

A CADAVERIC STUDY ON THE MORPHOLOGY AND MEASUREMENTS OF THE HUMAN SPLEEN

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ABSTRACT

Background: The spleen is a vital lymphatic organ that plays a significant role in the body's immune system. Its morphology, including shape, size, and weight, varies according to age, sex, and physiological conditions. Understanding these anatomical variations is essential for distinguishing normal splenic features from pathological conditions and preventing diagnostic errors during clinical and radiological evaluations. **Materials and Methods:** A descriptive observational cadaveric study was conducted on 60 adult human spleen specimens in the Department of Anatomy, Katuri Medical College and Hospital, Guntur. Each specimen was examined for morphological characteristics, including shape, number and location of splenic notches, and the presence of accessory spleens. Morphometric parameters such as length, breadth, thickness, and weight were also measured and analyzed. **Result:** The present study evaluated the morphological and morphometric characteristics of 60 spleen specimens. The wedge-shaped spleen was the most common morphological type, observed in 28 specimens (47%), followed by triangular (25%) and tetrahedral (17%) shapes, while oval, irregular, heart-shaped, and crescent-shaped spleens were less frequently observed. The splenic length ranged from 6.2–14.0 cm, with a mean of 10.48 ± 1.87 cm, and the majority of specimens (50%) measured 10.1–12 cm. The breadth ranged from 2.3–9.5 cm, with a mean of 6.59 ± 1.76 cm, with 51.67% measuring 6.6–8.0 cm. The thickness ranged from 1.8–7.0 cm, with a mean of 3.52 ± 1.18 cm, with 63.33% measuring 1.5–3.5 cm. Splenic weight ranged from 30–380 g, with an estimated mean of 174.64 ± 56.87 g, and the majority of specimens (38.33%) weighed 181–230 g. Splenic notches were present in 48 specimens (80%), with the superior border being the most common location (72.9%). The number of notches ranged from 1–5, with a mean of 1.63 ± 0.98 ; a single notch was the most frequent finding (62.5%). An accessory spleen was identified in 1 specimen (1.7%), whereas 59 specimens (98.3%) showed no accessory spleen. Overall, the study demonstrated considerable morphological and morphometric variation in the spleen, with wedge-shaped spleens, superior-border notches, and single splenic notches being the predominant findings. **Conclusion:** This study highlights the morphological and morphometric variations of the human spleen, providing valuable anatomical data that can aid clinicians, surgeons, and radiologists in accurate diagnosis, surgical planning, and interpretation of imaging findings. Recognition of these normal variations is essential for minimizing diagnostic errors and improving patient care.

INTRODUCTION

The spleen is the largest lymphoid organ of the human body and is situated in the left hypochondrium. It is typically wedge-shaped and consists of two ends (anterior and posterior), two surfaces (diaphragmatic and visceral), and three

borders (superior, inferior, and intermediate). The superior border usually exhibits one or more characteristic notches, which serve as important anatomical landmarks. In adults, the spleen generally measures approximately 12 cm in length, 7 cm in breadth, 3–4 cm in thickness, and weighs about 150–

200 g. Under normal conditions, it is not palpable on clinical examination.^[1-20]

Although congenital anomalies of the spleen are relatively uncommon, several developmental variations have been described, including agenesis, lobulation, duplication, wandering spleen (splenoptosis), polysplenia, and accessory spleens. Among these, accessory spleens are frequently encountered and are of considerable clinical importance because they may influence the management of hematological disorders and splenic surgeries.^[8,14]

The spleen plays a vital role in both the immune and circulatory systems. It is involved in immune surveillance, removal of aged erythrocytes, filtration of blood, and storage of blood cells. Morphological and morphometric variations of the spleen, including differences in its shape, size, weight, and the number and location of splenic notches, are of significant clinical and surgical relevance. Knowledge of these variations aids in the interpretation of radiological images, diagnosis of splenic diseases, and planning of surgical procedures, particularly spleen-preserving operations.^[6,18,19]

Despite its anatomical and clinical importance, morphometric studies of the spleen remain relatively limited. Further research is necessary to establish population-specific anatomical data that can improve clinical practice and anatomical education. Therefore, the present study was undertaken to evaluate the morphological and morphometric variations of the spleen in cadaveric specimens. The findings are expected to provide valuable information for anatomists, surgeons, radiologists, and physicians, contributing to accurate diagnosis, effective surgical management, and improved patient care.^[3-5,7,10-12]

