



Original Research Article

Quantitative analysis of morphometric variations of human spleen - A cadaveric study

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ABSTRACT

Introduction: The spleen is a largest collection of lymphoid tissue with diverse hemopoietic and phagocytic function. Recent experimental data have clearly defined immunological functions of spleen in innate and adaptive immunity, as a frontline of host defense against various infections. A comprehensive knowledge of splenic anatomical variations and morphometric dimensions is crucial in deciphering the role of spleen in health & infirmity.

Aim: The aim of the study is to perform detailed morphometric analysis human splenic specimens with relation to age & gender differences and compare the findings with earlier studies.

Materials and Methods: The present study included 40 cadaveric spleen and morphometric features i.e., length, breadth, width and weight of spleen were measured.

Results: The average splenic weight observed was 178.5 gm and range was 100 to 300 gm. The average length, breadth and width of spleen were 11.9 cm, 7.33 cm and 3.4 cm respectively. The average splenic volume in the present study was 167.27 cc. There was a significant increase in splenic volume till 40-49 years followed by steady decline.

Conclusion: The awareness of the morphology and dimensions of the spleen is of fundamental importance to the hematologists, clinicians, radiologists, prosectors and surgeons while performing surgical procedures on spleen.

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1. Introduction

The spleen is one of the cardinal organs with overwhelming significance which did not get enough recognition it deserved. The spleen is a largest encapsulated collection of lymphoid tissue of human body that plays a significant role in extramedullary hematopoiesis & immune defense in fetal & adult life.^{1,2} Spleen is situated in the left hypochondrium and in healthy adult humans is usually 12 cm long, 7 cm broad and 3–4 cm wide.² The spleen is the most vascular organ in human body which receives 5 % of cardiac output and 40% source of the blood in the portal circulation.^{3,4} According to harris dictum spleen measures spleen measures 1 x 3 x 5 inches, 7 oz weight, and relates to 9 through 11 ribs. In healthy adults, it is most

frequently located between the tenth and twelfth ribs, with its long axis along the eleventh rib.^{5,6} Its posterior border is approximately 4 cm from the midline at the level of the tenth thoracic vertebral spine and it extends about 3 cm anterior to the mid-axillary line The average adult weight is dependent on the volume of contained blood; emptied of blood, it weighs between 70 and 120 g, whereas in vivo its weight ranges from 150 to 350 g.^{4,7,8} The awareness of the morphology and morphometric dimensions of the spleen is of fundamental importance to the clinicians & surgeons. Thus a comprehensive study on the morphometric variations of spleen will provide insights in to diverse splenic pathologies which warrants the need for this study.

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2. Aims and Objectives

The aim of the study is to perform detailed morphometric analysis human splenic specimens and compare the parameters with the existing literature.

3. Materials and Methods

The present study is a prospective type of study conducted in the department of Anatomy, S.V. Medical College, Tirupati. The ethical committee approval and consent of the relatives were obtained. During routine cadaveric dissection in department of Anatomy, S.V. Medical College, Tirupati, the spleen were collected. This includes 40 spleen specimens of both sexes ranging from 10 to 70 yrs. The spleen were observed insitu and then removed by routine dissection method and subjected to morphological & morphometric analysis. By using digimatic calipers (vernier-digital - MHUtoyo 6" mitutoyo), thread, measuring scale and the digital weighing balance, the following parameters were recorded.

1. Length - measured between the splenic tips along diaphragmatic surface of spleen.
2. Breadth - between superior and inferior border at a plane perpendicular to the length.
3. Width - by using sliding digital calipers, maximum antero-posterior dimension.

The collected data of both pre and postnatal age groups were subjected to statistical analysis by computing the mean of each parameter with respect to the age - wise groups by using SPSS 20 version (XL STAT). Student's t test, ANOVA & DMRT were used to compare the gender and morphometric parameters

4. Results and Analysis

The spleen were categorized in 6 groups as 0-19 Years, 20-29 Years, 30-39 Years, 40-49 Years, 50-59 Years and 60 - 69 Years. The largest group was samples with age 30-39 years with 11 specimens closely followed by 40-49 years group with 9 specimens. The gender-wise distribution is 75 % and 25 % for male and female groups respectively.

