

## Ultrasonographic Evaluation of Splenic Volumes in Normal Subjects in South-East, Nigeria.

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### ABSTRACT.

The spleen is the largest organ in the reticuloendothelial system. Anthropometric studies using ultrasound suggest there may be racial or geographical differences in organ sizes and dimensions. Since some pathological health conditions affect the haematological parameters of the body organs, the spleen inclusive, there is therefore a need to establish a normogram of splenic dimensions for clinical practice in our environment. This has necessitated this study and also a determination of the effect of age, gender, body weight and body mass index (BMI) on splenic volumes for our locality as no such studies have been done in our environment to the best of our knowledge.

### METHOD:

Measurements of splenic sizes were carried out on 261 healthy subjects (142 males & 119 females). i.e those without any history or evidence of splenic affectations or immunologic/haematologic disorders and whose age fall between 18 and 72 years. The length, width and thickness of the spleen were measured and using standard prolate ellipsoid formula of  $L \times W \times T \times 0.524$ . the volume of the spleen is calculated for each subject. The age, height, weight and body mass index Independent sample T-test was carried out for the subjects. Pearson's correlation co-efficient was calculated between the anthropometric parameters and splenic volume.

### RESULTS:

Mean splenic volume was  $216.40 \pm 11.86 \text{ cm}^3$ . The age range of the subjects was 18-72 years. There was significant correlation of height and body weight with splenic volume ( $r=0.2, p=0.015$ ). No significant correlation with age ( $r=0.07, p=0.4$ ) or

BMI. The male subjects had significantly higher splenic volume than females ( $241.22 \pm 13.16$  vs  $204.16 \pm 11.53$   $p=0.004$ ).

### CONCLUSION:

Men have higher splenic dimensions than women. The height and weight correlated with splenic volumes but there was no significant correlation with age and BMI.

### INTRODUCTION AND LITERATURE REVIEW.

The spleen is the largest organ in the reticuloendothelial system (RES). It is a lymphoid organ and is located in the left side of the upper abdomen, behind the fundus of the stomach. In clinical practice splenic size is often used as an indicator of many disease conditions and disorders of the immune system<sup>1</sup> With real time ultrasonography of the upper abdomen the spleen is very much accessible<sup>2</sup>. Measurement of splenic volume is highly sensitive and more accurate in detecting splenomegaly than clinical assessment or one dimensional measurement of the organ<sup>3</sup>. As normal splenic size varies with age, sex, weight, height and underlying metabolic conditions, Yetter et al<sup>4</sup>. have shown that computed tomography (CT) determined splenic volume is the gold standard measurement and is thus considered the best imaging modality for assessment of splenic volumes. Ultrasonography has been shown however to be very effective, reliable, less expensive, readily available and does not use ionizing radiation; hence it is preferred in developing countries such as Nigeria.

Magnetic resonance imaging (MRI) and

radionuclide imaging are other modalities that can be used for splenic evaluation.

Anthropometric studies using ultrasound suggests there may be racial or geographical differences in organ sizes and dimensions. There is therefore need for normograms of organ sizes for different localities. This study is designed therefore to establish a normogram of splenic sizes and volumes for our environment as no such study has been done in our locality to the best of our knowledge and to determine the effect of age, gender, height, body weight and BMI on the splenic volume. The normogram of splenic sizes and volume will help to determine when the organ is enlarged.

