Abdominal girth has a strong correlation with actual and ultrasound estimated epidural depth

Abstract

**Background/aim:** To assess the correlation between actual epidural depth (ND), ultrasound estimated epidural depth in the paramedian sagittal oblique plane (ED/PSO) and transverse median plane (ED/TM) with the abdominal girth (AG), body mass index (BMI), and weight of the patients.

**Materials and methods:** One hundred and thirty patients of either sex scheduled for unilateral inguinal hernia repair were enrolled. ED/PSO and ED/TM were assessed with a 2 – 5 MHz curved array probe at L3 – 4 intervertebral space. Epidural needle was marked with a sterile marker on locating the epidural space. ND was assessed by measuring the distance from the sterile marker to the tip of the epidural needle with a linear scale. Anthropometric measures of the patients were recorded.

**Results:** ED/PSO was 49.6 ± 7.9 mm, ED/TM was 49.5 ± 7.9 mm, and ND was 50.0 ± 8.0 mm. AG was 99.8 ± 12.9 cm. Pearson correlation coefficient between ND and ED/PSO was 0.997 and 0.996 with ED/TM (p < 0.001 for both). Pearson correlation coefficient for ND with AG, BMI, and weight was 0.757, 0.547, and 0.638 respectively (p < 0.001 for all).

**Conclusion:** AG, weight, and BMI have a strong correlation with the ND.

**Keywords:** Abdominal girth, anesthesia, epidural, ultrasound.

1. **Introduction**

Combined spinal epidural anesthesia (CSE) is widely used for inguinal hernia repair surgeries. The precise location of the epidural needle navigated with ultrasound has a crucial role in the success rate of CSE providing the needle trajectory and the exact
level of desired intervertebral space.[1] Preprocedural ultrasound scanning of the vertebral column may facilitate the insertion of the epidural needle during CSE.[2]

Former studies assessing the depth of lumbar epidural space with ultrasound used the transverse median plane (TM) and reported positive correlations with the actual epidural depth (ND).[3-5] In a limited number of study conducted on parturients, longitudinal plane ultrasound examination was combined with TM to estimate the ND.[1, 2, 6] Grau et al. [7] have reported paramedian access to epidural space as the optimal window for ultrasound imaging. The accuracy of paramedian epidural depth assessment was also reported for thoracic epidural insertions.[8, 9] In 2014, Kim et al. [10] reported the superiority of the paramedian sagittal approach on the paramedian approach during pararadicular injection at the lumbar spine.

Several patient characteristics and anthropometric measurements were assessed to predict the ND.[3, 11-16] Of these parameters, weight, and body mass index (BMI) were reported to have a strong correlation with the ND.

In the current study, we assessed the correlation of ND with abdominal girth (AG), weight, height, and body mass index (BMI) to derive a mathematical predictor formula of the ND at L3–4 level.

2. Materials and methods

2.1. Ethics and patients

After approval from the institutional review board and local ethics committee (2017-20/241,26/12/2017), the study was prospectively registered at Australian New Zealand Clinical Trials Registry (ACTRN12618000586213), signed informed consent was obtained from one hundred and twenty-four ASA physical status I–III patients, aged 18–80 years, scheduled for elective unilateral inguinal hernia repair surgery. Patients
were excluded from the study if they met one or more of the following criteria: prior spine or spinal canal surgery, vertebral canal deformities, coagulopathy or patients on anticoagulant drug medication, pregnant patients, ASA physical status > III, any neurological disease, rejecting to participate in the study, infection at the site of epidural injection, and other contraindications for neuraxial blocks.

Patients were monitored with electrocardiogram, pulse oximeter, and non-invasive blood pressure. An intravenous line was secured on the dorsum of the left hand for intravenous hydration and medication.

Data for age, weight, height, and BMI were recorded in the medical fields of the patients at their preoperative visit. Abdominal girth was measured by the same investigator at the level of the umbilicus in the transverse plane with a tape measure while the patients were at sitting position and the data was recorded.

2.2. Ultrasound scanning

Patients were placed at the sitting position on the operation table with a stool under their feet. Patients’ knees, hip, and neck were flexed. Ultrasound imaging was done before sterile draping by the same investigator using a portable ultrasound (Esaote MyLab30, Florence, Italy). The 2 – 5 MHz curved array probe was first placed in the midline sagittal plane to determine the hyperechoic shadow of the sacrum. The probe was then advanced cranially to determine the L3 – 4 intervertebral space. With the location of the intervertebral space in the center of the ultrasound probe, the skin was marked on both sides of the probe in the midline. The skin marks were elongated as a horizontal line, and the probe was located on this line and inclined cephalad or caudal to obtain the
acoustic window of L3 – 4 intervertebral space. The midpoint of the probe was marked on the skin in the sagittal plane, and these two skin marks were elongated in the sagittal plane. The intersection of the horizontal and vertical lines determined the epidural needle insertion point.

