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Original Article

Anaesthesia Section

Correlation between Abdominal Girth and Skin to Epidural Space Distance of Thoracic and Lumbar Spine: A Cross-sectional Study

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ABSTRACT

Introduction: The Skin-to-Epidural Space Distance (SESD) is likely to be different at two different parts of the spine in the same individual and also in the same part of the spine in two different individuals. The knowledge of the expected depth of the epidural space can be very useful in placing the epidural needle appropriately and avoiding unwanted dural puncture. Although many studies have been conducted to study the relation of lumbar SESD with various physical and anthropometric parameters, the literature on thoracic SESD is scant.

Aim: To determine the correlation between SESD and Abdominal Girth (AG) in the mid-thoracic, lower thoracic, and lumbar regions of the spine in adult patients scheduled for elective surgical procedures.

Materials and Methods: After obtaining Ethics Committee clearance (EC/NIMS/2671/2020, 51st ESGS No: 1082/2020), this prospective observational study was carried out at Nizam's Institute of Medical Sciences, Hyderabad, India, from October 2021 to February 2022. The study recruited 202 patients, and data from 194 patients was analysed. During the preoperative visit, all physical parameters, including AG, were noted. Using an 18G Tuohy needle, the epidural space was identified, and SESD was measured. Its correlation with AG, age, height, weight, and body mass index was studied. The data was analysed using the Statistical Pacakge for Social Sciences Software (SPSS) (2011, IBM, Armonk, NY, United States of America) version 20.0.

Results: The mean SESD was 4.7±1.09 cm in the mid-thoracic region, 4.71±0.98 cm in the lower thoracic region, and 4.8±0.82 cm in the lumbar region. The correlation coefficient of SESD with AG was 0.42, 0.44, and 0.78 in the mid-thoracic, lower thoracic, and lumbar regions, respectively, and the significance level was <0.001 in all three regions. Body weight had a good correlation (r-values of 0.56, 0.66, 0.53 in mid-thoracic, lower thoracic, and lumbar areas, respectively, and p-value of <0.001 in all three anatomical regions of the spine) with SESD. All other physical parameters were correlated weakly with SESD.

Conclusion: AG has a strong correlation with SESD in the lumbar area but a moderate correlation in the thoracic spine. SESD in the lumbar, mid, and lower thoracic regions have a good correlation with weight.

Keywords: Body mass index, Epidural anaesthesia, Epidural analgesia

INTRODUCTION

Epidural anaesthesia is being increasingly used to provide perioperative anaesthesia and analgesia in orthopaedic, genitourinary, vascular, gynaecologic, colorectal, and cardiothoracic procedures. The identification of the lumbar and lower thoracic epidural space is relatively easy due to the nearly horizontal alignment of the spinous processes. However, extreme angulation of the spinous process in the mid-thoracic spine makes the insertion and upward movement of the Tuohy needle very difficult [1]. Thus, knowledge of the depth of the epidural space can help avoid unintended dural puncture in these cases.

The epidural space exists circumferentially between the dura mater and the ligamentum flavum, extending from the foramen magnum to the sacral hiatus. When using a midline approach, an epidural needle traverses the skin, subcutaneous tissue, and three ligaments (supraspinous, interspinous, and ligamentum flavum) from superficial to deep [2]. There is literature supporting the fact that ligamentum flavum thickness increases with age, atleast in the lumbar region, thus increasing the SESD [3]. Furthermore, the thickness of the ligamentum flavum in the lumbar area varies in cadaveric and imaging data reported from different countries [4]. Ethnicity-specific literature on thoracic SESD is scarce, and none exists from the Indian subcontinent. Epiduroscopy and cryomicrotome studies of the epidural space have shown that the thoracic epidural space has significantly less fat content than the lumbar area [1,5]. However, it is largely unknown whether an increase in total body fat affects the epidural space fat and, thus, the SESD.