Spielmann et al<sup>5</sup> sonographically evaluated the size of the spleen in 129 tall healthy athletes, (82 men, 47 women). The length, width and thickness were measured in addition to weight, height and age of each athlete. The splenic length was greater than 12cm in 31.7% of the men. (mean splenic length was 11.4±1.7), and in 12.8% of the women (mean splenic length was 10.3±1.3). Yetter et al<sup>4</sup> studied the spleen sonographically and correlated the measurement with CT estimation of splenic volume in 142 patients. Maximum splenic length (ML) and width (W), thickness (T) and craniocaudal length (CCL) were measured sonographically. Standard ellipsoid volume formula ( $0.524 \times L \times W \times T$ ) and linear regression formula were used to estimate splenic volumes. The findings revealed mean CT determined volume as  $512.6\text{cm}^3 \pm 349.1\text{cm}^3$ . Sonographically determined volume using different lengths were thus calculated. With mean length (ML) the mean volume using the formula ( $0.524 \times \text{ML} \times W \times T$ ) was  $528.7\text{cm}^3 \pm 314.5\text{cm}^3$ . Using the CCL the splenic volume ( $0.524 \times \text{CCL} \times W \times T$ ) was  $450.8 \pm 302.7\text{cm}^3$ . Using the AVL as the average splenic length, the mean splenic volume ( $0.524 \times \text{AVL} \times W \times T$ ) was calculated to be  $508.1 \pm 312.7\text{cm}^3$ . From this study it was found that the conventional ellipsoid formula method using average length measurement i.e.  $0.524 \times W \times T \times (\text{ML} + \text{CCL}) / 2$  was the best formula that correlated with the CT determined splenic volume which is the gold standard<sup>4</sup>

De-Odorico et al<sup>6</sup> in their study estimating normal splenic volumes using three dimensional ultrasonography reported that 3-dimensional studies were superior to 2-dimensional evaluations of such irregularly shaped organs as the spleen.

In ultrasonographic assessment of splenic sizes in collegiate athletes Hosey et al<sup>7</sup> noted that the mean splenic length was  $10.6 \pm 1.55\text{cm}$  and width  $5.16 \pm 1.21\text{cm}$ . Men had larger spleens than women ( $p > 0.001$ ) and Caucasians had larger spleens than African American blacks ( $p > 0.001$ ).

While studying normal spleen sizes in adults of African populations using ultrasonography, Mustapha et al<sup>8</sup> reported splenic sizes correlating with age, gender, height, weight and BMI. The mean splenic volume was  $120\text{cm}^3$ . Men had larger mean splenic volumes than women. The mean splenic volume in African adults was found to be smaller than the values from Western sources.

#### METHOD:

Abdominal ultrasound (with 2D ultrasound machine) was carried out on 261 normal and healthy subjects (142 males and 119 females). The inclusion criteria for the "healthy" subjects recruited for the study were absence of any history or evidence of any splenic pathology such as cysts, tumours, congenital splenic anomalies, haematologic or immunologic diseases. With the subject in supine position the probe was placed longitudinally to measure the splenic length and then the probe is oriented transversely to measure the width and thickness in arrested inspiration. The splenic hilum was used as reference point for all measurements (Fig.1. & Fig.2). The weight (kg), height (m), age (yrs), BMI, and gender of the subjects were noted. The data collected was analysed using statistical package for social sciences (SPSS-version 16.0) (SPSS Inc., Chicago, Illinois, USA.). Both inferential and descriptive statistics were applied to the data. Pearson's correlation co-efficient was used to compare the effect of height, weight, gender and age on splenic size. Based on geometry, the formula for the volume of a 3D ellipsoid which is  $\frac{4}{24} \times \pi \times L \times W \times T$  was

applied and this is approximately  $0.524 \times L \times W \times T^{9,10}$ . By linear regression volume is established as  $0.57 \times L \times W \times T$ . This formula uses the splenic index to sonographically determine the splenic volume by multiplying the three dimensions of length, width and thickness and dividing the product by 27 i.e prolate ellipsoid formula<sup>11</sup>.  $P < 0.05$  was used as criteria for significance

**RESULT:**

In this study, 261 apparently healthy subjects (142 males, 119 females) with no history or evidence of splenic pathology were assessed for splenic dimensions. The mean age was  $47.60 \pm 11.21$  years (range 18-72 years), mean height was  $1.67 \pm 0.06$  m (range 1.5-1.8 m), mean weight was  $71.09 \pm 8.82$  kg (range 44-94 kg) and mean body mass index (BMI) was  $23.61 \pm 2.63$  kg/m<sup>2</sup> (range 17.4-36.3 kg/m<sup>2</sup>).

