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Height and weight-adjusted intrathecal 0.5% hyperbaric Bupivacaine for elective cesarean section: an outcome analysis in a rural Nepal tertiary centre

Robin Khapung[1], Subi Basnyat[2], Nabin Thapa[1], Praveen Kumar Giri[3], Ramesh Bhatterai[4], Jeetendra Bhandari[5], Prerana Shrestha[1], Subika Banjade[1], Alan Pandey[1], Apil Adhikari[1], Posan Samser Limbu[6], Shirish Silwal[7], Ramu Maharjan[8], Nikita Basnyat[9], Anuradha Pradhan[5]

[1]Dept. of Anesthesiology, Critical Care & Pain Medicine; [2]Dept. of Obstetrics & Gynecology; [5]Dept. of General Practice & Emergency Medicine, [8]School of Nursing & Midwifery, Karnali Academy of Health Sciences, Jumla, Nepal; [3]Dept. of Critical Care, Kritipur Hospital, Kathmandu, Nepal; [4]Dept. of Anesthesiology, Lumbini Eye Institute, Bhairahawa, Lumbini, Nepal; [6]Dept. of Internal Medicine, Division of Nephrology & Division of Pulmonary, Critical Care, and Sleep Medicine, SSM St. Louis University Hospital, St. Louis, Missouri, USA; [7]Dept. of Anesthesiology and Critical Care, Chitwan Medical College, Bharatpur, Chitwan, Nepal; [9]Sunshine Hospital Western Health, Australia

Correspondence:
Dr. Robin Khapung
Dept. of Anesthesiology, Critical Care & Pain Medicine, Karnali Academy of Health Sciences, Jumla, Nepal
Email: robinkhapung@hotmail.com

Abstract

Introduction: Spinal anesthesia with 0.5% hyperbaric bupivacaine is preferred for cesarean section(CS) but often causes maternal hypotension with potential fetal effects. Using Harten's chart to dose based on height and weight may limit block height and reduce hypotension. We compared fixed-dose and adjusted regimens.

Method: This prospective observational study at Karnali Academy of Health Sciences (Aug–Dec 2022) included 58 term singleton ASA II women undergoing elective CS. Intrathecal 0.5% hyperbaric bupivacaine was given as either fixed dose (11 mg) or Harten's chart–calculated dose. Primary outcome was change in mean arterial pressure; secondary outcomes were systolic blood pressure, heart rate, block characteristics, vasopressor use, and adverse effects. Significance was P < 0.05.

Result: Adjusted-dose group received lower median intrathecal dose than fixed-dose group (9 mg [IQR 8.5–9.5] vs 11 mg; P<0.001), with slower onset to T6 (median 4 min [IQR 4–5] vs 2 min [IQR 2–4]; P<0.001) and lower 20-min maximum sensory level (median T5 vs T3; P<0.001). No adjusted-dose patients reached T2, compared with 6(20.7%) in fixed-dose group (P=0.023). Maternal hypotension was less frequent with dose adjustment (17.2% vs 31%; P=0.357), with comparable reductions in MAP and SBP (ΔMAP 26.0 [20.0–34.0] vs 26.0 [23.0–41.0] mmHg, P=0.290; ΔSBP 26.0 [17.0–36.0] vs 32.0 [23.0–46.0] mmHg, P=0.134). Fewer adjusted-dose patients required mephentermine (10.3% vs 41%; P=0.015), bradycardia and vomiting occurred only in the fixed-dose group.

Conclusion: Height and weight-adjusted intrathecal bupivacaine provides adequate anesthesia with less maternal hypotension and lower block height than standard dose.

Keywords: Cesarean section; Harten chart, Height and weight adjusted dosing; Hyperbaric bupivacaine; Intrathecal bupivacaine; Karnali Academy of Health Sciences

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INTRODUCTION

Spinal anesthesia with 0.5% hyperbaric bupivacaine is widely used for elective cesarean section (CS) because it provides rapid, dense anesthesia without exposing the fetus to systemic anesthetics. However, the use of conventional fixed intrathecal doses is frequently associated with clinically significant maternal hypotension, as demonstrated in Nepalese parturients by KC KK et al.[1] Maternal hypotension can cause nausea, vomiting, and reduction in uteroplacental perfusion leading to fetal hypoxia and acidosis.[2-6] Block height and sympathetic blockade lead to hemodynamic instability, both of which are dose-dependent.[7–9] Traditionally, a fixed dose of hyperbaric bupivacaine (10-12.5 mg) is used irrespective of individual patient characteristics.[10,11] Factors such as height, cerebrospinal fluid volume, and overall body habitus influence intrathecal drug spread.[7, 12, 13] A study by Harten et.al introduced a dosing scheme with height and weight adjustment to mitigate hypotension and excessively high sensory blocks.[14] Though findings have been inconsistent,[15] subsequent trials have found benefits of dose adjustment leading to decreased alterations in maternal hemodynamics, thus decreasing episodes of maternal hypotension.[1,16, 17]

