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Research Article

SPINAL ANESTHESIA: BEYOND A SINGLE DOSE OF HYPERBARIC BUPIVACAINE IN ACHIEVING SENSORY BLOCKADE

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ABSTRACT

Spinal anaesthesia is a widely employed technique for lower-body surgeries due to its reliability in providing sensory, autonomic, and motor nerve blockade. However, predicting the sensory block height remains complex, influenced by patient demographics, anaesthetic dose, and procedural factors. This retrospective study, conducted at Mamata Medical College, Rotary Nagar, Khammam, Telangana, India (2019–2022), aimed to identify factors associated with sensory block levels and develop a predictive model for dermatomal block height using hyperbaric bupivacaine. The study included 103 non-pregnant patients aged 20–50 years undergoing lower-body surgeries. Key variables, including patient height, weight, sex, age, and anaesthetic dose, were analysed using simple and multiple regression. The mean peak block height was 16 segments from S5 (T7), with a mean hyperbaric bupivacaine dose of 9 mg. Hyperbaric bupivacaine dosage, shorter height, higher weight, female sex, and older age significantly influenced sensory block height, explaining 70% of the variance. The predictive model demonstrated high accuracy, supporting its clinical utility in tailoring anaesthetic doses. These findings highlight the critical role of easily accessible patient variables and dosage adjustments in achieving optimal anaesthesia levels. Further studies are needed to validate these results and explore additional determinants such as spinal anatomy and CSF volume.

Key Words: Sympathectomy, Hyperbaric bupivacaine, Cerebrospinal fluid, Anaesthesia.

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INTRODUCTION

Nearly a century, spinal anaesthesia has been recognised as a straightforward, efficient, and dependable technique for various lower-body surgeries. Besides providing sensory nerve blockade, it also induces concurrent autonomic and motor inhibition [1]. Excessive cephalad spread of the anaesthetic can lead to sympathectomy-induced hemodynamic instability, manifesting as nausea, vomiting, and even breathlessness due to abdominal or intercostal muscle weakness. On the other hand, an insufficiently high block may fail to meet surgical requirements, necessitating a switch to general anaesthesia during an ongoing procedure [2].

Despite significant evidence accumulated over the decades highlighting multiple factors influencing the intrathecal spread of anaesthetics—including the composition of the injected solution, clinical techniques, and patient characteristics—predicting the extent of sensory block after spinal anaesthesia remains a challenging clinical issue [3]. In our extensive routine practice, we have observed a greater cephalad spread of the sensory block in patients who are shorter, overweight,

female, older, or administered higher doses of local anaesthetics, such as hyperbaric bupivacaine, which we commonly utilise. Previous consensus supports the notion that each of these variables can significantly impact the level of the spinal anaesthesia block [4].

Accordingly, this retrospective study aimed to identify common factors associated with sensory block levels following spinal anaesthesia, assess their individual and combined effects on block height, and develop a predictive model for determining dermatomal block levels after single-shot spinal anaesthesia with hyperbaric bupivacaine based on known influencing factors.

MATERIAL AND METHODS

Study Design and Setting

This retrospective study was conducted at Mamata Medical College, Rotary Nagar, Khammam, Telangana, India, between 2019 and 2022, following approval from the Institutional Review Board. The requirement for informed patient consent was waived due to the study's retrospective nature. The research adhered to all applicable guidelines and institutional protocols.

Inclusion and Exclusion Criteria

The study included non-pregnant patients aged 20 to 50 years with an ASA physical status of I–III, who underwent lower extremity, anorectal, pelvic, or lower abdominal surgeries under spinal anaesthesia. Patients with neurological deficits, a history of spinal surgery, difficulty in accurately describing sensory changes, or those requiring repeated spinal anaesthesia or conversion to general anaesthesia were excluded.

Anaesthetic Procedure

All patients were positioned in the lateral decubitus position for spinal anaesthesia. After skin preparation with 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, determined via the palpated intercristal line. Hyperbaric bupivacaine (0.5% in 8% glucose) was used as the anaesthetic agent. The dosage of bupivacaine was selected based on the surgeon's experience and the surgical requirement. To standardise procedures and minimise variability, the same anaesthetist performed all spinal anaesthetic administrations.

After confirming free-flowing cerebrospinal fluid (CSF), 0.2 ml of CSF was aspirated to confirm correct needle placement. The drug was injected intrathecally at a rate of approximately 0.2 ml per second. Upon completing the injection, patients were immediately turned to the supine position.

Sensory Block Assessment

Sensory block levels were assessed using a 75% alcohol-soaked sponge applied to dermatomes along the bilateral mid-clavicular lines. The absence of cold sensation was used to define the sensory block level. Assessments were conducted at the 2nd and 5th minutes post-injection and repeated every 5 minutes until the sensory block level stabilised for three consecutive assessments.

