Scope
Volume 13 Number 4 December 2023

Original article

Effect of Conicity Index and Body Mass Index on the Level of Spinal Anaesthesia

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Abstract:

Introduction

Spinal anaesthesia is a popular form of regional anaesthesia for surgeries below the umbilicus. It involves injecting a small amount of drug into the subarachnoid space to achieve adequate anaesthesia. Recent studies suggest that obesity may lead to greater spread of spinal anaesthesia due to reduced CSF volume. Obesity also affects the level of anaesthesia achieved and is associated with increased cephalic extension levels. This study aims to investigate the effects of Conicity Index (CI) and Body Mass Index (BMI) on the level of spinal anaesthesia.

Methodology

Patients height, weight and waist circumference are noted. Based on the obtained values, patients were divided into two groups:

Group I—BMI 18.5–24.9

Group II—BMI>24.9

Vital parameters were observed and noted prior and post-spinal anaesthesia

After performing a routine spinal block, the time needed for:

- the block to reach up to the T10 level (in minutes),
- the maximal sensory block level,
- the time needed to reach the maximum sensory block level (in minutes),
- the relief time from the motor block (in minutes)

was recorded for every patient.

Results

A total of 108 patients aged between 18 to 65 years old were enrolled and completed the study without any protocol contraventions. Patients' demographics and baseline data were noted and BMI was calculated. Using the obtained BMI values, CI was calculated.

Correlating the Conicity Index to the time needed to reach block of T10 segment, a positive Pearson's correlation of coefficient of 0.265 which is statistically significant obtained. (p-value: 0.005).A statistically significant difference was observed in the time needed for blocks to reach a Bromage score of 4 between the groups . (Group A: 10.27 minutes (1.74) vs Group B: 8.07 minutes (0.96))The time taken to reach Bromage score 4 was significantly shorter (P < 0.001) in group B.

Correlating the Conicity Index to the time needed to reach Bromage 4 score, a positive Pearson's correlation of coefficient of 0.294 which is statistically significant obtained. (p-value: 0.002).When the Conicity Index was correlated to the time needed for 2 segment regression of spinal anaesthesia, statisticallyin insignificant Pearson's correlation of coefficient value of 0.207 obtained.(p-value: 0.032)

Conclusion: We found that there is a positive correlation between Conicity Index and the level of spinal anaesthesia achieved. The lower conicity index value, the larger the waist circumference and the faster the highest level of spinal anaesthesia blockade attained. Similarly, with higher BMI patients, the maximum blockade of spinal anaesthesia was achieved quicker.

Key Words: Conicity Index, Spinal Anaesthesia,

Introduction

Spinal anaesthesia is tremendously popular as a form of regional anaesthesia for surgical procedures below the umbilicus levels. This technique mainly involves injecting a minimal volume of the drug into subarachnoid space which in turn produces adequate anaesthesia and analgesia required for surgical procedures. After the administration of drugs through the spinal needle, differential autonomic, sensory, and motor blockade are achieved accordingly. However, the greatest challenge of this method appears to be the control of the spread of the local anaesthetic into the cerebrospinal fluid (CSF) for an adequate blockade.

Though various factors contribute to the spinal spread of local anaesthetic drugs, the influences are relatively minimal, occasionally unpredictable, and beyond the anaesthesiologist's control. Recent studies are suggesting that obesity results in greater cephalad spread of spinal anaesthesia in view of reduced CSF volume due to extradural vein distention and epidural fat.

However, these correlations have not been widely extrapolated for spinal anaesthesia. Also, 1997 WHO Expert Consultation on Obesity recognized the importance of abdominal fat mass which can vary considerably within a narrow range of total body fat and Body Mass Index (BMI). Hence, a few new indices including the Conicity Index have been established as a measure of central obesity.

It is also to be noted that, for patients who fall in the obese category BMI-wise, regional anaesthesia is rather preferred compared to other forms of anaesthesia. In overweight patients, increased intraabdominal pressure increases inferior vena cava pressure, which in turn causes distention of lumbar plexus; this distention reduces cerebrovascular volumes (2).Secondary to obesity, adipose tissue in the epidural space is observed to be more causing epidural veins dilatation, hence increased epidural pressure raises the block level (3,5)

In addition to that, it is observed that the local anaestheticwhich is injected during spinal anaesthesia becomes more concentrated with reduced cerebrovascular fluid as in obese patients increasing the level of spinal anaesthesia achieved. Also based on prior researches on the factors affecting extension levels in spinal anaesthesia, it is shown that there is increased cephalic extension levels whenthere is subarachnoid space's compression and hence a positive correlation between BMI and cephalicextension levels(7).The studies noticed a positive correlation between BMI and cephalic extension of the level of blockade achieved. This shows that the compression over the subarachnoid space increases the level of anaesthesia achieved.

Against this background, the correlation between the level of spinal anaesthesia and body adiposity, especially central obesity; merits closer attention. Hence, this study aims to determine the effects of Conicity Index (CI) and Body Mass Index (BMI) on the level of spinal anaesthesia.

Objectives of Study

- To assess the degree of correlation between preoperative conicity index value of the patient and the level of spinal anaesthesia achieved intraoperatively.
- To assess the degree of correlation between preoperative body mass indexof the patient and the level of spinal anaesthesia achieved intraoperatively.

Material and Methods

Source of Data

Study was conducted on patients undergoing spinal anaesthesia for elective surgeries at R. L. Jalappa Hospital, Tamaka, Kolar after informed consent .

