

Computed Tomography Based Estimation of Splenic Volume in Adult Kashmiri Population Attending a Tertiary Care Hospital

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Abstract: The volume of various abdominal organs varies with age, height, weight and body mass index (BMI). Scanning of the viscera is carried out to know the normal dimensions and volumes. Studies have shown that the volume of spleen is influenced by age, gender, ethnicity, weight, height and BMI. Organ volume and function reflect the health of the organs. Altered volume of spleen is associated with infective, infiltrative, immunological, infestative and malignant conditions. Anthropometry varies with races and regions of the world. Specific ethnic population nomograms are needed for proper medical diagnosis and for monitoring disease progress. A total of 300 eligible subjects between 20-60 years of age, who were to undergo abdominal computed tomography (CT) due to various indications, were included in the study. In our study the mean splenic volume (SV) was 216.32+- 75.85cm³. There was a significant negative correlation between SV and age. The average SV was significantly higher in males than in females. The SV correlated significantly with weight, height and BMI of the subjects in our study.

Keywords: Age, Body mass index, Computed tomography, Height, Splenic volume, Weight.

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I. Introduction

The dimensions of visceral organs like spleen, kidneys, liver and pancreas mentioned in anatomy books are generally the cadaveric dimensions which measure less than the dimensions of solid organs in living state. The morphology of visceral organs varies from person to person. The characteristics of abdominal organ volumes and sizes have potential clinical importance^{1,2}. The volume of various abdominal organs varies with age, height and weight. Normal anatomic ranges should first be described in order to define pathological conditions and detect changes in size and volume of an organ. Computed tomography (CT) is known to be a reliable and accurate method for assessing volumes and sizes of the pancreas, spleen, kidney and other intra-abdominal organs, taking normal anatomical dimensions and establishing diagnosis^{3,4}.

As the morphology differs regarding the race, therefore, a study on the splenic volumetry in Kashmiri subjects with no history of splenic diseases was undertaken. The study was conducted to assess the range of volume of normal spleen in the adult Kashmiris using CT and to evaluate if the splenic volume is related to various demographic markers.

II. Materials And Methods

This study was conducted in the Postgraduate Department of Anatomy in collaboration with the Department of Radiodiagnosis and Imaging of Government Medical College and associated hospitals, Srinagar for a period of eighteen months. A total of 300 eligible subjects, 20-60 years old, were included in the study. It was a cross-sectional observational type of study and proper approval from institutional ethical committee was obtained. The subjects included in this study were of Kashmiri ethnicity. Height was recorded in metres (m) and weight in kilogram (kg), and BMI was calculated by using following formula:

$$\text{BMI} = \frac{\text{Weight (kg)}}{\text{height (m)}^2}$$

Selection of patients was done as per following inclusion and exclusion criteria;

INCLUSION CRITERIA: The in and out –patients, of either sex, who after the routine clinical evaluation, were to undergo CT examination due to various indications for the abdominal CT. Only those CT images, which were declared as ‘normal’ by the radiologists were included in this study.

EXCLUSION CRITERIA: Presence of either clinical or CT signs of any splenic or peri-splenic pathology, with consecutive compression, infiltration or displacement of the spleen, previous splenectomy, difficult identification splenic margins from the adjacent structures, history of malaria, fever.

Contrast Enhanced CT (CECT) examination of abdomen was done using Siemens Emotion 16 Slice Multidetector Spiral CT Scan and various measurements (in centimetres) were taken viz. maximum length (L)

as the greatest overall dimension of spleen on longitudinal images, maximum width (W) as the greatest overall dimension on transverse images and the maximum thickness (T) as the distance between the hilum and the outer convex surface of the spleen keeping them perpendicular to each other. The splenic volume was computed using the standard Prolate Ellipsoidal Equation:

$$SV = 0.524 \times L \times W \times T$$

All statistical analyses were performed using SPSS 21.0 for Windows. Subject characteristics and results were reported as mean±SD. Correlation between organ measurements including splenic volume and body height, weight, BMI and age were studied by performing the Pearson Correlation. The strength of the correlation between organ volumes and the various parameters was considered significant at P value < 0.05.

