ORIGINAL RESEARCH

Assessment of Correlation of Morphometric Parameters of the Spleen and Height of the Deceased: A Cross-Sectional Study

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ABSTRACT

Background: For forensic experts, it is crucial to estimate the identity of a deceased individual. The largest unit of lymphoid tissue in the body is the spleen. The present study was conducted to assess the correlation between the morphometric parameters of the spleen and height of the deceased. Materials & Methods: The study was carried out on spleen specimens (n=70) acquired from deceased adults aged 16-70 years during autopsy at the Department of Forensic Medicine. Spleen parameters (weight, length, breadth, thickness and surface area) were measured using direct measurement (standard methodology) accepted by anthropologists. Results: Out of 70 specimens, 40 were of males and 30 were of females. The mean height in males was 164.2 ± 5.1 cms and in females was 152.7± 8.6 cms. The mean weight in males was 57.4± 2.3 kgs and in females was 53.1±2.8 kgs. The difference was significant (P< 0.05). The 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=0.61 and p- value=0.03) and splenic length (r- value=0.63; p-value=0.02) in females. It was significant for splenic thickness in males (r- value=0.49; p-value=0.01) and significant for total surface area of spleen for both males and females (r- value=0.81 and p-value <0.01 in males and r- value=0.61 and pvalue=0.01 in females). Conclusion: In both males and females, height showed a positive correlation with all splenic measurements. In females, correlation was significant for splenic weight and length; in males, it was significant for splenic thickness. For both males and females, correlation was significant for the total surface area of the spleen.

Keywords: Spleen, Height, Morphometry, Forensic Identification, Surface Area, Stature Estimation

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INTRODUCTION

For forensic experts, it is crucial to estimate the identity of a deceased individual. The largest unit of lymphoid tissue in the body is the spleen.¹It is located in the upper left part of the abdomen, positioned between the stomach's fundus and the diaphragm.² It is situated in the left

hypochondrium and partly in the epigastrium. Its axis is oriented obliquely and directed downwards, forwards, and to the side, aligning with the tenth rib.³It is highly vascular, moves with respiration, and has two ends: the medial and lateral. two surfaces (diaphragmatic and visceral) and two borders (superior and inferior).

It arises as a lobulated mass from the mesoderm in the upper region of the dorsal mesogastrium, concealed by its left layer.⁴

Due to its unique architecture, the spleen plays a crucial role in the interactions among the circulatory, reticuloendothelial, and immune systems.⁵ The spleen can take on various shapes, including tetrahedral, wedge, and triangular. Its average measurements are about: length of 5 inches, width of 3 inches, and thickness of 1.5 inches.6The typical weight in adults is roughly 80-150 gm. An individual's stature is one of the factors used to establish their identity. For this reason, anthropometric studies have been conducted over the past few decades to examine the correlation between a person's height and the morphometry of body organs.⁷

AIM AND OBJECTIVES

Aim

To evaluate the correlation between the morphometric parameters of the spleen (length, breadth, thickness, surface area) and the height of deceased individuals in a Eastern Indian population.

Objectives

- 1. To measure and record the morphometric parameters (length, breadth, thickness, surface area) of the spleen in deceased individuals.
- **2.** To assess the height of the deceased individuals from forensic records.
- **3.** To analyze the relationship between spleen morphometry and the height of the deceased individuals.
- 4. To compare the spleen dimensions and their correlation with height between male and female deceased individuals.
- **5.** To contribute baseline morphometric data on spleen dimensions relevant for forensic, anatomical, and surgical applications.

MATERIALS AND METHODS

Study Design

This was a **cross-sectional observational study** conducted to evaluate the correlation between morphometric parameters of the spleen and the height of deceased individuals.

Study Population

The study population comprised deceased individuals undergoing autopsy at the Department of Forensic Medicine, with spleens collected in collaboration with the Department of Anatomy at Patna Medical College and Hospital, Patna, Bihar, India. The age of subjects ranged from **16 to 70 years**, and they were residents of the Bihar region of Eastern India (verified by permanent address).

