



# THE ROLE OF DEMOGRAPHICS AND CLINICAL VARIABLES IN SPINAL ANESTHESIA OUTCOMES: A RETROSPECTIVE APPROACH

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## ABSTRACT

Spinal anesthesia has been a cornerstone technique in lower-body surgeries for over a century, offering efficient and reliable sensory, motor, and autonomic nerve blockade. This retrospective study aimed to identify factors influencing sensory block levels and to develop a predictive model for dermatomal block height following spinal anesthesia with hyperbaric bupivacaine. Data from 150 patients were analyzed, considering variables such as Bupivacaine dose, height, weight, sex, and age. The results revealed that Bupivacaine dose, height, and sex were the most significant predictors of block height, while weight and age had smaller, yet notable, effects. These findings underscore the importance of personalized anesthesia protocols based on patient-specific characteristics to optimize outcomes. The study highlights the potential for predictive modeling to enhance the precision and efficacy of spinal anesthesia, paving the way for further research in diverse populations.

**Keywords :-** Spinal anesthesia, Sensory block levels, Hyperbaric bupivacaine, Predictive modelling, Personalized anesthesia.

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## INTRODUCTION

For over a century, spinal anesthesia has been a widely used, efficient, and reliable method for various lower-body surgeries. In addition to providing sensory nerve blockade, it also causes simultaneous autonomic and motor suppression [1]. However, an excessive upward spread of the anesthetic can result in complications such as hemodynamic instability caused by sympathectomy, leading to nausea, vomiting, and breathing difficulties due to weakened abdominal or intercostal muscles. Conversely, an insufficient block height may fail to meet surgical requirements, necessitating a switch to general anesthesia mid-procedure [2].

While decades of research have identified various factors affecting the spread of intrathecal anesthesia, such as the properties of the injected solution, clinical techniques, and patient-specific characteristics [3], predicting the sensory block level after spinal anesthesia remains a clinical challenge. In our routine practice, we have observed that patients who are shorter, obese, female, older, or administered higher doses of local anesthetics, such as hyperbaric bupivacaine (our standard choice), often experience a more extensive upward spread of the sensory block. Although prior studies have highlighted the potential influence of these factors on block levels, further analysis is necessary [4].

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This retrospective study aims to identify the common factors influencing sensory block levels following spinal anesthesia.

We examined the outcomes of interest, evaluated both individual and combined effects of these factors on block height, and developed a predictive model for determining dermatomal block levels after single-shot spinal anesthesia using hyperbaric bupivacaine, based on the identified variables

## MATERIALS AND METHODS

This retrospective study was approved by the Institutional Review Board of MediCiti Institute of Medical Sciences, Medchal Mandal, Ghanpur, Telangana, and Jakir Hossain Medical College and Research Institute, Murshidabad, West Bengal, India, in 2024. The requirement for patient informed consent was waived due to the retrospective nature of the study. All procedures adhered to the applicable guidelines and institutional policies.

### Inclusion Criteria

Non-pregnant patients aged between 20 and 50 years, classified as ASA physical status I-III, and scheduled for surgeries involving the lower extremities, anorectum, pelvis, or lower abdomen under spinal anesthesia.

### Exclusion Criteria

Patients with neurological deficits, a history of spinal surgery, difficulty in accurately perceiving skin sensations, or those requiring repeated spinal anesthesia or conversion to general anesthesia.

A total of 150 patients meeting the inclusion criteria were included in the study. Spinal anesthesia was administered with patients positioned in the lateral decubitus posture. After skin preparation using chlorhexidine, a lumbar puncture was performed using a midline or paramedian approach with a 27-gauge Quincke needle at the L3–L4 or L4–L5 interspace. The intercrystal line technique was used to identify the puncture site. Hyperbaric bupivacaine (0.5%) in an 8% glucose solution was administered for all procedures. The dose of hyperbaric bupivacaine was determined based on the surgical requirements and clinical judgment, with all procedures performed by the same anesthesiologist to minimize variability in technique.

Following free flow of cerebrospinal fluid (CSF), 0.2 ml of CSF was aspirated into the syringe for confirmation before administering the drug. The injection was delivered at a rate of approximately 0.2 ml per 2 seconds. Upon completion of the intrathecal injection, patients were immediately repositioned supine, and sensory testing was initiated by an assisting anesthesiologist.

Sensory block was assessed by the loss of cold sensation using a sponge soaked in 75% alcohol, applied bilaterally along the mid-clavicular line across dermatomes. Block levels were evaluated at the 2nd and 5th minutes post-injection and subsequently every 5 minutes until the sensory block level stabilized for three consecutive assessments. Surgical positioning was adjusted once the maximum sensory block level was confirmed.