4.1. Age-wise correlation of splenic weight

The maximal splenic weight is seen in 30 -39 years age group (211 ± 68 gm). Low splenic weights were observed in 10-19 years group and 60-69 years groups with latter being the lowest with mean splenic weight of 140 ± 22 gm.

The difference in splenic weight in relation to age is statistically insignificant (P value .15 and F value 1.73). The lowest and highest splenic weights observed were 150gm and 310 gm respectively.

The statistical one way ANOVA and Duncan's multiple range test (DMRT) were applied to the parameters of the

spleen of different age groups revealed that the splenic weight gradually increases with age till 30-39 years and decreases thereafter with increasing age. The mean splenic weight in male samples is 178 ± 56 gm where as in females is 179 ± 54 gm.



Fig. 1: Digimatic calipers & dissecting instruments



Fig. 2: Showing spleens of different age groups

The maximal splenic length was in 40-49 years group with mean $8.5 \text{ cm} \pm 2.7$ cm with gradual and significant increase with age till 40 -49 years and declines gradually there afterwards. The mean splenic length observed was 11.9 ± 2.1 cm. The minimal and maximal splenic lengths observed were 8.3 and 17 cm respectively.

The maximal splenic breadth was in 30-39 years group with mean $13 \text{ cm} \pm 2.1$ cm with gradual and significant increase (P value 0.01 and F value of 3.35) with age till 30

Table 1: Summary of ANOVA and Duncan's Multiple Range Test (DMRT) in postnatal group by age and morphological parameters

Adults	Age	N	Mean	Std. Deviation	F-value	p-value	Min	Max
Splenic weight [gm]	0 - 19 years	3	168.333	27.5379	1.733	0.154	150.0	200.0
	20 -29 years	6	166.667	58.4523			100.0	250.0
	30 - 39 years	11	211.818	68.2376			130.0	310.0
	40 - 49 years	9	185.000	50.6211			120.0	300.0
	50 - 59 years	6	156.667	36.1478			120.0	200.0
	60-69 years	5	140.000	22.3607			100.0	150.0
	Total	40	178.500	55.0548			100.0	310.0
Length [cm]	0 - 19 years	3	10.100	0.3606	0.003	9.8	10.5	
	20 -29 years	6	10.567	1.1466		8.3	11.5	
	30 - 39 years	11	12.709	2.2775		10.0	15.5	
	40 - 49 years	9	13.711	2.1038		10.5	17.0	
	50 - 59 years	6	11.617	1.8027		9.9	14.5	
	60-69 years	5	10.000	0.7382		9.0	10.8	
	Total	40	11.915	2.1966		8.3	17.0	
Breadth [cm]	0 - 19 years	3	7.167	0.9074	3.351*	0.014	6.2	8.0
	20 -29 years	6	6.100	0.6899			5.0	7.0
	30 - 39 years	11	8.527	2.7774			5.5	15.0
	40 - 49 years	9	8.122	1.0756			6.5	9.7
	50 - 59 years	6	6.633	0.5715			6.0	7.2
	60-69 years	5	5.740	0.6229			5.0	6.5
	Total	40	7.338	1.8929			5.0	15.0
Width [cm]	0 - 19 years	3	2.333	0.5859	4.707**	0.002	1.9	3.0
	20 -29 years	6	3.000	0.5831			2.3	3.8
	30 - 39 years	11	3.718	0.7998			2.4	5.5
	40 - 49 years	9	3.944	0.6930			3.2	5.6
	50 - 59 years	6	3.517	0.4309			3.0	4.0
	60-69 years	5	2.840	0.3847			2.4	3.3
	Total	40	3.417	0.7834			1.9	5.6

-39 years and declines significantly thereafter. The lowest splenic breadth was observed in 60-69 years age group with mean breadth 5.7 ± 0.62 cm. The average splenic breadth observed was 7.33 ± 1.89 cm. The minimal and maximal splenic breadths observed were 5 and 15 cm respectively.

The maximal splenic width was in 40-49 years group with mean $3.9 \text{ cm} \pm 0.69$ cm with gradual and highly significant increase (P value 0.002 and F value of 4.7) with age till 40 -49 years and declines significantly thereafter. The lowest splenic width was observed in 0-19years age-group with mean width 2.3 ± 0.58 cm. The average splenic width observed was 3.4 ± 0.78 cm. The minimal and maximal splenic width observed were 1.9 and 5.6 cm respectively.