**Table.1: Mean Splenic Dimensions with Biodata of Subjects(Male & Female).**

	Age(yrs)	L(cm)	W(cm)	T(cm)	VOL(cm <sup>3</sup> )	Ht(m)	Wt(kg)	BMI((kg/m <sup>2</sup> ))
Mean	47.60±11.21	11.38±0.19	7.29±0.53	4.83±0.07	216.40±11.86	1.67±0.06	71.09±8.82	23.61±2.63
Range	18-72	9.45-13.50	6.20-8.74	3.0-6.8	116.60-362.02	1.5-1.8	44-94	17.4-36.3

**Table.2: Mean Splenic Dimensions and Biodata of Male and Female Subjects.**

	Age(yrs)	L(cm)	W(cm)	T(cm)	VOL(cm <sup>3</sup> )	Ht(m)	Wt(kg)	BMI(kg/m <sup>2</sup> )
Male	51.33±11.21	12.25±0.82	7.50±0.56	5.02±0.16	241.22±13.16	1.70±0.06	76.31±10.14	24.56±1.22
Female	33.20±6.72	10.78±0.80	7.05±0.12	4.83±0.63	204.16±11.53	1.65±0.31	66.85±11.48	25.58±0.18
P-value	0.000	0.000	0.652	0.505	0.004	0.000	0.003	0.336

**Table.3: Correlation of Age, Height, Weight and Bmi with Splenic Volume.**

	VOLUME		COMMENT
	Correlation(r)	P-value(p)	
Age(yrs)	0.075	0.460	NS
Ht(m)	0.560	0.0000	S
Wt(kg)	0.240	0.015	S
BMI((kg/m <sup>2</sup> ))	-0.049	0.629	NS

NS=Non significant.  
S=Significant.

The mean splenic dimensions as seen in Table 1 are as follows: length  $11.38 \pm 0.19$  cm (range 9.45-13.50 cm); width  $7.29 \pm 0.53$  cm (range 6.20-8.74 cm); thickness  $4.83 \pm 0.07$  cm (range 3.06-6.8 cm); and volume  $216.40 \pm 11.86$  cm<sup>3</sup> (range 116.60-362.02 cm<sup>3</sup>)

In Table 2 the mean splenic dimensions of both male and female subjects shows the male subjects with significantly higher splenic lengths than the females ( $12.25 \pm 0.82$  cm vs  $10.78 \pm 0.80$  cm),  $p = 0.000$ . The splenic volume was also significantly higher in males than females ( $241.22 \pm 13.16$  cm<sup>3</sup> vs  $204.16 \pm 11.53$  cm<sup>3</sup>),  $p = 0.004$ . There were no significant differences in the splenic widths and thicknesses between the male and female subjects. ( $7.50 \pm 0.56$  cm vs  $7.05 \pm 0.12$  cm,  $p = 0.6$ ) and ( $5.02 \pm 0.16$  cm vs  $4.83 \pm 0.63$  cm,  $p = 0.5$ ) respectively.

The correlation statistics in Table 3 showed no

significant correlation with age ( $r = 0.075$ ,  $p = 0.4$ ) and BMI ( $r = -0.049$ ,  $p = 0.6$ ). The table however shows significant correlation with height ( $r = 0.5$ ;  $p = 0.000$ ) and weight ( $r = 0.2$ ;  $p = 0.015$ ) with the splenic volumes. Figure 1a, 1b, & 1c are Sonograms of Spleen Showing Measurements of Length, Width and Thickness.

Fig.1a: Longitudinal sonogram of spleen showing measurement of length.