Method of Collection

108 patients undergoing undergoing spinal anaesthesia for elective surgeries were selected and informed consent was be obtained.

Inclusion Criteria

- Patients aged 18 to 65 years
- American Society of Anesthesiologists (ASA) physical status grades I– III
- Scheduled for elective surgery under spinal anaesthesia

Exclusion Criteria

- Patients above 65 years old
- Patients under 18 years old
- Patients with central nervoussystem disease
- Patients with height under 150cm or over 185 cm
- Patients who have undergone surgical procedures lasting more than 2 hours
- Patients who had undergone a failed spinal block

Methodology

Study Design

Cross-sectional analytical study (two group comparison)

Sample Size

Mustafa Gunkaya et al. has reported the mean (SD) time to reach the T10 level to be 8.63 (3.2) among normal BMI group, 6.38 (2.26) among overweight BMI group, and 5.50 (1.51) among Obese BMI group. Since the minimum difference is between normal BMI vs overweight BMI group, these groups were used for sample size estimation.

Assuming alpha error of 1% (99% Confidence limit) to account for compounding alpha error due to multiple comparisons,

Power of 80%, ratio of normal: overweight= 1:1

The minimum required sample size to find the difference in mean time to reach T10 level between the two-study group was **54 subjects** in each group (108 subjects in total).

Formula

Sample size (n) = $\frac{2{S_p}^2[Z_{1-\frac{\alpha}{2}} + Z_{1-\beta}]^2}{{\mu_d}^2}$; ${S_p}^2 = \frac{{S_1}^2 + {S_2}^2}{2}$

where, S_1: Standard deviation in the group 1

S_2: Standard deviation in the group 2

μ_d : Mean difference between the samples

α: Significance level

1-β: Power

Sampling Procedure

1. **Patients' height and weight was measured.**

Height: Height is measured using a stadiometer to the nearest 0.1 cm with shoes and headbands off. Patients are made to stand with their feet flat on the floor with their heels against the corner where the wall and floor meet. Making sure their head, shoulders, and buttocks are touching the wall. Patients are ensured to be standing up straight with their eyes looking straight ahead. Their line of sight and chin are ensured to be parallel to the floor. For ease purpose, the following picture is shown to enable better patient compliance.

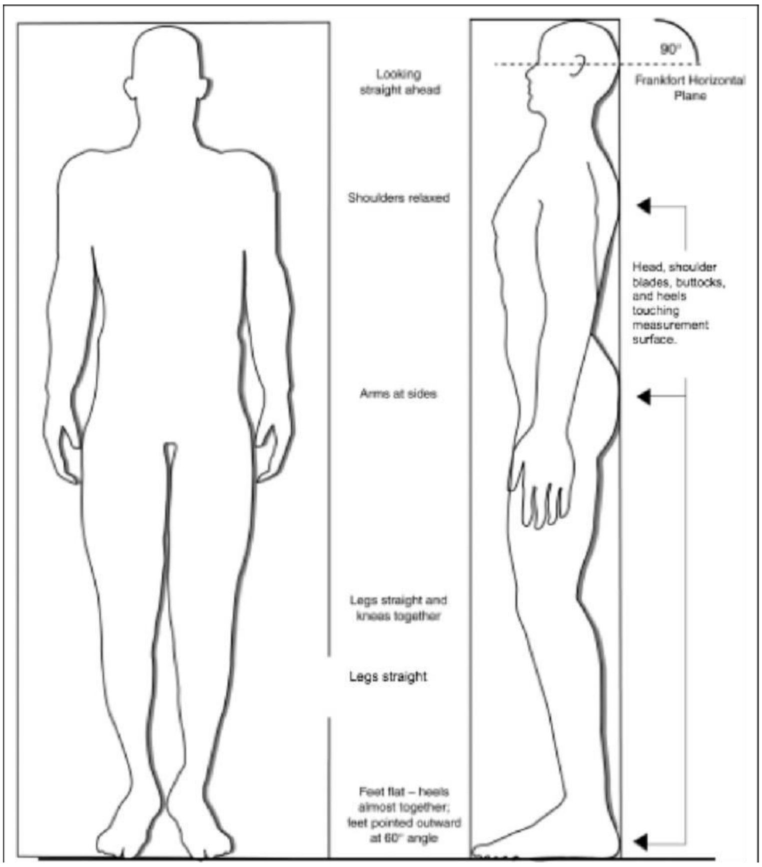


Figure 1 : Sample picture to measure height of the patients

Weight: Weight is measured using a digital standing scale, rounding off to the nearest 0.1 kg with light clothing and no shoes.

Based on the above obtained values, patients will be divided into two groups:

Group I—BMI 18.5–24.9

GroupII—BMI>24.9

Waist circumference is measured, in duplicate, at the midpoint between the lowest costal ridge and the upper border of the iliac crest using a non-stretchable and non-flexible measuring tape, whereby values are rounded off to the nearest 0.1 cm.

Whenever more than 2cm discrepancy is encountered, then a third measurement will be performed and the average of the 2 nearest values will be considered as Waist Circumference.

2. Before the start of the surgical procedure, an 18 G intravenous cannula will be secured and patient will be started on crystalloid infusion rate of 10 ml/kg/h.

3. Standard monitoring of pulse oximetry and electrocardiography and non-invasive arterial pressureof all patient will be monitored and noted.

