regression. Complete recovery of sensory block was defined as the presence of painful sensations on pin prick at S1 dermatome level, and the time was recorded. Motor block was assessed using modified Bromage scale by asking the patient to flex the limb at hip, knee, and ankle joints (Grade 0: No paralysis, Grade 1: Inability to raise extended leg, can bend knee, Grade 2: Inability to bend knee, can flex ankle, Grade 3: No movement). Onset time of motor block was taken as the time to acquire complete motor block (Grade 3) after the intrathecal injection of local anesthetic and total duration was taken as time to completely recover from the motor block. If the patient was feeling pain, i.v. fentanyl (1 ug/kg) was given. In the case of discomfort, i.v. midazolam (1 mg) was given and repeated if needed. Quality of intraoperative anesthesia was assessed using "four-grade scale"[7] which is defined as:

- Excellent: No supplementary sedative or analgesia required.
- Good: Only sedative required.
- Fair: Both sedative and analgesic required.
- Poor: General anesthesia and tracheal intubation required.

Bradycardia (heart rate <60 beats/min) when encountered, was recorded and treated with intravenous atropine which was administered in small incremental doses. Hypotension (fall in systolic blood pressure >30% from baseline) when encountered, was recorded and treated with intravenous ephedrine which was administered in small incremental doses. The patients were observed for first 24 h for nausea, vomiting, and any other complication.

The primary objective of this study was to test the hypothesis that intrathecal ropivacaine is a safer option as compared to bupivacaine in terms of central nervous system and cardiovascular system toxicity. Secondary end points were earlier recovery of sensation and motor power in the ropivacaine group.

### Statistical analysis

Data were presented as median (range), mean symbol +/− SD frequencies, as appropriate. Nominal patient's characteristics were compared using the Fisher's exact test. A Bonferroni correction was applied for multiple two-way testing. In all categories, $P < 0.05$ was considered statistically significant. Pulse and blood pressure were compared using multiple comparison test (Dennett test), $q > 2.740$ considered statistically significant ($P < 0.05$). InStat statistical software was used for statistical analysis (GraphPad Software, Inc, USA).

## Results

The characteristics of the two groups were comparable in terms of age, weight, gender, and ASA classification [Tables 1 and 2].

The mean onset of sensory block at T-10 level (6 ± 1.3 min vs. 3 ± 1.1 min; $P < 0.001$) and motor block (13 ± 1.6 min vs. 9 ± 1.3 min; $P < 0.001$) was significantly slower in ropivacaine group as compared to bupivacaine group [Table 3]. The mean duration of sensory block was significantly shorter with ropivacaine group (160 ± 12.9 min) than with bupivacaine group (260 ± 16.1 min; $P < 0.001$). The mean duration of motor block was also shorter in the ropivacaine group compared to bupivacaine group (126 ± 9.2 min vs. 174 ± 12.6 min; $P < 0.001$). The intraoperative quality of anesthesia was excellent and similar in both groups ($P = 0.4$). However, it was fair in 3% patients in the ropivacaine group and 1% in the bupivacaine group. None of the patients in either groups had poor quality of anesthesia [Table 3].

Hypotension was the most common side effect in both groups. There was a significant difference in the incidence of hypotension between the two groups ($P < 0.001$). In bupivacaine group, 66 patients developed hypotension while in the ropivacaine group, only 19 developed hypotension [Table 2]. The mean dose of ephedrine required for treating hypotension per patient (10.5 ± 5.4 mg in Group R vs. 12 ± 4.2 mg in Group B) did not differ significantly between two groups. The incidence of bradycardia, nausea, vomiting, and shivering during the intraoperative period did not differ significantly between the two groups [Table 3].