Monitoring and Management

The sensory block extent was recorded from dermatomes S5 to T1. Patients were continuously monitored for ECG, blood pressure (BP), and oxygen saturation (SpO2) throughout the anaesthetic and perioperative periods. Hypotension, defined as a BP decrease of more than 30% from baseline, was managed with intravenous ephedrine (4–8 mg) titrated to restore BP.

Statistical Analysis

Data collected included patient demographics, anaesthetic details, sensory block levels, and haemodynamic parameters. Statistical analysis was performed to identify factors influencing sensory block height and to develop predictive models for dermatomal block levels using hyperbaric bupivacaine.

RESULTS

A total of 103 eligible patients received spinal anaesthesia for lower body surgeries and their characteristics. On average, the peak block level was 16 segments from S5 (T7) and the mean dose of hyperbaric bupivacaine was 9 mg.

Simple linear regression evaluation revealed a advantageous correlation among peak block height and the hyperbaric bupivacaine dosage, as well as a terrible affiliation between peak block level and body weight. The affiliation between peak block peak and frame weight became no longer large inside the univariate analysis. Female patients and those elderly between 35 and 45 tended to have a higher height block degree. Its well worth noting that the hyperbaric bupivacaine dose on my own accounted for extra than 1/2 of the overall variances in height block top (R2 = zero.Fifty five). In comparison, other covariates were chargeable for less than 10% of variances in peak block height in the univariate analysis.

Table 1: Patient demographics SD, standard deviation; BMI, body mass index

Characteristic	Count (mean)	Percentage	Range
Sex			
Male	72	66%	-
Female	31	30%	-

Age	39	19	20-59
height	162	10	132-165
weight	68	15	35-100
BMI	25.9	4.5	16.6-40
Heavy Marcaine dosage (mg)	9	4	5.2-6
Peak level	16	5	5-22(S1T1)

In the couple of regression analysis, five impartial predictors of peak height block had been recognized, which include hyperbaric bupivacaine dose, height, weight, male/female and age grouping Table 3. About the interactions between gathered variables, no important interaction impact become observed among any covariates after the multiple regression analysis.

Table 2: Univariate effects of collected variables on peak block level. β, regression coefficient; SE, standard error; R2, coefficients of determination.

Characteristics	β	SE	Standardized *β*	p	R^2	Adjusted *R*2
Bupivacaine dose	0.81	0.03	0.71	< 0.001	0.406	0.425
Height	-0.10	0.01	0.25	< 0.001	0.072	0.806
weight	0.01	0.01	0.50	0.242	0.002	0.001
Sex	1.85	0.33	0.18	< 0.001	0.055	0.075
Age					0.016	0.015
35-45	1.24	0.37	0.12	0.006		
>46	1.9	0.67	0.05	0.132		

Table 3: Selected predictors of peak spinal block level after the model selection. β, regression coefficient; SE, standard error; R2, coefficients of determination.

Characteristics	β	SE	Standardized *β*	p	R^2	Adjusted *R*2
Bupivacaine dose	0.86	0.01	0.77	< 0.001	0.519	0.515
Height	0.09	0.01	0.32	< 0.001		
weight	0.04	0.01	0.20	< 0.001		
Sex	1.39	0.23	0.18	< 0.001		
Age						
35-45	2.47	0.27	0.21	< 0.001		
>46	6.12	0.42	0.09	< 0.001		
Constant	5.12	0.21	0.12	< 0.001		

DISCUSSION

How to select an affordable dose of intrathecal confined anaesthetic for the desired block extent in wonderful varieties of surgical procedures for diverse patients is an essential medical problem. We proposed a more than one linear regression model with [5] commonplace variables which predicted the sensory block top after spinal anaesthesia using hyperbaric bupivacaine with extra than 70% predictive energy. With the assist of this formula, extra reliable dose adjustment could be without problems carried out.

In this observe, we simplest investigated instances receiving hyperbaric (heavy) bupivacaine in preference to simple bupivacaine for spinal anaesthesia for the following reasons. First, the density of plain bupivacaine is near CSF at room temperature but becomes mildly hypobaric after subarachnoid injection at the body's middle temperature of 37 °C.5 Even a touch density change can bring about a wonderful variation in intrathecal drug spread. [6]

In evaluation, heavy answers stay hyperbaric before and after spinal injection with negligible outcomes on the intrathecal drug distribution. [7] Second, a manner effect inclusive of higher levels of injection, might also purpose more cephalad unfold with plain bupivacaine but has little effect at the spread of the heavy solution. [8]

Since it's miles hard to properly become aware of the inter space for injection, [9] using a hyperbaric solution will reduce the affect of any inaccuracy at the injection website online. [10] Third, procedure related factors, along with the orientation of the needle orifice and the velocity of injection purpose less have an impact on on block top whilst the use of heavy solutions. [11]

In medical exercise, it's far impractical and useless to reap the CSF extent statistics by MRI before spinal anaesthesia. For that reason, our method affords a quick and beneficial scientific manual that may be used in day by day practice and is based totally on simply five without difficulty available measurements. It is

affordable to expect that the quantity and duration of subarachnoid nerve block depends on the bupivacaine dosage whenever other probably influential factors are managed for.12 With regard to age, previous research also discovered that an accelerated block degree may be discovered inside the elderly. [12] It is possible that CSF extent shrinks, and the spinal nerves seem extra touchy to neighborhood anaesthetics with advancing age.