Embryological Development of the Spleen: The spleen develops during the fifth to sixth week of intrauterine life from mesenchymal cells within the dorsal mesogastrium. With the rotation of the stomach, the developing spleen is displaced toward the left side of the abdomen and ultimately occupies the left hypochondrium. Initially, it develops as multiple mesenchymal condensations that fuse to form a single organ. Incomplete fusion of these condensations may result in accessory spleens (splenunculi). The fetal spleen is characteristically lobulated, and these lobulations usually disappear before birth. Persistence of grooves between the fetal lobules may contribute to the formation of the characteristic splenic notches, particularly along the

superior border. A detailed understanding of splenic embryogenesis is important for recognizing congenital anomalies, accessory splenic tissue, and anatomical variations, and is clinically relevant during radiological evaluation and spleen-preserving or splenic surgical procedures.^[1,8, 14, 15, 20]

AIM

To study the morphological and morphometric characteristics of the human spleen using cadaveric specimens.

Objectives

1. To determine the length of the spleen.
2. To determine the breadth of the spleen.
3. To determine the thickness of the spleen.
4. To evaluate the morphological variations of the spleen with respect to its shape, splenic notches, and the presence of accessory spleens.
5. To compare the morphometric and morphological findings of the present study with those documented in previous studies

MATERIALS AND METHODS

The present descriptive observational cadaveric study was conducted on 60 human spleen specimens obtained from the Department of Anatomy, Katuri Medical College and Hospital, Guntur. The specimens were carefully dissected following the standard dissection procedures described in Cunningham's Manual of Practical Anatomy.^[21] Surrounding adipose tissue and connective tissue were meticulously removed, and the specimens were cleaned with water before examination.

Each spleen was evaluated for morphological and morphometric parameters, including shape, length, breadth, thickness, and weight. The length, breadth, and thickness of each spleen were measured using a Vernier caliper, while the weight was recorded using a weighing balance. Morphological variations such as the presence, number, and location of splenic notches along the superior and inferior borders, notches involving other surfaces, and the presence of accessory spleens (splenunculi) were documented systematically.^[3-6, 18-20]

The collected observations were tabulated and subjected to descriptive statistical analysis. Quantitative variables were expressed as mean $\pm$ standard deviation (SD) and range, while qualitative variables were presented as frequency and percentage.^[3,4,7,10,12,14]

RESULTS

Table 1: Distribution of Spleens According to Morphological Shape

Spleen shape	Number of specimens	Percentage (%)
Wedge	28	47
Triangular	15	25
Tetrahedral	10	17
Oval	4	7
Irregular	1	2
Heart	1	2

Crescent	1	2
Total	60	100

The morphological shapes of the spleen were analyzed in 60 specimens and expressed in terms of frequency and percentage. The wedge-shaped spleen was the most common, observed in 28 specimens (47%), followed by triangular-shaped spleens in 15 specimens (25%) and tetrahedral-shaped spleens in

10 specimens (17%). Oval-shaped spleens were observed in 4 specimens (7%), while irregular, heart-shaped, and crescent-shaped spleens were each observed in 1 specimen (2%). Overall, the wedge shape was the predominant morphological type in the present study.

Table 2: Morphometric Analysis of Splenic Length (cm)

Spleen length (cm)	Number of specimens	Percentage (%)
6.0–8.0	8	13.3
8.1–10.0	12	20.0
10.1–12.0	30	50.0
12.1–14.0	10	16.7
Total	60	100.0

The length of the spleen in the present study ranged from 6.2 cm to 14.0 cm, with a mean length of 10.48 ± 1.87 cm and a range of 7.8 cm. Among the 60 spleen specimens examined, 8 specimens (13.3%) had a length between 6–8 cm, 12 specimens (20%)

measured 8.1–10 cm, 30 specimens (50%) measured 10.1–12 cm, and 10 specimens (16.7%) measured 12.1–14 cm. The maximum proportion of specimens (50%) was observed in the 10.1–12 cm length category.