4. Spinal anaesthesiawill be performed with patients in a sitting position where a 25 G Quincke needle will be used to make the lumbar puncture at the L3–L4 level. After sterile opalescent cerebrospinal fluid is observed flowing out of the needle,3ml of Injection Bupivacaine HCl 0.5% (Heavy) will be injected.

5. Upon shifting into operation theatre, routine monitoring (Heart rate, electrocardiogram, blood pressure measurements, and peripheral oximeter readings) done and noted. Heart rate (HR) and mean blood pressure (MBP) are to be measured three times before anaesthesia with an interval of 2 minutes between measurements, and the average values will be recorded.

6. Under aseptic precautions, after confirming the L3-L4 interspace and proper positioning, spinal anaesthesia was administered with a 25-G Quincke needle. The drug was slowly injected intrathecally over 10 seconds after free flow of opalescent cerebrospinal fluid is obtained. After injection, patients are immediately positioned in the supine position prior to surgery.

7. At the same time, non-invasive blood pressure measurements along with other vital parameters was observed and noted continuously post-spinal anaesthesia

8. After performing a routine spinal block, the time needed for:
    a. the block to reach up to the T10 level (in minutes)
    b. the maximal sensory block level
    c. the time needed to reach the maximum sensory block level (in minutes)
    d. the relief time from the motor block (in minutes) was recorded for every patient.

9. During surgical procedure, every five minutes, patient's sensory level was evaluated with a pin-prick test, and motor block levels was evaluated with a Modified BromageScale.

Modified Bromage Scale

0—patients can easily move their legs,feet, and knees
1—patients just able to flex knees with free movement of feet
2—patients unable to flex knees but with free movement of feet
3—patients cannot move their feet and knees

10. The maximum level achieved is noted and the duration to achieve respective maximum blockade noted. The time taken for both sensory and motor blockade regression were also noted.

11. Any intraoperative complications to be encountered like nausea and vomiting, discomfort, shivering, or allergic reactions was noted and managed accordingly.

12. After obtaining ethical clearance, study was registered with CTRI.

Results

A total of 108 patients aged between 18 to 65 years old were enrolled and completed the study without any protocol contraventions. Patients' demographics and baseline data were noted and are presented in Table 1.

	Group 1 (BMI 18.5 – 24.9) n=54	Group 2 (BMI >24.9) n=54	Total (n=108)	p-value
Mean (SD) Age, in years	43.9 (13.5)	44.2 (12.9)	44.0 (13.2)	0.890
Sex				
Male	32 (59.3%)	27 (50.0%)	59 (54.6%)	0.334
Female	22 (40.7%)	27 (50.0%)	49 (45.4%)	
ASA class				
1	24 (44.4%)	28 (51.8%)	52 (48.2%)	
2	30 (55.6%)	26 (48.2%)	56 (51.8%)	0.441
Mean (SD) Weight	58.8 (6.0)	75.3 (8.5)	67.1 (11.0)	<0.001
Mean (SD) Height	163.3 (5.7)	162.3 (6.4)	162.8 (6.1)	0.423
Mean (SD) BMI	22.0 (1.6)	28.6 (2.7)	25.3 (3.9)	<0.001
Mean (SD) waist circumference	84.0 (8.1)	92.0 (11.4)	88.0 (10.6)	<0.001
Mean (SD) Conicity Index	1.28 (0.11)	1.24 (0.12)	1.26 (0.12)	<0.001
Hemodynamic Parameters				
Heart rate	80.7 (12.0)	88.3 (12.4)	84.5 (12.7)	0.002
SBP	121.8 (15.0)	125.0 (15.4)	123.4 (15.2)	0.284
DBP	76.1 (10.7)	79.0 (12.2)	77.5 (11.5)	0.184
MAP	91.3 (10.7)	94.3 (11.5)	92.8 (11.2)	0.161
SpO2	98.94 (0.99)	98.96 (1.06)	98.95 (1.02)	0.926

Table 1: Demographic characteristics of cases

Parameters such as age, height, ASA class, baseline HR, SBP, DBP, MAP and SpO_2 values were found comparable between the two groups with no significant differences were observed. (Table 1). However, significant difference in mean body weight and waist circumference noted between the groups.

Group 1: weight 58.8 kg, BMI 22 kg/m^2, waist circumference 84.0 cm, Conicity Index 1.28

Group 2: weight 75.3 kg, BMI 28.6 kg/m^2, waist circumference 92.0 cm, Conicity Index 1.24

Based on the weight, height of patients, BMI was calculated. The obtained BMI values showed significant difference amongst both the group. Using the obtained BMI values, Conicity index was calculated whereby significant difference was noted amongst both the groups too.

Group 1: BMI 22 kg/m2, Conicity Index 1.28

Group 2: BMI 28.6 kg/m2, Conicity Index 1.24

From Group 1 to Group 2, BMI increased proportionally with waist circumference and in turn Conicity index reduced in proportion to the BMI values. A statistically significant difference was observed in these regards between the two groups ($p < 0.01$).

