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A prospective randomized study to identify the factors affecting the depth of insertion of spinal needle for subarachnoid block

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I. Introduction :

Spinal Anaesthesia is the anaesthesia wherein we deposit local anaesthetic into the subarachnoid space using a specialized needle called the spinal needle. Spinal blocks result in sympathetic blockade, sensory analgesia, or anesthesia and motor blockade, depending on the dose, concentration, or volume of local anesthetic, after insertion of a needle in the plane of the neuraxis[1]. Spinal anesthesia requires a small mass (i.e., volume) of drug, virtually devoid of systemic pharmacologic effect, to produce profound, reproducible sensory analgesia[1].

In a patient, the skin to Subarachnoid Space Depth (SSD) varies considerably at different levels of the spinal cord. It also varies from patient to patient at the same vertebral level as per age, sex and Body Mass Index (BMI)[2]. If we can determine the variants that influence the depth of needle insertion during spinal anaesthesia, the time required for a successful lumbar tap, the number of attempts needed and the associated complications may be reduced.

II. Aims and objectives :

1. To determine the relation between demographic characteristics and anthropometric measurements with the depth of spinal needle insertion
2. To find out the most important variant with which the depth of spinal needle insertion varies.

Key words : Subarachnoid block, spinal needle, depth, anthropometry

III. Methodology:

We conducted this prospective randomized observational study in a tertiary health centre. The inclusion criteria included

1. Patients above age of 18 years
2. All patients posted for elective surgeries under spinal anaesthesia.

The exclusion criteria were

1. All patients below 18 years of age
2. All patients posted for elective surgeries under general Anaesthesia
3. Patients with relative / absolute contraindications for spinal anaesthesia
4. Patients undergoing emergency surgeries.
5. Patient posted for Orthopaedic surgeries for fractures of lower limb where taking weight or height can be technically difficult.

The patients were explained about the study in vernacular language and written informed consent taken in a language they can understand. Before taking the patients for surgery, following anthropometric measurements were taken:

1. Weight recorded on a weighing scale and recorded.
2. Height measured with a tape fixed to a wall and recorded.
3. BMI calculated using the formula BMI = Weight (Kg) / Height (meters)^2
4. Distance from C7 to Tuffier's line measured with a measuring tape and recorded.
5. Abdominal girth measured at the level of umbilicus and recorded.

Patients were Nil by mouth for at least six hours before surgery. ECG leads, pulse-oximeter and NIBP were attached after taking the patient on OT table and preoperative vitals recorded. A 20 G intra-cath was secured in the left upper limb under all aseptic precautions and a Ringer Lactate infusion started slowly.
In sitting position, under all aseptic precautions, subarachnoid block was given in L_2-L_3 or L_3-L_4 space, by median or para-median approach, with 25G/27G spinal needle, after confirming clear and free flow of CSF. While giving subarachnoid block, the distance of the needle at which dural tap was obtained, was measured with a scale and recorded. With the help of a protractor, the angle at which the needle was inserted was also measured.
The data thus collected was compiled. Statistics of compiled data done and outcome recorded.

IV. Observations And Results:

- Results were carried out as per the provided data and requirement of author for analysis.
- SPSS version 22.0 statistical software package for Microsoft Windows (SPSS Inc., Chicago, IL) and MS-Excel were used for analysis purpose.
- The collected data were analyzed using Statistical Fisher's Chi-square exact test for inter-group comparisons where P values less than 0.05 considered as significant value.

1. Age of patient versus depth of needle

	Depth of Needle					
Age group	**3.5-4**	**4-4.5**	**4.5-5**	**5-5.5**	**> 5.5**	Total
10 to 19	2	1	1	4	1	9
20 to 39	5	13	9	8	4	39
40 to 59	6	12	19	11	4	52
60 and above	1	10	6	8	2	27
	14	36	35	31	11	127

Conclusion:

Test applied		Significance
Chi-square	10.47	No significant association between age and depth of needle
p-value	0.5741	

2. Gender of patient versus depth of needle

	Depth of Needle					
Gender	3.5-4	4-4.5	4.5-5	5-5.5	> 5.5	Total
F	10	28	12	9	3	62
M	4	8	23	22	8	65
Total	14	36	35	31	11	127

The chi-square statistic is 24.807. The *p*-value is .000055. The result is significant at $p < .05$.