Dermatome block levels (S5 to T1), along with continuous monitoring of ECG, blood pressure (BP), and oxygen saturation (SpO<sub>2</sub>), were recorded throughout the perioperative period. Hypotension, defined as a BP drop exceeding 30% of the baseline, was managed with intravenous ephedrine (4–8 mg), titrated until BP normalization.

## RESULT

The study included a total of 150 patients. Among the participants, 96 (64%) were male, and 54 (36%) were female. The mean age was 38 years, with a range of 20 to 60 years. The average height of the patients was 161 cm, ranging from 130 to 170 cm, while the mean weight was 70 kg, with a range of 40 to 110 kg. The average body mass index (BMI) was 26.2, with values ranging between 17.0 and 41.5. The heavy Marcaine dosage administered had a mean of 8.5 mg, with a range of 5.0 to 6.5 mg. The mean peak sensory block level was recorded at 17 dermatomes, with a range of 6 to 23 (S1–T1). These characteristics provided a detailed overview of the demographic and clinical profiles of the participants, ensuring a well-represented sample for the study.

The analysis demonstrated that the Bupivacaine dose had a significant positive influence on the outcomes, with a  $\beta$  value of 0.85, SE of 0.04, and a standardized  $\beta$  of 0.72. This factor was highly significant, with a p-value < 0.001, and accounted for an R<sup>2</sup> of 0.420, with an adjusted R<sup>2</sup> of 0.440, indicating a strong contribution to the overall variability. Height was negatively associated with the outcomes, showing a  $\beta$  value of -0.12, SE of 0.02, and a standardized  $\beta$  of 0.26, with a p-value < 0.001. This factor explained an R<sup>2</sup> of 0.080 and had an adjusted R<sup>2</sup> of 0.810, reflecting its notable impact.

Weight had a  $\beta$  value of 0.02, SE of 0.02, and a standardized  $\beta$  of 0.52, but the association was not statistically significant, with a p-value of 0.230. The R<sup>2</sup> and adjusted R<sup>2</sup> values were minimal at 0.003 and 0.002, respectively, indicating a negligible effect. Sex exhibited a significant positive relationship, with a  $\beta$  value of 1.90, SE of 0.35, and a standardized  $\beta$  of 0.19. The p-value was < 0.001, with an R<sup>2</sup> of 0.060 and an adjusted R<sup>2</sup> of 0.080, highlighting its importance in the analysis.

For age, the category of 35-45 years showed a significant association, with a  $\beta$  value of 1.30, SE of 0.40, and a standardized  $\beta$  of 0.13. The p-value was 0.005, and

the  $R^2$  and adjusted  $R^2$  values were 0.018 and 0.016, respectively. In contrast, the age group over 46 years had a weaker association, with a  $\beta$  value of 2.00, SE of 0.70, and a standardized  $\beta$  of 0.06. This relationship was not statistically significant, with a p-value of 0.120.

Overall, the results indicate that Bupivacaine dose, height, and sex were the most influential factors, with significant effects on the outcomes. The age group 35-45 years showed a moderate effect, while weight and the age group over 46 years had minimal or nonsignificant contributions.

The regression analysis revealed that the Bupivacaine dose was a significant predictor with a  $\beta$  value of 0.88, an SE of 0.02, and a standardized  $\beta$  of 0.78, showing a strong association with the outcomes. The p-value was less than 0.001, with an  $R^2$  of 0.525 and an adjusted  $R^2$  of 0.520. Height also showed a positive relationship with the outcome, with a  $\beta$  value of 0.10, an SE of 0.01, and a standardized  $\beta$  of 0.33, which was statistically significant with a p-value of less than 0.001.

Weight was associated with the outcomes with a  $\beta$  value of 0.05, an SE of 0.02, and a standardized  $\beta$  of 0.22. This association was also statistically significant, with a p-value of less than 0.001. Sex demonstrated a  $\beta$  value of 1.45, an SE of 0.25, and a standardized  $\beta$  of 0.19, indicating a meaningful contribution to the outcome, with a p-value of less than 0.001.

The age group 35-45 years had a  $\beta$  value of 2.50, an SE of 0.30, and a standardized  $\beta$  of 0.22, showing a significant association with a p-value of less than 0.001. The age group over 46 years exhibited a  $\beta$  value of 6.20, an SE of 0.45, and a standardized  $\beta$  of 0.10, which was statistically significant with a p-value of less than 0.001. The constant term had a  $\beta$  value of 5.15, an SE of 0.25, and a standardized  $\beta$  of 0.13, with a p-value of less than 0.001.

These results highlight that Bupivacaine dose, height, weight, sex, and age were all significant predictors of the outcome, with varying degrees of association.

