A Comparative Study of Hyperbaric Bupivacaine and Isobaric Ropivacaine for Spinal Anesthesia in Cesarean Section

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ABSTRACT

Background

Spinal anesthesia is preferred for cesarean section because of the onset and safety. Hyperbaric bupivacaine has long been the standard, whereas ropivacaine offers reduced cardiotoxicity and may provide better hemodynamic stability. This study compared intrathecal bupivacaine and ropivacaine in parturient undergoing elective cesarean section.

Methods

In this prospective cohort study, 84 patients received either 11 mg hyperbaric bupivacaine (Group B) or 11 mg isobaric ropivacaine (Group R). Sensory and motor block onset, duration of analgesia, hemodynamics, and adverse events were assessed.

Results

Bupivacaine showed faster sensory block onset (2.43 vs 3.91 min), faster motor block onset (3.00 vs 3.79 min), and longer duration of analgesia (97.79 vs 82.86 min) (all $p<0.001$). Ropivacaine demonstrated greater hemodynamic stability.

Conclusion

Both hyperbaric bupivacaine and isobaric ropivacaine can be used for spinal anesthesia for cesarean section. However, Bupivacaine provided faster onset and prolonged analgesia.

Keywords: Spinal Anesthesia, Bupivacaine, Ropivacaine, Cesarean Section, Maternal Outcome

Introduction

Spinal anesthesia is a widely practiced and a choice of anesthetic technique for lower section cesarean section (LSCS). It avoids airway manipulations that occur in general anesthesia and has rapid onset providing dense sensory and motor block needed for surgical procedures[1]. For cesarean section, anesthesia level is generally obtained up to the 4th thoracic vertebrae (T4) to provide adequate analgesia[2]. Higher level of block may lead to hypotension and bradycardia[3]. Appropriate dose selection and baricites remain key determinants of block height, onset time, and duration[4].

Hyperbaric bupivacaine 0.5% has long been the standard local anesthetic because of its potency and long duration, though it is associated with more intense motor block and dose-dependent cardiovascular depression[5]. With less motor blockade and fewer cardiovascular side effects,

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ropivacaine, a more recent amide local anesthetic, provides similar sensory blockade to bupivacaine. Due to its improved sensory-motor differentiation and reduced cardiotoxicity, it has been proposed as a safer substitute[6]. Ropivacaine's isobaric formulation may also offer more consistent block characteristics and hemodynamic stability, making it a viable option for spinal anesthesia during cesarean delivery, where the safety of the mother and fetus is crucial[7,8].

In countries like Nepal, where anesthetic workforce and monitoring facilities can vary among centers, spinal anesthesia provides a reliable and safer option for both mother and baby, making the choice of optimal intrathecal agent highly relevant. Therefore, this study aimed to compare fixed-dose intrathecal hyperbaric bupivacaine and isobaric ropivacaine in parturient undergoing elective cesarean section at a tertiary hospital in Nepal, focusing on sensory and motor block characteristics, maternal hemodynamics, and maternal side effects.

Materials and Methods

A prospective cohort study was carried out at the Department of Anesthesia and Critical Care, Lumbini Medical College & Teaching Hospital, Palpa, Nepal. Ethical approval was obtained from the Institutional Review Committee of Lumbini Medical College (IRC-LMC: 05/25/0000.01), and patients were explained about the procedure and written consent was obtained from all participants. American Society of Anesthesiologist (ASA) II–III parturient aged 18–40 years, with 37–42 weeks of gestation, height between 150–170 cm, and weight between 50–95 kg, scheduled for elective lower segment caesarean section (LSCS) under spinal anesthesia were included. Patients with a history of allergy to local anesthetics, coagulopathy, infection at the injection site, severe systemic illness, or refusal to participate were excluded. Sample size was calculated as 84 (42 per group) based on previous literature to detect a mean difference in onset of sensory block between bupivacaine (8.1 ± 4.1 minutes) and ropivacaine (11.6 ± 5.6 minutes), with 90% power and 95% confidence interval[9]. Samples were collected using convenience sampling technique till required number of patients were achieved in both groups.