There is literature stating that SESD in the lumbar region has gradually increased over the last few decades, possibly due to the increased prevalence of obesity [6]. However, evidence on the effect of obesity on thoracic SESD is limited [7,8]. Various authors have attempted studies to correlate markers of obesity, such as weight, weight-to-height ratio, Body Mass Index (BMI), abdominal subcutaneous fat thickness, waist circumference, waist circumference-to-height ratio, mid-arm thickness, subscapular fat pad thickness, to SESD [6,8-12]. More recently, AG, an indicator of central obesity, has been correlated with SESD [12-15]. Much of the evidence mentioned above comes from pregnant patients, and almost all studies are conducted on lumbar SESD [9,11,13,16,17]. Therefore, its validity in the thoracic region is not well established.

Considering the paucity of literature on non-parturient lumbar SESD and the lack of data on thoracic SESD in Indian patients, the present study was conducted to determine the correlation of SESD with AG in the mid-thoracic, lower thoracic, and lumbar regions of the spine in adult patients scheduled for an elective surgical procedure with epidural anaesthesia. The secondary objective was to check the correlation of SESD with age, height, weight, and body mass index.

MATERIALS AND METHODS

The present cross-sectional study was conducted at Nizam's Institute of Medical Sciences, Hyderabad, India, between October 2021 and February 2022 after obtaining institutional ethics committee approval (EC/NIMS/2671/2020, 51st ESGS No: 1082/2020).

Inclusion criteria: All patients of either gender in the age group of 18-60 years, in whom epidural catheter placement was planned for perioperative anaesthesia or analgesia at the mid-thoracic (T5-T9) vertebral level, lower thoracic (T9 to T12), or lumbar (L1 to L5) levels for elective surgeries, were considered for the study.

Exclusion criteria: Patients who had contraindications to the placement of epidural catheter, neurological disease, raised intracranial pressure, pregnant patients, and those who did not give consent were excluded from the study.

Sample size calculation: The formula for calculating the sample size, when estimating the correlation between two independent continuous variables, is:

$n=\{(z_{1-\alpha}+z_{1-\beta})^2/z02\}+3.$

With an alpha error of 0.05 and power of 95% and a correlation coefficient of 0.5

$Z_{1-\alpha}=Z_{0.95}$, $z_{1-\beta}=Z_{0.95}$ and $Z_0=0.549$ at a correlation coefficient of 0.5

$n=\{(z_{0.95}+z_{0.95})^2/0.549^2\}+3$

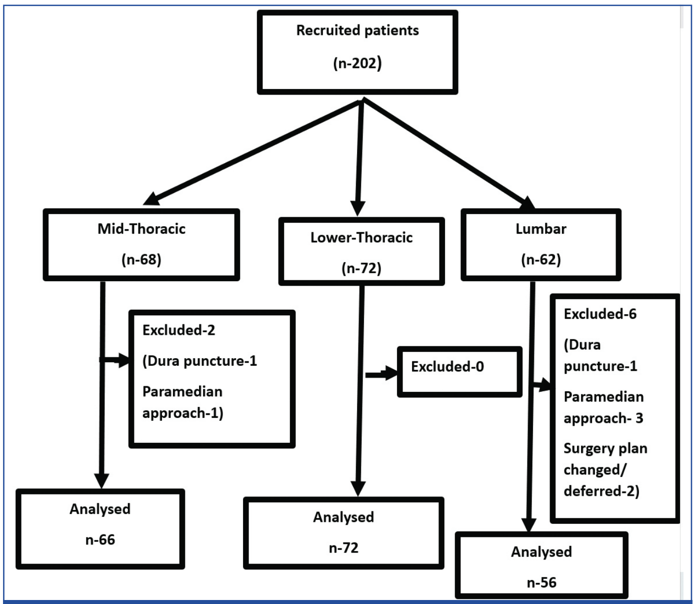
$n=\{(1.96+1.96)^2/0.549^2\}+3$

$n=\{(3.92\}^2/0.301\}+3$

$n=(15.36/0.301)+3$

$n=51+3=54$

Thus, a minimum of 162 patients were to be recruited (54 each in the lumbar, mid, and lower thoracic epidural groups). However, to account for possible exclusions, 202 patients were recruited, and data from 194 patients were analysed after exclusions. Specifically, there were 72, 66, and 56 patients in the mid thoracic, lower thoracic, and lumbar groups, respectively [Table/Fig-1].



[Table/Fig-1]: Sample distribution.