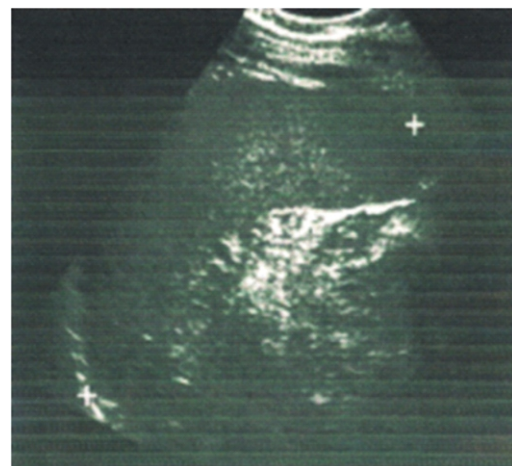


Fig.1b: Transverse sonogram of spleen showing measurement of the width.

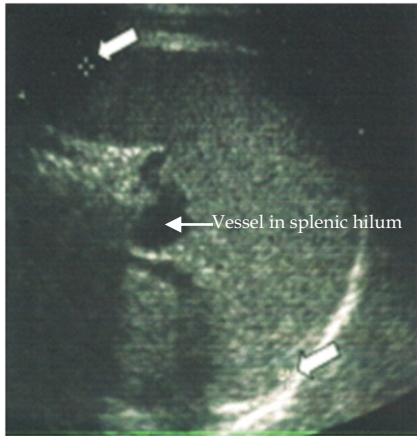


Fig.1c: Transverse sonogram of the spleen showing measurement of the thickness.

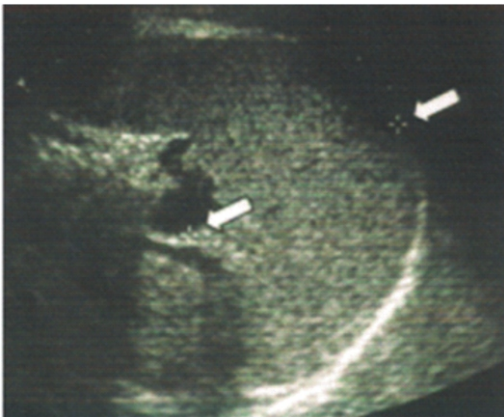


Figure 2: A line diagram of the longitudinal and transverse sections of the spleen showing the accurate method of splenic measurement.

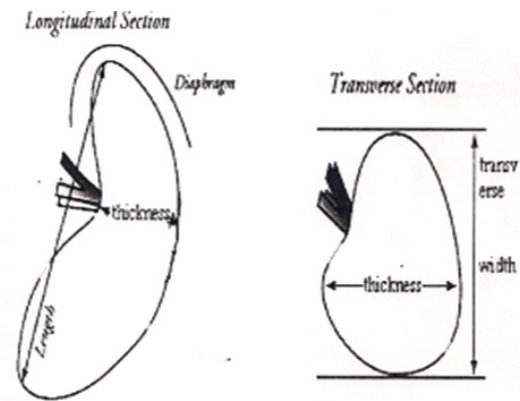


Figure3: Scatter Plot Graph Showing Correlation of Height with Splenic Volume in Normal Subjects ( $r=0.5, p=0.000$ ).

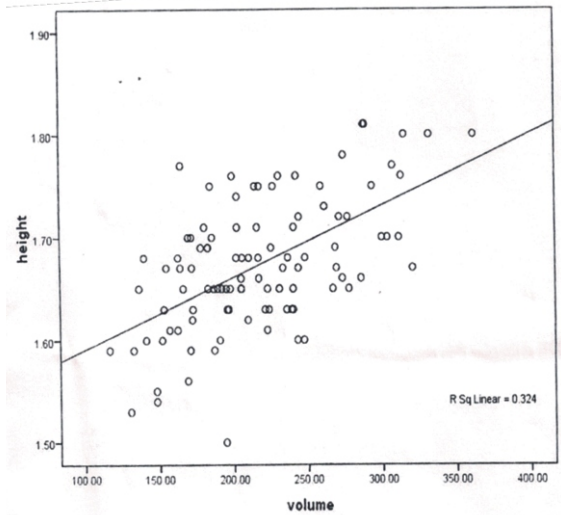
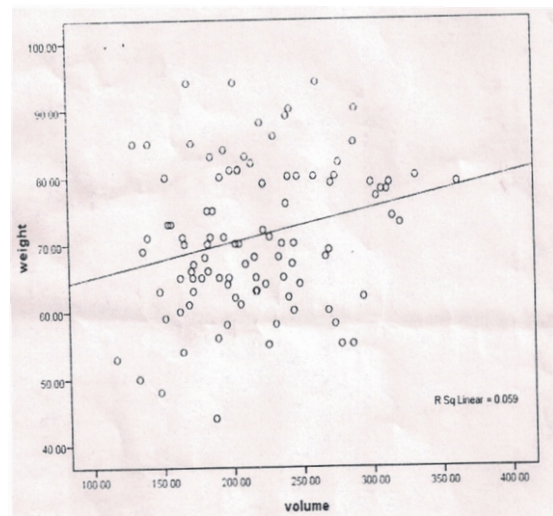


