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Original Research Article

Measurements of Epidural Space Depth Using Pre-Existing CT-Scan Correlate with Loss of Resistance Depth during Lumber Epidural Catheter Placement

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Abstract

Background*:** The use of epidural catheters provides the best quality intra- and post-operative pain relief for various major thoraco-abdominal and lower limb surgeries. The process of placing an epidural catheter into the epidural space between the vertebrae can be challenging due to variations in spinal anatomy of different level, narrow intervertebral spaces and can cause catastrophic neurological complications. Though various studies have been shown to overcome the placement of epidural catheter using standard ultrasound method, using the pre-existing computer tomography depth correlate with loss of resistance in placing the epidural catheter would be a well adjunct tool for the procedure. ***Objectives: To correlate measurements taken from pre-existing computed tomography (CT) imaging to the loss of resistance depth as recorded during epidural placement. ***Methods*:** This Single procedural observational study was performed in Combined Military Hospital (CMH), Dhaka from 1st December 2018 to 30th November 2019. Fifty adult patients scheduled for lower abdominal and lower limb surgery under epidural anaesthesia (EA). The patient's advised/routine abdominal CT film was inspected by a radiologist, who was blinded to the results of the actual needle length, to determine the distance from the skin to the ligamentum flava the corresponding level of L2 to L5 interspinous spaces. The distance on the CT film in the midline was measured using a ruler against the measurement scale, conventionally represented as a 5 cm-10 cm scale with 1-cm divisions. The CT-derived depth was calculated using the principle of Pythagorean triangle trigonometry. ***Result***: In this study, Sixty eight percentages of patients (68%) Epidural-skin distance (ESD) had 4.7-6.8cm. Mean Epidural-skin distance 5.8±1.7cm. On evaluation of Loss of Resistance Depth, 46% of patients had 5.2-7.3cm depth of LOR, followed by 30% patients had 3.0-5.1cm and 12% patients had 7.4-9.5cm. Mean loss of resistance depth was 6.3±1.4 cm. It was evident from this study that positive significant correlation (r=0.941; p=0.001) between the CT-derived distance and Loss of Resistance Depth. ***Conclusion*:** It is conclude that using pre-existing CT-scan derived distance is helpful in prediction of the epidural space depth and it is correlates with actual loss of resistance epidural needle insertion depth placing the catheter in lumber region.

Keywords: Epidural Anaesthesia, Computed Tomography.

INTRODUCTON

Epidural anesthesia is a versatile technique widely used in anesthetic practice, it's potential to decrease post- operative morbidity and mortality has been demonstrated by numerous studies. To maximize its peri operative benefits while minimizing potential adverse outcomes, the knowledge of factors affecting successful catheter placement is essential [1]. Maintenance of analgesia by epidural catheters that allows patient control enhances patient satisfaction [2].

Drugs injected into the epidural space can block or modulate afferent impulses and cord processing of those impulses, same as the mechanism which operates when the same drugs are injected intrathecally. It is the fact that the epidural space is a relatively indirect method of access compared with intrathecal that provides potential clinical advantage, but also complicates matters [3]. The process of placing a catheter into the epidural space between the vertebrae can be challenging due to variations in vertebral anatomy, narrow spaces and causes neurological complications. One of the consequent risks is dural puncture with the potential complication of post dural puncture headache and, rarely, needle induced injury to the cord, making epidural placement a riskier procedure than a intrathecal anaesthesia procedure. The potential complications of spinal cord damage and lifelong quadriplegia, although relatively rare, are catastrophic. Having prior knowledge of the distance for epidural insertion may be helpful during this procedure in the prevention of complications.

Anaesthesiologists increasingly use ultrasound imaging to guide the placement of needles into the body for the purpose of doing medical procedures. For this, numbers of authors have studied the relationship of factors such as gender, body weight, weight-to-height ratio and body mass index (BMI) to the measure the distance from skin to the epidural space [4-6]. While most anesthesiologists have a general idea at what depth they should expect to encounter the epidural space, there can be a wide range of variability between individuals. However, none of these factors has proved helpful in predicting depth of the epidural space during insertion, for any individual patient it would be quite beneficial to know the specific depth to the epidural space prior to epidural needle placement.