Data from low-resource and rural settings in South Asia remain limited.[18, 19] Hence, our study aimed to compare the effects of fixed versus height/ weight adjusted dosing of intrathecal hyperbaric bupivacaine on maternal hemodynamics among parturients undergoing elective caesarean delivery. Our research hypothesis was that height and weight-adjusted dosing reduces maternal hypotension without compromising anesthesia adequacy.

METHOD

Following Institutional Review Committee (IRC) approval at Karnali Academy of Health Sciences (KAHS)(ref no: 2078/079/24), a prospective, randomized, and comparative study was conducted at KAHS Teaching Hospital from Aug to Dec 2022.

Pregnant women aged 18-40 years with a single term pregnancy with American Society of Anesthesiologists-physical status II (ASA-PS), whose height and weight fall within Harten's chart, and who are planned for elective caesarean section were included in the study. Patients' exclusion criteria were patients' refusal to undergo spinal anesthesia, contraindication to spinal anesthesia, preexisting or pregnancy-induced hypertension, cardiovascular or respiratory illness.

Participants were randomly allocated to one of two groups: a fixed-dose group (FD) and a calculated-dose group (CD), using a sealed-envelope technique after generating random numbers via a computer-generated sequence. This was done by an anesthesia provider not involved in the research activities, with group FD receiving a fixed dose of 2.2 ml 0.5% heavy bupivacaine and group CD receiving a volume calculated according to the height and weight from the mentioned Harten's chart (Table 1).

Primary outcome of the study was mean arterial pressure (MAP) change from baseline and secondary outcomes of the study were systolic blood pressure (SBP) and heart rate (HR) change from the baseline, sensory blockade level, the duration of complete motor blockade, vasopressor requirement and the incidence of adverse events like hypotension (defined as decrease in noninvasive MAP with reduction greater than 20% from baseline or MAP is less than 60 mmHg), bradycardia (defined as HR< 20% baseline or less than 50 bpm), nausea and vomiting.

After recruitment of the participants, the patients' height and weight were documented, and a 6-hour fast was ordered during the pre-anaesthetic checkup (PAC). Patients' baseline SBP, DBP, MAP, HR, and SpO2 were recorded, and they were preloaded with 10 ml/kg of Ringer's lactate solution via an 18-G intravenous cannula. All patients were premedicated with injection Metoclopromide 10 mg and injection Ranitidine 50 mg. Following aseptic precautions, a subarachnoid block was performed by an anesthesia provider not involved in the research study at the L4-L5 or L3-L4 space using a 26-G Quincke's spinal needle, and the drug was administered at a rate of 0.2 ml/ sec according to the group allocation. After administration of spinal anesthesia, patients were kept supine with the placement of a folded towel under the right pelvic region for a slight lateral tilt. Assessment of sensory blockade and motor function was performed using the pinprick test with a 27-G blunt-bevel needle and the Bromage scale, respectively, and recorded every 1 minute until sensory blockade reached the T6 level and motor blockade Grade 3. Surgery

Table 1. Harten Chart[14]

Patient weight (Kg)	Patient's Height (cm)								
	140	145	150	155	160	165	170	175	180
50	1.5	1.7	1.8	1.9					
55	1.5	1.6	1.8	1.9	2.0				
60	1.4	1.6	1.7	1.8	2.0	2.1			
65	1.4	1.5	1.7	1.8	1.9	2.1	2.2		
70	1.3	1.5	1.6	1.8	1.9	2.0	2.2	2.3	
75		1.4	1.6	1.7	1.9	2.0	2.1	2.3	2.4
80		1.4	1.5	1.7	1.8	2.0	2.1	2.2	2.4
85			1.5	1.6	1.8	1.9	2.1	2.2	2.3
90			1.4	1.6	1.7	1.9	2.0	2.2	2.3
95				1.5	1.7	1.8	2.0	2.1	2.3
100				1.5	1.7	1.8	1.9	2.1	2.2
105					1.6	1.7	1.9	2.0	2.2
110						1.7	1.8	2.0	2.2

was permitted to commence only after confirmation of desired sensory and motor blockade. Participants with inadequate sensory and motor blockade after 20 minutes were converted to general anesthesia and excluded from the study thereafter. With experience of pain after the start of surgery, 0.3 mg/kg ketamine combined with 0.5 mcg/kg Fentanyl was administered post-delivery of the newborn as rescue analgesics.

