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Original Article

Anatomy Section

Correlation of Morphometric Parameters of Spleen and Height of the Deceased: A Cross-sectional Study in North Indian Population

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ABSTRACT

Introduction: Estimation of stature is a major forensic anthropological concern used in the identification of unknown and mutilated human remains. Studies considering spleen morphometric parameters to decipher the height of the deceased are very rare especially in Haryana, though, research studies involving correlation between height and other body organs have been done.

Aim: To determine the correlation between the morphometric parameters of the spleen and height of the deceased.

Materials and Methods: The cross-sectional study was carried out in the Department of Anatomy in collaboration with the Department of Forensic Medicine in Pandit Bhagwat Dayal Sharma Post Graduate Institute of Medical Sciences, Rohtak, Haryana, India, from September 2010 to September 2012. The spleen specimens (30 males and 30 females) obtained from deceased adults in the age group of 16-70 years (both age inclusive) belonging to north India from the Department of Forensic Medicine during autopsy. The measurement of splenic parameters (weight, length, breadth, thickness and surface area) was done using direct measurement (standard methodology) accepted by anthropologists. The data was analysed using Statistical Package for the Social Sciences (SPSS) software version 20.0. Pearson's correlation test was used to evaluate the association between the splenic parameters and height. Correlation formula was derived to calculate the height from the splenic measurements.

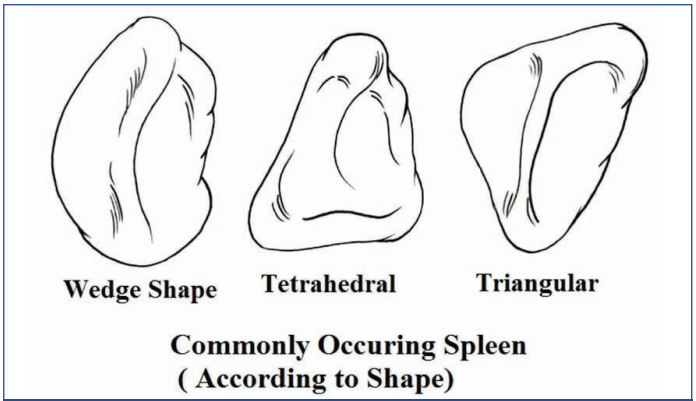
Results: Correlation of height was positive with splenic measurements (weight, length, breadth, thickness and total surface area) in both males and females and was significant with splenic weight (r-value=0.54 and p-value=0.02) and splenic length (r-value=0.548; p-value=0.002) in females. It was significant for splenic thickness in males (r-value=0.042; p-value=0.018) and significant for total surface area of spleen for both males and females (r-value=0.80 and p-value <0.00001 in males and r-value=0.58 and p-value=0.000781 in females).

Conclusion: Correlation of height was significant for splenic weight and length in females; significant for splenic thickness in males and significant for total surface area of spleen for males and females. This study would help anthropologists and Forensic Medicine experts to calculate the height of the deceased using various regression equations, if spleen is intact and is measured.

Keywords: Morphometry, Splenic breadth, Splenic height, Splenic length, Splenic weight