The use of computed tomography (CT) for not only the diagnostic purposes but also in preoperative planning, most patients undergoing epidural catheter placement for control of pain for major surgeries will have recent regional imaging available for review at preoperative clinic. During epidural midline insertion, a CT-derived distance from the skin to the epidural space can be calculated using the perpendicular distance obtained from abdominal CT films and the angle of needle insertion.

Several studies support the examination of a recent CT scan to aid in the placement of a thoracic epidural catheter too. Making use of these scans may lead to faster epidural placements, fewer accidental dural punctures, and better epidural blockade [4]. Another study also shows that used of CT scan in locating the epidural space, may help to reduce the potential risk for cord damage and perhaps make thoracic epidural insertion safer [5]. Therefore aim of the study is to correlate distance taken on CT scan to the actual depth of loss of resistance during insertion.

MATERIALS & METHODS

This Single procedural observational study was performed in Combined Military Hospital (CMH), Dhaka from 1st December 2018 to 30th November 2019. Fifty adult patients scheduled for lower abdominal and lower limb surgery under epidural anaesthesia (EA).This data-based study was done after taking proper permission from the concerned departments, and the local ethical committee for the fulfillment of the requirements for the dissertation of the FCPS (Part -II) Examination of Bangladesh College of Physicians, and Surgeons (BCPS).

Inclusion Criteria

1. Adult patients undergoing elective surgery.

Exclusion Criteria

1. Patient's refusal.
2. Patients allergic to local anaesthetics.
3. History of bleeding disorders.
4. Taking anticoagulants.
5. Sepsis & infection at the site of catheter placement.
6. Pre-existing neurological deficit.
7. Patient had CT scan image paper of more than 6 months old.

Operational Definition

a. The hemodynamic variability will be defined as variability in SBP, DBP, MAP, HR.
b. Hypotension will be defined as systolic BP 30% below the base line.
c. Hypertension will be defined as systolic BP 30% above the base line.
d. Bradycardia defined as pulse rate below 50beats/minute.

Research Materials

- All the data were recorded in a preformed structured questionnaire.
- Epidural needle.
- CT scan machine.
- Multiparameter monitor will provide continuous SBP, DBP, MAP, PULSE, HR, SPO_2, ECG monitoring.

Data Collection Procedure

This prospective observational study was conducted among 50 patients scheduled for lower abdominal and lower limb surgery under epidural anaesthesia (EA) in Combined Military Hospital (CMH), Dhaka. Permission for the study was taken from ethical committee of combined military hospital, Dhaka. The patients were explained in details about the procedure, benefits and complications of the study and obtain informed written consent on the preoperative day. After arrival at the operation theater, base-line parameters like heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), SpO2, ECG were measured noninvasively.

Calculation of the CT-Derived Distance from the Skin to the Epidural Space

The patient's advised/routine abdominal CT film was inspected by a radiologist, who was blinded to the results of the actual needle length, to determine the distance from the skin to the ligamentum flava the corresponding level of L2 to L5 interspinous spaces. The distance on the CT film in the midline was measured using a ruler against the measurement scale, conventionally represented as a 5 cm-10 cm scale with 1-cm divisions. The CT-derived depth was calculated using the principle of Pythagorean triangle trigonometry.

Lumber Epidural Insertion and Measurement of the Actual Epidural Needle Insertion Length

Standard monitoring with non-invasive arterial pressure, ECG and pulse oximetry was used during the epidural catheter placement. The patient was then placed in an appropriate sitting decubitus position for lumber epidural catheter insertion. The imaginary line crossing the highest point of the iliac crest identified at the level of the fourth lumber vertebral body (L4) [7] was used to identify the level of the cephalad end of the spinous processes of L2 to L5 for insertion. An aseptic technique with a standard epidural pack was employed. Using a midline approach, the epidural needle was advanced slowly until loss of resistance to air was observed. The actual needle length at this point was marked on the needle and subsequently measured with a ruler.

All the observations were recorded in a preformed data sheet and all the results were analyzed using Statistical Package for Social Science. Qualitative data such as age and maximum dermatome achieved was analyzed statistically using Chi-square test. Quantitative data was presented as mean ± standard deviation (SD) and analyzed using the unpaired t-test. P value of <0.05 considered as data is statistically significant. Data processing work consist of registration schedules, editing computerization, preparation of dummy table, analyzing and matching of data.