	Group 1 (BMI 18.5 – 24.9) n=54	Group 2 (BMI >24.9) n=54	Total (n=108)	p-value
Time needed for block to reach T10 level (min)	6.80 (1.14)	3.91 (1.34)	5.35 (1.91)	<0.001
The time needed to reach Bromage 4 (minutes)	10.27 (1.74)	8.07 (0.96)	9.17 (1.78)	<0.001
Maximum sensory blockade level – Median (IQR)	6 (6 – 6)	6 (5 – 6)	6 (6 – 6)	<0.001
The time needed for 2 segment sensory regression (in minutes)	157.8 (7.4)	150.5 (5.5)	154.2 (7.4)	<0.001

Table 2 : Comparison of outcomes between two study groups

In comparing the times needed for blocks to reach the T10 level, the following mean values noted: group Group A: 3.91 minutes (1.34), Group B: 6.80 minutes (1.14). In both groups the maximum block level achieved extended up to T6. In group A, the time needed to reached desired T10 was longer than the corresponding time taken in group B.

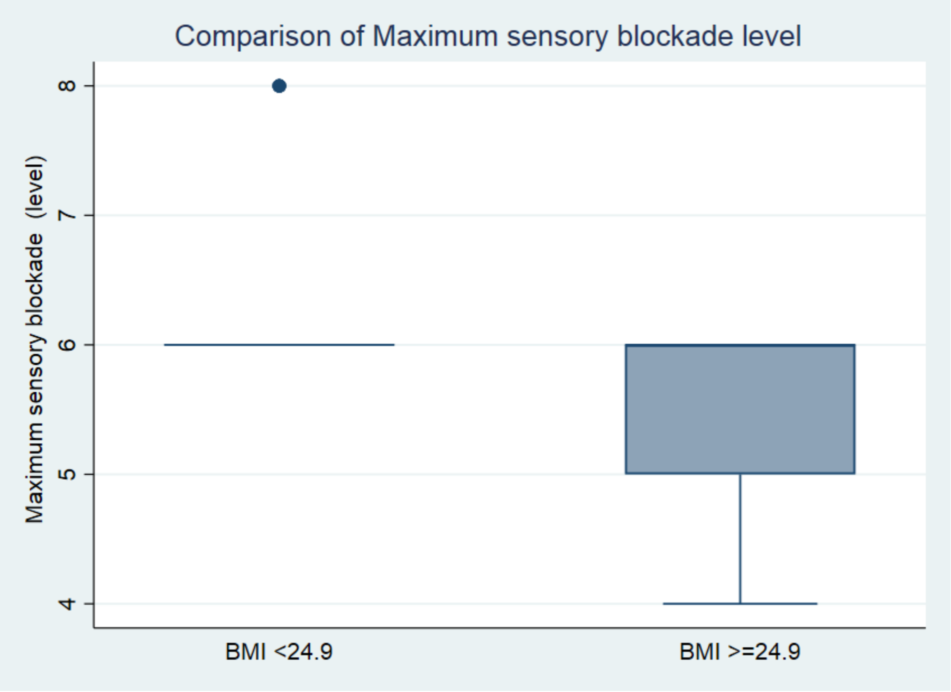
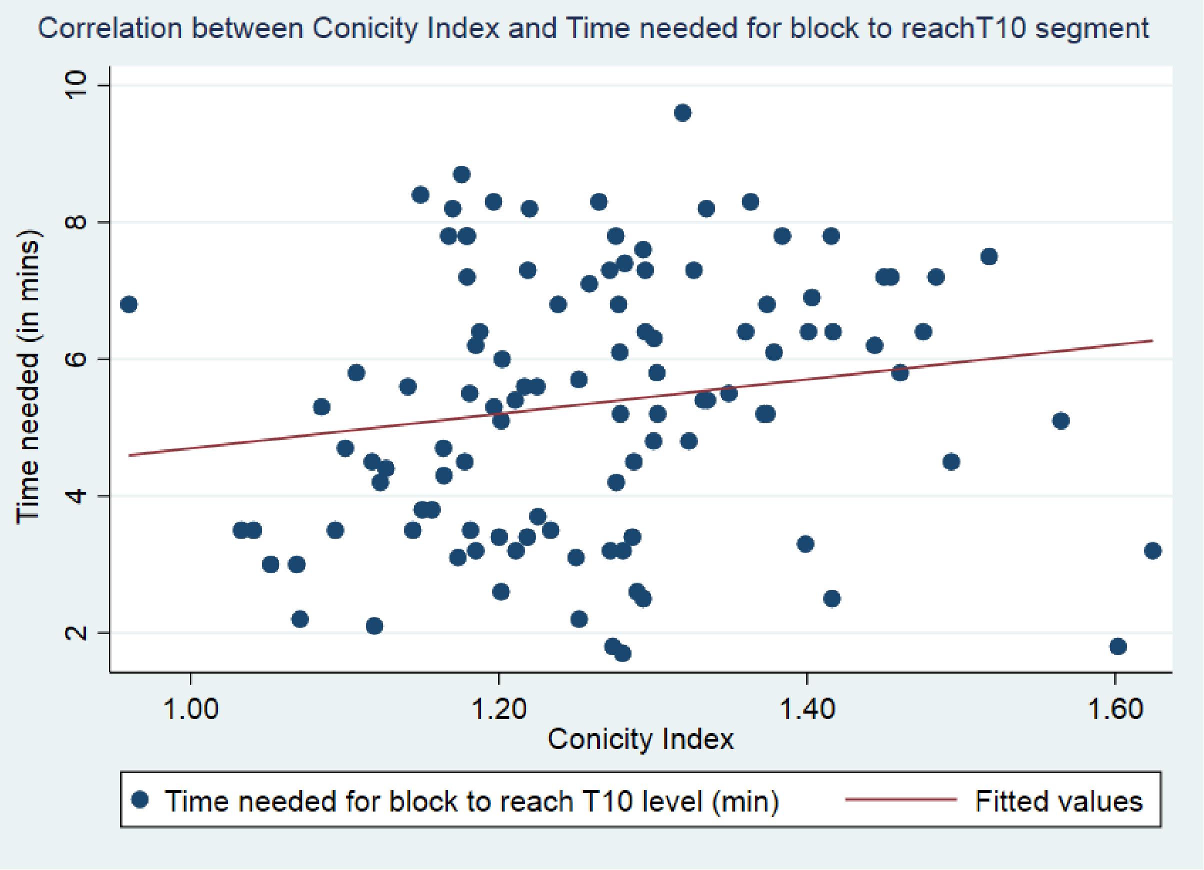