INTRODUCTION

The estimation of identity of a deceased individual is very important for forensic experts [1]. Spleen is the largest unit of lymphoid tissue in the body. It is situated in the upper and left part of the abdomen between the fundus of stomach and the diaphragm [2]. It lies in the left hypochondrium and partly in epigastrium. Its axis is oblique and is directed downward, forwards and laterally coinciding with the tenth rib. Spleen moves with respiration and is highly vascular and has two ends i.e, medial and lateral; two surfaces i.e, diaphragmatic and visceral and two borders i.e, superior and inferior. It develops as a lobulated mass from the mesoderm of the upper part of the dorsal mesogastrium under cover of its left layer. Anterior part of dorsal mesogastrium forms gastrosplenic ligament while the posterior part persists as lienorenal ligament [3,4]. Spleen plays a key role in the interactions between the circulatory, reticuloendothelial and immune systems due to its unique architecture [3]. The different types of shapes of spleen are tetrahedral, wedge and triangular. The diagrammatic representation of different shapes of spleen has been shown in [Table/Fig-1] [2]. Its average dimensions are approximately: length 5 inches, breadth 3 inches and thickness 1.5 inches. The average weight in the adult is about 80-150 gm [3,5,6]. One of the factors in establishing the identity of a person is his stature and since the last few decades the anthropometric work related to the correlation between the height of an individual and morphometry of body organs has been carried out [7,8]. Demissie S et al., in Southern Ethiopia studied morphometric assessment of spleen dimensions and its correlates among individuals in Arba Minch Town, Southern Ethiopia [7]. Gowraiah HL and Machikalapati SR, studied correlation between anthropometric parameters and volume, weight and size of normal spleen in Andhra Pradesh and found it significant [8]. The present study will be of use to anthropologists and forensic experts to find the height of the deceased when the parameters of the splenic specimen is known and is different from other studies done using Ultrasound (USG) and Computed Tomography (CT) [7,9].



[Table/Fig-1]: Different types of spleen (according to shape).

The present study was conducted to see the correlation of height with morphometric parameters of spleen (weight, length, breadth, thickness and total surface area) in North Indian population

(specifically of Haryana). Spleen was chosen for the study in place of other organs because of its ease of measurement and handling and procurement.

MATERIALS AND METHODS

The cross-sectional study was carried out in the Department of Anatomy in collaboration with the Department of Forensic Medicine in Pandit Bhagwat Dayal Sharma Post Graduate Institute of Medical Sciences, Rohtak, Hrayana, India, from September 2010 to September 2012. Prior to commencement of the study, permission from the Institutional Ethics Committee was taken. Informed consent was obtained from the relatives before the procurement of the specimens.

Source of the history had been the file of the patient wherein all the details as name, age, sex, height, weight, medical history as previous illness and present illness and address had been noted.

Inclusion criteria: The specimens were selected only from fresh cadavers within 24 hours of death because after this time-duration the morphometry is altered due to decomposition and the spleen becomes pulpy, greenish steel and gets reduced to a different mass [3].

Exclusion criteria: The burn cases and deaths occurring due to known diseases that affect spleen size grossly, such as malaria, typhoid, miliary tuberculosis, Human Immunodeficiency Virus (HIV), hepatitis, connective tissue disorders, such as Systemic Lupus Erythematosus (SLE), rheumatoid arthritis, thalassaemia, polycythemia, lymphomas and other malignancies have been excluded from the study.

Sample Collection

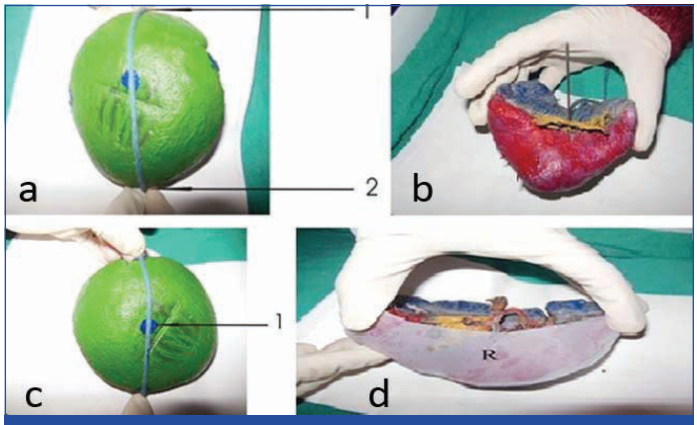
Before proceeding for collection of data, detailed history of the deceased was obtained from records of the Forensic Department. Considering the duration and frequency of availability of deceased in Forensic Department the sample size was estimated as 60 (30 males and 30 females) by using Epi software. A total of 60 spleens were chosen by employing convenience sampling during postmortem examination of apparently healthy individuals (30 males and 30 females) of age ranging from 16-70 years belonging to Haryana Region of North India, verified based on their permanent addresses. Source of the history had been the file of the patient wherein all the details as name, age, sex, height, weight, medical history as previous illness and present illness and address had been noted.

