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Research Article

An Observational Study on the Relationship of Patient's Body Mass Index and Depth of Spinal Needle Insertion

Shirley Paulina, Haripriya Ramachandran*, Rakesh Kalappa, Shilpa Sathyamurthy

Department of Anaesthesia, MVJ Medical College & Research Hospital, RGUHS, Bengaluru, India.

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ABSTRACT

Background: The distance from the skin to the subarachnoid space varies at different levels of the vertebrae and from patient to patient. Knowing the distance from the skin to the subarachnoid space beforehand may help the procedure go more smoothly and ensure that the spinal needle use is of the right length.
Methods: An observational study was conducted on 100 patients posted for infra umbilical surgeries of various specialties under spinal anaesthesia. Intraoperatively after a successful spinal with midline approach at the L3-L4 level, the length of the needle from the skin to the subarachnoid space was immediately measured and this actual length was compared with the expected length obtained using Bonadio's formula. The relationship between a patient's BMI and depth of spinal needle insertion and the reliability of Bonadio's formula to predict skin-to-subarachnoid space was studied.
Results: From our study, a positive correlation was obtained between patients' weight, BMI, waist circumference and depth of spinal needle insertion and also between the Skin to Subarachnoid space distance (SSD) measured intraoperatively with the predictive value obtained using Bonadio's formula. The correlation between height and arm circumference was not much significant.
Conclusion: Skin-to-subarachnoid space distance correlates with weight more than BMI. Bonadio's formula can be used to calculate the skin to subarachnoid space depth before performing spinal anaesthesia. After seeing the results, weight was the variable which had a significant correlation with Spinal Needle Depth (SND), hence we formulated two equations using weight to predict the depth of spinal needle insertion to reduce the incidence of multiple attempts during the procedure and to enhance patient comfort.
The regression equation using actual values of needle depth:
SND = 2.292 + [0.044 x weight]
And regression equation using Bonadio's values of needle depth is:
Needle depth= 2.681 + [0.037 x weight]

Introduction

Spinal anaesthesia was the first major regional anaesthesia technique introduced into broad clinical practice and is also the technique of choice to provide anaesthesia for most of the lower limbs as well as lower abdominal surgeries.

Subarachnoid block is a skill that is difficult to acquire and the success of a block influenced by a number of variables, including the anesthesiologist's knowledge, skill and abilities, the patient's body habitus and positioning. The subarachnoid block is traditionally accomplished by adopting the surface landmark-guided approach in which the approximate location of the neuraxial midline is identified by palpation of the tips of the spinous processes. Due to obesity, spine deformity, prior spine surgeries, or degenerative changes associated

The authors declare no conflicts of interest.
*Corresponding author.
E-mail address: haripri20@gmail.com

with aging, these surface markers may be difficult to palpate or distorted in many adult patients, especially while the block is being performed by a beginner or a junior resident [1-2].

Due to these technical difficulties, there may be multiple attempts of spinal needle insertion which not only causes patient discomfort and dissatisfaction but may also increase performer (anaesthesiologist) anxiety. To avoid these complications, this study attempted to estimate the approximate skin to subarachnoid space depth (SSD) using Bonadio's formula, before performing the spinal anaesthesia and compare the value obtained with the actual length of needle that was inserted to achieve the block and also to estimate a correlation between the spinal needle depth and the Body mass index (BMI) [3-4].

Methods

SOURCE OF DATA: This is a prospective observational study done at our medical college after obtaining ethical clearance from the Institutional ethics committee. The study includes 100 patients of either sex, age groups ranging from 20 to 60 years, admitted to our hospital for elective infra umbilical surgeries during the period from November 2019 to October 2021, with all the patients belonging to ASA I/ II/ III.

STUDY TYPE: Prospective observational clinical study.

Inclusion criteria

1. Both male and female patients.
2. The age group is between 20 – 60 years.
3. Undergoing elective infra umbilical surgeries under spinal anaesthesia.
4. ASA I to III.

Exclusion criteria

1. Patients with Lordosis, Kyphosis, and Scoliosis.
2. Other than the midline approach for spinal anaesthesia.
3. Patients with oedema at the site of spinal anaesthesia.
4. Patients with previous lumbar spine surgeries.

After getting ethical clearance from the Institutional ethics committee, 100 consecutive patients coming for elective infra umbilical surgeries were enrolled for the study.

A pre-anaesthetic evaluation was done comprising of history of previous medical or surgical illness, previous anaesthetic exposure, drug allergies, respiratory tract infections, epilepsy and any other cardiac, hepatic or renal disorders. General physical examination, airway assessment, and a systemic examination were done and also preoperative assessment of the lumbar spine and anthropometric data like height, weight, BMI, arm circumference and waist circumference were measured and Body surface area (BSA) was calculated using Mosteller formula and noted down.