Table 3: Morphometric Analysis of Splenic Breadth (cm)

Spleen breadth (cm)	Number of specimens	Percentage (%)
2.0–3.5	4	6.7
3.6–5.0	8	13.3
5.1–6.5	10	16.7
6.6–8.0	31	51.7
8.1–9.5	7	11.7
Total	60	100

The breadth of the spleen in the present study ranged from 2.3 cm to 9.5 cm, with a mean breadth of 6.59 ± 1.76 cm and a range of 7.2 cm. Among the 60 spleen specimens examined, 4 specimens (6.7%) had a breadth of 2.0–3.5 cm, 8 specimens (13.3%) had a breadth of 3.6–5.0 cm, 10 specimens (16.7%)

measured 5.1–6.5 cm, 31 specimens (51.7%) measured 6.6–8.0 cm, and 7 specimens (11.7%) measured 8.1–9.5 cm. The highest proportion of spleens (51.7%) was observed in the 6.6–8.0 cm breadth category.

Table 4: Morphometric Analysis of Splenic Thickness (cm)

Spleen Thickness (cm)	Number of specimens	Percentage (%)
1.5–3.5	38	63.3
3.6–5.5	16	26.7
5.6–7.5	6	10.0
Total	60	100

The thickness of the spleen in the present study ranged from 1.8 cm to 7.0 cm, with a mean thickness of 3.52 ± 1.18 cm and a range of 5.2 cm. Among the 60 spleen specimens examined, 38 specimens (63.3%) had a thickness of 1.5–3.5 cm, 16 specimens

(26.7%) had a thickness of 3.6–5.5 cm, and 6 specimens (10.0%) had a thickness of 5.6–7.5 cm. The highest proportion of specimens (63.3%) was observed in the 1.5–3.5 cm thickness category.

Table 5: Morphometric Analysis of Splenic Weight (g)

Spleen Weight (g)	Number of specimens	Percentage (%)
30–80	3	5.0
81–130	8	13.3
131–180	21	35.0
181–230	23	38.3
231–280	2	3.3
281–330	2	3.3
331–380	1	1.7
Total	60	100

The spleen weight in the present study ranged from a (5.0%) weighed 30–80 g, 8 (13.3%) weighed 81–130 g, minimum of 30 g to a maximum of 380 g, with a mean 21 (35.0%) weighed 131–180 g, 23 (38.3%) weighed weight of 174.64 ± 56.87 g and an overall range of 350 181–230 g, 2 (3.3%) weighed 231–280 g, 2 (3.3%) g. Among the 60 specimens examined, 3 specimens weighed 281–330 g, and 1 (1.7%) weighed 331–380 g.

The highest proportion of specimens (38.3%) was observed in the 181–230 g weight category, followed by 35.0% in the 131–180g category.

Table 6: Morphological Analysis of Splenic Notches

Splenic notches	Number of specimens	Percentage (%)
With notches	48	80
Without notches	12	20
Total	60	100

Splenic notches were present in 48 specimens (80%), while 12 specimens (20%) showed no notches. Thus,

the presence of splenic notches was the predominant finding in the present study.

Table 7: Morphological Analysis of the Location of Splenic Notches

Location of spleen notches	Number of specimens	Percentage (%)
Superior border	35	72.92
Inferior border	7	14.58
Both borders	3	6.25
Diaphragmatic surface	3	6.25
Visceral surface	0	0
Total	48	100

Among the 48 spleen specimens with notches, the superior border was the most common location, accounting for 35 specimens (72.9%). Notches on the inferior border were observed in 7 specimens (14.6%), while 3 specimens (6.3%) showed notches

on both borders. Notches on the diaphragmatic surface were also observed in 3 specimens (6.3%). No notches were observed on the visceral surface. Thus, the superior border was the predominant location of splenic notches.