Study Place

The study was carried out in the Department of Anatomy, Patna Medical College & Hospital (PMCH), Patna, Bihar, India.

Study Period

The study was conducted over a period of two years and three months, from September 2022 to November 2024.

Ethical Considerations

Prior to commencement, Institutional Ethics Committee approval was obtained. Informed consent was taken from the legal relatives of the deceased before specimen procurement. Strict confidentiality and adherence to ethical standards were maintained throughout the study.

Inclusion Criteria

- Fresh cadavers within 24 hours of death.
- Deceased individuals without any known history of diseases affecting splenic size.
- Residents of the Bihar region, verified from permanent addresses.

Exclusion Criteria

- Cadavers beyond 24 hours after death (to avoid decomposition artifacts).
- Burn cases.
- Deaths caused by diseases known to grossly alter spleen size, such as:
 - o Malaria
 - o Typhoid
 - o Miliary tuberculosis
 - HIV infection
 - Hepatitis
 - Connective tissue disorders (e.g., Systemic Lupus Erythematosus, rheumatoid arthritis)
 - Hematological disorders (e.g., thalassemia, polycythemia)
 - Lymphomas and other malignancies.

Sample Collection

- Sample size estimated to be 70 cadavers (40 males, 30 females) using Epi software based on feasibility.
- Convenience sampling was employed.
- Specimens were collected during routine forensic autopsies after detailed examination of the deceased's medical and forensic records.
- Data including name, age, sex, height, weight, past and present medical history, and address were recorded from patient files.

Morphometric Parameters

The following spleen measurements were recorded:

- 1. Length: Measured on the diaphragmatic surface using a thread from superior to inferior angle, along the maximum convexity.
- **2. Breadth**: Measured horizontally at the maximum convexity and at the midpoint of the length.
- **3. Thickness**: Assessed by inserting a needle at the point of maximum convexity and measuring the embedded portion.

4. Surface Areas:

- Surfaces (diaphragmatic, gastric, renal, colic) were traced onto butter paper.
- The outlines were transferred onto graph paper and the areas were calculated by counting squares.
- The total surface area was calculated as the sum of visceral and diaphragmatic surfaces.
- **5. Height of Deceased**: Retrieved from forensic records.

Study Procedure

Samples were collected from department of Anatomy and the postmortem examination was **RESULTS**

performed following standard protocols. After procurement, each spleen was carefully cleaned, and morphometric measurements were performed immediately to prevent dehydration and tissue distortion. Surface area measurements were performed manually using graph paper due to limited time available during autopsy procedures.

Outcome Measures

- Primary outcome: Correlation of spleen morphometric parameters (length, breadth, thickness, surface areas) with height of the deceased.
- Statistical Analysis
- Data were entered into Microsoft Excel and analyzed using SPSS version 25.0.
- Independent t-test was used for comparing continuous variables between groups (e.g., male vs female).
- Pearson's correlation coefficient (r) was used to assess the relationship between spleen morphometry and height.
- A p-value <0.05 was considered statistically significant.

Table I: Gender wise distribution of patients

Total- 70				
Gender	Male	Female		
Number	40 (57.14%)	30 (42.86%)		

Table I shows that out of 70 specimens, 40 were of males and 30 were of females.

Table II: Assessment of parameters					
Parameters	Parameters Male		P value		
Height (cms)	164.2 ± 5.1	152.7 ± 8.6	0.05		
Weight (Kgs)	57.4± 2.3	53.1±2.8	0.16		



Table II, Figure I shows that the **mean height** of male deceased individuals was **164.2 cm** (\pm 5.1), whereas the mean height for females was **152.7 cm** (\pm 8.6). The **p-value** of **0.05** indicates that the difference in height between males and females was **statistically**

significant. The **mean weight** of males was **57.4 kg** (± 2.3) compared to **53.1 kg** (± 2.8) in females. The p-value of 0.16 shows that the difference in weight between males and females was not statistically significant.

