

Correlation Of Linear Measurements Of Spleen With Splenic Volume in Computed Tomography

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Abstract

Introduction: The purpose of this study was to assess the normal linear measurements of spleen in Nepalese adults by Computed Tomography (CT) and their correlation with splenic volume.

Methods: This was a prospective cross sectional observational study done in 264 peoples undergoing abdominal CT examination for various clinical indications not pertaining to spleen, in Department of Radiology & Imaging, Tribhuvan University Teaching Hospital (TUTH). Four linear measurements of spleen were obtained in axial plane. Craniocaudal length of the spleen was also obtained. The volume was obtained by adding cross-sectional area of spleen from 10 mm contiguous axial images and multiplying them with the slice thickness. The relationships between various linear measurements of spleen with splenic volume were derived.

Results: The mean length of spleen along long axis was 9.3 ± 1.3 cm, and the mean length along the craniocaudal axis was 7.6 ± 1.5 cm. The mean width, maximum thickness, and thickness at hilum of the spleen were 9.3 ± 1.7 cm, 5.1 ± 1.2 and 3.2 ± 0.6 cm respectively. The mean splenic volume was $151.20 \text{ cm}^3 \pm 59.62 \text{ cm}^3$. Significant positive correlations were noted between linear measurements and volume, the strongest being the width followed by the craniocaudal length.

Conclusion: Linear measurements of the spleen in CT show strong correlation with volume and hence can replace the splenic volume measurements while defining splenomegaly.

Key words: Computed Tomography, Spleen, Linear measurement, Volume.

Introduction

Enlargement of spleen, termed splenomegaly, can be a manifestation of many pathological conditions including infections; immunological, hematopoietic and circulatory disorders; and various storage disorders.¹⁻³

Significantly enlarged spleen can be palpated in left hypochondrium or lower positions; however, mild enlargement of the spleen is often missed clinically. Imaging modalities may help in these mild splenic enlargements.³⁻⁵ Also, exact quantification of the splenic enlargement can be reliably done by various imaging modalities like USG, CT and MRI which accurately measure splenic volume which best reflects the spleen

size. CT is non-operator dependent, reproducible, can accurately visualize the margins of the spleen required for the accurate measurement. Limitations of CT are its higher cost and the ionizing radiation.^{6,7}

Many attempts have been done for defining splenic enlargement based upon various measurements of spleen. The parameter best reflecting the size is splenic volume, which is tedious to calculate. The linear measurements are easier to obtain than calculation of splenic volume and which can be used to assess the splenic size. This study was conducted to obtain the different linear parameters of the spleen and find the best parameter correlating with splenic volume.

Methodology

This was a prospective cross sectional study done in Department of Radiology & Imaging, Tribhuvan University Teaching Hospital from December 2013 to September 2014.

A total of 264 patients who were referred for CT scan of the abdomen for various clinical indications not influencing the splenic size. The CT scans of the patients were performed in the Neusoft 16 slice MDCT with standard protocol for abdomen of the department. The ethical approval was obtained from institutional review board (IRB). A written informed consent was obtained from each patient before the study. Subjects with clinical and laboratory evidence of infection, lympho-hematogenous disorders, immunological conditions such as connective tissue disease and storage disease, liver diseases including portal hypertension, hematopoietic malignancy, chronic infections were excluded from the study.

Splenic length was measured in two ways. Simple method was to measure craniocaudal length (cL) by summing up the number of consecutive sections through the spleen. Other method was to measure the length of the spleen along its long axis (L) by measuring the distance from superior pole of spleen to inferior pole of the spleen in coronal image.

Splenic width (W) was measured as the maximum distance between lateral and medial margin of spleen in any axial plane. Thickness (T) was measured as maximum distance between splenic margins in plane perpendicular to the axis of width (W). Similarly, thickness at hilum (hT) was measured as the distance between splenic margin at the hilum and peripheral margin in plane perpendicular to the width.