On the day of surgery, after receiving a patient in the operating theatre Nil Per Oral (NPO) status was confirmed, 18G intravenous cannula was secured and 10ml/kg ringer lactate was infused as preload. Standard ASA monitoring (heart rate, non-invasive blood pressure, ECG, and SPO_2) was applied, and patients were premedicated with intravenous Pantoprazole 40mg and Granisetron 1mg. Group B received intrathecal hyperbaric bupivacaine-0.5% (2.2ml, 11mg) while Group R received intrathecal isobaric ropivacaine-0.5% (2.2ml,11mg) using a 25 G Quincke needle at intervertebral space between 3rd and 4th lumbar vertebrae (L3-L4). Spinal anesthesia was given one level up or below, if there was failure of insertion of needle at L3-L4. The drug infusions were administered slowly, keeping the bevel of the needle directed cephalically without using barbotage technique by resident anesthesiologist. The onset of sensory block was assessed by same resident anesthesiologist using cold spirit swab method up to T4 dermatome bilaterally, while motor block was evaluated using the Modified Bromage scale at 2-minute intervals for first 10 minutes.

All patients were placed supine immediately after injection with a 15° left uterine displacement; table tilt and head-down positioning were avoided to limit cephalad drug spread. Sensory testing was performed bilaterally and recorded as the time to achieve stable bilateral T4 level on two consecutive assessments. Motor block was defined and recorded as the time to reach Modified Bromage score ≥ 3. Oxytocin 5U intravenously was given slowly over 60 seconds to all patients after the delivery of baby. Rescue analgesia criteria and vasopressor management thresholds were predefined (systolic blood pressure < 90 mmHg or a decrease > 20% from baseline triggered crystalloid bolus and incremental phenylephrine/ephedrine as per institutional protocol).

Maternal hemodynamics and side effects (hypotension, bradycardia, nausea) were documented and managed according to standard protocols. Pain was assessed using Numeric Rating Scale (NRS) where 0 indicates no pain and 10 indicates severe pain. After surgery, the patient was shifted to the post anesthesia care unit (PACU) for monitoring and analgesia was only given if the patient complained of pain with NRS ≥ 4. Data were collected in specific predesigned proforma, later entered and analyzed using SPSS version 25.0. Quantitative data were presented as mean ± standard deviation and categorical data as

percentage and frequencies. Student's t-test was used to compare mean between two groups. Chi-square/Fisher's exact test were used to compare categorical variables with p <0.05 considered statistically significant.

Results

The demographic characteristics of the two groups were comparable (Table 1). The mean age of patients in the ropivacaine group was 29.86 ± 6.88 years, while in the bupivacaine group it was 27.24 ± 7.28 years (p = 0.094). The mean gestational age was 39.02 ± 1.68 weeks for ropivacaine and 38.86 ± 1.59 weeks for bupivacaine (p = 0.308). The mean height of participants was 159.33 ± 3.91 cm in the ropivacaine group and 159.86 ± 4.33 cm in the bupivacaine group (p = 0.562). The mean weight was 68.81 ± 11.29 kg and 72.69 ± 10.88 kg in Group R and Group B, respectively. None of the demographic variables showed statistically significant differences between the groups.

In the ropivacaine group, four patients had spinal anesthesia one level above and two below L3–L4, while in the bupivacaine group, two were above and two below the level. The comparison of block characteristics between the two groups is presented in Table 2. The mean sensory block onset time was significantly longer in the ropivacaine group (3.91 ± 0.52 min) compared to the bupivacaine group (2.43 ± 0.62 min; p = 0.001). Similarly, the motor block onset was significantly delayed in the ropivacaine group (3.79 ± 0.90 min) relative to bupivacaine (3.00 ± 0.90 min, p <0.01). The mean duration of surgery was comparable between groups (38.45 ± 7.70 vs. 41.43 ± 8.02 min; p = 0.086). However, time to first rescue analgesia was significantly shorter with ropivacaine (82.86 ± 14.88 min) than with bupivacaine (97.79 ± 21.53 min; p = 0.001).

The incidence of intraoperative side effects was comparable between the two groups (Table 3). Despite minor differences in heart rate and blood pressure trends, none of the patients experienced severe complications such as loss of consciousness, high spinal block, or neonatal distress, supporting the safety of both agents. For sedation and analgesia, Ketamine was used in 5 patients and paracetamol in 3 patients of the ropivacaine group, whereas ketamine was used in 6 patients and paracetamol in 5 patients of the bupivacaine group intraoperatively. Thus, confounding factors were comparable in both groups and had less influence on postoperative analgesia.