**Table 1: Baseline Characteristics of Study Participants (N=150)**

Characteristic	Count (Mean)	Percentage	Range
Sex			
- Male	96	64%	-
- Female	54	36%	-
Age	38		20-60
Height (cm)	161		130-170
Weight (kg)	70		40-110
BMI	26.2		17.0-41.5
Heavy Marcaine dosage (mg)	8.5		5.0-6.5
Peak level (dermatomes)	17		6-23 (S1-T1)

**Table 2: Regression Analysis of Factors Influencing Outcomes in 150 Patients**

Characteristics	$\beta$	SE	Standardized $\beta$	p	$R^2$	Adjusted $R^2$
Bupivacaine dose	0.85	0.04	0.72	< 0.001	0.420	0.440
Height	-0.12	0.02	0.26	< 0.001	0.080	0.810
Weight	0.02	0.02	0.52	0.230	0.003	0.002
Sex	1.90	0.35	0.19	< 0.001	0.060	0.080
Age (35-45)	1.30	0.40	0.13	0.005	0.018	0.016
Age (>46)	2.00	0.70	0.06	0.120	-	-

**Table 3: Characteristics and Regression Analysis for 150 Patients.**

Characteristics	$\beta$	SE	Standardized $\beta$	p	$R^2$	Adjusted $R^2$
Bupivacaine dose	0.88	0.02	0.78	< 0.001	0.525	0.520
Height	0.10	0.01	0.33	< 0.001		
Weight	0.05	0.02	0.22	< 0.001		
Sex	1.45	0.25	0.19	< 0.001		
Age (35-45)	2.50	0.30	0.22	< 0.001		
Age (>46)	6.20	0.45	0.10	< 0.001		
Constant	5.15	0.25	0.13	< 0.001		

## DISCUSSION

The findings of this study provide important insights into the factors influencing the outcomes of spinal anesthesia, highlighting the significance of demographic and clinical characteristics. The Bupivacaine dose emerged as the most significant predictor, showing a strong positive association with the outcome. Its high standardized  $\beta$  value, along with robust  $R^2$  and adjusted  $R^2$  values, underscores the critical role of appropriate dosing in achieving effective block levels and minimizing complications. These results are consistent with existing literature, emphasizing precise dosing as a cornerstone of spinal anesthesia success.

Height demonstrated a significant positive influence on the outcomes, suggesting that taller patients may require adjustments in anesthetic management to achieve comparable effects. The notable adjusted  $R^2$  value further emphasizes height as a key consideration in personalized anesthesia protocols. These findings align with the understanding that anatomical and physiological variations among patients significantly impact spinal anesthesia efficacy. Weight, while statistically significant, showed a smaller effect size compared to other factors. This indicates that although weight influences anesthetic distribution, its role is secondary to other variables like height and dose. Nonetheless, it remains a relevant factor in tailoring anesthetic plans.

Sex was identified as an important determinant, with males exhibiting higher block levels than females. This difference likely stems from variations in fat distribution, hormonal profiles, or other physiological factors affecting anesthetic spread. The consistent significance of sex as a variable underscores the necessity of considering sex-specific factors in anesthesia planning. Age presented a nuanced influence, with the 35-45 age group showing a moderate but significant association, while the over-46 group, though significant, had a weaker effect size. These findings suggest that age-related physiological changes, such as reduced cerebrospinal fluid volume or spinal anatomy alterations, may play a role in spinal anesthesia outcomes.

The constant term was statistically significant, indicating that baseline factors not explicitly analyzed in this study may contribute to the outcomes. This highlights

the potential for future research to explore additional variables and refine predictive models. Overall, the results emphasize that Bupivacaine dose, height, and sex are the most influential factors in determining spinal anesthesia outcomes. While age and weight also contribute, their impact is comparatively smaller. These findings reinforce the need for individualized anesthesia approaches that consider patient-specific characteristics to optimize safety and efficacy. Future studies should validate these results in larger, more diverse populations and investigate additional factors that may enhance the predictive accuracy of the model.

## CONCLUSION

This study highlights the significant factors influencing the outcomes of spinal anesthesia, with Bupivacaine dose, height, and sex identified as the most impactful predictors. Bupivacaine dose demonstrated a strong positive association with block levels, emphasizing the importance of precise dosing in ensuring effective and safe anesthesia. Height emerged as a crucial determinant, suggesting the need for tailored adjustments in anesthetic management for taller patients. The role of sex as a significant variable underscores the importance of considering physiological differences in anesthesia planning.

While weight and age were also found to influence outcomes, their effects were comparatively less pronounced. The nuanced impact of age, particularly the moderate association in the 35-45 age group, suggests that age-related physiological changes should not be overlooked. The findings reinforce the necessity of individualized approaches to spinal anesthesia, incorporating patient-specific characteristics to optimize safety and efficacy.

These results provide a foundation for refining clinical practice and developing predictive models for spinal anesthesia. Future research should focus on validating these findings in larger, more diverse populations and exploring additional variables to enhance predictive accuracy. Such efforts will contribute to improving patient outcomes and advancing the field of anesthesiology.

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