Splenic volume (V) was measured by summing up the area of spleen in each 10 mm axial sections and multiplied by slice thickness (1cm in our case).

Data collection was done in predesigned proforma, compiled and analyzed using standard statistical analysis softwares. SPSS 21 and Microsoft Excel were utilized for the data analysis and presentation. Pierson correlation was used to see the relation of age, linear measurements of spleen, and spleen volume. Student t-test was used to see the relation of sex with the splenic volume.

Results

The abdominal CT scans of 264 patients who met the selection criteria were evaluated. Among them 124 were male and 140 were female. Maximum patients were in the age group of 31-40 years, minimum in age group of <10 years. 7 patients were in the age group of >80 years.

Mean width of spleen was 9.3 cm $\pm$ 1.7 cm (Range 4.8 cm – 13.6 cm). Mean thickness of spleen was 5.1 $\pm$ 1.2 cm (Range 2.4 cm – 7.9 cm). Mean thickness at hilum was 3.2 cm $\pm$ 0.6 cm (Range 1.7 cm – 5.5 cm). Mean length along the long axis was 9.3 cm $\pm$ 1.3 cm (Range 5.9 cm to 13.1 cm). Mean craniocaudal length was 7.6 cm $\pm$ 1.5 cm (Range 3 cm – 11 cm). (Table 1)

Mean splenic volume was 151.20 cm³ $\pm$ 59.62 cm³. Maximum volume was 331.66 cm³ and minimum was 25.95 cm³. (Table 1)

Significant positive correlations ($p < 0.01$) were noted between splenic volume and linear measurements. Strongest correlation of the volume among its linear measurements was the width followed by craniocaudal length of the spleen. (Table 2, Figure 1 & 2)

There was no significant correlation of craniocaudal length of the spleen with age ($p > 0.05$).

Discussion

There is increasing trend for utilizing various imaging modalities for diagnosis and follow up of splenomegaly. Most commonly used modality is ultrasonography, however, CT is the most sensitive and specific imaging modality for evaluation of splenic size, along with changing size during follow up.⁷⁻¹⁰ Splenic volume and various indices used for evaluation of the size are time consuming methods. The simplified method would be any single linear parameter to represent the size.

In the current study all the linear measurements of spleen (W, T, hT, L, cL) showed significant positive correlations with the splenic volume, the best correlation seen was the width, followed by the craniocaudal length. These findings are similar to the findings of Lamb et al who correlated linear ultrasound measurements with the CT volume of the spleen.⁷ Similar findings of significant positive correlations of the splenic volume with linear measurements were seen in other studies as well.^{1, 5, 11} Bezerra et al also found best correlation of the splenic

volume with craniocaudal length and width among all the linear parameters.^{1, 11} Rosenberg et al also found splenic length correlating well with the volume, as confirmed by the current study as well.¹² Cools et al also found similar correlation of linear measurements with spleen volume. However, they found the best correlation with half-way thickness on the slice with maximal width.¹³ Larson et al had scintigraphic study of spleen and found linear correlation between the linear parameters with mass of spleen.¹⁴

Among the two best correlating linear measurements, the craniocaudal length of the spleen is easier to obtain since it can be calculated by counting the number of slices in which the spleen is visualized and multiply it with the slice thickness. However, for the width, spleen must be measured in each slice for maximum width. Thus, if single parameter is to be used, craniocaudal length can best represent the size of the spleen.

Based on present study, 10.6 cm is the upper limit of normalcy of craniocaudal length. For simplicity, 10.5 cm can be used as the upper limit of normal splenic length (craniocaudal).