Conclusion:

Test applied		Significance
Chi-square	24.81	Significant association between gender and depth of needle
p-value	0.000055	

3. Height Vs Depth of Needle

Table: Height versus depth of needle

	Depth of needle						
Actual Height	3.5-4	4-4.5	4.5-5	5-5.5	5.5-6	6-6.5	Grand Total
130-139	1	2					3

140-149	6	12	8	4	2		32
150-159	7	17	15	10	1	1	51
160-169		5	12	15	4		36
170-179				2	1	1	4
180-190						1	1
Total	14	36	35	31	8	3	127

Conclusion:

Test applied		Significance
chi-square	82.594	Significant association between height and depth of needle
p-value	4.00E-08	

4. Weight Vs Depth of Needle

Table: Weight versus depth of needle

	Weight				
Count of depth of needle	30-49	50-69	70-89	90-110	Grand Total
3.5-4	9	4	1		14
4-4.5	17	19			36
4.5-5	8	25	2		35
5-5.5	4	17	8	2	31
5.5-6	2	1	3	2	8
6-6.5				3	3
Grand Total	40	66	14	7	127

Conclusion:

Test applied		Significance
Yate's chi-square	64.689	Significant association between height and depth of needle
p-value	4.00E-08	

5. BMI Vs Depth of Needle

Table :BMI versus depth of needle

	BMI			
Depth of needle	10-20	20-30	30-40	Grand Total
3.5-4	7	6	1	14
4-4.5	12	24		36
4.5-5	7	27	1	35
5-5.5	4	21	6	31
5.5-6	2	4	2	8
6-6.5		1	2	3
Grand Total	32	83	12	127

Conclusion:

Test applied		Significance
Chi-square	30.73	Significant association between BMI and depth of needle
p-value	0.00065	

6. Distance from C7 to Tuffiers line Versus depth of needle

Table :Dist from c7 versus depth of needle

	dist c-7				
Count of depth of needle	20-30	30-40	40-50	50-60	Grand Total
3-4		7	7		14
4-5	1	19	47	4	71
5-6		6	25	8	39
6-7			2	1	3
Grand Total	1	32	81	13	127

Conclusion:

Test applied		Significance
Chi-square	15.498	No Significant association between dist from c7 and depth of needle
p-value	0.0781	

7. Abdominal girth Versus depth of needle

Table : Abdominal girth versus depth of needle

	Abdominal girth			
Depth of needle	40-70	70-100	100-130	Grand Total
3-4	8	6		14
4-5	6	62	3	71
5-6	3	25	11	39
6-7		1	2	3
Grand Total	17	94	16	127

Conclusion:

Test applied		Significance
Chi-square	47.60.	Significant association betweenCount of abdominal girth and depth of needle
p-value	1.00E-08	

8. Angle of needle Versus depth of needle

Table :Angle of needle versus depth of needle

	Count of angle of needle				
Depth of needle	60-69	70-79	80-89	90-100	Grand Total
3-4	1	4	9		14
4-5	1	24	43	3	71
5-6	3	15	20	1	39
6-7		3			3
Grand Total	5	46	72	4	127

Conclusion:

Test applied		Significance
Chi-square	9.869	No Significant association between angle of needle and depth of needle
p-value	0.3612	

9. Position of patient versus depth of needle

Depth of needle	Position		
	LD	WLD	Grand Total
3.5-4	6	8	14
4-4.5	6	30	36
4.5-5	7	28	35
5-5.5	8	23	31
5.5-6	4	4	8
6-6.5	1	2	3
Grand Total	32	95	127

Conclusion:

Test applied		Significance
Chi-square	6.93	No Significant association between position of needle and depth of needle
p-value	0.226	

V. Discussion:

We conducted an observational study in a tertiary health centre in patients posted for elective surgeries under spinal anaesthesia, to determine the relation between demographic characteristics and anthropometric measurements with the depth of spinal needle insertion and to find out the most important variant with which the depth of spinal needle insertion varies.

Demographics characteristics

In our study, there was no significant association between age of patient and the depth of the spinal needle. This finding was expected because the distance between skin and the spinal canal is not related to changes in age.

However, our finding regarding gender and depth of insertion of spinal needle was interesting. Among females, 61.29% had a depth of insertion between 3 – 4.5 cm, 35.48% had a depth of insertion between 4.5 to 5.5, while around 4.84% had a depth of insertion more than 5-5 cm.