History of the deceased had been examined carefully to adhere to inclusion and exclusion criteria.

Morphometric Parameters

The morphometric parameters and the methods used were as follows:

1. **Length of spleen:** It was noted on diaphragmatic surface by a thread from superior angle to inferior angle passing through maximum convexity [9]. The measurement of length has been shown in [Table/Fig-2a].
2. **Breadth of spleen:** Breadth was noted on diaphragmatic surface again by the thread passing horizontally through maximum convexity and through the mid-point of the length [9]. The measurement of breadth has been shown in [Table/Fig-2b].
3. **Thickness of spleen:** The thickness of spleen was done by inserting a needle at the maximum convexity and was then evaluated by measuring the length of needle embedded inside [9]. The measurement of thickness has been shown in [Table/Fig-2c].
4. **Areas of various surfaces** (diaphragmatic, gastric, renal and colic): These were calculated after wrapping each surface in butter paper and cutting neatly from the borders; they were outlined on the graph paper. Counting of the squares within the outline gave the surface area in square centimeters. The summation of the area of both visceral and diaphragmatic surfaces of the spleen was carried out [6]. The measurement of surface area has been shown in [Table/Fig-2d]. The present study was conducted in autopsy room and time available to carry out observations was comparatively short, so, it was thought pertinent to go for methodology of surface area estimation using graph paper method. Researchers adopted radiological imaging methods for estimation of morphometry and surface areas of visceras [7,10].
5. **Height of the deceased:** The records of the stature of the deceased were obtained from the Department of Forensic Medicine.



[Table/Fig-2]: Methodology of measurement of splenic parameters; a) Method to measure splenic length (1,2: farthest points on superior angle and inferior); b) Method to measure splenic thickness (needle shown on visceral); c) Method to measure splenic breadth (1: midpoint of splenic length); d) Method to measure surface area (R: renal surface).

STATISTICAL ANALYSIS

The splenic parameters and other data were noted carefully and recorded in Microsoft Excel sheet and data were analysed using the Statistical Package for the Social Sciences (SPSS) software 20.0. Independent t-test was used to evaluate the differences between the continuous variables. Pearson's correlation test was used to assess the relationship between the splenic morphometric parameters with height of the deceased. The p-value <0.05 was considered as significant.

RESULTS

The study population belonged to north India and 30 male and 30 female spleens were obtained from deceased adults in the age group of 16-70 years. The average age being 35.52 years in case of males (range 17-67 years) and 39.68 years in case of females (range 16-69 years).

Height of deceased in male and female: The mean height irrespective of sex was 159.61±6.24 cm. The mean height of males was 165.41±2.71 cm with a range of 162.5-170 cm. The females had a mean height of 153.25±4.64 cm with a range of 132.5-157.5 cm. This is shown in [Table/Fig-3].

Variable	Male (n=30)	Female (n=30)	p-value
Height (cm)	165.41±2.71	153.25±4.64	0.000714**

[Table/Fig-3]: Comparison of height of deceased males and females.
*p<0.05 statistically significant; **p<0.001 statistically highly significant. Student's t-test was used to test the significance

Correlation of height with weight of spleen in male and female: The mean weight of spleen, irrespective of gender was 109.23±9.2 gm. The weight of the male spleen varied from 90 gm-148 gm and in females varied from 70 gm-94 gm The splenic weight showed a weak positive (r-value=0.049) and strong positive (r-value=0.54) correlation with the height of males and females respectively. The p-value for correlation in males was 0.79 and in females was 0.002 [Table/Fig-4].