Table 8: Distribution of splenic notches according to number

Number of spleen notches	Number of specimens	Percentage (%)
1	30	62.5
2	10	20.8
3	5	10.4
4	2	4.2
5	1	2.1
Total	48	100

Among the 48 spleen specimens with splenic notches, the number of notches ranged from 1 to 5, with a mean of 1.63 ± 0.98 . A single notch was the most frequently observed pattern, present in 30 specimens (62.5%), followed by two notches in 10

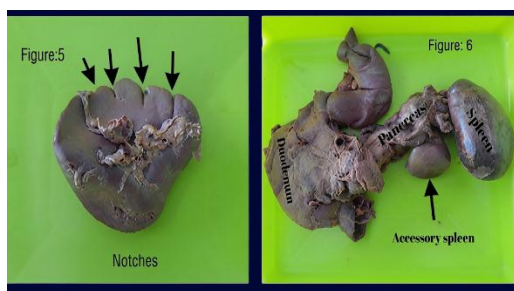
specimens (20.8%), three notches in 5 specimens (10.4%), four notches in 2 specimens (4.2%), and five notches in 1 specimen (2.1%). Thus, a single splenic notch was the predominant finding.

Table 9: Morphological Analysis of Accessory Spleen

Type of spleen	Number of specimens	Percentage (%)
Normal spleen	59	98.3
Accessory spleen	1	1.7
Total	60	100

An accessory spleen was identified in 1 specimen (1.7%), whereas 59 specimens (98.3%) had no accessory spleen. Thus, the presence of an accessory spleen was an uncommon finding in the present study.





DISCUSSION

The present study demonstrated considerable variation in splenic morphology, with the wedge

shape being predominant (47%), followed by triangular (25%) and tetrahedral (17%) shapes. The prevalence of wedge-shaped spleens was comparable to Rao et al. (40%), Hollinshead (44%), Chaudhari et al. (33.87%), Ashwini et al. (34%), and Gumede et al. (30%), but lower than Chaware et al. (61.26%). The triangular and tetrahedral forms showed variable frequencies across the compared studies, reflecting differences in population and sample characteristics. Oval (7%), irregular (2%), heart/leaf (2%), and crescent (2%) shapes were less frequent in the present study. Overall, the findings indicate that the wedge shape is the most common splenic morphology, although considerable inter-study variation exists.^[2-5,9-11,19,23]

Table 10: Comparative Analysis of Splenic Shape in the Present Study and Previous Studies

Shape	Rao et al	Hollinshead Wh	Chaware et al	Chaudhari et al.	Ashwini et al.	Gumede et al	Present study
Wedge	40%	44%	61.26%	33.87%	34%	30%	47%
Triangular	32%	42%	12.61%	19.35%	17%	15%	25%
Tetrahedral	20%	14%	21.62%	32.25%	17%	42.5%	17%
Oval	8%	-	3.60%	8.06%	21%	12.5%	7%
Irregular	-	-	0.90%	6.45%	9%	-	2%
Heart/Leaf	-	-	-	-	1%	-	2%
Crescent	-	-	-	-	1%	-	2%

Table 11: Comparative Analysis of Splenic Dimensions in the Present Study and Previous Studies

Measurement	Gray's Anatomy	Michels NA et al	Rao et al	Chaware et al	Chaudhari et al.	Present study
Average Length	12cm	11cm	10.5cm	9.66cm	9.59cm	10.48cm
Average Breadth	7cm	7cm	8.3cm	6.22cm	6.59cm	6.59cm
Average Thick-ness	3 to 4 cm	3cm	4cm	3.06cm	4.54cm	3.52cm

The present study recorded mean splenic length, breadth, and thickness of 10.48 cm, 6.59 cm, and 3.52 cm, respectively. The mean length was comparable with Rao et al. (10.5 cm), but lower than Gray's Anatomy (12 cm) and Michels et al. (11 cm), while being higher than Chaware et al. (9.66 cm) and Chaudhari et al. (9.59 cm). The mean breadth was comparable with Chaware et al. (6.22 cm) and Chaudhari et al. (6.59 cm), but lower than the values reported by Gray's Anatomy (7 cm), Michels et al. (7

cm), and Rao et al. (8.3 cm). The mean thickness was 3.52 cm, which was within the range described in Gray's Anatomy (3–4 cm) and close to the values reported by Michels et al. (3 cm) and Rao et al. (4 cm). The differences observed across studies may be related to population characteristics, age, sex, sample size, nutritional status, and methodological variations. Overall, the morphometric findings of the present study were broadly comparable with previously reported observations.^[1,3-5,20]

Table 12: Comparative Analysis of Splenic Weight in the Present Study and Previous Studies