Paramedian sagittal oblique plane (PSO) measurement of epidural depth was performed initially. The curved array probe of ultrasound was placed 1 – 2 cm lateral to the midline on the horizontal plane at the level of L3 – 4 intervertebral space. The probe was tilted through midline to obtain the PSO view of the vertebral canal. The image on the ultrasound screen was frozen and recorded for measurement of ultrasound-estimated epidural depth in the paramedian sagittal oblique plane (ED/PSO). The distance from the skin to the posterior border of ligamentum flavum – posterior dura complex (posterior complex) was accepted as ED/PSO.

With the completion of PSO scanning of the vertebral canal, the curved array ultrasound probe was oriented in transverse plane at L3 – 4 intervertebral space in the midline and the screen was frozen for the measurement of ultrasound-estimated epidural depth in transverse median plane (ED/TM).

2.3. Combined spinal-epidural anesthesia and actual epidural depth

The skin was cleansed from the ultrasound gel and prepared with an antiseptic solution. The patient position was same during the ultrasound scanning and the CSE procedure. The CSE was performed from the previously marked insertion point determined by ultrasound. Following sterile draping and local anesthetic infiltration of skin and subcutaneous tissue with 1% 5ml lidocaine, the epidural needle of the combined spinal-
epidural set (BBraun, Melsungen AG, Melsungen, Germany) was advanced until it reached interspinous ligament. The guide of the epidural needle was withdrawn, and the air-filled sterile syringe was locked to the hub of the epidural needle. Epidural needle was advanced until the identification of epidural space with loss of resistance to air technique with the midline approach. The spinal needle was introduced with the needle-through-needle technique. After observing the free flow of clear cerebrospinal fluid, 3 ml 0.5% hyperbaric bupivacaine was injected into the intrathecal space. The spinal needle was removed, and the epidural catheter was advanced with five centimeters to epidural space. Epidural needle was marked with a sterile marker on the skin before it was withdrawn. Actual epidural depth was measured on the epidural needle between the sterile marker and the tip of the needle with a linear scale that had millimeter calibration on it. The epidural catheter was fixed, and the patient was turned to the supine position. The spread of spinal anesthesia was assessed with loss of pain sensation with the pin-prick test. Surgery was commenced when the level of spinal block reached to T6 dermatome level.

The primary outcomes of the study were the determination of ND, ED/PSO, and ED/TM. Secondary outcomes of the study were the measurement of AG, weight, height, and BMI of the patients. The objective of the study was to assess the correlation of the ND with AG, weight, height, and BMI of the patients and determining the correlation of the ND with ED/PSO and ED/TM in patients scheduled for elective unilateral inguinal hernia repair surgery with CSE. A mathematical equation to estimate the ND was generated from the regression analysis model performed with IBM SPSS 21.0 (SPSS Inc., Chicago, IL, USA) package program. Keeping ND as dependent variable and age,
weight, height, BMI and AG independent variables in the linear stepwise regression analysis model, a mathematical formula is derived to estimate the ND.

Statistical Analysis

IBM SPSS 21.0 (SPSS Inc., Chicago, IL, USA) package program was used for the analysis of data in the current study. Descriptive data was expressed as means and standard deviations for continuous parameters and percentages for nominal parameters. A bivariate linear correlation analysis (Pearson correlation analysis) was used to test the correlation between the ND, ED/PSO, and ED/TM with the age, weight, height, AG, and BMI of patients. The correlation between ND with ED/PSO and ED/TM were also analyzed with Pearson’s correlation analysis. A linear regression analysis was used with a stepwise method to detect the correlation of the ND, ED/PSO, and ED/TM with patients’ age, weight, height, AG, and BMI. Skin to epidural depth was determined as the dependent variable in all three linear regression models (ND, ED/PSO, and ED/TM) and the patient characteristics and anthropometric measures were the independent variables. $p$-value < 0.05 was considered statistically significant.