RESULT

In this study, Sixty eight percentages of patients (68%) Epidural-skin distance (ESD) had 4.7-6.8cm. Mean Epidural-skin distance 5.8±1.7cm. On evaluation of Loss of Resistance Depth, 46% of patients had 5.2-7.3cm depth of LOR, followed by 30% patients had 3.0-5.1cm and 12% patients had 7.4-9.5cm. Mean loss of resistance depth was 6.3±1.4 cm. It was evident from this study that positive significant correlation (r=0.941; p=0.001) between the CT- derived distance and Loss of Resistance Depth.

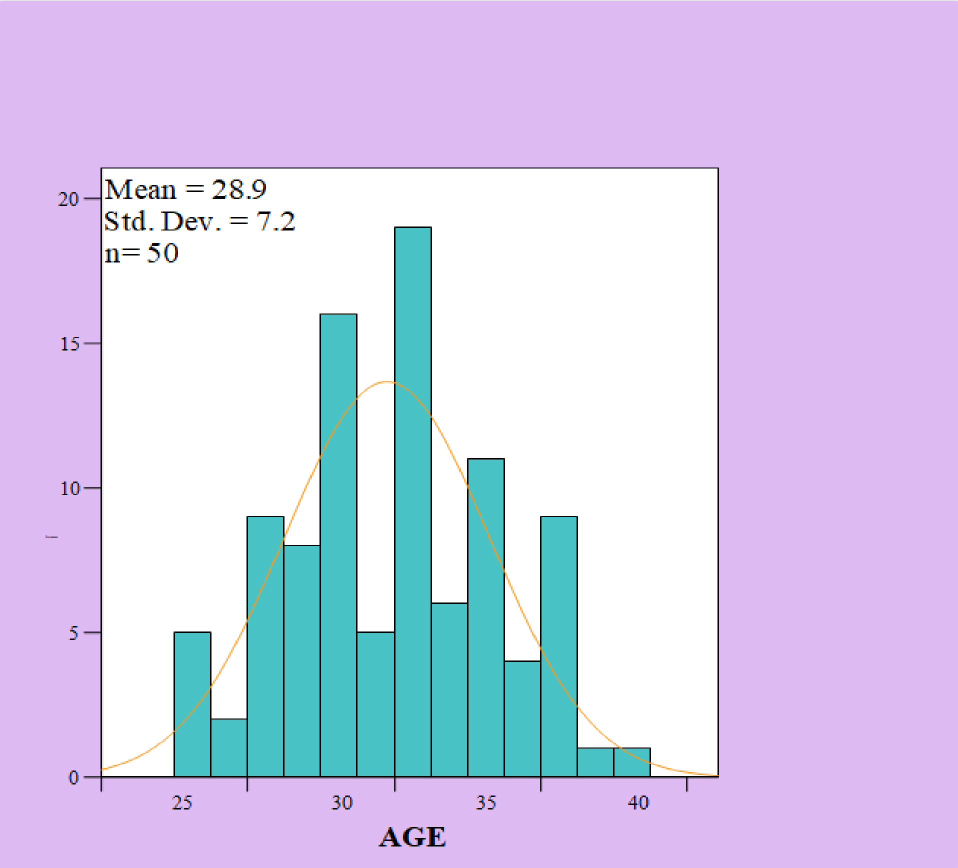

Figure 1: Histogram showing age distribution of the patients

Figure depicts the age distribution of the patients. Mean age was 28.9(SD±7.2) years. Age distribution resembles normal distribution where the numbers of younger aged patients were high in contrast to elderly age groups. About 82% patient's age was between 25 to 34 years. Least numbers of patients was present from other age groups.

