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RESEARCH ARTICLE
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ASSESSMENT OF SKIN-TO-EPIDURAL SPACE DISTANCE IN PEDIATRIC PATIENTS UNDERGOING SURGERIES: A SINGLE-CENTER STUDY AT THE SINDH INSTITUTE OF UROLOGY AND TRANSPLANTATION

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Abstract:
Background: Consider the growing gap between the skin and the epidural space, together with the potential risk of puncturing the protective meninges around the spinal cord in a narrower area, when giving lumbar and thoracic epidurals to children. The Loss of Resistance technique is used to identify the epidural space as we lack any visual modality to locate epidural space.
Objective: To determine the skin-to-epidural space distance in children presenting to Sindh Institute of Urology and Transplantation, Karachi, Pakistan.

Method: A retrospective observational study comprised a sample size of 214 participants. Consecutive non-probability sampling was employed. The study was undertaken by the anesthesia department of the Sindh Institute of Urology and Transplantation from January 2021 to December 2022. The mean and standard deviation of age, height, weight, and skin-to-epidural distance were computed. The post-stratification chi-square test results were statistically significant at a level of 0.05.
Results: The mean distance from the skin to the epidural gap was 1.74 ± 0.69 cm, with a range of 0.50 to 5 cm. The majority of individuals have an epidural distance ranging from 0.5cm to 3cm. Some individuals have an epidural distance ranging from 3.1 to 5 cm.
Conclusion: Most participants had a skin-to-epidural space distance between 0.5-3 cm. A weak positive correlation was observed between age and distance (5.1% variance), with a moderate Pearson correlation of 0.542.

Keywords: Epidural, skin to epidural distance, children, tuhoy needle, anesthesia

Introduction:

In children, pain management is very difficult task as they cannot significantly tell us about degree of pain perceived by them.[1] Opioids are important for paediatric perioperative pain treatment but have been associated with perioperative complications.[2] Therefore, safe and effective perioperative pain management should be on the basis of personalized approaches to the individual and surgical procedures, and multimodal analgesic techniques or regimens are recommended in many situations.[3] As an important factor in multimodal analgesia, the role of regional analgesia has been proven

effective in both adult and paediatric patients.[4] Caudal and epidural significantly decrease the postoperative pain in children and adult as well.[5] Therefore, Epidural analgesia is effective and safe procedure.[6] But sometimes we encountered potential side during epidural anesthesia effects include hypotension, bradycardia, nausea, vomiting, and shivering.[7] Caudal route is commonly employed for epidural anaesthesia in younger population. [8] The technique of loss of resistance (LOR) to air is employed to ascertain the presence of the epidural space. The distance is determined by measuring the length from the starting point of the needle to the location where we initially come across LOR.[9] The distance between the skin and the epidural space can be determined using several formulas. However, most of these formulas were developed for Western people and cannot be directly applied to our culture due to factors like as low BMI and malnutrition. The objective of this study is to determine the distance between the skin and the epidural space in children, and to investigate any potential association between the children's age, weight, and height. This research aims to reduce the occurrence of dura punctures and the associated complications. Having knowledge of the distance between the epidural and the skin helps enhance the efficiency of the treatment. As far as we know, there is no available data on this topic in Pakistan. Therefore, this study would help fill the gap in information in a setting with minimal resources.

Methodology:

A retrospective observational study was conducted at the Department of Anesthesia at SIUT. The study spanned a duration of one year, commencing in January 2021 and concluding in December 2022. The patient's files were examined following approval from the ethical review committee. The sample size for our study was determined using the Raosoft calculator, with a margin of error of 5%, a confidence interval of 90%, a population size of 1000, and a response distribution of 50%. As a result, the calculated sample size for our study was 214. Our research included patients ranging from 1 month to 15 years of age, who were classified as ASA I and II and undergoing elective surgery. Patients were excluded if they had a prior diagnosis of developmental delay, mental retardation, known coagulation disorder, allergy to any of the study medications, infection at the proposed caudal block location, anatomical deformity, or inability to successfully implant an epidural catheter. The study included all children who received epidural anesthesia in conjunction with general anesthesia, following approval from the institutional ethics committee. All of them received a comprehensive pre-anesthesia examination.