The ANOVA correlation shows morphometric parameters splenic length, breadth and width steadily varied with age and the difference is highly significant (P values 0.003, 0.014 and 0.002 respectively) for length and width.

4.2. Correlation of splenic weight, length, breadth and width with gender

The difference in splenic weight in relation to gender was statistically insignificant (P value 0.9 and t value 0.06). The

mean splenic length, breadth and width followed the same pattern as splenic weight in relation to gender without any statistically significant difference.

4.3. Observation of linear correlation between morphometric parameters

The pearson product-moment correlation coefficient for degree of linear dependence calculated for splenic weight, length, breadth and width in postnatal group showed significant positive correlation between splenic weight and splenic length, breadth and width (Pearson coefficient 0.51, 0.70 and 0.51 respectively).

The splenic length correlated with breadth and width in positive direction. However the maximal correlation dependence was observed between the splenic weight and the breadth (Pearson coefficient 0.70) and the least dependence was observed between splenic length and breadth (Pearson coefficient 0.48). The splenic weight, length and breadth steadily increased with age and the difference was highly significant (P < 0.05, High F value) for length, width and significant for breadth.

Table 2: Independent sample t -test by gender for morphometric parameters in postnatal group

Postnatal	Gender	N	Mean	Std. Deviation	t-value	p-value
Splenic weight [gm]	Male	30	178.167	56.2550	0.065	0.948
	Female	10	179.500	54.1833		
Length [cm]	Male	30	12.213	2.2752	1.512	0.139
	Female	10	11.020	1.7441		
Breadth [cm]	Male	30	7.303	1.5348	0.195	0.846
	Female	10	7.440	2.8143		
Width [cm]	Male	30	3.520	.8100	1.453	0.154
	Female	10	3.110	.6367		

Table 3: Correlation of weight of spleen with various studies

Splenic weight	Present study	Chaudhari ML et al ⁹	Rao et al ¹⁰	Charware et al ¹¹	Gray's anatomy
Average	178.5 gm	150 gm	138.4 gm	150 gm	150 gm
Range	100-300 gm	80-350 gm	30-325 gm	80-300 gm	80-300 gm

5. Discussion

5.1. Correlation of splenic weight with age

In the present study the average splenic weight observed was 178.5 gms. The splenic weight ranged from 100 to 300 gms which appears close to the normal range of 80 to 300 gms and an average of 150gms described in the previous studies done by Chaudhari ML,⁹ Rao et al,¹⁰ Charware et al¹¹ and from the descriptions in the standard literature by Gray^{1,5}.

5.2. Observations of splenic length, breadth and width

In the present study, the lengths of the spleens varies from 8.3 cm to 17 cm, with an average length of 11.915 ± 2.19 cm. The observations in the present study were in accordance with the studies of Chaudhari ML et al⁹, Charware et al¹¹, Michels NA¹², Rayhan KA¹³.

The breadth of the spleen varied from 5 cm to 15 cm, with an average of 7.33 cm. The width of the spleen varies from 1.9 cm to 5.6 cm with an average of 3.4 cm. These observations of breadth & width were in accordance with the studies of Chaudhari ML et al,⁹ Rao et al,¹⁰ Charware et al,¹¹ Michels NA,¹² Rayhan KA.¹³

The mean values of the length, breadth, and width of the spleen in our study were, 11.9 cm, 7.33 cm and 3.4 cm respectively which correlated with the parameters described in the standard literature. There was a significant positive correlation between splenic weight and splenic length, breadth, width (Pearson coefficient 0.51, 0.70 and 0.51 respectively).

The morphometric parameters splenic weight, length and breadth steadily increased with age and the difference is highly significant (P < 0.05, High F value) for length, width and significant for breadth. This observation differed with the study of Rayhan KA¹³ who noticed a statistically insignificant association between age and morphometric parameters.

