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Comparison of Motoric Block Duration between 0.5% Hyperbaric Bupivacaine and 0.5% Levobupivacaine Cesarean Section

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ABSTRACT

Introduction:The choice of anesthesia regimen affected each patient's recovery. Hyperbaric bupivacaine, a racemic mixture of S- and R-enantiomers, was more commonly used, while isobaric levobupivacaine, the S-enantiomer of bupivacaine, had fewer side effects. The anesthetic regimen chosen will determine postoperative recovery outcomes. Several studies have shown that the use of isobaric levobupivacaine accelerated postoperative motor recovery. ***Objectives:*** *This study aims to compare the duration of motoric block from hyperbaric bupivacaine and isobaric levobupivacaine in pregnant women undergoing cesarean section with spinal anesthesia procedures.* ***Methods:*** *This quantitative analytical study was conducted on 52 cesarean section patients with spinal anesthesia procedures at Ukrida Hospital in 2024. The sample was randomly and equally divided into two groups, namely the Isobaric Levobupivacaine (IL) group of 26 people and the Hyperbaric Bupivacaine (HB) group of 26 people. Then the duration of motoric block will be assessed using the Bromage scale and observed every 30 minutes postoperatively until the patient reaches a Bromage score of 0 (can elevate the lower extremity).* ***Results:*** *The duration of motoric block was longer in the HB group than in the IL group (231.35 ± 16.944 versus 204.50 ± 38.472 minutes), with a significant difference ($p < 0.001$).* ***Conclusion:*** *Using the same technique and dosage, isobaric levobupivacaine with fentanyl offers faster relief of motoric block than hyperbaric bupivacaine with fentanyl.*

1. INTRODUCTION

The selection of an appropriate anesthetic technique and regimen plays a crucial role in preventing postoperative complications in patients undergoing cesarean section. A study conducted between 2019 and 2020 reported several complications experienced by 261 patients after undergoing cesarean section with spinal anesthesia.[1] These complications included hypotension, with an incidence of 85.4% in the studied patients, bradycardia in 15.1%, and prolonged recovery time in 37.4%.[1] The 37.4% incidence of prolonged recovery time is considered significant enough to be a cause for concern.[1] Therefore, in addition to internal patient

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factors, determining the anesthetic regimen for surgery is also crucial. This needs to be taken into consideration to minimize the risk of complications that could delay patient recovery time.

In addition to the type and technique of anesthetic administration, drug factors must be considered when providing anesthetic effects to patients. In general, these factors can include the dose, volume, concentration, temperature, and also the barity given.[2,3] In this case, what needs to be prioritized besides the dose also includes the barity of the drug given.[4] The selection of an anesthetic regimen includes the selection of barity, which is the ratio of the density between the anesthetic drug solution and the density of the patient's brain fluid or Cerebrospinal Fluid (CSF). This density is derived by comparing the mass of the solution to its unit volume (g/mL) at a specific temperature.[5] Conventionally, the temperature has been set at 37°C with a cerebrospinal fluid density of 1.00059 gr/L so that barity is divided into hypobaric (low density), isobaric (density similar to CSF), and hyperbaric (high density).[4] These three types of barity describe the ability of the drug solution given to influence the distribution of anesthetic effects in the patient's body based on gravity.[6] Hyperbaric bupivacaine is an older anesthetic drug and is widely used in cesarean sections. However, its higher density often causes more unpredictable recovery of motoric block, nausea, vomiting, and even hypotension.[7,8] The onset of a spinal block is determined by a combination of factors related to the patient, the characteristics of the local anesthetic drug, and the anesthesia technique used. The chemical properties of the local anesthetic and the injectate influence how quickly it takes effect. Extremely elderly patients may experience a delayed onset of the block. Obesity can affect CSF volume and dynamics, influencing the spread and potentially the onset of the block. Anatomical variations, deformities (e.g., scoliosis), or ligament calcification can make the procedure technically more difficult and delay its onset. The patient's position during and immediately after injection (e.g., sitting, lateral, prone) significantly influences the spread and onset, especially with hyperbaric or hypobaric solutions.[9]

Lately, isobaric levobupivacaine has begun to be developed as an alternative to hyperbaric bupivacaine. This drug offers a density almost similar to cerebrospinal fluid, so that the resulting side effects are minimal compared to hyperbaric bupivacaine.[10,11] Although the use of isobaric levobupivacaine is becoming known in cesarean section, data regarding its effectiveness and safety are still limited, especially in direct comparison with hyperbaric bupivacaine. Even today, there are still many differences of opinion regarding the duration of motoric block recovery between hyperbaric bupivacaine and isobaric levobupivacaine. In addition, there is a minimally studied aspect, namely its use in combination with adjuvants such as fentanyl, often utilized to extend analgesia duration and enhance the quality of the anesthetic block.[12]

To the authors' best knowledge, there are few studies assessing the effectiveness of hyperbaric bupivacaine versus isobaric bupivacaine for spinal anesthesia in pregnant women in Indonesia. Thus, the objective of this research was to evaluate the duration of motor block in patients undergoing cesarean section who received hyperbaric or isobaric bupivacaine. We expect that patients receiving isobaric bupivacaine will have a quicker recovery of motoric block duration in contrast to other patients who receive hyperbaric bupivacaine. To examine this hypothesis, we analyzed the duration of the motoric block in both patient groups undergoing cesarean section.