Variables	Male (n=30)	Female (n=30)
Splenic weight (gm)	131.6±12.9	87.86±5.69
Correlation coefficient	0.049	0.54
p-value	0.79 (not significant)	0.02 (significant)
Regression equation	y=0.234x+92.86	y=0.702x-20.15
Coefficient of determination	0.002	0.30

[Table/Fig-4]: Correlation between splenic weight and height of individuals. Where y=splenic weight in g and x=height in cm, *p<0.05 statistically significant; *p< 0.001 statistically highly significant

Correlation of height with dimensions (length, breadth and thickness) of spleen

1. Length of spleen: The mean splenic length irrespective of gender was 10.68±1.3 cm. The length of the spleen in males ranged between 9.5 cm to 17 cm and varied from 8 cm to 13 cm in females. The p-value of correlation of height with splenic length in males was 0.79 and was not significant whereas p-value in females was 0.002 and was significant [Table/Fig-5].

Variables	Male (n=30)	Female (n=30)
Splenic length (cm)	11.45±1.43	9.91±1.18
Correlation coefficient	0.049	0.548
p-value	0.79	0.002
Regression equation	y=0.008x+9.99	0.024x+6.096
Coefficient of determination	0.00	0.009

[Table/Fig-5]: Correlation between splenic length and height of individuals. Where y=splenic length in cm and x=height in cm, *p<0.05 statistically significant; *p< 0.001 statistically highly significant

2. Breadth of spleen: The mean splenic breadth irrespective of gender was 6.13±0.82 cm. The breadth of the spleen varied from 5 cm to 8 cm in males and varied from 4 cm to 8 cm in females. Correlation with height was found to be positive and moderate in females (r-value=0.11 in males and r-value=0.20 in females) [Table/Fig-6].

Variables	Male (n=30)	Female (n=30)
Splenic breadth (cm)	6.26±0.73	6.01±0.91
Correlation coefficient	0.11	0.2
p-value	0.56	0.28
Regression equation	y=0.053x-2.58	y=0.041x-0.308
Coefficient of determination	0.036	0.044

[Table/Fig-6]: Correlation between splenic breadth and height of individuals. Where y=splenic breadth in cm and x=height in cm, *p<0.05 statistically significant; *p<0.001 statistically highly significant

3. Splenic thickness: The mean splenic thickness irrespective of gender was 1.92±0.12 cm. The thickness of the spleen ranged between 1.5 cm to 2 cm in males and varied from 1.5 cm to 2 cm in females. Correlation between splenic thickness and height was significant in males (p-value=0.018) and not significant in females (p-value=0.36) [Table/Fig-7].

Variables	Male (n=30)	Female (n=30)
Splenic thickness (cm)	1.92±0.09	1.92±0.15
Correlation coefficient	0.426	0.17
p-value	0.018	0.36
Regression equation	y=0.026x-2.594	y=0.0059x+1.01
Coefficient of determination	0.181	0.030

[Table/Fig-7]: Correlation between splenic thickness and height of individuals. Where y=splenic thickness in cm and x=height in cm, *p<0.05 statistically significant; *p<0.001 statistically highly significant

4. Correlation of height with total surface area of spleen: The mean splenic surface area irrespective of gender was 207.59±24.63 cm^2. The total surface area of the spleen varied between 213 cm^2-308 cm^2 in males and varied between 123 cm^2-202 cm^2 in females. Correlation with height was positive in both males and females. (r-value=0.80 in males and r-value=0.58 in females) [Table/Fig-8].

Variables	Male (n=30)	Female (n=30)
Splenic surface area (cm^2)	256.23±23.46	158.96±25.81
Correlation coefficient	0.80	0.58
p-value	<0.00001	0.000781
Regression equation	y=0.093x+141.5	0.106x+136.3
Coefficient of determination	0.650	0.336

[Table/Fig-8]: Correlation between total splenic surface area and height of individuals. Where y=splenic surface area in cm^2 and x=height in cm, *p<0.05 statistically significant; *p<0.001 statistically highly significant

DISCUSSION

In the present study, the average weight of spleen in males was 131.6±12.90 gm and in females, the average weight was 87.86±5.69 gm. Correlation of splenic weight with height in males was positive in present study. Chow KU et al., worked on establishment of normal values for spleen size in the US with 1200 individuals. They had found that splenic volume and length correlated partly with sex, height and body weight [10]. Correlation was also observed in studies by Sprogøe-Jakobsen S and Sprogøe-Jakobsen U, de la Grandmaison GL et al., and Kim YS et al., [11-13]. Correlation of weight with height in females was also positive in the present study. Similar findings were also supported by the studies done by Sprogoe-Jakobsen S et al., de la Grandmaison GL et al., Kim YS et al., and Deland FH [11-14]. Correlation was significant in females in present study (p-value=0.002) but not in males (p-value=0.79).