S. No.	Author	Weight Range (g)	Average Weight (g)
1	Bergman et al.	80–250	165
2	Hollinshead	80–250	165
3	Sivanageswara Rao et al.	80–250	165
4	Sangeetha et al.	53–444	248.5
5	Chaware et al.	80–150	145.76
6	Present study	30–380	174.64

The present study recorded an estimated mean splenic weight of 174.64 g, with a weight range of 30–380 g. This mean value was higher than those reported by Bergman et al., Hollinshead, and Sivanageswara Rao et al. (165 g), and Chaware et al. (145.76 g), but lower than the mean weight reported by Sangeetha et al. (248.5 g). The wider range

observed in the present study indicates considerable variation in splenic weight among the specimens. Differences in splenic weight between studies may be attributed to variations in age, sex, population characteristics, nutritional status, sample size, and methodological factors. Overall, the mean splenic

weight in the present study was broadly comparable with previously reported values.^[2-4,7,17]

Table 13: Comparative Analysis of the Location of Splenic Notches in the Present Study and Previous Studies

Location of splenic notches	Das S et al.	Siva nageshwa Rao et al.	Shiva chidambaram et al.	Sudhakar et al.	Present study
Superior border	98%	70%	63.3%	70%	72.9%
Inferior border	2%	14%	10%	8%	14.6%
Diaphragmatic surface	–	–	–	1%	6.3%
Both borders	–	–	–	–	6.3%
Medial or posterior end	-	-	-	-	-

In the present study, splenic notches were predominantly observed along the superior border (72.9%), which was comparable to the findings of Siva Nageshwa Rao et al. (70%) and Sudhakar et al. (70%), but lower than that reported by Das S et al. (98%). Notches along the inferior border (14.6%) were higher than those reported by Das S et al. (2%), Shiva Chidambaram et al. (10%), and Sudhakar et al. (8%), but similar to Siva Nageshwa Rao et al. (14%).

Notches on the diaphragmatic surface (6.3%) and involving both borders (6.3%) were also noted in the present study. No notches were observed at the medial or posterior end. Overall, the findings confirm that the superior border is the most common location of splenic notches, although variations in their distribution were observed across different studies.^[3,6,18,19]

Table 14: Comparative Analysis of Accessory Spleen Prevalence in the Present Study and Previous Studies

Author / Study	Study type	Incidence / Prevalence of Accessory Spleen
Mohammadi et al. [2016]	Cadaveric study	0.7%
Unver et al.	Autopsy study	6.7%
Ghanto & Maharana [2025]	Cadaveric study	5%
Liu et al.	Cadaveric study	9.1%
Present study	Cadaveric study	1.7%

The incidence of accessory spleen in the present study was 1.7%, which was lower than the prevalence reported by Unver et al. (6.7%), Ghanto and Maharana (5%), and Liu et al. (9.1% in cadaveric studies). However, it was higher than the 0.7% reported by Mohammadi et al. The variation in prevalence may be related to differences in study methodology, sample size, population characteristics, and the sensitivity of imaging or cadaveric examination. The present findings indicate that accessory spleen is an occasional anatomical variation that should be considered during surgical and radiological evaluation of the spleen.^[14-16]

CONCLUSION

The present cadaveric study demonstrates considerable morphological and morphometric variation of the spleen, with the wedge-shaped spleen being the predominant morphological type and splenic notches occurring frequently, particularly along the superior border. The observed variations in splenic length, breadth, thickness, weight, shape, and notch pattern highlight the importance of understanding normal anatomical diversity. These findings have important clinical implications in radiological assessment, diagnosis of splenic enlargement, abdominal trauma, and surgical procedures involving the spleen. Recognition of prominent splenic notches is particularly relevant in differentiating normal anatomical variations from splenic lacerations or focal defects on imaging. The identification of an accessory spleen, although

uncommon in the present study, is clinically significant because it may be overlooked during splenectomy and can contribute to persistence or recurrence of splenic function in conditions requiring complete removal of splenic tissue. Thus, detailed knowledge of splenic morphology and morphometry is valuable for anatomists, radiologists, surgeons, and clinicians in accurate interpretation of imaging findings, surgical planning, and avoidance of diagnostic and operative complications.

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