Prior to the procedure, all children were administered general anesthesia and had their airway secured using an appropriately sized endotracheal tube. The children were positioned in a lateral decubitus position, and the relevant anatomical landmarks were identified and covered with drapes. The epidural space was found using a midline approach, taking advantage of the loss of air resistance technique. Children received medical treatment using a 19 G Tuohy needle and a 22 G catheter. The needle was pushed forward using the left index finger and thumb, while the right thumb consistently exerted pressure on the syringe. Once all resistance has been eliminated, the needle is securely fastened and its distance from the skin is indicated. Once the area was identified, a catheter was placed and the needle was carefully removed. The measurement of the distance between the tip of the needle to the marking is conducted using a standardized scale and recorded. During the surgery, a solution containing 0.125% bupivacaine was administered at a rate of 6 ml per hour. Following the surgery, the children were transferred to the pediatric intensive care unit and administered a 0.125% bupivacaine infusion for pain relief.

The data were examined through descriptive statistics to encapsulate the demographic characteristics of the individuals. The mean, standard deviation, and range were computed for age, weight, height, and skin-to-epidural distance. Frequencies and percentages were calculated for gender and vertebral space distribution. Pearson correlation and regression analysis were conducted to examine the association between age and skin-to-epidural distance. The Pearson correlation was employed to evaluate the strength and direction of the linear association between age and the skin-to-epidural distance. The regression model was employed to forecast the skin-to-epidural distance in relation to

age. The regression model incorporated the computation of the R-value, R-squared, ANOVA, and coefficients to assess the degree of correlation and the model's predictive efficacy.
All statistical analyses were performed utilising SPSS software 22, with a significance threshold established at 0.05. The findings were analysed to ascertain the correlation between age and skin-to-epidural distance, as well as to evaluate the predictive significance of age in estimating epidural distance.

Results:
The study revealed that 65.4% of participants were male (140 patients), whereas 34.6% were female (74 patients). The spinal spaces most commonly utilised for the epidural procedure were T12-L1 (43.8%), T11-T12 (20.6%), and L1-L2(14.5%). The least often selected places were L4-L5 (1.9%) and T7-T8(1.4%), demonstrating variability in the selection of vertebral locations. (Table 1).

Table 1: Gender Distribution and Vertebral Space Frequency for Epidural Procedure in Study Participants

Gender	**Frequency(percentage)**
Female	74(34.6%)
Male	140(65.4%)
Vertebral Space	**Frequency(percentage)**
L1-L2	31(14.5%)
L2-L3	15(7.0%)
L3-L4	10(4.7%)
L4-L5	4(1.9%)
T10-T11	29(13.6%)
T11-T12	44(20.6%)
T12-L1	66(43.8%)
T7-T8	3(1.4%)
T8-T9	5(2.3%)
T9-T10	7(3.3%)

The mean age of the patient was 4.70 ± 3.15, ranging from a minimum of 5 months to a maximum of 15 years. The mean weight of the patient was 14.19±6.59, with a minimum weight of 4 kg and a maximum weight of 54 kg. The mean height of the patient was 92.89+25.43, ranging from a low of 20cm to a maximum of 160cm.The mean distance from the skin to the epidural space was 1.74 ± 0.69 cm, ranging from a minimum of 0.50 cm to a maximum of 5 cm (Table 2).

Table 2: Descriptive Statistics Of Age/Weight/Height/ Skin To Epidural Space Distance

Variables	Mean	Std. Deviation
Age(years)	4.7033	3.15473
Weight(kg)	14.19	6.597
Height(cm)	92.89	25.437
Skin to epidural space distance	1.7407	.69218

The predominant observation in Table 3 reveals that children aged 1-4 years primarily exhibited a skin-to-epidural space distance ranging from 0.5 to 3 cm, with 70 participants in the 3-4 years' cohort and 54 in the 1-2 years cohort. This implies that younger children generally possess a comparatively shorter distance from the skin to the epidural space. Conversely, older age groups displayed a reduced number of individuals within this range, resulting in a less uniform distribution of measurements. This pattern indicates a probable age-related anatomical variation in the epidural space. The p-value

of 0.482 indicates no statistically significant correlation between age and skin-to-epidural space distance. (Table 3).