**Table 1: Demographic data**

| Parameter | Group B ($n$ = 100) | Group R ($n$ = 100) |
|---|---|---|
| Age (years) | 58.5±8.5 | 56.4±10.1 |
| Weight (kg) | 59.4±9.2 | 57.3±9.4 |
| Duration of surgery (h) | 112.0±8.5 | 108.0±7.8 |

*Data are mean symbol +/− deviation*

**Table 2: Distribution of gender and ASA class**

| Parameter | Group B ($n$ = 100) | Group R ($n$ = 100) |
|---|---|---|
| Gender | | |
| Male | 55 | 60 |
| Female | 45 | 40 |
| ASA status | | |
| I | 65 | 69 |
| II | 35 | 31 |

*ASA = American Society of Anesthesiologists*

## Discussion

This present study confirms the findings of the previous studies[8,9] that a glucose-containing solution of ropivacaine can produce predictable and reliable spinal anesthesia for a wide range of surgical procedures. However, the present study is in variance with the results of the two earlier clinical studies, which have described blocks with ropivacaine inadequate for surgery.[10,11] The variance can be because these authors have used glucose-free solutions of ropivacaine. The variation confirms that the addition of glucose to solution of ropivacaine has the same effect as with other drugs.[12-15] In the present study, the onset of both sensory and motor block was delayed in the ropivacaine group as compared to bupivacaine group. The

**Table 3: Characteristics of spinal anesthesia and frequency of adverse effects**

| Parameters | Bupivacaine group | Ropivacaine group | Significance |
|---|---|---|---|
| Sensory block | | | |
| Onset at T10 (min) | 3 (2-10) | 6(2-25) | $P$<0.001 |
| Total duration (min) | 260 (150-450) | 160 (120-300) | $P$<0.001 |
| Motor block | | | |
| Onset (min) | 9 (2-16) | 13 (10-20) | $P$<0.001 |
| Total duration (min) | 174 (110-120) | 126 (60-190) | $P$<0.001 |
| Quality of intraoperative anesthesia (%) | | | |
| Excellent | 90 | 92 | $P$=0.407 |
| Good | 9 | 5 | |
| Fair | 1 | 3 | |
| Poor | 0 | 0 | |
| Intraoperative side effects (%) | | | |
| Hypotension | 66 | 19 | $P$<0.001 |
| Bradycardia | 5 | 9 | $P$=0.407 |
| Nausea | 20 | 11 | $P$=0.117 |
| Vomiting | 3 | 1 | $P$=0.621 |
| Shivering | 16 | 10 | $P$=0.293 |
| Postoperative side effects (%) | | | |
| Vomiting | 3 | 2 | $P$=1.00 |

*Data are median (range), or number of patients, P < 0.05 was considered statistically significant*

total duration of sensory and motor block was also shorter in the ropivacaine group as compared to bupivacaine group. This study correlates with those of Erturk *et al.*[16] and Bigat *et al.*[17] who also found earlier onset of sensory block to T-10 level and longer duration of sensory block with hyperbaric spinal bupivacaine compared to the hyperbaric spinal ropivacaine, which was statistically significant. This may be because of higher lipid solubility and slightly higher protein binding of bupivacaine as compared to ropivacaine. Lipid solubility is an important determinant of local anesthetic activity. The onset time of conduction block is directly correlated with the lipid solubility of local anesthetic.[18,19] Increased lipid solubility increases sequestration of local anesthetic in myelin and other surrounding neural compartments. Thus, action is increased as absorption of local anesthetic molecule into myelin and surrounding neural compartments creates a depot for slow release of local anesthetic.[20] This observation may be explained by a correlation between lipid solubility and both sodium channel receptor affinity and ability to alter sodium channel conformation by direct effects on lipid cell membranes. In general, the more lipid soluble and longer acting agents have increased protein binding. The lesser lipid solubility of ropivacaine may cause this drug to penetrate the large myelinated A fibers more slowly than the more lipid soluble bupivacaine.[21] It is also postulated that because ropivacaine is less lipophilic it has a greater effect on the nonmyelinated pain fibers rather than the myelinated motor fibers.[22] Although the patients' satisfaction to recovery of motor block was not assessed clinically and objectively in this study, earlier recovery with a spinal ropivacaine is associated with more patient satisfaction.[23]

We found no evidence of any late sequelae such as backache or other transient symptoms, and this correlates with the previous studies of ropivacaine when used in spinal anesthesia.[6,7]

In the present study, intrathecal ropivacaine produced excellent intraoperative anesthesia, indistinguishable from spinal bupivacaine. Statistically, the difference in quality of anesthesia was insignificant between the two groups. This study correlates with those of Osama-Al-Abdulhadi *et al.*[23] and Luck *et al.*[24] who also found statistically insignificant difference in quality of anesthesia between ropivacaine and bupivacaine when given intrathecally.