Figure.4: Scatter Plot Graph Showing Correlation of Body Weight with Splenic Volume ( $r=0.2; p=0.015$ )



## DISCUSSION:

The spleen is a large irregularly shaped and encapsulated mass of vascular and lymphoid organ located in the left upper quadrant of the abdominal cavity, lying between the fundus of the stomach anteriorly, the left hemi-diaphragm posteriorly, the left kidney medially and the splenic flexure of the colon inferiorly. The size and weight vary with age and between sexes. In systemic disease states the various dimensions of the organ show varied changes.

In the past it was the standard practice for many years to use splenic size as an indicator for many disease conditions and varieties of immune system disorders<sup>1</sup>. With the advent of real time sonography, the spleen is no longer inaccessible for proper measurement.

Real time ultrasound imaging is however preferred to other conventional methods of evaluating changes in splenic dimensions because of its simplicity<sup>2</sup> and this facilitates availability of diagnostic information to further strengthen clinical decision and commencement of empirical treatment.

Routine examination of the spleen however using ultrasound in one dimension or physical examination are less sensitive in detecting mild changes in the size of the spleen in diseased states and thus underestimates the true size of the organ<sup>3</sup>. Multidimensional measurements of the spleen using ultrasound which is rapid, reliable, and cost effective in detecting the true sizes of the spleen is preferable<sup>12</sup>. Therefore standards of normal splenic sizes need to be established for different geographical areas using multidimensional approach.

In this study therefore the mean normal splenic dimensions are established for our locality as seen in table 1. and these dimensions were in agreement with earlier studies done on normal spleen elsewhere using ultrasonography<sup>13,14,15</sup>. The results of this study show significant correlation of height and weight with splenic volume ( $r = 0.05$ ;  $p = 0.000$ ) and ( $r = 0.2$ ;  $p = 0.015$ ) respectively.

The male subjects were seen to have had

significantly higher mean splenic dimensions than the females and this may probably be accounted for by the males being taller and weighing more on the average than the females. This is in agreement with the positive correlation established between the height, the weight and the volume of the spleen and this is graphically shown in figs.3 and 4 in which the taller and heavily built subjects had higher splenic volumes.

On account of the findings in this study we make bold to recommend that multidimensional measurements of the spleen be adopted by sonologists and sonographers for the evaluation of patients with splenic affectations and that the normogram of splenic volumes established here be used with confidence as an index to determine abnormal changes in splenic sizes.

## CONCLUSION:

A normogram of splenic volumes of the range  $116.60\text{cm}^3$  to  $362.02\text{cm}^3$  (i.e mean volume  $\pm 2$  standard deviation at 95% confidence interval) has been established for our environment. Any dimensions outside this range should be considered abnormal. There is significant correlation between the height and weight and the splenic volumes established hence individuals whose body habitus and size are at the extremes of the normal range may have splenic dimensions that are outside of this normal range. No such correlation is seen with age and BMI. It is also established here that though men have higher splenic dimensions than women the width and thickness of the spleen does not affect the volume of the spleen, gender notwithstanding.

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