III. Results

The mean height of female subjects was 1.524±0.817 [1.2-1.7] m and for male subjects was 1.663± 0.081[1.4-1.9] m. The overall mean height of the study population was 1.59±0.10 m. TABLE 1

AGE GROUP	TABLE 1:HEIGHT (m)							
	FEMALES			P Value	MALES			P Value
	N	Mean	SD		N	Mean	SD	
20-30	30	1.5330	0.0961	0.002	39	1.6854	0.0840	0.108
31-40	46	1.5511	0.0730		25	1.6716	0.0869	
41-50	35	1.5278	0.0848		34	1.6635	0.0719	
51-60	40	1.4853	0.0624		51	1.6439	0.0794	
TOTAL	151	1.5247	0.817		149	1.6639	0.0812	

The mean weight of female subjects was 59.40±13.06 [35-95] kg and for male subjects was 63.47±11.15 [41-95] kg. The overall mean weight of the study population was 61.41±12.30 kg. TABLE 2

AGE GROUP	TABLE 2:WEIGHT (Kg)							
	FEMALES			P Value	MALES			P Value
	N	Mean	SD		N	Mean	SD	
20-30	30	55.667	11.015	0.222	39	60.974	10.803	0.268
31-40	46	61.826	13.255		25	66.120	9.550	
41-50	35	60.361	12.264		34	64.882	11.736	
51-60	40	58.550	14.615		51	63.137	11.609	
TOTAL	151	59.401	13.064		149	63.470	11.150	

The mean BMI of female subjects was 25.42±4.90 [16.4-38.1]Kg/m² and for male subjects was 22.85±3.62 [14.0-32.0]Kg/m². The overall mean BMI of the study population was 24.15±4.49kg/m². TABLE 3

AGE GROUP	TABLE 3:BMI (Kg/m ²)							
	FEMALES			P Value	MALES			P Value
	N	Mean	SD		N	Mean	SD	
20-30	30	23.597	3.6793	0.121	39	21.297	3.1119	0.018
31-40	46	25.572	4.5508		25	23.644	3.0428	
41-50	35	25.714	5.1598		34	23.394	4.0132	
51-60	40	26.363	5.6251		51	23.312	3.7213	
TOTAL	151	25.424	4.9029		149	22.859	3.6250	

The mean splenic volume (SV) in female subjects was 215.6±82.1 [49.60-388.49] cm³ which was less than in males 222.8±75.9 [74.18-391.39] cm³. The overall mean SV of the study population was 216.32±75.85 cm³. Mean splenic volume was higher in males than in females in our study population however the difference was statistically insignificant. TABLE 4

AGE GROUP	TABLE 4:SPLenic VOLUME (cm ³)							
	FEMALES			P Value	MALES			P Value
	N	Mean	SD		N	Mean	SD	
20-30	30	231.13	67.32	0.009	39	218.21	59.49	0.127
31-40	46	242.02	83.64		25	240.56	80.30	
41-50	35	196.47	76.79		34	240.08	88.35	
51-60	40	190.92	86.03		51	206.25	74.14	
TOTAL	151	215.63	82.11		149	222.85	75.98	

Height, weight and BMI showed positive correlation with SV and the results were statistically significant (<0.05). Age showed a negative correlation with SV and was statistically significant(r = - 0.136, p = 0.018). TABLE 5.

TABLE 5:CORRELATION WITH SPLENIC VOLUME				
PARAMETER	MEAN	SD	PEARSON COEFFICIENT	P VALUE
AGE	43.236	12.7601	-0.136	0.018
HEIGHT	1.5936	0.1071	0.200	0.000
WEIGHT	61.415	12.3038	0.365	0.000
BMI	24.154	4.4980	0.245	0.000

IV. Discussion

The characteristics of abdominal organ volumes and sizes have potential clinical significance. A change in volume of an organ is often either the predominant feature of a disease process or a secondary manifestation of pathology elsewhere e.g. measurements of splenic volume may be useful in the assessment of patients with portal hypertension, glycogen storage disorders, leukemia, lymphoma, melanoma, celiac disease and other haematological diseases². Determination of splenic volume is important in diagnosing small, normal or enlarged spleens⁵, as splenomegaly is the most common manifestation of splenic involvement in many disorders⁴. The volume of various abdominal organs varies with age, height and weight. The use of CT imaging is receiving increasing attention to estimate splenic volume^{6,7}. In vivo volume calculation of tumours also has clinical potential in radiation oncology. Due to precise definition of organ and tumour contours with cross-sectional CT and the ease of scanning these structures in their entirety, CT potentially offers the most accurate non-invasive means of estimating in vivo volumes⁸.

The variation in the anthropometric features of various populations, races and regions is an established fact. In contrast to many previous studies which were mainly done on the foreign population, our data was obtained from subjects of Kashmiri ethnicity.