HR, SBP, and MAP were measured every 2.5 minutes for the first 20 minutes following spinal anesthesia, with subsequent measurements taken every 5 minutes thereafter. All parturients received five units of oxytocin intravenously as a slow bolus. Bias was minimized by blinding the study, following a strict protocol for hydration, positioning, and spinal technique, and adhering to predefined criteria for hypotension and vasopressor use. Hypotension was treated with administration of 5 mL/kg of Ringer's lactate, and if hypotension persisted, Mephentermine 6 mg was administered intravenously. Bradycardia was managed by administration of atropine 0.6 mg, and nausea or vomiting was managed by administration of ondansetron 0.1mg/kg given intravenously.

Sample size was calculated by using the difference in MAP reduction as the primary outcome measure. Based on the results of the study by KC KK et al. 1, the difference in MAP reduction was 3.1 mmHg. Using the two-independent means formula with a 95% confidence level ($Z\alpha$=1.96), 80% power ($Z\beta$=0.84), and a pooled standard deviation of 3.85 mmHg, the sample size was calculated as 25 participants per group. To account for potential dropouts and protocol deviations, 15% attrition was added, resulting in a final sample size of 58 participants (29 per group) (Figure 1).

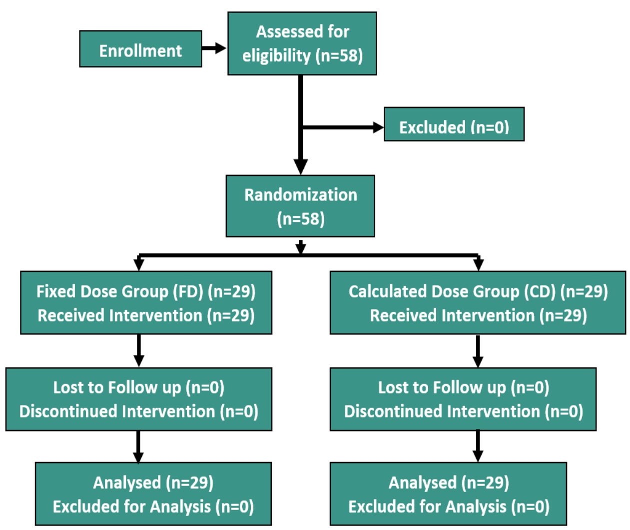

Figure 1. Consort flow diagram of the study

Collected data were entered into Microsoft Excel and analyzed using SPSS version 20.0. All data were tested for normal distribution using the Kolmogorov-Smirnov test. Continuous variables– age, height, weight, SBP, MAP, and HR were analyzed by the student's t-test. Categorical data – ASA, parity, and adverse effects were analyzed with the Pearson Chi-square test or the Fisher Exact test as appropriate. Skewed data, such as Bupivacaine dosage, time to sensory block at T6, maximum block height, time to motor block at Bromage-III, and dose of Mephentermine consumed, were analyzed using the Mann-Whitney U test. A p-value of < 0.05 was considered statistically significant.

Normality of continuous variables in both study groups (Fixed Dose and Calculated Dose) was first evaluated using the Shapiro–Wilk test, conducted separately for each variable within each group, and appropriate statistical tests were applied and reported. In addition to the Shapiro–Wilk test, the Kolmogorov–Smirnov test was also used to validate the distributional characteristics of continuous variables. For variables that demonstrated normal distribution on both tests, parametric statistical methods, specifically the independent samples t-test, were used to compare mean values between the FD and CD groups. Variables exhibiting significant deviations from normality were analyzed using the Mann–Whitney U test. Categorical variables were summarized as frequency and percentage [n (%)] for each group. Comparisons of categorical data between the FD and CD groups were performed using either the Chi-square test or Fisher's exact test.

