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A Prospective Observational Analytical Study to Evaluate the Variability of Skin Epidural Depth at Various Lumbar Spinal Levels Using Ultrasound

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Abstract

Background: Epidural placement in lumbar spine is used to provide anaesthesia for surgeries below umbilicus. However the success depends on correct identification of epidural space taking into consideration anatomic variations. Studies have found that ultrasound is an useful tool to help in identification of the epidural space. Hence we used ultrasound to study the variability of skin to epidural space depth at various lumbar spinal levels. *Study Method:* We conducted a prospective observational study of 100 patients in age group of 40 to 60 years to compare the skin to epidural space depth (SED) at L1-L2,L2-L3 and L3-L4 space. We also compared the variation at these levels with respectto sex and BMI. *Results and Conclusion:* We found that the SED was highest at L3-L4 space with a mean distance of 4.15 +/-0.21cm from skin followed by L2-L3 (4.12 +/-0.22 cm) and least distance in L1-L2 space (4.1 +/-0.22cm). Age and sex had no correlation to the SED. However the SED had a significant correlation with the BMI (kg/m^2) from which we could compute a formula. Mean (cm)=0.074(BMI)+2.534 where 0.074 is regression coefficient and 2.534 is a constant.

Keywords: Epidural; Lumbar Spine; Skin to Epidural Space Depth (SED); BMI.

Introduction

Lumbar epidural anaesthesia is being used to provide anaesthesia for surgery on the lower abdomen, pelvis and lower extremities. But a successful epidural placement depends upon the correct identification of epidural space.

At present one has to mostly rely on surface anatomical landmarks and 'loss-of-resistance' (LOR). Anatomical landmarks are useful but they are difficult to palpate in the obese and those with oedema in the back as well as do not take into account anatomical variations or abnormalities, and frequently lead toincorrect identification of a given lumbar interspace. The LOR technique (to air or saline) which is the considered gold standard for locating the epidural space is also a blind technique. This may lead to multiple attempts at epidural needleplacement, pain and discomfort to the patient, a failed block, complications and poor patient satisfaction. Therefore, any alternative technique that can overcome some of these shortcomings and facilitate localization of the epidural space is desirable.

A strong correlation between the depth of the epidural space measured on ultrasound and actual needle depth on puncture has been observed. Thus, the ultrasound has been considered a useful tool to identify the depth of the epidural space from skin.

In the lumbar spine,the skin epidural depth varies at the same level in different patients and also varies at different lumbar spinal levels in the same patient. The depth may also vary due to obesity, oedema of the back, post laminectomy surgeries, spinal

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instrumentation, age related changes, disc herniation, presence of spine abnormalities like scoliosis. By evaluating these variations in the skin to epidural depth in the lumbar spine using ultrasound we can improve the success rate of epidural insertion at first attempt, reduce the number of attempts and improve patient comfort.

Aims and Objectives

The aim of this study is to study the variability of the skin epidural depth at various lumbar spinal levels.

Primary Objective

To compare the skin to epidural depth at L_1-L_2, L_2-L_3, L_3-L_4 level.

Secondary Objective

To compare the variation of skin to epidural depth at these levels with respect to following:

1. Sex
2. BMI

Material and Methods

Study Area: Tertiary teaching institute

Study Design: Prospective analytical observational study

Methodology

Sample size was calculated considering previous study with nMaster 1.0 software. After approval from the hospital ethics committee and having written informed consent obtained from the patients, a total of 100 patients who fitted into the inclusion criteria were enrolled in the study.

Inclusion Criteria

Patients included in this study were in the age group of 40-60 years undergoing any elective surgery under any form of anaesthesia.

Criteria for Exclusion from the Study: Patient's refusal for participation.

Withdrawal/Discontinuation Criteria: None

Study Method

A pre anaesthetic evaluation consisting of general details, chief presenting complaints, past medical and surgical history, any medications and addictions was done. A detailed physical examination was done. BMI (kg/m2) was calculated from the weight and height of the patient. Written informed consent was taken from the patient in a language best understood. (English/Hindi/Marathi). Vital parameters such as pulse rate, blood pressure and saturation were recorded.