The sample size of the study was calculated by using the data obtained from the preliminary results of the study (AG = 99.9 ± 10.7 cm, ED/PSO = 49.9 ± 6.7 mm, ED/TM = 49.8 ± 6.8 mm, ND = 50.2 ± 6.8 mm) with G*Power 3.1.9.2. Minimum required sample size (n) was 120 to detect a desired statistical power level of 0.95 and p-value 0.05.

3. Results

A total of 130 patients were enrolled for the study, and there were six dropouts (two patients refused to be involved in the study, anticoagulant medication was prescribed to
one patient, and three patients wanted to postpone their surgical procedure to a future
date.). Data obtained from 124 patients were included in the statistical analysis of the
current study. Patient characteristics are presented in Table 1. Mean patient age was
50.12 ± 14.72 years, mean patient height was 169.45 ± 9.05 cm, mean patient weight
was 78.49 ± 12.40 kg, and the mean BMI was 27.51 ± 4.80 kg/m². Thirty-seven patients
were female (29.8%), and eighty-seven were male (70.2%). Sixty-one patients were in
ASA physical status I (49.2%), forty-nine in ASA physical status II ((39.5%), and
fourteen patients were in ASA physical status III (11.3%) group. Mean ND was 49.96 ±
8.01 mm, the mean ED/PSO was 49.63 ± 7.91 mm, the mean ED/TM was 49.46 ± 7.90
mm, and the mean AG was 99.8 ± 12.9 cm. ND was strongly correlated with AG (r =
0.757, 95% CI 0.685 – 0.814, p < 0.001), weight (r = 0.638, 95% CI 0.526 – 0.725, p <
0.001), and BMI (r = 0.547, 95% CI 0.394 – 0.687, p < 0.001) of the patients.
Correlation coefficients of the ND, ED/PSO, and ED/TM with age, height, weight,
BMI, and AG are presented in Table 2. The correlation of AG with ND, ED/PSO, and
ED/TM are presented in Figure 1–3. Keeping ND as dependent variable and age,
weight, height, BMI and AG independent variables in the linear stepwise regression
analysis model, a mathematical formula is derived estimating the ND as $a = 0.469 \times b +$
3.17 where $a =$ ND in millimeters and $b =$ AG in centimeters. Keeping ED/PSO
dependent variable with the same independent variables, the mathematical equation to
estimate ED/PSO was $a = 0.473 \times b + 2.43$ where $a =$ ED/PSO in millimeters and $b =$
AG in centimeters. Keeping ED/TM dependent variable with the same independent
variables, the mathematical equation to estimate ED/TM was $a = 0.470 \times b + 2.58$
where $a =$ ED/TM in millimeters and $b =$ AG in centimeters.

4. Discussion
Our study demonstrated a strong correlation between ND with AG, weight, and BMI in patients scheduled for elective unilateral inguinal hernia repair surgery with CSE. And also in the present study we demonstrated a strong correlation between the ND, ED/PSO, and ED/TM.

Former studies reported a strong correlation between ND and ED/TM.[2-6, 8, 17] The result of the current study is in line with the previous studies. The correlation of ND with ED/PSO, however, has not been assessed widely in the lumbar region. Sahota et al.[18] have assessed the correlation of ED/TM with ED/PSO in sixty parturients. In that study, they concluded that both planes could be used interchangeably to estimate epidural depth during midline neuraxial punctures. The usefulness of PSO ultrasound scanning was reported in two studies during thoracic epidural insertion.[8, 9] Both studies presented a strong correlation between the ND and the ED/PSO at the thoracic level. Our study presented a strong correlation between ND and ED/PSO ($r = 0.997$, $p<0.001$) at lumbar region. We conducted our study in the non-pregnant patient population, and the ultrasound estimated epidural depth measurements were at the level of L3 – 4 intervertebral space. Although the patient population in the current study was different from the study by Sahota et al.[18] and the vertebral level was different from the studies by Khemka et al.[8] and Salman et al.[9], our study results were in accordance with these studies to suggest that ED/PSO reliably estimates the ND.

