Original article

Assessment of normal splenic volume by Computed Tomography in Nepalese population

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Abstract

Introduction: The purpose of this study was to assess the normal splenic volume in Nepalese population by Computed Tomography and its variability with age, sex and body habitus.

Methods: This was a cross sectional observational study involving 264 patients undergoing CT abdomen examination for pathologies not pertaining to spleen, in Department of Radiology, Tribhuvan University Teaching Hospital.The spleen volume was obtained by adding cross-sectional area of spleen from 10 mm contiguous CT slices in axial CT images and multiplying them with the slice thickness. The relationships between spleen volume and age, sex and body habitus were also derived.

Results: The mean splenic volume was 151.20 cm^3 ± 59.62 cm^3, ranging from 25.95 cm^3 to 331.66 cm^3. Weak negative correlation of spleen volume with age ($r = -0.173$, $p < 0.01$) and body habitus ($r = -0.132$, $p < 0.05$) were also noted. No significant correlation of spleen volume with gender was noted.

Conclusion: The finding provided defining the criteria for splenomegaly. The mean splenic size in Nepalese population is similar and/or larger compared to Asian population, and smaller compared to western population. However a larger sample size is required for corroboration of our findings.

Key words: Computed Tomography, Normal, Spleen, Volume.

Introduction

Spleen is a functionally very diverse organ with main function in immune-surveillance and hematopoiesis. It is the largest lymphatic organ of the body with morphological and structural similarity to a lymph node except for its large size. Spleen shows variable shape, and its size varies with age. Spleen size may also differ in male and female. Spleen may be involved in many pathological conditions including infections; immunological, hematopoietic and circulatory disorders; and various storage disorders, which may be manifested most commonly as increase in its size, termed as splenomegaly.[1-3]

Spleen enlargement may be difficult to diagnose in-vivo, unless it is significantly enlarged. USG, CT and MRI are reliable imaging modalities for measurement of accurate splenic volume which best reflects the spleen size.

CT is a reliable method for assessing the size of spleen and for linear measurements of the spleen, since it can accurately visualize the irregular margins of the spleen. It is non operator dependent and reproducible. It can also be helpful for determining the cause of splenomegaly if present. However, its limitations include its higher cost and use of ionizing radiation and IV contrast agents.[4, 5]

In regular practice, the basis for diagnosing splenomegaly on CT is subjective or crude criteria. Lackner et al proposed splenic index, which is the product of width, thickness and length of the spleen, as an indicator for evaluating splenomegaly on CT. Prassopoulos et al described splenic volume estimation on CT by measuring volume of spleen at each cross section and adding them.[1] These studies were basically done in western population, and since spleen size varied in different populations, they may not be used as reference values for our population. Hence, this study was conducted to obtain normal splenic size parameters in Nepalese population.

Methods

This was a prospective cross sectional study involving 264 patients in Department of Radiology, Tribhuvan University Teaching Hospital. Medical ethics committee, Institute of Medicine approved the study protocol and all the patients gave prior informed consent. 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.

These patients underwent CT scan of the abdomen for indications/ diseases not influencing the splenic size. The CT scans of the patients were obtained from the Neusoft 16 slice MDCT. Images were acquired with 2 mm thickness and reviewed at 10 mm thickness. For spleen volume (V) measurement, each 10 mm axial sections showing spleen were selected. Using CT software, spleen parenchymal areas from each section were measured by tracing the margins of the spleen. These areas were summed up. Since the slice thickness used was 1 cm, the cross-sectional area of the spleen in each slice was equal to volume of spleen{volume (cm^3) = cross-sectional area (cm^2)x length (1 cm)}.Thus, the summed up splenic areas measured gave the values of splenic volume.

Transverse diameters of L1 vertebral body were also obtained as this is considered as an internal standard on CT representing the body habitus of the patient. Diameter of L1 vertebra (D) was measured in axial plane perpendicular to the vertical axis of L1 vertebral body. In the same plane, transverse diameter of L1 vertebral body at mid-section was measured.

Age and sex of the patients were also noted for comparison with the spleen volume.

Data thus obtained from the predesigned collection sheet were 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, diameter of L1 vertebral body (representing body habitus), and spleen volume. Student t-test was used to see the relation of sex with the spleen volume.

Results

We evaluated abdominal CT of 264 patients who met the selection criteria. Among them 124 were male and 140 were female (Figure1). 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 (Figure 2 and Table 1).