All measurements were done with the patients in sitting position with arms resting on a pillow. The skin was cleaned with an appropriate solution such as 2% chlorhexidine in 70% isopropyl alcohol.

A curvilinear probe of low frequency(2-5 Mhz) was selected. Initial depth of 7-8cm was set. Ultrasound gel was applied and the probe was placed in paramedian saggital plane i.e. 2-3 cm away from the spinous process in the lower back. The transducer was then tilted towards the midline to insonate in paramedian oblique sagittal plane. First the sacrum was visualised as a flat hyperechoic structure with a large acoustic shadow anteriorly. The transducer was then slid upwards.

A gap was seen between sacrum and lamina of L5 vertebra. This is the L_5-S_1 gap. The L_3-L_4,L_2-L_3,L_1-L_2 interlaminar spaces were located by counting upwards. The lamina was the first structure to be visualised which was hyperechoic in appearance. In between two laminae (interlaminar space) was the acoustic window through which all the neuraxial structures were visualised. The ligamentum flavum was seen as a hyperechoic structure in the interlaminar space.

Next the posterior dura was seen as hyperechoic structure anterior to the ligamentum flavum. The epidural space is hypoechoic gap between the two structures. As the epidural space and posterior dura are almost in distinguishable, the distance from the skin to the posterior dura was considered as the skin to epidural space depth. The probe was applied to the skin with minimal pressure to avoid tissue compression to minimise error in recording the depth.

The gain and focus of ultrasound machine was adjusted to obtain an optimal image. As soon as an optimal image was obtained the image was freezed. The depth from the skin to posterior dura was measured in L_3-L_4, L_2-L_3, L_1-L_2 spaces with built-in callipers in the ultrasound machine.

Statistical Analysis

After data collection, data entry was done in Excel. Data analysiswas done with the help of SPSS Software version 16. Quantitative data was presented with the help of Mean, Std Dev, Median and IQR. Comparison between skin epidural depth and physical parameters was done using Pearson's correlation analysis and linear regression analysis. Correlation at 0.01 level was taken as significant.

Observations and Results

Table 1: Distribution of study group as per Sex

Sex	Frequency	Percent
Female	40	40.00%
Male	60	60.00%
Total	100	100.00%

Table 2: Descriptive statistics of various study parameters

Parameter	N	Mean	Std Dev	Median	IQR	Minimum	Maximum
Age (yrs)	100	48.48	5.86	47.00	10.50	40.00	60.00
Weight (kg)	100	55.62	8.57	55.50	14.00	40.00	78.00
Height (m)	100	1.61	0.07	1.60	0.10	1.47	1.80
(Height) 2	100	2.59	0.23	2.56	0.32	2.16	3.24
BMI (kg/m2)	100	21.50	2.56	21.22	3.59	16.33	28.76
L1-L2 (cm)	100	4.10	0.22	4.09	0.29	3.10	4.63
L2-L3 (cm)	100	4.12	0.22	4.10	0.29	3.13	4.64
L3-L4 (cm)	100	4.15	0.21	4.13	0.29	3.16	4.66
Mean (cm)	100	4.12	0.22	4.11	0.29	3.13	4.64

Table 3: Correlation among study groups

Study Parameter	N	Mean	Std. Dev
Age(yrs)	100	48.48	5.86
BMI(kg/m2)	100	21.50	2.56
Mean(cm)	100	4.12	0.22

Table 4: Correlation between study parameters

	Mean(cm)		
	Pearson Correlation	Sig. (2-tailed)	N
Age(yrs)	-0.096	0.341	Not Sig
BMI(kg/m2)	0.879	0.000	Sig

Discussion

In the lumbar region, the skin to epidural space depth varies at the same level in different patients. Also there is intraperson variation in the skin to epidural space depth at different lumbar spinal levels. Due to these variations correct identification of the epidural space helps in minimising number of attempts required to accurately place an epidural catheter and maximising patientcomfort.

Numerous studies have been done to correlate the depth of theepidural space from skin with physical parameters likeage, sex, weight, height and weight/height ratio (BMI). Amongst these parameters maximum correlation has been found between the weight and weight/height ratio(BMI) and the distance measured between the skin and lumbar epidural space.