Correlation of weight and BMI with the ND was previously reported, and the correlation coefficient ranged from 0.597 – 0.762 for BMI and ND[11, 12, 14, 15] in these studies. The correlation coefficient between ND and BMI in the current study was also in accordance with the former studies.
One of the novel findings presented in our study was the correlation of ND with the AG of the patients. In the linear regression model, we derived a mathematical formula estimating the ND as $a = 0.469 \times b + 3.17$ where $a = ND$ in millimeters and $b = AG$ in centimeters. Assuming a patient with AG measurement of 99.84 cm (this is the mean AG value in the current study), estimated ND would be $0.469 \times 99.84 + 3.17 = 49.97$ mm. The mean ND in the current study was 49.96 mm. The AG based equation derived from the linear regression model reliably estimates the ND. When ultrasound guidance is not readily present in the operating room, clinicians can have a reliable estimate of the epidural depth with the equation presented above. However, we have to inform clinicians not to discard the loss of resistance technique while performing epidurals in the guidance of ND estimates obtained from the equation suggested in the current study. Limitations of the current study were ASA physical status > III patients, patients younger than 18 years and older than 80 years, and parturients were not included in the study population. In conclusion, both PSO and TM ultrasound scanning provides a reliable estimate for the ND. When ultrasound is not available for preprocedural assessment of epidural depth because of its being sophisticated and expensive equipment, the AG based mathematical equation suggested in the current study may provide a reliable estimate of the ND for the clinicians while performing epidurals.

References


7 [15] Sharma V, Swinson AK, Hughes C, Mokashi S, Russell R. Effect of ethnicity and body mass index on the distance from skin to lumbar epidural space in


<table>
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<tr>
<th></th>
<th>Values</th>
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<tr>
<td>ASA I / II / III (n, %)</td>
<td>61, 49.2 / 49, 39.5 / 14, 11.3</td>
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<tr>
<td>Gender F/M (n, %)</td>
<td>37, 29.8 / 87, 70.2</td>
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<tr>
<td>Age (y)</td>
<td>50.12 ± 14.72</td>
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<tr>
<td>Weight (kg)</td>
<td>78.50 ± 12.40</td>
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<tr>
<td>Height (cm)</td>
<td>169.45 ± 9.06</td>
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<tr>
<td>BMI (kg/m$^2$)</td>
<td>27.52 ± 4.80</td>
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<tr>
<td>AG (cm)</td>
<td>99.85 ± 12.94</td>
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<tr>
<td>ED/PSO (mm)</td>
<td>49.63 ± 7.91</td>
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<tr>
<td>ED/TM (mm)</td>
<td>49.46 ± 7.91</td>
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<td>ND (mm)</td>
<td>49.96 ± 8.01</td>
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ASA: American Society of Anesthesiologist physical status, F: female, M: male, BMI: body mass index, AG: abdominal girth, ED/PSO: ultrasound estimated skin to epidural depth in paramedian sagittal oblique plane, ED/TM: ultrasound estimated skin to epidural depth in the transverse median plane. ND: actual skin to epidural depth. Values are expressed as mean ± standard deviation except for ASA and gender.
Table 2 Correlation of patient characteristics with ND, ED/PSO, and ED/TM

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<tr>
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<th>ND</th>
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<td>Age (y)</td>
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<td>– 166</td>
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<tr>
<td>Weight (kg)</td>
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<td>&lt;0.001</td>
<td>0.648</td>
<td>0.541</td>
<td>&lt;0.001</td>
<td>0.654</td>
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<tr>
<td>Height (cm)</td>
<td>0.025</td>
<td>-0.164</td>
<td>0.784</td>
<td>0.021</td>
<td>-0.169</td>
<td>0.817</td>
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<td>0.215</td>
<td>0.209</td>
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<tr>
<td>BMI (kg/m²)</td>
<td>0.547</td>
<td>0.394</td>
<td>&lt;0.001</td>
<td>0.558</td>
<td>0.406</td>
<td>&lt;0.001</td>
<td>0.564</td>
<td>0.415</td>
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<tr>
<td>AG (cm)</td>
<td>0.757</td>
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<td>&lt;0.001</td>
<td>0.773</td>
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ND: Actual epidural depth, ED/PSO: Ultrasound estimated skin to epidural depth in paramedian sagittal oblique plane, ED/TM: Ultrasound estimated skin to epidural depth in transverse median plane, BMI: body mass index [weight / (height)²], AG: abdominal girth.
r: Pearson correlation coefficient, p: statistical significance, 95%CI: 95% confidence interval for Pearson correlation coefficient (r).
Figure 1 Correlation of AG with ND

ND: actual epidural depth, AG: abdominal girth.
Figure 2 Correlation of AG with ED/PSO

ED/PSO: ultrasound estimated skin to epidural depth in paramedian sagittal oblique plane,

AG: abdominal girth.
Figure 3 Correlation of AG with ED/TM

ED/TM: ultrasound estimated skin to epidural depth in transverse median plane, AG: abdominal girth.