The average length of spleen in males was 11.45±1.43 cm and in females it was 9.91±1.18 cm. Correlation of length with height was reported by Asghar A et al., and was negative in both males and females [15]. Results of the present study also matched with this study.

Correlation of splenic width with height was positive in the study by Spielmann AL et al., and Asghar A et al., [16,17]. Findings of the present study corroborates with these two studies. In present tudy, correlation was not significant for males (p-value=0.562) and females (p-value=0.28).

Splenic thickness was calculated, and average came out to be 1.89±0.16 cm. In males, average thickness was 1.86±0.17 cm and in females, it was found to be 1.92±0.15 cm. No correlation with height was found by Spielmann AL et al., [16]. Correlation with height was also positive in the study done by Asghar A et al., [15]. In present study, correlation was positive in both males (r-value=0.42) and females (r-value=0.17). Correlation was significant in males (p-value=0.018 and not significant in females (p-value=0.36).

Average total surface area in present study was 207.59±24.43 cm^2. In males, it was 256.23±23.46 cm^2 and in females it was 158.96±25.41 cm^2. Correlation of surface area with height was strongly significant (r-value=0.80) in males and in females, correlation was moderately positive (r-value=0.58). This was also best supported by the study of Asghar A et al., [15]. Correlation was significant in males (p-value <0.00001), as well as in females (p-value=0.000781). The comparative account of findings of other studies and present studies have been shown in [Table/Fig-9] [11-16].

Differences in the results of other studies and the present study can be attributed to the many factors as environmental and racial causes [7]. Mohtasib RS et al., did ultrasonographical examination of splenic length of full-term neonates to kids 16 years of age between 2003 to 2018 and found that spleen size had significant correlation with age and height across all ages and in both sexes [18]. The present study showed positive correlation between height of the deceased and morphometry of the spleen.

Correlation of height with	Gender	Sprogøe-Jakobsen S and Sprogøe-Jakobsen U, [11] 1997	de la Grandmaison GL et al., [12] 2001	Kim YS et al., [13] 2009	Deland FH [14] 1970	Speilmann AL et al., [16] 2005	Asghar A et al., [15] 2011	Present study
Place of study		Denmark	France	Korea	US	Vancouver	North India	North India
Splenic weight	Males	Positive	Positive	-	-	-	-	Positive
	Females	Positive	Positive	Positive	Positive	-	-	Positive
Length of spleen	Males	-	-	-	-	-	Negative	Positive
	Females	-	-	-	-	-	Negative	Positive
Breadth of spleen	Males	-	-	-	-	Positive	-	Positive
	Females	-	-	-	-	Positive	-	Positive
Thickness of spleen	males	-	-	-	-	No correlation	Positive	Positive
	Females	-	-	-	-	-	Positive	Positive
Surface area of spleen	Males	-	-	-	-	No correlation	Positive	Positive
	Females	-	-	-	-	-	Positive	Positive

[Table/Fig-9]: Comparative account of findings of other studies with the present studies [11-16].

Limitation(s)

The biggest bottleneck of the study was limited time with uncertain number of postmortems. Though findings could have been more precise if latest modalities such as USG, CT scan could have been used with larger number of sample size.

CONCLUSION(S)

Correlation of height was positive with all the splenic measurements in both males and females. Correlation was significant for splenic weight and length in females, significant for splenic thickness in males and significant for total surface area of spleen for both males and females. Spleen morphometric parameters can be further correlated with age using larger number of spleen specimens. The present study would have important applications in forensics and crimes involving homicides.

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