Figure 2: Comparison of maximum sensory blockade level and BMI

Correlating the Conicity Index to the time needed to reach block of T10 segment, a positive Pearson's correlation of coefficient of 0.265 which is statistically significant obtained. (p-value: 0.005)



Pearson's Correlation Co-efficient	p-value
0.265	0.005

Figure 3: Correlation between Conicity and Block parameters

A statistically significant difference was observed in the time needed for blocks to reach a Bromage score of 4 between the groups . (Group A: 10.27 minutes (1.74) vs Group B: 8.07 minutes (0.96))The time taken to reach Bromage score 4 was significantly shorter (P < 0.001) in group B.

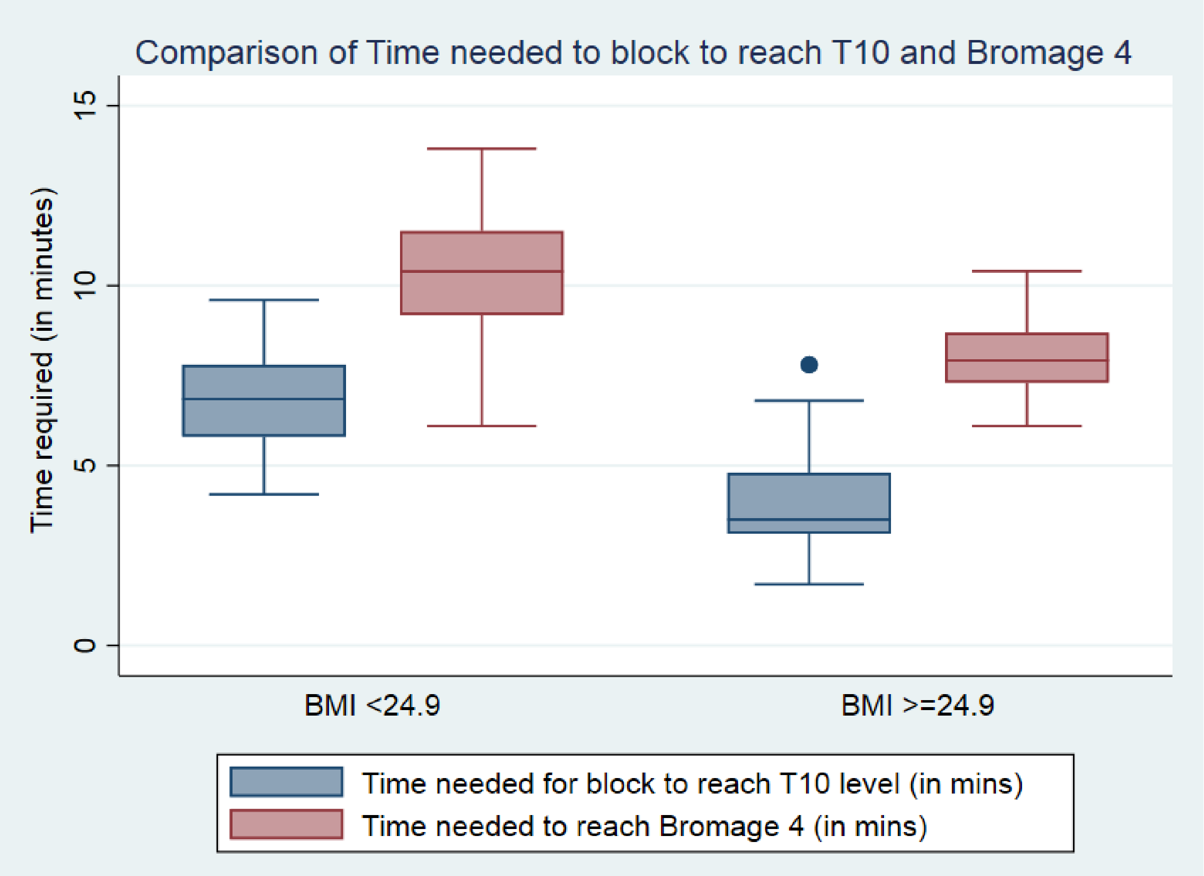


Figure 4: Comparison of time needed for block to reach T10, time needed to reach Bromage 4 and BMI

Correlating the Conicity Index to the time needed to reach Bromage 4 score, a positive Pearson's correlation of coefficient of 0.294 which is statistically significant obtained. (p-value: 0.002)