Table 3: Age with respect to distance from skin to epidural space

Age(years)	Distance from skin to epidural space (cm)		P-value
	0.5-3	3.1-5	
1-2	54	3	0.482
3-4	70	2	
5-6	37	0	
7-8	21	0	
9-10	14	0	
>10	12	1	

Table 4: Regression Analysis Summary for Predicting from loss of resistance (skin to epidural distance and age)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.225	0.051	0.046	0.69536

ANOVA for Predicting loss of resistance (skin to epidural distance) and age

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	5.474	1	5.474	11.321	0.001
Residual	102.507	212	0.484		
Total	107.981	213			

Coefficients for Predicting loss of resistance (skin to epidural distance) and age

Model	Unstandardized Coefficients (B)	Std. Error	Standardized Coefficients (Beta)	t	Sig.
(Constant)	1.210	0.096		12.604	0.000
Age_	0.110	0.033	0.225	3.365	0.001

This regression analysis examines the correlation between age_ (the independent variable) and loss of resistance (skin to epidural distance (the dependent variable). An R value of 0.225 indicates a modest positive linear correlation between the two variables, while an R-squared value of 0.051 reveals that merely 5.1% of the variance in loss of resistance (skin to epidural distance) is attributable to age This indicates that additional factors may have a more significant influence on deciding loss of resistance (skin to epidural distance. The Adjusted R-squared score of 0.046, which accounts for the number of predictors, is low, signifying the model's weak explanatory ability. The Standard Error of the Estimate of 0.69536 indicates that the model's predictions exhibit a degree of imprecision. The F-statistic of 11.321, accompanied by a p-value of 0.001, signifies that the regression model is statistically significant, indicating a genuine association between age and loss of resistance (skin to epidural distance This indicates that age significantly influences loss of resistance (skin to epidural distance , although its limited explanatory capacity.

The unstandardized coefficient for age (B = 0.110) signifies that for each one-unit increment in age, loss of resistance (skin to epidural distance rises by 0.110 units. The t-value of 3.365 and a p-value of 0.001 indicate that this effect is statistically significant. The comparatively low Beta value of 0.225 signifies that the effect is minimal. In summary, although age is a notable predictor, the model's low

R-squared indicates it only partially accounts for the variability in loss of resistance (skin to epidural distance), implying that more predictors may be necessary for enhanced model precision. (table 4)

Table 5: Pearson Correlation between Age and loss of resistance (skin to epidural distance)

Variable	Age	loss of resistance (skin to epidural distance)
Age	1	0.542
loss of resistance (skin to epidural distance)	0.542	1
Sig. (2-tailed)	–	0.000
N	214	214

Note:

Correlation is significant at the 0.01 level (2-tailed).

The Pearson correlation analysis between age and loss of resistance (skin to epidural distance) indicates a modest positive correlation of 0.542, implying that as age increases, LOR also tends to increase. The correlation is statistically significant at the 0.01 level (2-tailed), evidenced by a p-value of 0.000, indicating that the observed association is exceedingly improbable to have arisen by chance. A correlation value of 0.542 signifies a moderate strength of link, suggesting that although a positive relationship exists, additional factors may also influence variations in loss of resistance (skin to epidural distance).

The sample size (N = 214) for this analysis is adequate to guarantee dependable results. A sample of this magnitude offers a robust foundation for generalisability, particularly given the large correlation that suggests a substantial link between the two variables. This data suggests that age may be a significant component in elucidating lor to some degree, however the correlation is insufficient to indicate a complete relationship. The association is moderate, indicating the potential presence of other impacting variables or nuances warranting further exploration.