Recent studies have shown a positive correlation of the skin to epidural space depth measured using ultrasound with the depth measured by actual puncture using epidural needle. Hence ultrasound is emerging as a tool for identification of the epidural space.The aim of our study primarily was to compare the variability skin to epidural space depth at L_1-L_2,L_2-L_3,L_3-L_4 space in age group of 40-60 years using ultrasound. Secondarily we compared the variation at these levels with respect to sex and BMI.

We conducted a prospective observational analytical study with 100 patients in the age group of 40-60 years. All patients were subjected to ultrasound scanning of the lumbar spine. The skin to epidural depth was measured at above mentioned lumbar spinal levels.

In our study,there were 40 females and 60 males. (Graph 1) The mean age of study group was 48.48 years with minimum of 40 years and maximum of 60 years.The mean weight recorded was 55.62 kgs with minimum weight recorded being 40kgs and maximum of 78kgs. The mean BMI(kg/m2) of the study group was 21.50. The minimum BMI was 16.33 and maximum was 28.76.

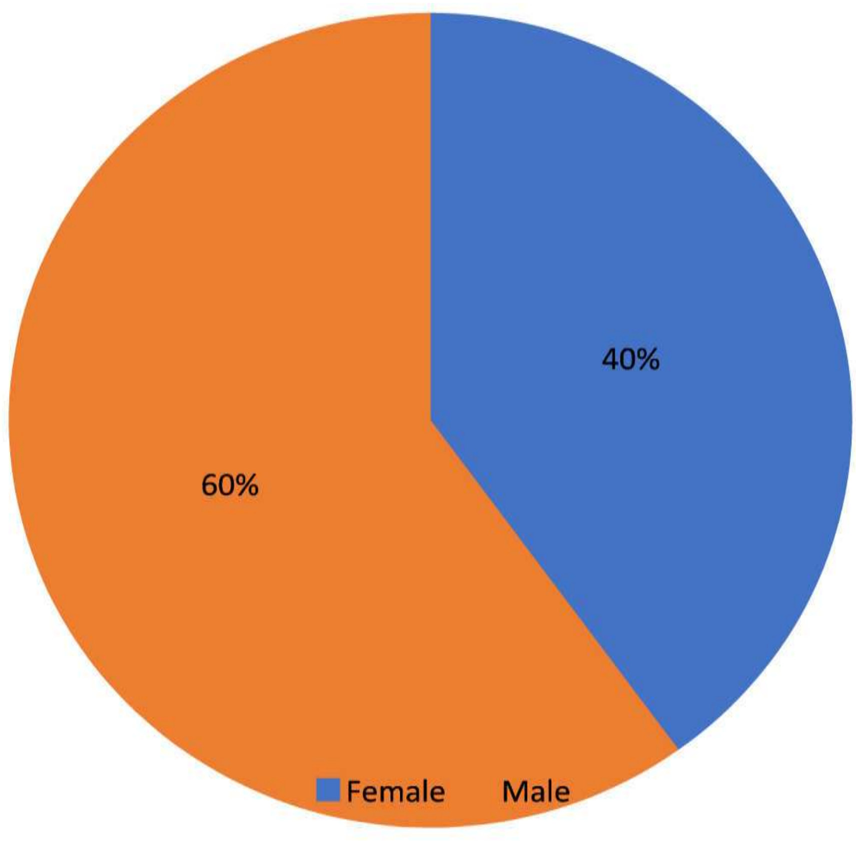
The mean distances measured with straight back posture at L_1-L_2, L_2-L_3 and L_3-L_4 were 4.1cm, 4.12cm and 4.15cm respectively. The median distance was 4.11cm. From this we infer that the skin to epidural space depth was highest at L_3-L_4 level and lowest at L_1-L_2 level. In the study done by GR Harrison et al. [19] in 1985 in 1000 parturients the median distance was found to be 4.7cm with maximum distance being measured at L_3-L_4 interspace i.e.4.93cm and minimum at L_1-L_2 interspace = 4.23cm.