On the contrary, among males, only 18.46% had a depth of insertion between 3 – 4.5 cm, while 69.23% had a depth of insertion between 4.5 to 5.5 cm, and 12.30% had a depth of insertion more than 5.5 cm. The chi-square statistic is 24.807. The *p*-value is .000055. The result is significant at $p < .05$

However, we found a significant difference as regards the gender of the patient, with more number of females having depth of needle insertion between 3.5 – 4.5 cm, while more number of males having an average depth of insertion between 4.5 – 5.5 cm. This difference can be attributed to the physical and anthropometric differences between males and females.

In their study titled 'A prospective observational study of skin to subarachnoid space depth in the Indian population,'[3] Smita Prakash, Parul Mullick et al, they found gender-based differences in SSD (subarachnoid space depth), with SSD in males (4.81 ± 0.68 cm) being significantly greater than that in the female population (4.55 ± 0.66 cm). These findings co-relate with our study.

In their original research article titled 'Estimation of Skin to Subarachnoid Space Depth: An Observational Study[4] by Rajib Hazarika, Dipika Choudhury et al, they found the SSD in adult males was 4.49±0.19cm which was significantly longer than that observed in female's 4.18±0.39cm.

Anthropometric measurements

The correlation between anthropometric measurements and depth of spinal needle insertion has been studied before. Our aim was to corroborate whether the findings of these studies matched with our finding.

In our study, we found a significant co-relation between the height of the patient and depth of needle insertion. The p value was 4.00E-08. Out of the 3 patients whose depth of insertion was between 6 – 6.5 cm, the heights were in the range of 150 – 159 cm, 170-179 cm and 180 – 189 cm. None of these had a height less than 150 cm. Of the 8 patients in whom the depth of insertion was between 5-5 to 6 cm, 50% were in the range of 160 – 169 cm. The single person whose height was in the range of 180 – 189 cm, had a depth of insertion between 6- 6.5cm.

Similarly, we also found a very strong association between weight of the patient and the BMI with the depth of spinal needle. All three patients who had a depth of insertion between 6 – 6.5 cm were in the weight

range of 90 to 110 kg. On the contrary, among the 40 patients whose weight range was 30 -9 kg, 17 (42.5%) had a depth of needle insertion between 4 – 4.5 cm.

As there was a co-relation of height and weight with the depth of spinal needle insertion, naturally, there was also a strong correlation of the depth of insertion with the BMI of the patient. (Weight/height^2). The test applied was chi-square test and the p value was 0.00065.

Since there is a strong co-relation between height of the patient and he depth of spinal needle insertion, we tried to measure the distance from the C_7 vertebra to the Tuffier's line (the line connecting the highest points of the iliac crests) and see if a correlation exists with the depth of needle insertion. Our expectation was that like height, there will be a strong correlation between these two. However, the results of our study were contradictory. There was no significant association between distance from C_7 and the depth of needle insertion, with a p value of 0.0781. This finding could be due to confounding factors or human errors, and more research is needed before any conclusions are drawn.

Another anthropometric parameter that we compared was the abdominal girth. The abdominal girth is affected by the amount fat and subcutaneous tissue. However, the increase in abdominal girth due to deposition of fat occurs mainly due to fat accumulating over the abdomen. We wanted to assess whether the increased girth increases the subcutaneous tissue and fat layer on the back as well sufficiently to affect the depth of needle insertion. We found a significant association between abdominal girth and depth of needle insertion, with the depth increasing with increase in abdominal girth. The p value was 1.00E-08.

We observed that none of the patients with an abdominal girth between 100 – 130 cm had a depth of insertion in the range of 3 – 4 cm. Similarly, None of the patients with abdominal girth between 40 – 70 cm had a needle of insertion above 6 cm. Of the 3 patients with depth of needle insertion between 6 – 7cm, one had abdominal girth between 70 – 100 cm while two were I the range of 100 – 130 cm.

Similar findings have been corroborated by many studies that compared the anthropometric measurements with the depth of insertion of needle during a subarachnoid block.

Smita Prakash, Parul Mullick et al conducted a study titled 'A prospective observational study of skin to subarachnoid space depth in the Indian population'[3]. They conducted this study

1. To determine the SSD (subarachnoid space depth) in Indian males, females, parturients and in the overall population
2. To derive formulae for predicting SSD
3. To determine which of the previously suggested formulae (Abe's, Bonadio's, Craig's, Stocker's and Chong's modified formula) for predicting SSD best suited our population in terms of both accuracy and ease of application.