Hypotension was the most common side effect in both groups. There was a significant difference in the incidence of hypotension between the two groups. The studies of various authors[6,25] support our results of low incidence of hypotension in hyperbaric ropivacaine, but the exact cause of low incidence of hypotension as compared to bupivacaine is not established. The intraoperative and postoperative complications (bradycardia, nausea, shivering, vomiting) did not differ significantly between the two groups.

However, our study was not without limitations. One of the limitations was that no blinding was done which would have resulted in some degree of bias. Furthermore, we did not standardize the dose based on age, height, and weight.

## Conclusion

The solution of hyperbaric ropivacaine can be used for spinal anesthesia and is comparable with hyperbaric bupivacaine in terms of quality of block with shorter recovery profile.

## References


1. Albright GA. Cardiac arrest following regional anaesthesia with etidocaine or bupivacaine. Anaesthesiology 1979;51:285-7.
2. 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;62:396-405.
3. Akerman B, Hellberg IB, Trossvik C. Primary evaluation of the local anaesthetic properties of the amino amide agent ropivacaine (LEA 103). Acta Anaesthesiol Scand 1988;32:571-8.
4. McClure JH. Ropivacaine. Br J Anaesth 1996;76:300-7.
5. McClellan KJ, Faulds D. Ropivacaine: An update of its use in regional anaesthesia. Drugs 2000;60:1065-93.
6. Chung CJ, Choi SR, Yeo KH, Park H, Lee S, Chin YJ. Hyperbaric spinal Ropivacaine for caesarean delivery: A comparison to hyperbaric Bupivacaine. Anesth Analg 2002;56:453-8.
7. McConache I, McGeachie J, Barrie J. Regional anaesthesia technique. In: Wylie, Davidson C, editors. A Practice of Anaesthesia. 7th ed., Chapter 37. p. 609.
8. Whiteside J, Burke D, Wildsmith JA. A comparison of 0.5% ropivacaine (5% glucose) with 0.5% ropivacaine (1% glucose) when used to provide spinal anaesthesia for elective surgery. Br J Anaesth 2001;86:241-4.
9. Schiffer E, Van Gessel E, Gamulin Z. Influence of sex on cerebrospinal fluid density in adults. Br J Anaesth 1999;83:943-4.
10. van Kleef JW, Veering BT, Burm AG. Spinal anesthesia with ropivacaine: A double-blind study on the efficacy and safety of 0.5% and 0.75% solutions in patients undergoing minor lower limb surgery. Anesth Analg 1994;78:1125-30.
11. Wahedi W, Nolte H, Klein P. Ropivacaine for spinal anesthesia. A dose-finding study. Anaesthesist 1996;45:737-44.
12. Bannister J, McClure JH, Wildsmith JA. Effect of glucose concentration on the intrathecal spread of 0.5% bupivacaine. Br J Anaesth 1990;64:232-4.
13. Chambers WA, Edstrom HH, Scott DB. Effect of baricity on spinal anaesthesia with bupivacaine. Br J Anaesth 1981;53:279-82.
14. Logan MR, McClure JH, Wildsmith JA. Plain bupivacaine: An unpredictable spinal anaesthetic agent. Br J Anaesth 1986;58:292-6.
15. Sanderson P, Read J, Littlewood DG, McKeown D, Wildsmith JA. Interaction between baricity (glucose concentration) and other factors influencing intrathecal drug spread. Br J Anaesth 1994;73:744-6.
16. Erturk E, Tutuncu C, Eroglu A, Gokben M. Clinical comparison of 12 mg ropivacaine and 8 mg bupivacaine, both with 20 microg