Study Procedure

During the preoperative visit, patients were briefed on the study procedures, and written informed consent was obtained. Alongside a general physical and systemic examination, data on age, sex, height, weight, and Abdominal Girth (AG) were recorded. AG was measured with the patients in a seated position using a measuring tape, at the level of the umbilicus in the transverse plane. Patients were required to fast for 8 hours before surgery. Upon arrival at the operating theatre, Electrocardiography (ECG), Non Invasive Blood Pressure (NIBP), and Pulse Oximetry (SPO_2) monitors were attached. Intravenous access was established with an 18G cannula under strict aseptic conditions. Subsequently, patients were positioned in a seated posture with neck flexion for the placement of the epidural catheter.

The identification of the epidural space was done using a midline approach with the Loss Of Resistance (LOR) to air technique. Under all aseptic precautions, the area was cleaned and draped. The skin was anaesthetised by locally infiltrating 2% lignocaine. Level identification was done using anatomic landmarks, with the line across the highest points of the iliac crests (Tuffier's line) as the L4 vertebral body or L4-L5 interspace, and the inferior angle of the scapula as T7 [1,18]. An 18G Tuohy needle was gradually advanced with its stylet in place and the bevel point facing cephalad. A 10 mL LOR syringe filled with air was used, and LOR was checked after each advancement. The epidural space was reached when there was no resistance to the movement of the syringe plunger. Care was taken to avoid pushing more than 1 mL of air at a time to avoid complications [1].

Once the epidural space was located, the LOR syringe was removed. The epidural needle was marked with a sterile marker at the skin level before it was withdrawn. The actual Skin-to-Epidural-Space Distance (SESD) was measured on the epidural needle between the sterile marker and the tip of the needle using a linear scale with millimeter calibration. The angle at which the needle was inserted (the acute angle between the skin and the epidural needle at the point of entry) was measured using the "protractor" software, which is a free application available on the Google Play Store. The epidural catheter was then advanced, and the epidural needle was withdrawn aiming to leave 3 to 5 cm of epidural catheter in the epidural space. The nature, type, and volume of the epidural drug were decided based on the requirements of the surgical procedure by the attending anesthesiologist. Patients in whom the epidural space could not be located through a midline approach, or a paramedian approach was used to localise the epidural space, or patients in whom inadvertent dural puncture occurred during the procedure were excluded from the study. Patients were also excluded from the study if the surgery was deferred or if the surgical plan changed.

STATISTICAL ANALYSIS

The data was entered into a Microsoft excel sheet, and statistical analysis was conducted using SPSS version 20.0. Continuous data was presented as mean±standard deviation, and categorical data as frequency and percentages. The correlation coefficient of AG, BMI, age, height, and weight with SESD was calculated. The correlation coefficient value can range between -1 and +1. Negative values indicate a negative correlation, while positive values indicate a positive correlation. Values above 0.7 indicate a strong correlation, values ≥0.4 signify a moderate correlation, and values <0.4 suggest a weak correlation [19]. A p-value of <0.05 was considered significant.

RESULTS

A total of 202 patients were recruited for the study after obtaining informed consent. Two patients in the mid-thoracic group and six patients in the lumbar group were excluded due to dura puncture, the use of a paramedian approach, or a change in the surgical plan/ deferred surgery. Therefore, data from 194 patients were analysed.

The patient demographics and anthropometric parameters are described in [Table/Fig-2]. The mean age in all groups was in the fifth decade. The angle of insertion was most acute (indicating that the path traversed by the epidural needle was most oblique) in the mid-thoracic region.

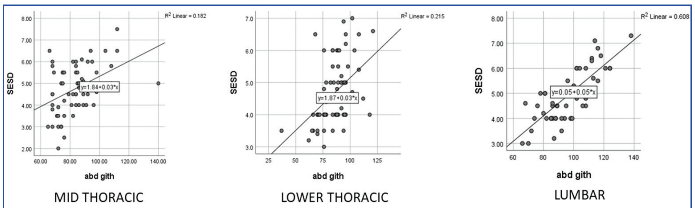
AG had a strong correlation with lumbar SESD ($r=0.78$, $p<0.001$) but a moderate correlation with thoracic SESD ($r=0.42$, $p<0.001$ and $r=0.44$, $p<0.001$ in the mid and lower thoracic regions, respectively). The details of all Pearson's correlation coefficients and their corresponding significance are tabulated in [Table/Fig-3]. The scatter plot of AG for all three anatomical regions is shown in [Table/Fig-4].