2. METHODS

The design of this study was a quantitative analytical study based on experimental research, in the form of a single-masked clinical trial. The researcher determined the therapy regimen and acted as an evaluator of the research outcomes. The research sample did not know the therapy regimen given. Sampling was carried out at Ukrida Hospital, West Jakarta, from September to December 2024 and has received approval from the Ethics Committee of the Faculty of Medicine and Health Sciences, Krida Wacana Christian University, Jakarta, Indonesia, on July 18, 2024, with registered number: 1774/SLKE/IM/UKKW/FKIK/KEPK/VII/2024. Following the approval from the Research Ethics Committee at the Faculty of Medicine and Health Sciences, Krida Wacana

Christian University, patients who meet the inclusion criteria received informed consent about the procedure to be performed.

A total of 52 patients with cesarean section with spinal anesthesia procedures became the research sample. Patients with comorbidities of heart disease and/or uncontrolled Diabetes Mellitus, who failed to use spinal anesthesia, experienced a change of procedure from regional to general anesthesia, and those with eclamptic pregnancy were excluded from this study. The study population was randomly divided into two groups, namely the Hyperbaric Bupivacaine (HB) group of 26 patients and the Isobaric Levobupivacaine (IL) group of 26 patients. Researchers determine the therapy regimen to be given based on the order of patients undergoing surgery, ensuring the number of samples per group is met.

All subjects received anesthesia with an upright sitting position and head down during a lumbar puncture procedure at the L3-L4 interspace using a 26-gauge Spinocan. We administered the drug through the syringe into the subarachnoid space. Group HB received 2.5 cc of hyperbaric bupivacaine 0.5% and 25 mcg of fentanyl added, while group IL received 2.5 cc of isobaric levobupivacaine 0.5% and 25 mcg of fentanyl added.

We assessed motor block using the Bromage scale after the patient completed surgery and was transferred to the recovery room. We checked leg motor skills every 30 minutes until the patient achieved complete recovery of motoric block, indicated by a Bromage score of 0. Data collected included the motoric block duration, measured from the start of the motoric block until the patient achieved complete recovery.

Sample size was calculated using the unpaired analytical formula with the following assumptions: Type I error (α) = 5% (Zα = 1.96), Type II error (β) = 5% (Zβ = 1.96), estimated standard deviation = 1.3, and minimum detectable difference = 1.5. A minimum of 26 participants per group was required.

Statistical analysis of the data was conducted using Statistical Product and Service Solution (SPSS) version 26.0 for Windows, employing an Independent T-Test to assess the two numerical variables. A p-value under 0.05 is regarded as statistically significant.

3. RESULTS

This study involved 52 participants who underwent cesarean section surgery at Ukrida Hospital, Jakarta, during September 2024 to December 2024 and met the inclusion criteria. Subjects were then divided into two groups: group HB, which used 2.5 cc of hyperbaric bupivacaine 0.5% and 25 mcg of fentanyl added intrathecally, and group IL, which used 2.5 cc of isobaric levobupivacaine 0.5% and 25 mcg of fentanyl added. Each group consisted of 26 research subjects.

Table 1
Evaluation of the Characteristics of Study Participants (N=52)

Variable	Group		p-value
	Hyperbaric Bupivacaine	Isobaric Levobupivacaine	
Age(year)			
Mean±Std	40 ± 14	41 ± 16	0.909
BMI (kg/m2)			
Mean±Std	25.9 ± 4.8	28.2 ± 4.7	0.854
Total operation time(minutes)			
Mean±Std	65 ± 21	55 ± 15	0.510

Notes: Analysis uses an independent t-test

Table 2
Description of Motoric Block Duration (N=52)

Group	Frequency	Mean	SD	SE	95% CI		Min	Max	p-value
					LL	UP			
IL	26	205,50	38,472	7,545	188,96	220,04	110	260	< 0,001
HB	26	231,35	16,944	224,50	224,50	238,19	200	260	< 0,001

Notes: Analysis uses an independent t-test

The characteristics of the research subjects, such as age, BMI, and the total duration of surgery, are shown in Table 1, while the comparison of motoric block duration between the groups is shown in Table 2. The outcomes of statistical tests for all research groups indicated that the p-values for all variables exceeded 0.05 (p-value > 0.05), indicating that none were significant. Therefore, there is no statistically significant variation among the patient characteristic variables in Group HB and Group IL, indicating that the two groups are homogeneous and can be compared statistically. Table 2 shows that the duration of motoric block in the HB group was 231.35 ± 16.944 minutes, while in the IL group it was 204.50 ± 38.472 minutes (p-value < 0.001). A statistically significant difference in the duration of motoric block was found between the two groups.