DISCUSSION:

Proper insertion of the epidural catheter is the crucial factor in epidural anesthesia. Nakamura observed that the epidural catheter can be inserted up to a distance of 5 cm in the thoracic vertebrae and up to 3 cm in most newborns.[10] In a recent study, researchers examined the distance between the skin and spinal cord in children ranging from 1 to 13 years old. No Dural or neuronal damage was detected during the anesthesia of laparoscopic cholecystectomy.[11-13] A recent study utilized a sample of 616 pediatric individuals to assess the distance between the skin and the lumbar epidural in two specific regions: thoracic (n = 225) and lumbar (n = 363). This measurement was conducted utilizing the midline technique. The study revealed that the distance between the skin and the lumbar epidural and the body weight exhibited the strongest link with age, weight, and ethnicity.[14] Our study also confirmed the same finding, indicating that most patients' epidural distances were within the range of 0.5 cm to 3 cm across all age groups. The epidural distance varies between 3.1 and 5 cm in certain individuals. Consequently, we usually moved the needle forward by a distance of up to 3 cm (with a mean skin to epidural distance of 1.74 + 0.69). Additionally, we recommended that in cases where an individual did not experience any decrease in resistance after 3 cm, they should cautiously progress the needle by one millimeter increments to avoid puncturing the dura. The Belgian equation yielded a depth of 2.4 cm, while the Singapore patients had a depth of 1.7 cm. This 7 mm difference has significant clinical implications, such as the potential for dural punctures.[15] This conclusion aligns well with the average distance between the skin and the epidural space observed in the study. Lai *et al.*[6] stated that the distance from the skin to the epidural space is accurately recorded until the advancing needle encounters a loss of resistance, indicating entry into the epidural space.[14] Incorrect positioning of the epidural catheter can lead to puncturing the dura, and administering a large amount of local anesthetic into the spinal canal can be deadly. Precise space identification is essential in order to prevent these issues.[14] Studies indicate that epidural analgesia exhibits a significant rate of failure.[16,17]

This statement is quite paradoxical, and our research provides evidence for the opposite conclusion. Our study found no difficulties or dural punctures when delivering epidural anesthesia to a substantial number of patients. Therefore, we can confidently conclude that epidural anesthesia is safe when performed by skilled practitioners. Ho AM *et al*. did not report any adverse effects in their study of 69 individuals who underwent thoracic epidural anaesthesia.[18]

Our study yielded findings that closely resemble what we have just discussed, as we saw no problems associated with the use of epidural anesthesia. Based on the research conducted by Komaljit Kaur Ravi et al, there is no correlation between age, sex, or height and the distance between the skin and epidural space. However, there is a strong relationship between the distance between the skin and epidural space and weight and BMI. [7] In our analysis, we discovered that there is no association between age and the distance between the skin and epidural. Children experience speech impairments that hinder their ability to effectively express their distress to others.[8,9] Due to these crucial criteria and others, the use of epidural anesthesia in children leads to a painless and rapid recovery, and it is considered safe when administered by experienced doctors.[19] The retrospective methodology of this study introduces biases, such as recollection bias and data availability concerns, which may impact the accuracy of the findings.

A small or limited sample size might diminish the statistical power of the investigation, hence impeding the ability to derive strong and reliable results. Increased data size and extended study period may necessitate the validation of the study.

CONCLUSION:

The majority of participants demonstrated a skin-to-epidural space distance between 0.5 cm and 3 cm, exhibiting age-related differences. Regression study revealed a slight positive connection between age and the distance from the skin to the epidural space, with age accounting for merely 5.1% of the variance. The Pearson correlation study revealed a moderate association (0.542) between age and loss of resistance (skin to epidural distance), indicating that other factors may affect the epidural distance.

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Authors' contribution:
Shakeel, Sagar : Conception and designing
Vijay,Shakeel : Acquisition of data, data gathering and analysis, the initial version of the article.
Tanzeel, Qamar Abbas, Muhammed Abbas: Manuscript's final review and approval.

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