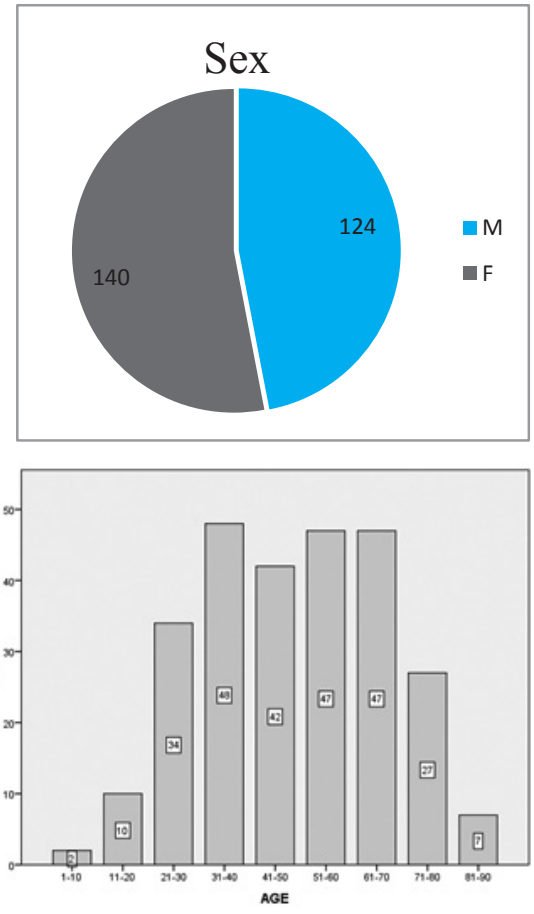

Figure 1 & 2. (1) Pie-chart showing distribution of patients based on gender. F= Female. M= Male (n= 264). (2) Bar diagram showing number of cases included in the study according to the age group (n= 264).

Table 1: Crosstabulation of age group and sex of the cases showing number of male and female patients in different age groups (n= 264).

Age Group (years)	Sex		Total
	Male	Female	
1-10	0	2	2
11-20	4	6	10
21-30	21	13	34
31-40	30	18	48
41-50	29	13	42
51-60	20	27	47
61-70	25	22	47
71-80	10	17	27
81-90	1	6	7
Total	140	124	264

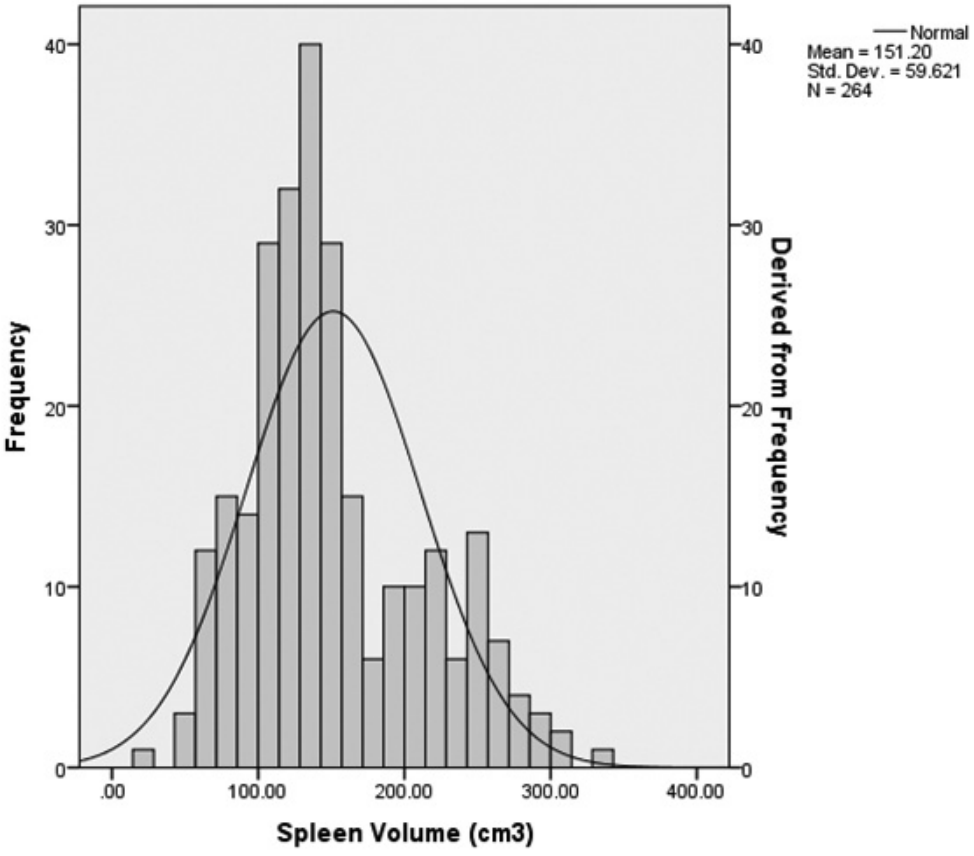

Figure 3. Histogram with distribution curve of spleen volume (n= 264).