Other parameters have also been used as indicator for splenomegaly based upon the relationship of splenic margin to surrounding organs. Contact of spleen with the left lobe of liver and extension of the splenic margin beyond the inferior third of the left kidney are being used by some radiologists for splenomegaly. However, these parameters also depend upon the status of surrounding organs, so it cannot be generalized. Detailed study is required before using these parameters, although Bezerra et al found high specificity and low sensitivity of extension of the splenic margin beyond the inferior third of the left kidney to indicate splenomegaly.¹¹

Lamb et al showed positive correlation of splenic length measured on ultrasonography to splenic volume measured on CT.⁷ In our study also the length along long axis showed good correlation with splenic volume, with upper limit for normal as 11.9 cm (12 cm for simplification). Thus this can be used in defining splenomegaly sonographically as well; however, further studies with ultrasound may be required as there may be disparity in length of spleen measured by CT and ultrasound.

Table1: Mean and standard deviation of different parameters of measurements of spleen (n=264).

	N	Minimum	Maximum	Mean	Std. Deviation
Spleen Volume (cm ³)	264	25.95	331.66	151.168	59.62302
Width of spleen (cm)	264	4.8	13.6	9.267	1.6828
Maximum thickness of spleen (cm)	264	2.4	7.7	5.129	1.1475
Thickness of spleen at hilum (cm)	264	1.7	5.5	3.182	0.6327
Length of spleen along long axis (cm)	264	5.9	13.1	9.299	1.3441
Craniocaudal Length of Spleen (cm)	264	3	11	7.55	1.527

Table 2: Parameters showing correlations of spleen volume with other variables (n=264).

	“r” “value	“p” value
Width of spleen	0.715	0.000
Maximum thickness of spleen	0.638	0.000
Thickness of spleen at hilum	0.565	0.000
Length of the spleen along long axis	0.657	0.000
Craniocaudal length of the spleen	0.708	0.000

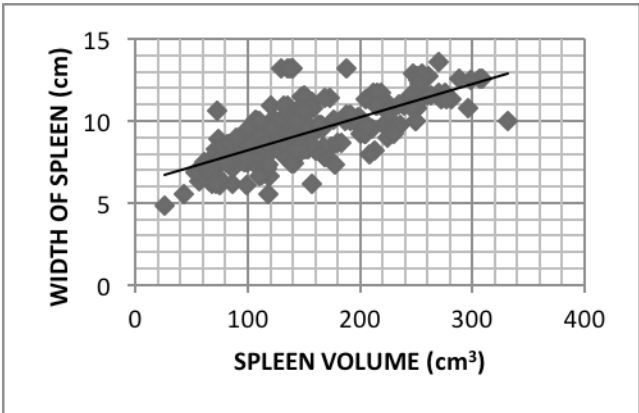


Figure 1. Scatter plot showing correlation between widths of spleen with spleen volume (n=264).

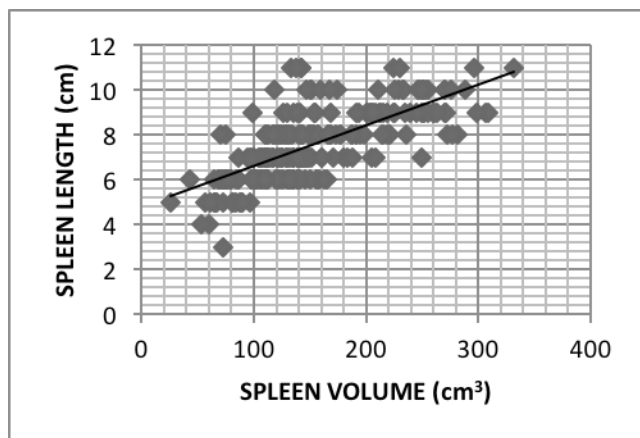


Figure 2. Scatter plot showing correlation between spleen length and spleen volume (n=264).

Conclusion

Computed tomography can be reliably used as an imaging modality for assessing the splenic volume along with the linear parameters of spleen.

Although splenic volume is gold standard for reflection of spleen size, linear spleen measurements can replace splenic volume for defining splenomegaly as they are easily obtainable. Among them craniocaudal length of spleen is easiest to obtain and shows linear correlation with the volume, it can be used in daily practice for evaluation of splenomegaly.

Conflict of interest: None declared

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