Table III: C	Correlation o	of Height w	ith Dimensions	(Length,	Breadth.	Thickness) of Spleen
				(

Parameters	Male (Mean	Female(Mean	Correlation	P value
	± SD)	± SD)	Coefficient	
Splenic weight (gm)	132.5 ± 4.2	89.4 ± 8.6	0.04 (M), 0.61 (F)	0.91 (M), 0.03 (F)
Splenic length (cm)	11.2 ± 5.6	10.1 ± 4.1	0.04 (M), 0.63 (F)	0.91 (M), 0.02 (F)
Splenic breadth (cm)	6.4 ± 2.9	6.1 ± 2.3	0.16 (M), 0.24 (F)	0.51 (M), 0.37 (F)
Splenic thickness (cm)	1.93 ± 1.1	1.94 ± 0.74	0.49 (M), 0.13 (F)	0.01 (M), 0.42 (F)
Splenic surface area	247.2 ± 17.5	164.2 ± 12.1	0.81 (M), 0.61 (F)	0.01 (M), 0.01 (F)
(cm ²)				

M= Male F= Female

Table III shows that 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=0.61 and pvalue=0.03) and splenic length (r- value=0.63; pvalue=0.02) in females. It was significant for splenic thickness in males (r- value=0.49; pvalue=0.01) and significant for total surface area of spleen for both males and females (rvalue=0.81 and p-value <0.01 in males and rvalue=0.61 and p-value=0.01 in females).Splenic weight and splenic length showed a significant positive correlation with height in females (p < p0.05) but not in males. Splenic thickness had a significant positive correlation with height in males (p = 0.01), but not in females. Splenic surface area had a highly significant positive correlation with height in both males and females (p = 0.01). Splenic breadth did not show significant correlation with height in either gender.

DISCUSSION

The spleen is the largest lymphoid organ in the human body. The morphology of spleen is affected by number of disorders, e.g. abnormalities of the cells, which populate within the spleen or disturbance of its storage function.8 Therefore, the size of the spleen can be regarded as an indicator of the disease process.^{9,10}

Spleen size is an integral part of abdominal ultrasonography because both enlarged and small spleens can be indicative of a variety of physical conditions. In addition, splenomegaly may be a risk factor for splenic rupture.¹¹The present study was conducted to assess the correlation between

the morphometric parameters of the spleen and height of the deceased.

We found that out of 70 specimens, 40 were of males and 30 were of females. Chow et al.¹² defined height- and sex-corrected normal values for spleen length and volume determined with ultrasonography (US). Spleen length and volume were significantly and independently associated with sex (length: P < .001; volume: P = .012), body height (P < .001 for both), and weight (P <.001 for both), with men and taller and heavier individuals having longer and larger spleens. The spleen length of 20 of 324 women (6%) and 234 of 906 men (26%) exceeded the previously reported upper limit of normal of 12 cm. Repeat measurements indicated that spleen length (median difference, 0.10 cm; range, -1.8 to 1.7 cm) and volume (median difference, 3 cm (3); range, -106 to 142 cm (3)) were quite stable. A mobile application that performs these calculations is available for download.

The present study results revealed that the **mean height of males** (164.2 cm) was **significantly greater** than that of females (152.7 cm) (**p=0.05**). This finding is in agreement with previous studies demonstrating that males are generally taller than females due to inherent biological and hormonal factors influencing growth patterns.^{13,14} **Weight**, however, did not differ significantly between the two groups (**p=0.16**), suggesting that in the studied population, body weight might not be as strongly sexually dimorphic as height.

The difference in height is crucial when analyzing spleen morphometry because previous studies have reported that spleen size positively correlates with body height and surface area.^{15,16}

Therefore, documenting such anthropometric differences helps in understanding and interpreting splenic measurements more accurately.