Mean spleen volume was 151.20 cm^3 with standard deviation of 59.62 cm^3 (Figure 3). Maximum spleen volume was 331.66 cm^3 and minimum spleen volume was 25.95 cm^3.

Minimum mean spleen volume was in the age group of 1-10 years (111.63 cm^3). With increasing age, mean spleen volume increased and reached maximum in the age group of 11-20 years (188.38 cm^3). However, the mean splenic volume decreased with increasing age thereafter, except for the age group of 51-60 years which also showed second peak of mean spleen volume (174.79 cm^3). Again later with increasing age, mean spleen volume decreased (Table 2). Overall, weak negative correlation of the splenic volume with age ($r= -0.173$, $p< 0.01$) was noted.

Mean spleen volume in male was 152.79 cm^3 with standard deviation of 56.40 cm^3 and mean spleen volume in female was 149.80 cm^3 with standard deviation of 62.50 cm^3. No significant correlation of splenic volume with sex ($p>0.05$) noted, and overall mean values of splenic volume in male and female genders were very close.

Mean diameter of L1 vertebral body was 3.6 cm with standard deviation of 0.4 cm. Range of transverse diameter of L1 vertebral body was 2.8 cm to 5.1 cm. Weak negative correlation of the vertebral body diameter with splenic volume ($r= -0.132$, $p<0.05$) was noted.

Table 2. Mean spleen volume in different age groups (n= 264).

Age Group (years)	Mean Spleen Volume (cm^3)
1-10	111.63
11-20	188.38
21-30	155.86
31-40	153.77
41-50	147.87
51-60	174.78
61-70	138.14
71-80	125.45
81-90	117.90

Discussion

Mean spleen volume in Nepalese population in the present study was 151.20 ± 59.62 cm^3 with a range of 25.95 – 331.66 cm^3 taking consideration of wide range of age group. The findings in the present study are similar to the findings of Picardi et al who studied European population by USG[6]. The findings in the present study are also similar to the findings of AdilAsghar et al who studied North Indian adult population by MDCT.[7] However, the findings in the present study are higher than those obtained by Hidaka et al in Japanese population by USG.[8] The findings in the present study are lower than those obtained by many authors in European and American population by various imaging modalities including CT. Maximum mean splenic volume was obtained by Spielman et al in American population by USG (333.6 ± 116.1 cm^3) which is far more than the findings in the present study.[9] These disparities in volume of spleen in these various studies might be due to various imaging modalities and techniques used for estimation of the spleen volume. Also the differences might be due to difference of population and race. Again in the present study, samples were taken from extreme age groups as well; these might have also influenced the findings in the current study. Also, the marked disparity in the findings of the present study from the study of Spielmann et al may be due to study of tall college athletes in their study which correlated with height of the individuals.

It is well known that age is an important factor in the involution of many visceras, however spleen seems to be exception to this. There was weak negative correlation of the spleen volume with age noted in the current study. The findings are similar to the findings of the study done by McCormick and Kashgarian[10], Krumbhaar and Lippincott[11], and Boyd[12].

According to results of the present study, the size of the spleen increased with the age in children and adolescent, with the maximum size during the age group of 11-20 yrs (adolescence). Then after, the size of the spleen decreased except for the second peak in the age group of 51-60 yrs. These findings of increased spleen size during the childhood and adolescence are similar to the findings of the study done by Prassopoulos and Cavouras[13], and Watanabe et al[14]. This maximum size of the spleen in this age group might be due to maximum lymphoid growth up to this age group, followed by cessation in their growth following the lymphoid growth curve.

The second peak of spleen size in the age group of 51-60 years was the new finding in the present study which was not observed or mentioned in any previous studies. The reason behind this increased spleen size in this age group should be further verified by other studies.

The current study also showed weak negative correlation of the splenic volume with transverse diameter of L1 vertebral body, which is currently considered as an internal standard on CT, representative of the body habitus. These findings are contrary to the findings of the study done by Prossopoulos et al[1] who found no significant correlation of the spleen volume with the body habitus.[1]

The findings in the current study also showed no significant difference of the spleen volume between male and female individuals. The mean spleen volumes were similar in both genders. These findings are also similar to the findings of Niederau et al[15], Pietri and Boscaini[16], and Prossopoulos et al[1].

Conclusion

Computed tomography can be reliably used as an imaging modality for assessing the splenic volume as well as the linear parameters of spleen. The reference ranges obtained in this study will be helpful in establishing the normality of splenic size in various clinical scenarios.

Conflict of interests: None Declared

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