Table 1: Distribution of patients demography and clinical characteristics (n=50)

Demography	Frequency	Percentage (%)
Age (years)		
25-29	24	48.0
30-34	17	34.0
35-40	9	18.0
Mean ± S.D.	28.9 ±7.2	
Body mass index (kg/m^2)		
18.5–24.9	5	10.0
25.0–29.9	26	52.0
30.0–34.9	19	38.0
ASA status		
I	15	30.0
II	35	70.0

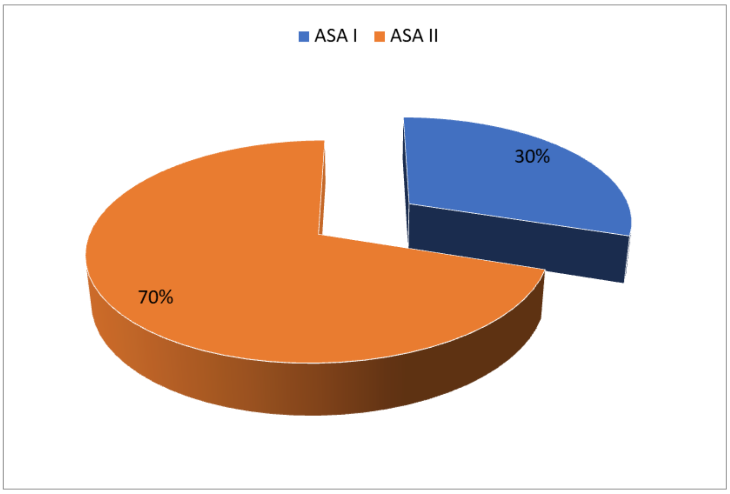

Figure 2: Distribution of the study population according to ASA status (n=50)

Table 2: Baseline haemodynamic status of the study subjects (n=50)

Variables	(Mean±SD)	Range
Vital signs		
Temperature (°C)	37.63 ± 1.27	36.3 −38.2
Heart rate (beats/min)	78.43 ± 19.34	65 −92
Respiratory rate (breath/min)	22.23 ± 7.23	18 −29
Mean arterial BP (mmHg)	92.50 ± 28.43	64 −98
Complete blood count (CBC)		
Hb% (gm/dl)	10.8 ± 1.9	8.3 – 11.6
TC of WBC (10^9/l)	14.2 ± 7.5	2.38 – 47.4
Platelet count (/mm^3)	184401±100003	7000-599000
Others		
S. Creatinine (mg/dL)	0.9± 0.01	0.7 – 1.2
Lactate level	37.5 ± 18.3	12 – 112

Table 3: Assessment of CT-derived Skin to Epidural space distance and Loss of Resistance Depth (n=50)

	Frequency	Percentage (%)	Mean±SD	CT-A
Epidural-skin distance (ESD)				0.5±0.2
2.5-4.6 cm	9	18.0		
4.7-6.8 cm	34	68.0	5.8±1.7	
6.9-9.0 cm	7	14.0		
Loss of Resistance Depth				
3.0-5.1 cm	15	30.0		
5.2-7.3 cm	23	46.0	6.3±1.5	
7.4-9.5 cm	12	24.0		