Every patient's SSD was determined with the assistance of BSA using Bonadio's formula.

The following are the formulas that earlier researchers used:

• Bonadio's formula: SSD (cm) = 0.77 cm+2.56 x BSA.

• Mosteller formula: BSA (m^2) = ([Height (cm) x Weight (kg)]/3600)2

After obtaining written informed consent, procedure was performed.

Materials: All supplies and equipment were arranged, which includes:

1) Emergency airway supplies and Emergency drugs [including Inj.Atropine, Ephedrine, Adrenaline, preservative-free Lignocaine 2 %, Dopamine, Noradrenaline]
2) Intravenous (IV) drip set, IV cannula of various sizes, laryngoscope with Macintosh blades, endotracheal tubes of various sizes, stylet, bougie, anaesthesia machine along with the circuits and cylinders.
3) Sterile tray with swabs and towels, sponge holding forceps
4) 25G Quincke needle
5) Sterile disposable 2ml syringe (2% lignocaine for skin infiltration) and 5ml syringe (to administer 0.5% Bupivacaine(H) in subarachnoid space)
6) A ruler to measure the depth of needle inserted.

Methodology

Pre-operative preparation: All patients received preoperative medication the night before surgery in the form of tablets of Alprazolam 0.25 mg and Pantoprazole 40 mg. Part preparation was done and patients were instructed to stay nil per oral 6 hours prior to surgery. On the morning of surgery tablet of Pantoprazole 40mg was given with a sip of water after which patients were shifted to the pre-operative room, where their baseline vital parameters (Pulse, Blood pressure, Respiratory rate, room air saturation) were assessed, and all investigations were checked and patients were counselled regarding the procedure. The intravenous line was secured with an 18 or 20 G cannula and patients were preloaded with 500ml of Ringer Lactate solution half an hour before administering spinal anaesthesia.

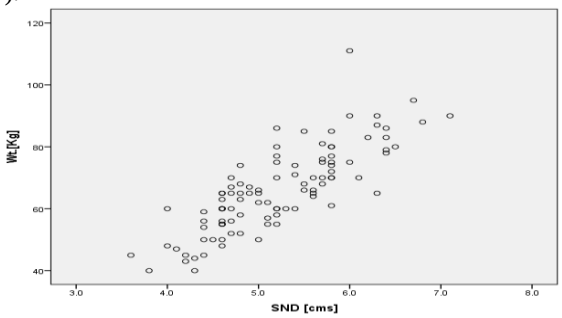
Technique: The patient was positioned in the sitting position with his/her back and neck fully flexed. Under strict aseptic precautions, the L3-L4 intervertebral space was identified and a Dural puncture was performed with a 25G Quincke spinal needle, under local anaesthesia using the midline approach. The needle was then inserted and progressed until cerebrospinal fluid (CSF) was obtained, indicating its penetration into the subarachnoid space and being verified by the free flow of CSF. After the medication was injected intrathecally, the spinal needle was carefully pulled out of the patient's back by being tightly held between the thumb and index finger. The depth of needle insertion was measured immediately using a standard scale and the value was noted. The value

obtained by actual measurement was compared with the estimated value obtained by Bonadio's formula.

Results

For this study, 100 patients of both sexes between the ages of 20 and 60 were recruited of which 39 were male patients and 61 were female patients. All 100 patients underwent elective infra umbilical surgeries under sole spinal anaesthesia.

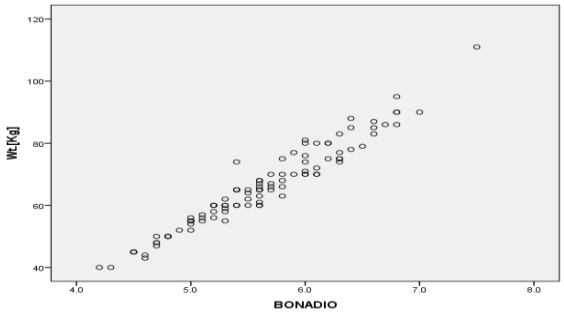
According to our study, it was noticed that weight, BMI, and waist circumference all significantly correlated with spinal needle depth, but the maximum correlation was seen between weight and spinal needle depth (Figure 1).



Correlation between weight (kgs) and spinal needle depth (cms); r=0.812, P<0.001

Figure 1- Correlation between weight and spinal needle depth

There was also a significant correlation between Bonadio's formula and weight, BMI, arm circumference and waist circumference. The maximum correlation was seen between Bonadio's formula and weight (Figure 2).