We also found that age and sex were not correlated to the skin to epidural space depth both with straight and flexed back.(Pearson's coefficient=-0.096 and -0.090 and 2-tailed significance value of 0.341 and 0.371 respectively). The skin to epidural space depth showed significant correlation with the BMI. (Pearson's coefficient=0.879 and 0.826 with 2 tailed significance value of 0.00).

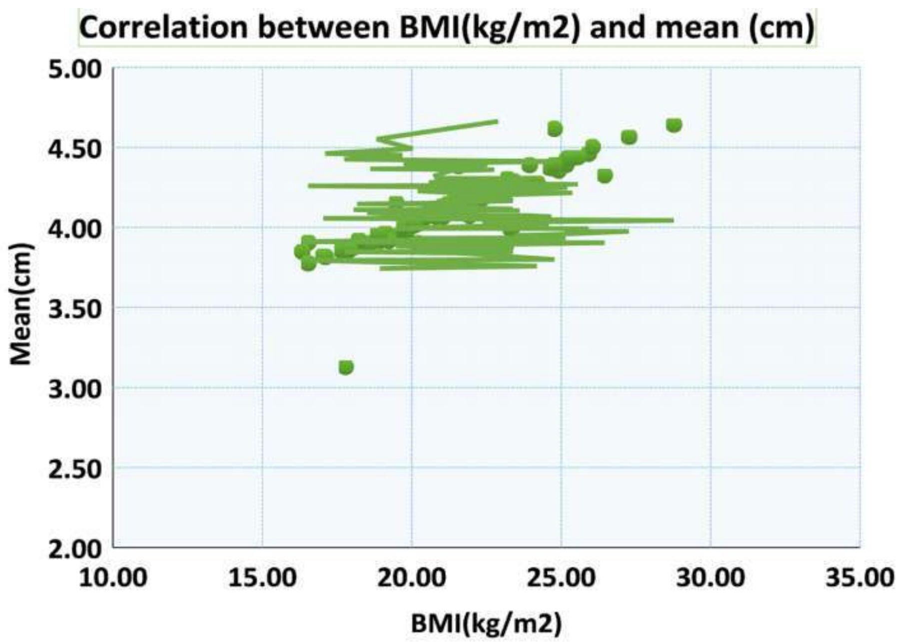
In the study done by Cha SM et al. [23] in Korean adults,the distances measured at the L_{2-3}, L_{3-4}, L_{4-5} and L5-S1 intervertebral space were 4.4 +/- 0.62, 4.6+/-0.69, 4.6+/-0.69 and 4.1+/-0.52cm, respectively. Correlation was found more significant between the epidural depth and weight/height ratio and BMI (correlation was significant at 0.01 level) than with height (correlation was significant at 0.05 level).

We could compute a formula to predict the mean skin to epidural space depth using BMI which is as follows.

Distribution of Study Group as per Sex



Graph 1:



Graph 2:

Mean(cm)= 0.074(BMI)+2.534

Where 0.074 is the regressioncoefficient and 2.534 is a constant. (r2=0.773). (Graph 2)

In the study done by Komaljit Ravi et al. [22] in 2009, it was found that there was no relationship between age and depth of epidural space in patients. But in all the age groups, as the BMI increased, the depth of the epidural space also increased and this difference was statistically significant ($p< 0.01$). They formulated a predictive equation of depth of epidural space in relation to BMI based on linear regression analysis:

Depth (mm) = a + b [BMI].

Where 'a' is the constant and is equal to 17.7966 and 'b' is the regression coefficient and is equal to 0.9777.

Abbreviations

US-ultrasound

LOR-Loss of Resistance

BMI-Body Mass Index

ASA-American Society of Anaesthesiology

Std Dev-Standard Deviation

N-Number

IQR-Inter Quartile Range

SED-Skin to epidural depth

Conclusion

Thus we could conclude that the skin to epiduralspace depth varies at different lumbar spinal levels with maximum being measured at L_3-L_4 and minimum at L_1-L_2. The skin to epidural space depth had no relation to age or sex of the patient and had a strong correlation with the BMI. These findings may help in improving the overall success rate of epidural catheter placement and better intraoperative and postoperative epidural anaesthesia or analgesia.

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