Table 3
Comparison of motoric block duration

Group	Mean differences	SE differences	95% CI		p-value
			LL	UP	
HB - IL	26,846	8,244	10,287	43,405	< 0,001*

Notes: p-value (Hyperbaric bupivacaine vs Isobaric Bupivacaine) using independent t-test.*)Statistically significant (p-value < 0,05)

The mean difference of 26,846 minutes, with a p-value <0.001, indicates a significant difference. The difference in Table 3 indicates that the hyperbaric bupivacaine group will produce a longer duration of motoric block than the isobaric levobupivacaine group

4. DISCUSSION

The anesthetic dose in pregnant women is indicated differently from anesthesia in other operations. According to Onishi et al. [13], the effective dose for 50% of the population (ED50) or 95% of the population (ED95) for cesarean section surgery with 0.5% hyperbaric bupivacaine is 6.0-12.6 mg. This states that a dose of 0.5% hyperbaric bupivacaine (12.5 mg) with 0.5% isobaric levobupivacaine (12.5 mg) is suitable for elective cesarean section surgery.

Based on the duration of motoric block obtained from this study, the estimated recovery time for patients receiving 0.5% isobaric levobupivacaine anesthesia is approximately 2 hours after the patient enters the recovery room or approximately 3 hours after the drug is applied. Meanwhile, the estimated recovery of patients from 0.5% hyperbaric bupivacaine anesthetic is approximately three and a half hours. In this case, the patient is declared recovered from the anesthesia if they can lift their legs completely or achieve a Bromage score of 0. The difference in the duration of motoric block between 0.5% isobaric levobupivacaine and 0.5% hyperbaric bupivacaine ranges from 10 to 40 minutes. This aligns with the statements and research of Amjad et al. [7], Goyal et al[11], and Rao. [14]

This research found that the length of motoric block with 0.5% hyperbaric bupivacaine exceeded that of 0.5% isobaric levobupivacaine. The results of this study will be compared with other studies using cesarean section patients with a target T6 block and motoric block assessment using the Bromage Scale.

Amjad et al. [7] reported the same findings, using 2.5 mL of 0.5% isobaric levobupivacaine and 2.5 mL of 0.5% hyperbaric bupivacaine. The results obtained for the duration of motoric block,

namely 0.5% isobaric levobupivacaine for 120.26 ± 4.835 minutes and 0.5% hyperbaric bupivacaine for 141.03 ± 6.653 minutes, with a p-value < 0.001. Amjad et al.[7] reported that the duration of motoric block with 0.5% hyperbaric bupivacaine was longer than with 0.5% isobaric levobupivacaine.

Another study by Goyal et al. [11] provided a comparison of 2 mL of 0.5% isobaric levobupivacaine combined with 25 mcg of fentanyl versus 2 mL of 0.5% hyperbaric bupivacaine with 25 mcg of fentanyl during surgical procedures. One of the categories compared was the duration of motoric block, namely 0.5% isobaric levobupivacaine for 96.35 ± 9.19 minutes and 0.5% hyperbaric bupivacaine for 129.43 ± 10.85 minutes, with a p-value <0.001. This research indicated that 0.5% hyperbaric bupivacaine resulted in a longer-lasting motor block than 0.5% isobaric levobupivacaine

Then, Rao et al. [14] in their study reported that the duration of motor block was shorter with 0.5% hyperbaric bupivacaine than with 0.5% isobaric levobupivacaine, a difference that was clinically and statistically significant. This statement is based on the results of their study with 1.6 mL of 0.5% isobaric levobupivacaine containing 25 mcg fentanyl and 1.6 mL of 0.5% hyperbaric bupivacaine with 25 mcg fentanyl. They demonstrated that the length of motor block with 0.5% isobaric levobupivacaine was 144.5 ± 18.21 minutes, while with 0.5% hyperbaric bupivacaine it was 297.83 ± 27.31 minutes, yielding a p-value <0.001.