Correlation between Weight (kgs) and Bonadio's formula; r = 0.969, P < 0.001

Figure 2- Correlation between weight and Bonadio's formula

Therefore, in our Regression analysis, we found a stronger association between weight and the depth of spinal needle insertion and is also the variable which contributes maximum to Bonadio's formula. The best statistical model for determining the depth of spinal needle insertion consisted of two regression equations, one for spinal needle depth correlation with weight (A) and the other for Bonadio formula correlation with weight (B):

A: Needle depth= 2.292 + 0.044 x weight (using actual values)

B: Needle depth= 2.681 + 0.037 x weight (using Bonadio's values)

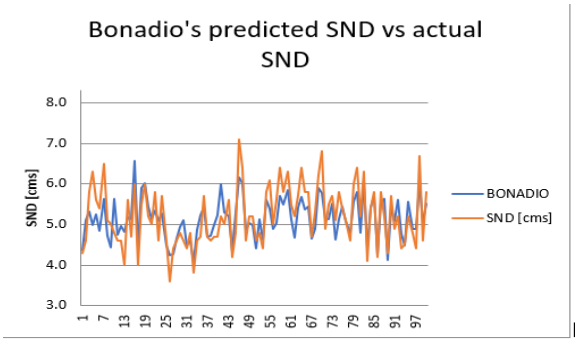


Figure 3- Correlation between Bonadio's predicted SND and actual SND

Graphical representation of the difference between Bonadio's predicted spinal needle depth and actual spinal needle depth (Figure 3).

Discussion

Spinal anaesthesia is widely used technique and is a straightforward procedure, yet, it can be technically challenging in some patients. The spinous process is the anatomic landmark that an anaesthesiologist identifies before performing a spinal, but the most common reason for the difficulty in identifying or palpating this spinous process is obesity, where there is excessive deposition of fat at the region (usually lumbar) where procedure needs to be performed [5-7]. Difficulty in palpating the spinous process means that the anaesthesiologist must attempt the procedure blindly and may require multiple attempts to be successful. This unnecessarily increases the patient anxiety, is more painful and increases the duration of the patient's stay inside the operation theatre.

Laying aside the technical difficulties, we also need to keep in mind that for a lean patient, the commonly used spinal needle may frequently be too long, whereas for an obese patient, it may be too short, leading to repeated unsuccessful punctures. There may also be a risk of breaking the spinal needle within the patient when the length is not adequate [8-9].

To reduce the challenges faced by the anaesthesiologist, the complications faced by patients and also to reduce the time taken for procedure performance, we decided to conduct an observational study on the patients with varying BMI, coming for surgeries for abdominal and lower limbs at our hospital. This study was intended to find out the association between the body mass index and the depth of spinal

needle insertion and also to compare the actual spinal needle depth with the expected spinal needle depth that can be calculated using various formulas.

The World health organisation's Asia-Pacific classification was taken as the guide for calculating BMI [10].

The variables taken for our study were weight, height, BMI, arm circumference and waist circumference and as per the results obtained from our regression analysis there was significant association between patients's weight and the depth of spinal needle insertion (r = 0.812, P <0.001, R2= 0.660), Body mass index (r = 0.668, P < 0.001, R2 0.446) and waist circumference (r = 0.666, P < 0.001, R2= 0.444).

When compared to weight and BMI in our study, the connection between height and depth of needle insertion in our study was poor (r = 0.444, P 0.001, R2=0.198), while the correlation between arm circumference and depth of needle insertion was significant but weak (r = 0.643, P 0.001, R2 = 0.414).

Arzola et al. also discovered a strong correlation between the patient's weight and BMI when they evaluated the association between the patient's anthropometric characteristics and skin to lumbar Dural sac distance [11].

Pregnant patients weren't included in our study because hormonal changes during pregnancy cause significant physiological changes like weight gain, softening of tissues and ligaments, lumbar lordosis, and accumulation of fat in the subcutaneous tissues, which could affect the validity of the present study's findings. This was corroborated by a study by Hazarika R et al., who found that pregnant women had longer skin to SSD [3].

In a study by Taman et al., the mean of the actual measured skin-to-subarachnoid space distance in the subject's was much shorter than the calculated values that were obtained using Bonadio's method, as this formula takes into account only the body surface area [12].

On analysing the study results, it was noticed that weight has a stronger association with the depth of spinal needle insertion than BMI, and among all the variables taken for study, weight contributes maximum to Bonadio's formula. Therefore, with the help of our statistician, the depth of a spinal needle insertion was predicted using the best statistical model and it can be represented in the form of two regression equations as follows:

A: Needle depth = 2.292 + 0.044 x weight (using actual values)

B: Needle depth = 2.681 + 0.037 x weight (using Bonadio's values).

All formulas generated from this study only work when the spinal needle is inserted perpendicularly to the skin using the midline technique.

Conclusion

We created two equations to predict the depth of spinal needle insertion using weight, as it is an important variable and this would mitigate multiple unsuccessful spinal attempts. The regression equations are:

A: Needle depth = 2.292 + 0.044 x weight (using actual values)

B: Needle depth = 2.681 + 0.037 x weight (using Bonadio's values).

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