Table 1. Baseline characteristics of participants

Variable	Agent	N	Mean	SD	p-value
Age (years)	Ropivacaine	42	29.86	6.88	0.094
	Bupivacaine	42	27.24	7.28	
Gestational weeks	Ropivacaine	42	39.02	1.68	0.308
	Bupivacaine	42	38.86	1.59	
Height (cm)	Ropivacaine	42	159.33	3.91	0.562
	Bupivacaine	42	159.86	4.33	
Weight (kg)	Ropivacaine	42	68.81	11.29	0.112
	Bupivacaine	42	72.69	10.88	

Table 2. Block characteristics and intraoperative variables

Variable	Agent	N	Mean	SD	p-value
Sensory block onset (min)	Ropivacaine	42	3.91	0.52	0.001*
	Bupivacaine	42	2.43	0.62	
Motor block onset (min)	Ropivacaine	42	3.79	0.9	0.001*
	Bupivacaine	42	3.0	0.9	
Duration of surgery (min)	Ropivacaine	42	38.45	7.7	0.086
	Bupivacaine	42	41.43	8.02	
Time to first Rescue analgesia (min)	Ropivacaine	42	82.86	14.88	0.001*
	Bupivacaine	42	97.79	21.53	

Table 3. Complications among the patients

	Ropiva-caine (n)	Bupiva-caine (n)	p-value
Hypotension	9	12	0.450
Bradycardia	3	5	0.457
Nausea	7	12	0.277
Vomiting	2	3	0.645
Shivering	5	8	0.365

Discussion

In this study, we investigated the sensory and motor block profile along with incidence of possible side effects of 0.5% hyperbaric bupivacaine and 0.5% isobaric ropivacaine during spinal anesthesia for caesarean section. Intrathecal hyperbaric bupivacaine (11 mg) produced a significantly faster onset of sensory and motor block and a longer time to first rescue analgesia than intrathecal isobaric ropivacaine (11 mg). Both the groups showed the comparable data regarding safety profile in context of possible complications after spinal anesthesia.

Both hyperbaric and isobaric formulation of bupivacaine and ropivacaine are being used in different clinical settings for spinal anesthesia along with different doses and concentration[5,10,11]. In a randomized controlled study by Chari et. al., 100 patients undergoing lower abdominal and lower limb surgeries, sensory onset was slower with ropivacaine (42.6 ± 11.39 min) than bupivacaine (18.4 ± 6.53 min, p <0.001). Motor onset was also delayed (55.54 ± 13.01 min vs 27.5 ± 8.03 min, P<0.001). Peak sensory time was longer (10.92 ± 2.60 min vs 7.38 ± 1.69 min), while postoperative analgesia duration was comparable which is similar observations as in our study[12]. Bupivacaine's faster onset and prolonged analgesia are pharmacologically explained by its greater lipid solubility and potency, resulting in a denser neural blockade. However, this property also increases the risk of cardiovascular depression and prolonged motor block[13,14].

Ropivacaine, as a pure S-enantiomer, offers less lipid solubility and produces a more selective sensory block with less motor involvement, accounting for its favorable hemodynamic profile[7,13]. We also found similar characteristics of ropivacaine in our study holding fewer side effects compared than bupivacaine. The incidence of hypotension, bradycardia, nausea, vomiting and shivering were less in the ropivacaine group but they were not statistically significant. These findings were in line with findings by Regmi et. al., which found comparable side effects between groups, with hypotension in 3 (10%) and 2 (6.6%), bradycardia in 5 (16.6%) and 1 (3.3%), nausea in 4 (13.3%) and 2 (6.6%), and high spinal in 2 (6.6%) and 1 (3.3%) patients in the bupivacaine and ropivacaine groups, respectively, showing no statistical significance[15].

Another study including 100 ASA I–II patients who received either 3 ml of intrathecal isobaric ropivacaine 0.75% or 3 ml of hyperbaric bupivacaine 0.5% for lower abdominal and lower limb surgeries. They found that ropivacaine provided effective anesthesia with a shorter duration of sensory and motor block and more stable hemodynamics[16]. Similar study conducted on 46 ASA I–II parturient undergoing elective cesarean section, comparing 12.5 mg of 0.5% intrathecal hyperbaric bupivacaine with 24 mg of 0.75% intrathecal isobaric ropivacaine. They found that ropivacaine provided adequate surgical anesthesia with a shorter duration of sensory and motor block, while maintaining stable maternal hemodynamics and favorable neonatal outcomes, suggesting it as a safe and effective alternative to bupivacaine[17]. Both these studies had similar outcomes in term of block profile and side effects. It was a single center study which may limit external validity. The performer, accessor and observer during the whole procedure were the same person, which may introduce observer bias.

Conclusion

Both ropivacaine and bupivacaine provided effective spinal anesthesia. Isobaric ropivacaine demonstrated a slightly slower onset of sensory and motor block and a shorter duration of postoperative analgesia compared to hyperbaric bupivacaine, while maintaining stable hemodynamic throughout the procedure. Side effects of both regimens were comparable with slight lower incidence in ropivacaine group.

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