RESULT

A total of 58 participants who met the inclusion criteria were enrolled in the study. They were assigned to two groups, each with 29 participants: the Fixed Dose (FD) group, which received a standard intrathecal dose, and the Calculated Dose (CD) group, in which the intrathecal dose was determined using Harten's chart. Both groups were subsequently analyzed.

The two groups were comparable in age, weight, height, gestational age, parity (primi vs multi), and previous caesarean section. Mean age was identical between groups (FD: 27.4 ± 5.6 vs CD: 27.4 ± 3.6 years; p = 1.000) (Table 2).

Time to achieve sensory block to T6 was significantly faster in the FD group [2.0 (2- 4) min] compared to the CD group [4.0 (4- 5) min] (p<0.01). Similarly, time to attain motor block (Bromage III) was shorter in the FD group. The distribution of maximum sensory level at 20 minutes differed significantly between groups. Higher blocks (T2–T4) were more common in the FD group, while T5 predominated in the CD group (T5: 62.1% in CD vs 6.9% in FD; p< 0.001). The incidence of hypotension, bradycardia, nausea, and vomiting was low and statistically similar between groups (Table 3).

The FD group showed a steeper initial fall in SBP, particularly between 0- 10 minutes, followed by fluctuating readings throughout the first 40 minutes. In contrast, the CD group exhibited a more stable SBP profile, with smaller minute-to-minute fluctuations and an overall smoother trajectory (Figure 2).

The FD group showed lower MAP values between 20 and 50 minutes, with the lowest point around 50 minutes. In contrast, the CD group demonstrated relative MAP preservation, with smaller dips and more gradual changes (Figure 3).

Both groups showed similar patterns of HR changes, with a mild initial rise followed by a progressive decline (Figure 4).

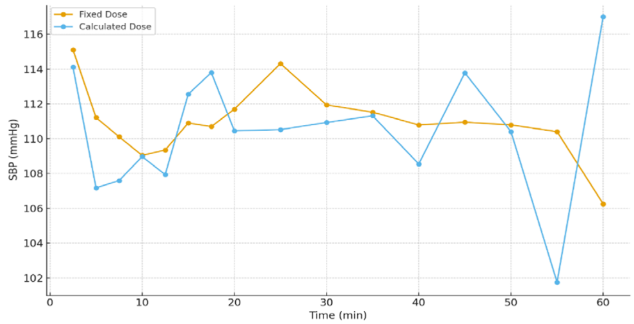

Figure 2. SBP trend of the fixed dose and the calculated dose of Hyperbaric Bupivacaine

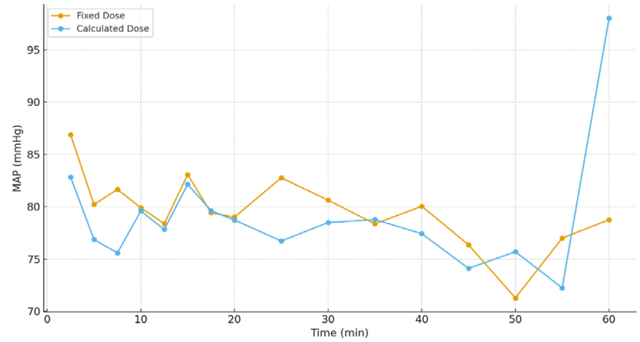

Figure 3. MAP trend of the fixed dose and the calculated dose of Hyperbaric Bupivacaine

Table 2. Demographic, obstetric, baseline hemodynamics, and surgical characteristics(n=58)

Variable		FD	CD	p- value
Age (years)		27.4 ± 5.6	27.4 ± 3.6	1.00*
Height (cm)		65.0(62.0-68.0)	64.0(58.0-70.0)	0.40**
Gestational weeks		40.0(39.0-41.0)	41.0(39.0-42.0)	0.94**
Parity	Multi	18(62.1%)	15(51.7%)	0.596***
	Primi	11(37.9%)	14(48.3%)	
Previous LSCS	No	16(55.2%)	18(62.1%)	0.79***
	Yes	10(34.5%)	8(27.6%)	
Baseline SBP (mmHg)		126.7 ± 11.6	122.4 ± 13.5	0.197*
Baseline MAP (mmHg)		95.7 ± 12.2	92.4 ± 11.2	0.293*
Baseline HR (bpm)		89.8 ± 13.7	86.4 ± 10.6	0.292*
Duration of surgery (mins)		40.0(30.0-45.0)	40.0(35.0-44.0)	0.794**
Maintenance iv fluids (ml)		1800(1600-1800)	1800(1500-1800)	0.098**
Δ SBP (baseline- minimum SBP) (mmHg)		32.0(23.0-46.0)	26.0(17.0-36.0)	0.134**
Δ MAP (baseline- minimum MAP)(mmHg)		26.0(23.0-41.0)	26(20.0-34.0)	0.290**