fentanyl, in spinal anaesthesia for major orthopaedic surgery in geriatric patients. Med Princ Pract 2010;19:142-7.
17. Bigat Z, Boztug N, Karsli B, Cete N, Ertok E. Comparison of hyperbaric ropivacaine and hyperbaric bupivacaine in unilateral spinal anaesthesia. Clin Drug Investig 2006;26:35-41.
18. Gissen AJ, Covino BG, Gregus J. Differential sensitivity of fast and slow fibers in mammalian nerve. III. Effect of etidocaine and bupivacaine on fast/slow fibers. Anesth Analg 1982;61:570-5.
19. Taheri S, Cogswell LP 3rd, Gent A, Strichartz GR. Hydrophobic and ionic factors in the binding of local anesthetics to the major variant of human alpha1-acid glycoprotein. J Pharmacol Exp Ther 2003;304:71-80.
20. Covino BG. Pharmacology of local anaesthetic agents. Br J Anaesth 1986;58:701-16.
21. Rosenberg PH, Kyttä J, Alila A. Absorption of bupivacaine, etidocaine, lignocaine and ropivacaine into n-heptane, rat sciatic nerve, and human extradural and subcutaneous fat. Br J Anaesth 1986;58:310-4.
22. Beaulieu P, Babin D, Hemmerling T. The pharmacodynamics of ropivacaine and bupivacaine in combined sciatic and femoral nerve blocks for total knee arthroplasty. Anesth Analg 2006;103:768-74.
23. Al-Abdulhadi O, Biehl D, Ong B, Boker A. Hyperbaric spinal for elective Cesarean section — Ropivacaine vs bupivacaine. Middle East J Anaesthesiol 2007;19:385-96.
24. 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;101:705-10.
25. Whiteside JB, Burke D, Wildsmith JA. Comparison of ropivacaine 0.5% (in glucose 5%) with bupivacaine 0.5% (in glucose 8%) for spinal anaesthesia for elective surgery. Br J Anaesth 2003;90:304-8.

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# Conference Calendar 2015

| Name of conference | Dates | Venue | Name of organising Secretary with contact details |
|---|---|---|---|
| 4th International Conference on Pain Management (ICPM 2015) and supported by "The Society of Ultrasound in Anaesthesia" (SUA) UK | November 7-9, 2015 | Shruti Auditorium, SGPGIMS, Lucknow, India | Dr. Sanjay Dhiraaj<br>Organizing Secretary<br>Department of Anaesthesiology<br>Sanjay Gandhi Postgraduate Institute of Medical Sciences<br>Raebareli Road, Lucknow 226014.<br>Telephone: +91-80 04 904595<br>FAX: +91-522-<br>Cell: +91 98 39 450244<br>E-mail: 2015icpm@gmail.com<br>http://www.icpm2015lko.com/ |
| 7th Annual Conference-Indian College of Anaesthesiologists Icacon 2015 | November 13-15, 2015 | Hotel Savera, Dr. Radhakrishnan Road, Chennai - 600 004 | Dr. K. Balakrishnan<br>Phone: +91 98410 29259<br>Email ID: ica2015 @ gmail.com |
| Global Update on Pain (VI) | November 19-22, 2015 | Mumbai Education Trust, AUdiorium, Bandra Reclamation, Bandra West Mumbai<br>&<br>Lilawati Hospital & Research Center, Mumbai | Org Secys: Dr. Satish Kulkarni & Dr. Kailash Kothari<br>Secretariat: 3rd floor, Marketing Dept., Lilavati Hospital and Research Centre, Bandra Reclamation, Bandra-West, Mumbai, India - 400 050<br>Email: guop2015@gmail.com<br>Web: www.painfoundationindia.c |
| TMC National Conference on "The Difficult Airway" TMC-DAC 2015 | December 4th-6th, 2015 | Tata Momorial Hospital Choksi Auditorium, Golden Jubilee Building, Parel, Mumbai, India. | Prof. Sheila Nainan Myatra MD, FCCM, FICCM<br>Department of Anaesthesia, Critical Care and Pain.<br>Tata Memorial Hospital<br>General Secretary – All India Difficult Airway Association (AIDAA)<br>Cell : +91 9820156070<br>Off : +9122 24177050<br>Fax : +9122 24146937 |
| 63rd Annual National Conference of Indian Society of Anaesthesiologists ISACON 2015 | December, 25th-29th, 2015 | B. M. Birla Auditorium & Convention Centre, Jaipur | Dr. SP Sharma,<br>Organizing Chairman<br>Dr. Suresh Bhargava<br>Organizing Secretary<br>C-1/516, Vashist Path, Chitrakoot,<br>Vaishali Nagar, Jaipur – 302021<br>Website http://www.isacon2015jaipur.com/<br>A-4, Vivek Vihar, Opp. Dainik Bhaskar, JLN Marg, Jaipur, Rajasthan<br>Contact No. : 0141-2711919<br>secretariat@isacon2015jaipur.com |