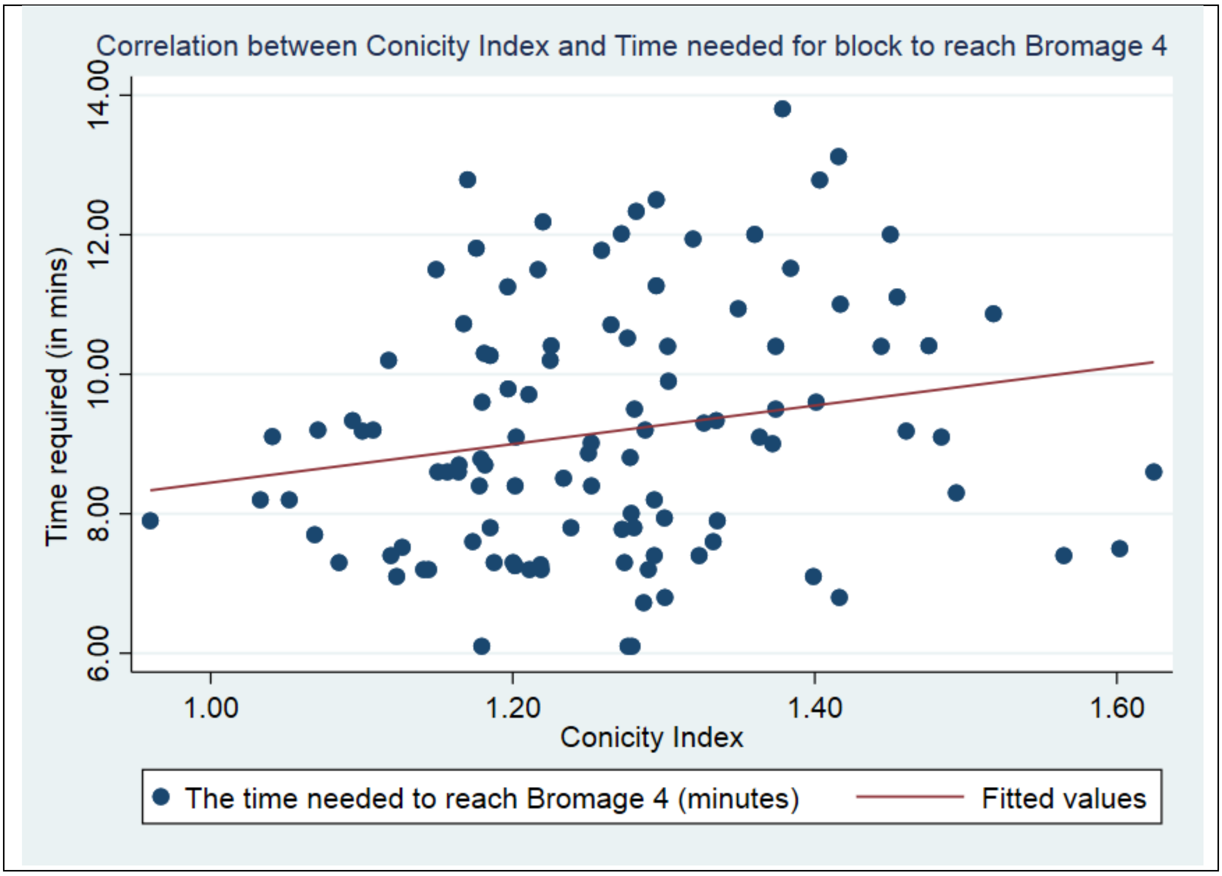


Figure 5: Correlation between Conicity Index and time needed for block to Bromage 4

As for the time needed for 2 segment sensory regression (in minutes), the following values were obtained (Group A: 157.8 minutes (7.4), Group B: 150.5 (5.5)) It was observed that the 2 sensory segment regression was prolonged in group B than group A, (P < 0.001)