*Independent T test, **Mann whitney U test, ***Chi-square test

Table 3. Spinal characteristics, efficacy and adverse events(n=58)

Variable		FD	CD	p- value
Bupivacaine Dose 0.5% Hyperbaric (ml)		2.2(2.2-2.2)	1.8(1.7-1.9)	0.007
Bupivacaine Dose 0.5% Hyperbaric (mg)		11(11-11)	9.0(8.5-9.5)	0.007
Time to sensory T6 (mins)		2.0(2.0-4.0)	4.0(4.0-5.0)	< 0.001
Time to motor block Bromage III (mins)		4.0(3.0-6.0)	6.0(5.0-8.0)	0.008
Maximum sensory level in 20 mins	T2	6(20.7%)	0	0.023†
	T3	7(24.1%)	3(10.3%)	0.297†
	T4	14(48.3%)	8(27.6%)	0.176***
	T5	2(6.9%)	18(62.1%)	<0.001†
Supplementary analgesia	Yes	1(3.4%)	1(3.4%)	1.00†
	No	28(96.6%)	28(96.6%)	
Interspace level	L3- L4	21(72.4%)	25(86.2%)	0.331†
	L4- L5	7(24.1%)	4(13.8%)	
	Other	1(3.4%)	0	
Hypotension	Yes	9(31.0%)	5(17.2%)	0.357***
	No	20(69%)	24(82.8%)	
Bradycardia	Yes	3(10.3%)	0	0.237†
	No	26(89.7%)	29(100%)	
Nausea	Yes	0	0	1.00†
	No	29(100%)	29(100%)	
Vomiting	Yes	1(3.4%)	0	1.00†
	No	28(96.6%)	29(100%)	
Mephentermine dose (mg)*		12.0(10.5-18.0)	6.0(6.0- 9.0)	0.167**
Number of patients receiving mephentermine		12(41.4%)	3(10.3%)	0.015†

Note: 0.5% hyperbaric bupivacaine contains 5 mg/mL, †Fisher's exact test, *Median (interquartile range); **Mann–Whitney U test, ***Chi-square test

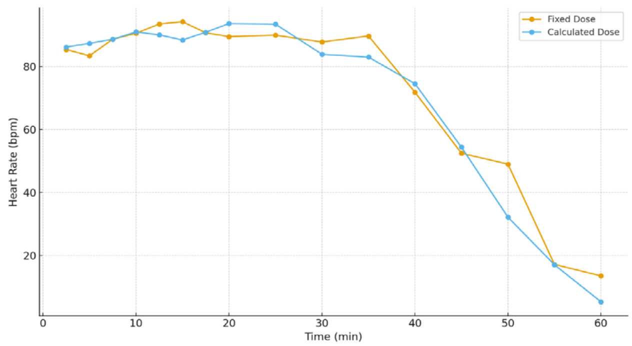

Figure 4. Heart rate trend of the fixed dose and the calculated dose of Hyperbaric Bupivacaine

ΔSBP and ΔMAP were calculated as the difference between baseline values and the lowest recorded intraoperative values during 2.5 - 60 minutes of monitoring.

DISCUSSION

Our study compared a conventional fixed intrathecal dose of 11 mg hyperbaric bupivacaine with a calculated dose based on height-adjusted criteria in parturients undergoing elective caesarean section. Our study showed that FD produced a significantly faster onset of sensory and motor block, whereas CD offered a more controlled block profile with fewer haemodynamic interventions. Importantly, serial SBP, MAP, and HR values were comparable between the two groups at individual time points. The FD group required more vasopressor support, suggesting clinically relevant differences in the depth of sympathetic blockade.

Harten et al. first popularised the concept of height- and weight-adjusted intrathecal dosing for caesarean delivery, demonstrating that individualised dosing reduced unnecessarily high block levels without compromising anaesthetic quality.[14] Our results echo this rationale: while an 11 mg FD produced a rapid onset, it also appeared to push some patients closer to the upper limit of acceptable block height, necessitating more active haemodynamic management. By contrast, CD achieved adequate surgical anesthesia with a more gradual onset and fewer episodes of pronounced hypotension. Subedi et al. similarly reported that fixed-dose regimens were associated with higher rates of hypotension and vasopressor use in South Asian parturients, particularly among those of shorter stature.[16] Their findings support the notion that anatomical and physiological variability within this population makes a single fixed dose potentially excessive for many patients.