Our findings align with those reported by Konan et al., who observed a statistically significant association between splenic length and height among adult cadavers in an African population.¹⁷ Similarly, Pradhan et al. also demonstrated that spleen dimensions correlate better with the individual's stature than with body weight.¹⁸

The current study investigated the correlation between height and various morphometric parameters of the spleen. The findings demonstrated that **splenic surface area** had the strongest positive correlation with height in both **males** and **females** ($\mathbf{r} = 0.81$ and 0.61, $\mathbf{p} = 0.01$, respectively), suggesting that spleen size, particularly surface area, proportionally increases with stature.

In females, **splenic weight** and **splenic length** were also found to correlate significantly with height ($\mathbf{p} = 0.03$ and 0.02, respectively), whereas no significant relationship was observed for these parameters in males. This observation may be attributed to the differences in fat distribution, hormonal influences, and body composition between males and females, which can impact organ sizes differently.¹³

Splenic thickness was found to correlate significantly with height in males ($\mathbf{p} = 0.01$), suggesting that although the length and weight may not vary greatly with stature in males, the organ's thickness could proportionally increase with body size. Interestingly, **splenic breadth** did not show any significant correlation with height in either sex, indicating that breadth may be relatively more consistent across individuals irrespective of their stature.

Previous studies have also emphasized the positive relationship between spleen size and body dimensions. For example, studies by Mustapha et al.¹⁵ and Konan et al.¹⁷ demonstrated that splenic length and volume are proportional to body height and surface area. In particular, splenic length has been suggested as a useful parameter for estimating normal spleen size across populations.

The findings of the present study are similar to those of Pradhan et al.,¹⁸ who noted a significant correlation of splenic length with height, highlighting the potential utility of using anthropometric data to predict normal splenic dimensions in forensic, anatomical, and radiological practices.

The strong association between **splenic surface area** and height observed here supports the view that larger individuals tend to have larger organs, consistent with the principle of somatic scaling seen in human anatomy.¹⁹

A study by Rayhanet al.²⁰ was performed on 70 post-mortem human spleens collected from unclaimed dead bodies. The samples were divided into six different age groups i.e. group A (0-19 years), B (20-29 years), C (30-39 years), D (40-49 years), E (50-59 years) and F (>60 years). The length, breadth and thickness of the spleen were measured. The number of the notch in its upper and lower poles was observed. The presence of any accessory spleen was also observed in situ. The length, breadth and thickness of the spleen were found to have no significant changes with advancing age. Notches were present on the upper border of spleen in 88.57% of samples and lower border of the spleen in 27.14% of samples. Accessory spleen was found in 24.28% of cases.

LIMITATIONS OF THE STUDY

- **Small sample size** (n = 70) may limit the generalizability of findings to the broader population.
- **Convenience sampling** rather than random sampling could introduce selection bias.
- Measurement errors could occur during manual recording of spleen surface areas using graph paper.
- **Influence of confounding factors** like undiagnosed or subclinical conditions affecting spleen size might not have been completely ruled out.
- **Post-mortem changes** and time elapsed after death (even within 24 hours) may slightly affect the spleen's morphometric parameters.
- **Limited external validity** as findings apply primarily to the specific North Indian population studied and may not reflect global populations.

CONCLUSION

Authors found that in the present cross-sectional observational study, a positive correlation was observed between the morphometric parameters of the spleen and the height of deceased individuals. Splenic weight, length, thickness, and total surface area showed significant positive correlations with height, although the degree of association varied between males and females. Splenic weight and splenic length demonstrated statistically significant correlations with height in

females, while splenic thickness showed significant correlation with height in males. Total surface area of the spleen exhibited a strong positive correlation with height in both genders. However, splenic breadth did not show a significant correlation with height in either sex. These findings suggest that spleen dimensions, particularly surface area, can serve as useful anthropometric indicators in anatomical studies and for surgical operations.

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