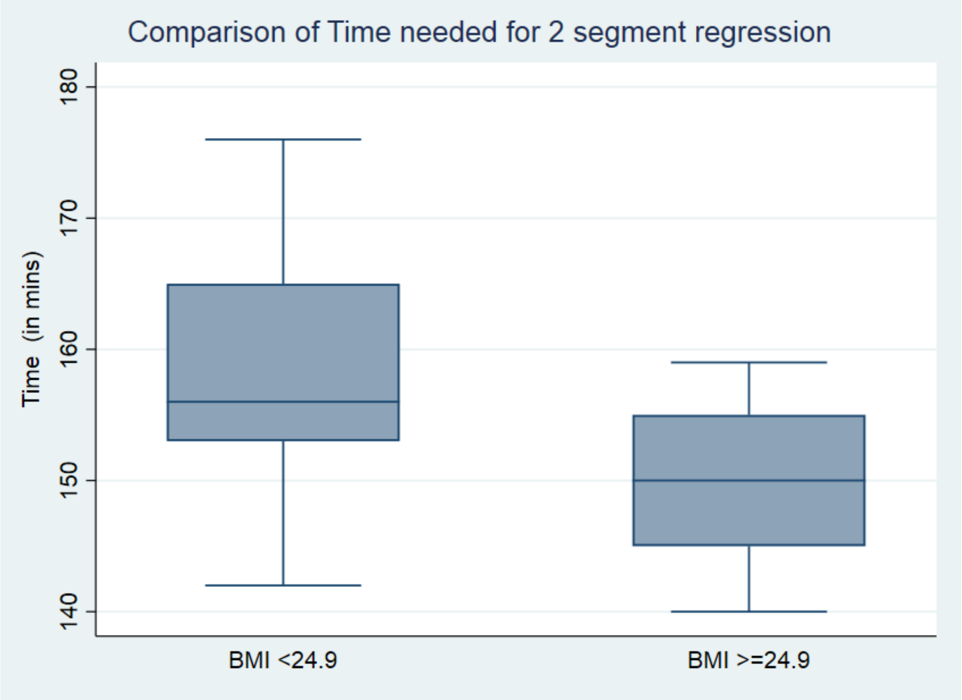
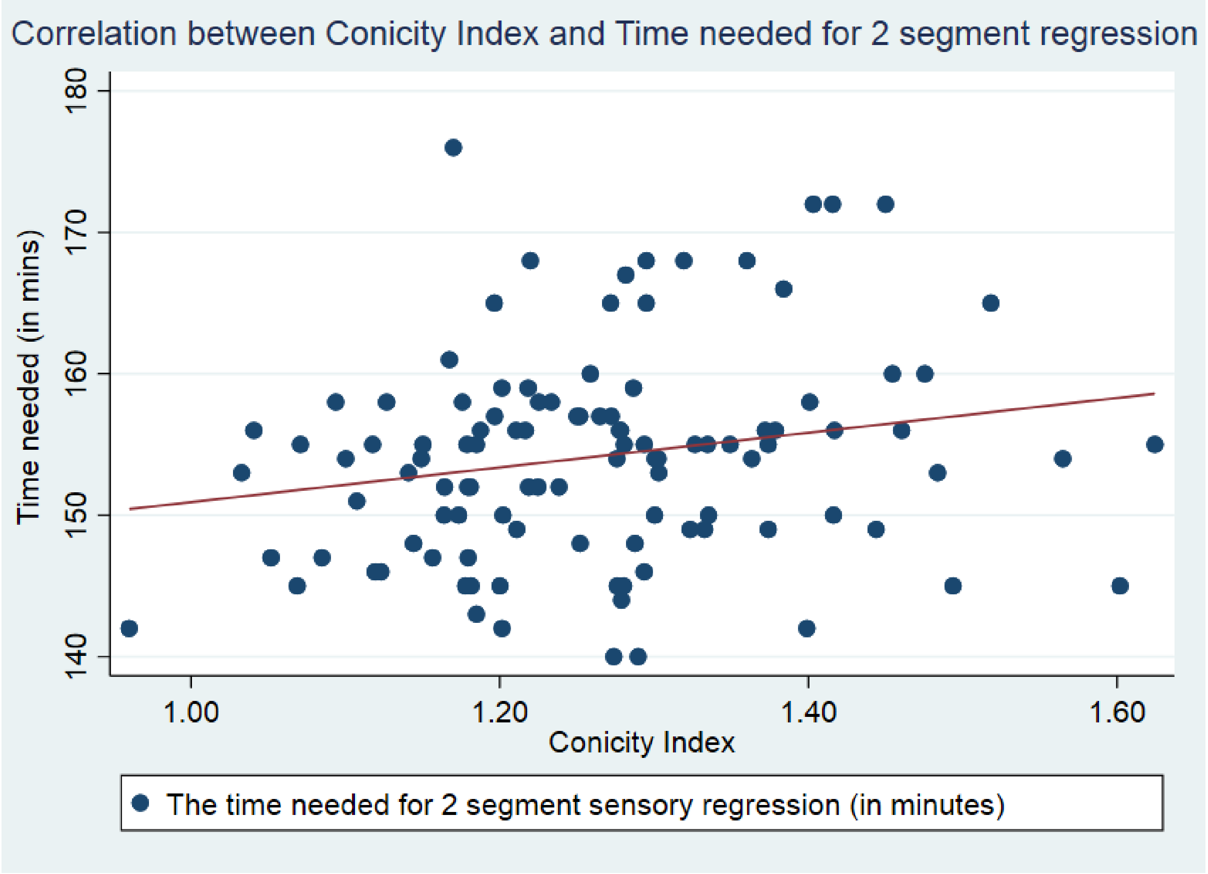


Figure 6: Comparison of time needed for 2 segment regression and BMI

When the Conicity Index was correlated to the time needed for 2 segment regression of spinal anaesthesia, statisticallyin insignificant Pearson’s correlation of coefficient value of 0.207 obtained.(p-value: 0.032)



Pearson's Correlation Co-efficient	p-value
0.207	0.032

Figure 7: Correlation between Conicity Index and time needed for 2 segment regression

No patients required intraoperative analgesic supplementation or generalanaesthesia conversion. No intra-operative and post-operative complications were recorded.

Discussion

The Conicity Index (CI) is a measure used to evaluate an individual's body shape by comparing the circumference of their waist to that of their hips. When the index is high, it suggests the person has more fat around their abdomen than their hips.

A higher conicity index indicates a narrower subarachnoid space, which can lead to a more concentrated distribution of local anaesthetic and a higher level of sensory block. On the other hand, a lower conicity index implies a wider subarachnoid space, resulting in a more diffuse spread and potentially lower block levels. Thus, Conicity index can be used to proffers effectiveness of local anaesthesia spread in spinal anaesthesia.

Meanwhile, Body Mass Index (BMI) is a widely used measure of body fat based on an individual's height and weight. It is commonly utilized to assess the risk of developing various health conditions, such as cardiovascular diseases and diabetes. However, recent studies have also explored the relationship between BMI and the level of spinal anaesthesia achieved during surgical procedures.

Research has shown a significant correlation between BMI and the level of spinal anaesthesia achieved (3). Higher BMI individuals tend to require lesser doses of local anaesthetics to achieve adequate anaesthesia levels compared to those with lower BMI. This can be attributed to several factors, including increased subcutaneous fat interfering with drug distribution and altered CSF dynamics in obese patients.