Mercier, et al. compared height-based and height–weight-adjusted regimens and found that both strategies improved haemodynamic stability compared with fixed dosing, with the more refined height–weight algorithm providing slightly better control.[20] Our observation that CD reduced vasopressor requirement while maintaining satisfactory anesthesia is consistent with these data. These findings are further supported by the randomized controlled trial by Manasa et al. who demonstrated that height–weight-adjusted intrathecal dosing significantly reduced the incidence of maternal hypotension compared with height-adjusted dosing alone, while maintaining adequate sensory block for caesarean delivery.[21]

Although our protocol did not routinely incorporate intrathecal opioids, we observed a broad pattern: CD produced fewer hypotension-related adverse effects and required less vasopressor support than FD, despite similar overall hemodynamic trends. This finding aligns with other studies employing Harten-based dosing, which have demonstrated that adjusted dosing reduces episodes of profound hypotension, decreases the incidence of nausea and vomiting, and improves maternal satisfaction scores.[16,21]

Nagata et al demonstrated that lower intrathecal doses may be sufficient to achieve adequate block height in Asian parturients.[18] At the same time, Carpenter et al described the relationship between intrathecal dose and sensory block characteristics, supporting the rationale for dose adjustment.[3] These observations help explain why FD, although effective, may overshoot the desired block level in a subset of patients. Studies by Bialowolska, et al.[22] and Lee, et al.[23] also advocated dose adjustment based on patient characteristics to minimize haemodynamic instability while preserving block efficacy. In our study, the lack of statistically significant differences in point-by-point SBP, MAP, and HR values might suggest that FD and CD are numerically equivalent. However, reliance on p-values alone may obscure clinically meaningful patterns. The greater vasopressor requirement in the FD group, together with a trend toward larger early drops in SBP, aligns with previous reports that higher intrathecal doses deepen sympathetic blockade and increase the need for pharmacological support.[18] While these events were manageable and did not translate into significant morbidity, they underscore the potential advantages of CD in routine practice.

Our findings should also be considered in the context of safety. Hawkins[24] and Chestnut[25] have emphasized that maternal hypotension remains one of the most critical complications of spinal anesthesia for caesarean section, with potential implications for uteroplacental perfusion and fetal well-being. Strategies that subtly reduce the incidence or severity of hypotension, such as individualized dosing algorithms, may therefore yield cumulative benefits at the population level, even if individual episodes are effectively treated with vasopressors. In this regard, CD dosing may represent an attractive compromise between the simplicity of FD and the rigour of fully weight-based titration.

Several limitations warrant discussion. The sample size, although comparable to many published trials, may be insufficient to detect slight differences in rare adverse events. Our study was conducted at a single centre, and we did not formally assess maternal satisfaction scores or neonatal outcomes beyond routine clinical parameters. Finally, the calculated dosing algorithm used in our study was adapted from published nomograms rather than derived de novo for this specific population. Despite these limitations, the present study adds to the growing body of evidence supporting individualized intrathecal dosing for caesarean delivery. Taken together with prior work, our results suggest that CD strategies can maintain high-quality anesthesia while reducing the intensity of hemodynamic perturbations and the need for vasopressor therapy. In busy obstetric units where both maternal safety and workflow efficiency are paramount, adopting such algorithms may offer a pragmatic way to optimize care.

CONCLUSION

FD intrathecal bupivacaine for elective caesarean section provides a rapid onset of dense sensory and motor block. Still, it is associated with greater vasopressor requirement and a trend toward more pronounced hemodynamic changes. CD based on a height-adjusted algorithm achieves adequate surgical anesthesia with a more controlled block profile and fewer hemodynamic interventions. In line with contemporary literature, individualised intrathecal dosing appears preferable to a one-size-fits-all approach and should be considered for routine practice in obstetric anesthesia.

DECLARATIONS

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Conflict of Interest

None

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None

Consent for Publication

All authors have approved the final version of the manuscript.

Consent of Study

Informed written consent was obtained from all the participants before data collection.

Ethical Clearence

Ethical approval was obtained form IRC KAHS with ref no: 2078/079/24.

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