In the study by Metta et al. [15], the 0.5% isobaric levobupivacaine, administered at a dose of 3 mL, resulted in a motor block duration of 203 ± 37 minutes. Meanwhile, the hyperbaric bupivacaine drug lasts 216 ± 30 minutes. The duration of motoric block with 0.5% isobaric levobupivacaine was reported to be faster than with 0.5% hyperbaric bupivacaine, with a p-value of 0.21. The results of this study were considered insignificant and therefore were not used as a parameter.

Fentanyl is an opioid commonly used in general anesthesia and is known to be able to manage postoperative pain. Fentanyl administered intrathecally as neuraxial analgesia is able to provide a longer analgesic effect, so that the anesthetic dose given to the patient is less.[7,16] The use of fentanyl is considered because the patient's hemodynamics are more stable and has been used as a multimodal postoperative pain therapy to date.[17] From this study, it was found that the addition of fentanyl in a ratio of 2.5 mL of 0.5% hyperbaric bupivacaine to 2.5 mL of 0.5% isobaric levobupivacaine still provides a picture of the duration of motoric block similar to previous studies.

According to Pal et al. [18], the duration of motoric block with hyperbaric bupivacaine 0.5% 3 mL was found to be faster than with isobaric levobupivacaine 0.5% 3 mL. In their study, which stated a p-value <0.001, the duration of motoric block of the HB group was 201.15 ± 5.37 minutes, while the IL group was 184.44 ± 5.47 minutes. However, this study was directed at samples of patients with infraumbilical or lower abdominal surgery, without including pregnant patients.

The effect of uterine enlargement on pregnant women is an increase in abdominal circumference. Increased abdominal circumference (AC) is associated with increased intra-abdominal volume. This suggests that the greater the mother's gestational age, the greater the maternal AC. This is influenced by the increasing age of the fetus, amniotic fluid, and uterine size. Consequently, as the uterus enlarges, these factors compress the inferior vena cava. The greater the aortocaval compression, the more cerebrospinal fluid will decrease, and the cephalad spread will accelerate. These two factors contribute to a higher level of blockade and sensitivity in pregnant women to local anesthetics. [19]

Kuok et al. [20] mentioned various factors that affect the extent of sensory blockade, specifically the density of the local anesthetic, volume, elevation of the injection site, type of needle, and patient characteristics (age, stature, weight, intra-abdominal pressure, and spinal structure). Among these many factors, it was emphasized that the major factor that commonly influences the duration of motoric block is the barity of the drug, whether hyperbaric or isobaric, as in this study.

The isobaric nature of levobupivacaine has the potential to produce a more consistent spread of spinal anesthesia. The density of isobaric levobupivacaine is very close to that of cerebrospinal fluid, so that its distribution is neutral to the force of gravity. Conversely, hyperbaric bupivacaine has a higher density than cerebrospinal fluid, so it tends to spread toward dependent areas under the force of gravity after injection. This distribution results in a longer, more pronounced sensory block than that of isobaric levobupivacaine. Therefore, with higher baricity, hyperbaric bupivacaine allows for greater distribution in the target area of anesthesia, contributing to a longer duration of motor block.[7,11]

This procedure involves injecting the drug into the patient in a sitting position, then positioning them supine. The hyperbaric solution will move upward or to the lower regions of the supine position, whereas the isobaric solution will stay localized around the injection area.[20,21] Due to physiological changes in pregnant women that narrow the subarachnoid space, the concentration of hyperbaric anesthetics tends to increase. This consequently leads to the duration of motor block with hyperbaric drugs extending beyond that seen with isobaric drugs.[19]

Table 4
Comparison of Motoric Block Duration with Other Studies[7,11,14,15,18]

No.	Studies	Duration of Motoric block	Duration of Motoric block
		IL	HB
1.	Amjad, et al	120,26 ± 4,835	141,03 ± 6,653
2.	Goyal, et al	96,35 ± 9,19	129,43 ± 10.85
3.	Rao, et al	144,5 ± 18,21	297,83 ± 27.31
4.	Metta, et al	205 ± 37	216 ± 30
5.	Pal, et al	201,15 ± 5.37	184,44 ± 5,47
6.	Present Study	204,50 ± 38,472	231,35 ± 16,944

Notes: IL = Isobaric Levobupivacaine, HB = Hyperbaric Bupivacaine

5. CONCLUSION

A substantial difference in the duration of the motoric block post-surgery was observed between the group given hyperbaric bupivacaine and the group receiving isobaric bupivacaine. Apart from that, in this study, there was variation in the onset time and duration of anesthetic medication between the samples, which could have influenced the results for motoric block duration. Slow- and rapid-onset blocks were not differentiated in this study and were therefore combined into a single unit for motoric block duration. It is hoped that future research can involve the onset of motoric block.

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