The maximal splenic length, breadth and thickness in the present study were observed in 40-49 years age group. There was a gradual and statistically significant increase of length, breadth and width with age till 40-49 years and declines significantly there afterwards, an observation in accordance with the findings of Rayhan KA. This pattern was not observed in relation to weight of the spleen with age.

The similar observations were described by N Arora et al^{15,16} with ultrasound measured dimensions of spleen, where the splenic parameters length, breadth and width decreased with increasing age above 40. They observed rapid growth in the splenic length up to the age of 20 years followed by a mild decrease up to the age of 50 years and then rapid fall after the age of 50 years.

In the present study, the mean splenic length, breadth, width and weight showed a statistically insignificant difference between male and female groups which differed with the observation of N Arora et al^{15,16} who noticed the parameters were significantly higher in males.

However, the slight differences in the morphometric parameters with respect to previous studies may be attributed to the genetic factors, body constitution, geographical conditions, dietary habits and the socioeconomic status of the population where these studies were done.

5.3. Splenic volume in postnatal group

The splenic volume was calculated by formula $19.6 + 0.5(\text{length} \times \text{breadth} \times \text{width})$ from observations of Sitthipong Srisajakul et al (2012).

The average splenic volume in the present study was 167.27 cc. The calculated splenic volume in different age groups was similar to the observations of Sitthipong Srisajakul et al¹⁴ (2012) where the average splenic volume was 124.1 ± 51.8 cc. In the present study there was a significant increase in splenic volume till 40-49 years and

Table 4: Correlation of length of spleen with various studies

Splenic length	Present study	Chaudhari ML et al ⁹	Rao et al ¹⁰	Charware et al ¹¹	Gray's anatomy ^{1,5}	Michels NA ¹²	Rayhan KA ¹³
Average	11.9 cm	9.59 cm	10.15cm	9.66 cm	12 cm	11 cm	9.83 cm
Minimum	8.3 cm	6 cm	7.5 cm	5 cm		6 cm	7.1 cm
Maximum	17 cm	14 cm	15.5 cm	13 cm		15 cm	13 cm
Correlation of breadth of spleen with various studies							
Splenic breadth	Present study	Chaudhari ML et al ⁹	Rao et al ¹⁰	Charware et al ¹¹	Gray's anatomy ^{1,5}	Michels NA ¹²	Rayhan KA ¹³
Average	7.33 cm	6.58 cm	8.3 cm	6.2 cm	7 cm	7 cm	5.46 cm
Minimum	5 cm	3.5 cm	4.5 cm	3.5 cm		4 cm	2.9 cm
Maximum	15 cm	8.5 cm	12.5 cm	9.5 cm		11.5 cm	8.2 cm
Correlation of width of spleen with various studies							
Splenic width	Present study	Chaudhari ML et al ⁹	Rao et al ¹⁰	Charware et al ¹¹	Gray's anatomy ^{1,5}	Michels NA ¹²	Rayhan KA ¹³
Average	3.4 cm	4.5 cm	3.96 cm	3.06 cm	3-4 cm	3 cm	2 cm
Minimum	1.9 cm	2 cm	2 cm	1.5 cm		2 cm	0.8 cm
Maximum	5.6 cm	7 cm	6 cm	5.5 cm		5 cm	3.3 cm

Table 5: Correlation of volume of spleen with various studies

Age	Present study Splenic volume	Sitthipong Srisajjakul et al (2012) ¹⁴
0 – 19 Years	102.06 cc	
20 – 29 Years	115.6 cc	156.6 cc (89.80 - 430.85)
30 – 39 Years	219.3 cc	131.5 cc (52.20-244.25)
40 – 49 Years	236.5 cc	127.9 cc (53.05-233.10)
50 – 59 Years	153.58 cc	118.1 cc (40.30-231.55)
60 – 69 Years	112.42 cc	119.5 cc (38.85-336.55)

steady decline afterwards.

6. Conclusion

The data regarding the various splenic parameters collected and analyzed in the present study emphasized the significance of morphometric dimensions of spleen in diagnosing various infectious, inflammatory and neoplastic diseases. The intricate knowledge of dimensions and morphometric variations of the spleen are of fundamental importance to the Hematologists, radiologists, prosectors and surgeons during surgical procedures on spleen.

7. Source of Funding

None.

8. Conflict of Interest

None.

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