Parameters	Mid thoracic region (n-66)	Lower thoracic region (n-72)	Lumbar region (n-56)
Age (years)	46.65±16.69	42.76±13.67	40.82±14.63
Gender			
(Male: Female)	29:37	31:41	39:17
Height (cm)	157.27±8.73	158.25±8.85	164.13±9.23
Weight (kg)	56.18±14.75	60.72±13.52	68.84±14.54
BMI (kg/m^2)	22.59±5.03	25.03±5.58	25.87±4.80
AG (cm)	83.89±13.43	86.07±13.94	95.7±15.51
SESD (overall in cm)	4.7±1.09	4.71±0.98	4.8±0.82
SESD (Male in cm)	5.06±1.03	4.72±1.03	4.99±0.99
SESD (Female in cm)	4.52±1.10	4.70±0.96	4.66±1.01
Angle of insertion (in degrees)	55.30±13.66	67.66±13.3	75.23±12.9

[Table/Fig-2]: Demographic and anthropometric details.

Parameters	Mid thoracic region (n-66) Pearson's correlation coefficient (r)/ significance	Lower thoracic region (n-72) Pearson's correlation coefficient (r)/ significance	Lumbar region (n-56) Pearson's correlation coefficient (r)/ significance
AG/SESD	0.42/**<0.001**	0.44/**<0.001**	0.78/**<0.001**
BMI/ SESD	0.45/**<0.001**	0.48/**<0.001**	0.447/**0.025**
Age/ SESD	0.10/0.39	0.010/0.938	0.29/**0.03**
Height/ SESD	0.48/**<0.001**	0.19/0.09	0.20/0.128
Weight/ SESD	0.56/**<0.001**	0.66/**<0.001**	0.53/**<0.001**

[Table/Fig-3]: Correlation of SESD with demographic and anthropometric parameters.



[Table/Fig-4]: Scatter plot of Abdominal Girth (AG) for all the three anatomical region.

DISCUSSION

Epidural analgesia provides an effective acute pain management strategy, reducing morbidity. It has shown improvement in surgical outcomes, particularly in high-risk patients [20]. The correct placement of the epidural needle and catheter in the epidural space is of paramount importance for the successful and effective functioning of this analgesic technique.

Previous studies have been conducted to establish the correlation between SESD and various demographic and anthropometric factors such as age, sex, weight, height, weight-to-height ratio, BMI, waist circumference, waist circumference-to-height ratio, mid-arm thickness, subscapular fat pad thickness, and more recently, AG [6,8-15,17,21-24]. The main objectives of similar studies and their results are summarised in [6-9,11-17,21,22,24] [Table/Fig-5].

The present study was conducted on 194 adult patients of either sex scheduled for elective surgery with epidural analgesia as the sole or a part of the anaesthetic plan. The mean SESD in the study was 4.7±1.09 cm, 4.71±0.98 cm, and 4.8±0.82 cm in the mid-thoracic, lower thoracic, and lumbar regions, respectively. In a study by Hirabayashi Y et al., the depth of the lower thoracic epidural space was in the range of 4-6.9 cm and 3-4.9 cm in the lumbar area [22]. In another study by Watts RW et al., the distance from skin to the epidural space in the L3-4 region was 4.6±1.7 cm and 4.9±0.7 cm in obstetric and non-obstetric patients, respectively [23]. The study results are in concurrence with the results of non-obstetric patients. However, the depth of the thoracic epidural space was higher compared to ours in a study by Piccioni F et al., [8]. They reported SESD as 6.24±1.34 cm at T3-T6, 5.8±1.38 cm at T7-T9, and 5.55±1.6 cm in the T10-T12 region. The authors attributed the increased depth at high thoracic levels to the obliquity of spinous processes. The discrepancy in the present study result and theirs could also be attributed to the difference in the ethnicity of the population and the higher weight of the population in their study. Studies on parturients have revealed increased depth of the epidural space compared to non-parturients [13,16,17]. Since the present study did not recruit obstetric patients, it can neither support nor refute the above findings.