Epidural level				
L1-L2	5	10.0		
L2-L3	20	40.0		
L3-L4	25	50.0		

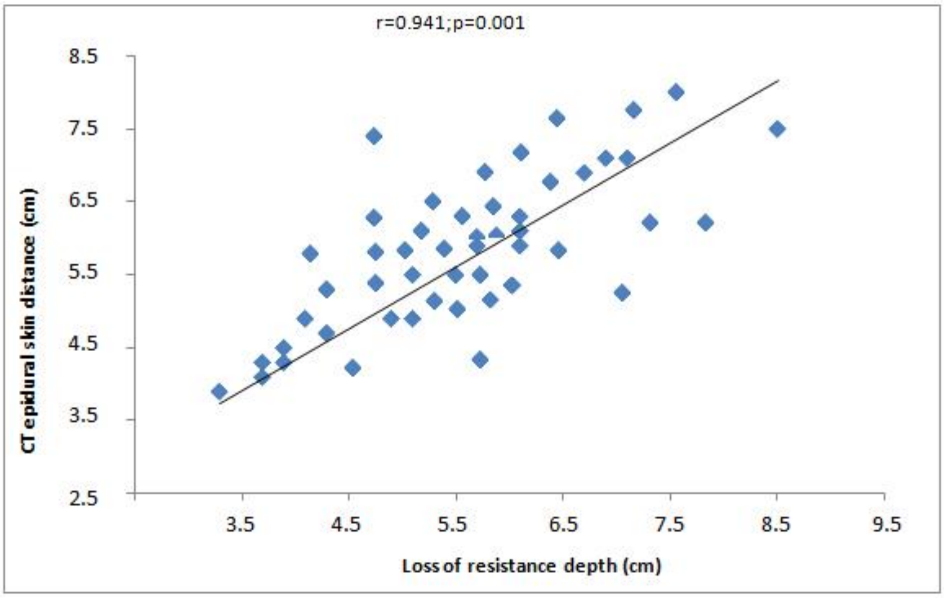

Figure 3: Correlation between CT-derived distance and Loss of Resistance Depth (n=50)

Figure shows the correlation between the CT-derived distance and Loss of Resistance Depth. It was evident from this study is positive significant correlation (r=0.941; p=0.001) between the CT-derived distance and Loss of Resistance Depth).

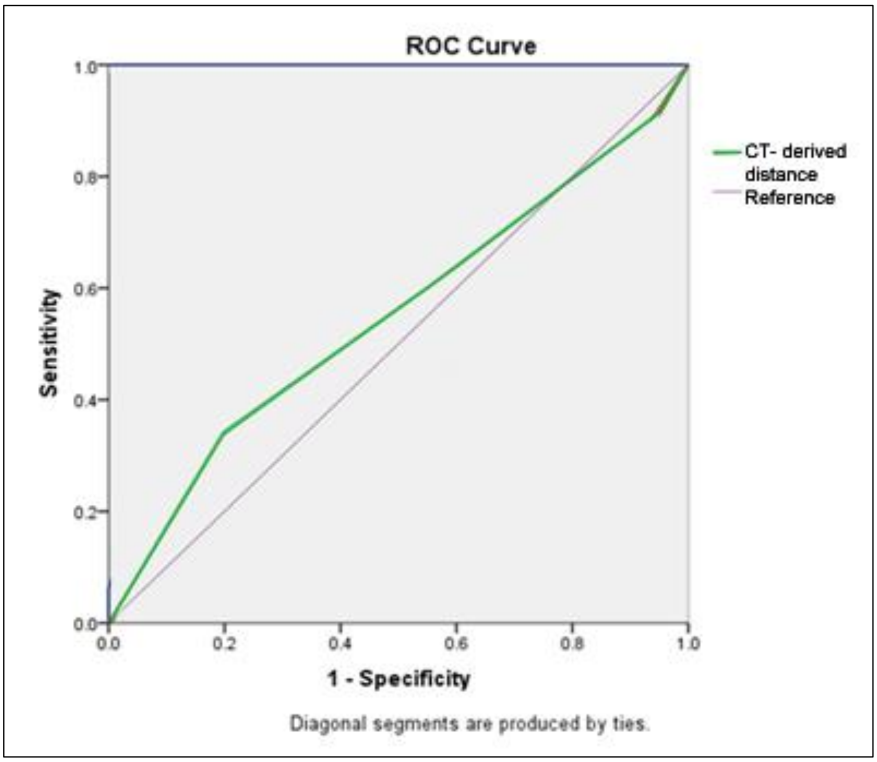

Figure 4: Receiver Operating Characteristic (ROC) curve showing validity of CT-derive distance in prediction of depth of loss resistance as recorded during epidural placemen (n=50)

	CT-derived distance	**CI**
AUROC (95%CI) P value	0.941 (0.327-0.486) 0.0019	0.550 (0.467-0.633) 0.167

Figure shows the validity of CT-derive distance in prediction of depth of loss resistance as recorded during epidural placemen. Results shows significant positive correlation (p=0.0019) in prediction of depth of loss resistance as recorded during epidural placemen. So it is conclude that the preoperative abdominal CT is helpful in prediction of the distance for epidural insertion (AUROC; Area under the Receiver Operating Characteristic).