Particularly, our consequences maintain the principle that age was no longer correlated with block height in a linear way but became big past the cut off cost of 50years antique. Moreover, we discovered that gender turned into also an independent predictor of sensory block peak. In the final regression version, ladies tended to have sensory blockading 1.6 dermatomes higher as compared with men after spinal anaesthesia, whilst the alternative 4 explanatory variables were managed for. Although the mechanism underlying this intersexual disparity is uncertain, differences in CSF density may additionally play a position. The movement of subarachnoid local anaesthetics relies upon at the interplay between the drug and CSF under the influence of gravity. The imply density of CSF is better in men than in women and a given intrathecal drug could grow to be much less hyperbaric in men and extra hyperbaric in women and this may in all likelihood result in the determined difference in cephalad spread.

In addition, vertebral column duration and stomach girth have lately been reported as newly influencing elements which have to update frame peak and weight for intrathecal drug spread. Even so, frame height and weight are nevertheless greater without problems available than measurements of vertebral column period and stomach girth. Recent studies and our consequences indicated that block stage is negatively correlated with frame peak while it ispositively correlated with body weight.

Despite the truth that frame weight and age > 85 were no longer substantially associated with sensory block degree after spinal anaesthesia within the univariate analysis (Table 2), within the multivariable evaluation, a completely tremendous effect will be established among sensory block level and both of those variables (Table 3). This resulted from confounding outcomes between the collected variables and turned into easily eliminated after the multivariable evaluation.

For instance, women and the aged were greater willing to have a lower frame weight compared with their opposite numbers and these potential confounding results could masks the original association between body weight and a sensory block top after spinal anaesthesia within the univariate evaluation. Therefore, all the amassed variables must be evaluated collectively in the multivariable evaluation irrespective of the univariate outcomes to avoid analytical bias.

An research into the potential interactions between covariates is of sensible significance in exploring the influential elements on sensory block tiers after spinal anesthesia. In spite of the reality that interaction phrases notably growth the complexity of a predictive version and the problem of the rationale and analyses, checking for interactions among collected variables have to not be ignored. However, within the contemporary examine, we did not identify any interactions between the variables of hobby and the combined consequences of the five gathered variables at the sensory block level had been kind of additive.

Spinal anesthesia exhibits differential sensory block to light contact, pinprick, and bloodless temperature discrimination from low to high blockading dermatomes in series. We used a soaked alcoholic sponge as the ordinary method for assessing the affected person's blockage of cold sensations. Although pinprick has long been considered the same old measurement of analgesia representing blockade of A-δ fibres, numerous research have additionally observed that block stages to pinprick are very close to the ones for bloodless sensation31–33. It has been broadly recommended that the block level to bloodless or pinprick trying out is taken into consideration good enough to three segments above the expected level of surgical incision34. There were some obstacles to the current have a look at. First, even though the advanced predictive version accounted for over 70% of versions in sensory block stage, there were nonetheless nearly 30% of unexplained variances which require in addition research.

Moreover, other patient characteristics, which include versions in spinal curvature lordosis, kyphosis, and scoliosis, subarachnoid area or CSF volumes also are capacity determinants of block stage but they have been no longer protected inside the evaluation. In addition, the assumption of identical quantity and period in every vertebral area in our version may also result in undeveloped bias. Finally, small doses of bupivacaine (< 5 mg) were less frequently utilized in our have a look at (7%), so the generalizability of our predictive version past the scope of our patient selection is debatable and it have to be used with warning.

CONCLUSION

Our study summaries' the connection amongst sensory block stages after spinal anesthesia and five effectively variables in a predictive regression model.This take a look at gives sensible and precious records about the associations among those features and is a useful manual for clinicians to predict sensory block top after single-shot spinal anesthesia. This may want to assist them to decide the hyperbaric bupivacaine dose with more ease for diverse sufferers who are receiving miscellaneous surgical methods. The generalizability of our findings calls for similarly research and extra

prospective research which acquire extra doubtlessly influential factors is important to better be expecting the sensory block height after spinal anesthesia with hyperbaric bupivacaine.

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