Our study comprised of 300 subjects between 20 and 60 years of age with 23.0% between 20 to 30 years, 23.6% between 31 and 40 years, 23.0% between 41 and 50 years and 30.3% between 51-60 years of age. Majority of the subjects were in the age group of 51-60years. Splenic volume continues to increase during 20-50years of age and then declines, so this age group was taken up for the study. The mean age was 43.32 years in total series. The mean age was more in other studies (Djuveric A², Caglar V^{1,9}) due to the fact that in our study subjects of 20-60years only were included, while as in their studies older subjects were also included. However, there was no statistically significant difference between the mean ages of males and females, hence, these two groups were comparable.

Our study group had 149(49.6%) males and 151(50.3%) females. Caglar V et al^{9,10} and Djuric-Stefanovic A et al² found that there were 136(50.0%) males and 136(50.0%) females; 107(50.4%) males and 105(49.5%) females; 118(53.6%) males and 102(46.3%) females respectively, in their studies with almost equal sex ratio as in our study. The mean weight of our study group was 61.41kgs with minimum weight 35kgs and maximum weight 95kgs. The mean height was 1.59m with minimum height 1.20m and maximum height 1.85m. The mean BMI was 24.15kg/m² with minimum BMI 14.0kg/m² and maximum 38.1kg/m².

The mean SV for the total study population of 300 subjects was 216.32±75.85cm³ with range from 51.10 to 391.39cm³. The SV in total and male population changes slightly during 20-50 years of age; in female population SV changes slightly during 20-40 years of age and then declines thereafter. There was a general decrease in SV as age increased. There was a significant negative correlation between SV and age for total study population (r = - 0.138, p = 0.018). This finding is supported by previous studies^{1, 11}. Ehimwenma and Tagbo¹²; and Caglar V¹ reported that there was no statistically significant correlation between age of the subjects and SV. Ehimwenma and Tagbo¹² reported that average SV was 202±49cm³ in 91 male and 153±33cm³ in 109 female individuals. Henderson et al¹³ calculated a normal SV of 219cm³ from axial CT acquisitions. Our results are very similar to those in literature mentioned above^{3, 4, 13}. Moreover, the same value was 119.5cm³ in African population (Mustapha et al¹⁴), 288.36cm³ and 217.44cm³ in males and females respectively by Asgar et al¹⁵. SV in Thai adults was 134.2cm and 115.6cm in males and females respectively, as reported by Sriajakulet al¹⁶. SV in USA was found to be 344cm³(Tonelliet al¹⁷). Differences in SV may be due to differences in number, mean age, gender and body habitus of individuals enrolled in the study and also due to regional variations, race, genetic factors, nutritional and socio-economic status between populations studied.

The mean body weight of the patients was 61.41±12.3kg and the height was 1.59±0.10m. A statistically significant correlation was found between the SV and the body weight and height of the subjects (r = 0.365, p = 0.000; r = 0.200, p = 0.000, respectively). Thus, the SV increases with an increase in body weight and height. Okoye et al¹⁸, Spielman et al¹⁹ and Loftus WK et al²⁰ reported a good correlation between splenic size and subject weight and height. Shekzadiet al²¹ found no correlation between SV and body height. So, having a correlation between SV and subject's height and weight, we would expect a larger average SV and splenic size in males due to their larger body size.

The BMI was $24.15 \pm 4.49 \text{ kg/m}^2$ for the total study population, that for male subjects was $25.42 \pm 4.90 \text{ kg/m}^2$ and for female subjects was $22.85 \pm 3.62 \text{ kg/m}^2$. There was a statistically significant correlation between the SV and BMI ($r = 0.245$, $p = 0.000$). The presence of a significant relationship between BMI and SV suggests an effect of obesity on the SV. There was a positive correlation between the SV and BMI in our study which is supported by the study of Caglar V et al¹; Altunkaynak et al²² who reported that high fat diet resulted in splenomegaly by sinusoidal dilatation and intra-cellular or inter-cellular deposits.

The potential limitations of this study include that the data cannot be generalized as this study included only subjects from an ethnic population, but our study was designed to formulate the data for this population only.

V. Conclusion

In conclusion, this study was conducted to establish a local reference of values for the splenic volume of the Kashmiri adult population. Nomograms from this data can be used locally for Kashmiri ethnic population to allow clinicians to estimate more accurately the degree of atrophy or hypertrophy of organs in certain disorders and thus, avoid false positive and false negative diagnosis of pathological enlargement or reduction of spleen in clinical practice.

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