S. No.	Author's name and year	Place of study	Number of subjects	Objectives	Parameters assessed	Conclusion
1	Canturk M et al., 2019 [13]	Turkey	130 parturients	To study correlation of Abdominal Girth (AG) and ultrasound estimated Epidural Depth (ED) in parturients	AG, BMI, weight, height and age	AG had strong correlation with ED, weight and BMI had moderate correlation and age and height had no correlation
2	Canturk M et al., 2019 [14]	Turkey	130 patients undergoing inguinal hernia surgery	Assessment of correlation of actual and ultrasound estimated depth with AG in non parturients	AG, body mass index and weight	AG, body mass index and weight have strong correlation with AG
3	Gupta A et al., 2020 [15]	India	200 adult patients	Correlation of skin epidural distance and posterior epidural space depth with age, weight, height, BMI, AG and position of the patient	Age, weight, height, BMI, AG	AG, weight and BMI positively correlated with skin to epidural depth
4	Bala M et al., 2020 [21]	India	74 patients	To determine correlation of age and height with Skin To Epidural Space Distance (SESD)	Age and height	Height correlated well with SESD but age had no correlation
5	Hirabayashi Y et al., 1988 [22]	Japan	1007 patients	To determine correlation between the distance from the skin to the epidural space and physical constitution	Body weight, height, BMI	Body weight has the best correlation with SESD in thoracic as well as lumbar area
6	Ravi KK et al., 2011 [12]	India	120 patients	To determine the correlation of distance between lumbar skin to epidural space and BMI	BMI	Skin to epidural distance increased with increase in BMI
7	Adegboye MB et al., 2017 [6]	Nigeria	120 patients	To determine correlation of Skin to Lumbar Epidural Space Distance (SLESD) with BMI, age sex, height and weight	BMI, age sex, height and weight	BMI and weight had good positive correlation with SLESD but age, sex and height had no correlation
8	Adachi YU et al., 2007 [7]	Japan	4964 patients	To retrospectively investigate the differences in the depth of the epidural space depending on the puncture site, approach type and physical findings of patients	Age, gender, weight and height	patient age, body weight and more cephalad puncture were significantly and positively correlated with the depth at thoracic sites

9	Sharma V et al., 2011 [17]	United Kingdom and Singapore	1210 parturients (1140 from UK and 70 from Singapore)	To study the effect of ethnicity and BMI on SESD	Ethnicity and BMI	Both Ethnicity and BMI correlated well with SESD. Black/British Black/ British white had greater depth of epidural space as compared to Asian counterparts
10	Stamatakis E et al., 2005 [24]	Greece	406 male and female Greek patients	To study the SLED and it's relation with various variables	Age, weight, height, body mass index, body surface area, intervertebral space used, pregnancy, and geographic origin within Greece	SLED was best associated with weight, body surface area, and body mass index
11	Piccioni F et al., 2015 [8]	Italy	2230 patients receiving thoracic epidural	To study relation of thoracic epidural space depth and anthropometric variables	Age, sex, height, weight, BMI	Weight is the most important predictor at higher and lower thoracic levels, whereas BMI is the principal predictor at mid-levels
12	Clinkscales CP et al., 2007 [16]	United state of America	2009 parturients	To observe the relationship between lumbar epidural space depth and body mass index in Michigan parturients	Maternal age, gestational age, intervertebral space, BMI	When maternal age, gestational age and vertebral interspace are controlled for, increasing body mass index is associated with increasing depth of epidural space
13	Eley VA et al., 2019 [11]	Australia	463 parturients	To determine if the abdominal subcutaneous fat thickness correlated with skin to epidural space distance at delivery, and compare this with the booking body mass index	Abdominal subcutaneous fat thickness and BMI	BMI had a stronger correlation with epidural space distance than abdominal subcutaneous fat thickness
14	Weininger CF et al., 2020 [9]	Israel	131 female parturients	Prospective observational investigation of body habitus measurements and relationship to epidural depth in term pregnant women	Midarm and subscapular fatpad thicknesses, length of cervical spine, BMI and ultrasound measured epidural depth	Measurements of body habitus and fat distribution were no better than measured BMI
15	Present study	India	194 patients receiving either lumbar or thoracic epidural	To study correlation of AG and other anthropometric parameters with SESD in mid thoracic, lower thoracic and lumbar spine	AG, age, height, weight and BMI	AG has a strong correlation with SESD in lumbar area but a moderate correlation with thoracic SESD. Weight correlated moderately with SESD in both lumbar and thoracic regions

[Table/Fig-5]: Similar studies from the literature [6-9,11-17,21,22,24].