Hence, understanding the relationships between conicity index, BMI, and spinal anaesthesia are crucial for anaesthesiologists to achieve optimal patient outcomes. By assessing these indices preoperatively, anaesthesiologists can predict the extent and quality of spinal anaesthesia.

Hogan et al. suggested that obesity may increase the cephalad spread of local anaesthetics due to decreased CSF volume in patients with high BMI. This could explain exaggerated spread and decreased dose requirement due to decreased anaesthetic dilution (5). Other factors include inferior vena cava compression and increased abdominal pressure. It is understood that the decrease in CSF volume due to increased abdominal pressure causes inward movement of soft tissues through the intervertebral foramen displacing CSF from the lumbar region(2). Supporting the above-suggested mechanism, Magnetic resonance imaging shows decreased lumbar volume of CSF in obese patients, with an inverse correlation between cephalad extent of spinal anaesthesia and lumbar CSF volume (5).

Greene, on the other hand, suggests that obesity per se does not increase local anaesthetic spread, but rather the large buttocks of obese patients, which position the vertebral column in a Trendelenburg position, favour cephalad spread of local anaesthetics.

Some studies suggest that obese patients may have higher levels of puncture in spinal anaesthesia due to the inaccurate assessment of spinal level by palpation (4). Others have found a significant correlation between the spread of pinprick analgesia and higher BMI.

In accordance with the findings of our study, Carpenter et al. found an inverse correlation between cephalad sensory block and CSF volume when a fixed dose of local anaesthetic (lidocaine 50 mg) was used. Interestingly, Pitkanen's study found each increase in BMI with 1 kg/m^2 increased the analgesic level by one dermatome. Similarly, McCulloch and Littlewood et.al found a highly significant correlation between BMI and the cephalic spread of spinal analgesia.

Though multiple studies revealed a tendency towards higher cephalad spread of local anaesthetics in obese patients compared to patients with normal BMI (2,3).

Contrastingly, Norris (1,6) showed no correlation between cephalad spread of sensory block and patient BMI. However, the drawbacks of this study include the fixed dose of hyperbaric bupivacaine usage and the exclusion of morbidly obese patients in the study.

The study by Carvalho and Collenges(4) used various local anaesthetic doses required to produce spinal anaesthesia in obese versus non-obese parturients. They concluded that the dose required to produce successful anaesthesia was not different in morbidly obese than non-obese parturients.

A retrospective analysis suggested no risk of cephalad spread in obese individuals unless their BMI is greater than 50 kg/m^2(2,5). This result aligns with Freund et al.'s report on sensory and motor block spread during spinal and epidural anaesthesia. The study found that the mean duration of surgery in obese patients was longer than other groups, emphasizing the need for careful assessment of subarachnoid local anaesthetic dose to avoid late spinal anaesthesia failure and risk of general anaesthesia conversion (3).

The study by Whitty et al. tried to control factors affecting the subarachnoid spread of local anaesthetics, using ultrasound for L3-L4 puncture level marking and strict control over injection duration and time between subarachnoid injection and patient positioning supine found that there was a direct correlation between waist circumference, weight and level of spinal anaesthesia block attained.

Conclusion

The findings of our study postulate in accordance to majority of prior studies on similar topic. We found that there's positive correlation between Conicity Index and the level of spinal anaesthesia achieved. The lower conicity index value, the larger the waist circumference and the faster the highest level of spinal anaesthesia blockade attained. Similarly, with higher BMI patients, the maximum blockade of spinal anaesthesia was achieved quicker.

Reference

1. Nkwana M, Monyeki K, Lebelo S. Body Roundness Index, A Body Shape Index, Conicity Index, and Their Association with Nutritional Status and Cardiovascular Risk Factors in South African Rural Young Adults. Int. J. Environ. Res. Public Health. 2021;18(1):281.

2. Günkaya M, Arar C, Mordeniz C, Baran O, Topçu B. Effect of waist circumference and body mass index on the level of spinal anaesthesia.Ain Shams J. Anesthesiol. 2022;14(1).

3. Wang H, Chen H, Fan Y, Jing Y, Song X, She Y. Relationship Between Body Mass Index and Spread of Spinal Anesthsia in Pregnant Women: A Randomized Controlled Trial.Med Sci Monit. 2018;24:6144-6150.

4. Kim W, Lee J, Ko J, Ahn H, Park S, Gwak M et al. The Effect of Body Mass Index on Spinal Anaesthesia for Total Knee Replacement Arthroplasty: A Dose-response Study.Anaesth Intensive Care. 2012;40(3):410-416.

5. Rato Q. Conicity index: An anthropometric measure to be evaluated. Rev Port Cardiol(English Edition). 2017;36(5):365-366.

6. Motamed N, Perumal D, Zamani F, Ashrafi H, Haghjoo M, Saeedian F et al. Conicity Index and Waist-to-Hip Ratio Are Superior Obesity Indices in Predicting 10-Year Cardiovascular Risk Among Men and Women.Clin. Cardiol. 2015;38(9):527-534.

7. Brendan Carvalho, Jeremy Collins, David R. Drover, Lindsey Atkinson Ralls, Edward T. Riley; $ED^{50}$and $ED^{95}$of Intrathecal Bupivacaine in Morbidly Obese Patients Undergoing Cesarean Delivery. Anesthesiology 2011; 114:529–535.