DISCUSSION

The study was conducted to compare measurements taken from CT imaging to correlate the depth of loss of resistance as recorded during epidural catheter placement at tertiary care hospital. In study average BMI was 28, with wide range represented from 15.5 to 53.9. There appears to be a linear relationship between loss of resistance depth and epidural-skin distance. Linear regression suggests a strong relationship between estimated skin depth (ESD) and loss of resistance (LOC). It was evident from this study is positive significant correlation (r=0.941; p=0.001) between the CT- derived distance and Loss of Resistance Depth. Similar observation reported that intercept in the model was significantly above zero as well. The area under the curve (AUC) of the ROC generated using ESD to predict a LOR greater than or equal to 8 cm was 0.7876 while the AUC of the ROC generated using ESD to predict a LOR less than or equal to 4 cm was 0.8009.

We found a strong relationship between the distance from the skin to the epidural space as measured on CT imaging and the clinically recorded depth of loss of resistance. Another study shows that mean (SD) EIL and AIL were 5.5 (0.7) and 5.1 (0.6) cm, respectively, with a significant correlation (r=0.899, P<0.01). The EIL tended to have a higher value than the AIL (0.4(0.3) cm). There were significant correlations of both EIL and AIL with weight (P<0.01), BMI (P<0.01), and body fat percentage (P<0.01), but not with height (P>0.05). The ESD measurement appeared to perform reasonably well in identifying very deep loss of resistance depths, potentially requiring the use of a nonstandard Tuohy needle, and very shallow depths, possibly alerting a clinician to prevent an inadvertent dural puncture.

There was no way to verify the loss of resistance depth by practitioner reported as the true loss of resistance. In our experience, clinicians may not always be completely accurate with the values reported, as documentation of placement of the epidural can be somewhat removed in time from the time of the procedure. Also, our analysis relies on the accurate identification of the vertebral interspace at which the epidural catheter was placed. It has been shown [9, 10] that clinicians are commonly one or two interspaces away from the targeted space. The relative precision of the CT ESD and LOR depth measurements are also dissimilar. The radiological software was used gave us precision down to the distance while the finest degree of precision routinely reported within loss of resistance measurements. When placing an epidural, it is also possible for a clinician to start at one inter-space and traverse up to one or two interspaces if a steep angle is used thus obtaining a much deeper LOR than would have been produced by a more perpendicular approach. We also could not verify that the putative epidural catheter was in the true epidural space.

Our findings are in agreement with two other published studies that have found good correlation between CT scan measurements to loss of resistance depth [8, 11]. The information derived from these previous studies is somewhat limited in its clinical utility. Both studies examine only one or two interspaces whereas epidurals can be placed at almost any thoracic or lumbar level as required by the location of the surgical incision. In both of these previous studies, the description of how the measurements were made was not specific enough to indicate how an anesthesiologist might reproduce and use measurement information taken from a CT scan. This study helps support that the examination of a CT scan can be applicable at various interspaces in the lumbar spine.

Similar study examined large number of patients' shows; the results do seem generalized despite a relative lack of precision of their model. We predicted a pure linear transformation based on an angle in the sagittal plane of 30° and an angle in the axial plane of 15° which would estimate a ratio of 1.2. This line can be drawn on the scatter plot and approximate some of the data, but our ordinary least squares regression suggests that this is not the best fit model. The true model describing the relationship between CT ESD and LOR depth probably does have an intercept that accounts for tissue compression and a coefficient that is based on the angles of approach, but we cannot expect that a study of 50 epidurals in different patients would have the same angles of approach making the coefficient the aggregate "average" of coefficients calculated by the various angles used to place an epidural.

The value of having a sense of distance to the epidural space prior to starting a procedure could be particularly helpful. For example, if the predicted depth by imaging was never less than the actual loss of resistance depth then overly tentative epidural placements with false loss of resistance at shallow depths could be avoided. Closer examination of the scatter plot almost seems to reveal such a relationship in both populations, although this population is different. On the other end of the spectrum and perhaps more importantly, epidural-skin distance on imaging appears to also be useful in predicting abnormally shallow loss of resistance depths, which could help prevent dural punctures and thusnerve injury with potential for permanent damage [12]. So findings of this study concluded that there are positive associations between either the CT-derived or the actual depth of the epidural space.

CONCLUSION

A simple measurement on CT scan of a patient prior to placing an epidural catheter can be helpful in determining loss of resistance depth of epidural space while needle insertion, which can be adequately made by an anesthesiologist without further assistance, would therefore do ease the epidural catheter placement procedure.

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