The average age in the present study was 46.65±16.69, 42.76±13.67, and 40.82±14.63 years in the mid-thoracic, lower thoracic, and lumbar regions, respectively. Most of the other studies on SESD in non-parturients reported patients with ages similar to ours [6,12,14,23], whereas studies recruiting parturients had a younger mean age for obvious reasons [13,16,23]. SESD was found to be significantly more in the thoracic region in elderly and obese patients in a Japanese study by Adachi YU et al., [7]. The authors reasoned that elderly Japanese often have vertebral kyphosis, and this anatomical change might increase the depth of the epidural space, especially at thoracic sites.

The present study observed a weak positive correlation between SESD and age in the thoracic region. This is similar to the results of earlier studies [6,14,23]. Using a multi-linear regression model, a study on 2009 parturients showed maternal age as a significant predictor of the centimeter depth of the epidural space [16]. In the present study, both the thoracic regions and the lumbar region showed an increased depth of the epidural space in males compared to females. Similar gender-specific differences were also noted by Hirabayashi Y et al., and Stamatakis E et al., [22,24]. The authors attributed this difference to the different body constitution of males and females.

The present study showed a weak correlation of height with SESD. The results of earlier studies on height and epidural depth have been conflicting. While Hirabayashi and colleagues reported a poor correlation to no correlation across both thoracic and lumbar subdivisions, Adegboyemb MB et al., described a negative correlation between height and SESD [6]. Interestingly, a recent article by Bala M et al., concluded that there was an increase in SESD with an increase in height [21].

The correlation coefficients for weight and SESD in the present sample were 0.56, 0.66, and 0.53 in the mid-thoracic, lower thoracic, and lumbar regions, respectively. Adachi YU et al., reported a positive correlation between weight and SESD in the thoracic region in an obese, elderly Japanese population [7]. Canturk M et al., also described a good correlation coefficient (0.638) between weight and epidural depth in the lumbar region, which is similar to the results of this study [14]. Gupta A et al., also reported a good correlation between weight and SESD in both sitting and lateral positions [15].

BMI has been shown to have a moderate to strong correlation in both parturients and non-parturients [6,8,11,12,16,17]. This is similar to the results of the present study.

The AG is a relatively new parameter that has been researched recently, and the available literature on it is limited. The present study demonstrated that the distance from the skin to the epidural space in the lumbar region is strongly related to AG. This result is in agreement with the results of earlier studies [13-15]. However, AG showed a weak correlation with thoracic epidural space depth. A possible explanation for this could be that truncal obesity is common in the middle-aged population, especially in an Indian setting [25,26]. There is excessive circumferential fat deposition around the lower abdomen and lumbar vertebral regions, leading to an increase in AG. However, the higher truncal region may remain relatively lean. Thus, due to the increase in subcutaneous fat, the path traversed by the epidural needle increases in the lumbar region but not in the thoracic vertebral territory. This hypothesis explains why there is a strong correlation of AG to SESD in the lumbar region, whereas a weak one in the thoracic area.

Limitation(s)

The technique of epidural was not ultrasound guided but rather blind. Additionally, the location of the intervertebral space was landmark-based, which may have been prone to errors.

CONCLUSION(S)

The AG had a strong correlation with SESD in the lumbar area and a moderate correlation in the thoracic SESD. Weight correlated moderately with SESD in both the lumbar and thoracic regions. Thus, AG may be used to assess the epidural space depth in the lumbar region.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: May 22, 2024
- Manual Googling: Jun 03, 2024
- iThenticate Software: Jun 20, 2024 (14%)

ETYMOLOGY: Author Origin

EMENDATIONS: 5

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. Yes

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