The mean SSD in their overall study population was 4.7 ± 0.70 cm (range 2 to 8 cm). They found gender-based differences in SSD, with SSD in males (4.81 ± 0.68 cm) being significantly greater than that in the female population (4.55 ± 0.66 cm). SSD in the parturient population (4.73 ± 0.73 cm) was significantly greater than that in the female non-pregnant population (4.55 ± 0.66 cm). A positive correlation was observed between SSD and the body mass index (BMI) in the parturient and the overall population. Amongst the previously proposed formulae, Stocker's formula was most accurate in predicting SSD in their population. The SSD in their subjects (Indian population) was comparatively shorter than that observed in the Western population.

In their original research article titled 'Estimation of Skin to Subarachnoid Space Depth: An Observational Study[4] by Rajib Hazarika, Dipika Choudhury et al, three hundred adult patients belonging to American Society of Anaesthesiologist class I and II, undergoing surgery using spinal anaesthesia in various surgical specialities of Gauhati Medical College were selected by systemic sampling. Patients were divided into three groups: Group M containing male patients, Group F containing non-pregnant female patients, and Group PF containing pregnant female patients. SSD was measured after performing lumbar puncture. The relationship between SSD and patient characteristics were studied, correlated and statistical analysis was used to find a formula for predicting the skin to SSD. Mean SSD was 4.37±0.31cm in the overall population. SSD in adult males was 4.49±0.19cm which was significantly longer than that observed in female's 4.18±0.39cm which was comparable with SSD in parturient 4.43±0.19 cm. They concluded that Skin to SSD correlated with the BMI in all the patients.

A study titled 'Depth of spinal needle insertion and its associated factors among patients who underwent surgery under spinal anesthesia[9]', was published by Nesra Fati et al. They concluded that the distance from the skin to the subarachnoid space was differed among individuals. The SSD was affected by individuals' pregnancy status, BMI and weight. Hence, to minimize complications, these factors should be taken into consideration at the time of spinal needle insertion.

In their original research, 'Predictions of the Length of Lumbar Puncture Needles[6]', Hon-Ping Ma,Yun-Fei Hung et al, conducted a retrospective study of patients who underwent magnetic resonance imaging (MRI) of the L-spine.. They concluded that the best formula for men and women provides the most accurate estimates for adults based on the MRI of the L-spine.

Mohammad Reza Razavizadeh,Mohammad Reza Fazel, conducted a study titled 'The Relationship Between Patients' Anthropometric Characteristics and Depth of Spinal Needle Insertion[8]'. There was no significant correlation between depth of needle insertion and weight, height, gender, or arm circumference, when considered separately. They concluded that there is a strong relationship between depth of needle insertion and BMI, and between depth and the weight/height ratio; appropriate depths can be determined according to the equations obtained.

Hani Ibrahim Taman, Ahmed Mohamed Farid et al conducted a study titled 'Measuring skin to subarachnoid space depth in Egyptian population: A prospective cohort study[7]', to measure the SDD in overall Egyptian population and to find a formula for predicting SSD in Egyptian patients. They concluded that SSD in adult males was significantly longer than that in both pregnant and non-pregnant females, but it was nearly the same in pregnant and non-pregnant females. SSD in Egyptian population can be calculated based on height, weight, BMI, and BSA. Craig's formula was the most suitable to be applied to Egyptian population.

As per the laws of Physics, it is understood that the greater the angle of insertion of the needle during lumbar puncture, the more the depth of insertion will be. To see if this fact tallies in the study, we also measured the angle of needle insertion and compared it with the depth of needle insertion. However, surprisingly, in our study, the difference was statistically insignificant, indicating that the angle of needle insertion does not affect the depth of needle insertion. We attribute this incongruity to other confounding factors that can create bias.

We also tried to correlate the depth of needle insertion with the position of patient (with or without legs dangling), however, statistically the difference in the depth of needle was not significant.

VI. Conclusion:

While giving a subarachnoid block, if the anaesthetist is aware of the factors that can influence the depth of spinal needle insertion, he/she will be in a better position to gauge the depth of needle during insertion and errors and complications can be minimized. In our study, we found a strong correlation between male gender and greater length of needle puncture. We also found a strong correlation between height, weight, BMI and abdominal girth of the patient, with greater depth at higher values of all of these parameters respectively. We expected there to be a strong correlation between depth of spinal needle and the distance from C7 to Tuffier's line. However, our study did not reveal any clinically significant correlation. We attribute this finding to confounding factors which may have affected the result. We also expected there to be a correlation between angle of insertion with depth of the needle insertion, and we attribute this too to other factors which may have confounded the results. We also did not find any correlation between depth of spinal needle and position (with or without legs angling) during a subarachnoid block.

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